Low-lying Roads: Wellfleet

Project funded by the Municipal Vulnerability Preparedness program and the Economic Development Administration

Cape Cod Commission: Heather McElroy, Martha Hevenor, Michele White, Liz Kellam, Steve Tupper, and Tara Lewis
Woods Hole Group: Joe Famely

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

- Welcome - Wellfleet Energy and Climate Committee
- Project Overview
- Vulnerability and Risk Assessment
- Results of Low-Lying Roads Screening
- Discussion/Breakout Groups
- Next Steps

Low Lying Roads Project

10

TOWNS

EDA and MVP funding thru 2023

Vulnerability assessment of low-lying roads and transportation infrastructure

Municipal prioritization

Potential design solutions

NEXT STEPS: PUBLIC MEETINGS

Prioritize most critical road segments for development of alternative solutions for sea level rise and storm surge adaptation

FALL - DECEMBER

6 public workshops

LATE WINTER - SPRING

4 public workshops

FALL — Yarmouth, Orleans, Eastham, Wellfleet, Sandwich, Dennis

WINTER

SPRING — Barnstable, Bourne, Brewster, Truro

HAZARD

Storms, SLR & Flooding

Adaptation Strategies

- Green Infrastructure, or Nature-based Solutions
- Gray Infrastructure, or Traditional Engineering Structures
- Other approaches – Managed Retreat, Abandonment

PROJECT TIMELINE

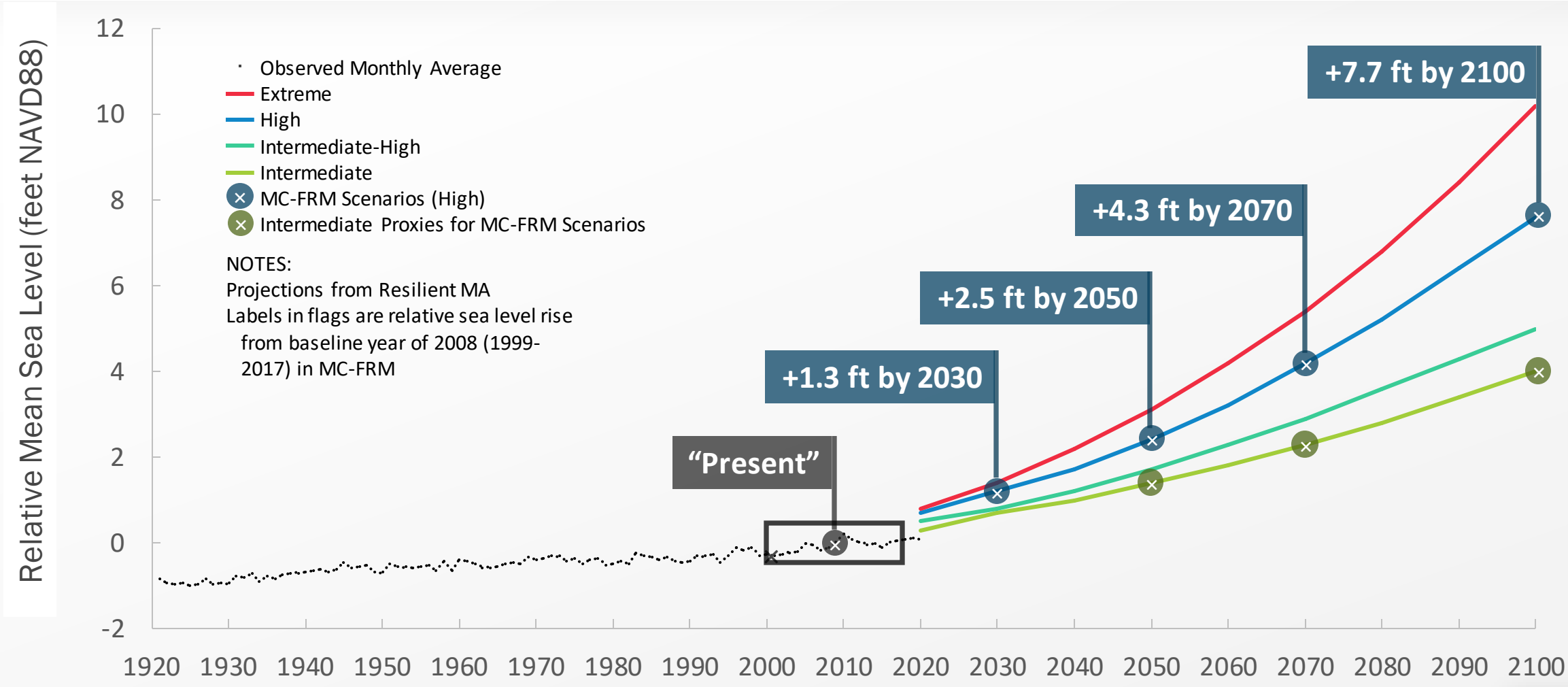
September	October	December	Winter 2022	Winter 2023
Shoreline Projections	Vulnerability Assessment	Prioritize Roadway Segments	1st Workshop: Vulnerable & At-Risk Roads	Roadway analysis & solutions ID	2nd Workshop: Present alternatives

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 NORTH (DeConto & Kopp, 2017)



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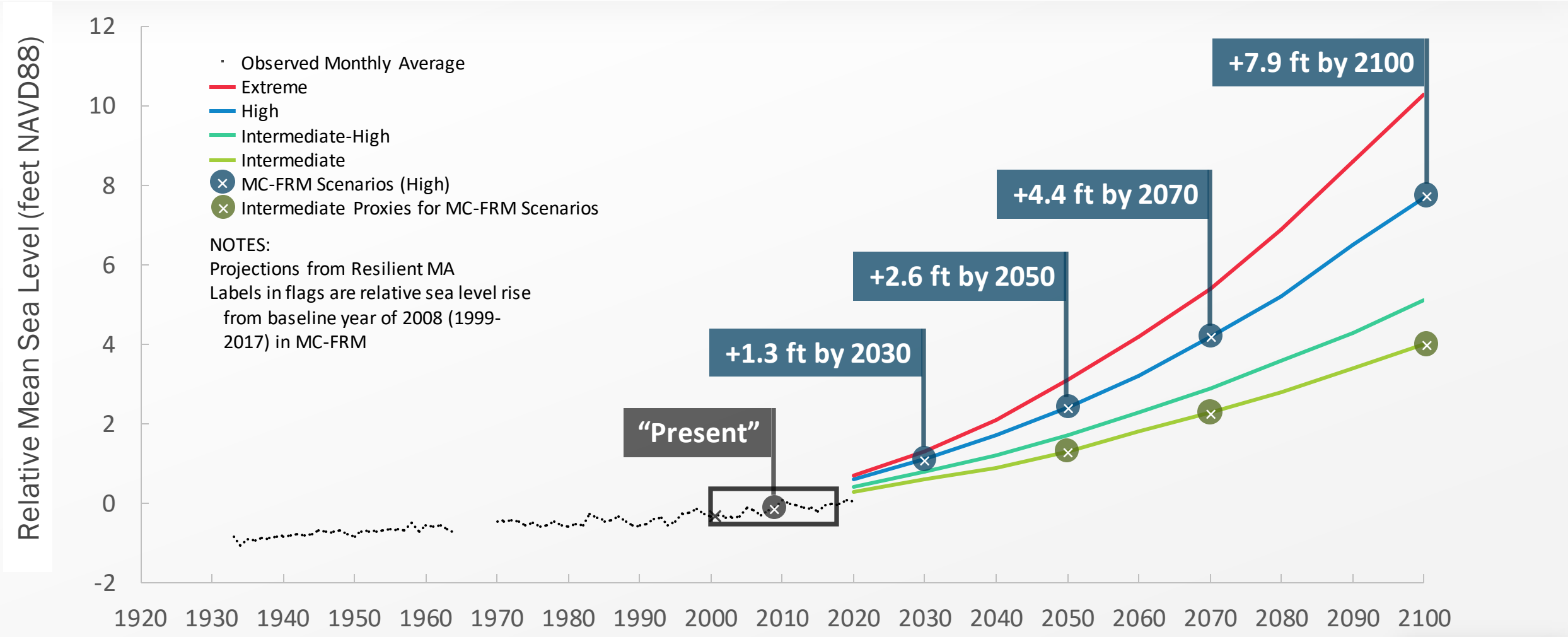
MA EOEEA Probabilistic Sea Level Rise Projections

MC-FRM SOUTH (DeConto & Kopp, 2017)



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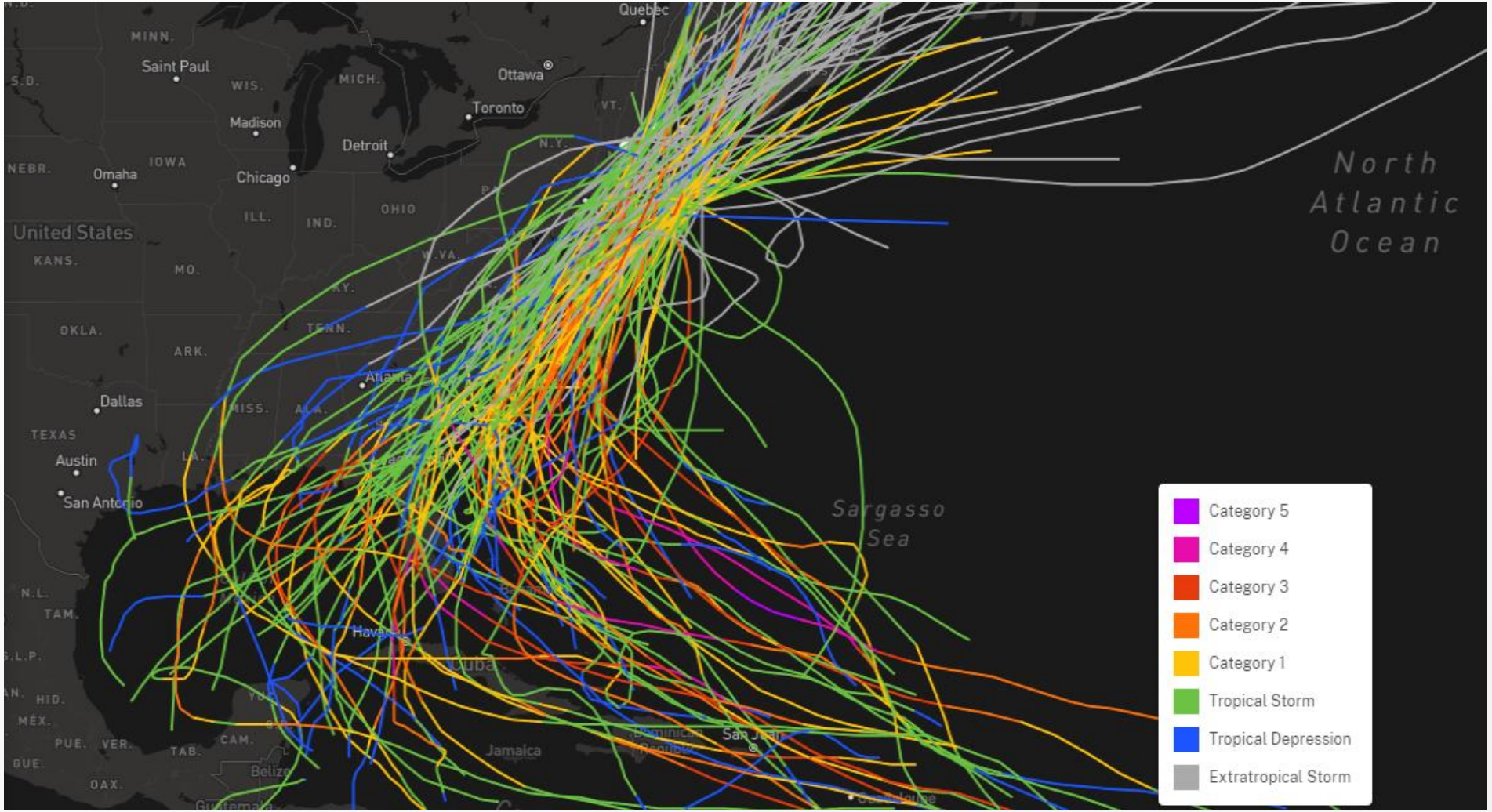
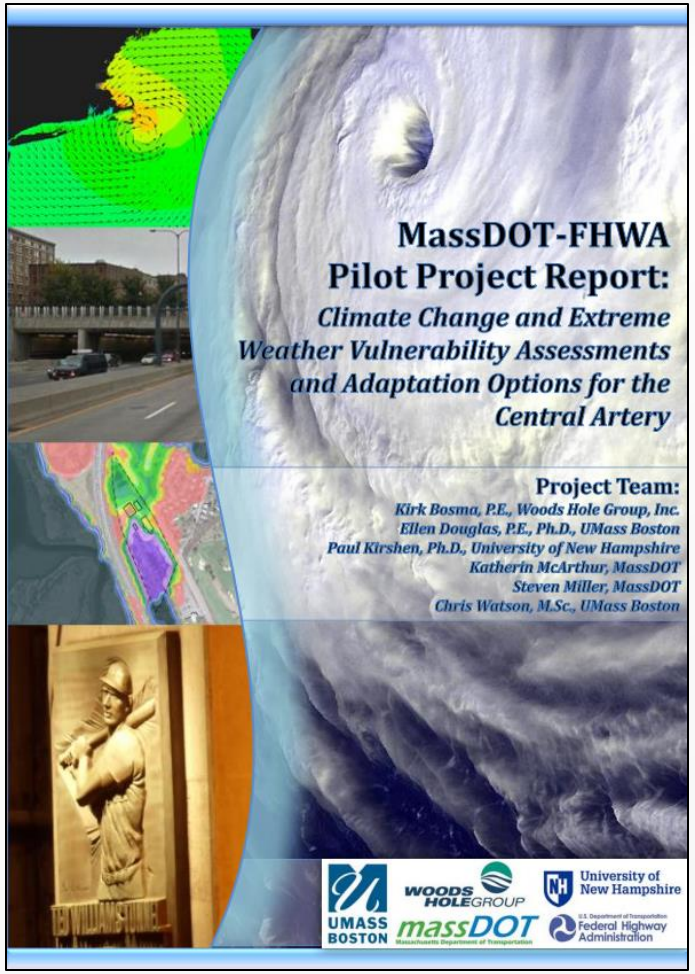
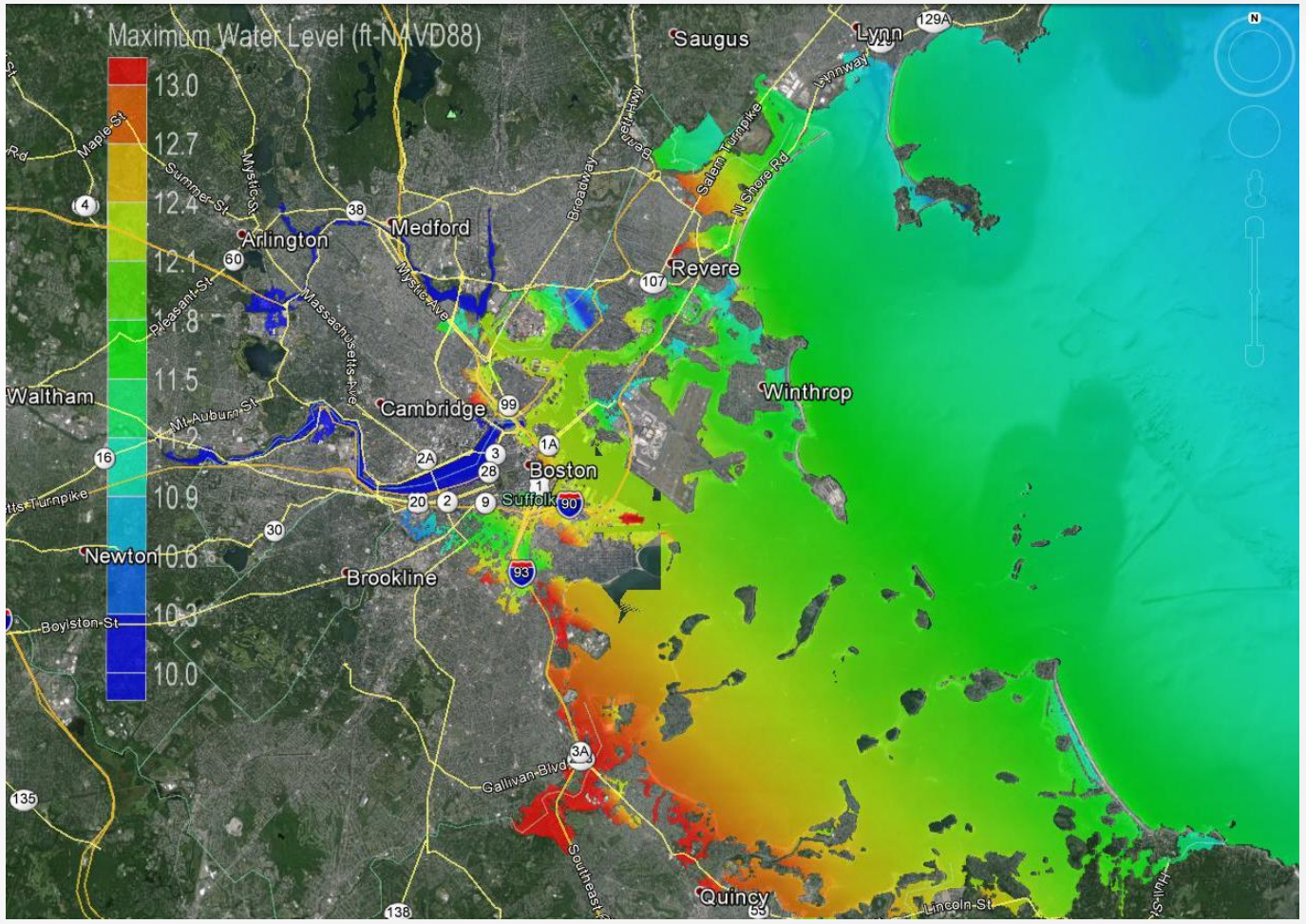
Tropical / Extra-tropical Storms



NOAA National Ocean Service

Why Hydrodynamic Modeling? Why Probabilistic?





Massachusetts Coast Flood Risk Model (MC-FRM)

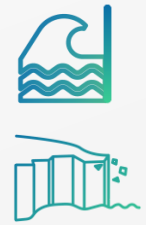
INPUTS

- 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



OUTPUTS

- FLOOD PROBABILITY
- FLOOD DEPTH
- FLOOD DURATION
- FLOOD VOLUMES
- FLOOD PATHWAYS
- WINDS
- WAVES
- CURRENTS

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MC-FRM Resolution - Wellfleet

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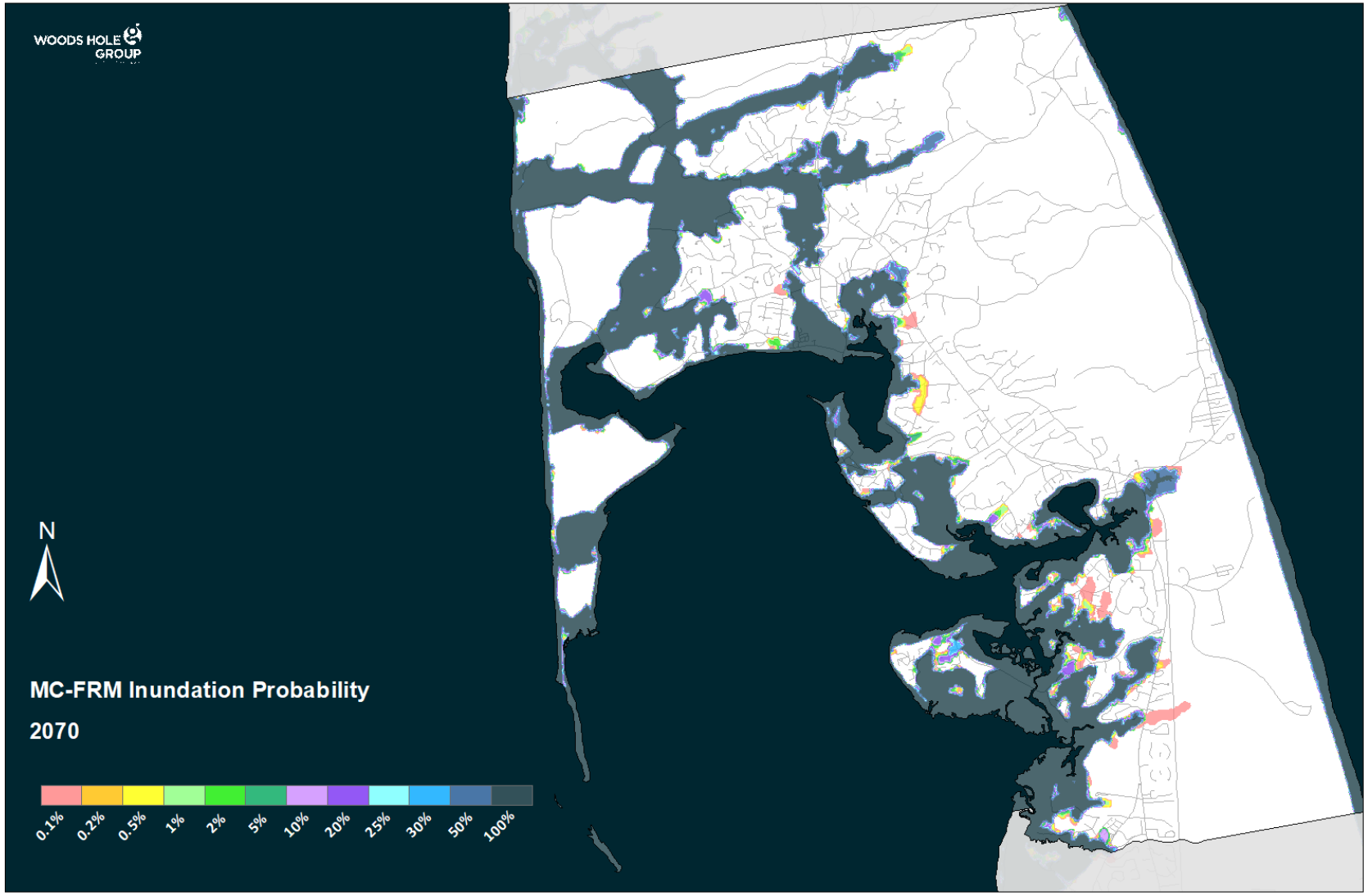
MC-FRM Coastal Flood Exceedance Probability – Wellfleet



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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?

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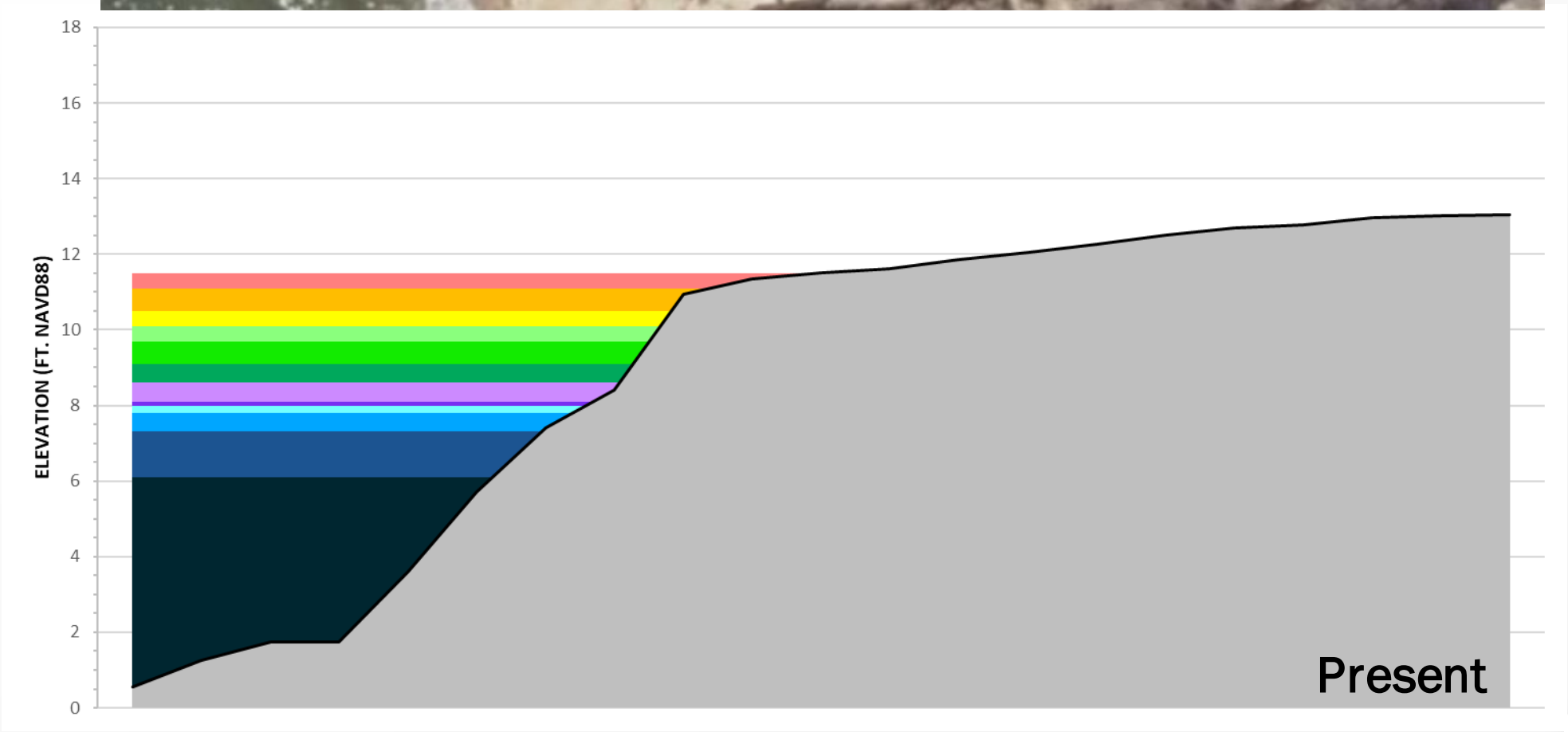
Cape Cod Low Lying Roads Vulnerability Assessment Methods



COASTAL FLOOD EXCEEDANCE PROBABILITY

0.1% 0.2% 0.5% 1% 2% 5% 10% 20% 25% 30% 50% 100%

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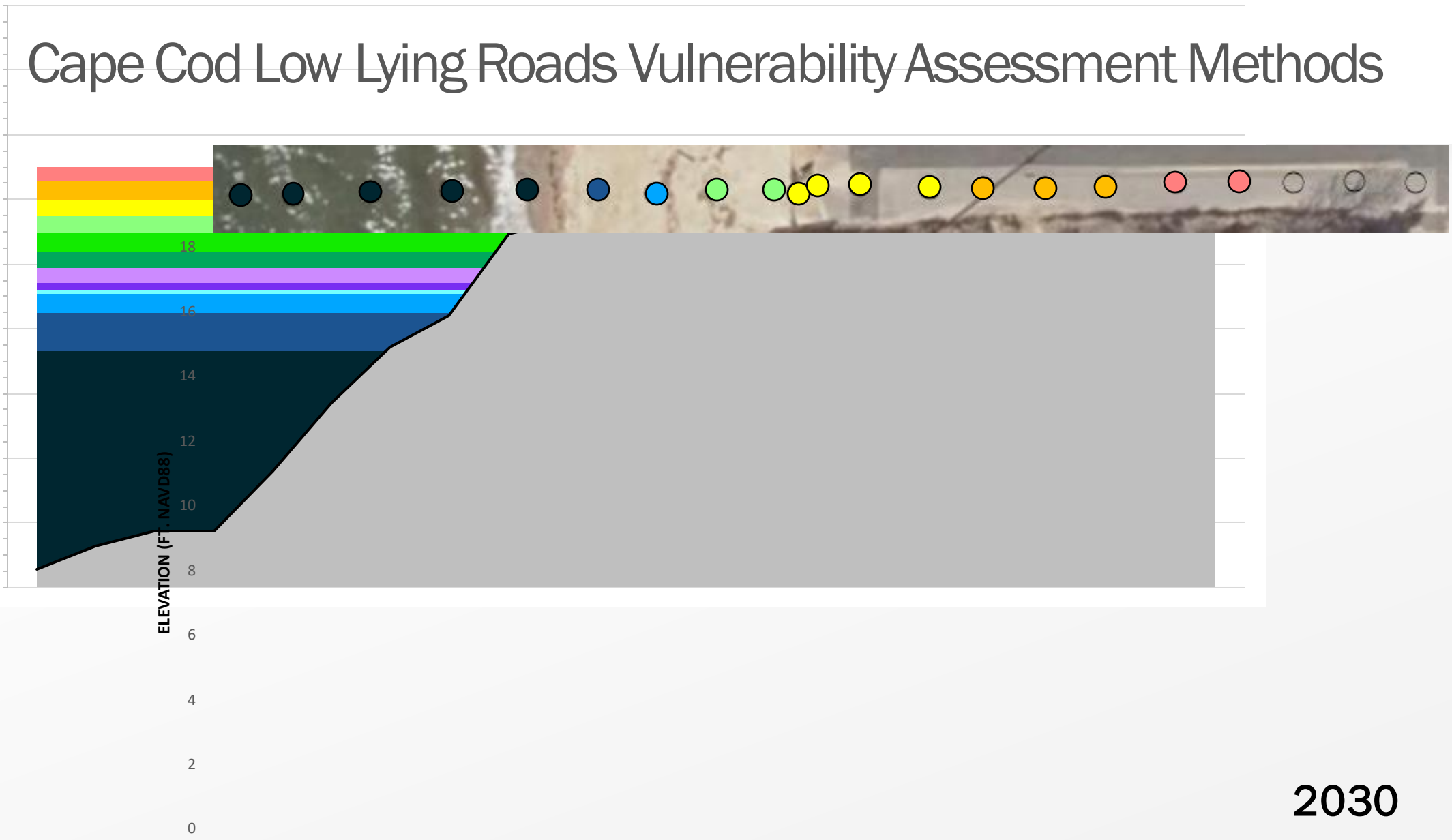
Cape Cod Low Lying Roads Vulnerability Assessment Methods



2030

COASTAL FLOOD EXCEEDANCE PROBABILITY

0.1% 0.2% 0.5% 1% 2% 5% 10% 20% 25% 30% 50% 100%

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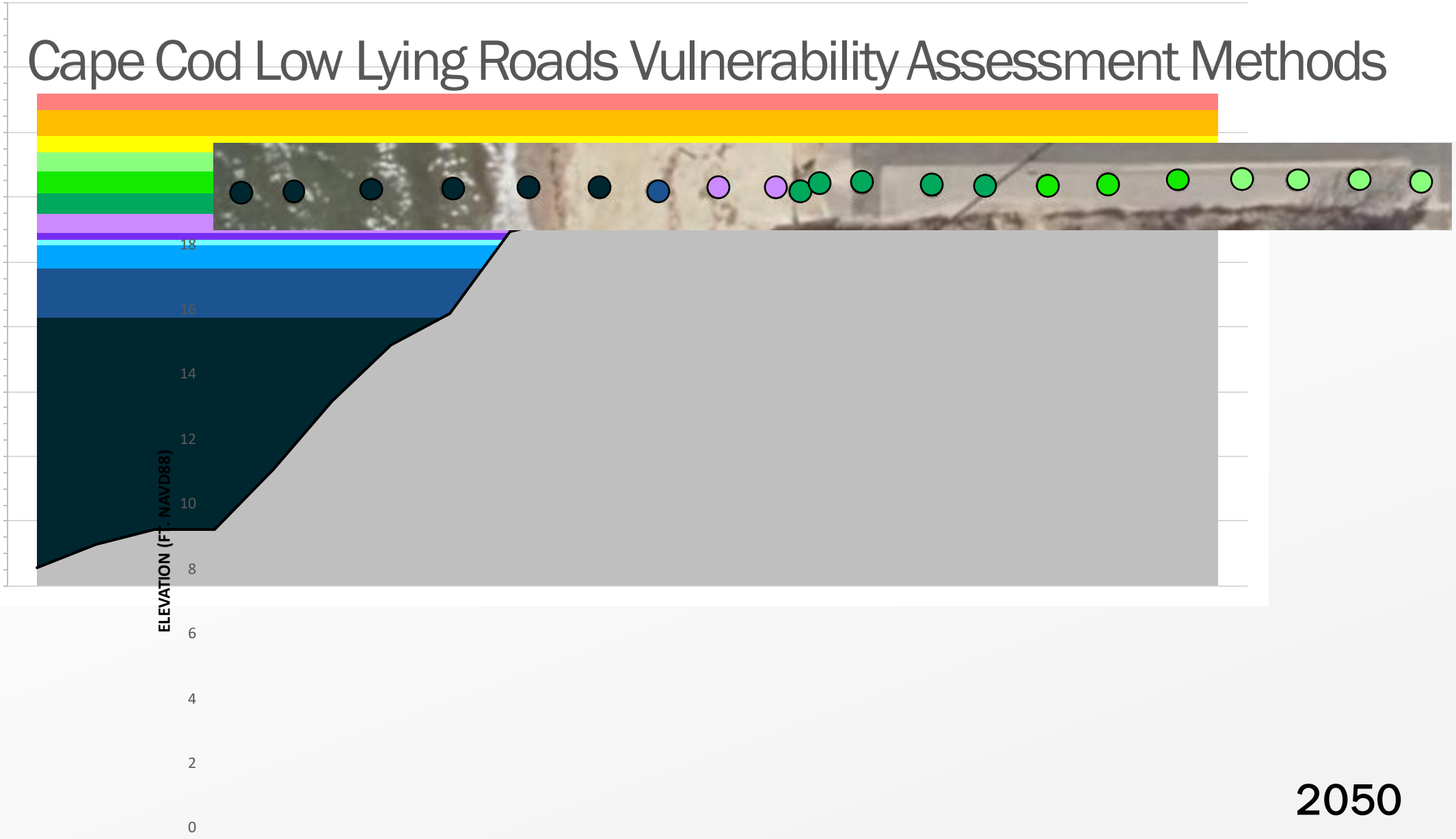

2050

COASTAL FLOOD EXCEEDANCE PROBABILITY

0.1% 0.2% 0.5% 1% 2% 5% 10% 20% 25% 30% 50% 100%

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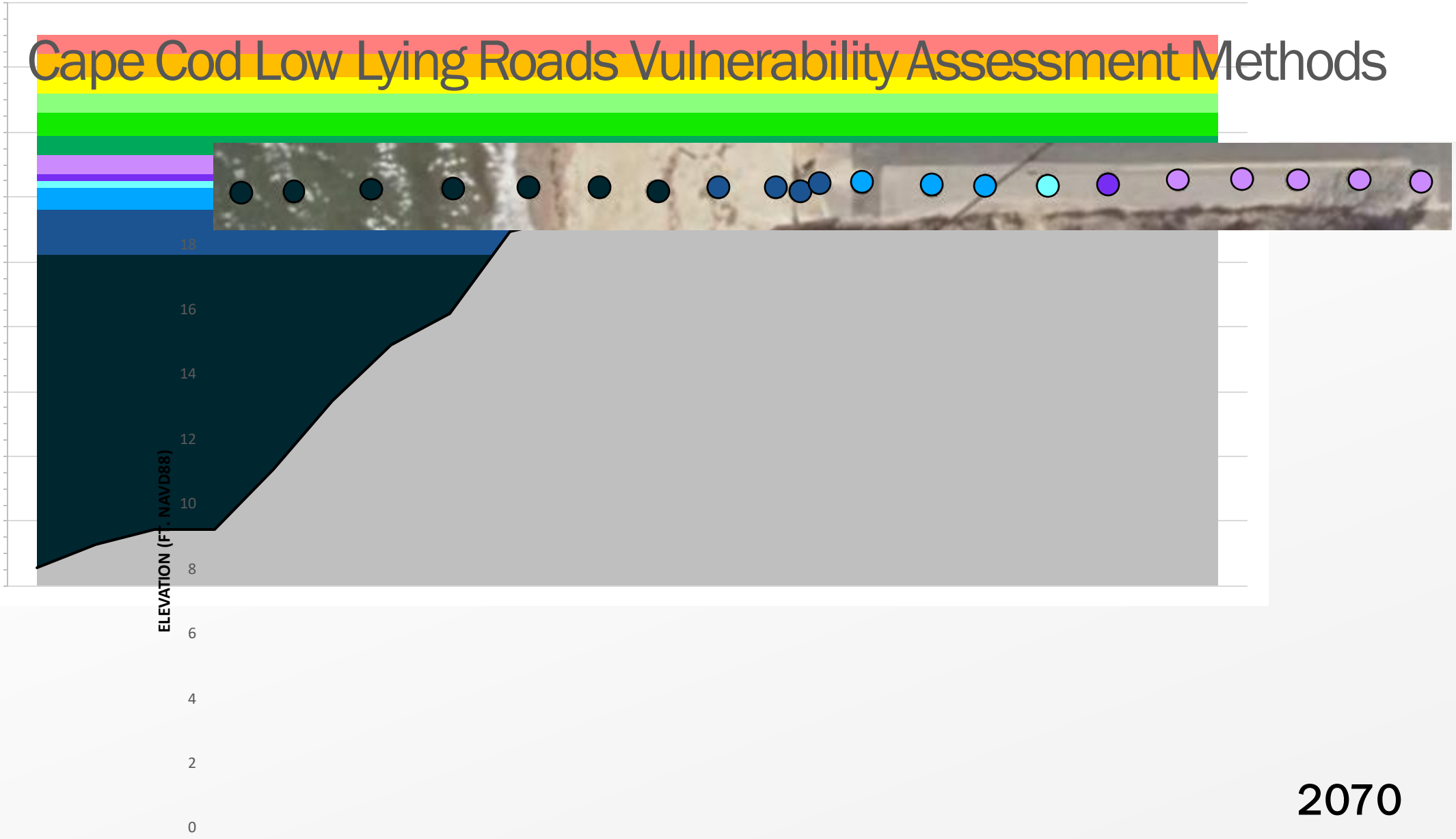
Cape Cod Low Lying Roads Vulnerability Assessment Methods



2070

COASTAL FLOOD EXCEEDANCE PROBABILITY

0.1% 0.2% 0.5% 1% 2% 5% 10% 20% 25% 30% 50% 100%

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Cape Cod Low Lying Roads Criticality Scoring Framework

Community / Emergency Services

Schools
Town Hall
Transit Facilities
Senior Services
Communications
Community Centers
Hospital / Urgent Care
Police Station
Fire Station
Harbormaster Office
Emergency Shelters
DPW Facilities

Usage/Network Function

MassDOT Functional Classification
Average Annual Daily Traffic

Vulnerable Populations

Environmental Justice Populations
Social Vulnerability Index (Housing /Transportation)

Economy

Business Activity Density

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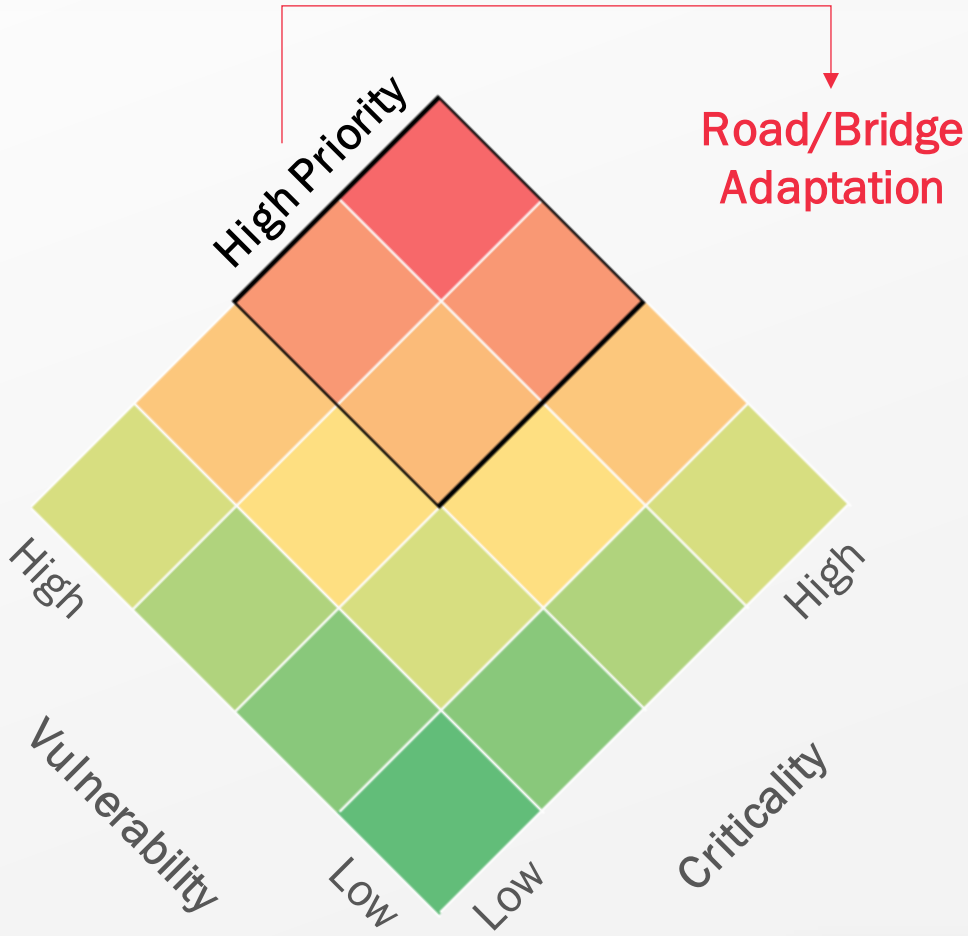
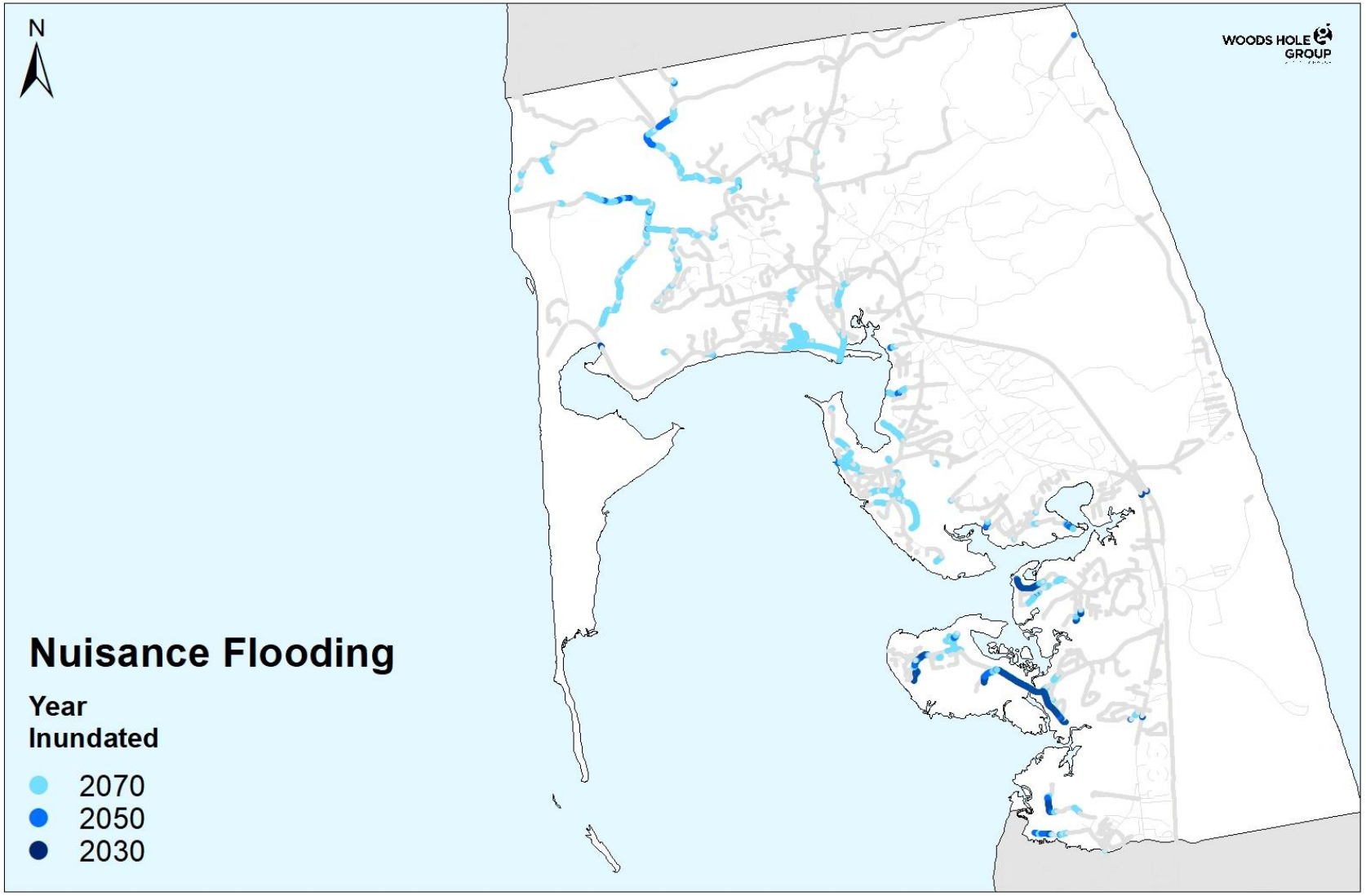
Cape Cod Low Lying Roads Risk Assessment Approach

1. Extract roadway/bridge critical elevations (CEs)
   - From LiDAR at 20m interval along surface
2. Compile 2030/2050/2070 MC-FRM water surface elevations (WSEs)
   - 0.1%, 0.2%, 0.5%, 1%, 2%, 5%, 10%, 20%, 100%
3. Compare CEs to WSEs to determine vulnerability
   - Highest probability WSE exceeding CE
4. Score road segment criticality
   - Usage/Network Function
   - Economy
   - Vulnerable Populations
   - Community and Emergency Services
5. Probability * Criticality = Risk
6. Prioritize high-risk road segments for community consideration



Low Lying Roads Nuisance (MHW) Flooding (Wellfleet)



Road Miles 2030

1.4/136.5

Road Miles 2050

2.3/136.5

Road Miles 2070

9.4/136.5

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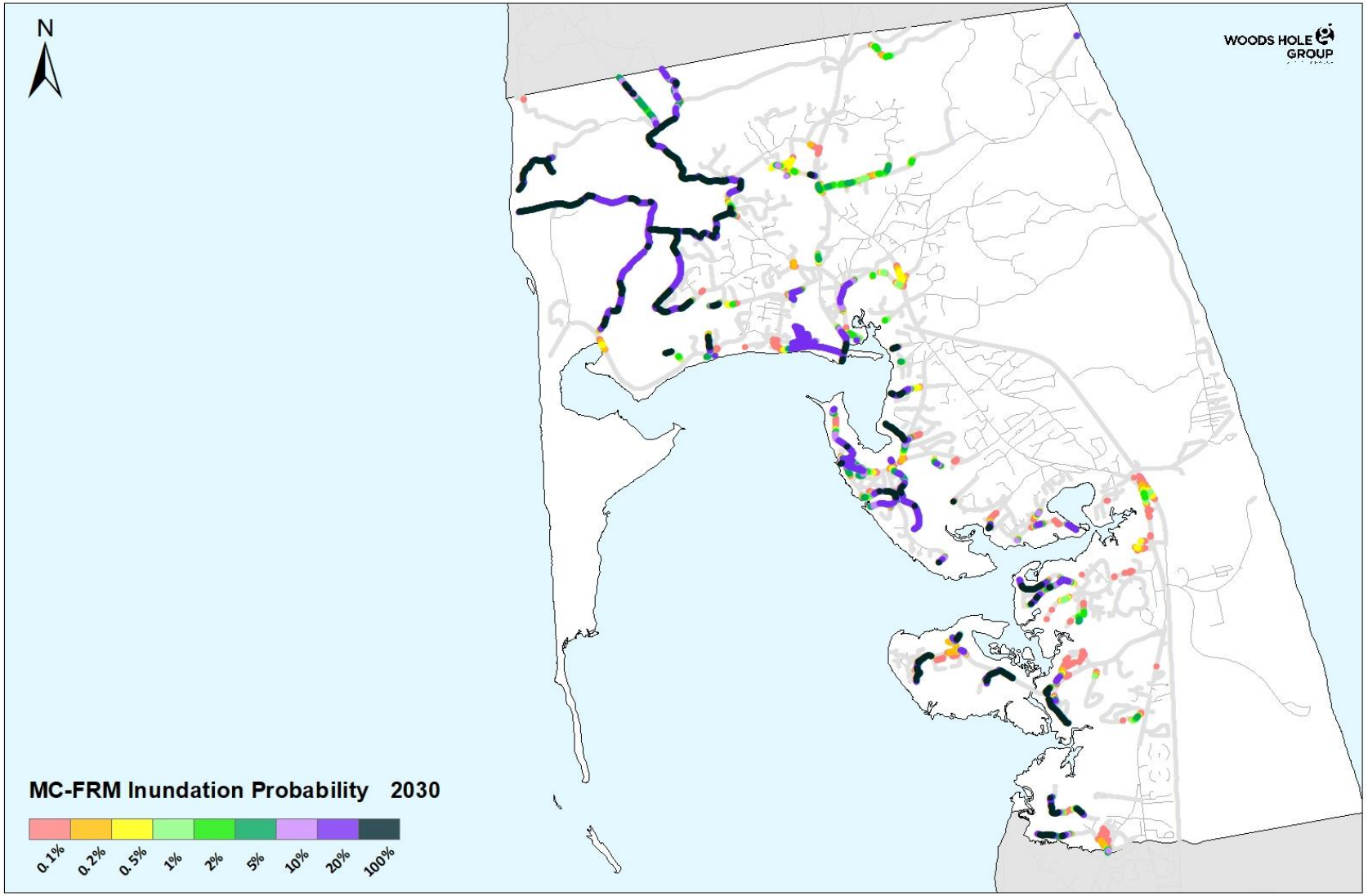
Low Lying Roads 2030 Inundation Probability (Wellfleet)



	%	Road miles
	0.1	21.1
	0.2	18.4
	0.5	17.2
	1	16.2
	2	15.4
	5	14.2
	10	12.9
	20	11.6
	100	5.0

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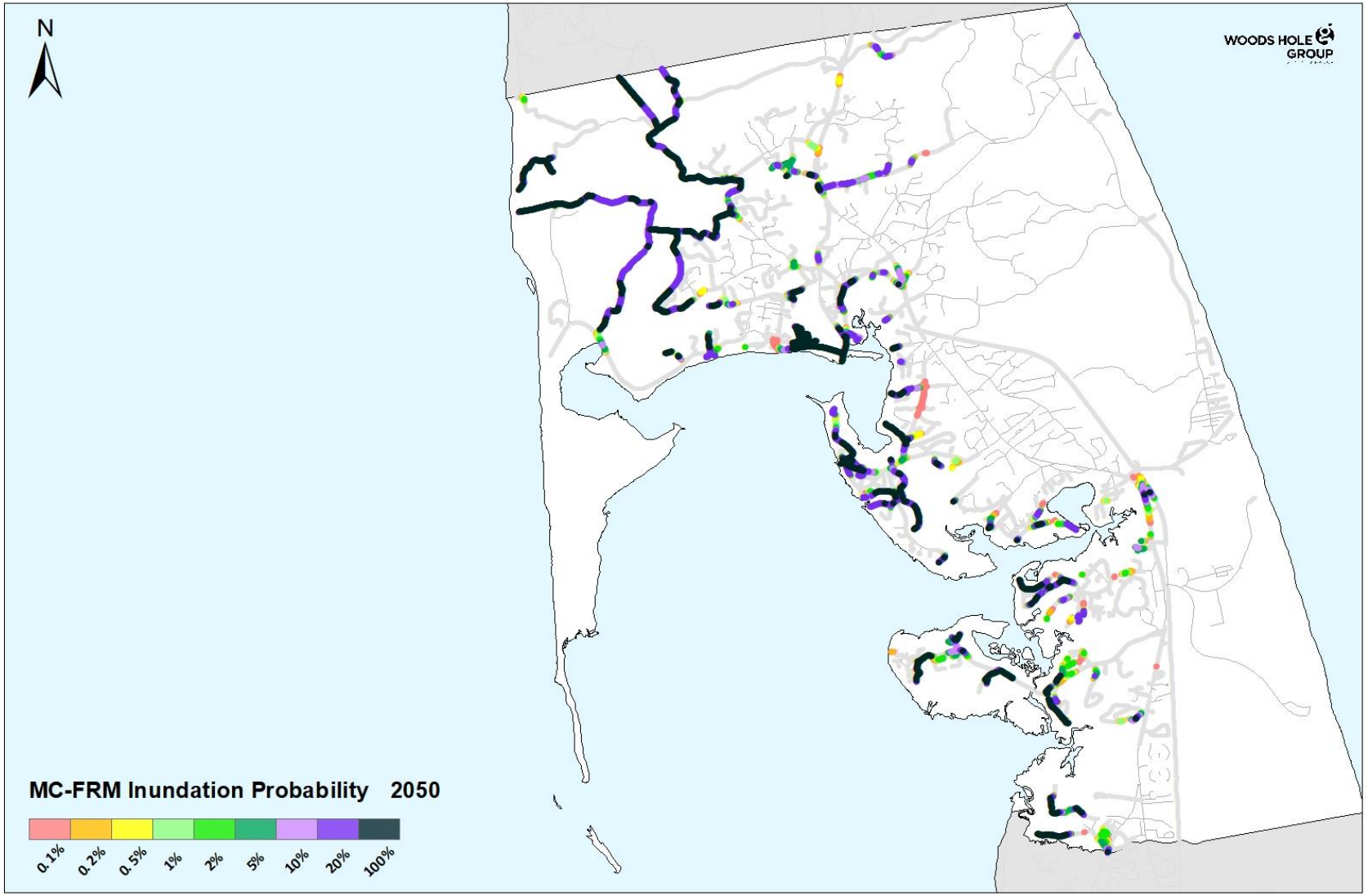
Low Lying Roads 2050 Inundation Probability (Wellfleet)



	%	Road miles
	0.1	24.1
	0.2	22.9
	0.5	21.7
	1	20.8
	2	19.9
	5	18.4
	10	16.9
	20	15.5
	100	8.8

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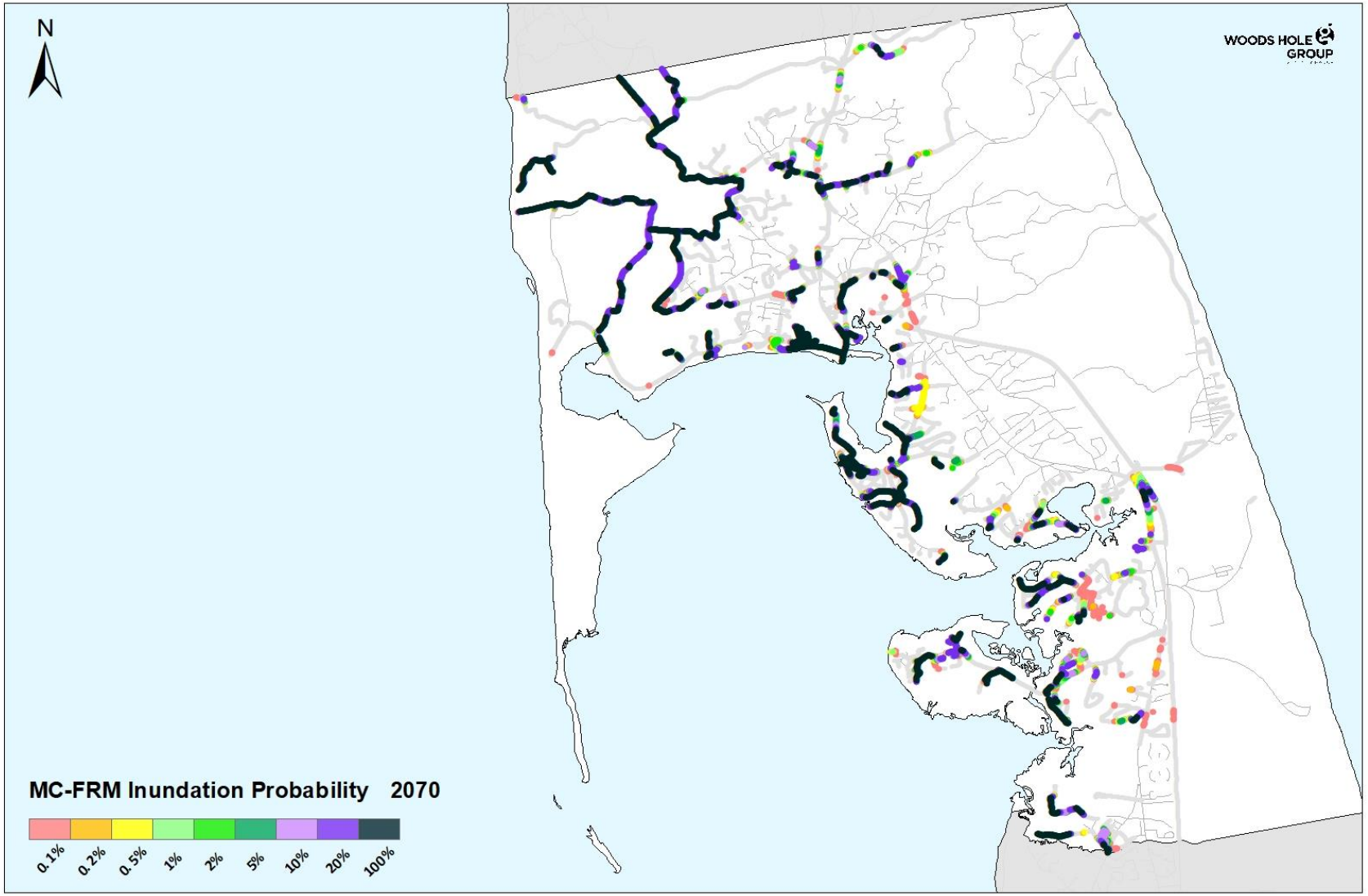
Low Lying Roads 2070 Inundation Probability (Wellfleet)



%	Road miles
0.1	28.6
0.2	26.0
0.5	25.1
1	24.2
2	22.9
5	21.7
10	20.7
20	19.3
100	12.8

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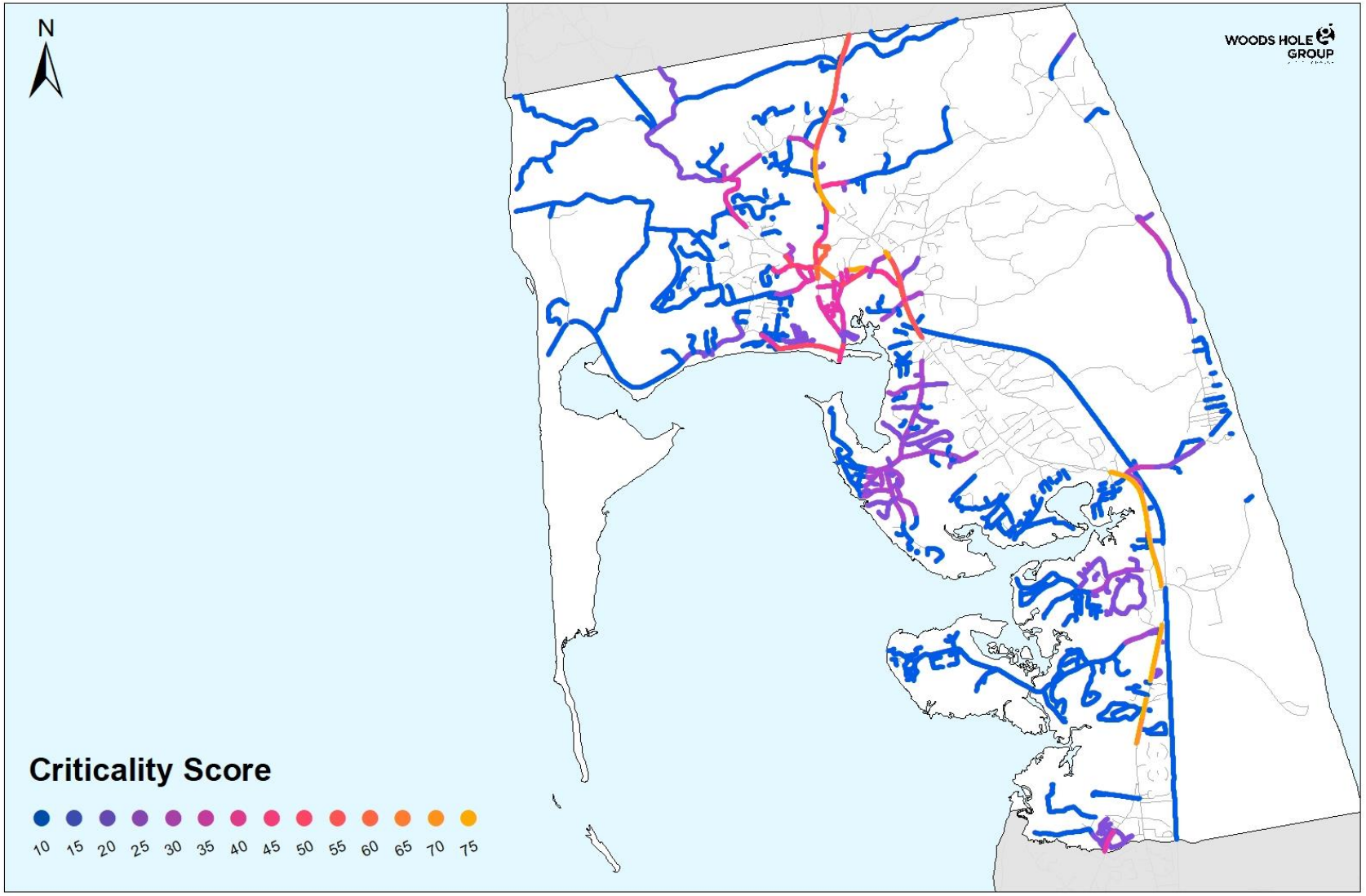
Low Lying Roads Criticality Scoring (Wellfleet)



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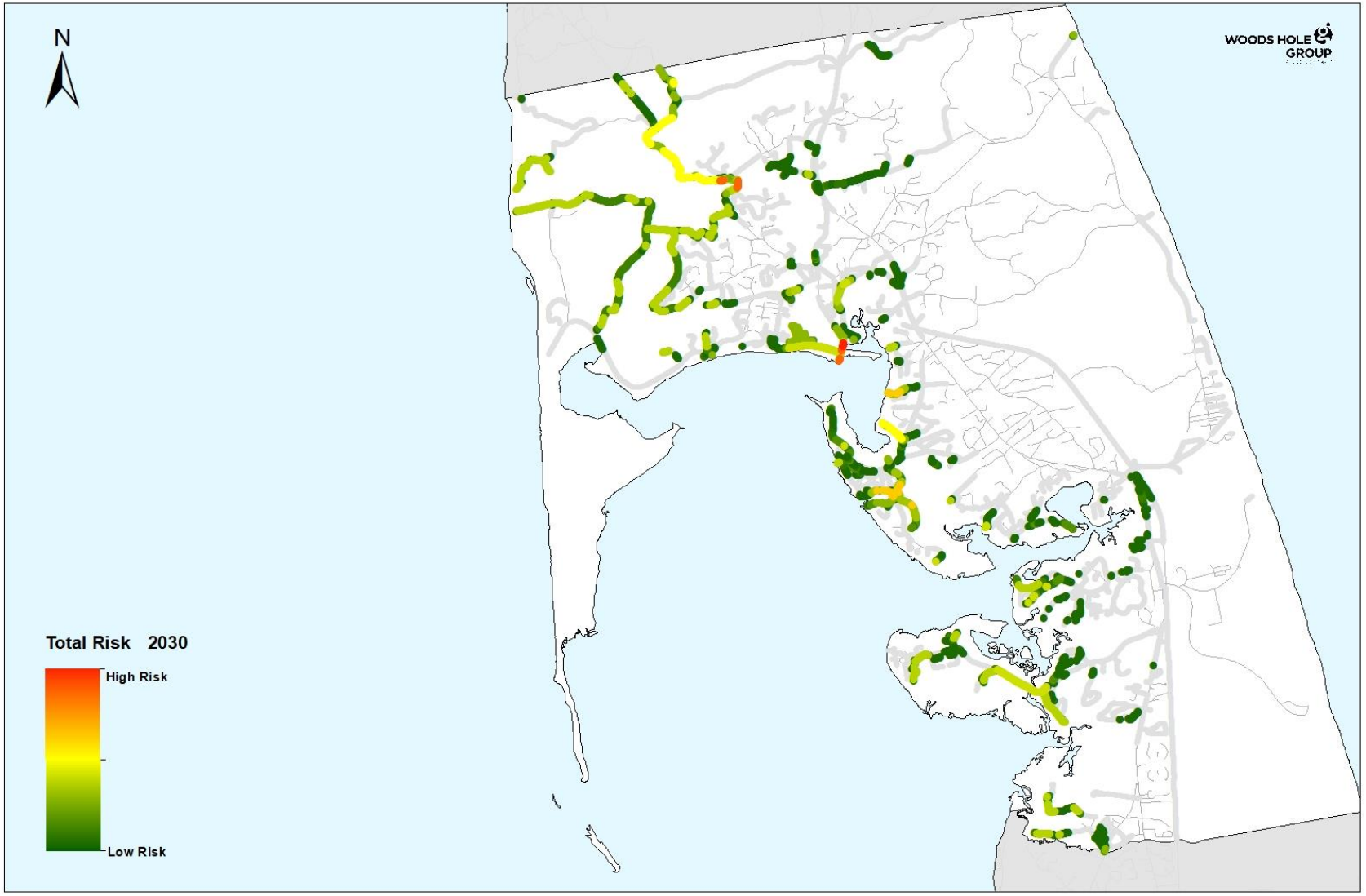
Low Lying Roads 2030 Risk Results (Wellfleet)



High Risk Road Segments

Commercial St (Town Pier)

Herring River Restoration Roads+

King Phillip Rd (Paine Hollow)

Old Pier Rd (Wellfleet Harbor)

East Commercial St (Downtown)

Lieutenant Island Rd

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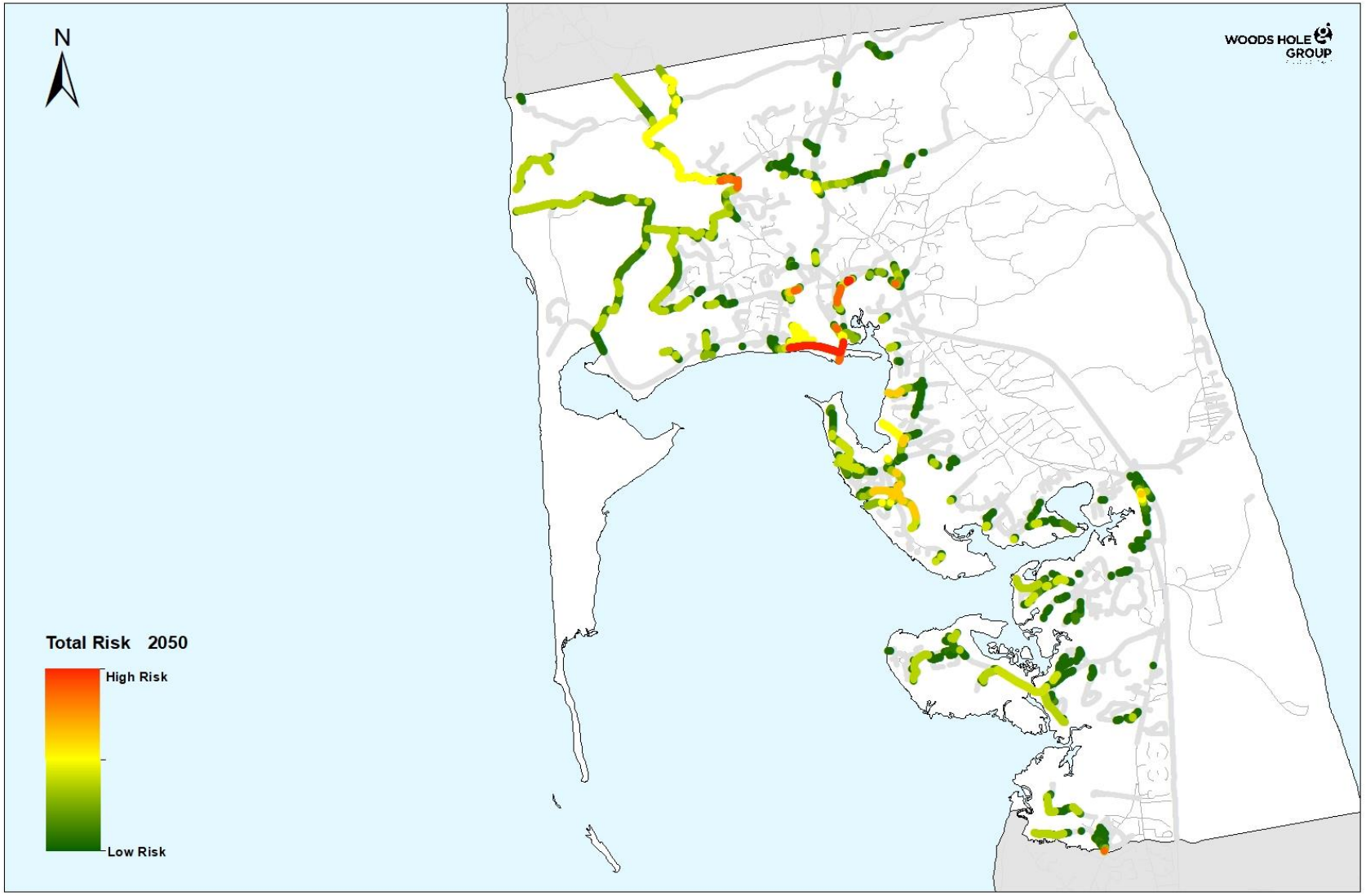
Low Lying Roads 2050 Risk Results (Wellfleet)



High Risk Road Segments

Commercial St (Town Pier)

Herring River Restoration Roads+

King Phillip Rd (Paine Hollow)

Old Pier Rd (Wellfleet Harbor)

East Commercial St (Downtown)

Lieutenant Island Rd

Route 6 at Black Fish Creek*

Main St (Downtown)

Chequessett Neck Rd (Davey's Path)

Holbrook Ave (Downtown)

Cove Rd (Chipman's Cove)

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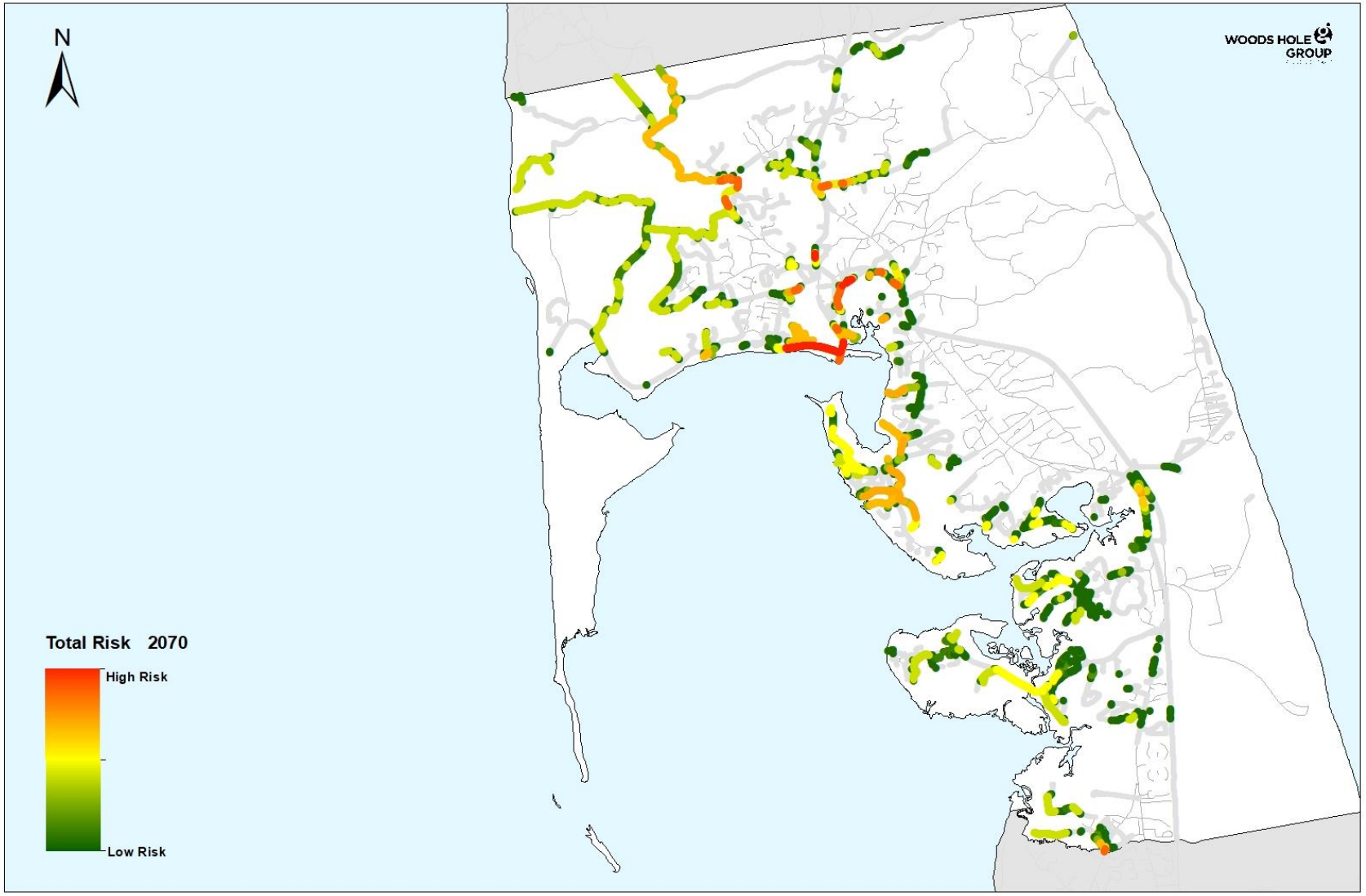
Low Lying Roads 2070 Risk Results (Wellfleet)



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King Phillip Rd (Paine Hollow)
Old Pier Rd (Wellfleet Harbor)
East Commercial St (Downtown)
Lieutenant Island Rd

Route 6 at Black Fish Creek*
Main St (Downtown)
Chequessett Neck Rd (Davey's Path)
Holbrook Ave (Downtown)
Cove Rd (Chipman's Cove)

Briar Ln (Squires Pond)
Gull Pond Rd and Route 6*
West Rd
Old Wharf Rd
Dike Bridge (Herring River)+

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Summary of High Priority Road Segments (Wellfleet)

	Name	Length (ft)	Description	Segment Storm Probability (%)			Nuisance Length (ft)		
				2030	2050	2070	2030	2050	2070
A	Commercial St (Town Pier)	3840	Leading south to Wellfleet Harbor	0.1-100	2-100	10-100	20	20	3420
B	Herring River Restoration Roads+	8020	Bound Brook Is, Old County, Coles Neck, Pole Dike Rd	0.1-100	0.5-100	20-100		1240	4800
C	King Phillip Rd (Paine Hollow)	380	Access to neighborhoods	0-100	1-100	5-100			260
D	Old Pier Rd (Wellfleet Harbor)	740	Off of Cove Rd on east side of Wellfleet Harbor	5-100	20-100	20-100		180	740
E	East Commercial St (Downtown)	1540	Access to downtown and Town landing	0.1-20	2-100	20-100			820
F	Lieutenant Island Rd	2340	Including bridge to Lieutenant Island	0.2-100	5-100	20-100	1900	2100	2240
G	Route 6 at Black Fish Creek*	520	Route 6 segment over Blackfish Creek	0.2-2	10-100	100			
H	Main St (Downtown)	340	Access to downtown from Route 6	0.1-1	2-100	100			
I	Chequessett Neck Rd (Davey's Path)	460	Access to neighborhoods	0.5-20	10-100	100			280
J	Holbrook Ave (Downtown)	600	Access to downtown	5-20	20-100	20-100			400
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M	Gull Pond Rd and Route 6*	1740	Access to Atlantic beaches, plus Route 6 intersection	0.1-5	1-20	20-100			
N	West Rd	200	Access to homes and Town boundary	0.2-10	5-100	20-100			
O	Old Wharf Rd	580	Access to homes on Old Wharf Pt	0.5-20	5-100	20-100			280
P	Dike Bridge (Herring River)+	600	Dike Bridge over Herring River	0-0.5	1-10	10-100			

+ = Herring River Restoration Project

* = MassDOT roadway

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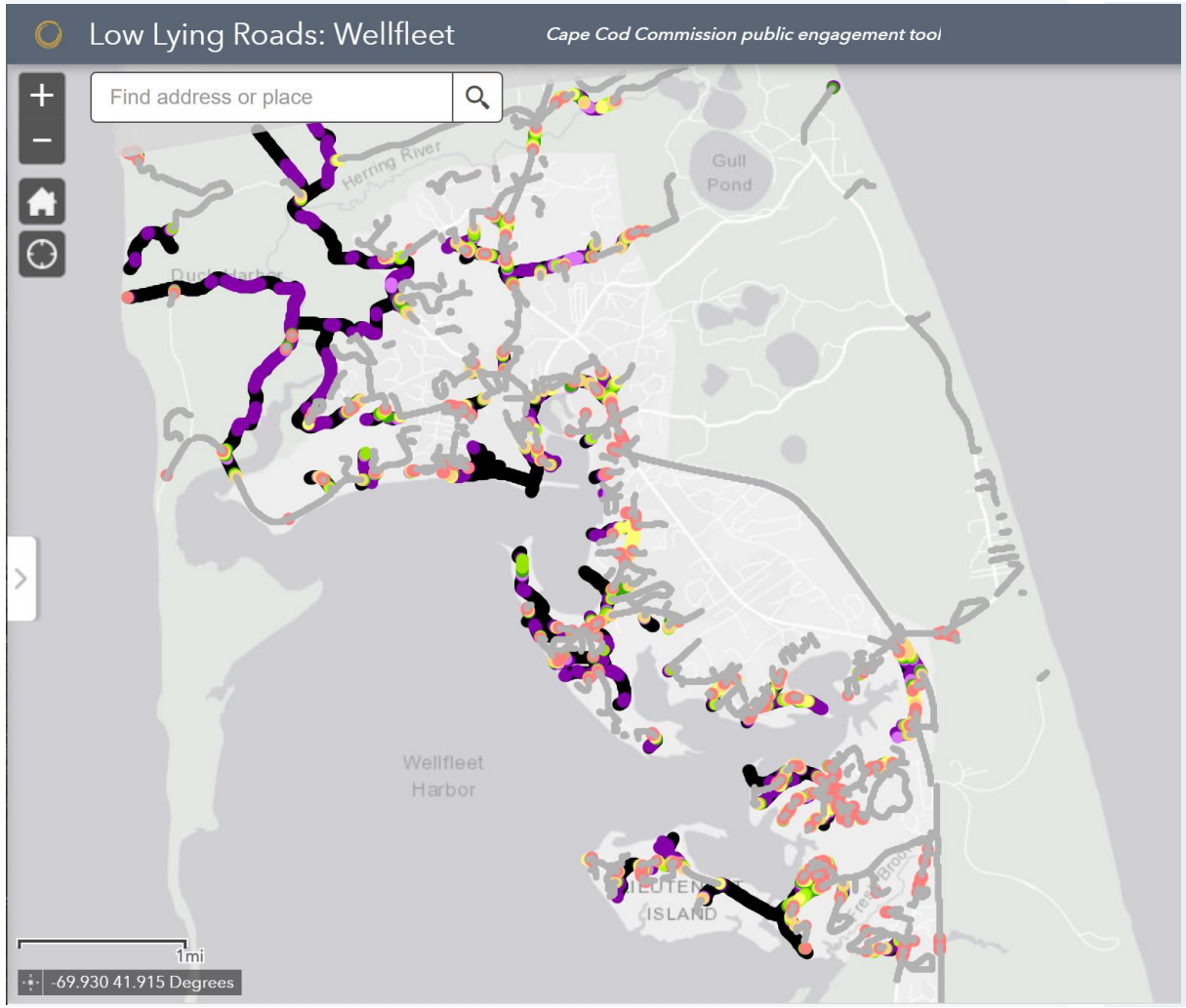
LOW LYING ROADS

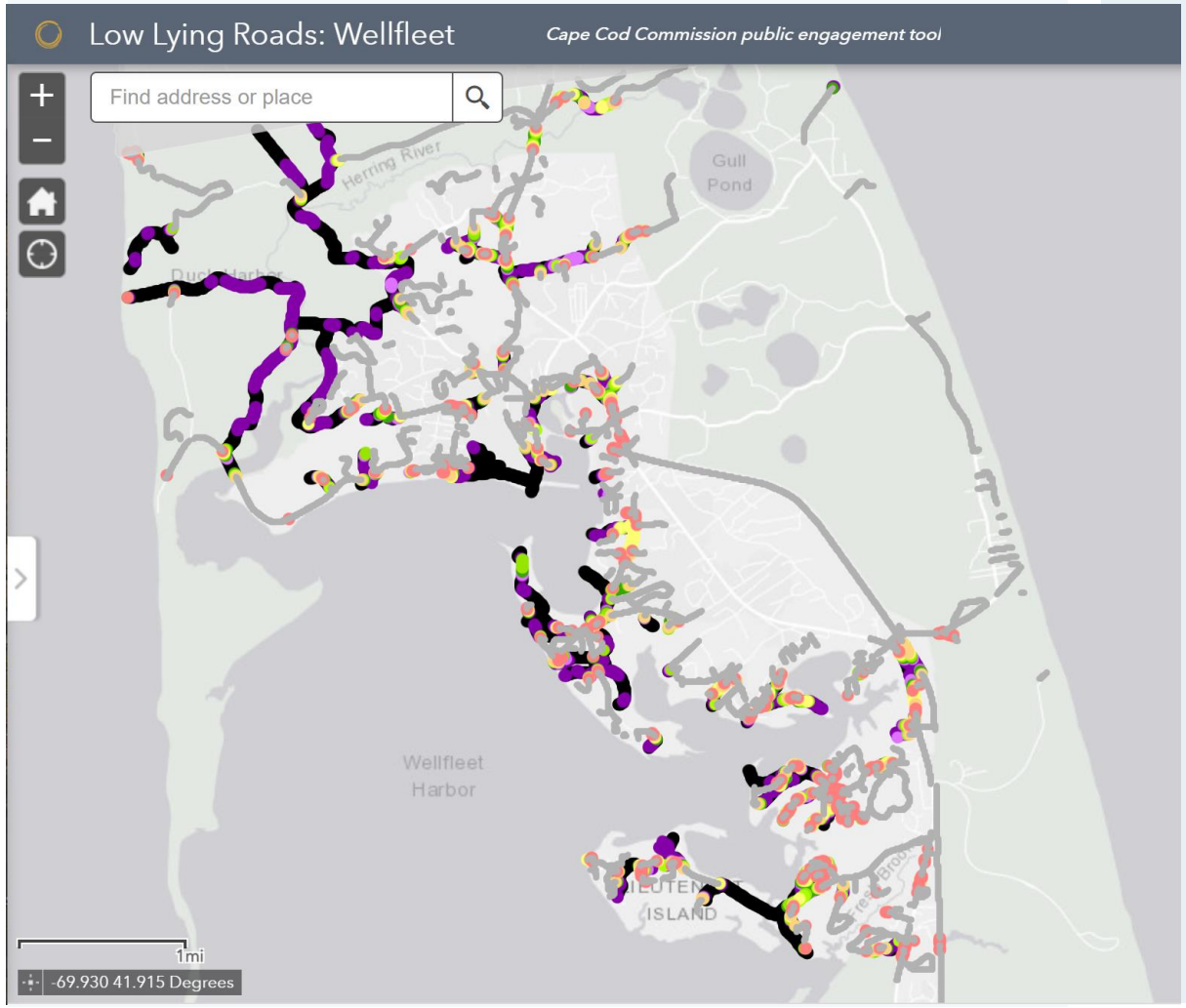
Group Discussion



DISCUSSION ORIENTATION

LOW LYING ROADS

Group Discussion



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 (Wellfleet)

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+ = Herring River Restoration Project

* = MassDOT roadway

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Breakout Groups

Breakout Group Discussion

GETTING STARTED

- Introductions
- Clarifying Questions

CONSIDERATIONS…

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?
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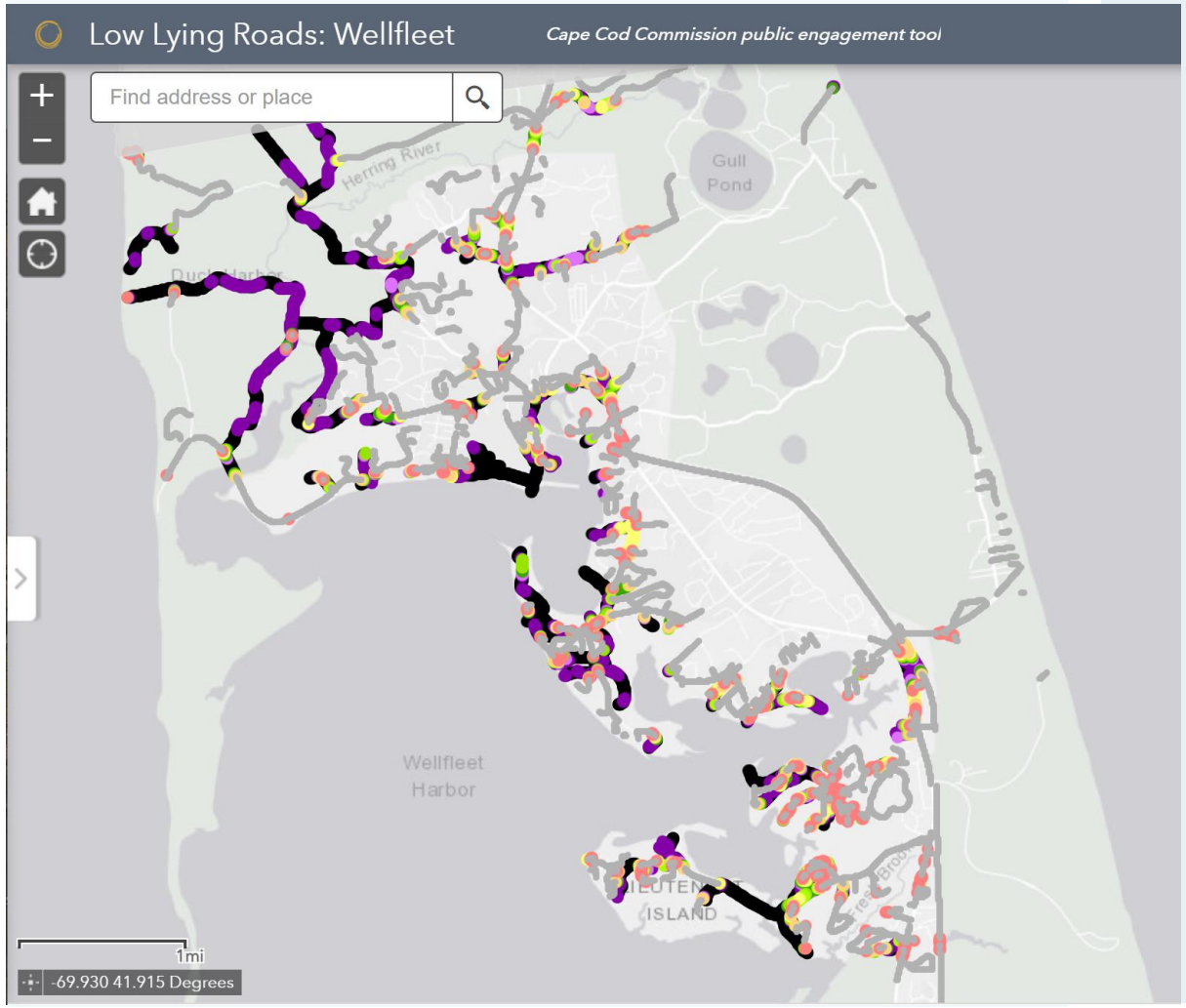
Summary: Vulnerability and Risk Analysis



- MC FRM
  - Data: SLR, Storms, Tides, Elevations
  - Flood projections 2030, 2050, 2070
- Road network vulnerable to flooding
- Criticality of road network to community
- Risk = probability x criticality

Summary of High Priority Road Segments (Wellfleet)

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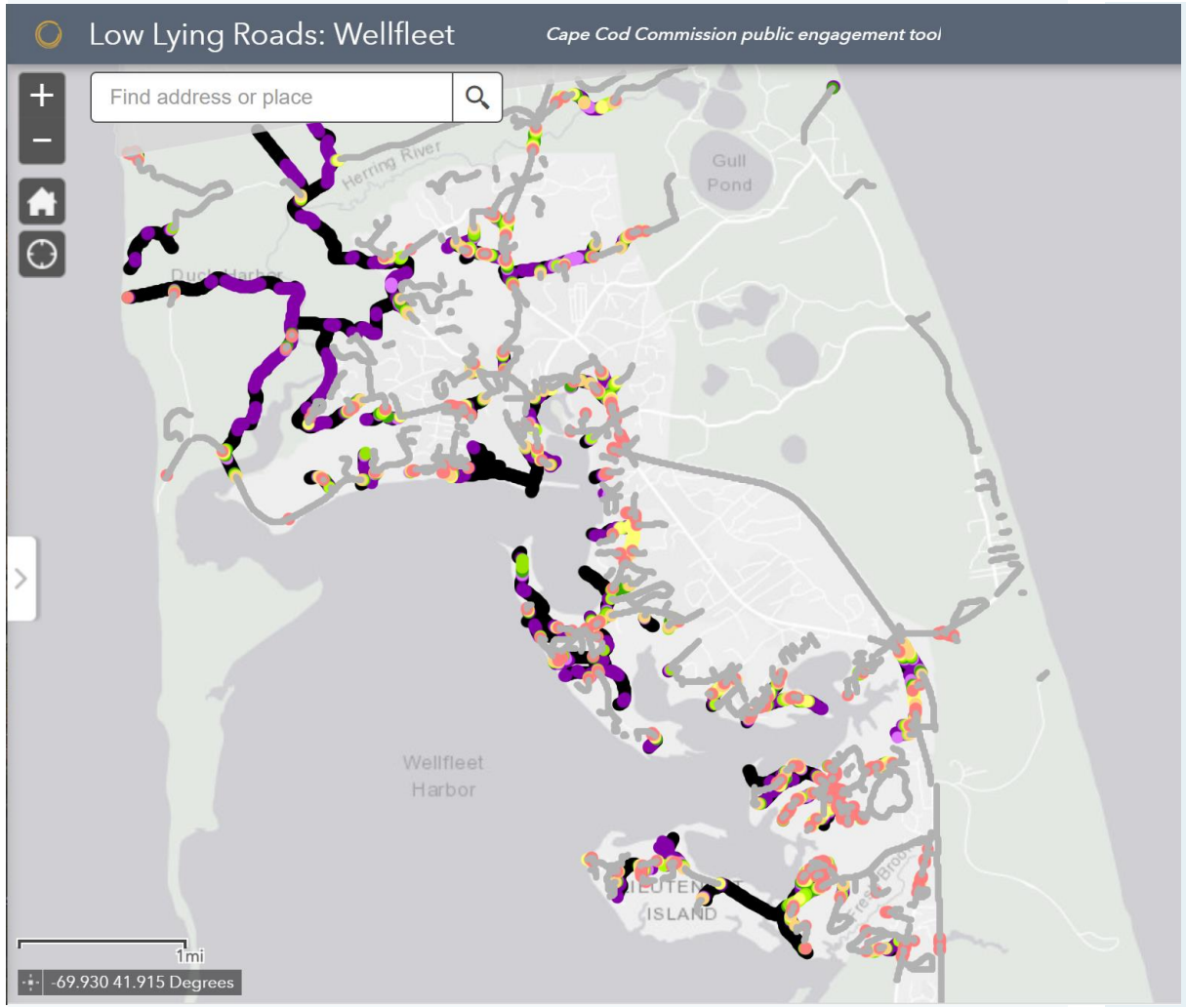
LOW LYING ROADS

Group Discussion



REPORT BACK

SYNTHESIS

NEXT STEPS

- Town staff to select 4 road segments
- Feasibility analysis
- 3 solutions + costs per segment
- Solutions available to view on Low Lying Road webpage later in 2022: https://www.capecodcommission.org/our-work/low-lying-roads-project/
- 2nd Workshop date TBD – winter 2023

THANK YOU!