Onsite wastewater treatment systems in southern New England:

Nitrogen removal performance, greenhouse gas emissions and climate change woes

Alissa Cox

Bianca Ross

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THE UNIVERSITY OF RHODE ISLAND

Disclaimer

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Special thanks to:

RI DEM

TOWN OF CHARLESTOWN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

MASSTC
The Massachusetts Alternative Septic System Test Center

NEIWPCC
New England Interstate Water Pollution Control Commission

BCDHE
Barnstable County Department of Health and Environment
Promote - Protect - Support
90 YEARS OF SERVICE
1926 - 2016

THE UNIVERSITY OF RHODE ISLAND

Who are we?

Laboratory of Soil Ecology & Microbiology @ URI

- **Jose Amador**, Principal Investigator
- **George Loomis**, Director of New England Onsite Wastewater Training Program

- PhD Students:
  - **Alissa Cox**
  - **Bianca Ross**
  - **Sara Wigginton**

Protecting Southern New England's Coasts

Protecting humans and the environment from OWTS

Narragansett, RI algal blooms
Caused by N pollution

N-removal I&A Technologies

N-removal Soil Treatment Areas

Monitoring N Removal

Protecting Southern New England's Coasts

Protecting OWTS from Coastal Hazards

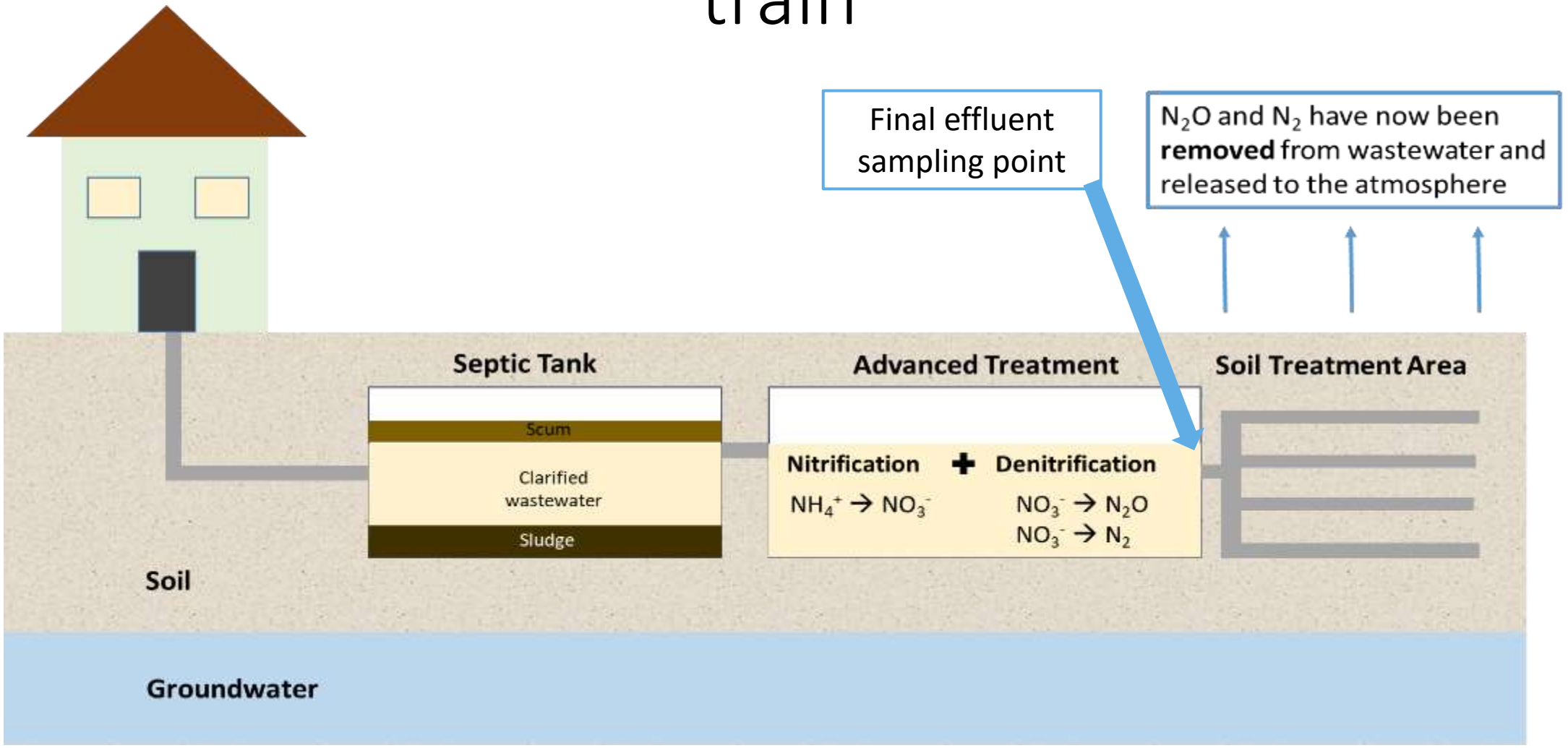
Rising Groundwater

Coastal Storms

Assessing Nitrogen-removal performance of Advanced Onsite Wastewater Treatment Systems in Charlestown

Bianca Ross

Advanced OWTS: Nitrogen removal treatment train



Project Description

- **46 study sites** in Charlestown, RI
  - **27 seasonally-occupied** – sampled 4 times throughout the summer
  - **23 year-round** – sampled quarterly throughout the year

- Field and lab analyses on final effluent to assess **system performance and N-removing effectiveness**

- **Optimize N removal**

Technologies

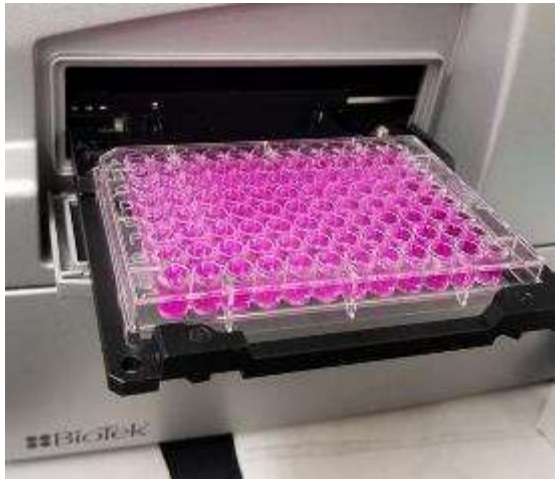
- Orenco Advantex® AX20 and RX30
- Biomicrobics MicroFAST®
- Norweco Singulair® models TNT, 960, and DN
  - Grouped all Norweco systems for statistical analyses

Sample Collection and Processing

Arrive at field site

Collect final effluent sample

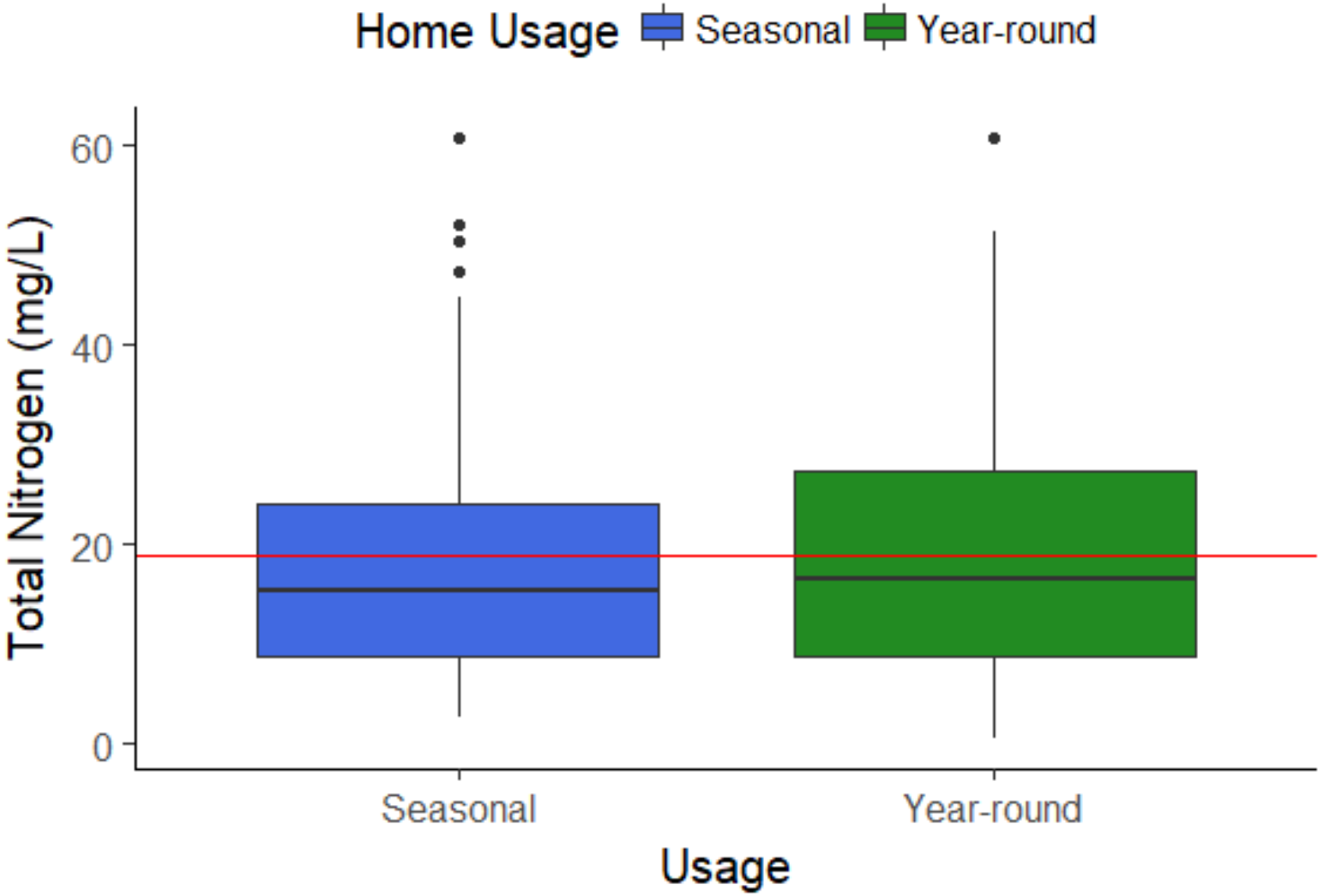
Field analysis (pH, DO, temperature, NH_4^+, and NO_3^-)



Standard lab analysis (BOD, pH, alkalinity, TN, NH_4^+, and NO_3^-)

Total Nitrogen Analysis

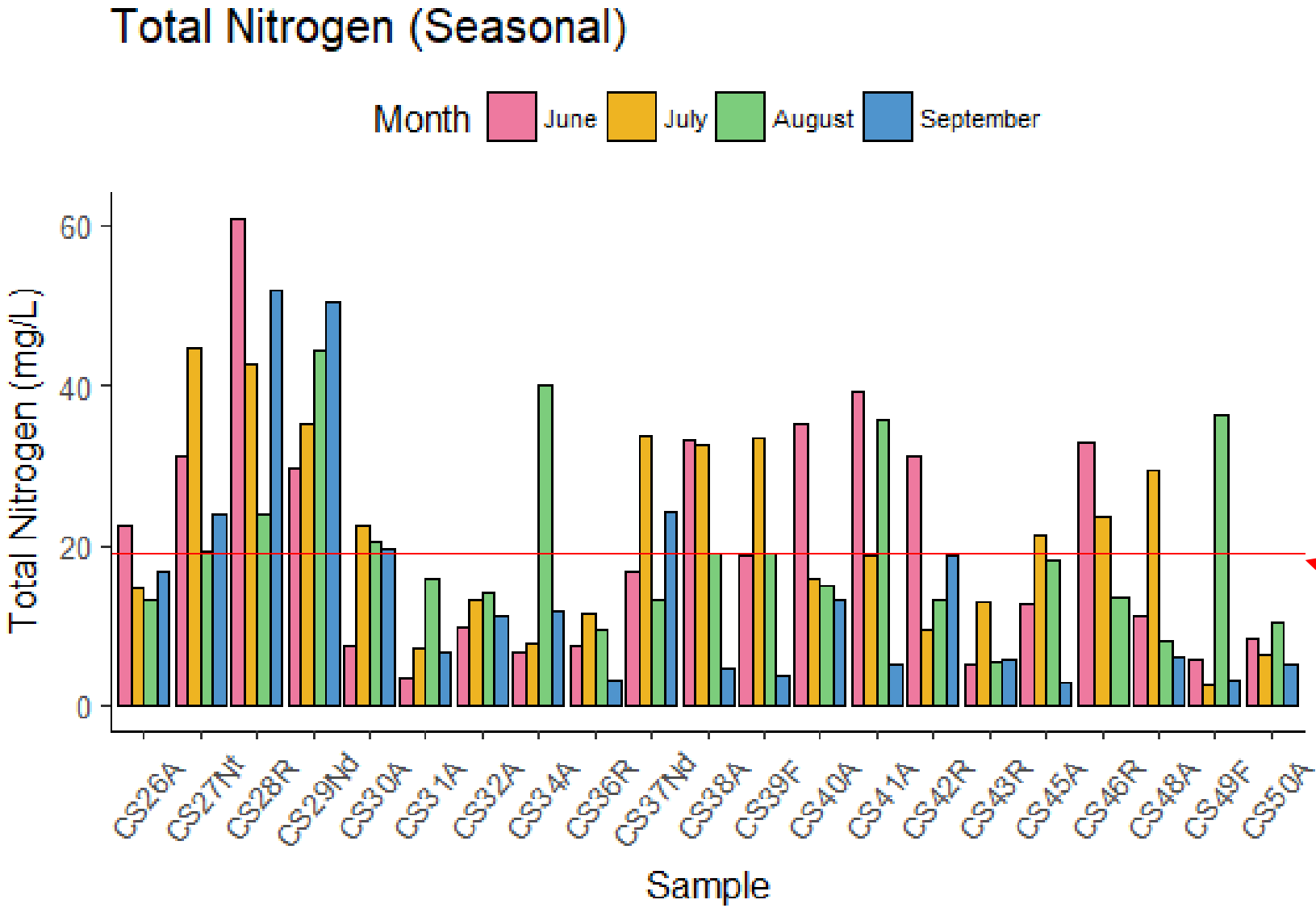
Total Nitrogen vs. Home Usage



Home usage: not significant

19 mg/L RIDEM standard

Total Nitrogen: Seasonal Start-up Time?



Home usage is **not** influencing performance

Sample Code Key:

A = AX20

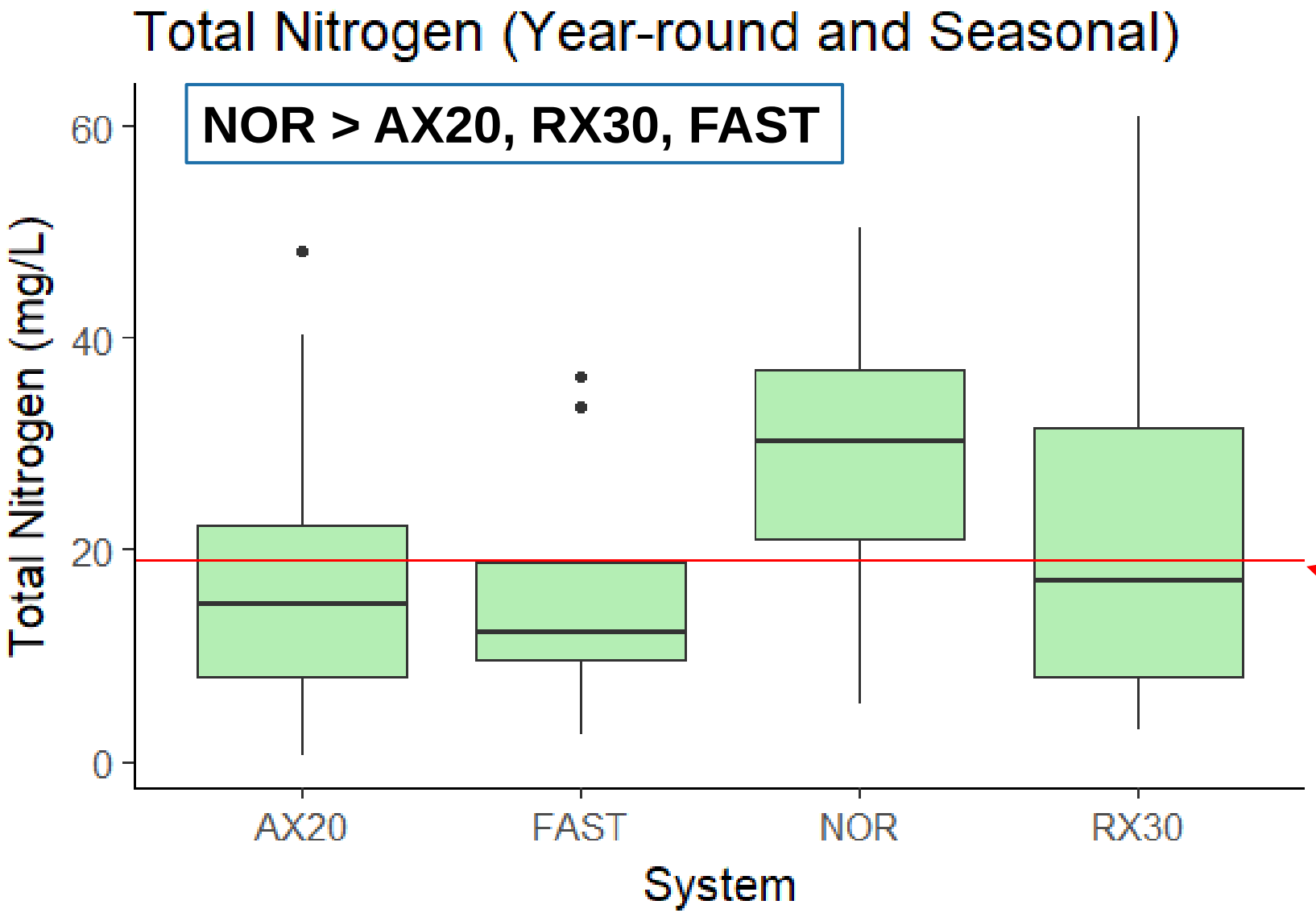
R = RX30

F = FAST

Nt/Nd = Norweco

19 mg/L RIDEM standard

Total Nitrogen vs. Technology Type



Technology type: significant

So far…

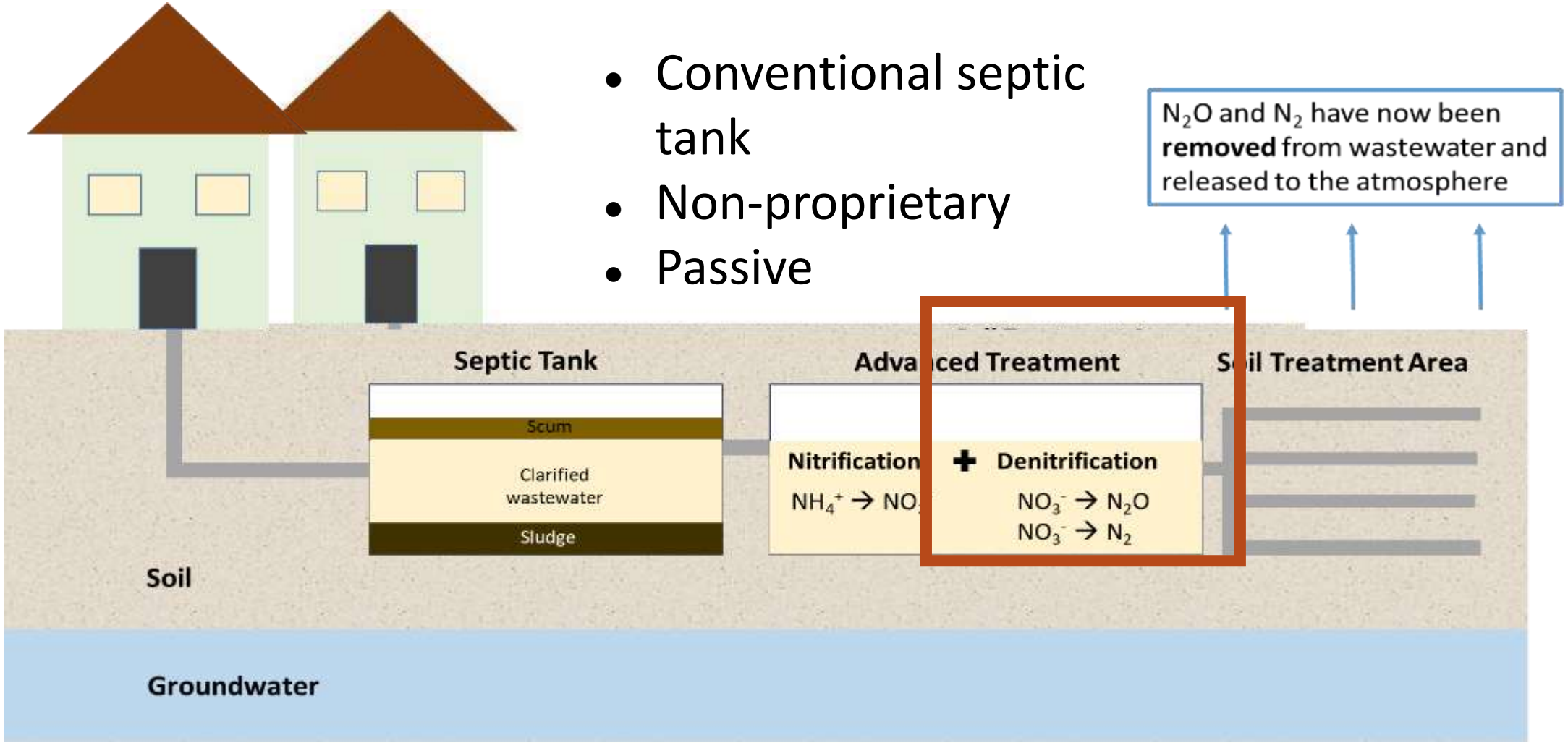
- Technology type does influence effluent total nitrogen concentrations
- BOD_5, alkalinity, ammonium, and total nitrogen data suggest that Norweco systems don't appear to be nitrifying sufficiently
- Home usage does not influence effluent nitrogen concentrations
  - No start-up time

Assessing performance and greenhouse gas emissions from a passive, nitrogen-removing septic system soil treatment area

Sara Wigginton

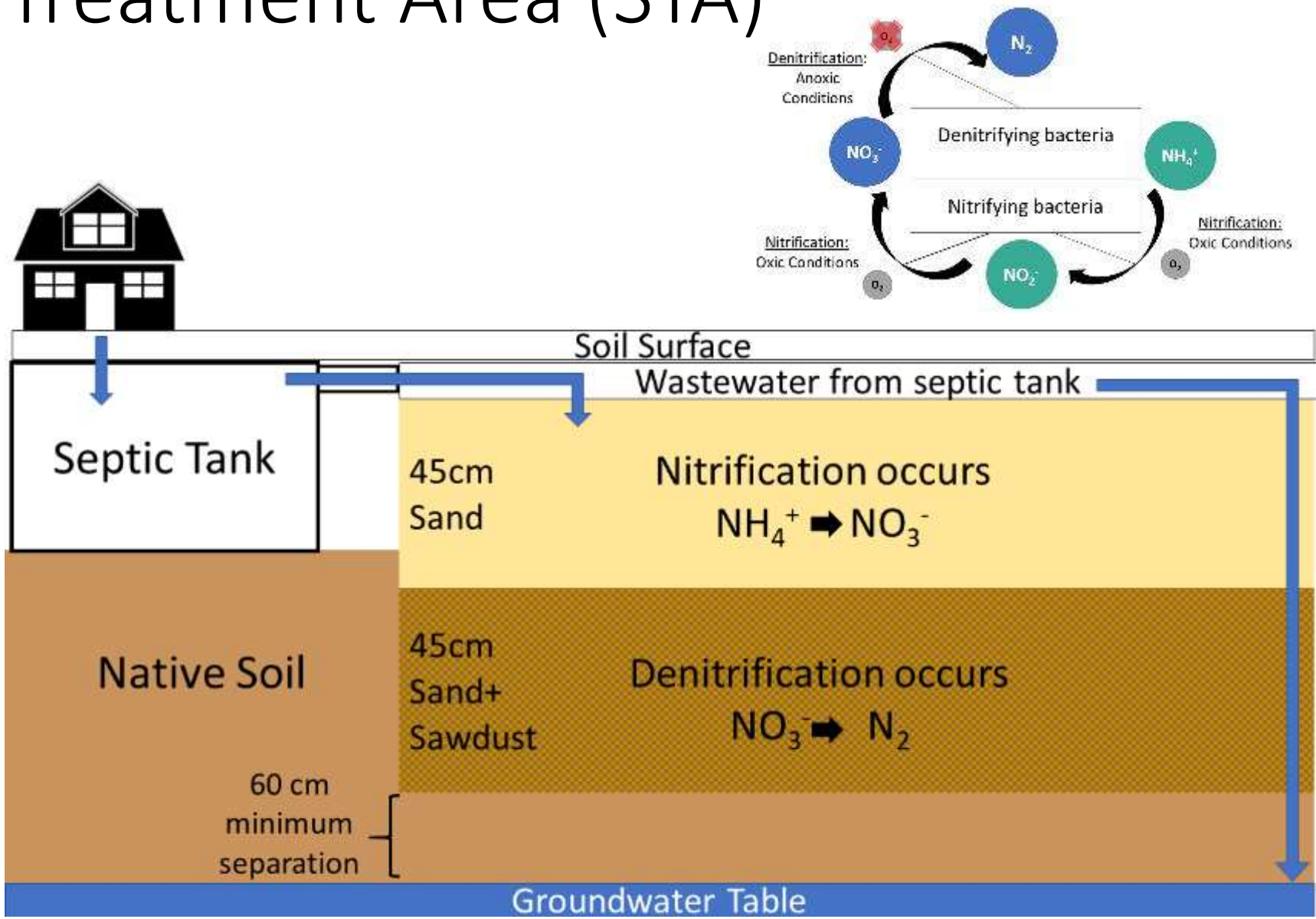
Advanced OWTS: Nitrogen removal treatment train in the STA

- Conventional septic tank
- Non-proprietary
- Passive



N-removing Soil Treatment Area (STA)

- Promotes nitrification in the top layer and denitrification in the lower layer.
- Sawdust amended sand gives microbes a **carbon source** and keeps bottom layer **saturated**



Research objectives:

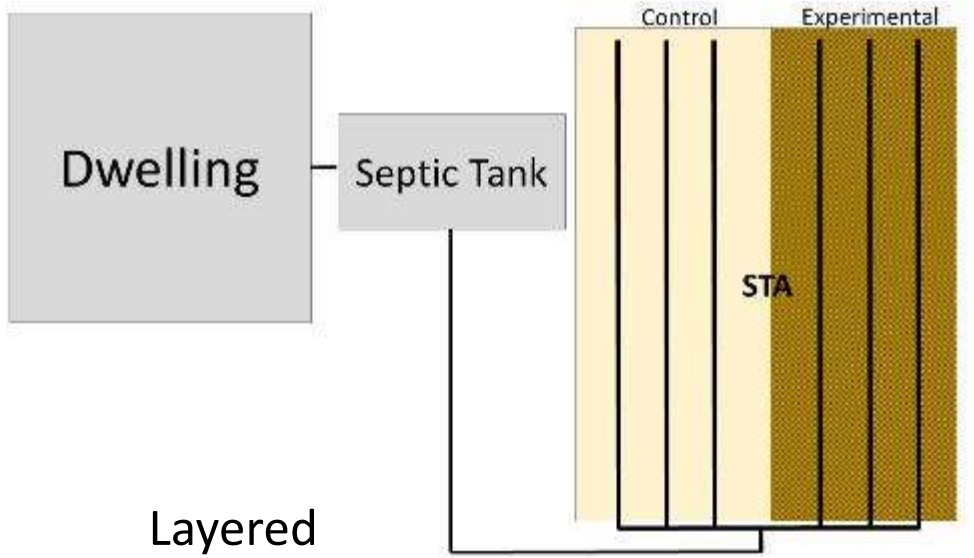
Assess N removal performance of layered soil treatment areas

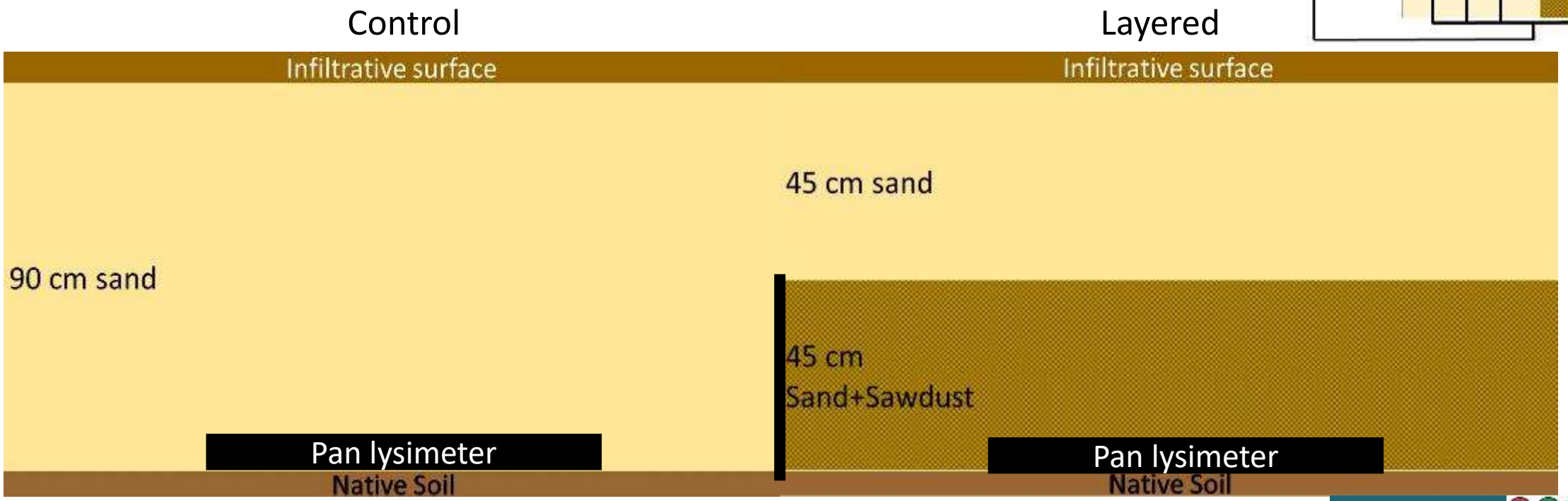
"Are layered systems meeting N removal regulation standards?"

Assess greenhouse gas emissions from layered soil treatment areas

"Are layered systems impacting air quality?"

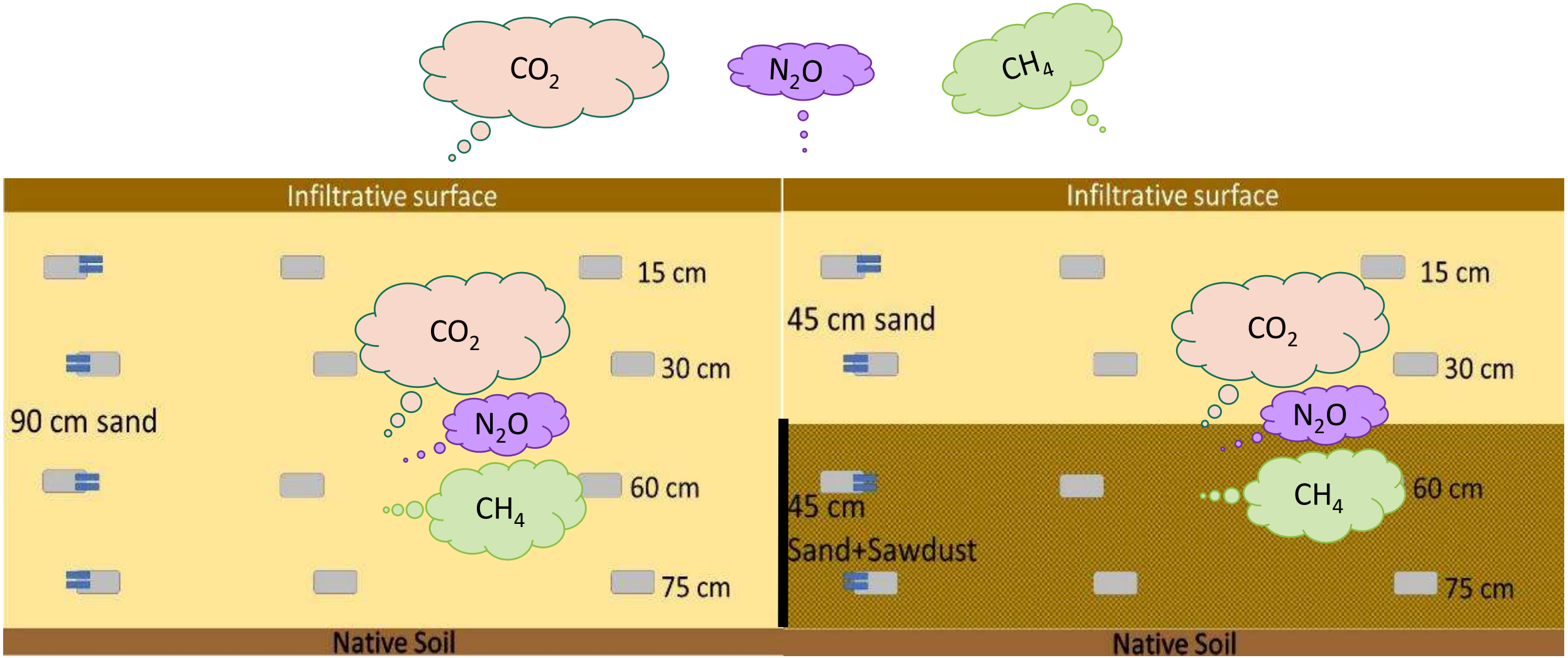
Layered Soil Treatment Areas: *Experimental Design*





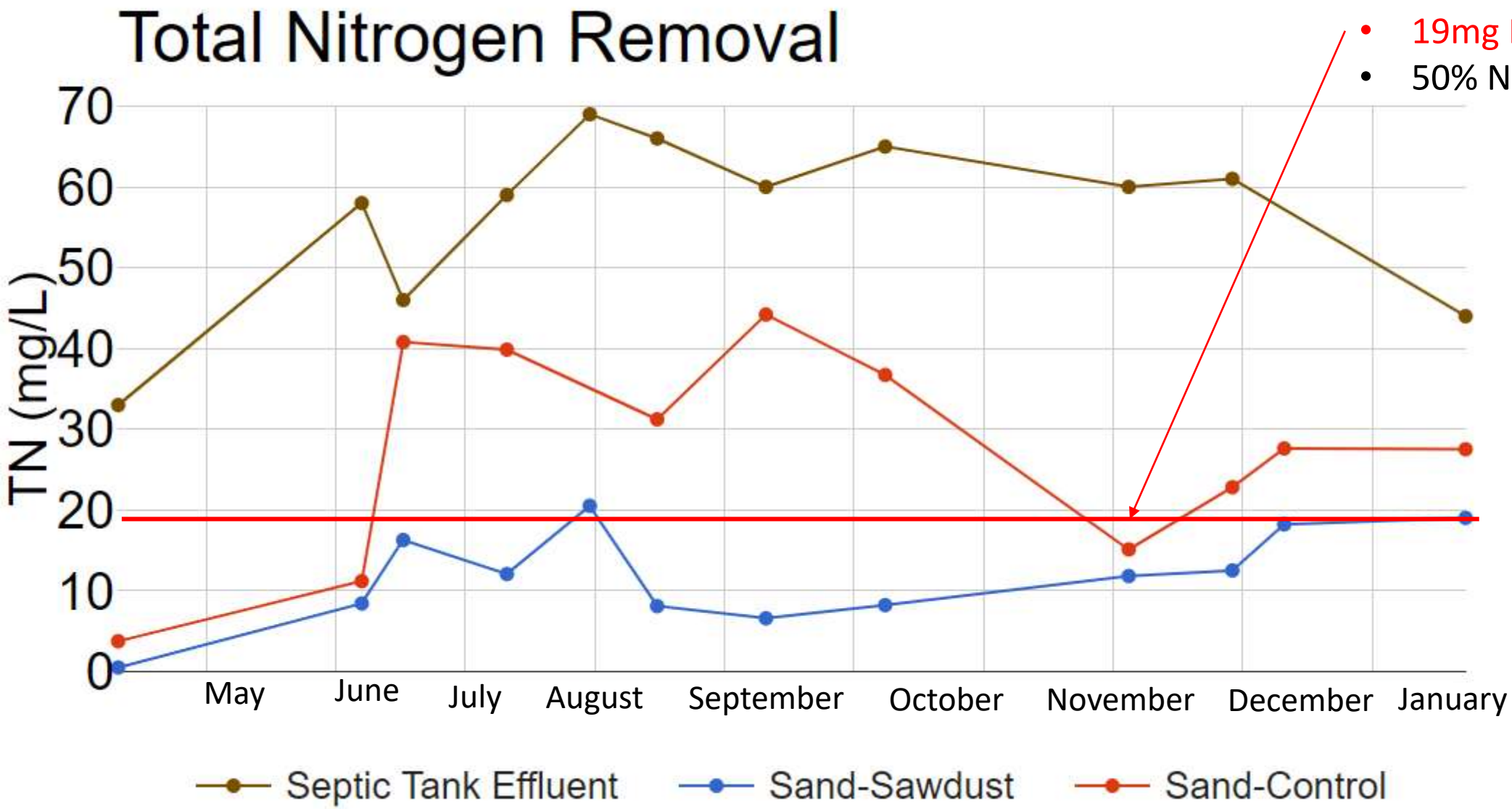
(Cross section)

Monitoring GHG emissions in Layered STAs: *Methods*



Massachusetts regulations:

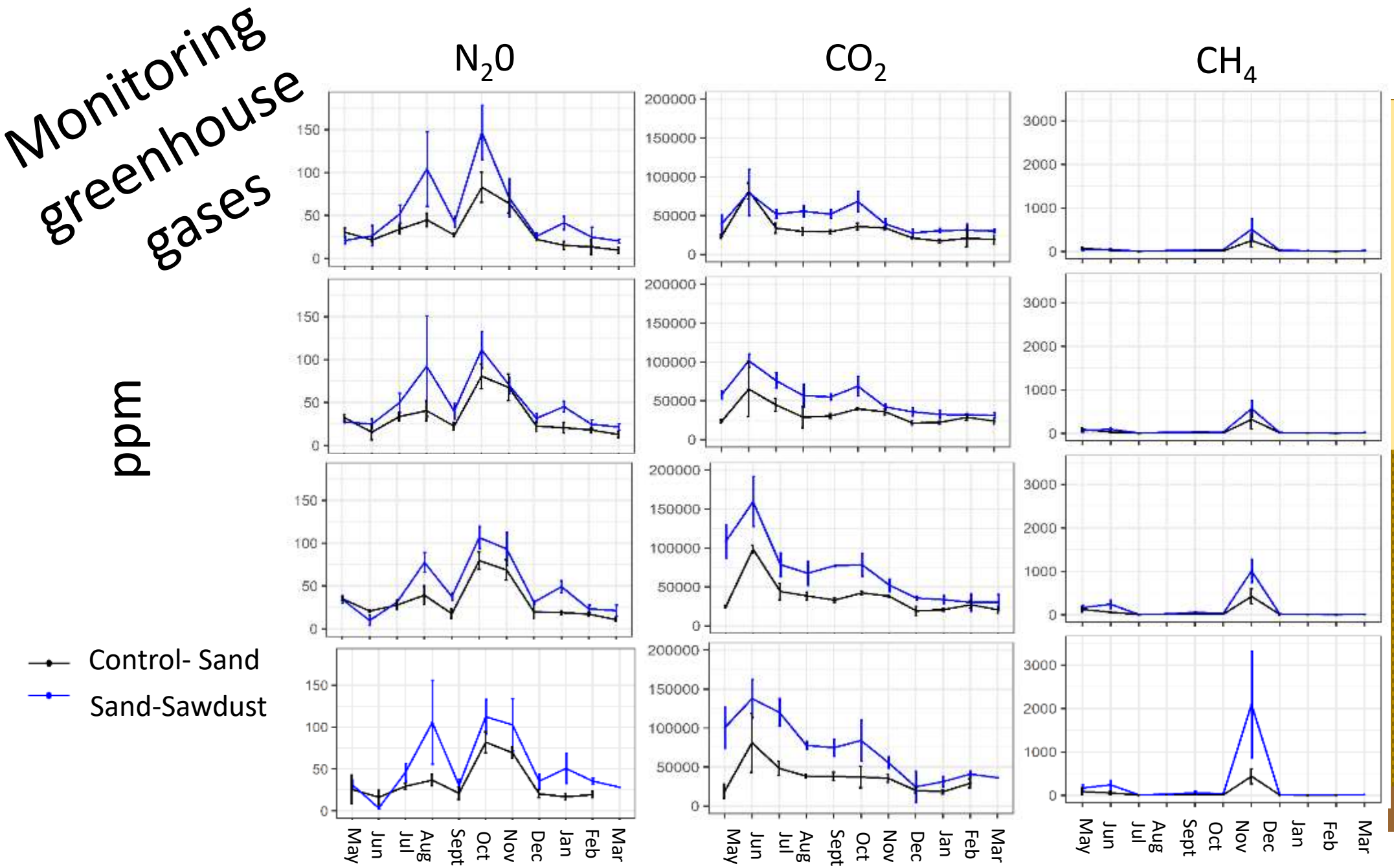
- 19mg N/L in effluent
- 50% N removal



%N removal from Layered STA: 65-98%

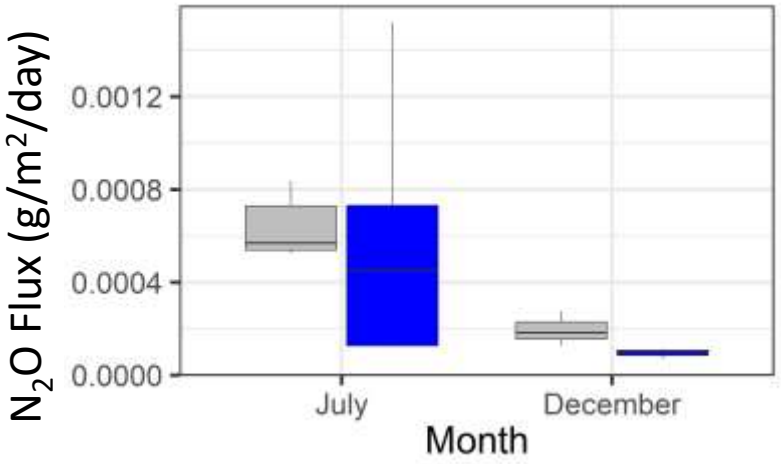
%N removal from Control STA: 11-88%

Monitoring greenhouse gases

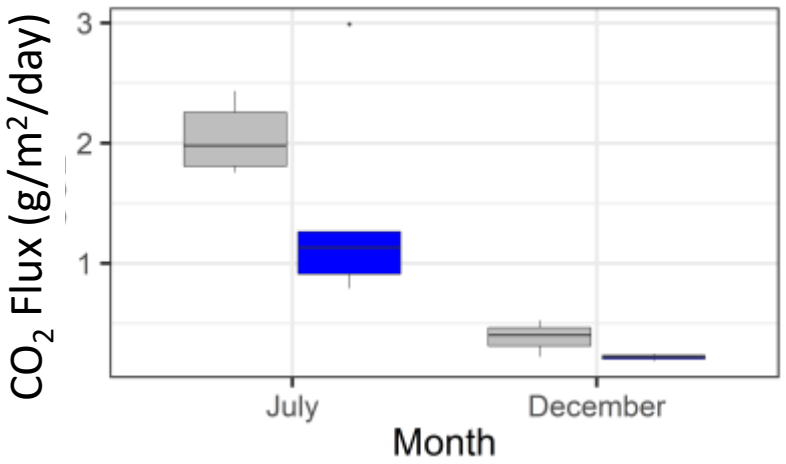


Monitoring emissions at the soil surface

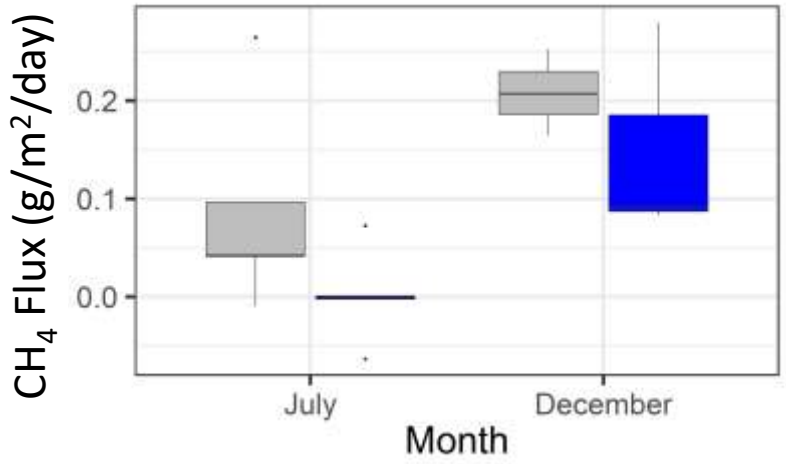
N_2O Flux



CO_2 Flux



CH_4 Flux



Control- Sand

Sand-Sawdust

Layered Soil Treatment Areas: *Findings*

- Layered STA removes N more consistently than control
  - Layered STA meets Massachusetts regulations in 100% of samples
  - Control STA meeting standards in less than 40% of samples
- Layered STA produced more GHGs than control below the surface

BUT…

- Layered STA emitted less GHGs to the atmosphere

Monitoring OWTS: Photometer

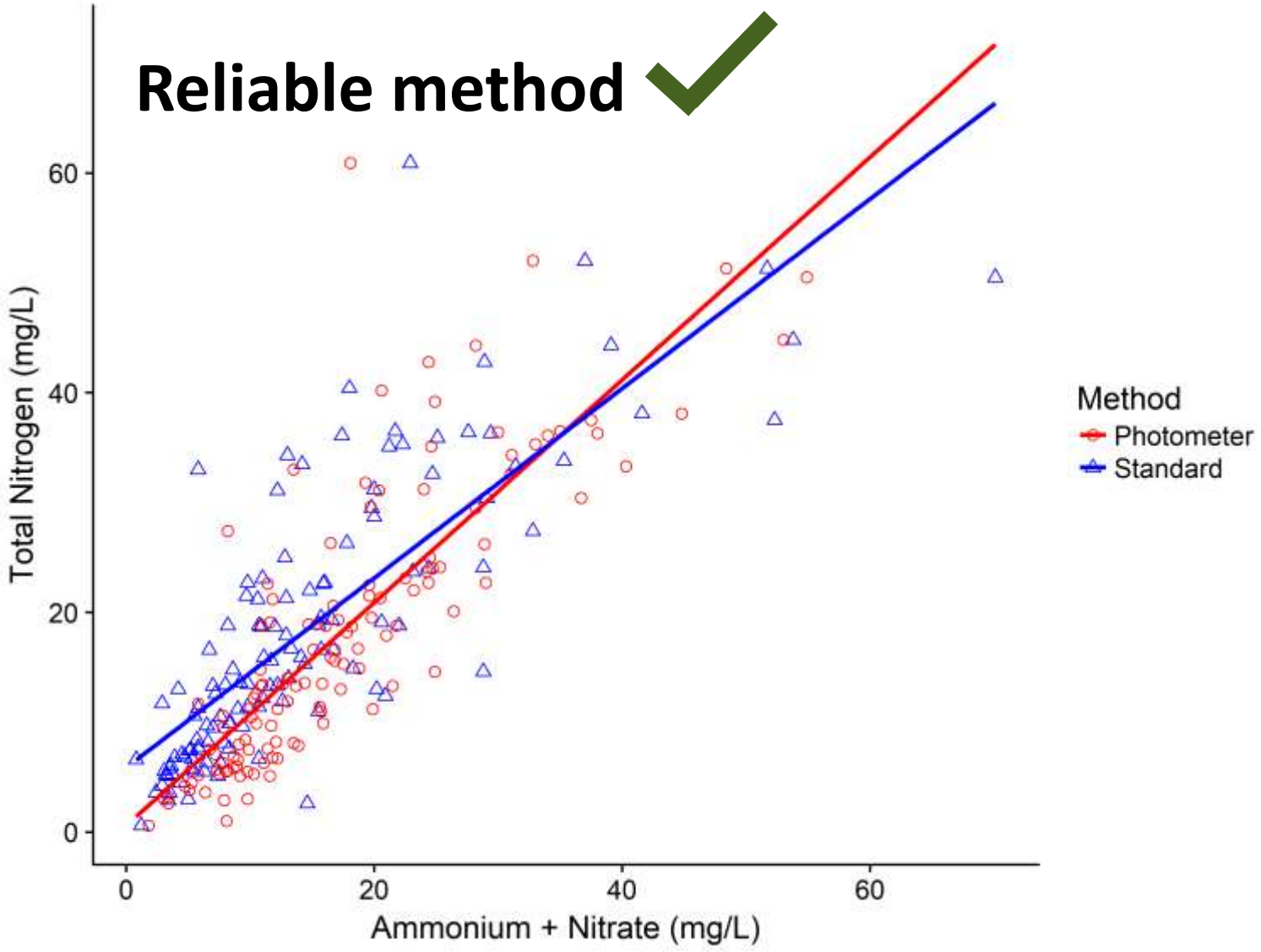
Bianca Ross

Photometer

- Colorimetric reaction measures ammonium and nitrate concentrations
- Total Nitrogen = Ammonium + Nitrate + Organic Nitrogen
- Can the photometer estimate total nitrogen concentrations?
  - Photometer vs. Standard Methods

Sum of Ammonium and Nitrate vs. Total Nitrogen

Reliable method ✓



Standard methods:

Slope = 0.86

Y-intercept = 5.7

R^2 = 0.64

$p < 0.001$

Photometer:

Slope = 1.01

Y-intercept = 0.62

R^2 = 0.68

$p < 0.001$

Summary

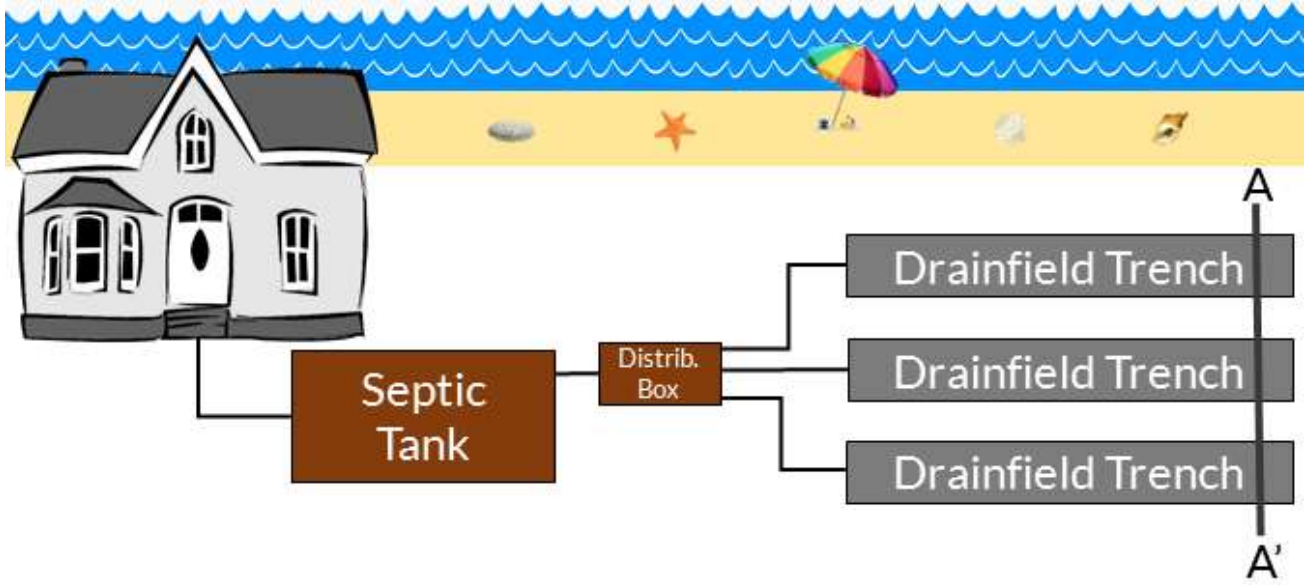
- Fast method that provides nearly immediate results
- Can be used in an outdoor and indoor setting
- Cost-effective
- Reliable “triage” method for identifying underperforming systems

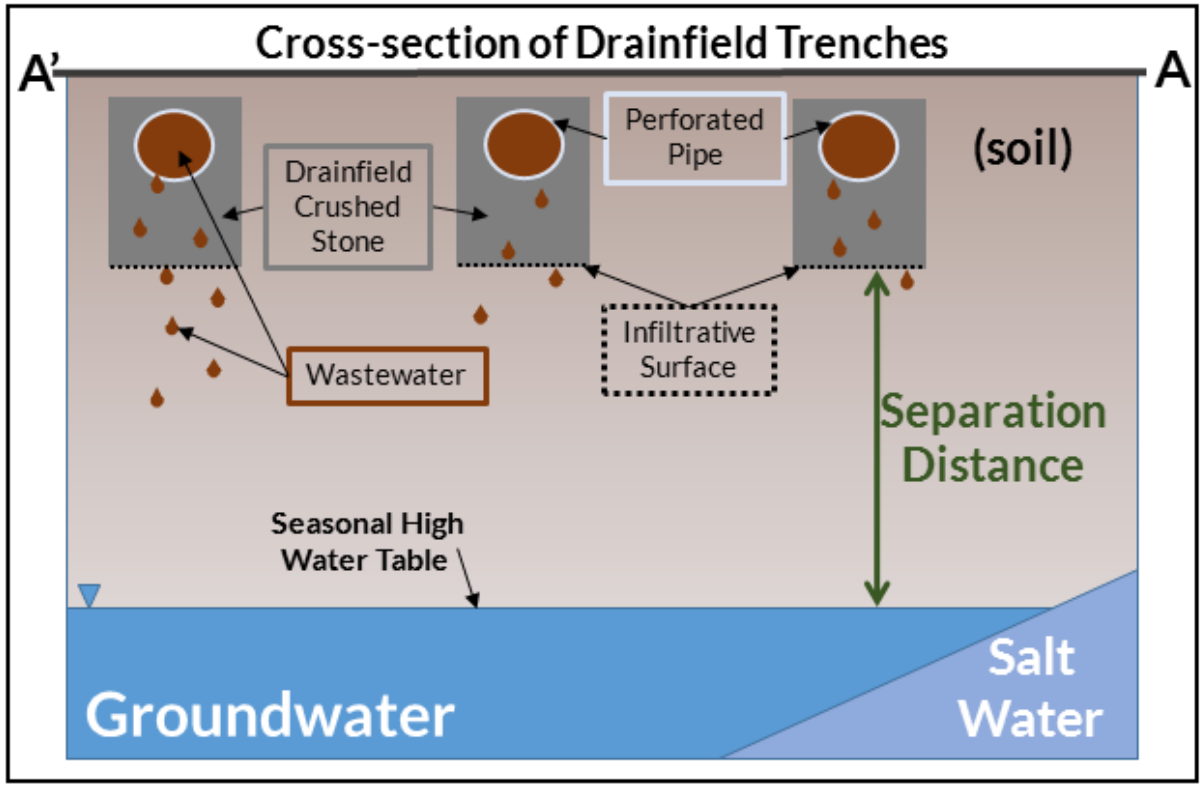
Dual threats to systems along the coast…

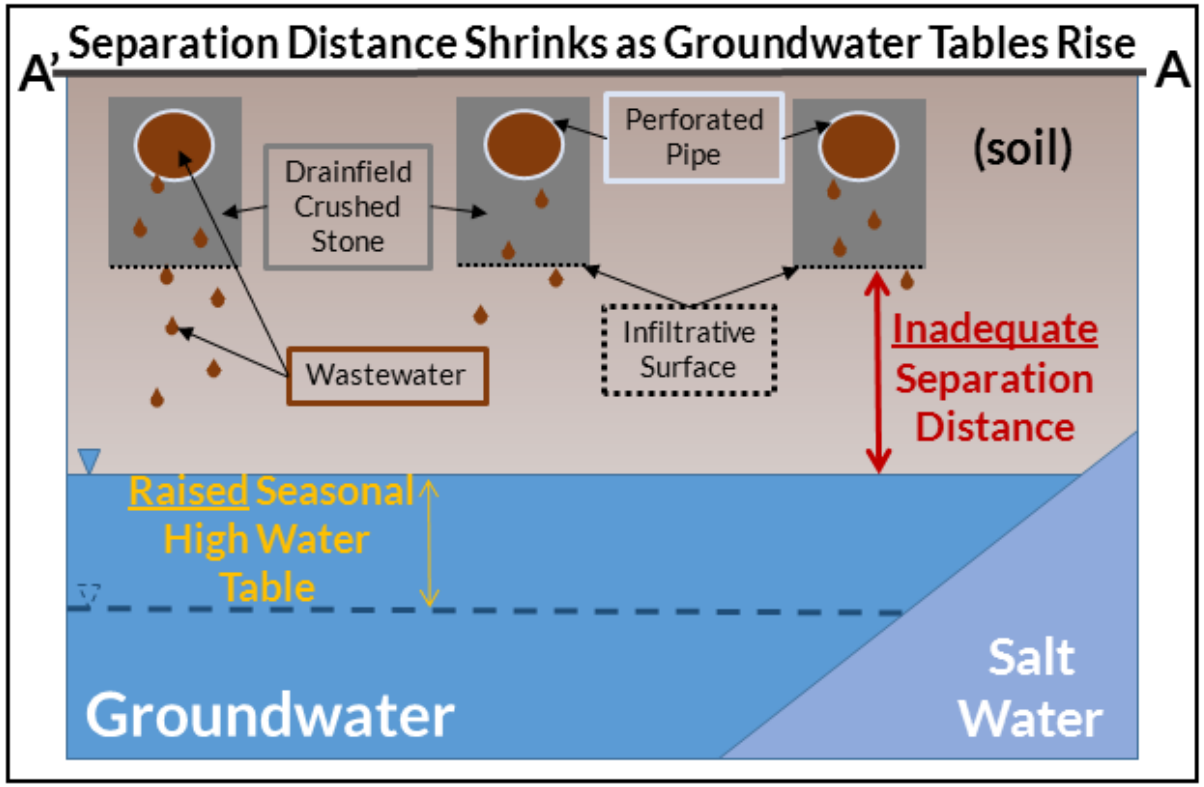
Alissa Cox


Coastal OWTS
Rising groundwater tables
Coastal storms

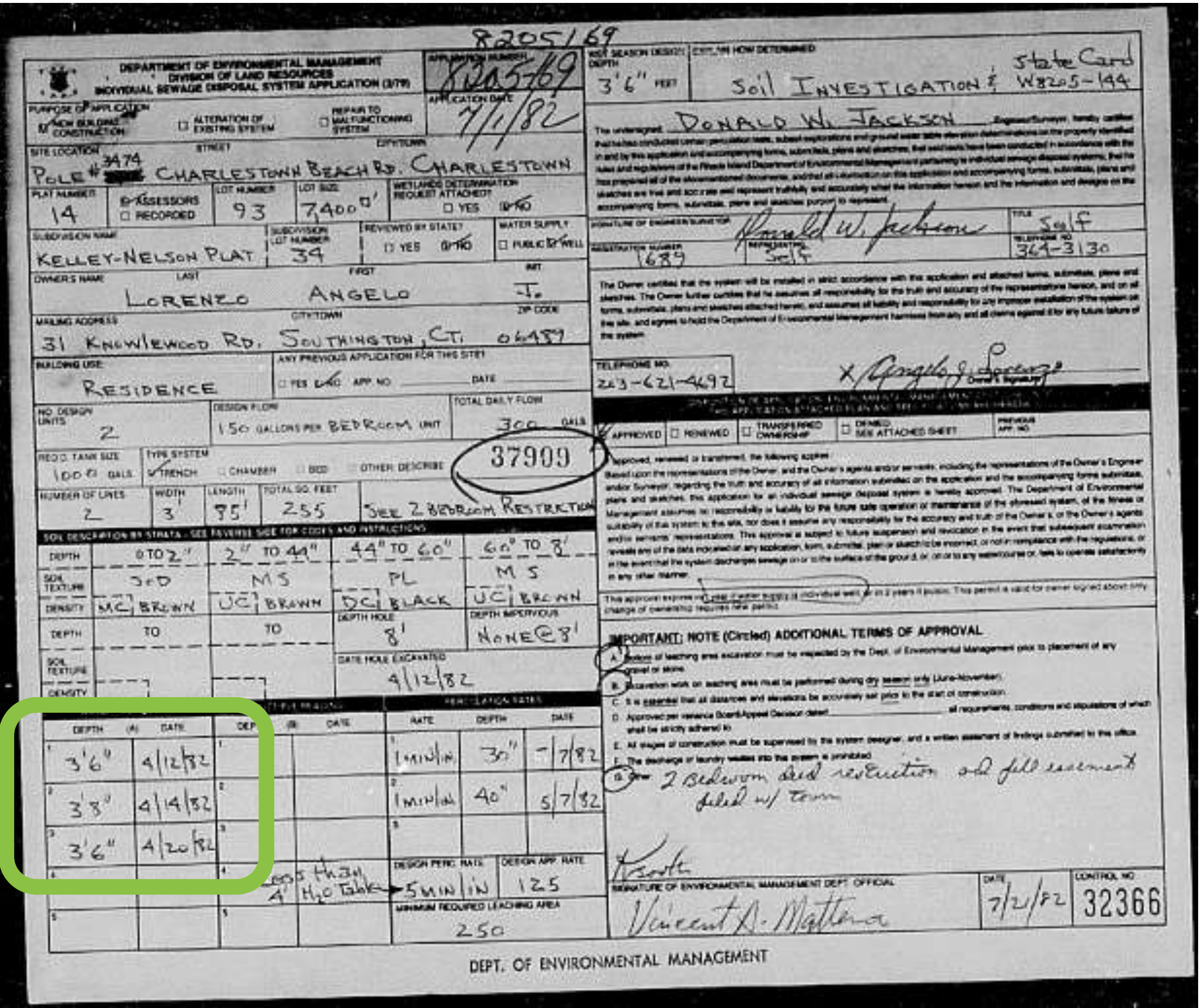
Coastal OWTS







Coastal groundwater tables in southern RI


DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
DIVISION OF LAND RESOURCES
INDIVIDUAL SEWAGE DISPOSAL SYSTEM APPLICATION

8205/69
APPLICATION NUMBER: 8205-69
APPLICATION DATE: 7/1/82
WET SEASON DESIGN DEPTH: 3' 6" FEET
HOW DETERMINED: Soil INVESTIGATION & State Card W8205-144
SITE LOCATION: POLE # 3474 CHARLESTOWN BEACH RD. CHARLESTOWN
PLAT NUMBER: 14
LOT NUMBER: 93
LOT SIZE: 7400□'
SUBDIVISION NAME: KELLEY-NELSON PLAT
LOT NUMBER: 34
OWNER'S NAME: LORENZO ANGELO JR.
MAILING ADDRESS: 31 KNOWLEWOOD RD. SOUTHINGTON, CT. 06489
BUILDING USE: RESIDENCE
NO. DESIGN UNITS: 2
DESIGN FLOW: 150 GALLONS PER BEDROOM UNIT
TOTAL DAILY FLOW: 300 GALS
REQ'D TANK SIZE: 1000 GALS
TYPE SYSTEM: TRENCH
NUMBER OF LINES: 2
WIDTH: 3'
LENGTH: 75'
TOTAL SQ. FEET: 225
SEE 2 BEDROOM RESTRICTION
37909
The undersigned DONALD W. JACKSON
REGISTRATION NUMBER: 1689
TITLE: Self
TELEPHONE: 364-3130
TELEPHONE NO.: 203-621-4692

DEPTH	0 TO 2"	2" TO 44"	44" TO 60"	60" TO 8'
SOIL TEXTURE	SOD	MS	PL	MS
DENSITY	MC BROWN	UC BROWN	DC BLACK	UC BROWN

DEPTH HOLE: 8'
DEPTH IMPERVIOUS: NONE @ 8'
DATE HOLE EXCAVATED: 4/12/82

DEPTH	DATE
3'6"	4/12/82
3'3"	4/14/82
3'6"	4/20/82

Less than 4' H₂O Table

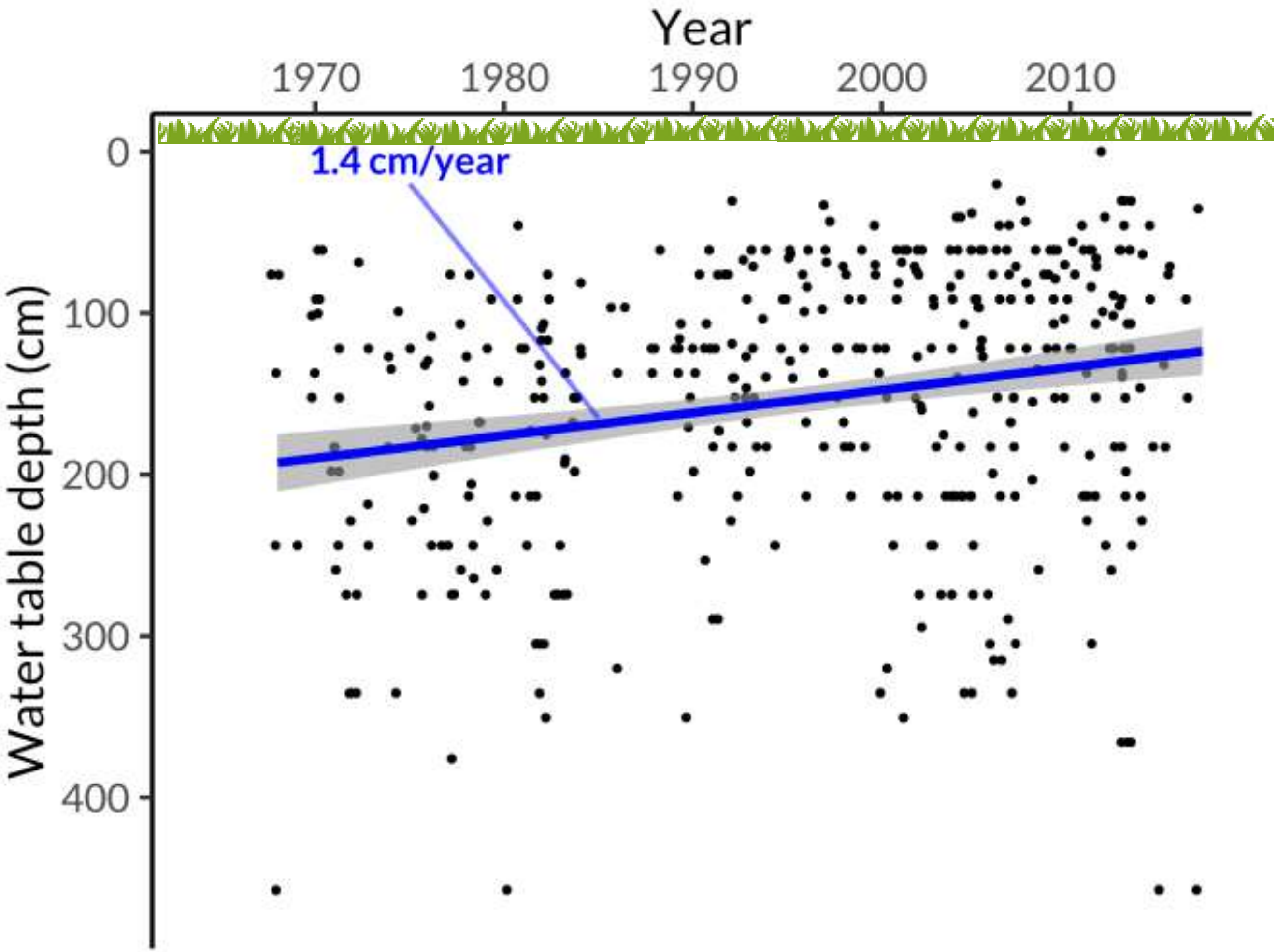
RATE	DEPTH	DATE
1 MIN/IN	30"	7/7/82
1 MIN/IN	40"	5/7/82

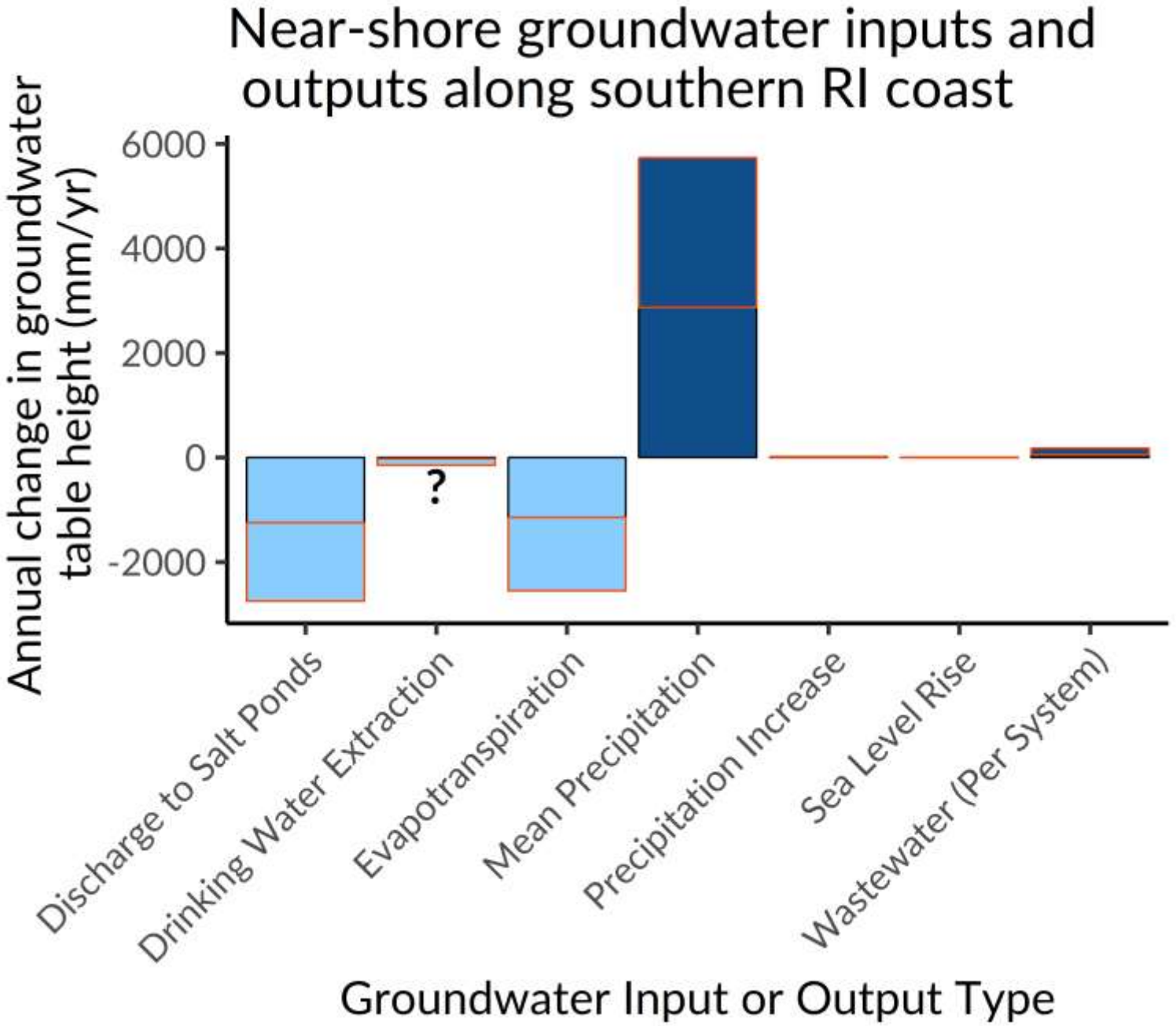
DESIGN PERC. RATE: 5 MIN/IN
DESIGN APP. RATE: 1.25
MINIMUM REQUIRED LEACHING AREA: 250

IMPORTANT: NOTE (Circled) ADDITIONAL TERMS OF APPROVAL
2 Bedroom deed restriction and fill easement filed w/ town

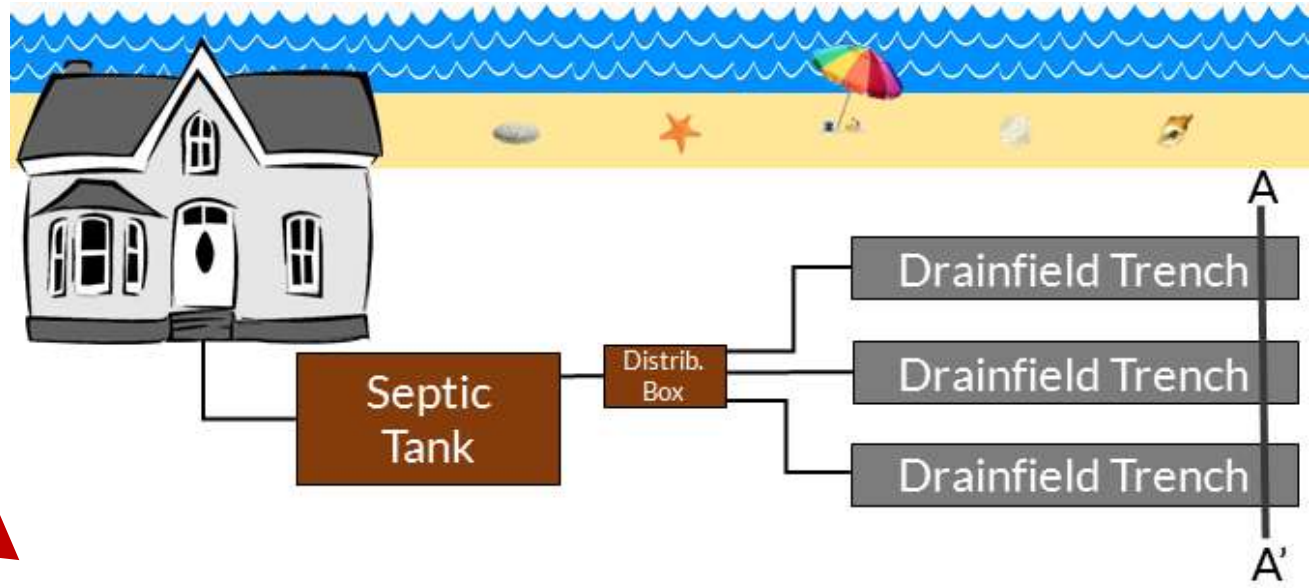
SIGNATURE OF ENVIRONMENTAL MANAGEMENT DEPT. OFFICIAL
DATE: 7/2/82
CONTROL NO.: 32366
DEPT. OF ENVIRONMENTAL MANAGEMENT

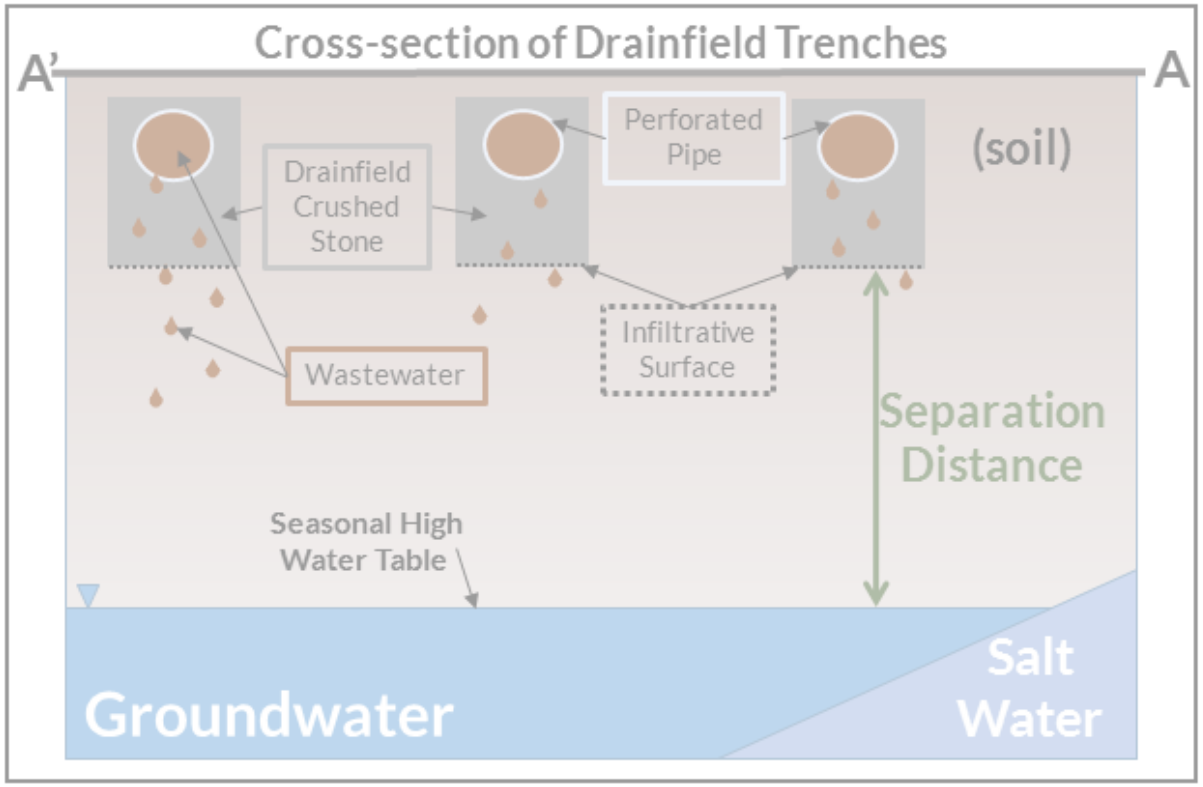
Near-shore groundwater tables along southern RI coast are rising

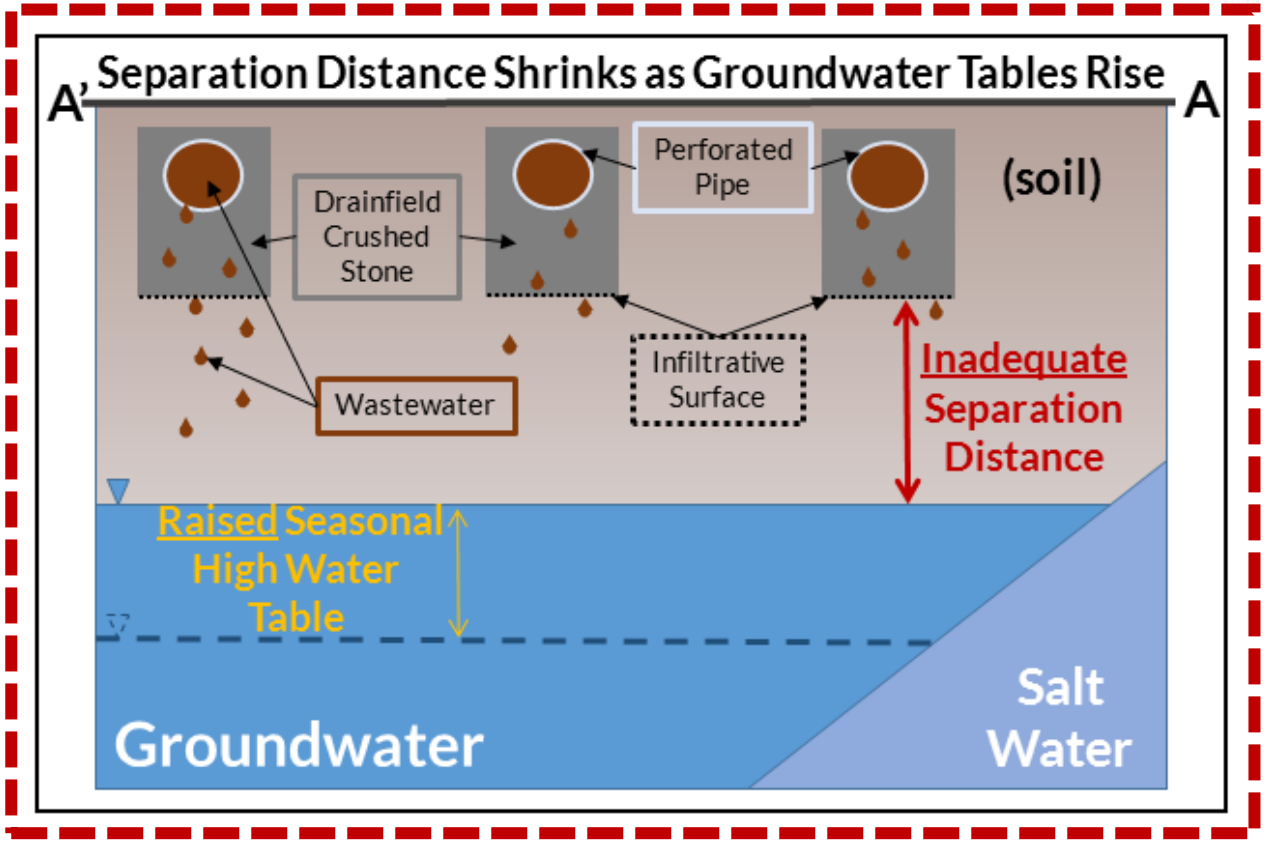



Near-shore groundwater inputs and outputs along southern RI coast
Annual change in groundwater table height (mm/yr)
6000
4000
2000
0
-2000
?
Discharge to Salt Ponds
Drinking Water Extraction
Evapotranspiration
Mean Precipitation
Precipitation Increase
Sea Level Rise
Wastewater (Per System)
Groundwater Input or Output Type

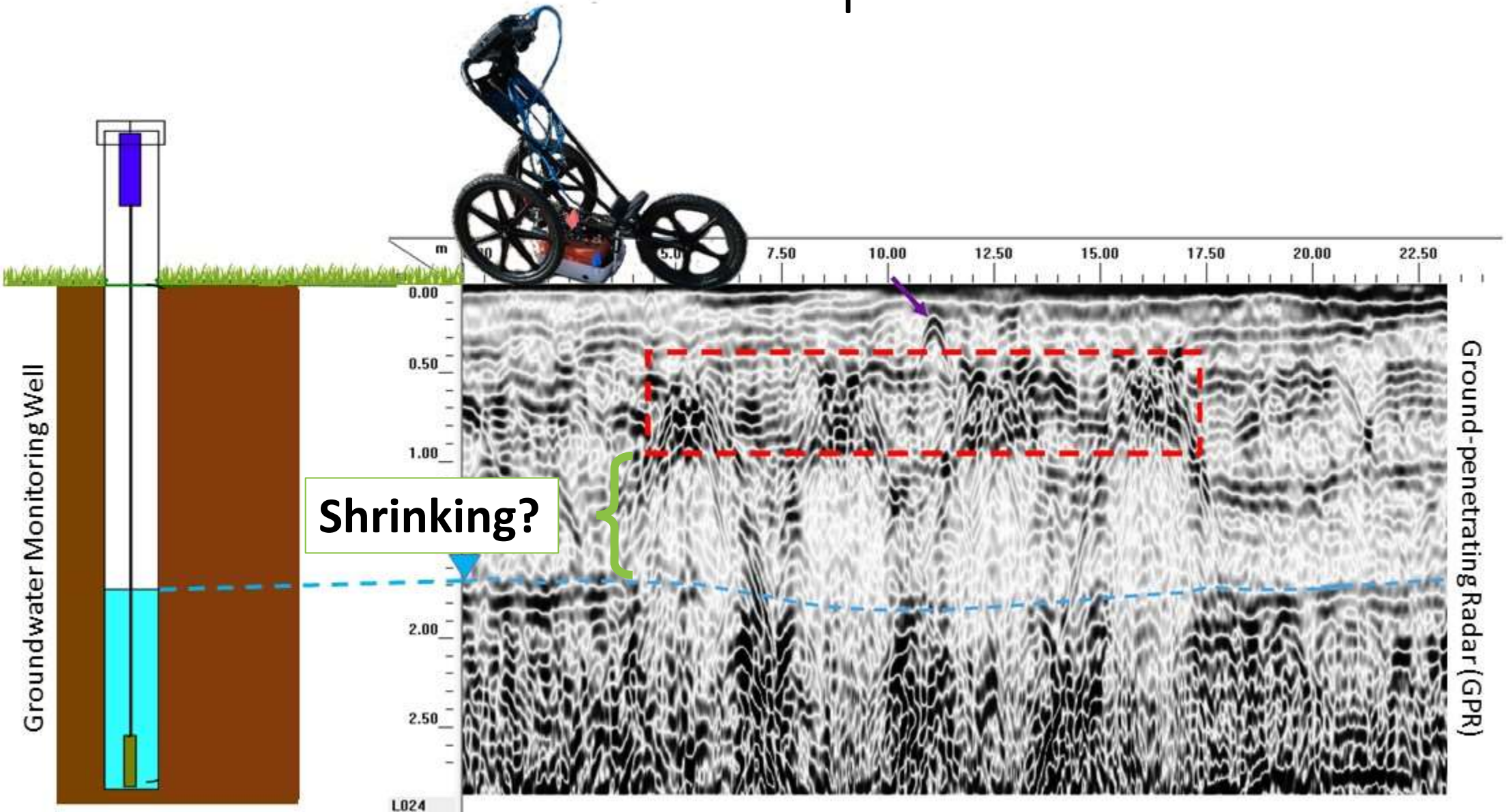
Septic systems along coast are losing separation distance







Groundwater tables: Next Steps

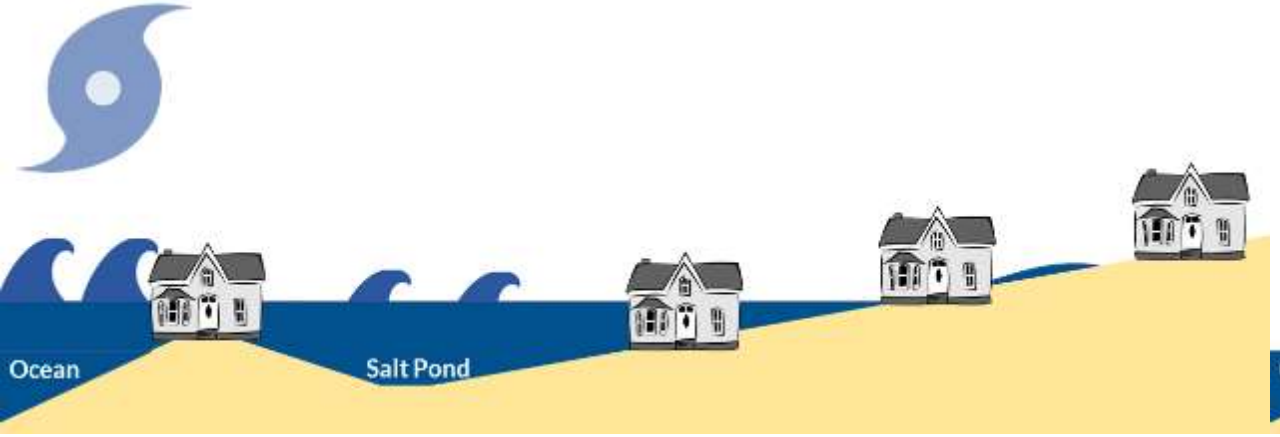



Coastal OWTS
Rising groundwater tables
Coastal storms

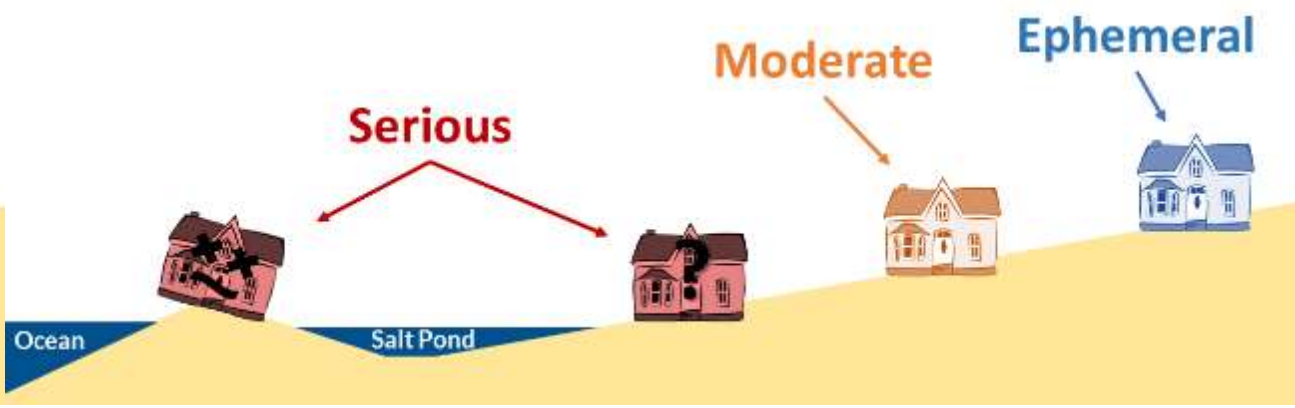
Army Corps proposes raising homes

Modeling storm impacts…

During a Storm:
Flooding and fast-moving water
inundates septic systems
(especially low-lying and near-shore systems)



After a Storm:
Septic systems may be damaged from
long-term flooding or scouring action of
fast-moving water

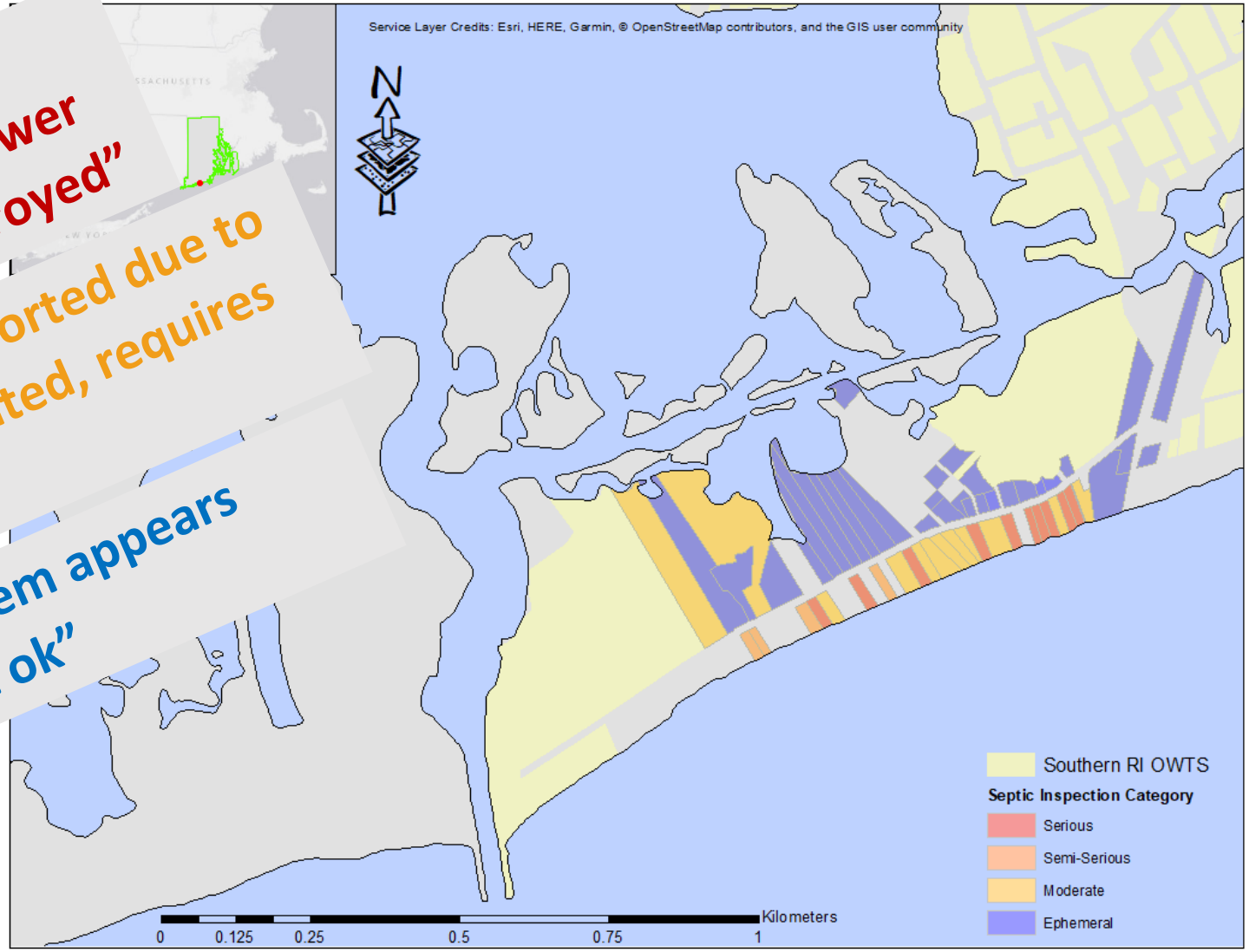


Damage post-Sandy (2012) – Observations from Town Officials

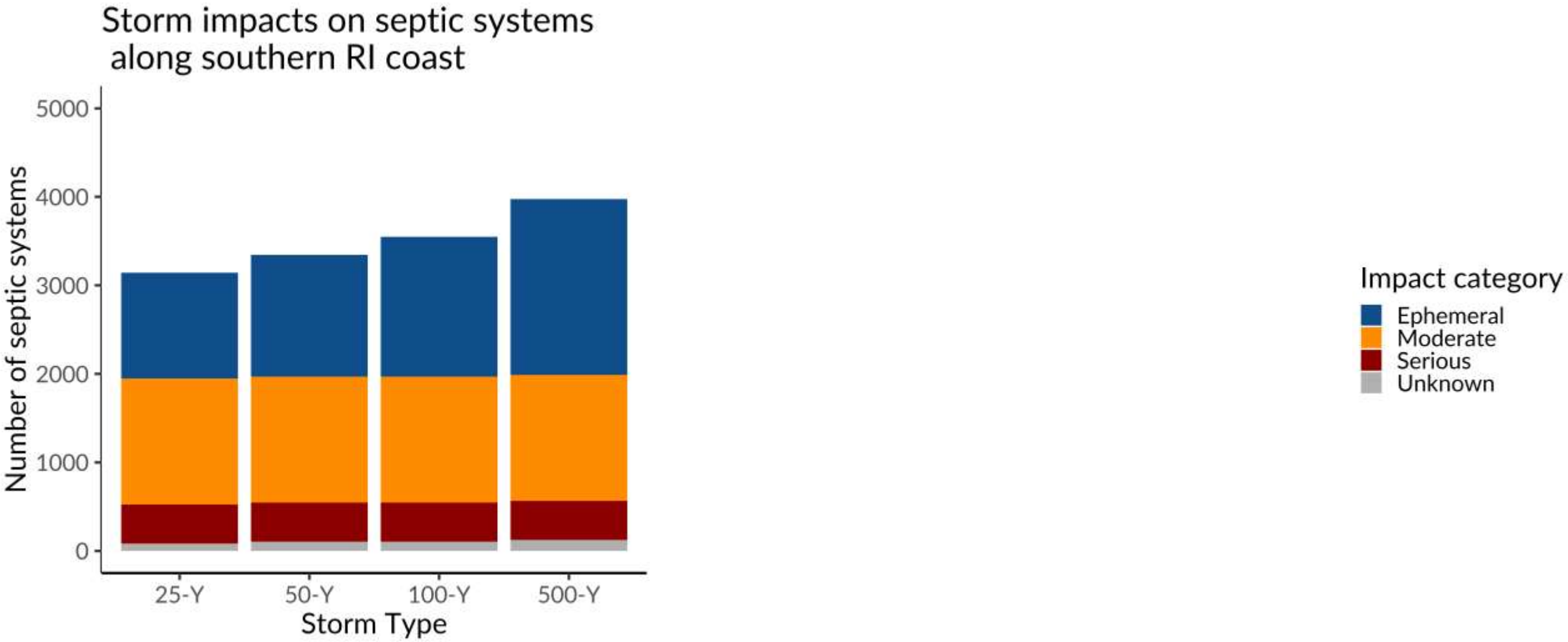
"fully exposed septic tank ocean side undermined, no outlet pipe, building sewer broken, covers off, tank full, likely destroyed"

"system in front, building sewer un-supported due to erosion, appears intact, system inundated, requires assessment"

"building sewer ok, system appears inundated but ok"



Coastal Storms



Why storm damage is concerning for OWTS

- Septic System Repairs & Replacements…
  - Take weeks – months!
  - Expensive!
    - Repairs: $1k – $15k
    - Installing Advanced Treatment Tech: $23k – $30k

…PER SYSTEM!

<u>…what happens to wastewater in the meantime?</u>

???

Why worry?

Rising Groundwater Tables

Coastal septic systems

Coastal Storms

Failing / failed septic systems

Nutrient & Pathogen Pollution

Contaminated Coastal Waters

Environmental Health Problems

Algal Blooms

Contaminated wells

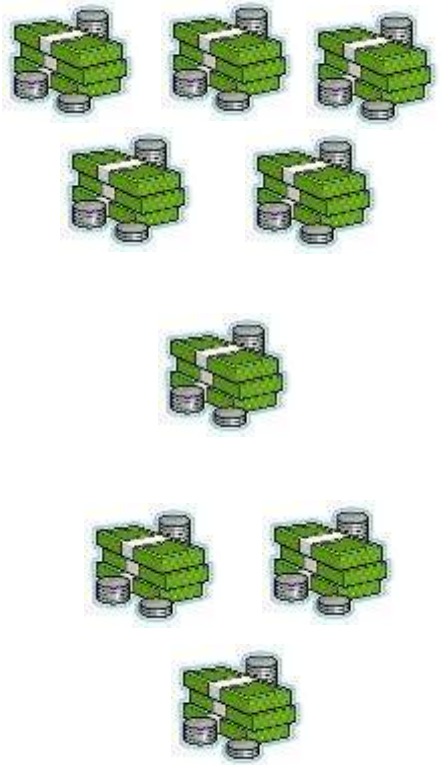
Human Health Problems

Protecting Southern New England's Coasts

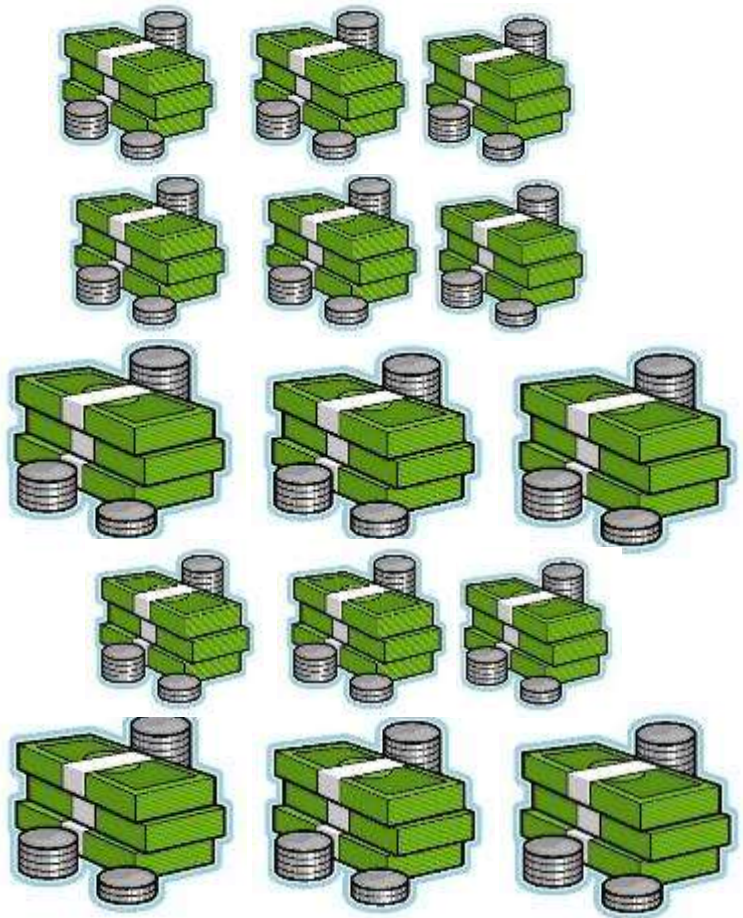
Multi faceted approach:

- Replace Conventional OWTS:
  - I & A Proprietary Tech
  - I & A Non Proprietary Tech
- Monitor and Adjust
- Prepare for climate change:
  - Rising groundwater
  - Storms

Investment



Return



Thank you!

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Lab website:
https://sites.google.com/site/soilecologyandmicrobiology/home

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University of Rhode Island