Murderkill River Study

Hassan Mirsajadi
Watershed Assessment Section
DNREC Division of Water Resources

8th Annual Nonpoint Source Advisory Committee

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Outline

• Background
• Elements of the study
• Some preliminary results
Murderkill River Watershed

- Area: 107 square miles
- Major land use: agriculture (52%), residential (16%)
- Major Point Source: Kent County Facility
  - Current Discharge flow: ~ 12 mgd
Background

- DNREC monitoring data has shown that waters of the Murderkill River have high nutrients, low dissolved oxygen, and high bacteria counts.
- To address the above water quality problems, a Total Maximum Daily Loads (TMDLs) was established in 2001 (and modified in 2005) for the Murderkill River watershed.
- TMDL is the maximum amount of pollutants that can enter a waterbody without causing water quality problems.
Background

- During TMDL development process, Kent County, which owns and operates Kent County Facility, questioned some of the assumptions and modeling results used for establishing the TMDL.
- One of the questions and concerns was the impact of nonpoint sources (both natural and man-made) on water quality of tidal Murderkill.
- As a result of subsequent negotiations, DNREC and the County agreed to start a jointly-funded study to answer some of the questions raised.
The Study Plan

• In early 2007 a Study Team was formed of representatives from DNREC, Kent County, University of Delaware, University of Maryland, and others

• The team was tasked with developing a plan for collecting data, conducting research, and developing modeling tools to quantify some of nonpoint source loads and to develop site-specific dissolved oxygen and nutrient criteria for tidal Murderkill River

• The team met for about 9 months to discuss various issues and to develop work plans, budget, and schedule
<table>
<thead>
<tr>
<th>Member Name</th>
<th>Affiliation</th>
<th>Email Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthony Aufdenkampe</td>
<td>Stroud Water Research Center</td>
<td><a href="mailto:aufdenkampe@stroudcenter.org">aufdenkampe@stroudcenter.org</a></td>
</tr>
<tr>
<td>Jeffrey Cornell</td>
<td>University of Maryland</td>
<td><a href="mailto:cornwell@hpl.umces.edu">cornwell@hpl.umces.edu</a></td>
</tr>
<tr>
<td>Andrew Homsey</td>
<td>University of Delaware, WRA</td>
<td><a href="mailto:ahomsey@udel.edu">ahomsey@udel.edu</a></td>
</tr>
<tr>
<td>Andrew Howard</td>
<td>DNREC Division of Water Resources</td>
<td><a href="mailto:andrew.howard@state.de.us">andrew.howard@state.de.us</a></td>
</tr>
<tr>
<td>Amy Jacobs</td>
<td>DNREC Division of Water Resources</td>
<td><a href="mailto:amy.jacobs@state.de.us">amy.jacobs@state.de.us</a></td>
</tr>
<tr>
<td>Tom McKenna</td>
<td>Delaware Geological Survey</td>
<td><a href="mailto:mckennat@UDel.edu">mckennat@UDel.edu</a></td>
</tr>
<tr>
<td>David McQuaide</td>
<td>DNREC Division of Water Resources</td>
<td><a href="mailto:david.mcquaide@state.de.us">david.mcquaide@state.de.us</a></td>
</tr>
<tr>
<td>Hans Medlarz</td>
<td>Kent County Department of Public Works</td>
<td><a href="mailto:Hans.Medlarz@co.kent.de.us">Hans.Medlarz@co.kent.de.us</a></td>
</tr>
<tr>
<td>Hassan Mirsajadi</td>
<td>DNREC Division of Water Resources</td>
<td><a href="mailto:hassan.mirsajadi@state.de.us">hassan.mirsajadi@state.de.us</a></td>
</tr>
<tr>
<td>Mark Nardi</td>
<td>United States Geological Survey</td>
<td><a href="mailto:mmardi@usgs.gov">mmardi@usgs.gov</a></td>
</tr>
<tr>
<td>Michael Owens</td>
<td>University of Maryland</td>
<td><a href="mailto:owens@hpl.umces.edu">owens@hpl.umces.edu</a></td>
</tr>
<tr>
<td>Ben Pressley</td>
<td>DNREC - Lab</td>
<td><a href="mailto:Ben.Pressley@state.de.us">Ben.Pressley@state.de.us</a></td>
</tr>
<tr>
<td>Kent Price</td>
<td>University of Delaware (Emeritus)</td>
<td><a href="mailto:ksprice@udel.edu">ksprice@udel.edu</a></td>
</tr>
<tr>
<td>Alison Rogerson</td>
<td>DNREC</td>
<td><a href="mailto:Alison.Rogerson@state.de.us">Alison.Rogerson@state.de.us</a></td>
</tr>
<tr>
<td>Bob Scarborough</td>
<td>DNREC Division of Soil and Water Conservation</td>
<td><a href="mailto:bob.scarborough@state.de.us">bob.scarborough@state.de.us</a></td>
</tr>
<tr>
<td>Jonathan Sharp</td>
<td>University of Delaware</td>
<td><a href="mailto:jsharp@udel.edu">jsharp@udel.edu</a></td>
</tr>
<tr>
<td>Bradford Smith</td>
<td>DNREC Division of Water Resources</td>
<td><a href="mailto:bradford.smith@state.de.us">bradford.smith@state.de.us</a></td>
</tr>
<tr>
<td>Chris Sommerfield</td>
<td>University of Delaware</td>
<td><a href="mailto:cs@udel.edu">cs@udel.edu</a></td>
</tr>
<tr>
<td>Anthony Tallman</td>
<td>United States Geological Survey</td>
<td><a href="mailto:atallman@usgs.gov">atallman@usgs.gov</a></td>
</tr>
<tr>
<td>Andrew Thuman</td>
<td>HydroQual, Inc.</td>
<td><a href="mailto:athuman@hydroqual.com">athuman@hydroqual.com</a></td>
</tr>
<tr>
<td>William Ulman</td>
<td>University of Delaware</td>
<td><a href="mailto:ullman@udel.edu">ullman@udel.edu</a></td>
</tr>
<tr>
<td>David Velinsky</td>
<td>Academe of Natural Science</td>
<td><a href="mailto:velinsky@ansp.org">velinsky@ansp.org</a></td>
</tr>
<tr>
<td>Jennifer Volk</td>
<td>DNREC Division of Water Resources</td>
<td><a href="mailto:Jennifer.Volk@state.de.us">Jennifer.Volk@state.de.us</a></td>
</tr>
<tr>
<td>Holly Weyers</td>
<td>United States Geological Survey</td>
<td><a href="mailto:hsweyers@usgs.gov">hsweyers@usgs.gov</a></td>
</tr>
<tr>
<td>David Wolanski</td>
<td>DNREC Division of Water Resources</td>
<td><a href="mailto:David.Wolanski@state.de.us">David.Wolanski@state.de.us</a></td>
</tr>
<tr>
<td>Xie Xie</td>
<td>DNREC Division of Water Resources</td>
<td><a href="mailto:xia.xie@state.de.us">xia.xie@state.de.us</a></td>
</tr>
<tr>
<td>Brian Dzwonkowski</td>
<td>University of Delaware CMES</td>
<td><a href="mailto:briandz@UDel.Edu">briandz@UDel.Edu</a></td>
</tr>
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• Critical Issues/needs identified by the Study Group:
  – Quantifying the impact of natural sources and tidal marsh on nutrient and oxygen levels of tidal Murderkill River
  – The role of sediment in oxygen and nutrient levels of tidal Murderkill River
  – Impact of nutrients on water quality of the Murderkill River
  – An advanced modeling framework that can incorporate above processes and can be used as a tool for developing site-specific DO and nutrient criteria
Study Plan Elements

• To address critical needs identified earlier, the team developed the following study elements:
  
  – Monitoring
    • Water Quality/Hydrologic
  
  – Research
    • Tidal Marsh Fluxes of nutrients and DO
    • Tidal Marsh inundation
    • Sediment Flux Survey
    • Sediment Nutrients and Ecological History
    • Primary Production Study
  
  – Modeling
    • Watershed
    • Hydrodynamic/water quality
• Time schedule: 3 years (2007-2010)
• Budget: About $1.6 million shared by DNREC and Kent County on about 50/50 basis
Monitoring

- **Water quality monitoring**
  - Monthly surface water quality
    Sampling at 16 stations for 2 years
  - YSI continuous water quality monitoring at 3 sites for more than a year
Monitoring

- **Hydrologic monitoring**
  - Installed 3 stream gages
  - Installed 3 tide gages w/current meters
  - This element of monitoring was continued for about 2 years
## Research/Modeling Elements

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<thead>
<tr>
<th>Study</th>
<th>Principal Investigator(s)</th>
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<tr>
<td>Tidal Marsh Loading and Flux Study</td>
<td>Bill Ullman (UD), Kuo Wong (UD), Anthony Aufdenkampe (Stroud Water Research Center)</td>
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<td>Tidal Marsh Inundation Study</td>
<td>Tom McKenna – DGS</td>
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<td>Sediment Flux Study</td>
<td>Jeff Cornwell, University of Maryland</td>
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<tr>
<td>Sediment Nutrient and Ecological History</td>
<td>David Velinsky (Academy of Natural Sciences), and Chris Sommerfield – UD</td>
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<td>Primary Production Survey</td>
<td>Jonathan Sharp, UD</td>
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<tr>
<td>Watershed and Water Quality Modeling</td>
<td>HydroQual, Inc.</td>
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Tidal Marsh Nutrients/DO Exchange Study
Bill Ullman (UD), Kuo Wong (UD), Anthony Aufdenkampe (Stroud)

• Nutrient and DO exchanges between tidal marsh and Murderkill River is estimated by measuring water, salt, and nutrient (N, P, C, Si, and some of their isotopes) entering and leaving a salt-marsh in the Murderkill River watershed.
Tidal Marsh Nutrients/DO Exchange Study

• For this study:
  – A tide gage and current meter was installed at the entrance to a tidal marsh for measuring water inflow/outflow
  – Water quality samples were collected hourly (or every 2 hours) at the gage site for 36 hours (3 tide cycles)
Tidal Marsh Nutrients/DO Exchange Study

– This 36-hour water quality sampling was repeated 5 times during the course of 2-year study

– The result of this study will be used to quantify the exchange of nutrients and DO between the marsh and Murderkill River
Nitrogen Species measured entering and leaving tidal marsh
Inundation of Tidal wetlands
Tom McKenna (DGS)

• The objective of this study is to determine tidal inundation of Murderkill River wetlands using LIDAR and thermal imagery

• The findings of this study along with tidal exchange study will determine the impact of tidal marshes on water quality of the Murderkill River
Inundation of Tidal wetlands
Tom McKenna (DGS)

• For this Study:
  – A LIDAR survey of tidal marshes was conducted to determine marsh topography
  – Thermal imagery surveys were conducted from ground and air using a Blimp (UD Airship)
  – Several temperature sensors were placed in tidal marsh area to track water inflow/outflow from tidal marshes
Marsh Zones

- Distance upriver (km)
Depth at tide level = 0.3 m
This study is conducted to determine the amount of nutrients and dissolved oxygen that is exchanged between sediments and water column.

Sediment samples are collected at 4 sites in the main stem of tidal Murderkill River and 6 sites in tidal marshes.
Sediment Nutrient Flux Study, cont.

Jeff Cornwell – University of Maryland

- Sediment samples are taken to the lab and are incubated in ambient water in dark for several hours.
- Nutrients and dissolved oxygen concentration of overlying water is measured hourly to calculate the rate of nutrients and dissolved oxygen exchange between sediment and water column.
Sediment Nutrient Flux Study Results

- Site 4321
- Site 4200
- Site 3210
- Site 2200
- Site 1210

Subtidal Marsh & Subtidal 210Pb-Dated
MK 01  MK 05  Geochron A
MK 02  MK 05  Geochron B
MK 03  MK 07
MK 04  MK 08
MK 09
MK 10

MK 04, MK 09, Geochron A Plot Together

Graph showing O2 μmoles m⁻² h⁻¹ for July and April.

Map showing locations of subtidal marsh and geochron sites.
Sediment Nutrients and Ecological Histories
David Velinsky and Don Charles (Academy of Natural Sciences) and Chris Sommerfield (UD)

- Sediment cores from marshes provide an excellent mean for documenting long-term (e.g., decadal scales) changes in land use, nutrient and contaminant loadings and related ecological changes
- In this study, sediment cores were collected from 4 marsh sites within the tidal Murderkill River
Sediment Nutrients and Ecological Histories
David Velinsky and Don Charles (Academy of Natural Sciences)
and Chris Sommerfield (UD)

• Sediment accumulation rates are calculated using $^{210}$Pb and $^{137}$Cs geochronology
• Furthermore, sediments are analyzed for C, N, P and indicators of ecological change (diatoms, stable isotopes) to reconstruct history of ecological changes in response to environmental management practices over time
Murderkill River: Coring sites

Site 1
MK1B
Cs-137 (dpm/g) 0 1 2 3 4 5
Depth in core (cm) 0 10 20 30 40 50
0.80 cm/yr

Site 2
MK3B
Cs-137 (dpm/g) 0 1 2 3
Depth in core (cm) 0 10 20 30 40 50
0.56 cm/yr

Site 3
0.36 cm/yr

Site 4
137-Cs (dpm/g) 0 0.5 1.0 1.5 2.0 2.5 3.0
Depth (cm) 0 10 20 30 40 50
Primary Production Study
Jonathan Sharp – University of Delaware

• Primary production is the amount of organic matter that is created by photosynthesis.
• For the Murderkill River, monthly samples were collected from April 07 thru Dec. 08 at 7 tidal monitoring sites.
• Samples were taken to UD lab, stable isotope $^{13}$C was added to samples and then were incubated for 24 hours under various light levels (from 100% to 1.5% of ambient light)
Primary Production Study
Jonathan Sharp – University of Delaware

• Measuring the amount of $^{13}$C isotope uptake at the end of the 24 hour incubation period determines primary production under the specific light and nutrient condition

• The results of primary production survey will be used to determine the effect of nutrients, to calibrate the Hydrodynamic/Water Quality Model, and to develop site-specific nutrient criteria
Primary Production Study Results

![Graph showing VProd (µM C/d) over months for Station 10, Station 14, and Station 16.](image)

![Map image with Station locations marked.](image)
Primary Production Study Results

- Equation 1: $y = 0.0002x + 11.78$
  - $R^2 = 0.26$

- Equation 2: $y = -0.362x + 79.65$
  - $R^2 = 0.12$

**Graphs:**
- Left graph: TSS (mg/L) vs. Volume Production (µM C d⁻¹)
- Right graph: Integrated Light vs. Volume Production (µM C d⁻¹)
Watershed and Hydrodynamic/Water Quality Modeling
HydroQual, Inc.

- Watershed (loading) Model – HSPF
  - Estimates flow and loads generated from the watershed

- Hydrodynamic/Water Quality Model – ECOM/RCA
  - Calculates concentration of nutrients, algae, and dissolved oxygen in tidal Murderkill River based on nutrient loads and stream flows entering the River as well as its interaction with Delaware Bay
Watershed and Hydrodynamic/Water Quality Modeling
HydroQual, Inc.
## Time Schedule

<table>
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<th>Study Element</th>
<th>Status</th>
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<tbody>
<tr>
<td>Monitoring, data collection</td>
<td>Completed</td>
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<tr>
<td>Research studies</td>
<td>Some completed. Others will be completed within the next few months</td>
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<tr>
<td>Modeling</td>
<td>Will be completed by the end of 2010</td>
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<tr>
<td>Site-specific nutrient and dissolved oxygen criteria</td>
<td>December 2011</td>
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Thank You!

For more information:
http://christina.wra.udel.edu/murderkill/