Watershed Sediment Model

Watershed Hydrological Analysis Team

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Primary Focus Areas

• **Support for “Save Our Water” - Artesian Broad Run Well:**
  
  – Base Flow monitoring (depth gages/conductivity)
  – Understand sources of water into BR stream (SL, Cockeysville, etc.)
  – Develop high precision/accuracy models to assess impact of production well:
    – Maintain relationship with DRBC

• **Support White Clay Creek Watershed Monitoring:**
  
  – Support monitoring (*Mayfly system*)
  – Developed Watershed Rain Event RunOff analysis tool
  – Support Broad Run – Somerset Lake Program (*reduce sediment from BR)*:

• **Support “Delaware River Basin Sensor Program”:**
  
  – Data analysis (*gage curves/sediment/, etc.)*
  – Model development to support needs (*eg. Bartram Tidal flow/RunOff flow model*)
WHAT Technology Tool Kit

• **Modeling Stream Flow:**
  – Daily Base Flow/RunOff Water Balance Models
  – Real-time 5 min. - 1 hr. RunOff Models
  – Base Flow Correlation with nearby USGS Streams or other Gaged Streams
  – Gage/Flow Correlation Analysis
  – Cockeysville Aquifer Water Balance Model:
  – Rain Event CN RunOff Model:

• **Sensor Data Analysis:**
  – Using Conductivity to determine % Cockeysville flow into Broad Run
  – Turbidity - TSS:  *Sediment Stream Loading Correlation vs. RunOff Intensity*
    *Multiple Watershed Generalize Sediment Loading Correlation*
  – Low cost sensor development: IR / Sonic / Turbidity

• **Linear and non-linear Multi-variable Analysis:**
Broad Run Watershed

Size: Above Lake - ~0.727 sq. mi.

Issue: Heavy Sediment Loading
Expensive Dredging needed

Primary Objectives:

- Quantify Sediment from stream
- Characterize current state
- Develop model to detect changes
- Work w/ SL and NGT to minimize
Watershed Sediment RunOff

Complex and influenced by many variables

Options to Correlate Erosion?

RO rate and Surface RunOff are critical variables
Example RunOff Hydrograph

- **RunOff Intensity**
- **Cum Surface RunOff when Rainfall stops**
- **Start of Surface RunOff**

**Sediment RunOff Intensity Index (SROI)**

ROI * CSRO
Stream SL117
Lab vs. Sensor Turbidity
(4/20 - 25/2019 data)

Marion's Lab, NTU vs. Sensor, NTU

y = 0.0056x^2 + 0.6826x
R^2 = 0.9707

y = 0.0065x^2 + 0.6826x
R^2 = 0.9707

Are the grab samples Representative?
y = 3.0366x + 0.0667
R² = 0.9919

Unit sediment loading (tons/rain event/sq. mi. watershed)

Sediment Runoff Intensity Index

Broad Run @ Somerset Lake

RO Sediment Analysis
Sediment RunOff Intensity Index

Applicable to other Watersheds

Watershed RunOff Sediment Loading

Slopes are Unique for a Watershed

EB Brandywine
- Ridley-upstream
- Broad Run-Somerset Lake
- White Clay
- Mill Creek
- EB Brandywine
- Red Clay
- French Creek
- Pennypack
Watershed Unit Sediment Loading Slope

Correlated to Watershed Characteristics

Key Variables:

- \( \sqrt{\text{drainage area}} \)
- Terrain Slope
- 1st & 2nd Order Stream Slope
- \% \text{ Soil Type A & D}
- \% \text{ Cultivated Crops}

(From Wiki-Watershed)

\[
y = 1.0071x - 0.0982
\]

\[R^2 = 0.9831\]
What if Turbidity Data is Compromised?

*Debris or Silt Coated Sensor*

- Turbidity Sensor has useful data...BUT may not have sufficient data to integrate over a rain event!

- Option to use an “auto-sampler:
  - Electronic ”Mayfly” System
  - Manual

- Upstream ½ PVC Pipe Shield
Ridley Creek - Upstream
6/11/18 RunOff Event

Peak Flow

7 cm depth vs. BF

Flow, cfs

Sediment, lbs.

5 min. time increments

RC Flow, cfs
Sediment, lbs.

Avg. Sediment/Flow:
@ Near Peak Flow
@ 7 cm > BF

Cum Total Flow to Peak Flow:
(start of RO to Peak Flow)

Estimated Sediment:
(Cum Flow to Peak * Avg. Sediment/Flow)

SL177 Steam Turbidity
Manual Auto-sampler vs. Sensor

SL177 Auto vs. Instream Sensor Turbidity Lab Basis

NOTE:
Instream Variability

y = 0.7403x + 4.8037
R² = 0.5298

y = 0.731x + 9.5539
R² = 0.8049
**Broad Run @ Somerset Lake**

**Rain Event Sediment**
Manual Sampler vs. Hydrograph Integration

![Graph showing the relationship between Manual Sampler Sediment and Hydrograph Sediment with the equation y = 2.0585x and R² = 0.9664.](image)

**Assumption:**
Manual Samples = Sensor

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**Rain Event Sediment Correlation**

*Auto Sampler vs. Hydrograph Slope*

![Graph showing the correlation between Hydro vs. Auto Sediment Slope and Square Root of Watershed Area, with the equation y = 1.4418x + 0.7596 and R² = 0.9914.](image)

**Slope is Correlated by watershed area**

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**Equations:**

- Manual Sampler Sediment vs. Hydrograph Sediment: $y = 2.0585x$, $R^2 = 0.9664$
- Auto Sampler Sediment vs. Hydrograph Slope: $y = 1.4418x + 0.7596$, $R^2 = 0.9914$