Welcome to the Md De DC USGS Water Science Center

- Center Activities and Response to Floods of August and September 2011 in MD-DE-DC
  - *Ed Doheny and many others*

- Update on recently released Water-Quality models of Nitrogen and Phosphorus (*Ator et al*)
  - Background
  - Findings
  - Applications

- Demonstrate a web based decision support tool

CENTER ACTIVITIES AND RESPONSE TO FLOODS OF AUGUST AND SEPTEMBER 2011 IN MD-DE-DC

August 14, 2011—Thunderstorms in Baltimore–DC region produced 3--3.5 inches of rain in 3 hours in some areas.

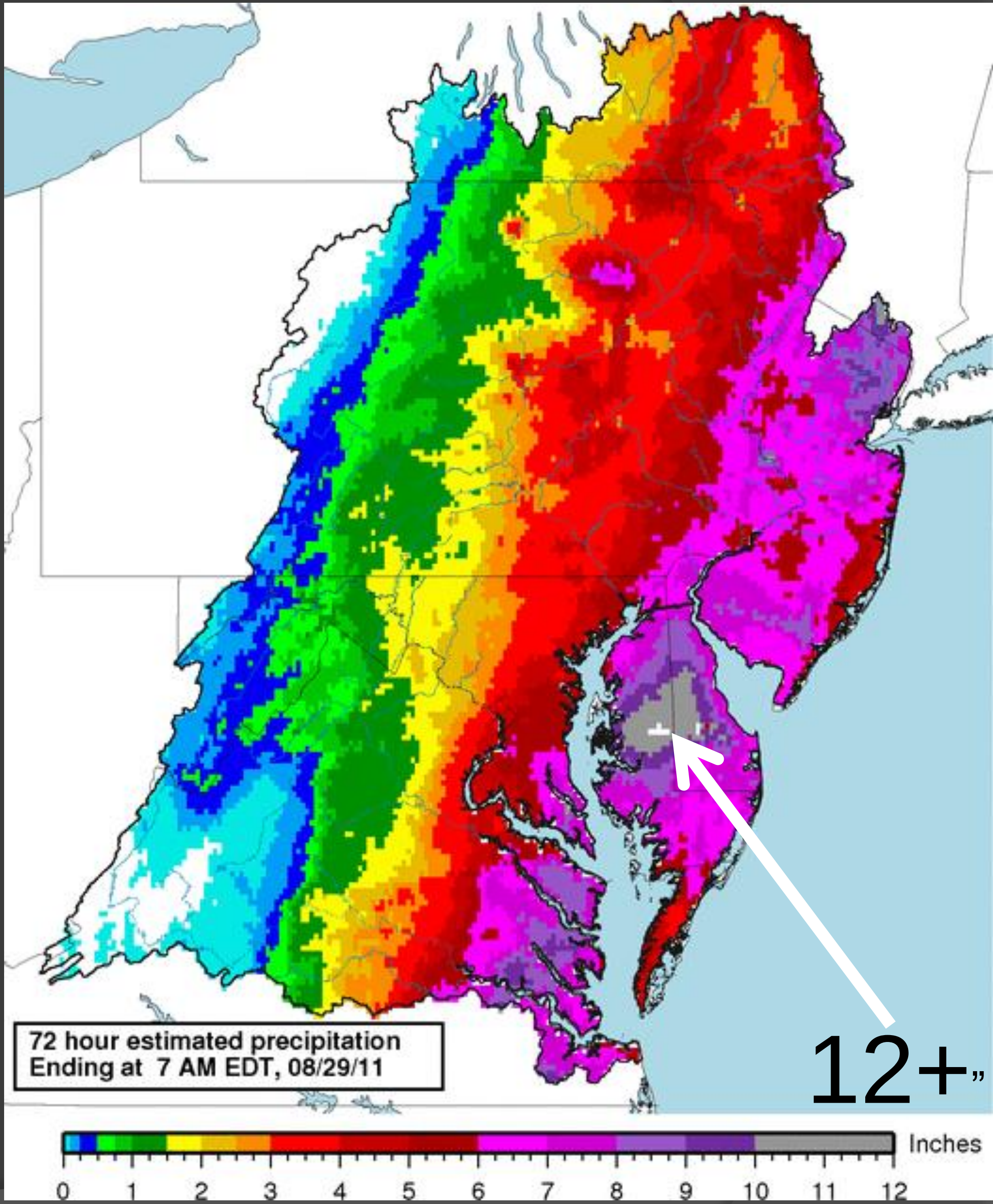
August 27-28, 2011—Hurricane Irene, 6--12 inches of rain in Southern Maryland and areas of the Eastern Shore and Delaware.

September 5-9, 2011--Tropical Storm Lee, up to 15 inches of rain in some areas, mostly west of the Bay. Some of the hardest hit areas included Montgomery, Howard, Carroll, Anne Arundel, Baltimore County, and areas of Southern Maryland.

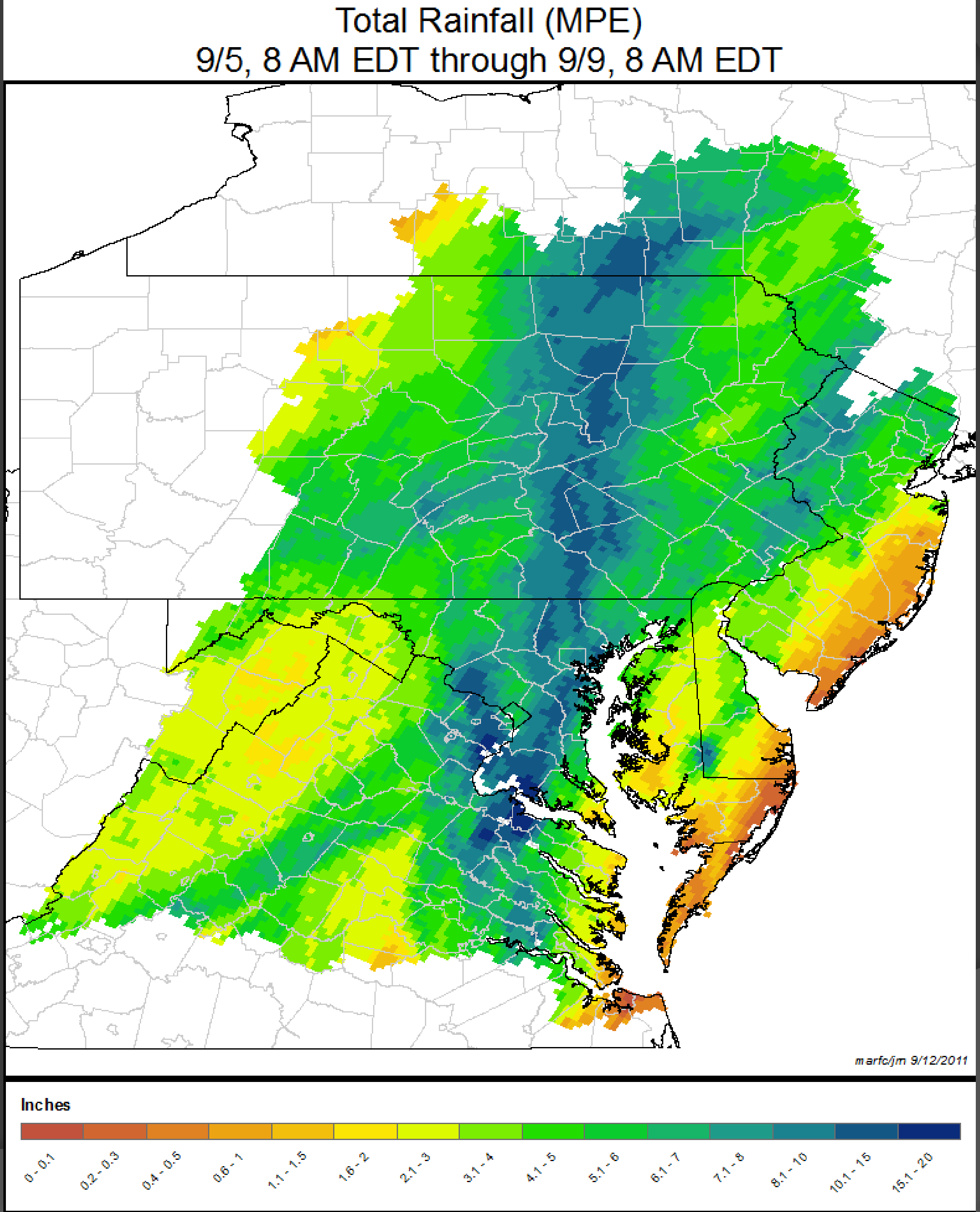
Irene--Total Rainfall August 27-28, 2011

- This map shows the rainfall total for Irene in the Middle Atlantic Region.
- MPE (Multi sensor Precipitation Estimates
  - Combination of precip. stations and radar, computed hourly.
  - Used to verify precipitation forecasts and National Meteorological Forecast Model input

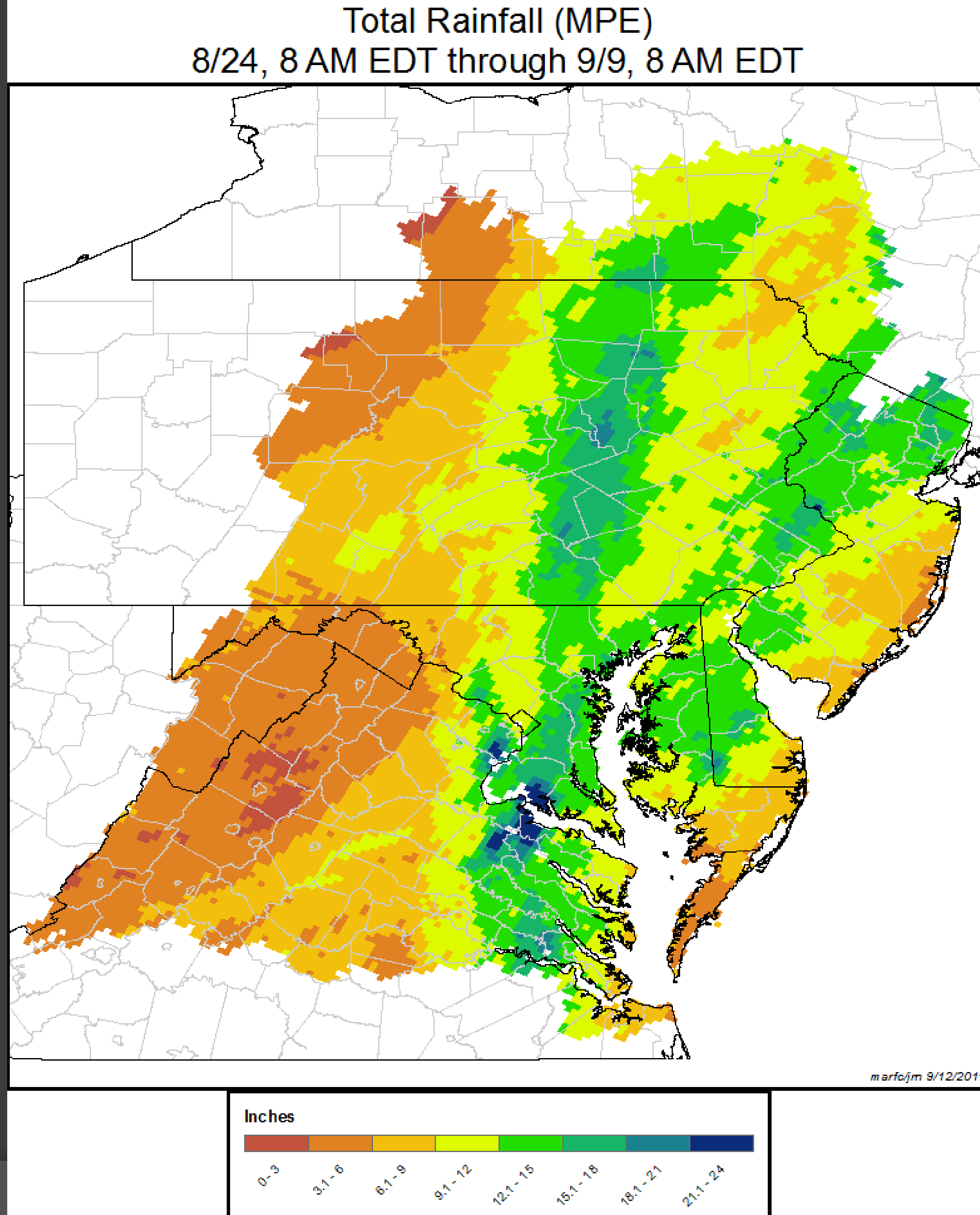
  - This graphic can be found at: http://www.erh.noaa.gov/marfc/Precipitation/MPE/index_java.html



Tropical Storm Lee Sept 5 - 9



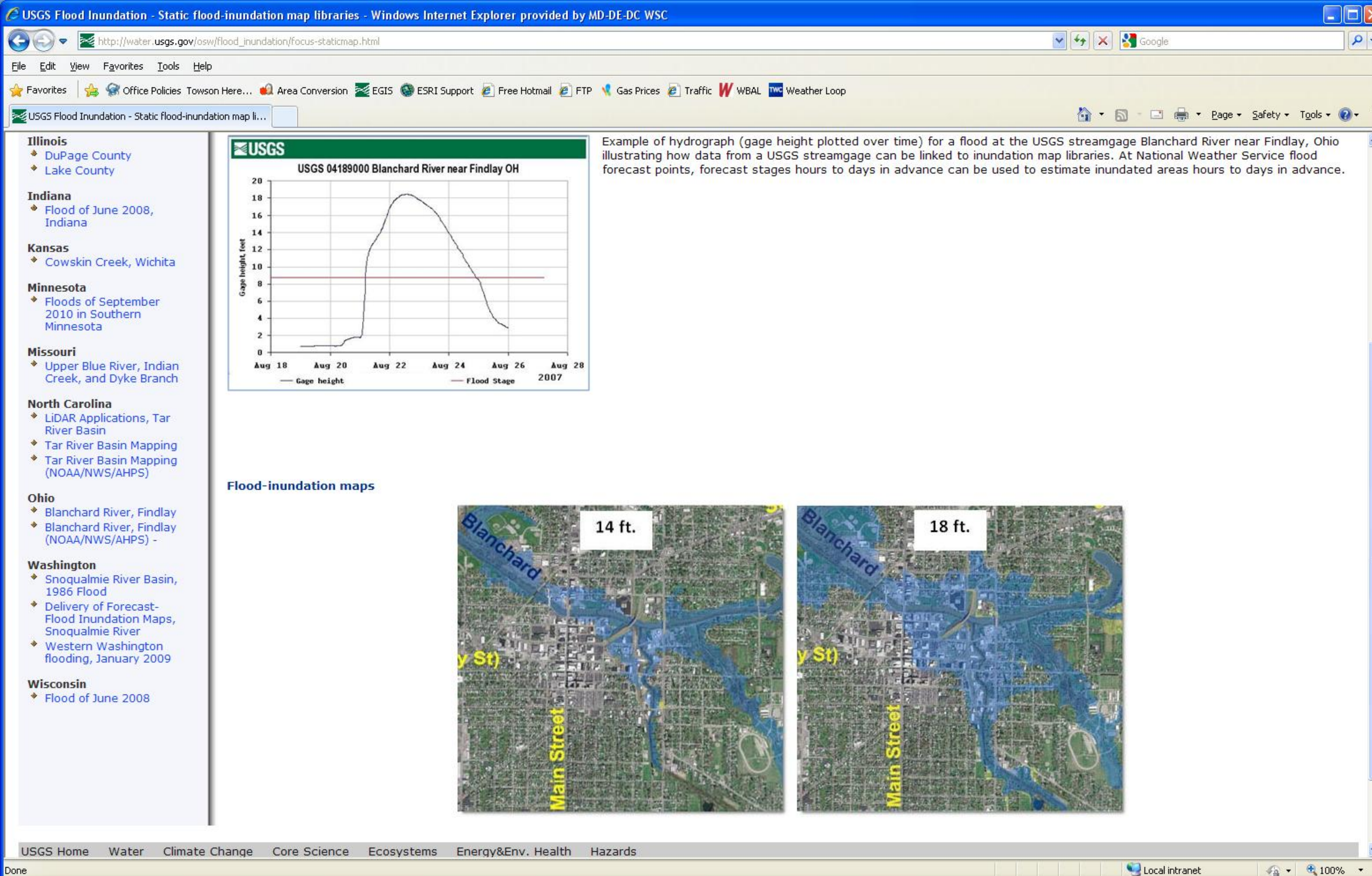
Irene
+
Lee


Total Rainfall (MPE)
8/24, 8 AM EDT through 9/9, 8 AM EDT
marfc/jm 9/12/2011
Inches
0 - 3
3.1 - 6
6.1 - 9
9.1 - 12
12.1 - 15
15.1 - 18
18.1 - 21
21.1 - 24

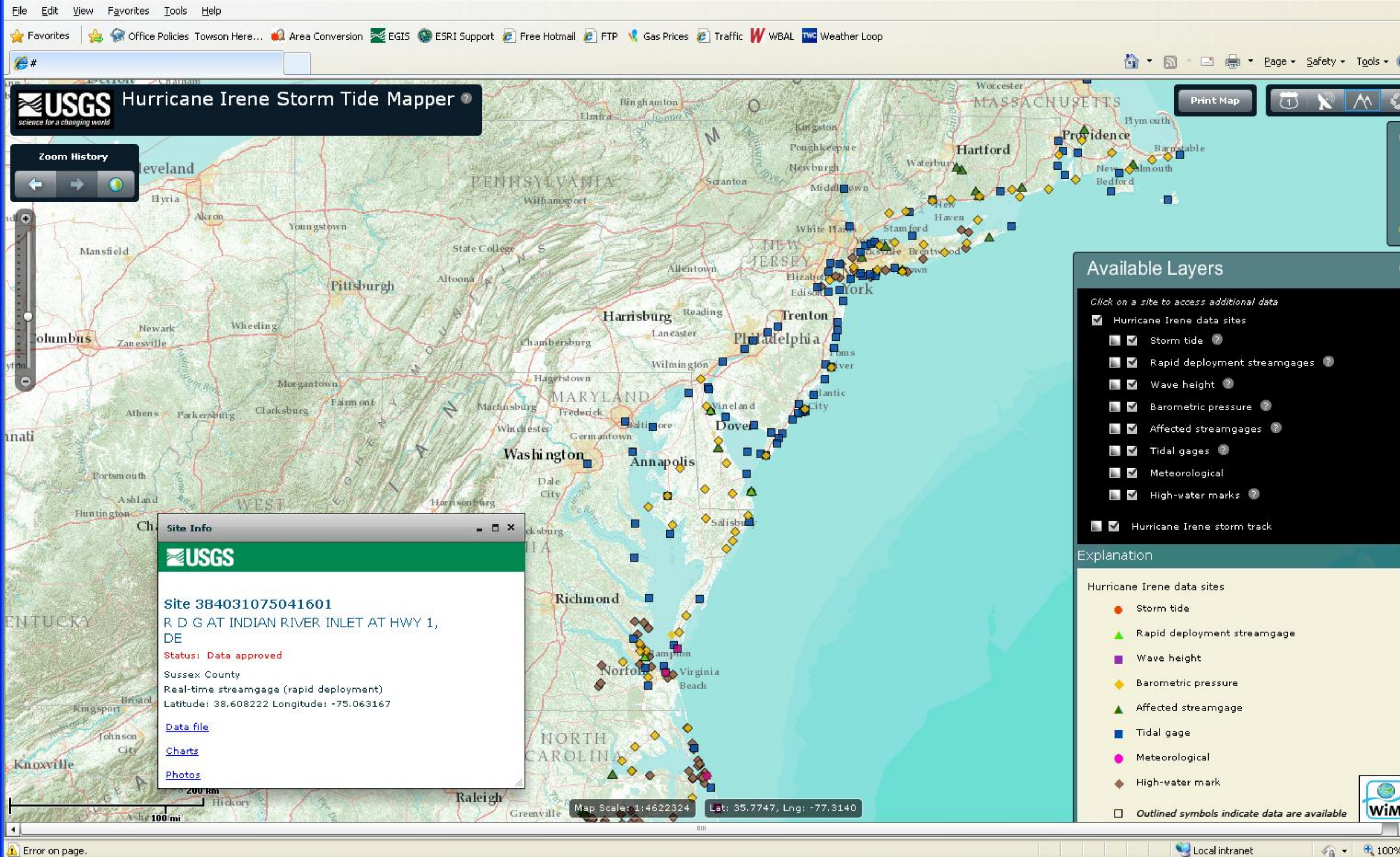
MD-DE-DC WSC Flood Related Activities

- **Direct discharge measurements and water quality samples during storms (Irene and Lee)**
- **Deployment, retrieval, and data reduction for nearly 50 storm surge sensors that were located along the DE coast and Eastern Shore of MD (Hurricane Irene), Aug. and Sept. 2011**
- **High-water mark flagging and surveying**
  - **4 Maryland towns on the Eastern Shore--Greensboro, Hillsboro, Federalsburg, Millington. (FEMA mission assignment—Hurricane Irene)—Sept. 2011**
  - **nearly 35 streamgages**
- **Nearly 40 indirect discharge measurement surveys (in reaches where hydraulic computations can be done to determine peak flows)—Oct. to Dec. 2011**
- **Repairs to several damaged and flooded streamgages**

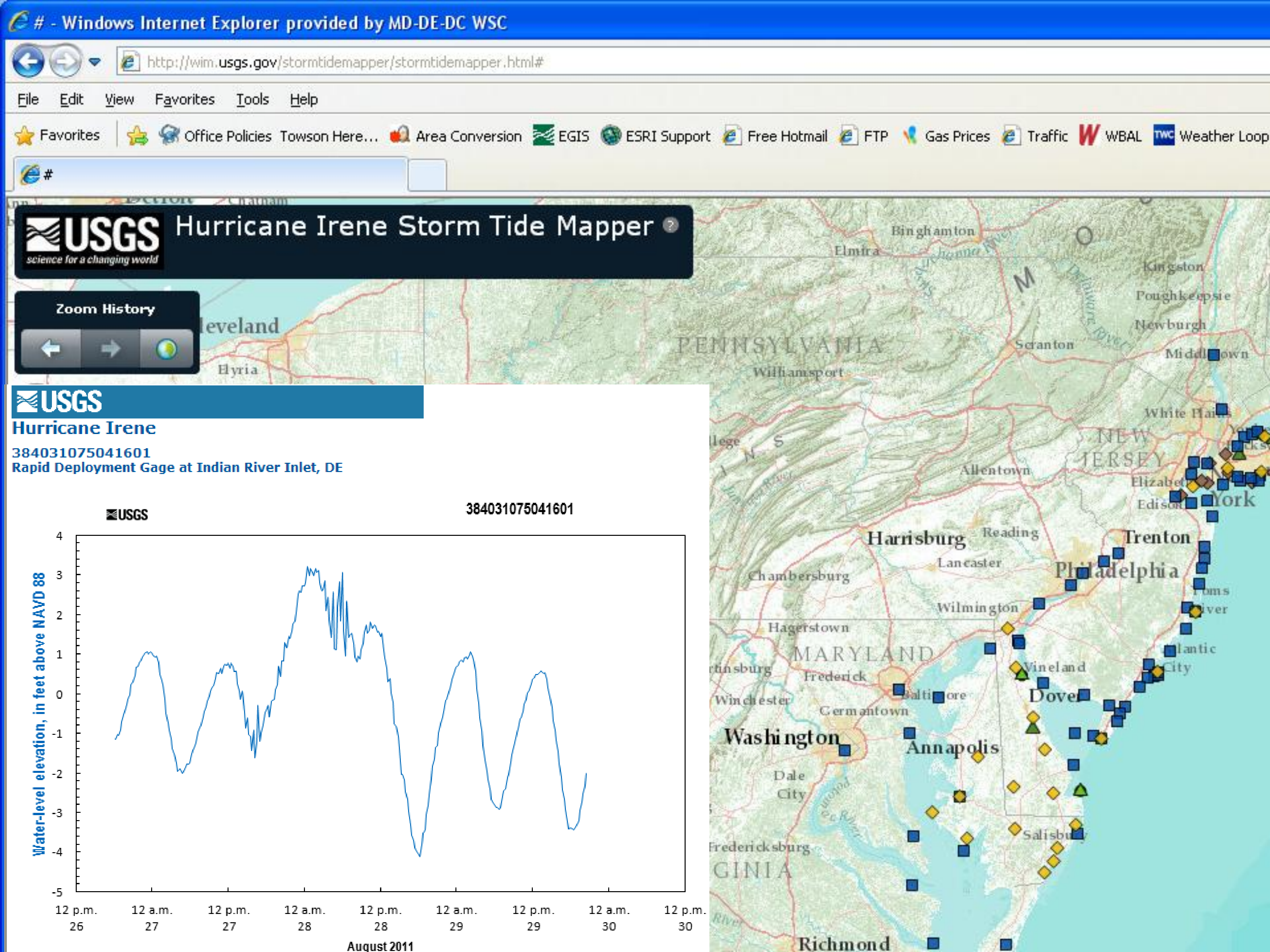
- Inundation http://water.usgs.gov/osw/flood_inundation/
- Storm Mapper http://wim.usgs.gov/stormtidemapper/stormtidemapper.html



USGS Flood Inundation Mapping



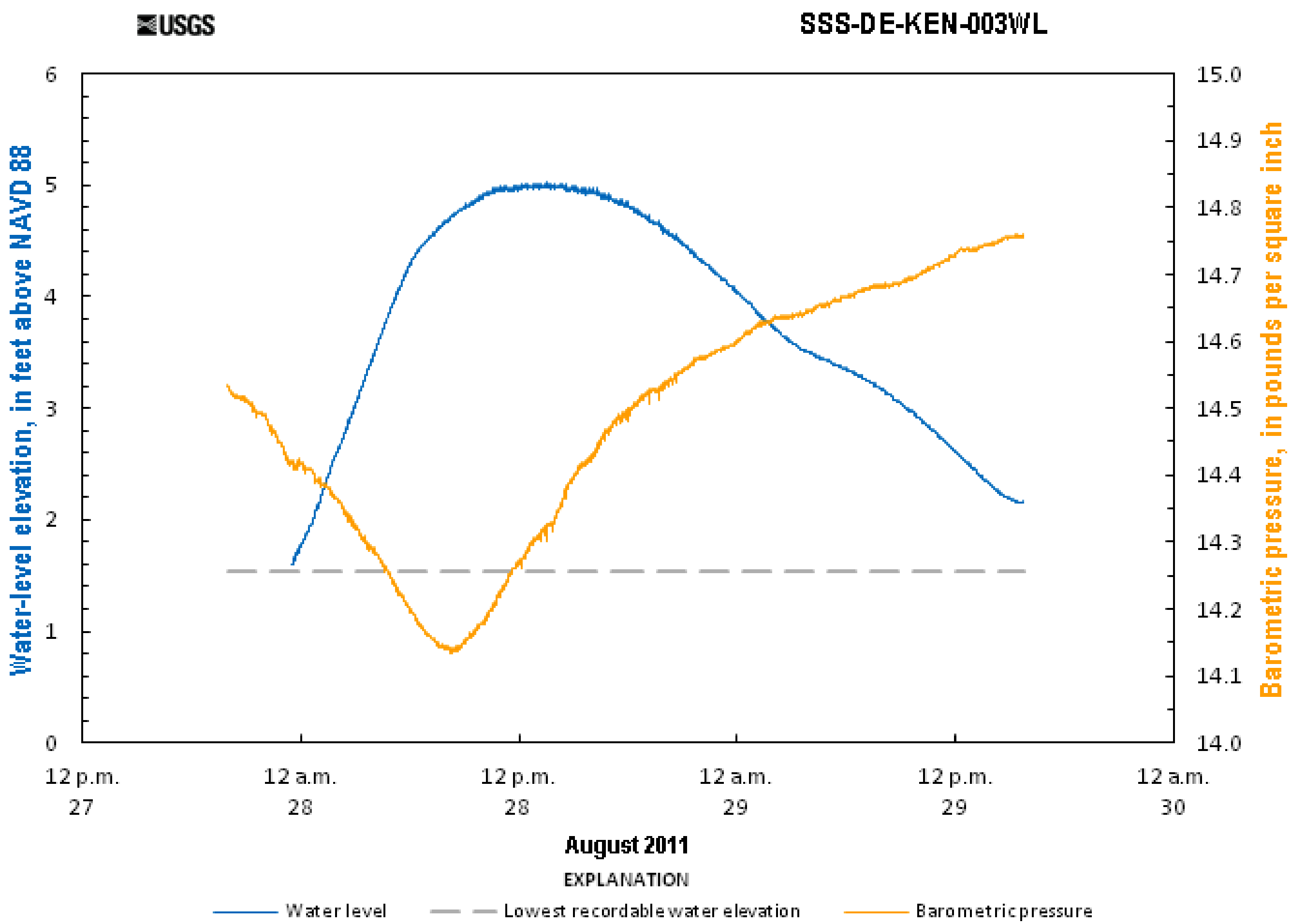
- Secondly, and interactive viewer was created so users can go in and identify where data was collected throughout the event



- Windows Internet Explorer provided by MD-DE-DC WSC
http://wim.usgs.gov/stormtidemapper/stormtidemapper.html#
File Edit View Favorites Tools Help
Favorites
Office Policies Towson Here...
Area Conversion
EGIS
ESRI Support
Free Hotmail
FTP
Gas Prices
Traffic
WBAL
Weather Loop
USGS science for a changing world
Hurricane Irene Storm Tide Mapper
Zoom History
USGS
Hurricane Irene
384031075041601
Rapid Deployment Gage at Indian River Inlet, DE
USGS
384031075041601
Water-level elevation, in feet above NAVD 88
4
3
2
1
0
-1
-2
-3
-4
-5
12 p.m. 26
12 a.m. 27
12 p.m. 27
12 a.m. 28
12 p.m. 28
12 a.m. 29
12 p.m. 29
12 a.m. 30
12 p.m. 30
August 2011
Cleveland
Elyria
PENNSYLVANIA
Williamsport
Binghamton
Elmira
Scranton
Kingston
Poughkeepsie
Newburgh
Middletown
White Plains
NEW JERSEY
Allentown
Elizabeth
Edison
York
Harrisburg
Reading
Trenton
Lancaster
Philadelphia
Chambersburg
Wilmington
Hagerstown
MARYLAND
Frederick
Baltimore
Winchester
Germantown
Vineland
Dover
Atlantic City
Washington
Annapolis
Dale City
Salisbury
Fredericksburg
Richmond

Hurricane Irene

SSS-DE-KEN-003WL
Murderkill River at Carpenter Bridge Rd



SUPPORTING CHESAPEAKE BAY RESTORATION BY MODELING NUTRIENT AND SEDIMENT SOURCES AND TRANSPORT

Applications and Results of SPARROW Models

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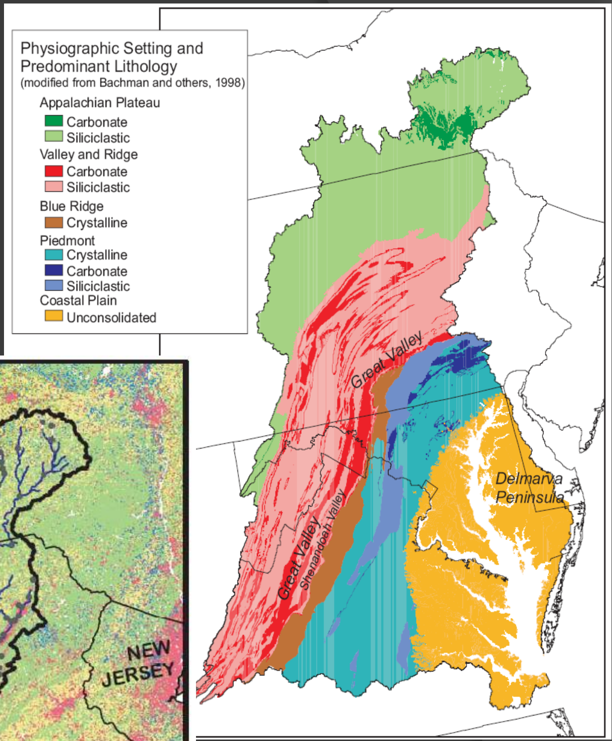
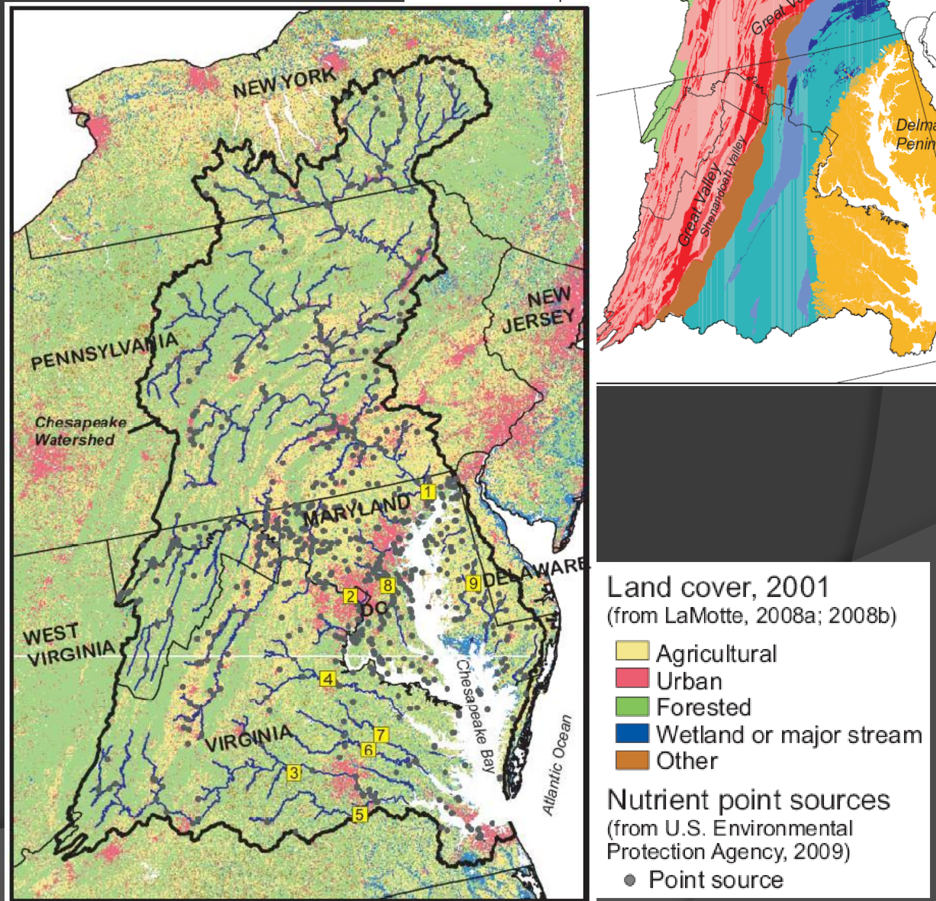
Chesapeake Bay Watershed

- Drains the largest estuary in North America
- Stresses led to the Bay and its tidal rivers being listed as "impaired waters" under the Clean Water Act
  - Largely because of low dissolved oxygen levels and other problems related to pollution like excessive nutrients and sediment
  - Imposed TMDL throughout watershed
- Restoration efforts have been ongoing for several decades.
- Challenges:
  - Diverse and changing land uses
  - Variety of contaminant sources
  - Diverse natural conditions relevant to contaminant fate and transport
- Restoration efforts have been designed and supported using numerical models:
  - Chesapeake Bay Program HSPF watershed model
    - TMDL's implemented and managed
  - USGS SPARROW
    - Help gain a comprehensive understanding of where nutrients and sediment originate
    - How they move throughout the watershed
    - Assist management actions

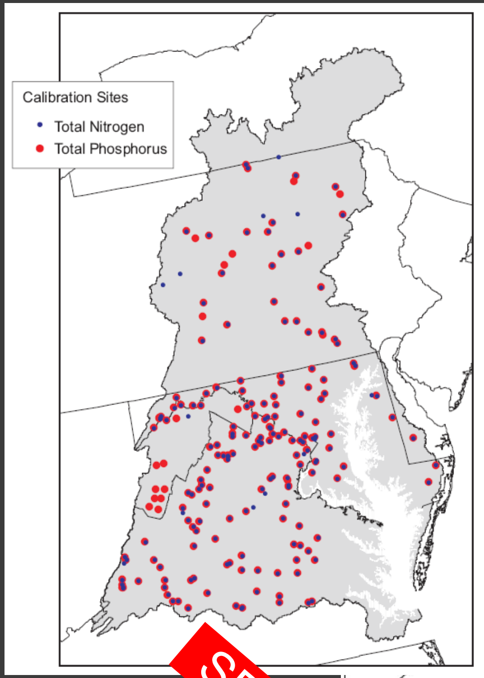


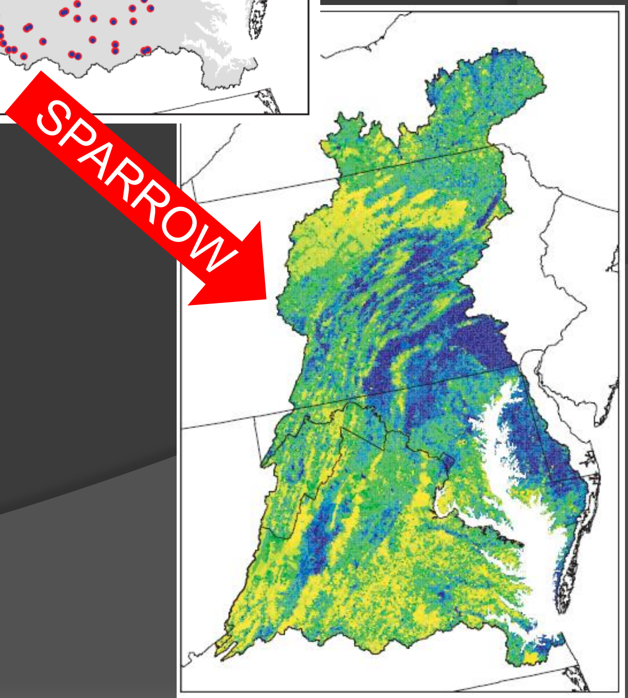


SPARROW

SPAtially Referenced Regressions On Watershed Attributes

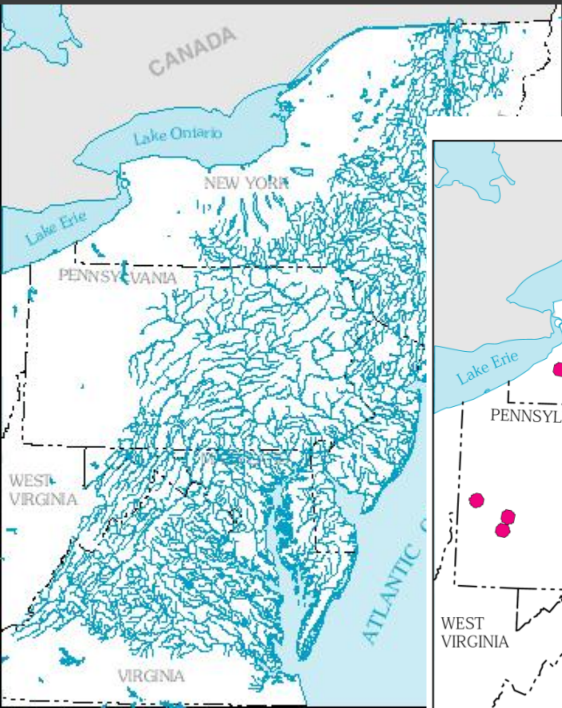
- Spatial Statistical Approach that Empirically Relates Contaminant Sources and Transport Factors to Measured Stream Flux
  - Identify the spatial variability and magnitude of contaminant supply
  - Quantify the contributions at various locations
- Tool Provides Spatially Detailed Predictions:
  - Map individual contaminant sources in unmonitored locations
  - Statistical importance and quantification of contaminant sources
  - Provides measures of uncertainty
- Spatial Framework
  - Explicit for evaluating geographic distribution of sources that can be used for WIP
  - Potential Geographic Targeting



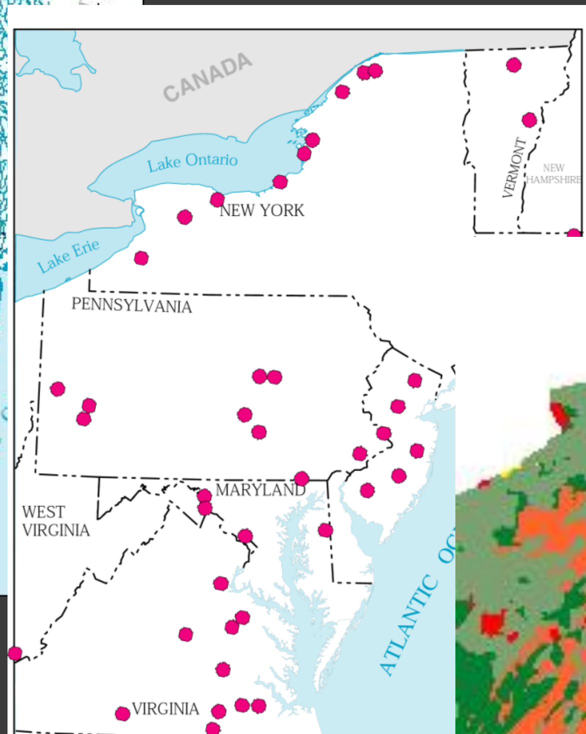


SPARROW Spatially Designed

Integrates spatial data over multiple scales to predict origin & fate of contaminants

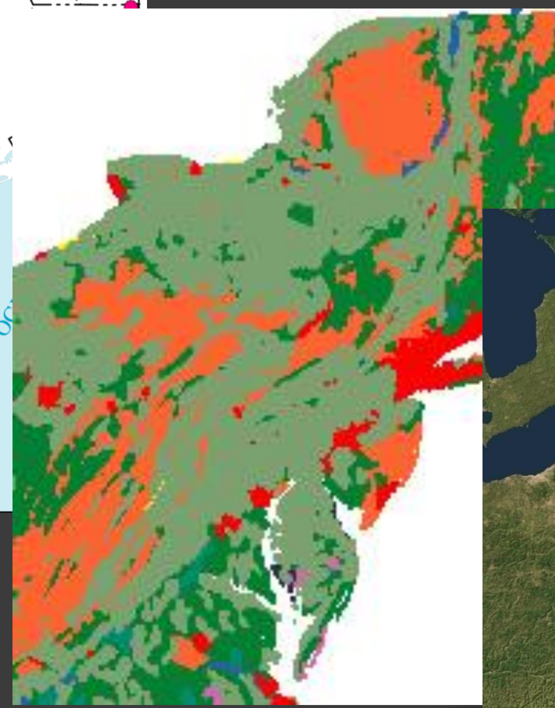


Network of connected and attributed streams and watersheds

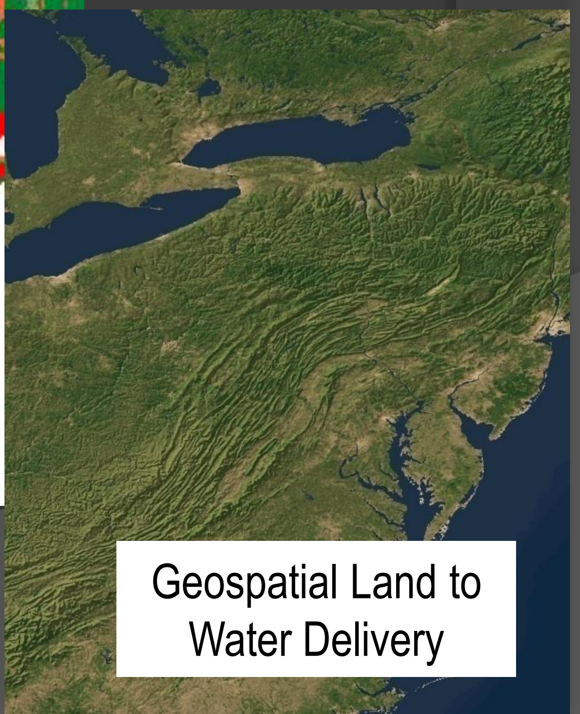


Monitoring Data (Dependent Variable)

Slope, Physiography, Soil Characteristics, Reservoir Systems



Geospatial Source data



Geospatial Land to Water Delivery

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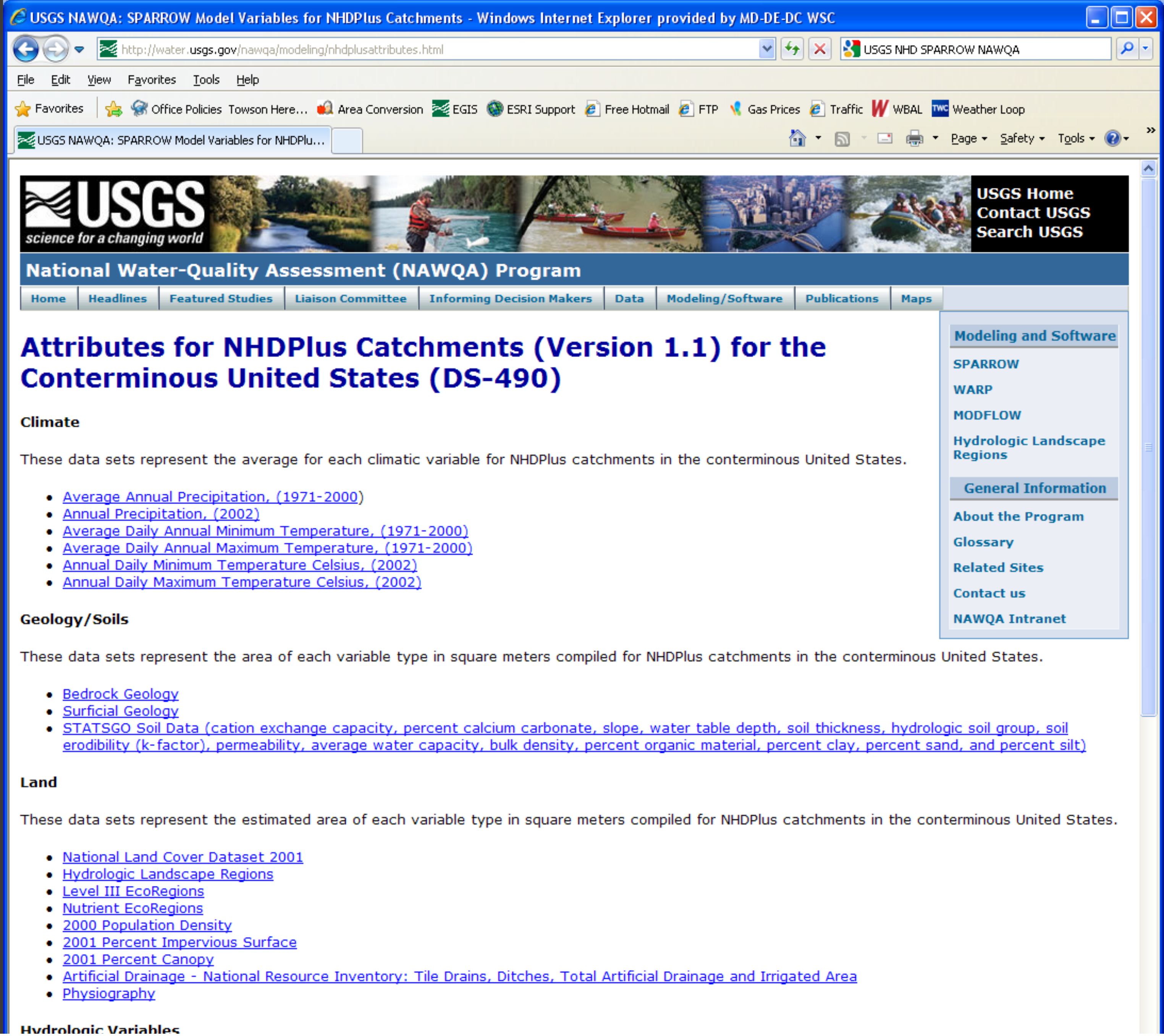
Data Access



- http://water.usgs.gov/nawqa/modeling/nhdplusattributes.html

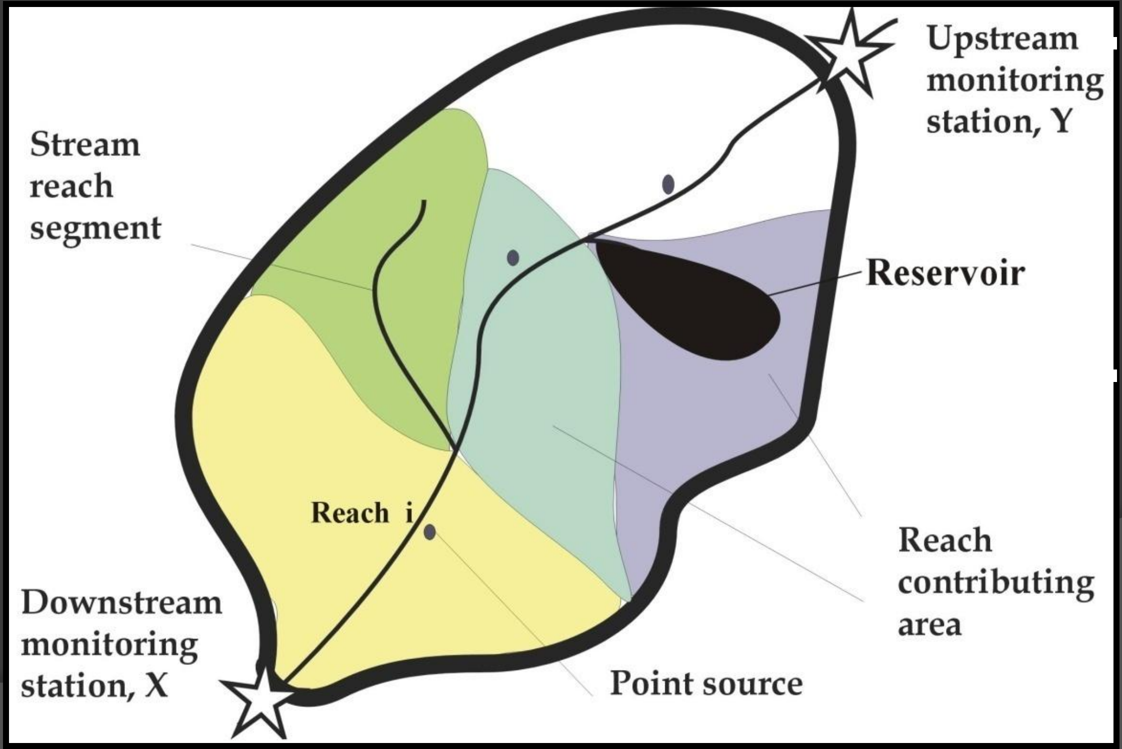
SPARROW Mass-Balance Model

Nonlinear regression

$$\text{Load}_i = \left\{ \sum_{j \in J(i)} \left[\sum_{n=1}^{N} S_{n,j} \beta_n \underbrace{\exp(-\alpha' Z_j)} \right] \underbrace{\exp(-\delta' T_{i,j})} \right\} \underbrace{\exp(\epsilon_i)}$$

Load leaving the reach	=	Load generated within upstream reaches and transported to the reach via the stream network	+	Load originating within the reach's incremental watershed and delivered to the reach segment

- Source
- Delivery
- Decay/storage
  - in-stream
  - reservoir
- Monitoring



- Nonlinear model structure includes topography and water routing; provides separation of land and water processes
- Steady-state, mass-balance structure gives improved interpretability of the model coefficients and predictions

Schwarz et al., 2006

USGS
science for a changing world

Nitrogen SPARROW

RMSE=0.2892,
R^2=0.9784,
yieldR^2=0.8580
N = 181

- Sources: On average:
  - 1,090 kg/km^2 of N from Urban areas reach the stream
  - 24% of N from fertilizer and fixation reaches streams
  - Only 6% of N in manure reaches streams
  - 27% of N from atmospheric deposition reaches streams

Nitrogen Model	Estimate	p
Sources		
Point sources (kg/yr)	0.774	0.0008
Urban land (km^2)	1090	<0.0001
Fertilizer/fixation (kg/yr)	0.237	<0.0001
Manure (kg/yr)	0.058	0.0157
Wet atmospheric (kg/yr)	0.267	<0.0001
Land to Water Transport		
Ln(mean evi)	-1.70	0.0039
Ln(mean soil AWC)	-0.829	0.0016
Ln(GW recharge (mm))	0.707	<0.0001
Ln (% Piedmont carb)	0.158	0.0018
Aquatic Decay		
Small streams (<122 cfs)	0.339	0.0118
Lg Streams, T > 18.5 C	0.153	0.0030
Lg Streams, T< 15.0 C	0.013	0.431
Impoundments	5.93	0.0424

Ator and others, USGS SIR 2011-5167.

Nitrogen SPARROW

RMSE=0.2892, R^2=0.9784, yieldR^2=0.8580
N = 181

- Fate and transport:
  - Delivery to streams is greater in areas of greater groundwater flow, particularly in the Piedmont carbonate
  - Delivery to streams is less in areas with reducing conditions or greater plant uptake
  - In-stream losses are greater in smaller streams
  - In-stream losses in larger streams are greater in warmer areas
  - Losses in impoundments are likely due mainly to denitrification

Nitrogen Model	Estimate	p
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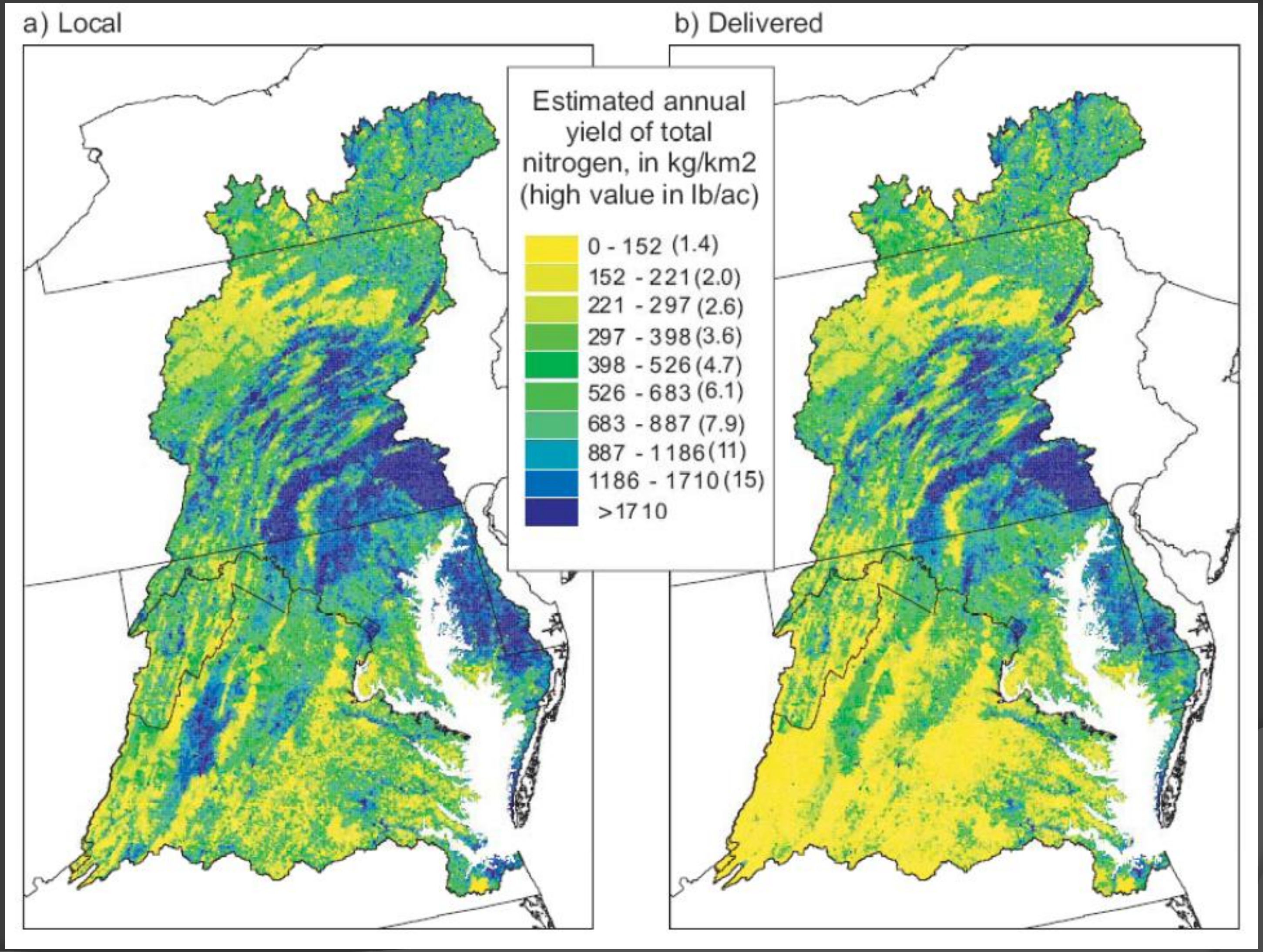
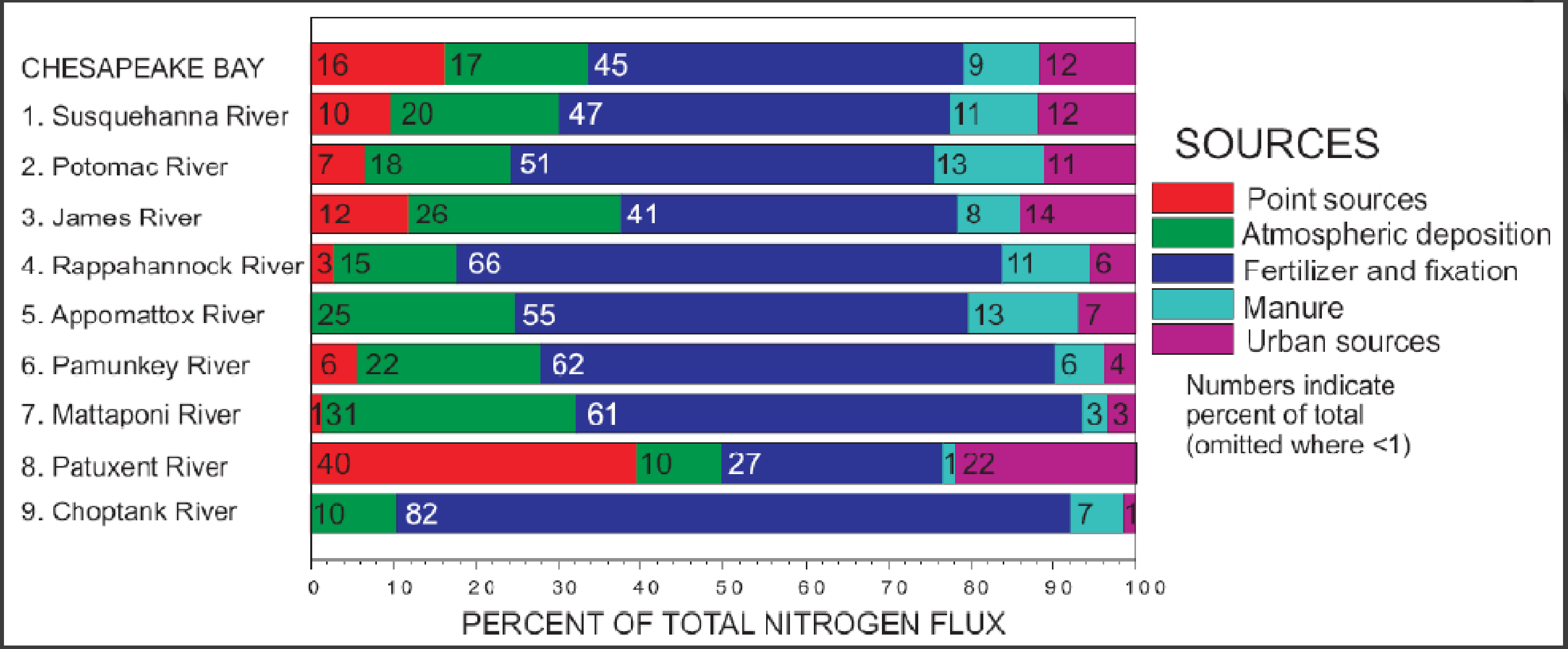
Ator and others, USGS SIR 2011-5167.

Spatial Distribution of TN



Ator and others, USGS SIR 2011-5167

Nitrogen Source Shares



- Agriculture is widespread, and a dominant sources of N to the Bay and most tributaries

Ator and others, USGS SIR 2011-5167.

Phosphorus SPARROW

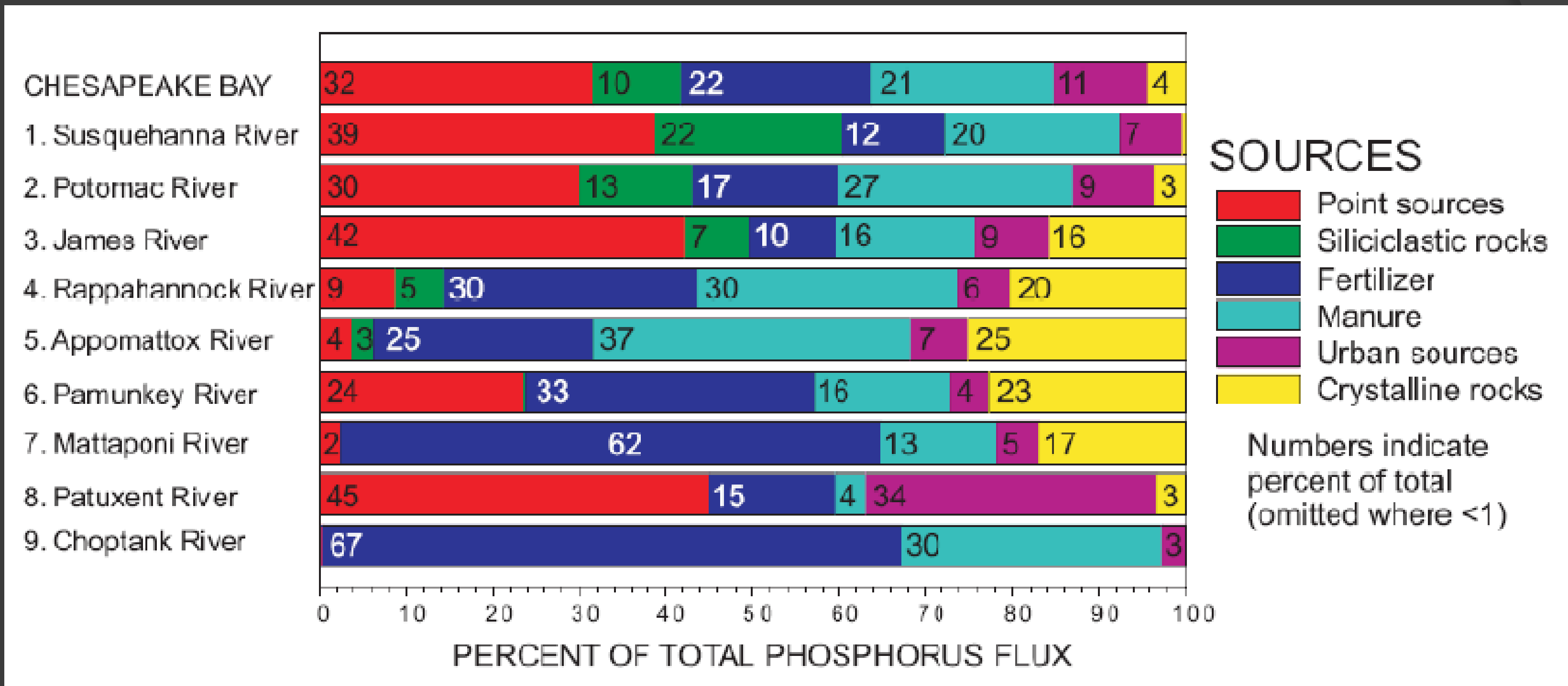
- On average, less than 5% of applied P in fertilizer and manure reaches streams
- Urban areas yield 49 kg/km^2
- Natural mineral sources are significant
- Delivery to streams is greater where runoff is more likely and in the Coastal Plain, possibly due to legacy applications or saturation
- Significant losses occur in impoundments

RMSE=0.4741
R^2=0.9510
yieldR^2=0.7300
N = 184

Phosphorus Model	Estimate	p
Sources		
Point sources (kg/yr)	0.877	<0.0001
Urban land (km^2)	49	<0.0001
Fertilizer (kg/yr)	0.0377	0.0014
Manure (kg/yr)	0.0253	0.0002
Siliclastic rocks (km^2)	8.52	<0.0001
Crystalline rocks (km^2)	6.75	0.0009
Land to Water Transport		
Soil erodibility (k factor)	6.25	0.0002
Ln(% well drained soils)	-0.100	0.0019
Ln(precipitation (mm))	2.06	<0.0237
Coastal Plain (% of area)	1.02	<0.0001
Aquatic Decay		
Impoundments	54.3	0.0174

Ator and others, USGS SIR 2011-5167.

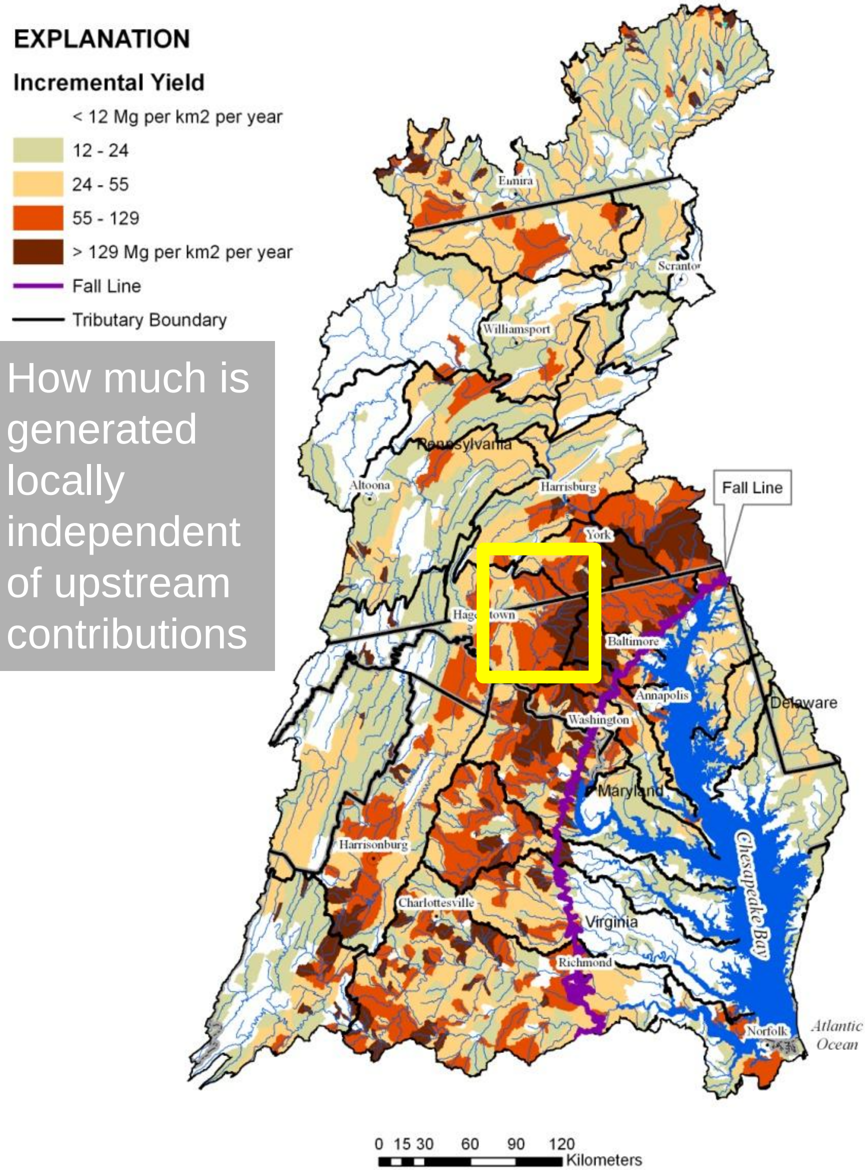
Phosphorus Source Shares



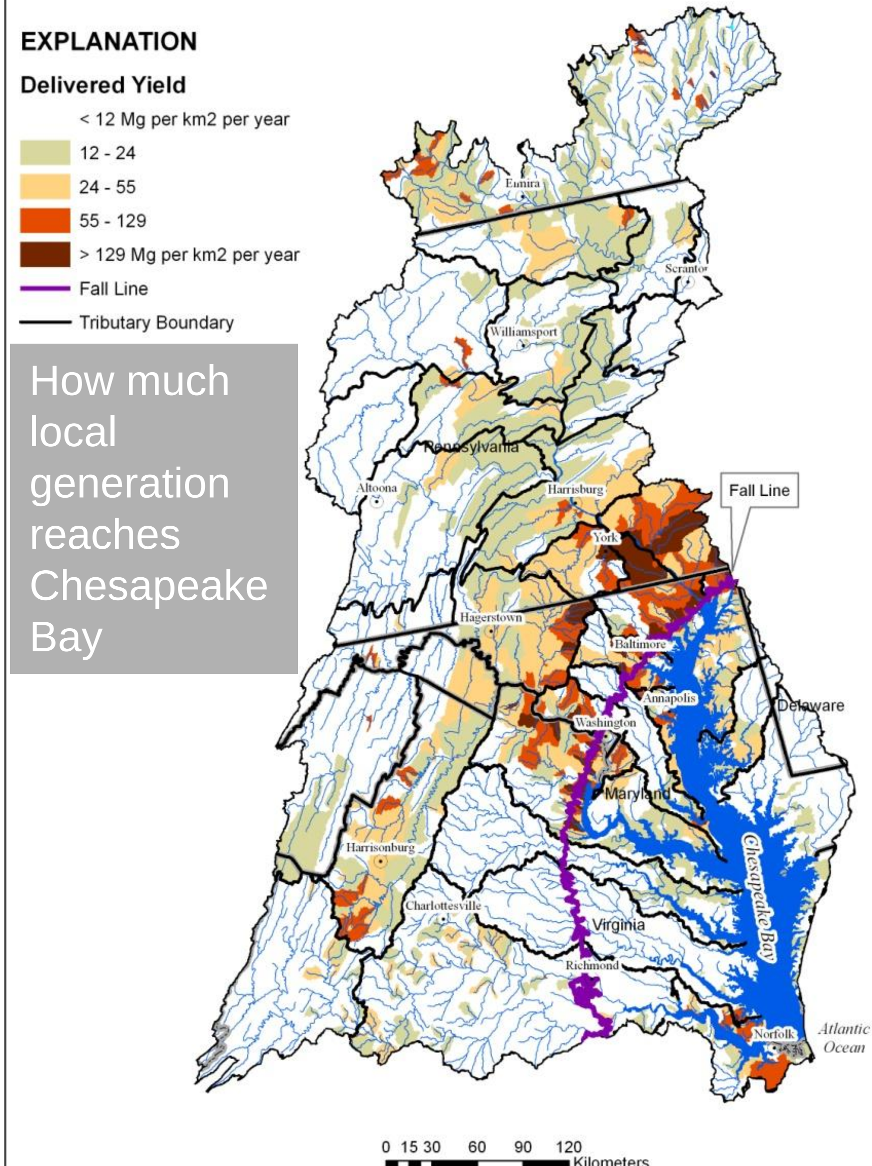
- TP from urban (including point sources) and agricultural sources are roughly equivalent
- Natural mineral sources represent about 14 percent of TP sources

Applications – Geographic targeting

How much is generated locally independent of upstream contributions



How much local generation reaches Chesapeake Bay



Incremental Yield

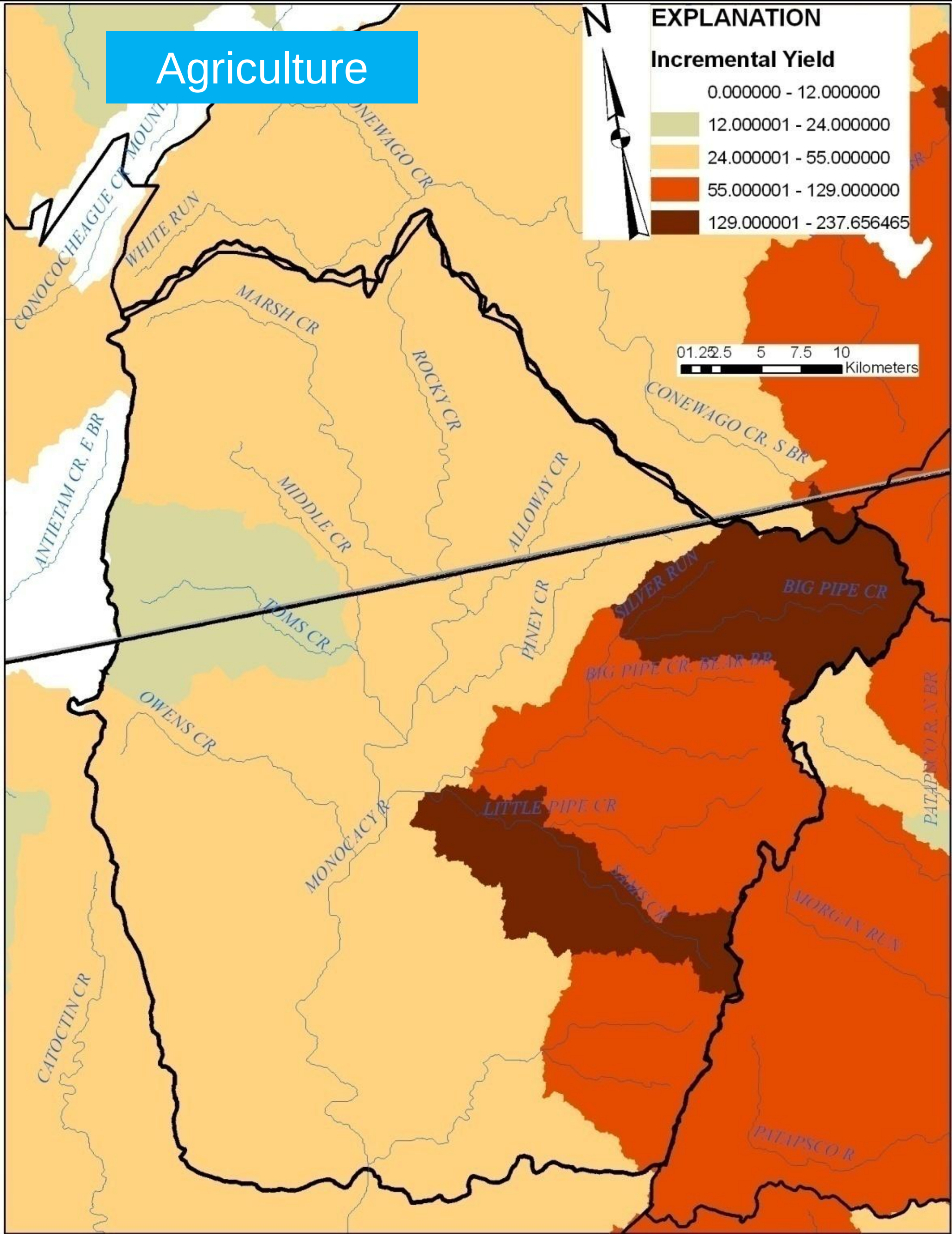
Modified from Brakebill et al., 2010, JAWRA

Delivered Yield

Additional information required?

- Ability to look at each source individually
  - Is sediment yield related to urbanization?
  - Is sediment yield related to agriculture?
- Other sources?
- Other factors?

Upper Monocacy River Basin



Applications

- USDA Farm Bill allocations
- Developing EPA water-quality grant guidance
- Local Pilot
  - Carroll County Bureau of Resource Management
  - Target actions to maximize investment return and meet local TMDLs
  - Based on EPA WSM, State of MD has provided:
    - Specific required N and P load reductions
    - Sector specific: POINT, URBAN, AG
    - List of BMPs and “credits” for each
    - No guidance on what to do or where to do it

Information

- 2002 Chesapeake Bay Sediment model
  - http://onlinelibrary.wiley.com/doi/10.1111/j.1752-1688.2010.00450.x/abstract - JAWRA
- 2002 Chesapeake Bay Nitrogen and Phosphorus SPARROW models
  - USGS SIR Report (including predictions related to NHDPlus)
    - http://pubs.usgs.gov/sir/2011/5167/
  - Results are now provided through a new and innovative online system
    - Allows anyone to map the amounts and sources of nutrients
    - Test strategies for reducing stream nutrient loads
    - Total Nitrogen: http://cida.usgs.gov/sparrow/map.jsp?model=54
    - Total Phosphorus: http://cida.usgs.gov/sparrow/map.jsp?model=55
  - Web demonstrations of SPARROW DSS – TBD

Thank You

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