Implications of Sea Level Rise on Onsite Wastewater Systems and Remediation Strategies for the Future

NOWRA Conference

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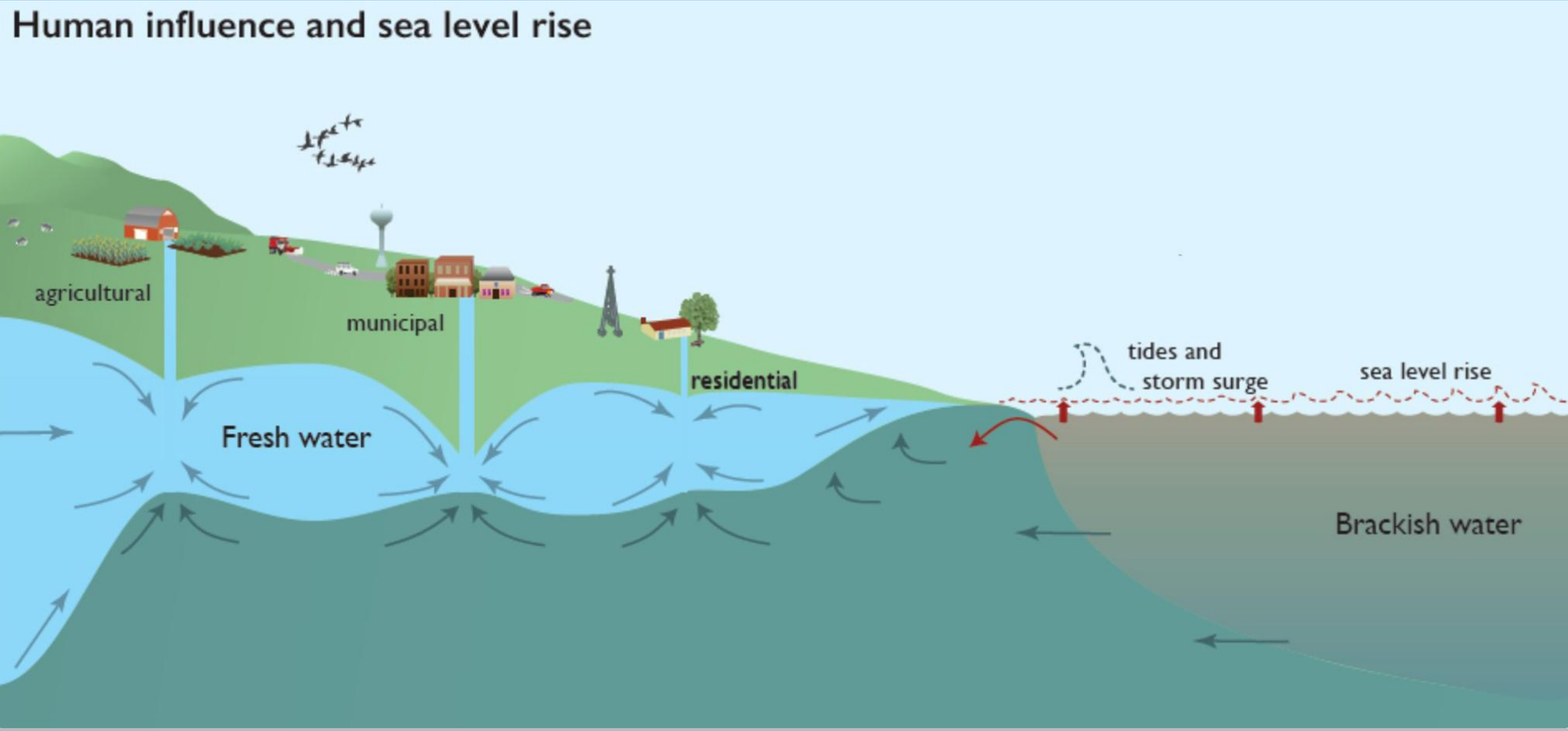
Discussion Topics

- Sea level rise introduction
- Health concerns of flooding and Sea level Rise (SLR)
- Impacts on soils/septic systems
- Resilience/Remediation strategies
- National coastal flooding survey summary

Land Use and SLR Impact to Groundwater



Adapted from: Maryland Department of Planning. 2019. State of Maryland Plan to Adapt to Saltwater Intrusion and Salinization,

National Projected Sea Level Rise

City	SLR (ft) 2060/2100	City	SLR (ft) 2060/2100
Seattle, WA	0.82/2.0	Fort Myers, FL	1.2/3.0
Port Oxford, OR	0.62/1.64	Port Canaveral, FL	1.2/3.0
San Francisco, CA	0.85/2.1	Charleston, SC	1.4/2.9
Los Angelos, CA	0.75/1.9	Wilmington, NC	1.3/2.7
Corpus Cristi, TX	1.64/3.7	Washington, DC	1.5/3.1
Galveston, TX	2.0/4.3	New York, NY	1.4/3/0
Grand Isle, LA	2.4/4.6	Newport, RI	1.4/3.0
Apalachicola, FL	1.4/2.6	Portland, ME	1.2/2.6

NASA Sea Level Projection Tool

Failing to curb future emissions could cause an additional 1.5 - 5 feet (0.5 - 1.5 meters) of rise for a total of 3.5 - 7 feet (1.1 - 2.1 meters) by the end of this century. NOAA

Wastewater Plant Infrastructure Exposure to SLR

	wastewater treatment plants exposed to SLR-induced flooding						residents served by wastewater treatment plants exposed to SLR-induced flooding (thousands)					
	1ft	2ft	3ft	4ft	5ft	6ft	1ft	2ft	3ft	4ft	5ft	6ft
Maine	5	5	6	10	13	17	8	8	29	50	65	80
New Hampshire	2	2	3	3	3	4	28	28	41	41	41	51
Massachusetts			4	7	7	10			1,757	1,960	1,960	2,180
Rhode Island			1	1	2	4			8	8	14	33
Connecticut	4	7	9	11	14	17	137	236	288	384	585	824
New York	4	10	14	22	37	47	806	1,217	1,791	1,954	5,581	7,811
New Jersey	8	16	19	28	36	41	795	1,004	1,046	3,347	4,246	4,905
Delaware	1	1	3	3	5	6			2	2	13	536
Pennsylvania												
Maryland	2	8	9	16	20	22	3	23	174	197	1,833	1,892
Washington, D.C.												
Virginia	2	2	3	4	5	6	540	540	789	1,107	1,108	1,118
North Carolina	1	3	6	9	12	13	17	20	32	44	175	238
South Carolina	1	3	4	6	7	8	128	337	462	466	520	523
Georgia	1	3	4	8	8	9		145	145	195	195	195
Florida	2	6	14	28	36	41	1	304	421	1,460	2,903	3,059
Alabama						2						27
Mississippi	1	1	2	2	4	4	28	28	46	46	69	69
Louisiana	6	12	16	21	34	38	20	39	50	103	196	207
Texas	7	13	19	24	30	34	408	491	506	528	593	1,483
California	8	13	15	23	34	36	1,037	2,620	2,642	3,871	5,499	5,581
Oregon	2	2	4	7	11	13	4	4	14	41	63	71
Washington	4	4	7	12	18	22	174	174	198	523	592	692
Total	60	110	162	245	336	394	4,132	7,216	10,442	16,325	26,252	31,573

Source: Hummel, M. et al. 2018. Earth's Future 6.

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Septic To Sewer?: Justice-focused Strategies for Addressing Coastal Septic Failures Under Sea-level Rise and Increased Flooding

Allison C. Reilly, Rachel Goldstein, Birthe Kjellerup, and Andy Lazur,
University of Maryland

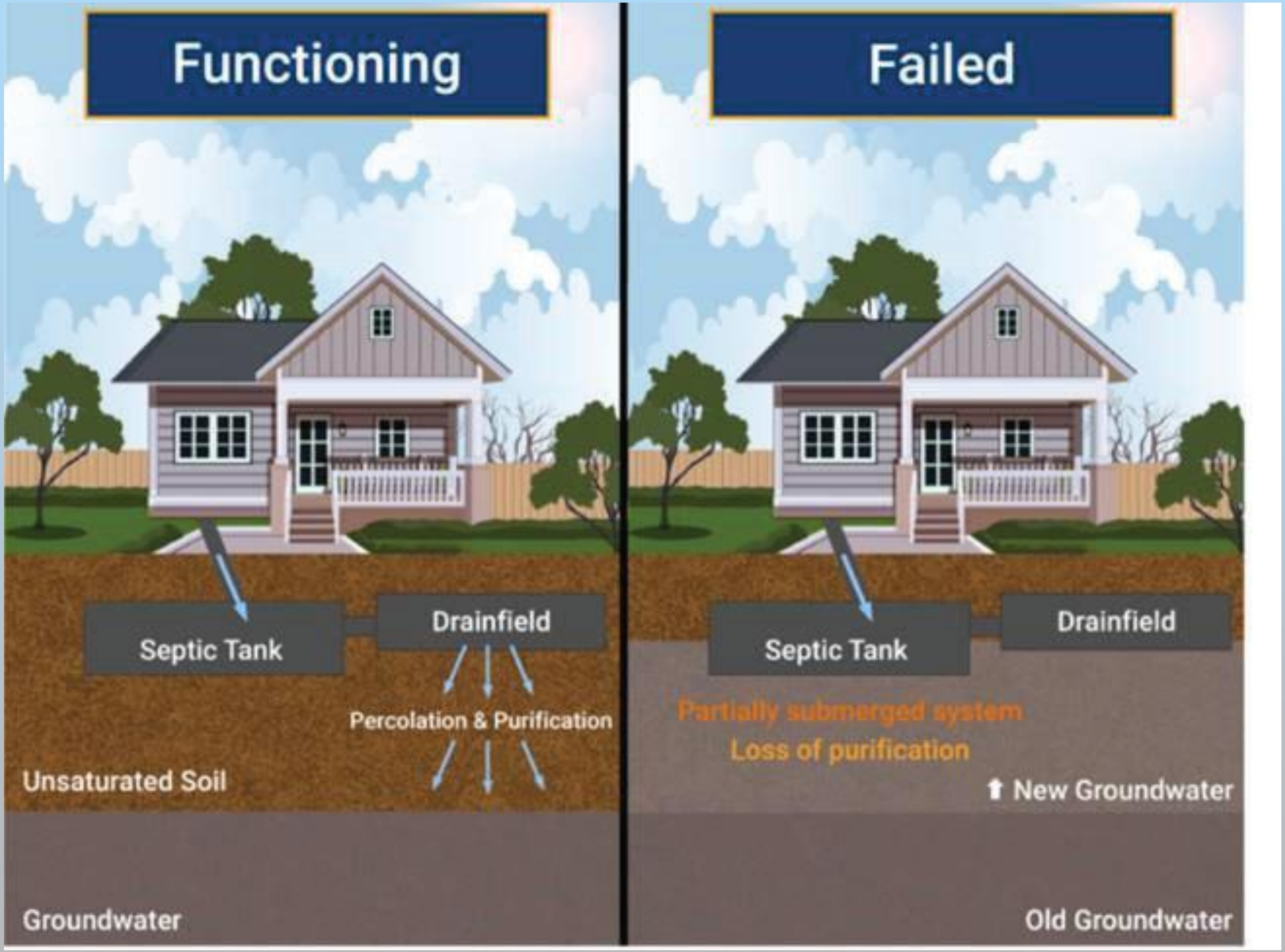
Margaret Walls and Penny Liao
Resources for the Future

Celso Ferreira and Andre de Lima
George Mason University

Juel Gibbons
SERCAP

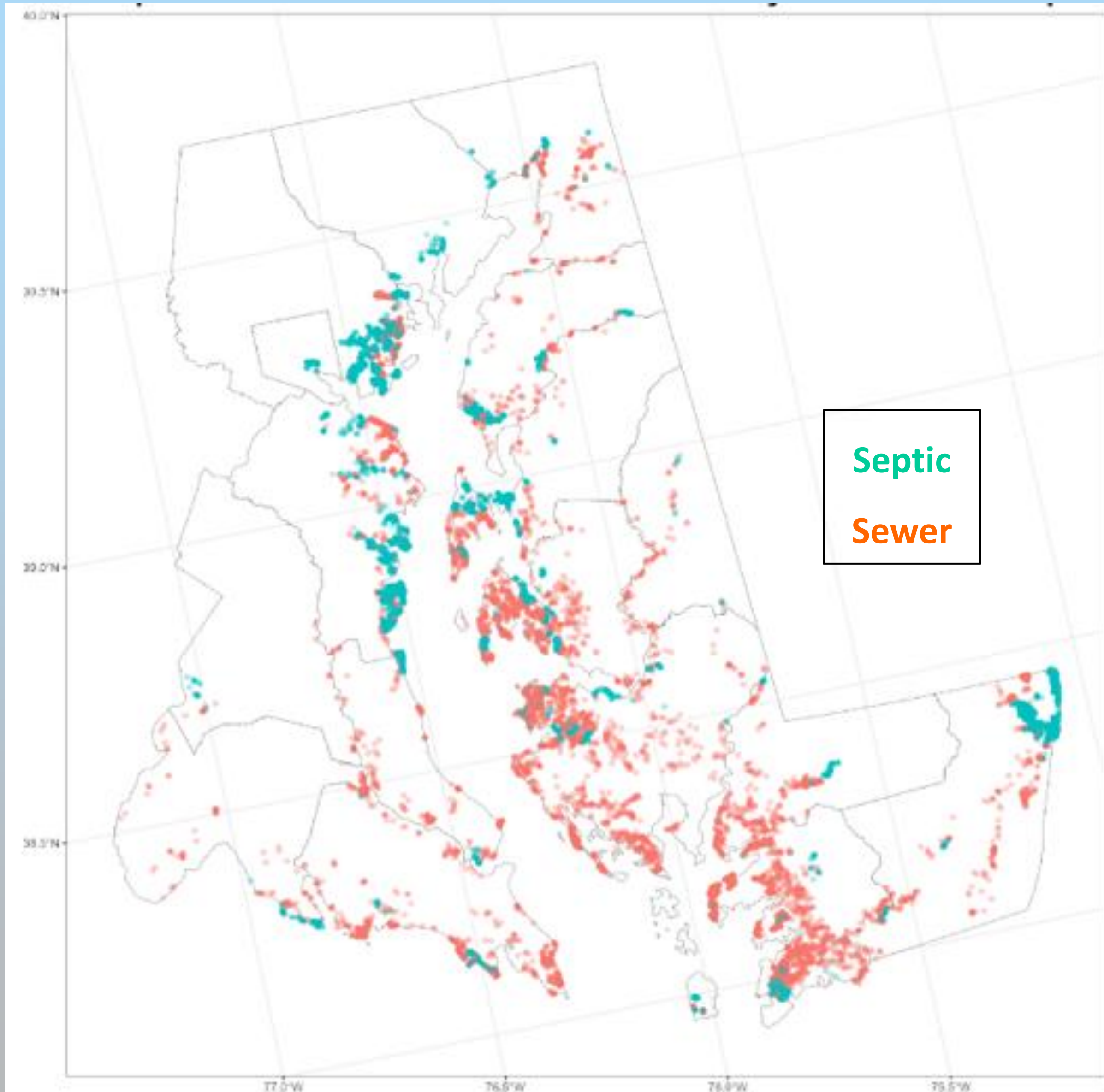
Research Questions:

- **Engineering:** How will sea-level rise influence the vulnerability of septic systems to failure and what are the locations of vulnerable systems?
- **Microbiology:** How does flooding with saltwater impact transformation of nutrients (organic matter, nitrogen, and phosphorus) and potential pathogen presence at sites with septic systems?
- **Public Health:** What are the cumulative health effects caused by pollution of nutrients and pathogens from septic systems stemming from increased flooding? How do these health effects vary across populations?
- **Environmental Justice:** Have communities have historically been excluded from sewer expansion?
- **Economics:** What is the economic value of public sewer access?
- **Engineering economics:** What are the options for sewer expansion or alternative technology implementation? What are the costs and benefits of these options and who bears those costs and reaps the benefits?
- **Policy analysis**: Can novel policy solutions cost-effectively reduce the cumulative risk?



Lusk, M. 2023. UF IFAS AE591

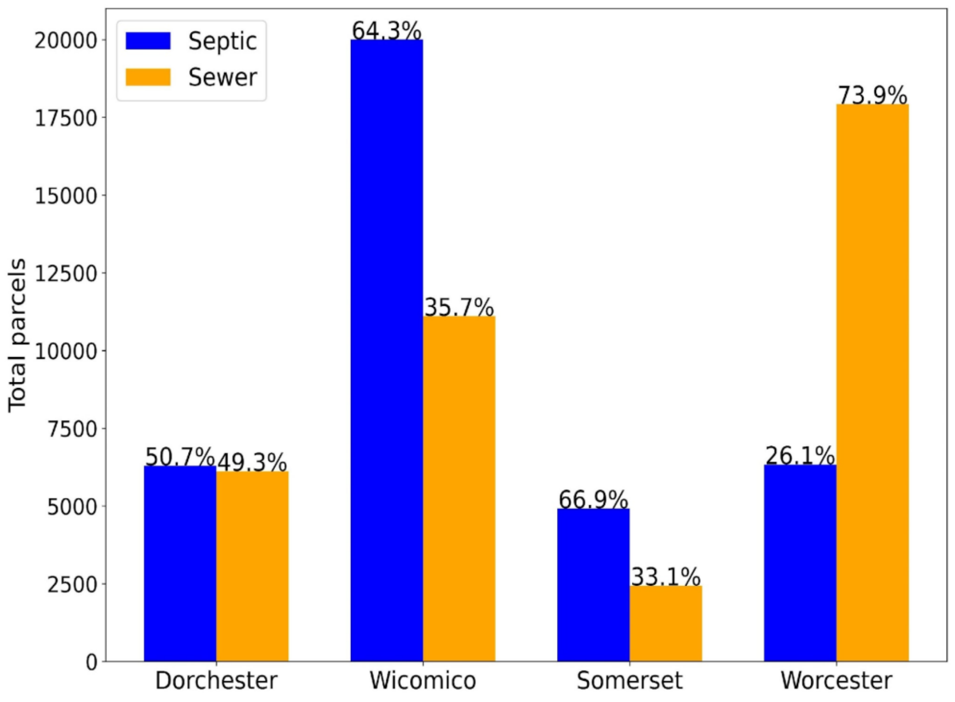
MD Properties with Flood Risk in 2050 by Sewer vs. Septic

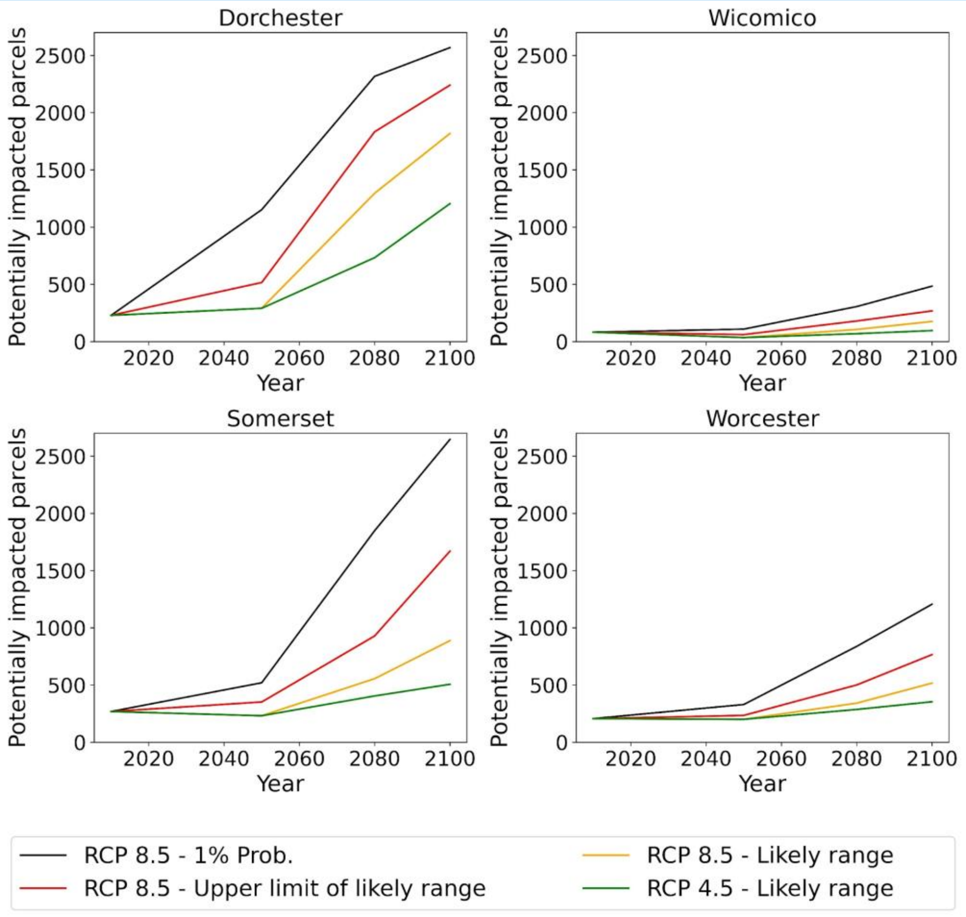


	Number of Parcels	Percent
Total Parcels	1,073,435	
Has Flood Risk 2020		
Septic	8,959	46.1
Sewer	10,461	53.9
Has Flood Risk 2050		
Septic	11,631	40.5
Sewer	17,096	59.5

Reilly et al. 2023. MD Environ. Health Conf. July 2023.

Lower Shore Wastewater Capacity and SLR Projections





de Lima, A., Lau, C., Walls, M. A., Liao, Y., Pesek, S., DeAngeli, E., & Ferreira, C. (2023). Identifying potential septic failures under sea-level rise and coastal extreme events in Maryland's Chesapeake Bay. AGU23.

Saltwater Intrusion Impacts on Soils and Groundwater

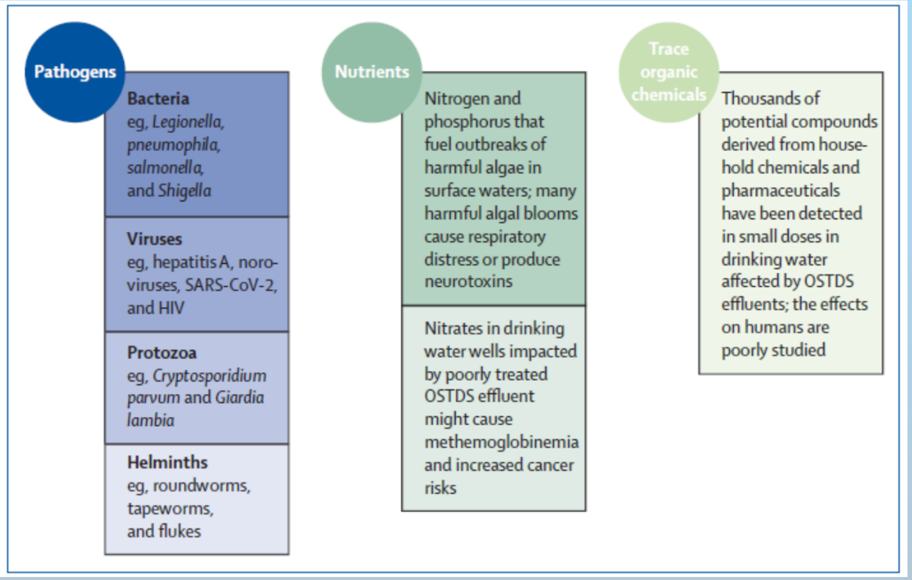
Research shows:

↑ Chloride/sodium in ground and surface waters
↑ Leaching of dissolved organic C
↑ Leaching of nitrogen
↑ Sodium and soil dispersion
↑ Mobilization of soil base cations
↑ Corrosivity on plumbing and lead leaching
↑ Mobilization of heavy metals and radionuclides
↑ Risks to public and environmental health

↓ Soil species population/diversity
↓ Soil pH
↓ Soil organic matter
↓ Soil microbial decomposition
↓ Drinking water quality
↓ Wastewater treatment performance

Sources: Cassanelli and Robbins 2013, Howard and Beck 1999; Kauschal et al. 2005; Kelly et al. 2008; Ledford, et al. 2016; Moore et al. 2017; Mullaney et al. 2009; Snodgrass et al. 2017; Strank et al. 2013; Corsi et al. 2010; Fay and Shi 2012; Karraker et al. 2008; Jones et al. 2017; Stranko et al. 2013; Amrhein et al. 1992; and Kaushal et al. 2005; Edwards and Triantafyllidou 2007; Kaushal 2016; St. Clair et al. 2016; Stets al et, 2018; Alam and Cheng 2014; McNaboe, et al. 2017; Riedel and Kubeck, 2018; Lazur et al. 2020.

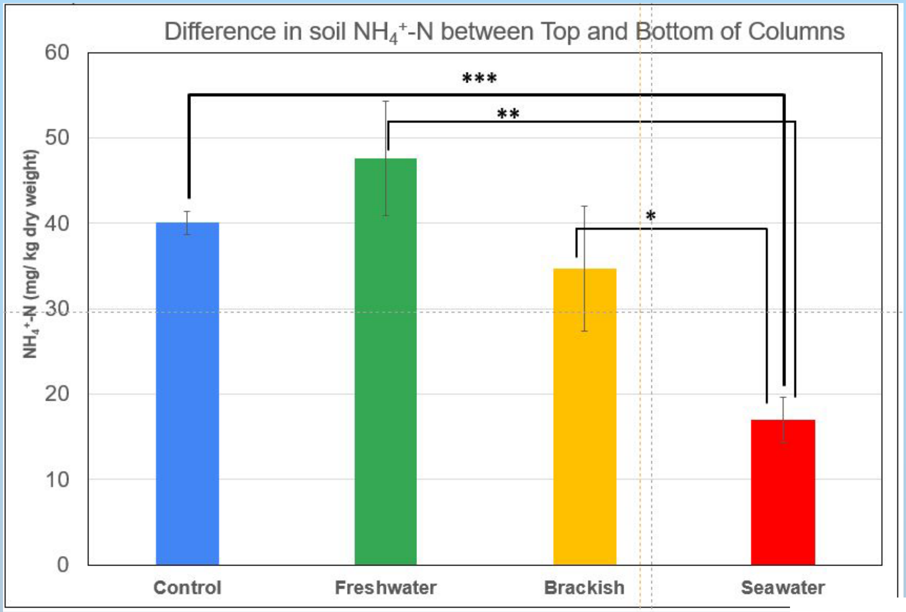
Public Health Concerns of Saltwater Intrusion



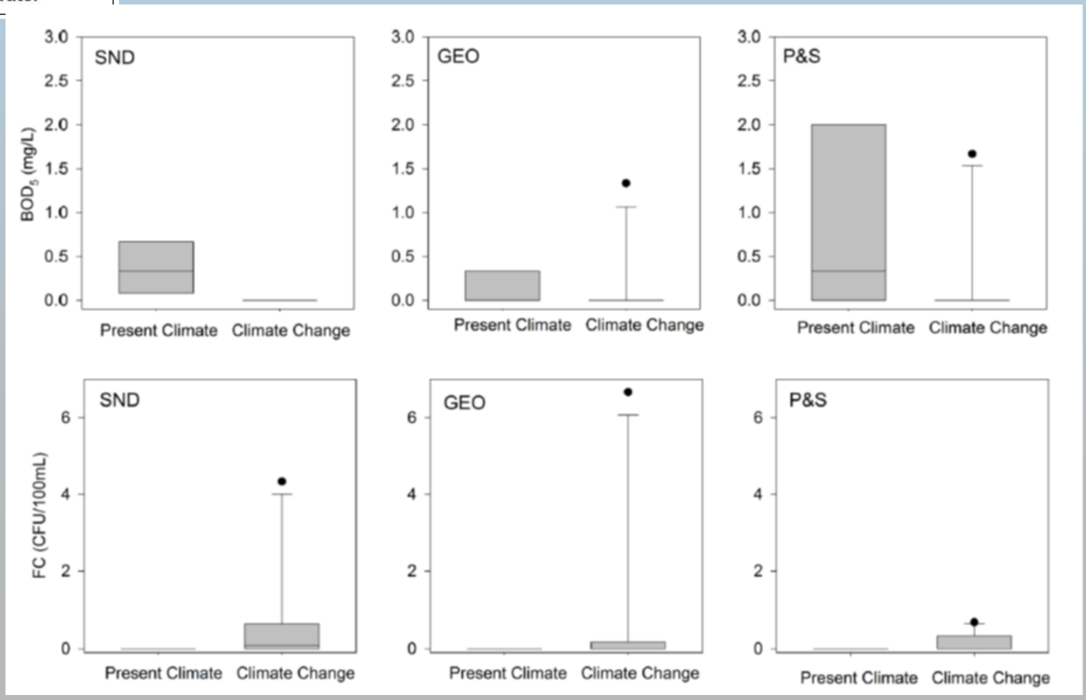
Lusk, M. 2022. www.thelancet.com/planetary-health Vol 6 September 2022.

- Saltwater intrusion into well water has caused closure of hundreds of drinking wells in coastal areas such as Cyprus, Israel, Mexico, and Oman, (Barlow and Reichard, 2010. Hydrogeology. 18.)
- Increased salinity fosters water corrosivity – plumbing life reduction and metal leaching; and mobilizes heavy metals: Cd, Cr, Cu, Pb, Ni, Mn and Zn in groundwater (Lazur et al. 2020)
- Increase of groundwater fecal coliform bacteria result from saturated septic systems due to SLR (Mitchell, et al. 021. Front. Mar. Sci 8.)

Salinity Impacts on Soil Microbes and Treatment



Aleem Waris. 2023. M.S. Thesis. UMD Civil and Environmental Engineering.

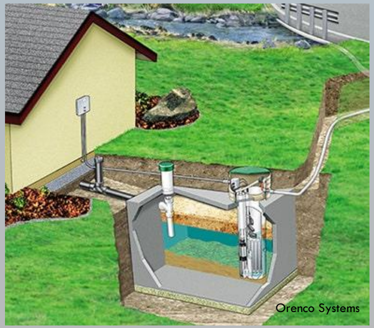


SWI:

- Decreased: soil microbial activity/nitrification; fecal coliform elimination
- Increased viral and BOD removal
- Varied impact on system types

Current Adaptation Strategies

- Connection to sewer
- Elevated soil dispersal system – mound, drip dispersal, sand filters
- Advanced Treatment Units (ATU)
- Community treatment system - package plant)
- STEP system
- Direct discharge
- Other innovative technologies/strategies



Results of National Coastal Onsite Professionals Survey

Survey description:

- 23 coastal states with emphasis on coastal counties
- Target audience included county and state agency environmental health personnel, onsite industry professionals (state associations), and onsite Extension personnel
- Distributed to ~400; 67 responses = 16.5% Response rate; 17 states

Example questions:

- How would you rate your concern of current and forecasted flooding impacts on onsite systems?
- How would you rate your organizations ability to provide solutions for current and future flooding of onsite systems?
- Have you observed an increase in the number of onsite systems exposed to flooding?
- What strategies/remediation approaches has your office employed with systems exposed to persistent flooding?
- Of the approaches above, which do you think are or would be effective in remediating the impact of flooding of onsite systems?

Survey Results – Roles of Participants

Role	%	n
State resource management agency/regulator	28.7	21
County based Environmental Health Specialist	26.0	19
Onsite designer/engineer	13.7	10
Academia	9.6	7
Other	9.6	7
Onsite technology manufacturer	6.8	5
Onsite installer	5.5	4
County/State planner	1.5	3

Rating of Concern of Current and Forecasted Flooding Impacts on Onsite Systems

Rating	%	n
Not at all important	2.9	2
Slightly important	8.9	6
Moderately important	35.8	24
Very important	34.2	23
Extremely important	17.9	12

Rating of Organization's Ability to Provide Solution for Current and future Flooding of Onsite Systems

Rating	%	n
Extremely incapable	9.0	6
Somewhat incapable	25.4	17
Neither capable or incapable	16.4	11
Somewhat capable	32.8	22
Extremely capable	16.4	11

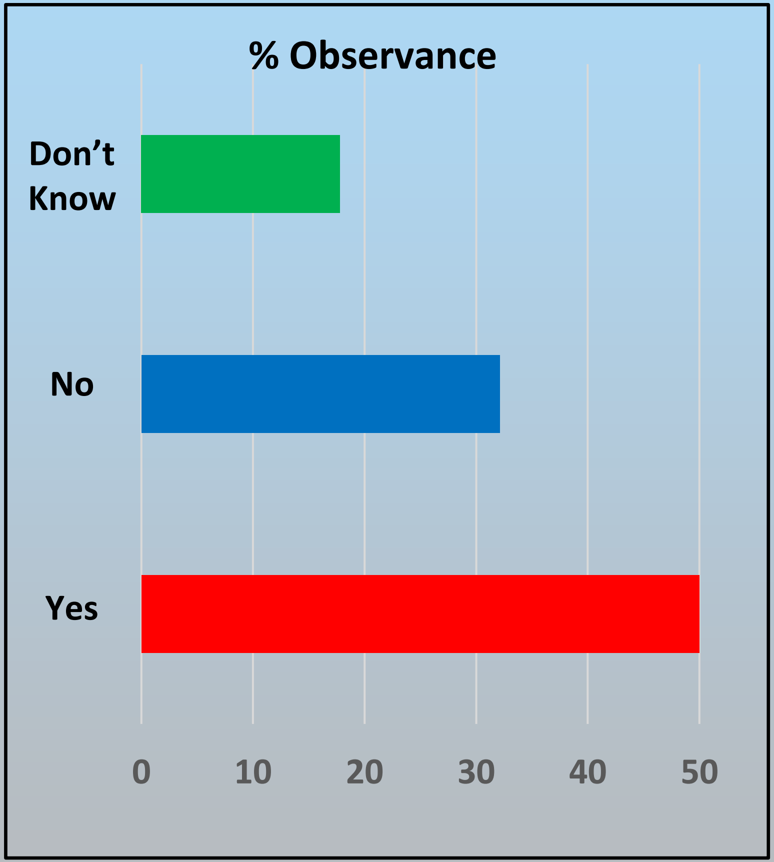
Rating of Concern With Flooding of Onsite Systems

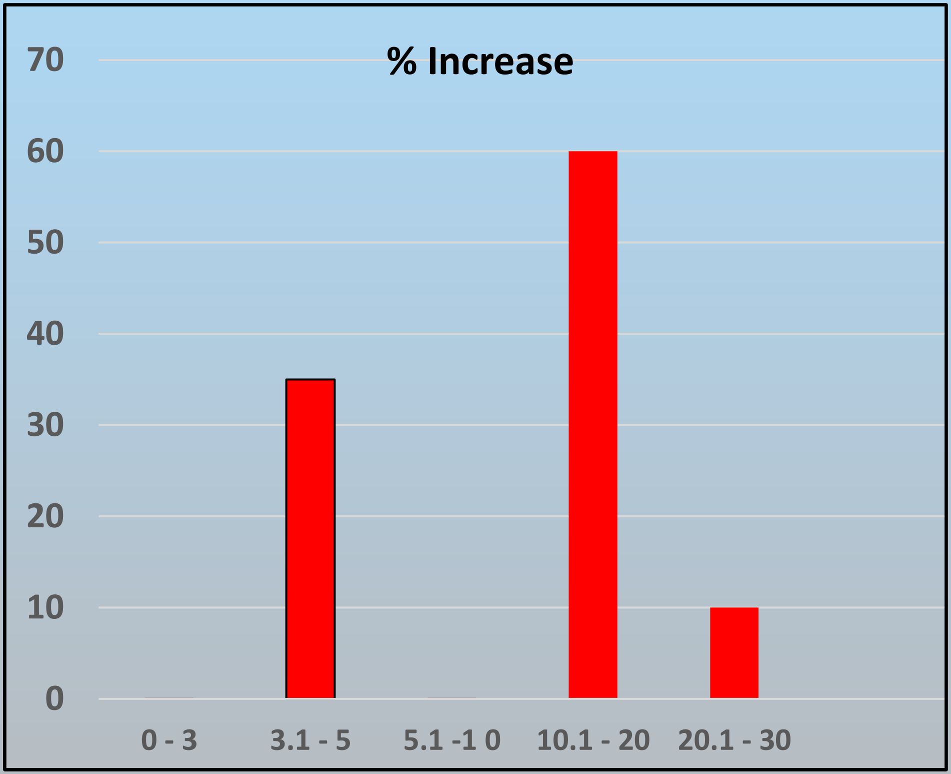
Issue	Ranking (1-10)
Nutrient contamination	6.97
Contaminants of concern	**7.20**
Pathogen contamination	**7.86**
Sewage backups	**7.50**
Impact on underserved households	**7.12**
Economic challenges for homeowners to upgrade	**7.63**
Outdated policies	6.55
Loss of real estate value	7.06
Limited grant/financial assistance funding	5.17
Limited technology to solve issue	6.22
Lack of R&D to verify technology/ mitigation practices	5.98
Other	7.44

Type of Flooding Observed

Issue	Percent	n
Rising water table	41.2	21
Increased rainfall and flooded waterways	39.2	20
Increased number of backups due to flooding	37.2	19
Flooding due to high/king tides	31.3	16
Both increased rainfall and SLR	31.3	16
Not observed issues with flooding	15.6	8
Brackish/marine flooding due to SLR	13.7	7
Do not know	3.9	2
Other	1.9	1

Survey Results –
Percent Observance and Increase in Flooded Systems Within 10 Years





Strategies Organization Used for Flooding

Strategy	%	n
Advanced treatment units	54.0	27
Connections to sewer	48.0	24
Elevated soil dispersal	22.0	22
Community of cluster systems	24.0	12
Financial assistance programs	20.0	10
Holding tanks	14.0	7
ATU, sterilization and direct discharge	12.0	6
Policy to prevent/reduce further development	10.0	5
Other – Education of designers; no systems in exposed areas; increasing setbacks to wetlands, other I&A	10.0	5

Organization's Preferred Strategies

Preferred Strategy	%	n	% Change
Connections to sewer	57.1	28	+ 9.1
Advanced treatment units	44.9	22	- 9.1
Community of cluster systems	40.8	20	**+ 16.8**
Financial assistance programs	38.7	19	**+ 18.7**
Elevated soil dispersal	32.6	16	**+ 10.6**
ATU, sterilization and direct discharge	30.6	15	**+ 18.6**
Policy to prevent/reduce further development	24.5	12	**+ 14.5**
Holding tanks	8.2	4	- 5.8

Other Flood Mitigation Strategies

Strategy
Advanced treatment plus UV
Stop development
Policies not keeping up with innovation
Sewers are a bigger issue
Need better GIS data – flood prone mapping
Promote develop in areas with less risk
Diking, emergency seawall, pump drainage
Grants for underserved communities

Moving Forward

Broad solutions include: changes to regulatory framework, innovative funding methods, and managed-retreat strategies (Jenkins and Delzell. 2022. UVA. (Working Paper Series)

- Technology R&D
  - Identify and validate innovative systems/ideas
- Policy/Regulatory
  - How can regulation keep up with science and technology?
  - What might future collaborations be and look like?
- Funding
  - How can private well and onsite systems receive more funding especially in underserved communities?
  - R&D funding is limited – how to invest?

Questions

UME Water Quality Program

http://extension.umd.edu/well-and-septic

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Link to Survey:

https://ume.qualtrics.com/jfe/form/SV_5hUe6NmajtMjN0q