Understanding groundwater – protecting infrastructure in coastal communities

Gulf of Maine Council - May 2026 Meeting
Coastal Flooding and Groundwater Modeling

NH Department of Environmental Services

City of Portsmouth

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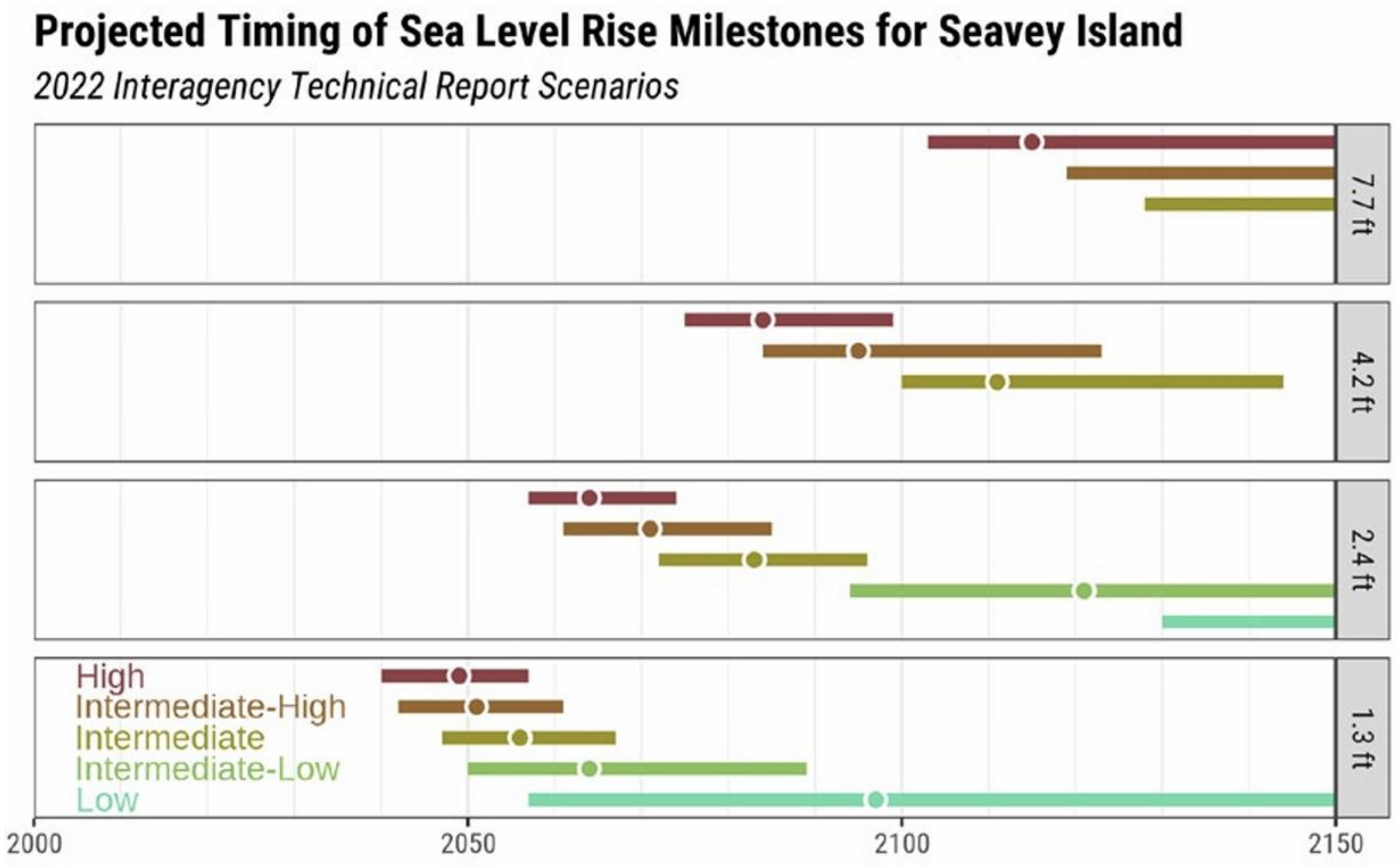
May 28, 2026

Sea-level rise projections for NH from the NH Coastal Flood Risk Science Report (2026)

Circles represent the year when the median value will be exceeded.

Bars – 83rd and 17th percentiles – "likely" range; i.e., > 66% likelihood.



Milestones are based on Sweet et al., 2022

Groundwater Rise - Three areas of coastal community vulnerability

INUNDATION

- Pavement layers
- Underground utilities
- Septic Systems
- Basements
- Wetland transition and expansion

WATER SUPPLY

- Deep bedrock domestic wells- salinization
- Near-shore municipal wells - salinization
- Seasonal aquifer recharge - altered availability
- Drought

WATER QUALITY

- Reduced groundwater discharge to estuaries,
- Septic system failure
- Mobilization of legacy contaminants
- Terrain – slope instability

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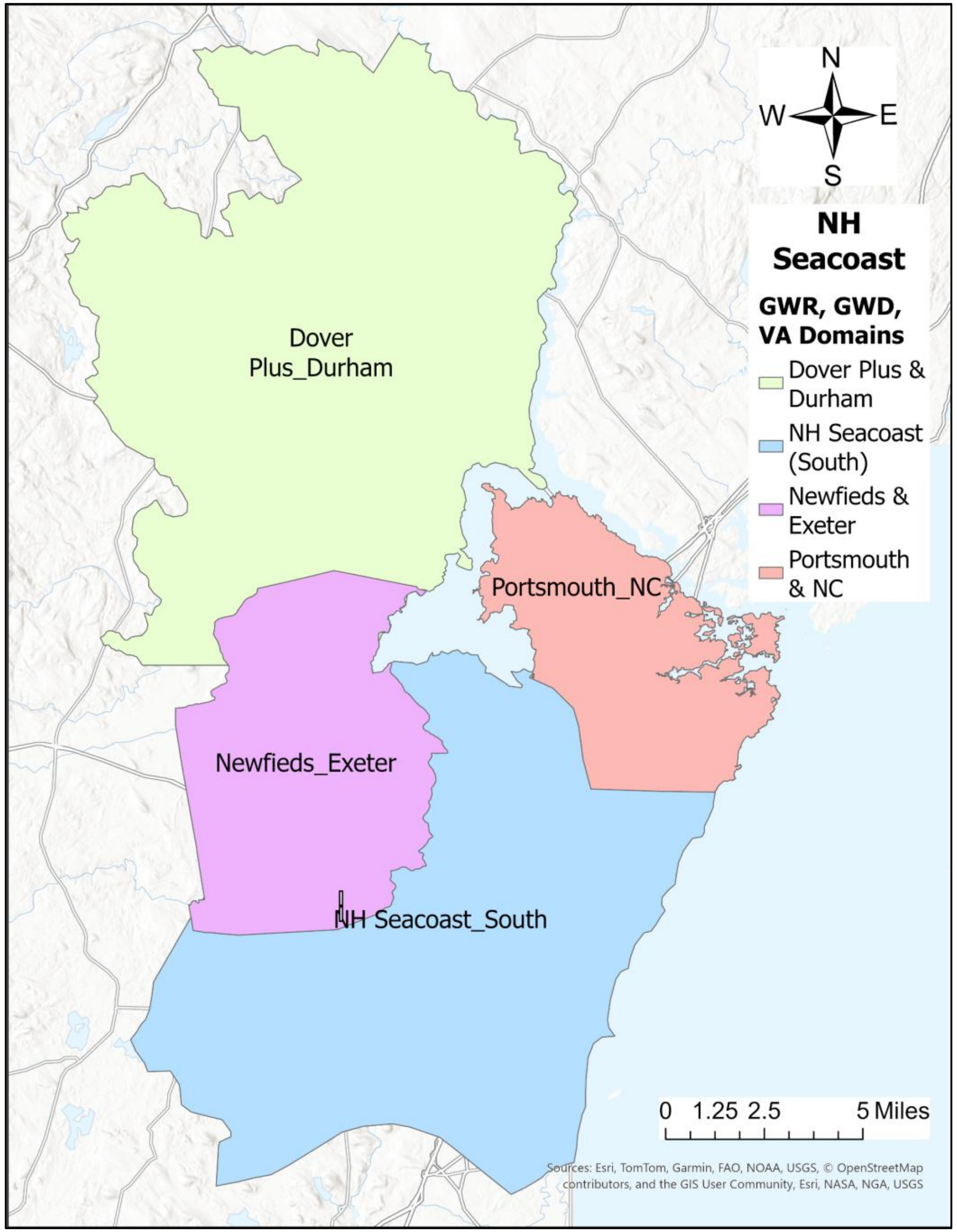
How do we Identify the vulnerable infrastructure?

Groundwater Flow & SWI Modeling

Groundwater flow modeling - All

SWI – All except NH Seacoast_South



GW Model Resolution

- Dover Plus – 400 ft x 400 ft
- Newfields_Exeter – 100 x100 ft; 400 x 400 ft
- Portsmouth_NC - 100 x 100 ft; 400 x 400 ft
- NH Seacoast S – 200 x 200 ft
- Rye – 50 x 50 ft; 200 x 200 ft

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Groundwater Rise Simulations with Sea Level Rise

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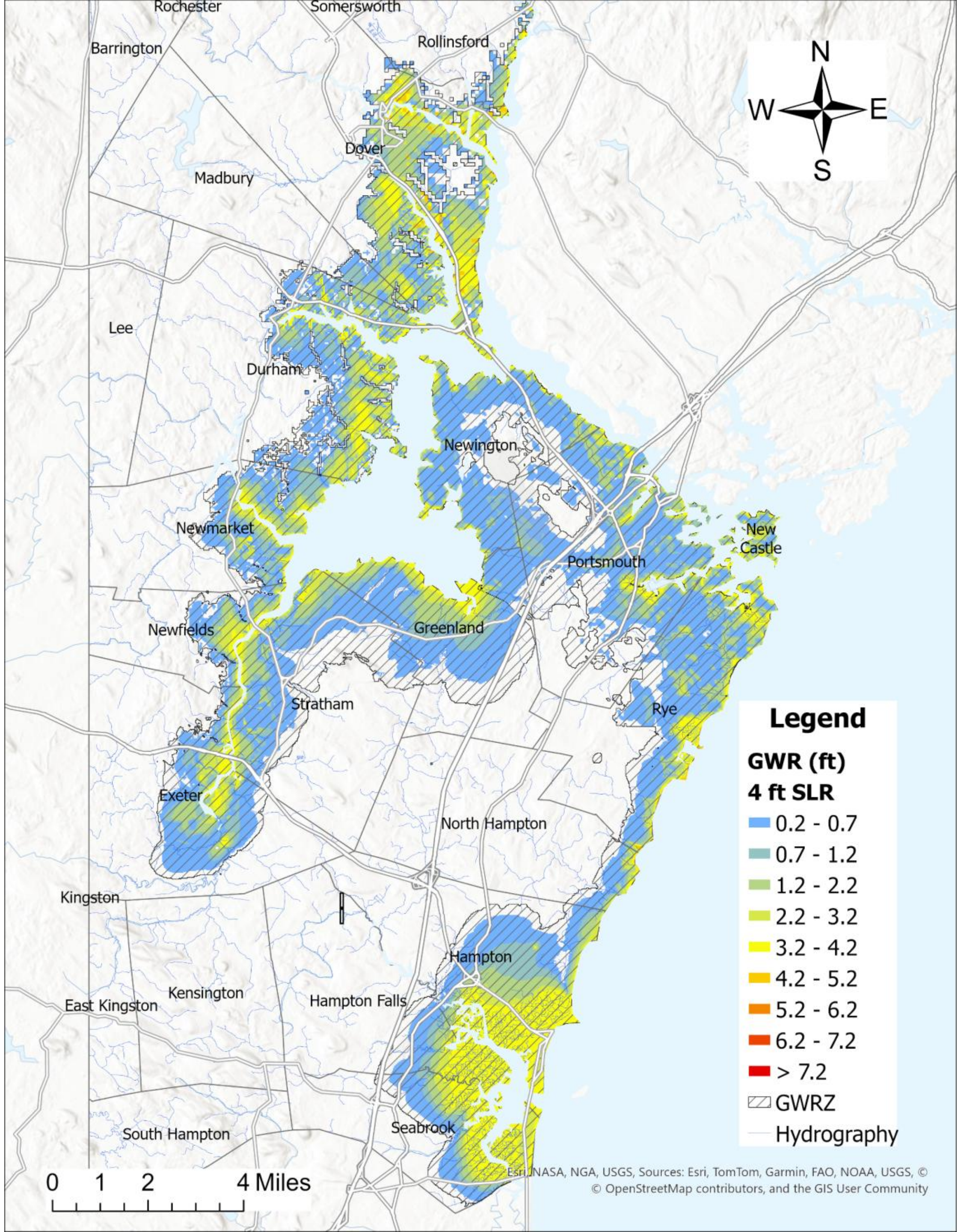
Groundwater Rise caused by Sea Level Rise (SLR)

Simulated GW Rise caused by 1, 2, 4, 6, and 8 feet of SLR.



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Depth to Groundwater – Why do we care?

Critically Shallow
(GWD: 0-5 ft)

- Road and pavements
- Basements and foundations
- Septic Systems
- Most buried utilities
- Stormwater assets
- Contaminated sites
- Critical facilities
- Wetlands

Transition Zone
(GWD: 5-10 ft)

- Deeper sewers and storm drains
- Basements/foundations
- Contaminated sites

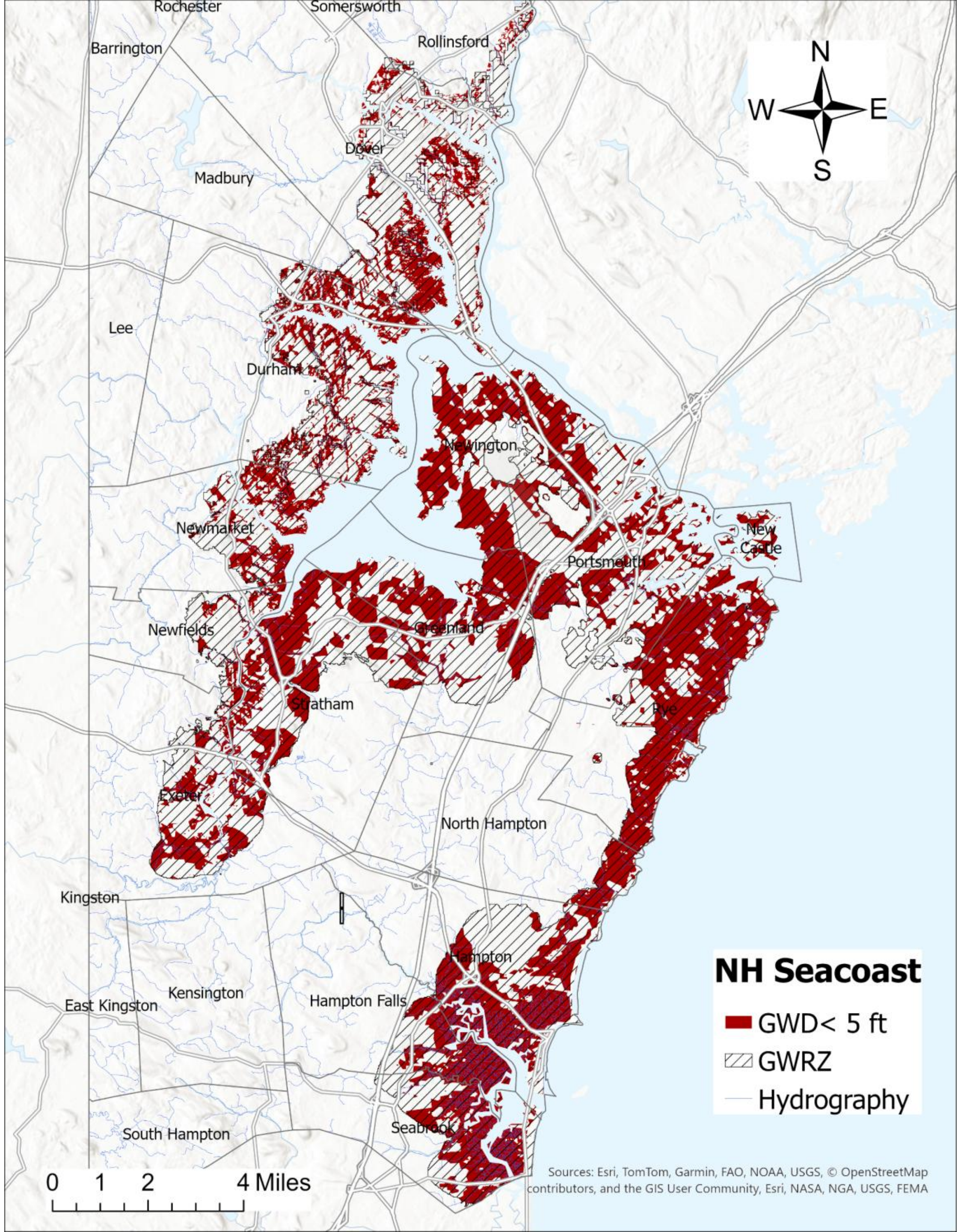
Future Risk
(GWD: 10-15 ft)

- Deep trunk utilities
- Large below-grade structures
- Long-lived infrastructure

Groundwater Depth Zones with no Sea Level Rise (SLR)

Simulated GW Depth Zones with no SLR:

- GWD<15 ft
- GWD<10 ft
- GWD<5 ft



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Groundwater Simulations
Vulnerable Areas
GWD < 5 ft

Important for roads and shallow infrastructure

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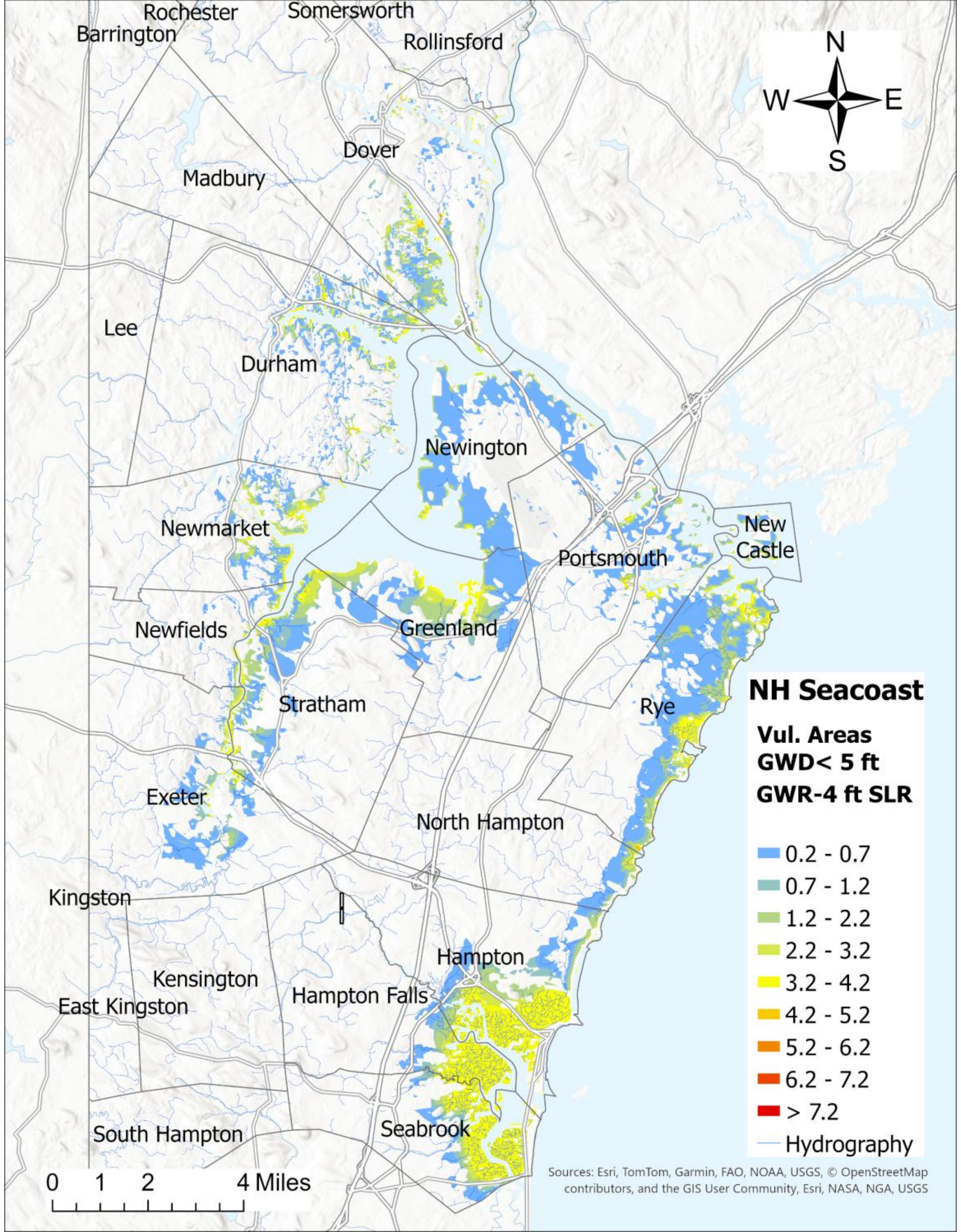
Vulnerable Areas with Sea Level Rise (SLR)

Vulnerable Areas, i.e., GWD currently < 5 ft deep

- SLR = 1 ft
- SLR = 2 ft
- SLR = 4 ft
- SLR = 6 ft
- SLR = 8 ft



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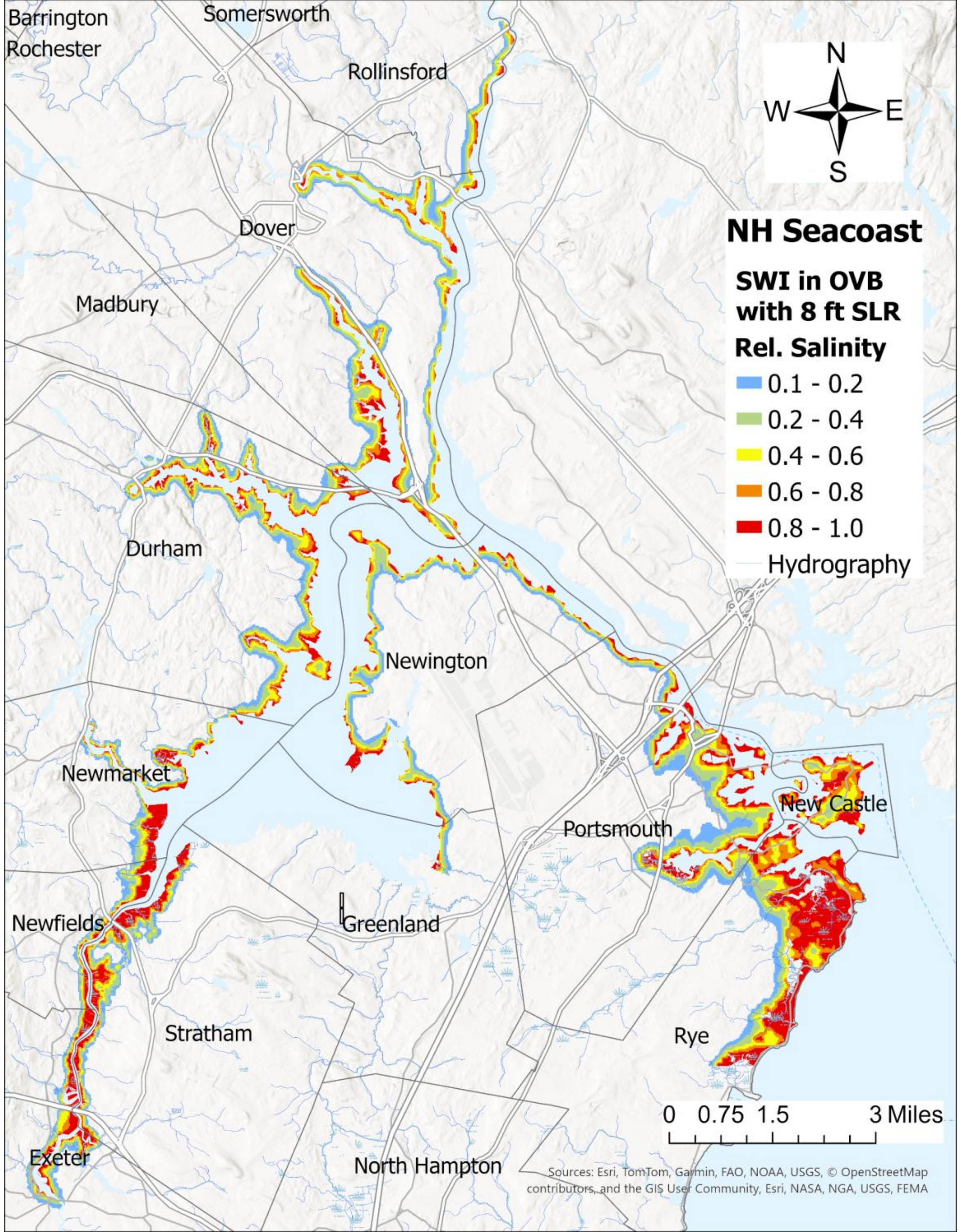
Saltwater Intrusion Simulations

Overburden – NSLR, 8 ft SLR

Bedrock – NSLR, 8 ft SLR

Saltwater Intrusion in Overburden

Simulated Saltwater Intrusion in the unconsolidated deposits with NSLR and 8 ft SLR



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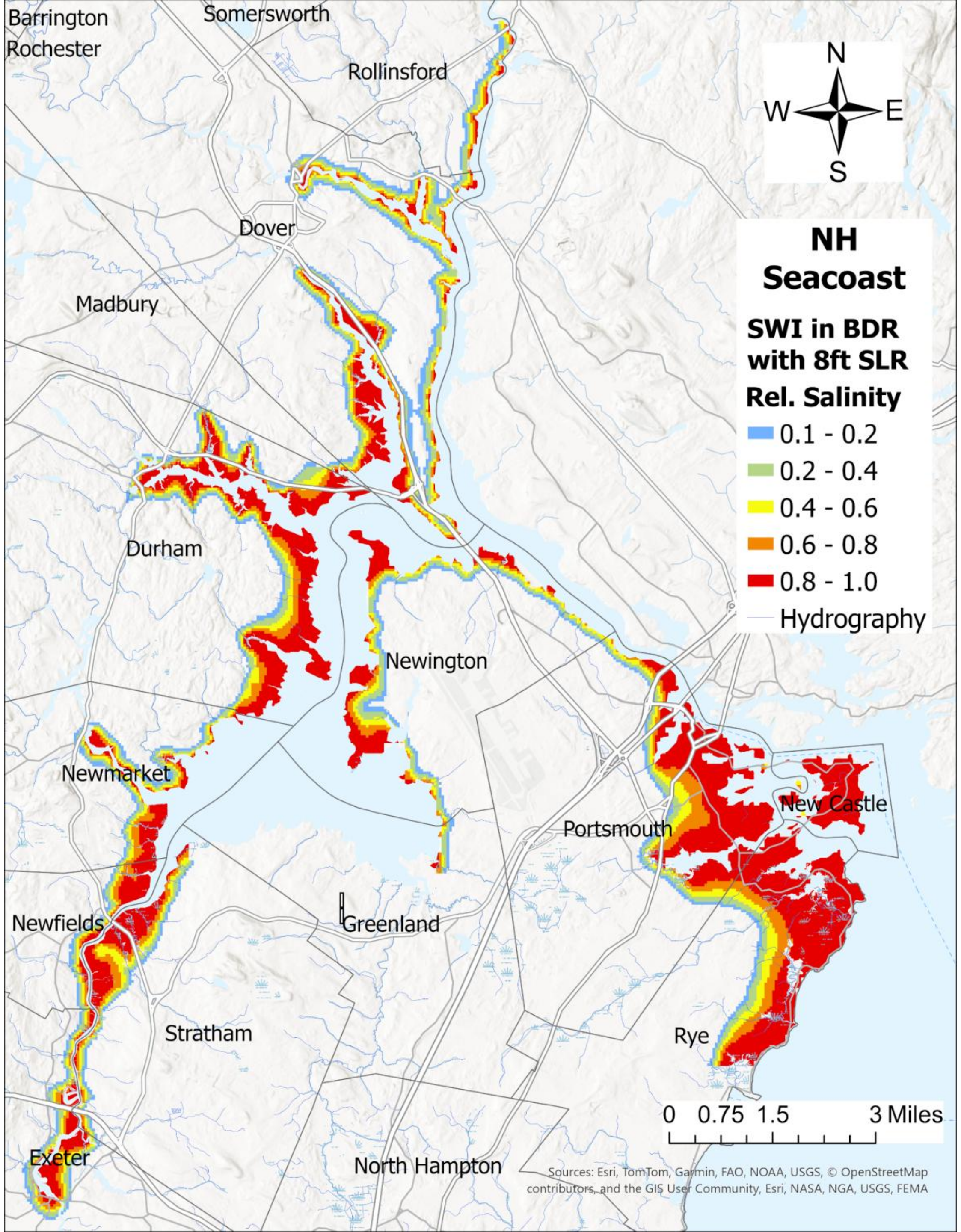
Saltwater Intrusion in Bedrock

Simulated Saltwater Intrusion in bedrock with NSLR and 8 ft SLR



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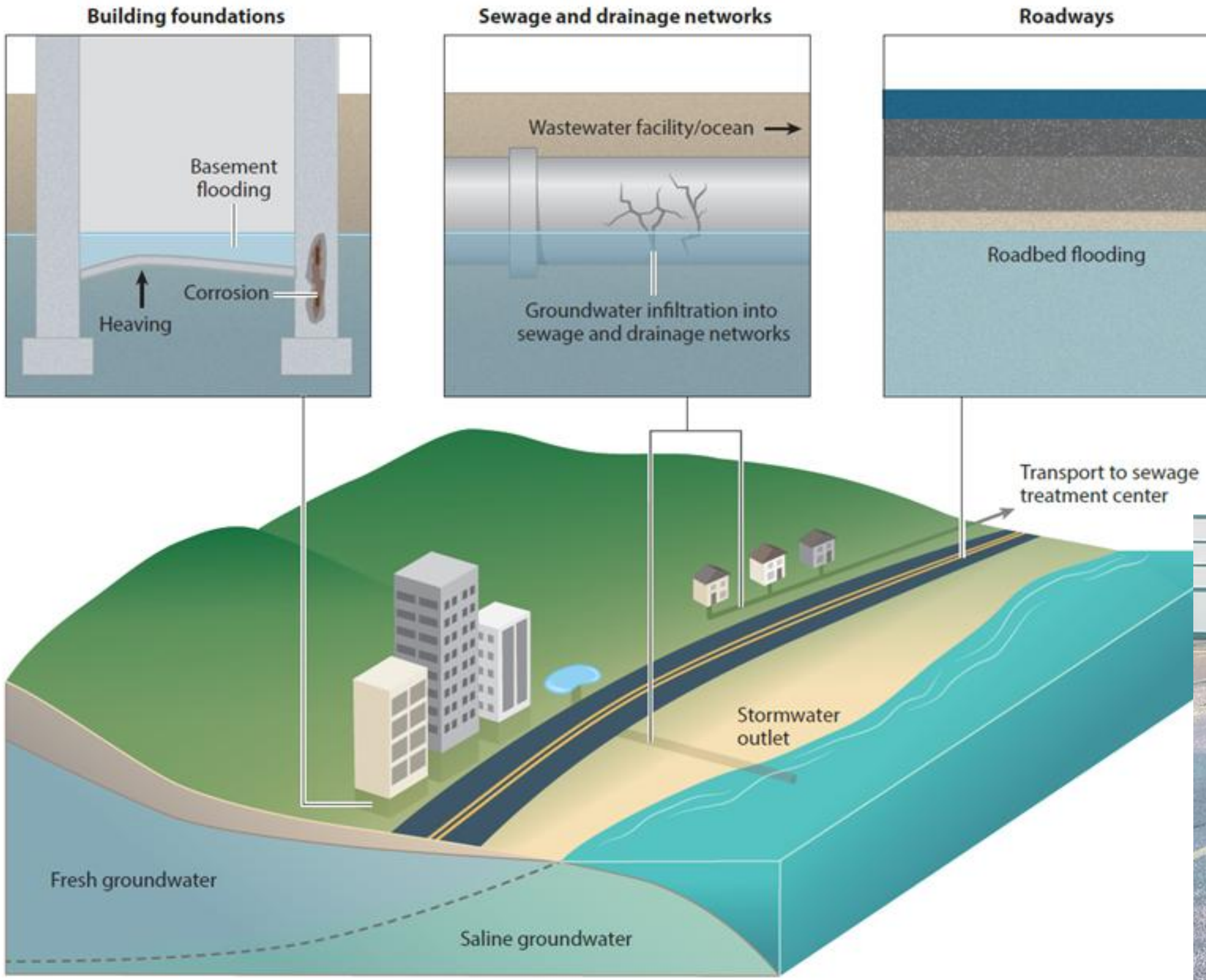
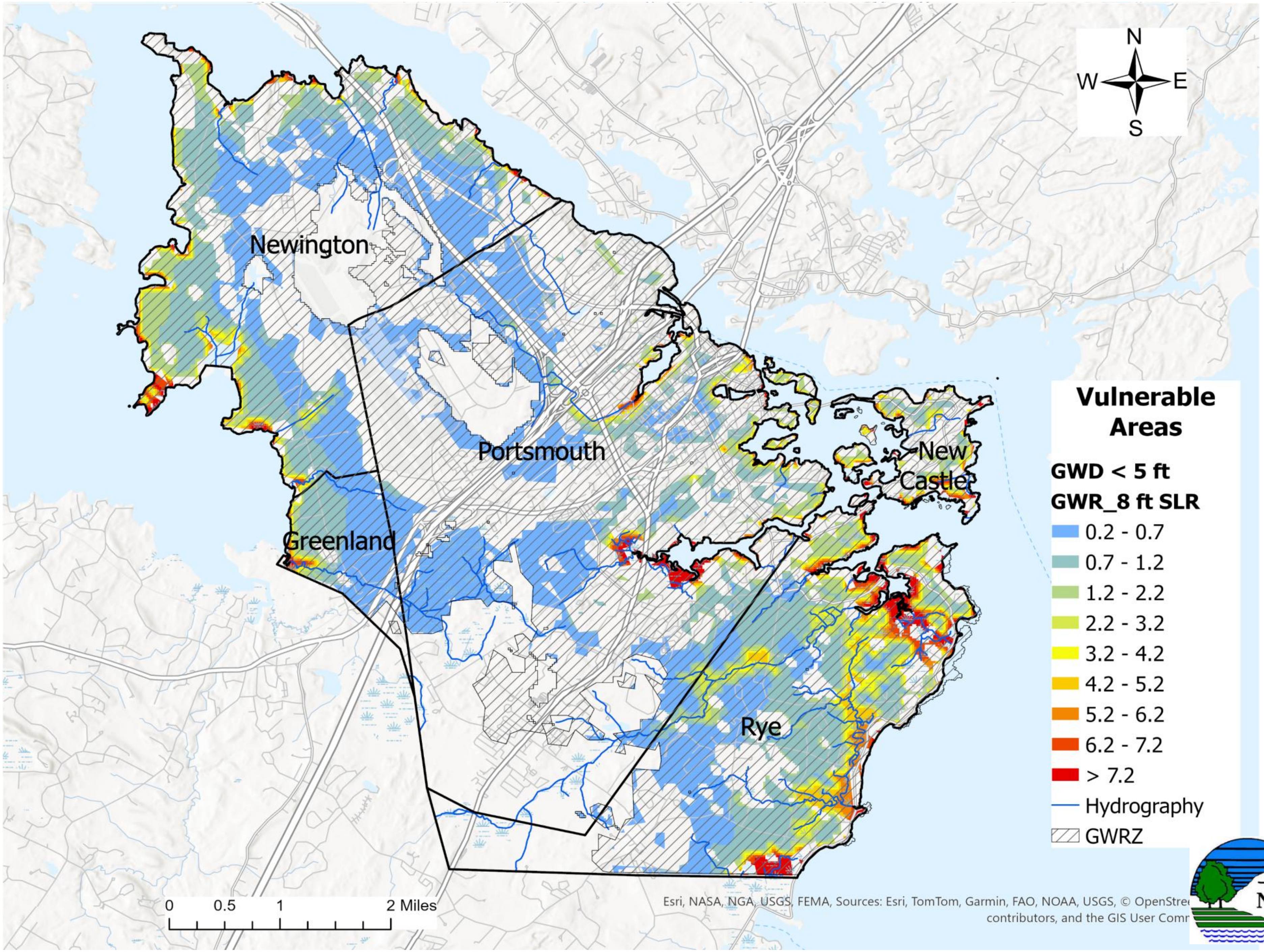
Coastal Roads and Sewer Infrastructure



Portsmouth Vulnerability Study

Vulnerable Areas, GWD<10 ft and 5 ft with 8 ft SLR:

- Newington
- Portsmouth
- Greenland
- Rye



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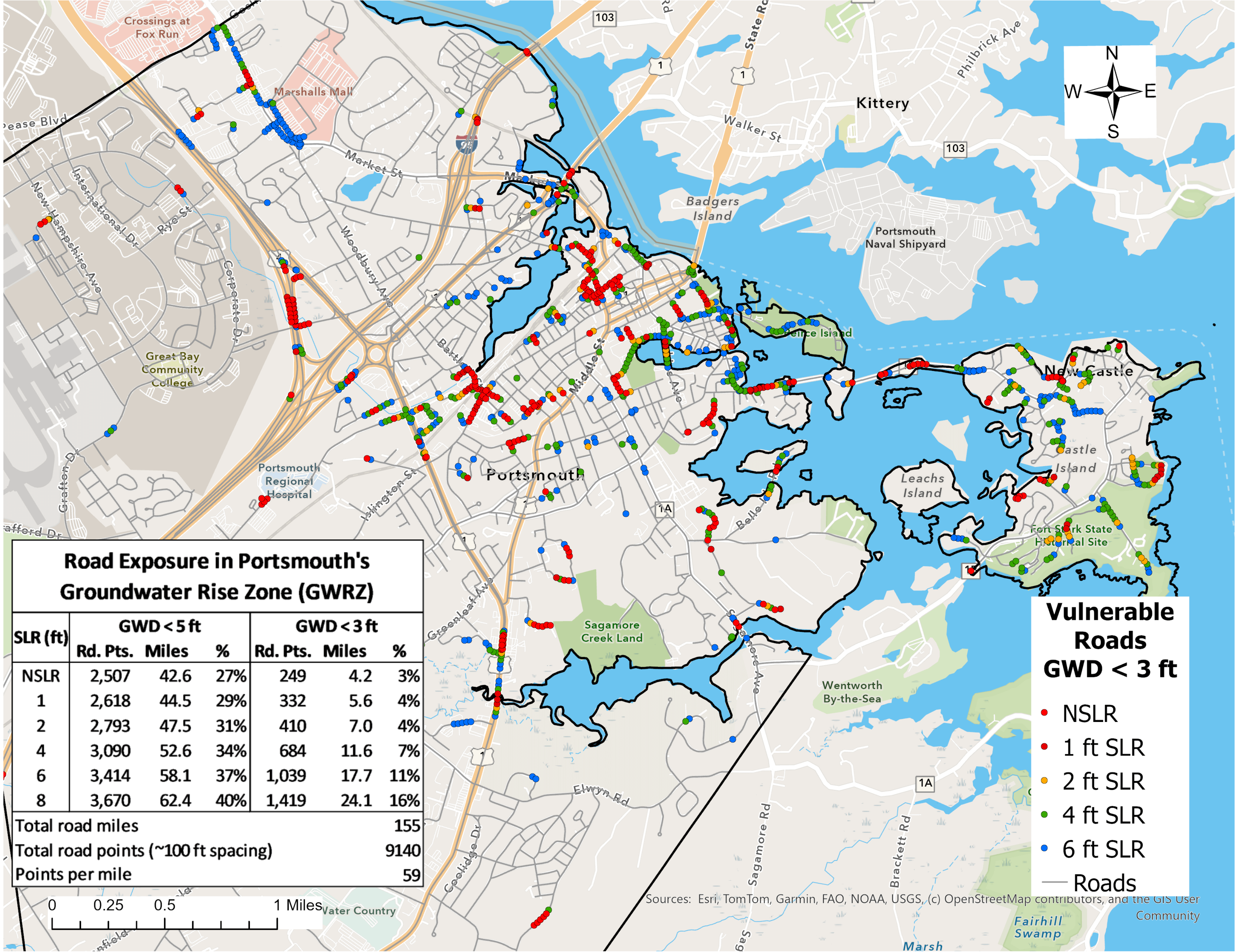
Vulnerable Road Sections

Premature pavement failure likely – GWD < 3 ft.

Where GW < 5 ft deep, the pavement's underlying supportive layers are weakened.



Road Exposure in Portsmouth's Groundwater Rise Zone (GWRZ)

SLR (ft)	GWD < 5 ft			GWD < 3 ft		
	Rd. Pts.	Miles	%	Rd. Pts.	Miles	%
NSLR	2,507	42.6	27%	249	4.2	3%
1	2,618	44.5	29%	332	5.6	4%
2	2,793	47.5	31%	410	7.0	4%
4	3,090	52.6	34%	684	11.6	7%
6	3,414	58.1	37%	1,039	17.7	11%
8	3,670	62.4	40%	1,419	24.1	16%
Total road miles						155
Total road points (~100 ft spacing)						9140
Points per mile						59

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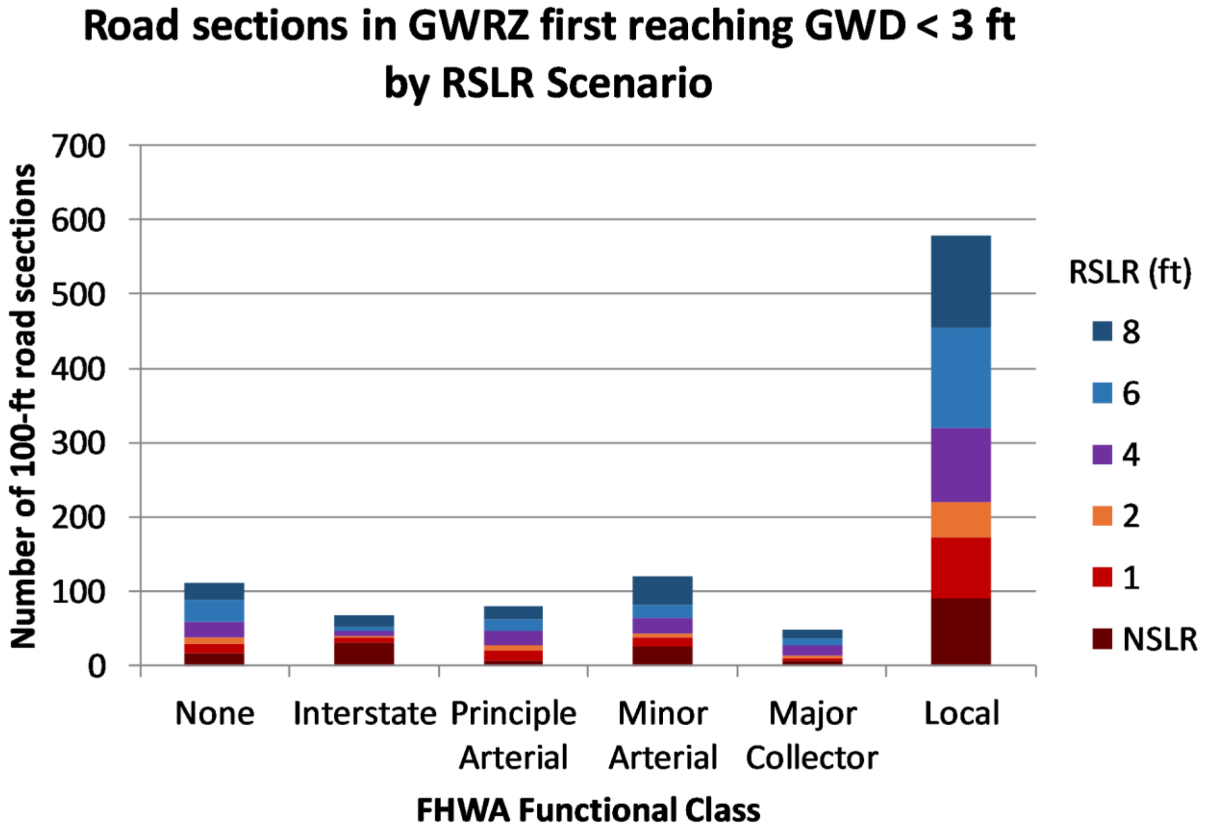
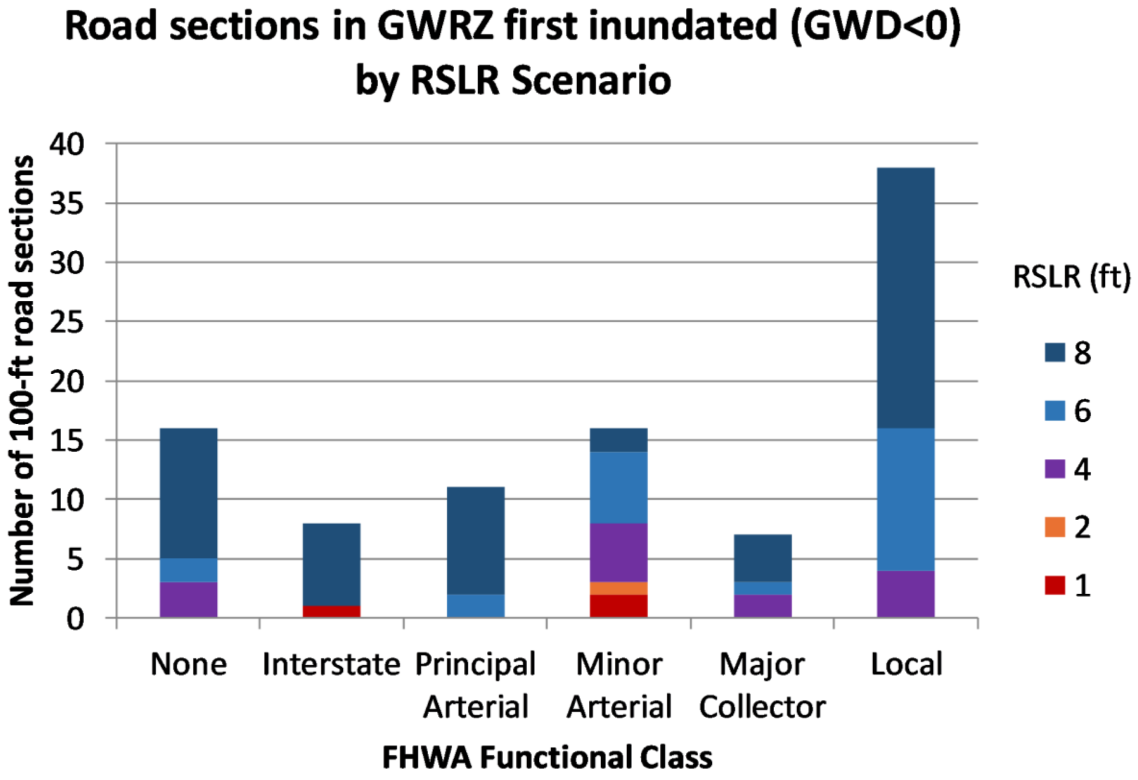
Relative SLR Thresholds for Premature Pavement Failure and Road Surface Inundation



Premature pavement failure is likely where GWD < 3 ft.

Groundwater Inundation of Road Surface



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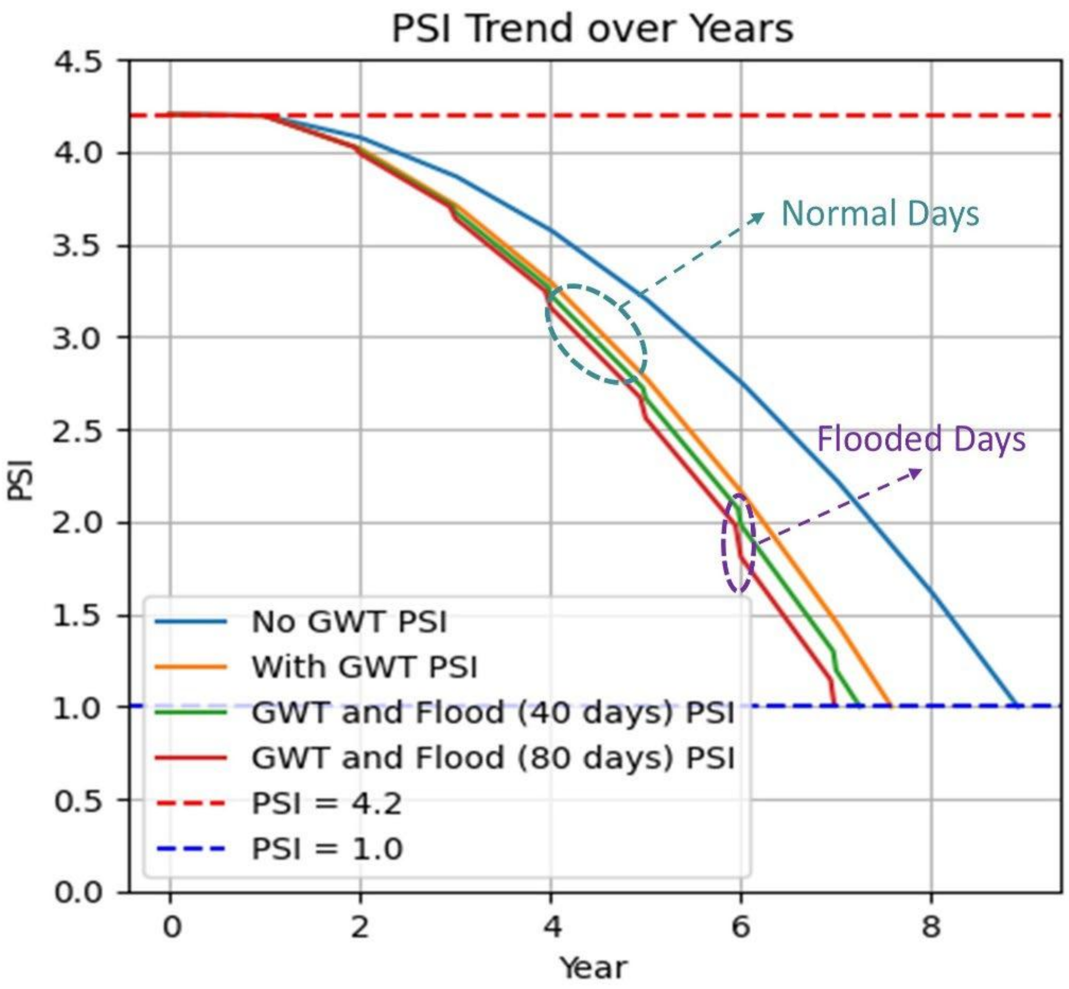
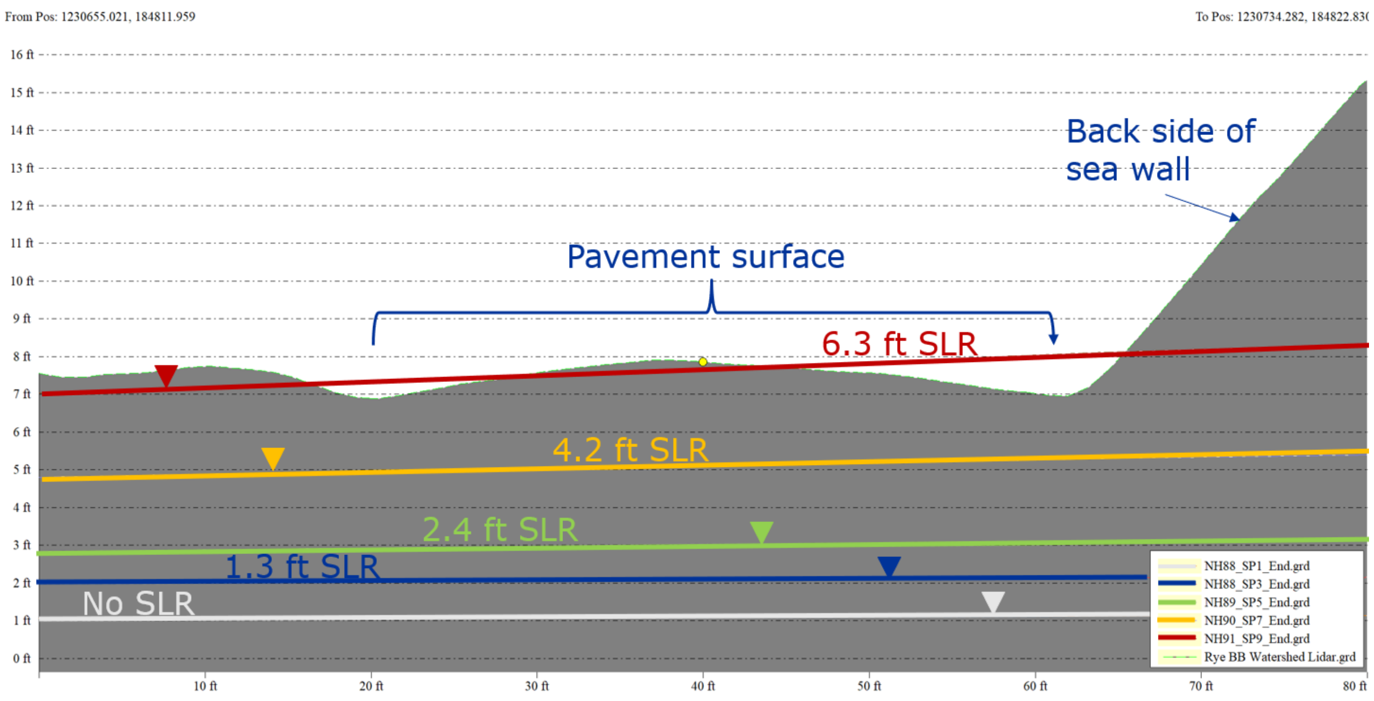
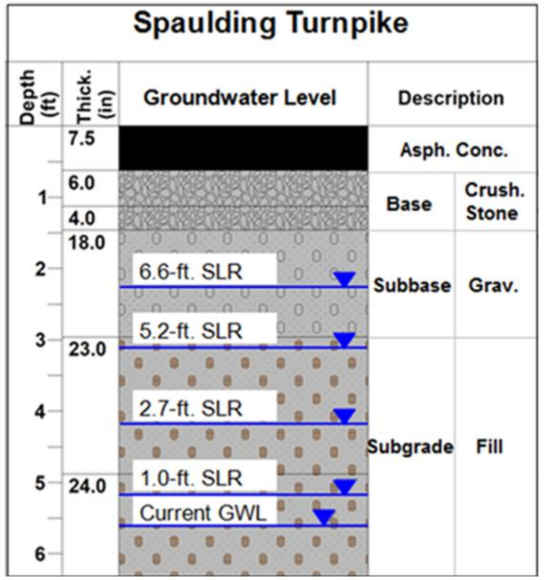
Pavement Life Curves Translate Impacts into Service Life

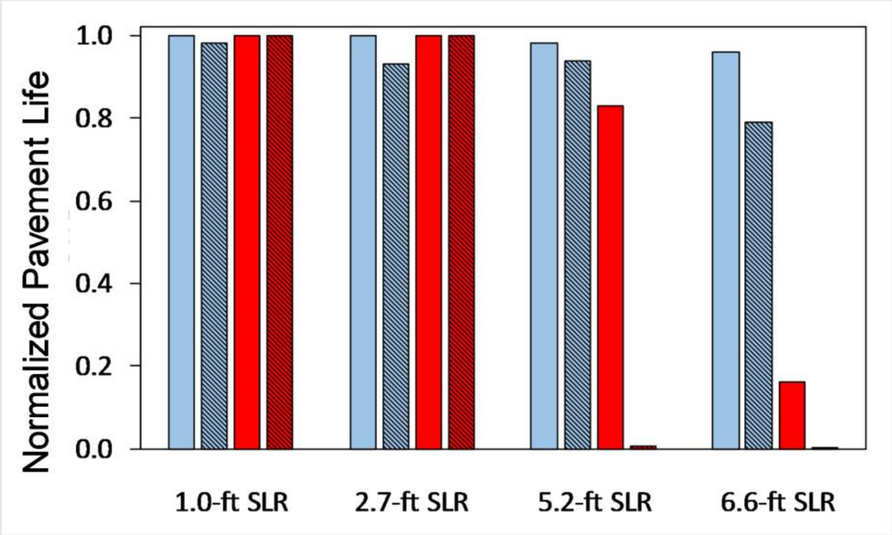


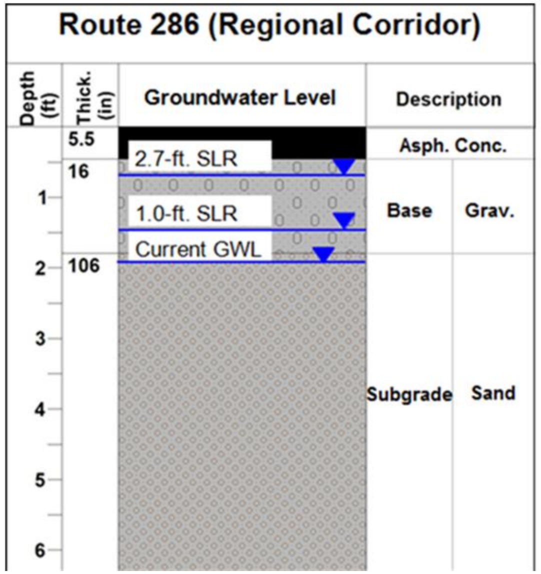


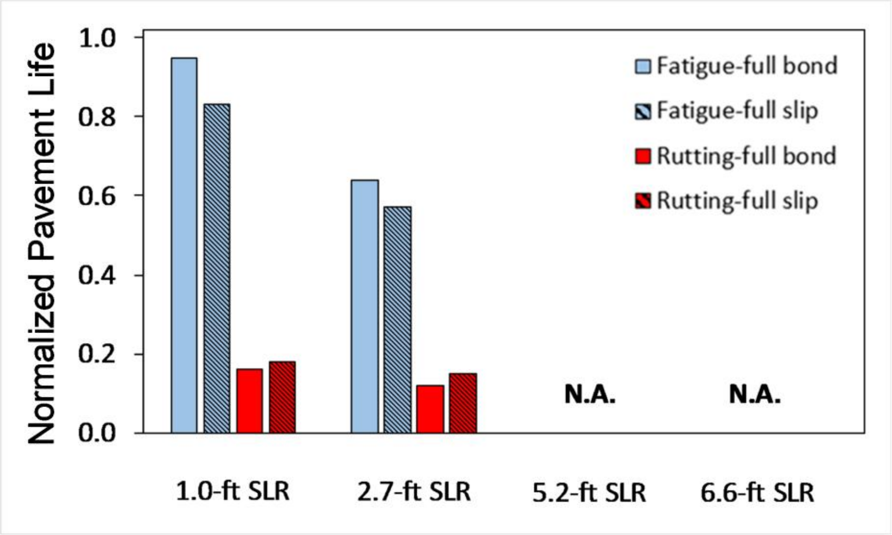
What is PSI? Pavement Serviceability Index, a simple way to represent pavement condition or ride quality over time.

Pavement Structure and Pavement Life









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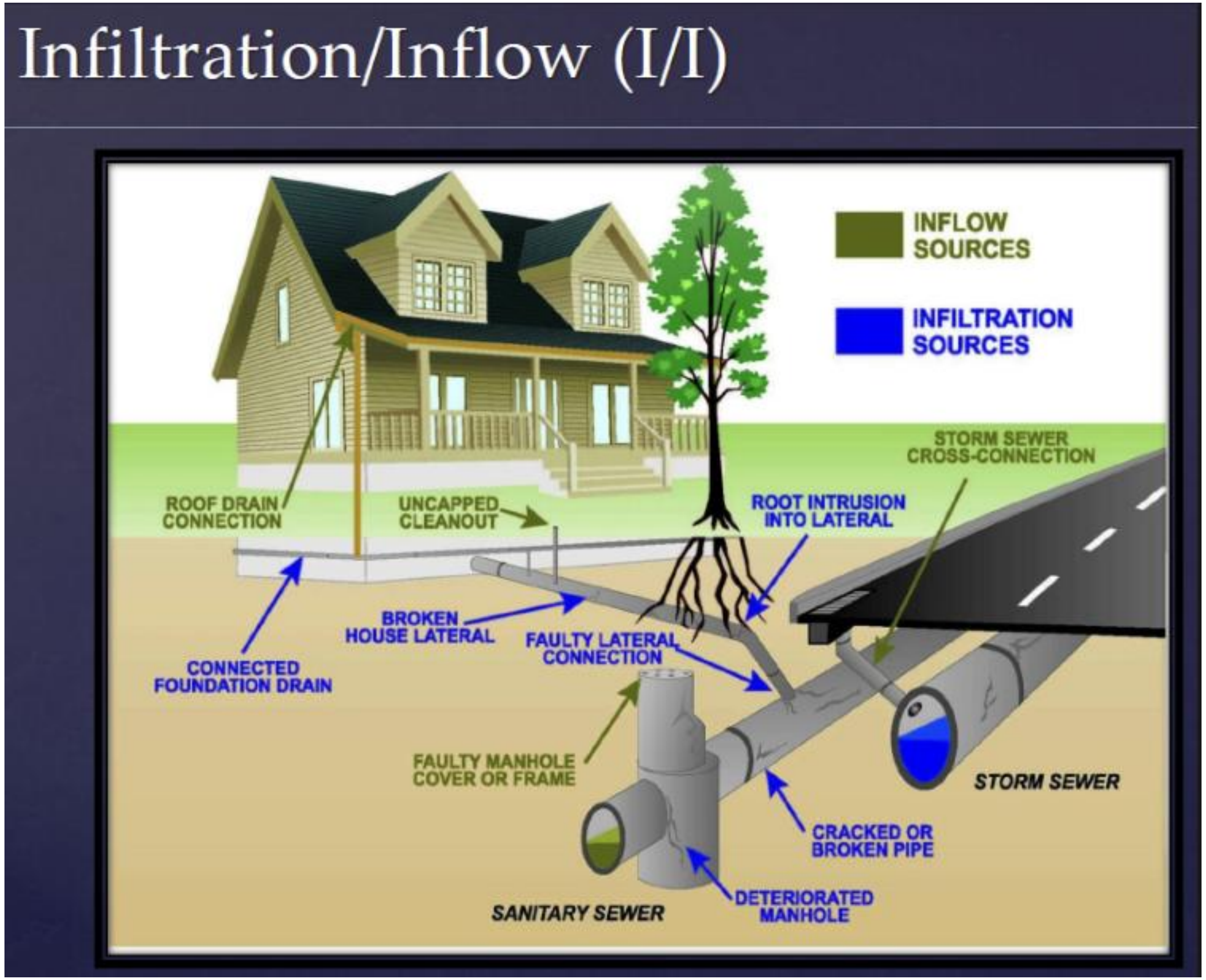
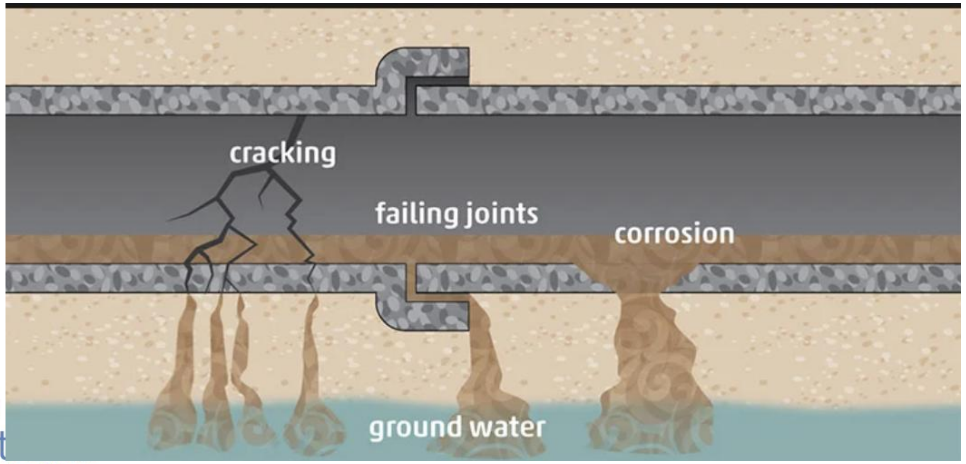
Sanitary Sewer Systems

Potential Impacts:

- Inflow and infiltration of groundwater in sewer pipes
- Exfiltration of sewage from sewer pipes
- Salinization
  - Saline groundwater in wastewater treatment
  - Pipe corrosion





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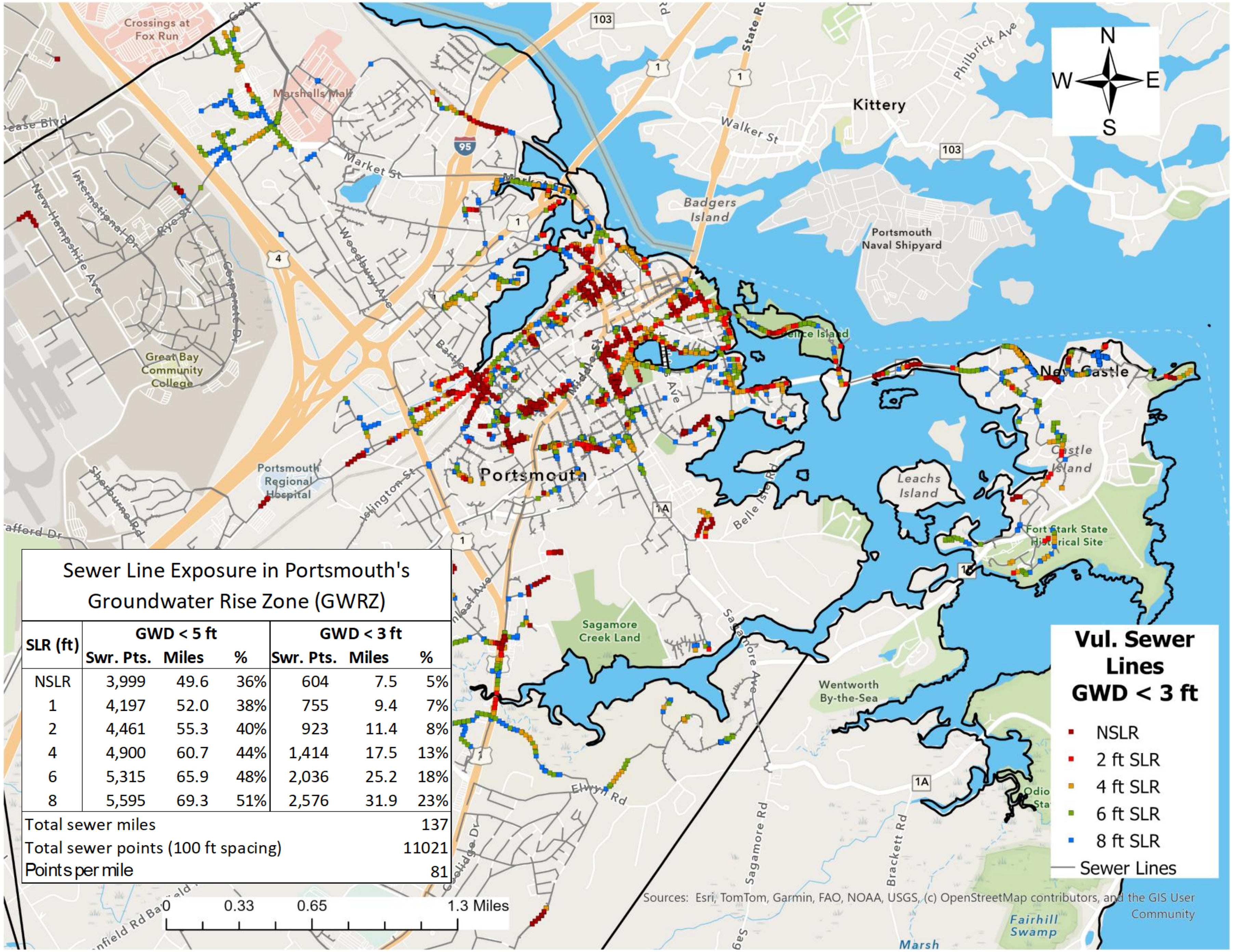
Vulnerable sewer lines - GWD < 3 ft



Sewer Line Exposure in Portsmouth's Groundwater Rise Zone (GWRZ)

SLR (ft)	GWD < 5 ft			GWD < 3 ft		
	Swr. Pts.	Miles	%	Swr. Pts.	Miles	%
NSLR	3,999	49.6	36%	604	7.5	5%
1	4,197	52.0	38%	755	9.4	7%
2	4,461	55.3	40%	923	11.4	8%
4	4,900	60.7	44%	1,414	17.5	13%
6	5,315	65.9	48%	2,036	25.2	18%
8	5,595	69.3	51%	2,576	31.9	23%
Total sewer miles						137
Total sewer points (100 ft spacing)						11021
Points per mile						81

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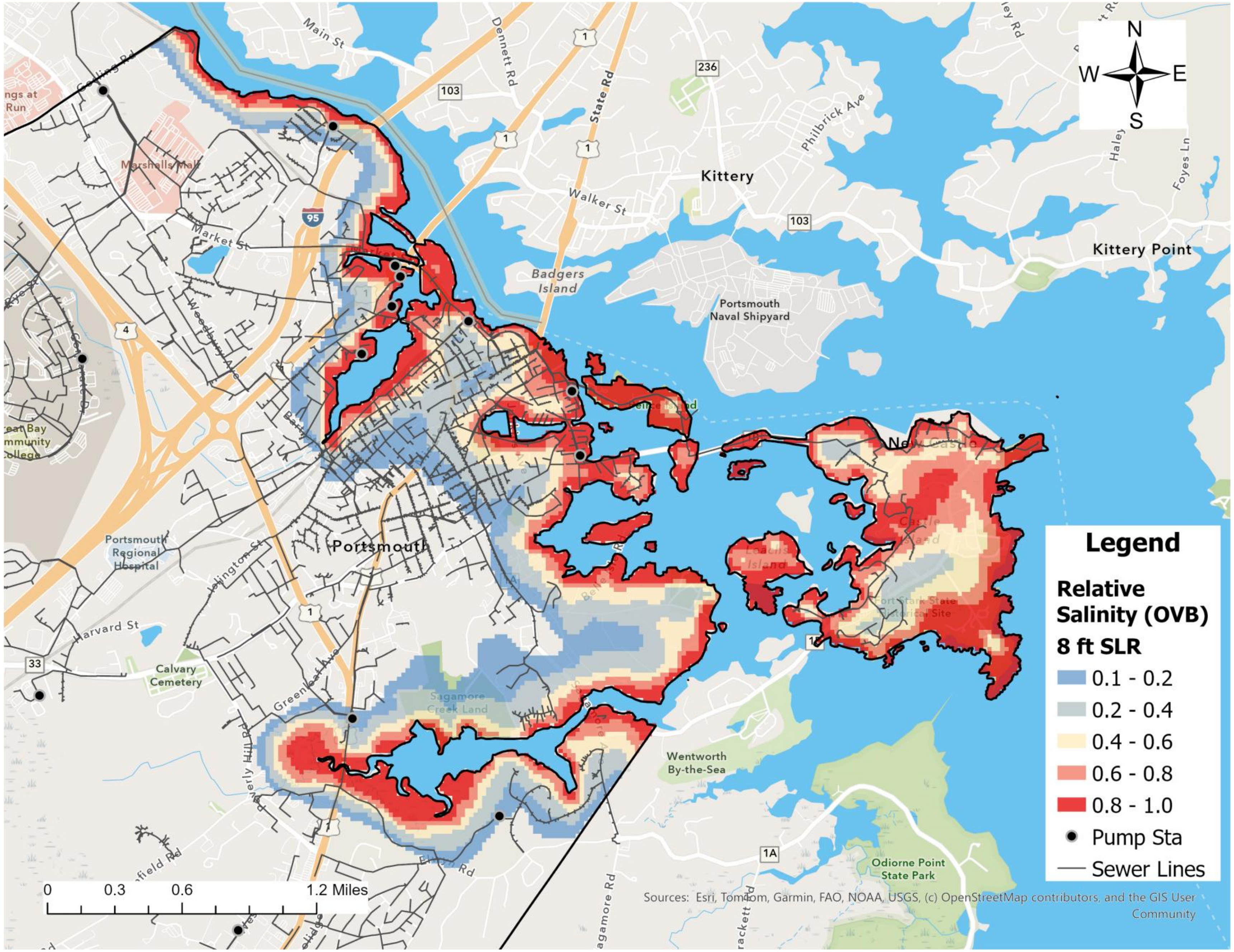
Saltwater intrusion (SWI) in overburden

Shown – sewer pipes and sewer pumping stations



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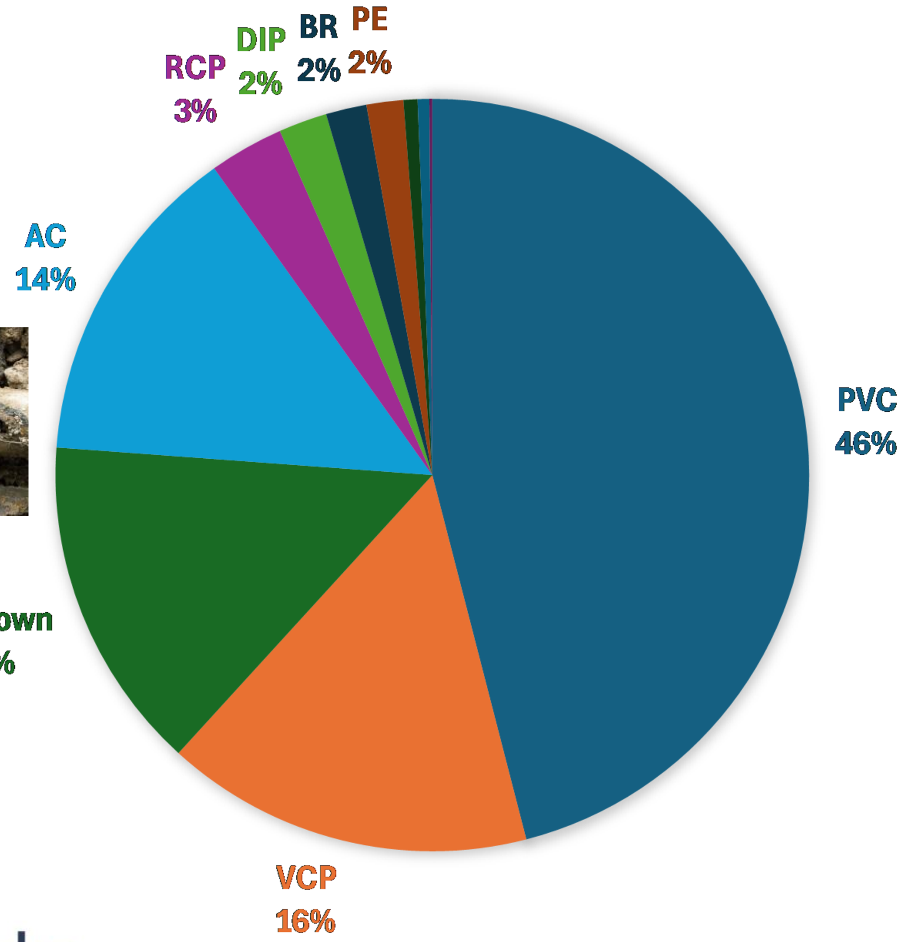
Portsmouth’s Vulnerable Sewer Pipes

PIPE MATERIAL COMPOSITION - GWD < 5 FT, NSLR



Asbestos Cement

Sewer Pipe Materials Ranked by Resistance to Coastal Groundwater Damage

Ranked best to worst using weighted scores (chemical/corrosion 50%, joint/infiltration 30%, structural 20%)

Rank	Pipe Material	Corrosion resistance (1–5)	Infiltration resistance (1–5)	Structural performance (1–5)	Weighted score (0–5)
1	High-Density Polyethylene (HDPE)	5	5	4	4.8
2	PVC (SDR-35 / gravity sewer)	5	4	4	4.5
3	Vitrified Clay Pipe (VCP)	5	3	3	4
4	Ductile Iron (DIP)	2	4	5	3.2
5	Reinforced Concrete (RCP)	2	3	4	2.7
6	Cast Iron (legacy) (CIP)	1	2	4	1.9
7	Asbestos Cement (AC)	1.5	2	2	1.75
8	Brick (BR)	1	1	2	1.2

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Sewer Pipe Material Options

Plastic – low pressure, degrades, can break when frozen or warp in heat.

Cast Iron – strong, corrodes/oxidizes

Vitrified clay – strong, heavy, can crack, difficult to join, porous & attracts roots

Source: Rocket Plumbing https://rocketplumbingnow.com/trenchless-sewer-repair/

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Public Water Supply and Saltwater Intrusion

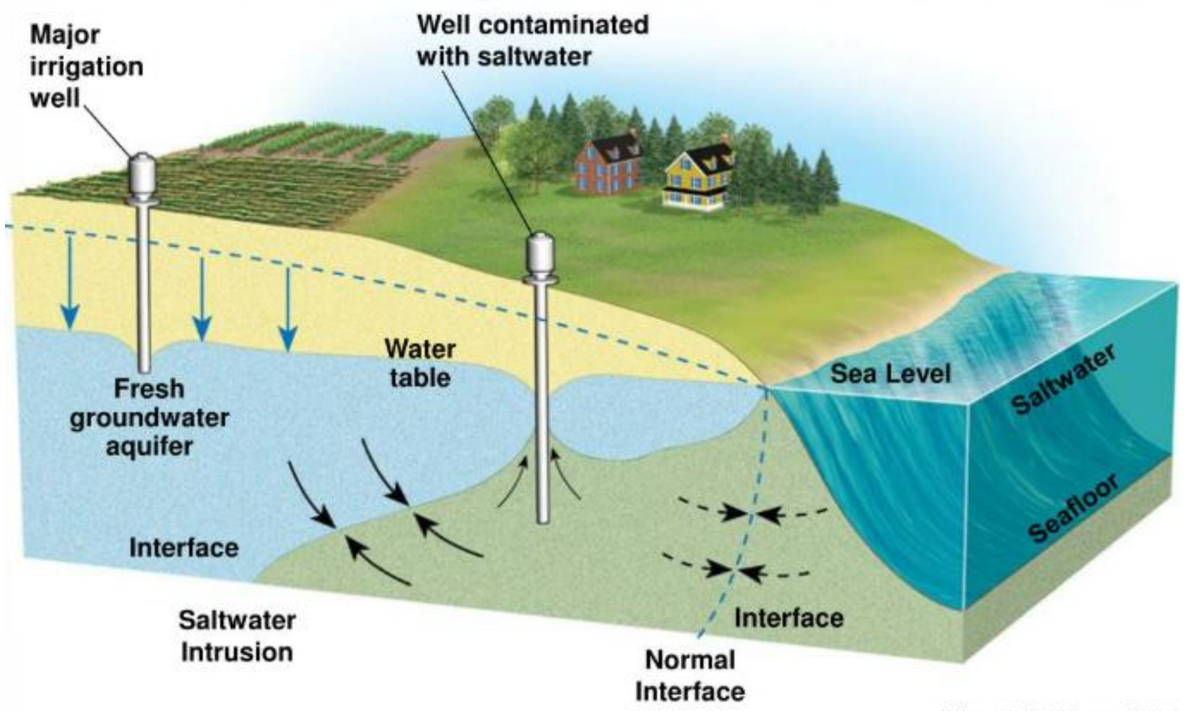
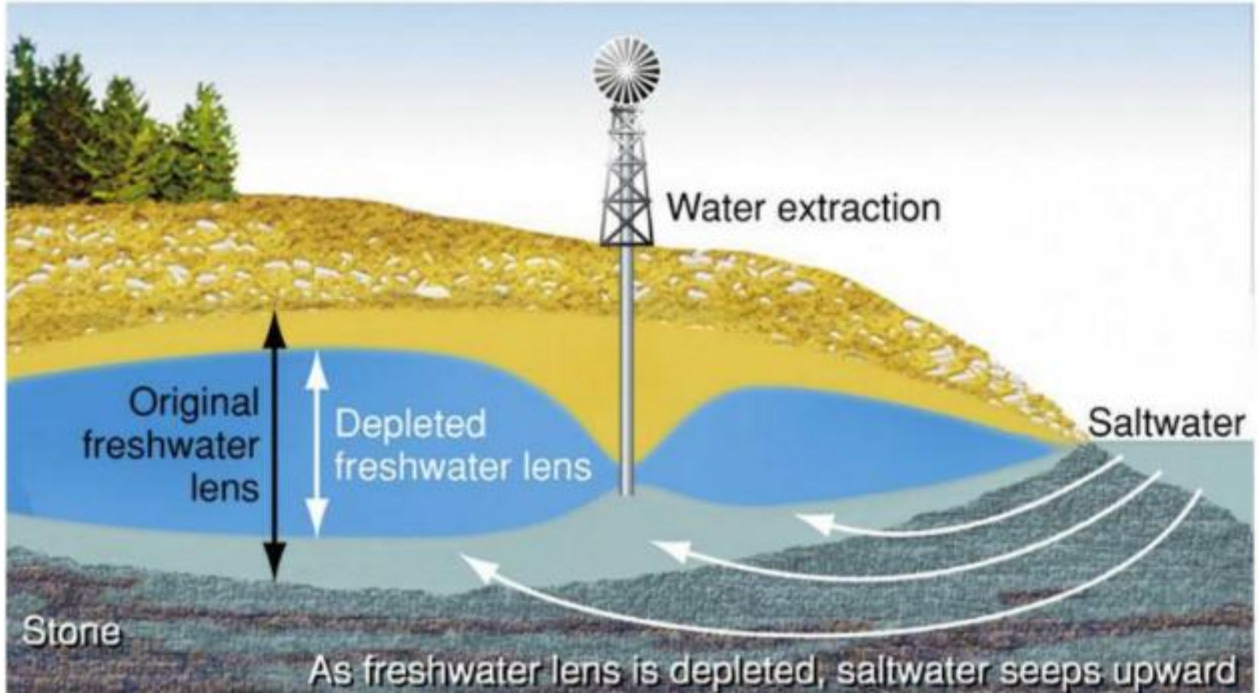
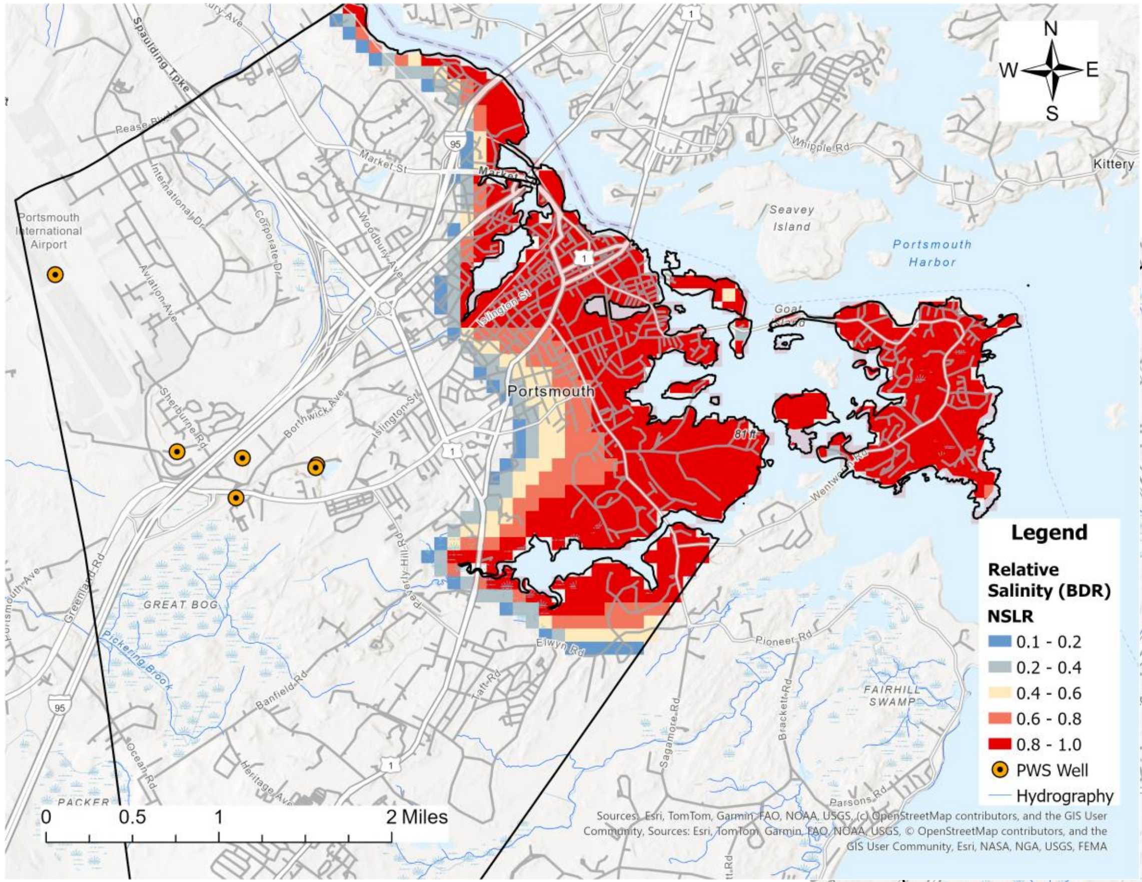


Fig. 11-15, p. 247

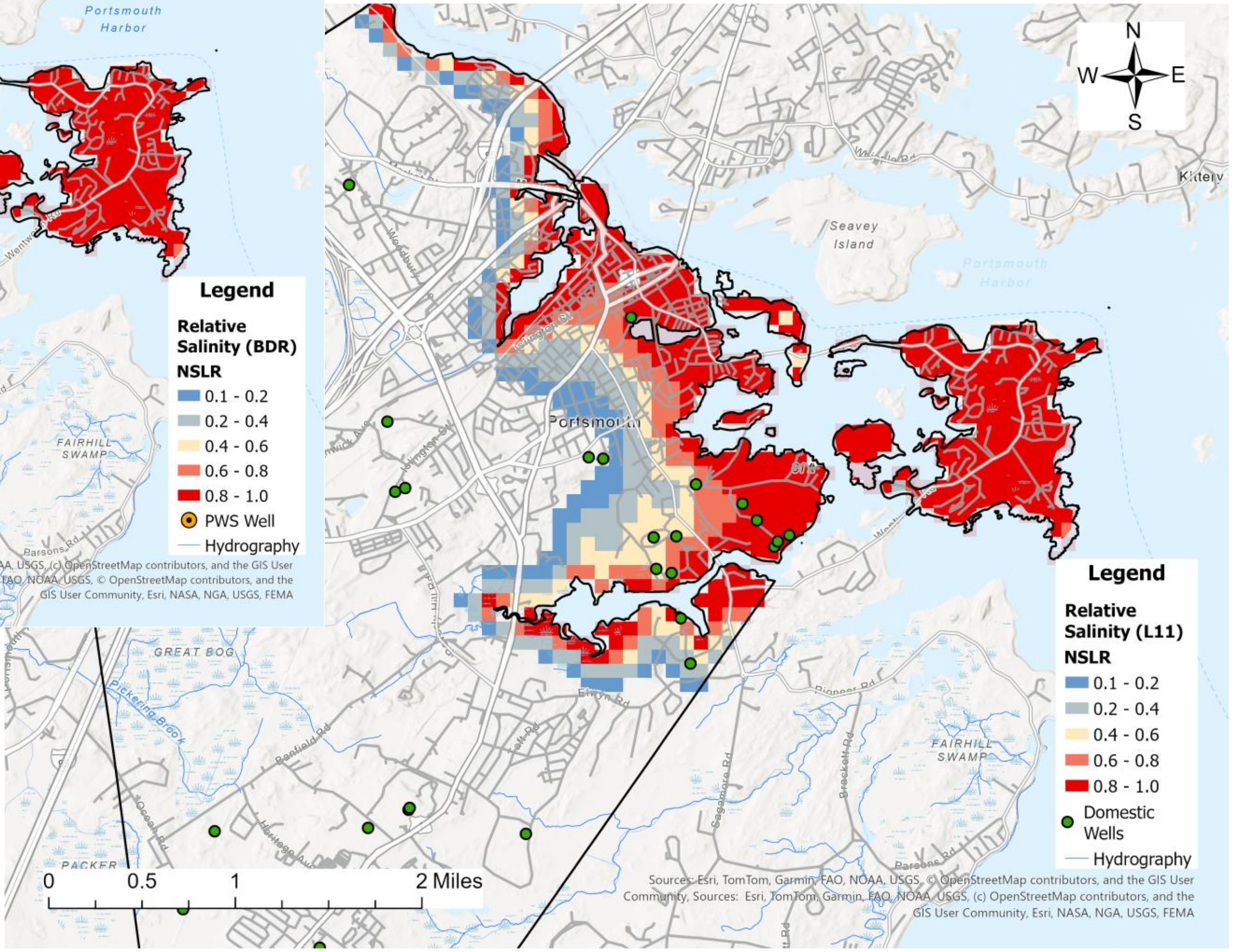


SWI in bedrock with drinking water wells



Public Supply Wells – are OK

Some domestic wells may be impacted



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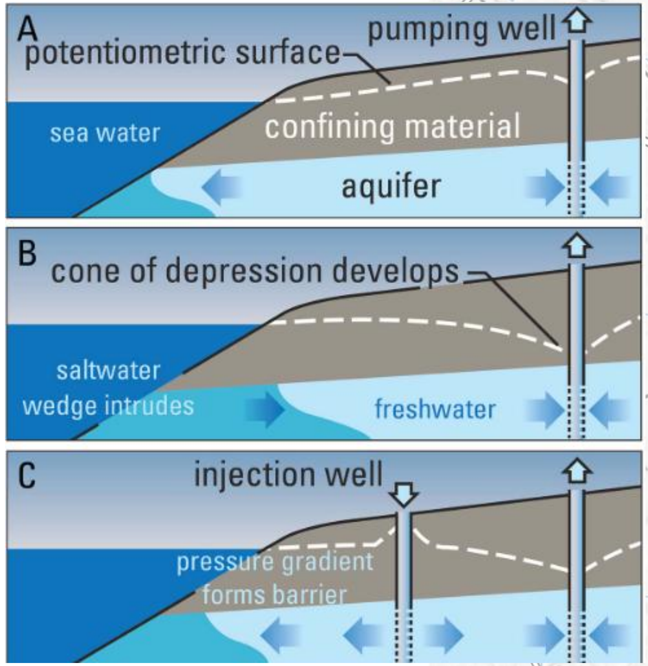
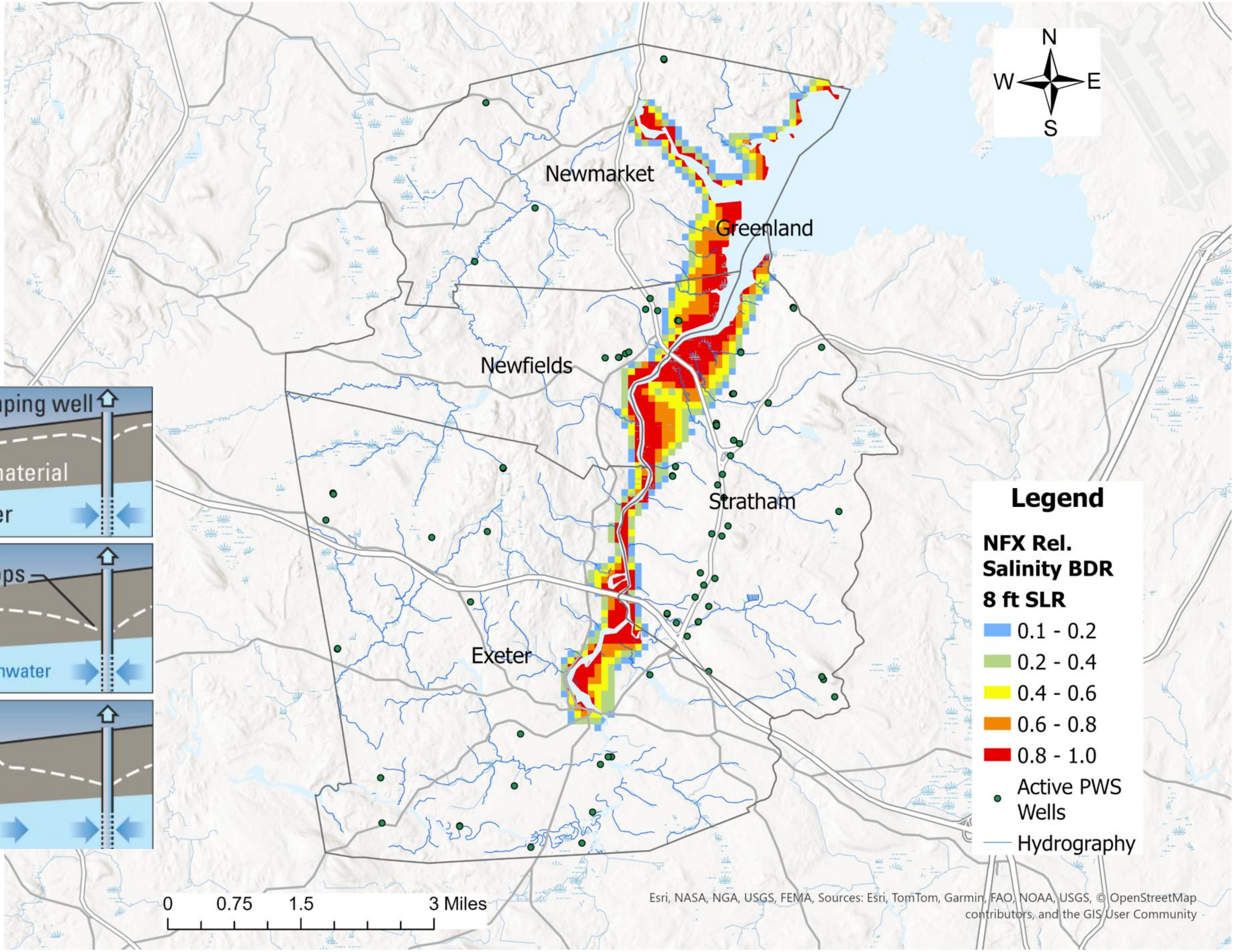
SWI in Bedrock with Water Supply Wells

What can be done?





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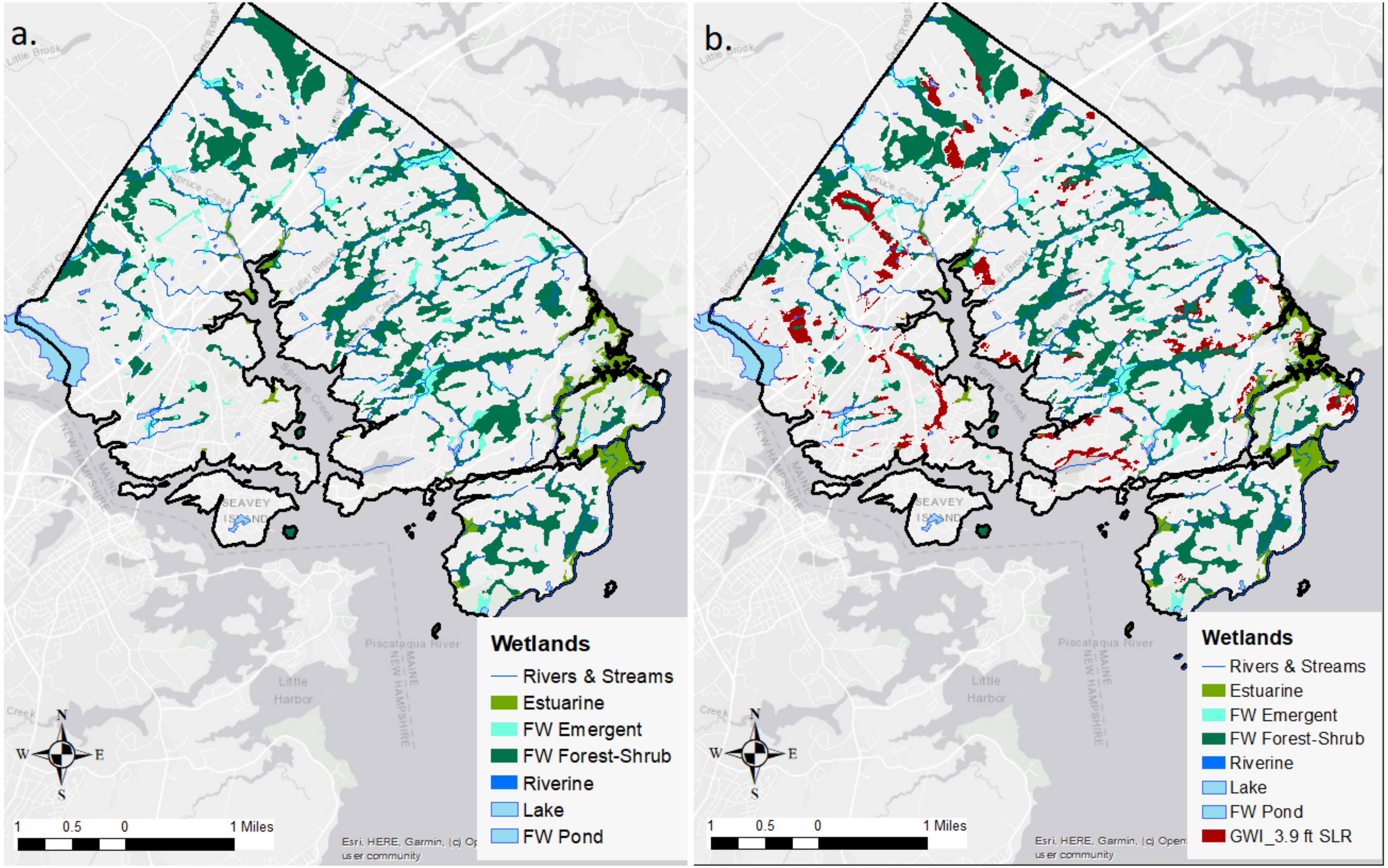
Wetlands and Projected Groundwater Inundation (GWI) in Kittery, Maine



- 2,580 acres of wetlands in Kittery
- 598 acres of projected GWI with 3.9 ft SLR
- 28% - within existing wetland
- 72% - newly saturated land

Infrastructure Vulnerability Assessment: Joint Land Use Study Phase IV, prepared for Southern Maine Planning and Development Commission by AECOM Technical Services, Inc. and HydroPredictions, July 2025.

Funded through a grant from Department of Defense (DoD), Office of Local Defense Community Cooperation (OLDCC).

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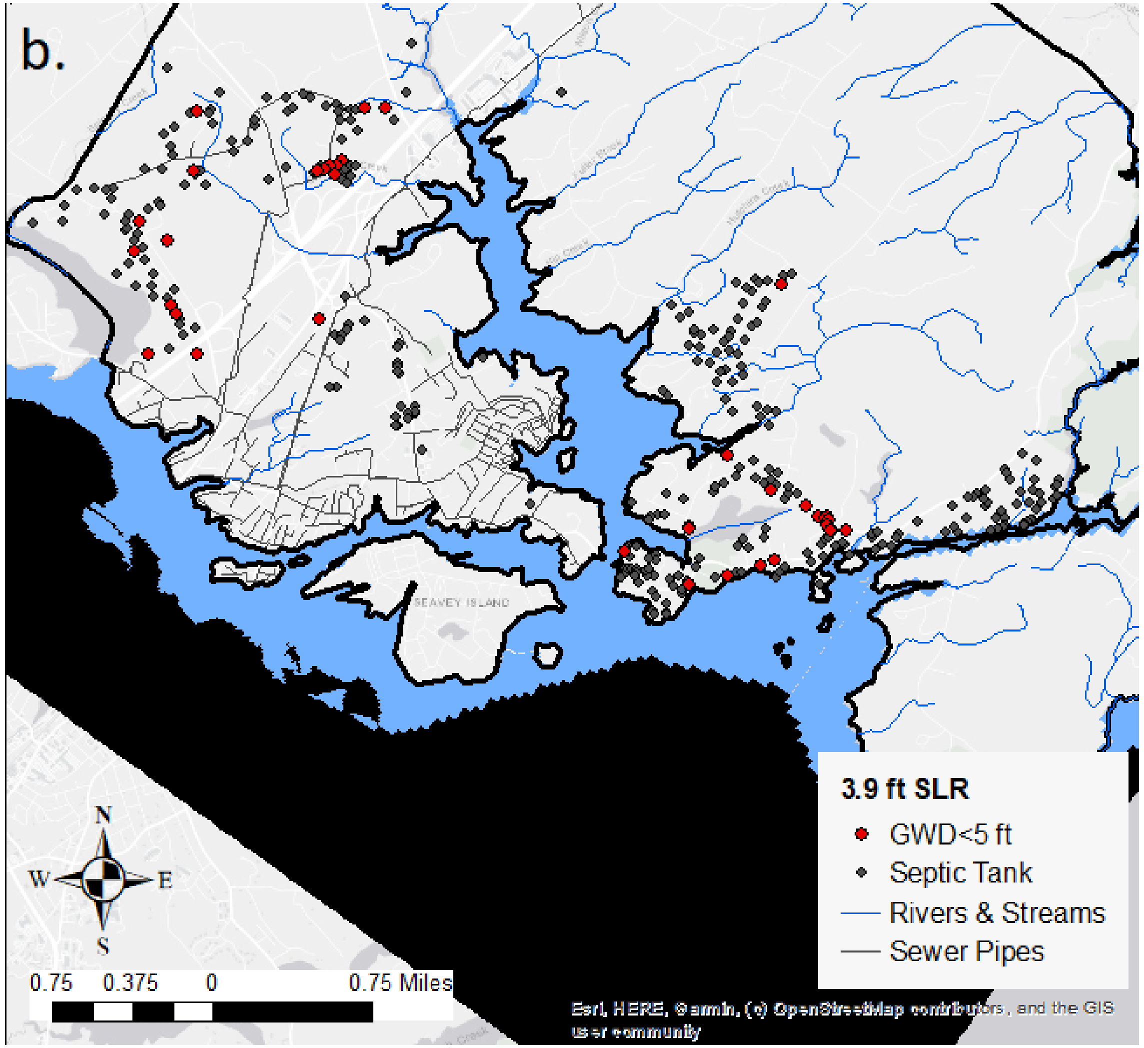
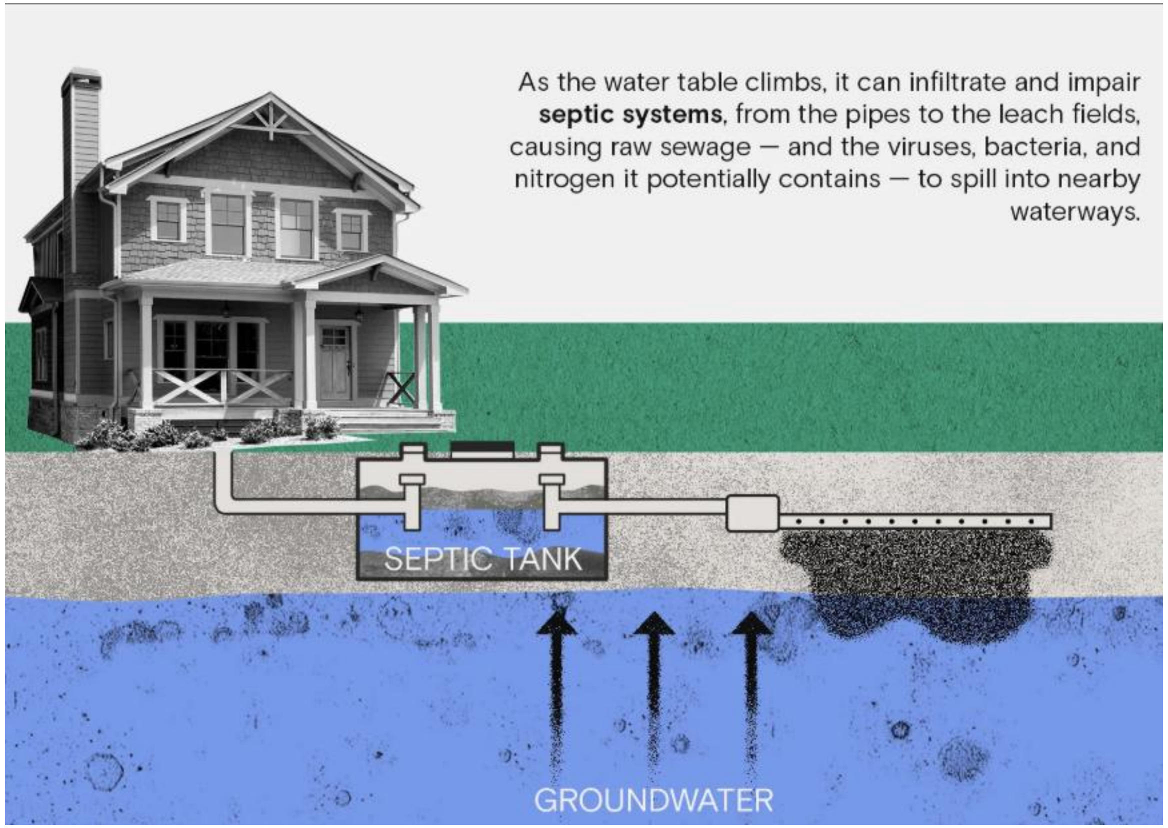
Vulnerable Septic Systems in Kittery, Maine





In Massachusetts, there must be a 4-ft (low K soils) and 5-ft (high K soils) separation between the bottom of the leach field and the seasonal high-water table.

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Groundwater Monitoring

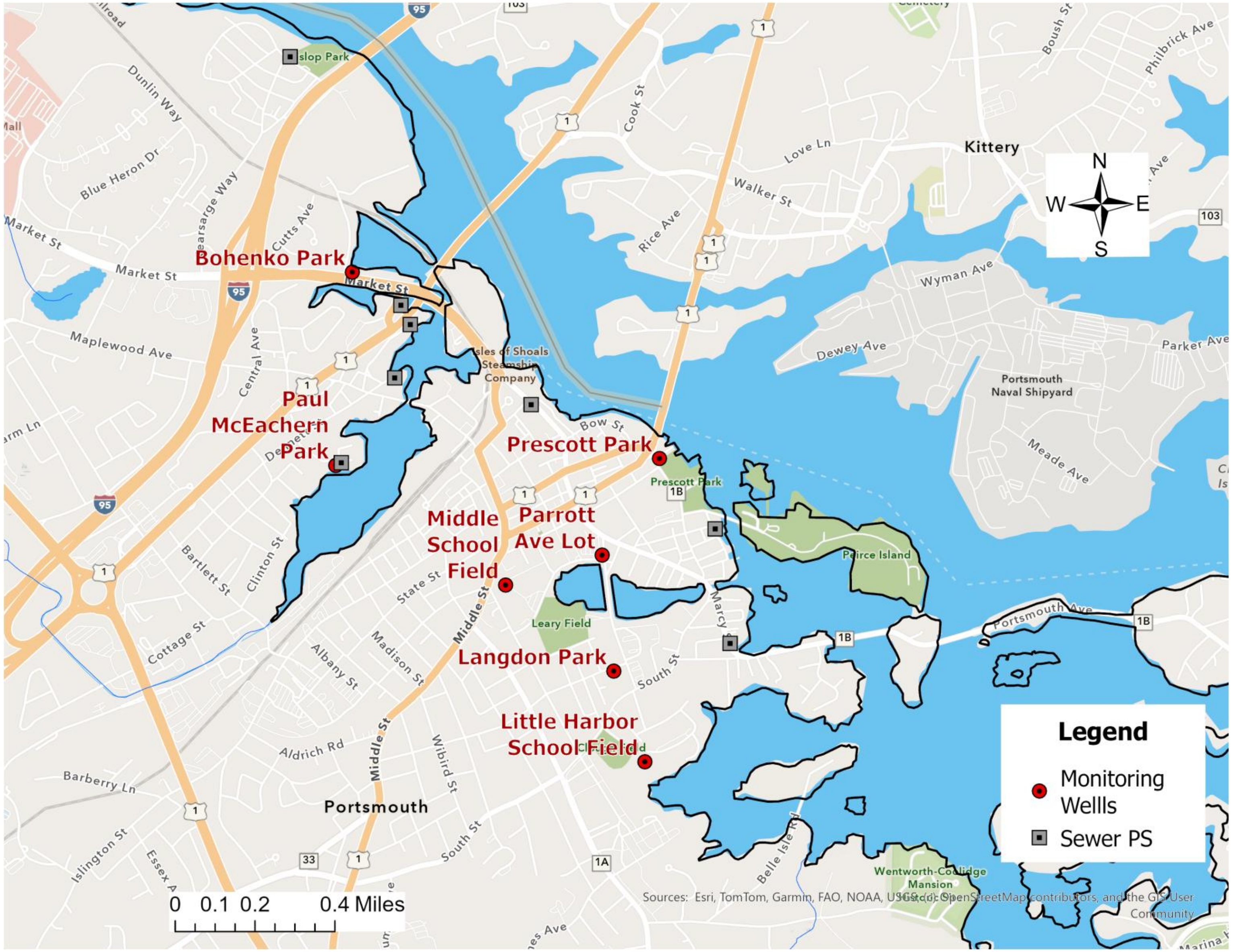
Portsmouth Monitoring Wells and Sewer Pumping Stations

GW Level, Temperature, Conductivity (LTC):

- Bohenko & Parrott Ave

GW Level and Temperature (LT):

- McEachern
- Langdon
- Little Harbor
- Middle School
- Prescott Park



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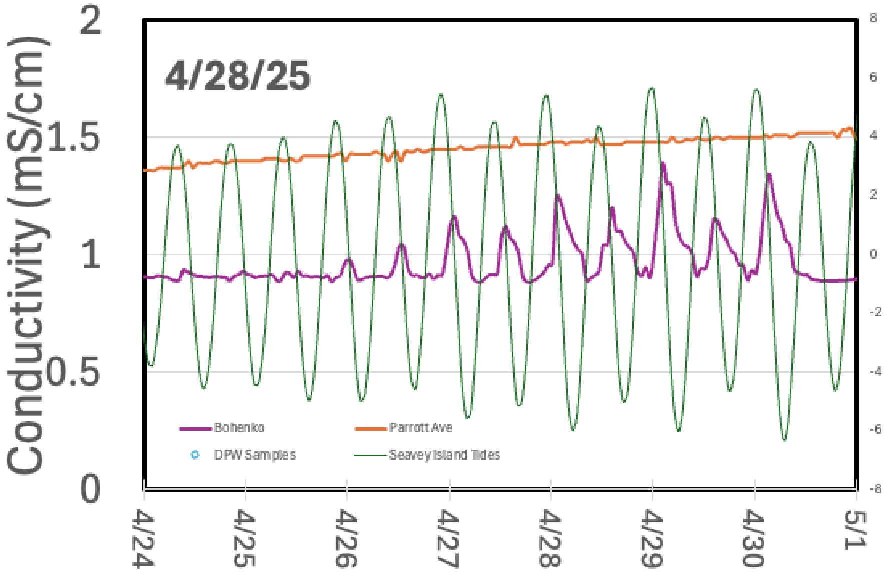
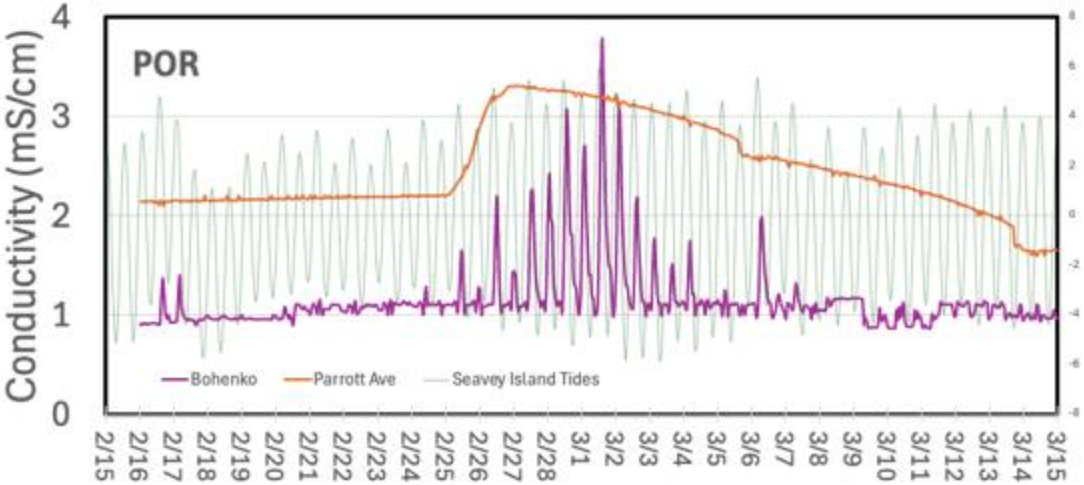
Salinity (Conductivity) - GW monitoring to determine optimal sampling times for salinity in nearby sewer pumping stations

- Use ***Bohenko Park*** for tidally influenced locations
  - Sample during highest high tide
  - 2 hrs after Seavey Island high tide
- Use ***Parrott Ave.*** for non-tidal locations
  - Sample during snowmelt for road salt impacts, and
  - Summer – large uncertainty





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Putting the Modeling to Work

A four-step framework for translating groundwater and saltwater intrusion modeling outputs into community decisions. Dynamic Adaptation Planning

1

Identify

Use modeled groundwater-depth and saltwater-intrusion maps to inventory at-risk infrastructure.

2

Prioritize

Rank assets by sea-level-rise milestones and consequence of failure.

3

Adapt

Select mitigating, hedging, seizing, and shaping actions; design for staged implementation.

4

Monitor

Track signposts with continuous monitoring; act on triggers; reassess as data accrue.

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Adapted from Walker et al. (2019), Marchau, & Kwakkel (2019); Haasnoot et al. (2013); Knott (2025)

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Step 1 – Identify Vulnerable Infrastructure

Overlay modeled groundwater-depth (GWD) and saltwater-intrusion (SWI) surfaces on infrastructure GIS to flag at-risk assets by zone.

Critically Shallow (GWD < 5 ft)

- Map roads and pavements for premature failure
- Flag septic systems and basements
- Identify stormwater assets and shallow utilities
- Cross-reference contaminated and critical sites
- Delineate wetland transition areas

Transition Zone (GWD 5–10 ft)

- Locate deeper sewers and storm drains
- Identify basements and foundation footprints
- Track contaminated-site plume depths
- Schedule monitoring on sentinel assets

Future Risk (GWD 10–15 ft)

- Inventory deep trunk utilities
- Identify large below-grade structures
- Plan for long-lived infrastructure (50+ yr)
- Reserve right-of-way for future relocation

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GWD zones per NHCFRS 2025, Ch. 6 (Knott, 2025); Knott et al. (2019); Bosserelle et al. (2022).

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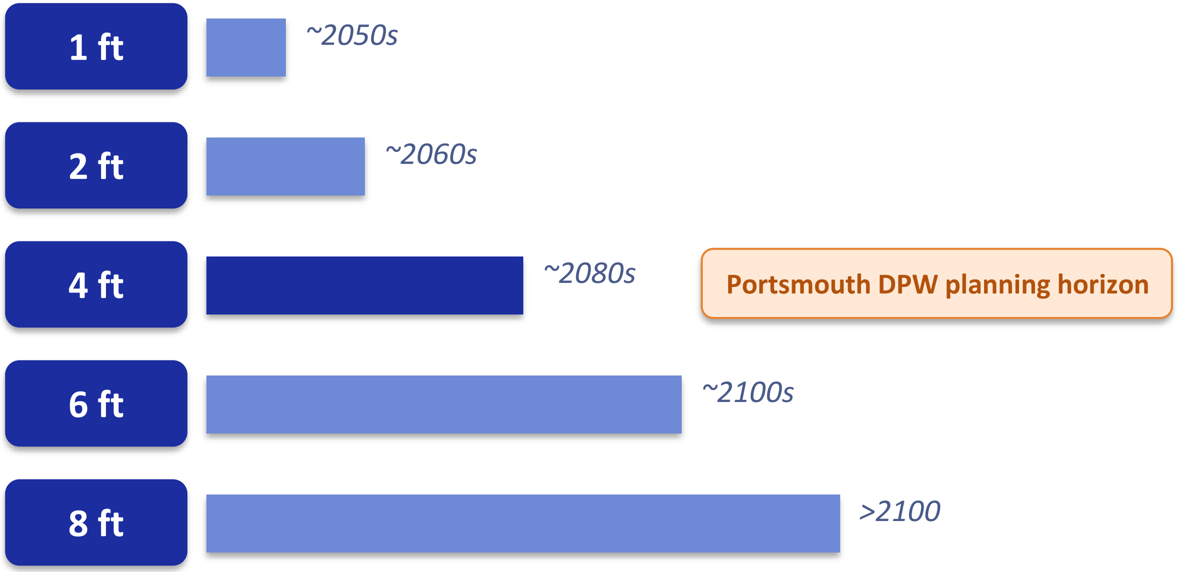
Step 2 – Prioritize by Sea-Level Rise Timeline

Roads, sewers, stormwater, wetlands, and water supplies are all affected at every SLR milestone. What increases with SLR is the height and extent of groundwater rise.

Sea-Level Rise Milestones (NH Seacoast)



Assets affected across all milestones: roads & pavements, sewer & stormwater, water supply, septic, basements, wetlands.

How to use the milestones

Match asset service life to SLR milestone

- Short-lived assets (≤20 yr): design for current and 1–2 ft scenarios
- Mid-life assets (20–50 yr): design for 2–4 ft scenarios
- Long-lived assets (>50 yr): stress-test against 4–8 ft scenarios
- Refresh priorities each time a milestone is exceeded
- Combine likelihood (likely / intermediate / low) with consequence of failure to set an investment order

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Milestones based on Sweet et al. (2022); approach adapted from Walker et al. (2019) and Knott (2025).

Step 3 – Select Adaptive Actions

Match each vulnerability to one of four action types. Sequence them so investments remain robust if projections change.

Mitigating Actions

Address likely vulnerabilities now

- Reinforce sewer pipes against infiltration and corrosion
- Raise or relocate vulnerable pump stations and electrical gear
- Apply corrosion-resistant linings and joint seals

Hedging Actions

Buy flexibility under uncertainty

- Install monitoring before committing to large capital projects
- Choose modular, replaceable components over fixed designs
- Phase rehabilitation to align with rising-risk zones

Seizing Actions

Take opportunities as they arise

- Integrate groundwater fixes into scheduled paving or sewer work
- Bundle adaptation with planned redevelopment projects
- Leverage state, federal, and FEMA funding cycles

Shaping Actions

Create the conditions for success

- Update municipal codes and design standards for shallow GW
- Coordinate across drinking water, wastewater, and roads agencies
- Engage the public with NH Coastal Viewer GWR maps

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Action typology adapted from Walker et al. (2019); see also Haasnoot et al. (2013) and Knott et al. (2019).

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Step 4 – Monitor, Trigger, and Adapt

Close the loop with continuous groundwater monitoring. Use observed signposts to implement pre-defined triggers and revisit the plan.

Monitoring network

- Groundwater wells with level, temperature, and conductivity sensors
- Sentinel wells at tidally influenced and inland reference sites
- Telemetry for near-real-time data and rapid alerting
- Sampling timed to high tide, snowmelt, and dry season for salinity
- Pair monitoring with re-runs of the GW model as observations grow

Signposts, triggers, and reassessment

- Signpost: rising water tables near sewer or septic systems
- Signpost: increasing conductivity in near-shore wells
- Trigger: GW infiltration up >15% → fast-track sewer repairs
- Trigger: conductivity exceeds threshold → reassess supply wells
- Reassess plan, update the model, and adjust pathway

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Monitoring framework after Bosserelle et al. (2022) and Walker et al. (2019); Portsmouth network described in Knott (2025).

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Thank you!

Contact: jfknott@hydropredictions.com