



# Low-lying Roads: Brewster

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Project funded by the  
Municipal Vulnerability  
Preparedness Program

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# Purpose and Objectives of Public Meeting

- **Overview of Low-lying Roads Project**
- **Review adaptation alternatives for priority low-lying roads**
- **Discuss advantages and disadvantages of green, gray, and hybrid alternatives**

# Agenda

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- Project Overview
- Presentation of conceptual design alternatives
  - Route 6A at Betty's Curve
  - Lower Road
  - Route 6A at Quivett Creek
- Questions, comments, and discussion
- Next Steps

# Low Lying Roads



**10**  
TOWNS

- |            |           |
|------------|-----------|
| Barnstable | Orleans   |
| Bourne     | Sandwich  |
| Brewster   | Truro     |
| Dennis     | Wellfleet |
| Eastham    | Yarmouth  |



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



# PROJECT TIMELINE



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# Additional Context & Information

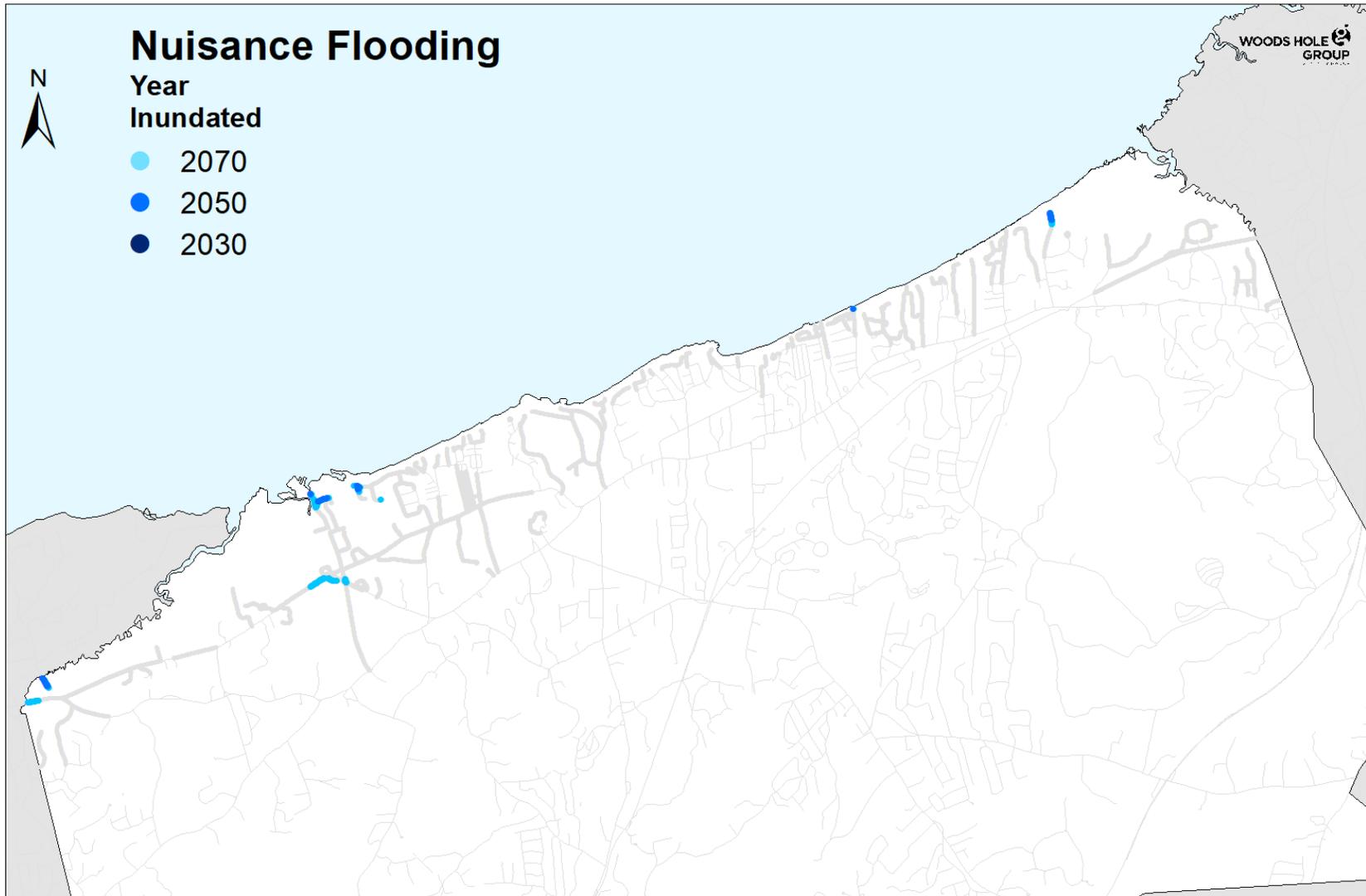
- **Detailed information on webpages:**

<https://www.capecodcommission.org/our-work/low-lying-roads-project/>

- **Clarifying questions**
- **Format for meeting**



# Low Lying Roads Nuisance Flooding (Brewster)



Road Miles 2030

0.0/24.8

Road Miles 2050

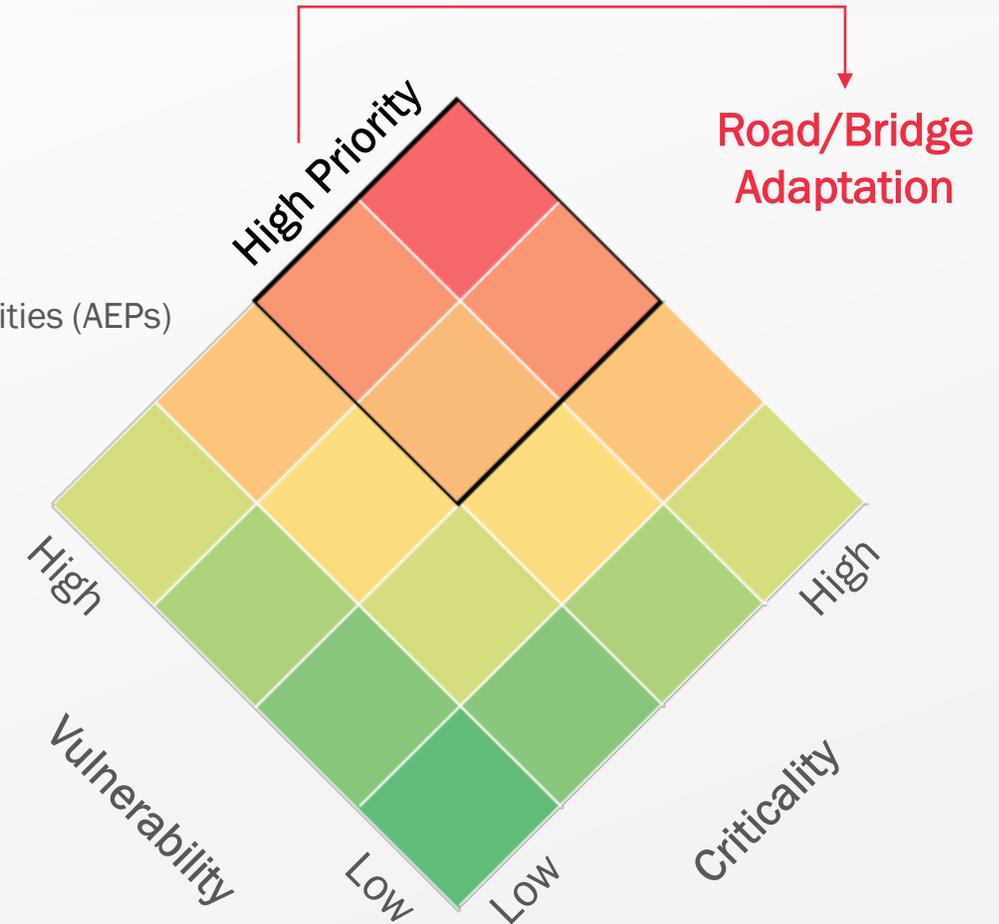
0.2/24.8

Road Miles 2070

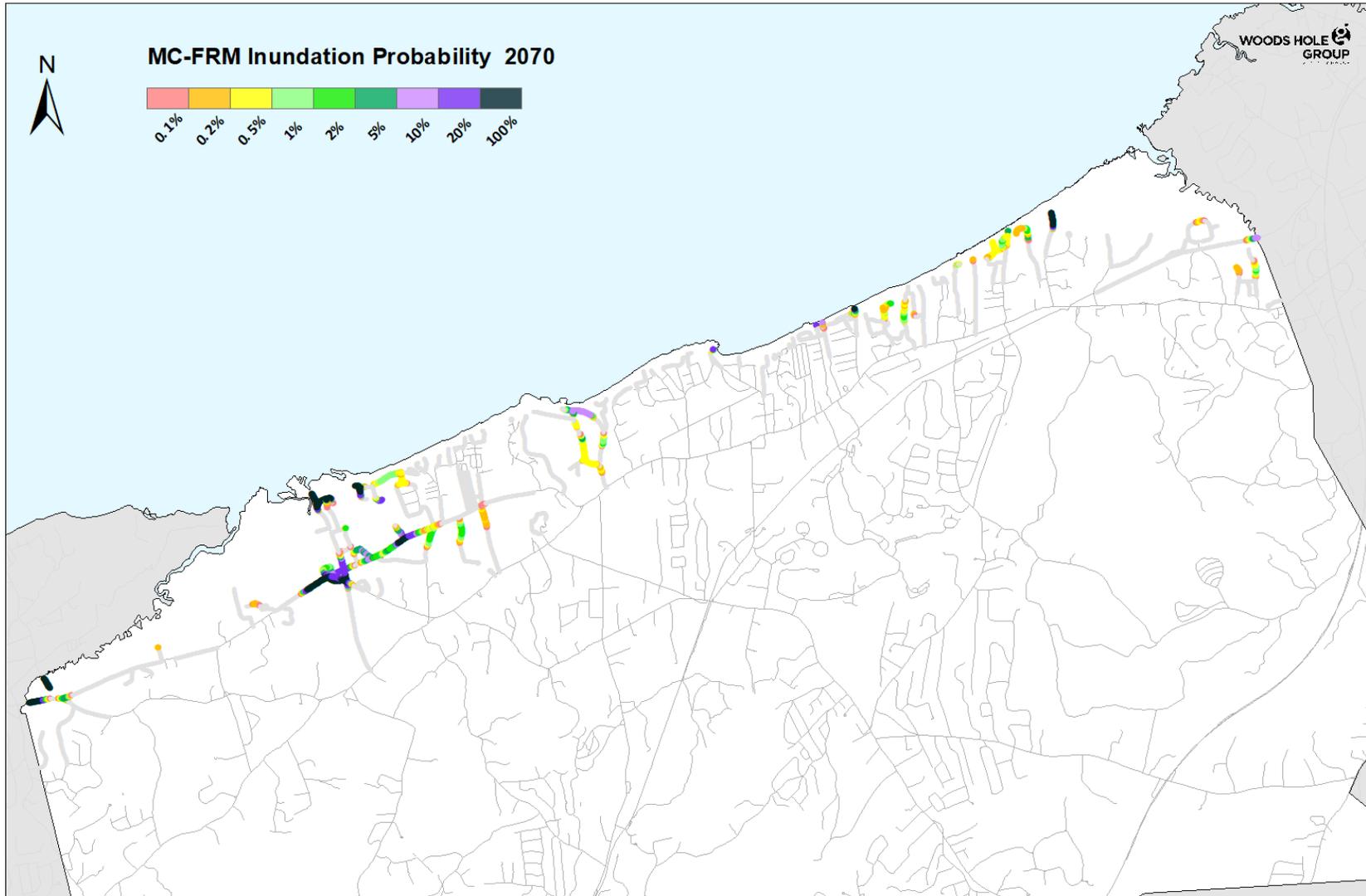
0.6/24.8

# 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% Annual Exceedance Probabilities (AEPs)
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.  $\text{Probability} * \text{Criticality} = \text{Risk}$
6. Prioritize high-risk road segments for community consideration

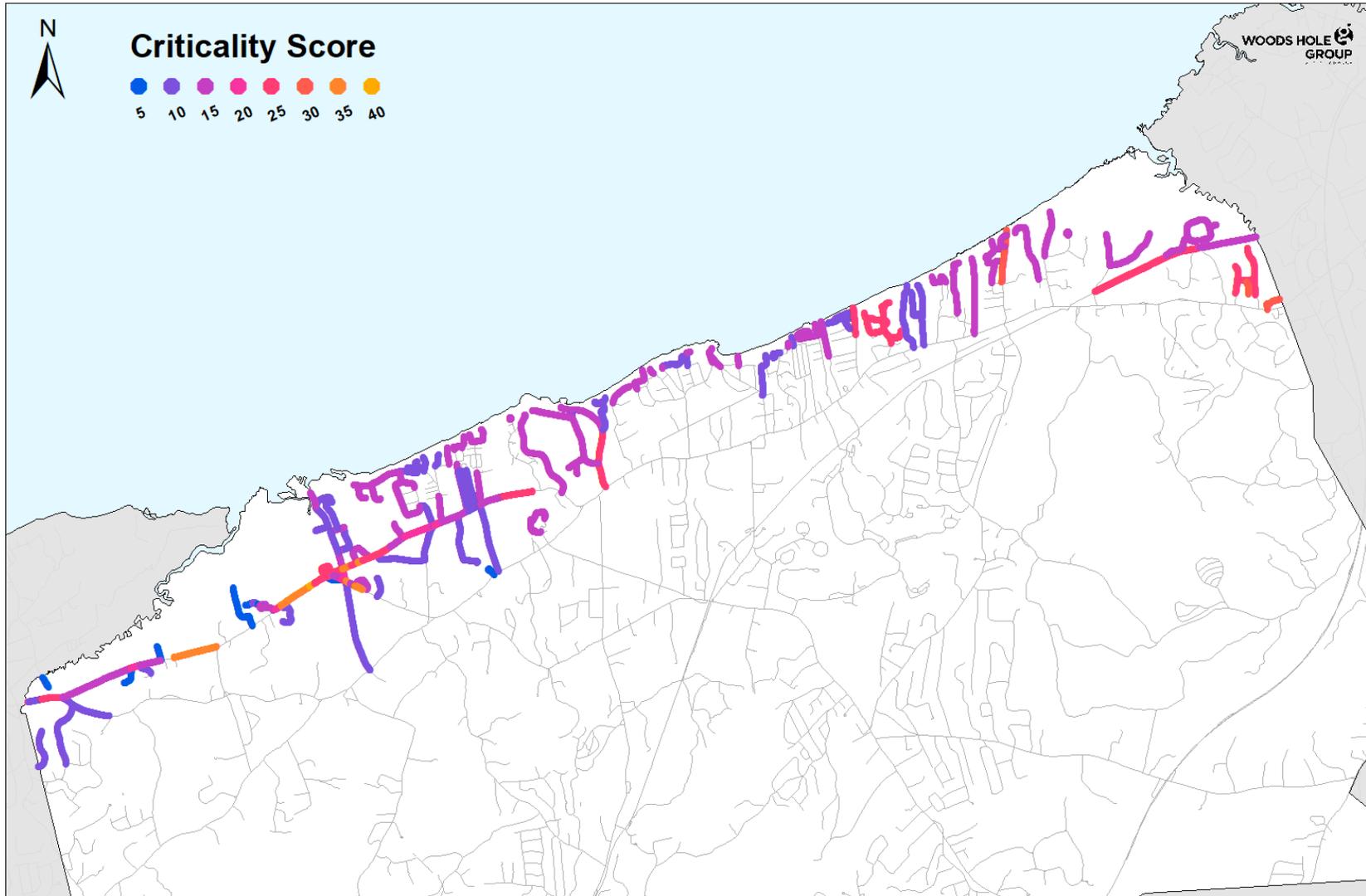


# Low Lying Roads 2070 Inundation Probability (Brewster)

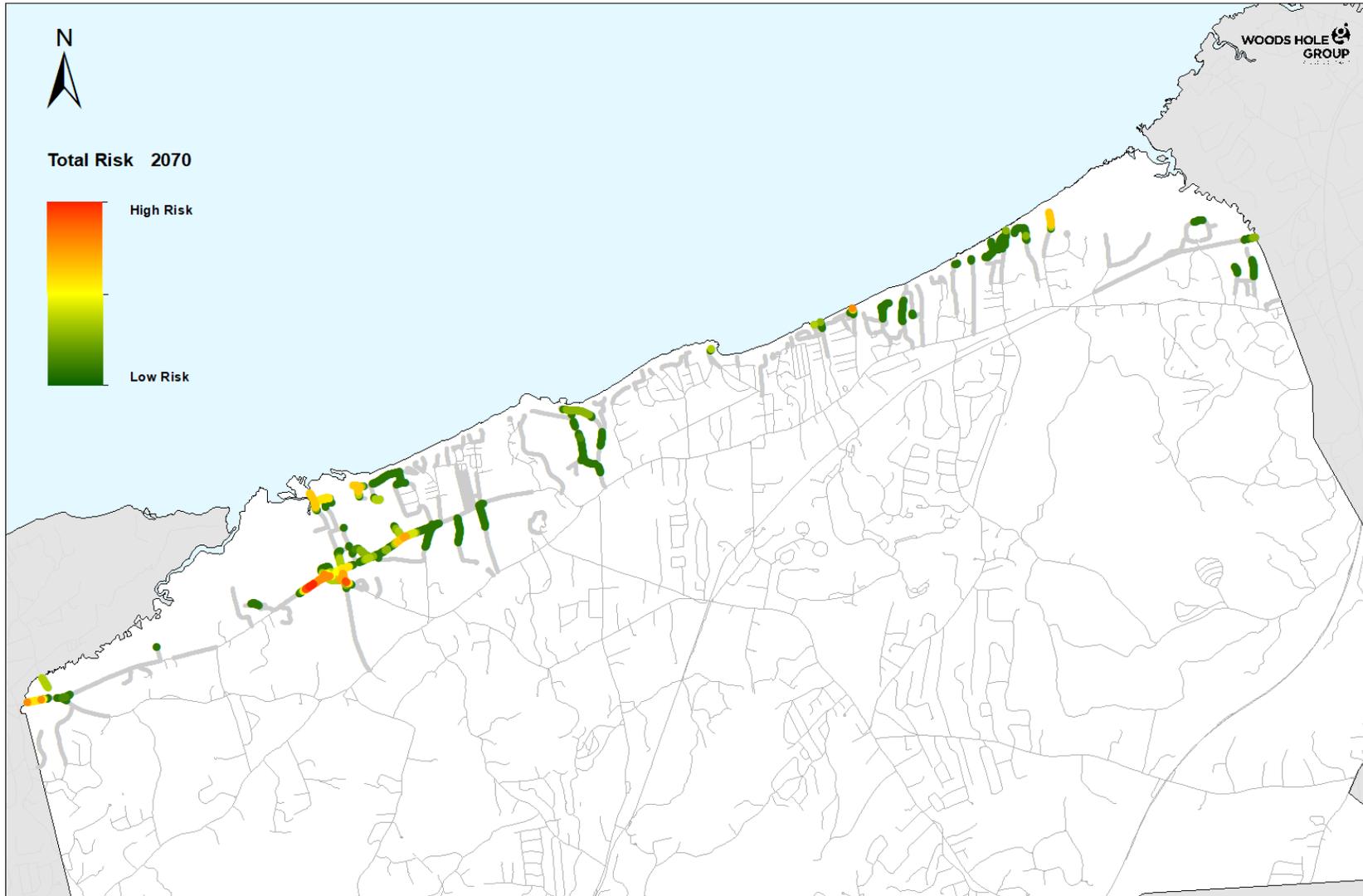


	%	Road miles
	0.1	5.6
	0.2	5.3
	0.5	4.6
	1	3.5
	2	2.9
	5	2.3
	10	2.1
	20	1.7
	100	1.0

# Low Lying Roads Criticality Scoring (Brewster)



# Low Lying Roads 2070 Risk Results (Brewster)



## High Risk Road Segments

Route 6A (Stony Brook)\*

Crosby Lane

Route 6A (Quivett Creek)\*

Robbins Hill and Warrens Road

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Lower Road and Paines Creek Road

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Lower Road

Cedar Hill and Paines Creek Road

Breakwater Road

# Summary of High Priority Road Segments (Brewster)

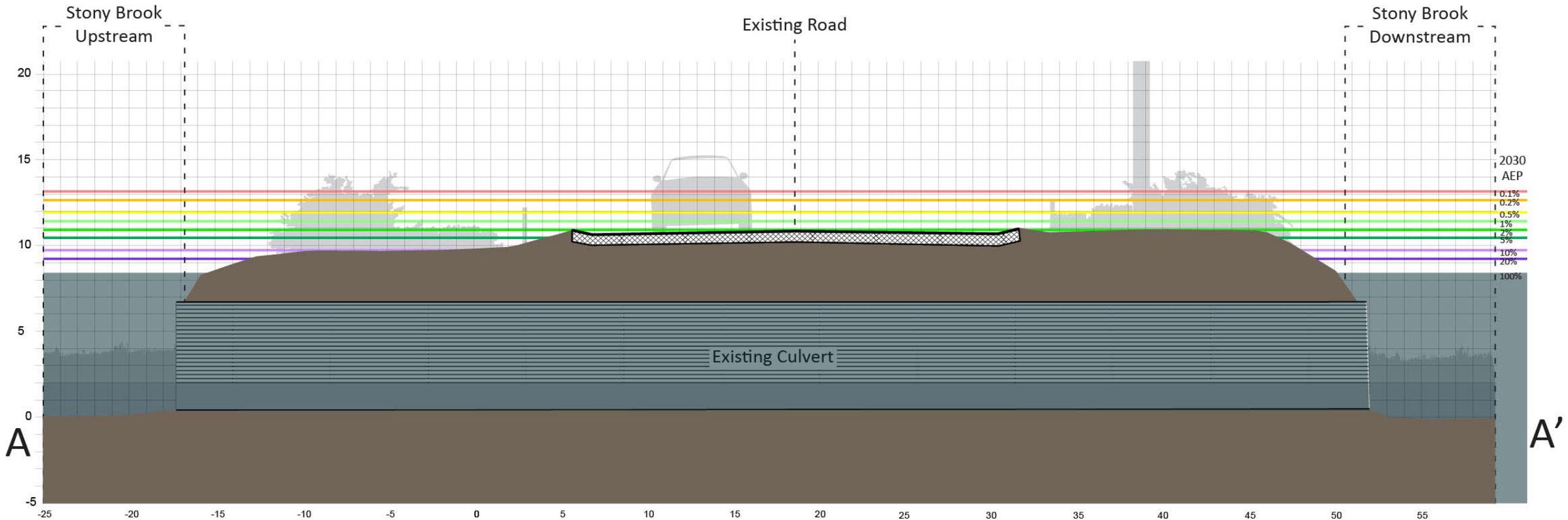
	Name	Length (ft)	Description	Segment Storm Probability (%)			Nuisance Length (ft)		
				2030	2050	2070	2030	2050	2070
<input checked="" type="checkbox"/>	A	*Route 6A (Stony Brook)	1480	Segment of Route 6A over Stony Brook	0.2-20	2-100	20-100		540
	B	Crosby Lane	400	Culverted Road leading to Crosby Landing Beach	2-20	10-100	100	240	360
<input type="checkbox"/>	C	*Route 6A (Quivett Creek)	420	Segment of Route 6A at Quivett Creek	5-20	20-100	100		340
	D	Robbins Hill and Warrens Road	480	Entrance to Robbins Hill Beach	2-10	20	20-100	200	380
	E	Lower Road and Paines Creek Road	1440	Intersection of Lower Road and Paines Creek Rd	0.1-2	1-20	10-100		80
<input checked="" type="checkbox"/>	F	Lower Road	660	Segment in front of Bloomer Path	0.2-5	2-20	20-100		
	G	Cedar Hill and Paines Creek Road	880	Private Road w/ Water and home access	5-20	20-100	100	240	780
	H	Breakwater Road	720	Road with access to Breakwater Beach	0.1	1	10		

\* = MassDOT roadway

# Route 6A at Betty's Curve



# Route 6A at Betty's Curve



**EXISTING CONDITIONS**  
Route 6A at Betty's Curve, Brewster

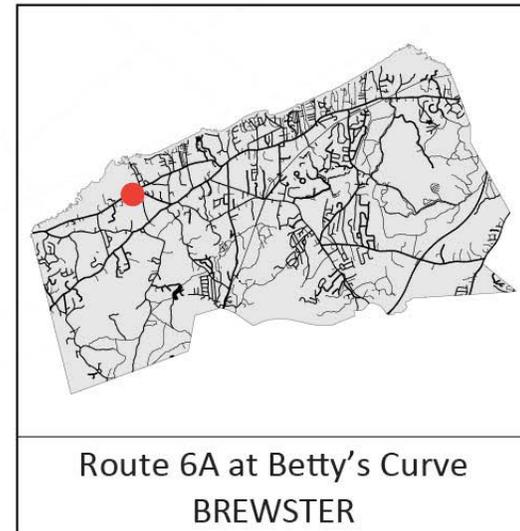
# Route 6A at Betty's Curve



**EXISTING CONDITIONS**  
Route 6A at Betty's Curve, Brewster



Note: Project overlap with wetland areas, rights of way and property lines is approximate and needs confirmation with a site survey

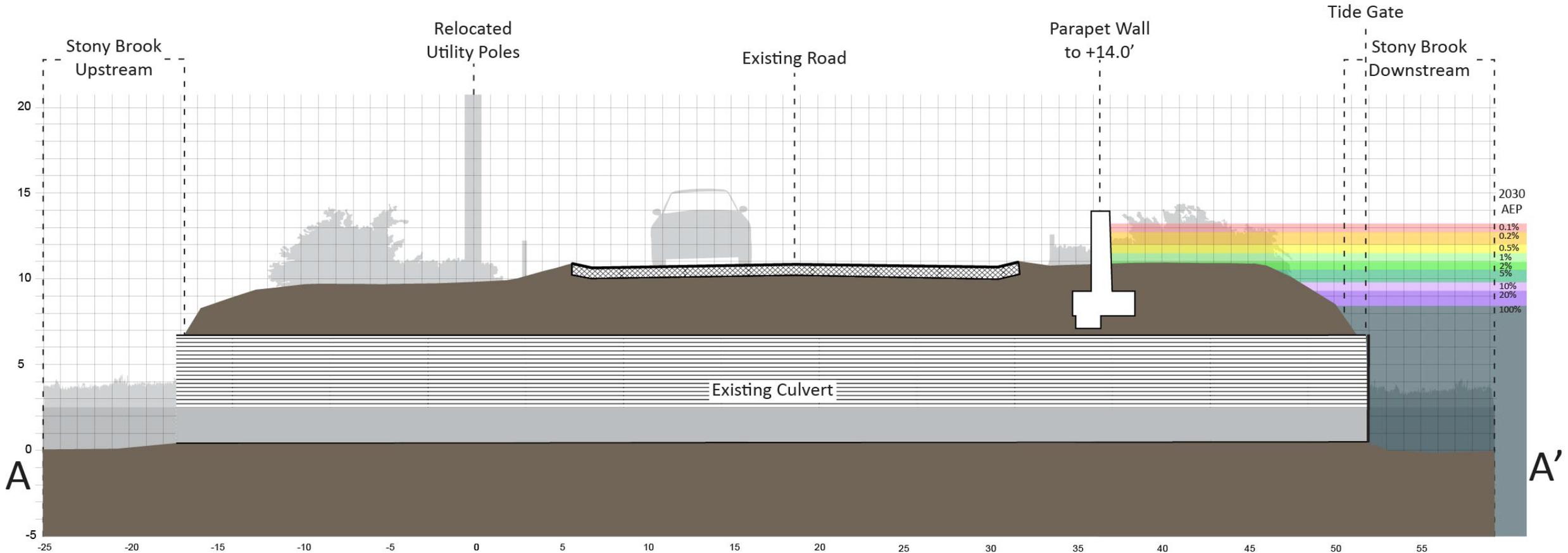


Route 6A at Betty's Curve  
BREWSTER

#### ALTERNATIVE 1: GRAY

A parapet wall to 14.0 feet is added on the north side of 6A, and continues along Paine's Creek Road to prevent flanking. Tide gates are added to the large culvert and smaller secondary culvert under Route 6A.

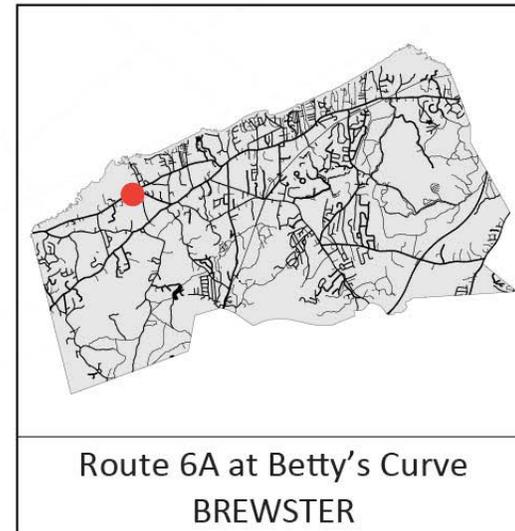
# Route 6A at Betty's Curve



**ALTERNATIVE 1: GRAY**  
Route 6A at Betty's Curve, Brewster



Note: Project overlap with wetland areas, rights of way and property lines is approximate and needs confirmation with a site survey

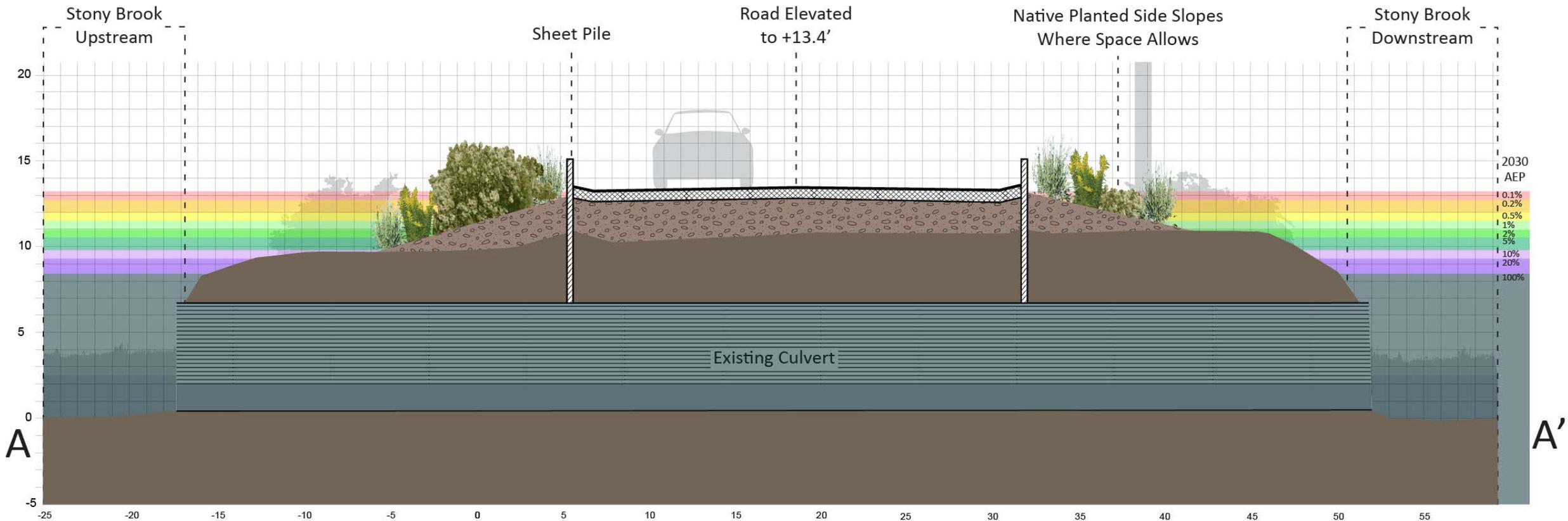


Route 6A at Betty's Curve  
BREWSTER

#### ALTERNATIVE 2: HYBRID

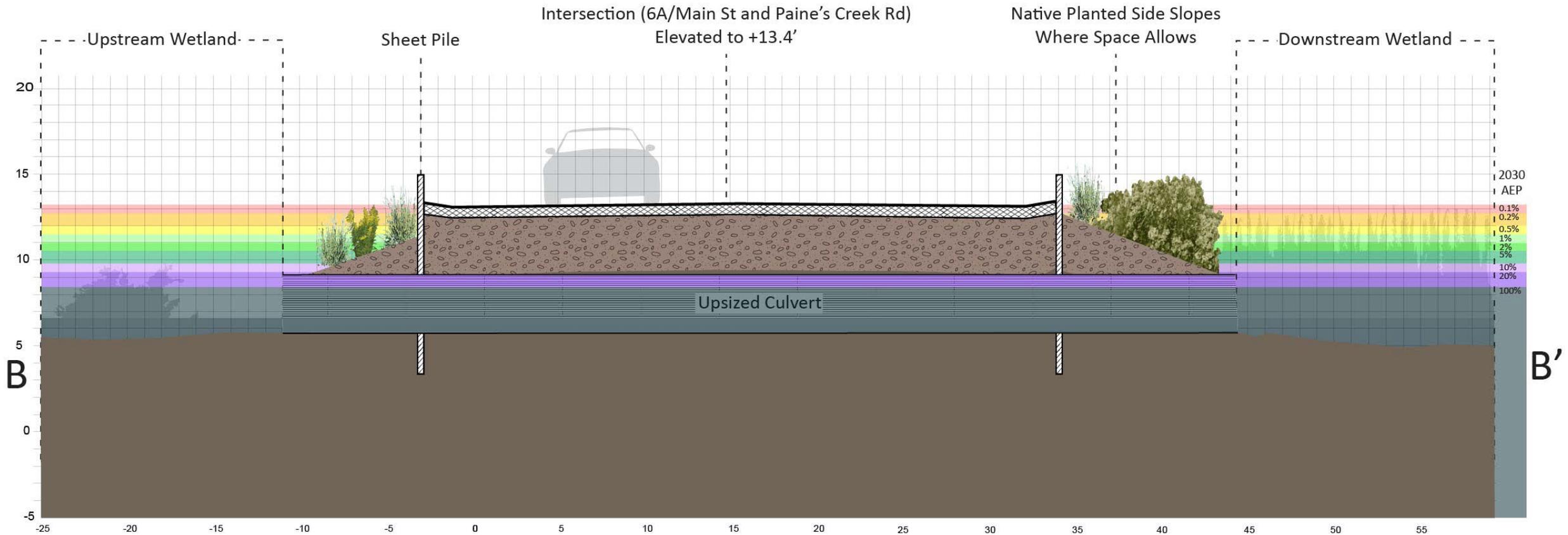
1506 linear feet of road are elevated to 13.4 feet using sheet pile and native vegetated 4:1 side slopes. The culvert at the intersection of 6A/Main Street and Paine's Creek Road is replaced with a larger culvert. A berm is added along Lower Road and Paine's Creek Road to block a flanking pathway. Rain gardens are constructed in the town-owned triangle and marsh-adjacent parcel to help manage stormwater.

# Route 6A at Betty's Curve



**ALTERNATIVE 2: HYBRID**  
Route 6A at Betty's Curve, Brewster

# Route 6A at Betty's Curve



**ALTERNATIVE 2: HYBRID**  
Route 6A at Betty's Curve, Brewster

# ROUTE 6A at BETTY'S CURVE, BREWSTER

## Summary of alternatives

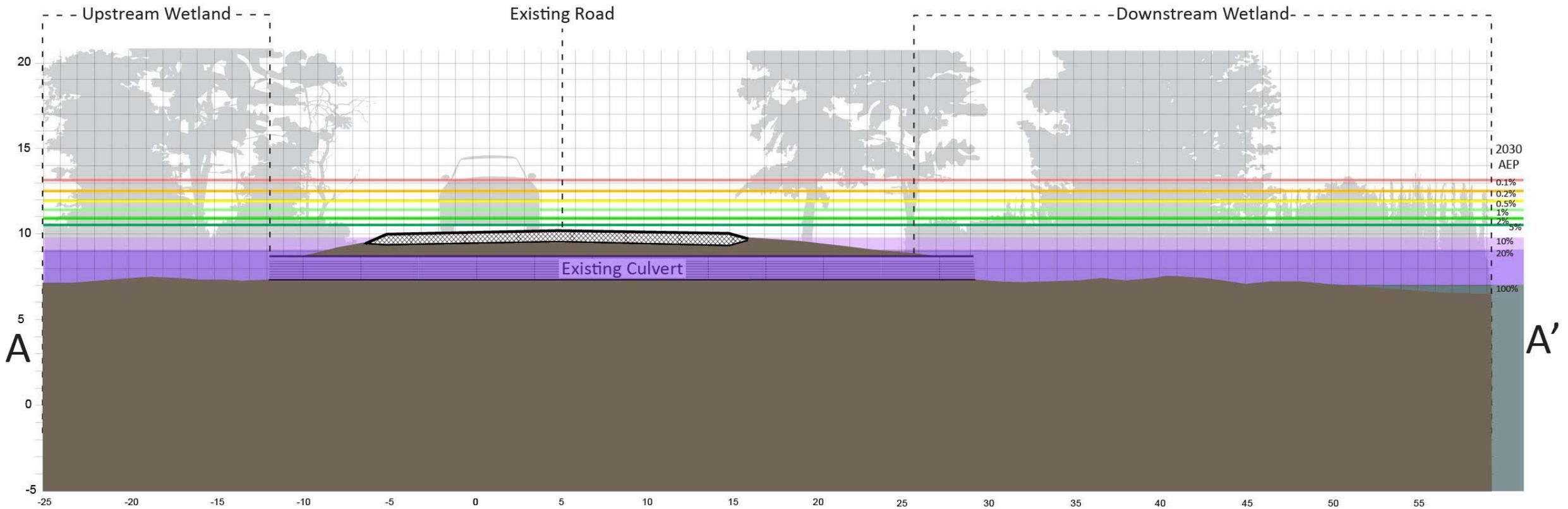
	Description	Critical Elevation	Annual Exceedance Probability			Vulnerable to Tidal Flooding	Impacts to Resource Area(s)	Impacts to Private Property	Estimated Cost*
			2030	2050	2070				
<b>EXISTING</b>	A segment of 30 foot wide road with multiple culvert crossings.	8.4 feet	20%	100%	100%	2070	N/A	N/A	N/A
<b>ALTERNATIVE 1: GRAY</b>	A parapet wall to 14.0 feet is added on the north side of 6A, and continues along Paine's Creek Road to prevent flanking. Tide gates are added to the large culvert and smaller secondary culvert under Route 6A.	14.0 feet	0%	0.2%	2%	2070	Minimal	Minor	\$1,880,000
<b>ALTERNATIVE 2: HYBRID</b>	1506 linear feet of road are elevated to 13.4 feet using sheet pile and native vegetated 4:1 side slopes. The culvert at the intersection of 6A/Main Street and Paine's Creek Road is replaced with a larger culvert. A berm is added along Lower Road and Paine's Creek Road to block a flanking pathway. Rain gardens are constructed in the town-owned triangle and marsh-adjacent parcel to help manage stormwater.	13.4 feet	0%	0.5%	5%	N/A	Possible Positive	Minor	\$3,860,000

\*2023 installed material cost +40% escalation (through 2029) and 15% contingency. Excludes design, permitting, mobilization, stormwater and wastewater infrastructure, and site controls. Costs based on experienced contractor opinion and MassDOT costing data.

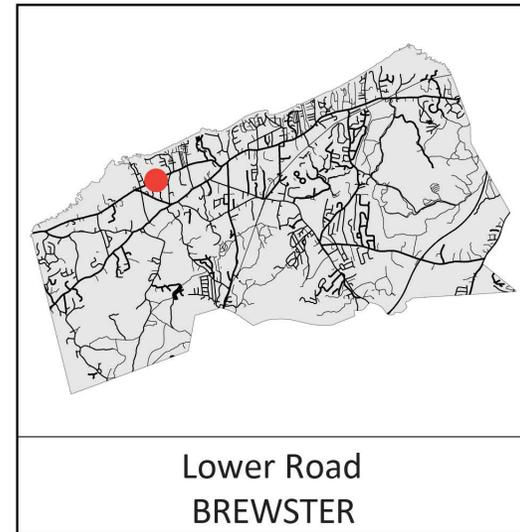
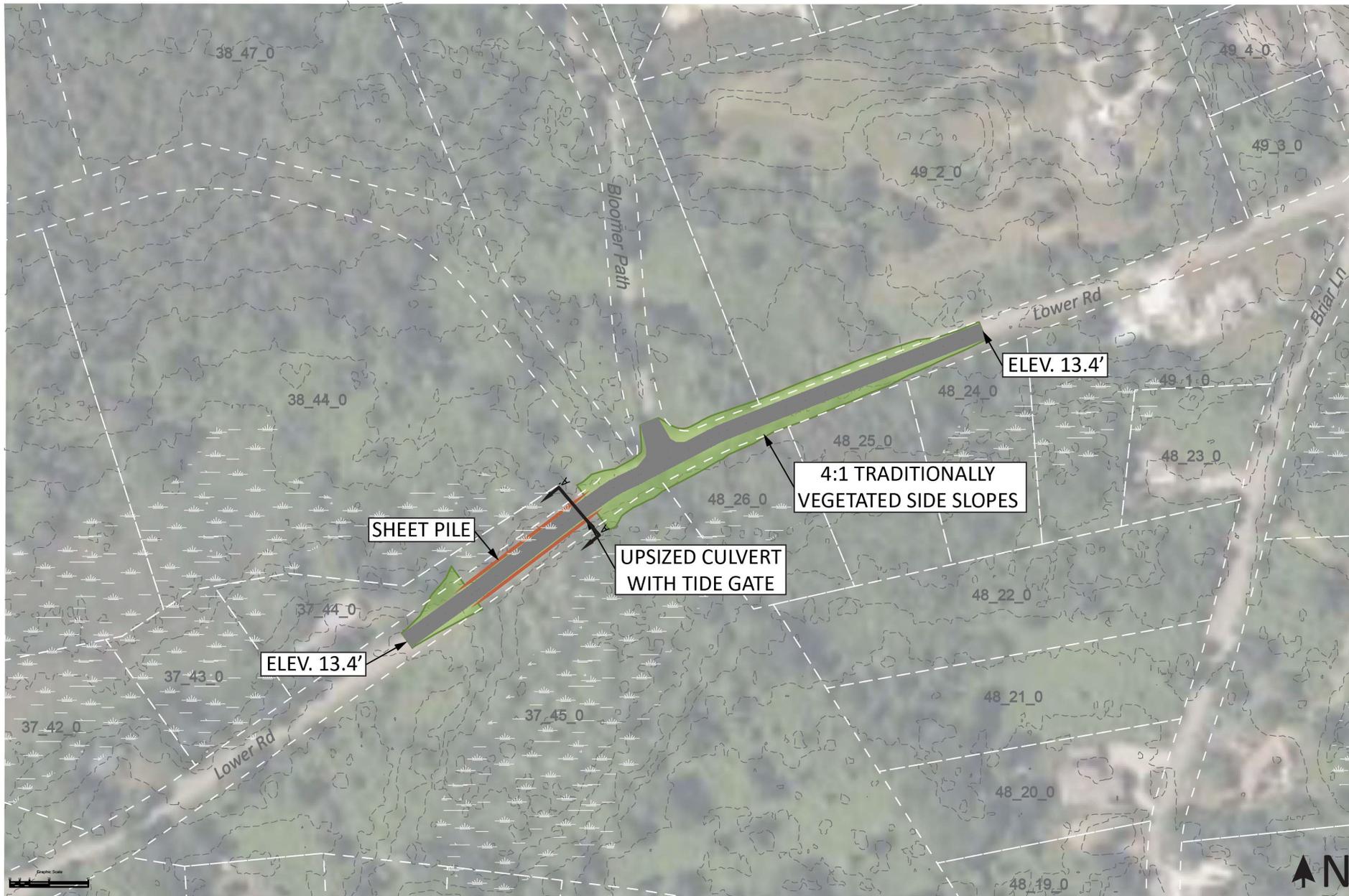
# Lower Road at Bloomer Path



# Lower Road at Bloomer Path



**EXISTING CONDITIONS**  
Lower Road, Brewster

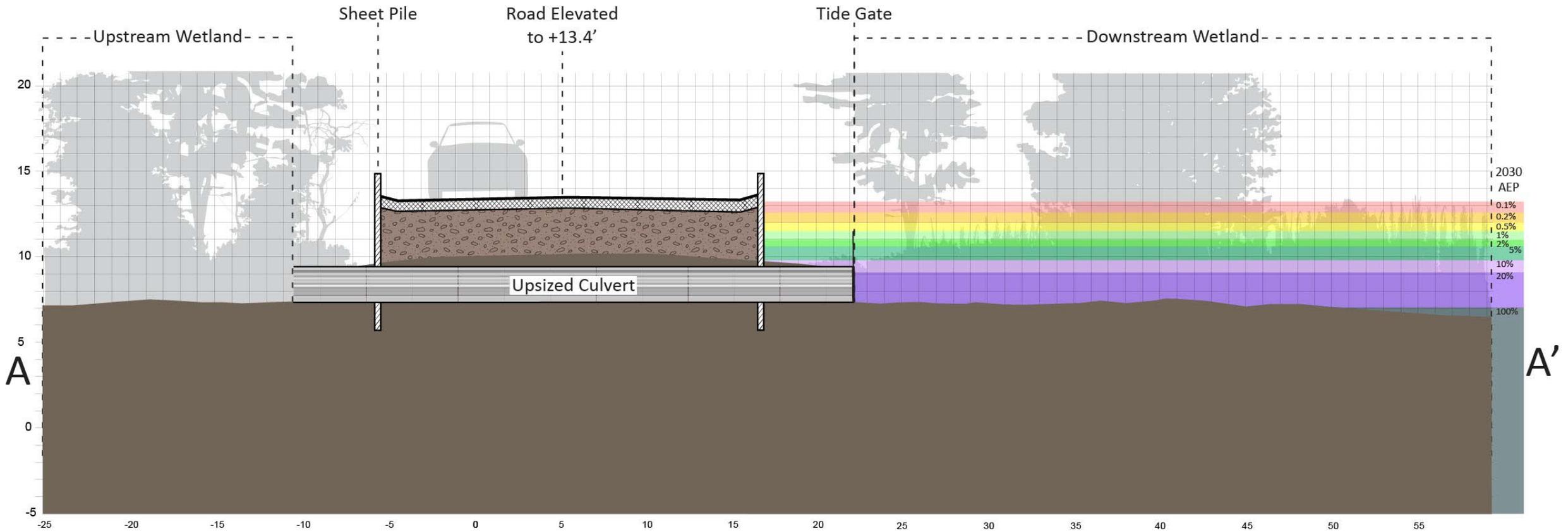


**ALTERNATIVE 1: GRAY**

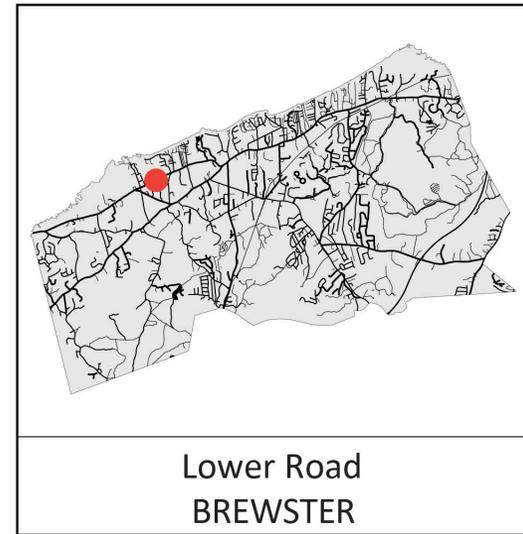
781 linear feet of road are elevated to 13.4 feet using sheet pile and traditionally vegetated 4:1 side slopes. The culvert is increased in size, and a tide gate is added to cut off a potential long-term flood pathway.

Note: Project overlap with wetland areas, rights of way and property lines is approximate and needs confirmation with a site survey

# Lower Road at Bloomer Path



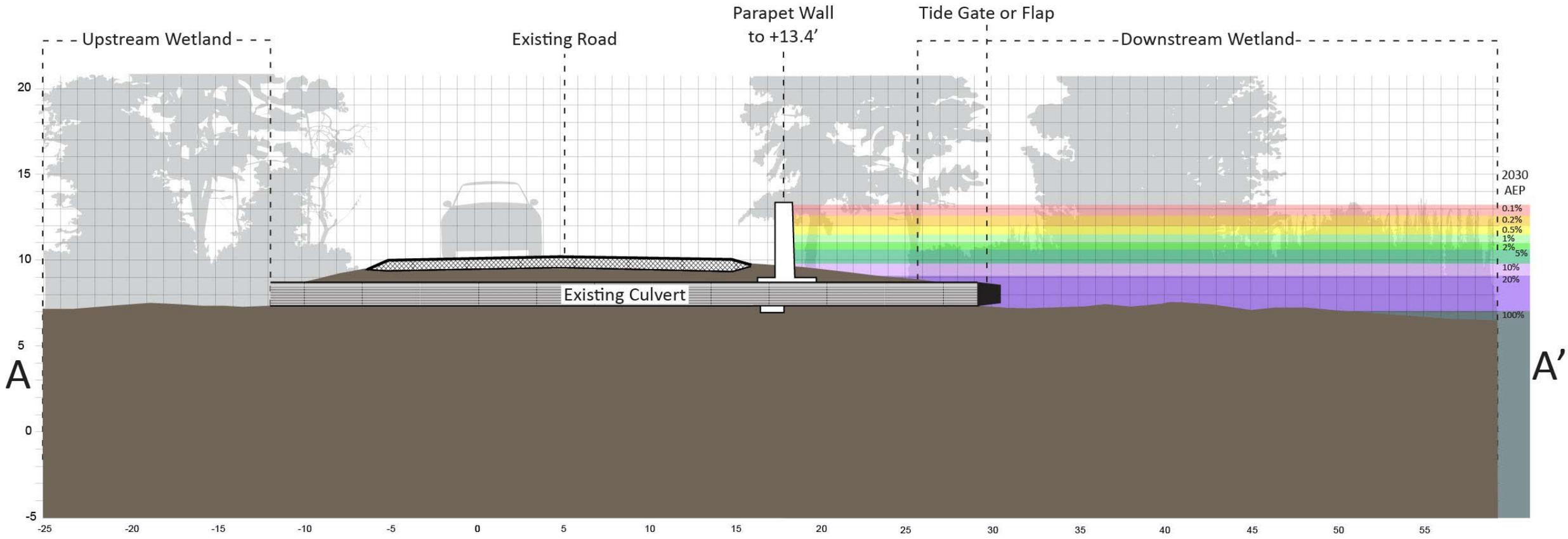
**ALTERNATIVE 1: GRAY**  
Lower Road, Brewster



**ALTERNATIVE 2: HYBRID**

A berm and parapet wall to 13.4 feet are constructed along Lower Road and in an unused right of way next to Bloomer Path. The berm is vegetated with native plants, and a tide flap is added to the existing culvert to prevent flanking.

Note: Project overlap with wetland areas, rights of way and property lines is approximate and needs confirmation with a site survey



**ALTERNATIVE 2: HYBRID**  
 Lower Road, Brewster

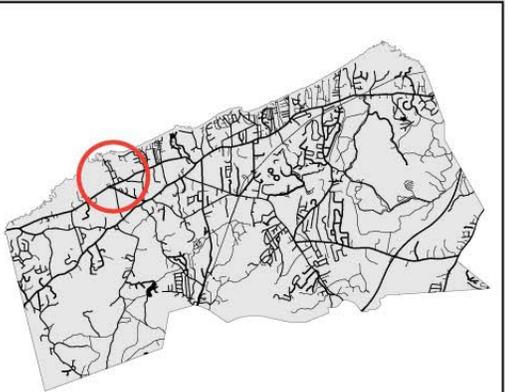
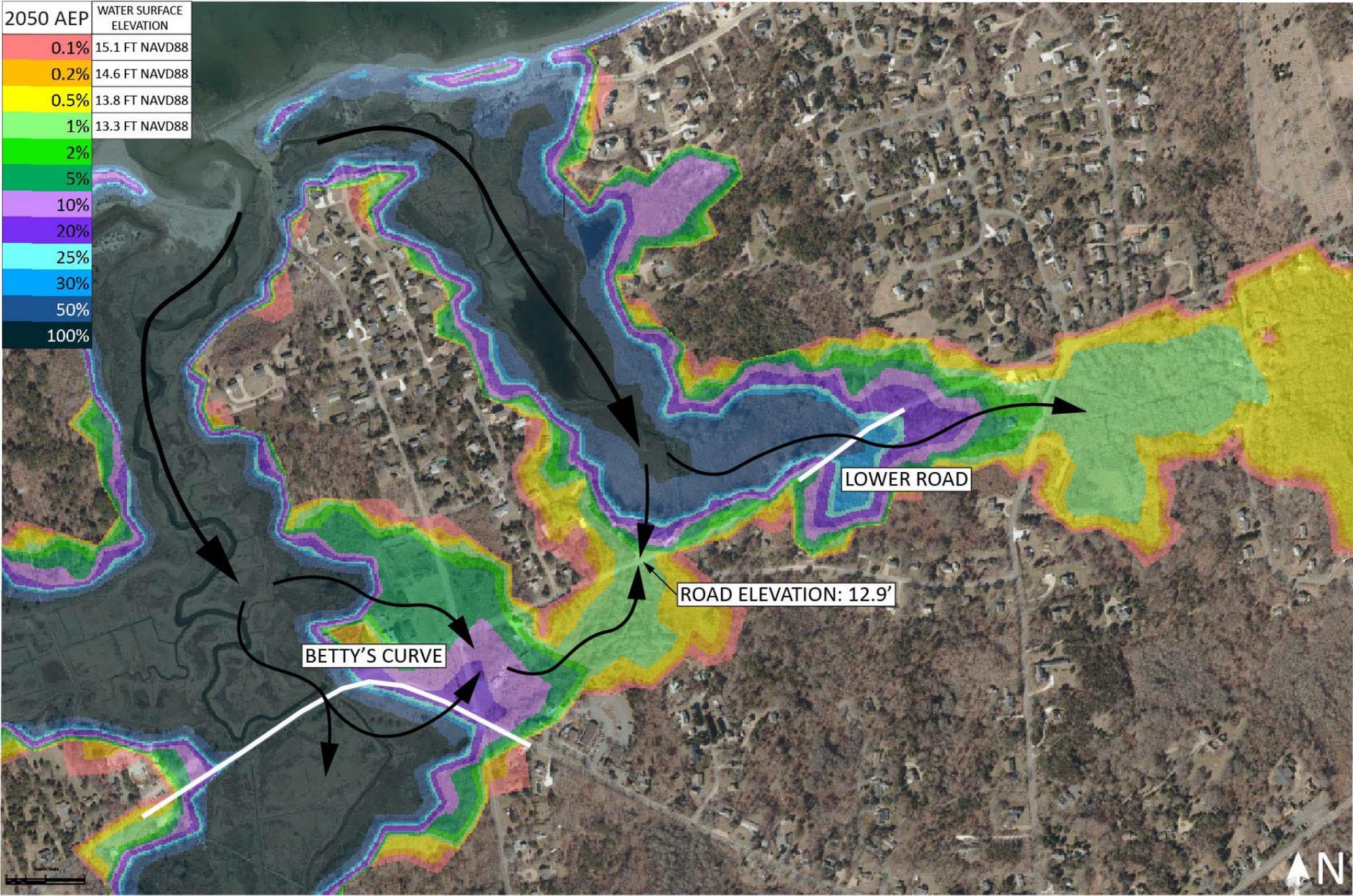
# LOWER ROAD, BREWSTER

Summary of alternatives

	Description	Critical Elevation	Annual Exceedance Probability			Vulnerable to Tidal Flooding	Impacts to Resource Area(s)	Impacts to Private Property	Estimated Cost*
			2030	2050	2070				
<b>EXISTING</b>	A segment of 20 foot wide road with a culvert crossing.	10.2 feet	5%	20%	100%	N/A	N/A	N/A	N/A
<b>ALTERNATIVE 1: GRAY</b>	781 linear feet of road are elevated to 13.4 feet using sheet pile and traditionally vegetated 4:1 side slopes. The culvert is increased in size, and a tide gate is added to cut off a potential long-term flood pathway.	13.4 feet	0%	0.5%	5%	N/A	Minimal	Minor	\$868,000
<b>ALTERNATIVE 2: HYBRID</b>	A berm and parapet wall to 13.4 feet are constructed along Lower Road and in an unused right of way next to Bloomer Path. The berm is vegetated with native plants, and a tide flap is added to the existing culvert to prevent flanking.	13.4 feet	0%	0.5%	5%	N/A	Minimal	Minor	\$218,000

\*2023 installed material cost +40% escalation (through 2029) and 15% contingency. Excludes design, permitting, mobilization, stormwater and wastewater infrastructure, and site controls. Costs based on experienced contractor opinion and MassDOT costing data.

2050 AEP	WATER SURFACE ELEVATION
0.1%	15.1 FT NAVD88
0.2%	14.6 FT NAVD88
0.5%	13.8 FT NAVD88
1%	13.3 FT NAVD88
2%	
5%	
10%	
20%	
25%	
30%	
50%	
100%	



Betty's Curve and Lower Road  
BREWSTER

EXISTING CONDITIONS

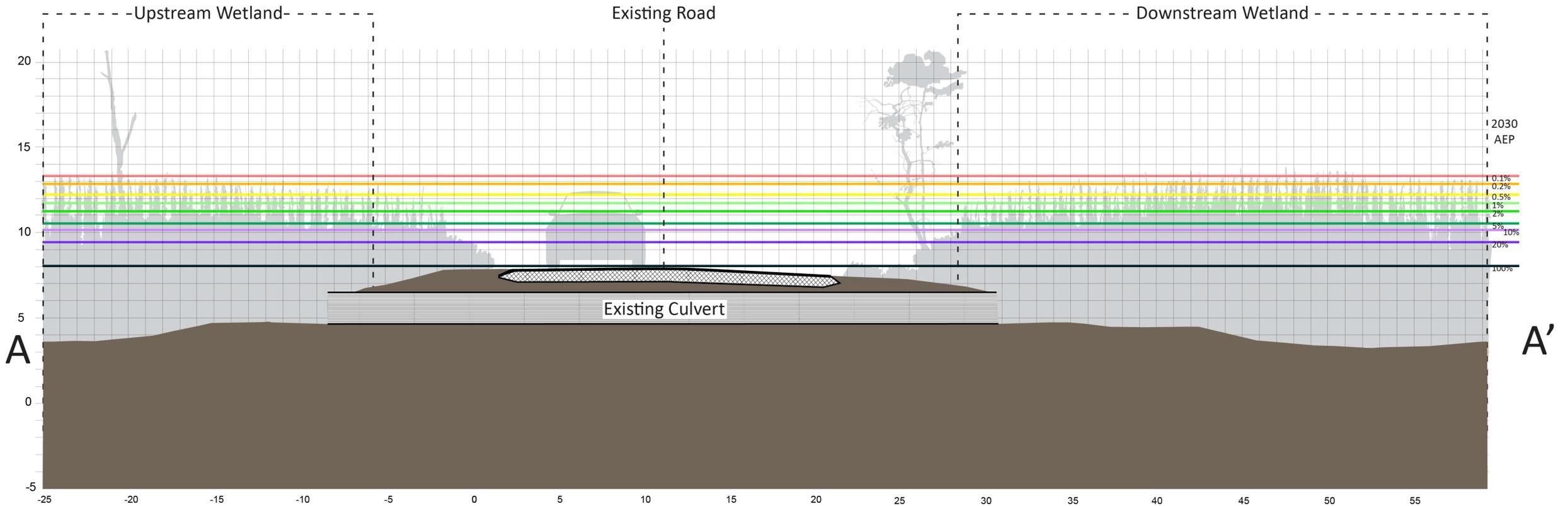
Multiple interconnected flood pathways affect risk at these two road segments, as well as portions of Lower Road in between them.

Note: Project overlap with wetland areas, rights of way and property lines is approximate and needs confirmation with a site survey

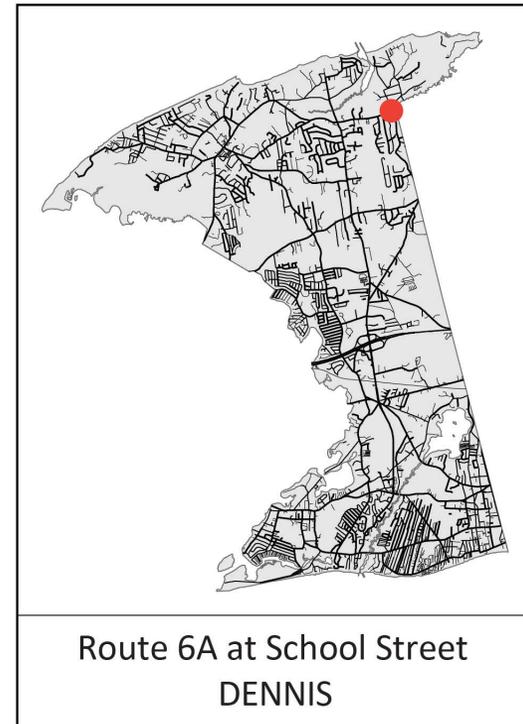
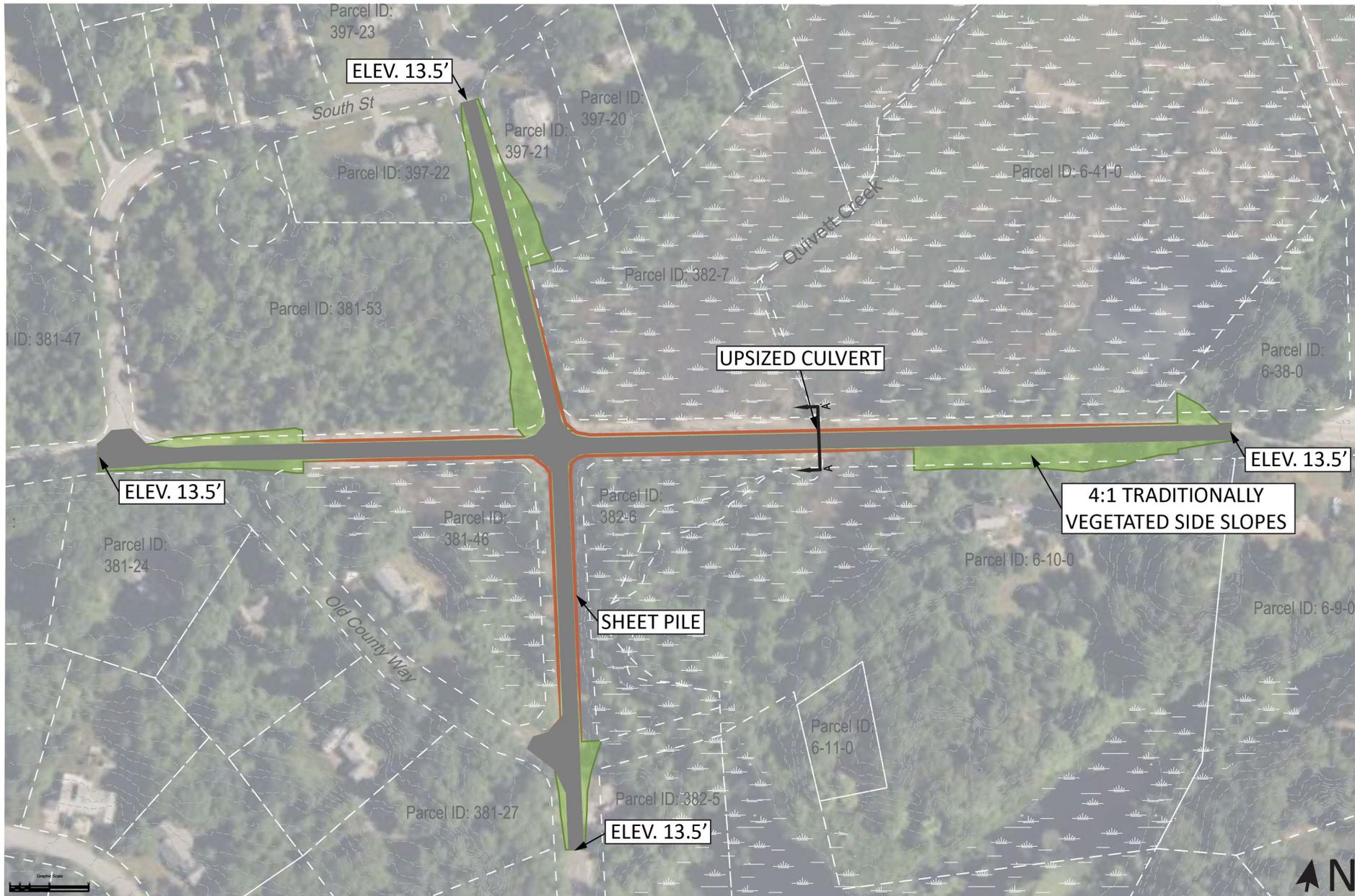
# Route 6A at Quivett Creek



# Route 6A at Quivett Creek



**EXISTING CONDITIONS**  
Route 6A at School Street, Dennis

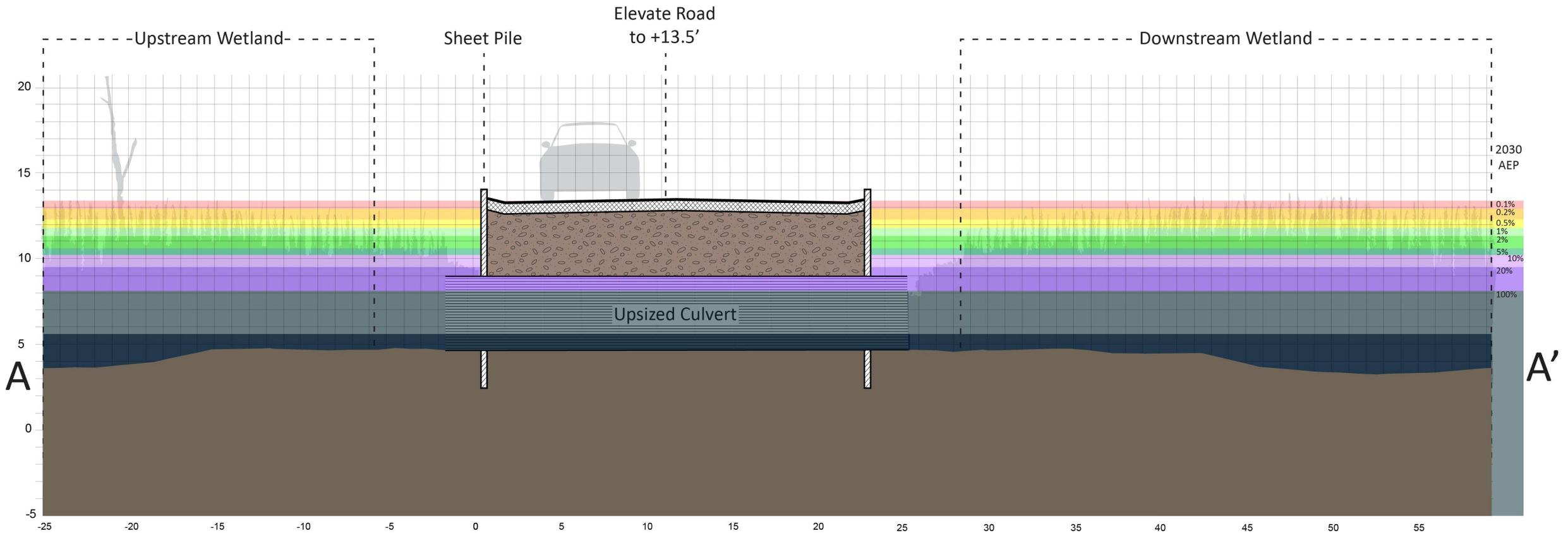


**ALTERNATIVE 1: GRAY**

2410 linear feet of road are elevated to 13.5 feet using sheet pile and traditionally vegetated side slopes. The culvert under Route 6 is replaced with a larger culvert to facilitate future tidal flow. This alternative extends into Brewster, and collaboration with the neighboring town would be necessary.

Note: Project overlap with wetland areas, rights of way and property lines is approximate and needs confirmation with a site survey

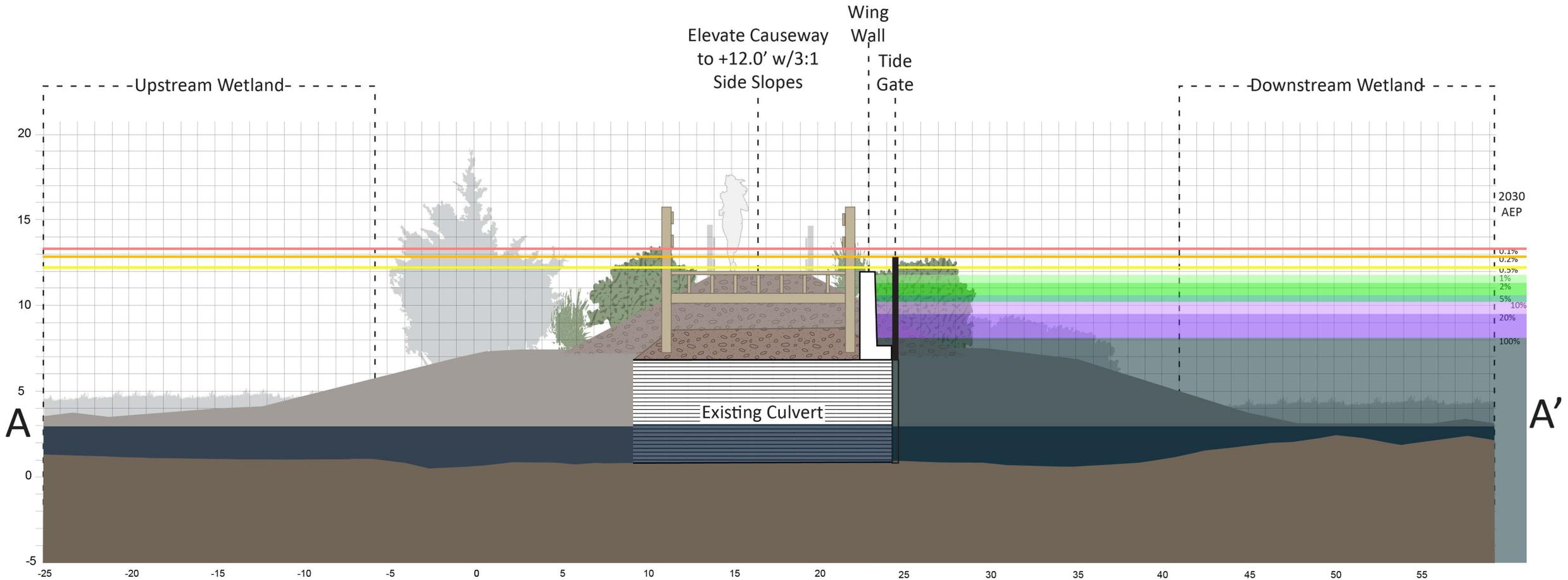
# Route 6A at Quivett Creek



**ALTERNATIVE 1: GRAY**  
Route 6A at School Street, Dennis



# Route 6A at Quivett Creek



**ALTERNATIVE 2: HYBRID**  
Route 6A at School Street, Dennis

# ROUTE 6A at SCHOOL STREET, DENNIS

Summary of alternatives

	Description	Critical Elevation	Annual Exceedance Probability			Vulnerable to Tidal Flooding	Impacts to Resource Area(s)	Impacts to Private Property	Estimated Cost*
			2030	2050	2070				
<b>EXISTING</b>	A road intersection with a culvert crossing and adjacent wetland.	7.5 feet	100%	100%	100%	2070	N/A	N/A	N/A
<b>ALTERNATIVE 1: GRAY</b>	2410 linear feet of road are elevated to 13.5 feet using sheet pile and traditionally vegetated side slopes. The culvert under Route 6 is replaced with a larger culvert to facilitate future tidal flow. This alternative extends into Brewster, and collaboration would be necessary.	13.5 feet	0%	1%	5%	N/A	Minimal	Minimal	\$6,000,000
<b>ALTERNATIVE 2: HYBRID</b>	The Sea Street causeway is elevated to 12.0 feet with 3:1 native vegetated side slopes. A 6-foot wide shared use path with railings and new bridge over the culvert maintain safe pedestrian use. A concrete wing wall to 12.0 feet and tide gate are added to the existing culvert. A small berm to 12.0 feet is constructed along South Street to manage a flanking flood pathway.	12.0 feet	0.5%	5%	20%	2070	Minimal	Minimal	\$446,000

\*2023 installed material cost +40% escalation (through 2029) and 15% contingency. Excludes design, permitting, mobilization, stormwater and wastewater infrastructure, and site controls. Costs based on experienced contractor opinion and MassDOT costing data.



- **Route 6A at Betty's Curve**
- **Lower Road**
- **Route 6A at Quivett Creek**

# NEXT STEPS

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- Comments! Use form on project webpages  
<https://www.capecodcommission.org/our-work/low-lying-roads-project/>
- Town staff to determine which projects, designs
  - Review of community input
  - Engineering, permitting
- Identify funding

# FUNDING OPPORTUNITIES

## Federal Bipartisan Infrastructure Law (BIL)

### Federal Highway Administration

- PROTECT – Competitive Resilience Improvement and Planning grants
- Culvert Aquatic Organism Passage Program - competitive grants for the replacement, removal, and repair of culverts or weirs that meaningfully improve or restore fish passage for anadromous fish

### [NEW] PROTECT Grants (discretionary)

Purpose	Planning, resilience improvements, community resilience and evacuation routes, and at-risk coastal infrastructure
Funding	\$1.4 B (FY 22-26) in Contract Authority from the HTF
Eligible entities	<ul style="list-style-type: none"><li>• State (or political subdivision of a State)</li><li>• MPO</li><li>• Local government</li><li>• Special purpose district or public authority with a transportation function</li><li>• Indian Tribe</li><li>• Federal land management agency (applying jointly with State(s))</li><li>• <i>Different eligibilities apply for at-risk coastal infrastructure grants</i></li></ul>
Eligible projects	<ul style="list-style-type: none"><li>• Highway, transit, intercity passenger rail, and port facilities</li><li>• Resilience planning activities, including resilience improvement plans, evacuation planning and preparation, and capacity-building</li><li>• Construction activities (oriented toward resilience)</li><li>• Construction of (or improvement to) evacuation routes</li></ul>
Other key provisions	<ul style="list-style-type: none"><li>• Higher Federal share if the eligible entity develops a resilience improvement plan (or is in a State or area served by MPO that does) and the State or MPO incorporates it into its long-range transportation plan</li><li>• May only use up to 40% of the grant for construction of new capacity</li></ul>



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## FUNDING OPPORTUNITIES

### Nature Based Solutions, Ecological Restoration, Culverts

- FEMA Building Resilient Infrastructure and Communities (BRIC)
- National Coastal Resiliency Fund (NCRF) through National Fish and Wildlife Fund
- Natural Resources Conservation Service (NRCS) through the Cape Cod Conservation District
- Municipal Vulnerability Preparedness Program (MVP)
- Division of Ecological Restoration (DER) Culvert Replacement Municipal Assistance Grant Program