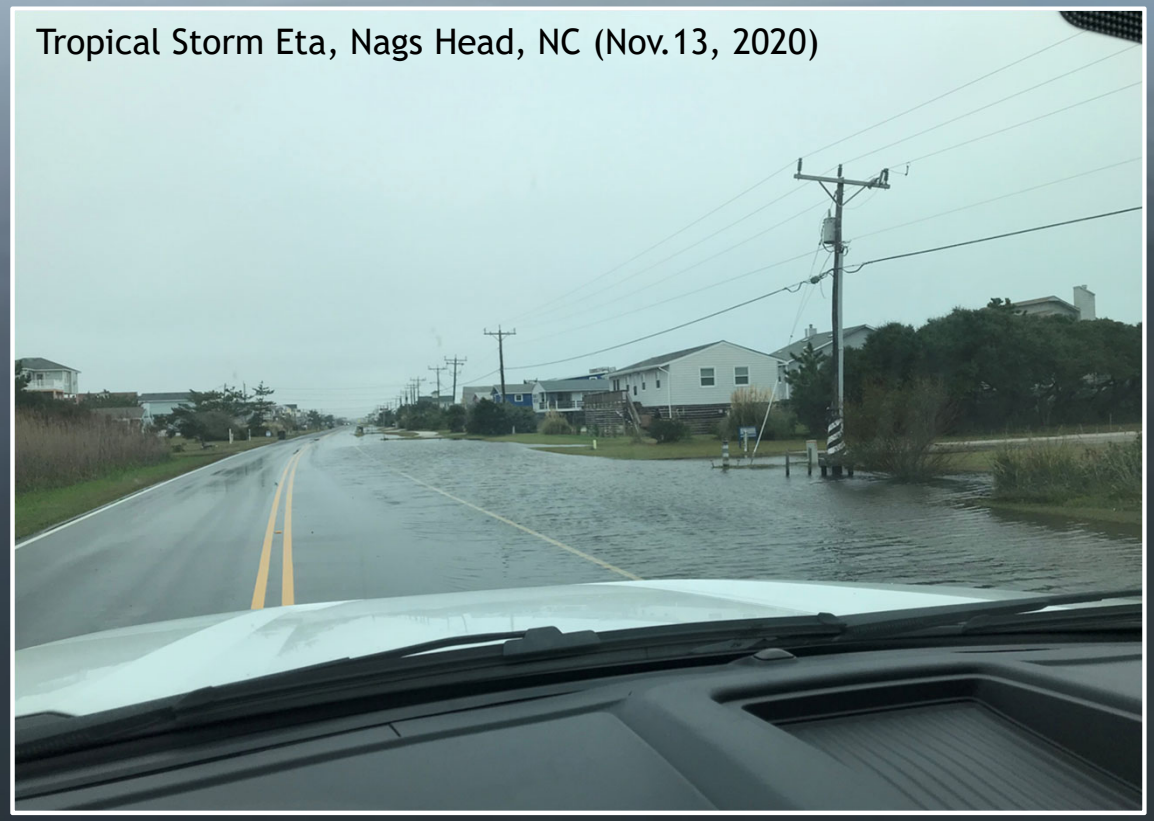
Climate Change Influence on Coastal Onsite Wastewater Infrastructure


Tropical Storm Eta, Nags Head, NC (Nov.13, 2020)

Jane Harrison & Lauren Vorhees
North Carolina Sea Grant

Eric Edwards & Jared Bowden
North Carolina State University

Charles Humphrey, Mike O'Driscoll & Guy Iverson
East Carolina University

Katie Hill
University of Georgia

Climate Change is Coming for Coastal Septic Systems

Flooded septic tank- Nags Head, NC (Nov. 13)

North Carolina

- Groundwater levels & extreme precipitation events are increasing in many coastal communities (Cox et al. 2019, Paerl et al. 2019, Kunkel et al. 2020).

- Changes pose a threat to onsite ww treatment, impacts to public health, and ecosystems.

- How can coastal communities that use onsite ww treatment protect water quality as climate changes?

Wastewater Infrastructure Tipping Points: Prioritizing Implementation of Climate Adaptation Plans in Decentralized Systems

Jane Harrison (PI) and Lauren Voorhees
North Carolina Sea Grant

Eric Edwards and Jared Bowden
North Carolina State University

Charles Humphrey, Mike O'Driscoll, and Guy Iverson
East Carolina University

Katie Hill
University of Georgia

Community Partners:
Nags Head, NC and Folly Beach, SC

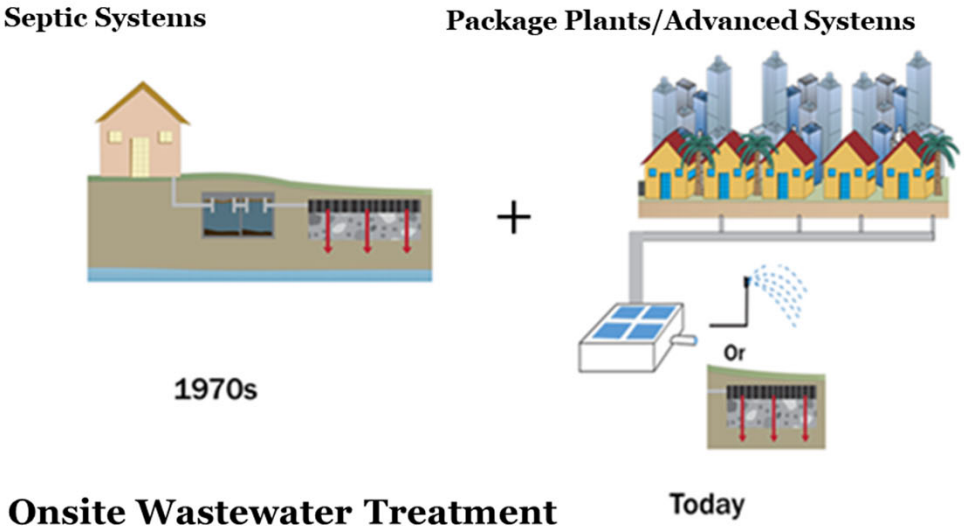
Changing conditions in coastal regions can cause unique ww management challenges (nuisance flooding, extreme precip., sl rise)

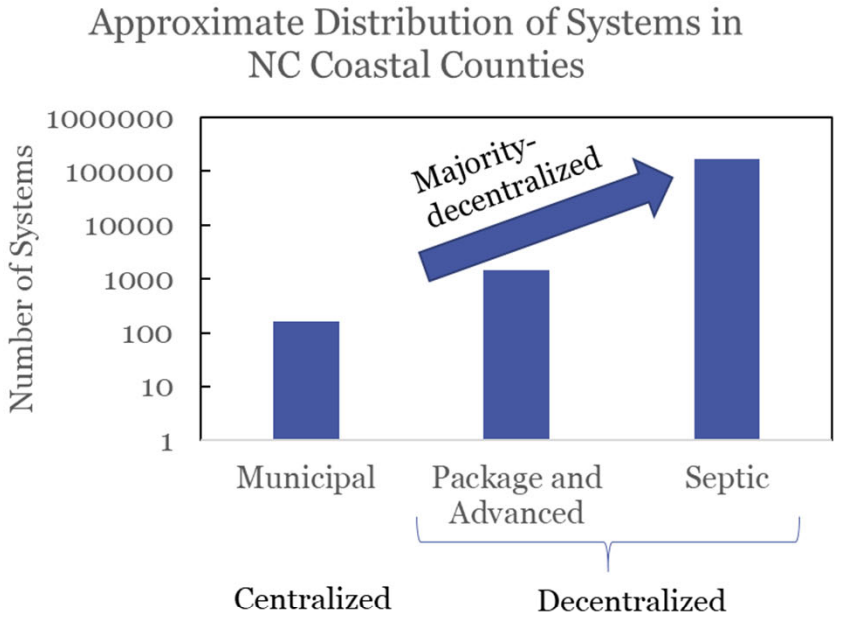
How can coastal communities cost effectively and legally implement climate adaptation plans for decentralized wastewater infrastructure?

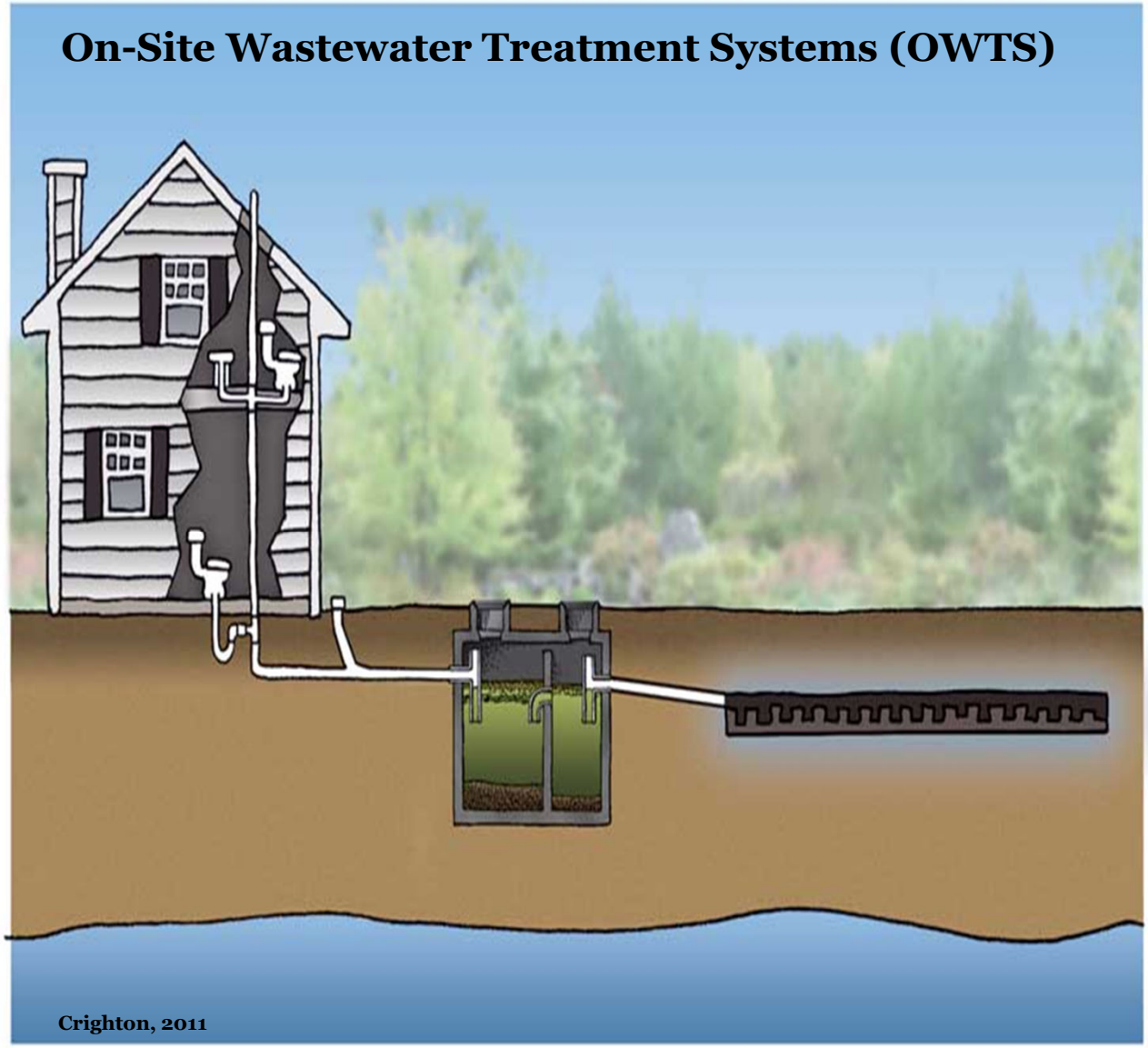
Interdisciplinary Perspectives

- Groundwater dynamics
- Expert interviews (operators/installer, health officials)
- Legal analysis

NC Reliance on Onsite Wastewater Treatment & Disposal







Vertical Separation Distance (VSD)

- Depth of unsaturated soil btwn the drainfield and the water table.
- Adequate VSD needed for degradation of organics, bacteria/virus removal, nitrification.
- Field & column studies* suggest VSD > 60cm needed for adequate soil treatment of ww.

VSD challenges near the beach

Unsaturated soil

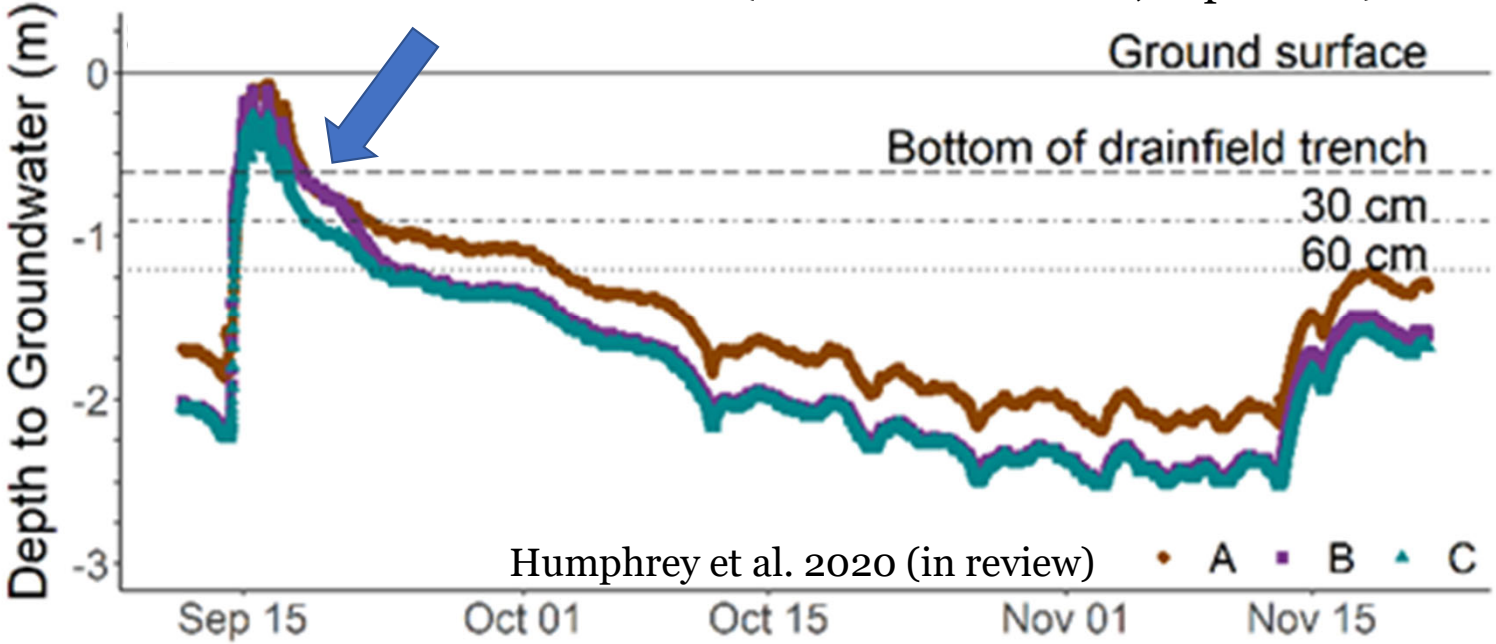
Depth to GW

*(Karathanasis et al. 2006a,b; Humphrey et al. 2011; Stall et al. 2014; Humphrey et al. 2015a: O'Driscoll et al. 2014; Humphrey et al. 2015b; Cooper et al. 2016; Humphrey et al. 2017).

Climate Change Threats to OWTS – Storms & Flooding (Acute)

- Flooding and storm-related erosion can reduce treatment capacity of coastal onsite wastewater treatment systems (OWTS).

Flooded drain lines (Hurricane Florence, Sept. 2018)

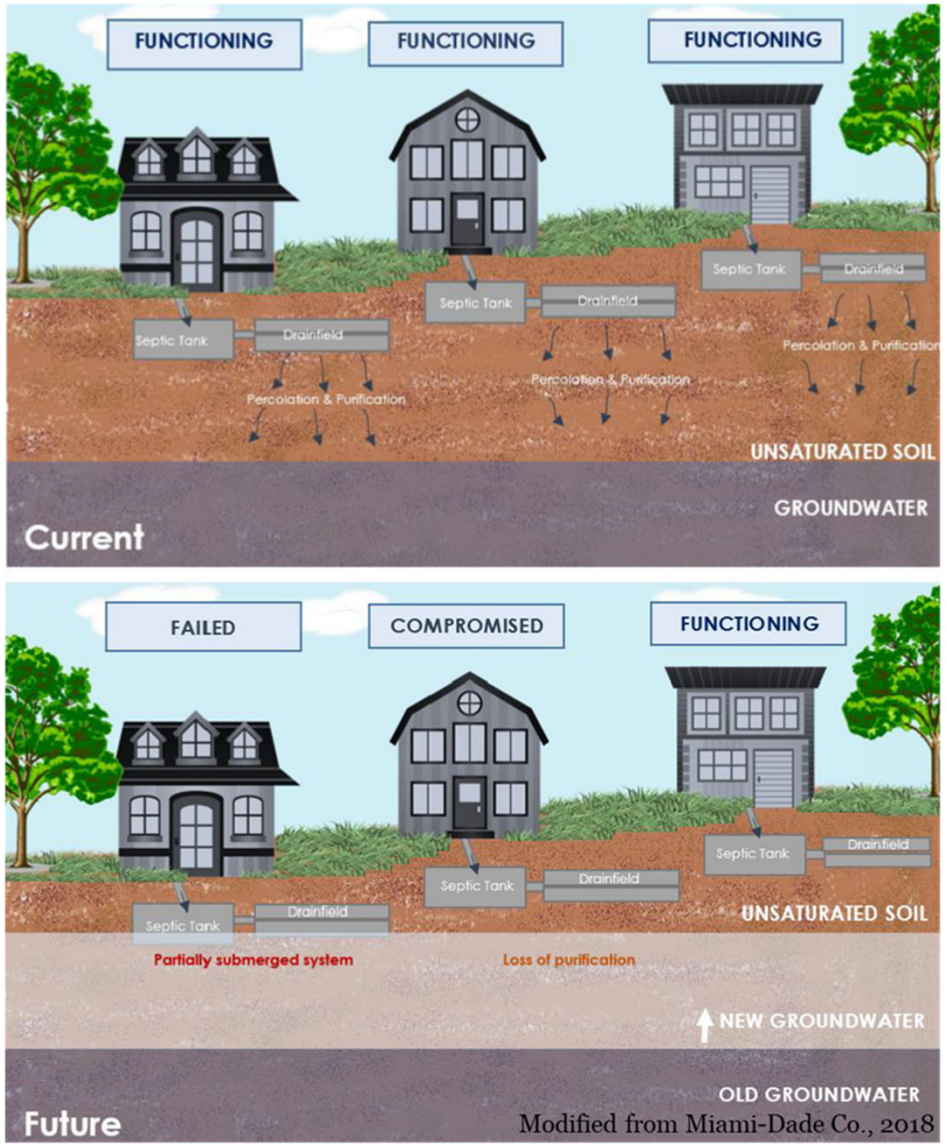


Humphrey et al. 2020 (in review)

GW depth in 3 wells near a Pitt Co., NC OWTS

Climate Change Threats to OWTS: Groundwater Inundation (Chronic)

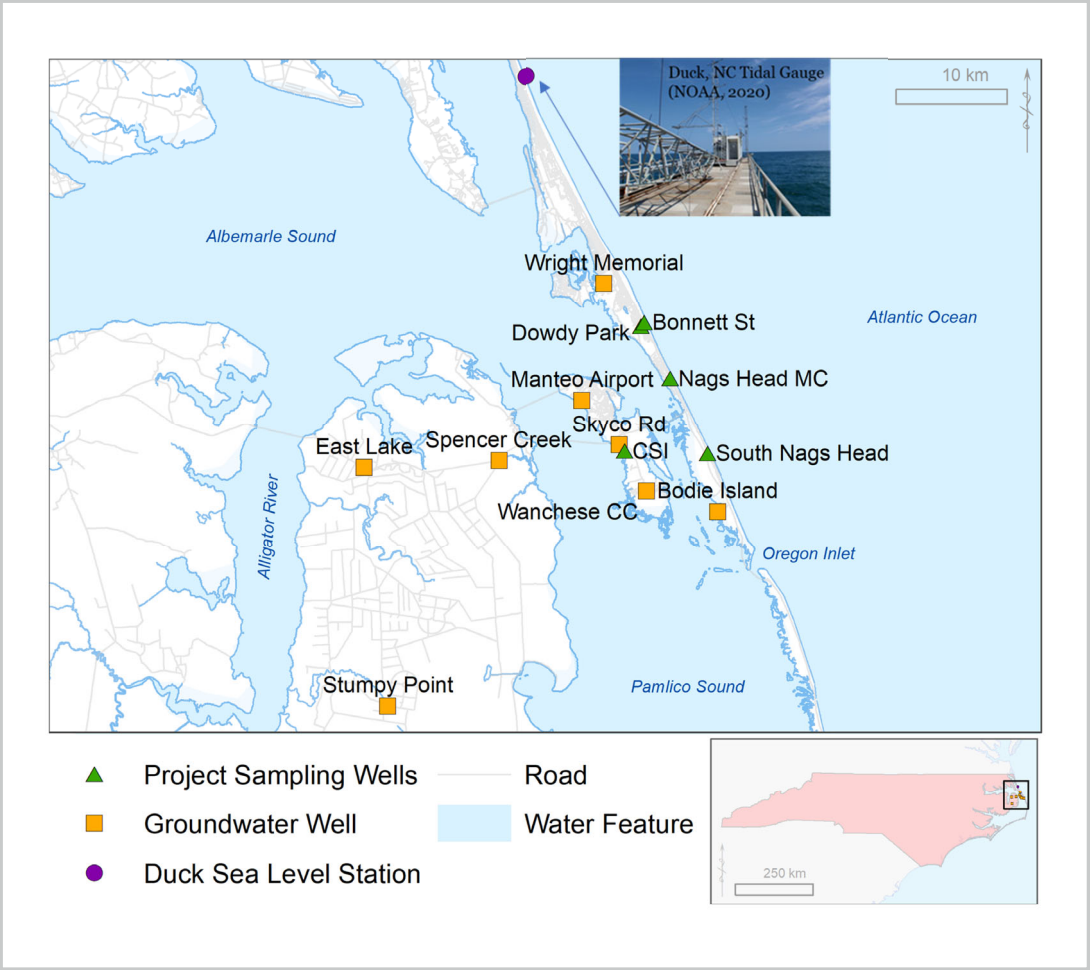
- Rising gw levels due to sea level rise and coastal storms can reduce the VSD.
- NC requires 30-45 cm VSD between the drainfield and the groundwater.
- Chronic failure can occur as gw rises and reduces the thickness of unsat. soils and compromises their ability to treat wastewater.



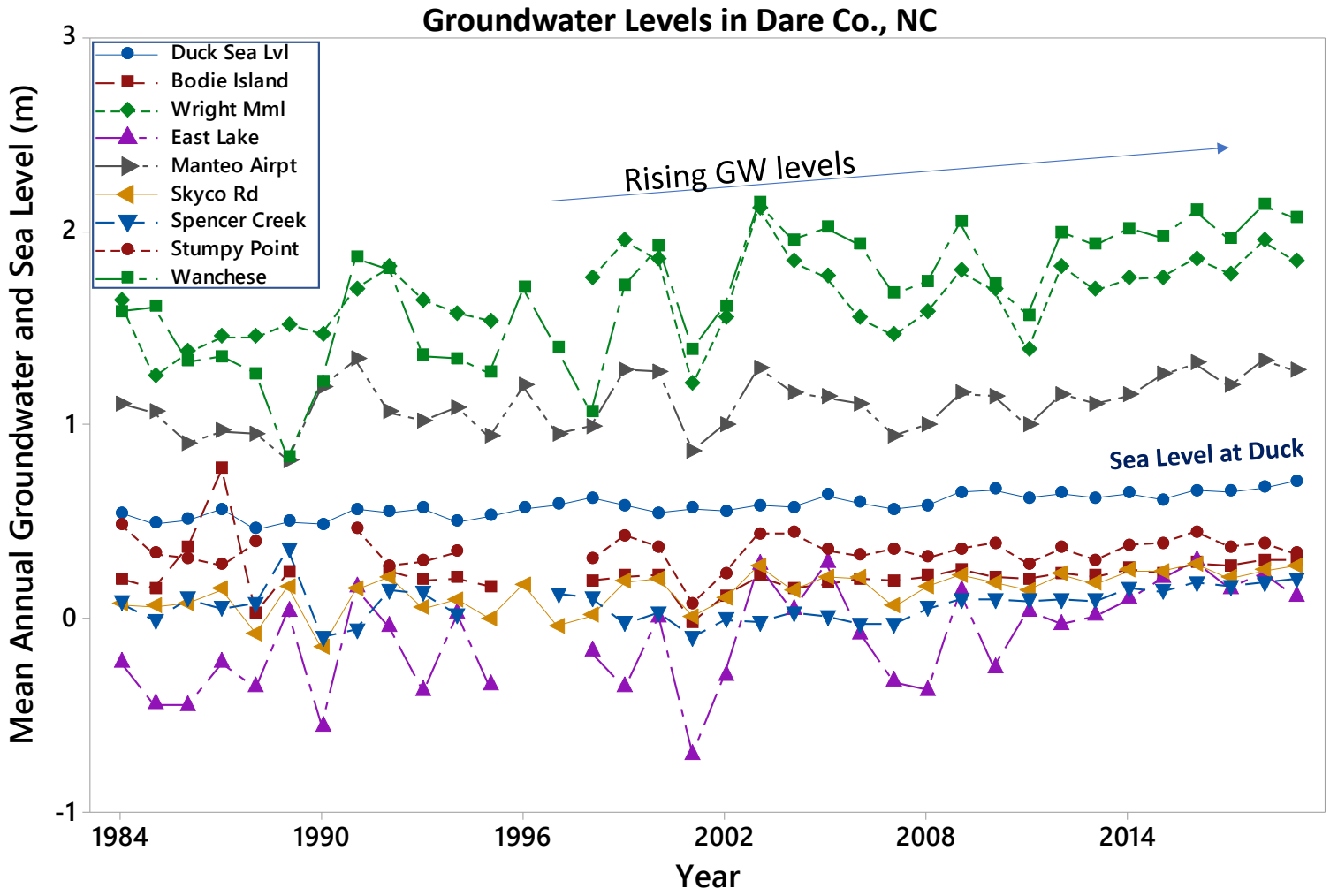
Groundwater and Sea Level Monitoring Sites – Dare Co. NC

- 8 well clusters (NC DEQ) ~ 1983-1984
- ~ monthly data collection, mid- 1980s
- daily data collection at most sites by 2008
- Duck, NC –NOAA Tidal Gauge; 1977
- additional project wells (since 2019)

- For this talk- focus on longer-term DEQ data



Sea Level Rise and Surficial Aquifer Groundwater Levels



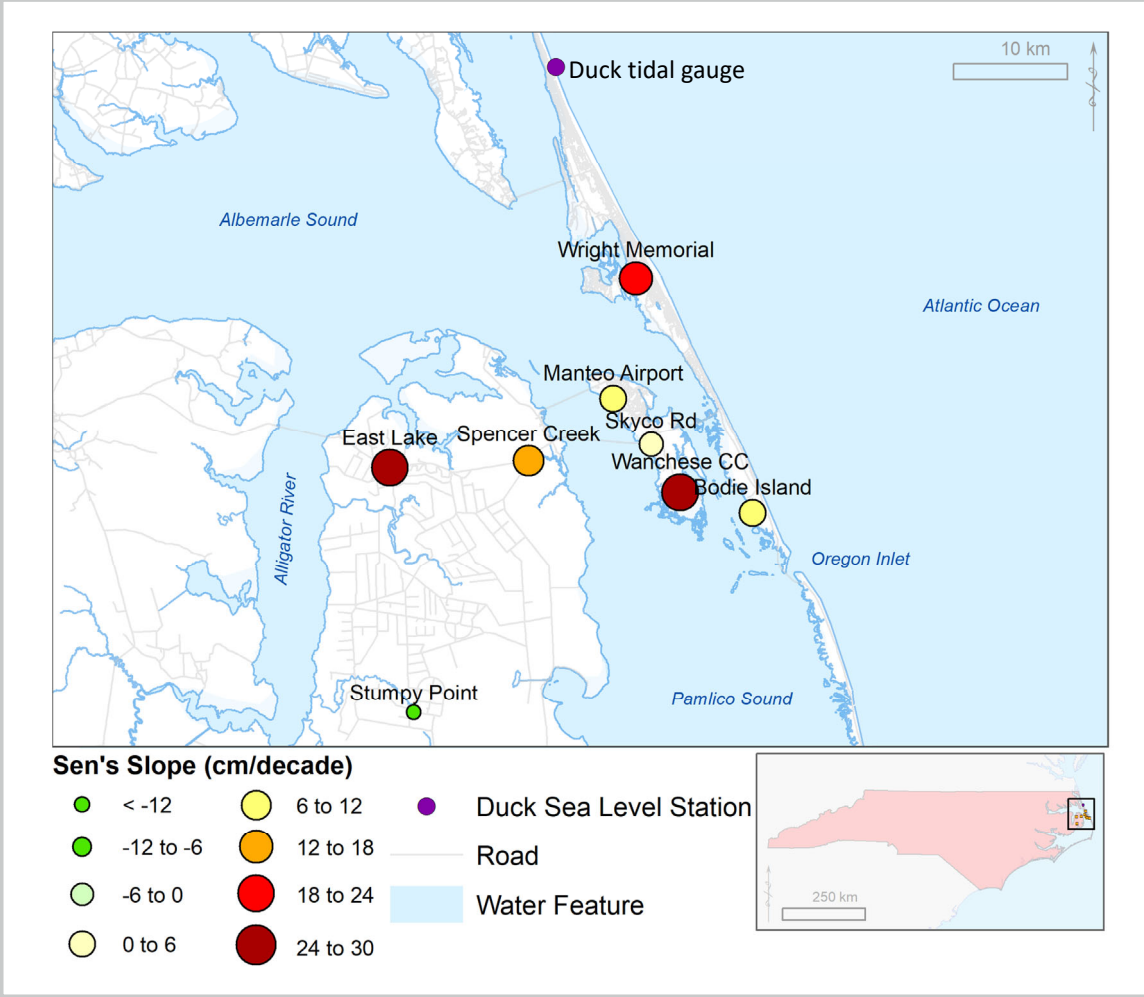
Groundwater levels have been rising in the surficial aquifer over period of record (1983-2019)

Sea level rise at Duck, NC (NOAA, 2020): 4.77 cm (1.9 in)/decade (1978-2019)

Groundwater Level Trends (Surficial Aquifer; 1983-2019)

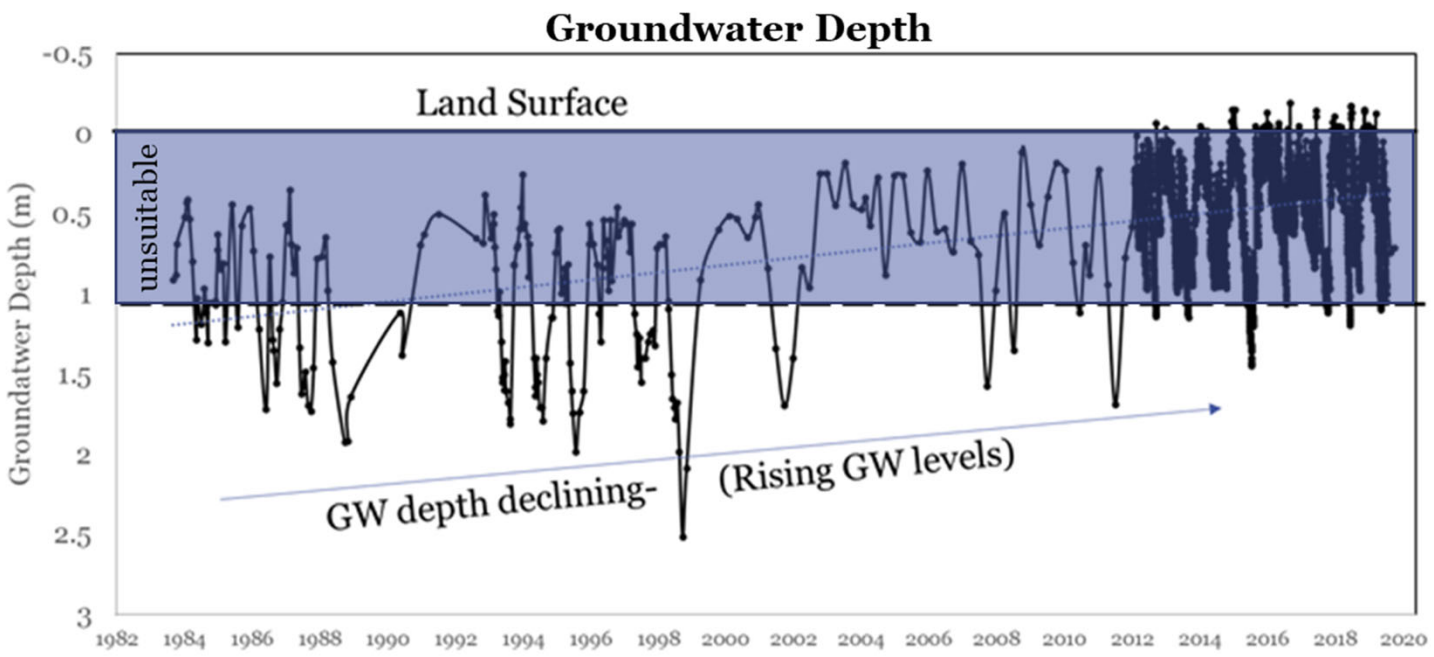
- Mean annual gw levels rose significantly from 1983-2019 (except Stumpy Pt)
- Median gw level rise trend-12.8 cm/decade (~5 in/decade)
- GW level rise ranged from 29 cm/decade (Wanchese) – 6cm/decade (Skyco Rd.)

GW Level Change (cm/decade)



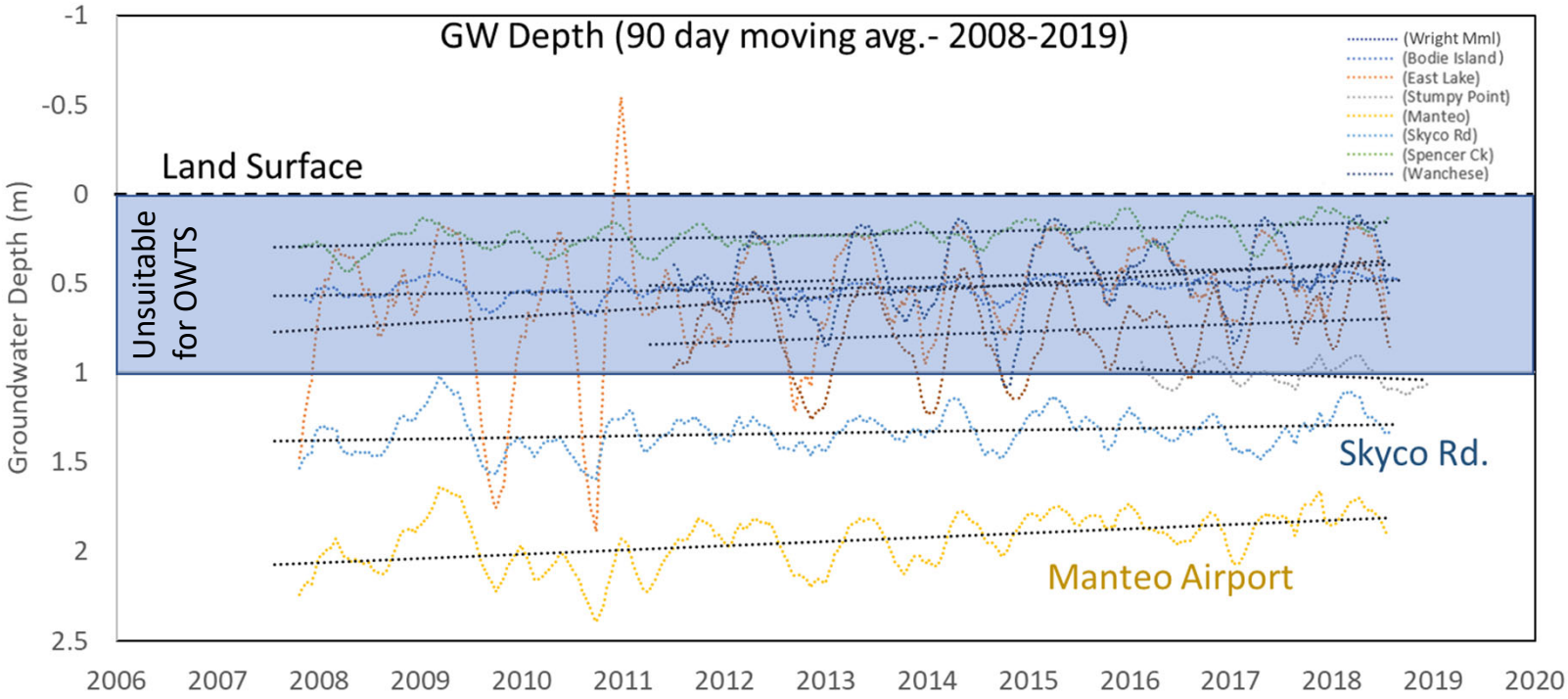
Groundwater Level Rise ➡ Reduction in GW Depth

- Greatest GW level increase (depth decrease) at Wanchese Community Building
- GW depth < 1 m (~ 0.4-.6 m depth to drainlines/ trench & 0.45m VSD) , unsuitable for conventional septic
- VSD decline over time- reduced suitability for conventional septic systems



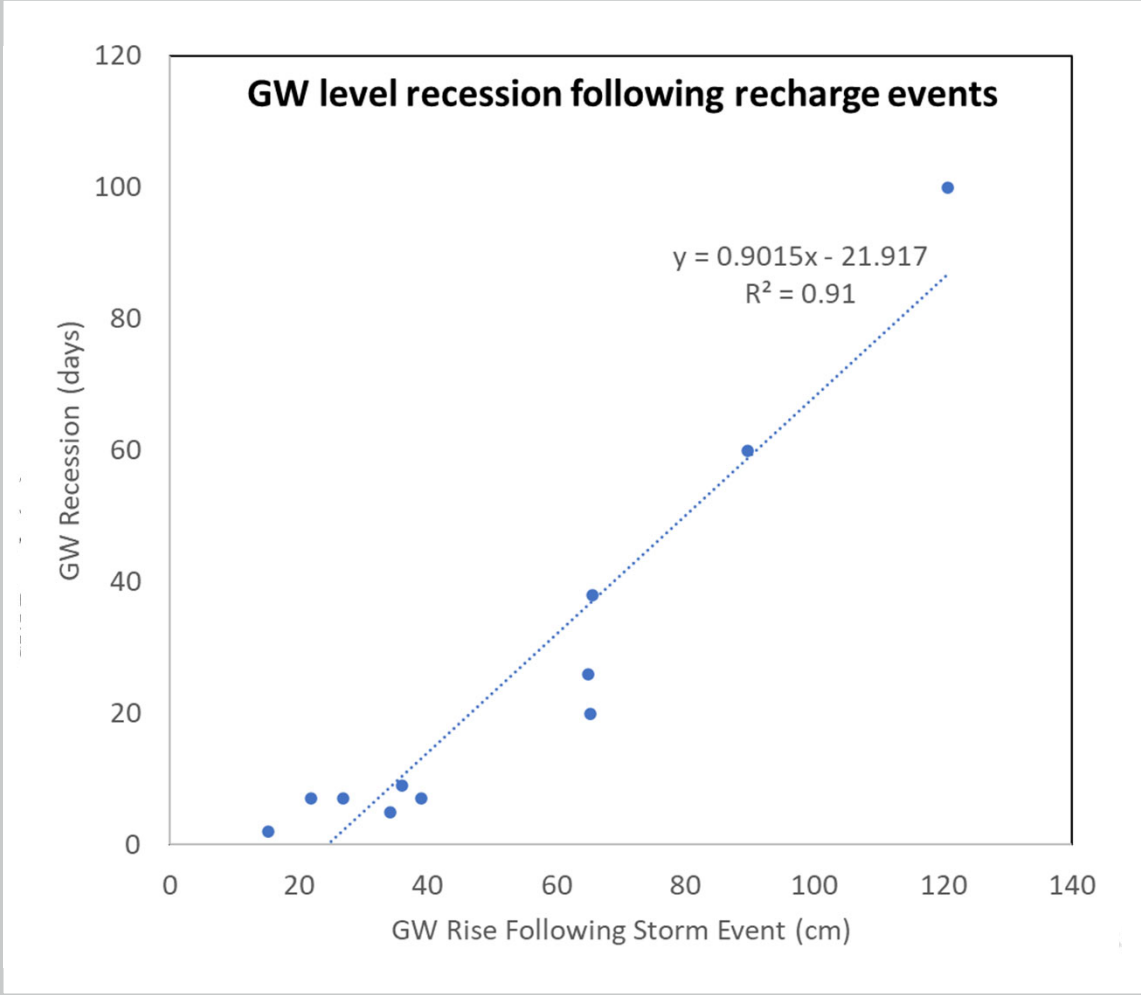
Effects of Sea Level Rise on GW Depth and VSD

- Majority of sites - gw < 1 m depth
- These areas would not be viable for conventional OWTS (VSD > 0.45 m)
- Only 2 areas had gw depth > 1 m for 30% of year (viable for OWTS)

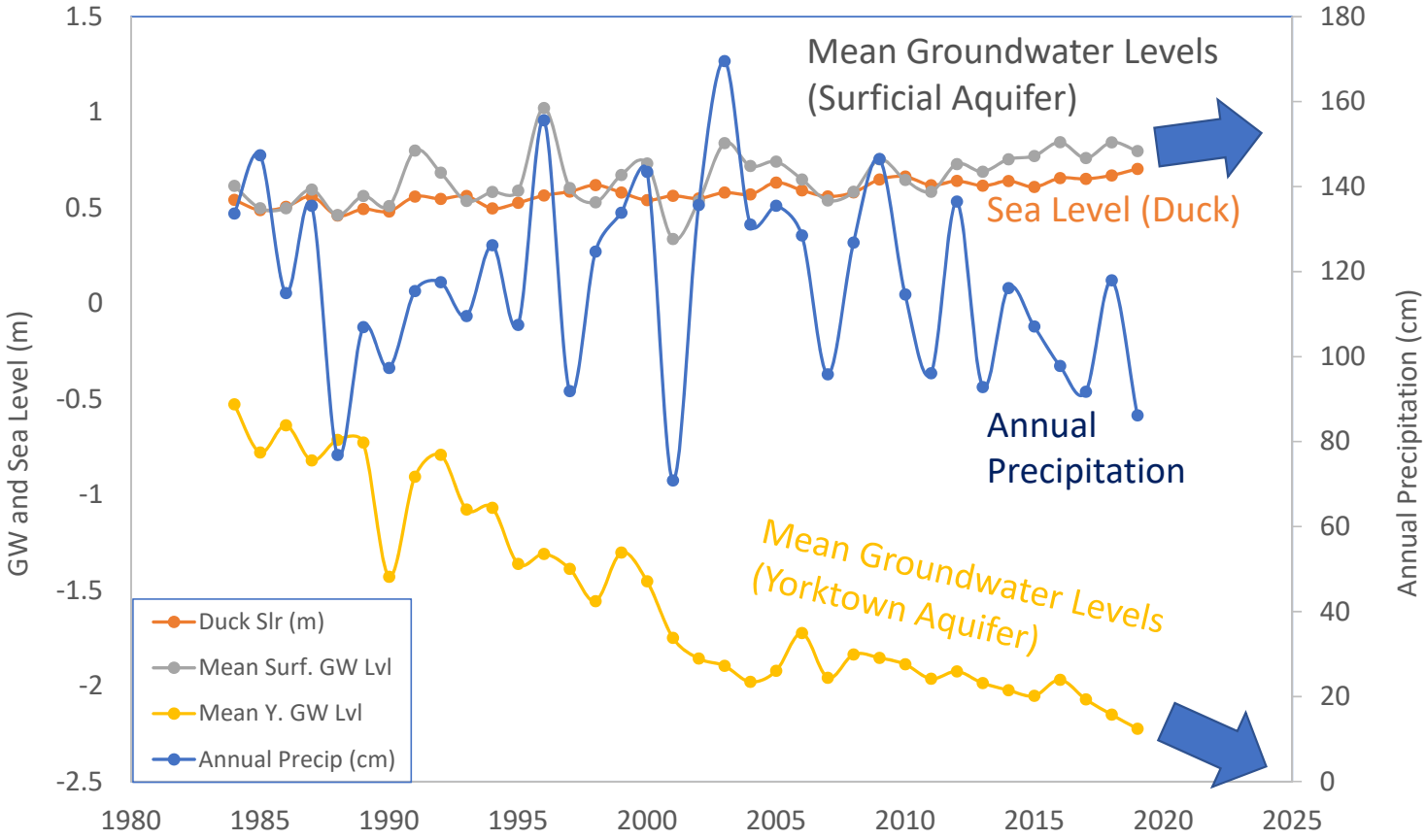


Coastal Storms and GW Response: Reductions in VSD

- GW Level Response to Rainfall @ Wanchese
- Extreme rain event (18 cm, 7 in.)
- 1.2m (3.9 ft.) GW rise
- ~100 days to return to pre-event GW levels
- At this site for > 5cm (2 in.) rain events, weeks to months for gw to return to pre-storm levels

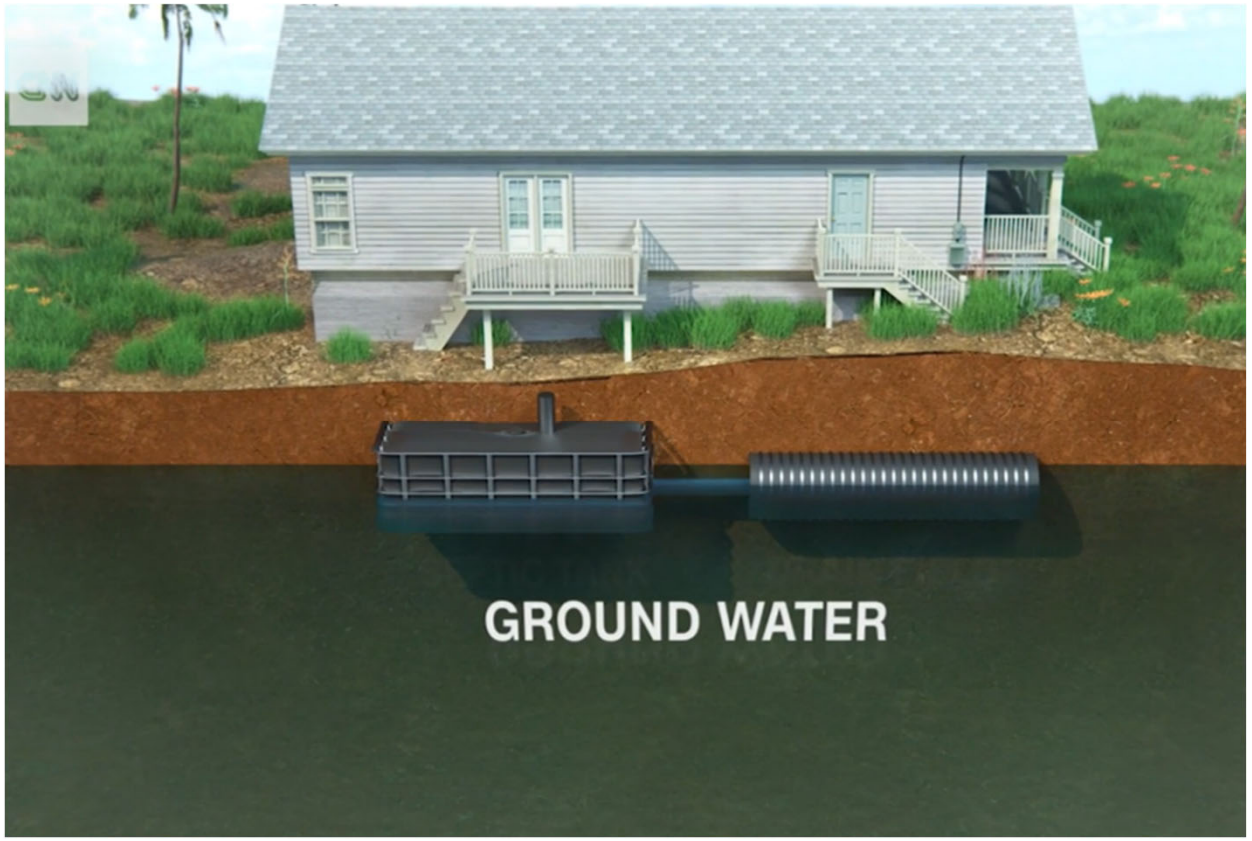


Why are the GW Levels Rising in the Surficial Aquifer?



- Sea Level Rise
- Precipitation
- Declining GW levels in the underlying Yorktown Aquifer
  - Potentially accelerating subsidence
  - Natural subsidence
- Withdrawals from the Yorktown typically discharged to the surficial aquifer via onsite systems
- Other factors (land-use change)

How are the rising GW levels affecting onsite wastewater treatment?



Modified from Christensen 2019

Learning From the Experts

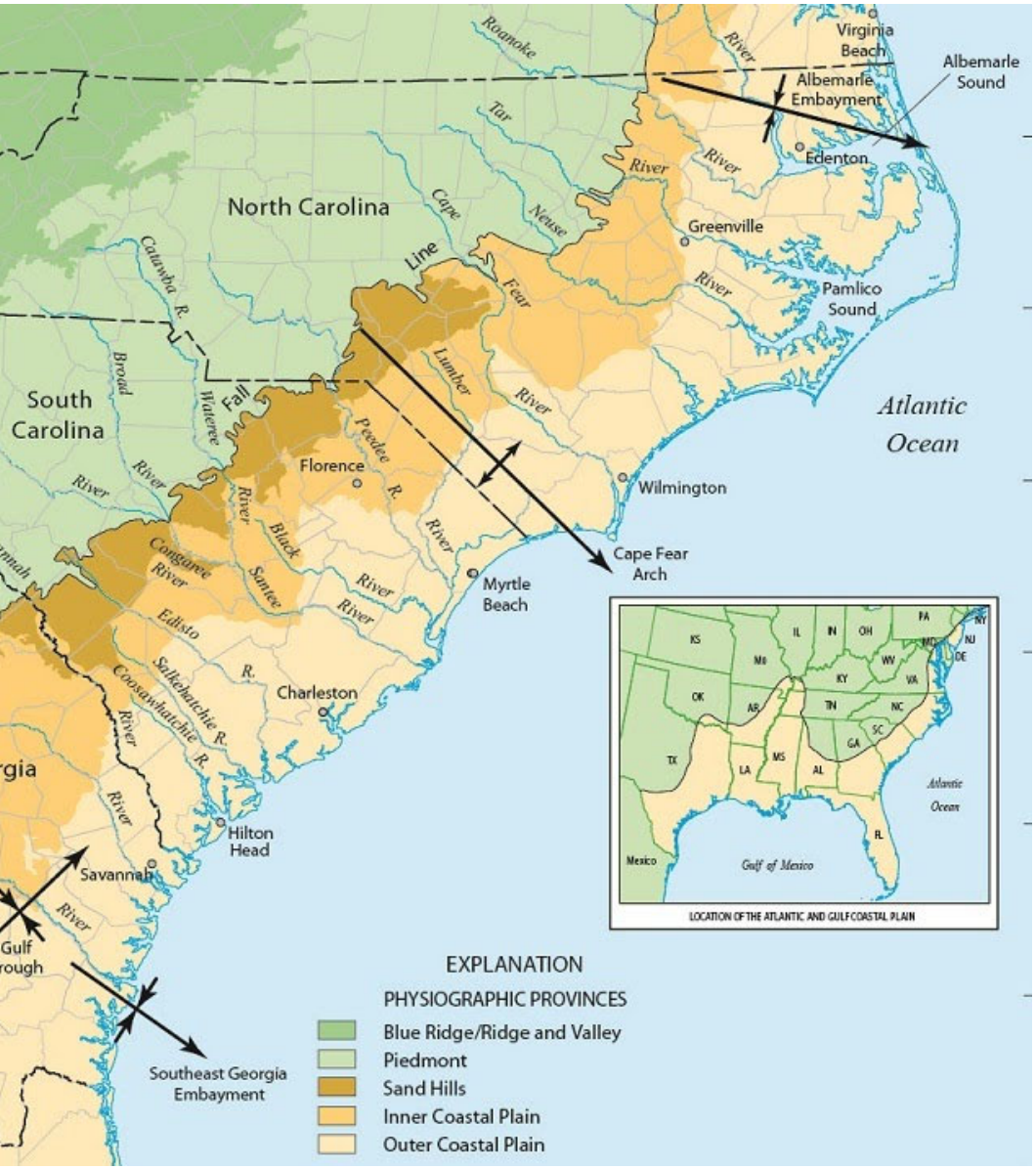
Interviews and surveys were conducted with coastal onsite wastewater treatment system operators and installers, as well as health officials.

Degler Waste Services, Ridgeland, South Carolina

Study conducted by:

Lauren Vorhees, NC Sea Grant

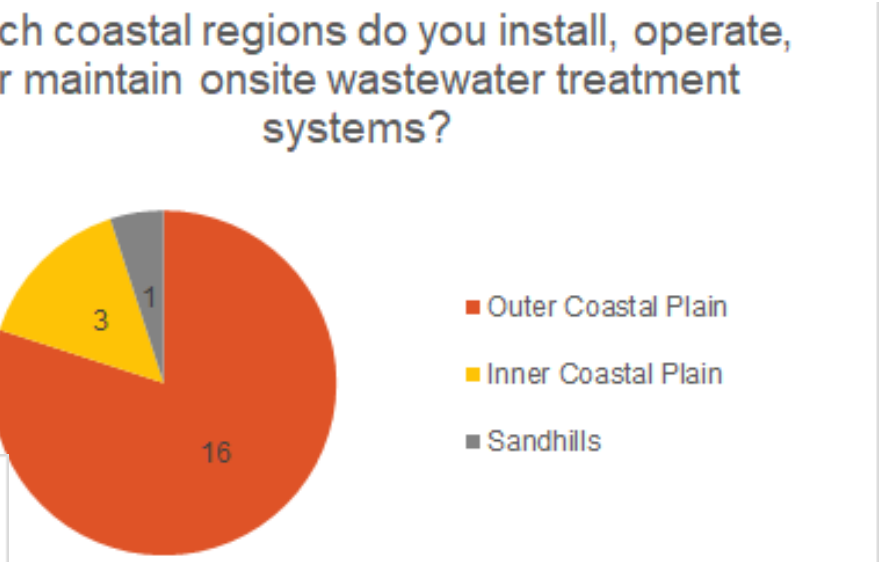
Jane Harrison, NC Sea Grant

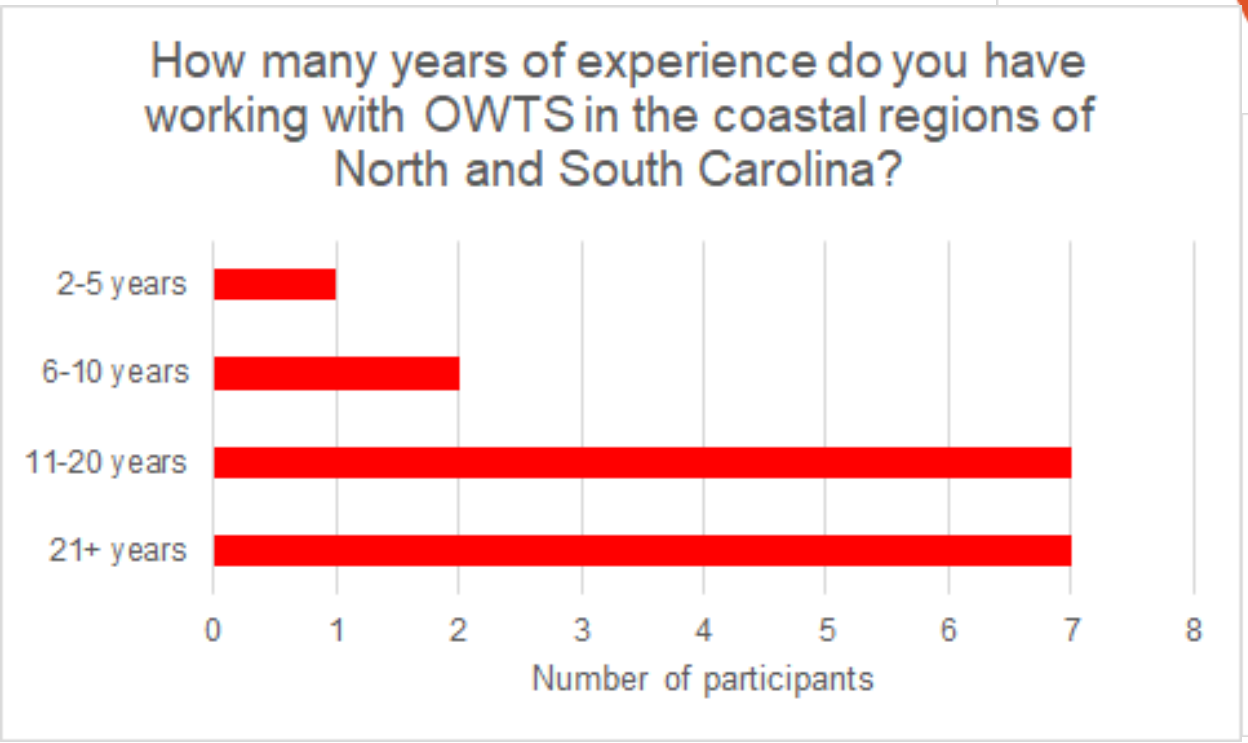


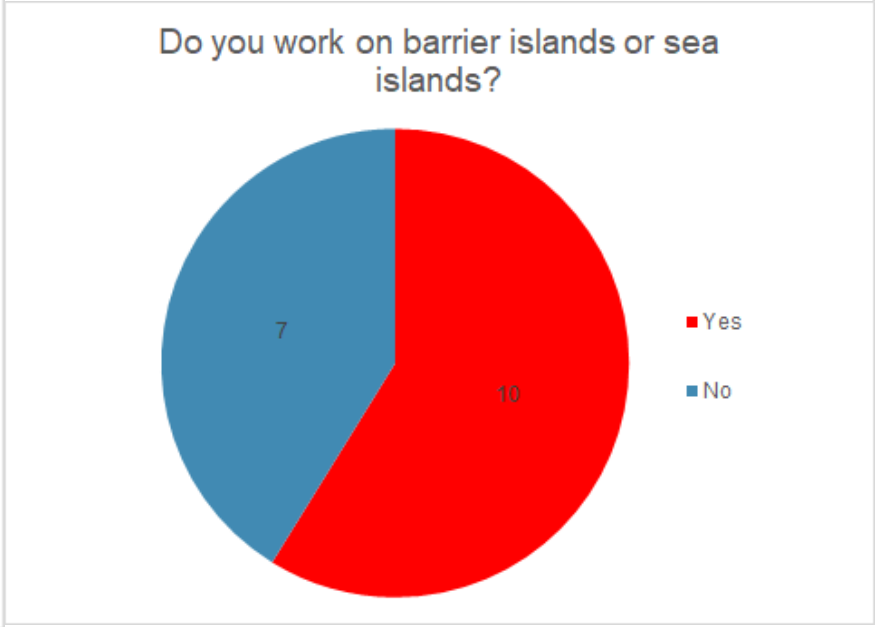
Study Area & Participants

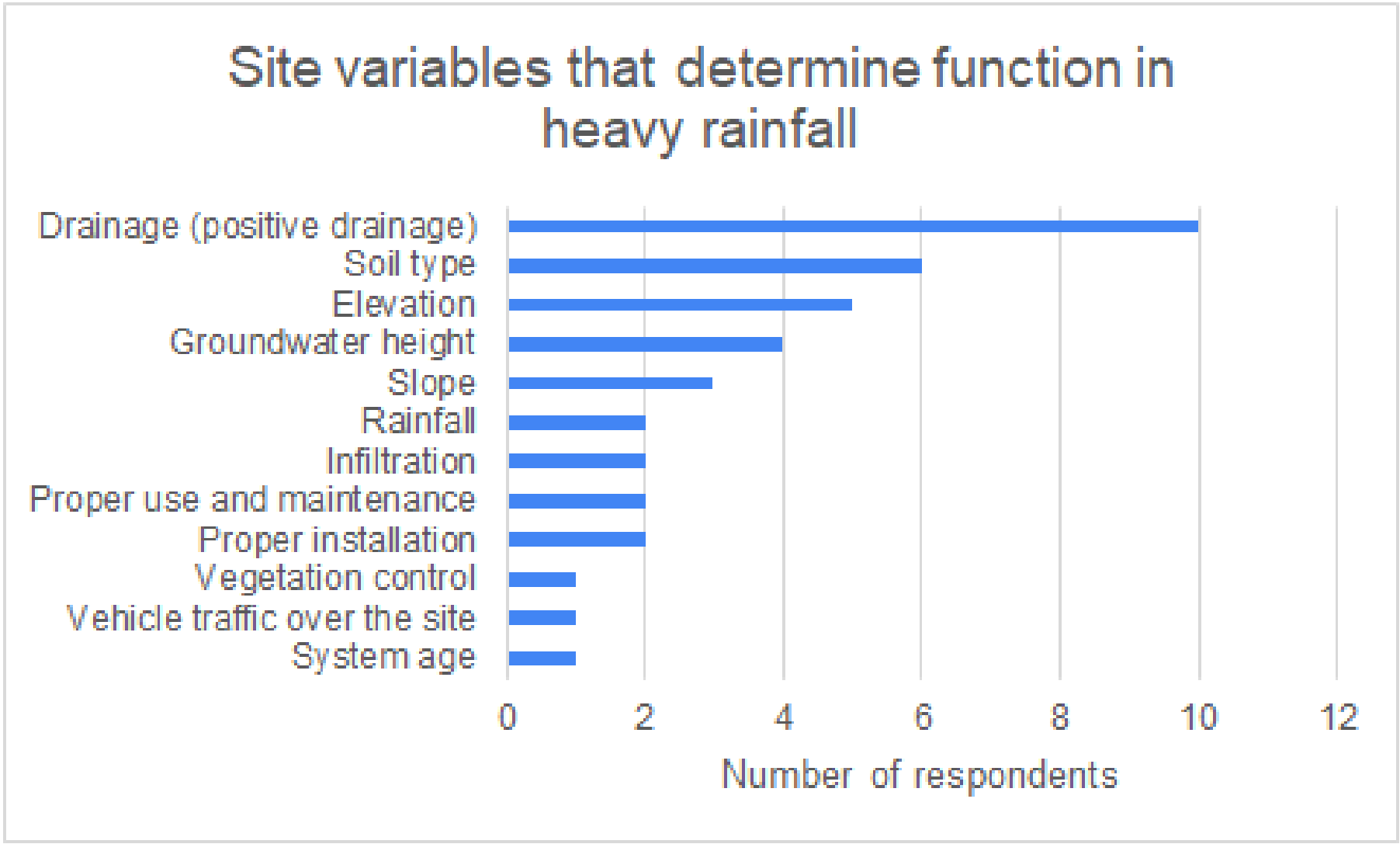
County, State	Wastewater O/I	Health Official
Beaufort County, N.C.	1	
Craven County, N.C.	2	1
Currituck County, N.C.	2	
Dare County, N.C.	2	1
Hyde County, N.C.	1	
Jones County, N.C.	1	
New Hanover County, N.C.	1	
Onslow County, N.C.	1	
Pasquotank County, N.C.	1	
Pender County, N.C.	0	1
Pitt County, N.C.	3	
State of N.C. (NCDHHS)		3
Beaufort County, S.C.	1	
Berkeley County, S.C.	1	
Charleston County, S.C.	1	
Chesterfield County, S.C.	2	
State of S.C. (SCDHEC)	0	2
TOTAL	**20**	**8 (TBD)**

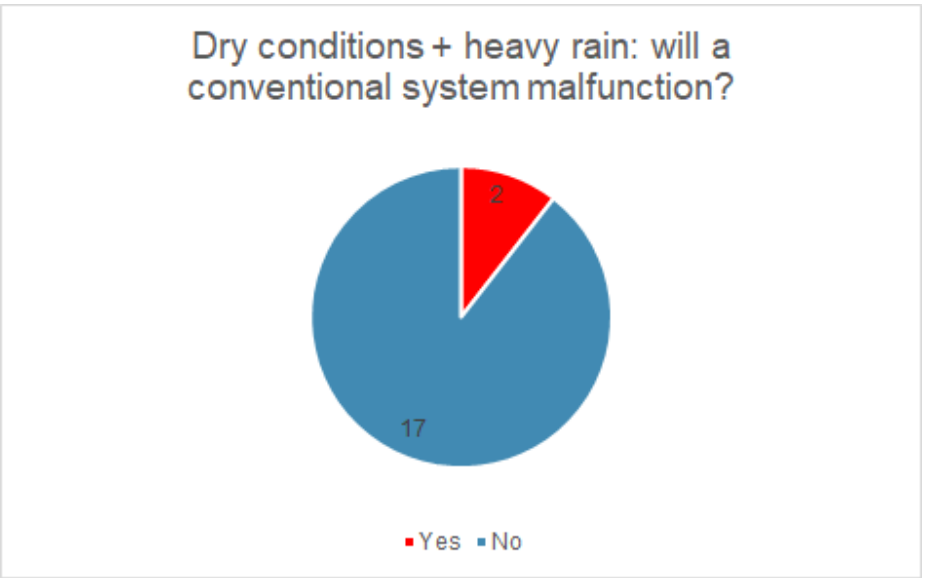
Professional Experience of Wastewater O/Is

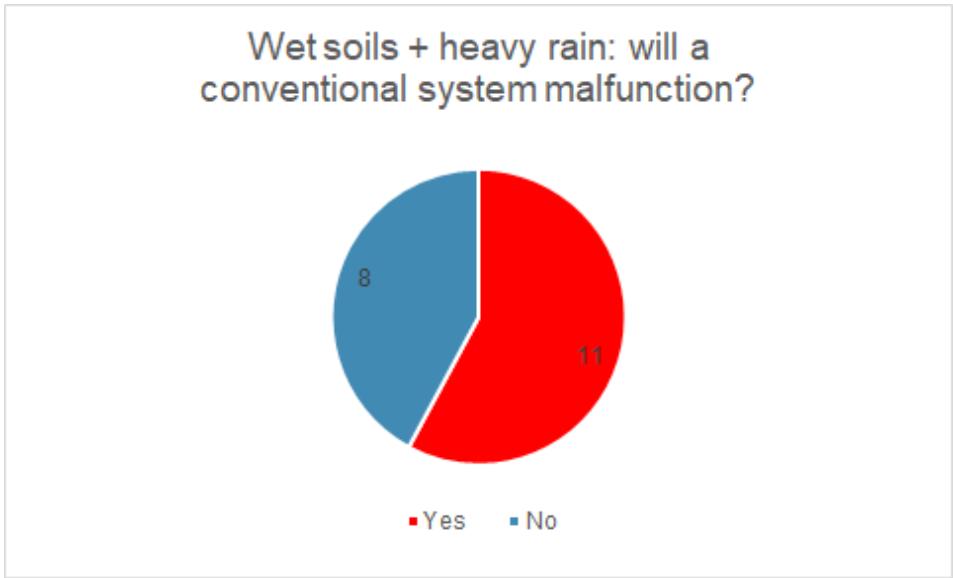


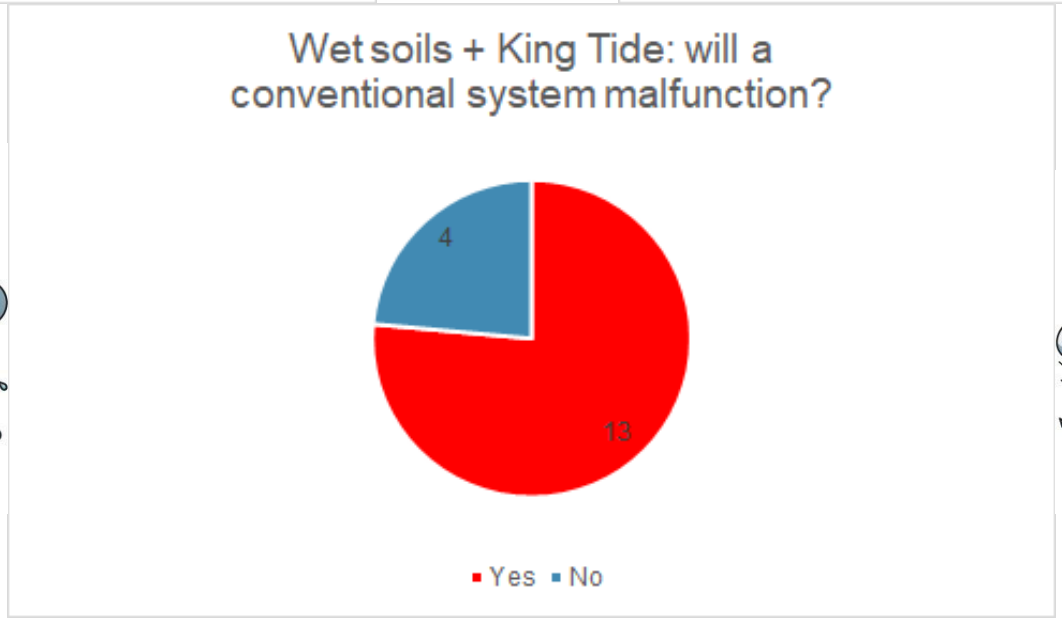





Site variables that determine function in heavy rainfall
Drainage (positive drainage)
Soil type
Elevation
Groundwater height
Slope
Rainfall
Infiltration
Proper use and maintenance
Proper installation
Vegetation control
Vehicle traffic over the site
System age
0
2
4
6
8
10
12
Number of respondents

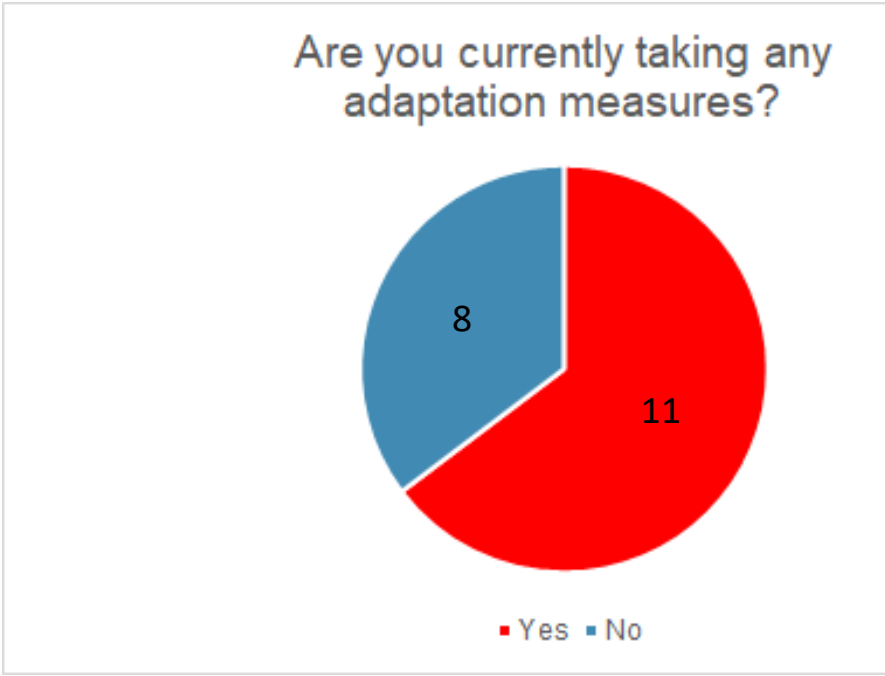

Dry conditions + heavy rain: will a conventional system malfunction?
2
17
Yes
No


Wet soils + heavy rain: will a conventional system malfunction?
8
11
Yes
No


Wet soils + King Tide: will a conventional system malfunction?
4
13
Yes
No

Adaptation measures to extreme weather events

- Raising septic tanks and drainfields
- Conservative installation measurements
- Greater tank capacity
- Advanced systems
  - Pretreatment
  - Drip irrigation
  - Modified e.g. chamber systems
  - Pressure systems
  - Curtain drains

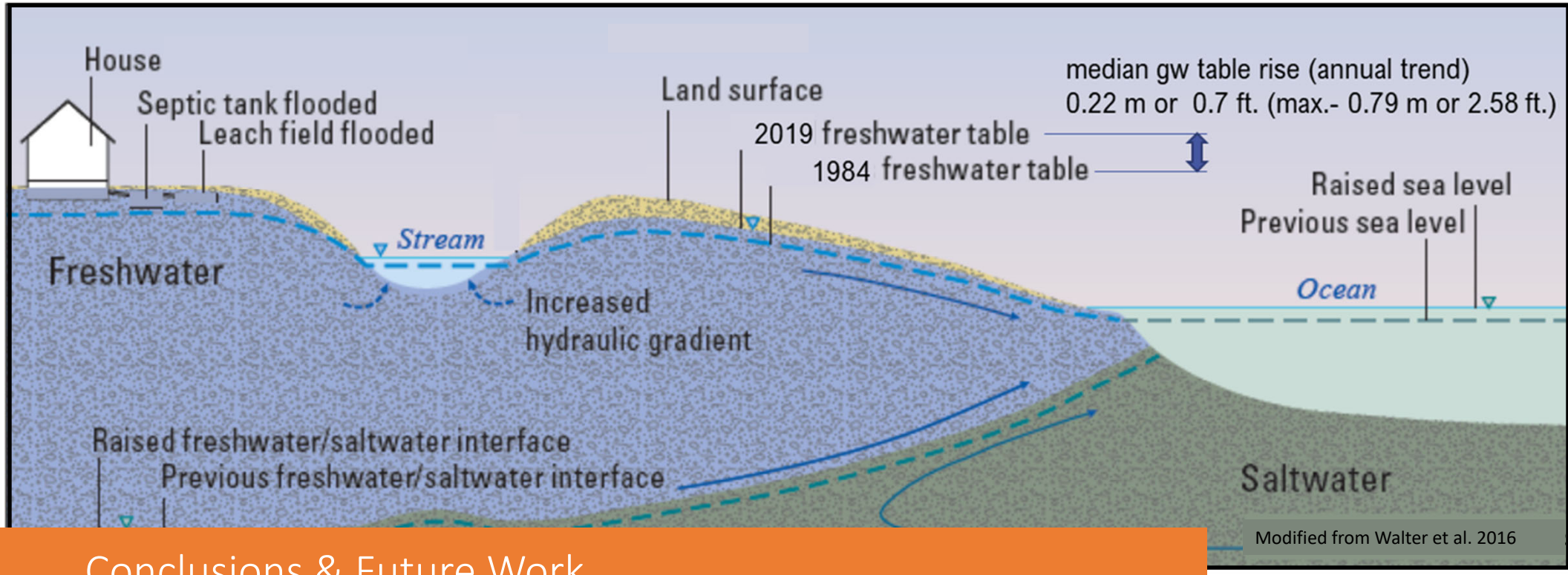


Onsite Wastewater Adaptation – Potential Policy Options

- Land use planning/zoning
  - Necessary for future development
  - Possibly limited options for existing systems
- Stricter siting/installation rules
  - Necessary for future development
  - Focus is on new systems
- Maintenance requirements
  - Can extend working life of systems
  - Not a long-term remedy for SLR
- Advanced/alternative onsite systems
  - Option for some sites, regularly used
  - Cost, may require enhanced management
- Cluster/community systems
  - Flexible, utility option
  - Need suitable site, cost, local government management likely needed
- Centralized sewer
  - Advanced treatment, centralized management
  - High cost, permitting issues, local gov't liabilities
- Retreat
  - Mitigates threats to human health, environment
  - Cost, political will, legal liabilities

Onsite Wastewater Adaptation – Legal Authority

- Local health agencies
  - Focus on imminent public health hazards
  - Existing rules don't provide flexibility to respond to changing conditions
- Local governments
  - Critical land use planning and zoning authorities
  - Authority to directly regulate onsite systems is unclear (preemption?)
- South Carolina
  - Haphazard statutory scheme
  - "Abate obnoxious and offensive odors"
  - Permits may be revoked for major system malfunctions
  - Only 6 inches of separation from groundwater for many systems
- North Carolina
  - Comprehensive septic statute
  - Focus on public health
  - Permits can be valid without expiration
  - Local health agencies may petition for stricter standards



Conclusions & Future Work

Sea level & gw are rising in the coastal Carolinas. Long-term & storm-related gw level rise can reduce the VSD & limit functionality of OWTS.

Evaluate alternative systems that can work effectively in shallow water table conditions and during storm events.

Economic analysis of wastewater infrastructure climate adaptation technologies.

Future regulatory approaches in coastal communities should consider rising gw tables & their effects on VSD and OWTS effectiveness, and adjacent water quality.

Thanks for your attention!
Acknowledgments

- Community Partners:
- **Nags Head, NC (Holly White and town staff) and Folly Beach, SC (Aaron Pope, Spencer Wetmore and city staff)**

- Nat Wilson and David May, **NC Dept. of Environmental Quality**

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- Maddy Roberts, Graduate Student (EH) , **East Carolina University**
- Jen Richardson, Graduate Student (Geol.) , **East Carolina University**

- Reide Corbett, **East Carolina University- ICP/Coastal Studies Institute**

- Junior Edwards and other wastewater professionals and homeowners