Monitoring water quality in urban watersheds

- Regulatory Compliance
- Ecological Health
- Economics
- Public Safety and Community Resilience
POLLUTION WARNING
WATER MAY BE POLLUTED AFTER HEAVY RAIN
• Water quality impacts in urban watersheds
  • Primary contaminants
    – Nutrients
    – Organic matter
    – Microbial pathogens
    – Heavy metals

• Monitored using primary indicators
  – Nutrients --> Nitrate/phosphate concentrations
  – Organic matter --> DOC
  – Microbial pathogens --> E. coli or Enterococcus
  – Heavy metals --> Mercury
  – Dissolved oxygen
  – Temperature
  – General appearance

http://www.dnr.sc.gov/marine/vessel/whypumpout.html
E. coli sampling, June 2009

Monthly Rainfall

### Beach Advisory Days (BADs) by Community

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Research Objectives

1. To create an adaptive monitoring network in a watershed to capture rain events
2. To integrate hydrological flows and water quality information into a predictive watershed model
3. To extend these approaches to a second urban watershed/estuary to determine the validity of the approach
Sampling Area

Neponset River Watershed

• 130 square miles
• 14 cities and towns
• ~330,000 people
• 30 miles long
• Freshwater flux $\sim$2 m$^3$s$^{-1}$ (range <2 to 40 m$^3$s$^{-1}$)
How would you design a sampling protocol in order to capture rain events in the Neponset Watershed?
Sampling Methods

– Monthly discrete sampling at 31 sites within the watershed

  • Have 12+ months of samples, continuing 20 months of previous work
First Flush

- Increased contaminant loads after beginning of rain event
- Flux not captured by conventional sampling methods

Sampling Methods

– Monthly discrete sampling at 31 sites within the watershed
  • Have 12+ months of samples, continuing 20 months of previous work
– High frequency discrete sampling (autosampler)

Runoff Flow Rate (L/s)

Time (min)

5 samples during first hour.
First sample, as soon as flow observed (zero time);
samples 2-5 @ 15 minute interval.

One sample every one hour until the end of storm event for up to 8 hours.

One additional composite sample for longer duration storm event (if desired).

Sampling Methods

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– High frequency discrete sampling (autosampler)
– Real time sensor network - Boston Environmental Area Coastal Observation Network (BEACON)
Sampling Methods

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– Discrete sampling with autosampler
– Real time sensor network - Boston Environmental Area Coastal Observation Network (BEACON)
– Autonomous Underwater Vehicle (AUV)
Sampling Methods

– Monthly discrete sampling at 31 sites within the watershed
  • Have 12 months of samples, continuing 20 months of previous work
– Discrete sampling with autosampler
– Real time sensor network - Boston Environmental Area Coastal Observation Network (BEACON)
– Autonomous Underwater Vehicle (AUV)
– GIS
– Remote sensing
• Samples will be analyzed for:
  – Dissolved Organic Carbon (DOC)
  – Chromophoric Dissolved Organic Matter (CDOM)
  – Nutrients
  – Caffeine (limited)

• Data sharing with Neponset River Watershed Association monitoring network
Research Objectives

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3. To extend these approaches to a second urban watershed/estuary to determine the validity of the approach
• Soil and Water Assessment Tool (SWAT) model
  – Developed by the US Department of Agriculture’s Agriculture Research Service
  – Possible to predict the influence of land use on constituent yields within a watershed (Arnold et al., 1998; Santhi et al., 2001)
  – Data collected will be input into SWAT model
Research Products

• Watershed model that will better capture episodic events
• Peer-reviewed publications
• Policy papers? (land use, stormwater management, ?)
• Sociological study? (NepRWA volunteers)

• End Goal: Resource managers will be better able to make decisions about land use and water policies in the Neponset River
Future Work

• Extend methods to second urban watershed to assess validity of methods
  • Location?
    • Jiulong River Estuary, near Xiamen, China
    • Mato Grosso, Brazil
Conclusion

• High resolution, adaptive sampling methods will show the influence of storm events on contaminant fluxes

• SWAT model will enable prediction of contaminant levels exported to Boston Harbor

• Resource managers will be better able to make decisions about land use and water policies in urban watersheds
Acknowledgments

• My advisor, Bob Chen
• NSF Graduate Teaching Fellows in K-12 Education (GK-12) Program, Watershed-Integrated Sciences Partnership (WISP)
• Yong Tian
• Bernie Gardner
• Francesco Peri
• Chen Lab: Wei Huang, Kim Frashure, Jason Olavesen
Questions?
Suggestions?
Calvin and Hobbes by Bill Watterson

October 26, 2009

Have you been reading the papers? Grown-ups really have the world fouled up.

Acid rain, toxic wastes, holes in the ozone, sewage in the oceans, and on and on!

The only bright side to all this is that eventually there may not be a piece of the planet worth fighting over.
Precipitation

- Evaporation
- Surface Runoff
- Percolate / Recharge
- Return Flow
- Transmission Losses
- Lateral Flow
- Irrigation
- 10 Soil Layers
- Soil Profile
- Soil Moisture Redistribution
- Percolation from Shallow / Recharge to Deep Aquifer
(a) [CSO] E. coli Data <
E. coli Model <
EPA Criteria <
Rainfall >
SB+MR Flow >

(b) note diff. scale [CSO]

E. coli (CFU/100 mL)

Rainfall (inches)
SB+MR Flow (cm/s/10)


Hellweger and Masopust 2008