The use of a saturation zone in rain gardens amended with biosolids to reduce nitrogen from stormwater

Sharon Hunter

Summer Research Intern

University of Washington-Tacoma, Center for Urban Waters

Senior, Environmental Science-Biology Track

University of Washington-Tacoma

Introduction

- Nitrogen is an essential element for life

- Problem:
  - Excess nitrogen leaches into waterways
  - Eutrophication
  - Nitrate concentrations 0.2 mg/L can trigger eutrophication in surface waters (NOAA 2012)

http://westseattleblog.com/2010/06/new-stencils-for-alki-storm-drains-thanks-to-matson-navigation

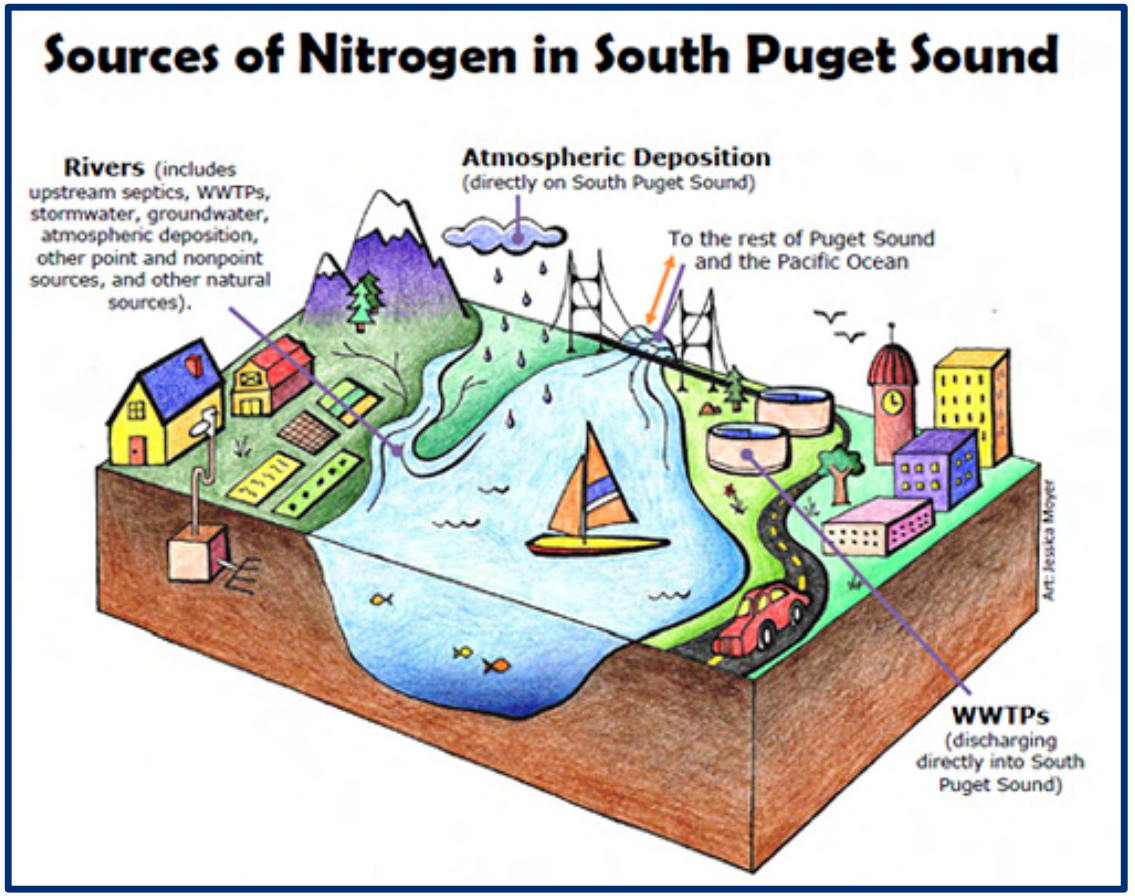
Eutrophication

- Algal blooms
  - Fresh water: phosphorus limited
  - Marine waters: nitrogen limited
- Global problem
- Local problem
  - Hood Canal: Sensitive to nitrogen (Newton 2012)

http://serc.carleton.edu/images/microbelife/topics/red_tide_genera.v3.jpg

Nitrogen Sources

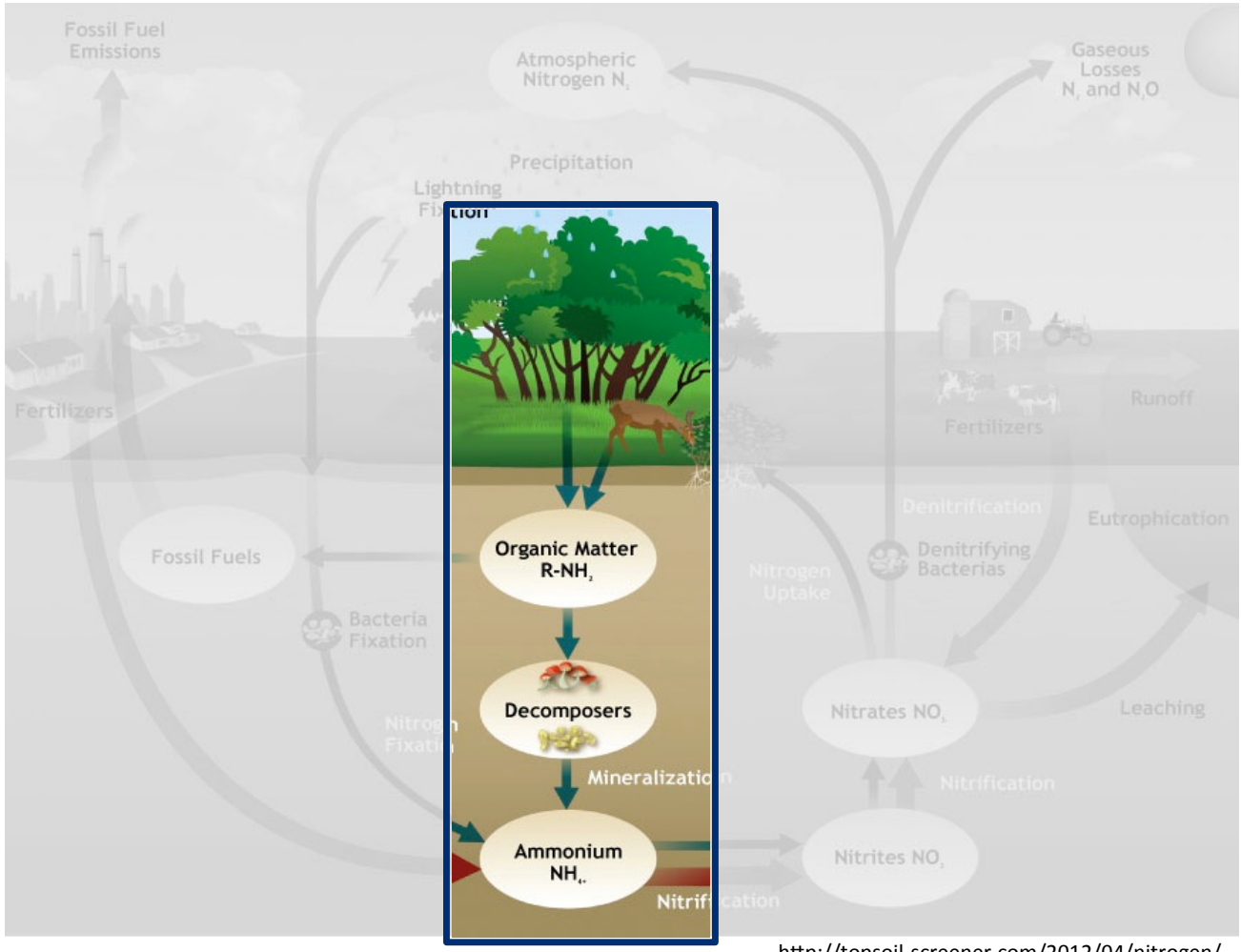
- Point Sources
- Natural
- Non-point
- Increased impervious surfaces decrease stormwater infiltration



http://www.ecy.wa.gov/puget_sound/dissolved02_problem.html

Nitrogen in soil

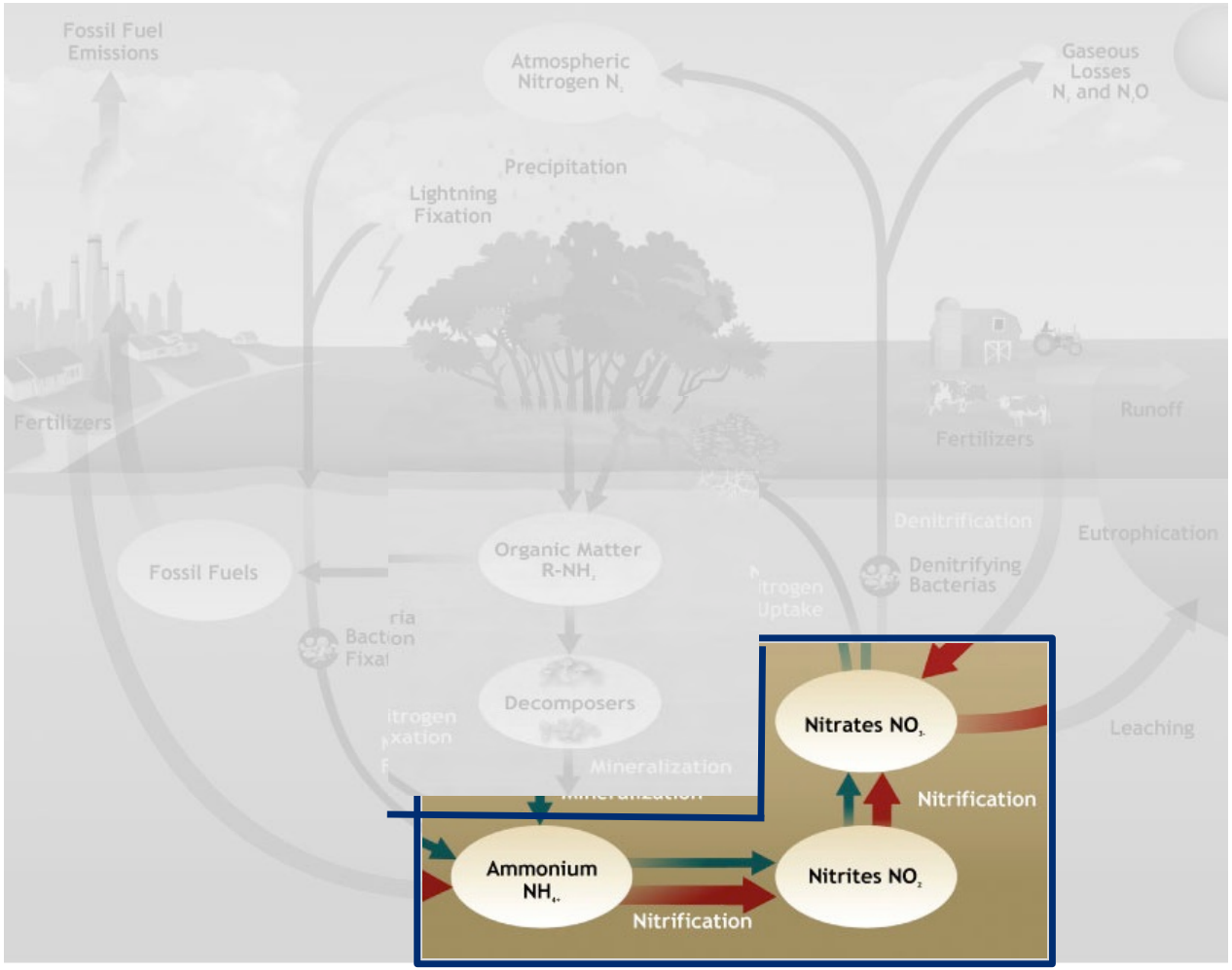
- Organic matter in soil breaks down to ammonia



http://topsoil-screener.com/2012/04/nitrogen/

Nitrogen in soil

- Organic matter in soil breaks down to ammonia
- Nitrification



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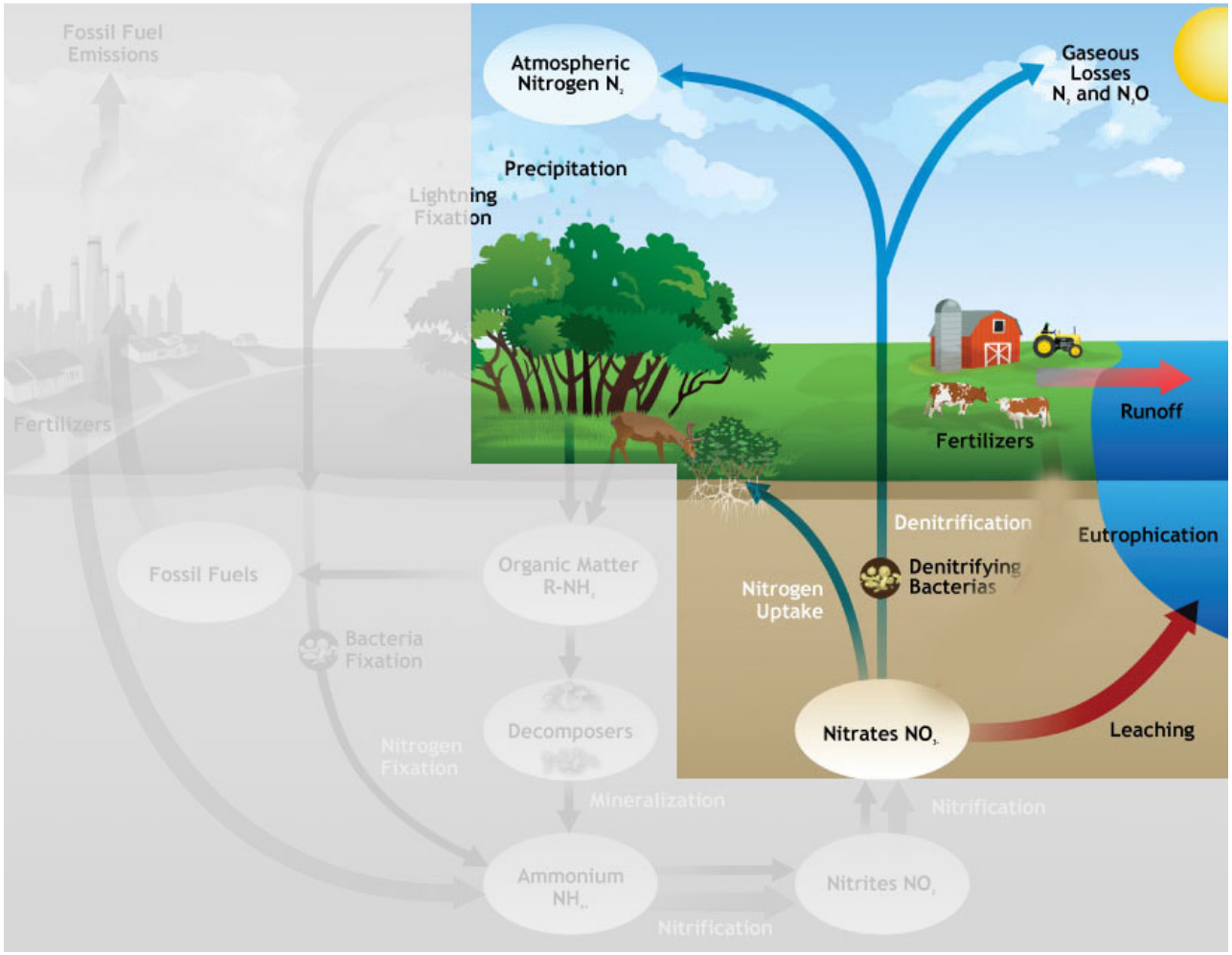
Nitrogen in soil

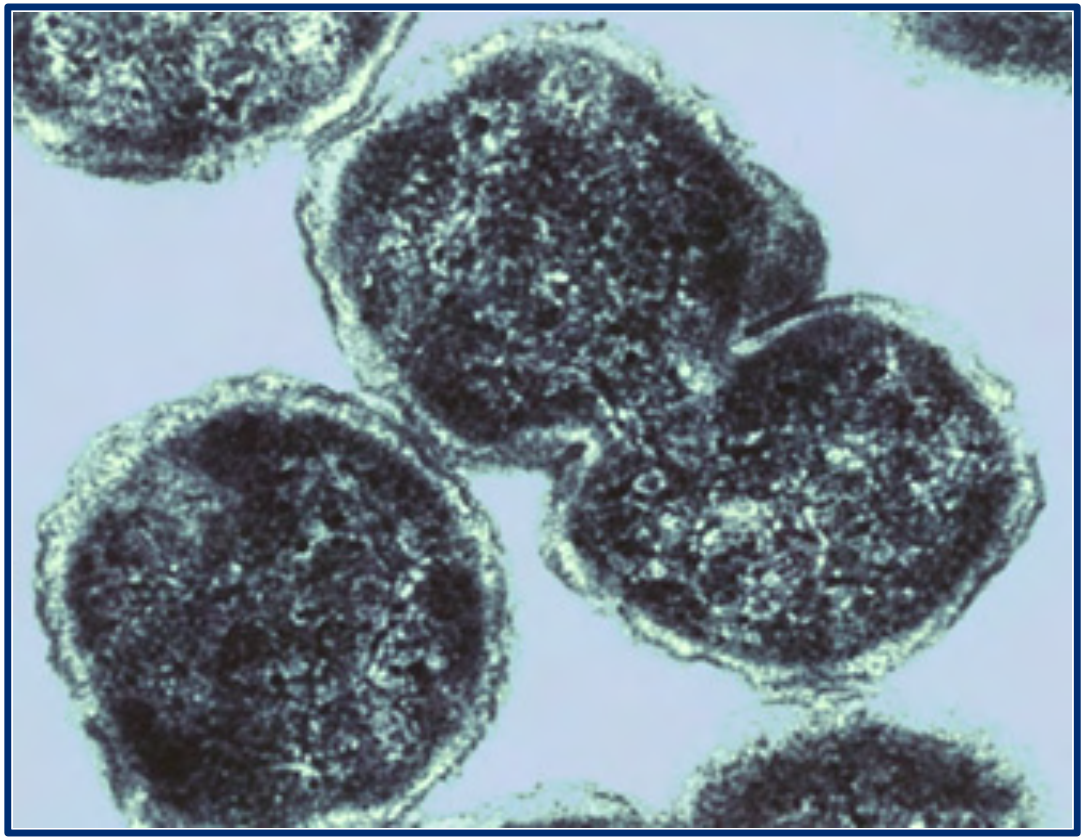
- Organic matter in soil breaks down to ammonia
- Nitrification
- Denitrification



http://topsoil-screener.com/2012/04/nitrogen/

Denitrification

- Favorable conditions for denitrifying bacteria:
  - Organic carbon
  - Absence of oxygen



http://genome.jgi-psf.org/parde/parde.home.html

Rain Gardens (Bioretention System)

- Intercept stormwater
- Increase infiltration
- Reduces storm water volume
- Removes solids
  - May remove dissolved particles

http://www.fosc.org/AmElmParkUpdateNov2007.htm

Rain Garden Soil Research at UW-T Urban Waters

Soil amendments to improve rain garden efficiency

- 2011 results for nitrogen:
  - Nitrogen higher in effluent than influent
  - Decomposing organics in compost and biosolids served as nitrogen source

http://www.tacoma.washington.edu/messages/news/2011/3/story1.html

Rain Garden Soil Research at UW-T Urban Waters

- 2012 Goals
  - Develop a solution to reduce influent nitrogen and *phosphorus from stormwater in a rain garden soil mixture
  - Find a productive use for biosolids

http://inhabitat.com/tacomas-center-for-urban-waters-can-actually-think-for-itself/

*The focus of this presentation is nitrogen. Please refer to Brian Hite's research for the phosphorus results.

Hypotheses

- Hypothesis 1:
  Saturated zone in rain gardens leads to lower concentrations of nitrates in the effluent

- Hypothesis 2:
  The use of a biosolids amendment in rain gardens will increase ammonia in the effluent

http://depts.washington.edu/uwbg/docs/stormwater/11-Photos_RainGardens_Cisterns.pdf

Biosolids

- Solids from municipal wastewater treatment plants
- High in nutrients
  - Used in horticulture, landscaping, forestry, gardening
- Currently not approved for rain gardens

http://www.cityoftacoma.org/Page.aspx?hid=1474

Soil Amendments

100% Class A Biosolids:
carbon source
nutrient source

Sand:
prevents pooling
high infiltration rate

Sawdust:
moisture retention
carbon source

WTR (water treatment residual):
aluminum and iron based
capture phosphates

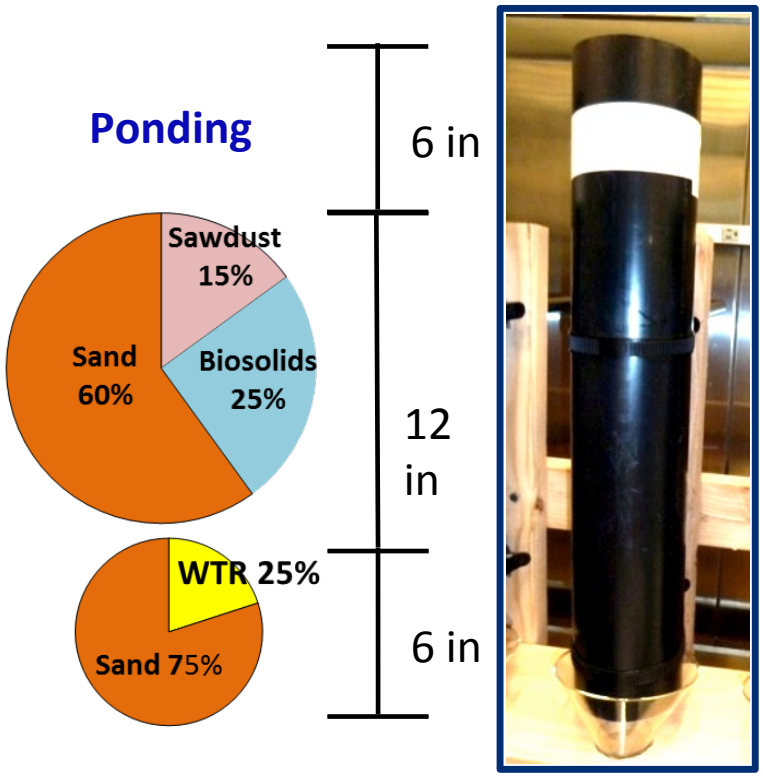
Methods: Soil Columns

- Stratified vs. Mixed
- Unsaturated vs. Saturated

Unsaturated Stratified	Saturated Stratified
Unsaturated Mixed	Saturated Mixed

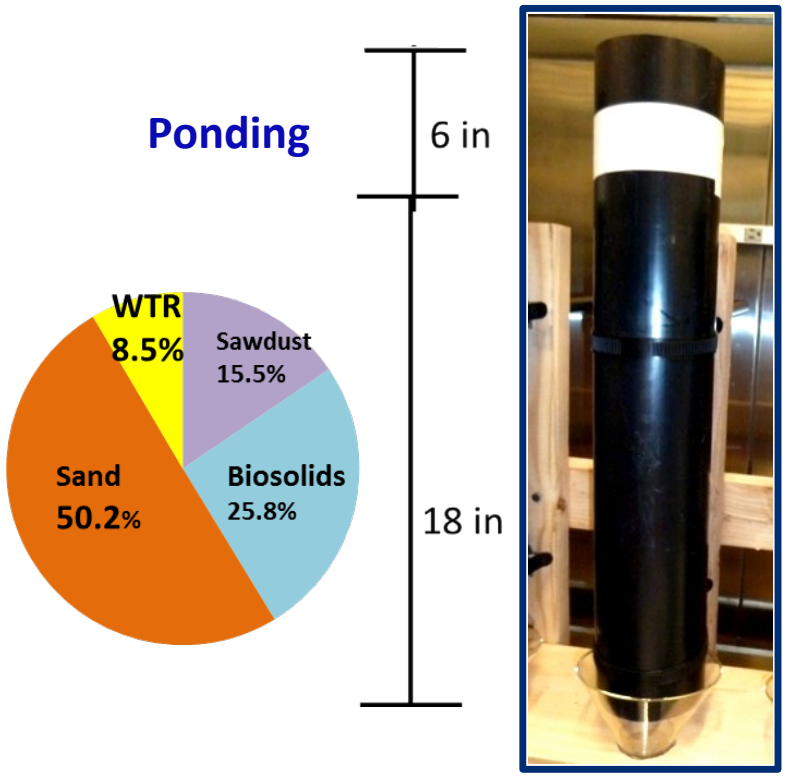
Soil Combinations

- Stratified soil columns
  - WTR/sand bottom 6 inch layer



- Mixed soil columns
  - WTR mixed throughout soil

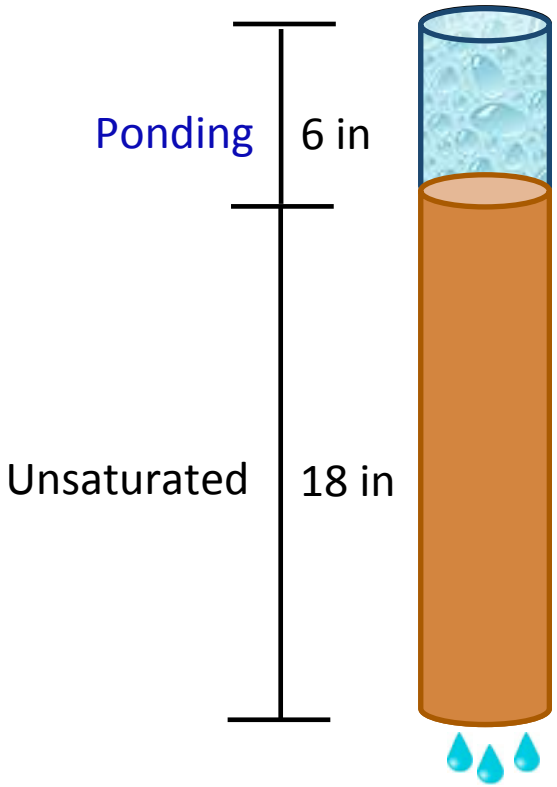
(same mass of WTR in both columns)



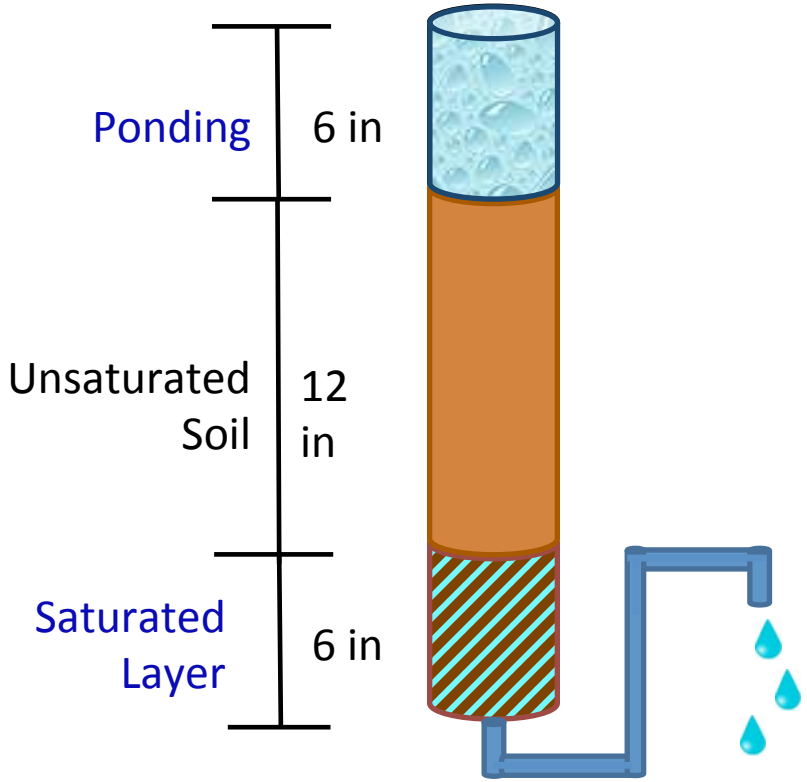
Unsaturated vs. Saturated

Unsaturated Stratified | Saturated Stratified | Unsaturated Mixed | Saturated Mixed

- Unsaturated



- Saturated

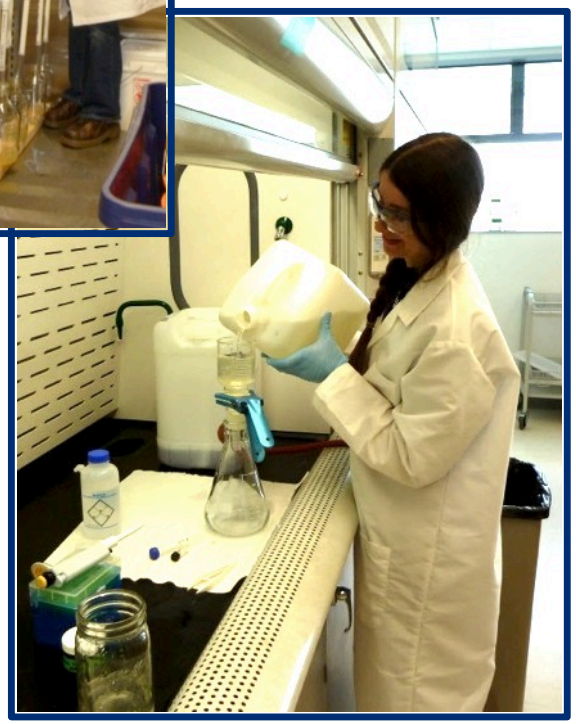


Methods

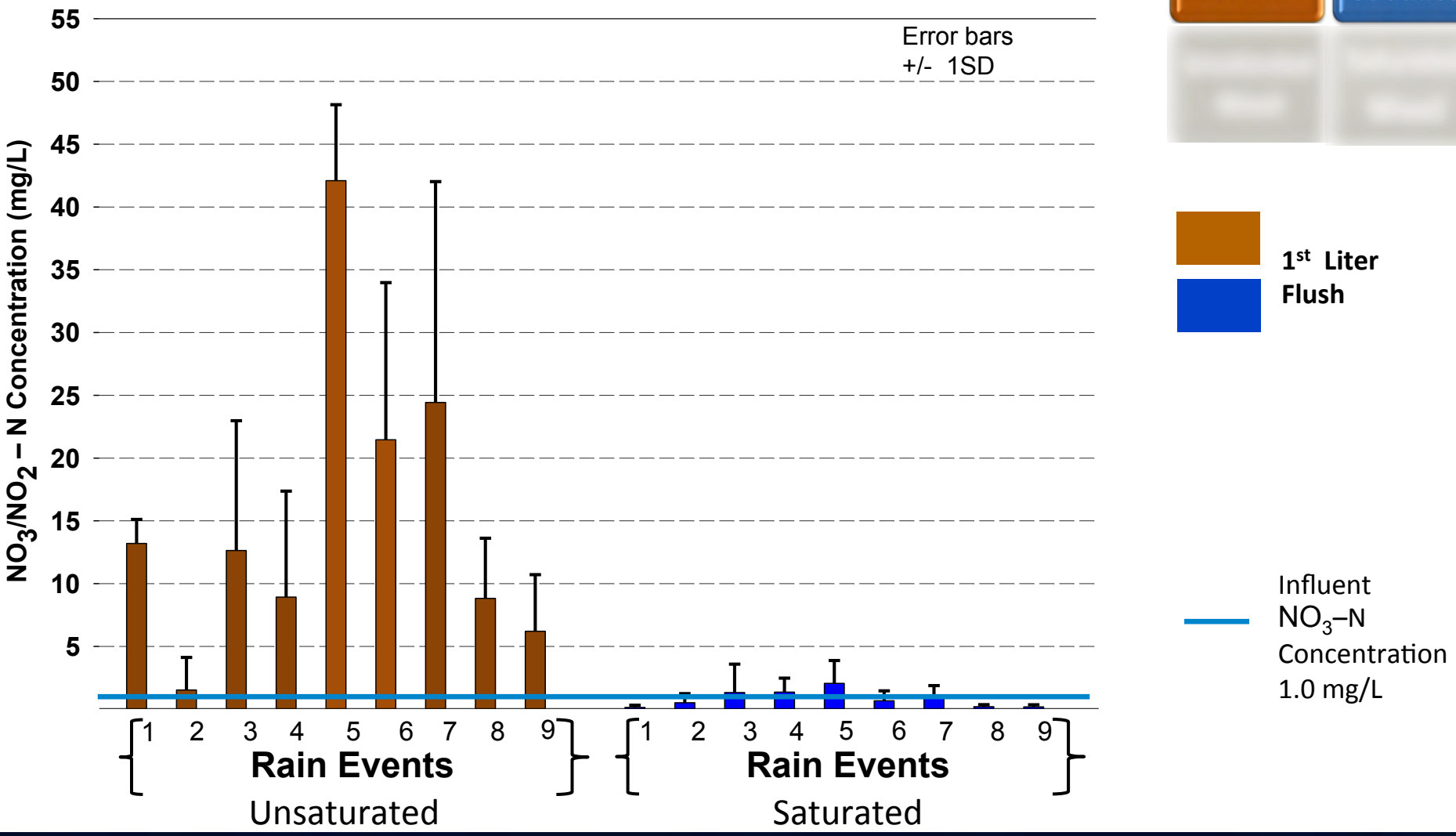
- Packing
- Loading
  - Synthetic storm water (influent)
    - 0.3 mg/L phosphorus
    - 1.0 mg/L nitrogen
  - 8 liters, 2 times/week
  - 9 “rain events”

Methods

- Sampling: Effluent
  - Collection
    - First liter flush
    - Composite: liters 2-8
  - Filtration
    - 0.45 micron filter
- Analysis
  - WESTCO Nutrient Analyzer (automated spectrophotometer) at UW-T



Nitrates/Nitrites as Nitrogen: Stratified



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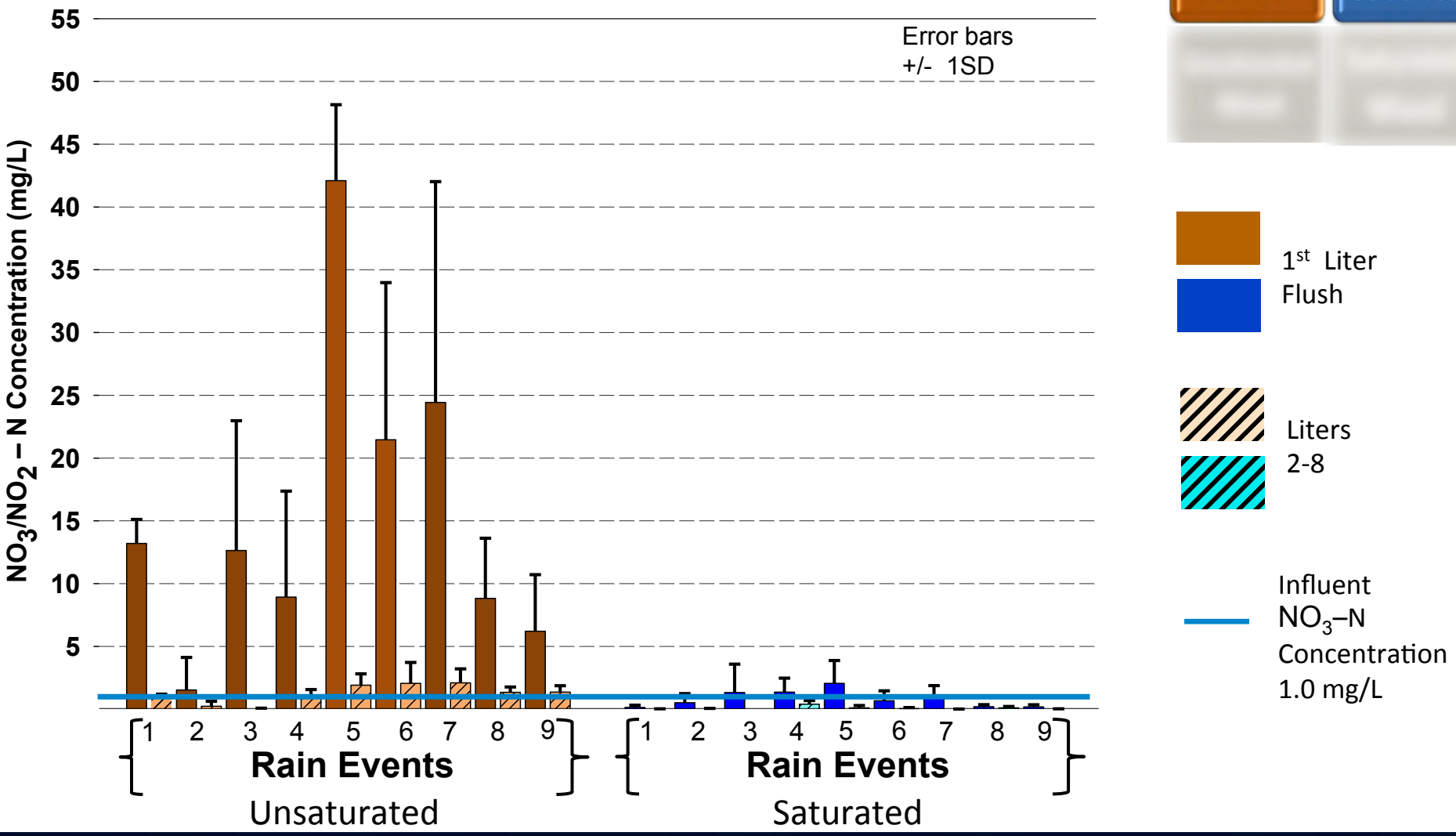
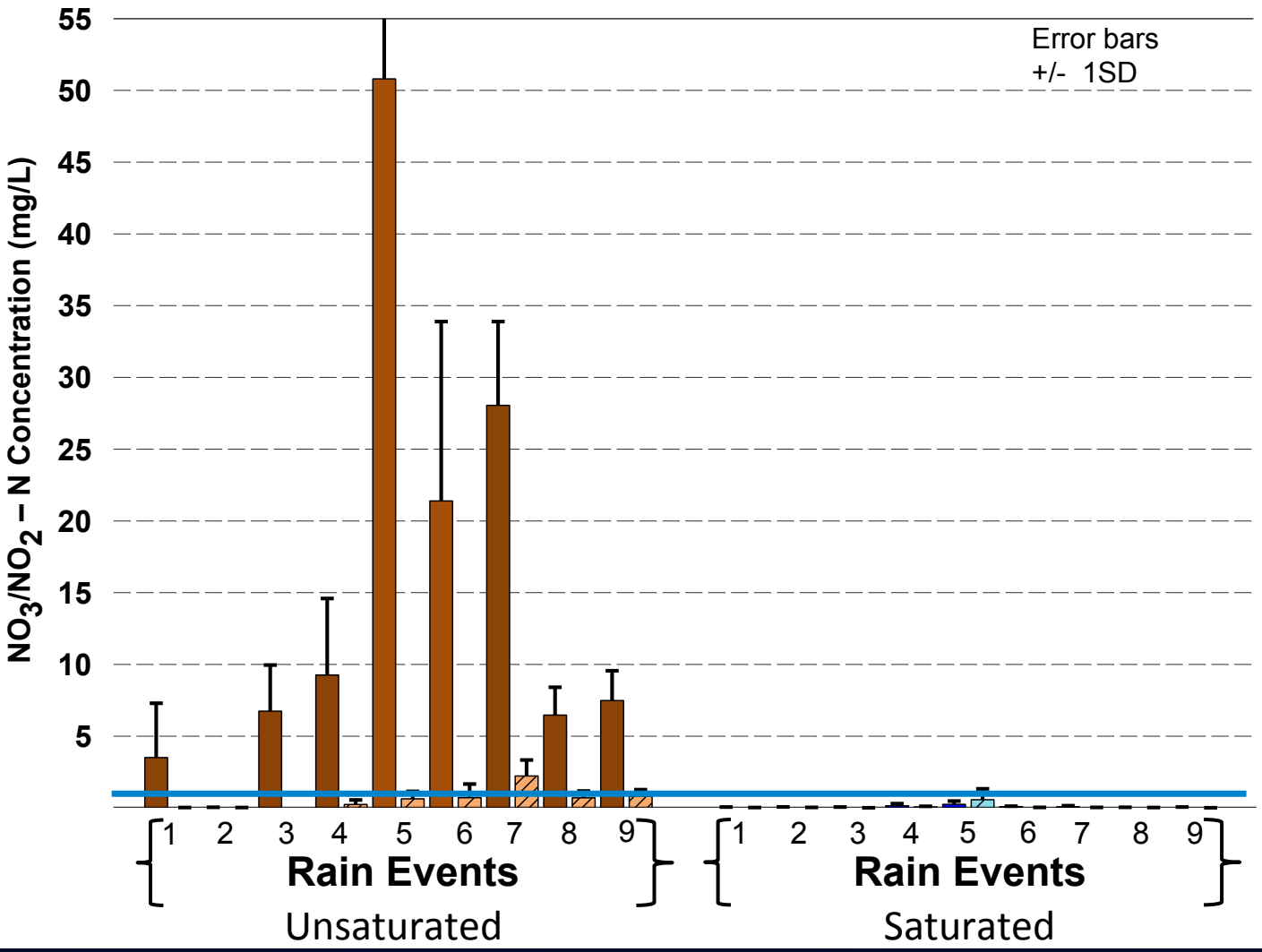


Nitrates/Nitrites as Nitrogen

- Stratified
  - First liter flush higher concentrations than liters 2-8
  - Lower nitrite/nitrate concentrations in saturated columns than unsaturated columns

Nitrates/Nitrites as Nitrogen: Mixed



Unsaturated Mixed

Saturated Mixed

1st Liter Flush

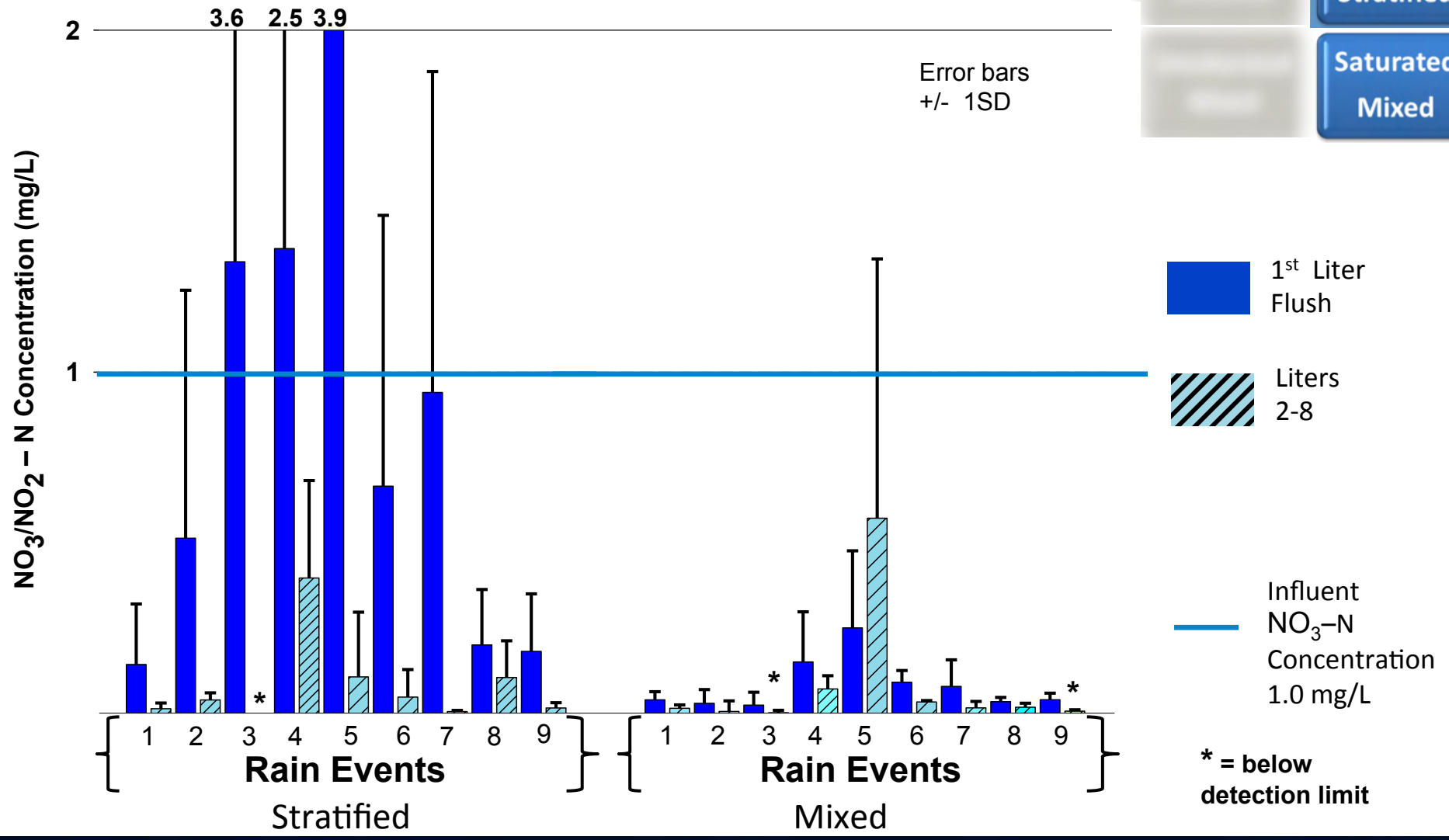
Liters 2-8

Influent NO_3–N Concentration 1.0 mg/L

Nitrates/Nitrites as Nitrogen

- Mixed
  - First liter flush higher concentrations than liters 2-8
  - Lower nitrite/nitrate concentrations in saturated columns than unsaturated columns

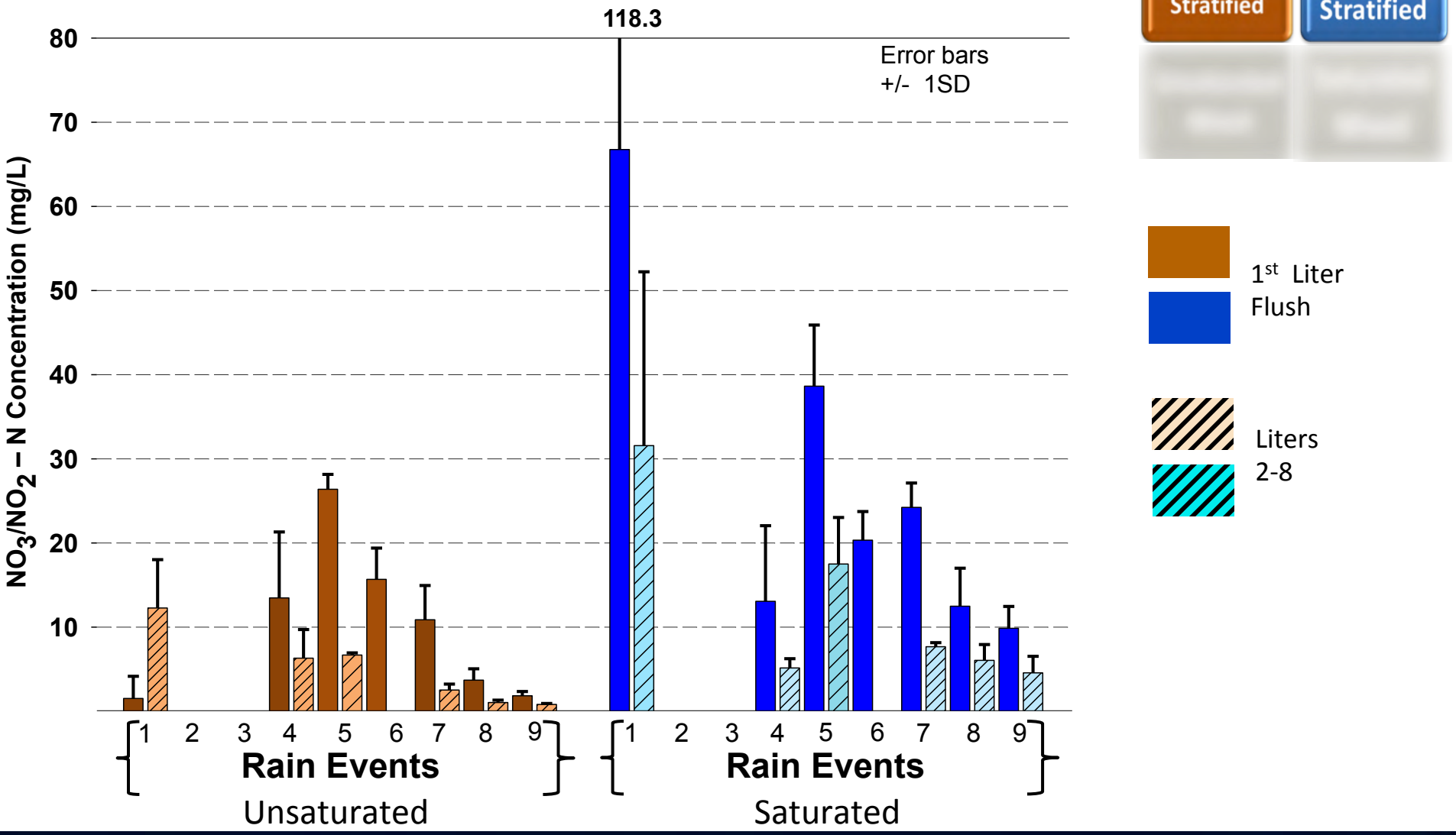
Nitrates/Nitrites as Nitrogen: Saturated



Nitrates/Nitrites as Nitrogen

- Saturated columns
  - Lower concentrations from mixed than stratified for most rain events
  - Concentrations from mixed effluent on all rain events were lower than influent

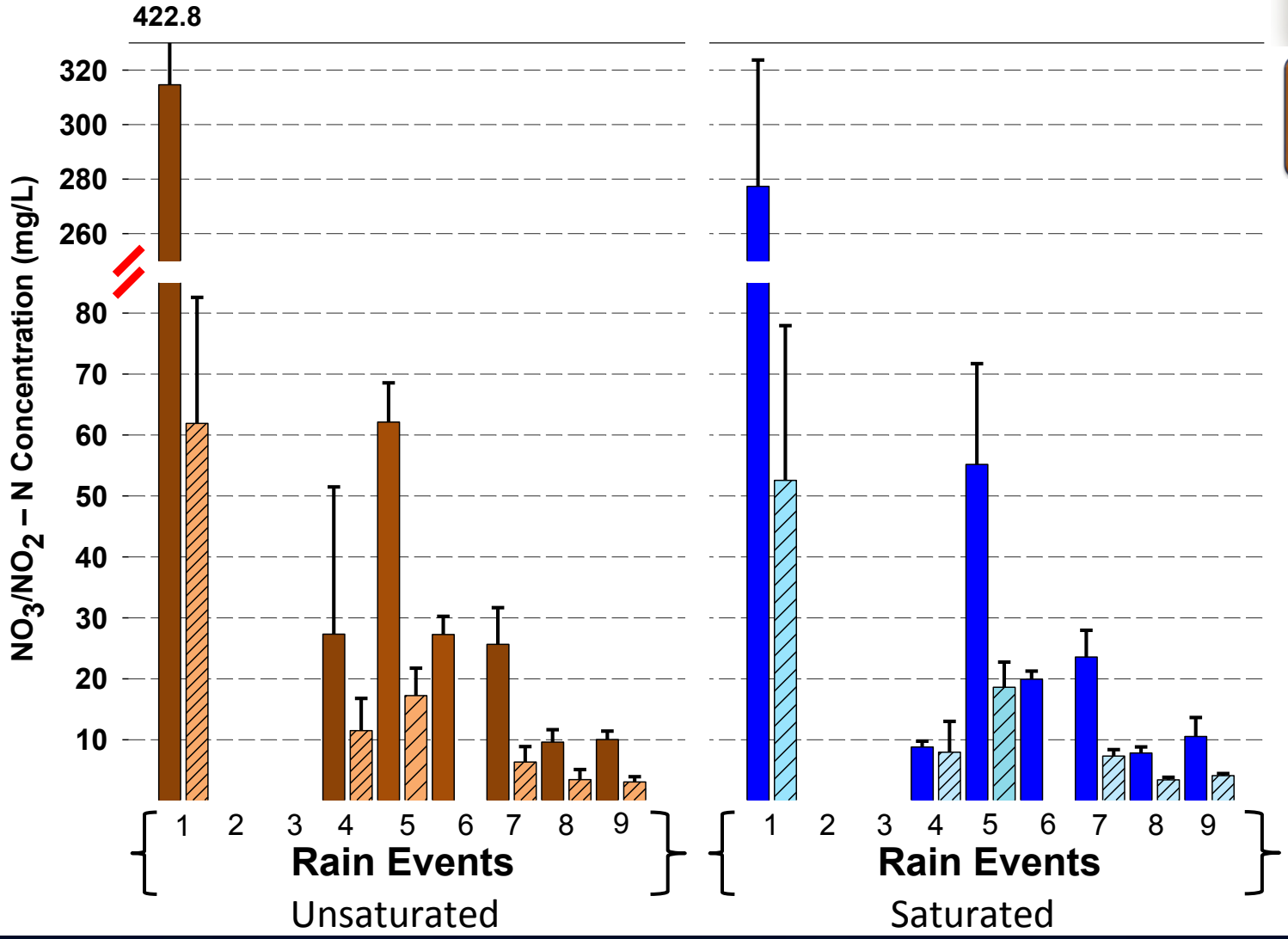
Ammonia as Nitrogen: Stratified



Ammonia as Nitrogen: Stratified

- Stratified columns
  - Ammonia most likely originated in biosolids as organic nitrogen
  - Unsaturated and saturated columns showed similar behavior, but without a discernible pattern

Ammonia as Nitrogen: Mixed



Unsaturated Mixed

Saturated Mixed

1st Liter Flush

Liters 2-8

Ammonia as Nitrogen

- Mixed columns
  - First rain event resulted in highest concentrations relative to other 8 rain events
  - Unsaturated and saturated columns showed similar behavior, but without a discernible pattern

Discussion

- As expected, a saturated layer influences nitrate concentrations
  - Saturation does not seem to influence ammonia concentrations
- As expected, high concentrations of ammonia were observed in effluent
  - Consistent with the 2011 study

Conclusion: Goal 1

- Develop a solution to reduce influent nitrogen from stormwater in a rain garden soil mixture
  - Hypothesis: Saturated zone in rain gardens leads to lower concentrations of nitrates in the effluent

- Columns with saturated zone released ~ 80% less nitrate/nitrites than columns without saturation
- WTR mixed throughout the soil column released less nitrite/nitrate than stratified column

Conclusion: Goal 2

- Find a productive use for biosolids
  - Hypothesis: The use of a biosolids amendment in rain gardens will increase ammonia in the effluent

- Our results imply biosolids were a nitrogen source
- Higher concentrations nitrogen in effluent than influent
- WTR mixed throughout the soil column released less nitrite/nitrate than stratified column
- Comparable amounts of ammonia were released in the two types of soil combinations and in the saturated vs. unsaturated columns

Next Steps

- Add plants to rain garden soil study
- Prewash biosolids at the TAGRO plant

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http://www.portoftacoma.com/Page.aspx?cid=3218

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Questions?