Monitoring and Modeling Water Quality in an Urban Watershed

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July 14, 2010

UMASS BOSTON

Background

- Monitoring water quality in urban watersheds
  - Regulatory Compliance
  - Ecological Health
  - Economics
  - Public Safety and Community Resilience

http://www.boston.com/news/local/massachusetts/articles/2007/07/19/again_algae_may_spoil_charles_swim/
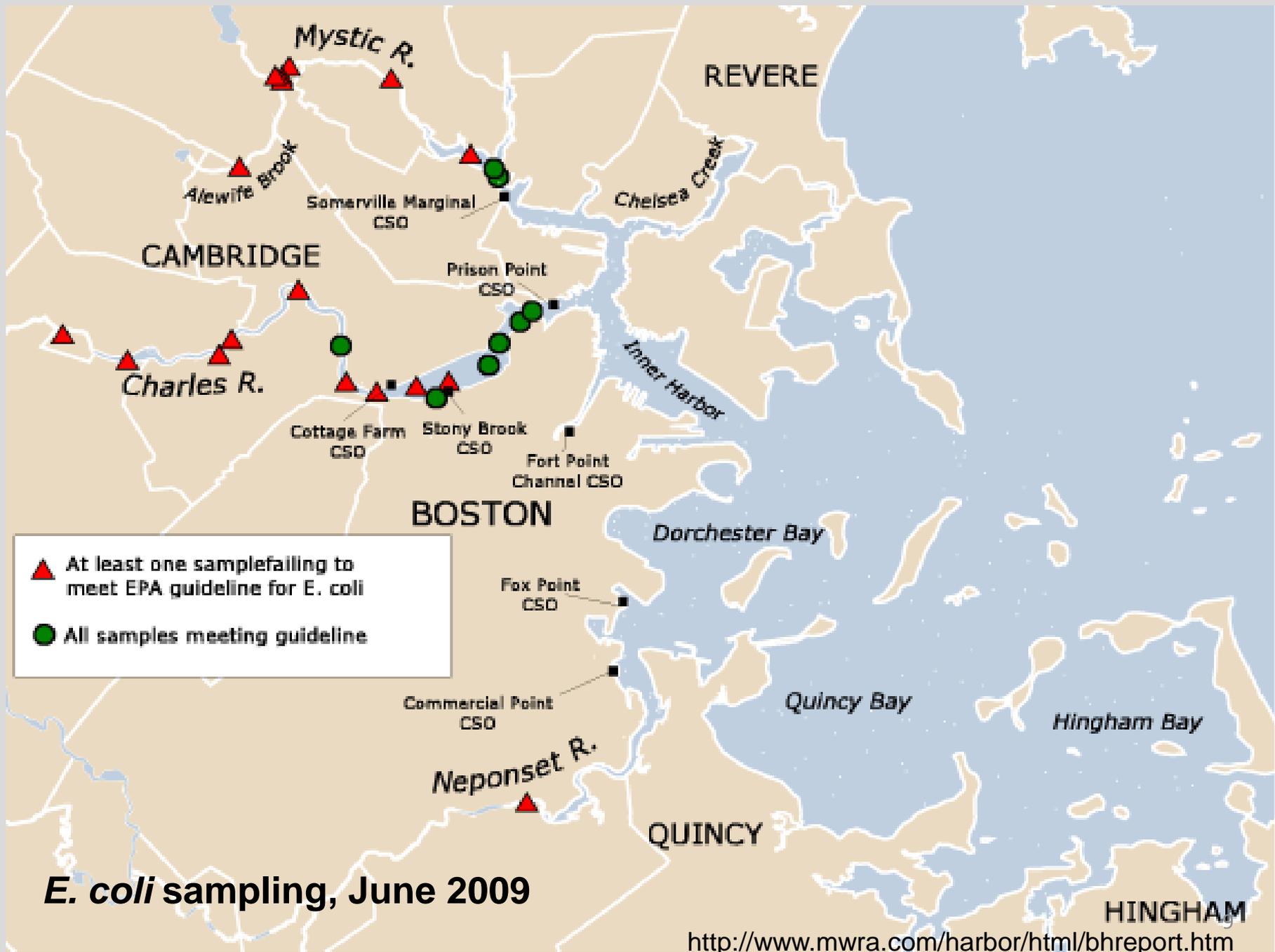
Background

- 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

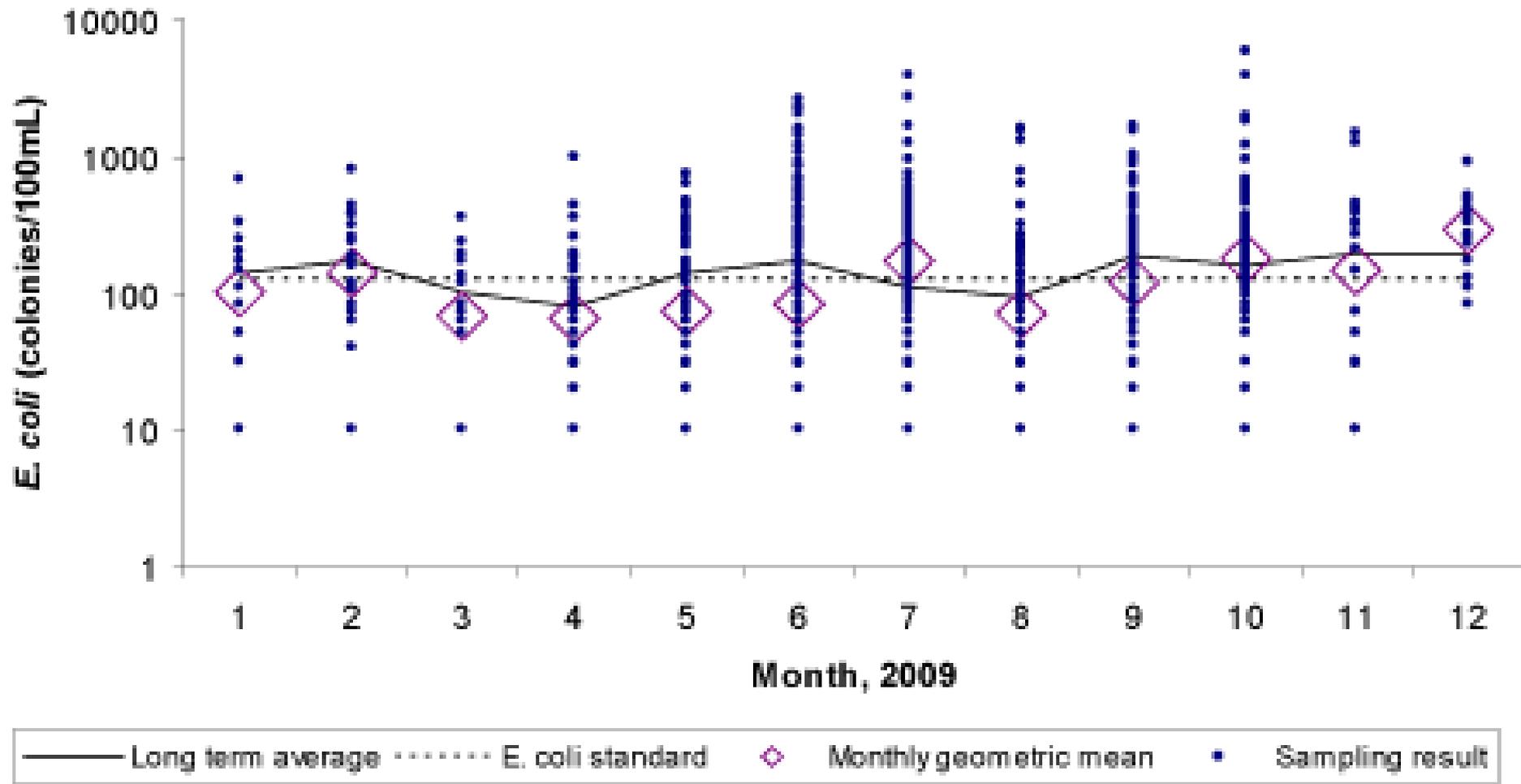http://www.dnr.sc.gov/marine/vessel/whypumpout.html

Massachusetts Map Scale

Map labels: Mystic R., REVERE, Alewife Brook, Chelsea Creek, CAMBRIDGE, Somerville Marginal CSO, Prison Point CSO, Inner Harbor, Cottage Farm CSO, Stony Brook CSO, Fort Point Channel CSO, Charles R., BOSTON, Dorchester Bay, Fox Point CSO, Quincy Bay, Hingham Bay, Commercial Point CSO, Neponset R., QUINCY, HINGHAM

Legend:
▲ At least one sample failing to meet EPA guideline for E. coli
● All samples meeting guideline

E. coli sampling, June 2009

Tributary Rivers

E. coli (colonies/100mL) vs. Month, 2009

Legend: Long term average ·········· E. coli standard ◇ Monthly geometric mean • Sampling result

http://www.mwra.com/harbor/html/bhreport.htm

http://www.mwra.com/harbor/html/bhreport.htm
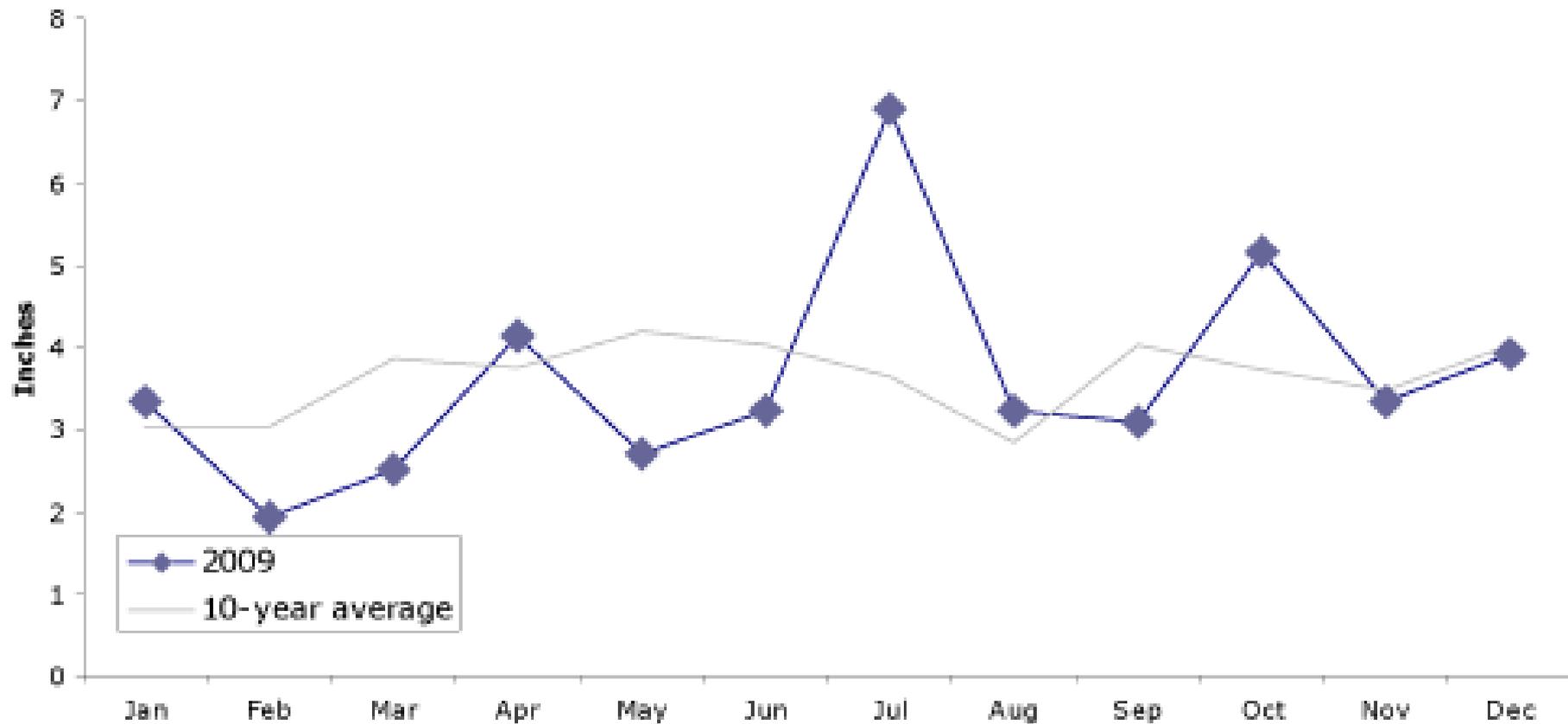
Beach Advisory Days (BADs) by Community

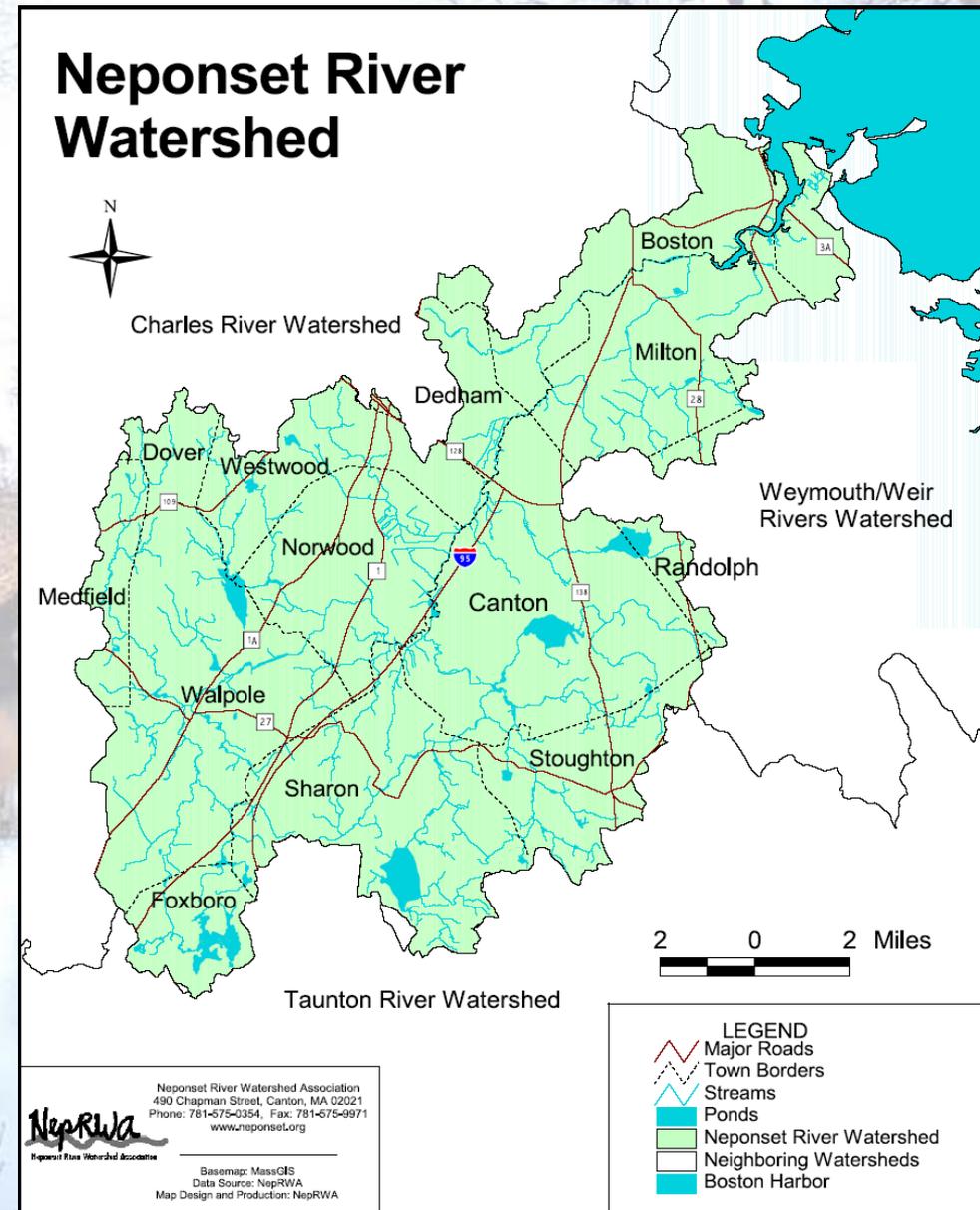|		Top 20 2004-2006			Top 20 2007-2008			Cumulative Top 20 2004-2008	
Rank	State	Town/City	BADs	State	Town/City	BADs	State	Town/City	BADs
1	MA	Boston	460	MA	Chatham	376	MA	Chatham	743
2	MA	Quincy	408	MA	Quincy	278	MA	Boston	725
3	MA	Chatham	367	MA	Boston	265	MA	Quincy	686
4	MA	Salem	324	MA	Lynn	114	MA	Salem	382
5	MA	Marion	253	MA	Wareham	94	MA	Marion	258
6	RI	Warwick	147	MA	Dartmouth	69	RI	Warwick	211
7	MA	Marblehead	138	MA	Dennis	68	MA	Provincetown	181
8	CT	Stamford	123	MA	Provincetown	66	CT	Stamford	165
9	CT	Norwalk	118	RI	Warwick	64	MA	Dartmouth	161
10	MA	Provincetown	115	MA	Falmouth	59	MA	Lynn	153
11	MA	Plymouth	94	MA	Manchester	58	MA	Marblehead	151
12	MA	Dartmouth	92	MA	Salem	58	MA	Camden	136
13	CT	Stratford	90	ME	Kennebunkport	57	ME	Kennebunkport	133
14	ME	Camden	86	ME	Camden	50	CT	Norwalk	130
15	ME	Kennebunkport	76	MA	Winthrop	48	CT	Stratford	111
16	CT	Greenwich	68	MA	Beverly	43	CT	Greenwich	110
17	MA	New Bedford	68	CT	Greenwich	42	MA	Wareham	103
18	MA	Nahant	67	CT	Stamford	42	MA	Plymouth	98
19	RI	Middletown	59	RI	North Kingstown	37	MA	New Bedford	89
20	MA	Barnstable	54	CT	Darien	35	RI	Middletown	85

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

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Sampling Area

Neponset River Watershed

- 130 square miles

- 14 cities and towns

- ~330,000 people

- 30 miles long

- Freshwater flux ~2 m^3 s^{-1}

  (range <2 to 40 m^{3}s^{-1})

Neponset River Watershed

Charles River Watershed

Boston

Milton

Dedham

Dover   Westwood

Weymouth/Weir Rivers Watershed

Norwood

Medfield

Randolph

Canton

Walpole

Stoughton

Sharon

Foxboro

Taunton River Watershed

2   0   2   Miles

Neponset River Watershed Association
490 Chapman Street, Canton, MA 02021
Phone: 781-575-0354, Fax: 781-575-9971
www.neponset.org

Basemap: MassGIS
Data Source: NepRWA
Map Design and Production: NepRWA
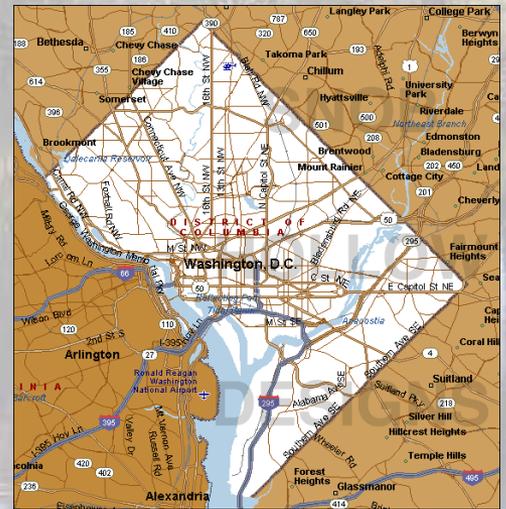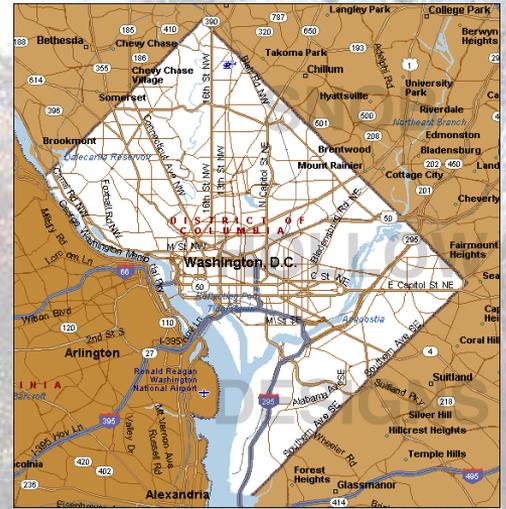
LEGEND
- Major Roads
- Town Borders
- Streams
- Ponds
- Neponset River Watershed
- Neighboring Watersheds
- Boston Harbor

http://www.neponset.org

How would you design a sampling protocol in order to capture rain events in the Neponset Watershed?

www.pedrascience.com

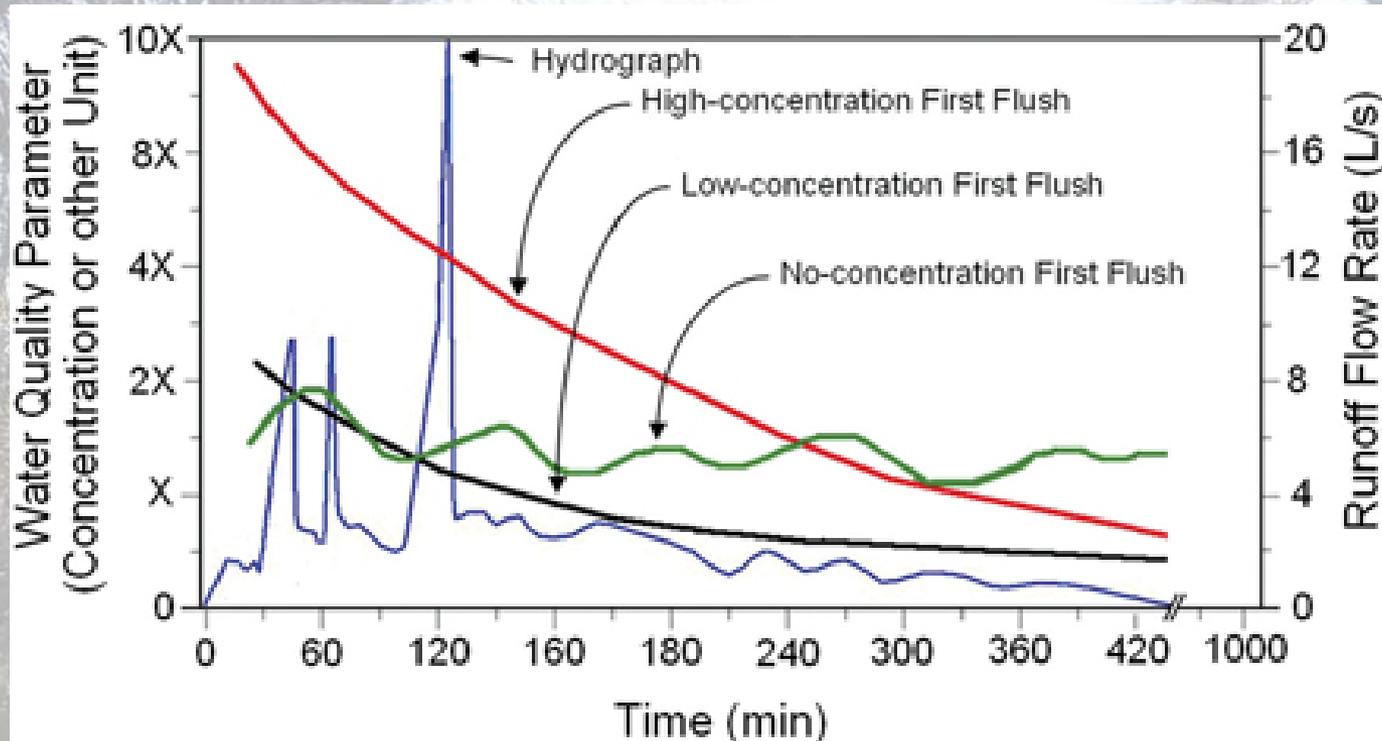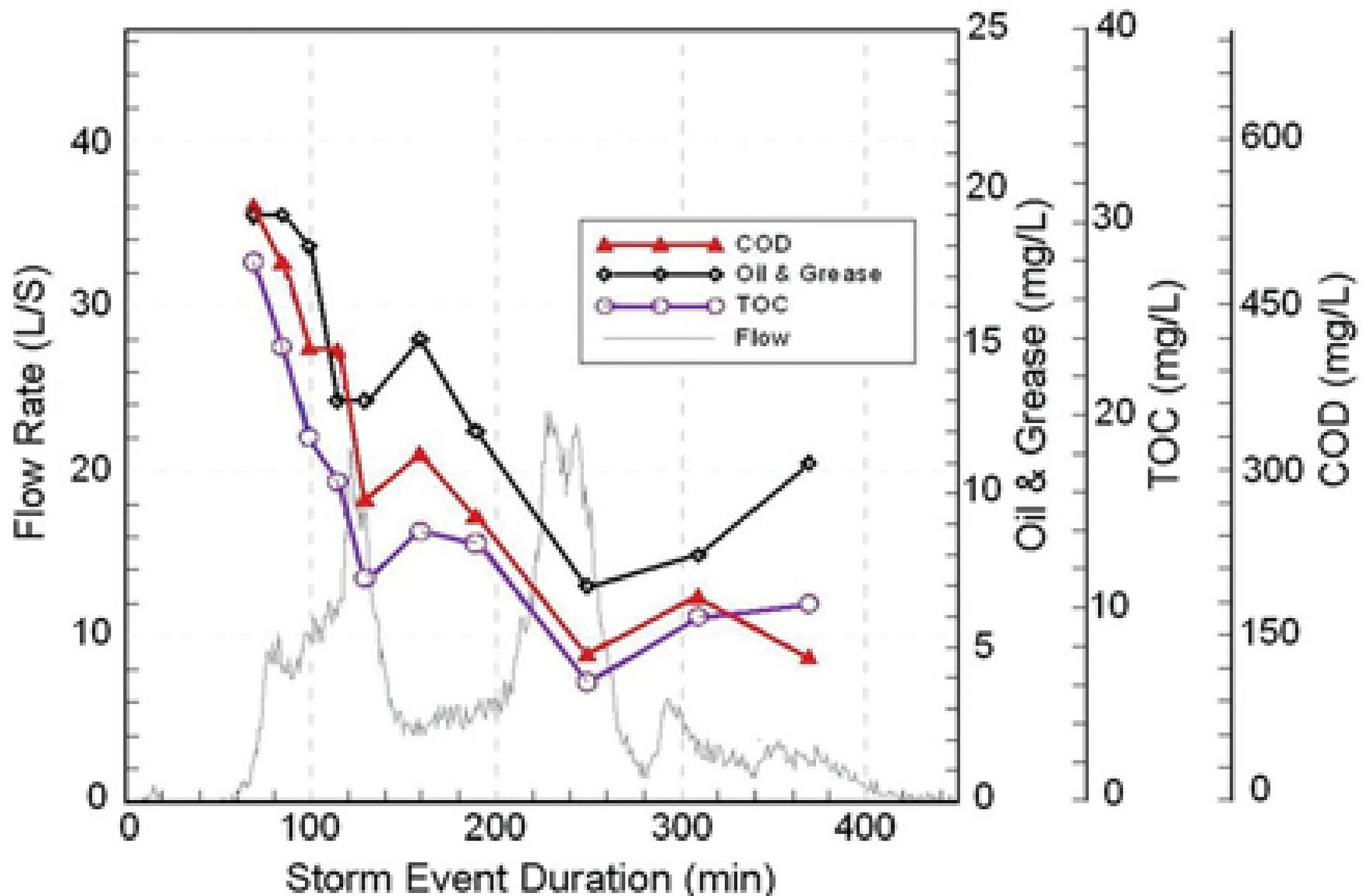# Sampling Methods

– Monthly discrete sampling at 31 sites within the watershed

- Have 12+ months of samples, continuing 20 months of previous work

Neponset Watershed

Legend:
- Residential
- Forest
- Industrial
- Wetland
- Golf Course
- streams

NEPONSET RIVER AT MILTON VILLAGE, MA

NEPONSET RIVER AT NORWOOD, MA

EAST BRANCH NEPONSET RIVER AT CANTON, MA
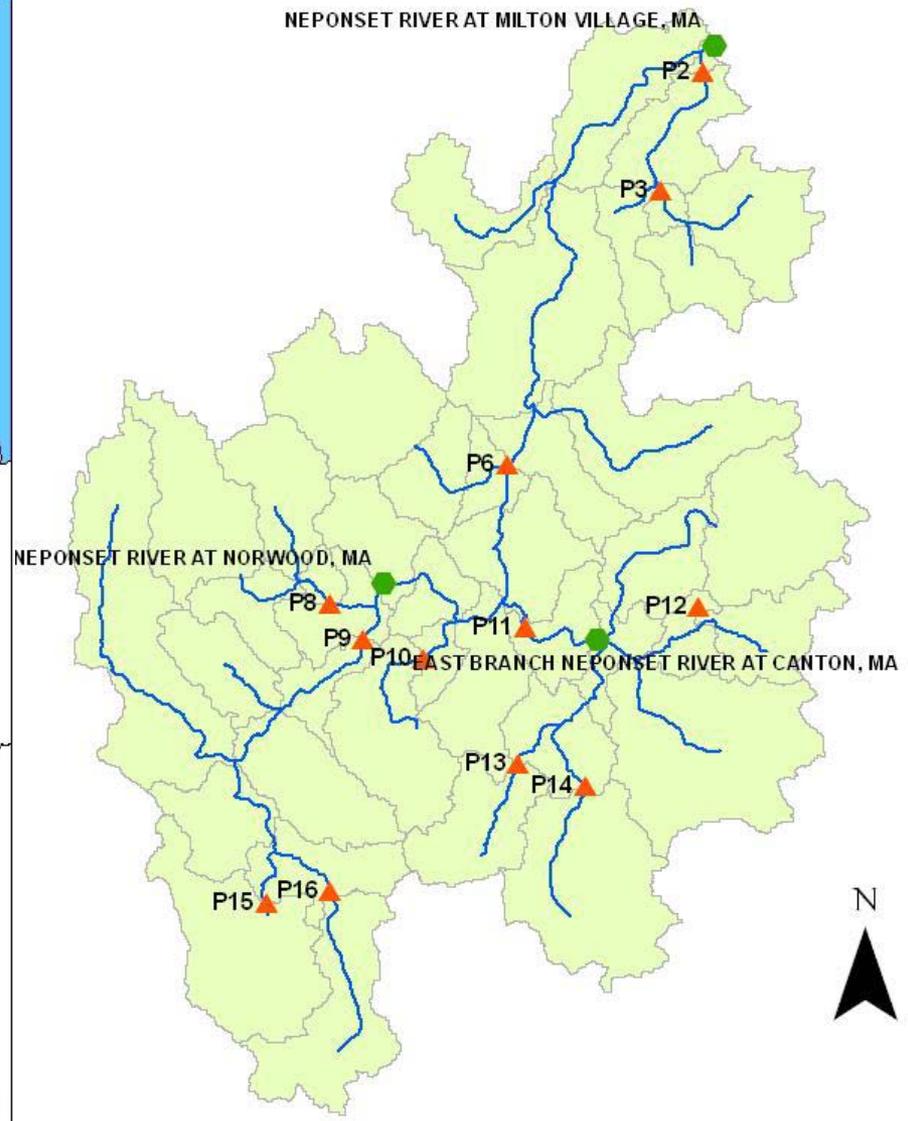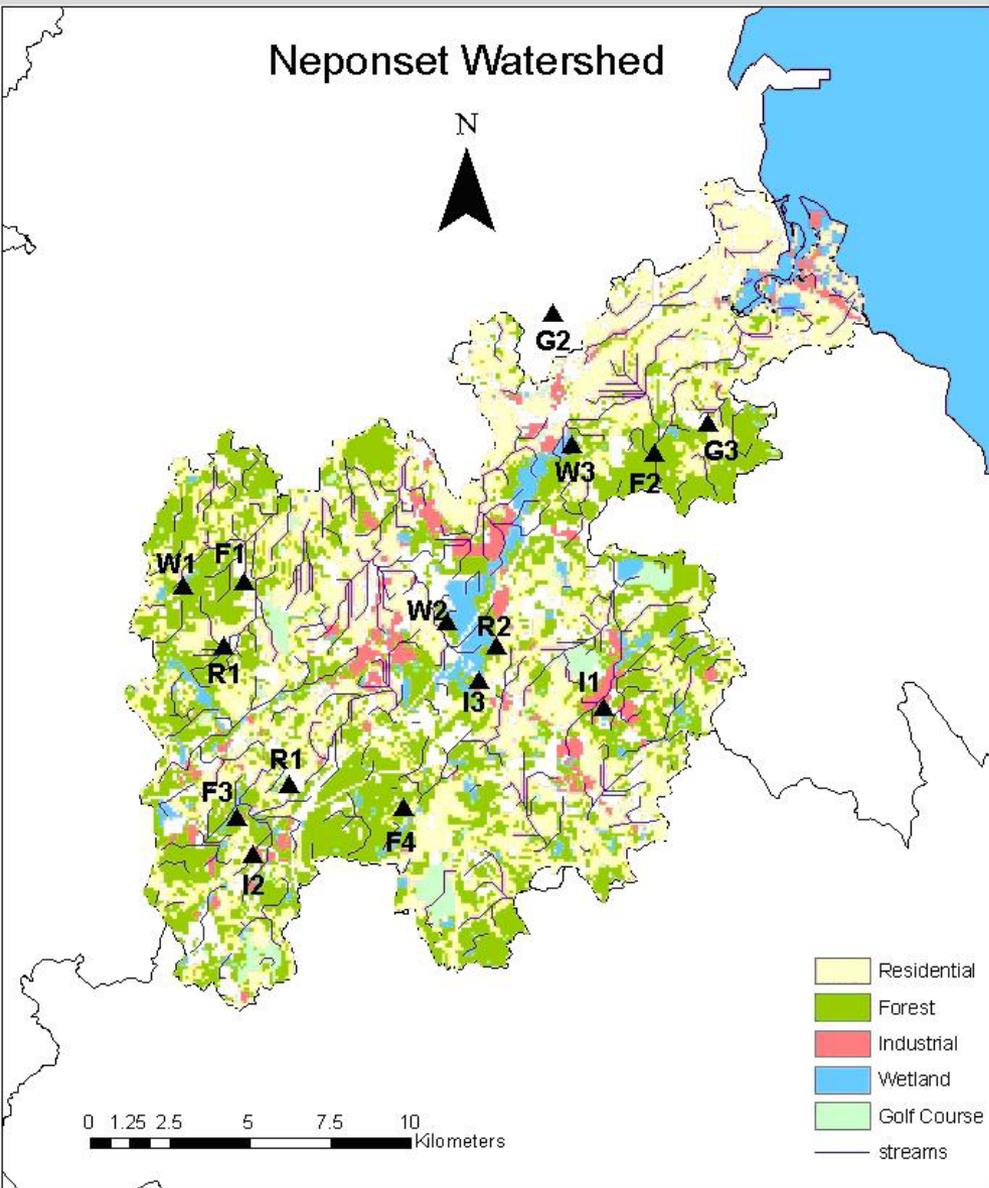
First Flush

- Increased contaminant loads after beginning of rain event

- Flux not captured by conventional sampling methods

http://www.stormh2o.com/march-april-2008/pollutants-run-off.aspx

Sampling Methods

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– High frequency discrete sampling (autosampler)

http://sigma900.watertest.com.cn/products/html/sampler_flowmeter/56.html
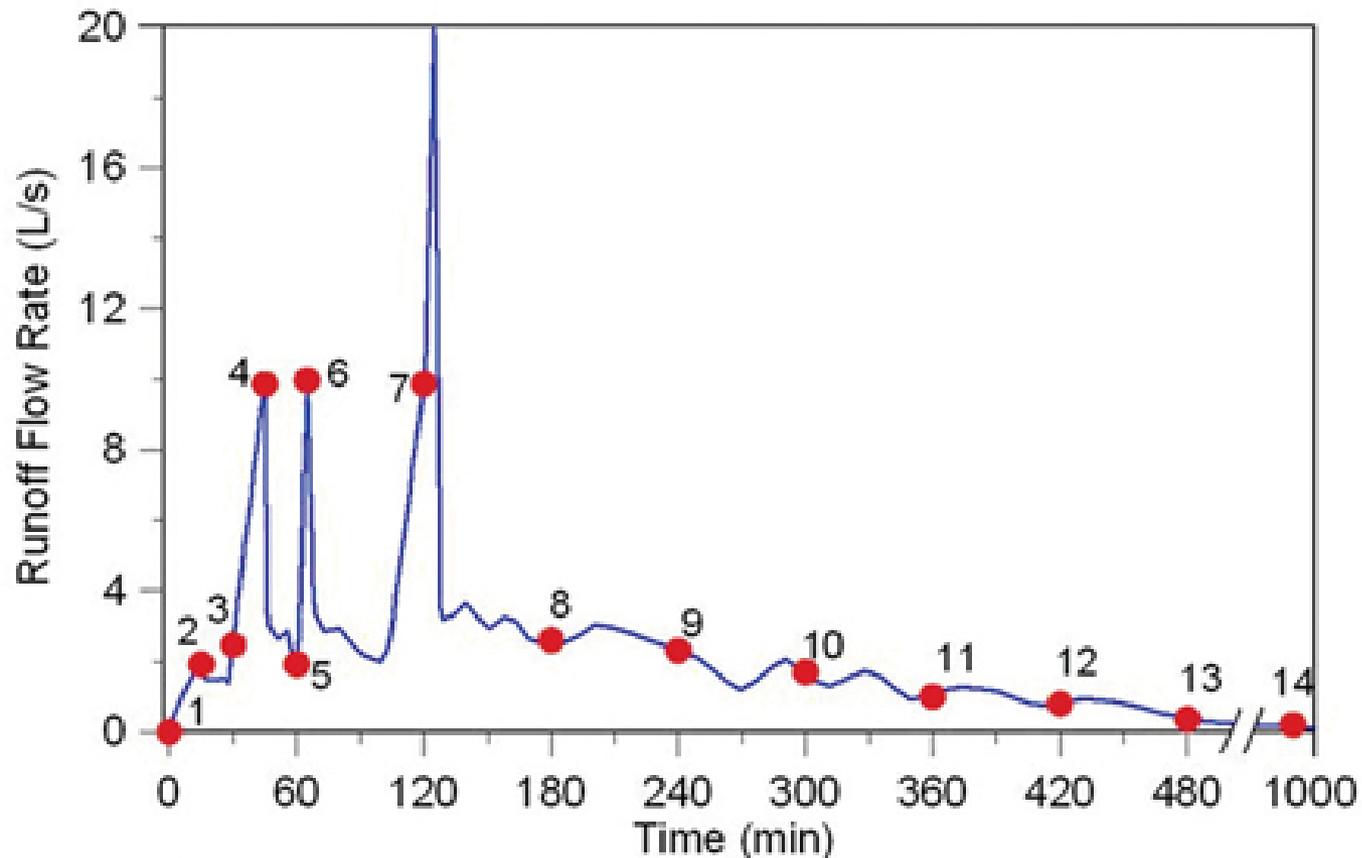
5 samples during first hour. First sample, as soon as flow observed (zero time); samples 2-5 @ 15 minute interval.

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).
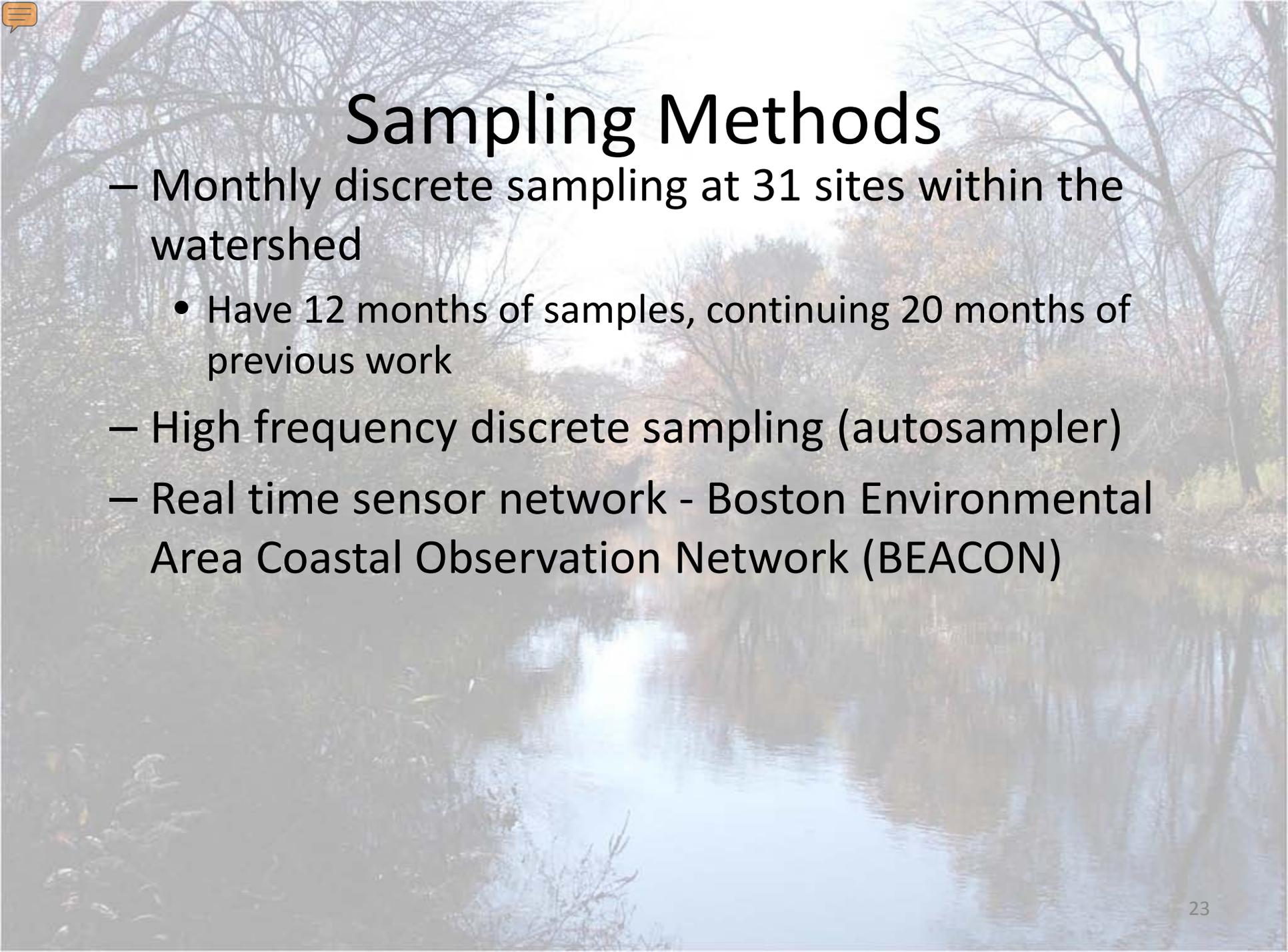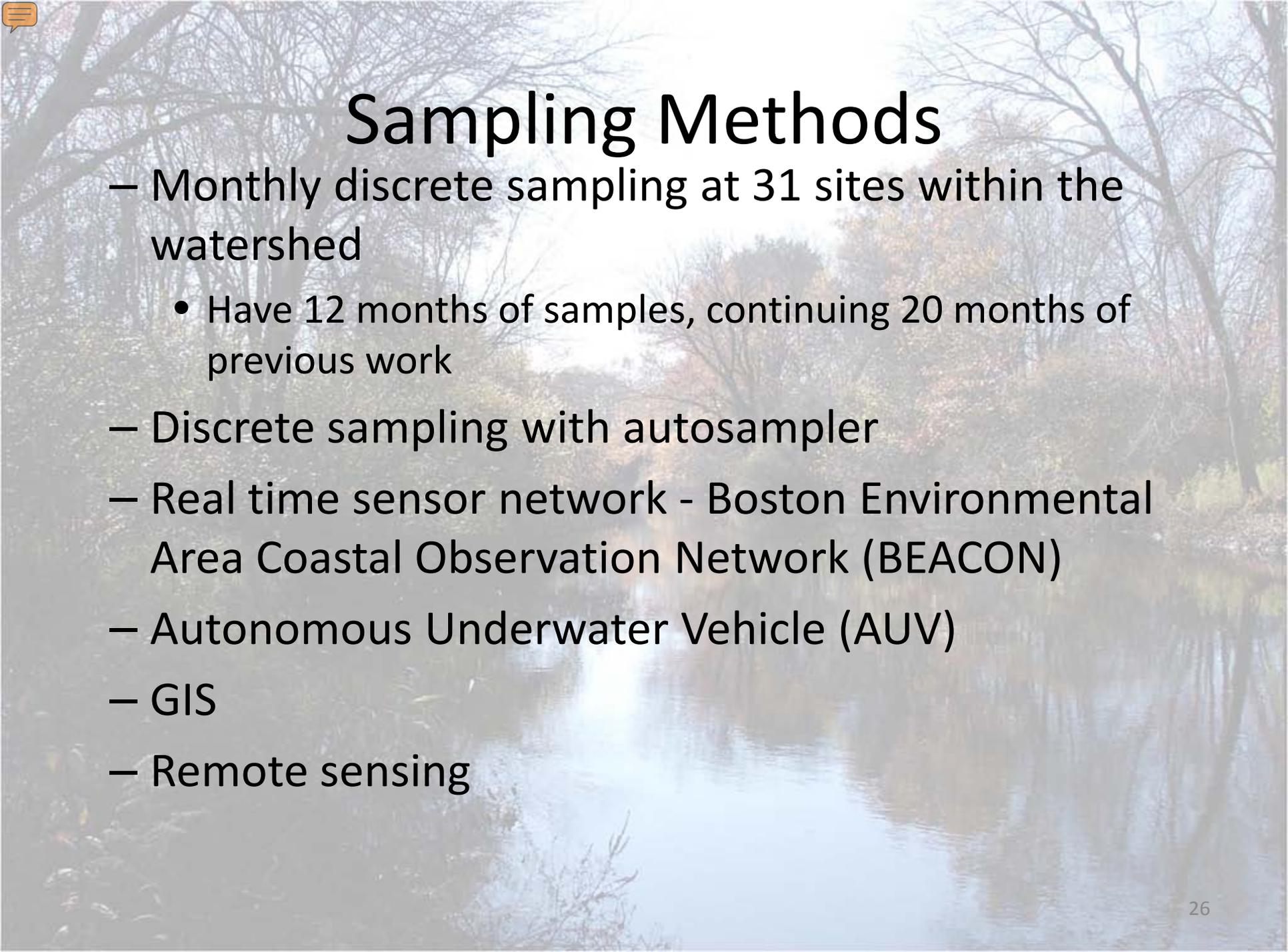
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– Real time sensor network - Boston Environmental Area Coastal Observation Network (BEACON)
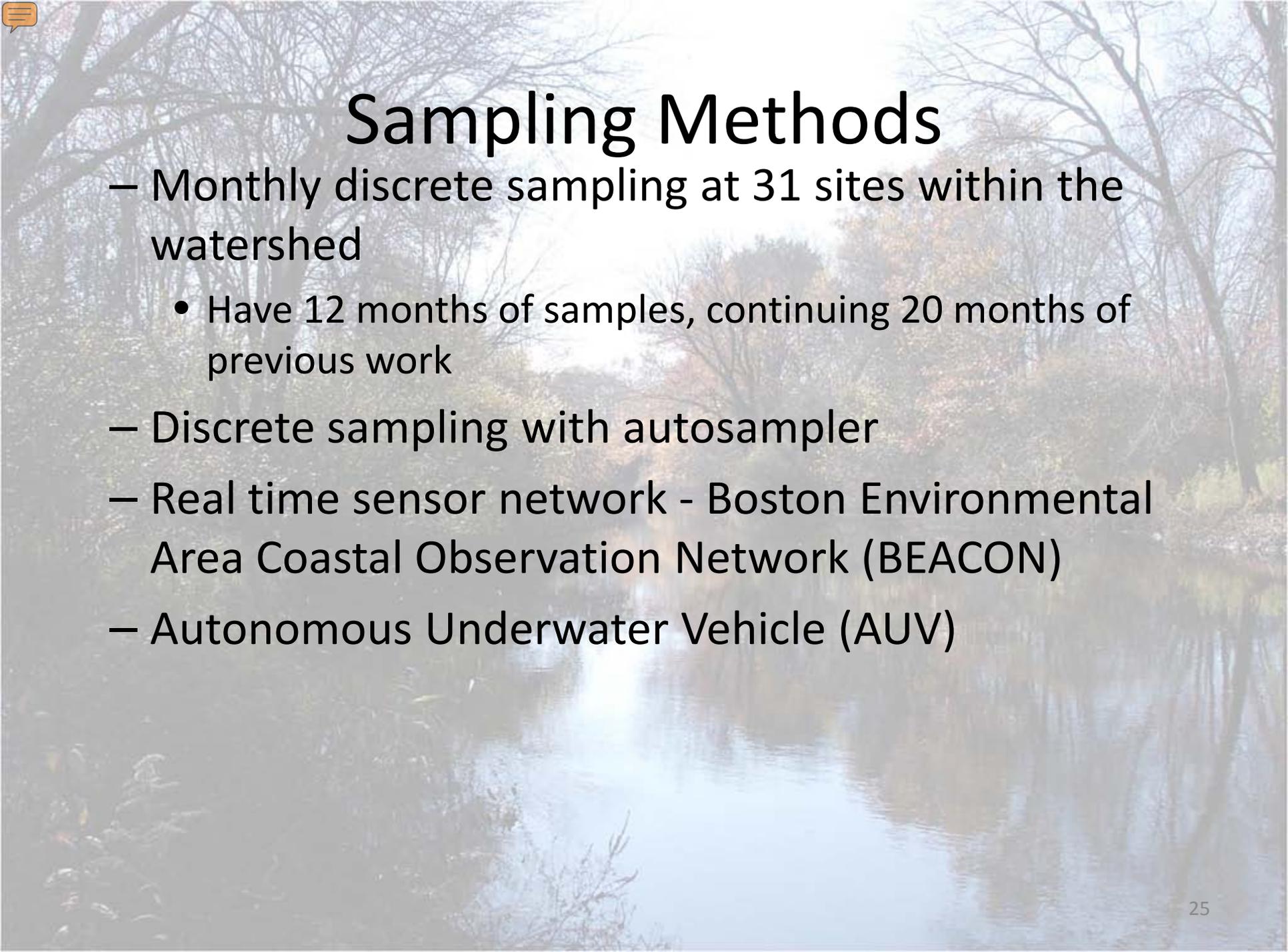
Sampling Methods

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– Discrete sampling with autosampler

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– Autonomous Underwater Vehicle (AUV)

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– 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

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- 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


Dawei Wang
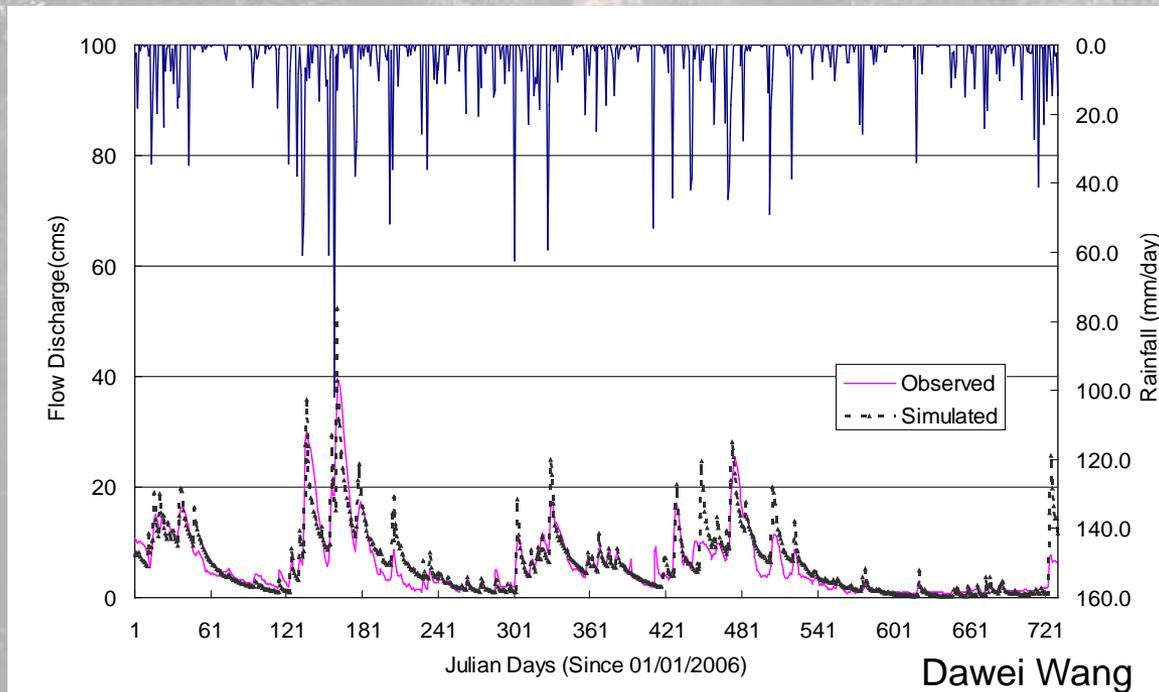
Research Products

- 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


Maskaoui et al. 2005
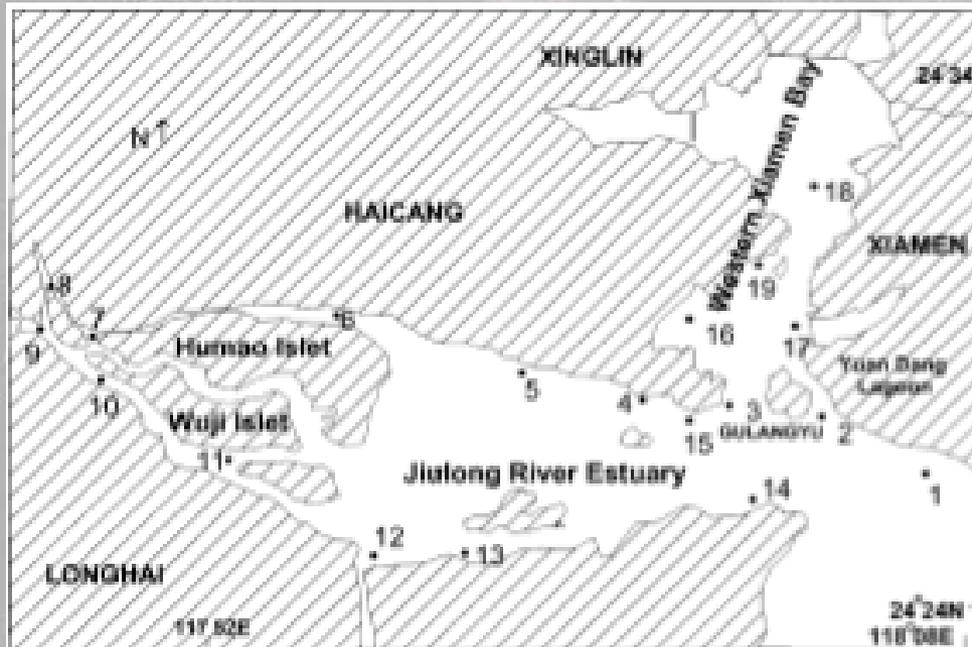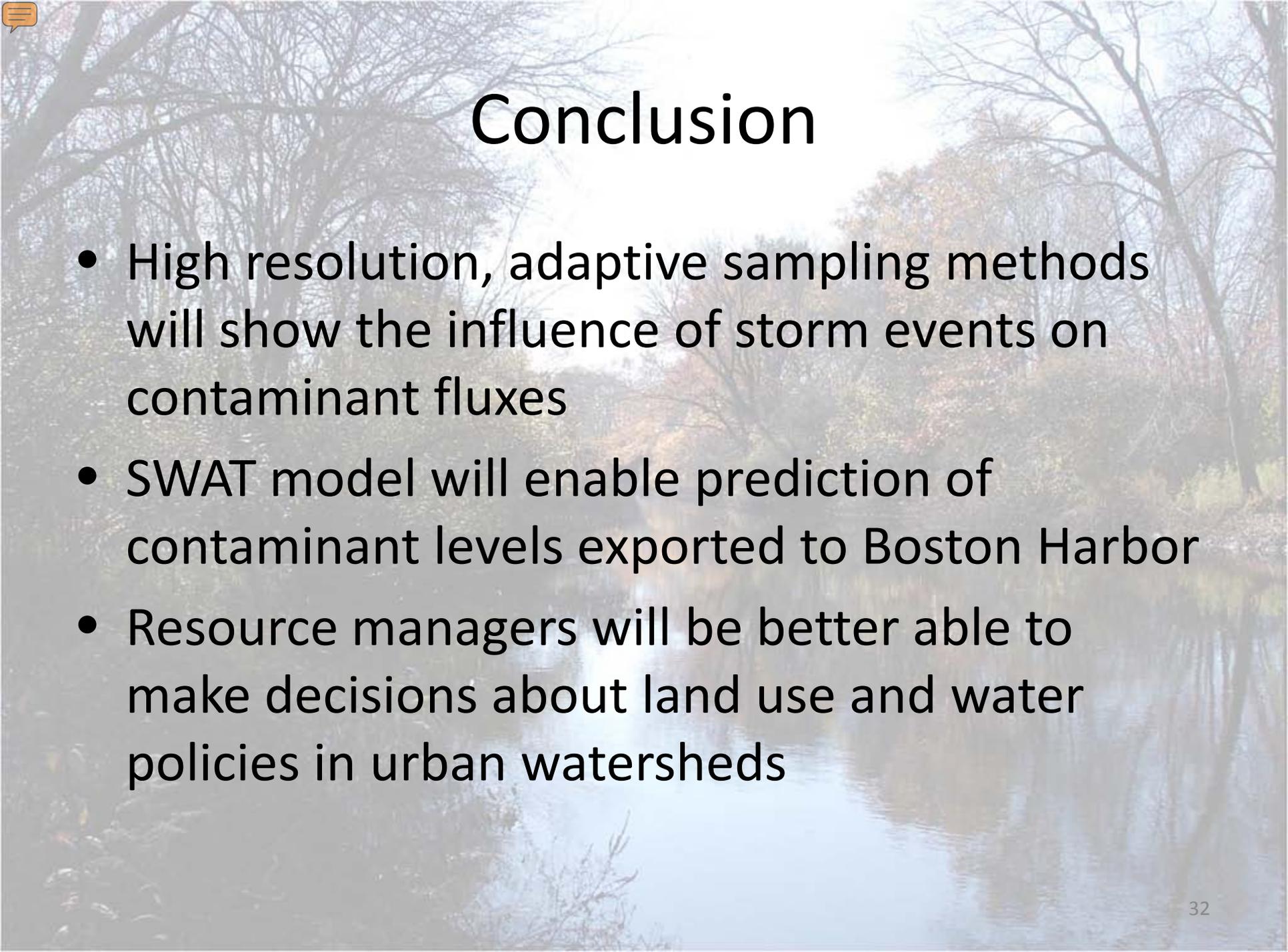
Conclusion

- 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
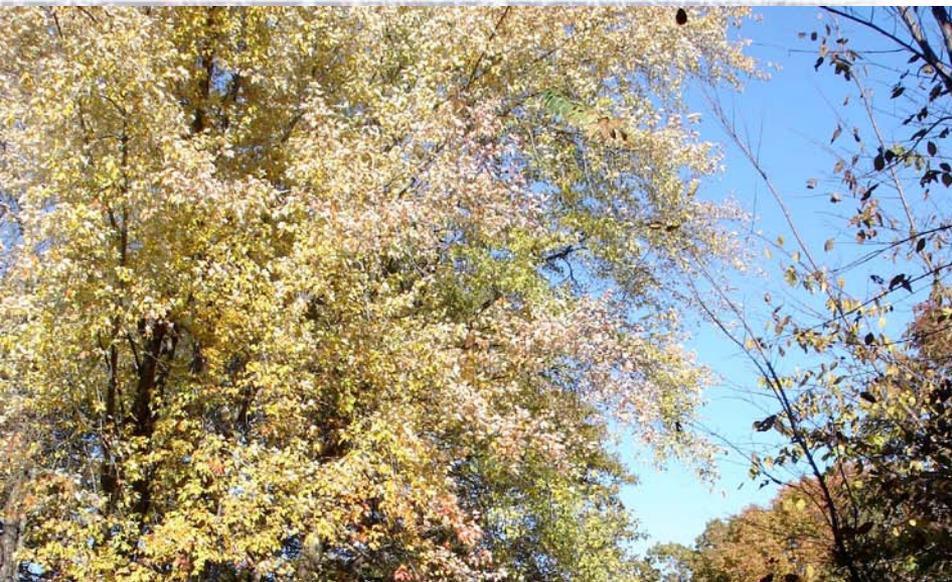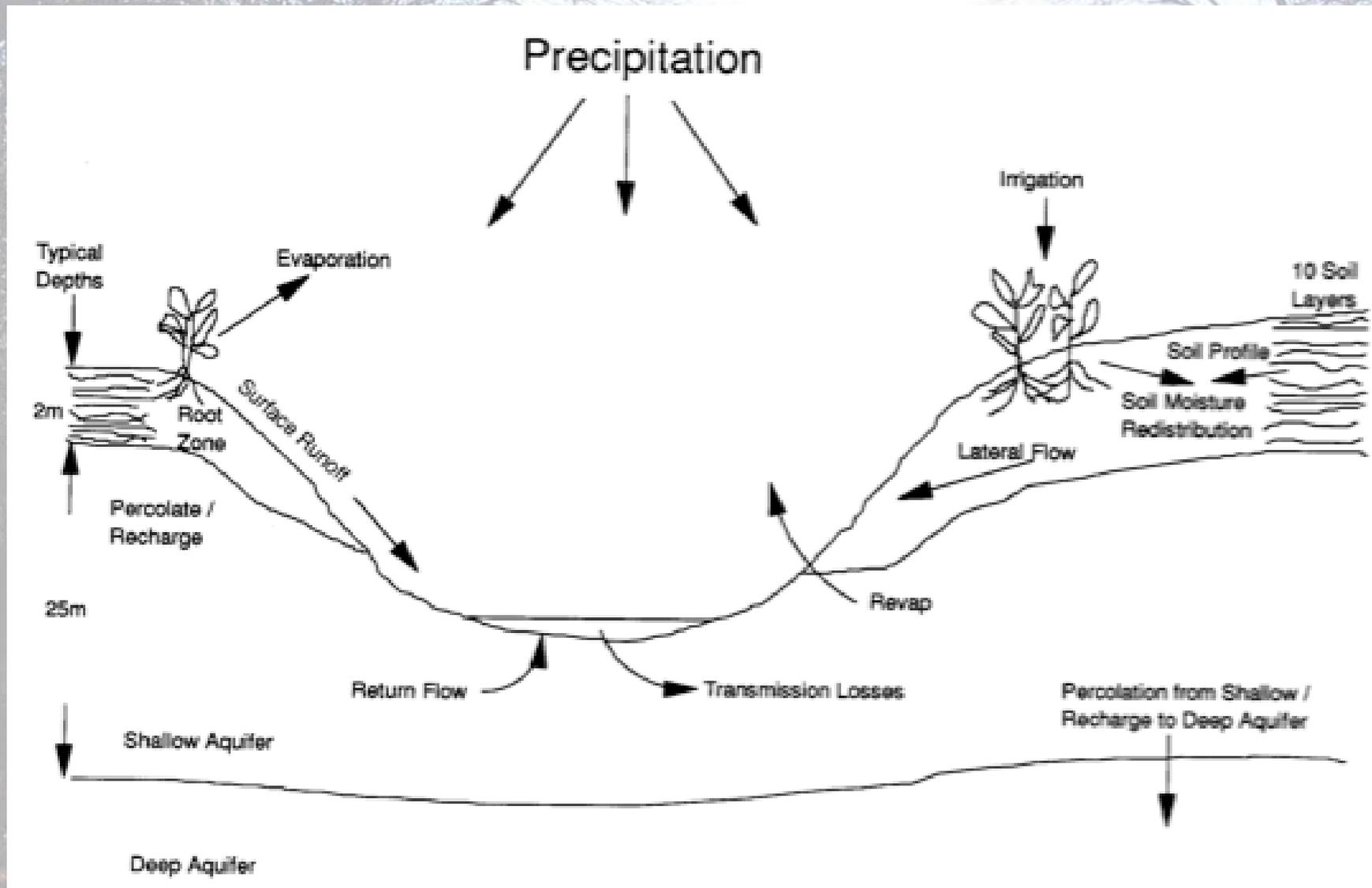
Questions?
Suggestions?

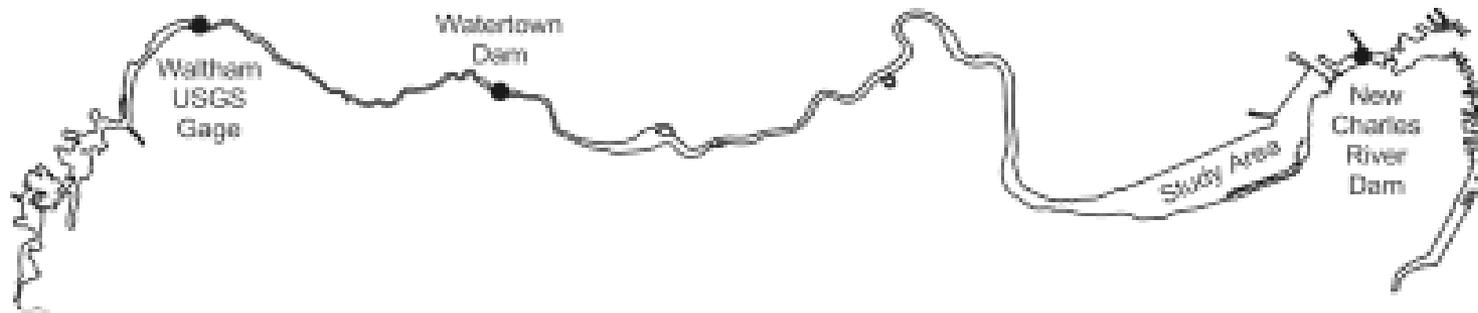**Calvin and Hobbes** by Bill Watterson
October 26, 2009

Arnold et al. 1998

(a) Lower Charles River

(b) Study Area

Hellweger and Masopust 2008

Hellweger and Masopust 2008