Water and Nitrogen Balance for Mounded Drip Irrigation Systems Receiving Septic Tank Effluent

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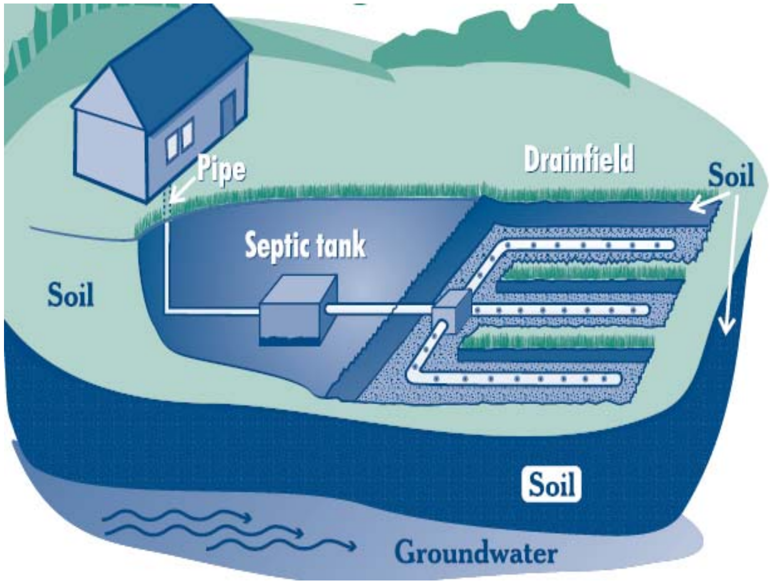

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Soil & Water SCIENCE

OUTLINE

- **Overview: *Excess N in water bodies***
- Methods
- Results: Water, Chloride, Nitrogen
- Summary/Conclusions
- Acknowledgments

OVERVIEW

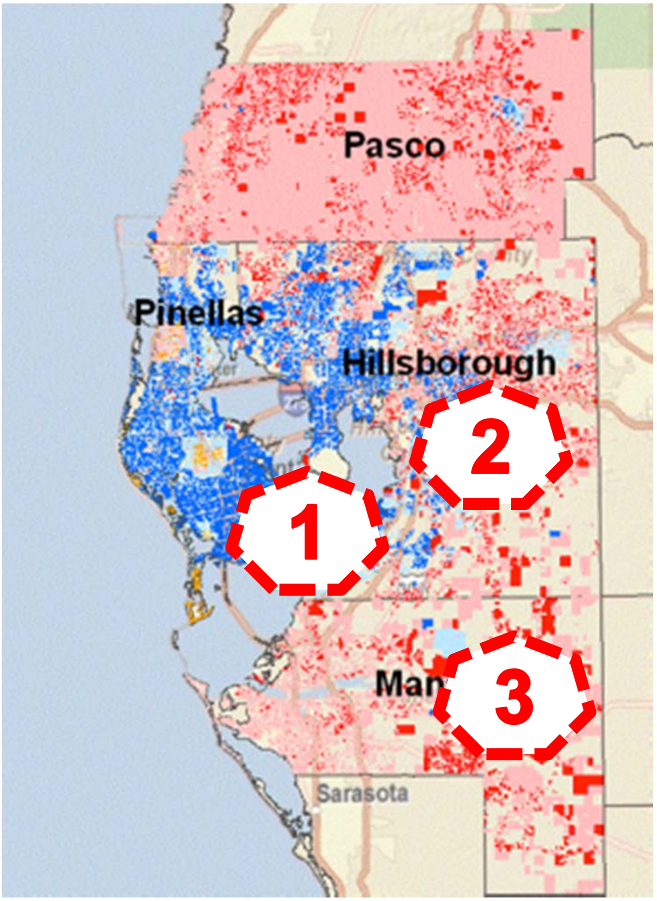
- **Nutrients: primary pollutants in water bodies**
  - 53% of river and stream miles
  - 67% of lake acres
  - 66% of estuarine square miles
- **Nutrient problems in Florida**
  - ***Coastal waters:*** N limitation
    - Tampa Bay, Miami, Orlando, Jacksonville
  - ***Inland waters (freshwater):*** P limitation
    - Lake Okeechobee, Everglades

N and P Rich Waters

Nitrogen in Florida's Waters

- **Tampa Bay Estuary (Hillsborough)**
  - TN: ~1.8 mg/L
  - Organic N: ~1.5 mg/L (85%)
  - NO_3-N: 0.22 mg/L (11%)
  - NH_4-N: 0.08 mg/L (4%)
- **Rivers (e.g., Alafia)**
  - TN: ~2 mg/L
  - Organic N: ~1.5 mg/L (75%)
  - NO_3-N: 0.38 mg/L (19%)
  - NH_4-N: 0.10 mg/L (5%)

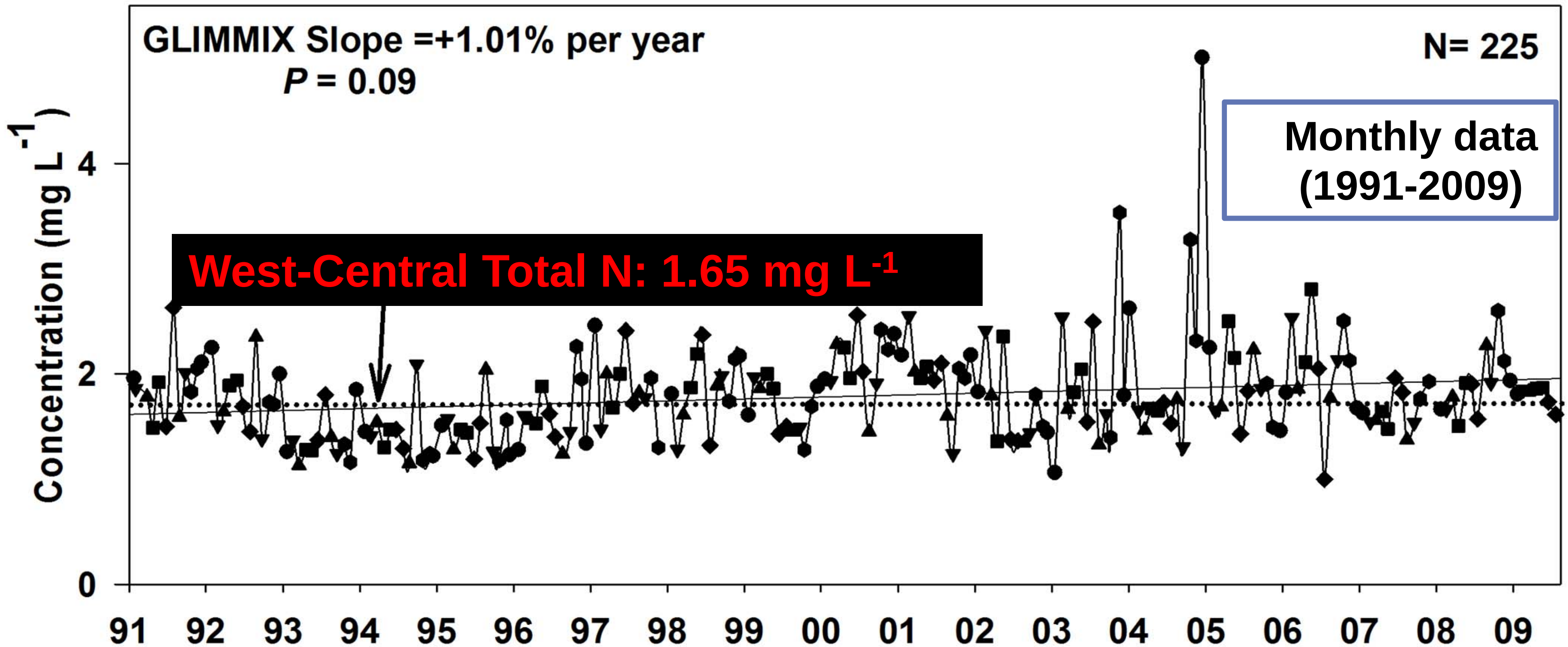
Tampa Bay, Florida



Blue-ish: sewered parcels
Red-ish: onsite parcels

Streamwater: Total N Trends

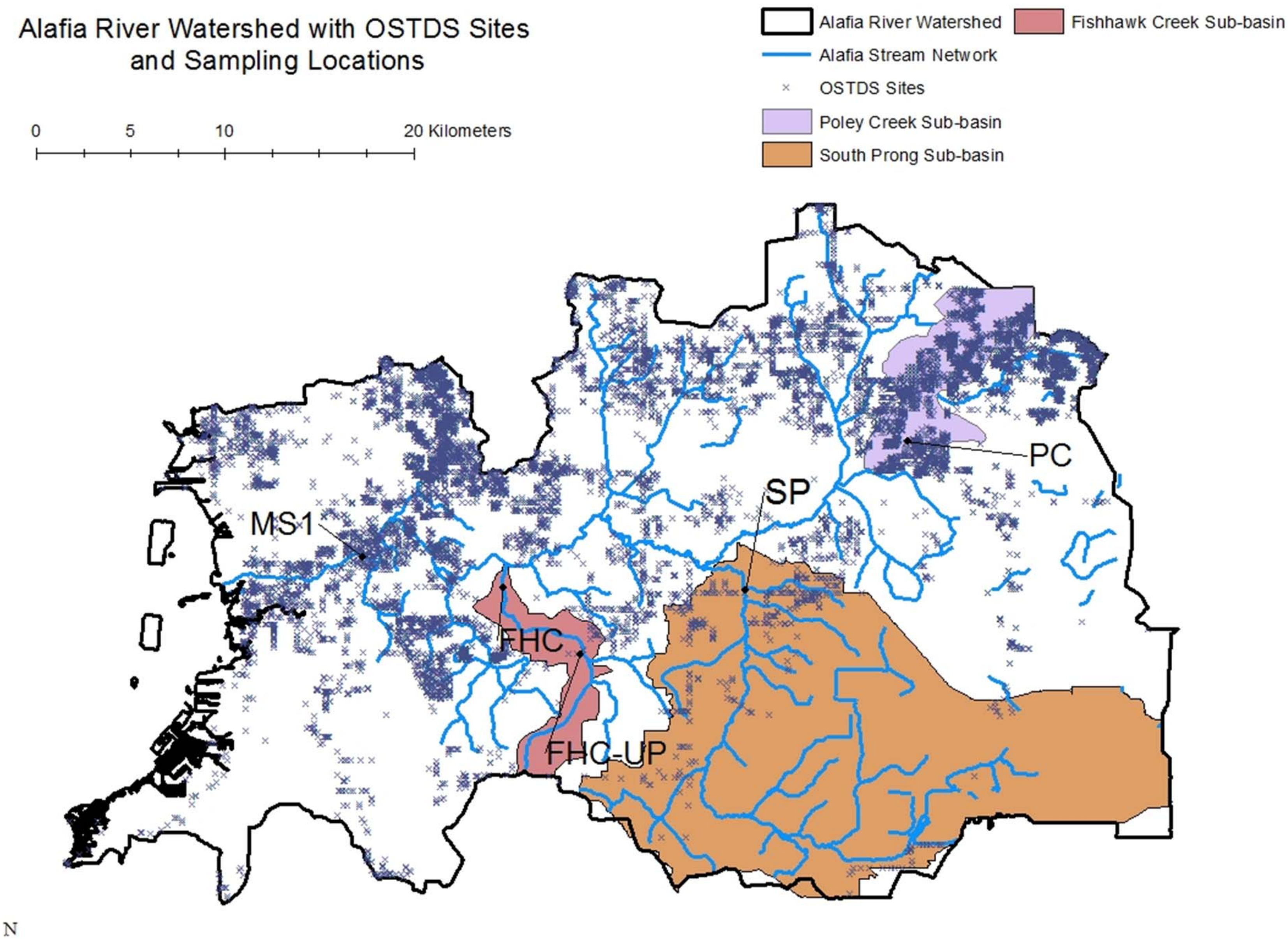
Land use (Mainstem)	% change (1990-2007)
Urban (residential+built-up)	+8
Pastures	-7
Forest	-5



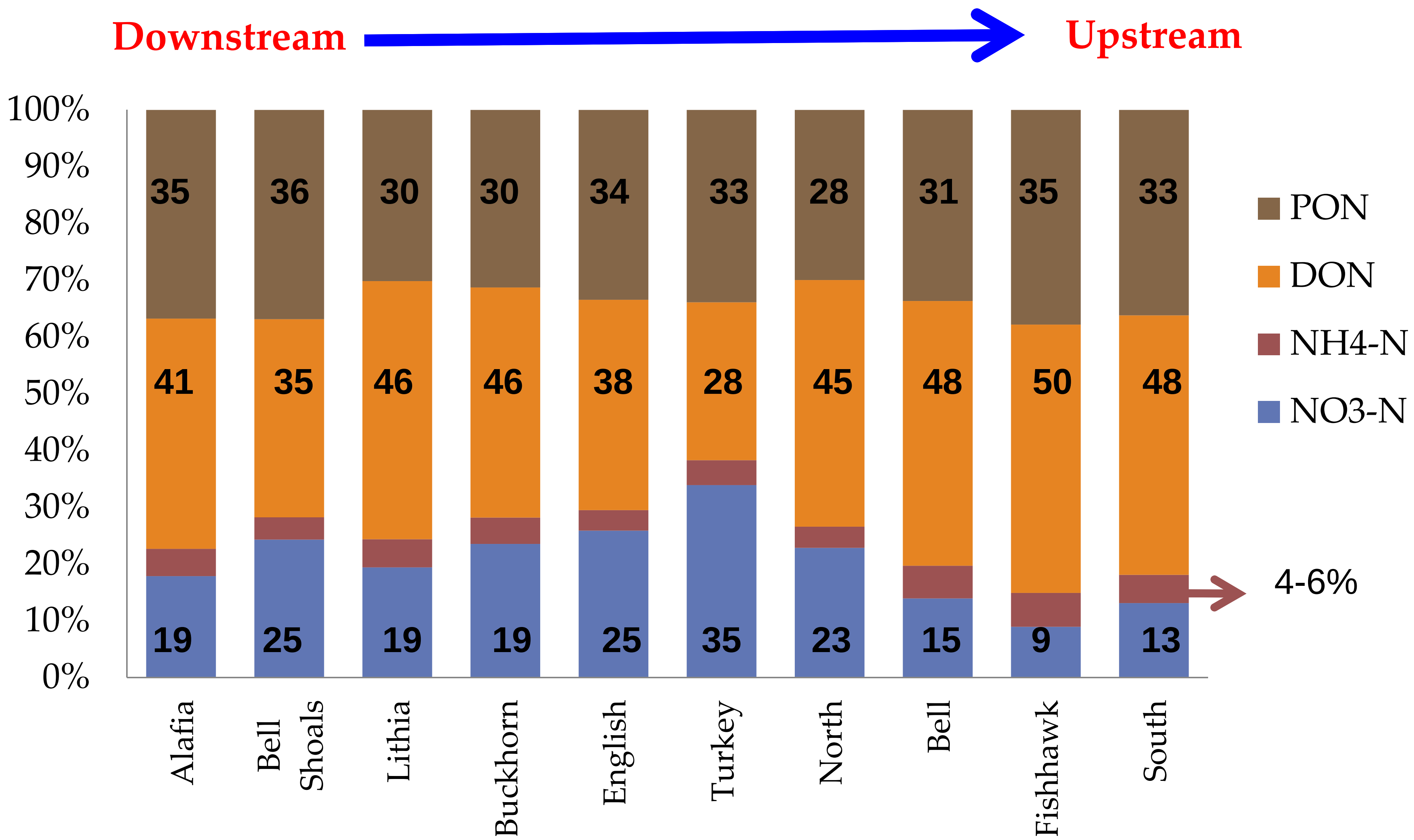
<u>From 1991 to 2009,</u> total N at the most downstream monitoring station increased by 17.7 µg L^{-1} year $^{-1}$, which is equivalent to <u>0.33 mg L^{-1} in 19 years</u> (~20% increase).

Khare et al.. 2012. J. American Water Resources Association. 48:1276-1293.

Streamwater: Sub-basins



Streamwater: N Forms in a Wet Season



Area = 1072 974 868 19 99 128 350 51 277 71 km^2

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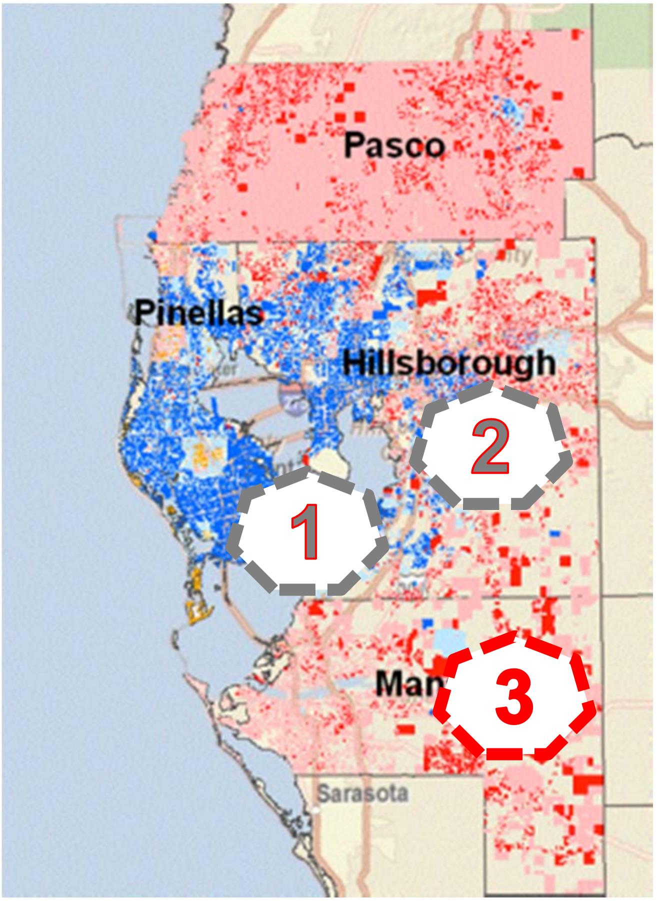
- **N in Lakes (e.g., Lake Manatee)**

Tampa Bay, Florida



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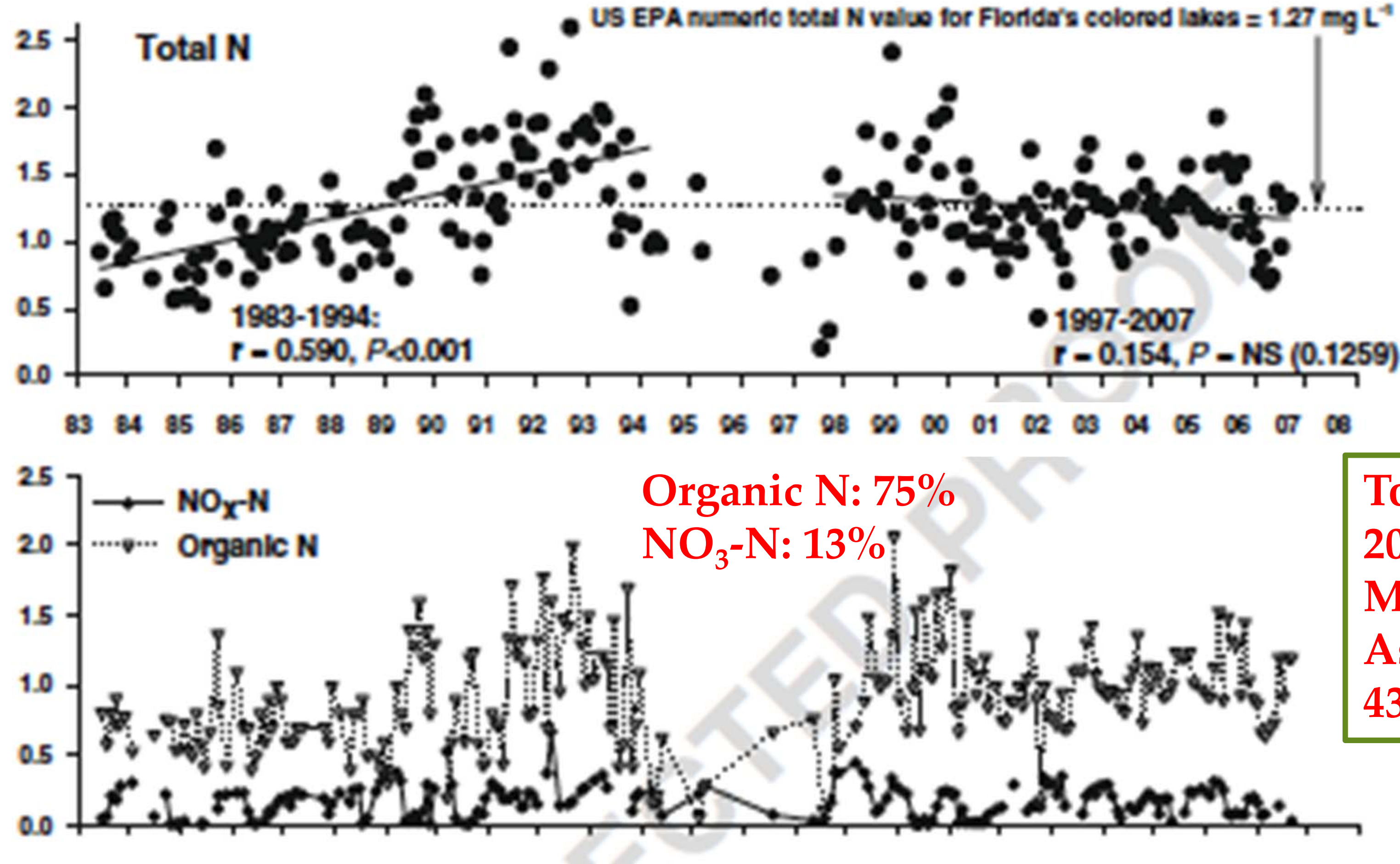
Nitrogen Conc. (mg/L) in Lake Manatee



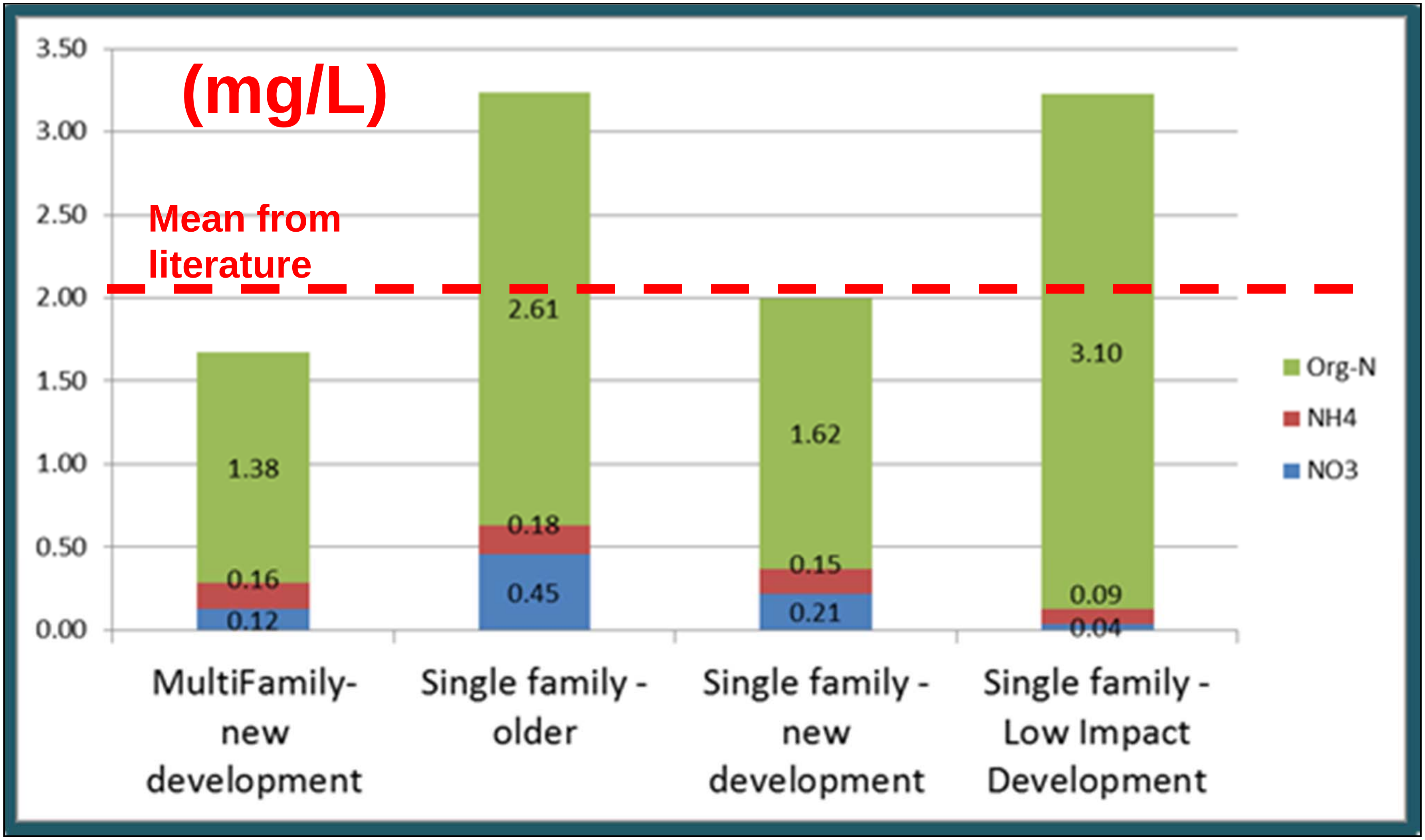
Organic N: 75%
NO_3-N: 13%

Toor et al. 2013. Env Monit. Assess. 185: 4305-4320

What is the source of Organic N?

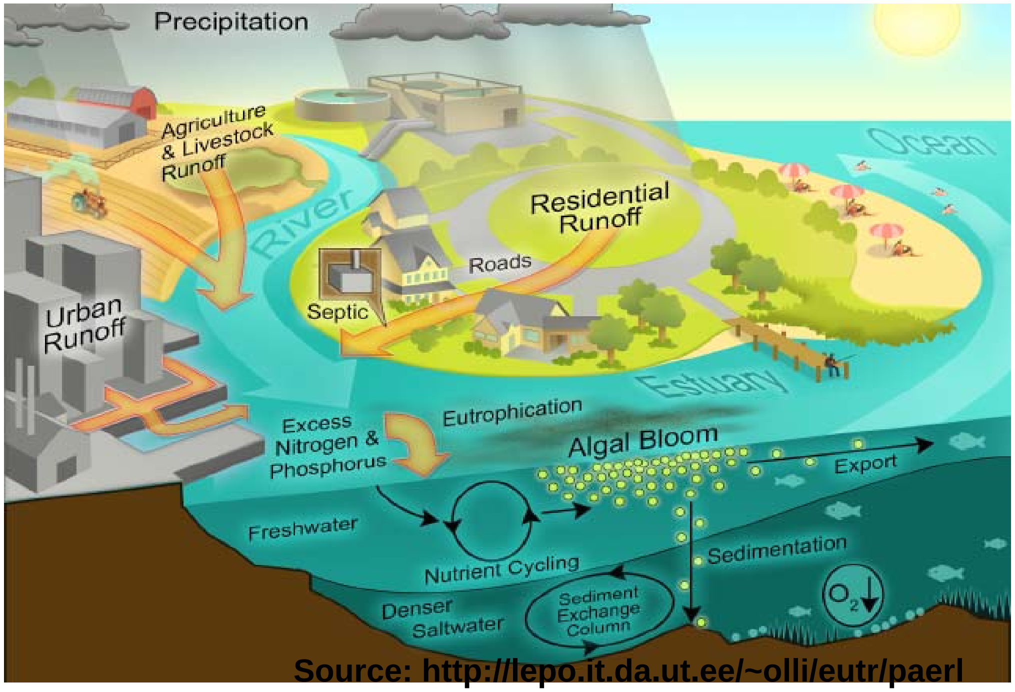
Example: Residential Stormwater Runoff N Conc.

2012 Wet Season



Multiple Nitrogen Sources

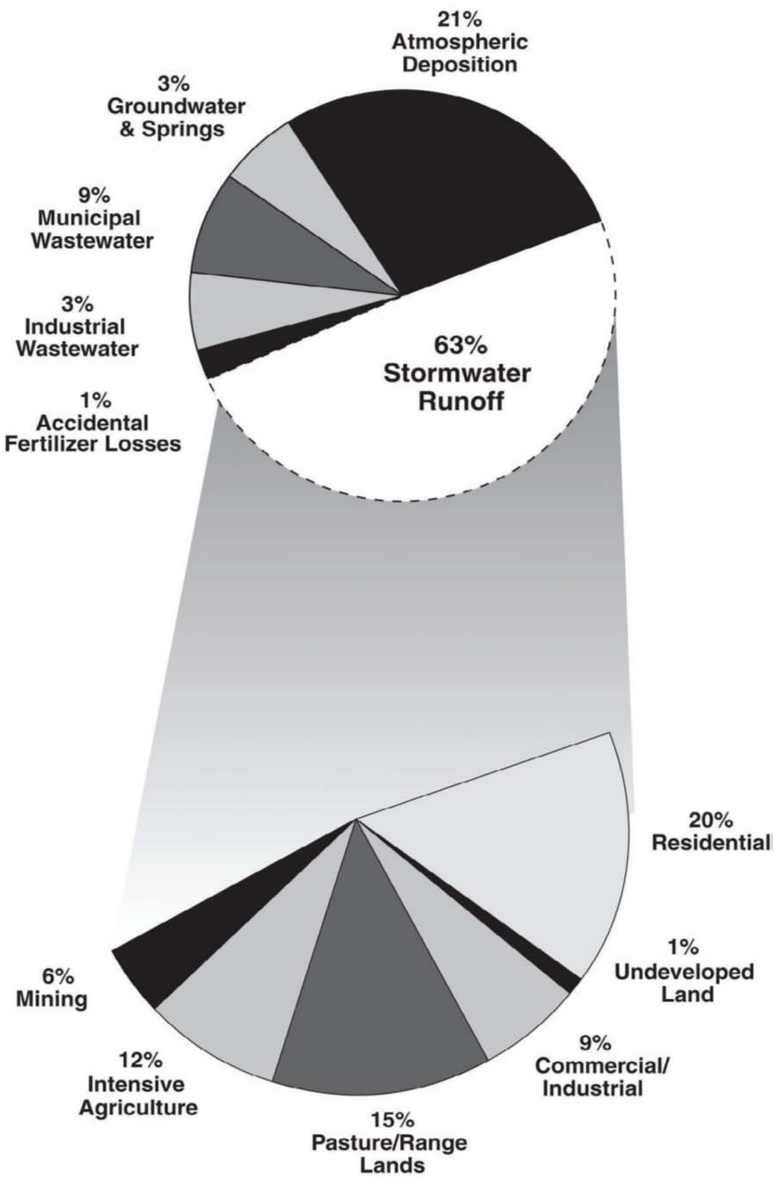
- Fertilizers
- Septic systems
- Point sources (WWTPs)
- Leaky sewers
- Animal Residues: Pet waste
- Plant Residues: Decaying plant material (grass, leaves)
- Atmospheric deposition



Source: http://lepo.it.da.ut.ee/~olli/eutr/paerl

❖ Nitrogen load in a water body is a combination of runoff and leaching of N from above sources!

Sources of Nitrogen in Tampa Bay Estuary

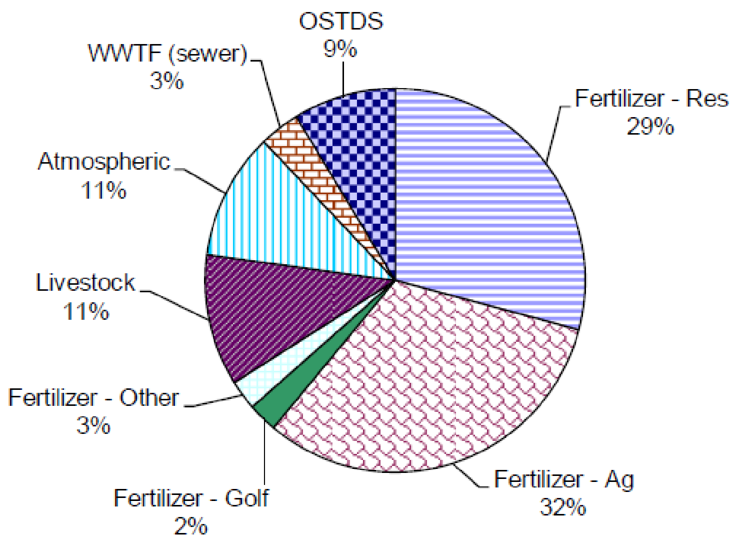


Source: TBEP, 2010.

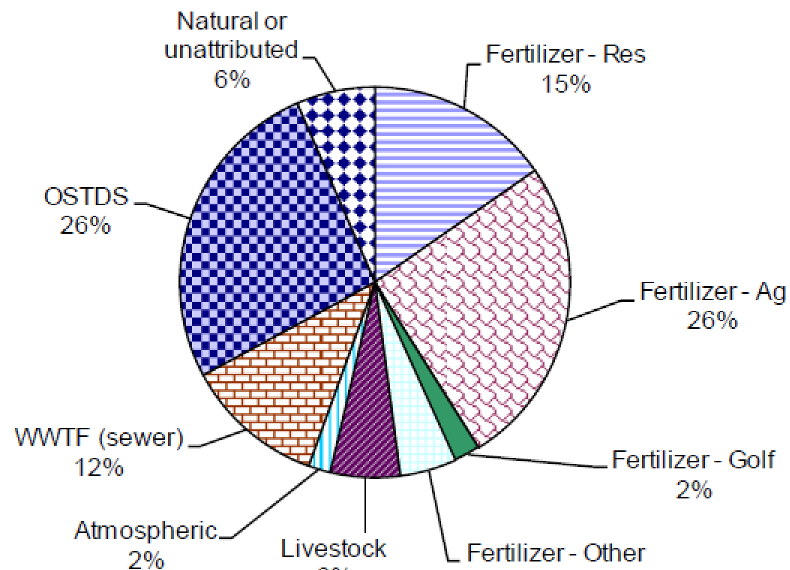
- Non Point Sources: 63%
  - Residential (20%)
- Atm. deposition: 21%
- WWTP: 9%
- Groundwater & Springs: 3%
- Comprehensive N management!

WEKIVA Basin, Florida

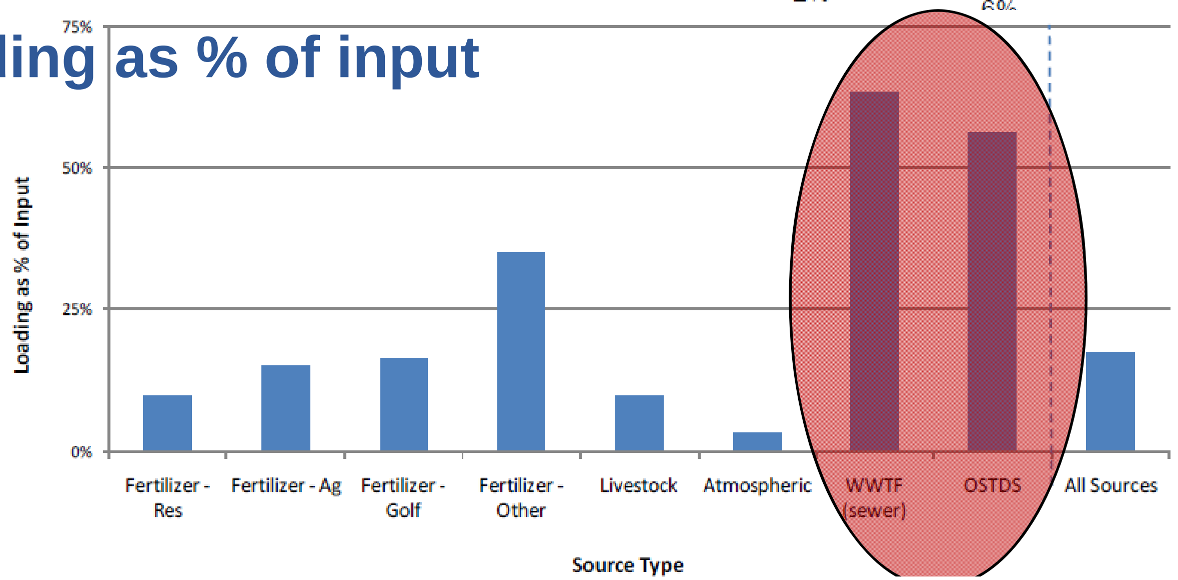
Relative contribution of N inputs



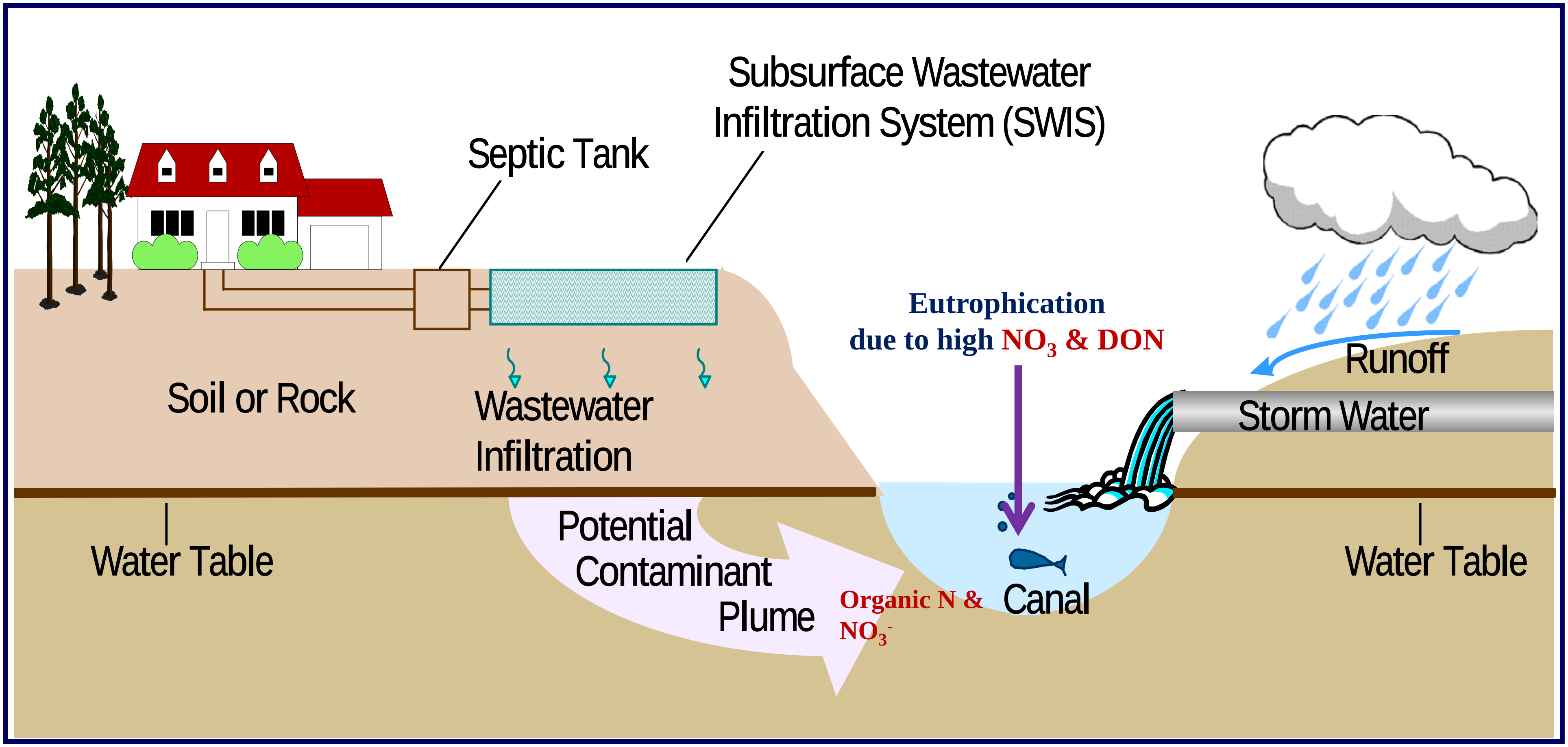
Relative contribution of N sources to groundwater



Loading as % of input



Impact on Water Quality



Sources of N in Wastewater

- **Main Sources:** Human body wastes and food materials from kitchen sinks and dishwashers.
- EPA (1992) estimated that one person discharges annually ~4 kg of total N/year (11 g/day)
- Typical total N concentrations: average: 60 mg/L

Source of N	Contribution	
	Grams per person per day	Percent of total
Toilet	8.7	78
Bath, Sinks, Appliances	1.9	17
Kitchen Sink	0.6	5

(EPA, 1992)

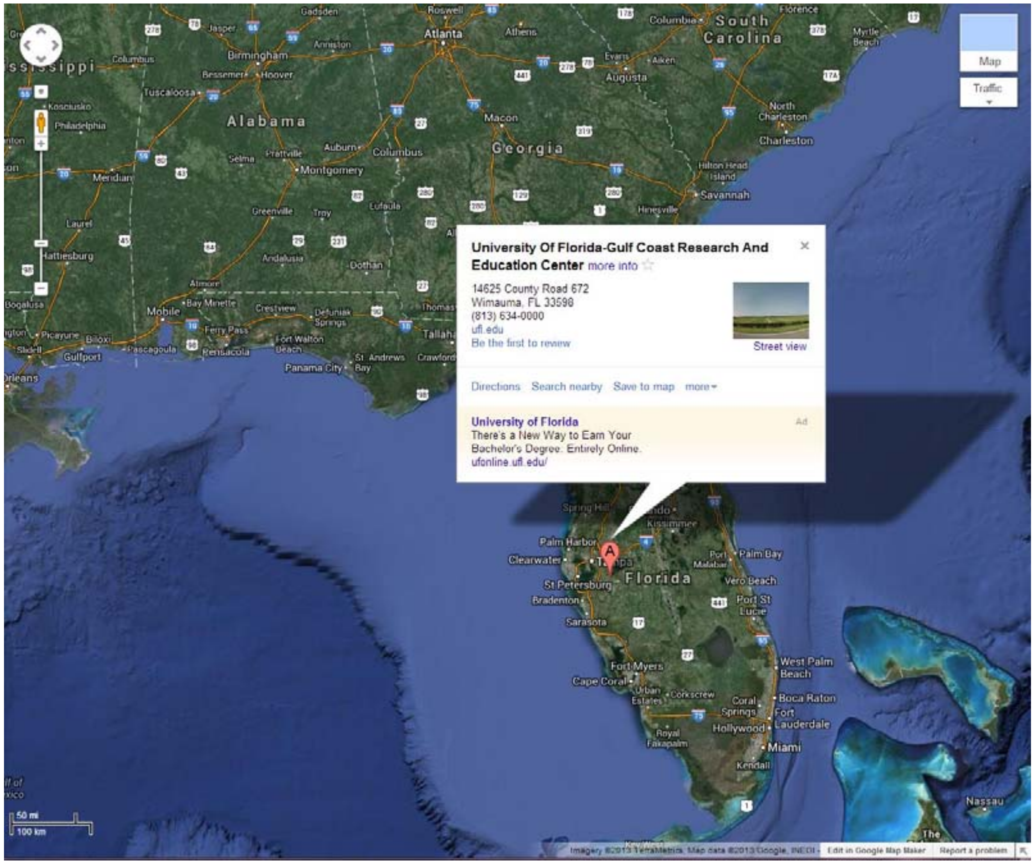
Example: Nitrogen Inputs from Different Sources

- Fertilizer application to crops: 40-80 kg total N per acre per year. In 1 Km^2: 10,000-20,000 kg of total N. [Plant uptake]
- Atmospheric deposition: ~2.4-4.9 kg of total N per acre per year, total N loading in 1 Km^2: 600-1,200 kg each year.
- Household N contribution: An average subdivision of 200 homes [1 Km^2 or 247 acres) with 4 people/house: 3,270 kg of total N each year.
- *Septic systems can be an important N source!*

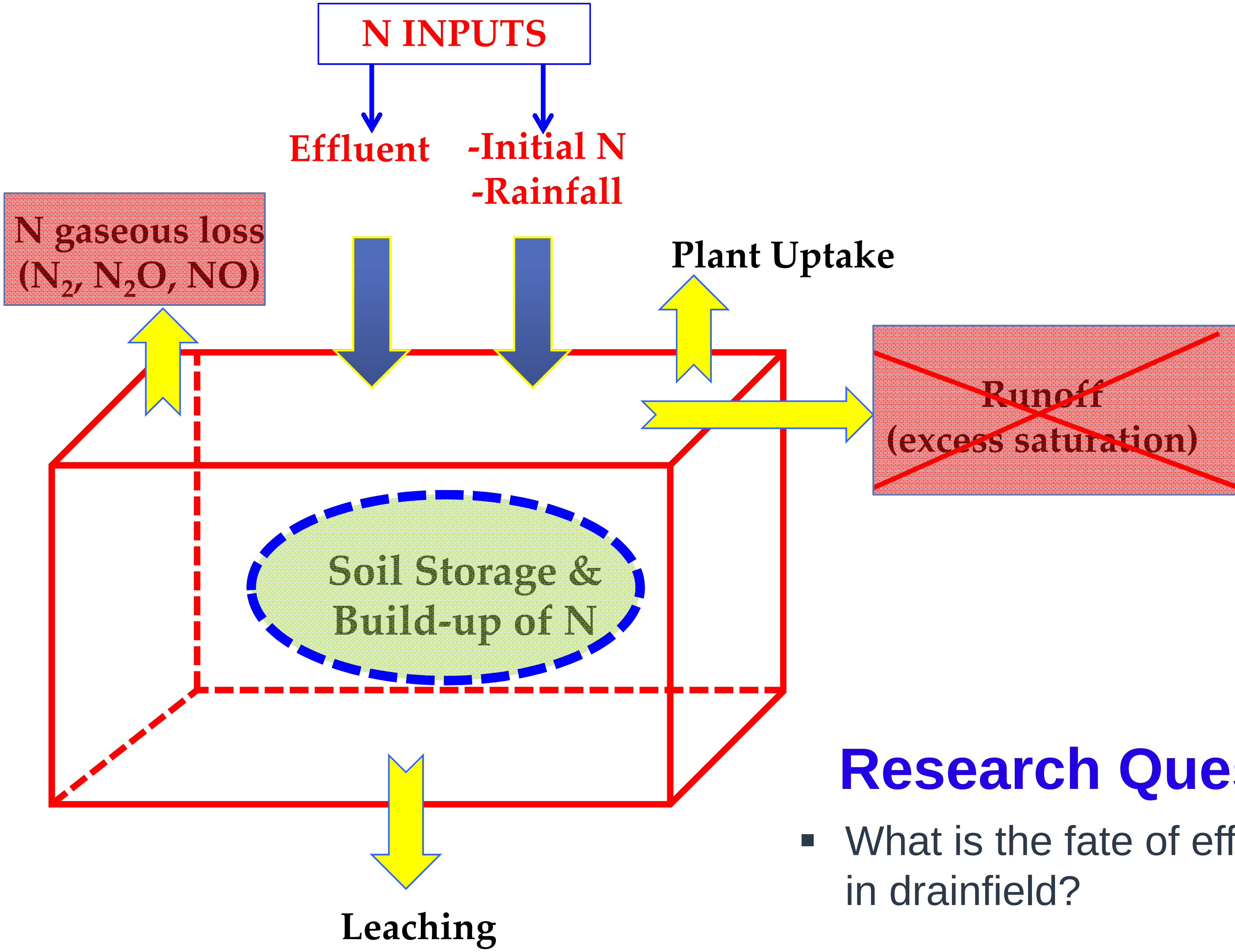
Objective & Methods

Objectives

- Objective: Determine the mass balance of nitrogen (and water) in septic drainfields.
- Site: Gulf Coast Research and Education Center (GCREC), Tampa, FL, USA.



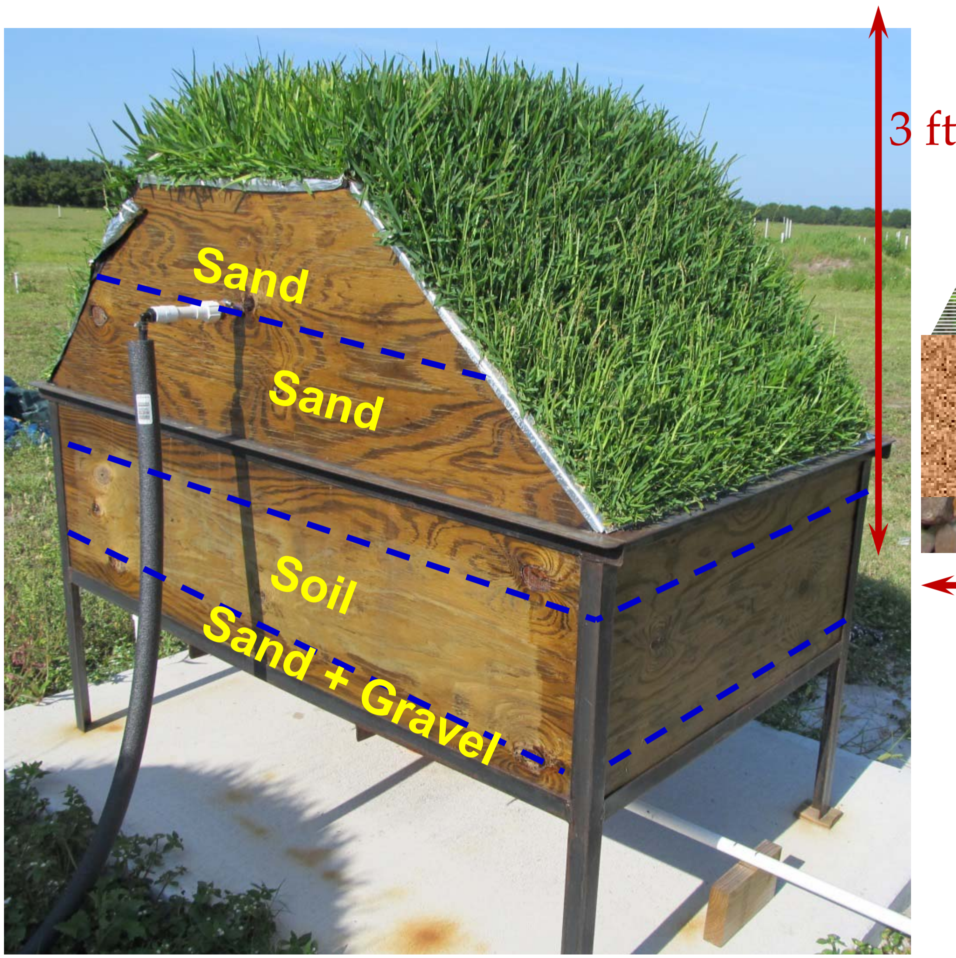
Approach: Mass Balance of Nitrogen

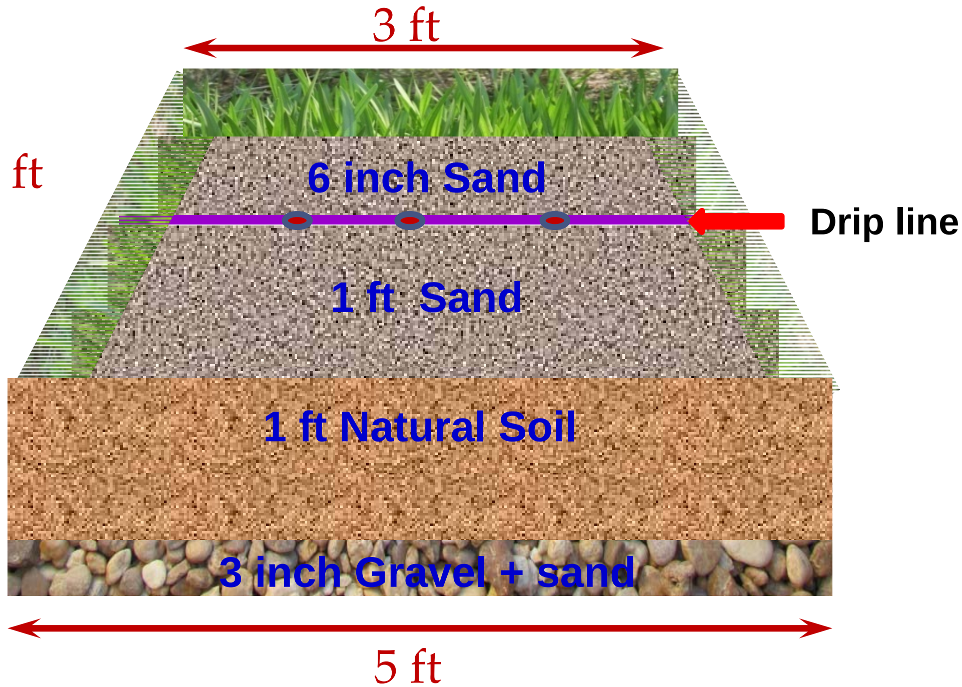


Research Question

- What is the fate of effluent N in drainfield?

Design/Construction: Replicating Drainfield in a Box





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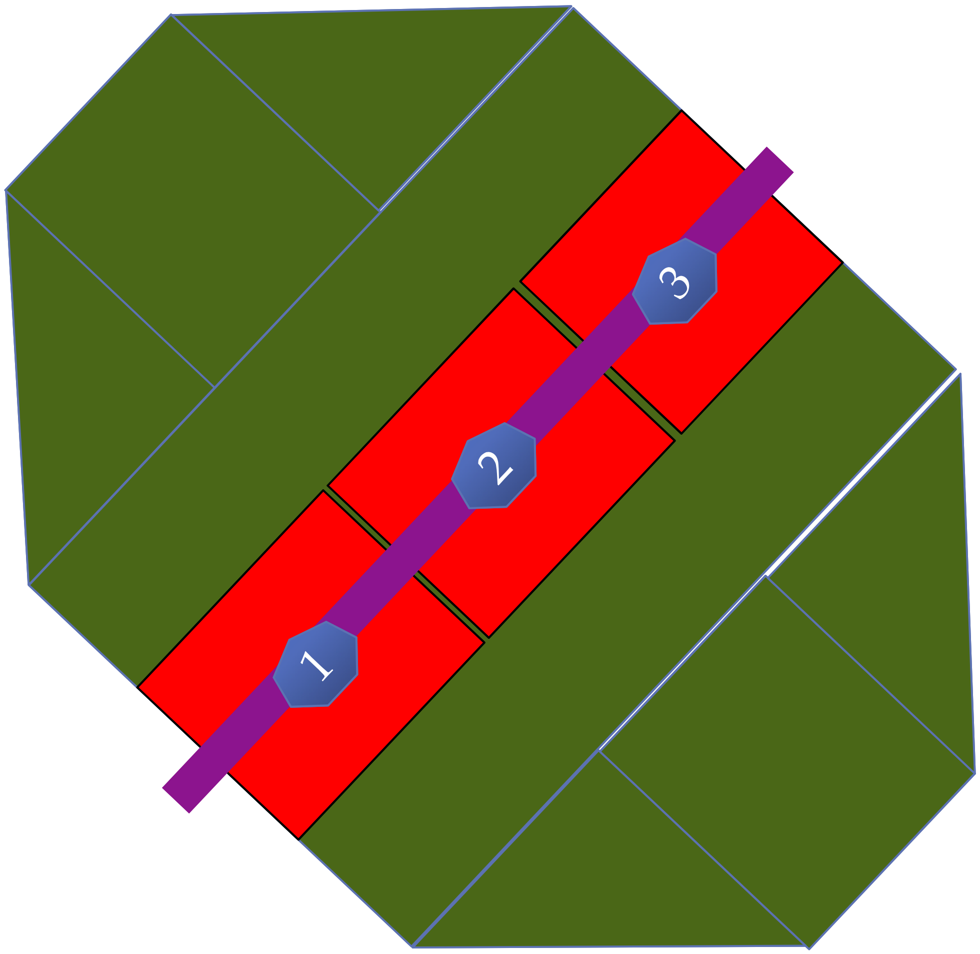
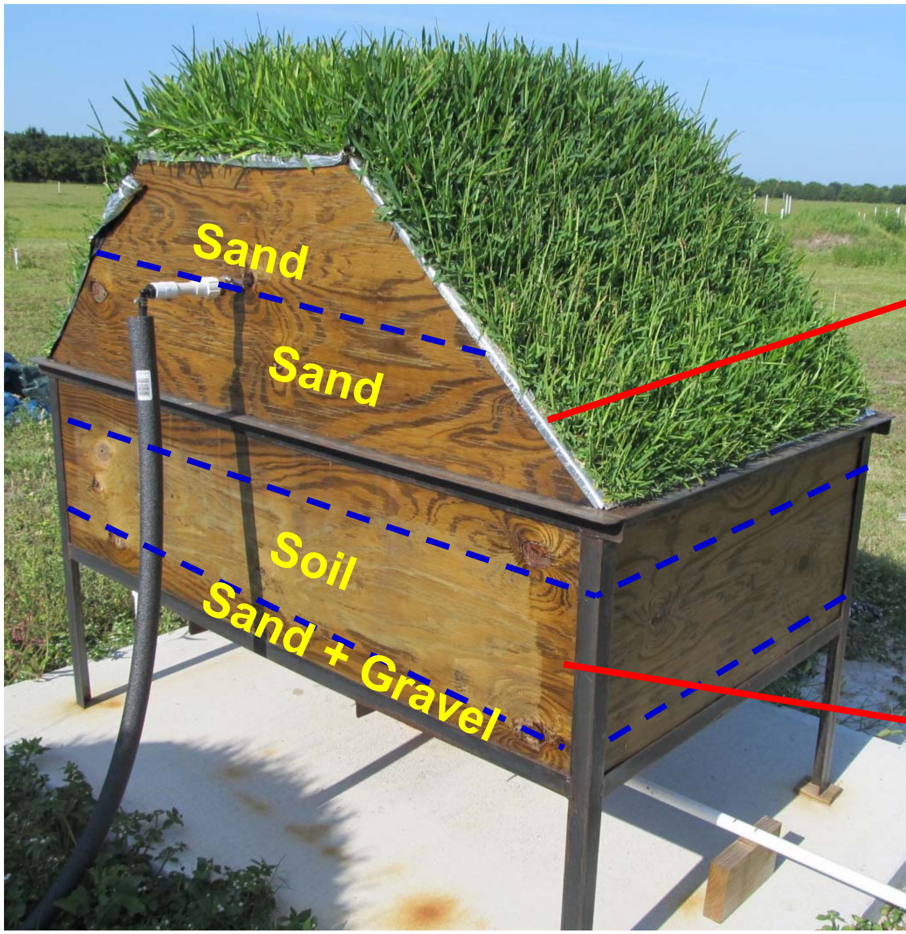
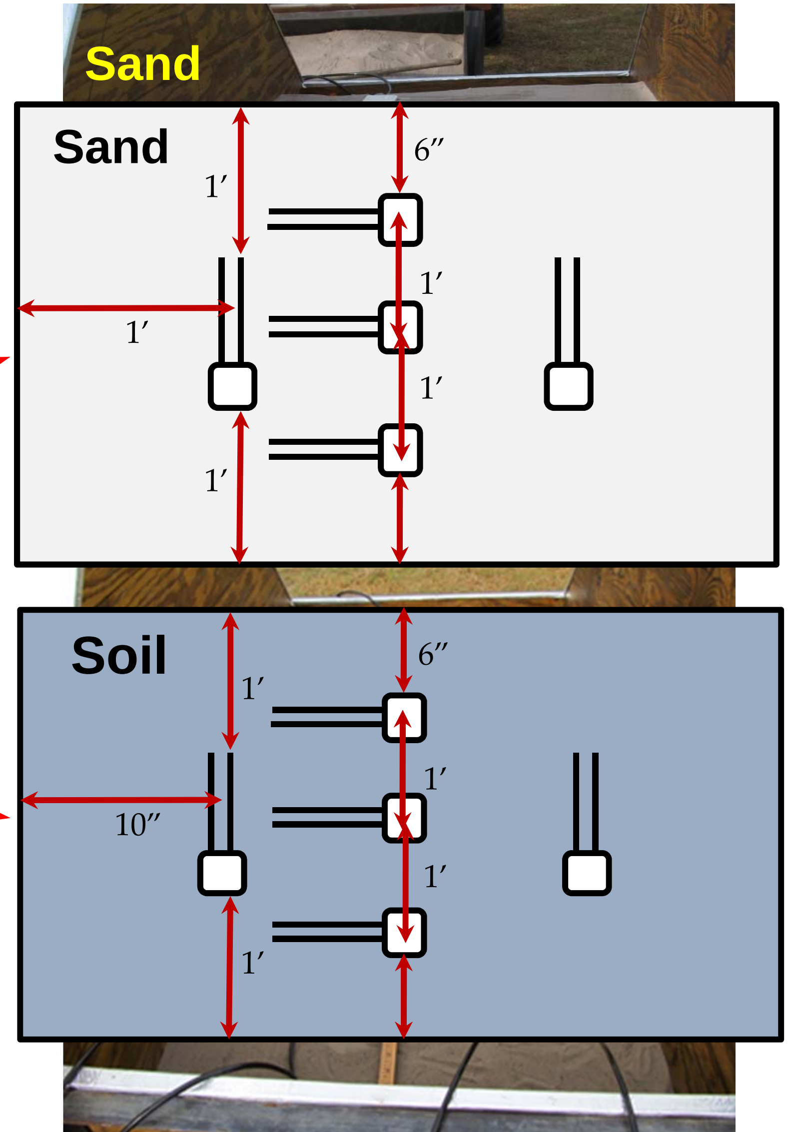


- Three replicates
- STE dosing: 0.8 gallons/sq feet/day
- Each mound had 3 drip tubes (total STE: 2.4 gallons per day)
- 10 multi-probe sensors/mound: water, EC, temp

Methods: *Sensors Installation*





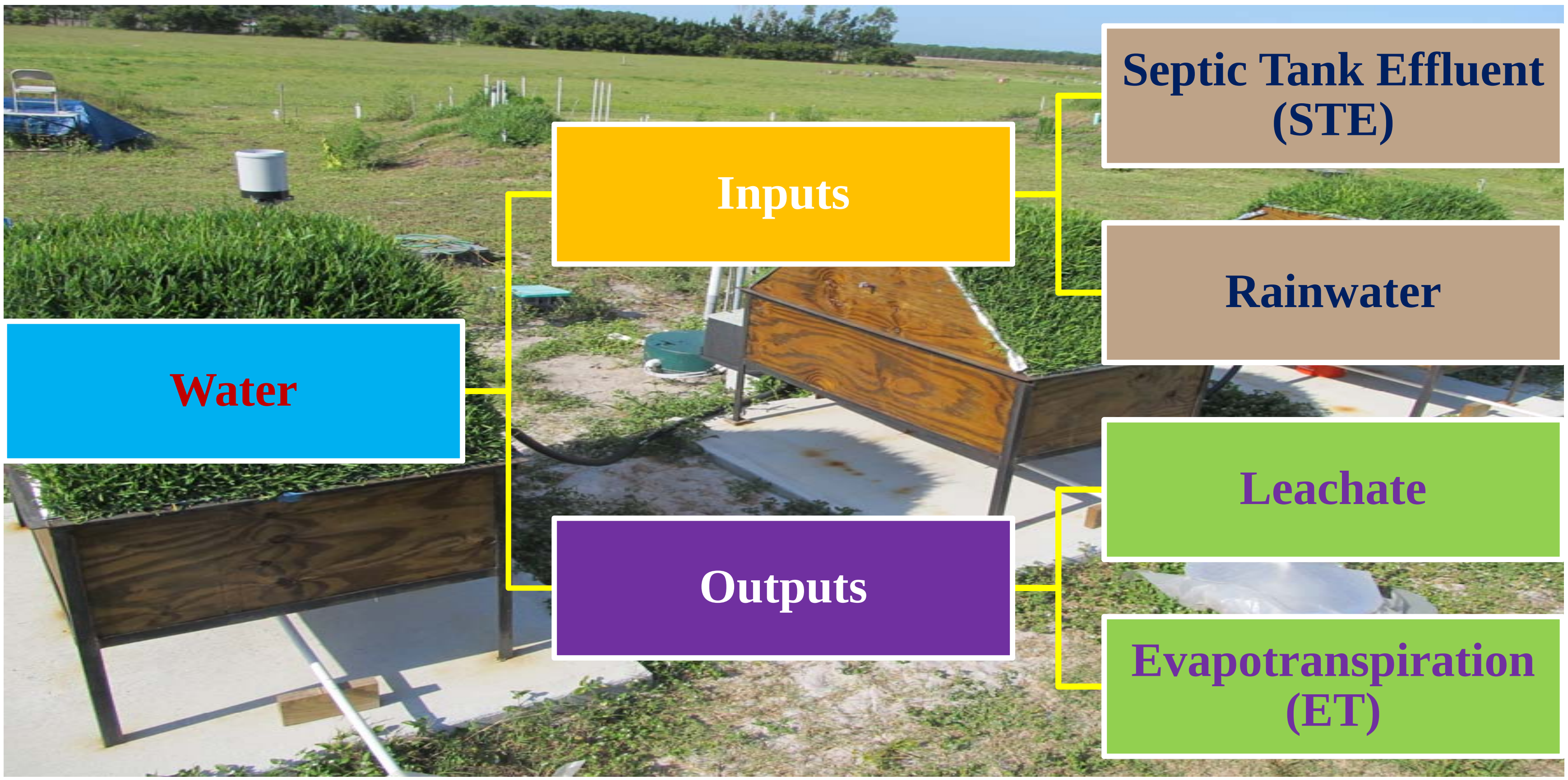
10 multi-probe sensors: volumetric water content, EC, soil temperature,

Drainfields in a Box

Results:

- Water
- Chloride
- Nitrogen

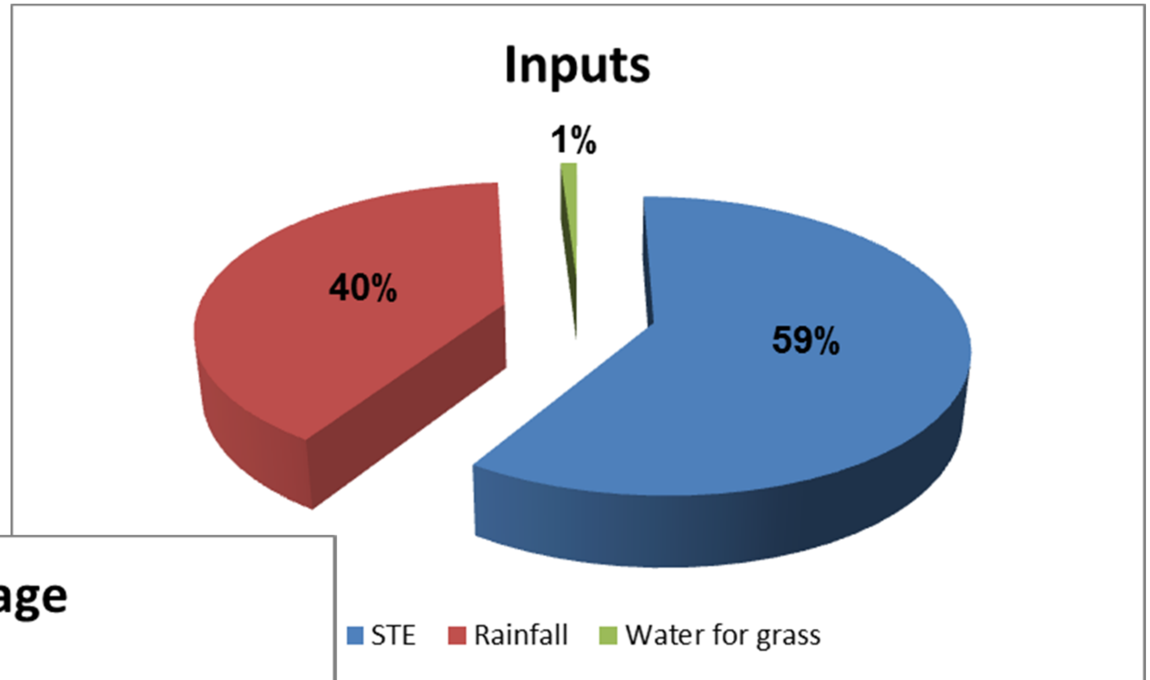
Total Water Balance in Drainfields

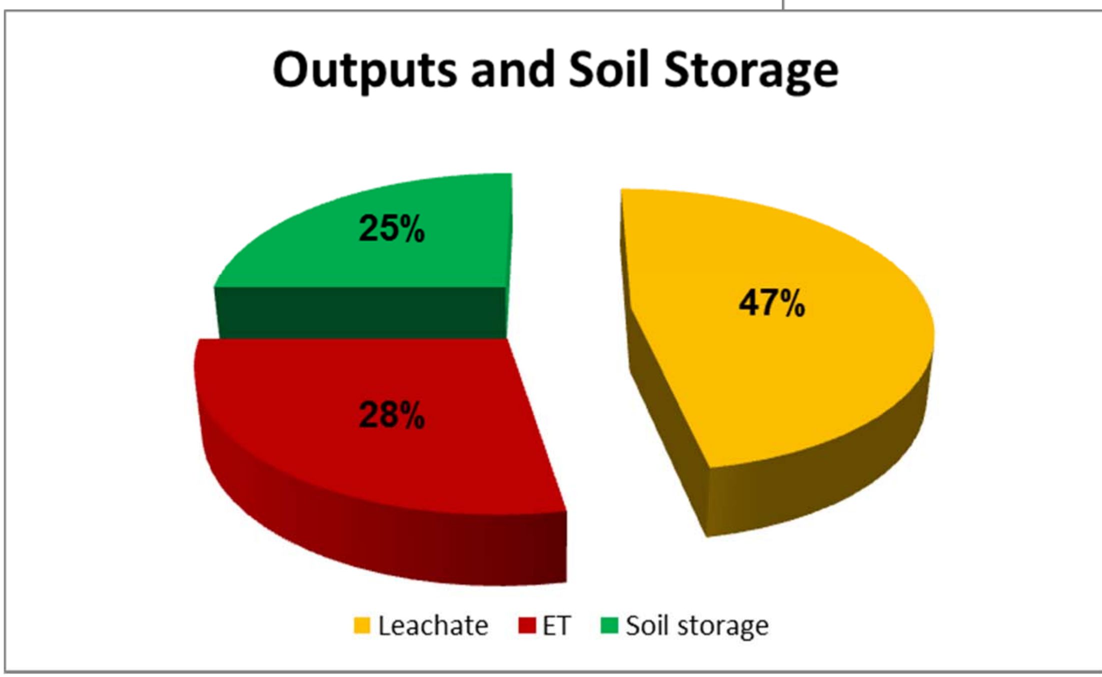


Soil storage = Input – output

Overall Water Balance in Micro-mounds (December 2012-January 2014)

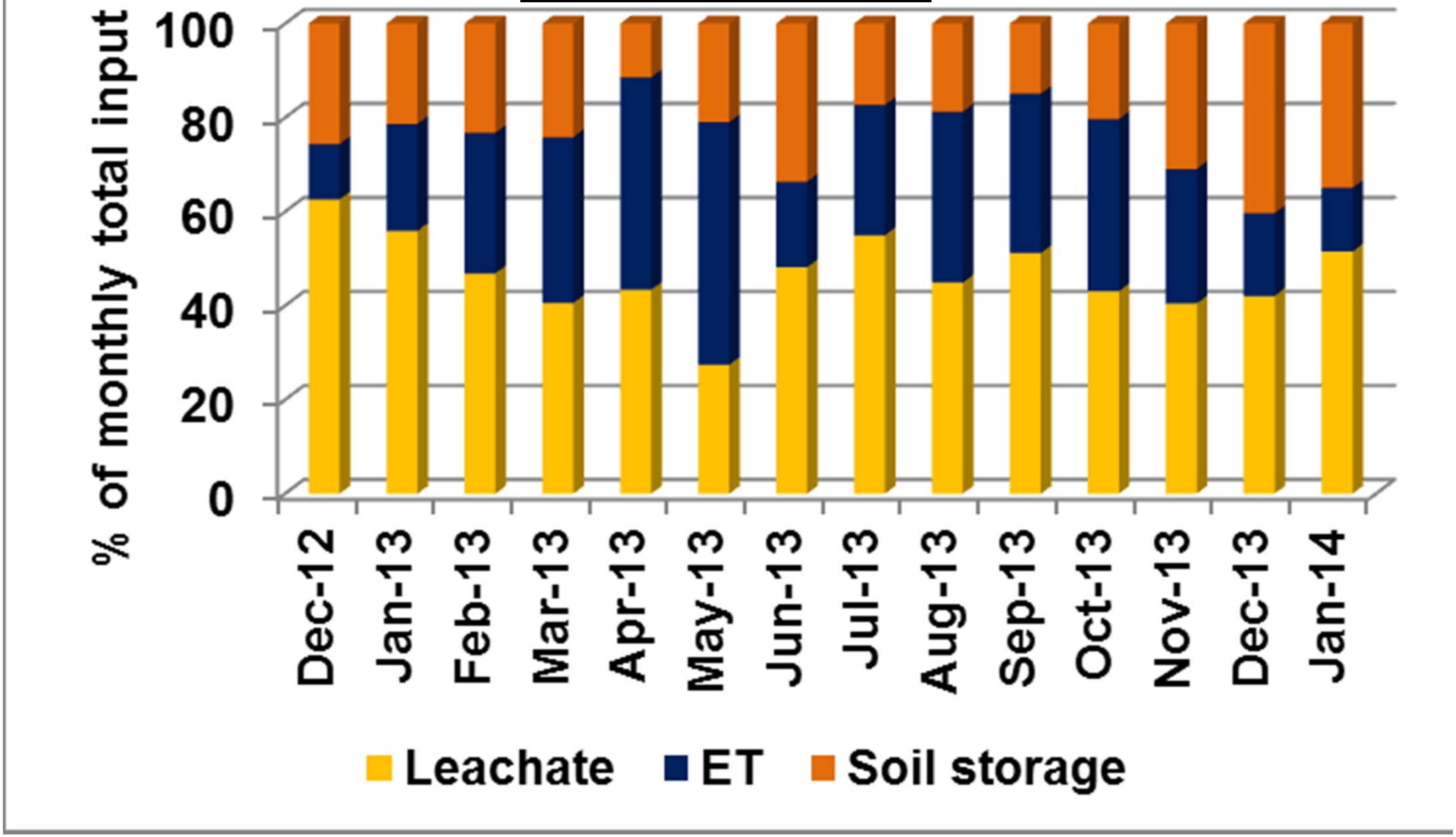
[Average data of 3 drainfields]()





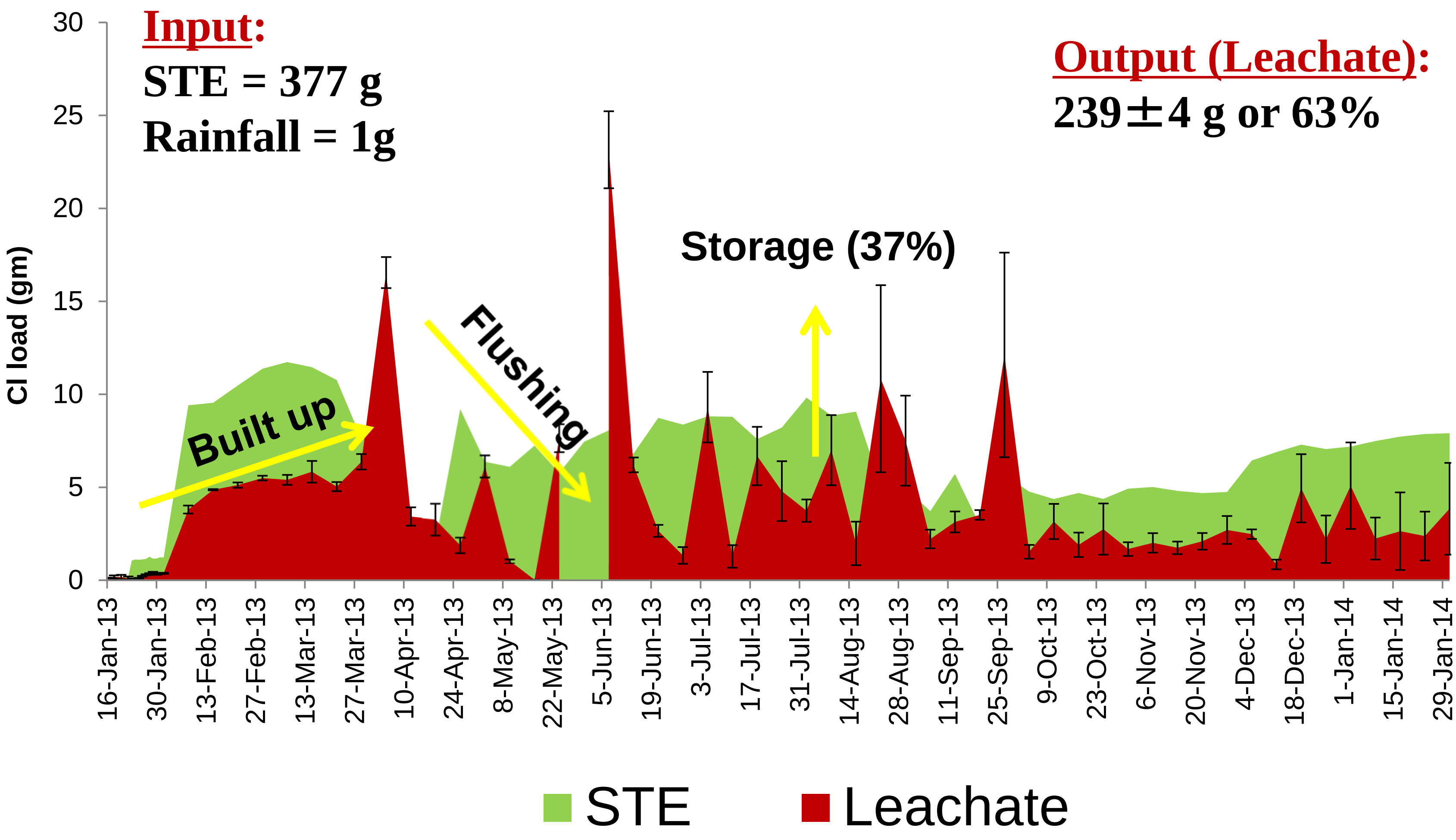
Monthly Water Balance (Dec 2012- Sept 2013)

OUTPUTS



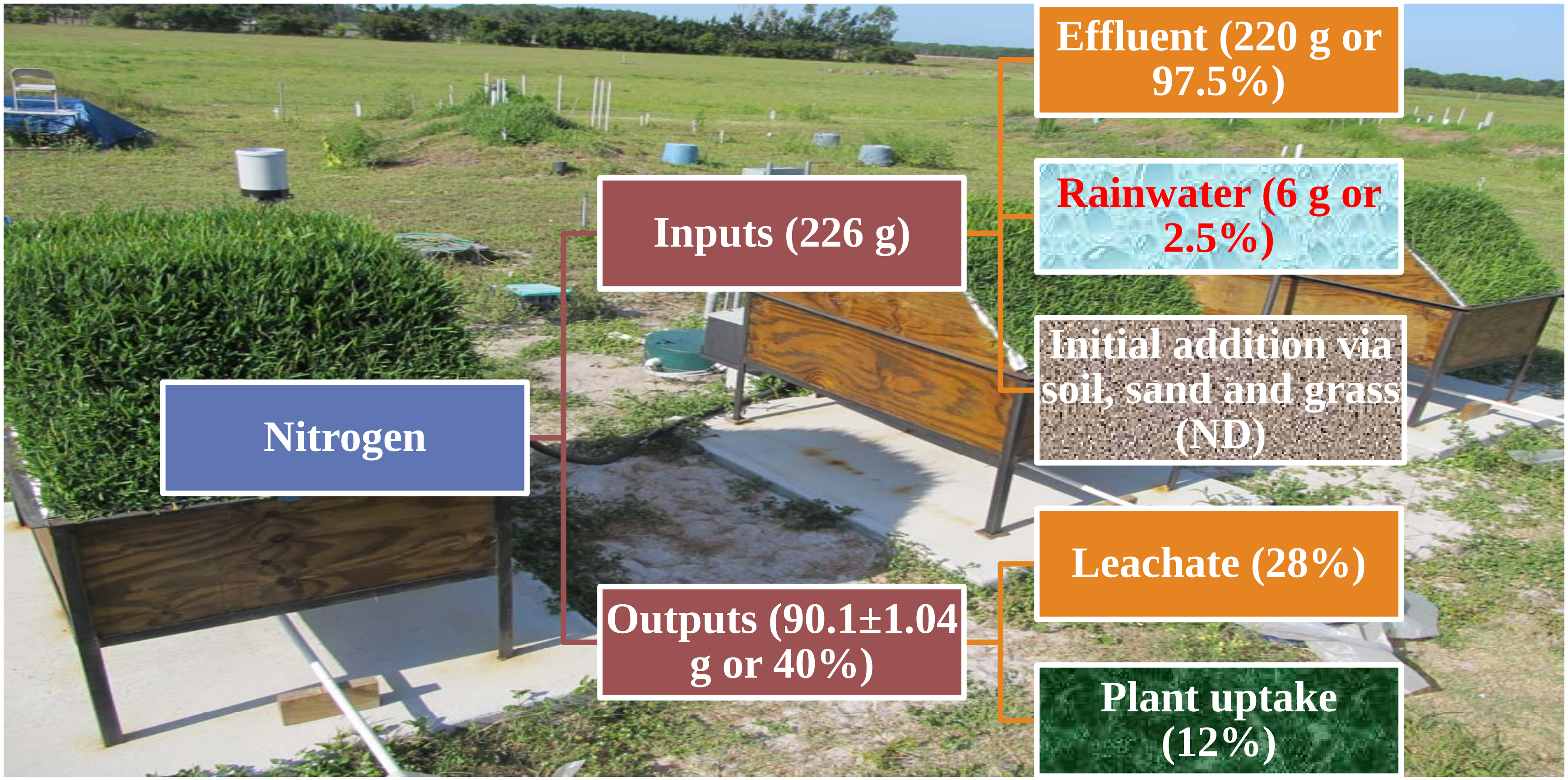
Mass Balance of Chloride
(n = 67; Jan 13 – Jan 14)

Average data of 3 drainfields



Total Nitrogen Budget (Jan 13 – Jan 14)

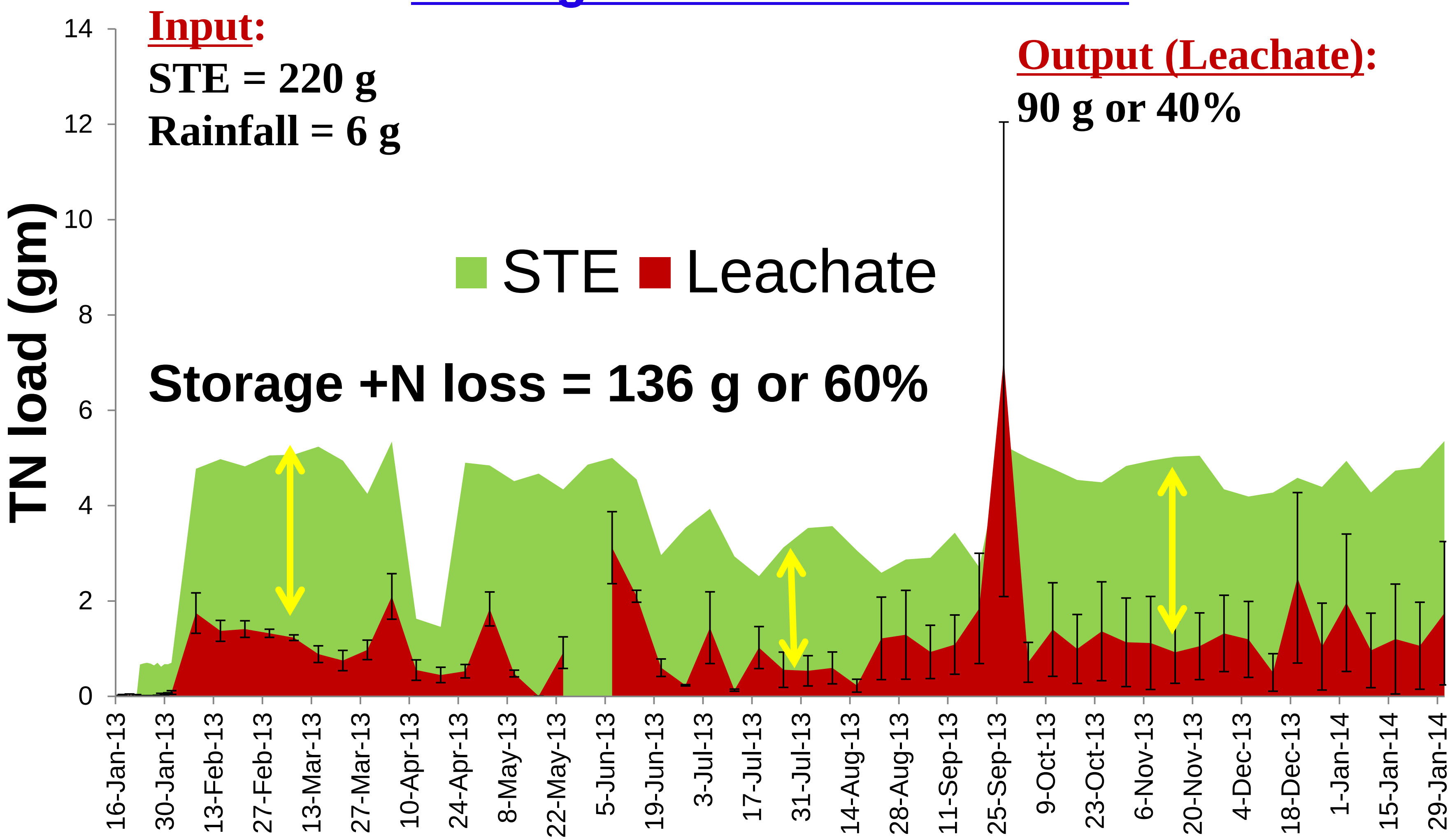
Average data of 3 drainfields



Soil storage + N loss (Denitrification, Anammox) = Input – output = 60%

Mass Balance of Nitrogen (Weekly) (n = 67; Jan 13 – Jan 14)

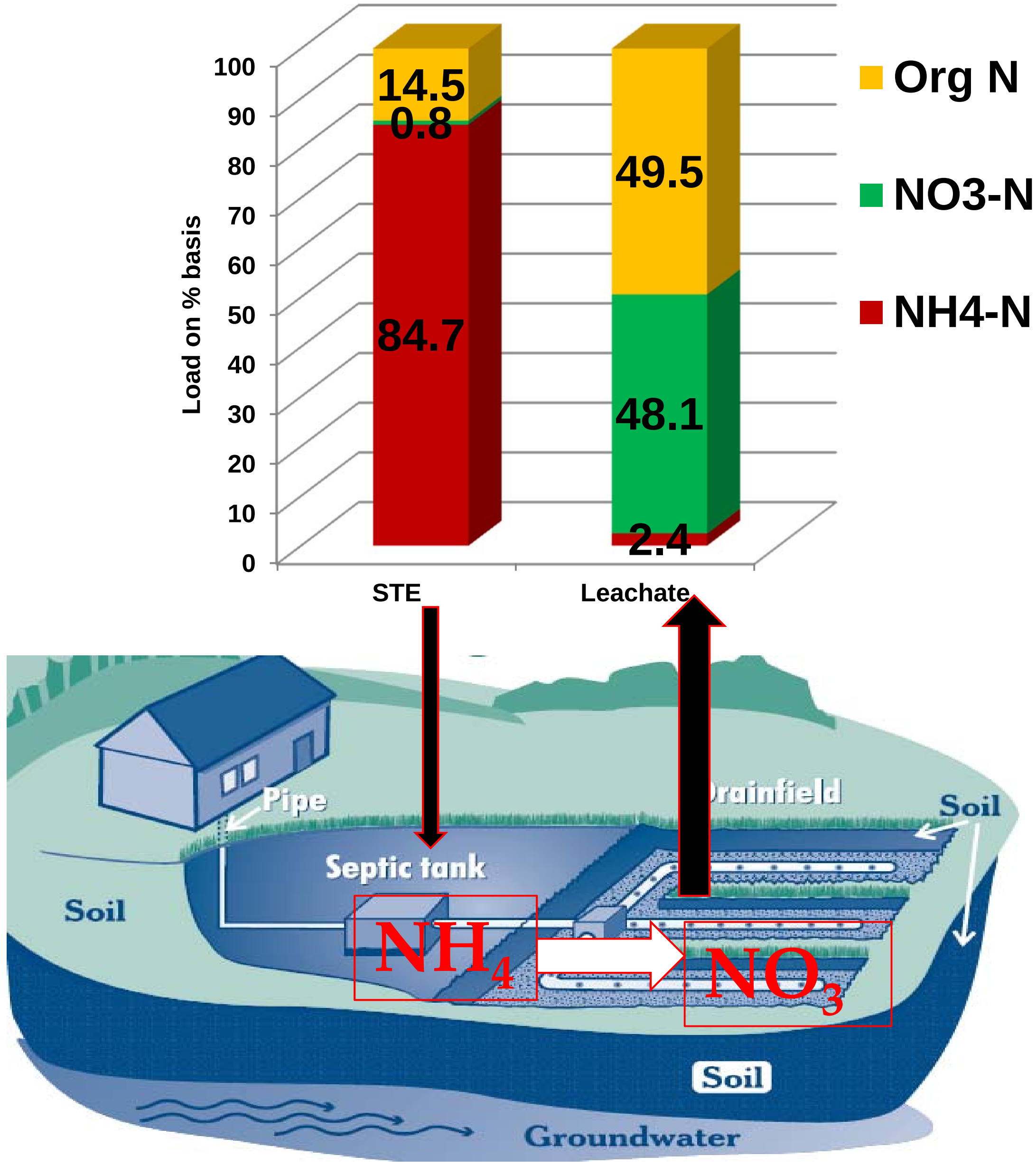
Average data of 3 drainfields



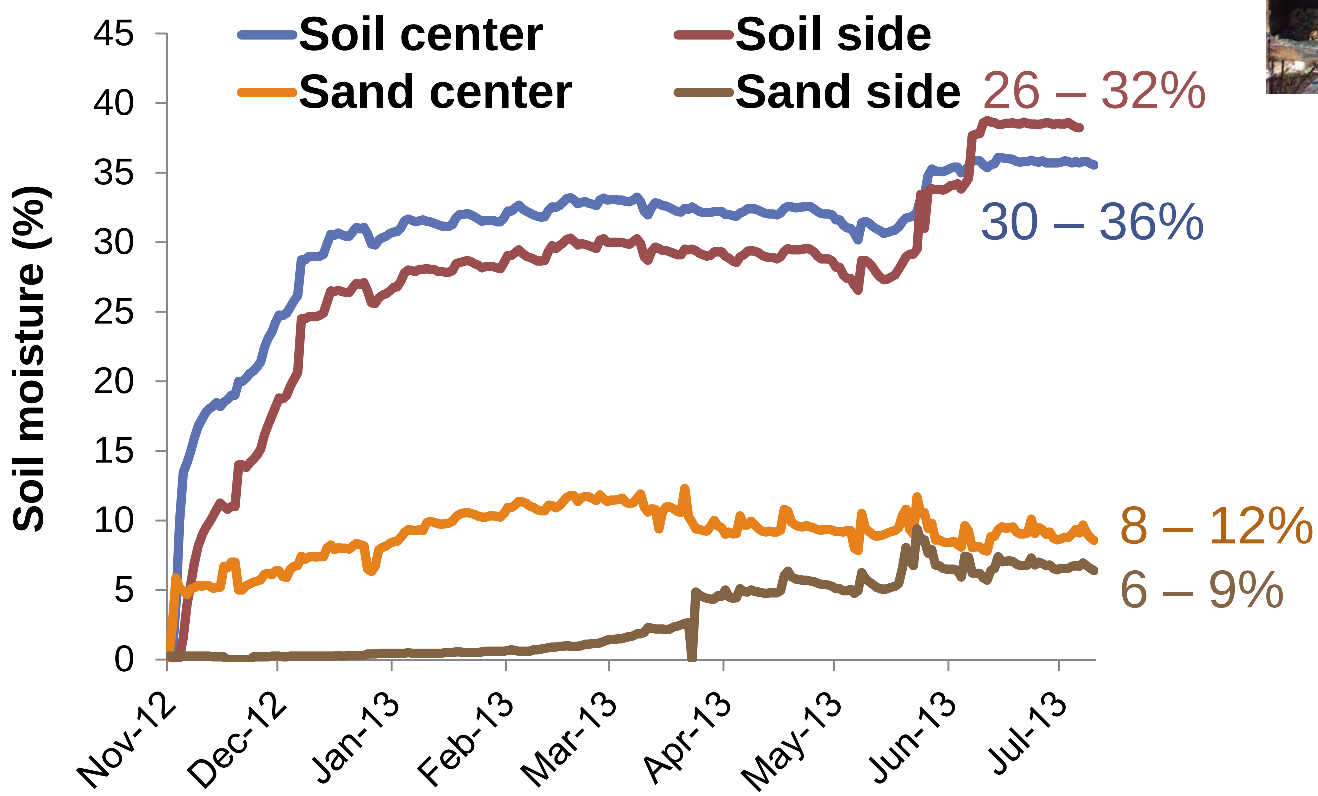
Percent Distribution of N Fractions in STE and Leachate

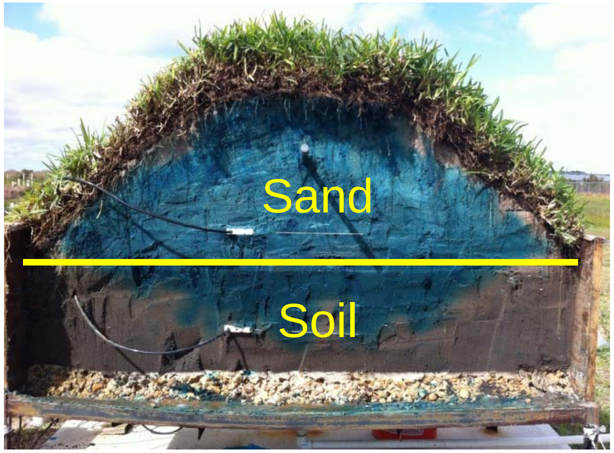
N= 67

- Sand layer contains 6–12% of moisture; *less water, more aerobic*
- Soil layer contains 26–36% of moisture; *more water, less aerobic*



Water Content in Drainfield



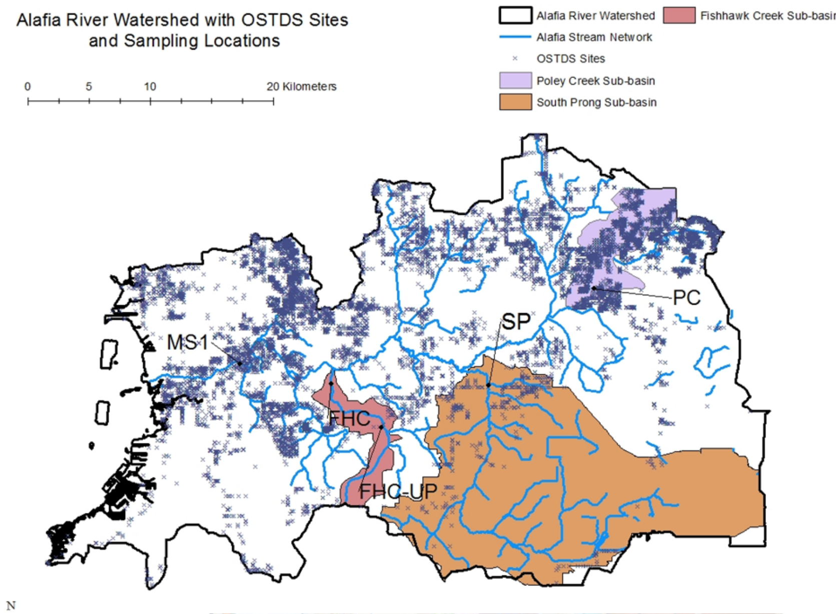


Summary

- **Water balance:**
  - Inputs: STE (59%) >rainfall (40%)
  - Outputs: leachate (47%) >ET (28%)>Soil storage (24%)
- **Chloride balance:**
  - Input: STE (99.5%)
  - Outputs: leachate (63%)>Soil storage (37%)
- **N balance:**
  - Major input: STE (99%)
  - Output: leachate (28%)>Plant uptake (12%)
  - 60% N unaccounted (stored in soil or lost via denitrification and anammox)
  - In leachate, 50% loading of organic N (DON>PON): *source of N in our water bodies?*

Ecological Significance of Organic N?

- Fractionate organic N into molecular groups (in groundwater, surface water, soils): amino acids, amino sugars, etc.
  - ➢ Amino acids are a good proxy variable for bioreactivity
- Sample drainfield soils to assess N pools with varying depths
  - ➢ *Hypothesize* less bioreactive ON (i.e. DON) with depth
  - ➢ *Hypothesize* more PON with depth
  - ➢ *Hypothesize* more NO_3 with depth



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HAZEN AND SAWYER
Environmental Engineers & Scientists

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

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More Talks?

Tomorrow: Track 1-Treatment and Fate of Contaminants

- **1:00 PM:** Fate and Transport of Phosphorus Beneath Mounded Septic Drainfields

- **2:00 PM:** Fate of Pharmaceuticals and Hormones in Mounded Septic Drainfields