



# Low-lying Roads: Provincetown

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Project funded by the  
Municipal Vulnerability  
Preparedness Program



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# Purpose and Objectives of Workshop

- 
- **Review flood projections and impacts on roadways for the town under future scenarios**
  - **Discuss vulnerable low-lying roads or other transportation infrastructure**
  - **Prepare the town to address priority road segments for design and permitting**

# Agenda

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- Project Overview – CCC
- Vulnerability and Risk Assessment – WHG
- Results of Low-Lying Roads Screening & Prioritization – WHG
- Discussion – CCC & WHG
- Next Steps – CCC
- Workshop concludes ~ 6:30 pm

# Low-Lying Roads 2

5

TOWNS

Chatham  
Falmouth  
Harwich

Mashpee  
Provincetown



Flooding vulnerability assessment of low-lying roads and transportation infrastructure



Support municipal road segment prioritization



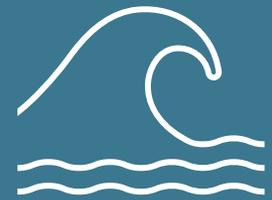
Identify range of potential design solutions, costs

Work performed by Cape Cod Commission and Woods Hole Group



# Hazards

Storms,  
Sea Level Rise,  
& Flooding



# Adaptation Strategies



- | Gray Infrastructure, or Traditional Engineering Structures
- | Green Infrastructure, or Nature-based Solutions
- | Other approaches – Hybrid, Planned Relocation, Abandonment



# PROJECT TIMELINE & ELEMENTS

Vulnerability Assessment:  
Roads and Bridges  
3 Future Time Horizons -  
2030, 2050, 2070

Criticality  
Assessment:  
Prioritize  
Roadway  
Segments

1<sup>st</sup> Workshop:  
Vulnerable &  
At-Risk Roads

Roadway  
analysis &  
solutions ID

2<sup>nd</sup> Workshop:  
Present  
alternatives

March 2023

April 2023

June 2023

Summer 2023

Spring 2024



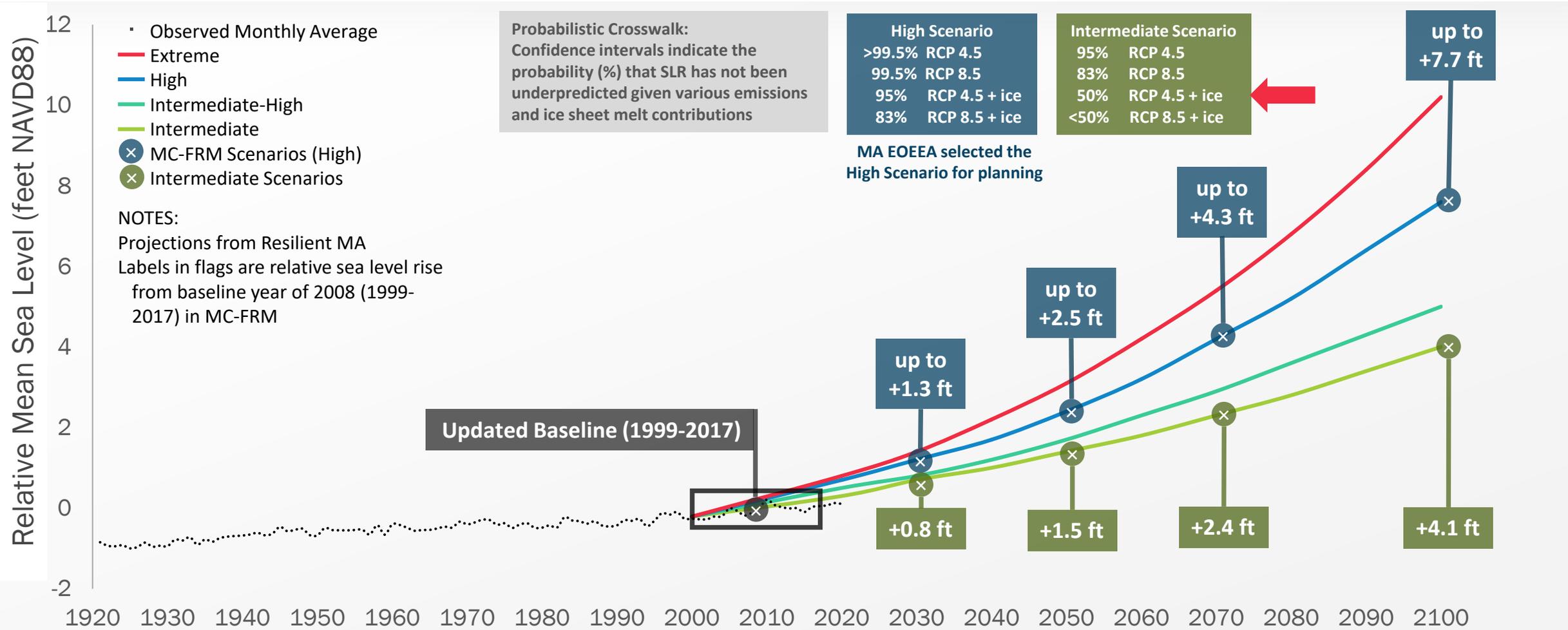
# Questions?

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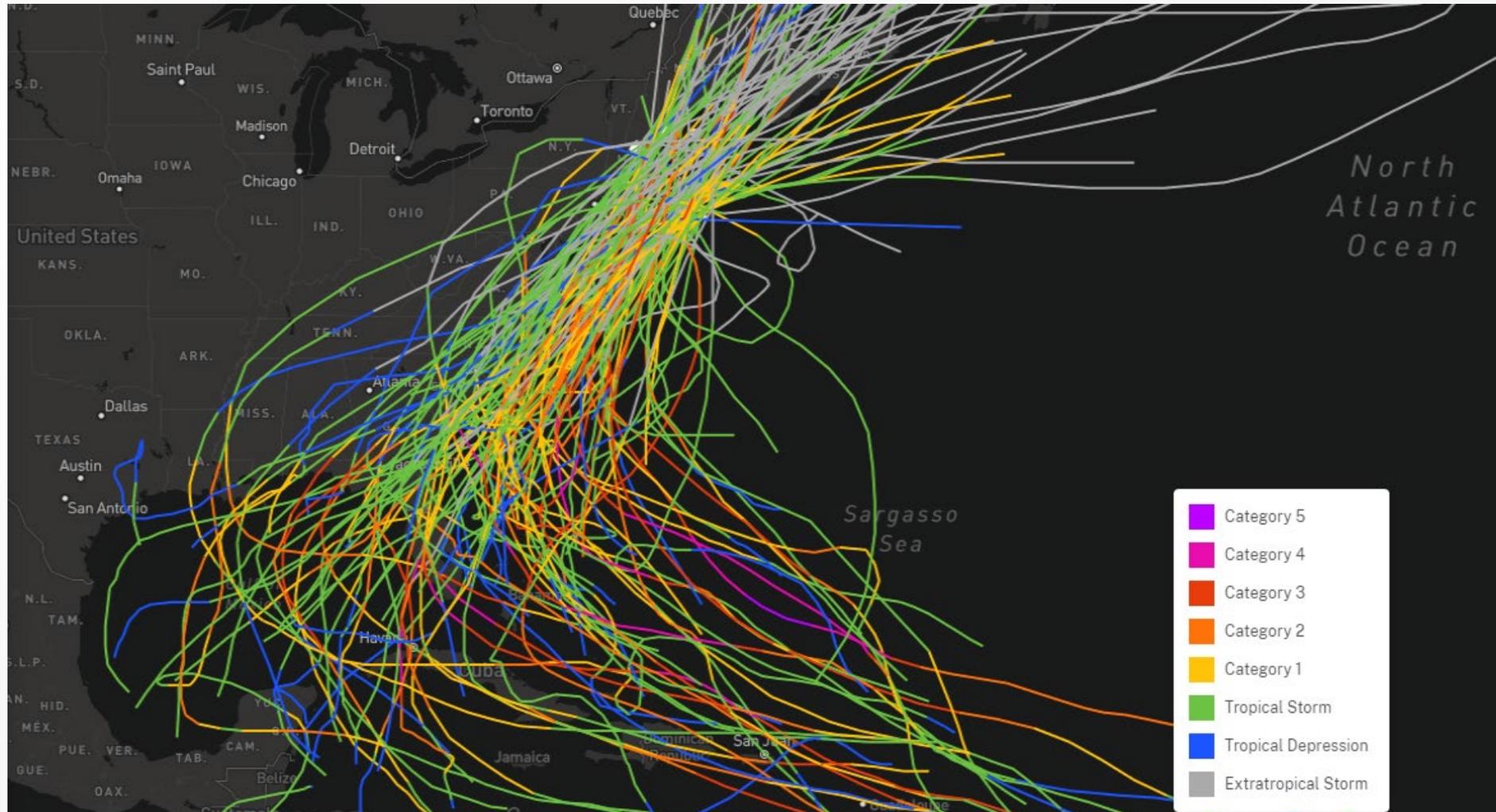
- Workshop Purpose or Objectives
- Low Lying Roads project
  - Key components
    - Vulnerability Assessment - Identify Potential Sites
    - Public Outreach and Engagement
    - Roadway Feasibility and Alternative Solutions
    - Solutions Identification
  - Timeline

# MA EOEEA Probabilistic Sea Level Rise Projections

MC-FRM NORTH (DeConto & Kopp, 2017)



# Tropical / Extra-tropical Storms



NOAA National Ocean Service



# Massachusetts Coast Flood Risk Model (MC-FRM)

INPUTS



SEA LEVEL  
RISE



TROPICAL / EXTRA-  
TROPICAL STORMS



LANDSCAPE



ELEVATION



CHANGING  
CLIMATE

PROBABILISTIC /  
HYDRODYNAMIC  
MODEL



Includes relevant physical processes:  
sea level rise, tides, storm surge, wind, wave setup  
/ run-up / overtopping, future climate scenarios

Future version to incorporate coastal erosion



FLOOD  
PROBABILITY



FLOOD  
DEPTH



FLOOD  
DURATION



FLOOD  
VOLUMES



FLOOD  
PATHWAYS



WINDS



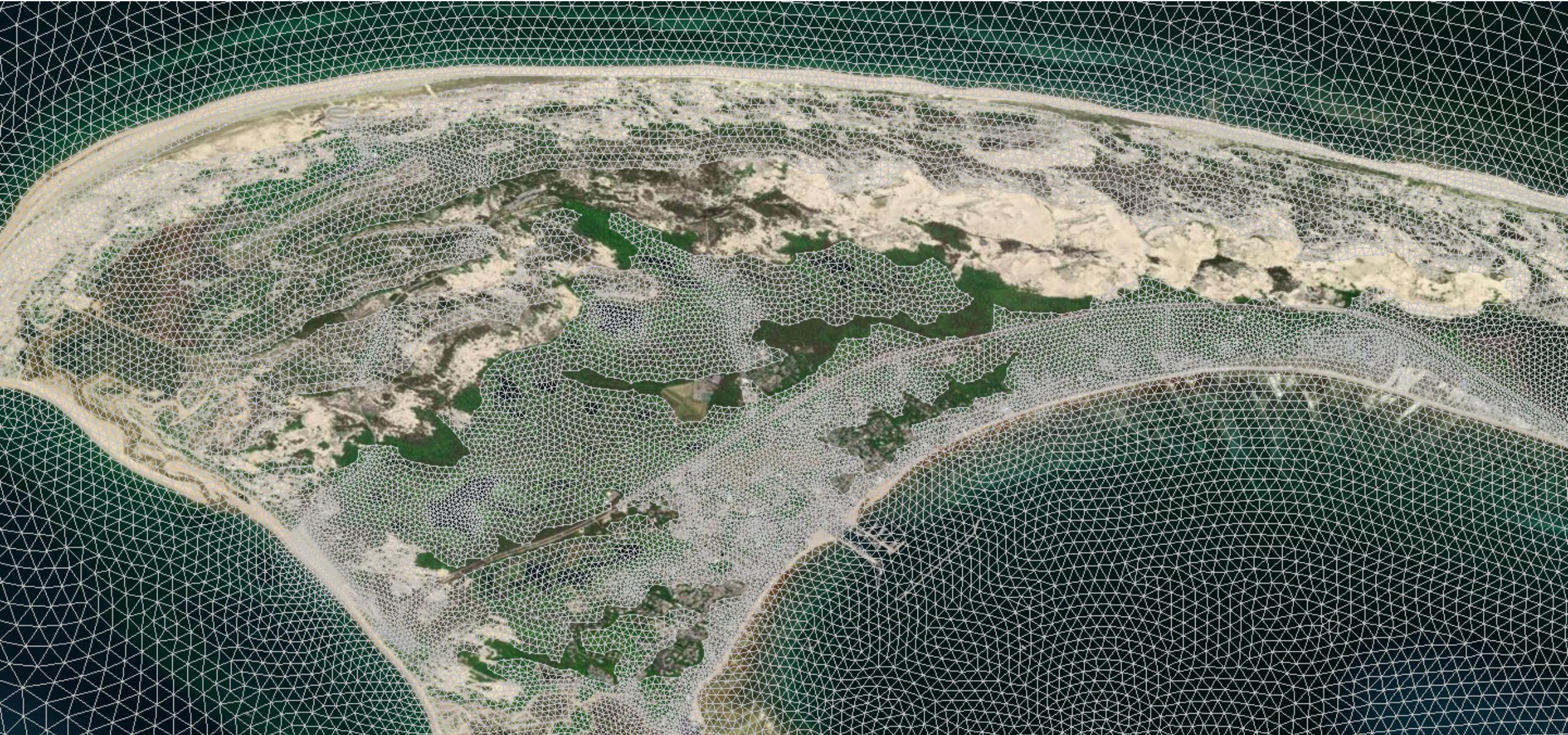
WAVES



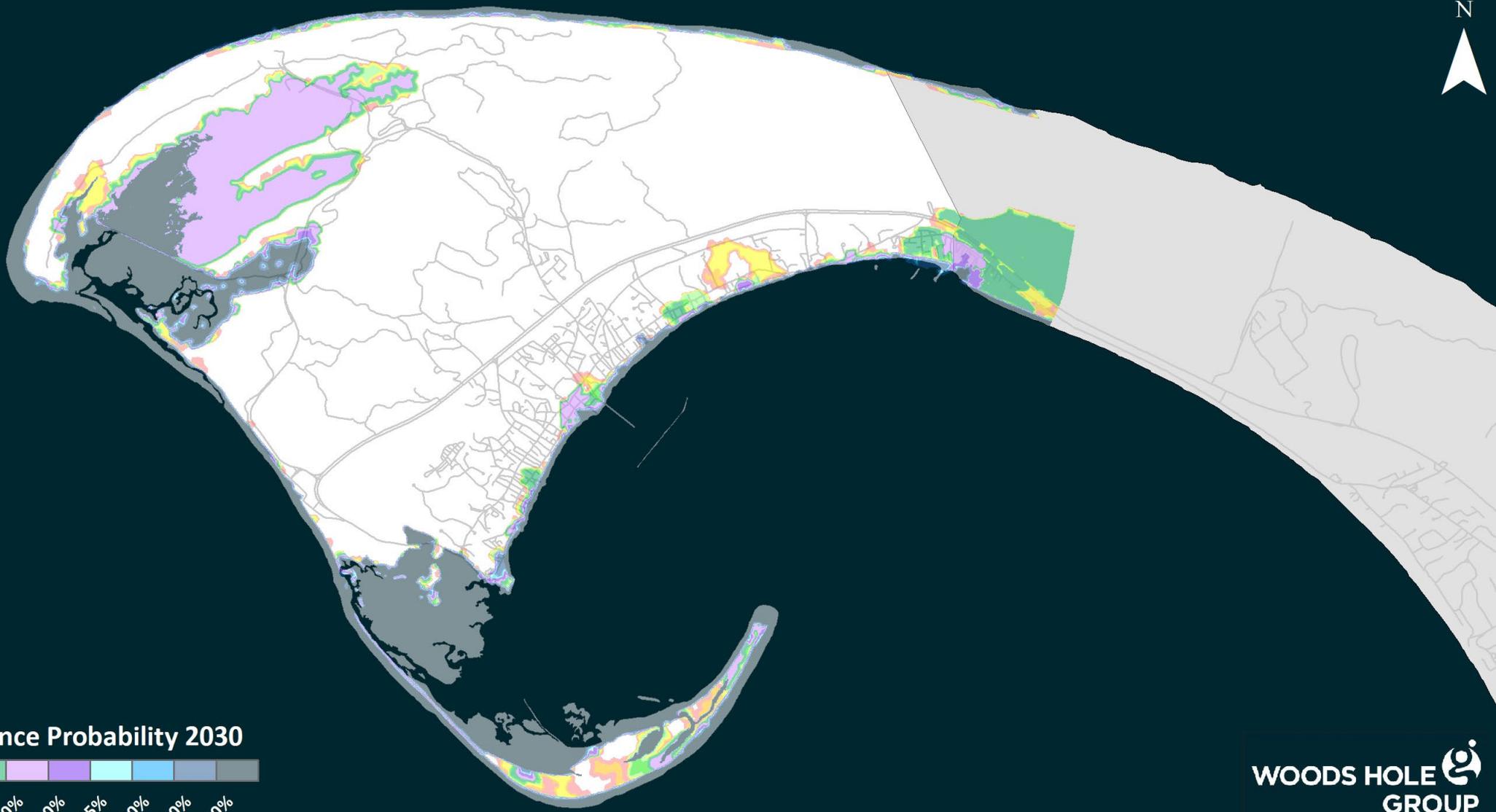
CURRENTS

OUTPUTS

# MC-FRM Resolution



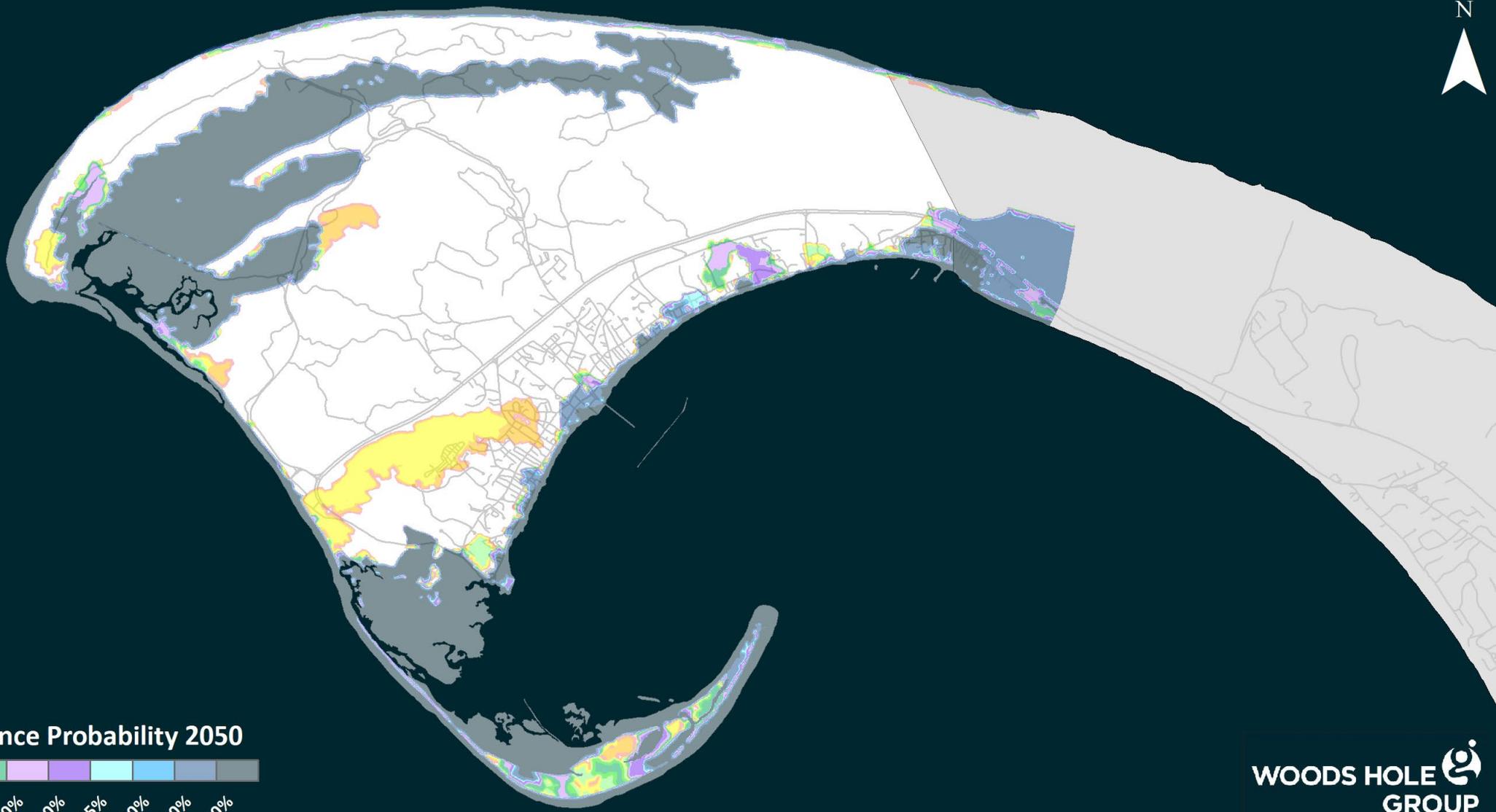
# MC-FRM Annual Coastal Flood Exceedance Probability – 2030



MC-FRM Annual Exceedance Probability 2030



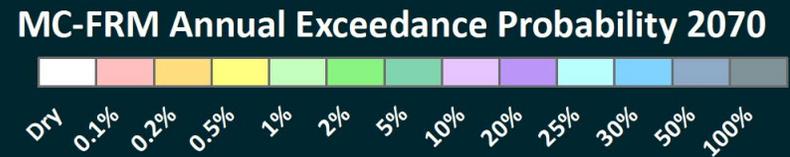
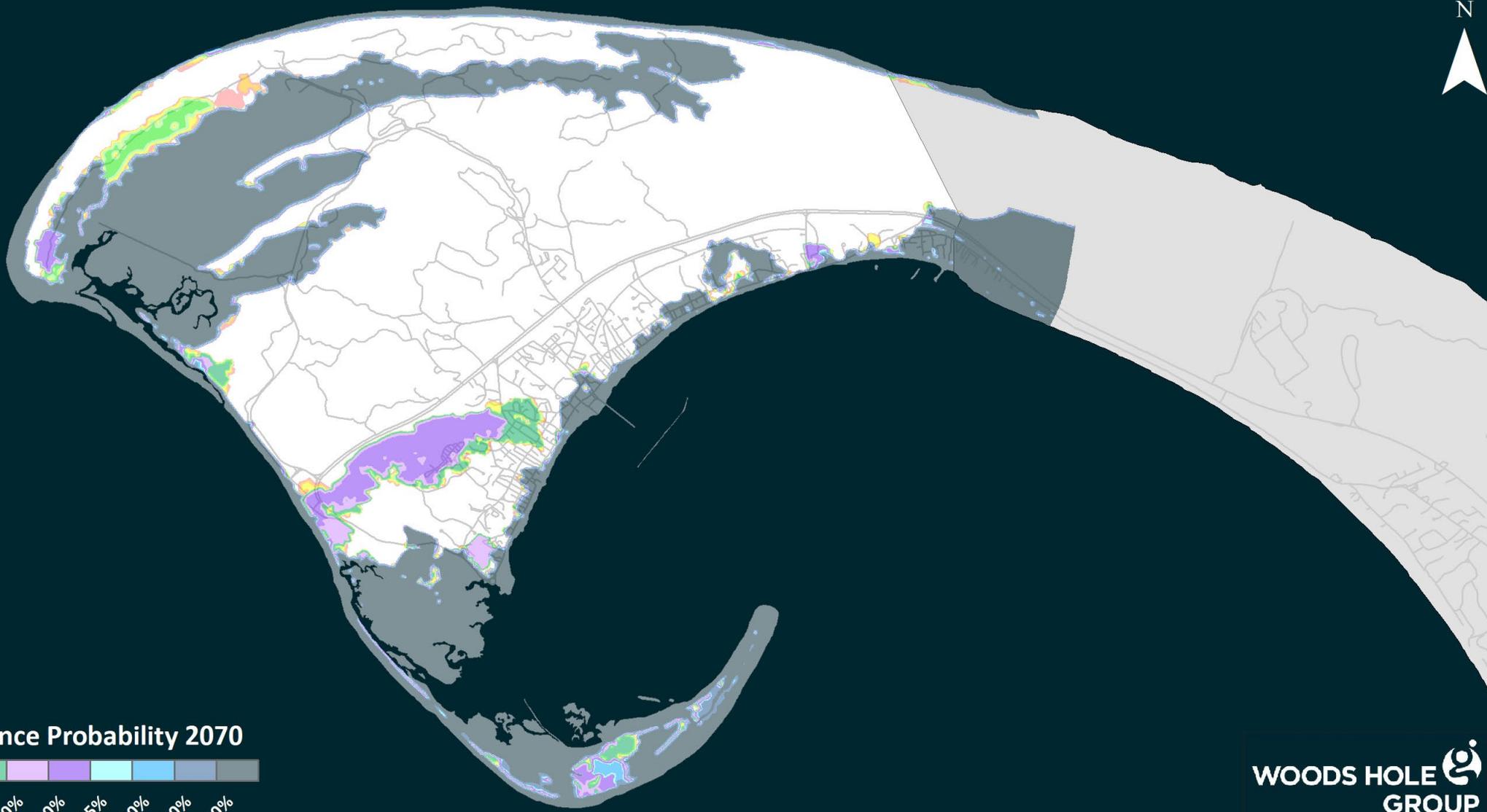
# MC-FRM Annual Coastal Flood Exceedance Probability – 2050



MC-FRM Annual Exceedance Probability 2050



# MC-FRM Annual Coastal Flood Exceedance Probability – 2070



# MC-FRM Annual Exceedance Probabilities

	0.1%	1/1000
	0.2%	1/500
	0.5%	1/200
	1%	1/100
	2%	1/50
	5%	1/20
	10%	1/10
	20%	1/5
	25%	1/4
	30%	1/3.33
	50%	1/2
	100%	1/1



Image source: [amazon.com/stores/Brybelly](https://amazon.com/stores/Brybelly)



Image source: [dicegamedepot.com](https://dicegamedepot.com)



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# Cumulative Probability

	AEP	Return	Cumulative Probability ( $P_e$ ) of 1 or more events occurring over:			
			10-yrs	25-yrs	50-yrs	100-yrs
	0.1%	1/1000	1.0%	2.5%	4.9%	9.5%
	0.2%	1/500	2.0%	4.9%	9.5%	18.1%
	0.5%	1/200	4.9%	11.8%	22.2%	39.4%
	1%	1/100	9.6%	22.2%	39.5%	63.4%
	2%	1/50	18.3%	39.7%	63.6%	86.7%
	5%	1/20	40.1%	72.3%	92.3%	99.4%
	10%	1/10	65.1%	92.8%	99.5%	100%
	20%	1/5	89.3%	99.6%	100%	100%
	25%	1/4	94.4%	99.9%	100%	100%
	30%	1/3.33	97.2%	100%	100%	100%
	50%	1/2	99.9%	100%	100%	100%
	100%	1/1	100%	100%	100%	100%

# Massachusetts Coast Flood Risk Model

## SUMMARY

Hydrodynamically modeled projections

Sea level rise and storm surge – combined

Annual chance of flooding under 2030/2050/2070 climate conditions

## QUESTIONS?



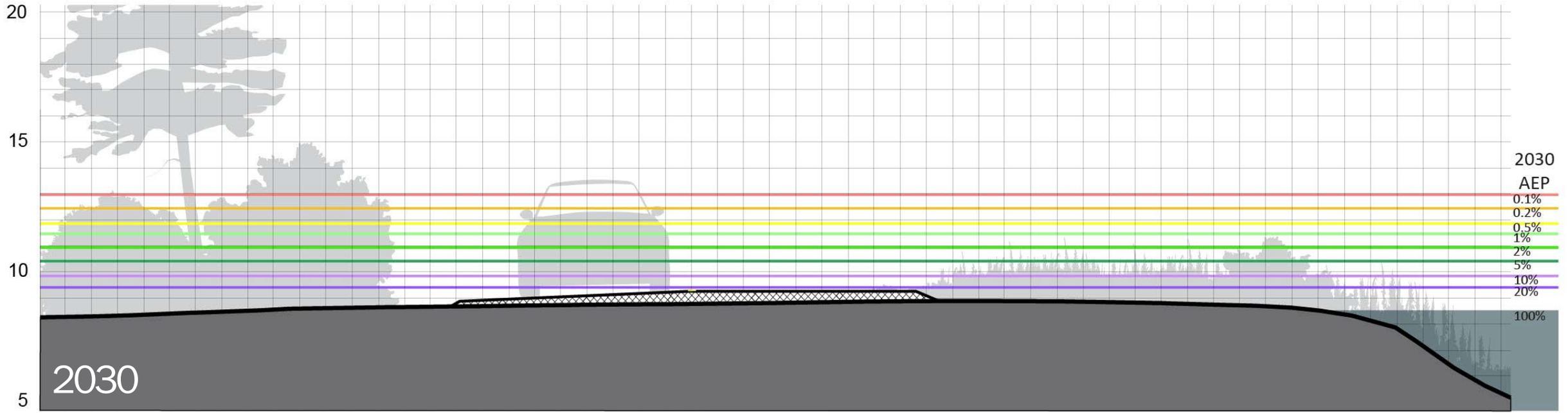
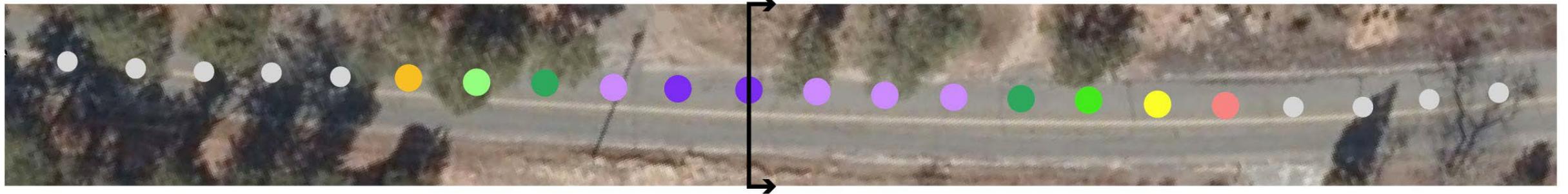
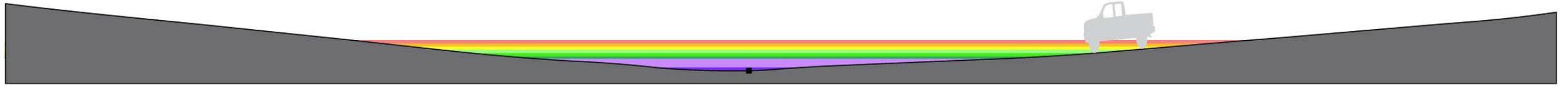
# Cape Cod Low Lying Roads Vulnerability Assessment Methods

COASTAL FLOOD EXCEEDANCE PROBABILITY



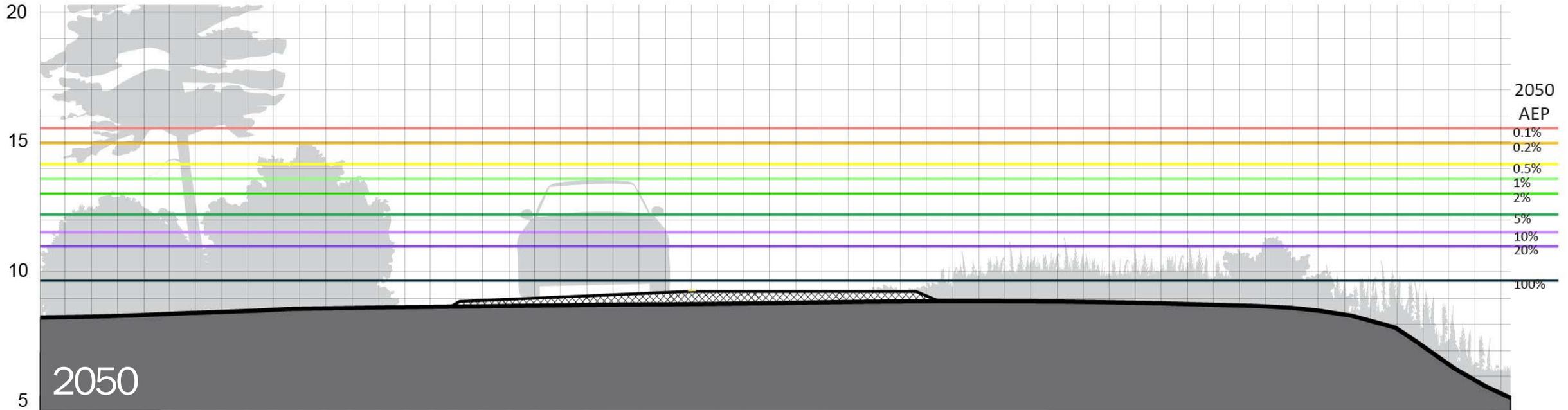
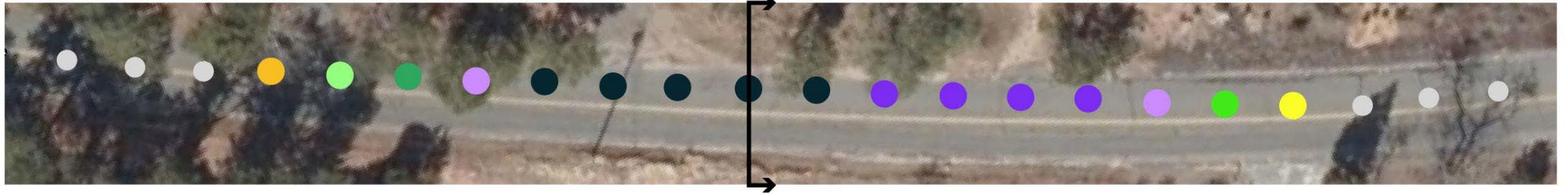
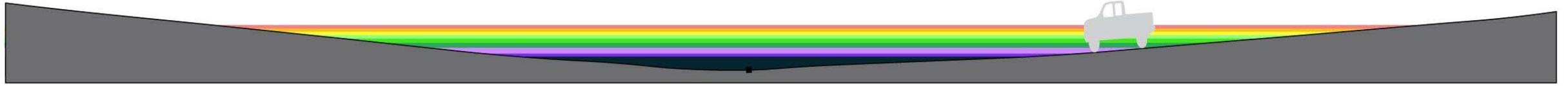
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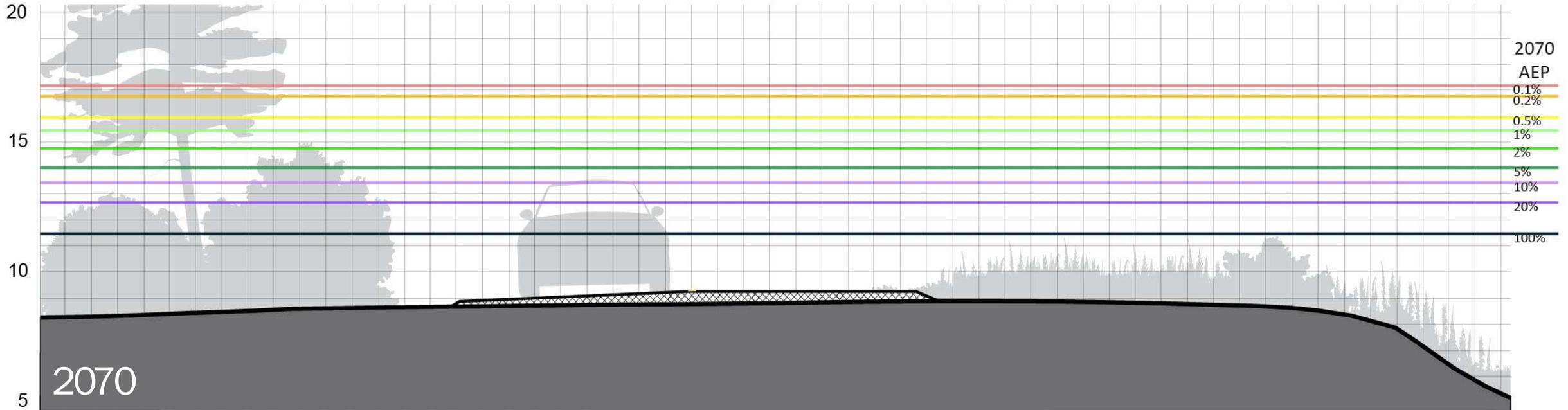
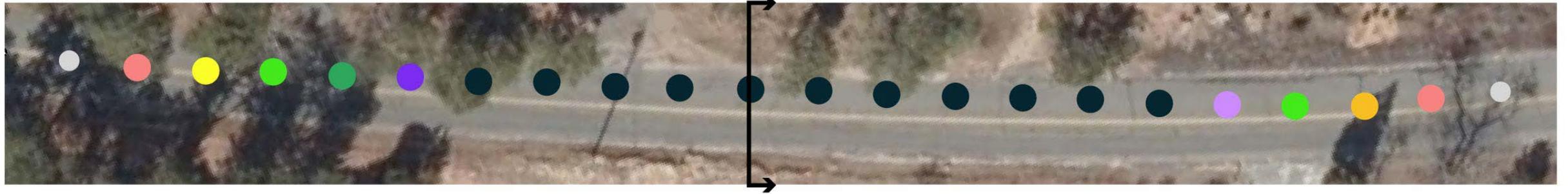
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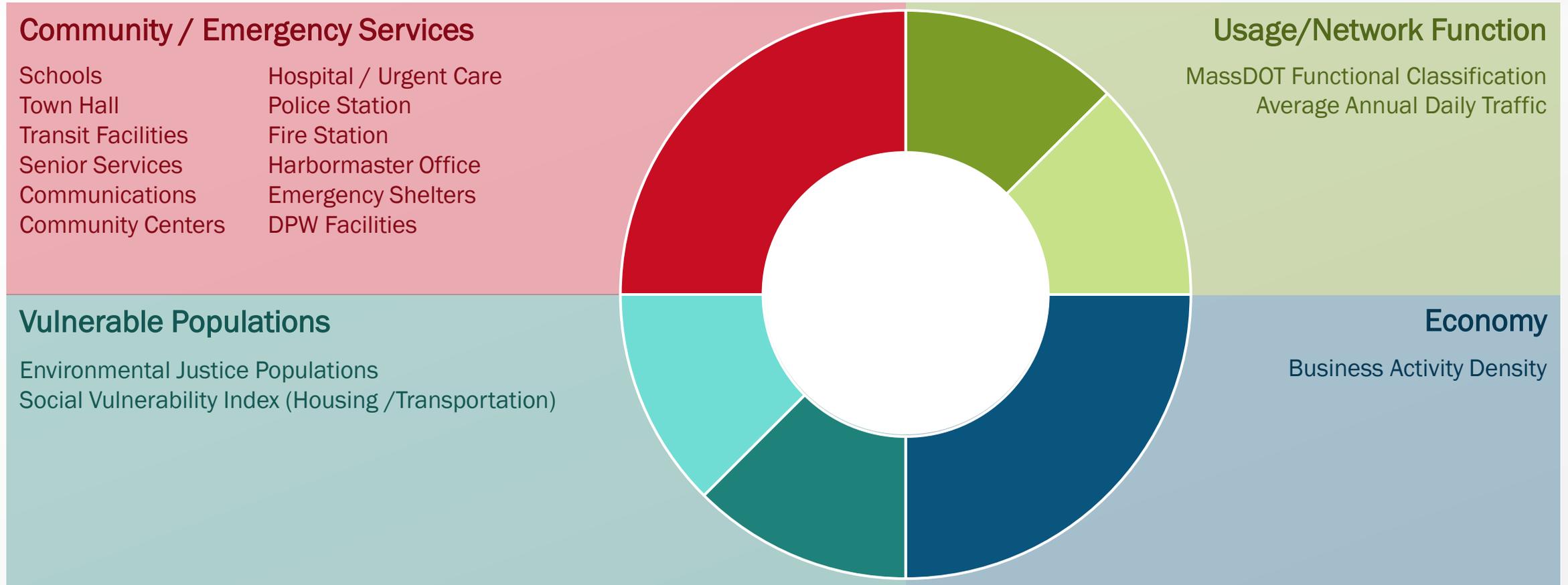


# Cape Cod Low Lying Roads Vulnerability Assessment Methods

COASTAL FLOOD EXCEEDANCE PROBABILITY

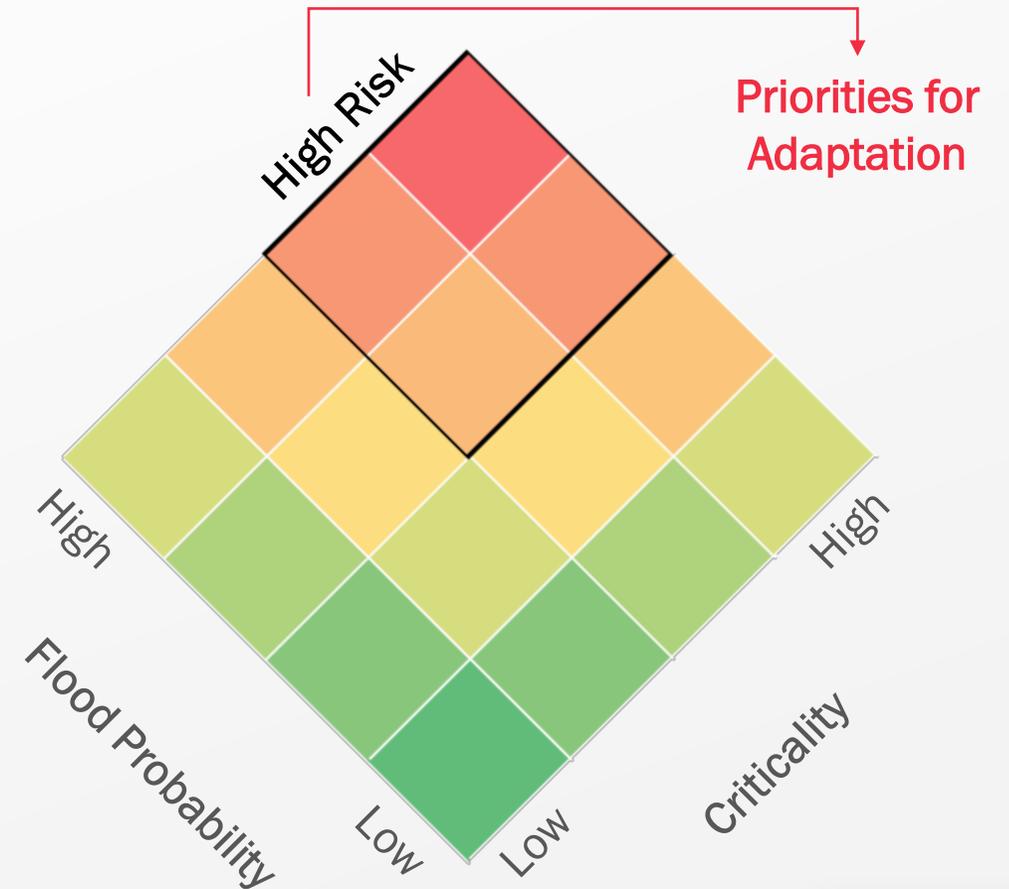


# Cape Cod Low Lying Roads Criticality Scoring Framework



# Cape Cod Low Lying Roads Risk Assessment Approach

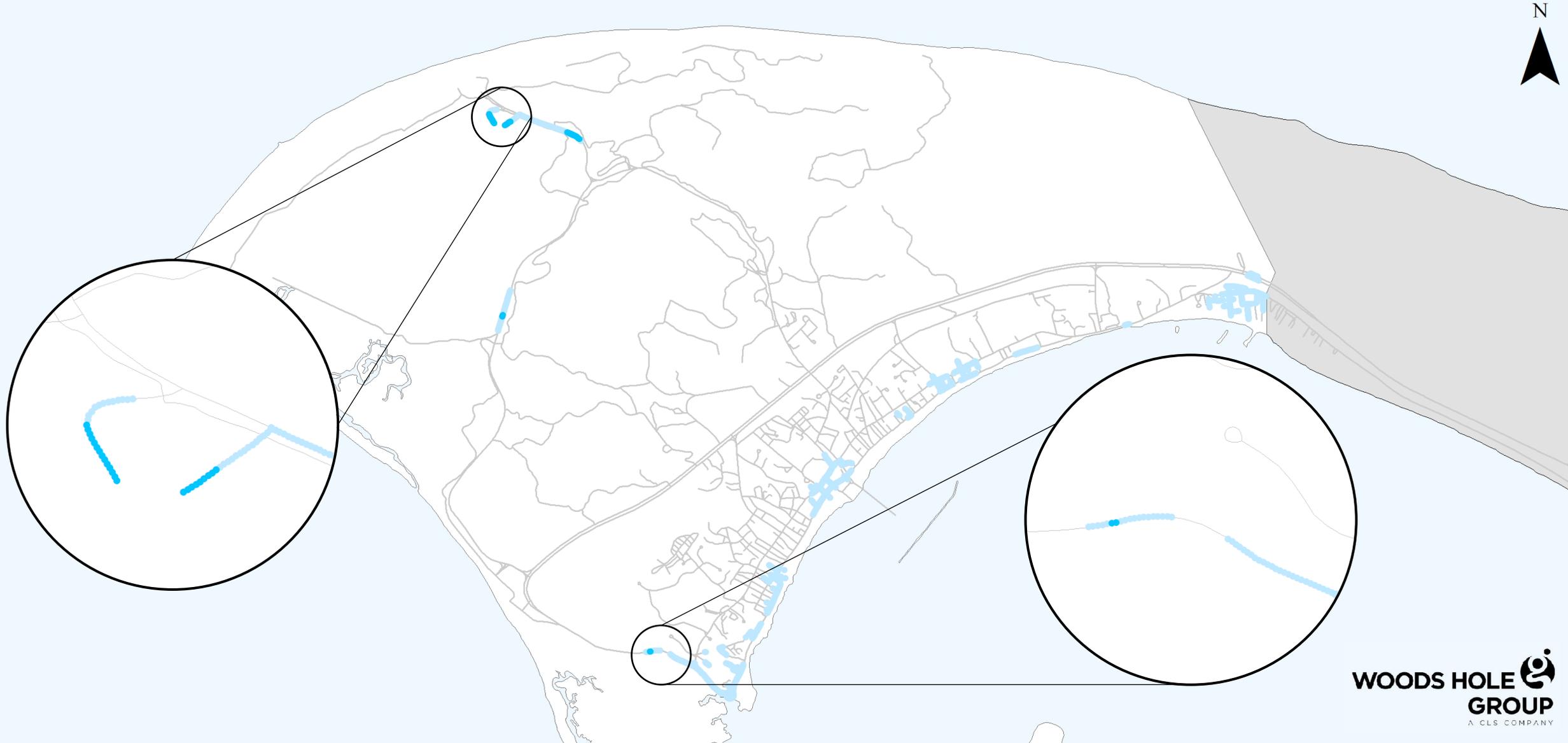
1. Extract roadway/bridge critical elevations (CEs)
2. Compile 2030/2050/2070 MC-FRM water surface elevations (WSEs)
3. Compare CEs to WSEs to determine flood probability
4. Score road segment criticality
5. **Probability \* Criticality = Risk**
6. Prioritize high-risk road segments for community consideration



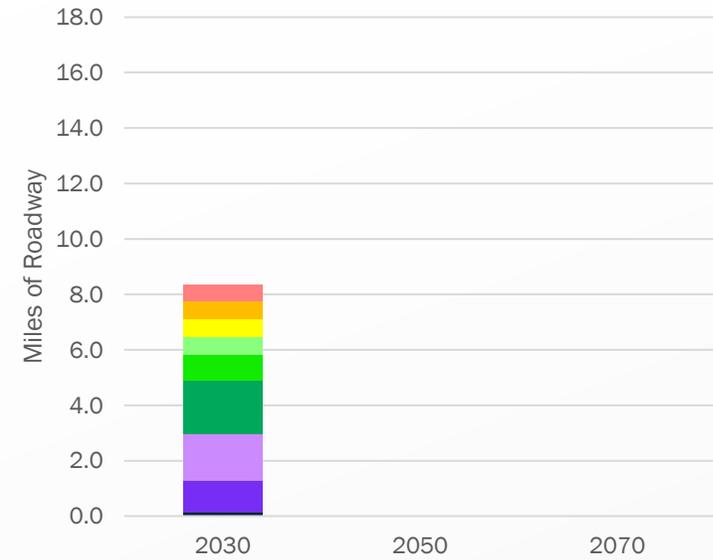
# Low Lying Roads Nuisance Flooding

Road Surface Elevations Below MHW

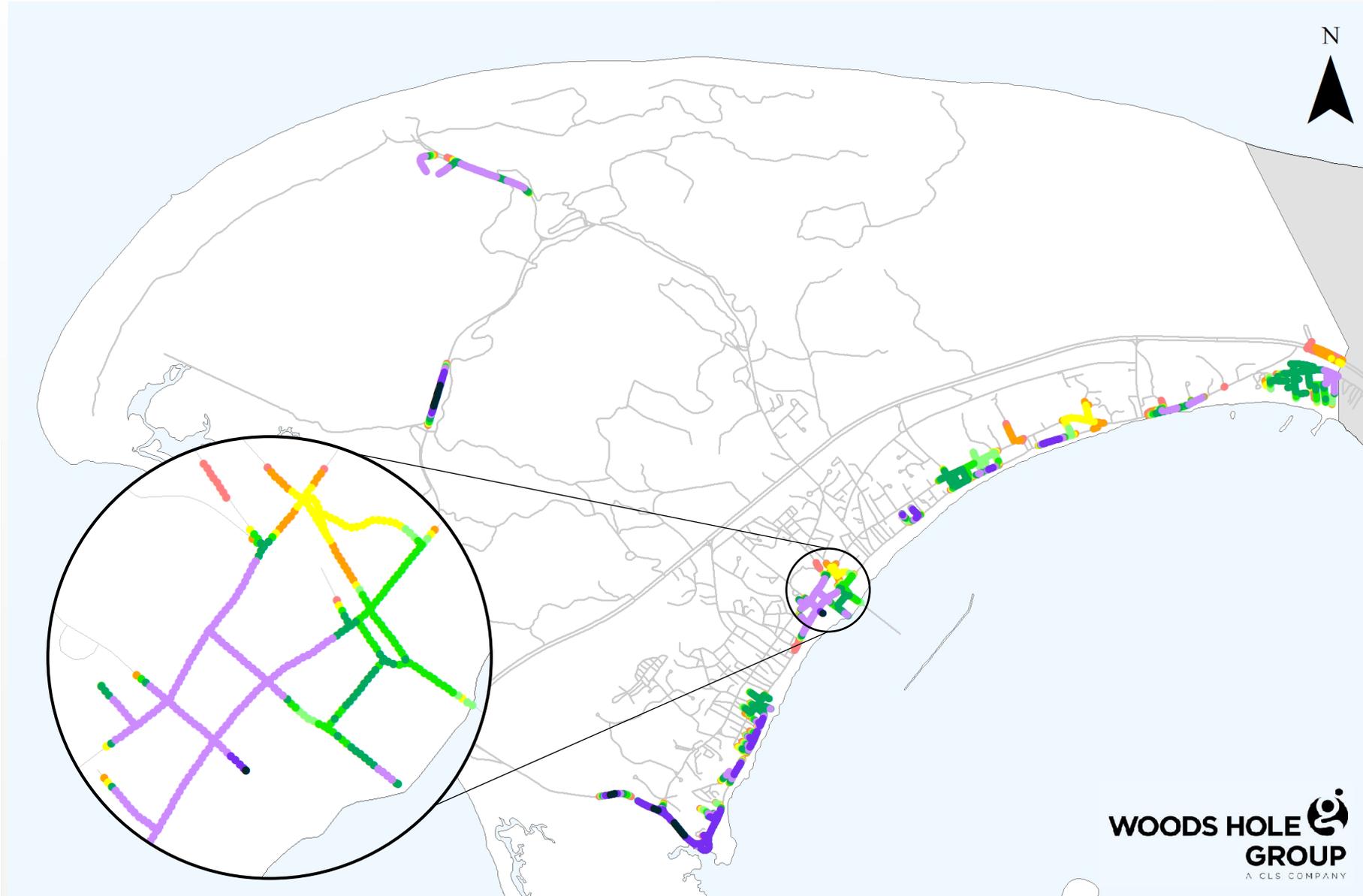
- 2070 (5.5 mi)
- 2050 (0.2 mi)
- 2030 (0.0 mi)



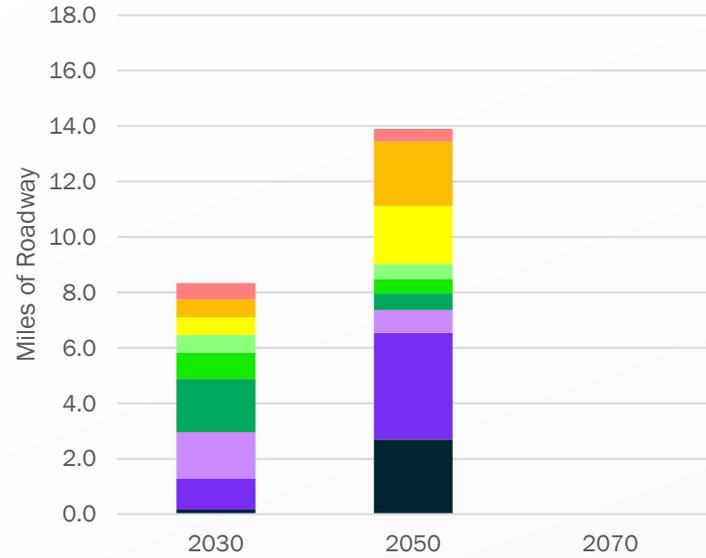
# Low Lying Roads 2030 Flood Probability (Annual Exceedance Probability)



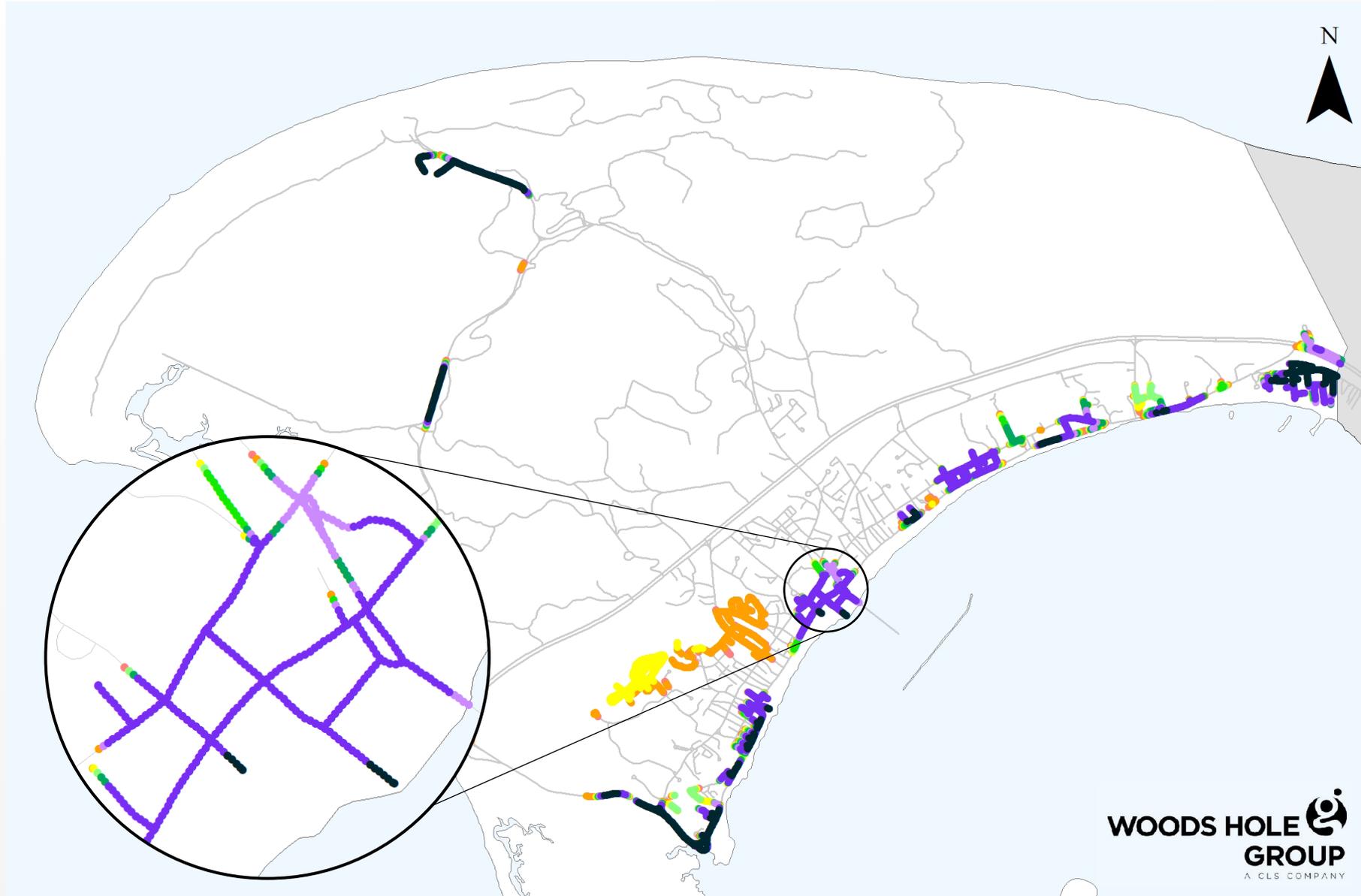
Flood Probability	Road Miles
0.1%	8.3
0.2%	7.8
0.5%	7.1
1%	6.5
2%	5.8
5%	4.9
10%	3.0
20%	1.3
100%	0.2



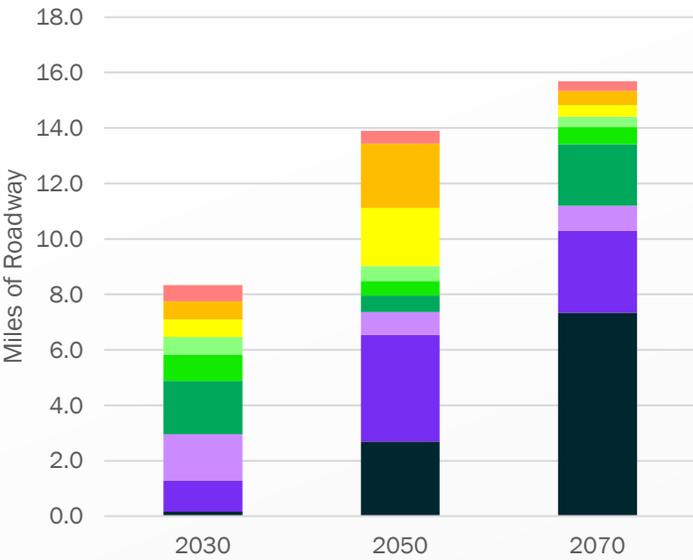
# Low Lying Roads 2050 Flood Probability (Annual Exceedance Probability)



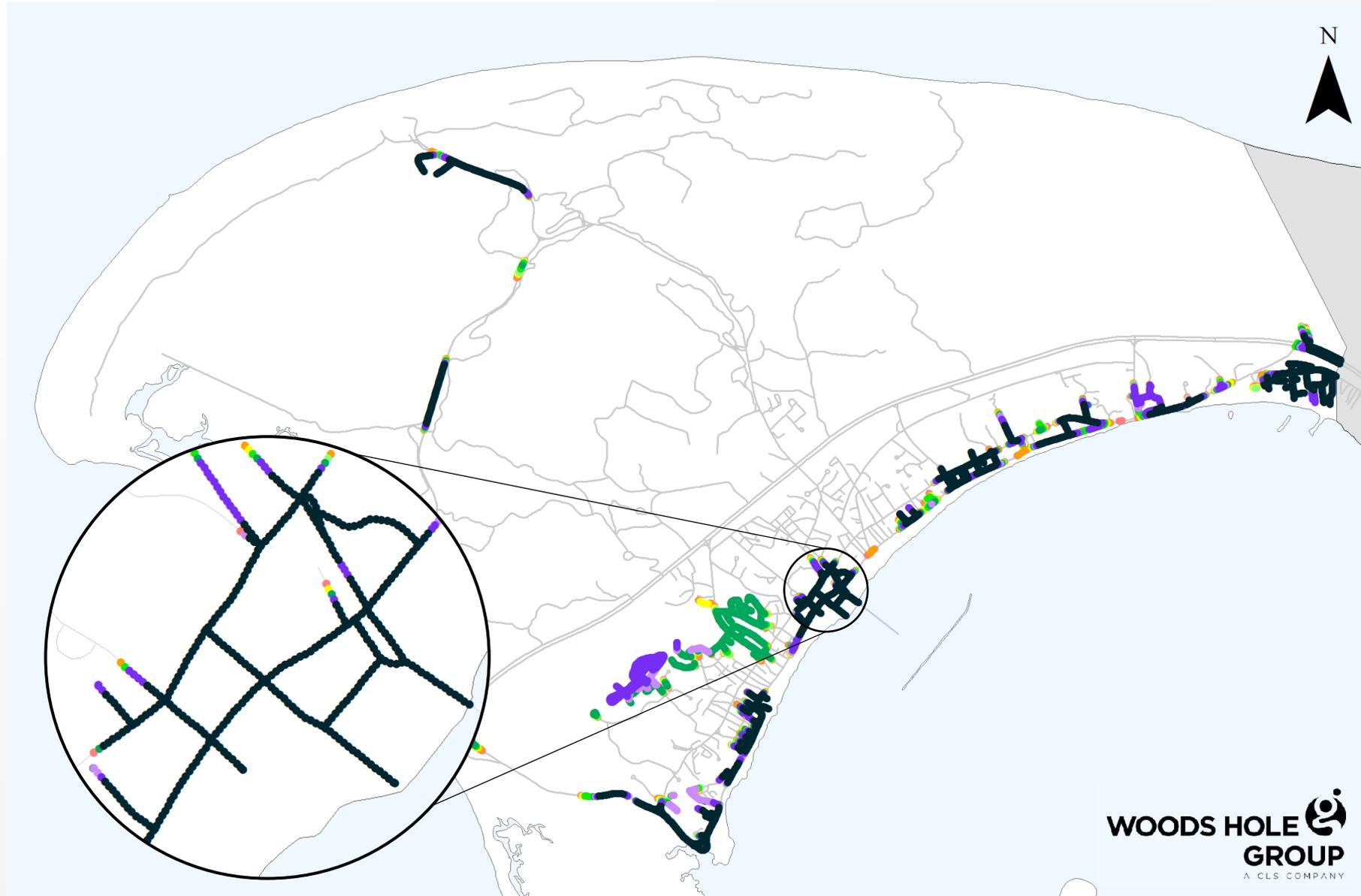
Flood Probability	Road Miles
0.1%	13.9
0.2%	13.4
0.5%	11.1
1%	9.0
2%	8.5
5%	8.0
10%	7.4
20%	6.5
100%	2.7



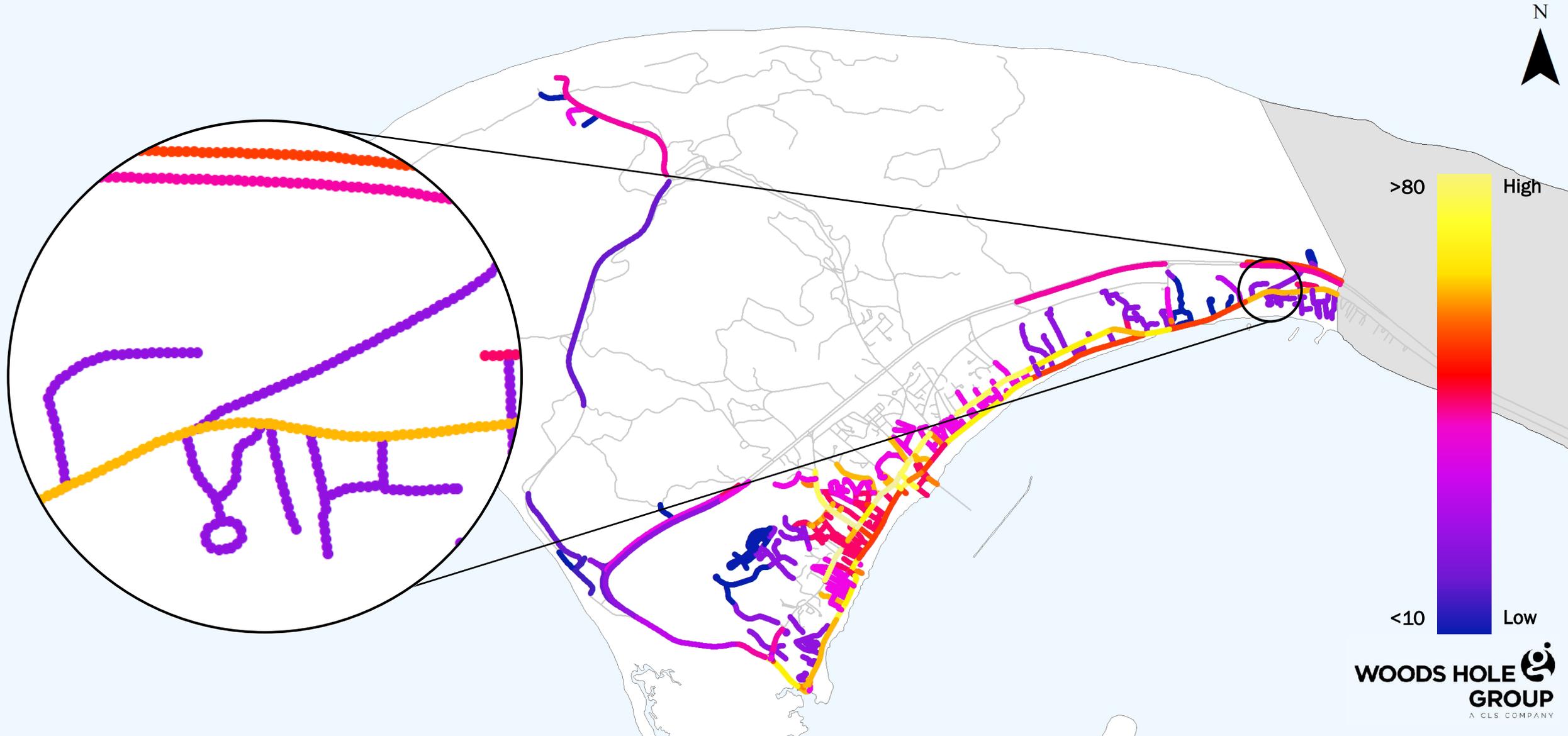
# Low Lying Roads 2070 Flood Probability (Annual Exceedance Probability)



Flood Probability	Road Miles
0.1%	15.7
0.2%	15.3
0.5%	14.8
1%	14.4
2%	14.0
5%	13.4
10%	11.2
20%	10.3
100%	7.3

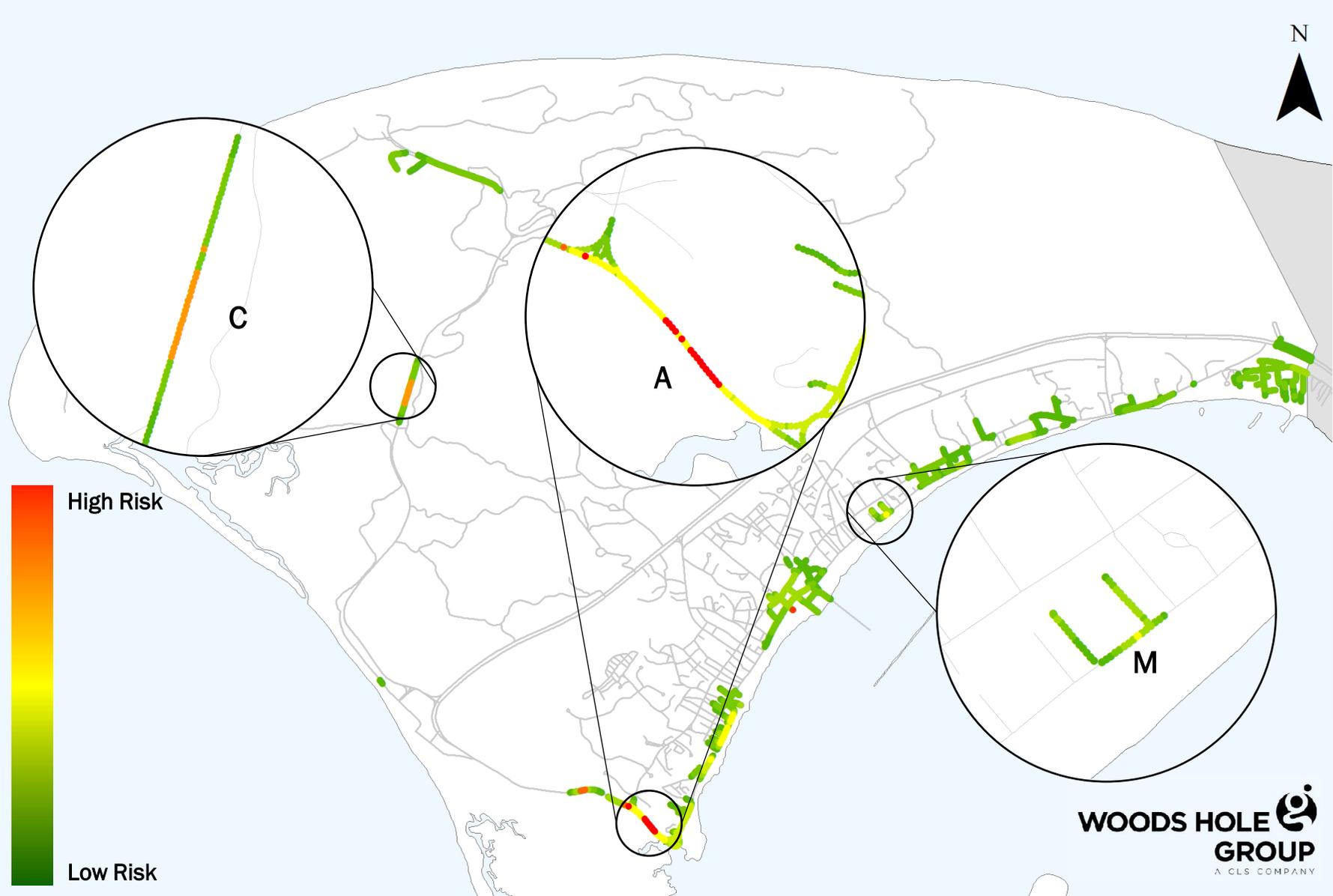


# Low Lying Roads Criticality Scoring



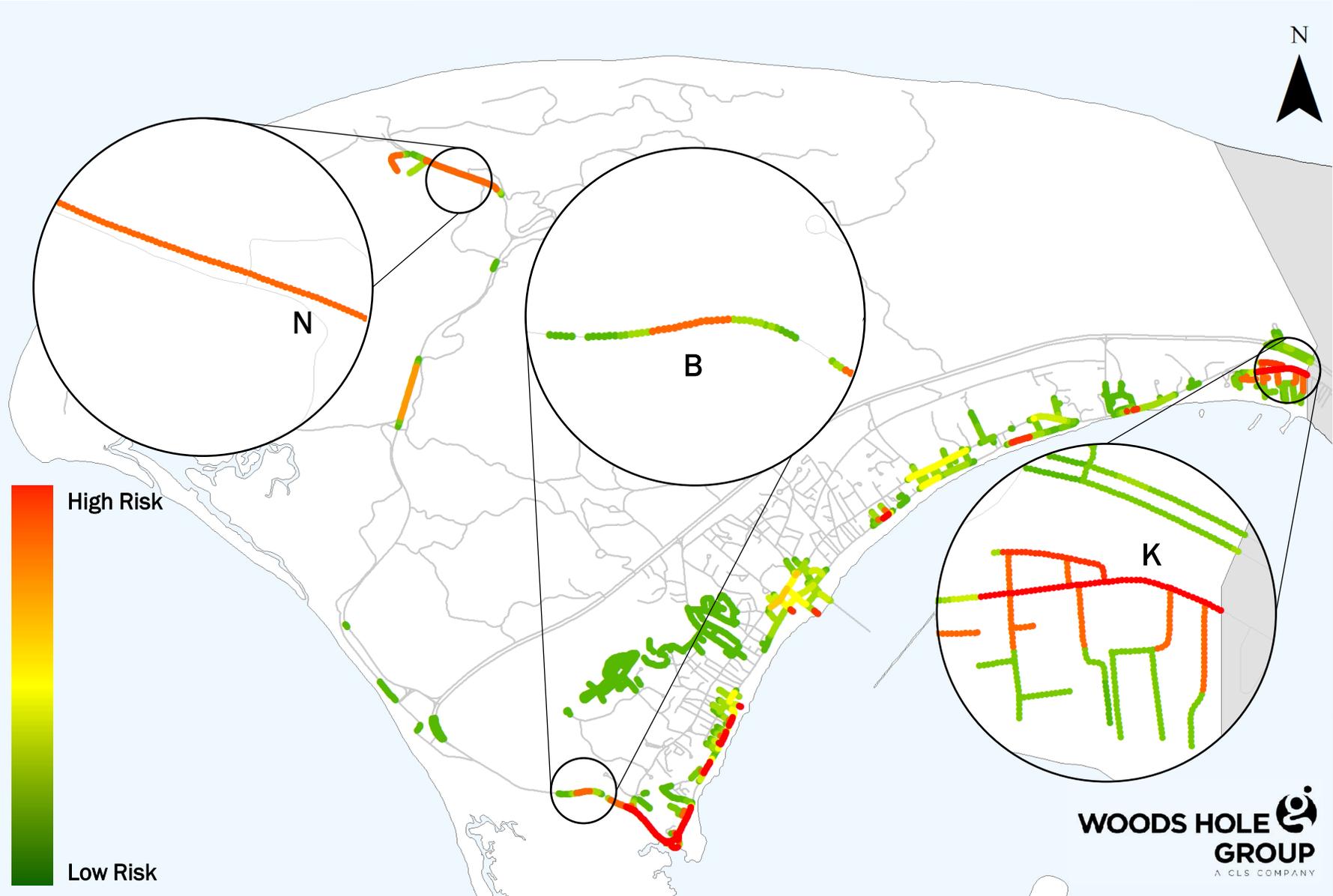
# Low Lying Roads 2030 Risk Results

	High Risk Road Segments
A	Province Lands Rd and Commercial St at West End
B	Province Lands Rd at Long Point Marshes
C	Province Lands Rd near Hatches Harbor Trailhead
D	Commercial St at Soper St
E	Commercial St at Point St
F	Commercial St between Hancock St and Kendall Ln
G	Commercial St at Suzanne's Garden
H	Commercial St at MacMillan Pier
I	Bradford St at Bas Relief Park
J	Ryder St
K	Shore Rd at Truro Town Line
L	Standish St
M	Commercial St at Kiley Ct
N	Race Point Rd
O	Commercial St at Berry Ln
P	Rte 6 at Truro Town Line



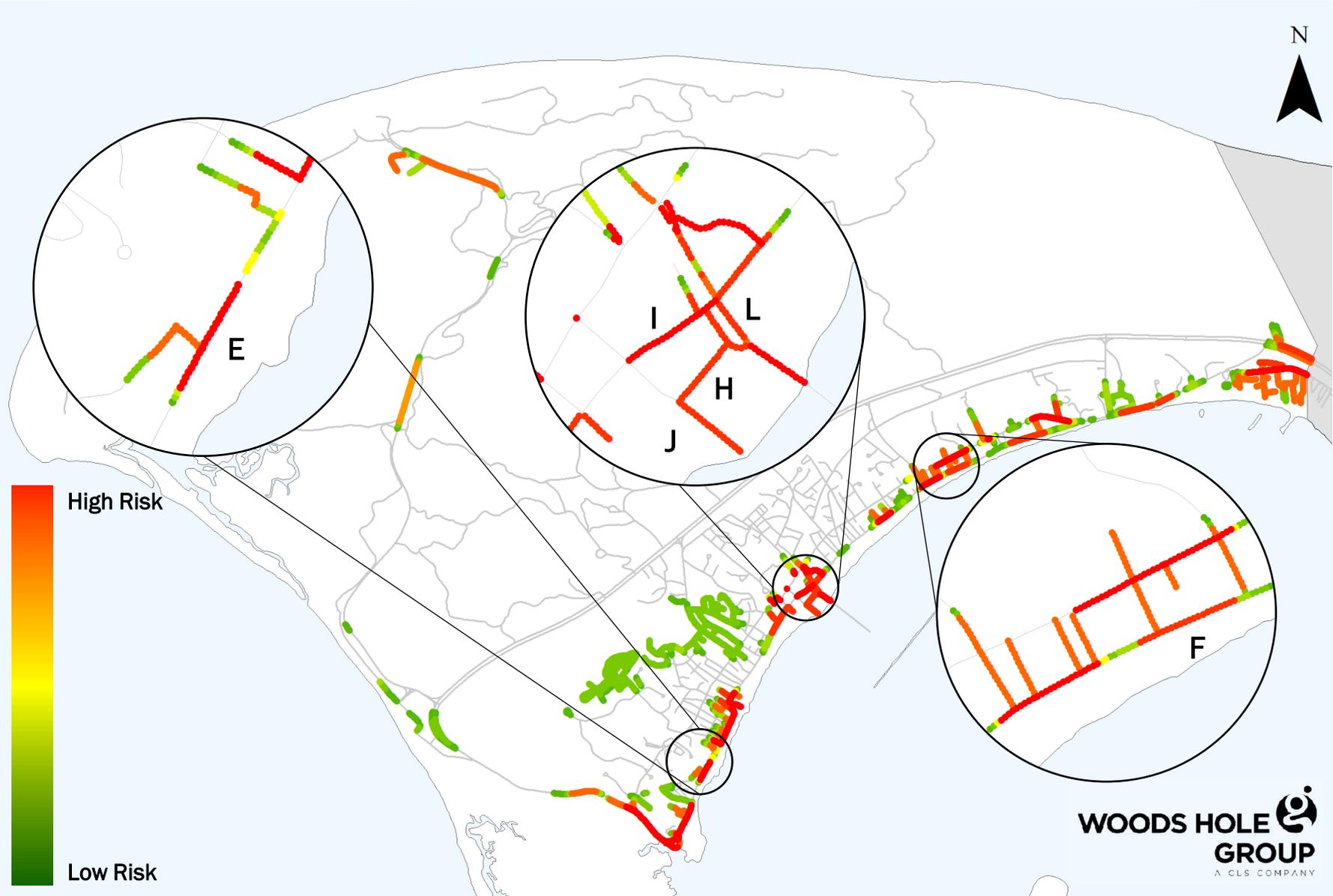
# Low Lying Roads 2050 Risk Results

	High Risk Road Segments
A	Province Lands Rd and Commercial St at West End
B	Province Lands Rd at Long Point Marshes
C	Province Lands Rd near Hatches Harbor Trailhead
D	Commercial St at Soper St
E	Commercial St at Point St
F	Commercial St between Hancock St and Kendall Ln
G	Commercial St at Suzanne's Garden
H	Commercial St at MacMillan Pier
I	Bradford St at Bas Relief Park
J	Ryder St
K	Shore Rd at Truro Town Line
L	Standish St
M	Commercial St at Kiley Ct
N	Race Point Rd
O	Commercial St at Berry Ln
P	Rte 6 at Truro Town Line



# Low Lying Roads 2070 Risk Results

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A	Province Lands Rd and Commercial St at West End
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L	Standish St
M	Commercial St at Kiley Ct
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O	Commercial St at Berry Ln
P	Rte 6 at Truro Town Line



# Summary of High Priority Road Segments

	Road Name	Length (ft)	Description	AEP 2030	Criticality Score	2030 Risk Score	Tidal Flooding Length (ft)		
							2030	2050	2070
A	Province Lands Rd & Commercial St at West End**	3660	NW and NE approaches to Pilgrims' First Landing Park	100	62	6200	0	0	3520
B	Province Lands Rd at Long Point Marshes*	580	culvert crossing west of Bradford St Extension	100	27	2700	0	40	380
C	Province Lands Rd near Hatches Harbor Trailhead*	1280	north of the Hatches Harbor lot parallel to Bike Trail	100	18	1800	0	60	1060
D	Commercial St at Soper St	840	West End south of Coast Guard Station	20	69	1380	0	0	820
E	Commercial St at Point St	520	West End near Dog Beach	20	69	1380	0	0	440
F	Commercial St between Hancock St and Kendall Ln	520	East End 500 block east of Fire Station No.5	20	50	1000	0	0	460
G	Commercial St at Suzanne's Garden†	580	East End 600 block between Allerton St and Snow St	20	50	1000	0	0	560
H	Commercial St at MacMillan Pier†	1380	200-300 block between Post Office and Lopes Square	10	75	750	0	0	1300
I	Bradford St at Bas Relief Park†	940	below Pilgrim Monument from Alden St to Prince St	10	81	810	0	0	920
J	Ryder St†	460	from Ryder St Beach to Bradford St	10	65	650	0	0	380
K	Commercial St at Truro Town Line†‡	1240	Route 6A from Dewey Ave east to Truro town line	10	60	600	0	0	1160
L	Standish St	600	from Lopes Square to Bradford St, behind MacMillan	5	36	184	0	0	0
M	Commercial St at Kiley Ct	260	East End 400 block south of Bangs St	20	62	1250	0	0	160
N	Race Point Rd*	1700	east of Provincetown Municipal Airport	10	37	370	0	360	1680
O	Commercial St at Berry Ln	1200	700 block east of Snail Rd by Foss Woods	10	50	500	0	0	140
P	Rte 6 at Truro Town Line*	1640	east of Mayflower Ave to Truro town line	0.5	36	18	0	0	540

\* = State or National Seashore Roadway  
 † = Existing planning work underway  
 ‡ = Segment also listed for Truro

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## LOW LYING ROADS

# Group Discussion



## DISCUSSION ORIENTATION

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## DISCUSSION QUESTIONS

1. Are you more concerned with high tide flooding or storm flooding?
2. What local knowledge or concerns can you bring to the discussion?
3. How would you prioritize these road segments?



# Summary of High Priority Road Segments

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							2030	2050	2070
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\* = State or National Seashore Roadway  
 † = Existing planning work underway  
 ‡ = Segment also listed for Truro

# NEXT STEPS

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- Town staff to select 2 road segments
- Site visits and feasibility analysis
- 3 solutions + costs per segment
- 2<sup>nd</sup> Workshop date TBD – spring 2024
- Materials available to view on Low Lying Road webpage:  
<https://www.capecodcommission.org/our-work/low-lying-roads-project/>



# Low Lying Roads: Provincetown



Home > Work > Low Lying Roads: Provincetown

**Start Date:** 2023

[Low Lying Roads Project Homepage](#), learn more about the background and process.

## NEXT MEETINGS

WEDNESDAY

JUNE 07, 2023

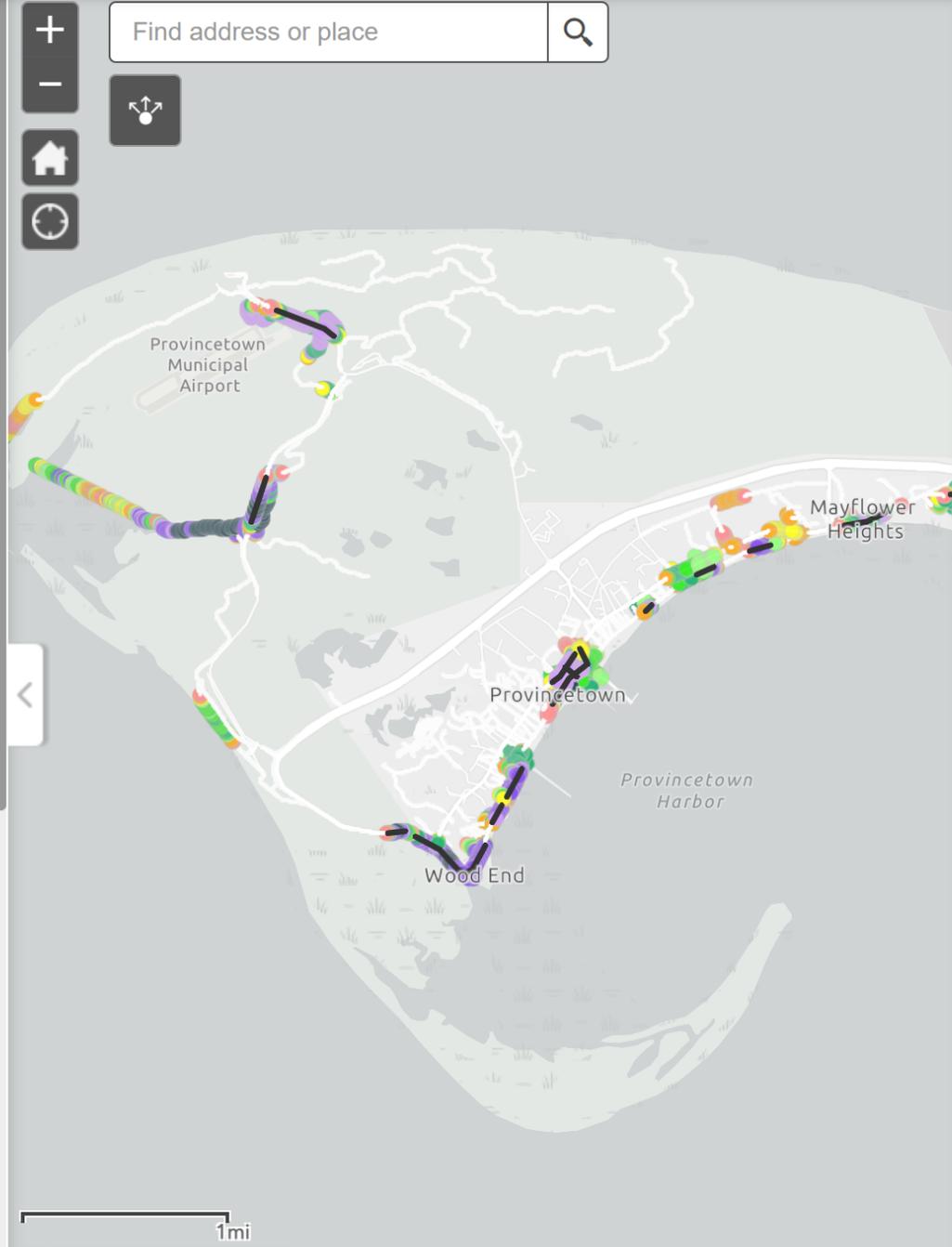
### ABOUT

With funding support from the Massachusetts Municipal Vulnerability Preparedness (MVP) program, the Commission has contracted with the Woods Hole Group (WHG) to conduct a vulnerability assessment of roadway segments, bridges, and culverts due to flooding from the combined effects of sea level rise and storm surge. WHG will employ the state-of-the-art Massachusetts Coast Flood Risk Model (MC FRM) to identify vulnerable road segments under different sea level rise scenarios and time scales. One output from this work is a projection of the probability and extent of flooding at defined future planning horizons, 2030, 2050, and 2070.

### NAVIGATION

-  Click the Legend to show the map key
-  Open the Layers to turn on more contextual features or create new suggestions
-  Use the Editor to provide feedback
-  Change Base Maps
-  Bookmarks help navigate Top Vulnerable Roads

 Click on a feature to see more information. You may need to click through multiple pop ups  
(1 of 7) 



### Legend

- Provincetown Top Vulnerable Roads
- Town mask
- Coastal Flooding Comments
- Coastal Erosion Comments
- Provincetown 2030 Inundation Probability

Prob\_2030

- 100%
- 20%
- 10%
- 5%
- 2%
- 1%
- 0.5%
- 0.2%
- 0.1%

**THANK YOU!**

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