

# Stormwater Best Management Practice (BMP) Performance Assessment in Montgomery County, Maryland



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Department of Environmental Protection

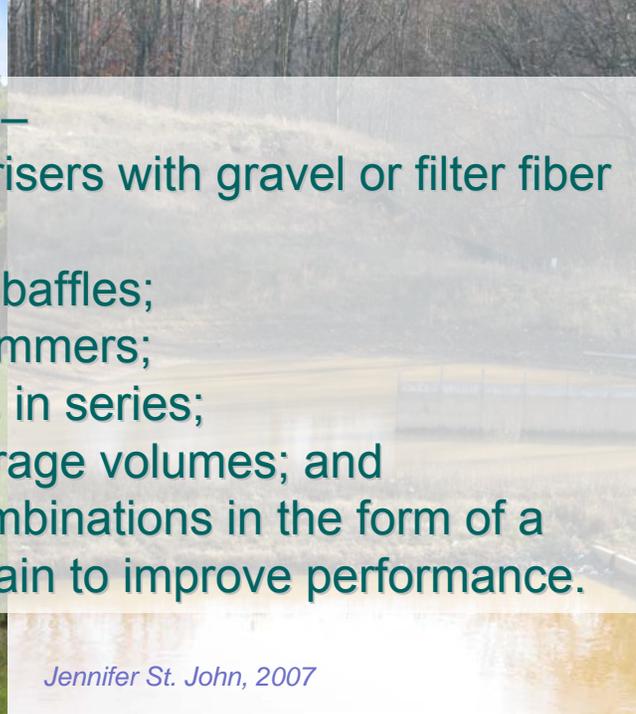
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# What is a Special Protection Area?

- Water resources or other environmental features that are of high quality or are unusually sensitive and would be impacted by development.
- Special environmental protection measures:
  - Limiting imperviousness
  - Protecting natural features
  - Minimizing and phasing of grading
  - Promoting groundwater recharge
  - Using innovative and redundant control structures

**Executive Regulation 29-95: *Water Quality Review for Development in Designated Special Protection Areas***



- **S&EC features –**
  - Perforated risers with gravel or filter fiber jackets;
  - Filter fence baffles;
  - Floating skimmers;
  - Dual basins in series;
  - Greater storage volumes; and
  - Utilizing combinations in the form of a treatment train to improve performance.

*Mike Thompson, 2008*

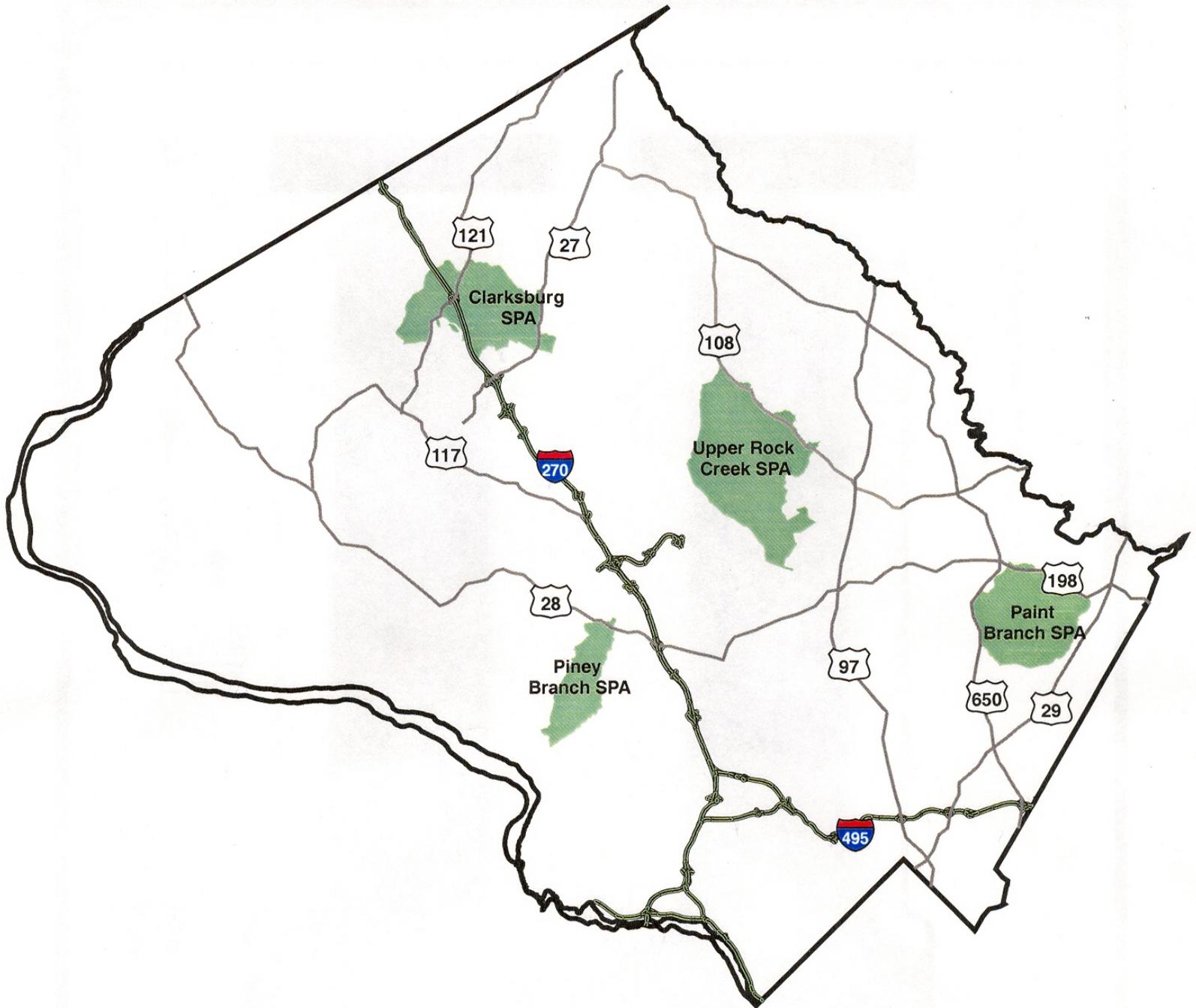
*Jennifer St. John, 2007*



- **Water quality volume –**
  - Treatment of first flush
  - D.A. limit of 3 ac. to a Surface Sand Filter and 1 acre for all other water quality structures.
- **Channel protection storage volume –**
  - One year 24 hour storm
- **Recharge volume**

*Diana Hogan, 2007*

*Randy Dymond, 2007*



# Performance Goals

1. Stream/aquatic life habitat protection.
2. Maintain stream base flow.
3. Protect seeps, springs, and wetlands.
4. Maintain natural on-site stream channels.
5. Minimize storm flow runoff increases.
6. Identify and protect stream banks prone to erosion and slumping.
7. Minimize increases to ambient water temperature.
8. Minimize sediment loading.
9. Minimize nutrient loadings.
10. Control insecticides, pesticides, and toxic substances.



# Data Collected

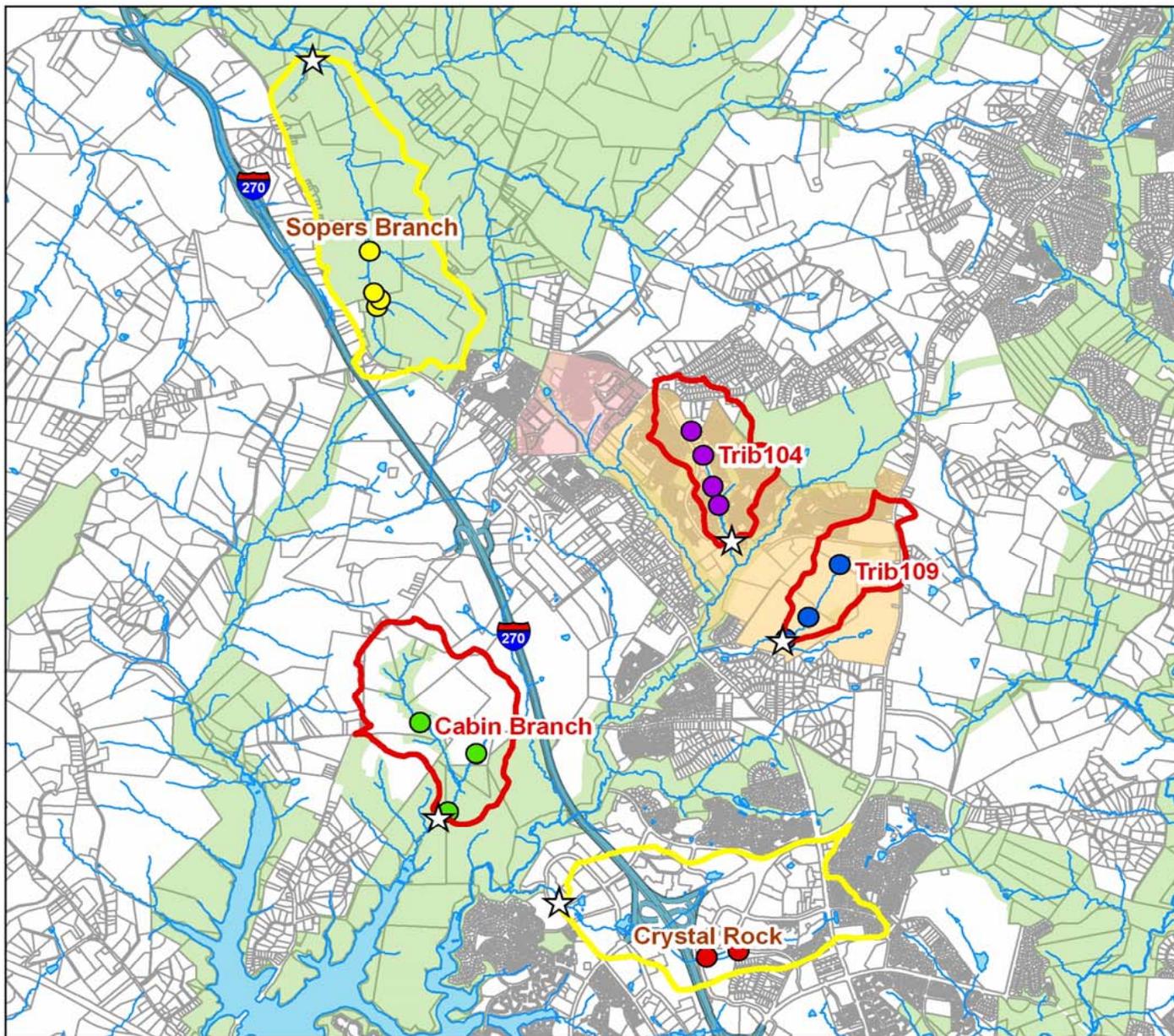
- **Developer/Consultant Monitoring** (within the property)
  - “Stream-specific” water quality parameters
    - Montgomery County Department of Environmental Protection Best Management Practice Monitoring Protocols (1998)
  - Structural monitoring (S&EC and SWM BMPs)
- **DEP Monitoring** (upstream and downstream of the development and within the watershed)
  - Biological monitoring: benthic macroinvertebrates, fish, herpetofauna
    - Maryland Biological Stream Survey (MBSS) Protocols
  - Rapid Habitat Assessment
    - US EPA for Riffle/Run Prevalent Streams (Barbour and Stribling)
  - *In situ* water chemistry sampling
    - Multi-parameter probe (MBSS)
  - Continuous Stream Temperature Monitoring
    - 1 June through 30 September
- **Clarksburg Monitoring Partnership**

# Clarksburg Monitoring Partnership

- Montgomery Co. Dept. of Permitting Services
- Montgomery Co. Dept. of Environmental Protection
- Maryland-National Capital Park and Planning Commission
- University of Maryland, College Park
- USGS, Water Resources Division, Baltimore, MD
- USGS, Environmental Resources Center, Reston, VA
- Virginia Polytechnic Institute and State University
- George Mason University
- United States Environmental Protection Agency (USEPA)
  - Landscape Ecology Branch, Reston, VA
  - National Risk Management Research Laboratory, Cincinnati, OH
  - Office of Research and Development, Atlanta, GA
  - Environmental Science Center, Ft. Meade, MD



# Clarksburg Study Areas, Biomonitoring, & Geomorphology Stations



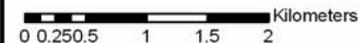
## Clarksburg Study Areas

-  Test Areas
-  Control Areas
-  Newcut Road Neighborhoods
-  Clarksburg Town Center

## ☆ Biomonitoring Sites

## Geomorphology Survey Areas

-  Little Seneca 104 Tributary
-  Little Seneca 109 Tributary
-  Little Bennett Sopers Branch
-  Cabin Branch
-  Crystal Rock



Location



# Results of developer-funded monitoring

- **14 projects completed; 29 ongoing**
- **Stream-specific parameters**
  - Stream temperature
  - Embeddedness
  - Groundwater (levels and chemistry)
  - Instream Chemistry
  - Continuous Flow
- **Sediment and Erosion Control (S&EC)**
  - Grab sampling
  - Automated flow-weighted sampling
- **Stormwater Management (SWM)**
  - Automated flow-weighted sampling



# Monitoring at completed projects

Parameter	No. of Projects	Results
Temperature	8	7 – no impacts; 1 – inconclusive
Embeddedness	6	4 – no impacts; 2 – impacted (during construction only)
GW Elevation	6	3 – no impacts; 1 – impacted; 1 – inconclusive; 1 – requirements dropped
GW Chemistry	2	2 - inconclusive
Instream Chemistry	1	1 – impacted (during construction only)
Continuous Flow	4	4 - inconclusive

# Sediment and Erosion Control Best Management Practices

(Monitoring During Construction)



# BMP Sampling: Current Limitations

## Grab sampling

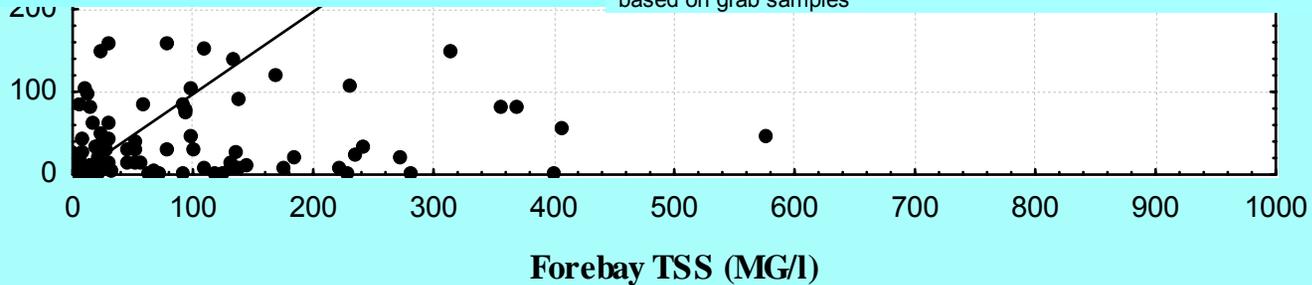
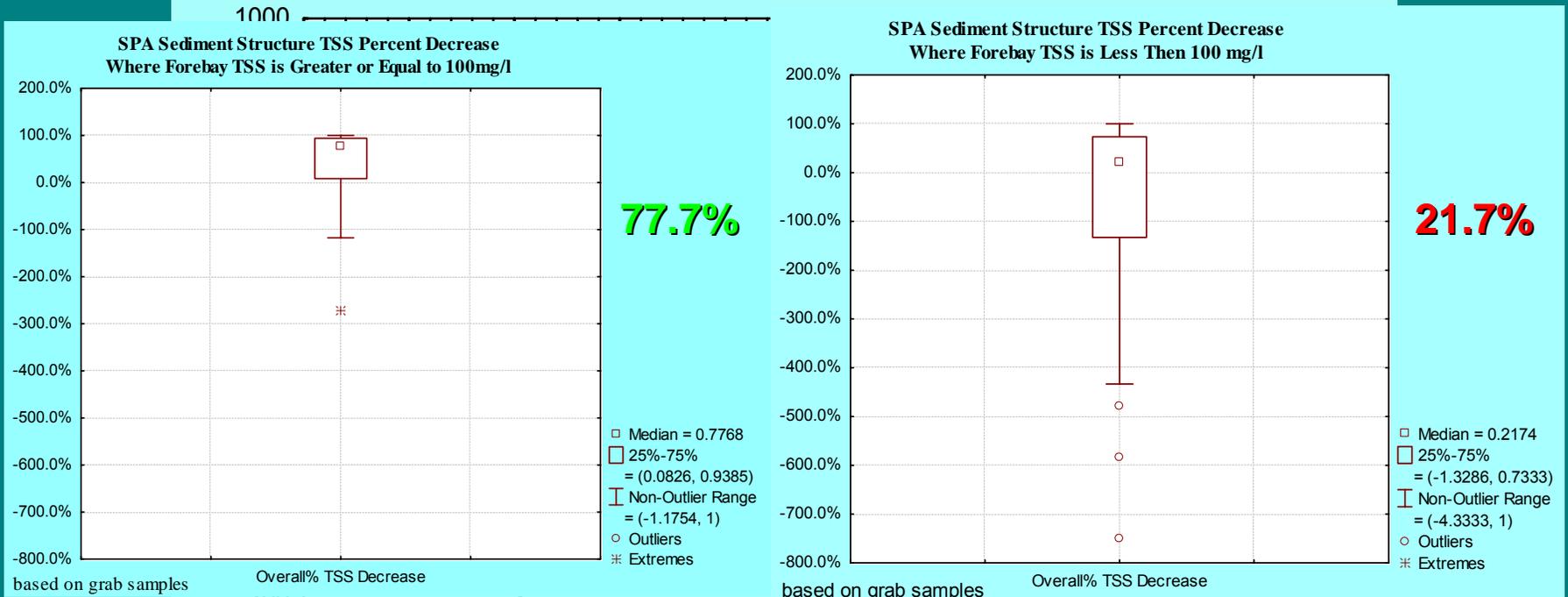
- Not representative of an entire storm event
- Gives equal weight to small and large storms
- Load efficiency considered more accurate
  - Volume of water entering the BMP and water losses
- Not comparable

## Flow-weighted composite sampling

- Sampling challenges
  - Equipment problems
  - Low flows
  - Weather-related difficulties
  - First flush composited in with rest of discharge
- Problems with structure configuration
  - Not sampleable
  - Backwater at inlets
  - Unaccounted for groundwater inputs

# S&EC Grab Sampling Results

## Forebay and Outfall TSS Concentrations

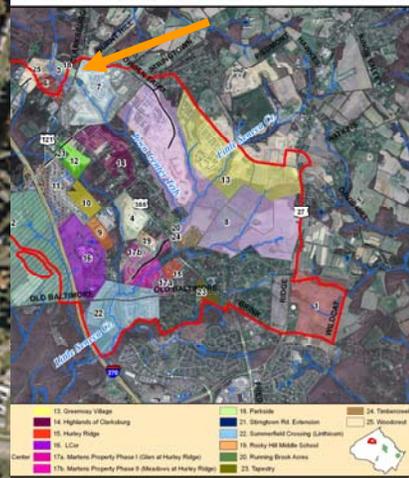


101 grab samples from 15 structures (2002-2007)

# Clarksburg Town Center

Clarksburg Town Center

2006



- 147 acres residential (multi-family, townhouse and single family)
- 13 acres commercial



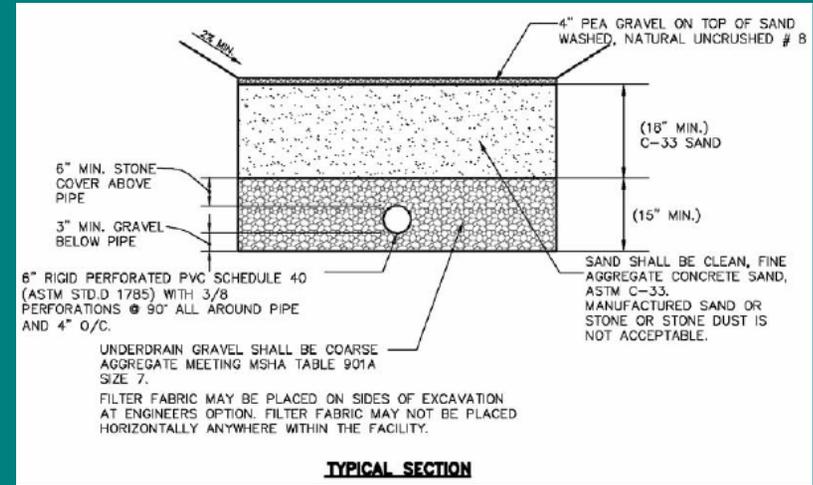
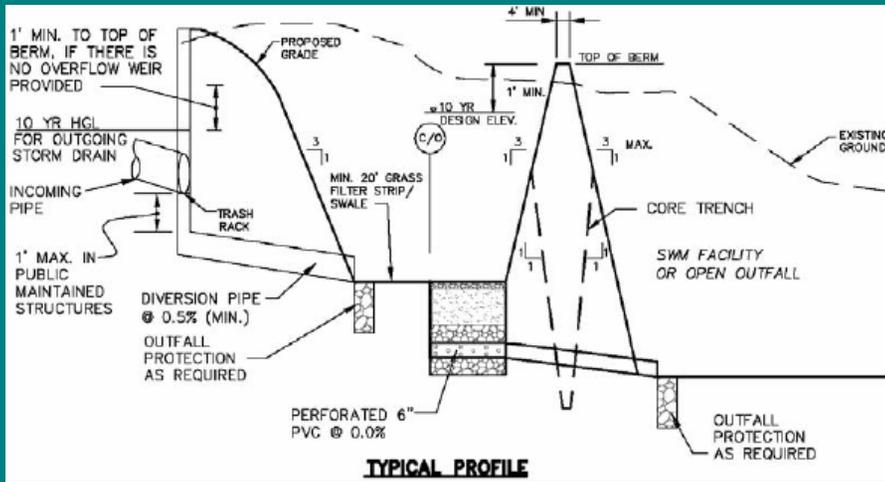


# Stormwater Management Best Management Practices



(Post Construction Monitoring)

# Surface Sandfilter



- Best-suited for managing first flush
- Recharge area beneath filter medium and underdrain pipe
- Removal efficiencies with reported TSS removal efficiency of 49 to 86%

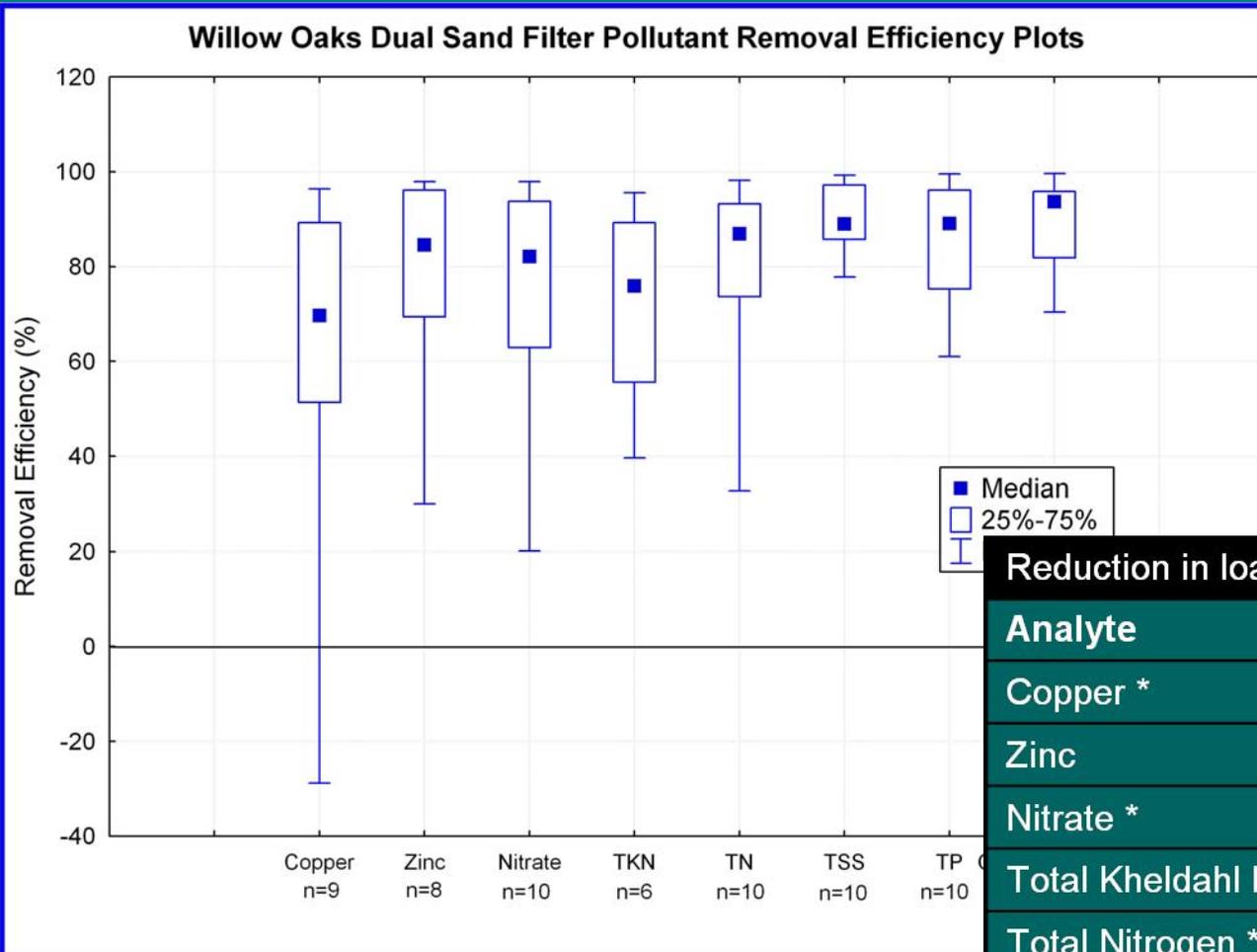


# Willow Oaks Surface Sand Filters

July 2005 –  
March 2008

13 storms

> 62%



## Reduction in loadings for cell 1

Analyte	Ave. Removal
Copper *	84.1%
Zinc	93.4%
Nitrate *	83.6%
Total Kheldahl Nitrogen	82.0%
Total Nitrogen *	87.4%
Total Suspended Solids *	89.1%
Total Phosphorus *	85.4%
Orthophosphate *	80.9%

\* - Statistically significant (paired t test)

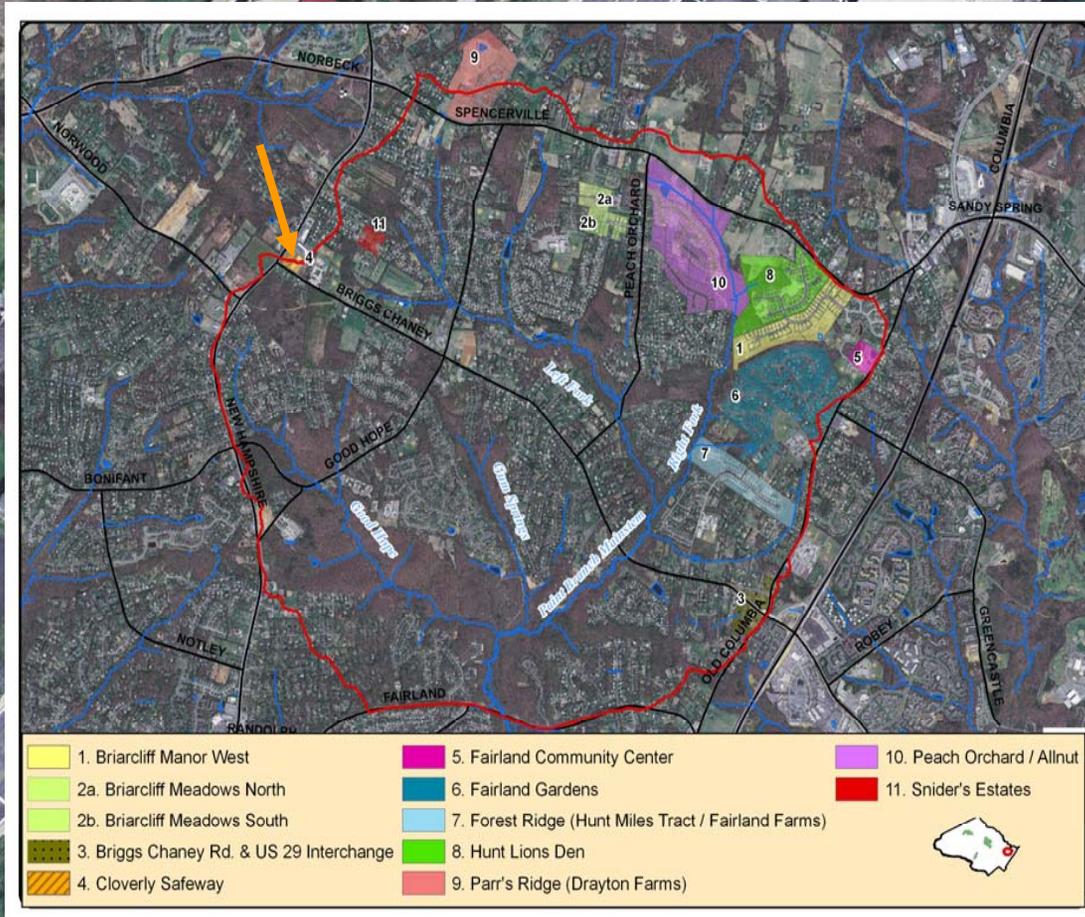
Concentrations below detection limits: Cadmium, Lead, Nitrite

# Stormceptor®

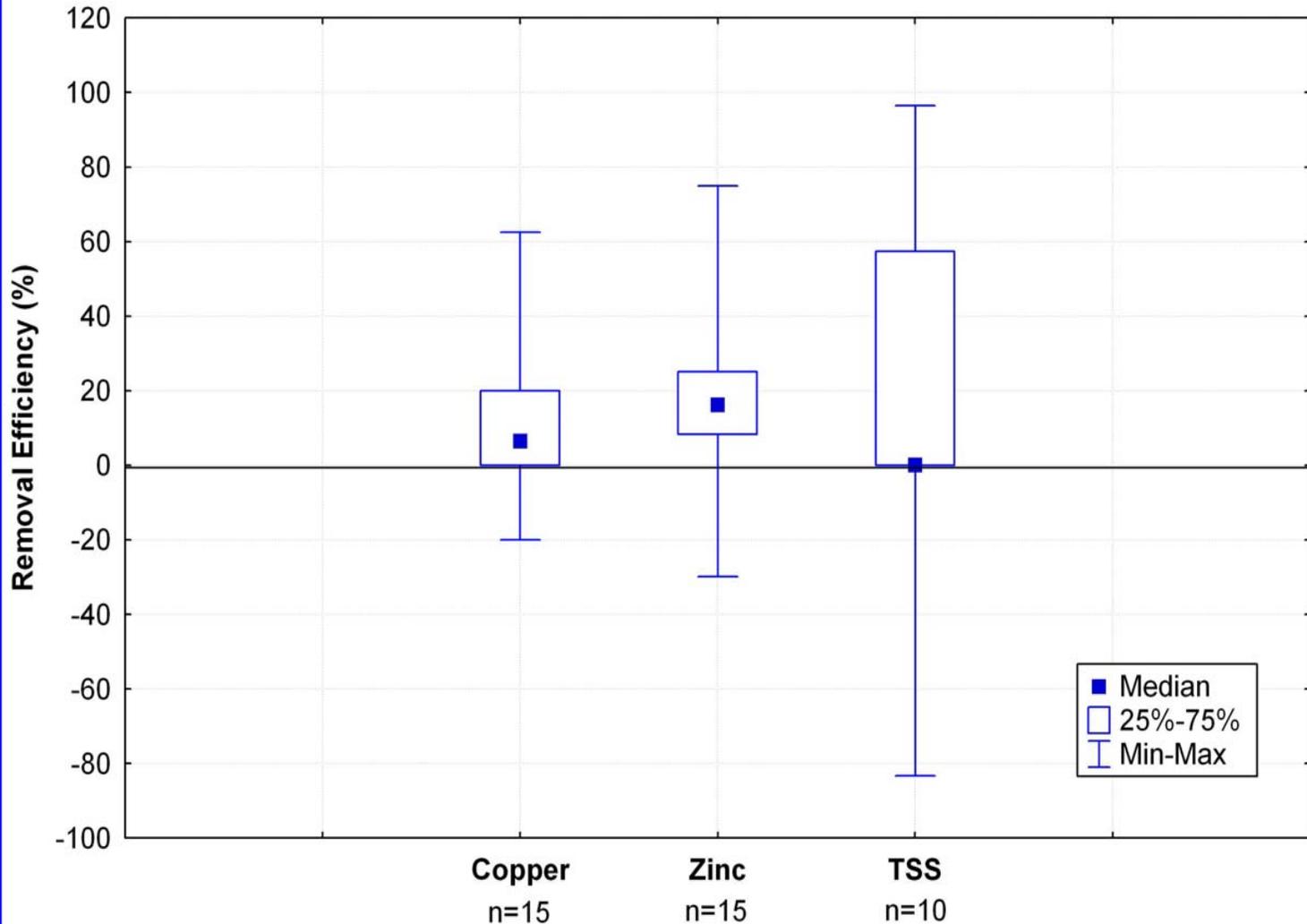


- Hydrodynamic device
- Treats a maximum flow rate and bypasses the remainder of the runoff volume
- Slows incoming stormwater to reduce turbulence which allows oils to rise and sediment to settle
- Variable removal efficiencies of TSS:
  - Manufacturer – **80%**
  - Massachusetts Strategic Environment Technology Partnership – **between 52 and 77%**
  - Center for Watershed Protection – **between 21% and 51.5%**

# Cloverly Safeway



## Cloverly Safeway Stormceptor® Pollutant Removal Efficiency Plots



- ***B.D.L. – Cadmium, Lead***
- ***In vs. out – Not statistically different***
- ***For 13 of the 15 storms (Nov. 2002 – June 2008), the runoff temperatures increased sharply between approx. 3 and 18°F***

BMP efficiencies of structures alone cannot be used to assess BMP effectiveness at protecting water quality.



# Biological Monitoring

- **57** stream monitoring stations:
  - **27** in the Clarksburg SPA (beginning in 1995);
  - **14** in Upper Paint Branch (1995);
  - **10** in Piney Branch (1995); and
  - **6** in the Upper Rock Creek SPA (beginning in 2004).
- Evaluate data through:
  1. Average stream conditions (benthics and fish)
  2. IBI time series / changes over time
  3. Changes to community structure and function



# Average Stream Conditions

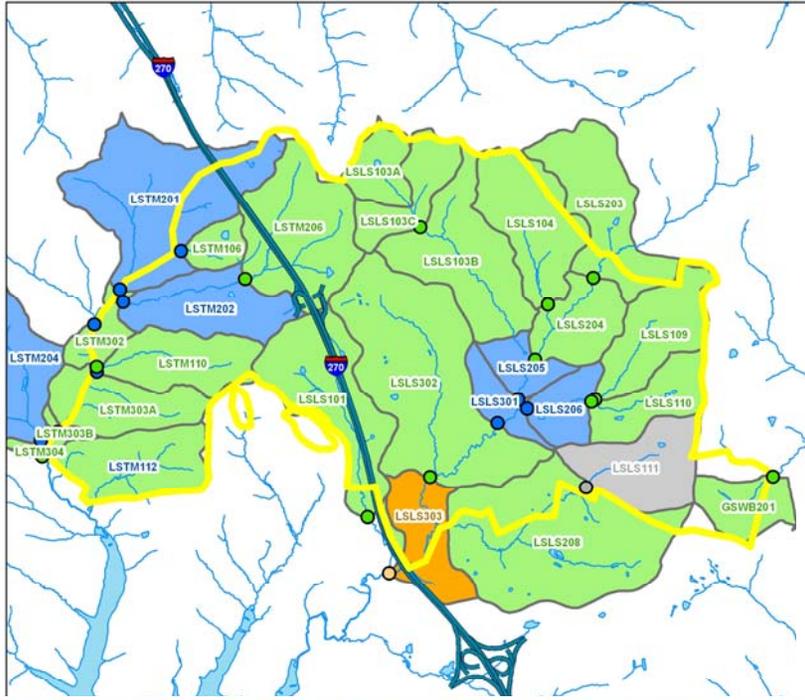
- % of possible IBI rating
  - 0-40 for benthics
  - 0-5 fish
- Combine in an average



Percentage	Rating
>87 and $\leq$ 100	Excellent
>63 and $\leq$ 87	Good
> 41 and $\leq$ 63	Fair
$\leq$ 41	Poor



Clarksburg SPA - Average Stream Conditions 1994-1998 (Pre-Development)

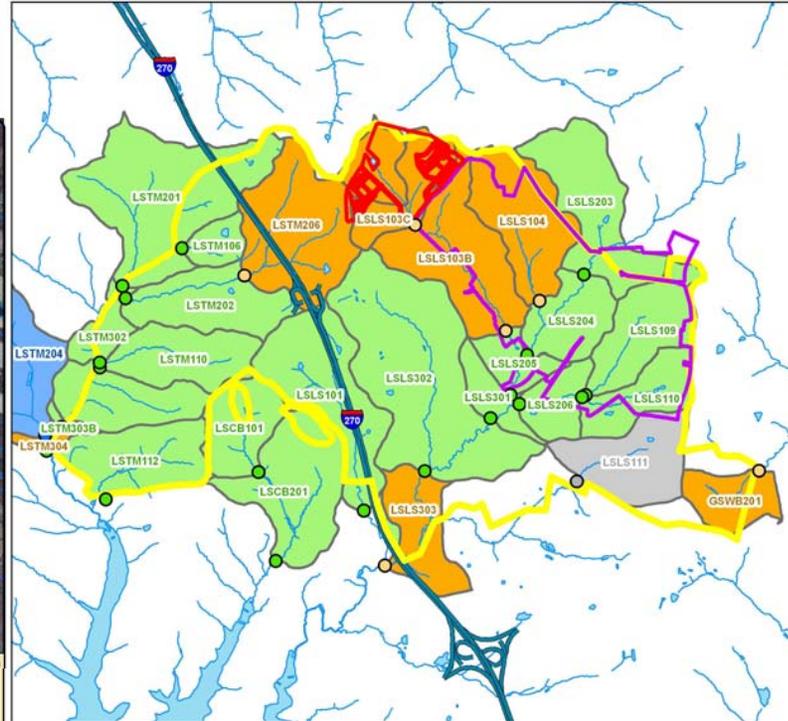


- Stream Condition IBI Categories**
- Excellent
  - Good
  - Fair
  - Not Monitored until 1999
  - Streams
  - Clarksburg SPA Boundary

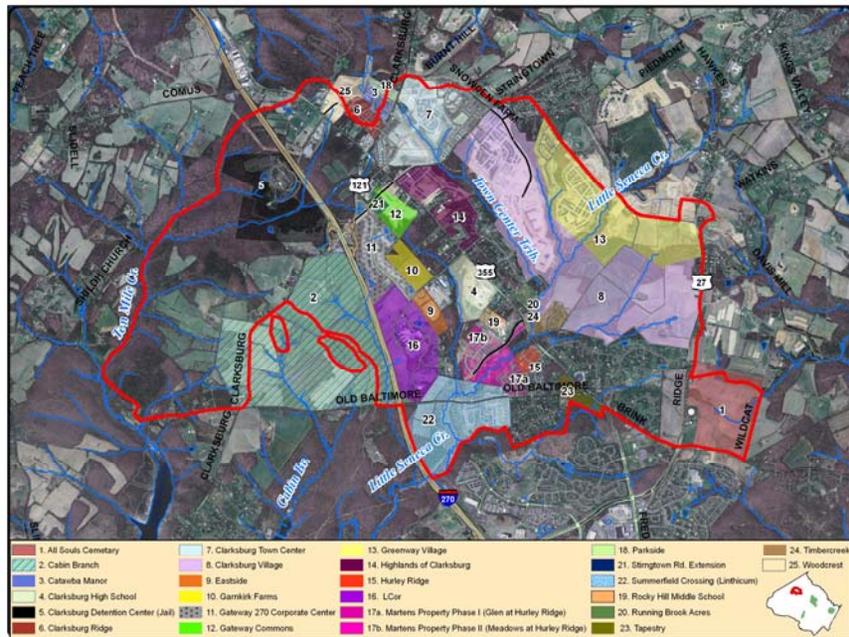
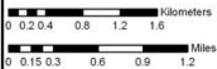


# Clarksburg Average Stream Conditions

Clarksburg SPA - Average Stream Conditions 2006-2007 (Current)

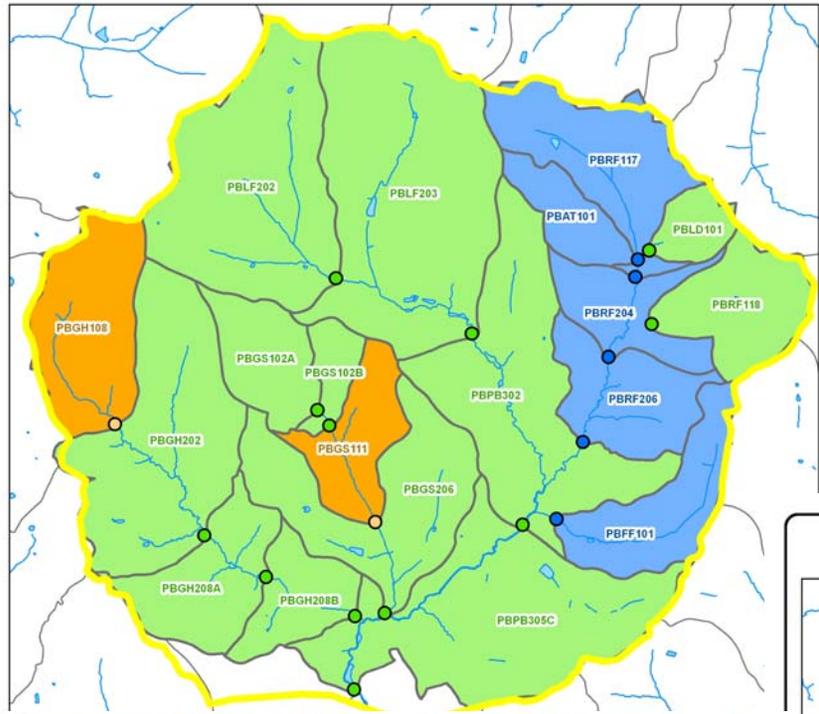


- Stream Condition IBI Categories**
- Excellent
  - Good
  - Fair
  - Not Monitored since 2000
  - Streams
  - Clarksburg SPA Boundary
  - Clarksburg Town Center
  - Newcut Road Neighborhoods



- |                                       |                                  |  |                                      |                 |
|---------------------------------------|----------------------------------|--|--------------------------------------|-----------------|
| 1. All Souls Cemetery                 | 7. Clarksburg Town Center        | 13. Greenway Village                                     | 18. Parkside                         | 24. Timbercreek |
| 2. Cabin Branch                       | 8. Clarksburg Village            | 14. Highlands of Clarksburg                              | 21. Stimpston Rd. Extension          | 25. Woodcrest   |
| 3. Cataeba Manor                      | 9. Eastside                      | 15. Hurley Ridge   | 22. Summerfield Crossing (Leithicum) |                 |
| 4. Clarksburg High School             | 10. Garrink Farms                | 16. LCoar  | 19. Rocky Hill Middle School         |                 |
| 5. Clarksburg Detention Center (Jail) | 11. Gateway 270 Corporate Center | 17a. Martens Property Phase I (Glen at Hurley Ridge)     | 20. Running Brook Acres              |                 |
| 6. Clarksburg Ridge                   | 12. Gateway Commons              | 17b. Martens Property Phase II (Meadows at Hurley Ridge) | 23. Tapestry                         |                 |

Paint Branch SPA - Average Stream Conditions 1994-1998 (Pre-Development)



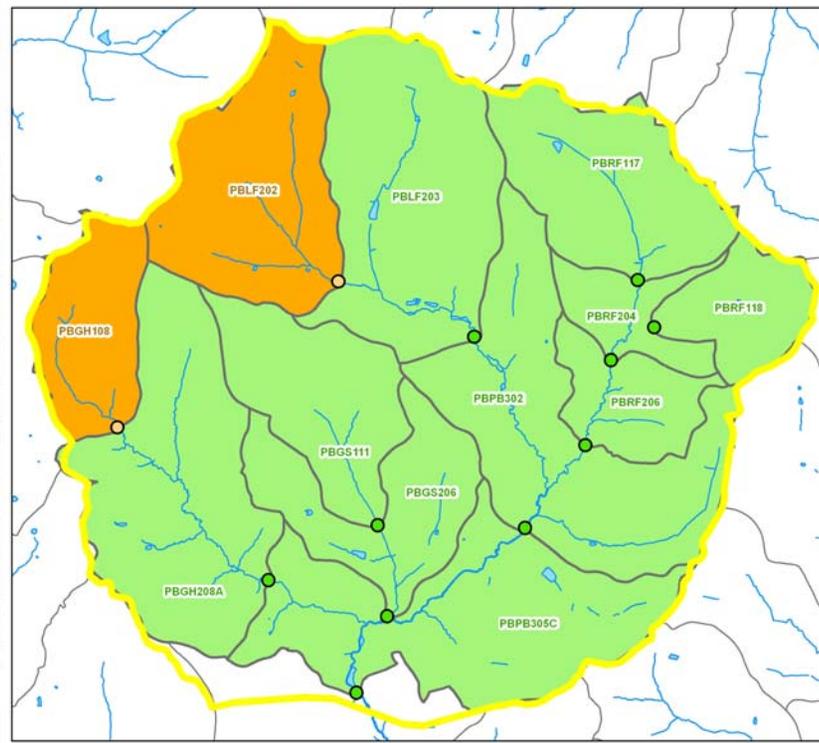
**Stream Condition IBI Categories**

- Excellent
- Good
- Fair
- Streams
- Paint Branch SPA Boundary



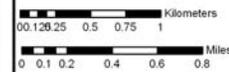
# Upper Paint Branch Average Stream Conditions

Paint Branch SPA - Average Stream Conditions 2006-2007 (Current)



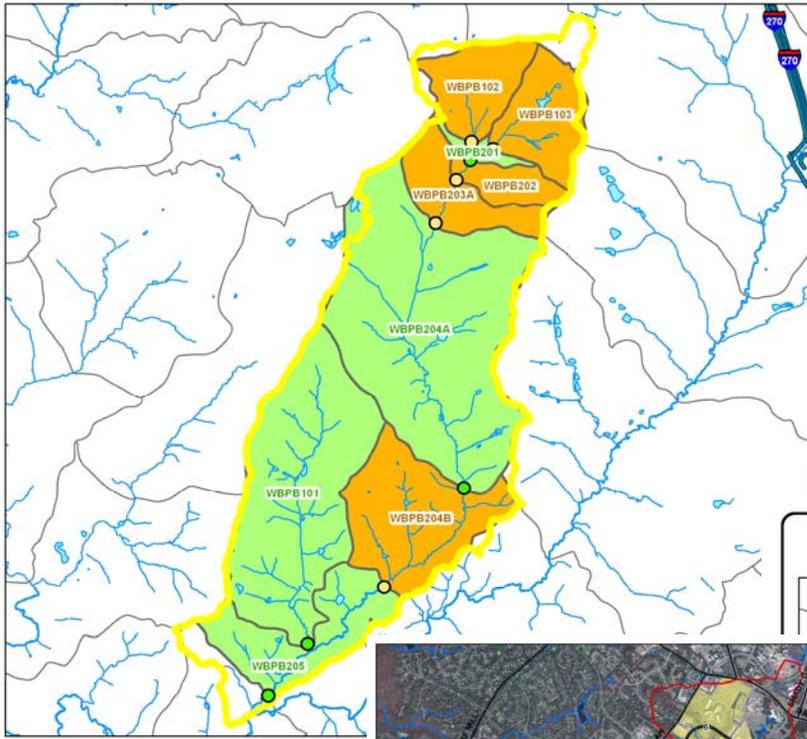
**Stream Condition IBI Categories**

- Good
- Fair
- Poor
- Streams
- Paint Branch SPA Boundary



- |  |   |                            |
|--|---|----------------------------|
| 1. Briarcliff Manor West                 | 5. Fairland Community Center                        | 10. Peach Orchard / Allnut |
| 2a. Briarcliff Meadows North             | 6. Fairland Gardens                                 | 11. Snider's Estates       |
| 2b. Briarcliff Meadows South             | 7. Forest Ridge (Hunt Miles Tract / Fairland Farms) |                            |
| 3. Briggs Chaney Rd. & US 29 Interchange | 8. Hunt Lions Den                                   |                            |
| 4. Cloverly Safeway                      | 9. Parr's Ridge (Drayton Farms)                     |                            |

Piney Branch SPA - Average Stream Conditions 1995-1997 (Pre-Development)



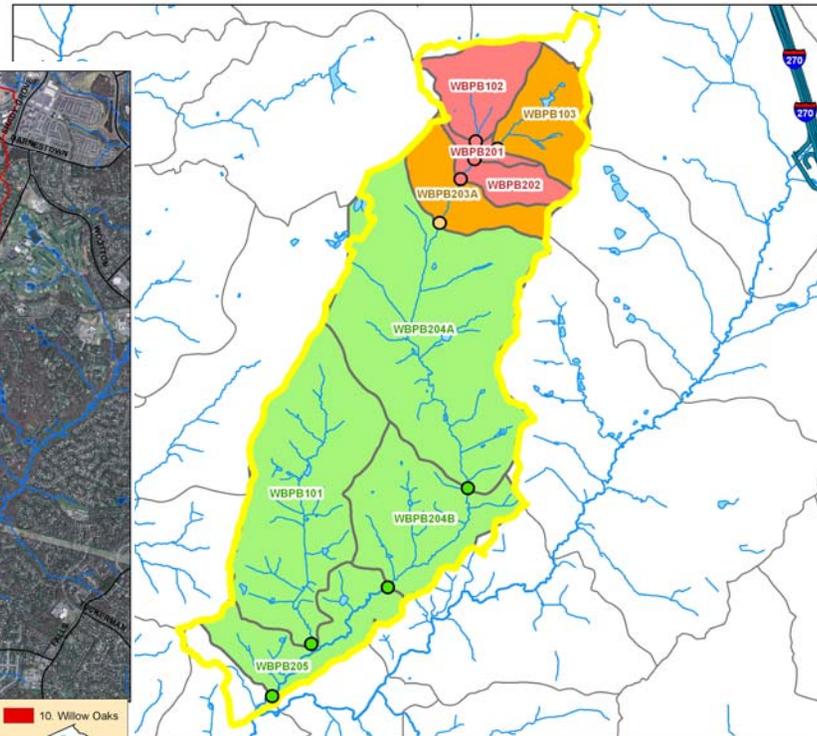
Stream Condition IBI Categories

- Good
- Fair
- Streams
- Piney Branch SPA Boundary



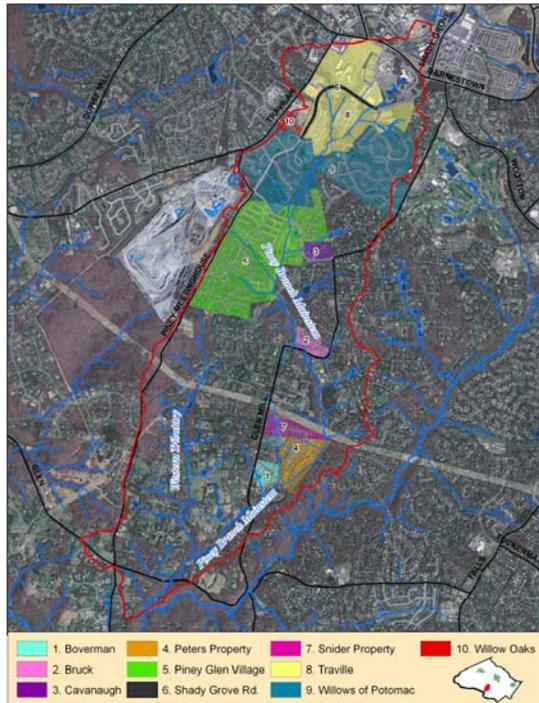
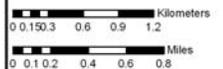
# Piney Branch Average Stream Conditions

Piney Branch SPA - Average Stream Conditions 2006-2007 (Current)



Stream Condition IBI Categories

- Good
- Fair
- Poor
- Streams
- Piney Branch SPA Boundary

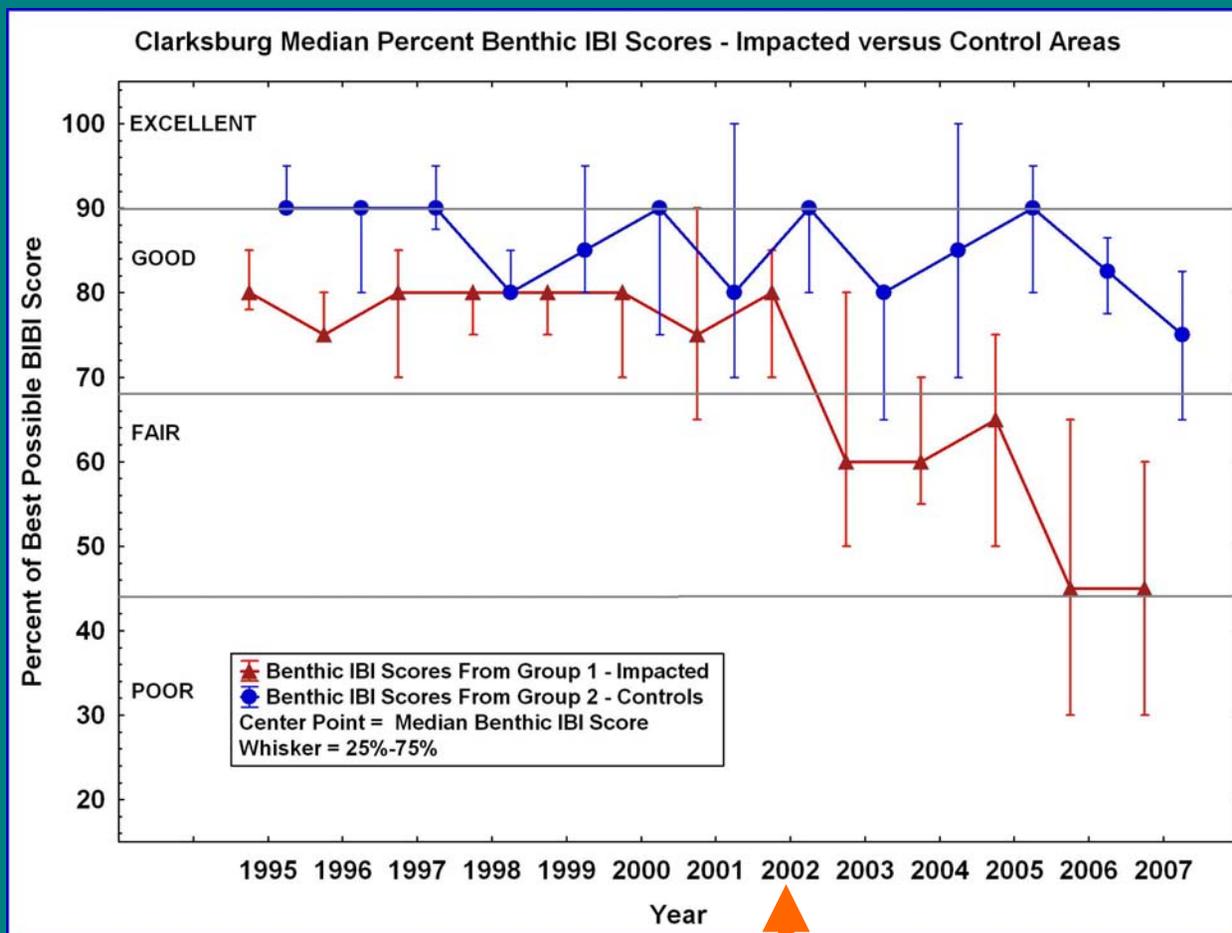


- |              |                       |                       |                 |
|--------------|-----------------------|-----------------------|-----------------|
| 1. Boverman  | 4. Peters Property    | 7. Snider Property    | 10. Willow Oaks |
| 2. Bruck     | 5. Piney Glen Village | 8. Traville           |                 |
| 3. Cavanaugh | 6. Shady Grove Rd.    | 9. Willows of Potomac |                 |

# Benthic community changes over time

- Control vs. test stations
  - **Control** = no *new* development
  - **Test** = drainage areas are *newly* disturbed through the development process
- All stations were:
  - Identified and analyzed from the same SPA watersheds
  - Monitored during same time of year
  - Monitoring using same methods
  - In close proximity

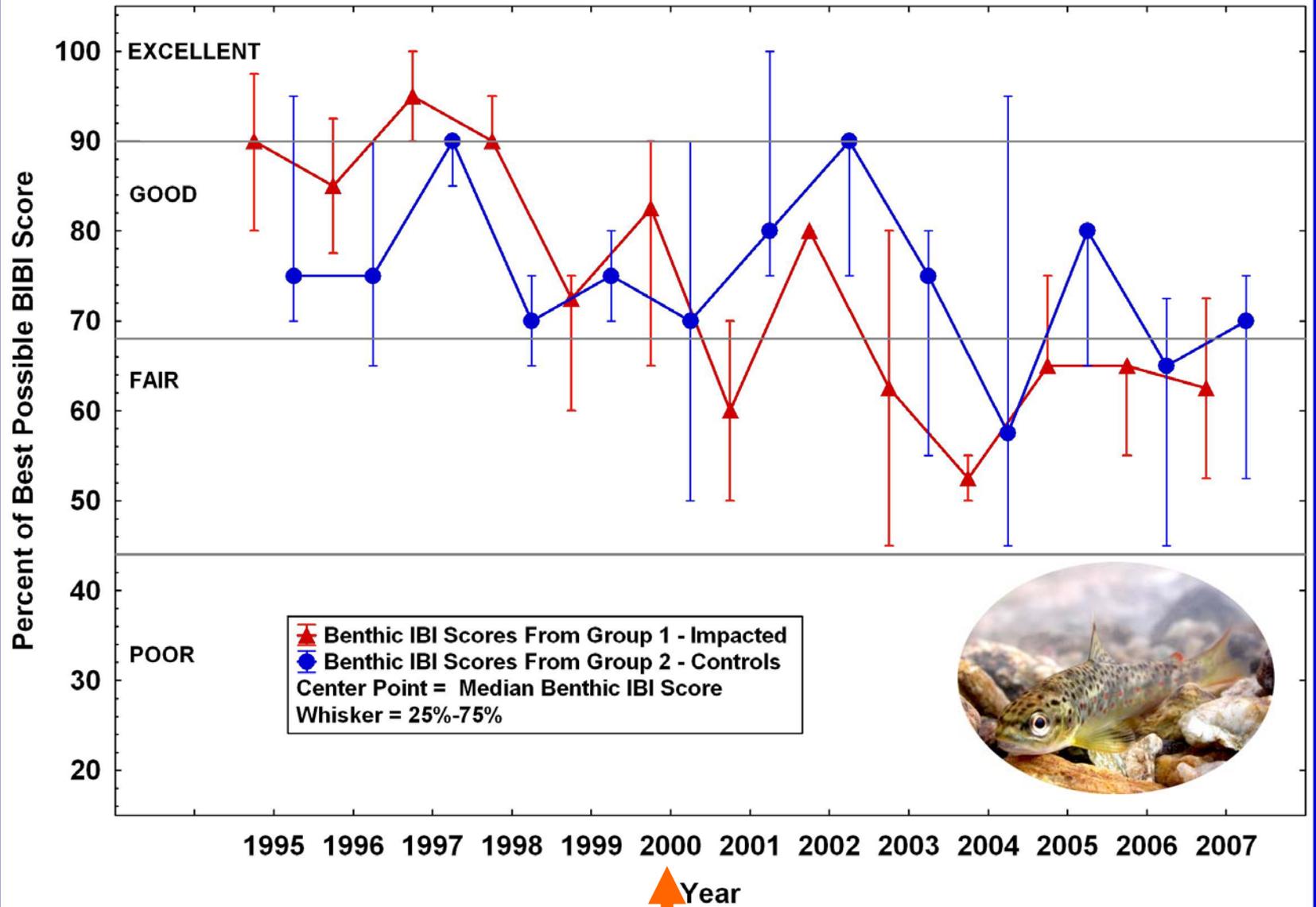




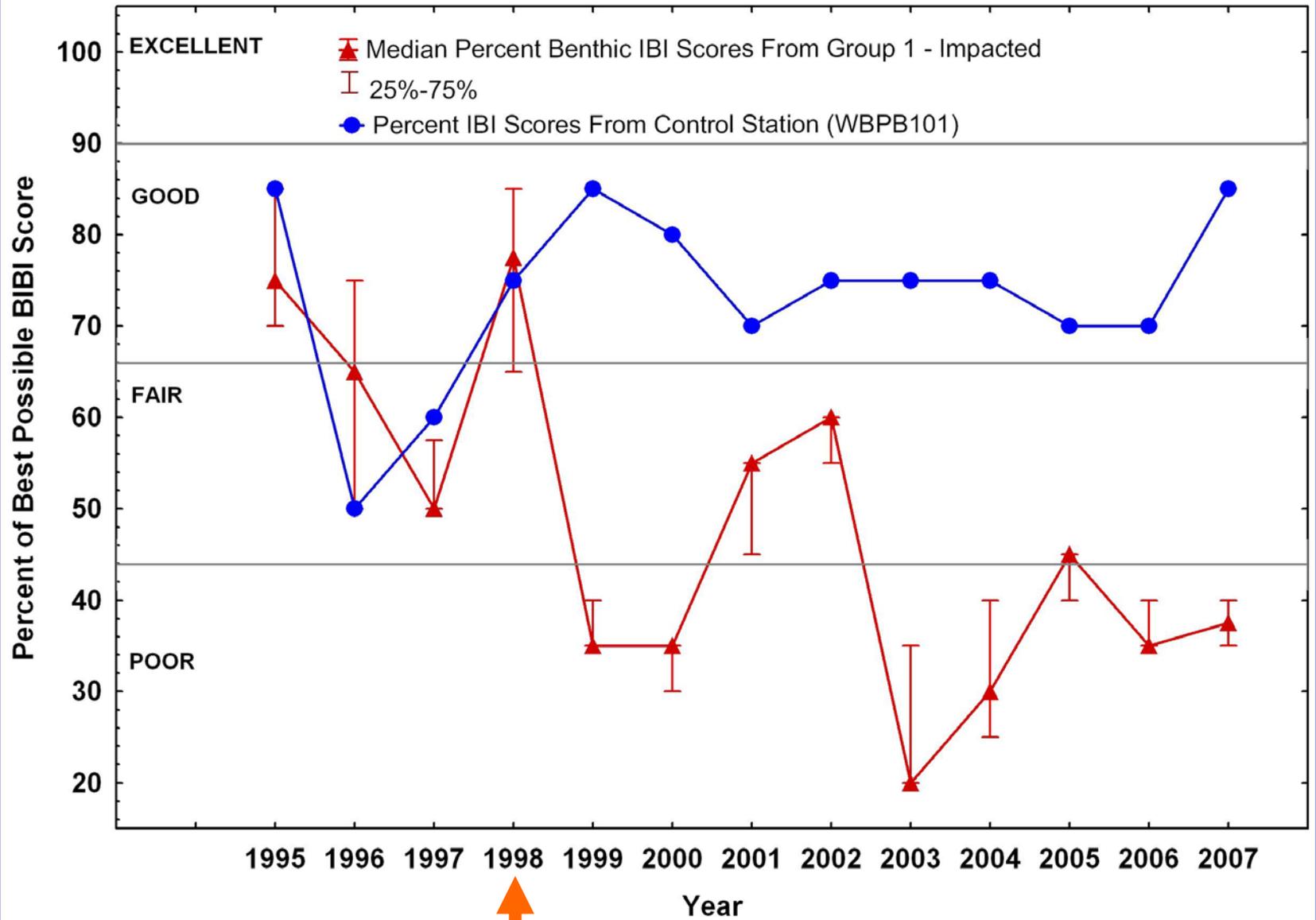
## Landuse

- **Control** – predominantly rural agricultural; unchanged topography
- **Test** – Majority of drainage areas disturbed through the development process

# Paint Branch Median Percent Benthic IBI Scores - Impacted versus Control Areas



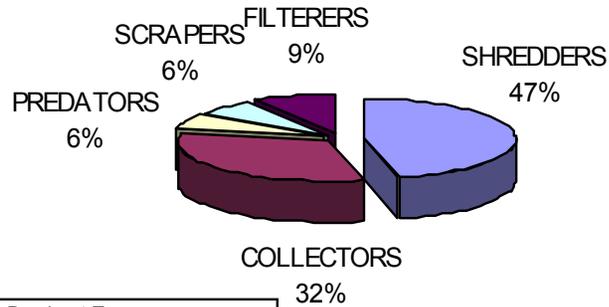
Piney Branch Median Percent Benthic IBI Scores - Impacted Areas vs Control (WBPB101)



# Changes to community structure and function

- Community structure = dominant taxa
- Community function = functional feeding groups
- Examine differences in individual metrics and determine impacts using additional information such as habitat, chemistry, and landuse information.
- Supplement the IBI score and provides insight into the direct effects of environmental change and decline

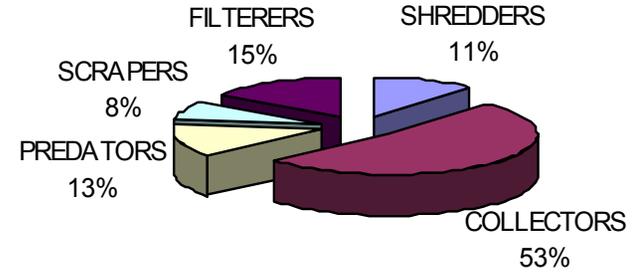
### Functional Feeding Groups; Clarksburg Pre-Construction (1996-2000)



Dominant Taxa

**Amphinemura sp.** (Shredder) = 43%  
**Chironomidae** (Collector) = 20%  
 N=35  
 Total # of Stations = 9

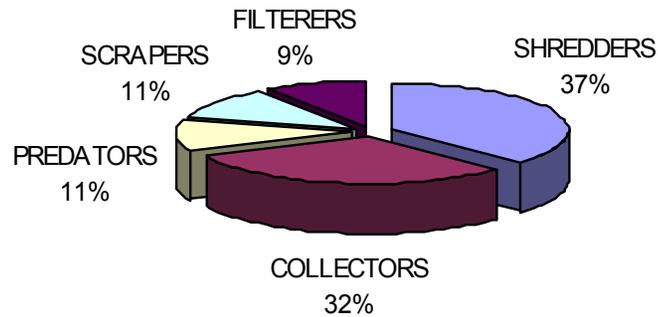
### Functional Feeding Groups; Clarksburg Through Construction (2003-2007)



Dominant Taxa

**Chironomidae** (Collector) = 52%  
**Amphinemura sp.** (Shredder) = 8%  
 N = 37  
 Total # of Stations = 9

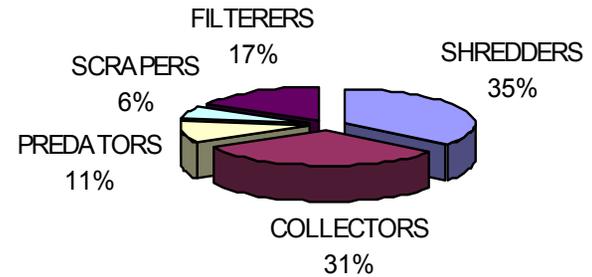
### Functional Feeding Groups; Clarksburg Control (1996-2000)



Dominant Taxa

**Amphinemura sp.** (Shredder) = 33%  
**Chironomidae** (Collector) = 21%  
 N=25  
 Total # of Stations = 8

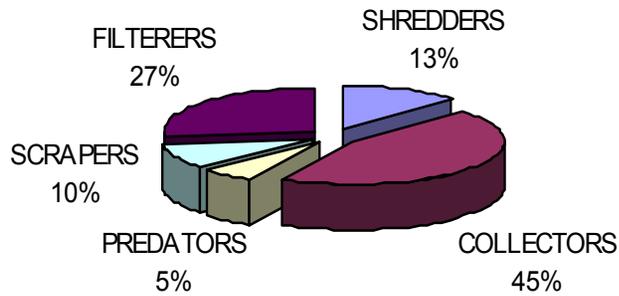
### Functional Feeding Groups; Clarksburg Control (2003-2007)



Dominant Taxa

**Chironomidae** (Collector) = 33%  
**Amphinemura sp.** (Shredder) = 32%  
 N = 27  
 Total # of Stations = 8

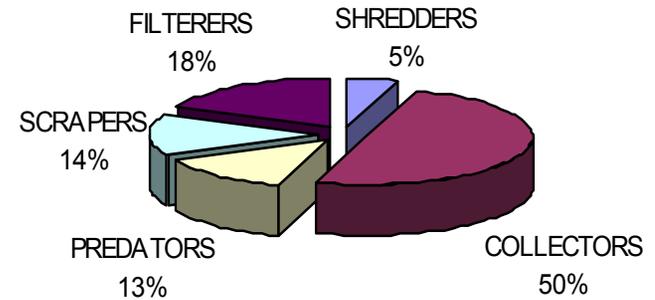
**Functional Feeding Groups; Paint Branch  
Pre-Construction (1995-1999)**



Dominant Taxa

**Chironomidae** (Collector) = 20%  
**Ephemerella sp.** (Collector) = 17%  
 N=23  
 Total # of Stations = 6

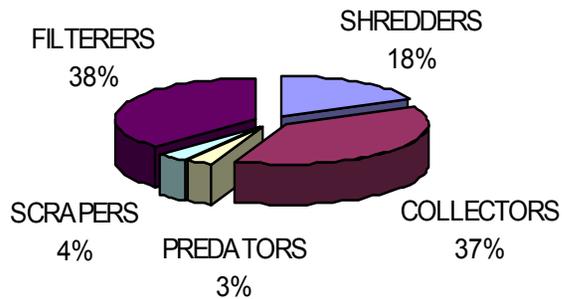
**Functional Feeding Groups; Paint Branch  
Through Construction (2001-2006)**



Dominant Taxa

**Chironomidae** (Collector) = 44%  
**Simulium sp.** (Filterer) = 5%  
 N=36  
 Total # of Stations = 6

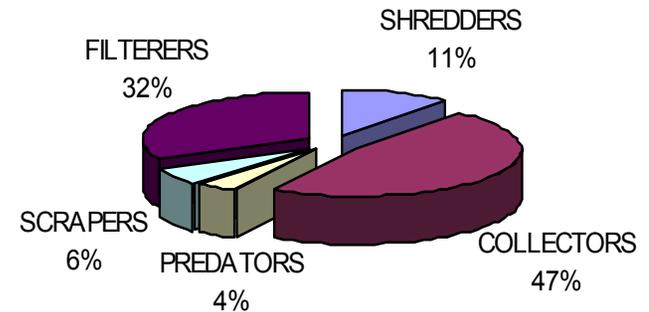
**Functional Feeding Groups; Paint Branch  
Control (1994-1999)**



Dominant Taxa

**Chironomidae** (Collector) = 20%  
**Ephemerella sp.** (Collector) = 15%  
 N=19  
 Total # of Stations = 4

**Functional Feeding Groups; Paint Branch  
Control (2001-2006)**

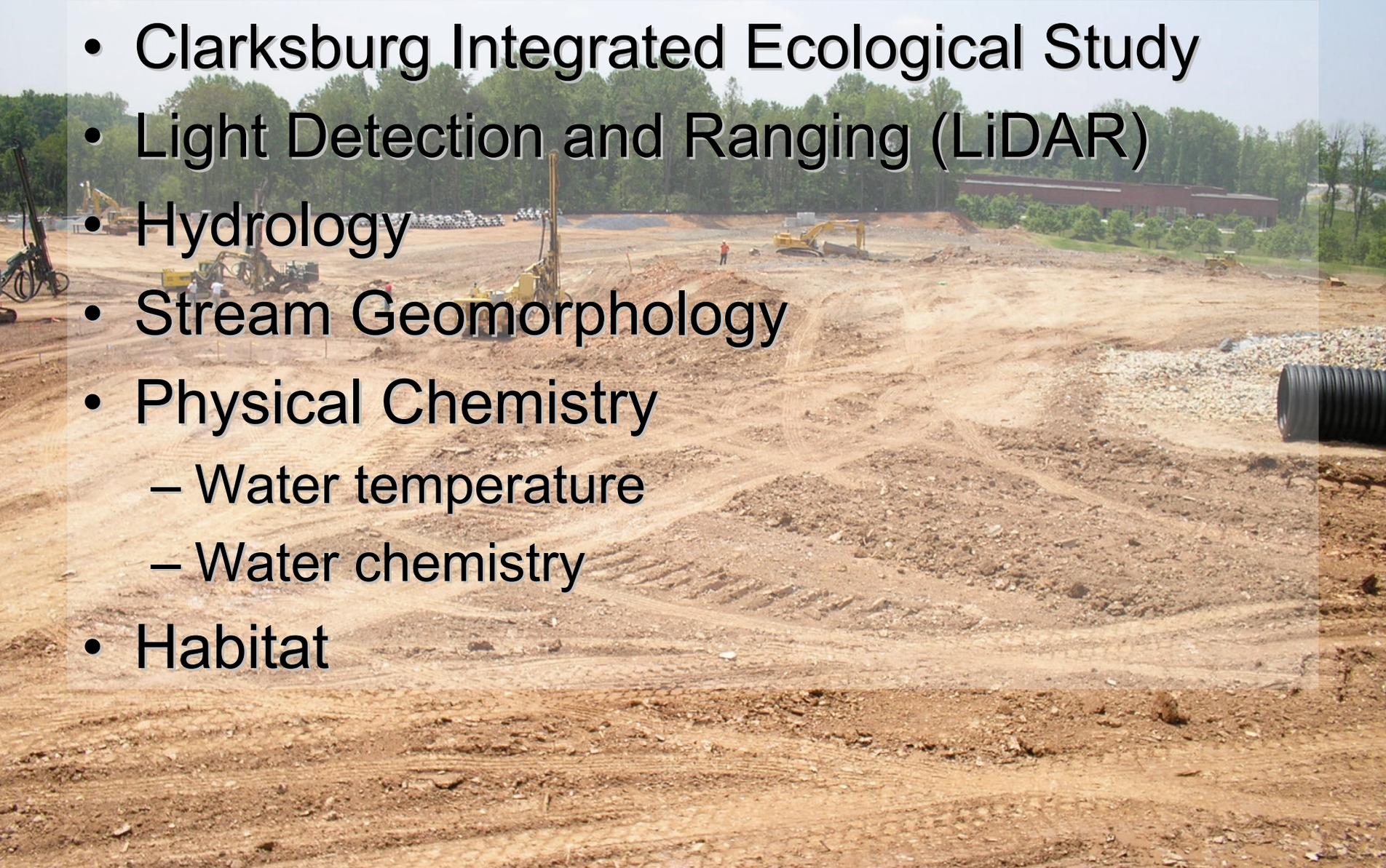


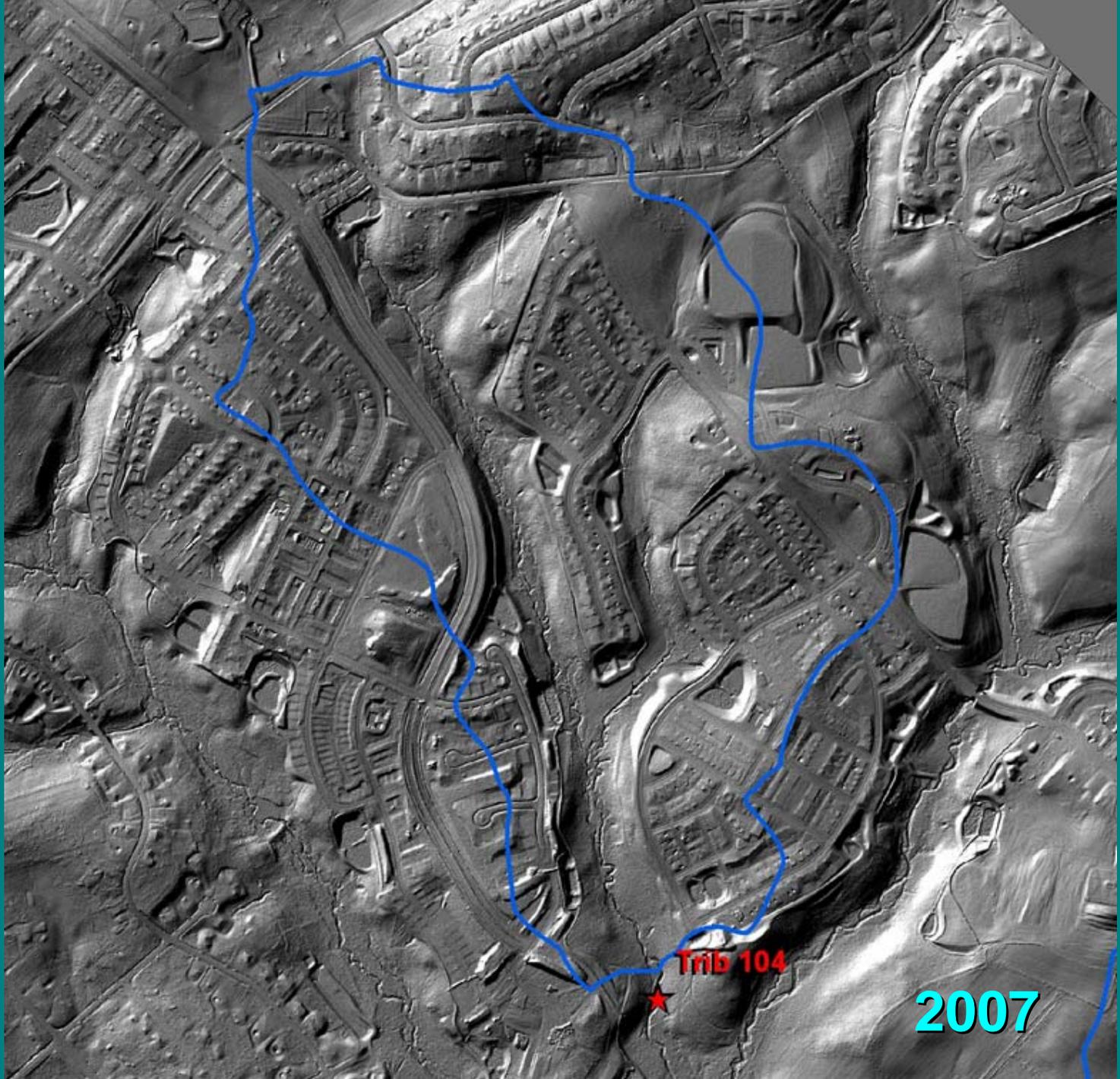
Dominant Taxa

**Chironomidae** (Collector) = 38%  
**Dolophilodes sp.** (Filterer) = 19%  
 N=26  
 Total # of Stations = 4

# Landscape Changes

- Clarksburg Integrated Ecological Study
- Light Detection and Ranging (LiDAR)
- Hydrology
- Stream Geomorphology
- Physical Chemistry
  - Water temperature
  - Water chemistry
- Habitat





**Trib 104**

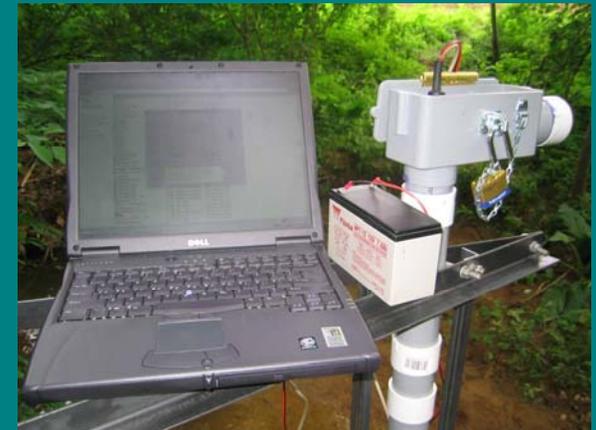
**2007**



**Trib 104**

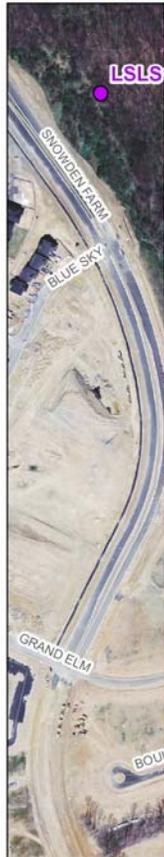
# Hydrology

- Rain gages
  - Total rainfall
  - Storm durations
  - Storm mean intensity
  - Storm peak intensity
- USGS stream gages
  - Instantaneous peak discharge
  - Daily mean discharge



# Changes in hydrology

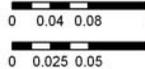
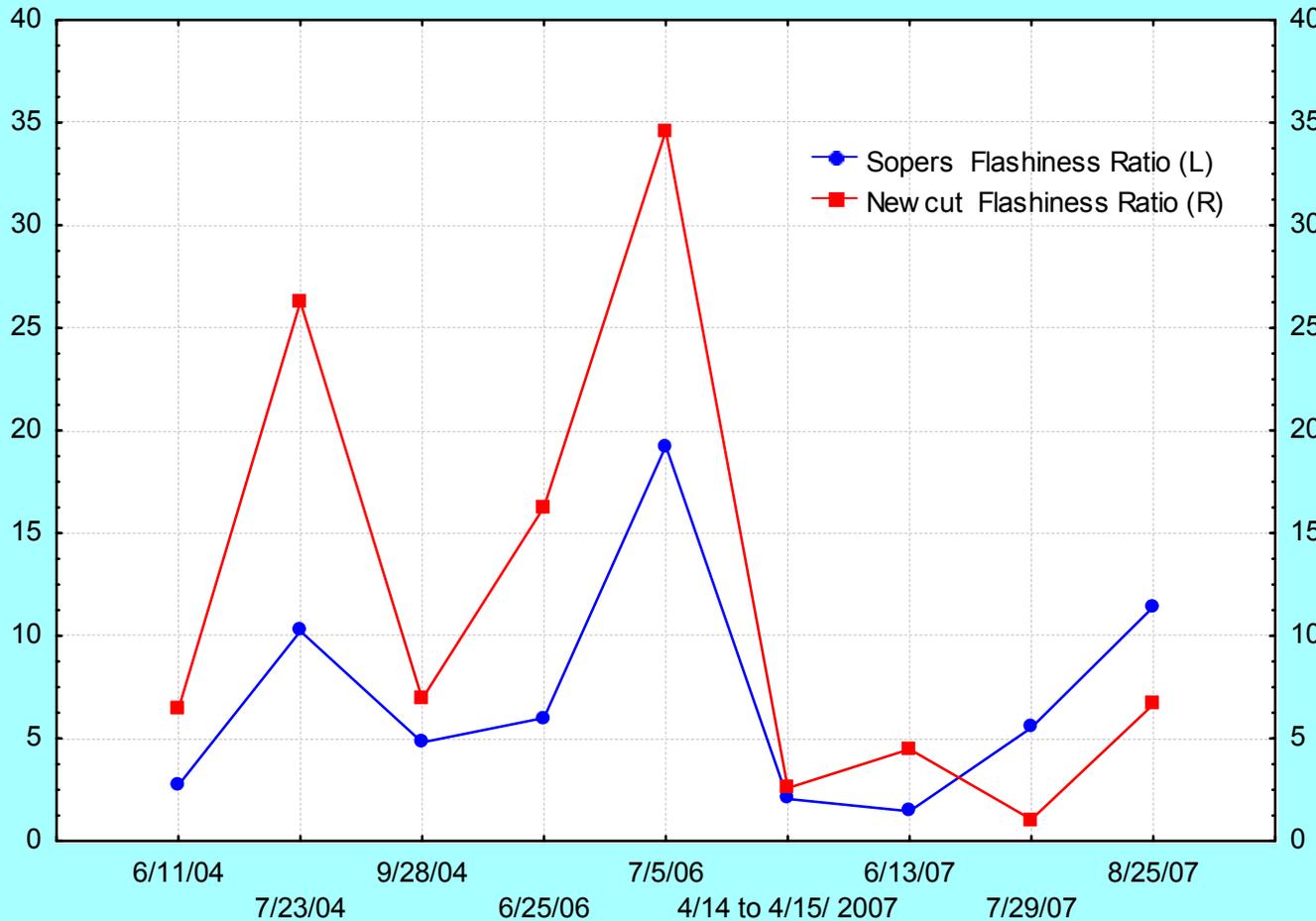
Montgomery County Stream Geomorphology Stations  
Little Seneca 104 Tributary Test Areas



Montgomery County Stream Geomorphology Stations  
Little Bennett, Sopers Branch - Control Areas



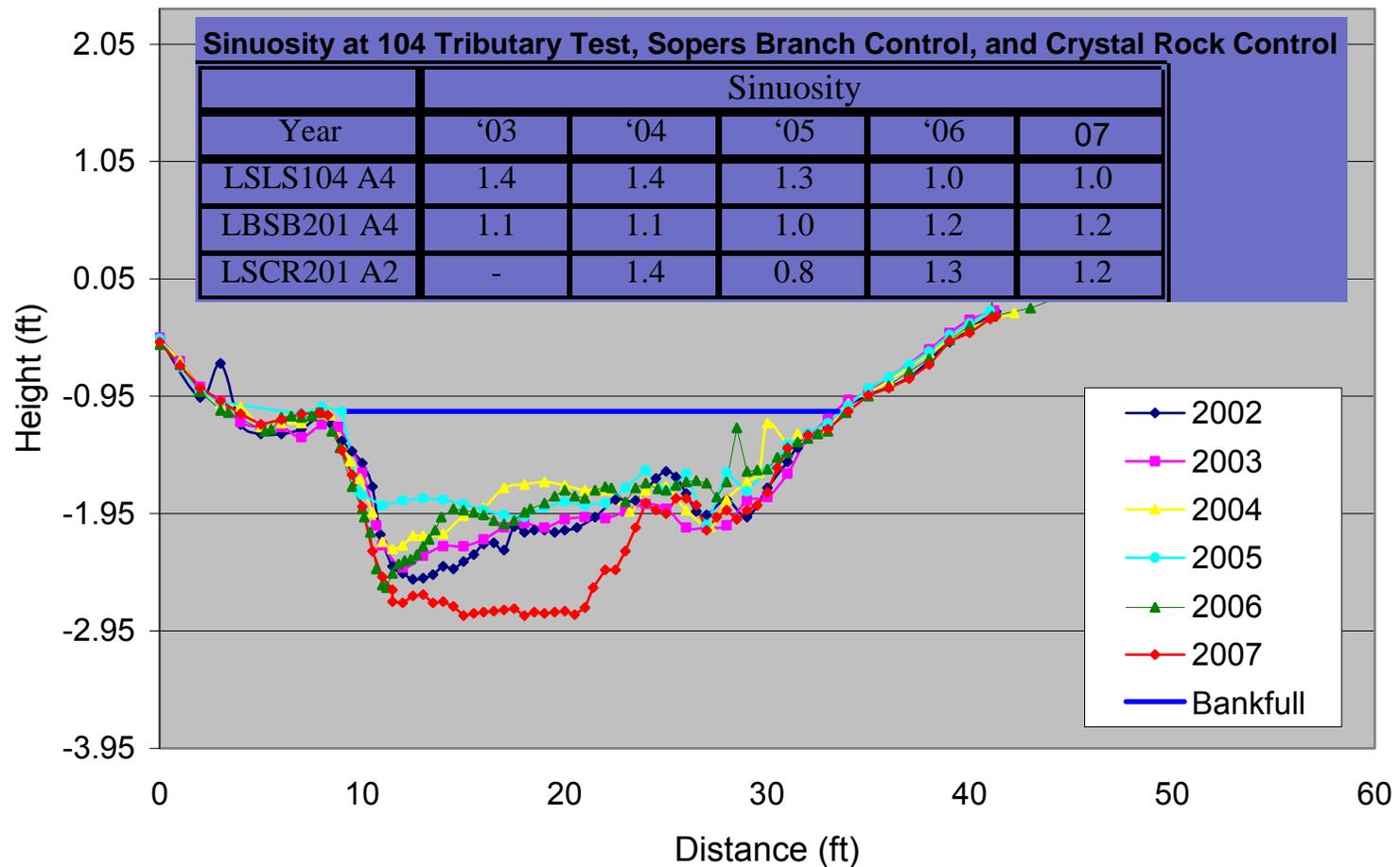
Stream Flashiness Response to Storms 2004 to 2007



# Stream Geomorphology

## Little Seneca 104 Tributary - Newcut Road Neighborhood

Test Location (Area 4, cross section 1) (Most downstream)



# Physical Chemistry and Habitat

- Instream temperature monitoring
  - Upstream and downstream of developments and throughout watershed
  - No results to report
- Water quality
  - *In situ* multi-parameter probe
  - No noticeable differences between Clarksburg control and test stations
- Habitat
  - 200 total score with break points (*optimal, suboptimal, marginal, poor*)
  - No clear trend

# Challenges encountered

## Study areas

- Change to S&EC design standards
- S&EC and SWM structures not considered in the early planning stages.
- Fast-paced development followed by a building moratorium and the economic downturn
- Slow conversion process from S&EC to SWM

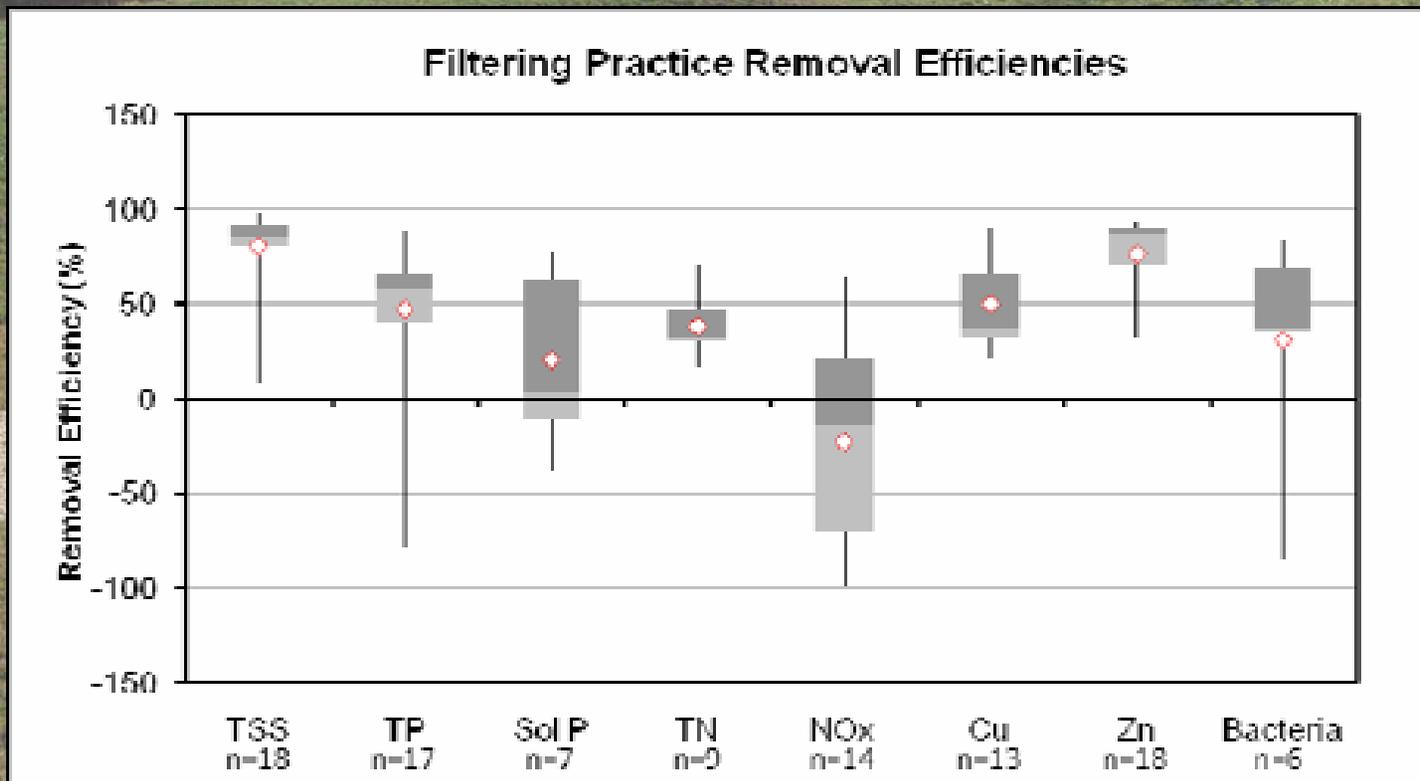
# Challenges encountered

## Monitoring

- Difficulty capturing required storms using automated sampling
- Permitting issues
- Lack of fulfillment of monitoring requirements
- Sediment spills and other extraneous factors

# Challenges Encountered

## Data interpretation

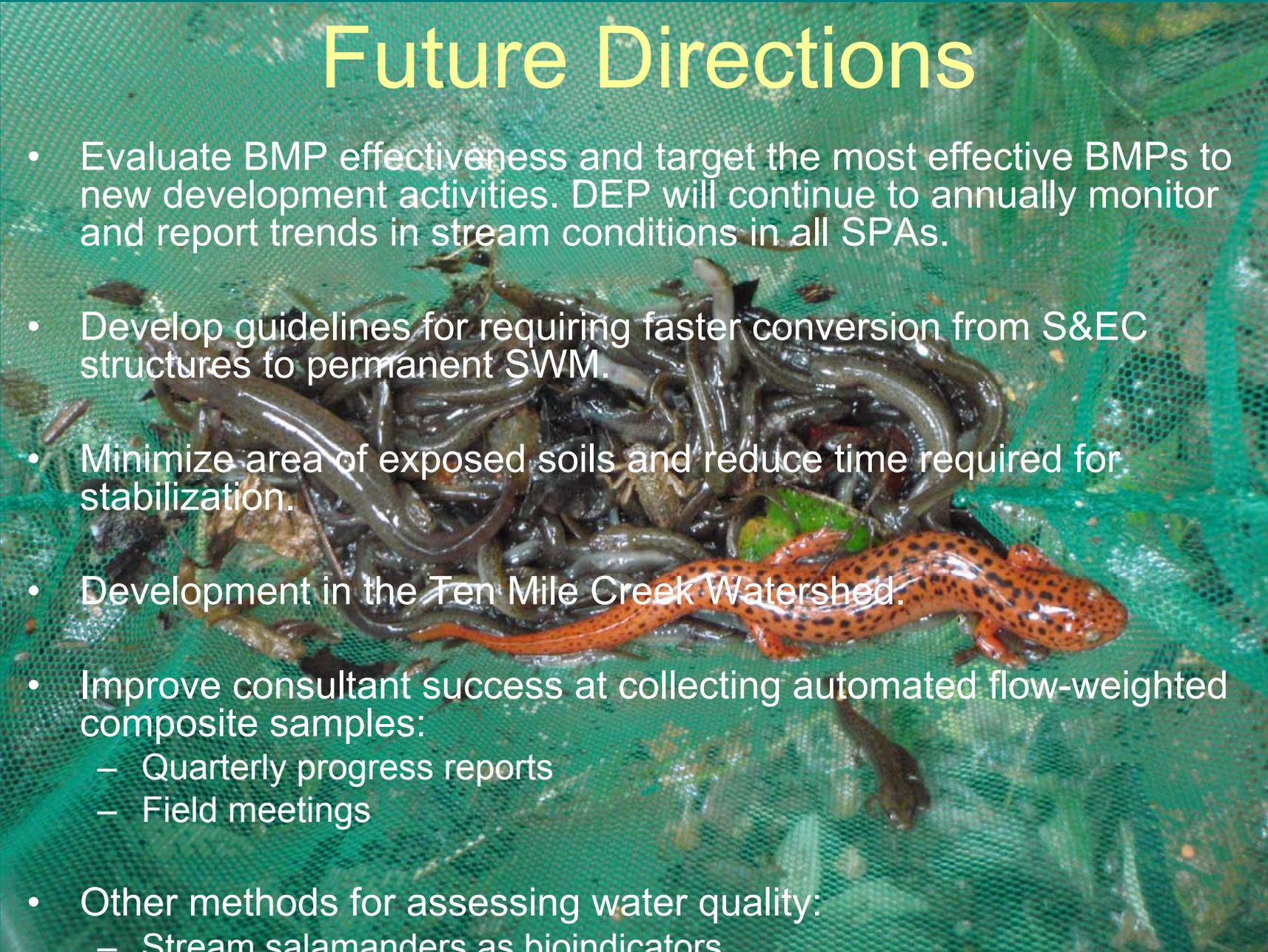


Center for Watershed Protection. 2007. National Pollutant Removal Database, Version 3.

# *In summary...*

- Results of early monitoring indicate that S&EC and SWM structures are generally performing as designed.
- Few studies have followed a small watershed from pre-construction through build-out.
- The majority of the BMP efficiency data in scientific literature is for pollutant removal efficiency of SWM BMPs, not S&EC basins.
- The development process permanently changes the character of the landscape.
- The development process had a measurable cumulative impact on stream conditions and benthic community structure and function in an area with rapid development and no impervious limit.
- Need to be further in the development process to verify trends and determine if there will be recovery.
- Structural efficiency alone does not provide the entire picture on how well a BMP is performing.

# Future Directions

- Evaluate BMP effectiveness and target the most effective BMPs to new development activities. DEP will continue to annually monitor and report trends in stream conditions in all SPAs.
  - Develop guidelines for requiring faster conversion from S&EC structures to permanent SWM.
  - Minimize area of exposed soils and reduce time required for stabilization.
  - Development in the Ten Mile Creek Watershed.
  - Improve consultant success at collecting automated flow-weighted composite samples:
    - Quarterly progress reports
    - Field meetings
  - Other methods for assessing water quality:
    - Stream salamanders as bioindicators
- 

# Acknowledgements

A diamond-shaped pedestrian crossing sign is visible in the background, mounted on a post. The sign depicts a person walking. The background is a dirt road with a slight curve and some vegetation.

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