Managing nitrogen from small wastewater discharges: some challenges and opportunities

Paul Mathisen
Civil and Environmental Engineering Department
Worcester Polytechnic Institute
Worcester, MA

NEWEA Small Communities Specialty Conference:
NUTRIENT REMOVAL COMPLIANCE STRATEGIES
FOR SMALL COMMUNITIES
November 18, 2015

Outline

- A brief overview/background
- Some research results
  - Nutrients
  - PPCP's - Sulfamethoxazole
- Brief case study –to sewer or not to sewer
- Next steps
  - Water Resources Outreach Center (WROC)
  - Wastewater innovations and testing
- Wrapup

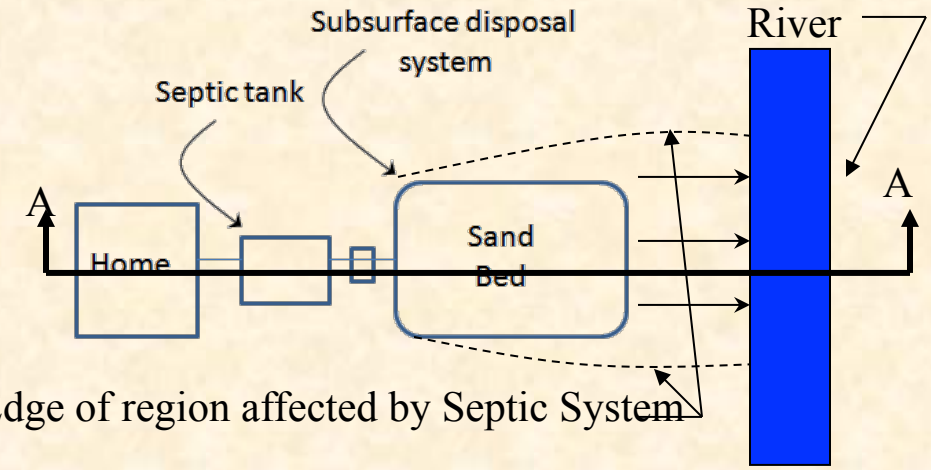
Subsurface discharges of wastewater effluent

- Applications:
  - septic and small-scale systems
  - larger treatment facilities
- Questions
  - How are nutrient/constituent concentrations transformed?
  - What are the impacts on surface-water bodies?
  - How can they be improved?

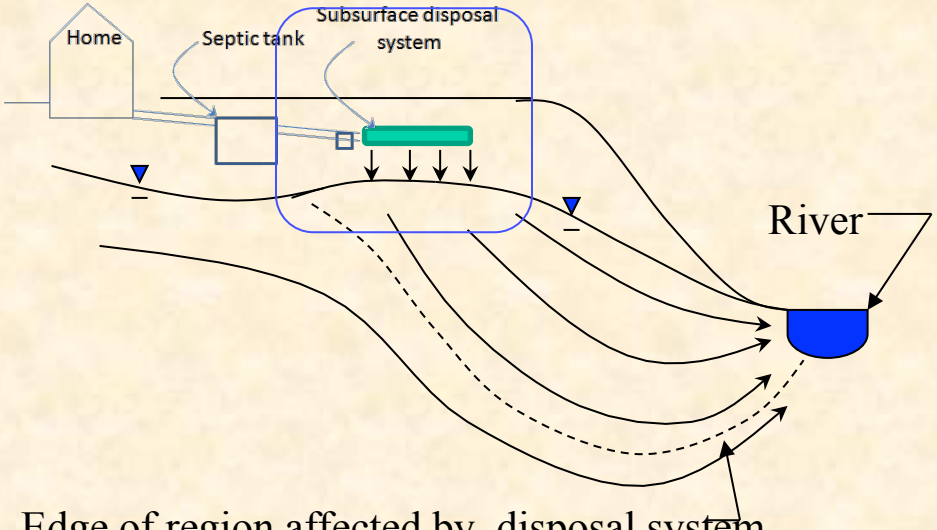
WPCF at Acton, MA

- Operation
  - Design flow=250,000 GPD
  - Avg. Flow=121,540 GPD
  - Chemical addition
    - Aluminum sulfate - flocculation
    - Soda Ash (Na2CO3) - alkalinity

Typical Septic System – Effects on Groundwater

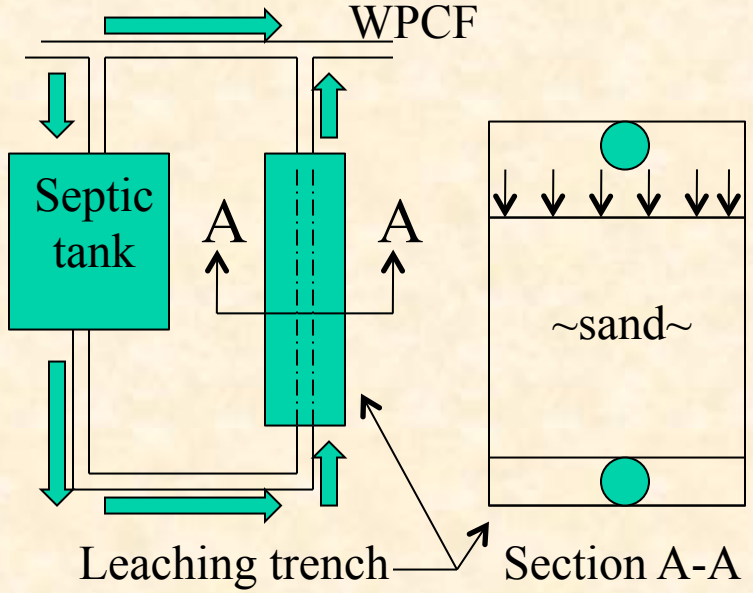


a. Plan view



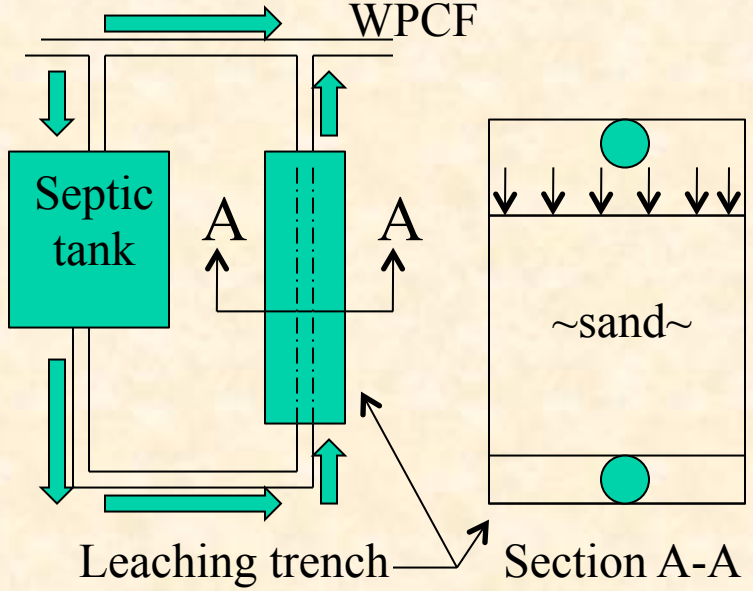
b. Profile view (Section A-A)

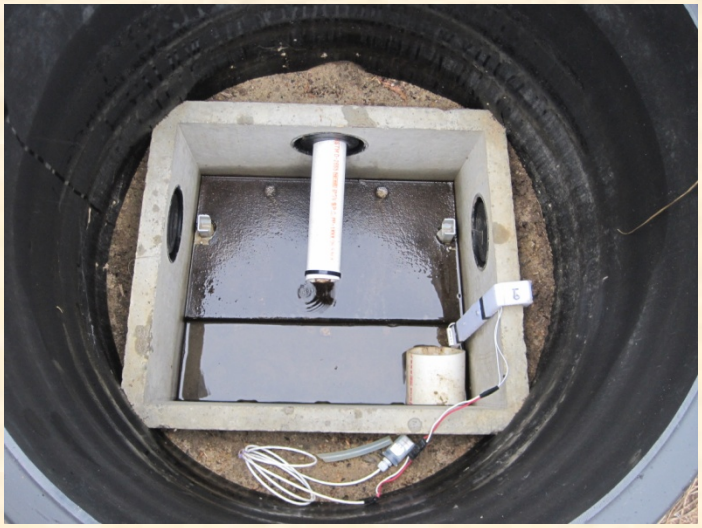
Massachusetts Alternative Septic System Test Center Background Information



- Purpose – Evaluation of new & innovative on-site systems
- Facility - Treat WW in septic tank, use effluent for field testing, return leachate back to WW flow stream
- Control beds:
  - 1 foot sand layer
  - 2-foot sand layer

MA Alternative Septic System Test Center – background characteristics



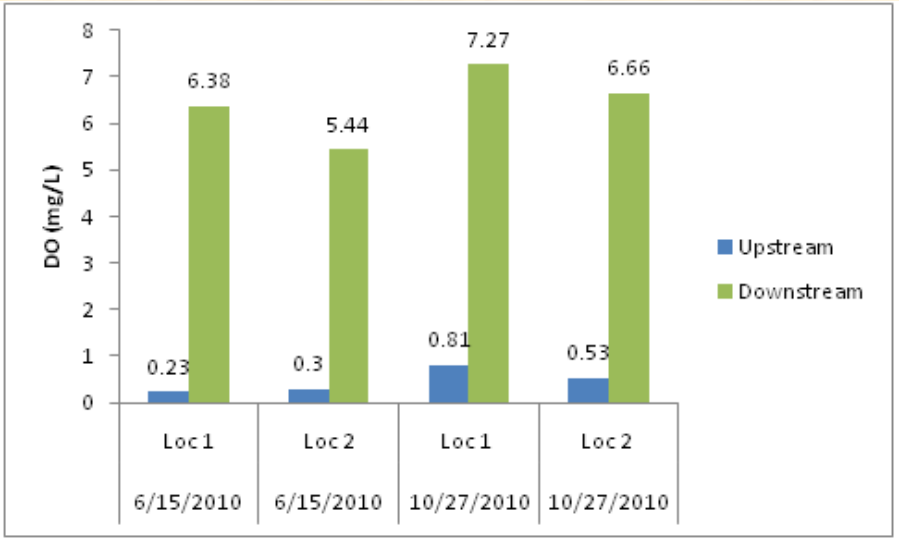


- Operation
  - Periodic daily discharge
  - Operating.flow:
    - Avg: 0.13 cm/hr (0.74 GPD/ft^2)
    - Peak: 0.25 cm/hr
- Sampling locations
  - Injection ports
  - Effluent chambers

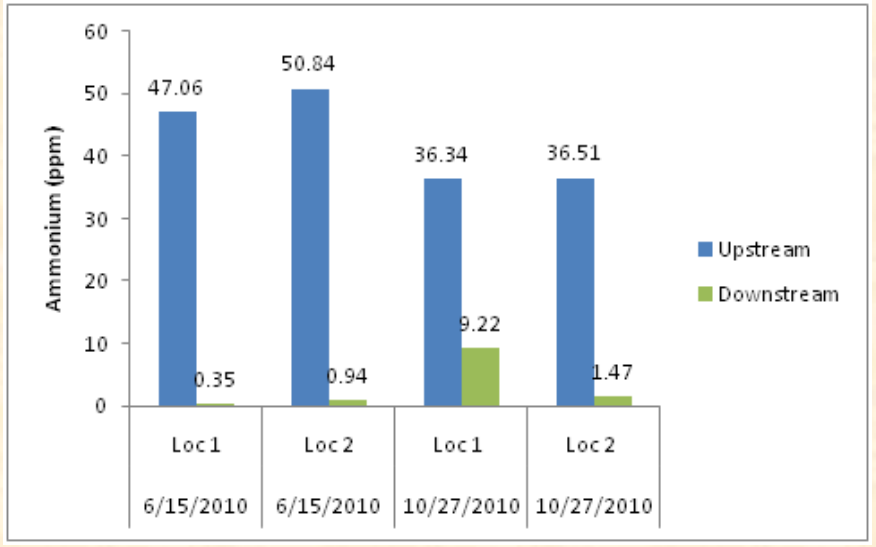
WPI Laboratory and field methods

- Field parameters & Samples
  - Effluent and key locations downstream
- Field parameters
  - DO; specific conductance; pH, Temp
- Sampled Constituents
  - Carbon (e.g. DOC, Alkalinity & pH)
  - Cations (e.g. Ca^{2+}, Mg^{2+}, Na^{+}, etc.) – using A/A Spec.
  - Anions (e.g. SO_4^{-}; Cl^{-}) – IC Analysis
  - Nutrients (PO_4^{-}, NH_4^{+}, NO_3^{-})

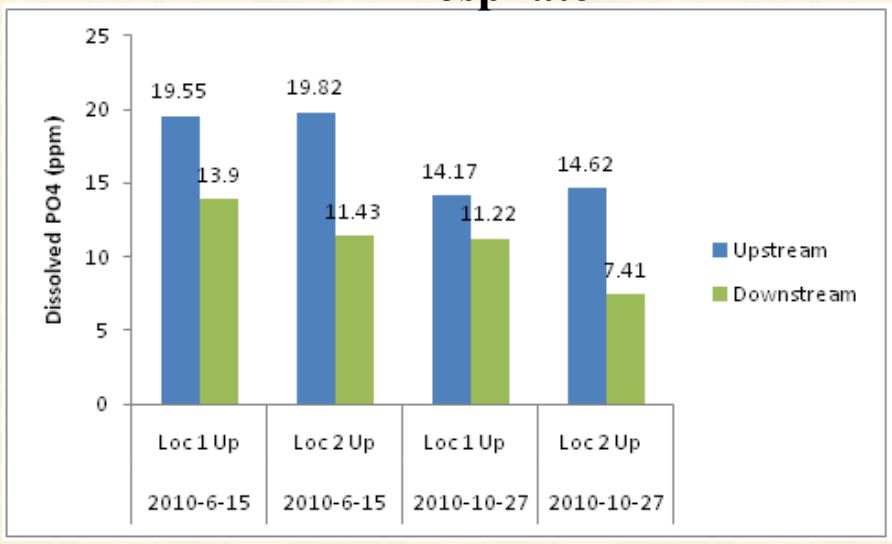
Dissolved Oxygen



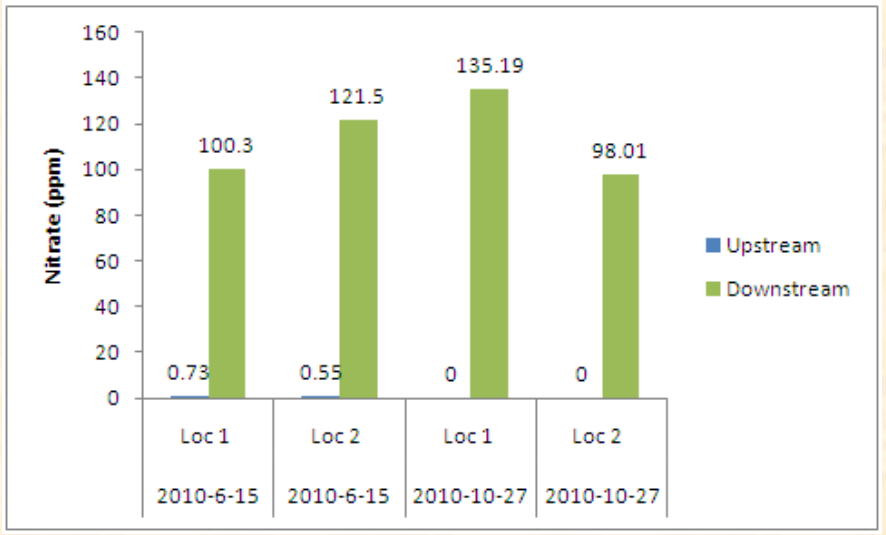
Ammonium



Phosphate

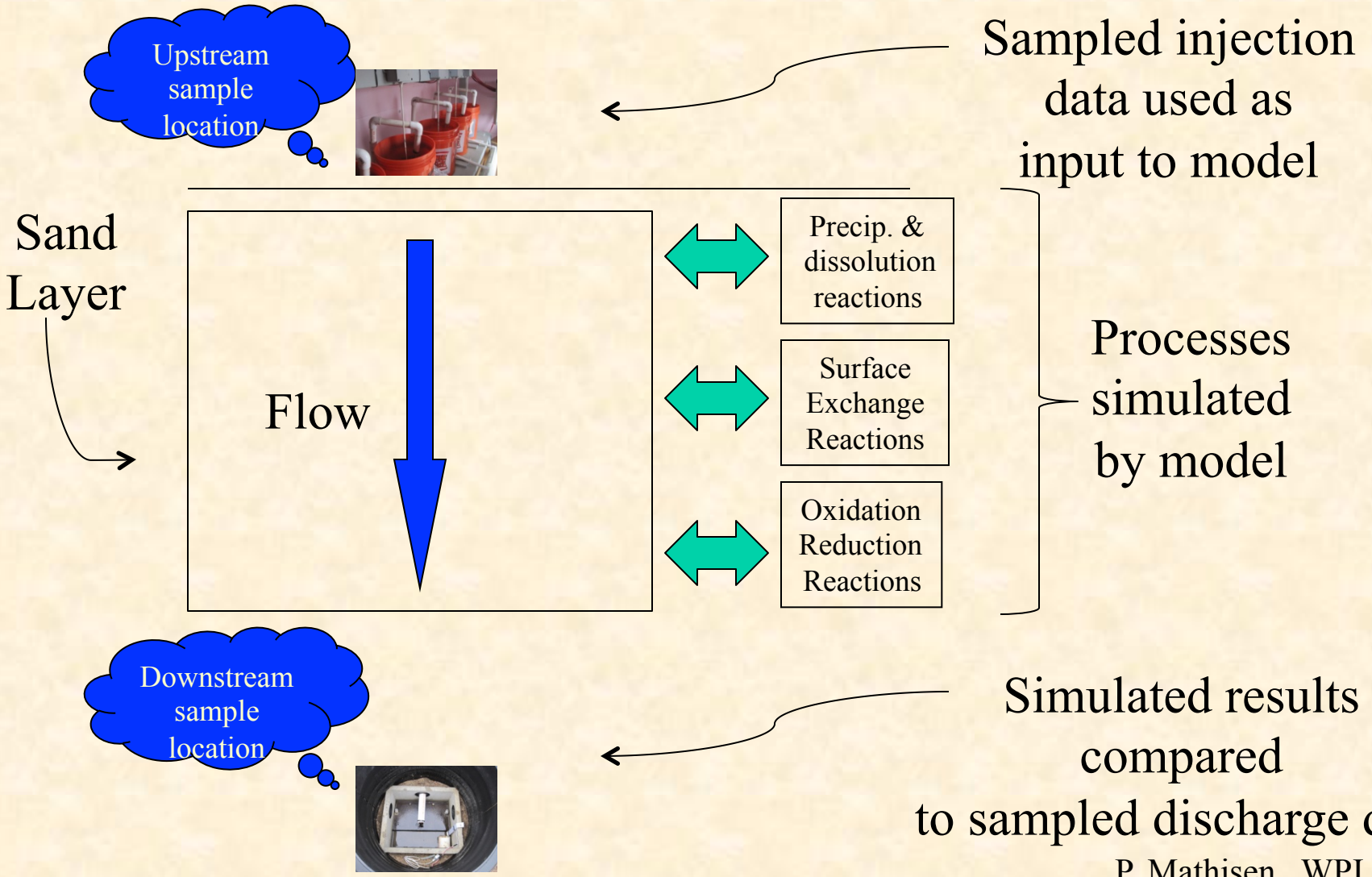


Nitrate

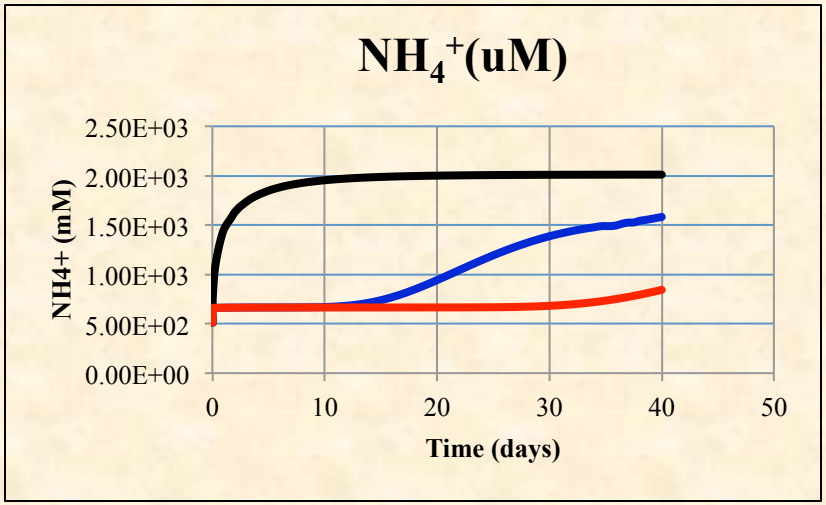


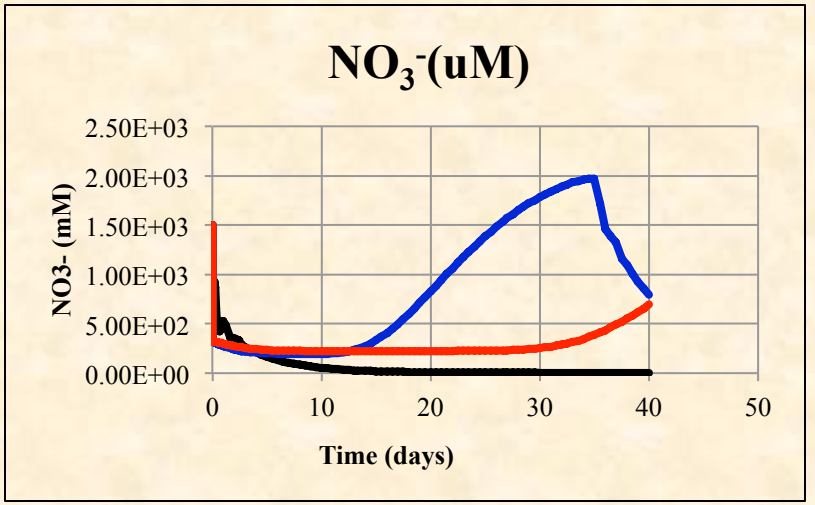
P. Mathisen , WPI - 2015

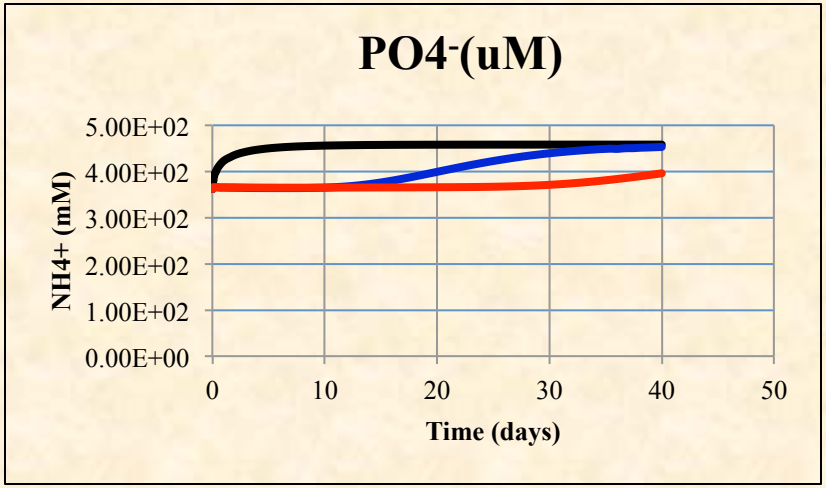
Advective modeling

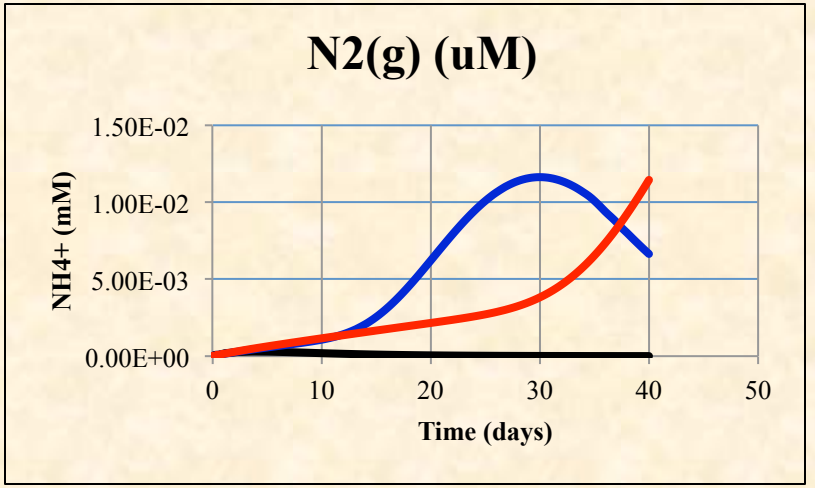


Nutrients downstream after 1 and 2 feet of transport





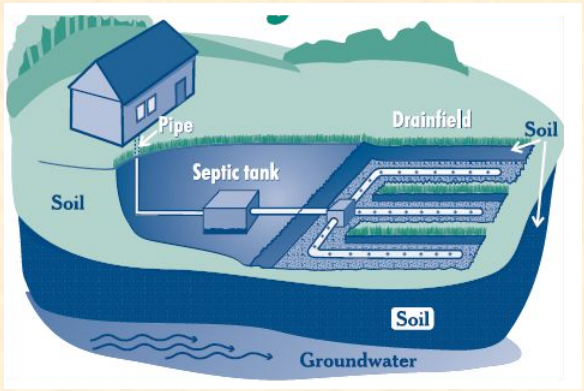




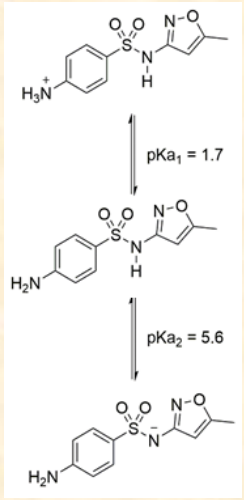
0 ft 1 ft 2 ft

P. Mathisen , WPI - 2011

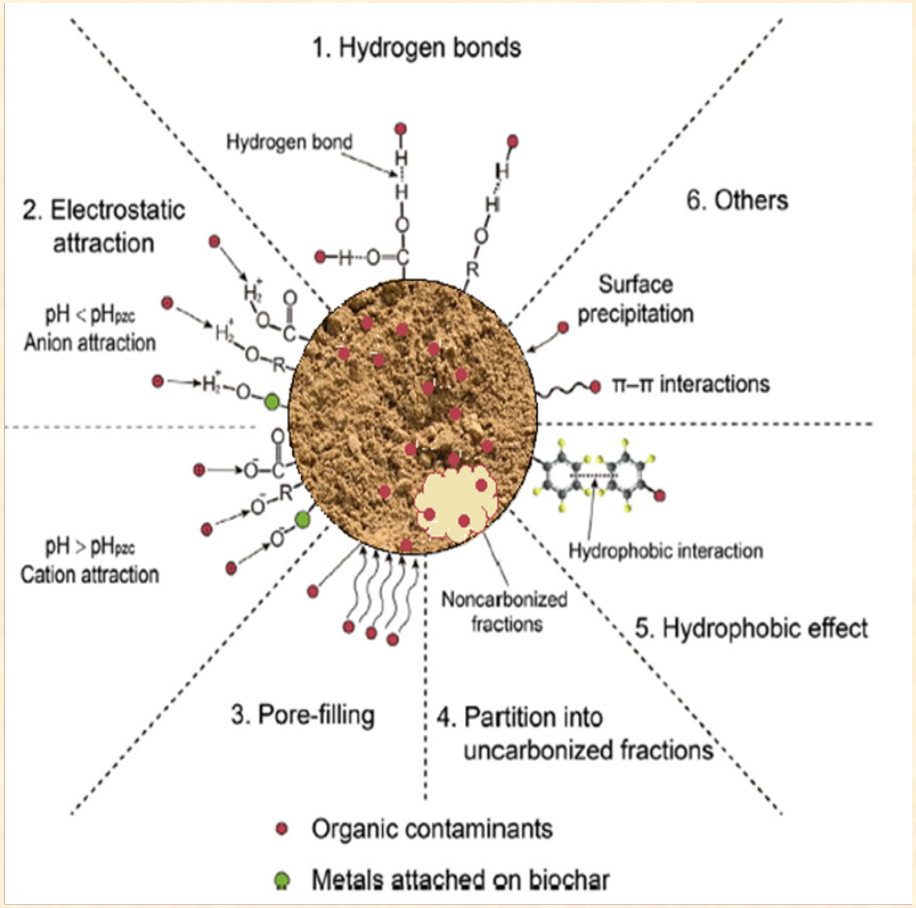
Emerging Contaminants
Sulfamethoxazole (SMX)



http://www.munsterseptictanks.com/services.php



Removal Percentage (%)	
Septic system (STS)	1-21
STS with constructed wetland	17-78
STS with activated sludge	10-51
STS with shallow drainfield	96-99



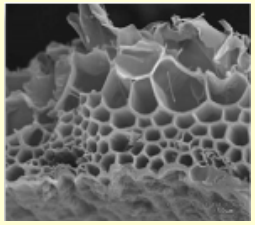
X. Tan et al., Chemosphere 125 (2015) 70-85

Slide modified from W. Yao

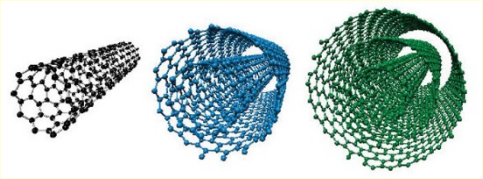
P. Mathisen , WPI - 2011

Effective, low-cost treatment alternatives

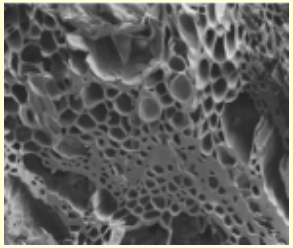
- Activated carbon



- Carbon nanotube



- Biochar

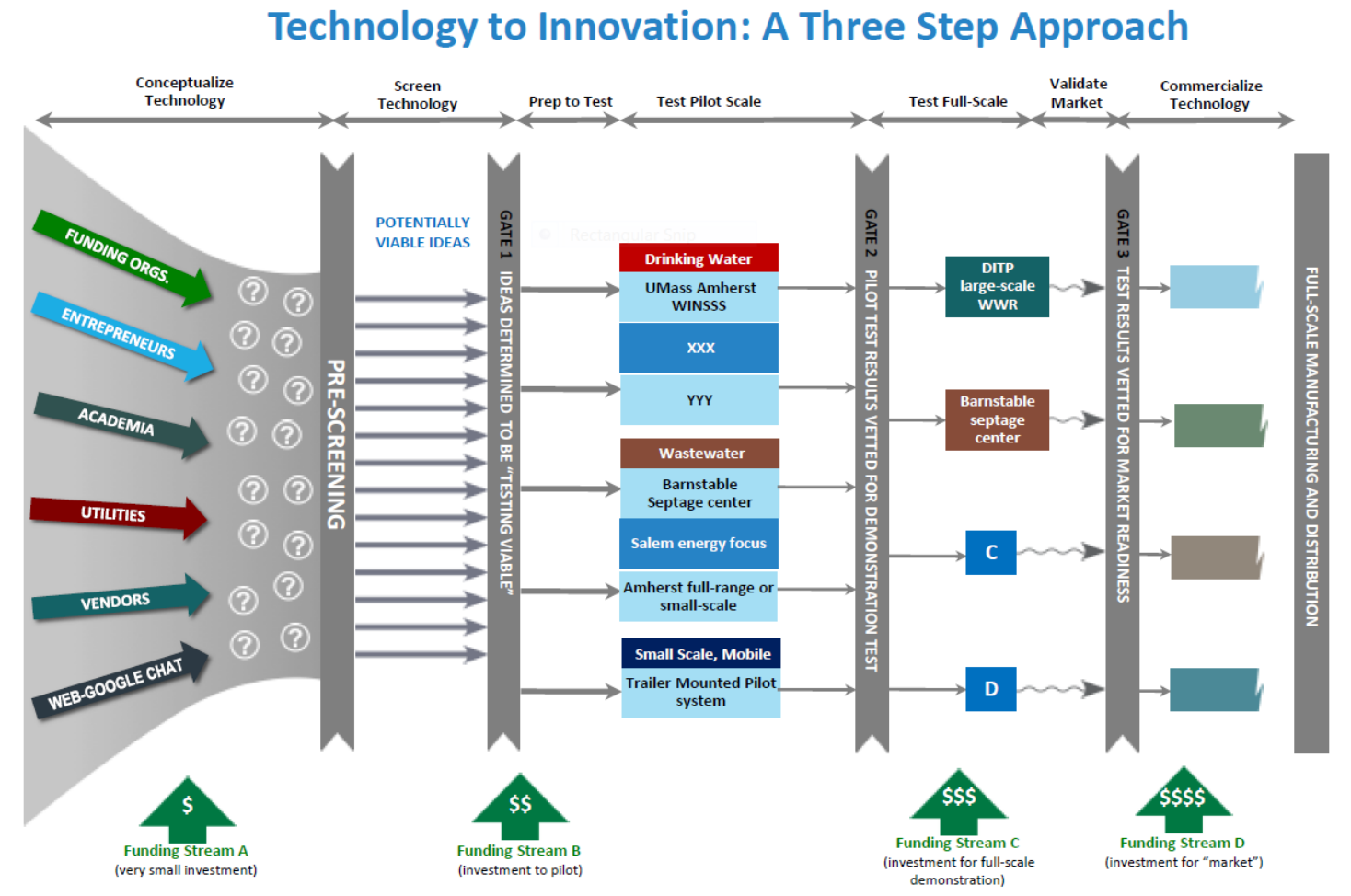


- Biochar
  - Developed from pyrolized organic matter
  - Some success with organics, metals, etc.
  - Found to alter the rates of nitrification and denitrification and NH3 adsorption
- Approach
  - Optimize the pyrolysis condition for Biochar production
  - Characterize the surface chemistry of biochar and its interaction with SMX
  - Optimize recipe for Biochar/soil/sand mix

M.B. Ahmed et al., 2015, Environ. Sci. Technol . 532, 112-126

Innovations in Wastewater Treatment

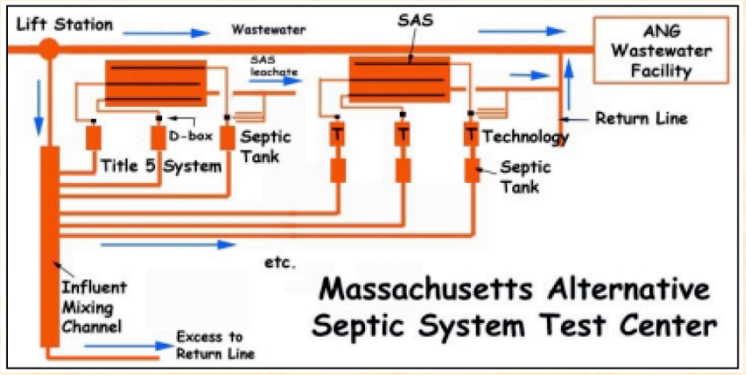
New England Water Innovation Network



Slide from Test Center Operations Working Group
In association with the New England Water Innovation Network

Test Centers – Promoting Innovation

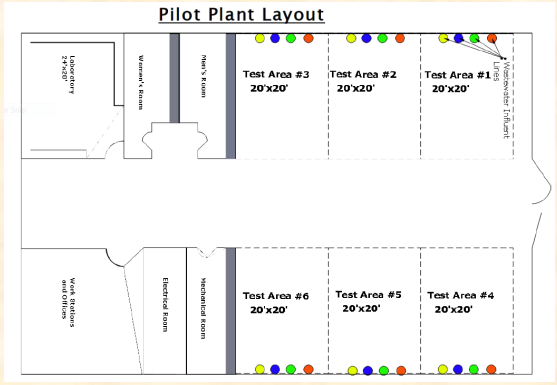
Septic System Test Center



(f/Costa and Heufelder et al, 1999)

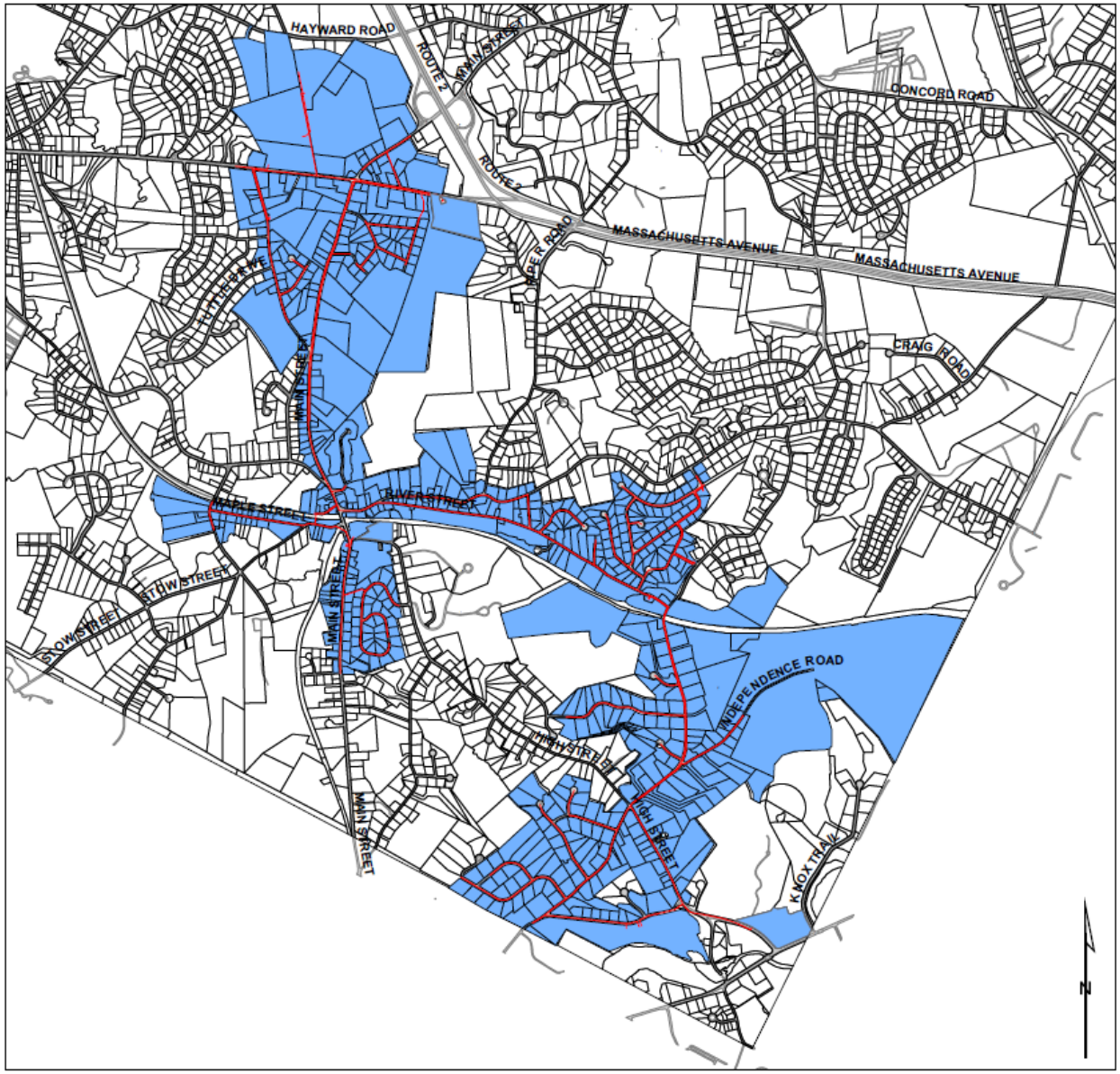
UMass Test Facilities

- CEE Laboratory
- EPA Center
- New Mobile Lab
- Amherst WWTP Pilot



(UMass facilityunder development – info. f/ D.Reckhow)

Septic/Sewering Example – Acton, MA



DISTRICT STREETS

Abel Jones Place
Adams Street
Beverly Road
Carlton Drive
Carriage Drive
Chadwick Street
1-36 Charter Street
Clover Hill Road
Concetta Circle
Doris Road
Dunham Lane
Faulkner Hill Road
Fox Hill Road
Francine Road
Gerald Circle
Giaconda Avenue
Hennessey Road
213-276 High Street
Hillcrest Drive
Independence Road
Kelley Road
59-307 Main Street
Maple Street
21-45 Martin Street
360-472 Mass. Ave.
Nadine Road
Nylander Way
Olde Surrey Drive
81-257 Parker Street
Pond View Drive
Powdermill Plaza
Putter Drive
Puritan Road
60-159 Prospect Street
Railroad Street
River Street
Robert Road
1-125 School Street
Silver Hill Road
St. James Circle
Tenney Circle
Vanderbelt Road

INCORPORATED 1735 ACTON

TOWN OF ACTON HEALTH DEPARTMENT

SEWER DISTRICT

Legend

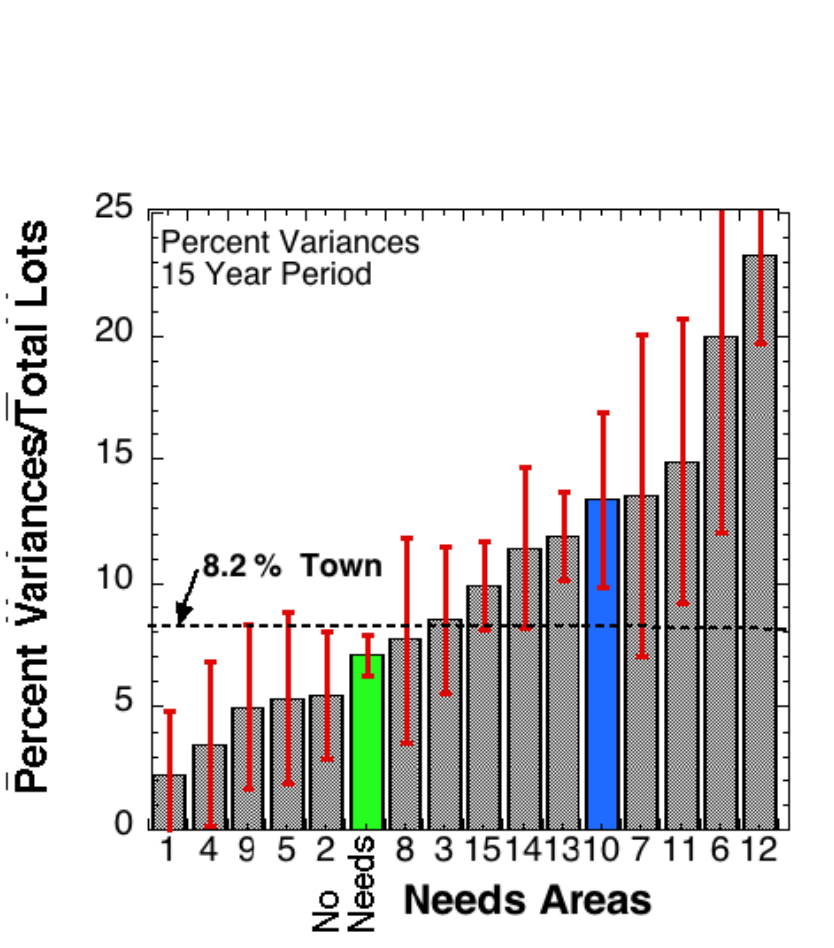
SEWER MAIN
SEWER SERVICE AREA
PARCEL

Locus

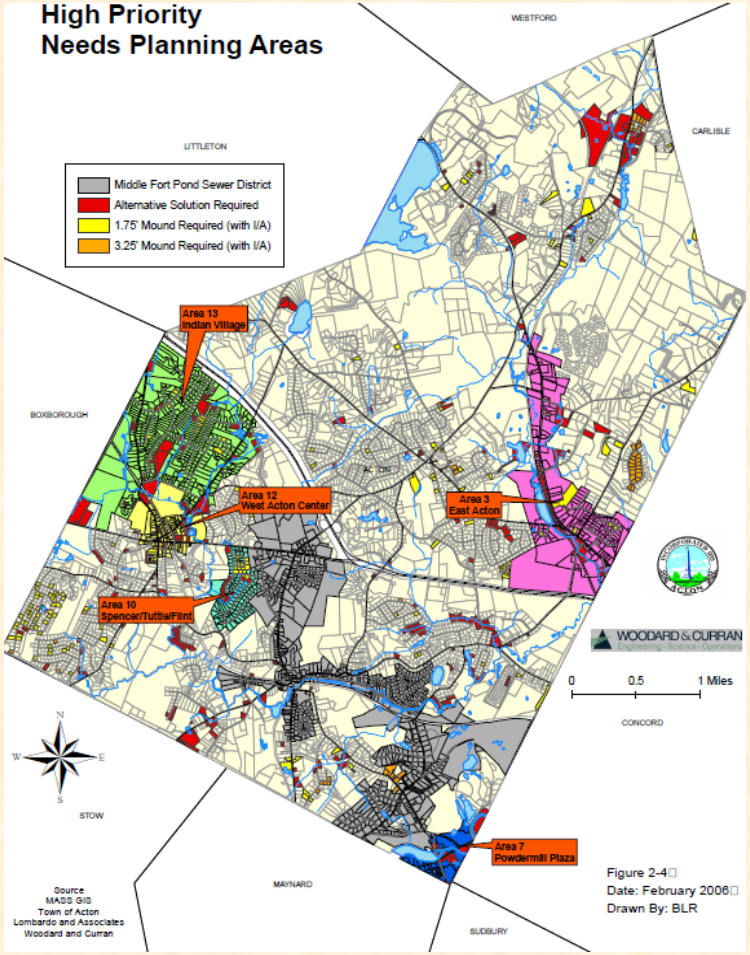
f/ Acton Health Dept.

P. Mathisen , WPI - 2015

Considering the need

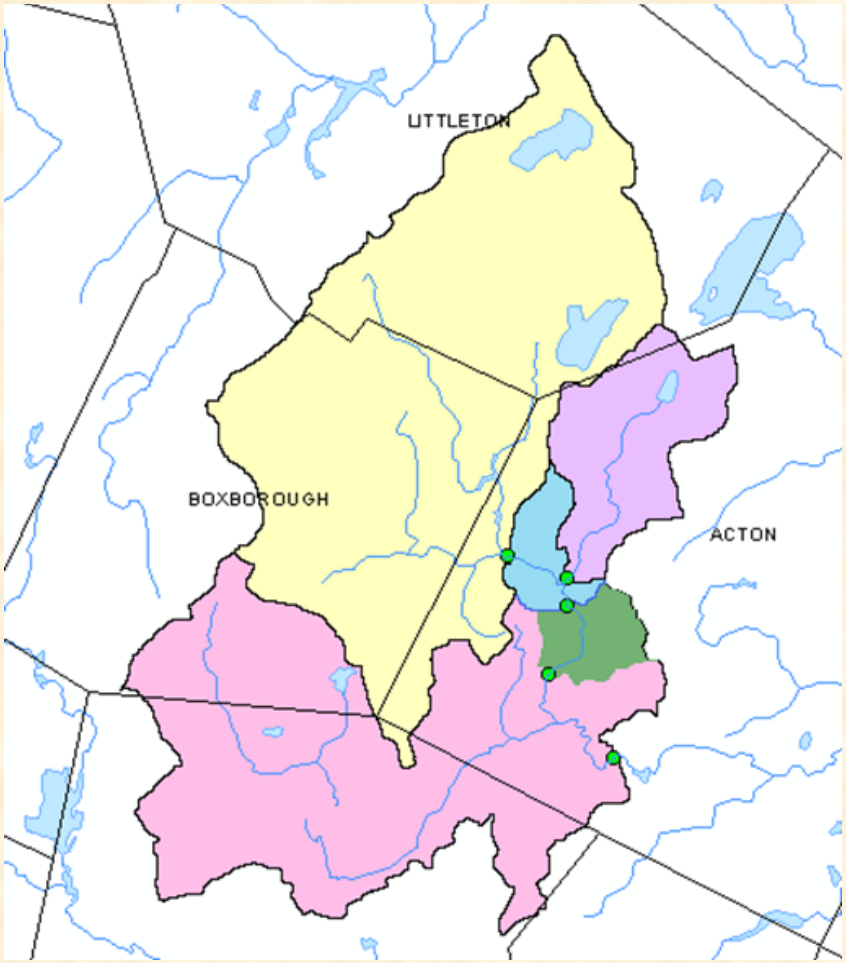


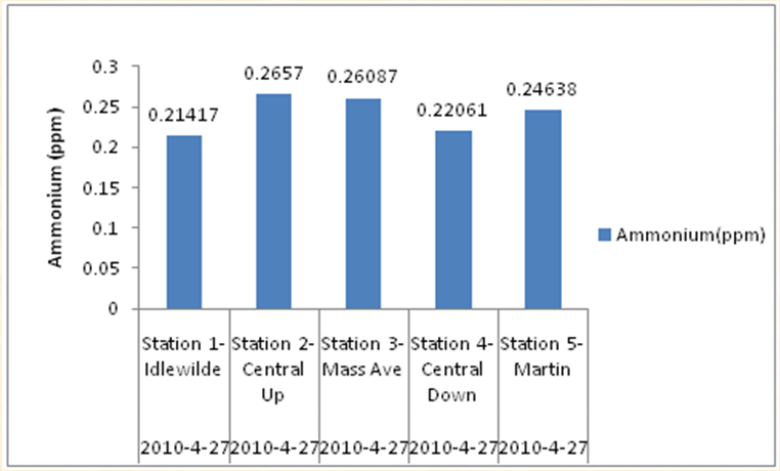
f/ Want Minutes (Giese, 2011)

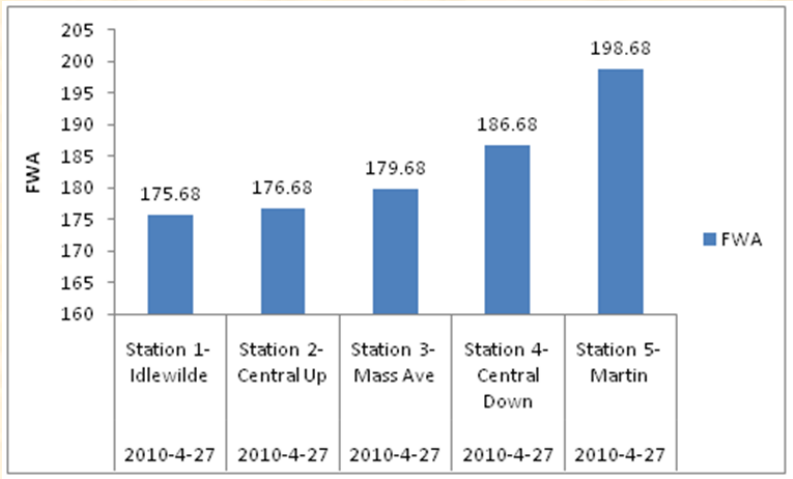


f/ Acton WRMP(2006)

Streamflow monitoring results







Cost considerations/impact

- Costs to extend the sewer system
  - Betterment
  - Supersizing
  - Maintenance
- Costs to replace septic systems
  - Basic System
  - Innovative systems

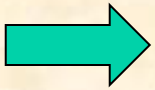
WPI's Water Resources Outreach Center (WROC)

Goal - To provide useful and meaningful education, training and/or project support on water resources issues to assist Central and Eastern Massachusetts municipalities and watershed associations.

Approach – Develop student projects in collaboration with organizations to provide support

Wrapup

- Challenges and Needs
  - Determining role of variability and complexity in the subsurface
  - Gaining community input/collaboration
  - Low cost approaches to address multiple constituents associated with wastewater
  - New approaches to reduce nutrients



Opportunities

Acknowledgements

Thanks to the following people/groups whose assistance, support or information was particularly helpful for this presentation:

- Cape Cod Alternative Septic Systems Research Center – G. Heufelder
- Test Center Operations Working Group (New England Water Innovation Network)
- Acton, MA - Info from Health Dept. and Wastewater Neighborhood Adv. Task Force
- WPI Staff/students - D. Pellegrino (lab mgr.), Y. Jiang (former grad student), W.Yao (current graduate student)