Decentralized Treatment Challenges and Options in Coastal North Carolina

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What is Next?

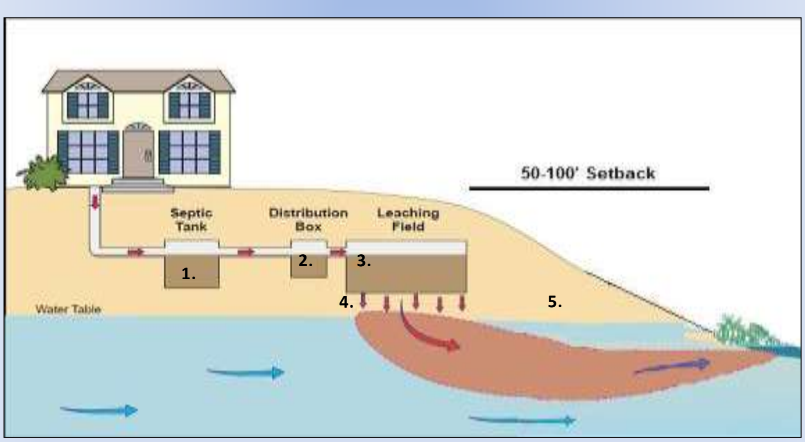
- Decentralized treatment challenges in coastal NC
  - Wastewater characteristics
  - Soils, separation distances, and setbacks
  - System densities
  - Sea level rise
- Options
  - Advanced treatment systems
  - Buffers
  - Reactive barriers
  - Drainage modifications
- References
- Summary
- Questions

Wastewater Characteristics

Parameter	Range of Concentrations	Typical Concentration
BOD_5	155 – 286 mg/L	250 mg/L
Fecal Coliform Bacteria	$10^6 – 10^8$ CFU/100mL	10^7 CFU/100mL
Ammonium-Nitrogen, NH_4-N	4 - 13 mg/L	40 mg/L
Total Nitrogen	26 – 75 mg/L	60 mg/L
Total Phosphorus	6 - 12 mg/L	10 mg/L

US EPA (2002)

Decentralized Wastewater Systems



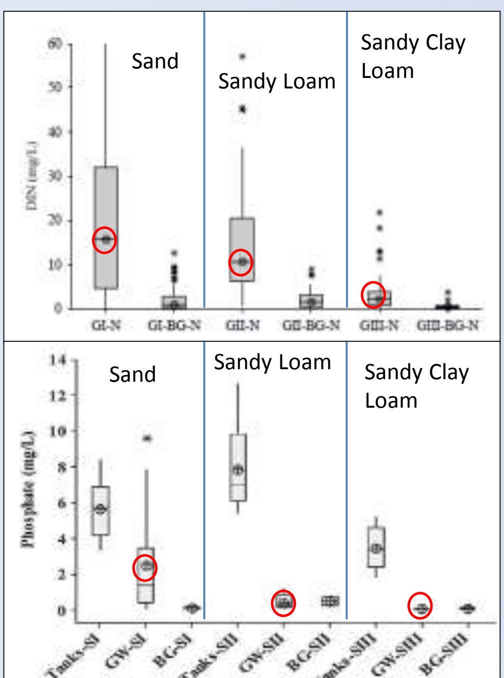
1. **Septic tank-solid separation, anaerobic digestion, and retention of sludge, scum**
2. **Effluent distribution device- distribute effluent to drainfield**
3. **Drainfield- store effluent until infiltration occurs**
4. **Soil- aerobic treatment of wastewater contaminants**
5. **Setbacks-between system and water resources, provide opportunity for more treatment**

Pollutant Treatment in Soils

Nitrogen treatment in soils
Nitrification (NH_4 to NO_3)
Denitrification (NO_3 to N_2 or N_2O)
Adsorption (NH_4 on CEC sites)
Immobilization (plant/microbe uptake of NH_4 or NO_3)
Dilution and dispersion

Pathogen treatment in soils
Die off due to aerobic conditions
Predation from soil microbes
Filtration by small soil pores
Competition by soil microbes
Dilution and dispersion
Adsorption

Phosphorus treatment in soils
Adsorption to exchange sites (Fe and Al oxides, clay)
Precipitation as a mineral (vivianite, variscite, strengite)
Immobilization (uptake by plants/microbes)
Dilution and dispersion

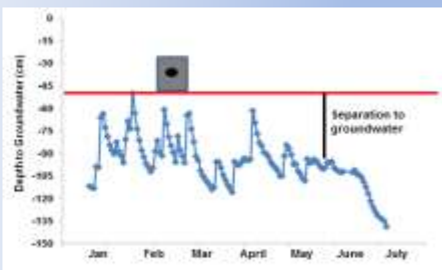


Humphrey et al 2010 (top); Humphrey et al 2011 (bottom)

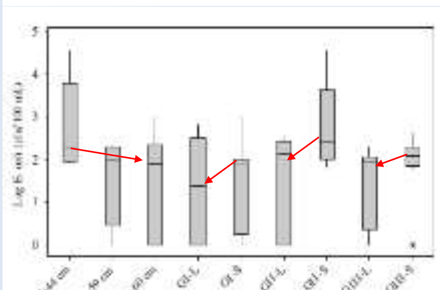
Soil Type Influences Treatment

Dissolved inorganic nitrogen (DIN)and soluble reactive phosphate (PO_4-P) concentrations were lower in groundwater beneath onsite systems in sandy clay loam relative to sandy loam and sands. These studies were conducted on 16 onsite systems in Carteret County, NC.

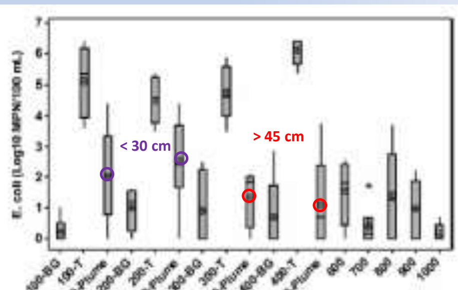
Vertical Separation Influences Treatment



Bacteria treatment is influenced by the amount of aerated soil between onsite system and groundwater. Groundwater levels, separation distance, and treatment fluctuate in response to groundwater recharge events.

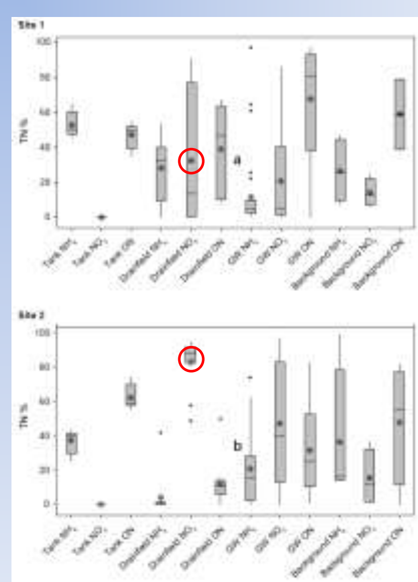


Humphrey et al., 2011



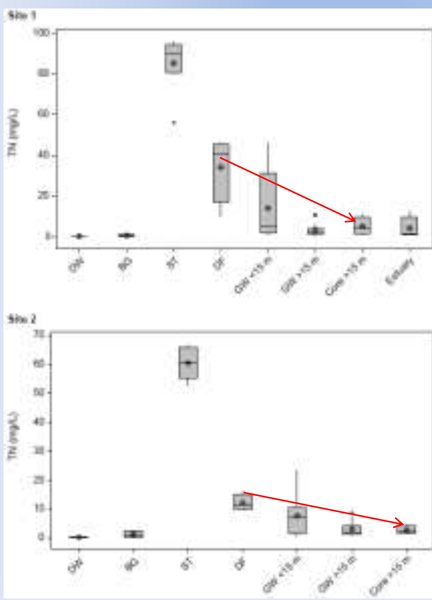
Humphrey et al., 2015

Vertical Separation Influences Treatment

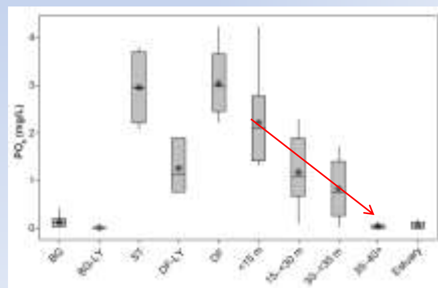


Humphrey et al., 2013

Nutrients are Mobile in Sandy Soils



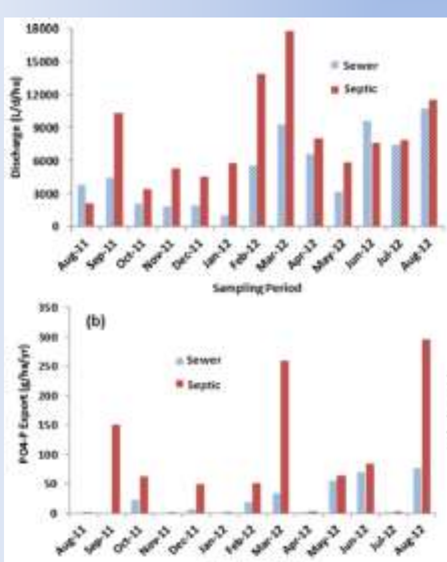
Dissolved nitrogen and PO_4-P concentrations in groundwater decline with increasing distance from onsite systems, indicating that setback distances are important for nutrient attenuation



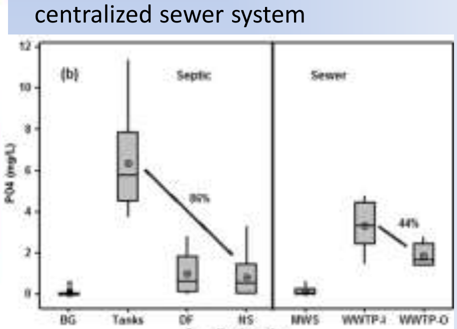
Humphrey et al., 2013

Humphrey et al., 2014

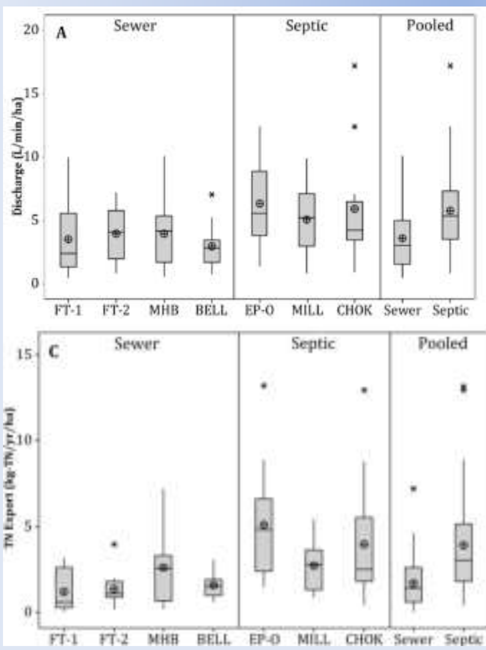
Streamflow and Phosphorus Exports



Watersheds served by onsite systems had elevated stream flow and phosphorus exports relative to watersheds served by centralized sewer. However, onsite systems were more efficient at reducing phosphorus concentrations and loads than the centralized sewer system



Humphrey et al., 2015

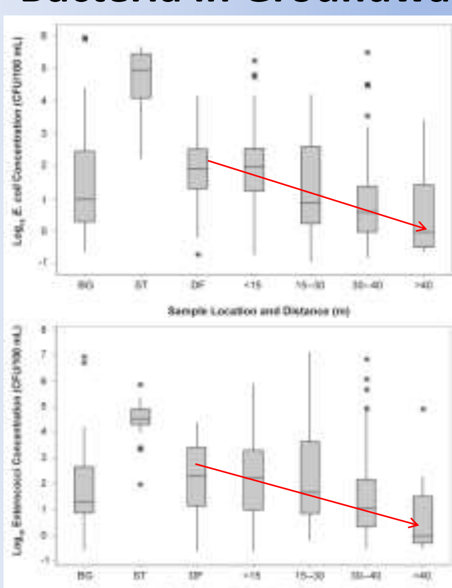


Iverson et al., 2015

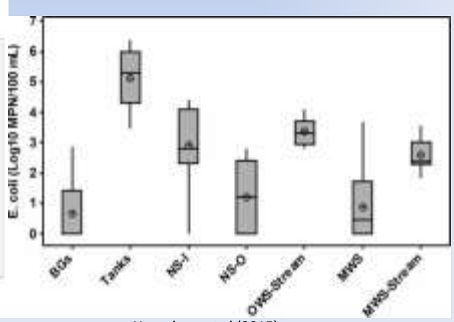
Streamflow and Nitrogen Exports

Watersheds served by onsite systems had elevated stream flow and nitrogen exports relative to watersheds served by centralized sewer. However the watershed scale treatment efficiency of onsite systems averaged 88% while the centralized sewer removed 78% of nitrogen in wastewater.

Bacteria in Groundwater and Surface Water



Bacteria concentrations decrease with increasing distance from onsite systems. Bacteria concentrations in groundwater may influence concentrations in surface water if onsite systems are not functioning efficiently.



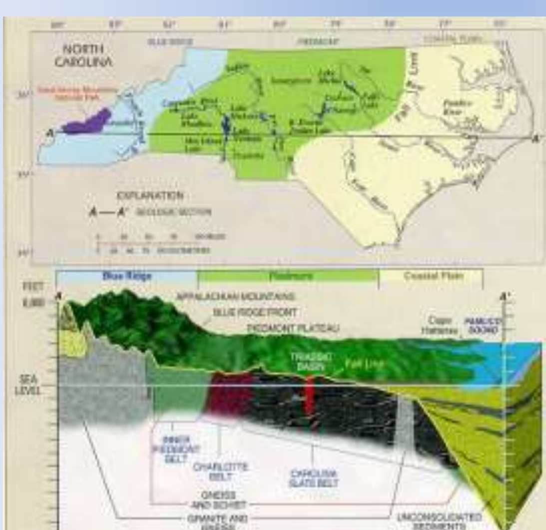
Schneeberger et al (2015)

Humphrey et al (2015)

Quick Review

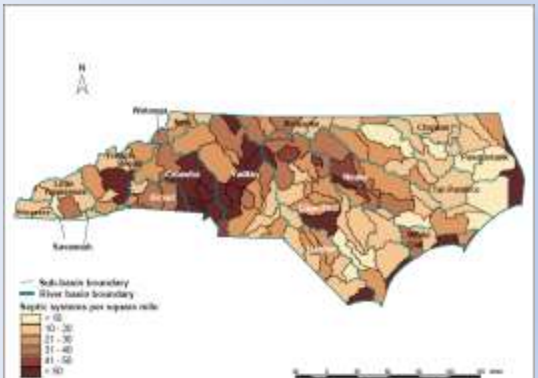
- Wastewater treatment influenced by
  - Percent sand, silt and clay in subsoil
  - Separation distance from system to groundwater
  - Setback distances to surface waters
- Onsite systems can influence groundwater and surface water nutrient and bacteria concentrations in some settings

Challenges: The Coastal Plain is Sandy



Soil type influences treatment. Coastal soils are sandy and relatively shallow, increasing the potential for groundwater transport of pollutants from onsite systems to surface waters

Challenges: High Densities of Systems



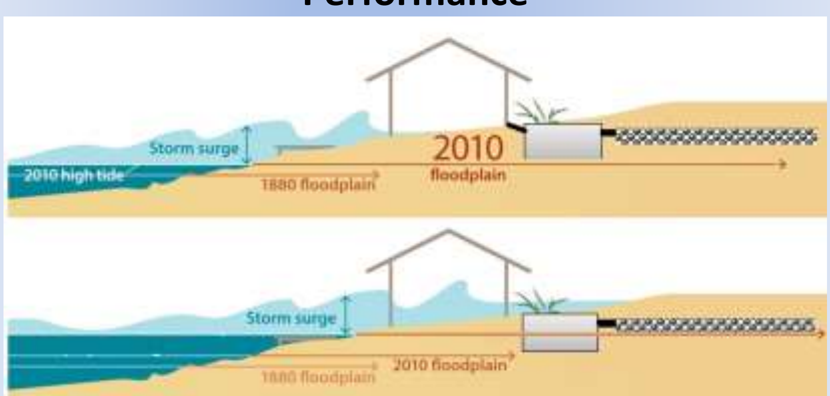
Pradhan (2007)

High densities of onsite systems are possible in sandy soils because of relatively high LTARs, which reduce the area required for drainfields

<u>Long Term Acceptance Rates (LTAR)</u>

Soil Group	LTAR (g/day/ft^2)
I: S, LS	1.2 - 0.8
II SL, L	0.8 - 0.6
III: SCL, SiL, CL, SiCL, Si	0.6 - 0.3
IV: SC, SiC, C	0.4 – 0.1

Challenges: Sea Level Rise and Decentralized Performance



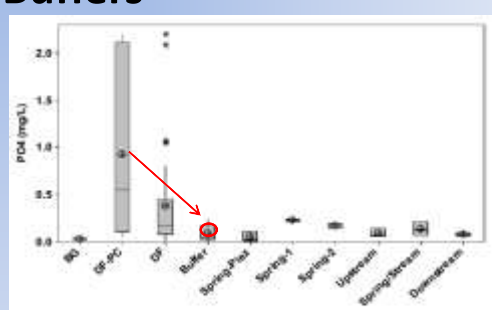
Onsite system treatment efficiency may be reduced because of rising sea level. Smaller vadose zones and less horizontal setback to surface waters will occur in some coastal areas.

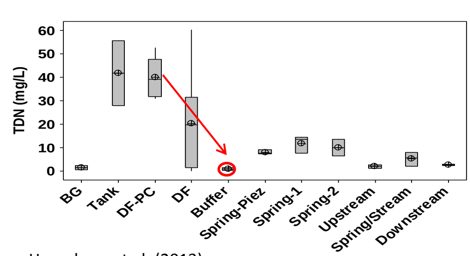
Onsite System Options

Parameter	TS-I	TS-II
CBOD (mg/L)	<15	<10
TSS (mg/L)	<15	<10
NH4-N (mg/L)	<10	<10
TN (mg/L)		<20 or >60% reduction
Fecal Coliform	<10,000	<1,000 (cfu/100 mL)

Advanced treatment systems (ATS) can reduce nutrient and pathogen concentrations in wastewater. The effluent from the ATS is discharged in soil for final treatment and dispersal. ATS are used mostly for new construction on expensive real estate.

Challenges & Options: Wetlands & Riparian Buffers



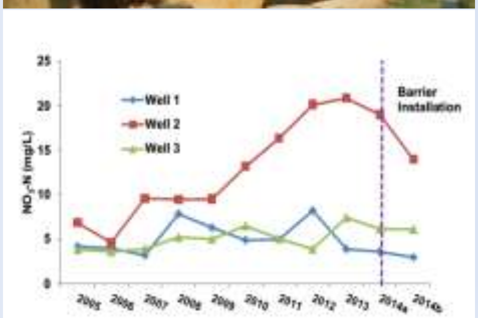


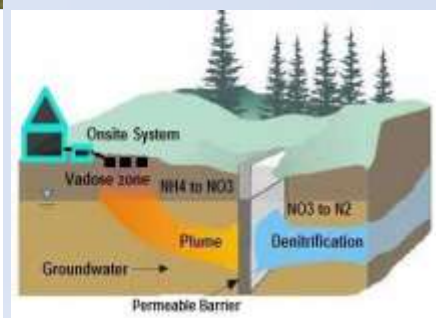
Humphrey et al. (2013)

Significant attenuation of nitrogen and phosphorus can occur adjacent to waterways in wetlands and riparian buffers. Establishing, maintaining, and preserving riparian buffers is important for nutrient attenuation.

Options: Reactive Barriers

Permeable reactive barriers may help reduce the groundwater transport of nutrients to surface waters from various non-point sources including onsite systems. Funding for research and functional demonstrations is needed to explore this BMP.





Humphrey et al (2015)

Options: Reactive Barriers, Wetlands, Modified Drainage Ways

Schipper et al., 2010

The implementation of reactive barriers, modified drainage ways with in-stream reactors, and use of created and natural wetlands could be a cost effective means of reducing pollution from onsite systems and other non-point sources. Funding sources and regulatory flexibility would be required to implement these strategies.

Challenges & Options: Funds for Decentralized Improvements and Education

If onsite systems are recognized as non-point sources of pollution, then funding should be made available to mitigate their impacts like with other non-point sources such as agriculture and stormwater runoff. Funding for inspections, maintenance, repairs, demonstrations, and education may help improve system efficiency.

Summary

- Onsite system challenges in coastal NC
  - Sandy soils
  - Shallow water tables
  - High densities of existing systems
  - Sea level rise
  - Funding for mitigation
- Onsite system options
  - Establishing and maintaining riparian buffers and wetlands
  - Use of permeable reactive barriers, created and natural wetlands, in-stream reactors
  - Seek funding opportunities for mitigation efforts (inspections, maintenance, repairs, retrofits, education)

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  - Craven, Martin
- NC WRRI
- NC DEQ 319 Non-point Source Program
- US CDC
- Volunteers
- Students

Questions?