Telling watershed stories with science
An example in Swatara Creek, PA

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* References & descriptions of data analyses are described at the end of these slides.
A LOT of new and updated info available...

Monitoring & Trends
- Nontidal water quality
- Tidal water quality
- Tidal attainment
- Stream & tidal benthic
- Submerged aquatic vegetation

Modeling Tools
- CBP Watershed Model
- Geographic load distribution
- Geographic influence on Bay
- BMP progress reports

Synthesis Analyses
- USGS Non-tidal Syntheses
  - Regional Nitrogen, Phosphorus and Sediment
  - Groundwater
- SAV Syntheses
- Water Clarity Synthesis
- Water Quality Synthesis

...and more to come
Swatara Creek Storyline
Key Lower Susquehanna Watersheds

- Raystown Branch
- Juniata River
- Trends
- Drivers
- Management implications

Water quality monitoring stations

Watersheds
- Swatara Creek
- West Conewago Creek
- Conestoga River
- Pequea Creek
- Octoraro Creek

Chesapeake Bay watershed boundary
Swatara Creek Watershed
Water Quality Trends in Nitrogen

- Total nitrogen and nitrate are decreasing
- Nitrogen loads are on the higher range for the Chesapeake Bay watershed

Change in Total Nitrogen per acre loads (2005-2014)

Change in Nitrate per acre loads (2005-2014)

From USGS Chesapeake Bay non-tidal network: https://cbrim.er.usgs.gov/
Water Quality Trends in Nitrogen

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Change in nitrogen and nitrate loads (2005-2014)

From USGS Chesapeake Bay non-tidal network: https://cbrim.er.usgs.gov/
Swatara Creek Watershed
Where is nitrogen coming from?

- Land-use is a mixture of natural, agricultural and developed.

From CBP WSM Phase 6 2013 Progress Report. See data analysis at end of this document.

USGS. Falcone, 2015.
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![Acres in Swatara Creek](image)

Where is nitrogen coming from?

1. Land-use is a mixture of natural, agricultural and developed

![Map of Swatara Creek watershed](image)

From CBP WSM Phase 6 2013 Progress Report. See data analysis at end of this document.

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Where is nitrogen coming from?

- Land-use is a mixture of natural, agricultural and developed
- The predominant source of nitrogen is agriculture, followed by developed land

![Acres in Swatara Creek](chart)

![Nitrogen Load to Swatara Creek (2013)](chart)

From CBP WSM Phase 6 2013 Progress Report. See data analysis at end of this document.
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How is nitrogen reaching streams?

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- A high proportion of nitrate in streams is likely indicative of groundwater sources

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Change in nitrogen and nitrate loads (2005-2014)

49% Nitrogen is from groundwater sources

How is nitrogen reaching streams?

- Nitrate in groundwater represents a range of ages from recent to decades old.
- Nitrogen in streams is a reflection of both recent and past nitrogen applications.
- The median groundwater age in this area is 1-10 years old.
What are drivers behind changes in nitrogen?

- The Swatara Creek drainage basin is made of Berks, Dauphin, Lebanon and Schuylkill Counties
- Lebanon County has most area

Swatara Creek Acres by County

- Berks: 10%
- Dauphin: 23%
- Lebanon: 43%
- Schuylkill: 24%
How have nitrogen inputs changed?

- Nitrogen inputs from atmospheric deposition have decreased

From CBP WSM Phase 6 inputs; https://mpa.chesapeakebay.net/Phase6DataVisualization.html
What are drivers behind changes in nitrogen?

- Loads from developed have increased as development has increased

From CBP WSM Phase 6 Progress Reports. See data analysis at end of this document.

USGS. Falcone, 2015.
How have nitrogen inputs changed?

- Nitrogen inputs on agriculture have decreased over the last two decades, but have recently been increasing in recent years.

From CBP WSM Phase 6 inputs; https://mpa.chesapeakebay.net/Phase6DataVisualization.html
How have nitrogen inputs changed?

- Removal of nitrogen in crops often mirrors nitrogen input on agriculture

From CBP WSM Phase 6 inputs; https://mpa.chesapeakebay.net/Phase6DataVisualization.html
Where to focus efforts geographically?

- Certain areas of the watershed are higher loading than others
- These can be the more effective areas to focus restoration efforts

**Average Total Nitrogen yield (2005-2014) in lbs/acre**
- 0 to 6.88
- 6.89 to 13.8
- 13.9 to 33.4

**Total nitrogen yield to local waters in lbs/acre**
- <5
- 5 to 10
- 10 to 15
- 15 to 20
- 20 to 25
- >25

Where to focus efforts geographically?

Modified from Jimmy Webber, USGS, using Ator, S. et al., 2011; Falcone, et al. 2015.
Where to focus efforts geographically?

- Geology makes the groundwater (and therefore streams) in some areas especially vulnerable to high nitrogen inputs
- These areas can be the most effective to focus practices for nitrate in groundwater

![Vulnerable geology map]

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Where to focus efforts geographically?

- Loads and practices can differ between counties

![County Nitrogen Loads per Acre](http://cast.chesapeakebay.net)

From CBP WSM Phase 6 2013 Progress Run.
http://cast.chesapeakebay.net
Where to focus efforts geographically?

- Loads and practices can differ between counties
- For example, Lebanon county has more intense application of nitrogen per acre, and increasing application of manure, correlating to animal production

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- The highest loading sources are different types of cropland and barnyards
- Effective practices for these sources can include buffers, barnyard management, and cover crops

*Percent implementation = acres with practice implemented out of acres available for practice
What practices to focus on?

- The highest loading sources are different types of cropland and barnyards
- Effective practices for these sources can include buffers, barnyard management, and cover crops
What practices to focus on?

- Loads from developed land are not insignificant in these areas and are increasing.
- Stormwater management will be important to address issues associated with increasingly developed areas.

![Implementation of Stormwater Management](chart)

- **PA state-wide implementation (2013)**
  - Schuylkill, PA: 2.9%
  - Lebanon, PA: 10.0%
  - Berks, PA: 20.0%
  - Dauphin, PA: 30.0%
Management Implications

Summary

• Certain geographic areas within this region can be more effective to target based on loads and geology

• Counties differ in their practices, which should be taken into account when focusing efforts

• In these areas, practices such as cover crops, forest buffers, and barnyard control can be effective

• Stormwater practices will be important to address increasing development
It’s not just about the Bay...

- Local waters benefit from the same conservation and restoration practices that help the Bay
- For example, many local streams are impaired due to a variety of problems
- In this area, impairment is often due to agricultural sources

From PA 303(d) impaired waters list. See References section at end of document.
And it’s not just about water quality...

• There are other economically and recreationally important goals influenced by water quality
• For example, stream health in this area ranges from fair to very poor

Macroinvertebrate Sampling as a Proxy for Stream Health

Stream Health Score
- Good
- Fair
- Poor

And it’s not just about water quality...

- These areas contain watersheds that have low predicted occurrence of Brook Trout due to a combination of factors such as habitat and natural and anthropogenic stressors.
And it’s not just about water quality...

- Local waters benefit from the same conservation and restoration practices that help the Bay
- For example, stream temperatures are rising across the region, which impacts native fish species such as brook trout

A LOT of new and updated info available...

...that can be integrated together to answer questions and inform efforts
References

USGS Chesapeake Bay non-tidal network: https://cbrim.er.usgs.gov/


Explaining nitrogen loads and trends in Chesapeake Bay tributaries: an interim report. Jimmy Webber, USGS, unpublished. DO NOT CITE OR DISTRIBUTE.


References


Chesapeake Bay Program Cross-GIT Mapping Project: [http://gis.chesapeakebay.net/intergit/overview.html](http://gis.chesapeakebay.net/intergit/overview.html). Visualization tool: [https://gis.chesapeakebay.net/mpa/scenarioviewer/](https://gis.chesapeakebay.net/mpa/scenarioviewer/).
Data Analysis

Land area and loads by source sector from monitoring station basins:

Drainage basins for the USGS stations were taken from USGS. Drainage basins were matched to their land-river segments using ArcGIS (also available on the CBP Watershed Model Segmentation Viewer available off CAST (http://gis.chesapeakebay.net/modeling/). For each land-river segment, total acreage, acreage by individual land-use, and loads by individual land-use were downloaded from Phase 6 CAST 2013 Progress Run (http://cast.chesapeakebay.net). Acreage and loads were aggregated for individual land-uses within each source sector.

Nitrogen applications:

Nitrogen applications by county and source (lbs/acre/yr) over time were obtained from the Phase 6 Model Calibration Inputs graphical interface available at https://mpa.chesapeakebay.net/Phase6DataVisualization.html.

BMP implementation by practice and county:

BMP percent implementation was obtained from Phase 6 CAST 2013 BMP Summary Report from http://cast.chesapeakebay.net. Percent implementation is defined as the percent of total acres credited out of the total acres of land-use available for a practice.

Nitrogen effectiveness values for individual agricultural BMPs were obtained from the Phase 6 Watershed Model Source Data, available on Phase 6 CAST (http://cast-beta.chesapeakebay.net/Home/SourceData). Nitrogen effectiveness values for individual agricultural BMPs were averaged by BMP type for the geologic region.
Status & Trends Summary

• Total nitrogen and nitrate trends are improving at Swatara Creek
• Swatara Creek is one of the watershed’s highest loading areas
• Swatara Creek is in the mid-range for monitoring stations in percent total nitrogen reduction (2005-2014)
Where is nitrogen coming from?

- Land-use is a mixture of natural, agricultural and developed.
- The predominant source of nitrogen is agriculture, followed by developed land.

From CBP WSM Phase 6 2013 Progress Report. See data analysis at end of this document.
Where is nitrogen coming from?

- **Turf grass** = grassy areas within developed land (e.g. lawns, parks, shopping centers, cemeteries)
- **MS4** = municipal separate storm sewer systems
- **Municipalities with MS4s** that meet certain standards must obtain NPDES permit coverage
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From CBP Model Scenario Viewer. Available at cast.chesapeakebay.net.
Drivers Summary

• Nitrogen loads come from mixed sources, predominantly agriculture
• Nitrogen reaches streams primarily as nitrate both from groundwater and surface runoff
• Nitrogen in streams reflects recent and past inputs
• Agricultural inputs have decreased over the past few decades, but have recently been increasing
• Inputs from developed land have been increasing
How have practices changed?

- Implementation of some conservation and restoration practices has increased over time

From CBP WSM Phase 6 BMP Progress Reports.
Where to focus efforts geographically?

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Restoration in Pennsylvania is helping the Bay

- Submerged Aquatic Vegetation recovery and resilience have drastically improved in the Susquehanna Flats due to a combination of reduced nutrients and low flow years

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