The Effectiveness of Layering a Sand-Sawdust Layer in a Soil Absorption System for the Removal of Nitrogen from Onsite Septic Systems in Northern Climates

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Barnstable County Department of Health and Environment
Massachusetts Alternative Septic System Test Center

Collaborative Effort

- Massachusetts Alternative Septic System Test Center
- Damann L. Anderson, P.E., a researcher of passive nitrogen removal systems for the State of Florida Onsite Sewage Nitrogen Reduction Study (FOSNRS);
- George Loomis, an onsite septic system specialist and published author from the University of Rhode Island;
- Dr. Will Robertson of the University of Waterloo;
- Jose Amador, a soil scientist at the University of Rhode Island;
- John Eliasson with the Wastewater Management Section of Washington State Department of Health's Division of Environmental Public Health
- More recently, researchers at Stony Brook University, NY

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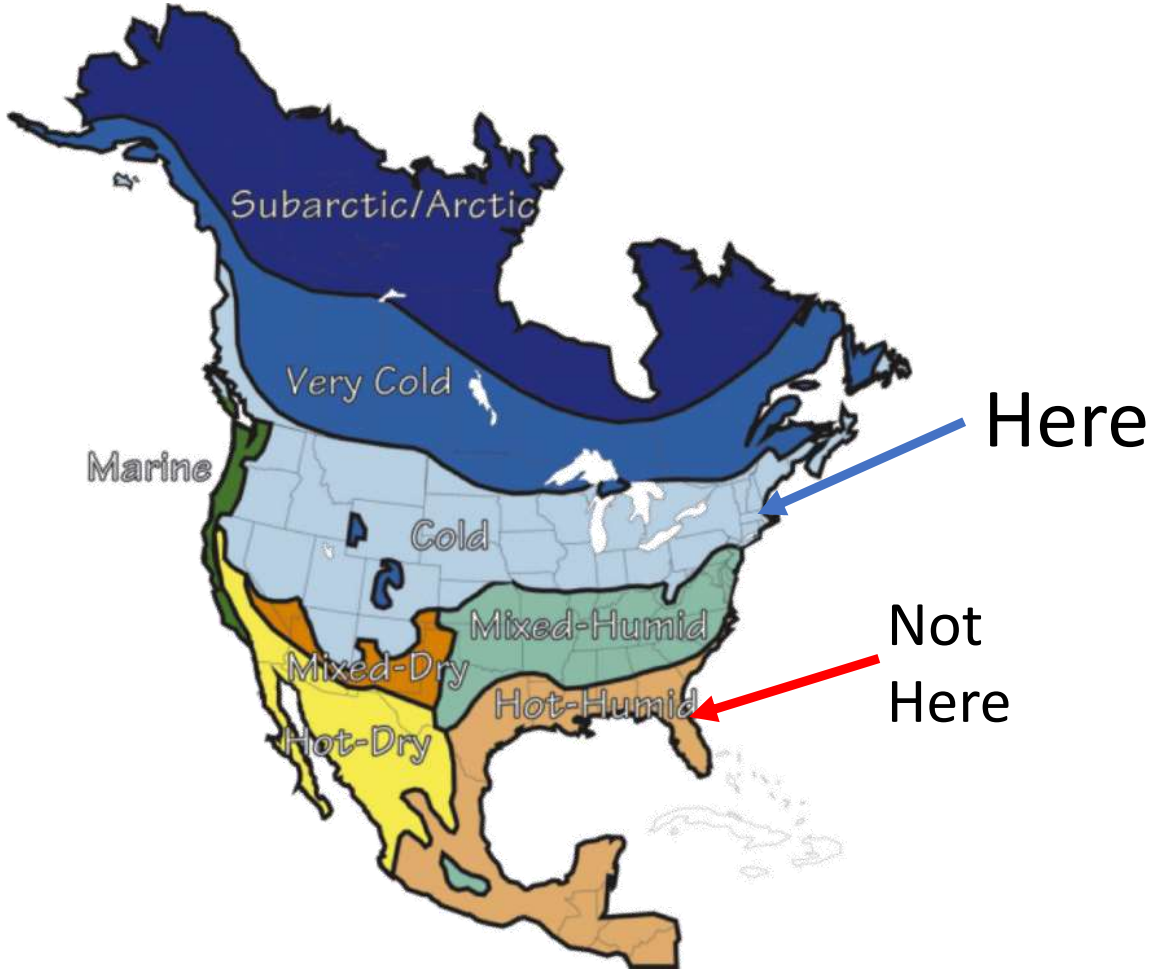
The Massachusetts Alternative Septic System Test Center

Pick your map

DEFINING CLIMATE



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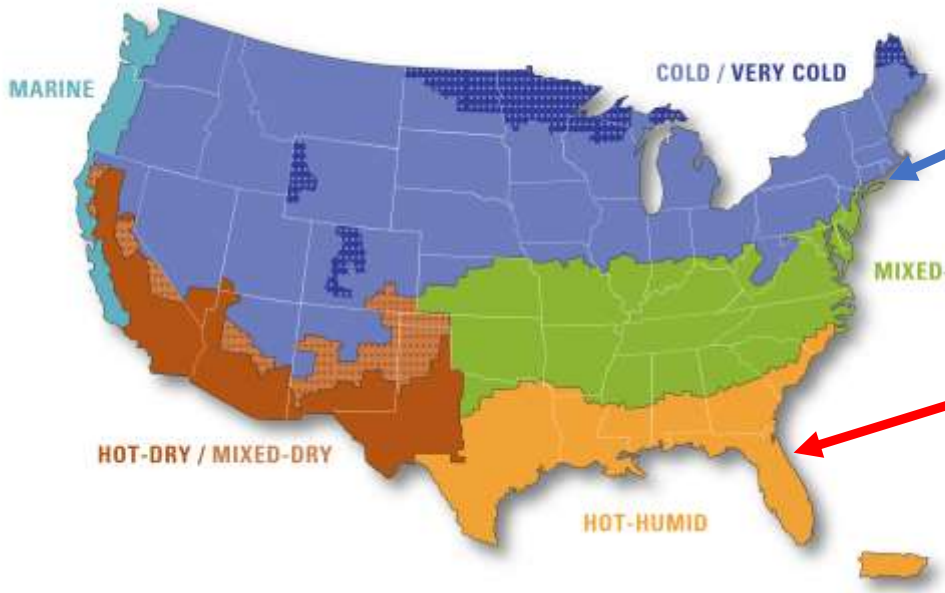

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Project Genesis

The search for a sustainable non-proprietary means to remove nitrogen in onsite septic systems leads to…

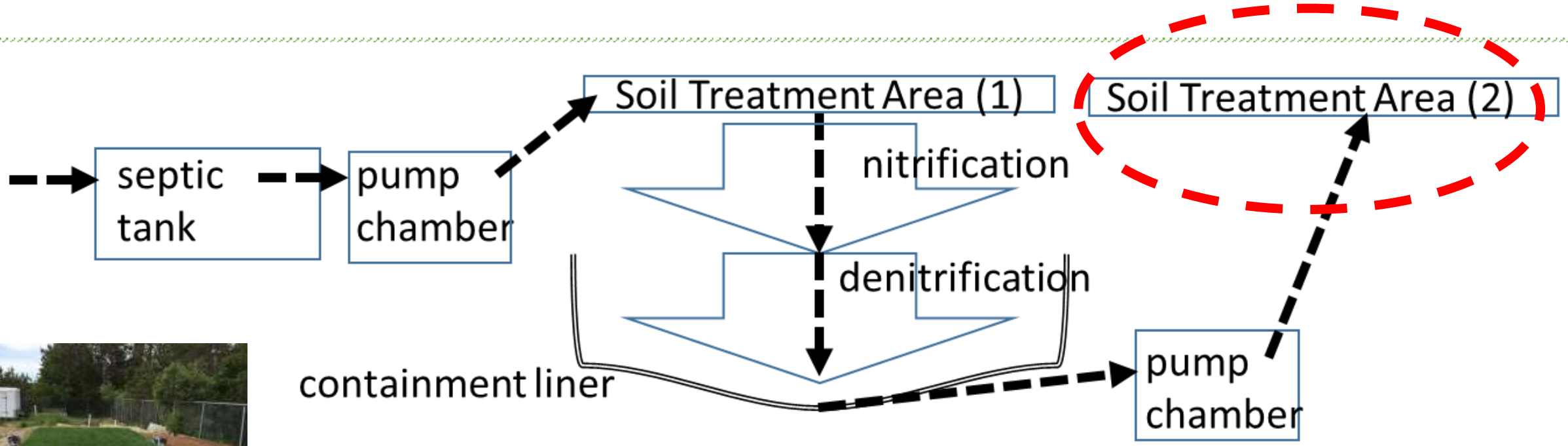
Cellulose-based denitrification research being done ….

- Woodchip barriers in agricultural settings
- State of Florida (Florida Onsite Septic System Nitrogen Removal)
- Waterloo Canada (W.D. Robertson et. al)
- Washington State
- Others


TWO DESIGN CHARRETTES
REVIEW OF DEMONSTRATION PROJECTS
NUMEROUS DISCUSSIONS WITH PRACTITIONERS
EXTENSIVE LITERATURE SEARCHES
Three feasible designs emerged

1 Design 1 of Three Basic Designs

The containment liner provided a saturated area that held water and occluded oxygen



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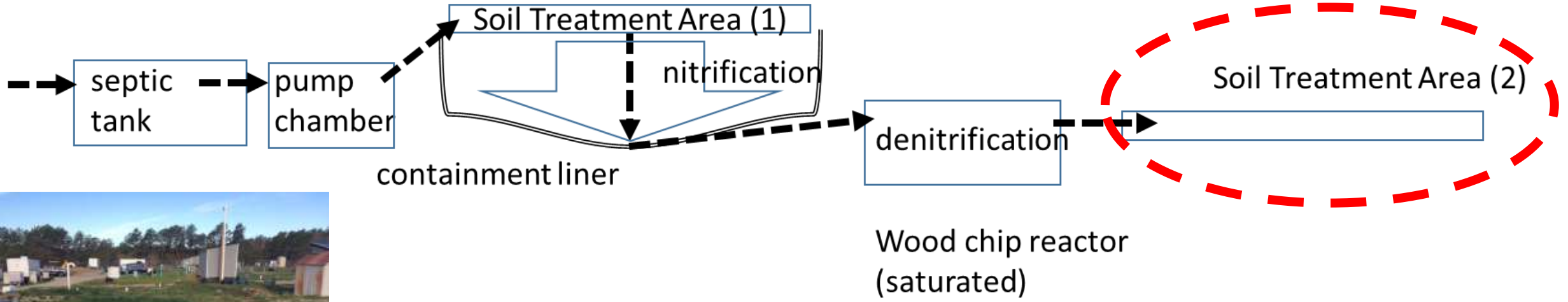
Design 2 of Three Basic Designs

2

The container provided a saturated area that held water and occluded oxygen



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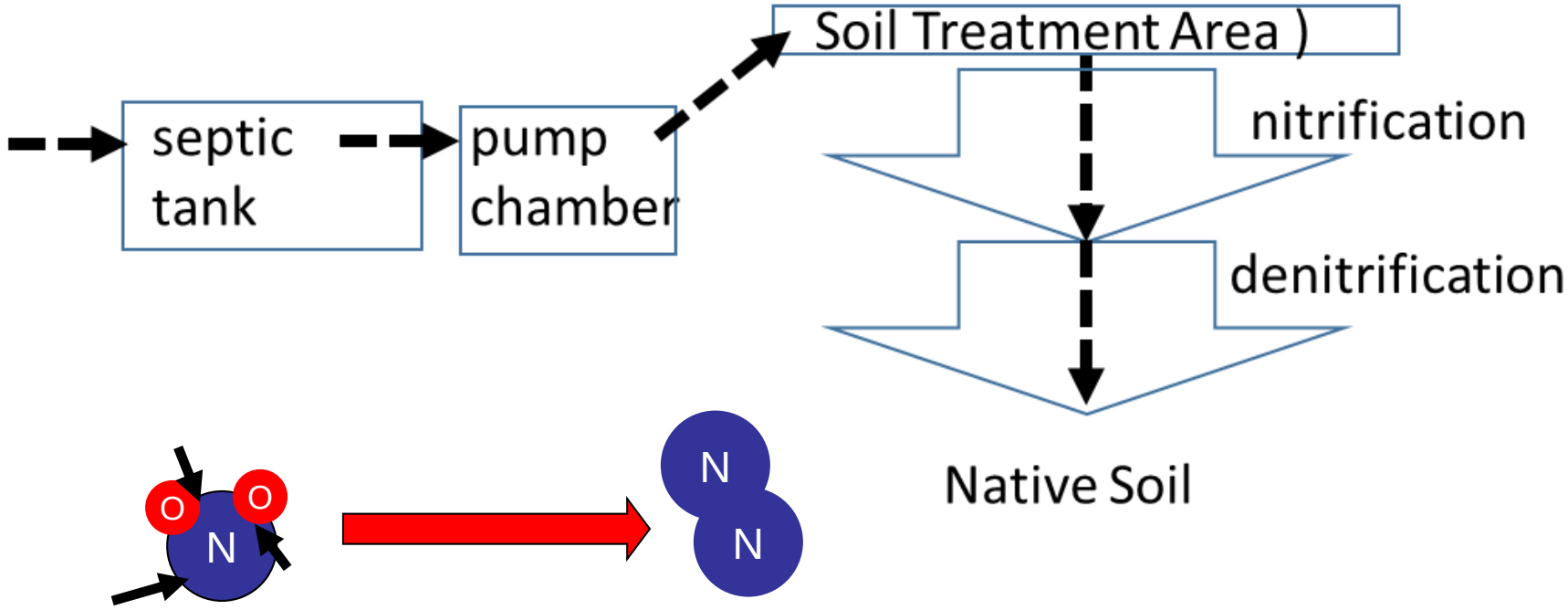
3 Design 3 of Three Basic Designs

Simple layering of sawdust/sand mix – no secondary soil absorption area.



Denitrification is facilitated by a layer of sand mixed with sawdust placed below the nitrification layer

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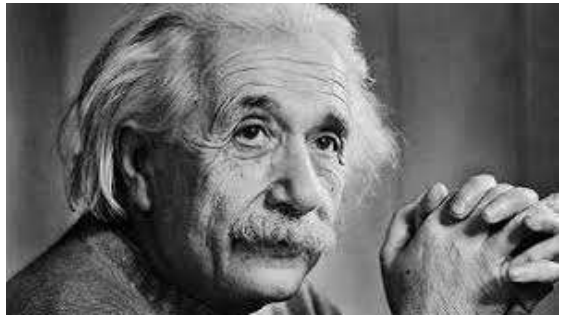
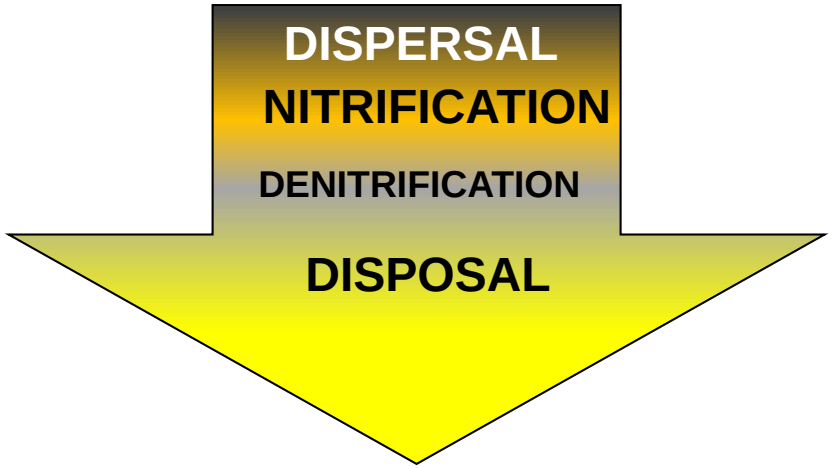
Design 1 & 2 require an addition disposal site so……

Design 3 meets the Einstein Principle



"Everything should be made as simple as possible, but not simpler"

keeping it Simple



But will it work?

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Simple layering

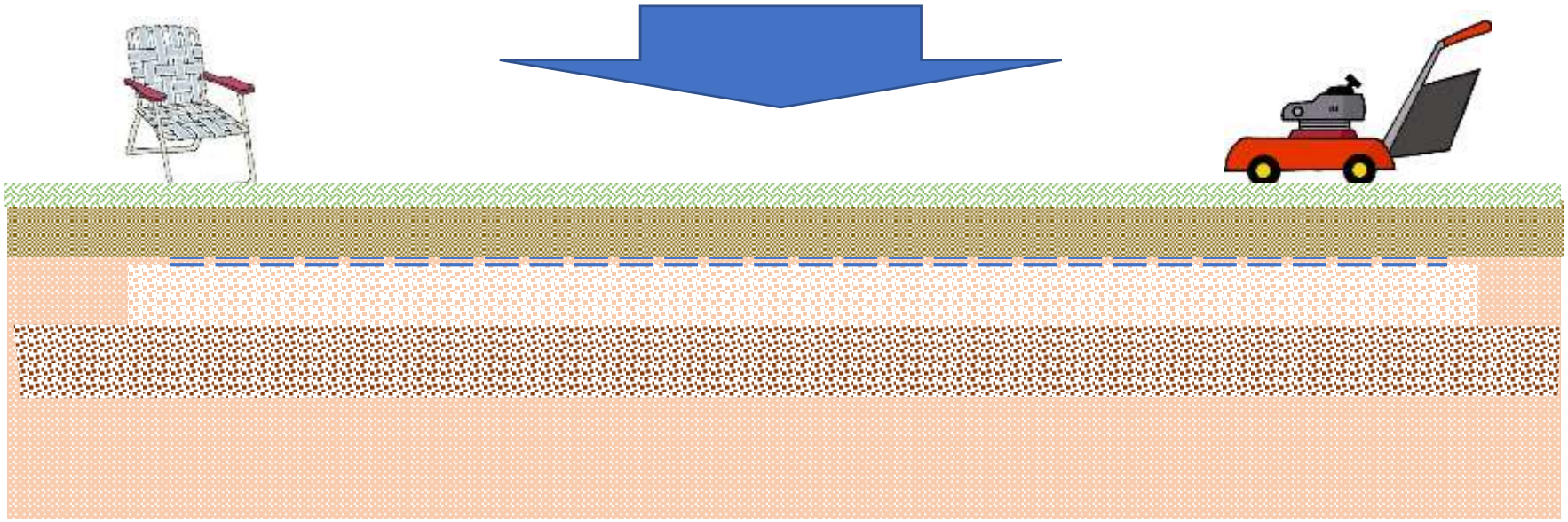
GRASS

TOP SOIL

Low pressure distribution system

SAND NITRIFICATION LAYER

SAND/SAWDUST LAYER



GRASS

TOPSOIL 6-9”

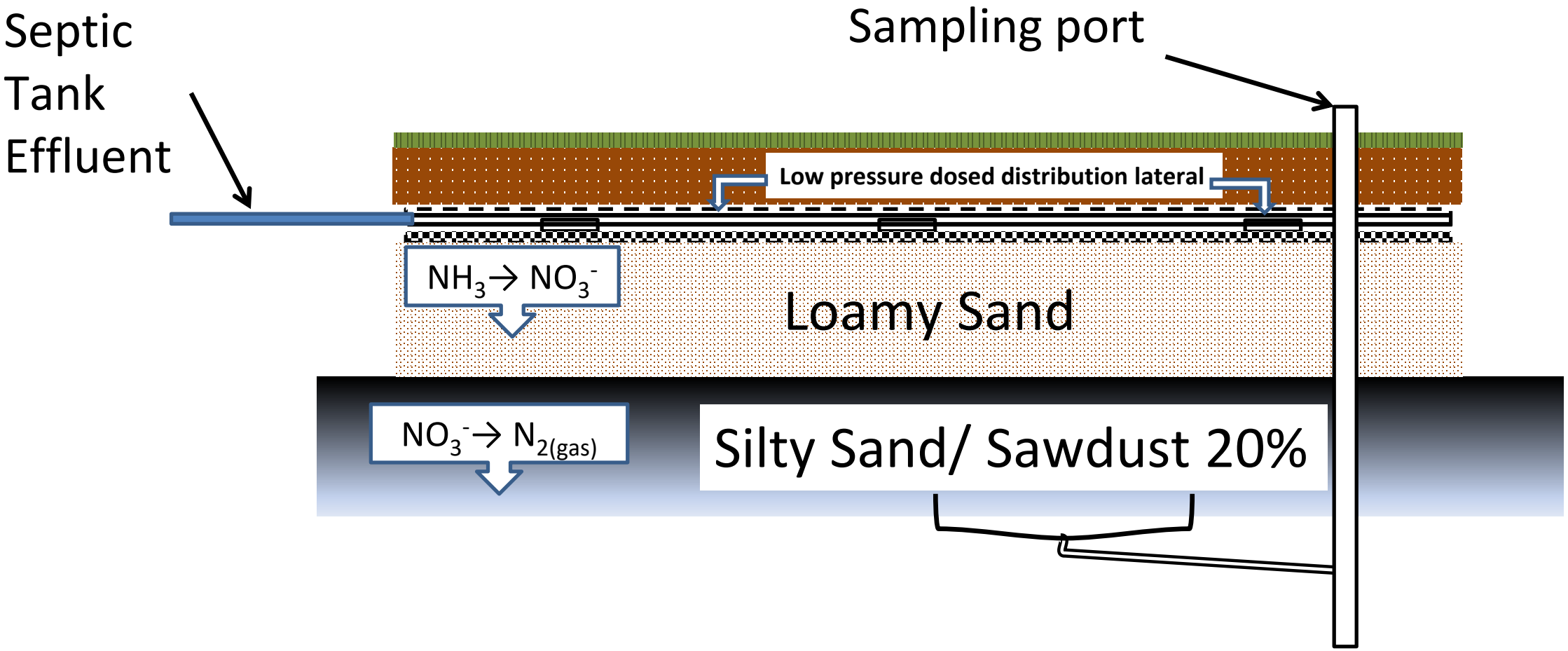
LOW PRESSURE DISTRIBUTION OF STE VAR

SAND NITRIFICATION LAYER 18”

SAND/SAWDUST DENITRIFICATION LAYER 18”

NATIVE SOIL

Attempt #1 – Hedging our bets with a little silt




HYUNDAI
Sawdust sand-silt mix
Place denitrification layer material (sawdust-sand-silt mix)

“Marry” denitrification layer material to nitrification material layer

Field area levelled and made ready for distribution piping

Low-pressure distribution piping placed


HYUNDAI

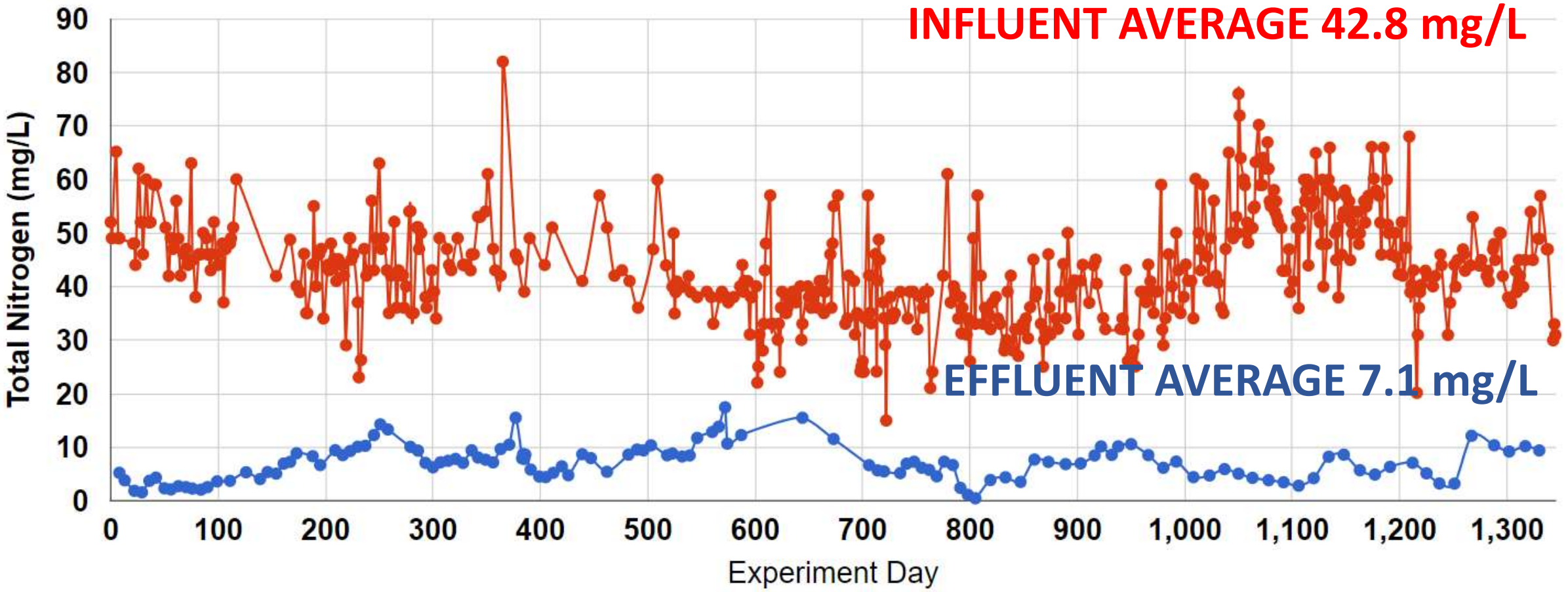
Final grade over soil treatment area

Grass planted over soil treatment area

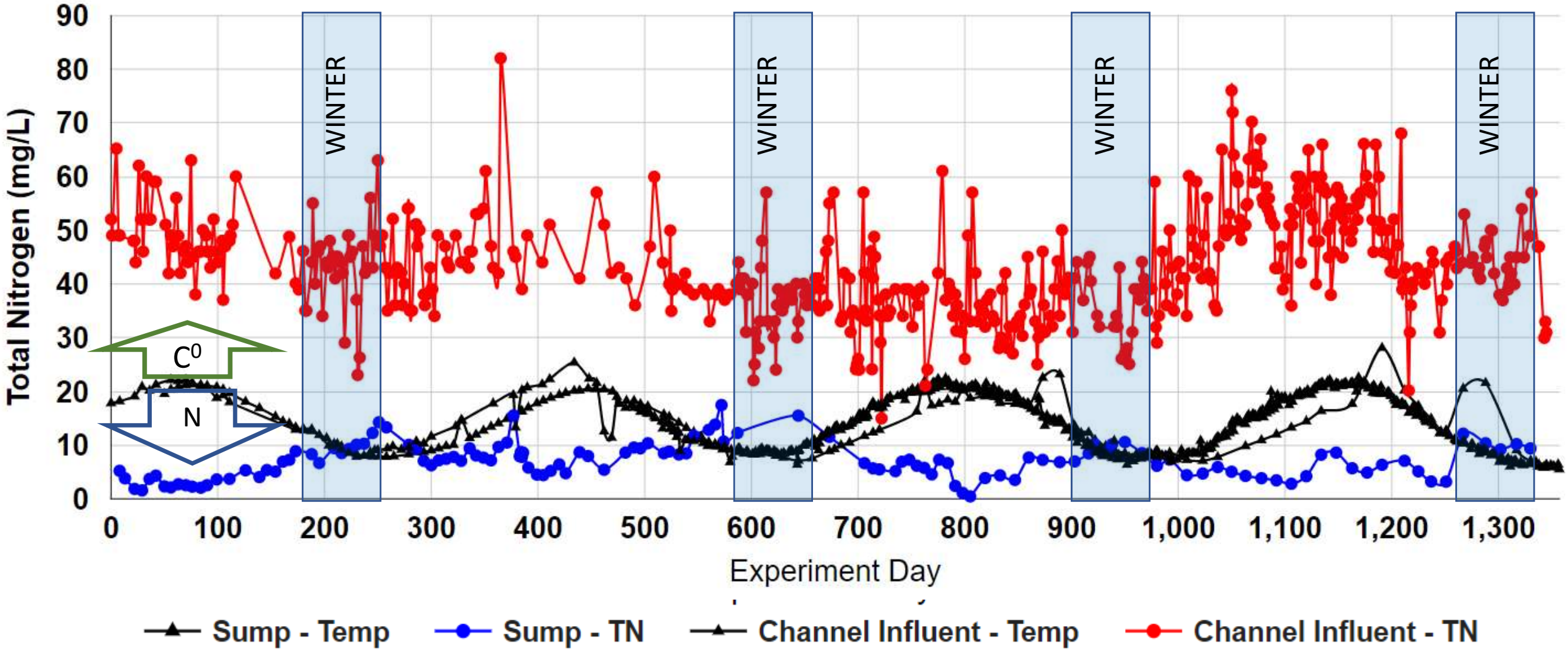

May 17, 2017

Results from simple layered system using silt mixed with sand/sawdust for denitrification layer

(Modification of Robertson, University of Waterloo)

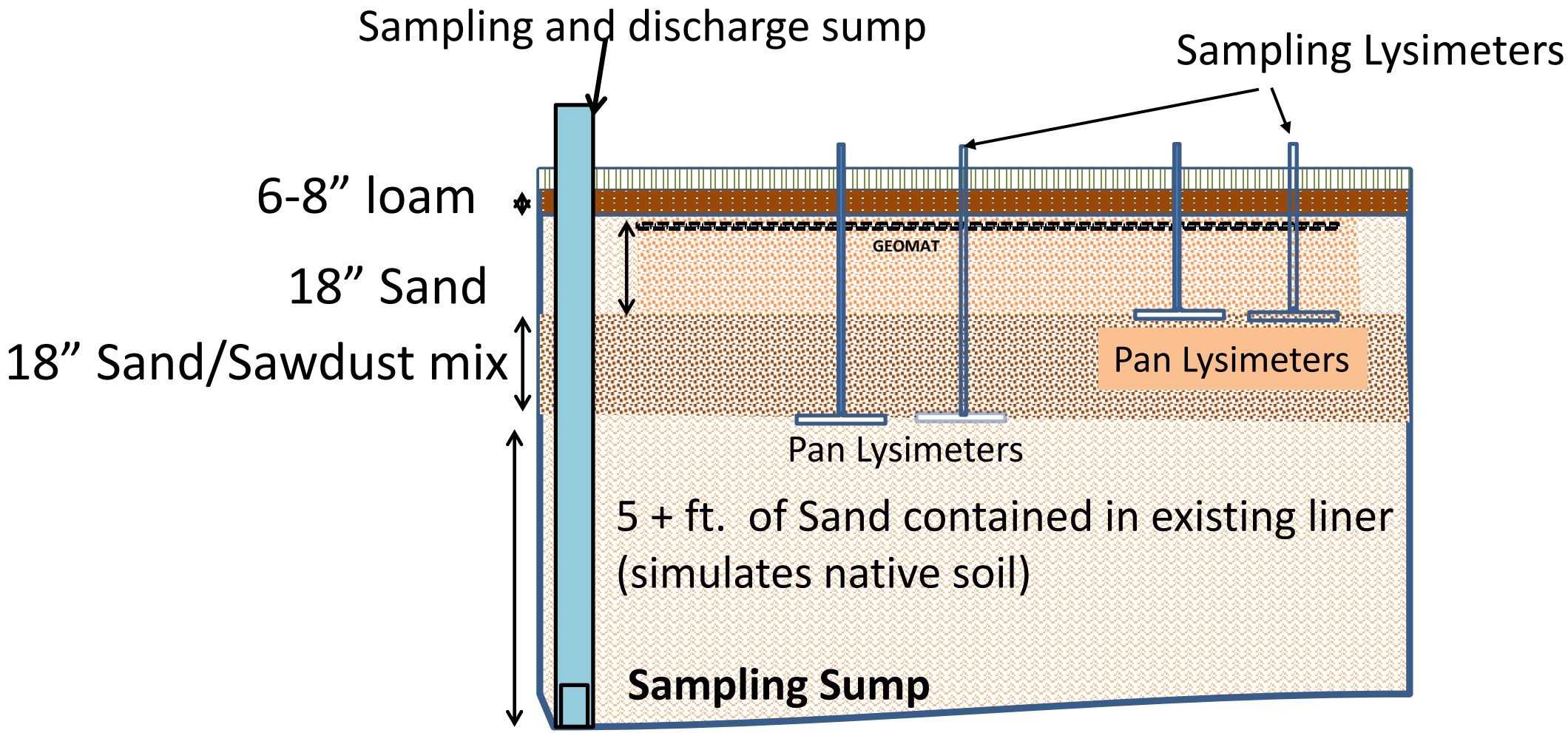


Effect of temperature/season on performance

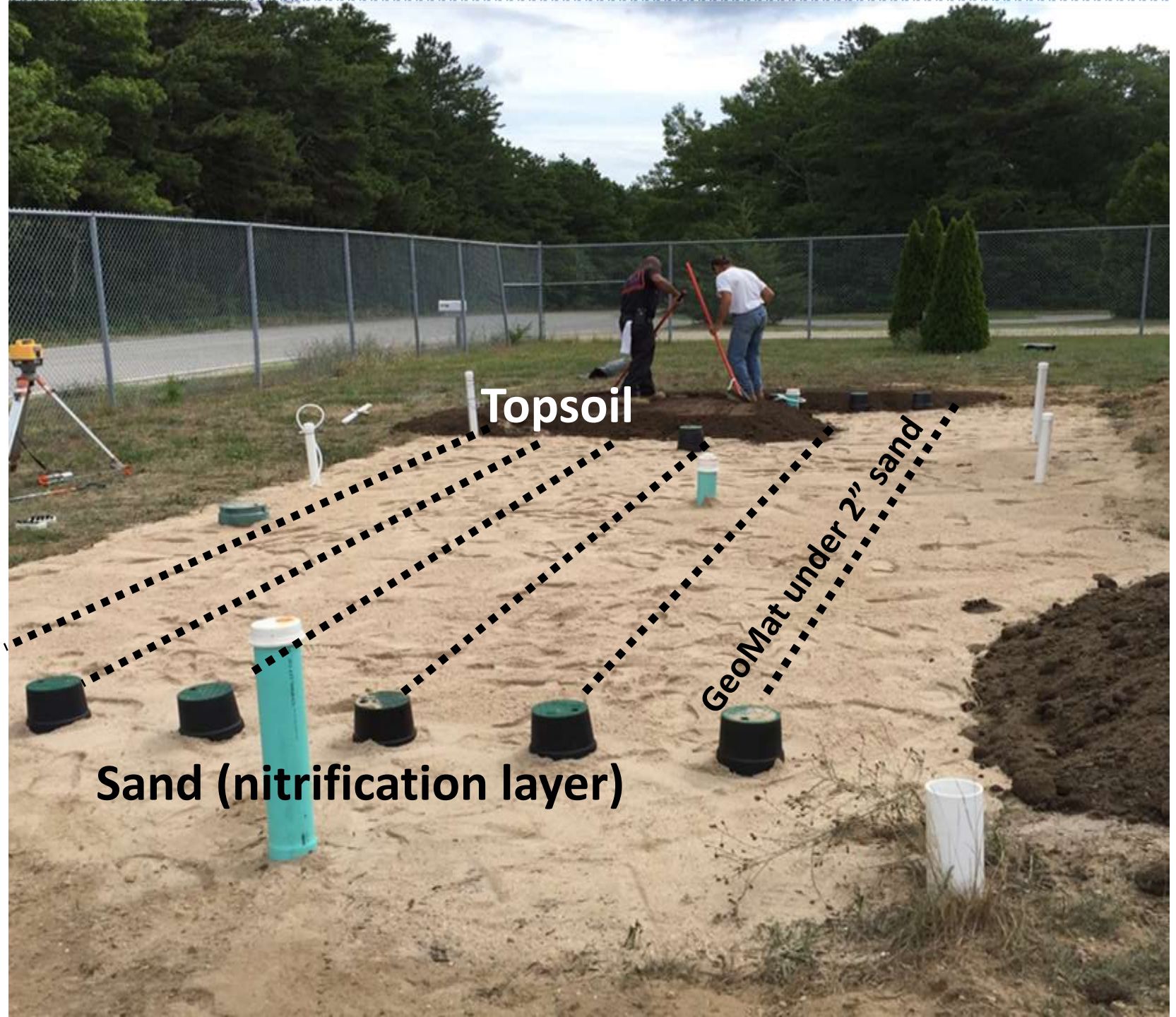



One step simpler
ASTM C-33
Using standard fill-sand mixed with sawdust (for the denitrification layer)

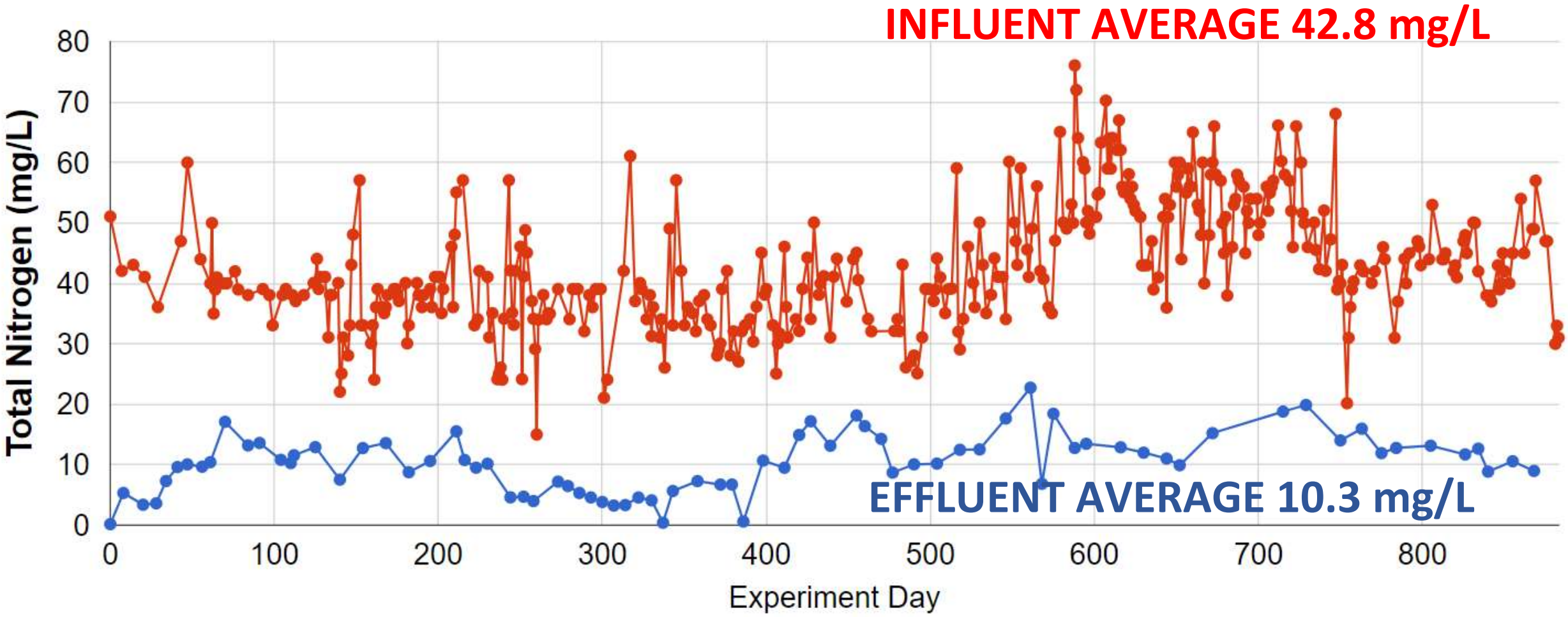
ATTEMPT #2 Simple layered system (no liner) Profile




Lysimeter port
Lysimeter port
Sand (nitrification layer)placement
Sand:Sawdust (denitrification) Layer

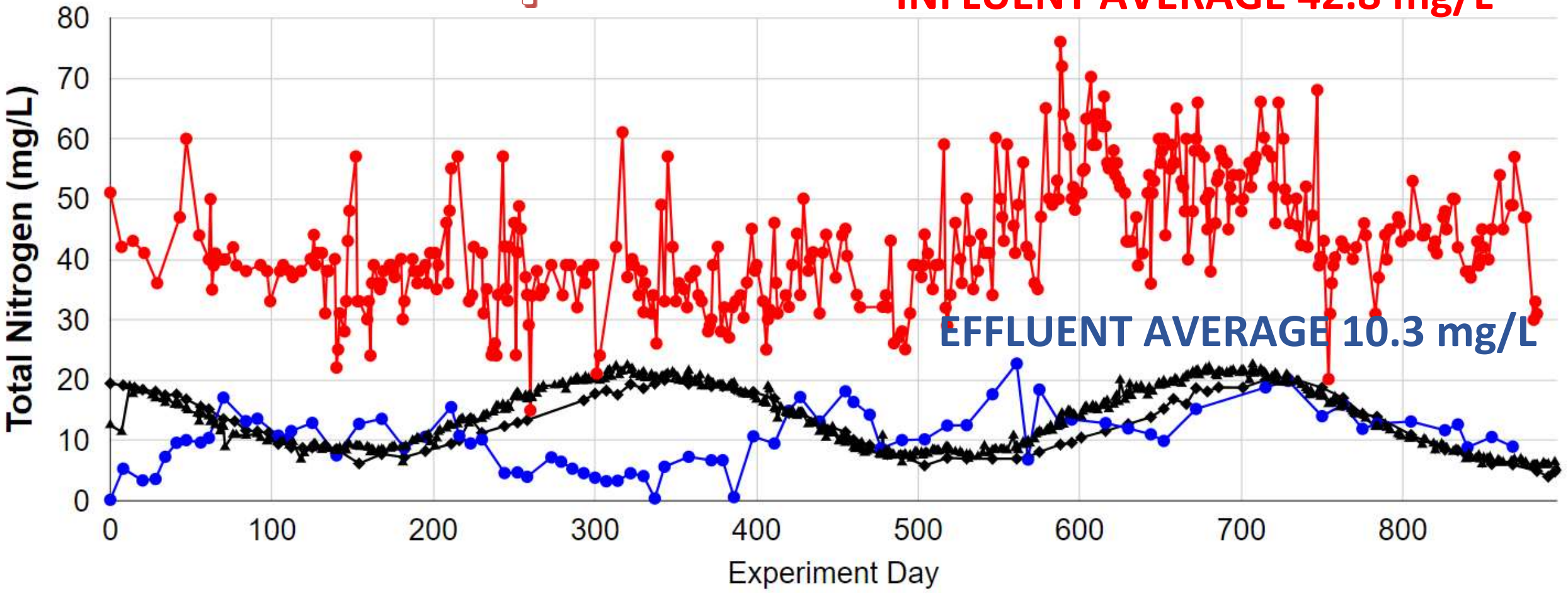

Topsoil
GeoMat under 2” sand
Sand (nitrification layer)

Results from simple layered system using standard sand mixed with sawdust for denitrification layer



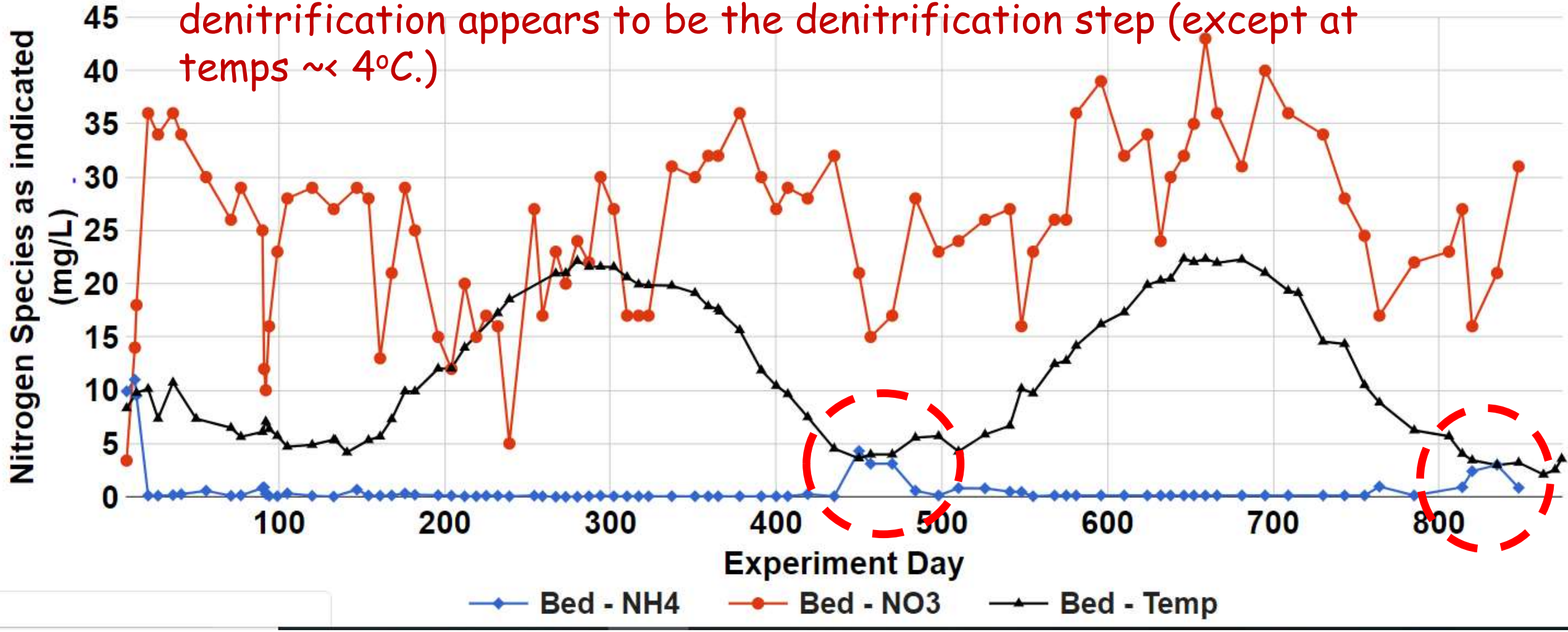
Results from simple layered system using standard sand mixed with sawdust for denitrification layer

Effect of Temperature

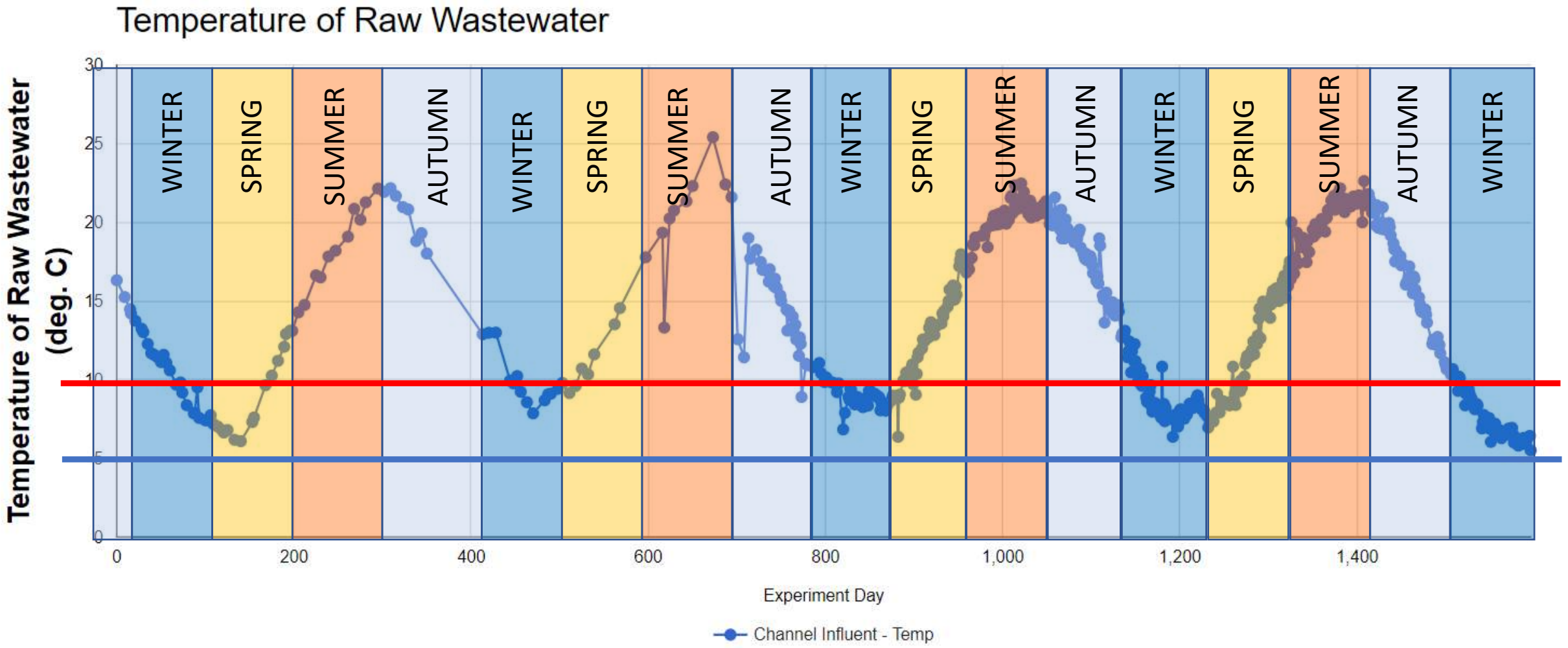


Effect of Temperature

The primary impact of the low temperatures on denitrification in systems using soils-based sequencing of nitrification-denitrification appears to be the denitrification step (except at temps ~< 4°C.)



Effect of Temperature



What about the Real World ?

vs. Test Center Studies

Configurations installed generally were installed with a control portion for comparison.

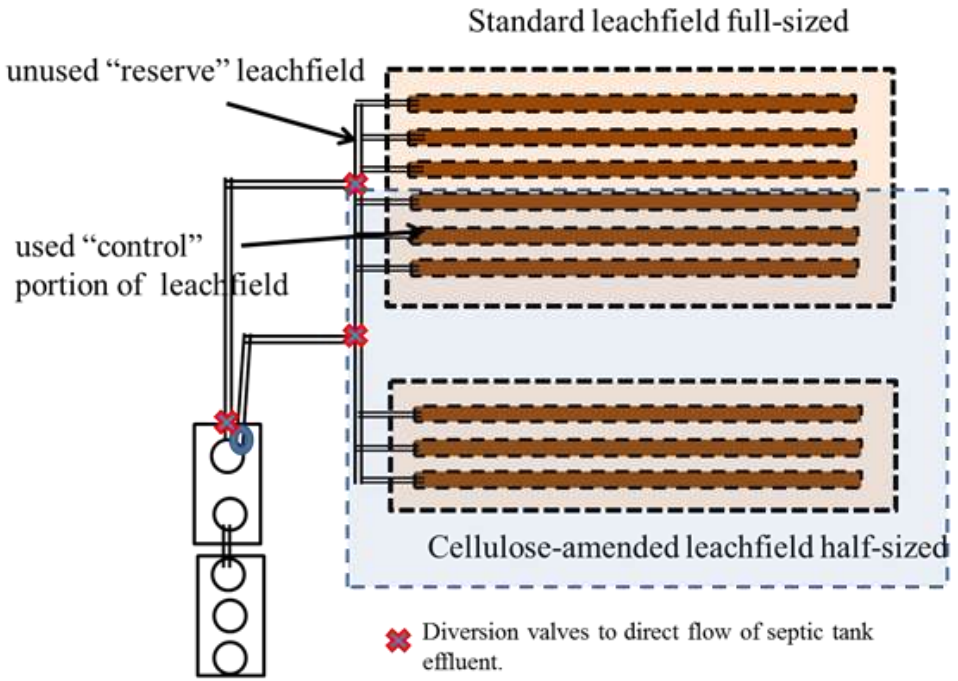


Figure A

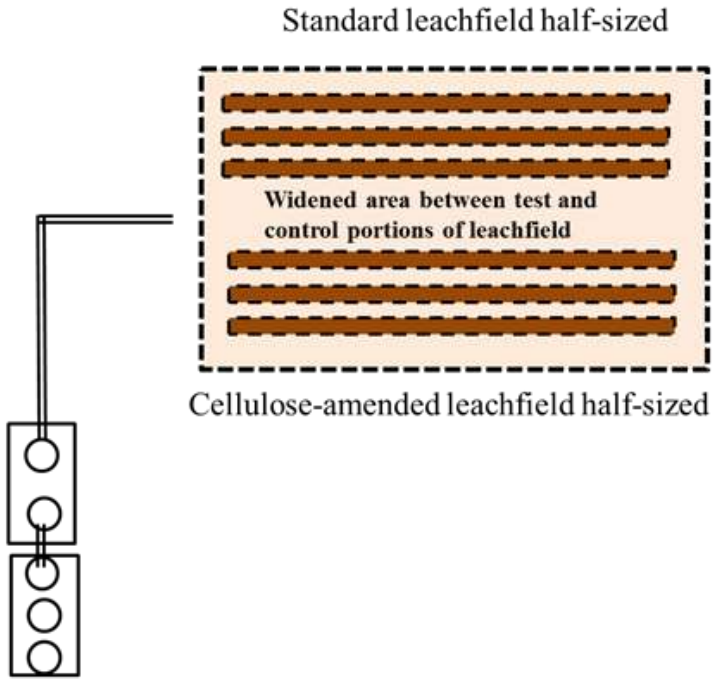
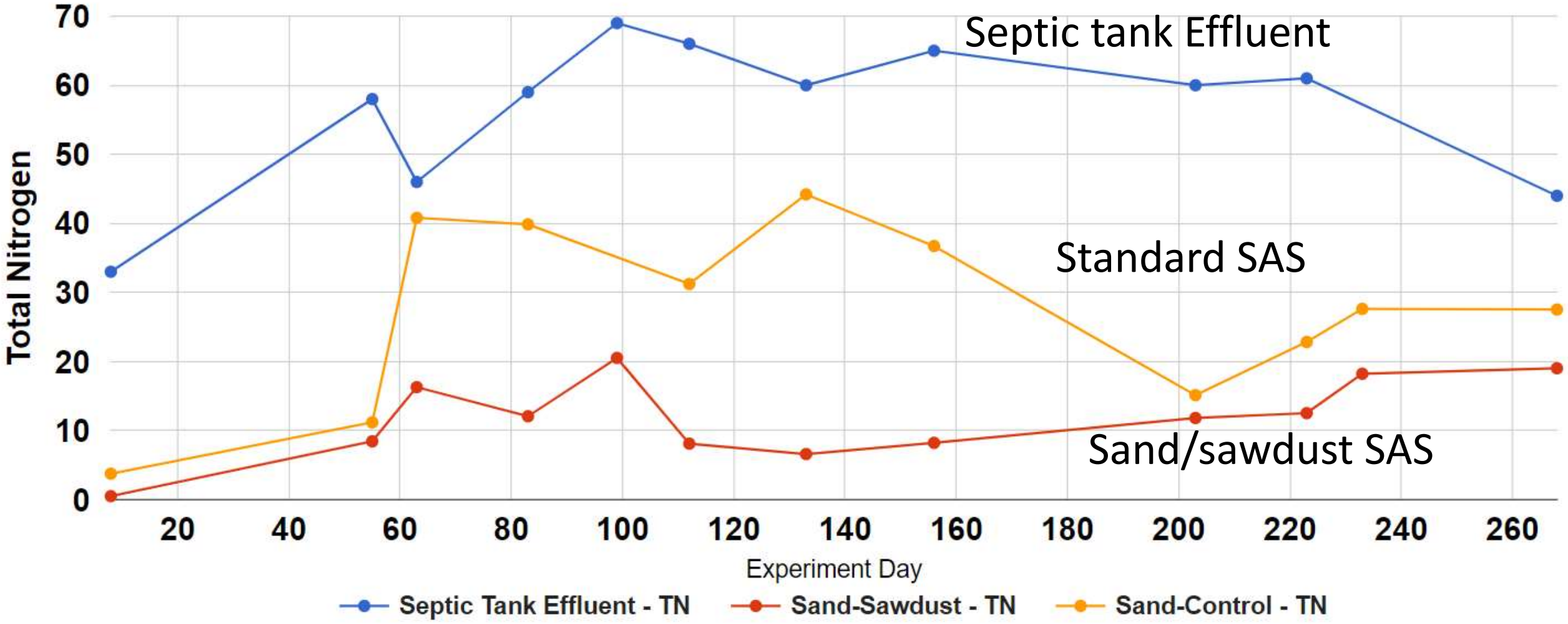
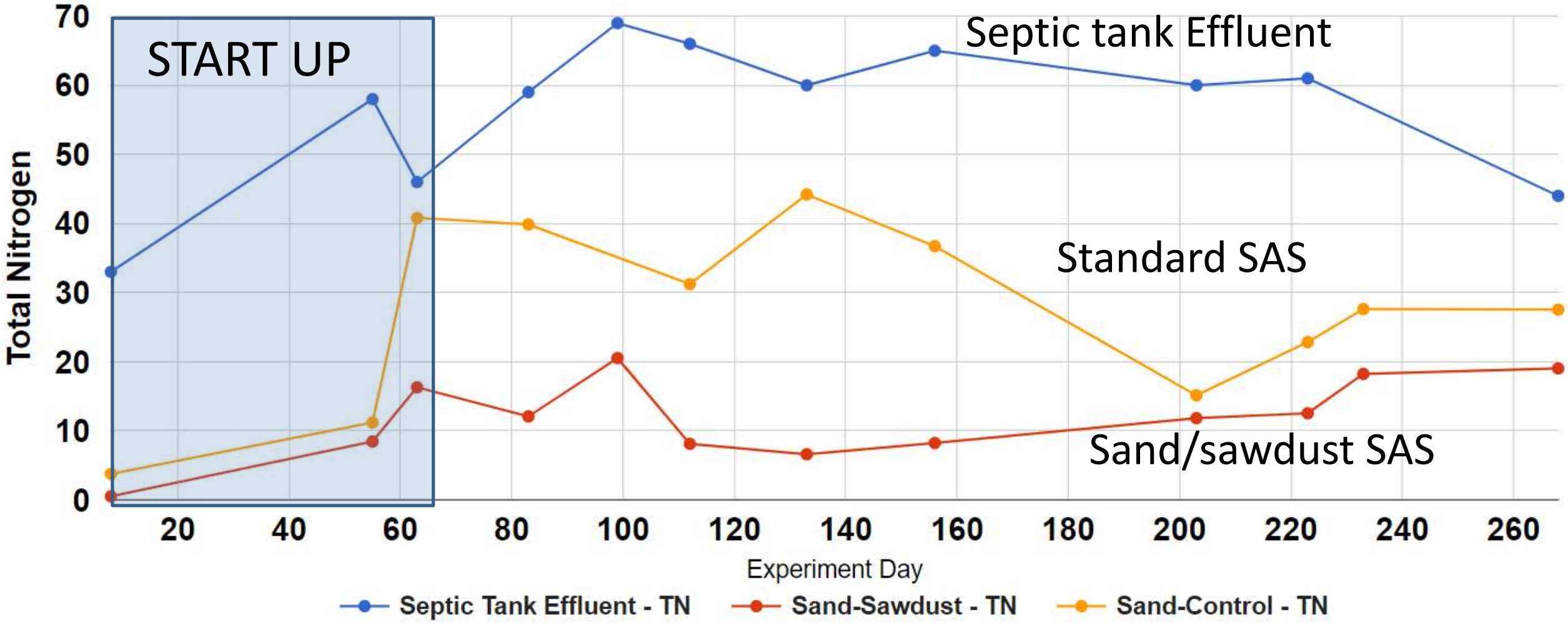


Figure B

System 1 – Residential – YR – 3 persons 212 GPD

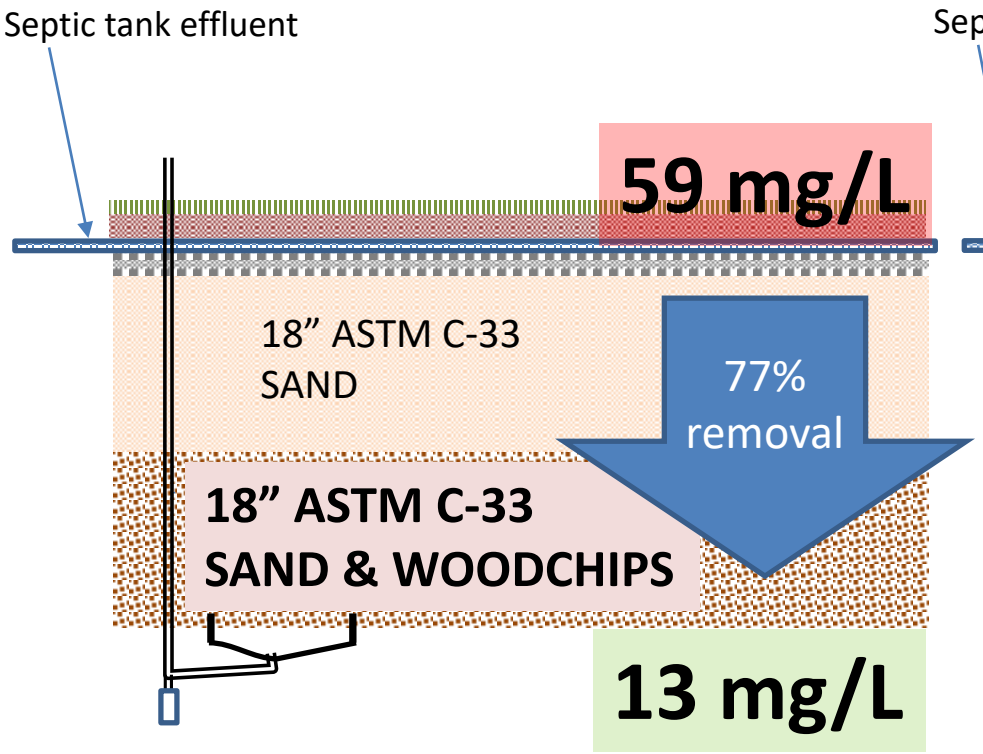


System 1 – Residential – YR – 3 persons 212 GPD

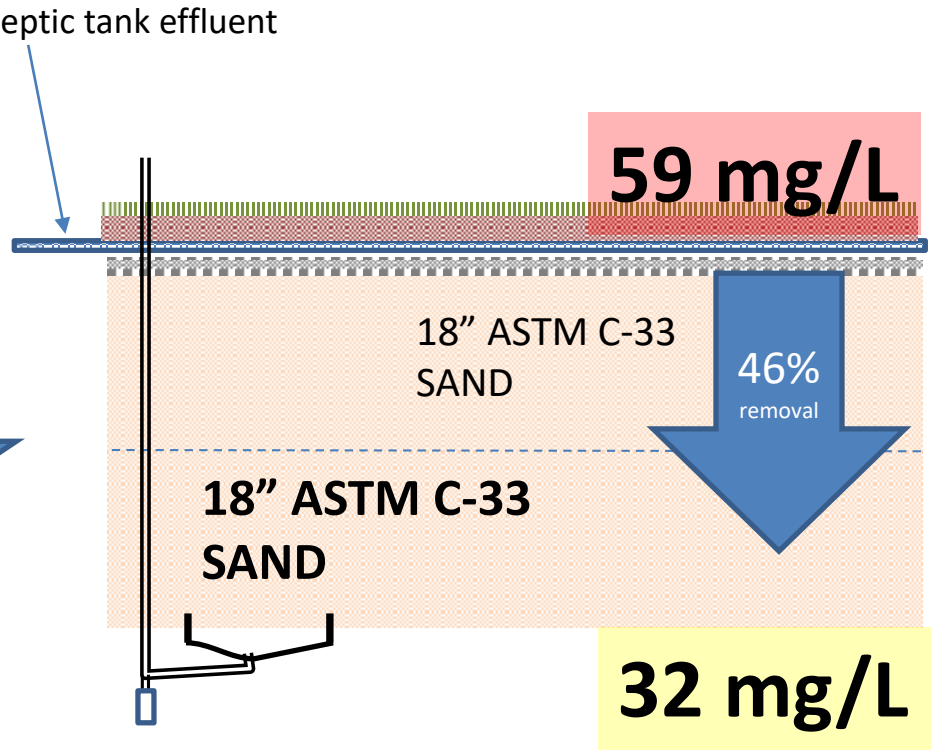


System 1 Acushnet Residence

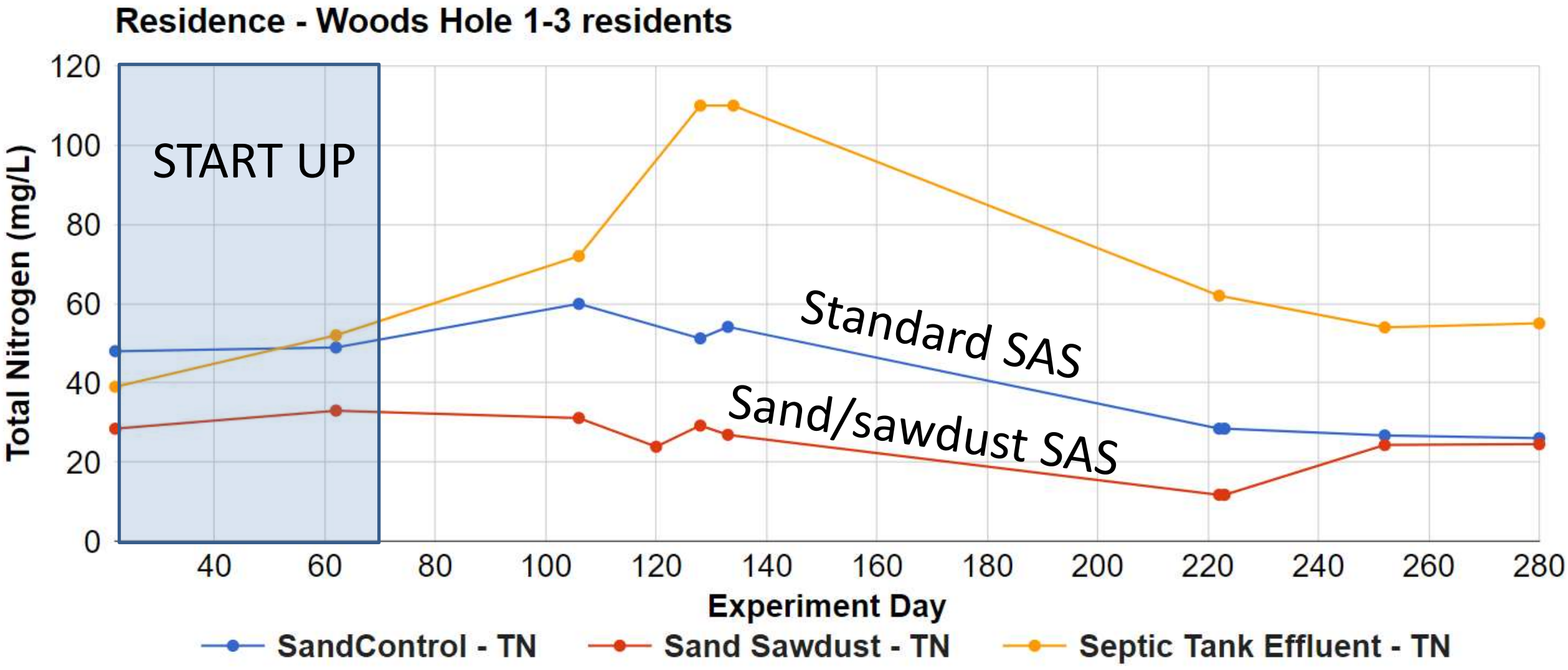
Treated Portion of Soil Absorption System



Un-Treated (Control) Portion of Soil Absorption System

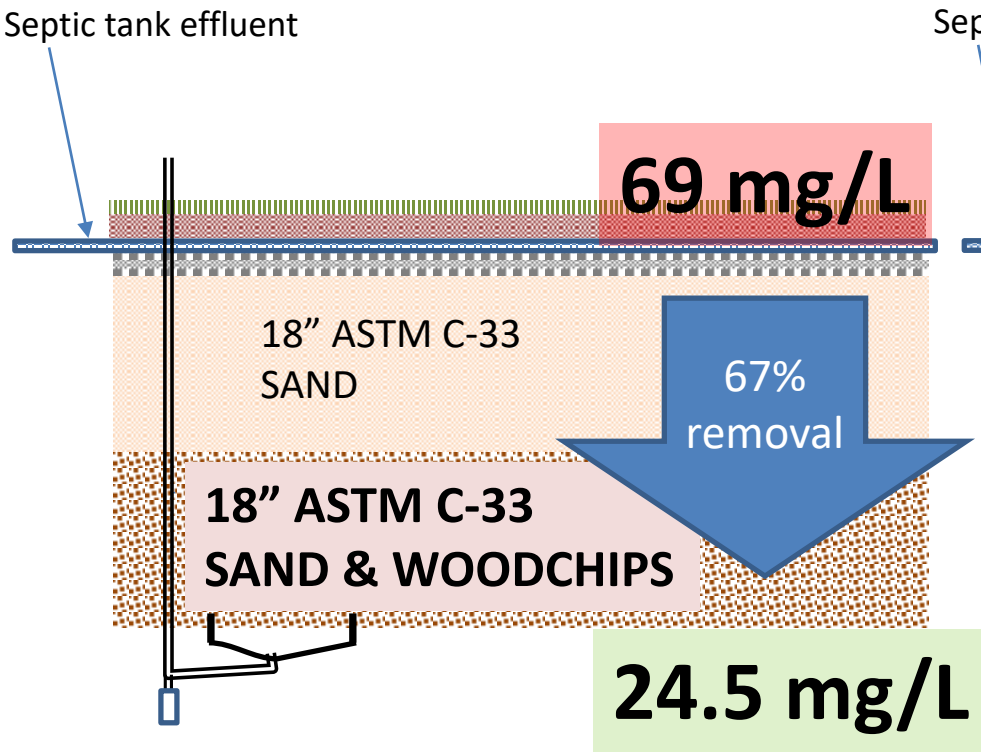


System 2

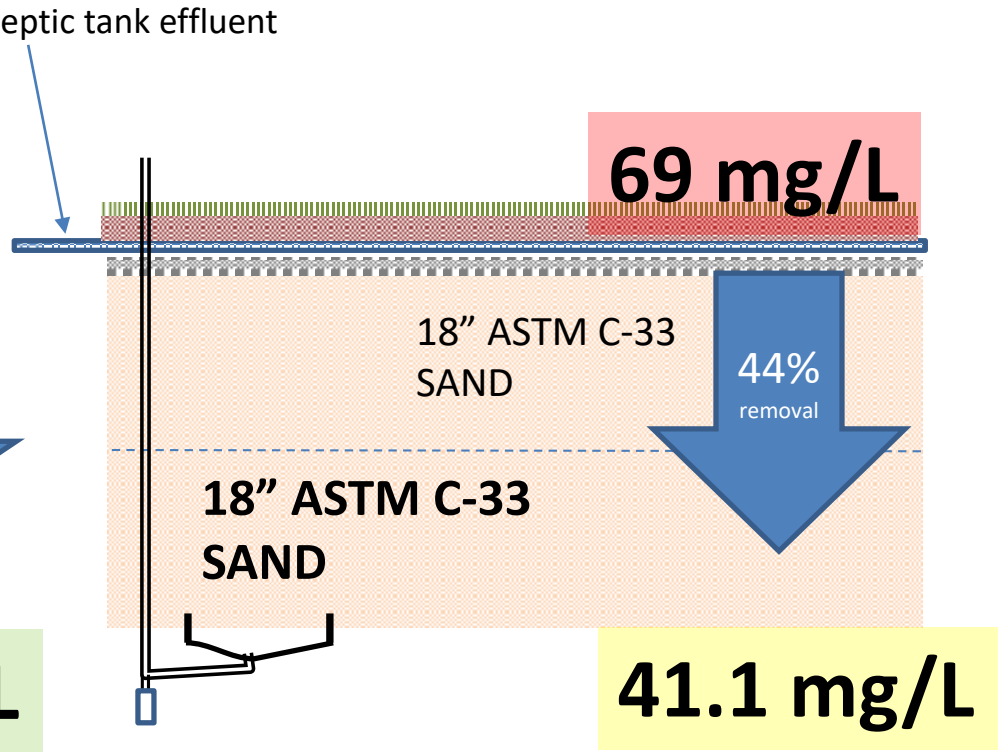

Residence - Woods Hole 1-3 residents
START UP
Standard SAS
Sand/sawdust SAS
Total Nitrogen (mg/L)
0
20
40
60
80
100
120
40
60
80
100
120
140
160
180
200
220
240
260
280
Experiment Day
SandControl - TN
Sand Sawdust - TN
Septic Tank Effluent - TN

System 2 Woods Hole Residence

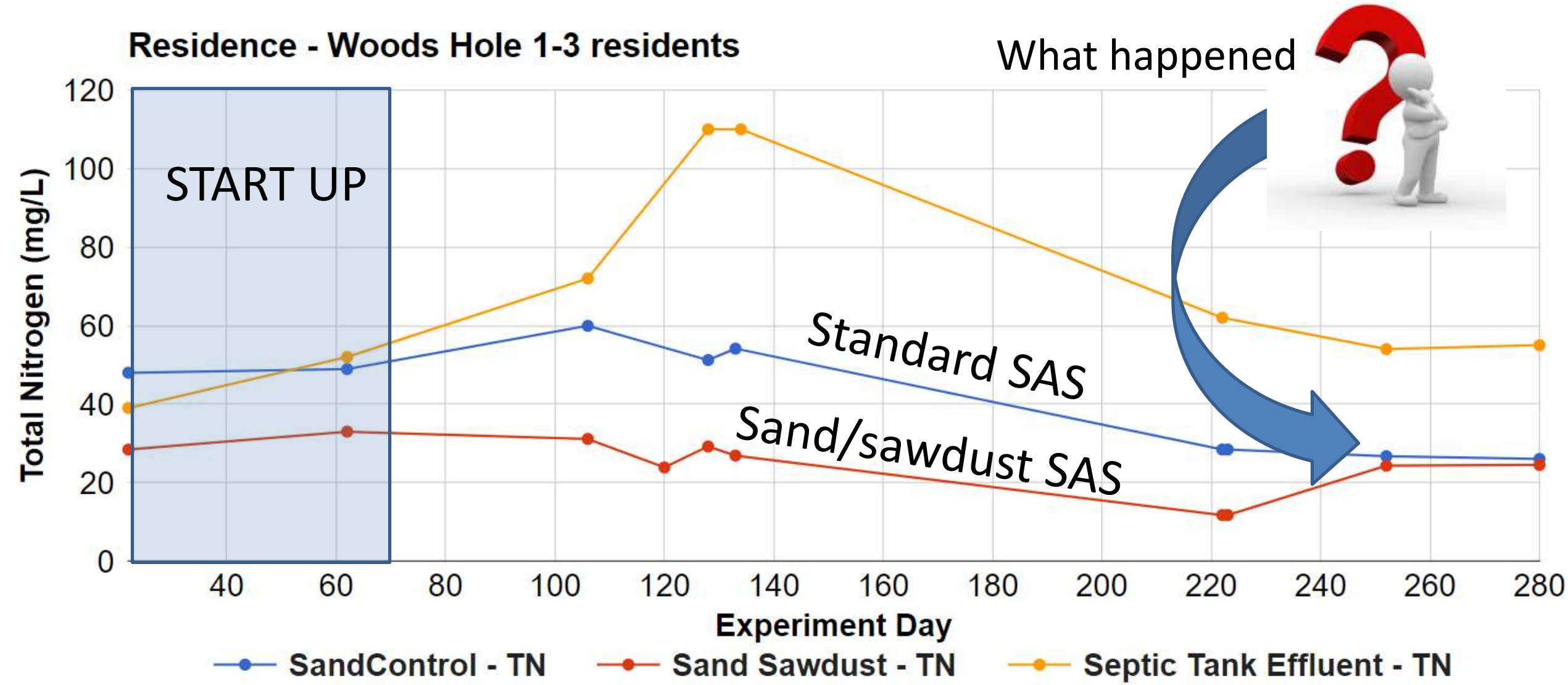
Treated Portion of Soil Absorption System

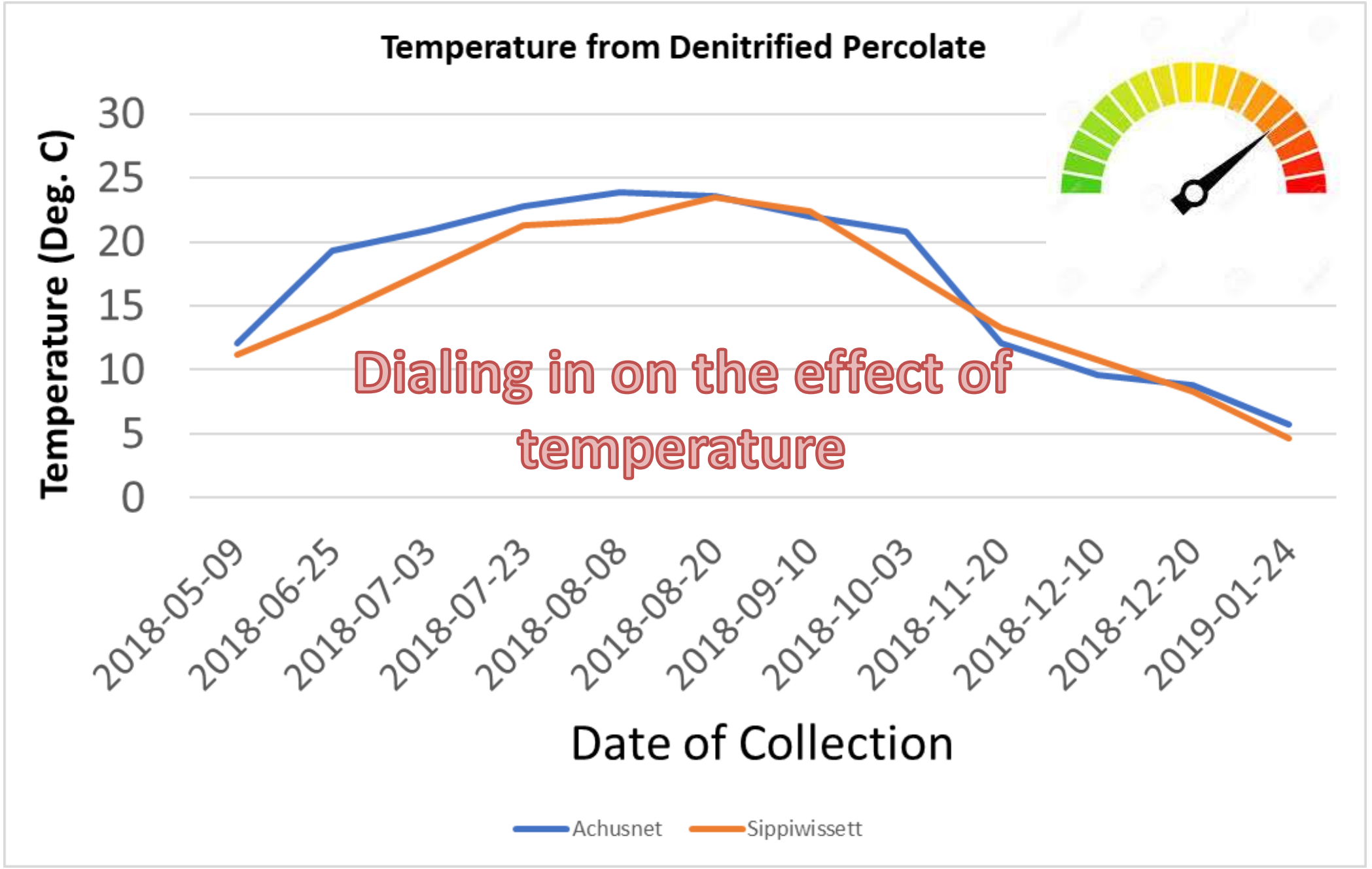


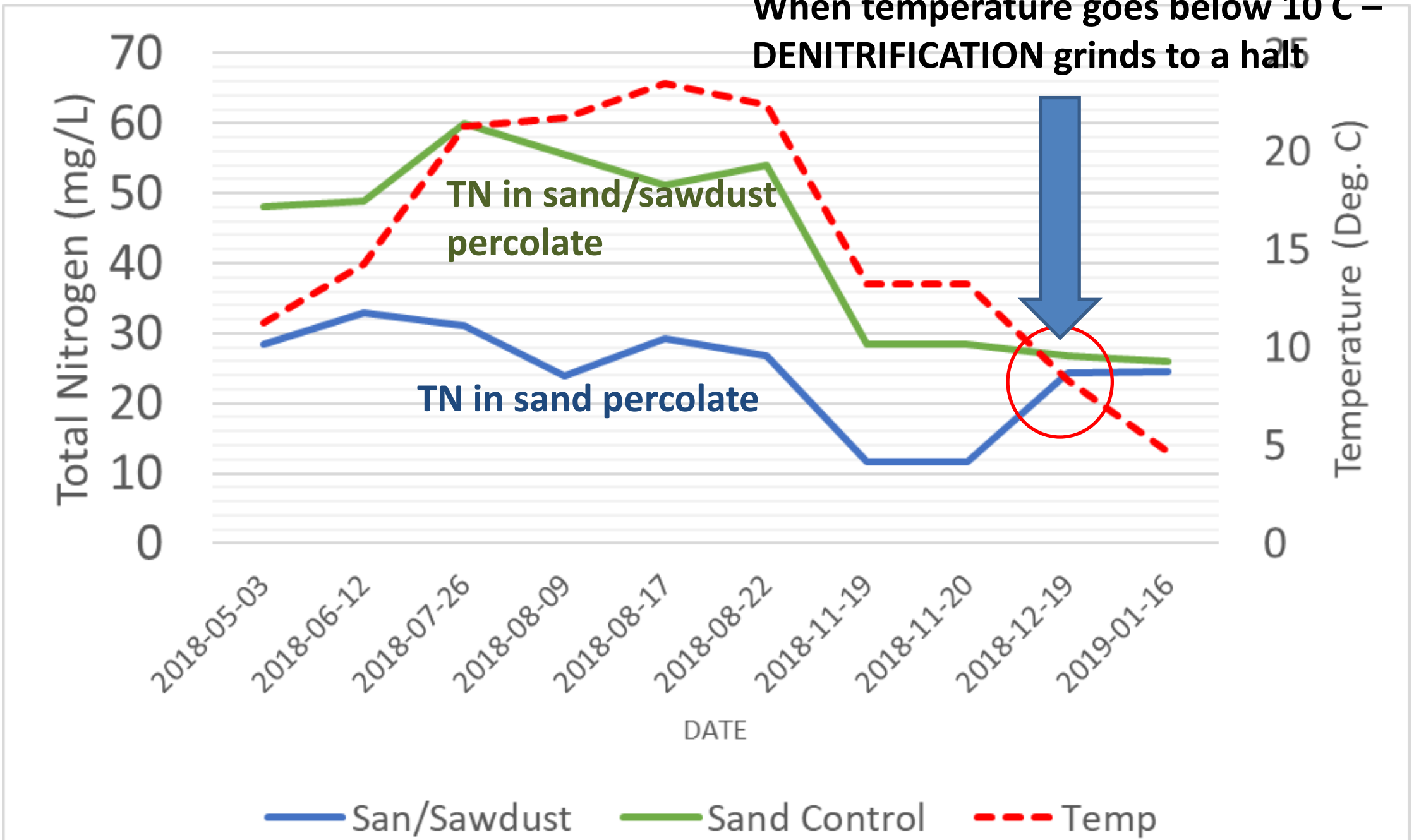
Un-Treated (Control) Portion of Soil Absorption System



System 2

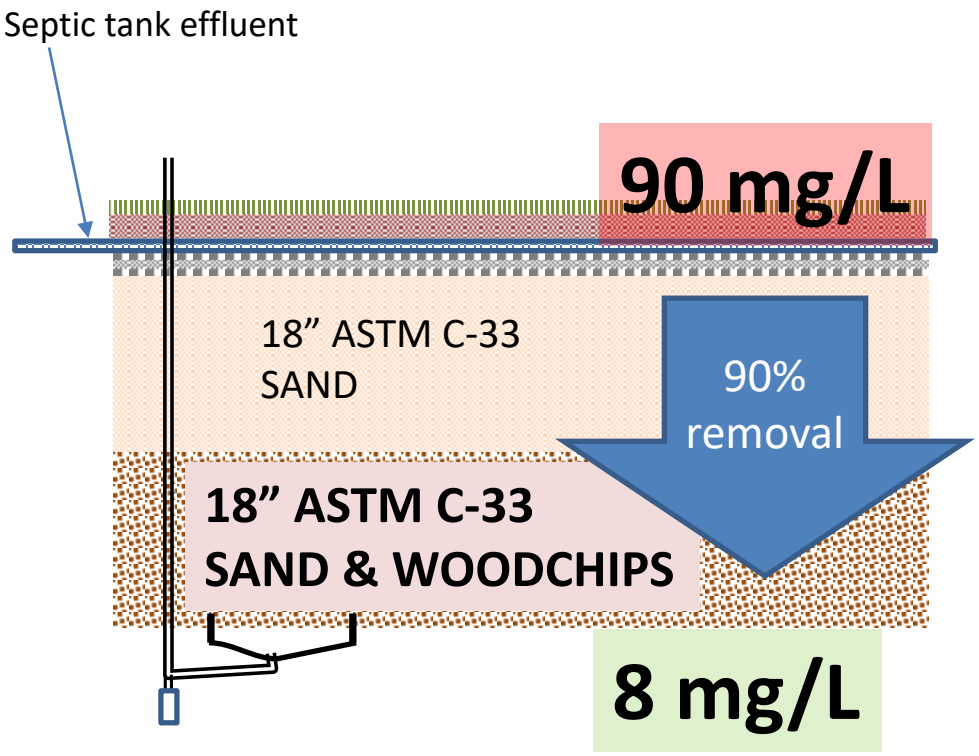

Residence - Woods Hole 1-3 residents
What happened
START UP
Standard SAS
Sand/sawdust SAS
Total Nitrogen (mg/L)
120
100
80
60
40
20
0
40
60
80
100
120
140
160
180
200
220
240
260
280
Experiment Day
SandControl - TN
Sand Sawdust - TN
Septic Tank Effluent - TN


Temperature from Denitrified Percolate
Temperature (Deg. C)
30
25
20
15
10
5
0
2018-05-09
2018-06-25
2018-07-03
2018-07-23
2018-08-08
2018-08-20
2018-09-10
2018-10-03
2018-11-20
2018-12-10
2018-12-20
2019-01-24
Date of Collection
Achusnet
Sippiwissett
Dialing in on the effect of temperature


When temperature goes below 10 C – DENITRIFICATION grinds to a halt
TN in sand/sawdust percolate
TN in sand percolate
Total Nitrogen (mg/L)
Temperature (Deg. C)
70
60
50
40
30
20
10
0
25
20
15
10
5
0
2018-05-03
2018-06-12
2018-07-26
2018-08-09
2018-08-17
2018-08-22
2018-11-19
2018-11-20
2018-12-19
2019-01-16
DATE
San/Sawdust
Sand Control
Temp

System 3 West Falmouth Harbor (seasonal)

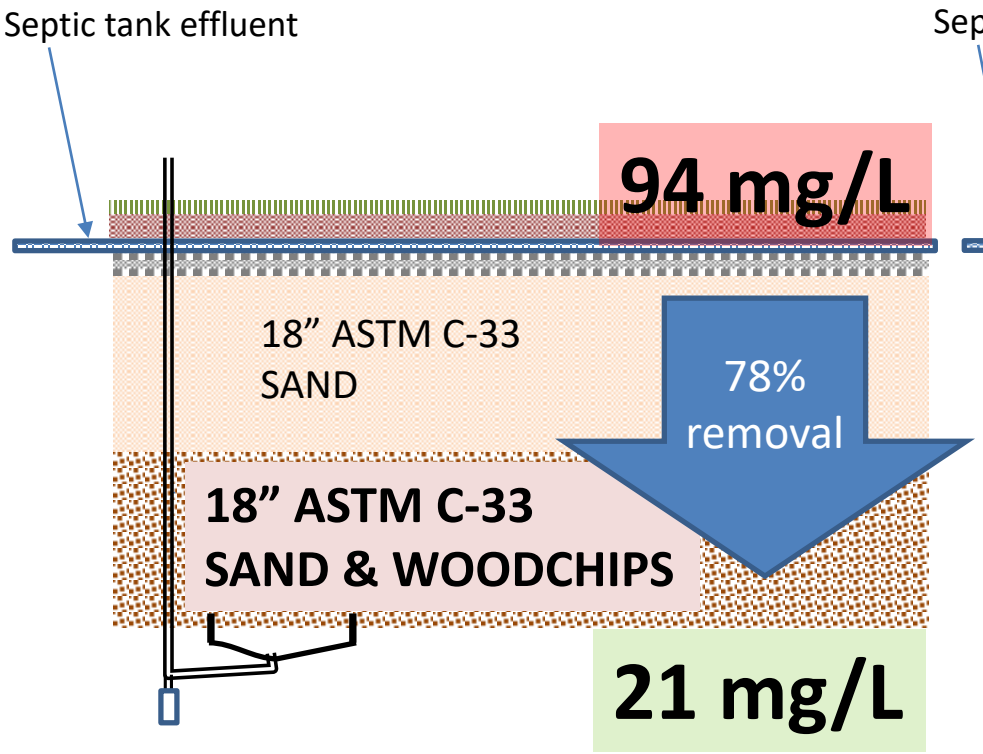
Treated Portion of Soil Absorption System



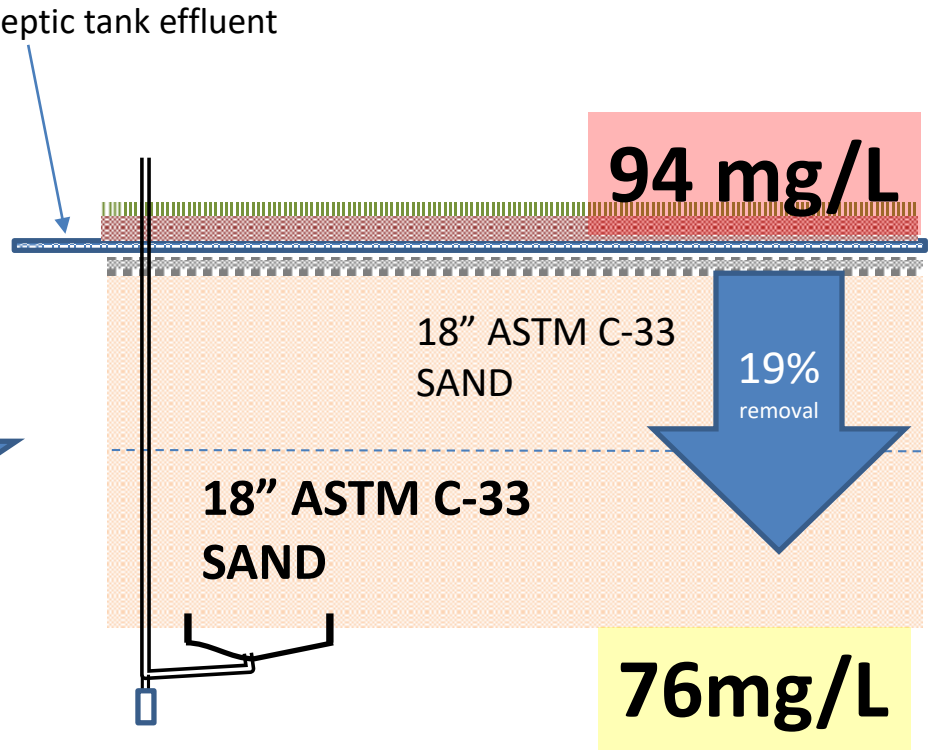
Un-Treated (Control) Portion of Soil Absorption System not installed at this location

System 4 West Falmouth Harbor (seasonal)

Treated Portion of Soil Absorption System



Un-Treated (Control) Portion of Soil Absorption System

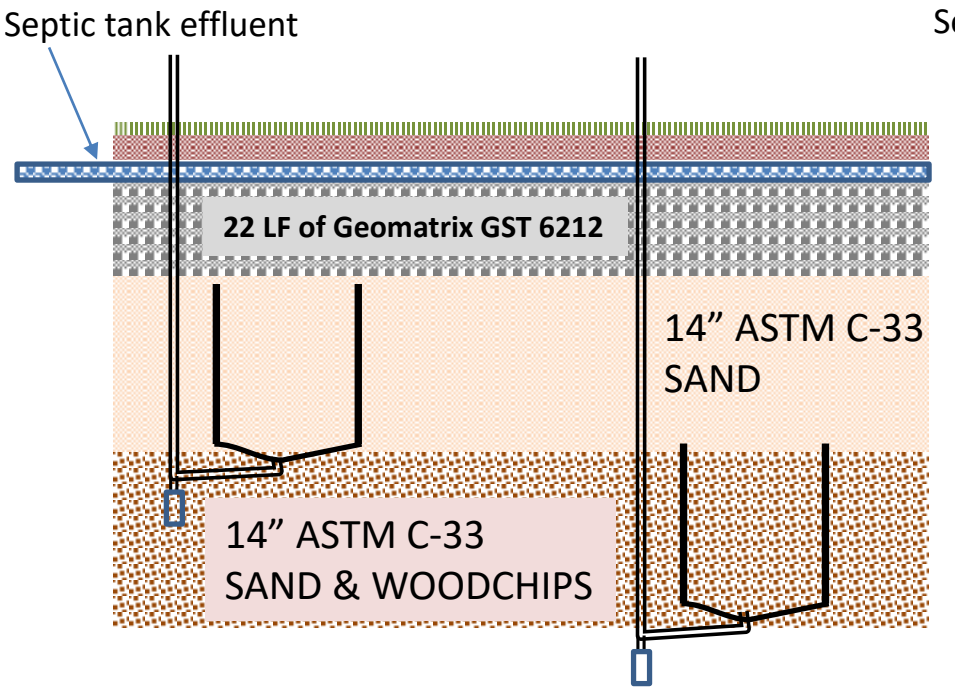


The Connecticut Experiment

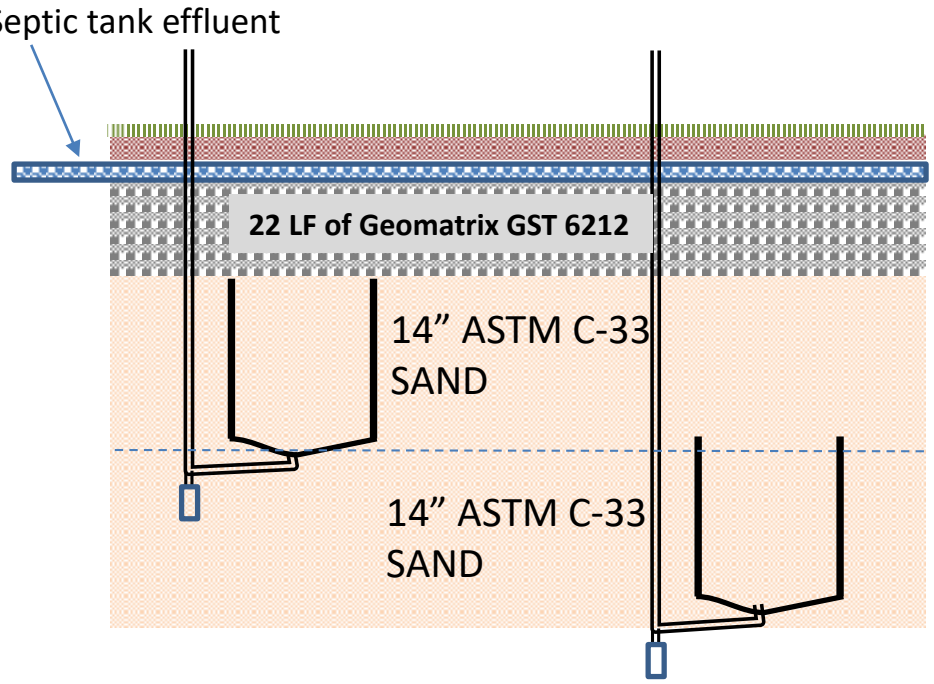
- DPW Garage
- Expected high nitrogen concentration
- Close to seasonal high groundwater

Town DPW Garage

Treated Portion of Soil Absorption System



Un-Treated (Control) Portion of Soil Absorption System



Town DPW Garage

Un-Treated (Control) Portion of Soil Absorption System

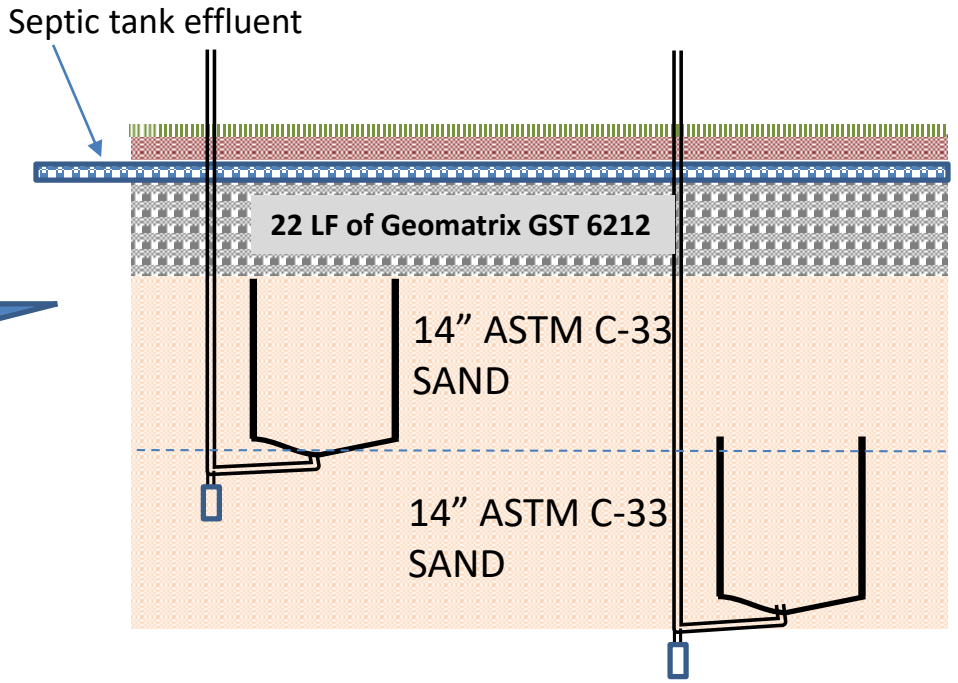
~ 260 mg/L TN

TN

257 mg/L TN

TN

98.5 mg/L TN



~ 62% Reduction in TN

Town DPW Garage

Treated Portion of Soil Absorption System

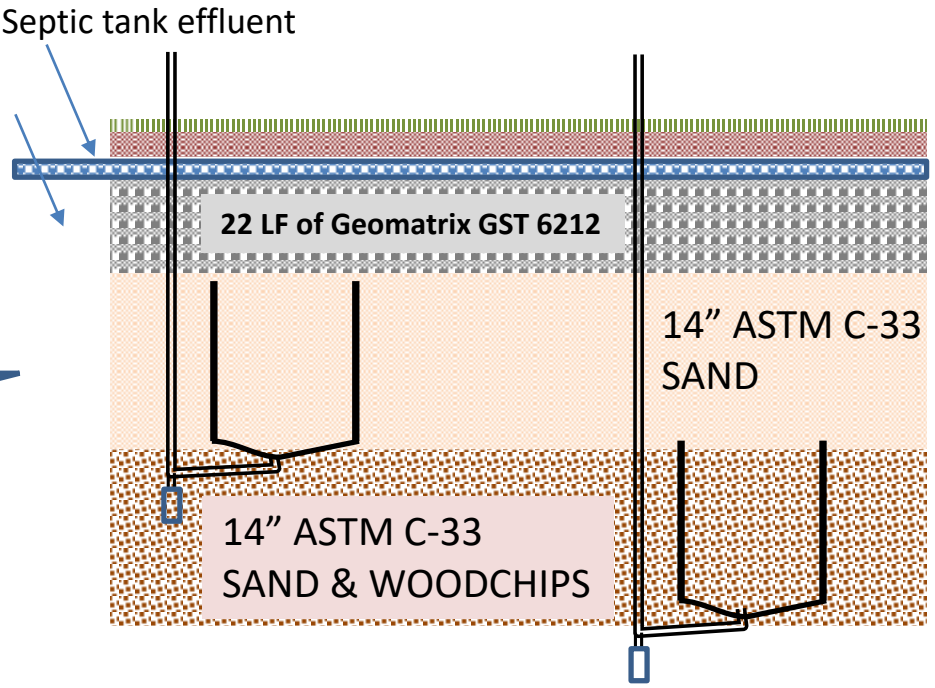
~ 260 mg/L TN

TN

248 mg/L TN

TN

56.5 mg/L TN



~ 78% Reduction in TN

Town DPW Garage

Treated Portion of Soil Absorption System

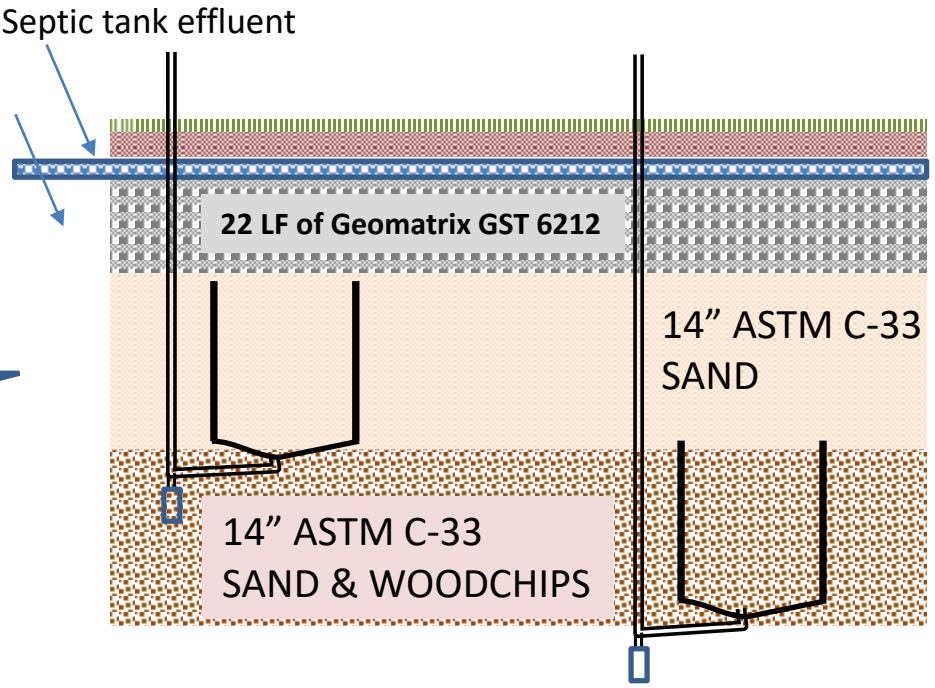
~ 260 mg/L TN

TN

248 mg/L TN

TN

56.5 mg/L TN



~ 78% Reduction in TN

Conclusions

- **Simple layering of an organic material like cellulose may offer a simple, sustainable and relatively inexpensive way to achieve nitrogen removal from onsite septic systems.**
- **Research in this area should continue to determine all the factors controlling the performance of the systems.**

Remaining Questions

- **Is it worth it $$$$?**
- **How long will the carbon last?**
- **What are all the possible negative impacts?**
- **Do they outweigh the positive impacts?**

Some final thoughts

- **Shallow drainfields used in these systems enhance removal of contaminants of emerging concern.**
- **Recent research suggests that wood-based denitrification may also reduce endocrine disrupting compounds.**

Ligninolytic enzymes: Versatile biocatalysts for the elimination of endocrine-disrupting chemicals in wastewater.
Ayodeji O. Falade Leonard V. Mabinya Anthony I. Okoh Uchechukwu U. Nwodo
First published: 17 October 2018 https://doi.org/10.1002/mbo3.722

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Questions ?

6th Northeast Onsite Wastewater Treatment Short Course and Equipment Exhibition

Technology of the Future TODAY!