Guidance for Climate Resilience of Tidal and Near-Tidal Waterway Crossings

Prepared for:
National Stream Restoration Conference
Technical Breakout L Session:
Flooding, Erosion, Urban Infrastructure & Tidal Creek Restoration

Prepared by:

50 YEARS | EA Engineering, Science, and Technology, Inc., PBC

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Overview

- The Issue: Climate change is transitioning upland river, stream, and waterway crossings to tidal crossings
- Objectives: Identify transitional crossings and provide guidance to enhance system resilience
- Elements of the Project: Guidance documents and pilot site assessments

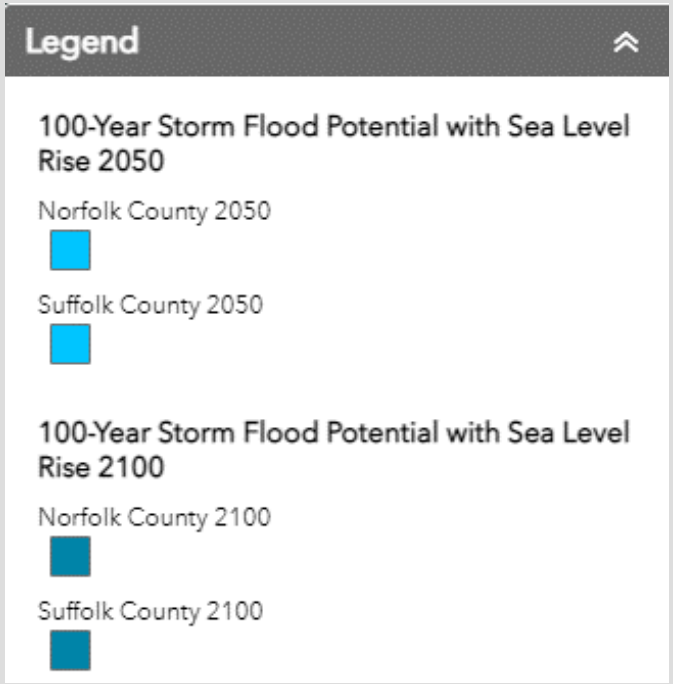
Massachusetts Department of Fish and Game
Division of Ecological Restoration
Invested in Nature and Community

Waterway Crossings in the Tidal and Transitional Zone

- Crossing in the tidal zone have been designed for a certain range of sea level and stormwater runoff/ riparian flow
- The problem: SLR, storm surge as well as precipitation runoff are changing –
  - Impacting current crossings differently than they were designed
  - Involving crossings never designed for tidal flow (transitional crossings)
- In Massachusetts there are in excess of 10,000 tidal and transitional crossings
  - In Maryland there are likely many more
  - In the US there could be 1M+

Transitional Zone Definition

- **For this project: The near-coastal area that is expected to be impacted by climate change by the year 2100. This includes:**
  - **Projected Sea Level Rise flat water impacts**
  - **Storm-surge related impacts including wave and precipitation impacts**



Transitional Zone Definition – Sea Level Rise

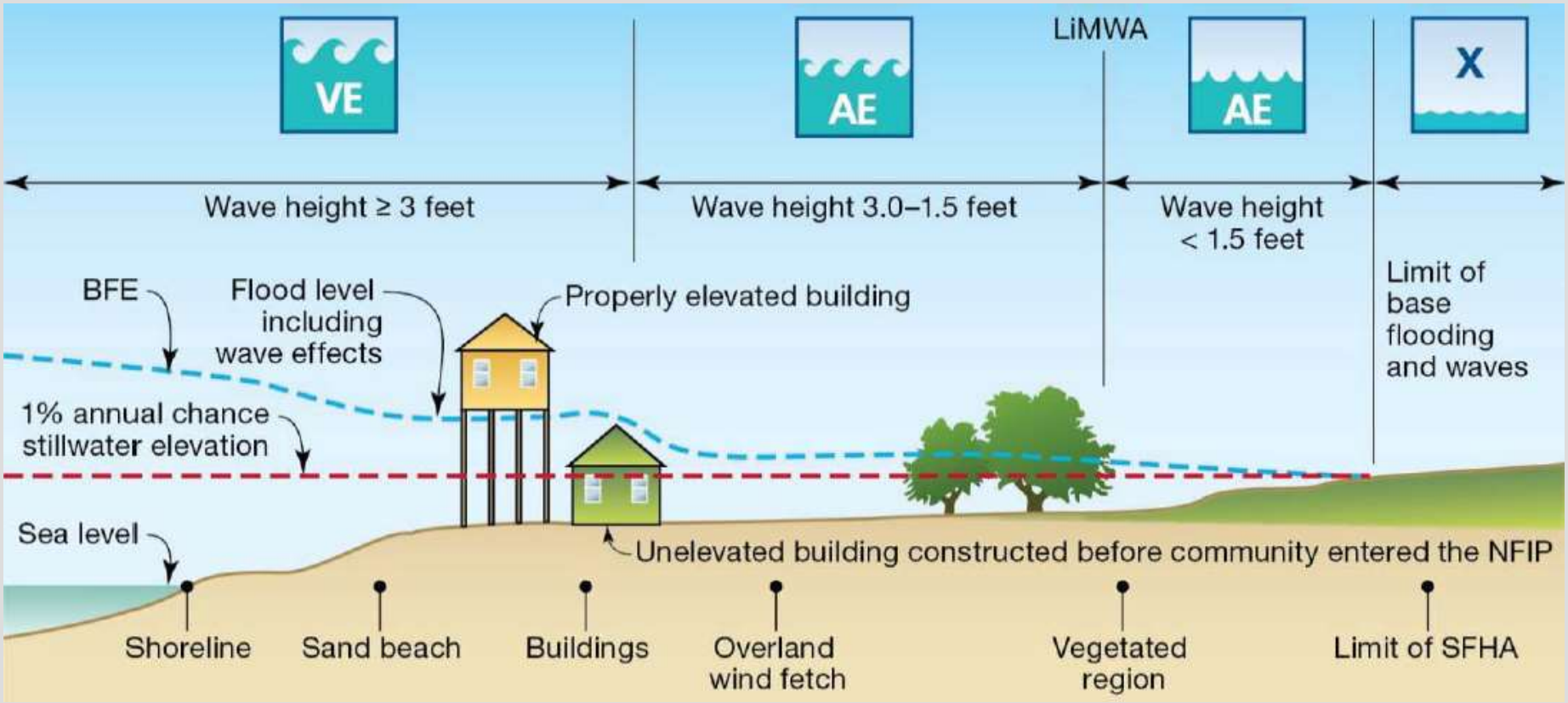
- **For this project: SLR is defined by the Resilient MA level for 'High' to provide a conservative level of impact.**
  - **Attached to the highest tide on a daily basis - the MHHW (Mean Higher High Water)**

Relative mean sea level (feet NAVD88) for Woods Hole, MA					
Scenario	**Probabilistic Projections**	**2030**	**2050**	**2070**	**2100**
Intermediate	Unlikely to exceed (83% probability) given a high emissions pathway (RCP 8.5)	0.6	1.3	2.3	4.0
Intermediate - High	Extremely unlikely to exceed (95% probability) given a high emissions pathway (RCP 8.5)	0.8	1.7	2.9	5.1
High	Extremely unlikely to exceed (99.5% probability) given a high emissions pathway (RCP 8.5)	1.1	2.4	4.2	7.7
Extreme (Maximum physically plausible)	Exceptionally unlikely to exceed (99.9% probability) given a high emissions pathway (RCP 8.5)	1.3	3.1	5.4	10.3

Resilient MA, Climate Change Clearinghouse for the Commonwealth

Transitional Zone Definition – Storm Impacts

- 1% annual chance stillwater elevation - includes coastal storm surge and precipitation runoff within the defined flood plain.
- BFE – Base Flood Elevation (FEMA 100-yr floodplain) incorporates hydrodynamic wave modeling and wave runup to identify water elevation along the coast.



Project Objectives

- **To facilitate natural resource and infrastructure planning by developing guidance for waterway crossings within near-coastal environments that will experience the impacts of climate change and SLR within the century.**
- **To support the identification, prioritization, and planning of crossing replacements to enhance both resource and infrastructure resiliency where replacements in the transitional zone may be planned.**

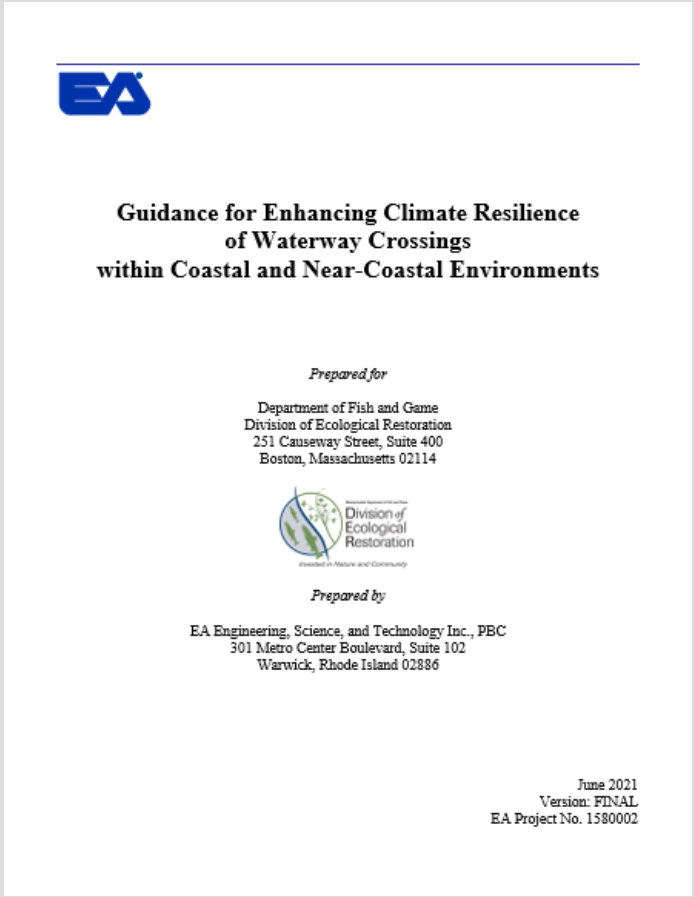
Resilient Crossing Systems

- The Massachusetts State Hazard Mitigation and Climate Adaptation Plan defines resilience as "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner".

- In the context of waterway crossings:
  - Resilient coastal wetlands can avoid SLR inundation by gradually migrating landward into available suitable habitat
  - Resilient infrastructure is designed and constructed to remain functional while SLR and climate changes
  - Resilient coastal communities can avoid flood damages associated with crossings and rely on crossings to support local economies and to transport people during emergencies

Project Deliverables

- Guidance for Enhancing Climate Resilience of Waterway Crossings within Coastal and Near-Coastal Environments
  - Based on 10 Resilience Criteria
  - Adaptation and Resilience Strategies
  - Full watershed context
- Tidal and Transitional Crossing Field Assessment Guidance
- Pilot Assessment Results – 12 sites
- GIS Transitional Crossing Assessment Tool
- Technical Assistance Committee (TAC) meeting minutes



Guidance for Enhancing Climate Resilience of Waterway Crossings within Coastal and Near-Coastal Environments

Prepared for

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10 Resilience Criteria

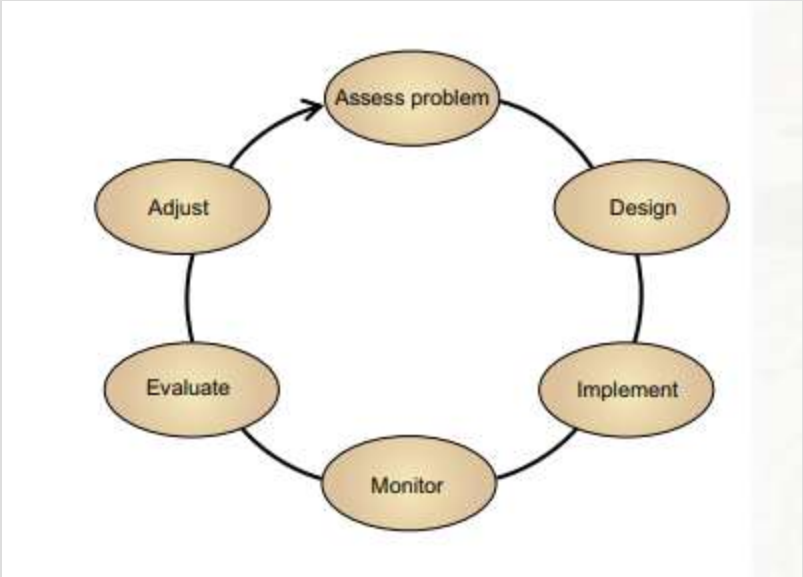
Resilience Criteria	Optimum Situation
Crossing Condition	Crossing type, material and dimensions are conducive to effective tidal flow
Tidal Restriction	Crossing does not restrict tidal flow at target design year
Aquatic Organism Passage	Crossing does not impede aquatic organism passage at target design year
Tidal Marsh Migration Potential	Crossing will not impede upstream tidal marsh migration at target design year
Vegetation	Crossing has no noticeable effect on upstream versus downstream marsh vegetation
Sensitive Species	Crossing has no noticeable effect on sensitive species
Accessibility	Loss of crossing would not impede transportation and access to critical sites
Crossing Infrastructure Risk	Crossing is not vulnerable to flood inundation at target design year
Adverse Impacts	Restoring full tidal range at the crossing will not adversely affect upstream infrastructure at target design year
Environmental Justice	Crossing does not negatively impact environmental justice populations at target design year

Adaptation and Resilience Strategies

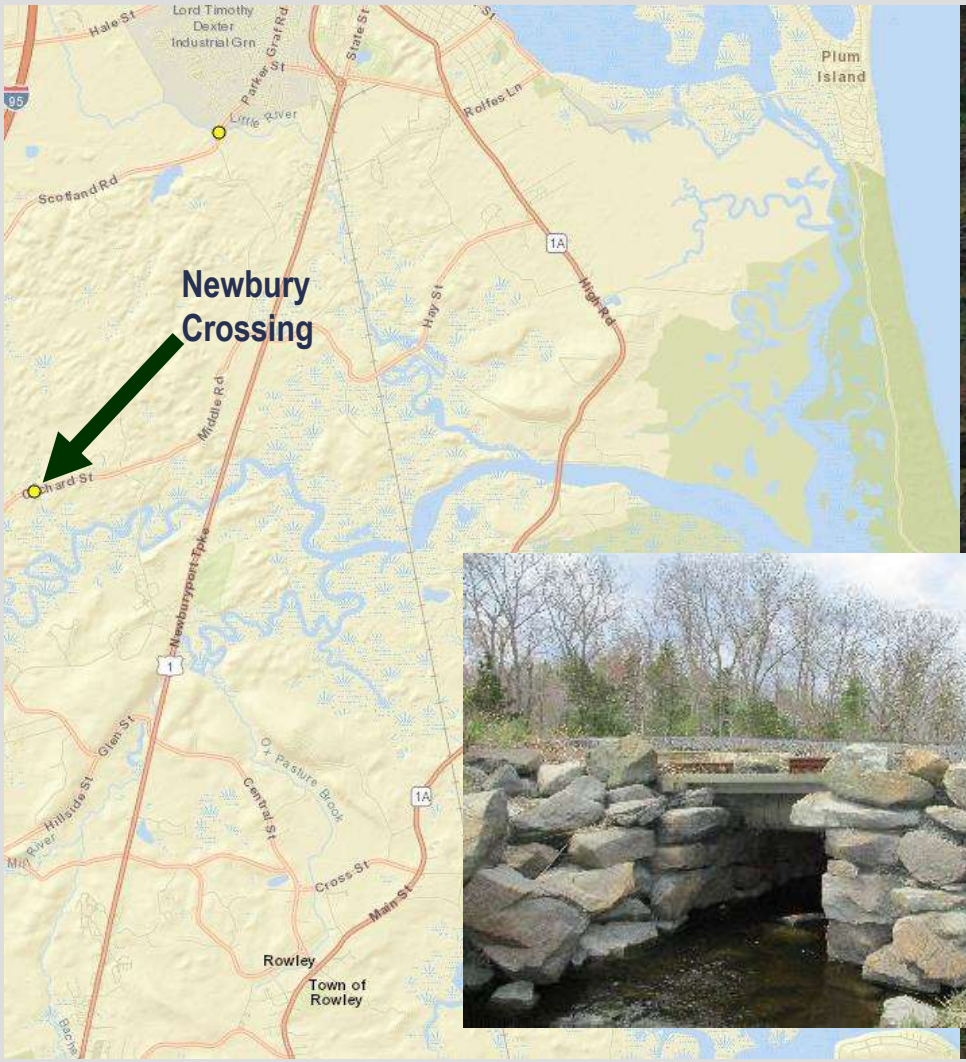
- **Accommodate – Focus on altering existing structures and environments and building new crossings that are better able to withstand sea level rise and storm surge, e.g.:**
  - Submersible bridge decks
  - Raise existing marsh elevation
- **Protect – Solutions to decrease risks for existing structures and environments without changing existing items or features, e.g.:**
  - Tide gates
  - Seawalls
  - Restore coastal wetlands
- **Managed Retreat – Relocation of crossings and limiting construction of new crossings within areas anticipated to be flooded, e.g.:**
  - Replace a crossing upstream of existing location
  - Establish marsh migration corridors

Adaptive Management

Adaptive management involves implementing a management strategy, monitoring its effects, and then adapting future actions based on the observed results.

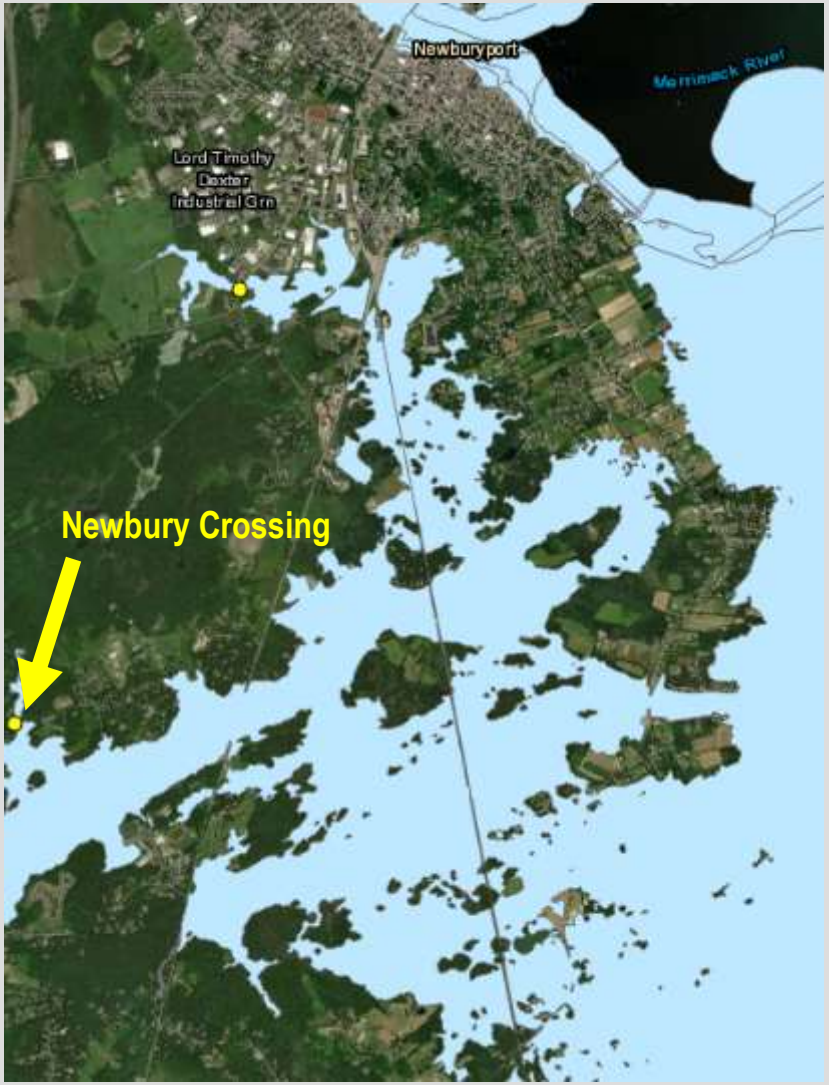


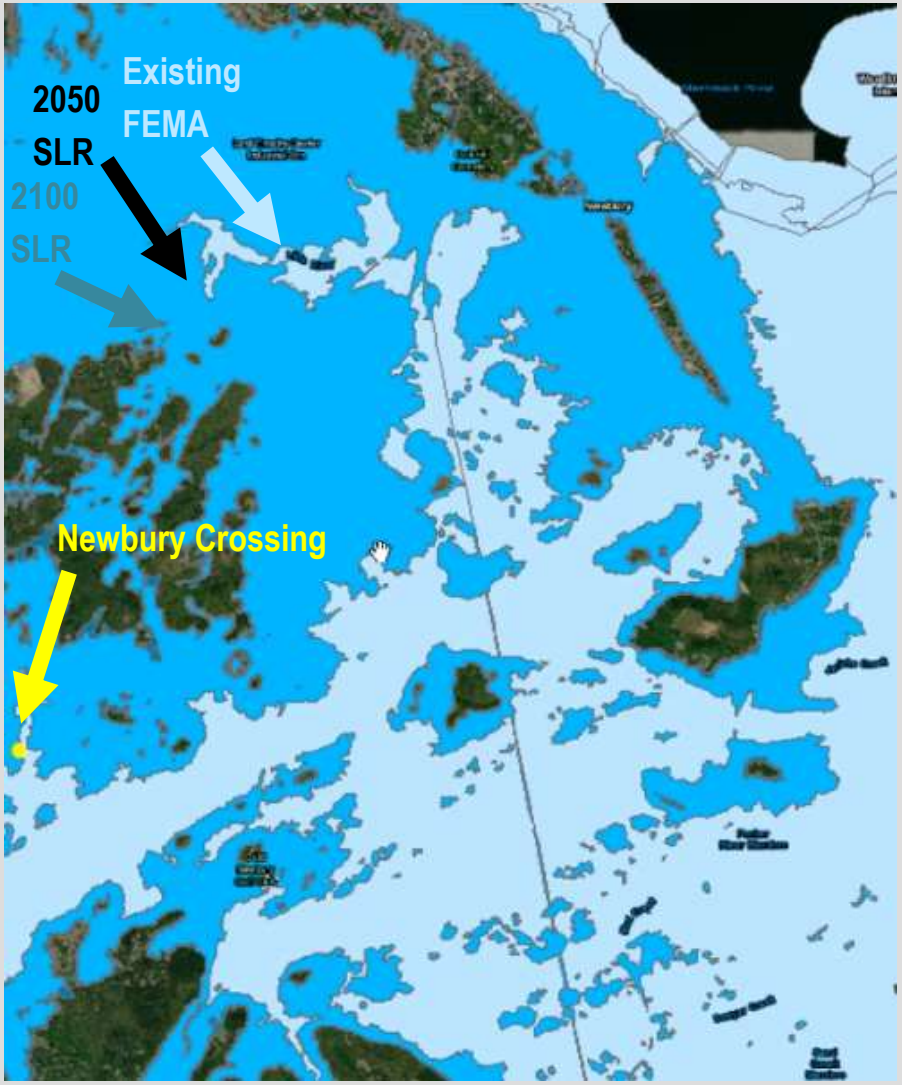
Guidance Use Example



Crossing Site Example

Newbury, Essex County, MA





Crossing Site Example

Newbury, Essex County, MA

Massachusetts Tidal Crossing Field Assessment Protocol Data Sheet

(v. 04/26/2021)

SITE VISIT DETAILS

Crossing ID/MassDOT Bridge ID:	
Town & Location	Newbury - Orchard Street over Cart Creek
Lat./Long.	42.760871, -70.914135

Observer(s) & Organization:	J. Koerner & M. Card - Alfred Benesch & Co.
Date:	4/21/2021
Start Time:	1:45 pm
End Time:	2:30 pm
Ex. Tidal Status:	Low Tide

Tide Prediction	High	Low
Time:	6:51 am	2:01 pm
Elevation (ft):	7.5	0.9
Tide Chart Location:	Newburyport Merrimack River	

Conduct site visit within one hour of low tide, if possible

If non-tidal record N/A

General Assessment Notes:

-Structure is a stone "clapper" span that consists of large dry laid stone abutments and large flat stones placed on top to span over the opening and support the roadway.
-Terrain both upstream and downstream consists fo flat salt marsh that is about 3' to 4' above water level.
-Roadway is is low point at bridge and provides a single lane in each direction with no shoulders.
-No guard rail or bridge railing provided at the structure.
-Site is adjacent to MA DFW Martin Burns Wildlife Management Area

PHOTOGRAPHS

Photo File Names:		Photo Comments
1-Newbury	View of upstream opening	
2-Newbury	Upstream view from above structure	
3-Newbury	Downstream view from above structure	
4-Newbury	View of downstream opening	
5-Newbury	View of upstream vegetation	
6-Newbury	View of downstream vegetation	
7-Newbury	View of roadway direction Lkg West	
8-Newbury	View of roadway direction Lkg East	
9-Newbury	View of utility	Water main under bridge at downstream side partially blocks opening and is the hydraulic low chord
10-Newbury	View of underside of crossing Lkg Downstream	

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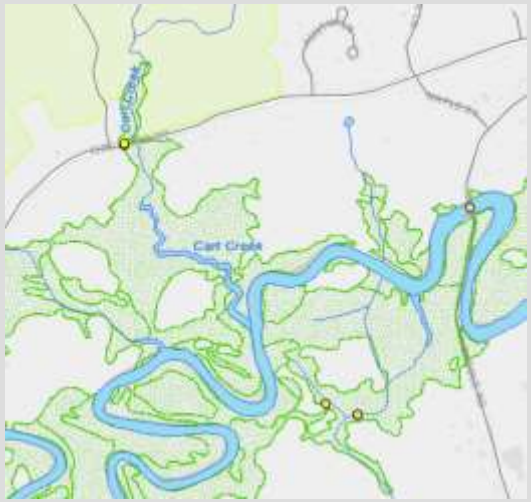
Crossing Site Example

Newbury, Essex County, MA

Guidance Use Example – Newbury Summary

- Crossing Condition - 'fair' may require work in near term; this situation, instead of SLR/BFE may dictate timing of work; water main issue
- Tidal restriction - potential appears low
- Aquatic Passage - appears good
- Marsh migration – there is some opportunity upstream
- Vegetation - appears good
- Sensitive species – some are in close proximity
- Accessibility – Minor road; further research needed
- Crossing infrastructure risk – SLR may be ok to 2100, BFE impact by 2050 likely
- Adverse impact – no issues identified
- Environmental Justice – no issues idenfied
- Summary – Based on 'fair' condition crossing could be updated to accommodate high flood waters and increased tidal flow.



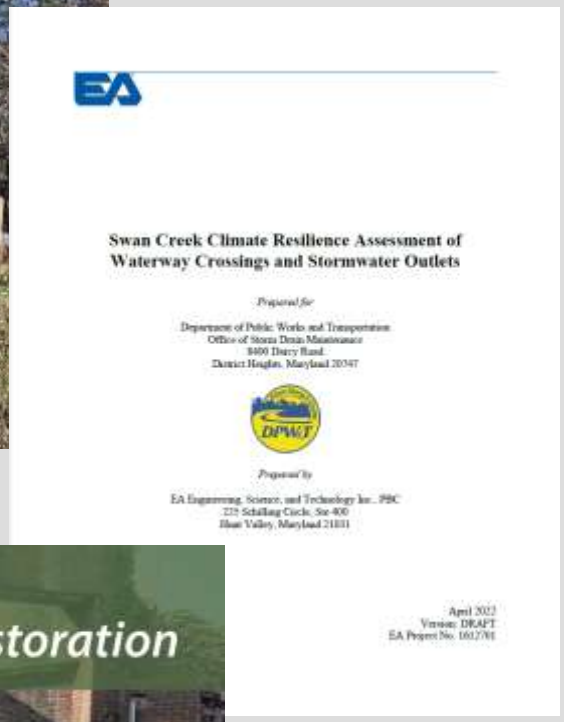
An Important Tool

The Guidance can be used to:

- Assess projected impacts at a site
- Plan for possible solutions
- Formulate watershed or regional plan
- Create adaptation plan for crossings

Next Steps

- Monitoring for adaptive management
- Additional information to refine the Guidance
- Community needs
- Sources of funding for identified projects
- Expansion of use to other coastal areas
  - Swan Creek watershed, Prince George's County, Maryland



Thank You!

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