



Low-lying Roads: Harwich


Project funded by the
Municipal Vulnerability
Preparedness Program

Agenda

- Project Overview – CCC
- Vulnerability and Risk Assessment – WHG
- Results of Low-Lying Roads Screening & Prioritization – WHG
- Discussion – CCC & WHG
- Next Steps – CCC
- Workshop concludes ~ 5:30 pm



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 select priority road segments for design and permitting**

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

1st Workshop:
Vulnerable &
At-Risk Roads

Roadway
analysis &
solutions ID

2nd Workshop:
Present
alternatives

March 2023

April 2023

May 2023

Summer 2023

Spring 2024

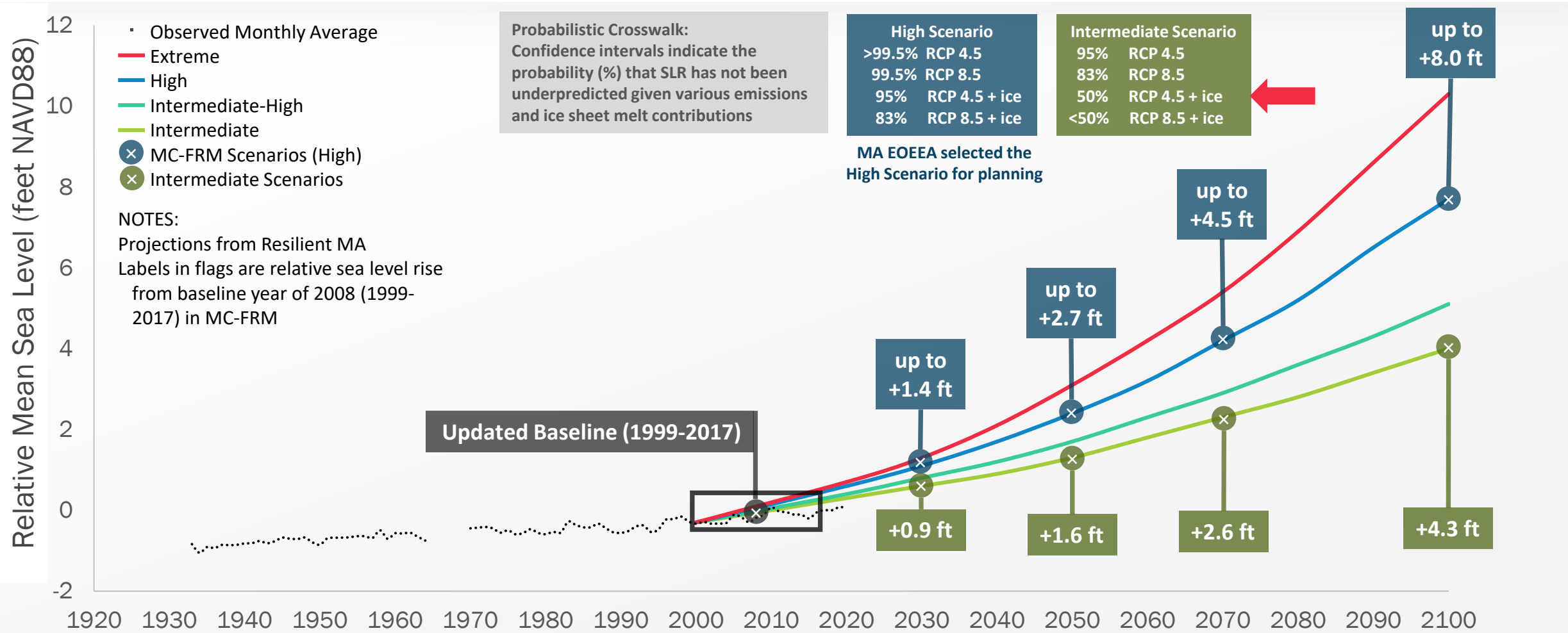


Questions?

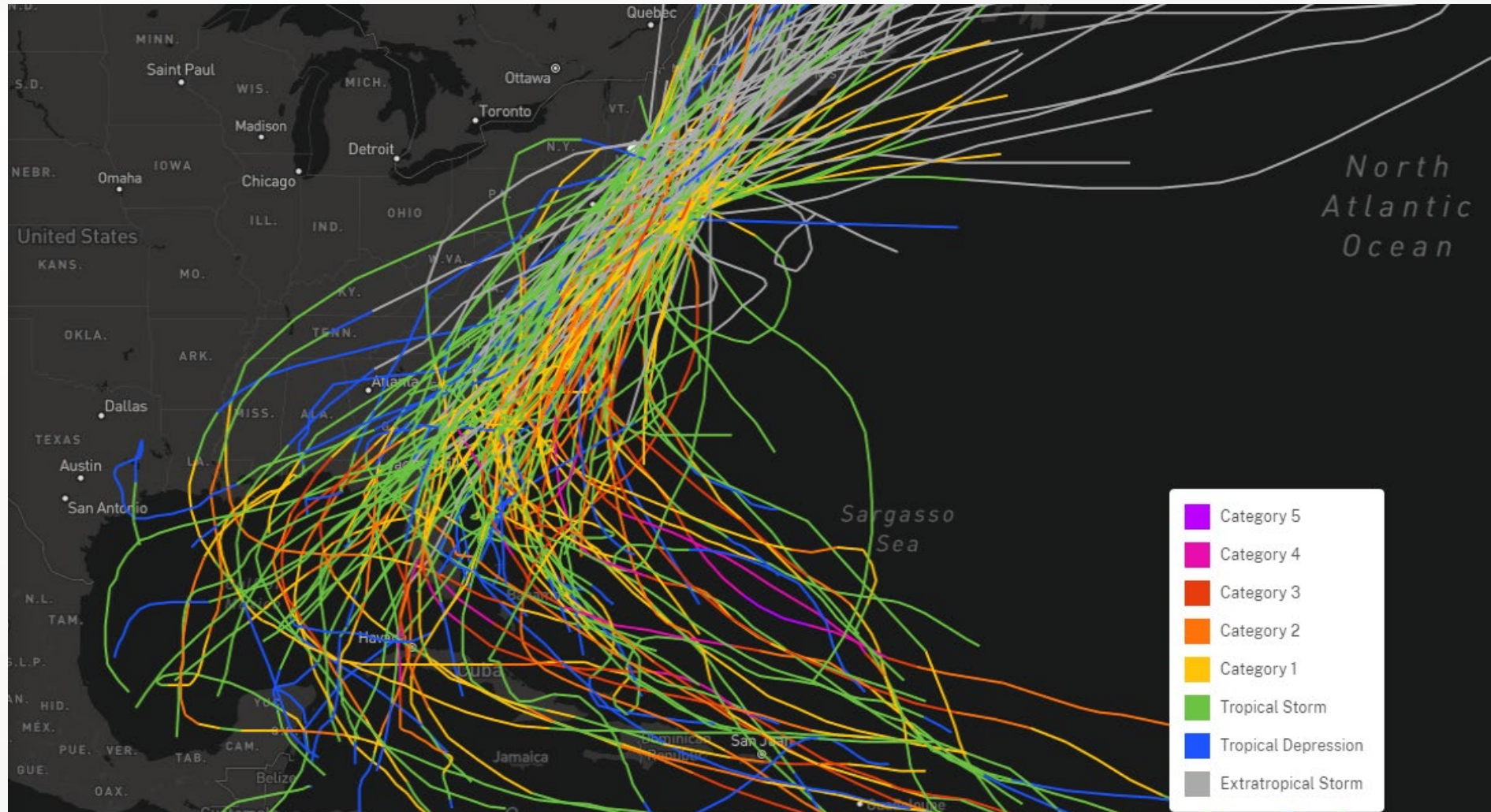
- Workshop Purpose or Objectives
- Low Lying Roads project
 - Key components
 - Vulnerability Assessment - Identify Potential Sites
 - Public Outreach and Engagement
 - Roadway Feasibility and Alternative Solutions
 - Solutions Identification
 - Timeline

MA EOEEA Probabilistic Sea Level Rise Projections

MC-FRM SOUTH (DeConto & Kopp, 2017)



Tropical / Extra-tropical Storms



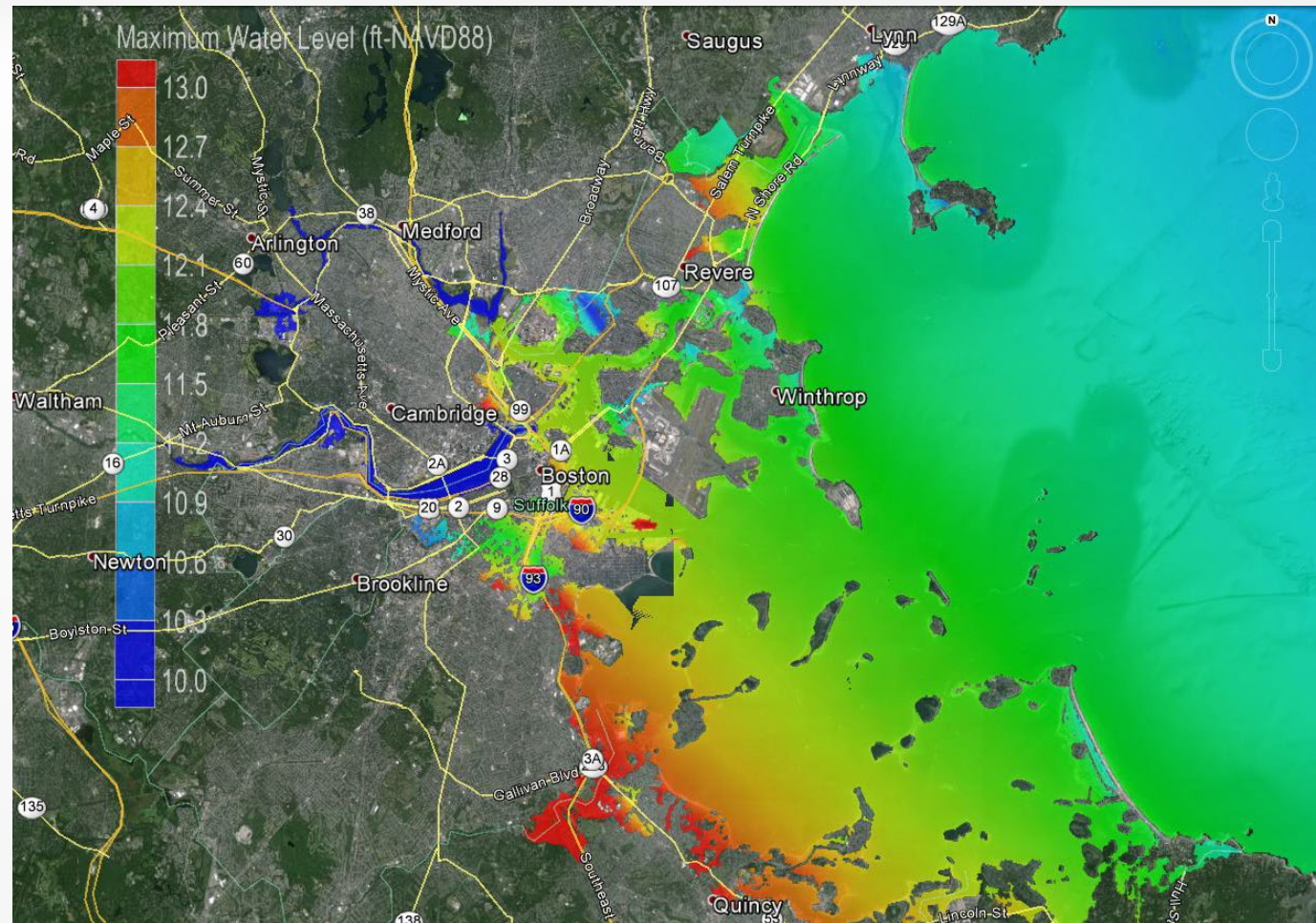
NOAA National Ocean Service

Why Hydrodynamic Modeling? Why Probabilistic?

**MassDOT-FHWA
Pilot Project Report:
Climate Change and Extreme
Weather Vulnerability Assessments
and Adaptation Options for the
Central Artery**

Project Team:
Kirk Bosma, P.E., Woods Hole Group, Inc.
Ellen Douglas, P.E., Ph.D., UMass Boston
Paul Kirshen, Ph.D., University of New Hampshire
Katherin McArthur, MassDOT
Steven Miller, MassDOT
Chris Watson, M.Sc., UMass Boston

Logos: UMass Boston, Woods Hole Group, University of New Hampshire, U.S. Department of Transportation Federal Highway Administration



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

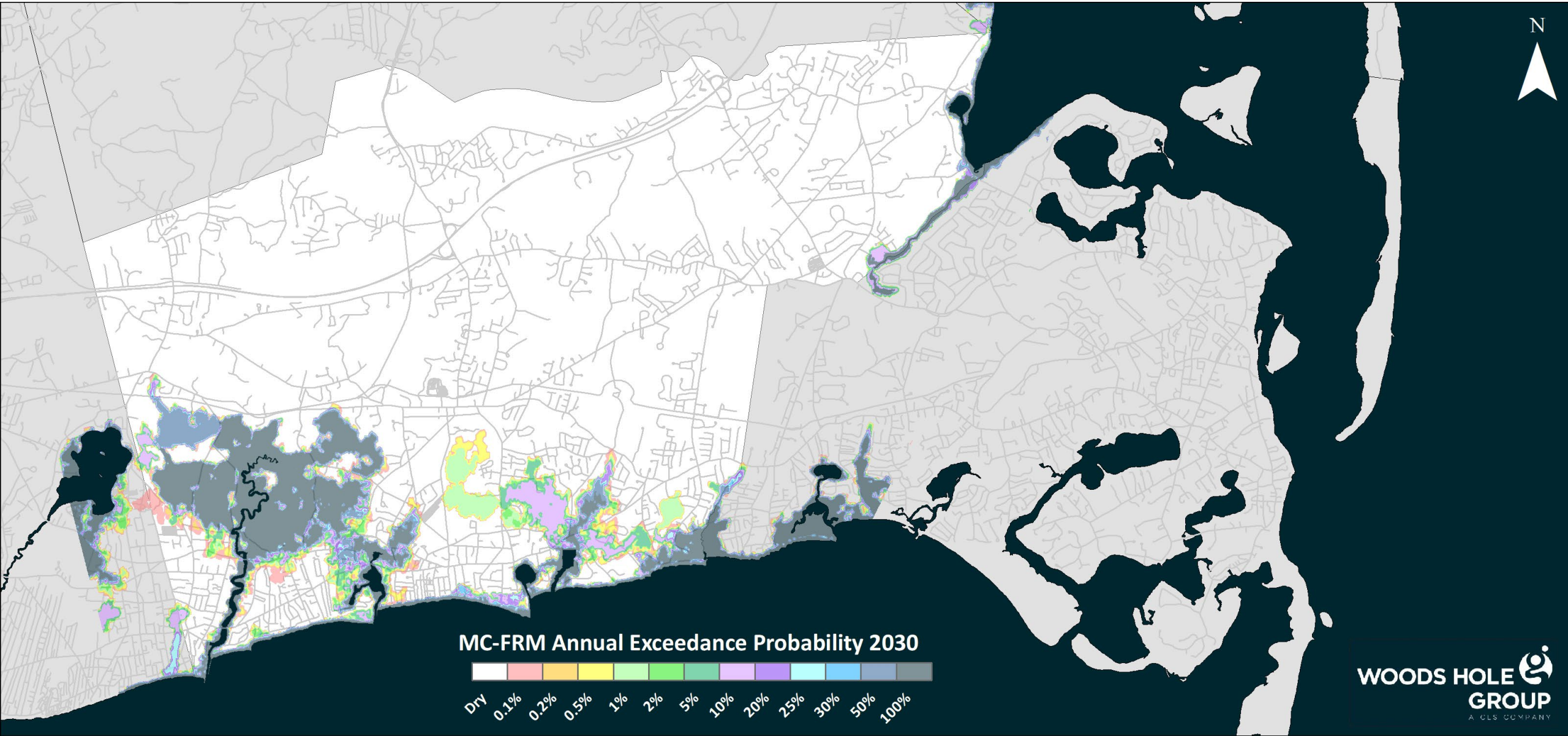


OUTPUTS

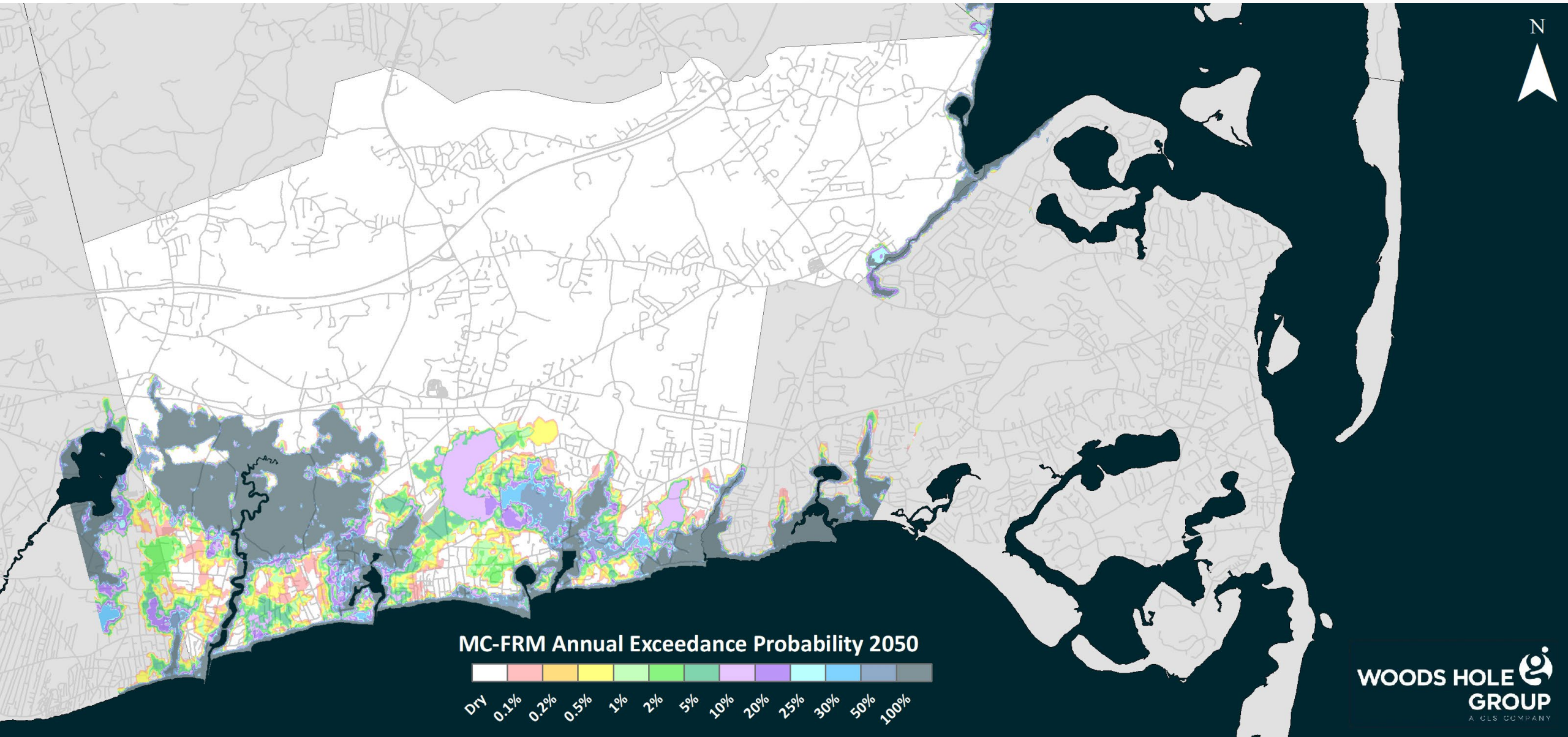
MC-FRM Resolution



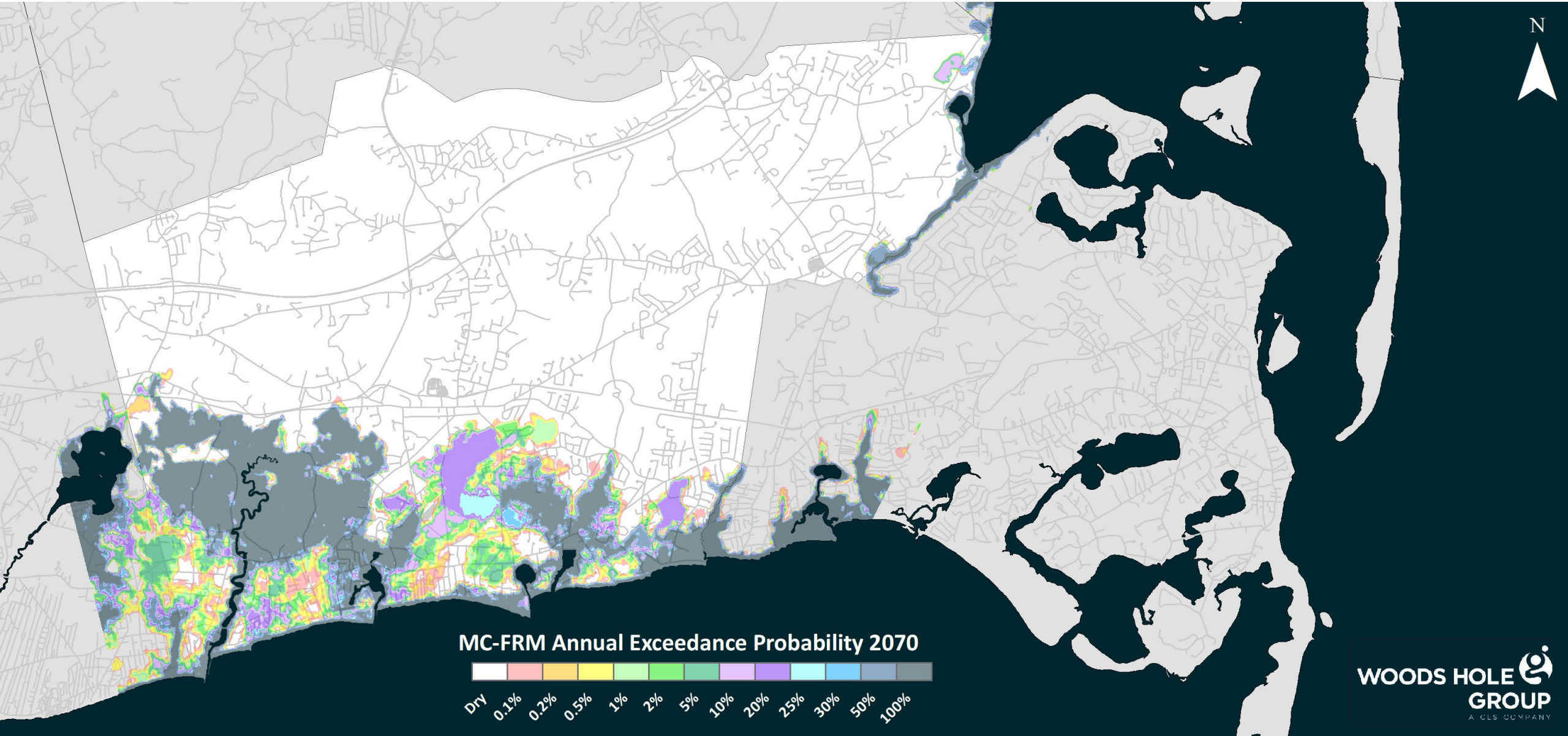
MC-FRM Annual Coastal Flood Exceedance Probability – 2030



MC-FRM Annual Coastal Flood 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

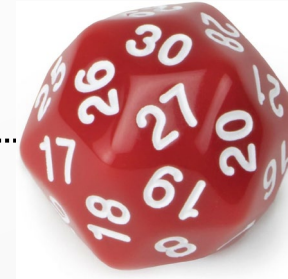


Image source: [amazon.com/stores/Brybelly](https://www.amazon.com/stores/Brybelly)



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



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

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

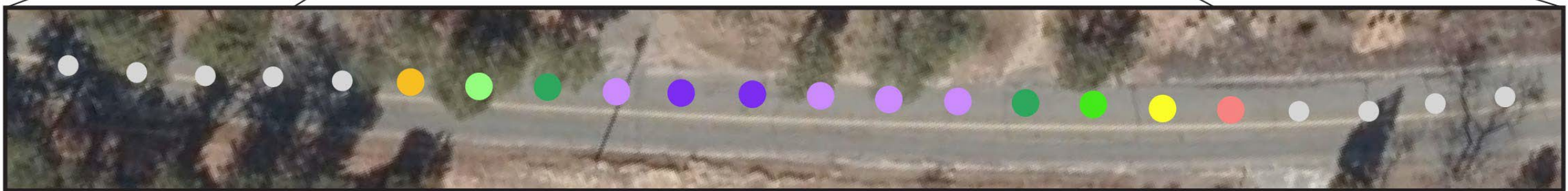
Sea level rise and storm surge – combined

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

QUESTIONS?

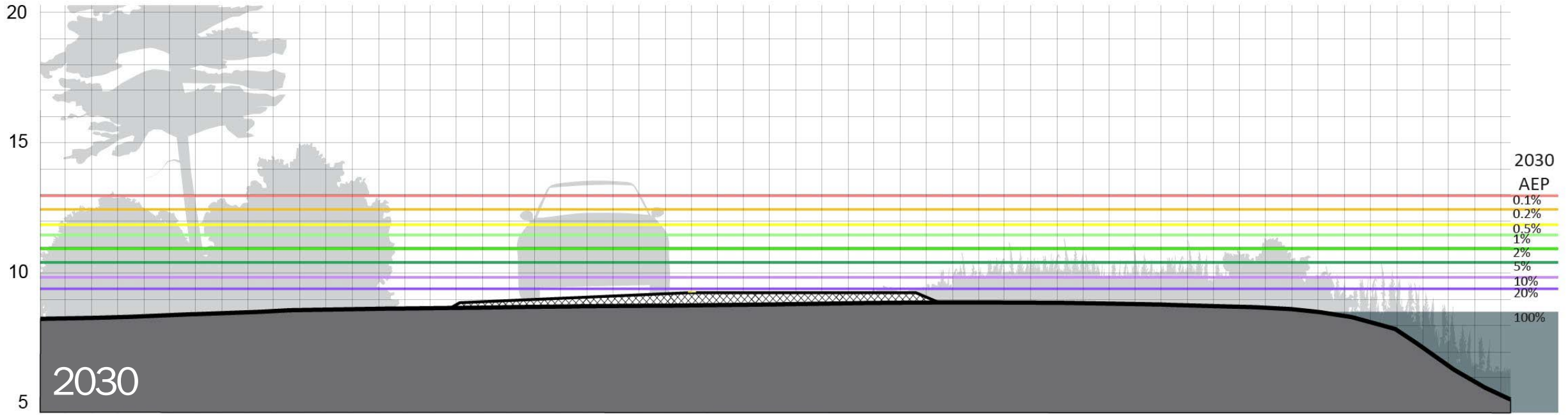
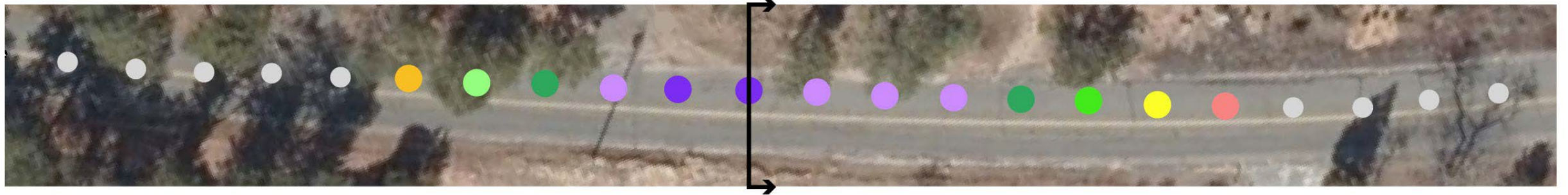
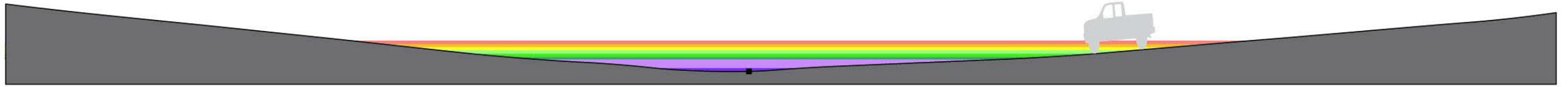


Cape Cod Low Lying Roads Vulnerability Assessment Methods



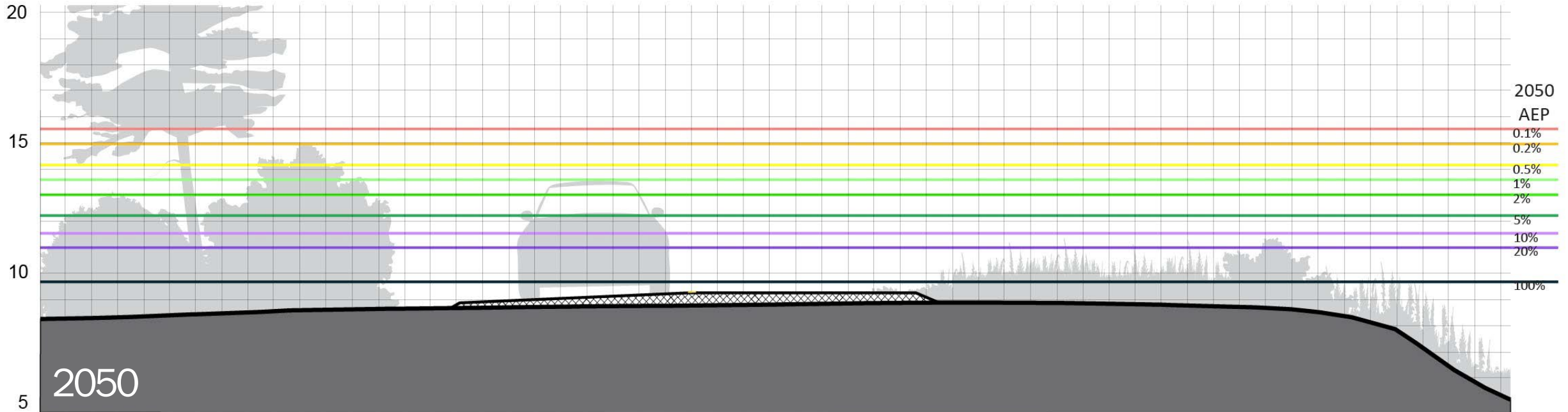
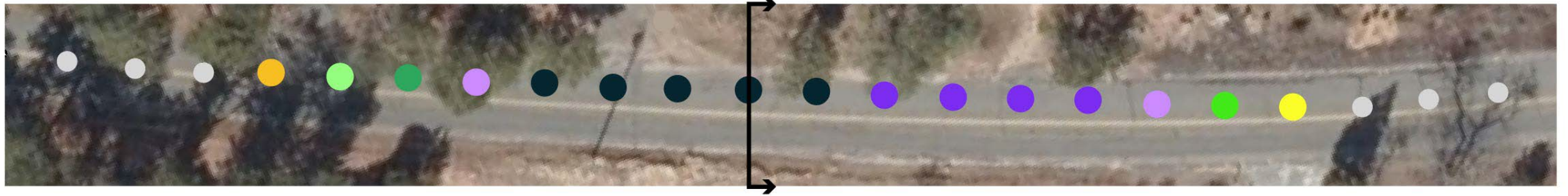
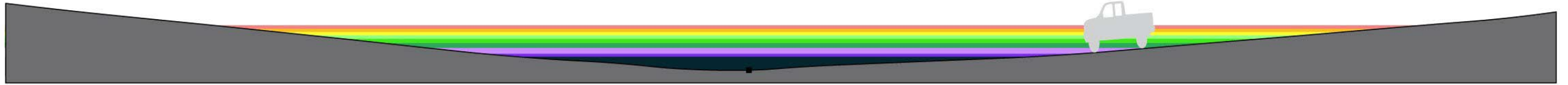
Cape Cod Low Lying Roads Vulnerability Assessment Methods

COASTAL FLOOD EXCEEDANCE PROBABILITY



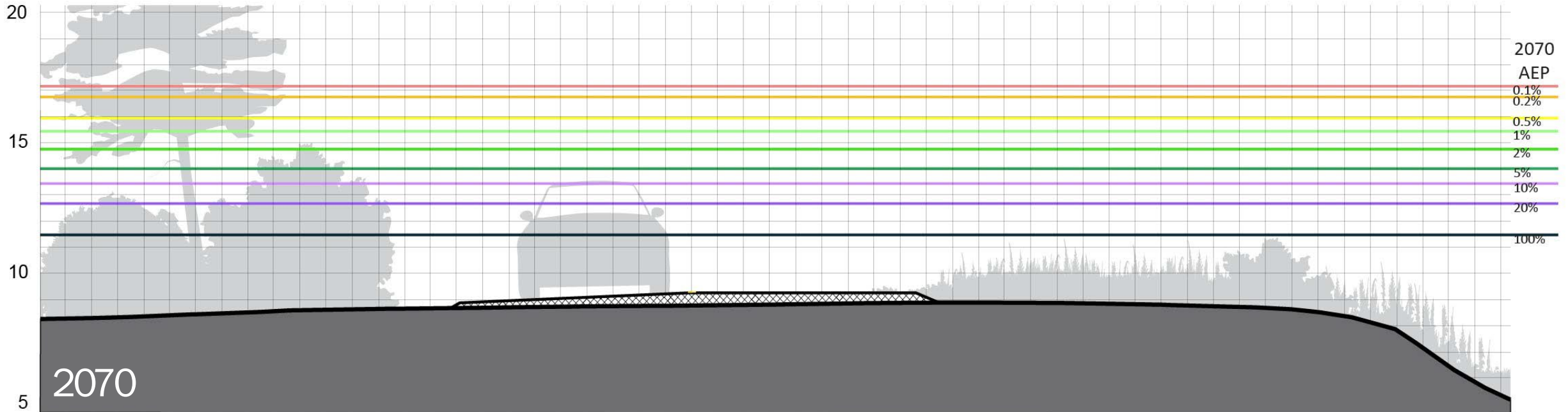
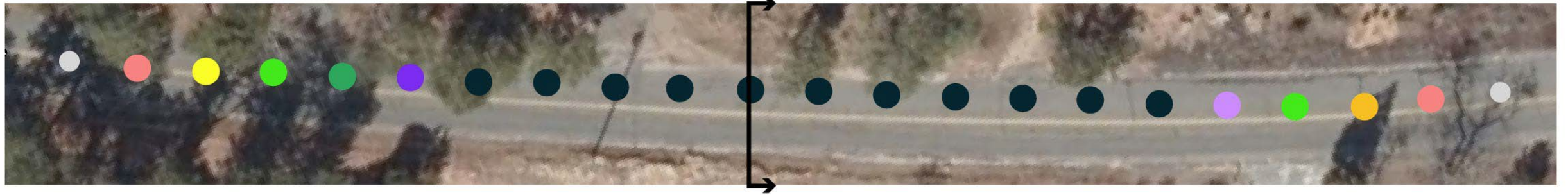
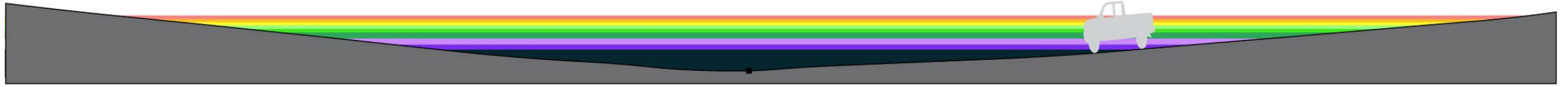
Cape Cod Low Lying Roads Vulnerability Assessment Methods

COASTAL FLOOD EXCEEDANCE PROBABILITY

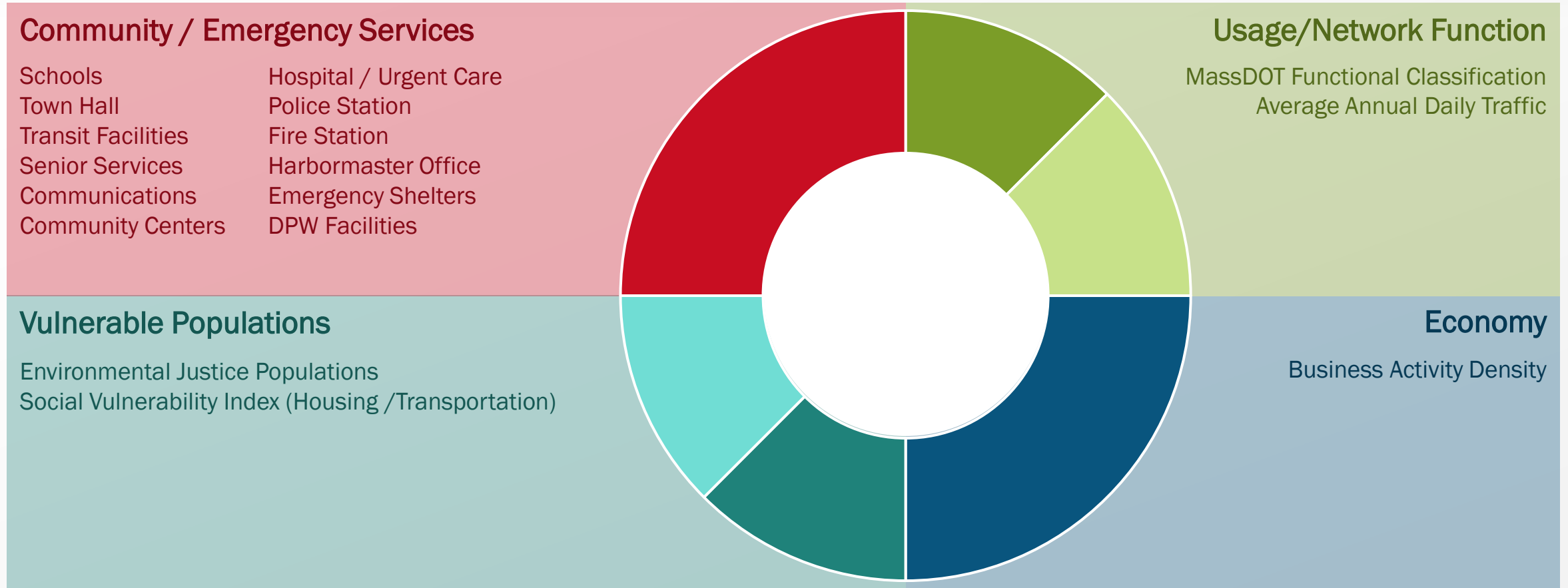


Cape Cod Low Lying Roads Vulnerability Assessment Methods

COASTAL FLOOD EXCEEDANCE PROBABILITY

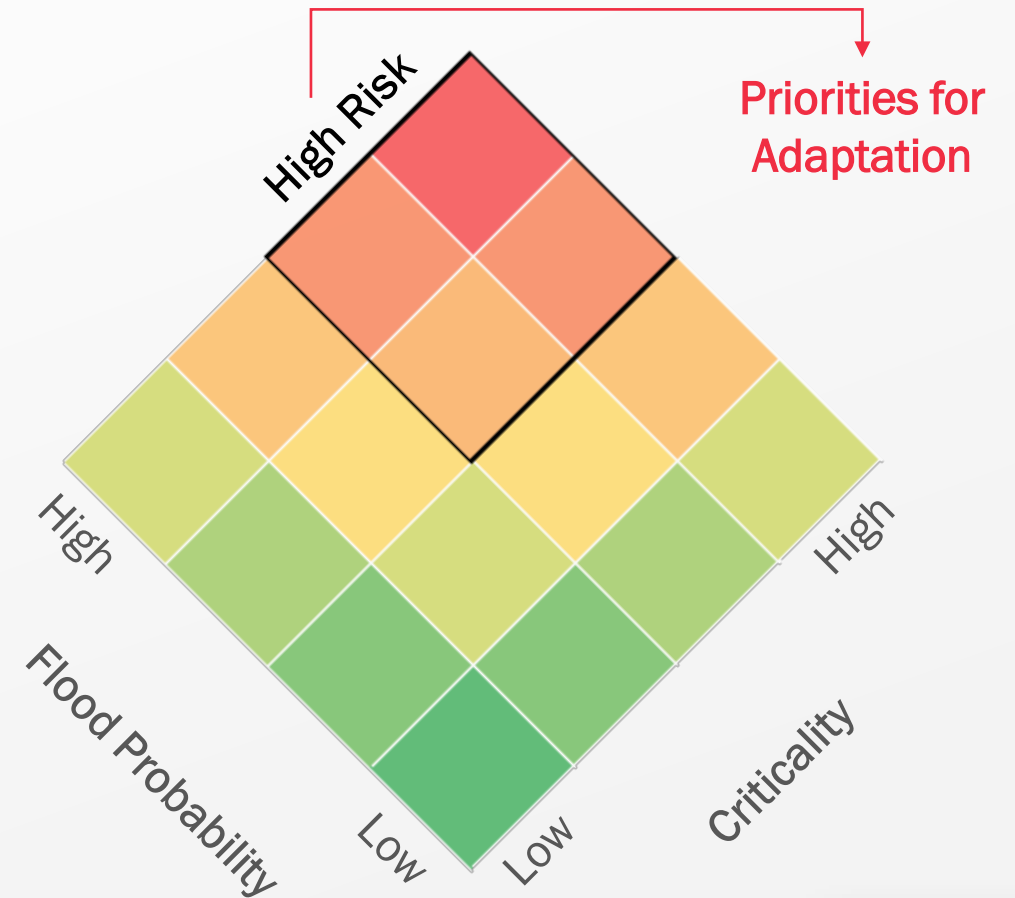


Cape Cod Low Lying Roads Criticality Scoring Framework



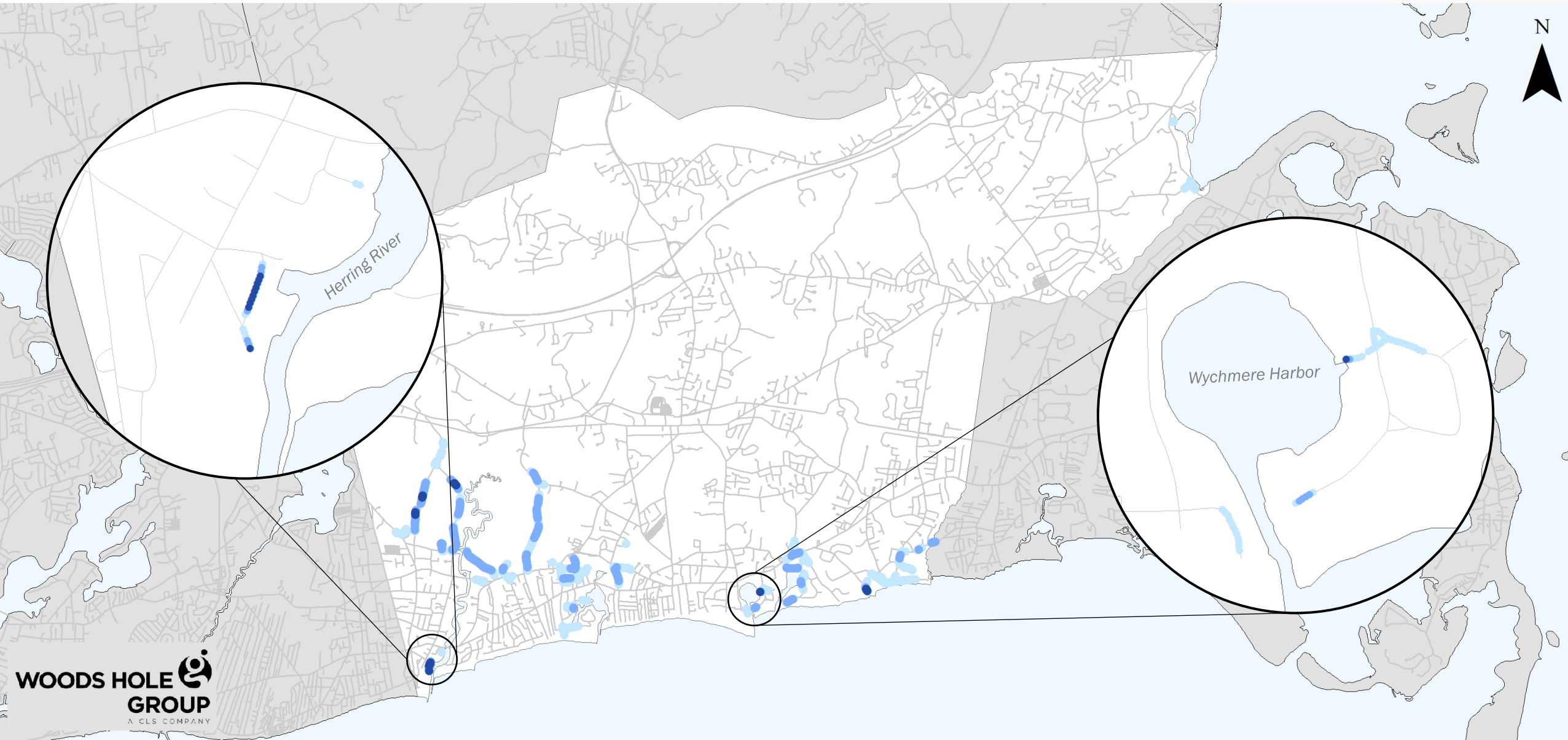
Cape Cod Low Lying Roads Risk Assessment Approach

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

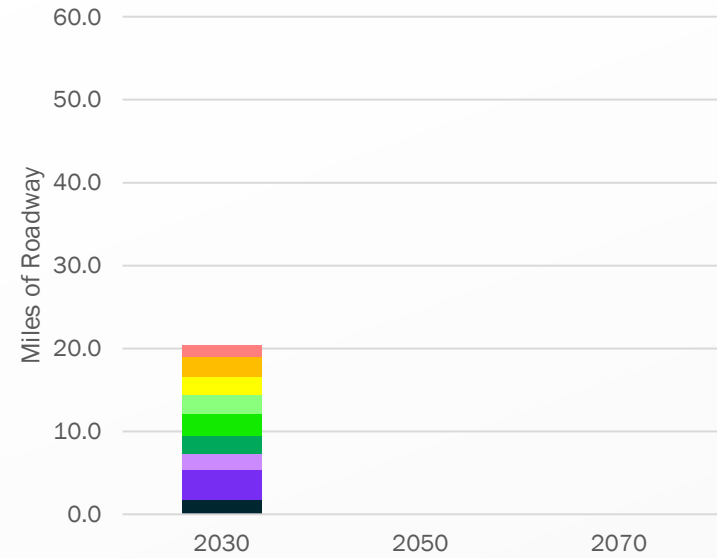


Low Lying Roads Nuisance Flooding

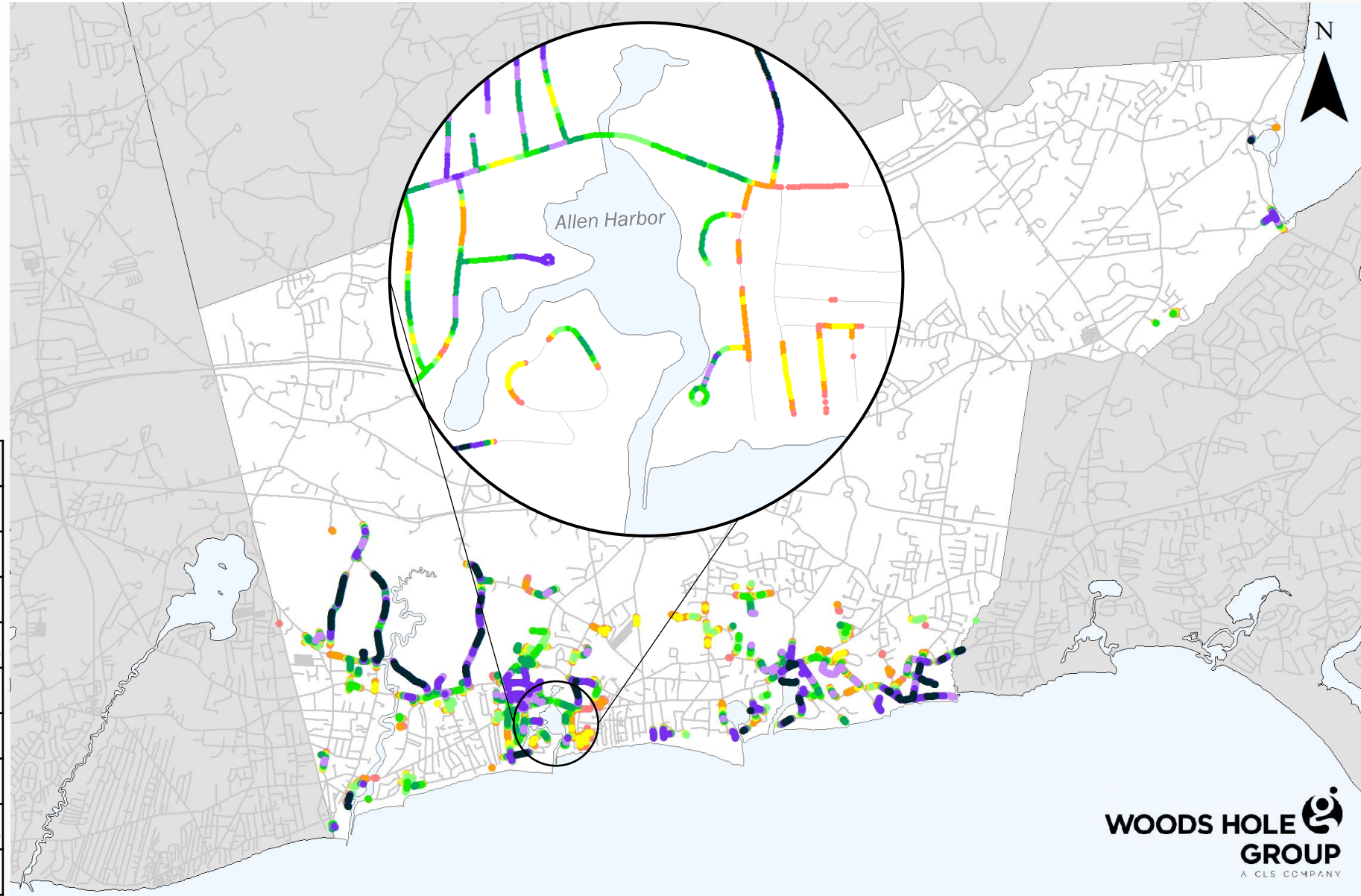
- Road Surface Elevations Below MHW
- 2070 (5.8 mi)
- 2050 (2.2 mi)
- 2030 (0.1 mi)



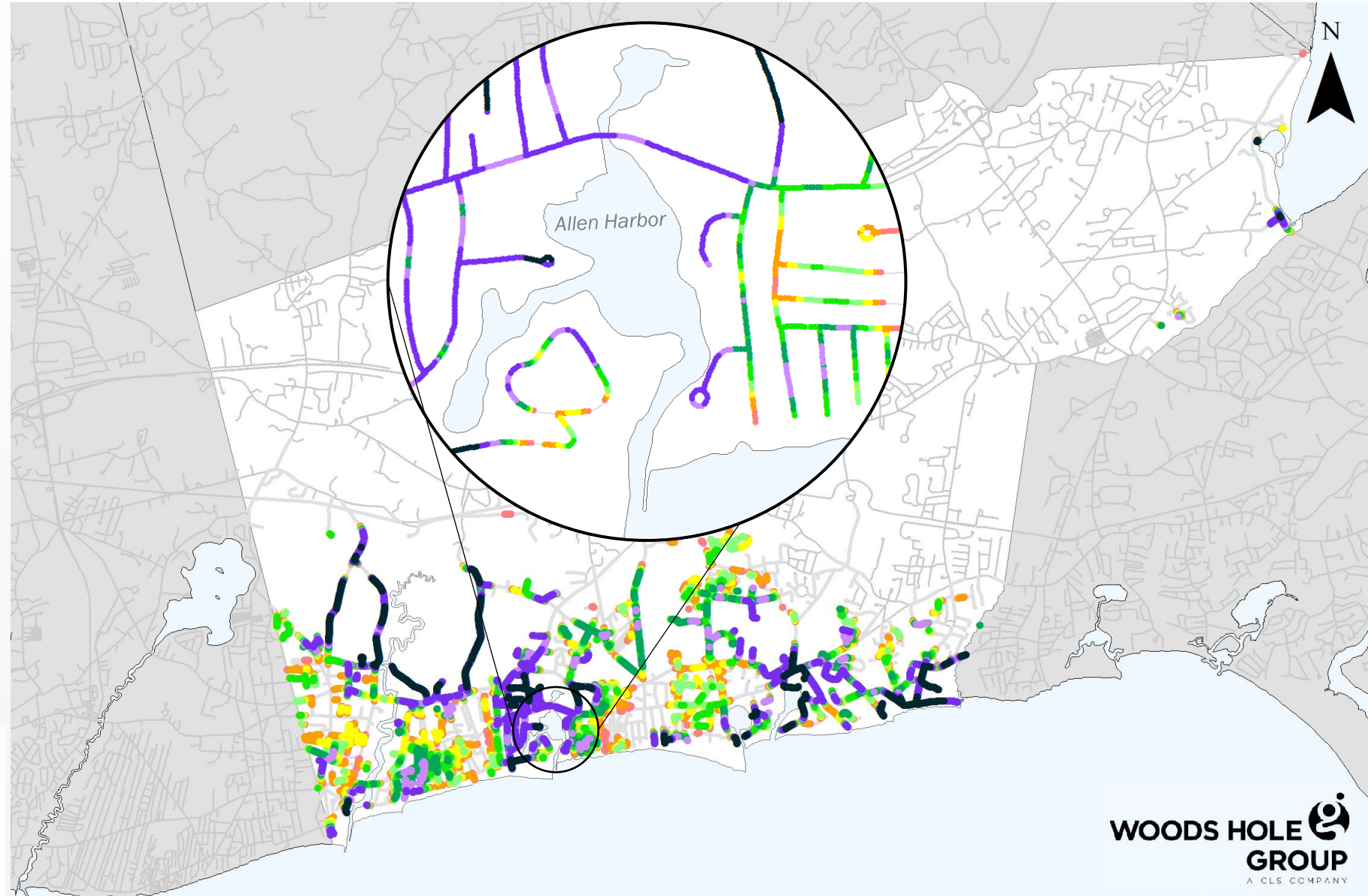
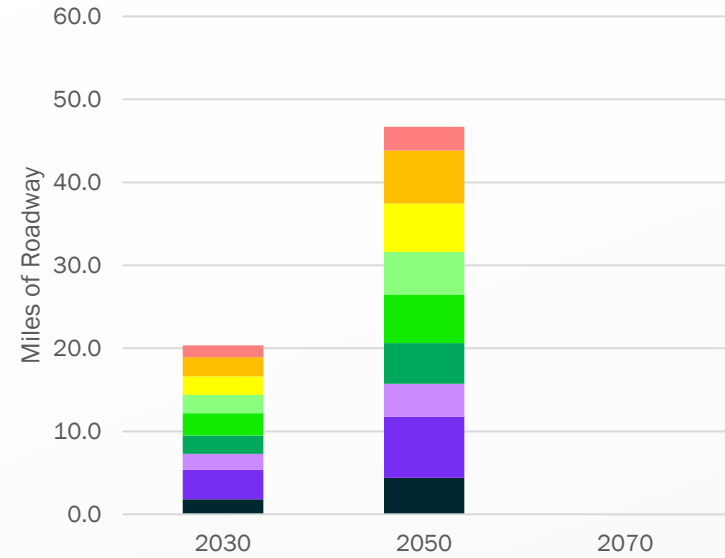
Low Lying Roads 2030 Flood Probability (Annual Exceedance Probability)



Flood Probability	Total Road Miles
0.1%	20.4
0.2%	18.9
0.5%	16.6
1%	14.4
2%	12.2
5%	9.5
10%	7.3
20%	5.4
100%	1.8

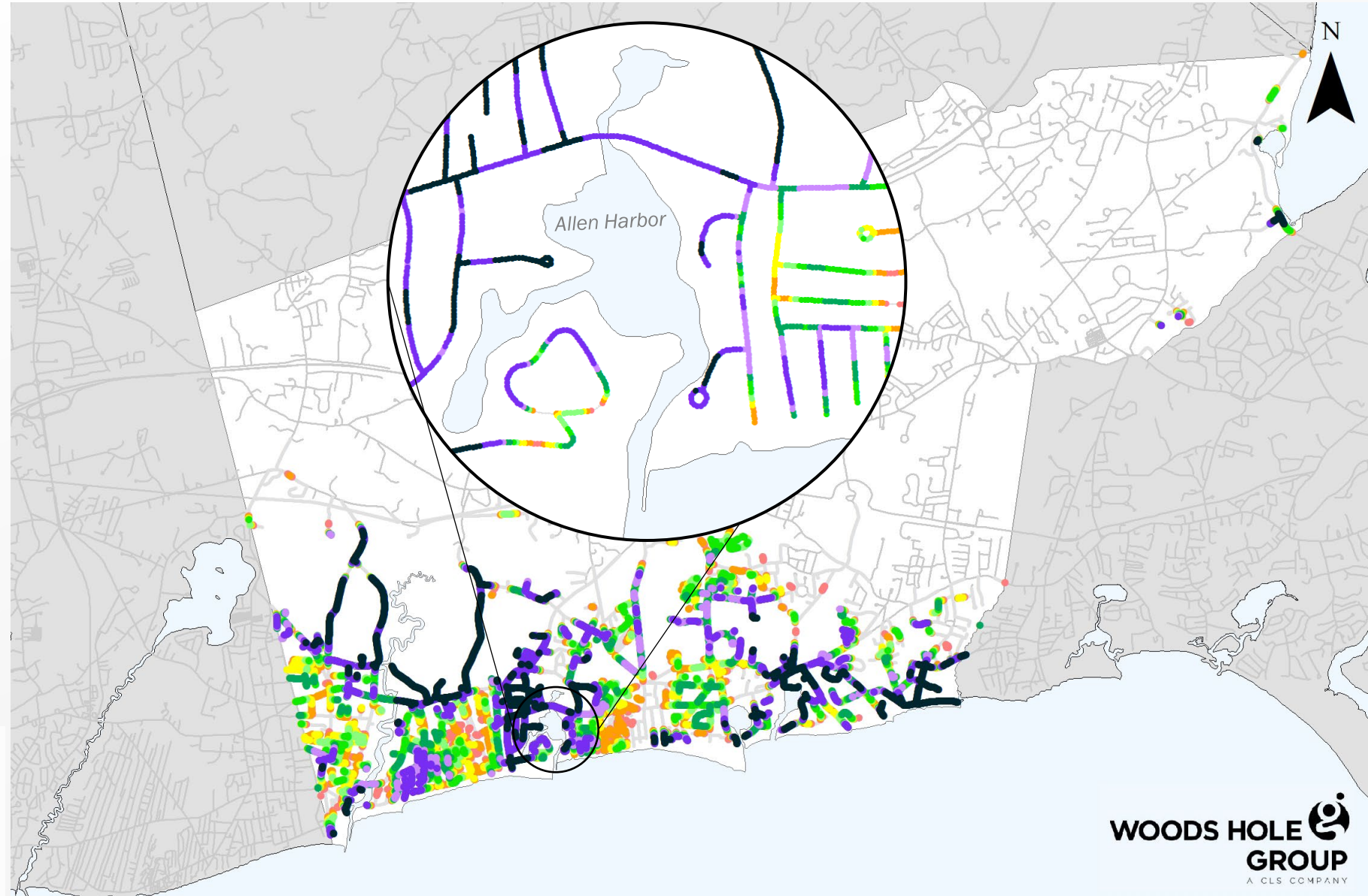
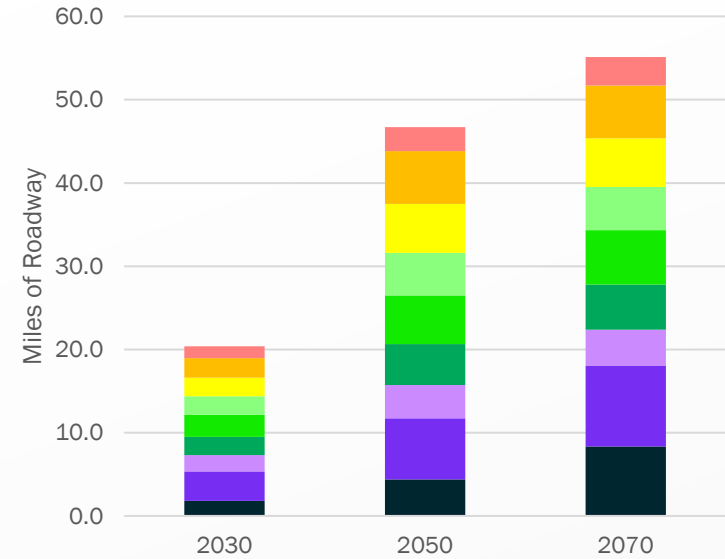


Low Lying Roads 2050 Flood Probability (Annual Exceedance Probability)



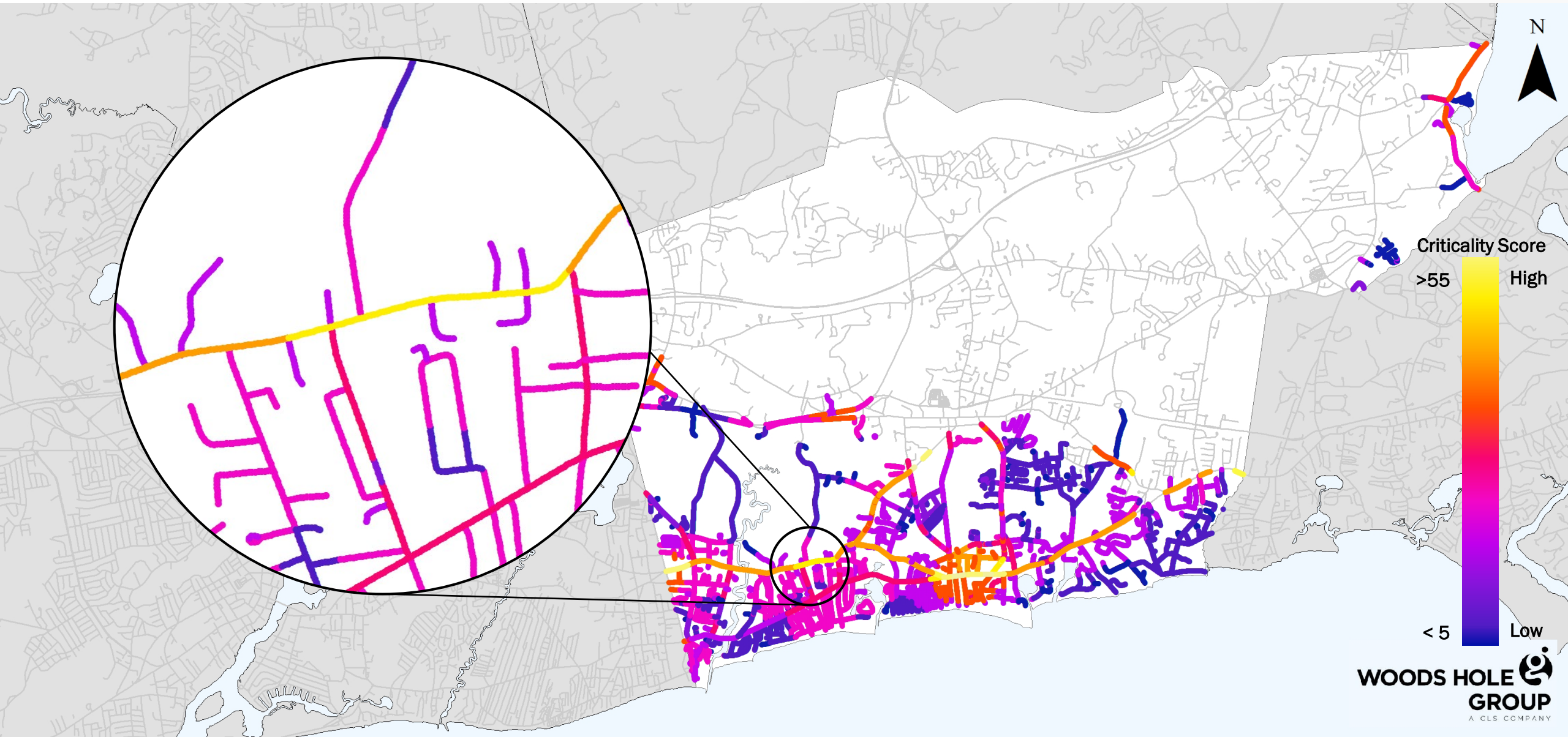
Flood Probability	Total Road Miles
0.1%	46.7
0.2%	43.8
0.5%	37.5
1%	31.6
2%	26.5
5%	20.6
10%	15.7
20%	11.8
100%	4.4

Low Lying Roads 2070 Flood Probability (Annual Exceedance Probability)



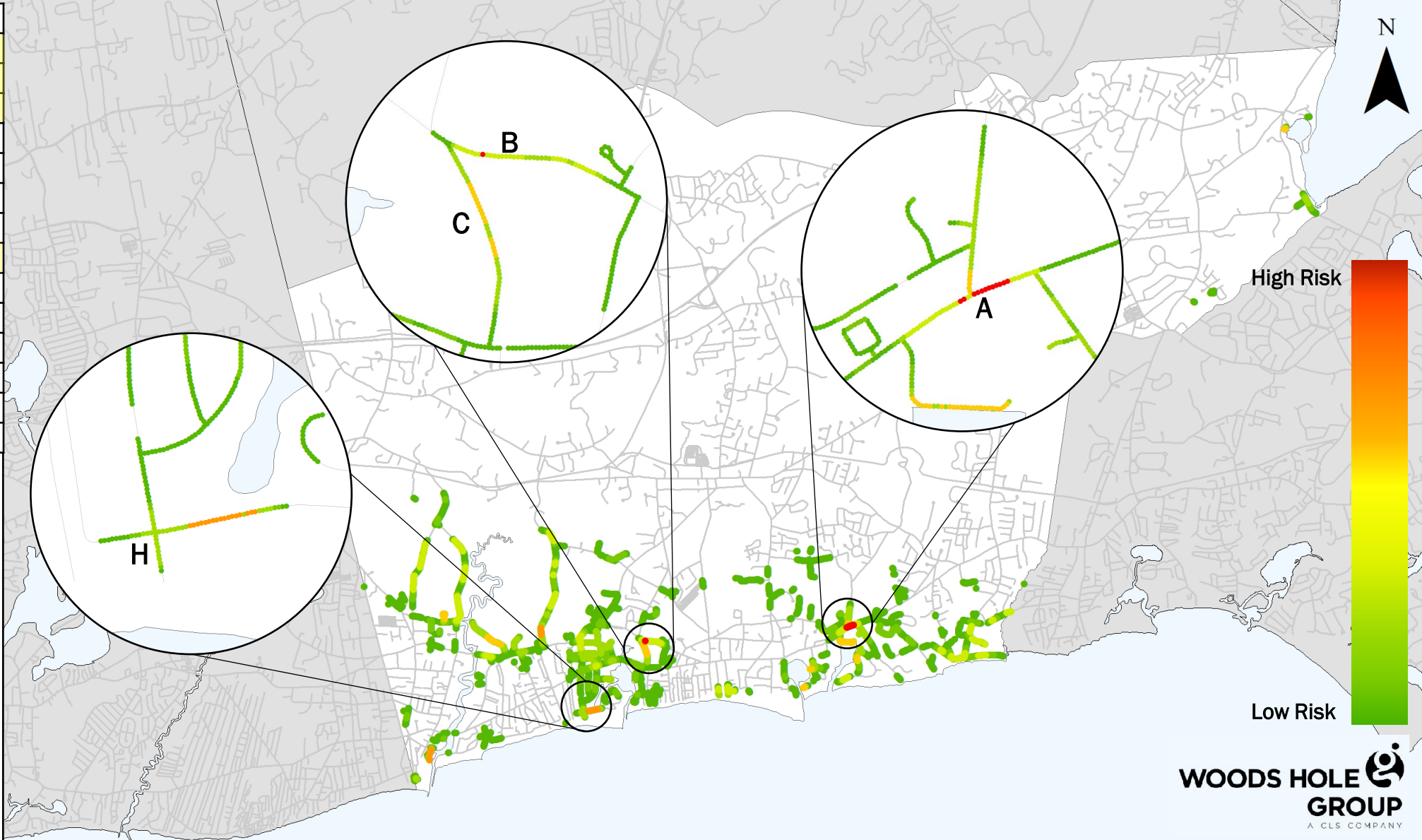
Flood Probability	Total Road Miles
0.1%	55.1
0.2%	51.7
0.5%	45.3
1%	39.5
2%	34.3
5%	27.8
10%	22.4
20%	18.1
100%	8.3

Low Lying Roads Criticality Scoring



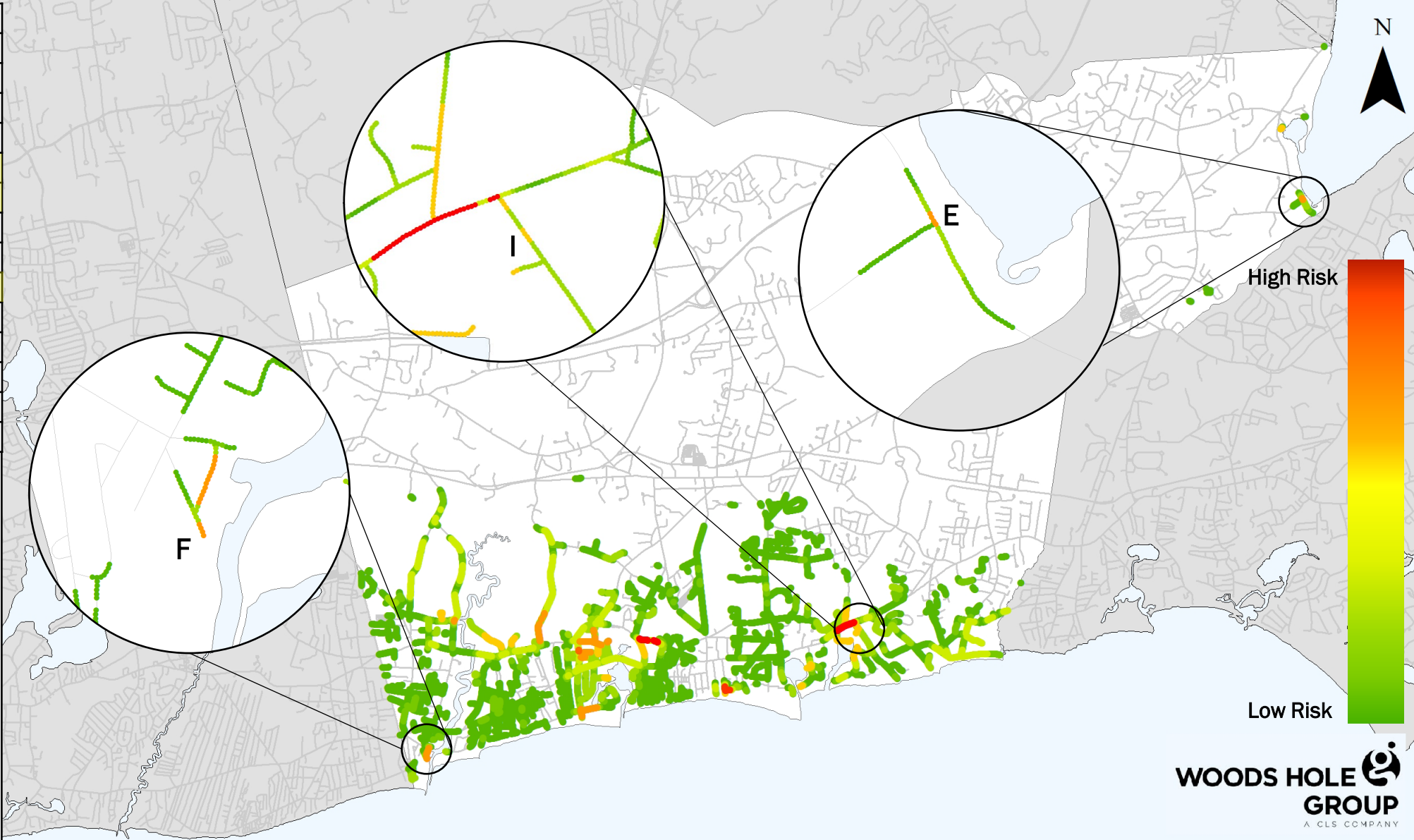
Low Lying Roads 2030 Risk Results

High Risk Road Segments	
A	Rte 28 at Gorham Rd
B	Rte 28 at Kildee Rd
C	Kildee Road
D	Uncle Venies Road
E	Rte 28 at Bay Rd
F	Harbor Way
G	North Rd at Smith St
H	Brooks Rd
I	Neel Road
J	South Chatham Rd
K	Rte 28 at Grey Neck Rd
L	Rte 28 at Brooks Rd
M	Rte 28 at River Rd
N	Lower County Rd at Wequasset Rd



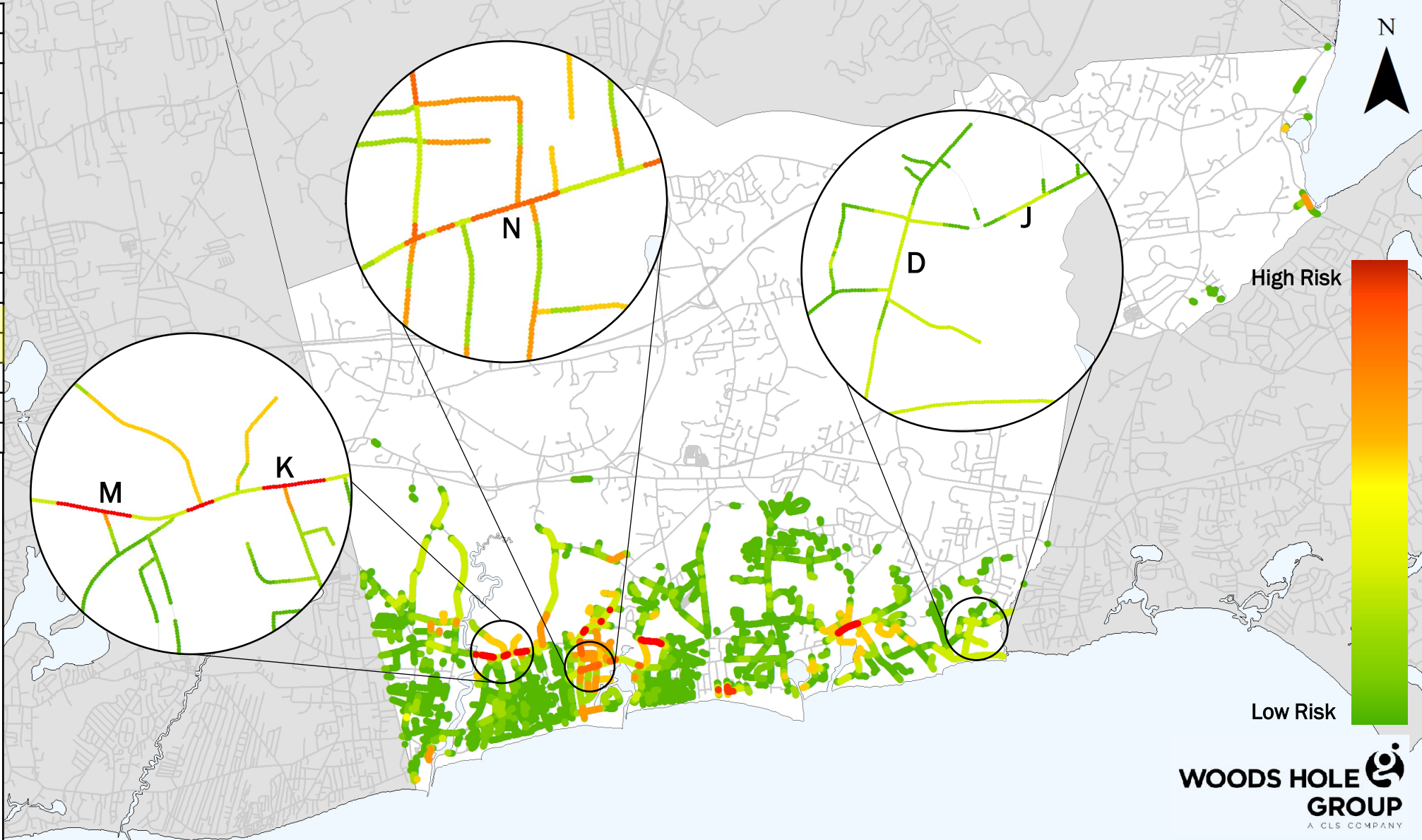
Low Lying Roads 2050 Risk Results

High Risk Road Segments	
A	Rte 28 at Gorham Rd
B	Rte 28 at Kildee Rd
C	Kildee Road
D	Uncle Venies Road
E	Rte 28 at Bay Rd
F	Harbor Way
G	North Rd at Smith St
H	Brooks Rd
I	Neel Road
J	South Chatham Rd
K	Rte 28 at Grey Neck Rd
L	Rte 28 at Brooks Rd
M	Rte 28 at River Rd
N	Lower County Rd at Wequasset Rd



Low Lying Roads 2070 Risk Results

High Risk Road Segments	
A	Rte 28 at Gorham Rd
B	Rte 28 at Kildee Rd
C	Kildee Road
D	Uncle Venies Road
E	Rte 28 at Bay Rd
F	Harbor Way
G	North Rd at Smith St
H	Brooks Rd
I	Neel Road
J	South Chatham Rd
K	Rte 28 at Grey Neck Rd
L	Rte 28 at Brooks Rd
M	Rte 28 at River Rd
N	Lower County Rd at Wequasset Rd



Summary of High Priority Road Segments

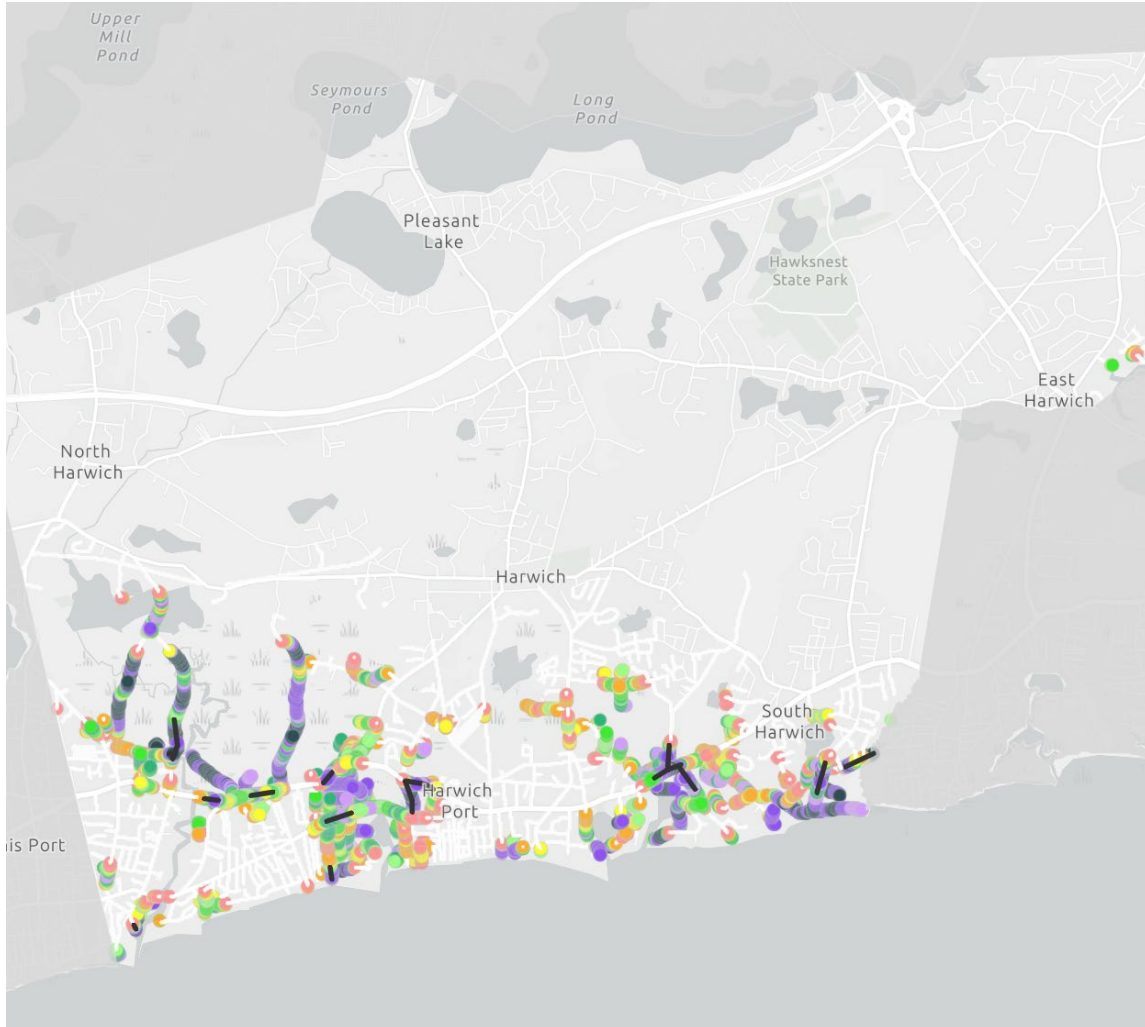
	Road Name	Length (ft)	Description	AEP 2030	Criticality Score	2030 Risk Score	Tidal Flooding Length (ft)		
							2030	2050	2070
A	Rte 28 at Gorham Rd*	1700	Main St between Squaket Harbor and Neel Rd, w/ Andrews River crossing	100	40	4000	0	220	1360
B	Rte 28 at Kildee Rd*	940	Main St between Doane Rd and Seaport Ln, w/ Doanes Creek crossing	100	37	3700	0	20	680
C	Kildee Road	1020	between Lower County Rd and Main St, w/ Doanes Creek crossing	100	19	1900	0	560	800
D	Uncle Venies Road	900	between Bob White Ln and South Chatham Rd	100	10	1000	0	180	400
E	Rte 28 at Bay Rd*	660	Head of the Bay Rd at Jackknife Cove	20	20	400	0	0	440
F	Harbor Way	180	to landing at Wixon Dock on Herring River	100	20	2000	20	60	120
G	North Rd at Smith St	1480	southern segment along Herring River	100	8	800	0	1100	1320
H	Brooks Rd	460	intersection with Dunes Rd	20	20	400	0	0	440
I	Neel Road	1060	between Main St and Geraldine Ave	20	19	380	0	0	360
J	South Chatham Rd‡	1000	between Brettwood Rd and Chatham line, w/ Red River crossing	100	9	900	0	200	440
K	Rte 28 at Grey Neck Rd*	760	Main St between Grey Neck Rd and Earle Rd	10	38	380	0	0	320
L	Rte 28 at Brooks Rd*	540	Main St at intersection w/ Brooks Rd	20	38	760	0	0	0
M	Rte 28 at River Rd*	560	Main St between Chase St and Herring River bridge	20	38	760	0	0	400
N	Lower County Rd at Wequasset Rd	900	between Brooks Rd and Wequasset Rd	20	30	600	0	0	0

‡Segment also listed for Chatham

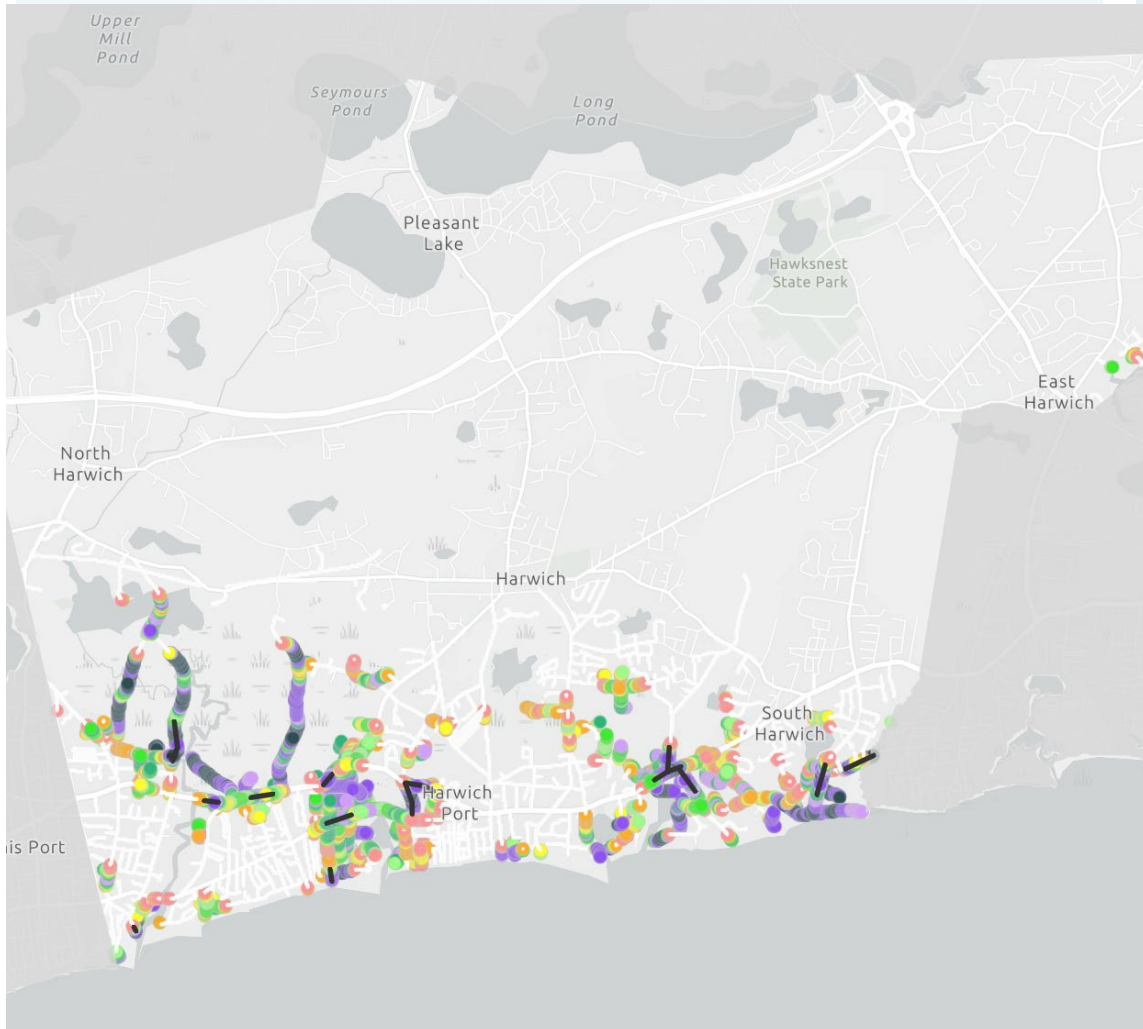
*MassDOT roadway

LOW LYING ROADS

Group Discussion



DISCUSSION ORIENTATION



DISCUSSION QUESTIONS

1. Are there roads that we missed?
2. How would you prioritize these roads – what local knowledge or concerns can you bring to the discussion?
3. What are the high-priority road segments?

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	Rte 28 at Gorham Rd*	1700	Main St between Squaket Harbor and Neel Rd, w/ Andrews River crossing	100	40	4000	0	220	1360
B	Rte 28 at Kildee Rd*	940	Main St between Doane Rd and Seaport Ln, w/ Doanes Creek crossing	100	37	3700	0	20	680
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D	Uncle Venies Road	900	between Bob White Ln and South Chatham Rd	100	10	1000	0	180	400
E	Rte 28 at Bay Rd*	660	Head of the Bay Rd at Jackknife Cove	20	20	400	0	0	440
F	Harbor Way	180	to landing at Wixon Dock on Herring River	100	20	2000	20	60	120
G	North Rd at Smith St	1480	southern segment along Herring River	100	8	800	0	1100	1320
H	Brooks Rd	460	intersection with Dunes Rd	20	20	400	0	0	440
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K	Rte 28 at Grey Neck Rd*	760	Main St between Grey Neck Rd and Earle Rd	10	38	380	0	0	320
L	Rte 28 at Brooks Rd*	540	Main St at intersection w/ Brooks Rd	20	38	760	0	0	0
M	Rte 28 at River Rd*	560	Main St between Chase St and Herring River bridge	20	38	760	0	0	400
N	Lower County Rd at Wequasset Rd	900	between Brooks Rd and Wequasset Rd	20	30	600	0	0	0

‡Segment also listed for Chatham

*MassDOT roadway

NEXT STEPS

- Town staff to select 2 road segments
- Site visits and feasibility analysis
- 3 solutions + costs per segment
- 2nd 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: Harwich

Home > Work > Low Lying Roads: Harwich

Start Date: 2023

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

Overview

Map Viewer

Overview

The Cape Cod Commission is working with all 15 Cape towns, including the **Town of Harwich**, to examine vulnerabilities in the roadway network and identify solutions.

With funding support from the Massachusetts Municipal Vulnerability Preparedness

NEXT MEETINGS

WEDNESDAY

MAY 24, 2023

Harwich Low-lying Roads Public Meeting

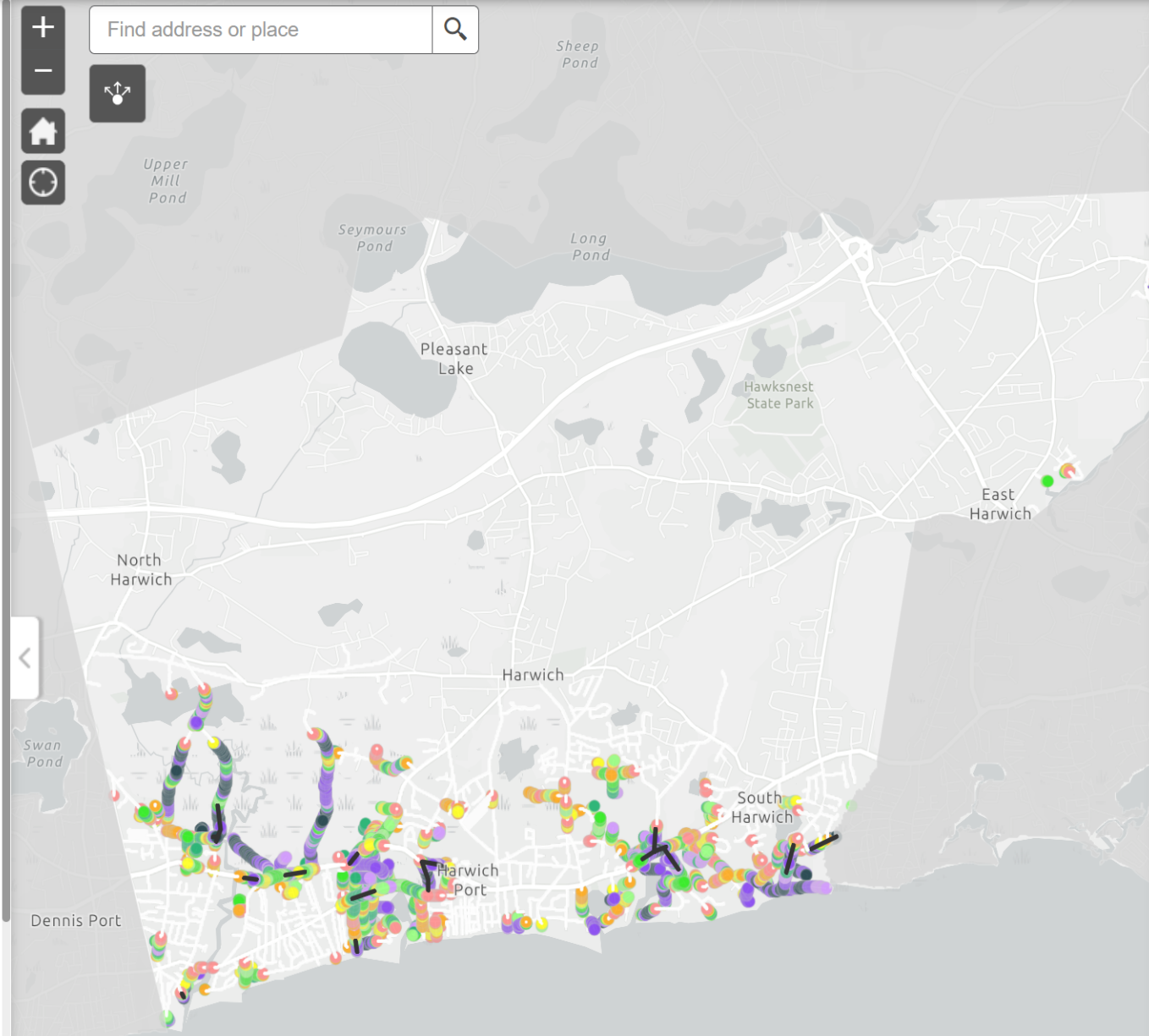
START TIME: 4:00 PM

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

- Coastal Erosion
- Coastal Flooding
- Harwich Top Vulnerable Roads
- Town mask

Harwich 2030 Inundation Probability

Prob_2030

- 100%
- 20%
- 10%
- 5%
- 2%
- 1%
- 0.5%
- 0.2%
- 0.1%
- 0

Tell Us What You Think!

Are there roads in town that have FLOODING or EROSION issues? How high of a priority do you think it is to address the issue? Follow the steps below:

THANK YOU!
