



Massachusetts Coastal Municipalities

Flood Risk Assessment & Adaptation Planning

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Connecticut Association of Flood Managers

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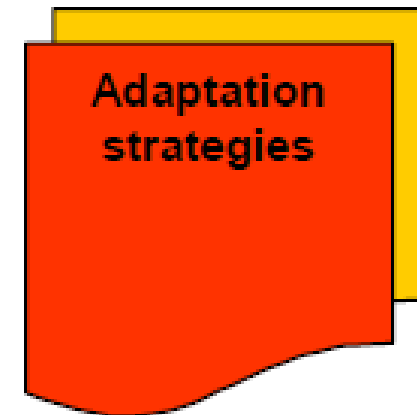
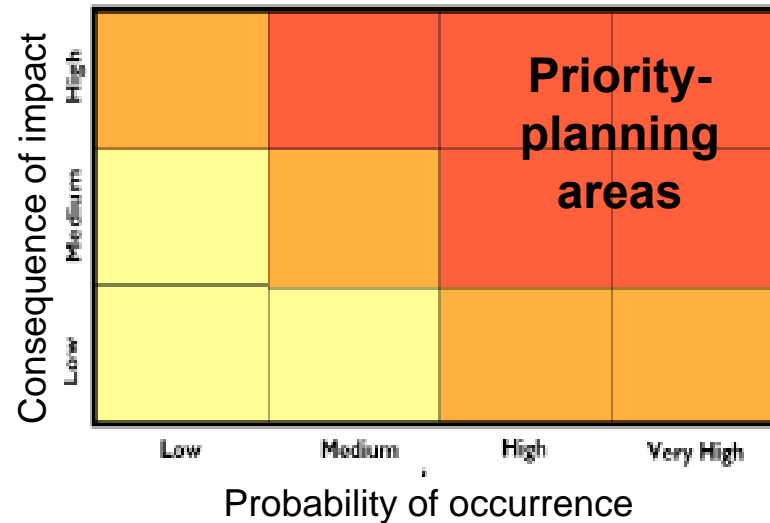


- Massport
- Cambridge, MA
- Boston, MA
- Gloucester, MA
- Swampscott, MA
- Hingham, MA
- Hull, MA
- Oak Bluffs, MA
- Scituate, MA
- Marshfield, MA
- Duxbury, MA
- Army National Guard, MA
- Healthcare Client, MA
- American Water, NJ
- Washington, DC

*Funded by MA Coastal Zone Management
Coastal Community Resilience Grants
(~\$50,000 to \$100,000 each)

- **Develop appropriate sea level rise and storm surge scenarios**
- **Understand vulnerability of municipal infrastructure and natural resources to sea level rise and storm surge**
- **Develop potential short-, mid- and long-term adaptation strategies**

- **Produce high quality maps, graphics and GIS layers**
- **Undertake public outreach and education programs**



Phase I

Sea Level Rise/Storm Surge Projections

Scenario Development

Phase II

Mapping Inundation Modeling Results

Vulnerability/Risk Assessment

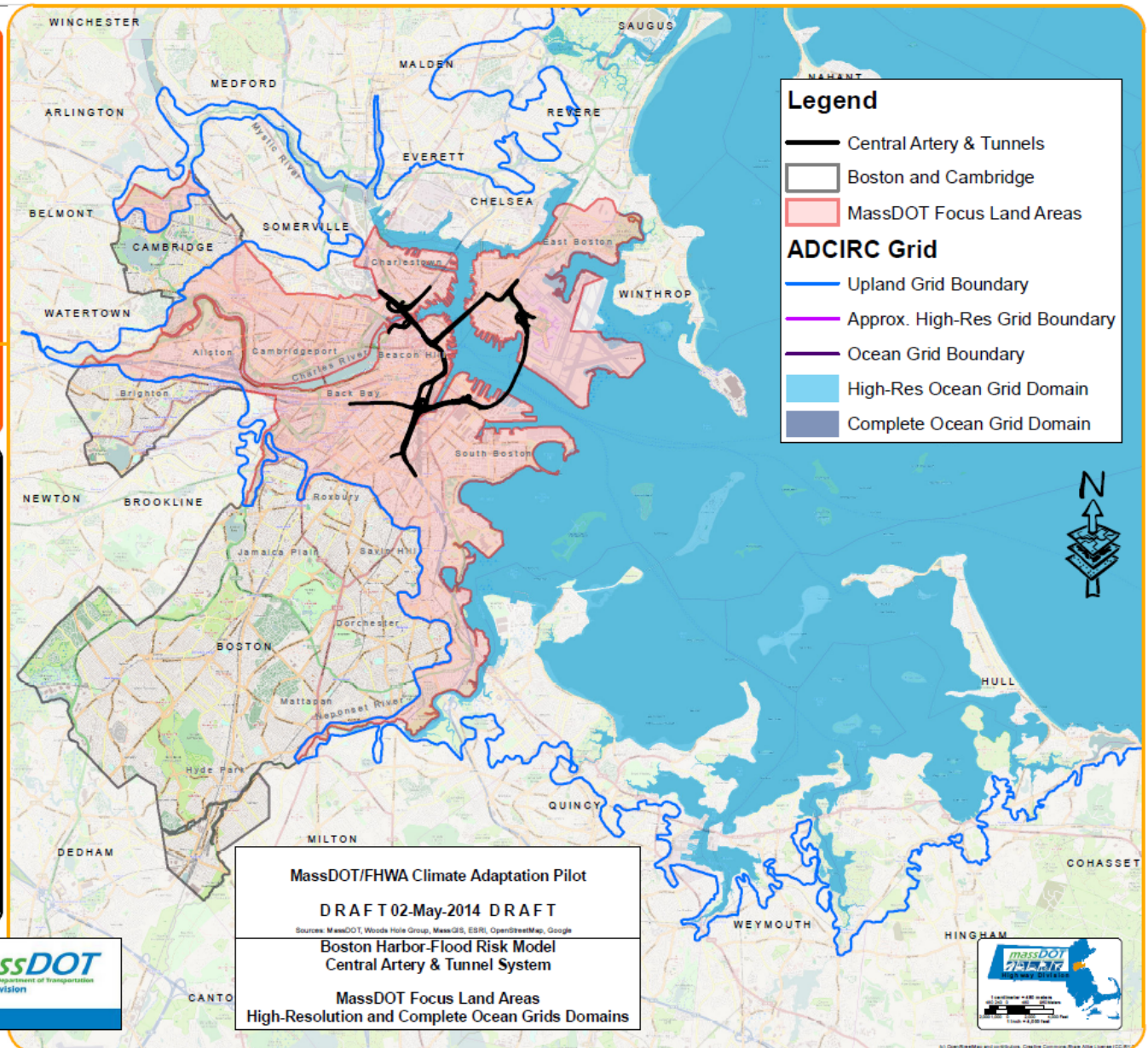
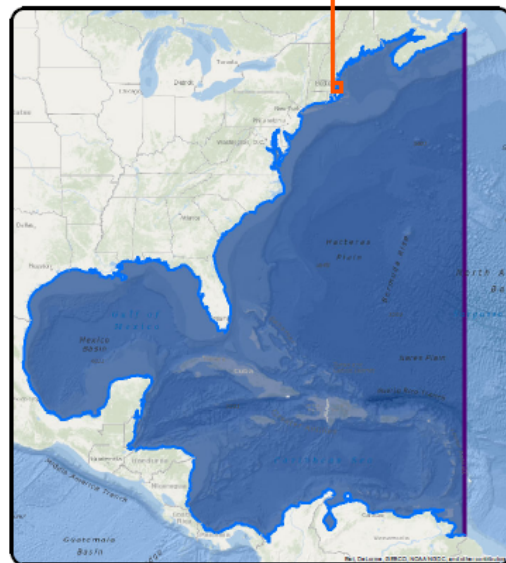
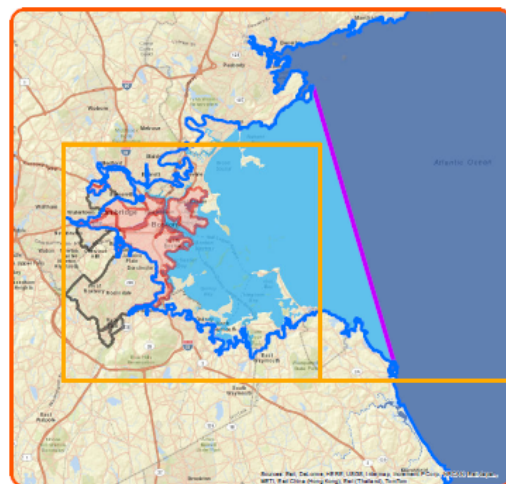
Phase III

Develop Adaptation Strategies

Public Outreach

- **2013 - Present**
- **2030 – 15 years out – Near term**
- **2070 – 55 years out – Long term**

Hydrodynamic Water Surface Model



A Probability-Based Model

**Not “worst-case” scenarios
but
“worst-likely” scenarios**

Vulnerability Assessment based on Risk

**Risk (R) = Probability of Flooding (P) x
Consequence of Flooding (C)**

$$R = P \times C$$

Consequence of Flooding based on:

- Area of service loss
- Duration of service loss
- Cost of damage
- Impacts to public safety and emergency services
- Impacts to economic activities
- Impacts to public health and the environment

What are some key takeaways that might apply to CT municipalities?

The highest risk assets tend to be:

- Seawalls and other coastal structures, particularly in harbor areas
- Major roadways with low points along the coast or at wetland crossings
- Wastewater infrastructure



COASTAL STRUCTURES

Seawalls, Bulkheads & Revetments

Additional height needed for 1% annual flood protection

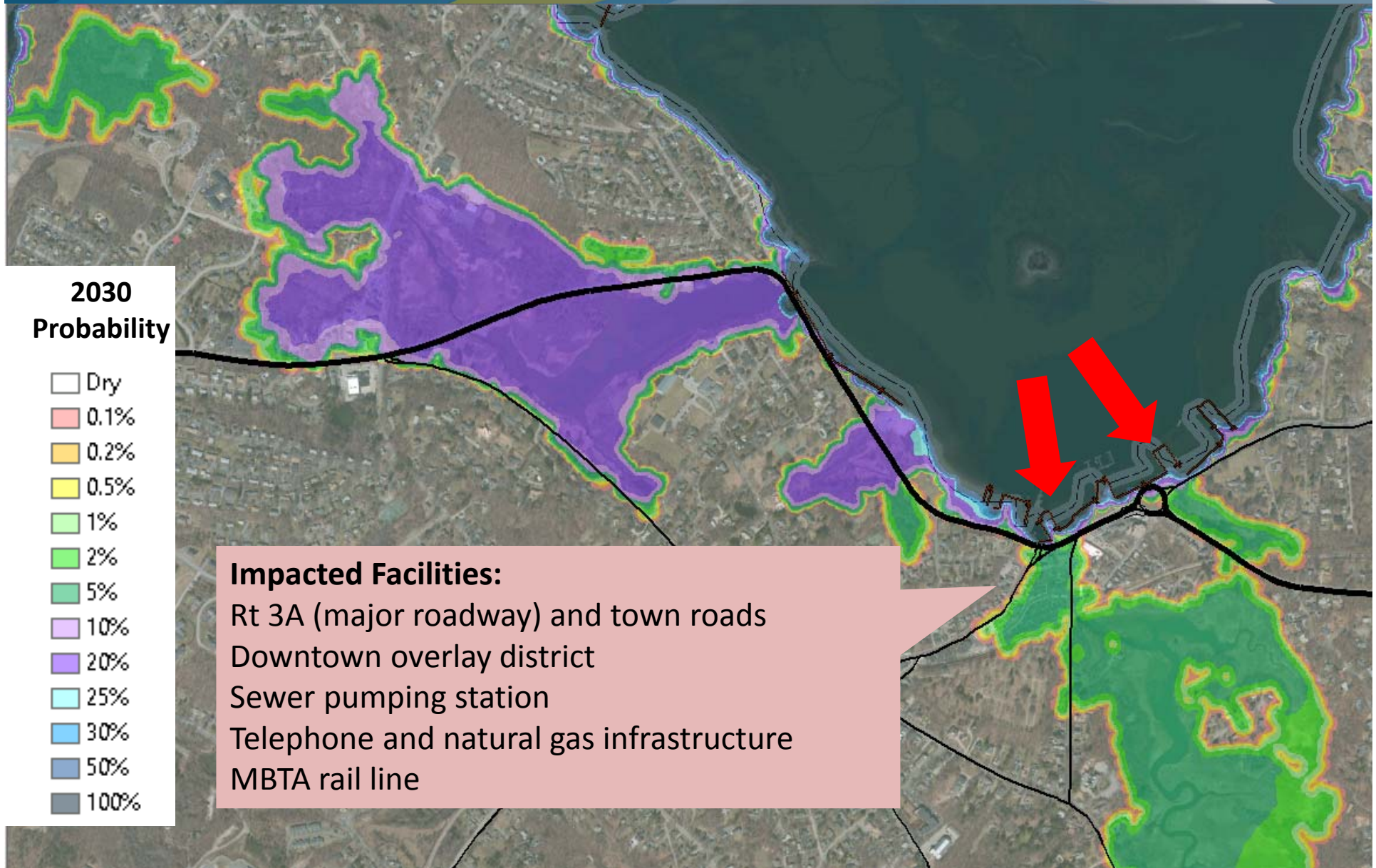
Municipality	Present	2030	2070
Gloucester	0.0* - 2.8 ft *1 of 9 structures	0.2 – 3.0 ft	4.0 – 6.8 ft
Hingham	0.0* – 3.7 ft *5 of 12 structures	0.0* – 5.2 ft *3 of 12 structures	1.9 – 8.0 ft
Oak Bluffs	0.0* – 6.2 ft *1 of 5 structures	0.7 – 7.2 ft	3.5 – 10 ft

With no action, municipal coastal infrastructure will provide decreasing levels of protection over time





Route 3A @ Inner Harbor – Hingham



○ **Gloucester**

- Harbor seawalls are mostly private, lots of water-dependent industry – incentivize or compel raising
- Wet and dry floodproofing for residential/commercial
- Upland “containment” options

○ **Hingham**

- All municipal structures, site can accommodate gray and green infrastructure

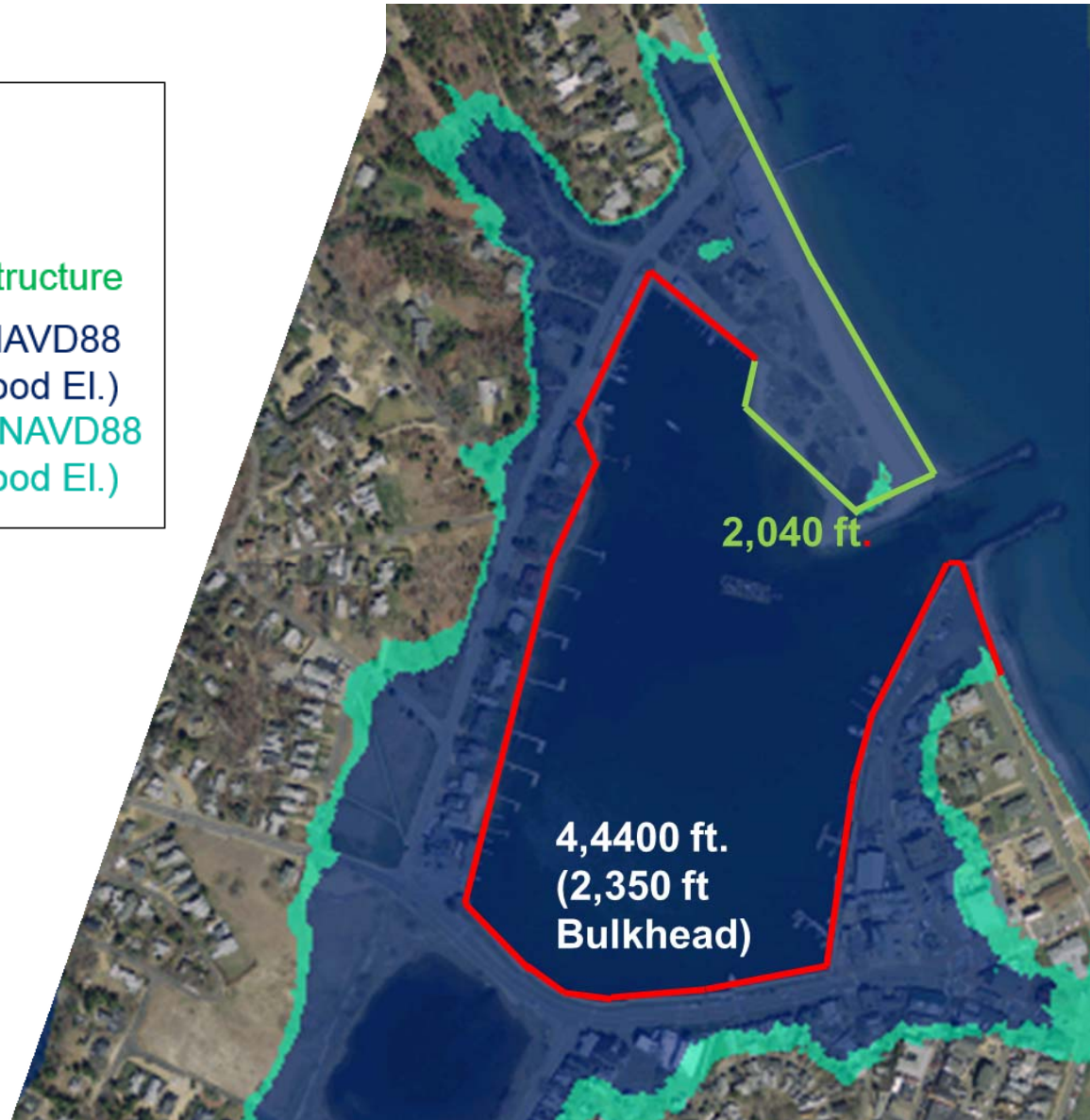
○ **Oak Bluffs**

- Also all municipal, but design would need to take into account tourism, water transit, and recreational uses.

Oak Bluffs Inner Harbor

Legend

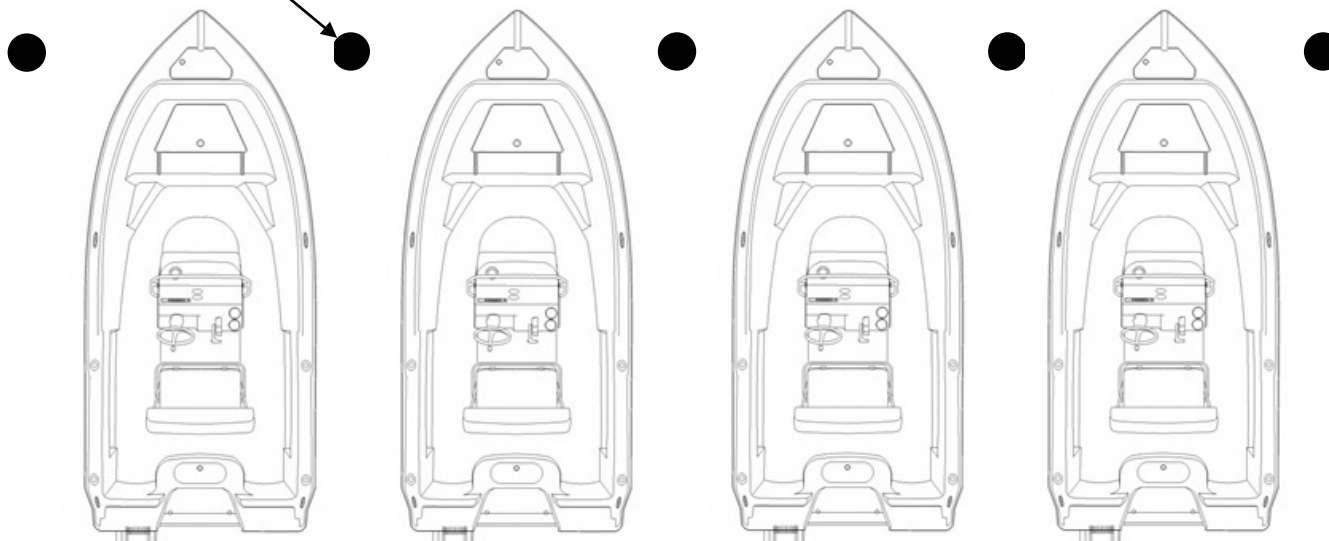
- Bulkhead
- Green Infrastructure
- El. < 9.7 ft. NAVD88
(2030 1% Flood El.)
- El. < 12.5 ft. NAVD88
(2070 1% Flood El.)



Harbor Bulkhead - Existing

*Not drawn to scale, for illustrative purposes only

**Timber Mooring
Piles (Typ.)**



Existing Sheet Pile Bulkhead with Concrete Cap

Existing Sidewalk

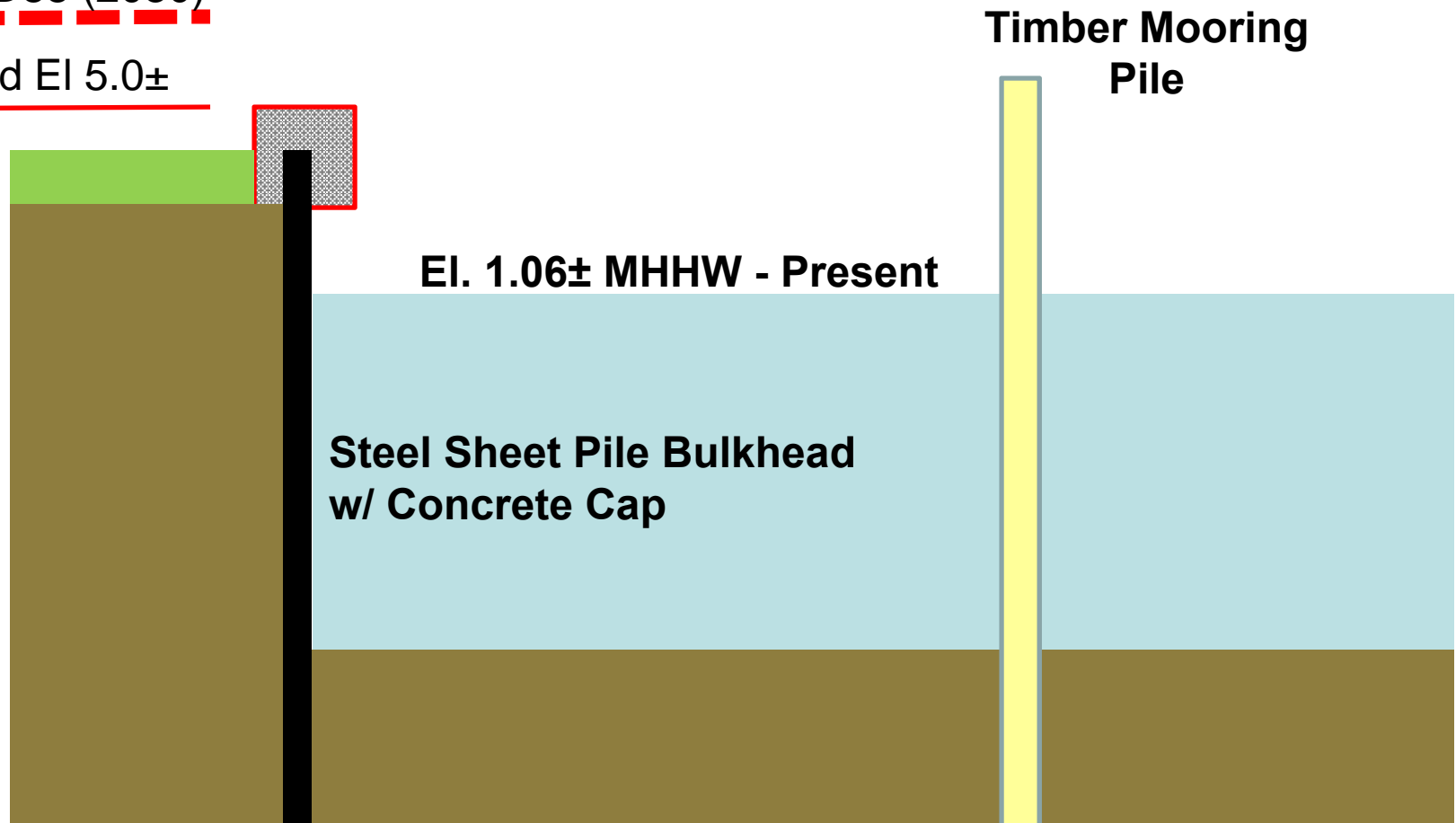
Harbor Bulkhead - Present

*Not drawn to scale, for illustrative purposes only

12.5 ft NAVD88 (2070)

9.7 ft NAVD88 (2030)

T. Bulkhead El 5.0±



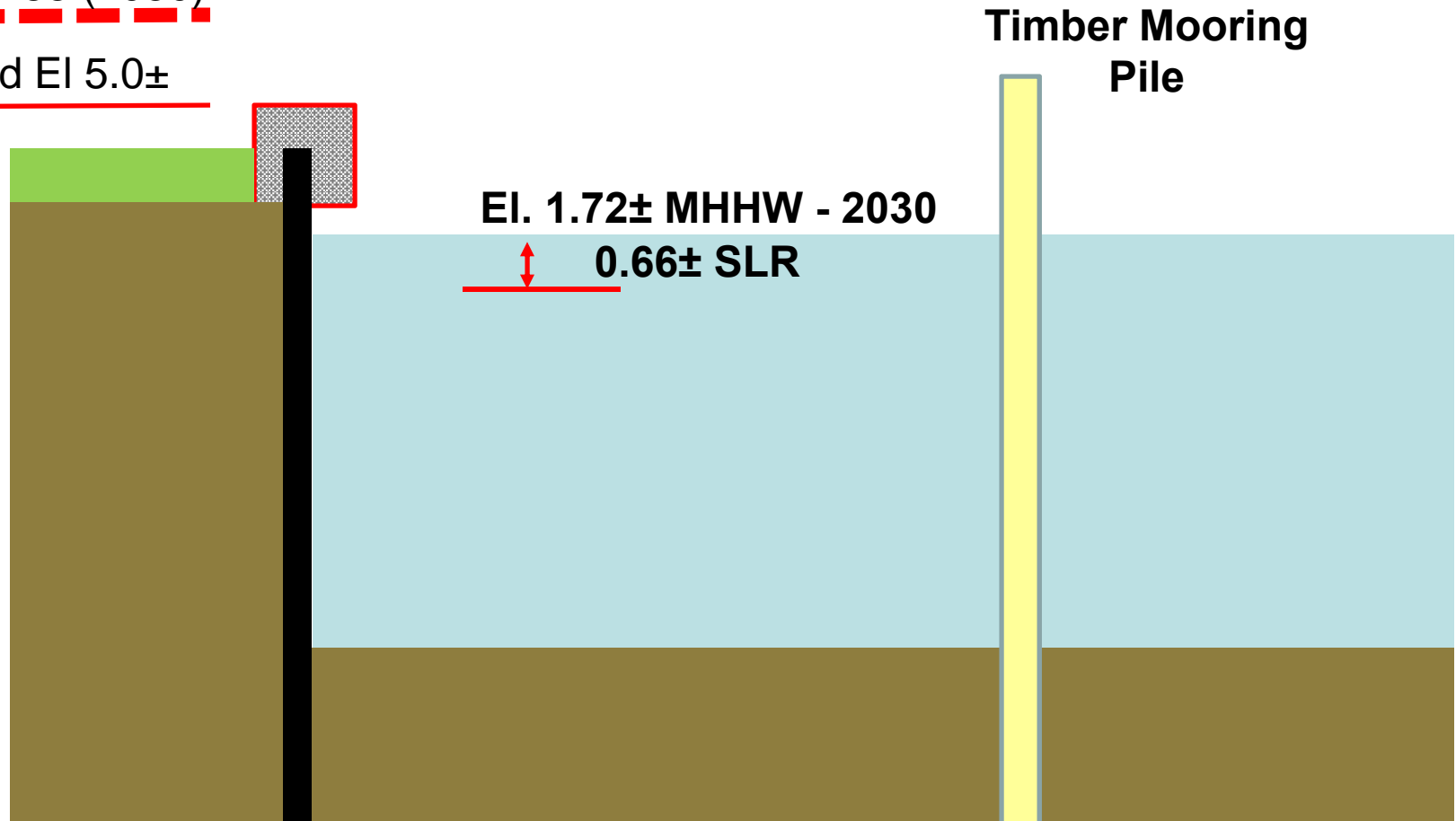
Harbor Bulkhead - 2030

*Not drawn to scale, for illustrative purposes only

12.5 ft NAVD88 (2070)

9.7 ft NAVD88 (2030)

T. Bulkhead El 5.0±



Harbor Bulkhead - 2070

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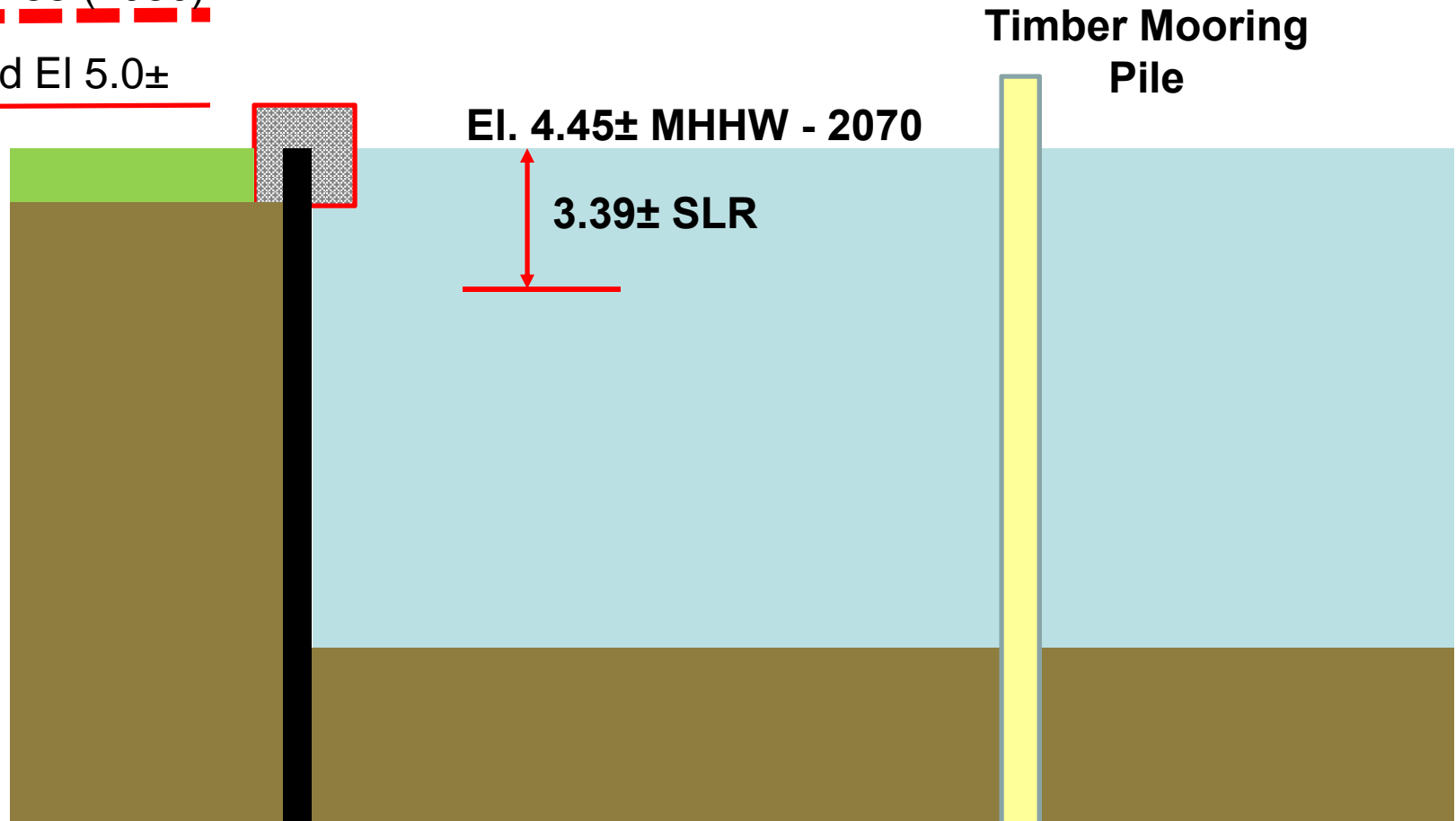
12.5 ft NAVD88 (2070)



9.7 ft NAVD88 (2030)



T. Bulkhead El 5.0±



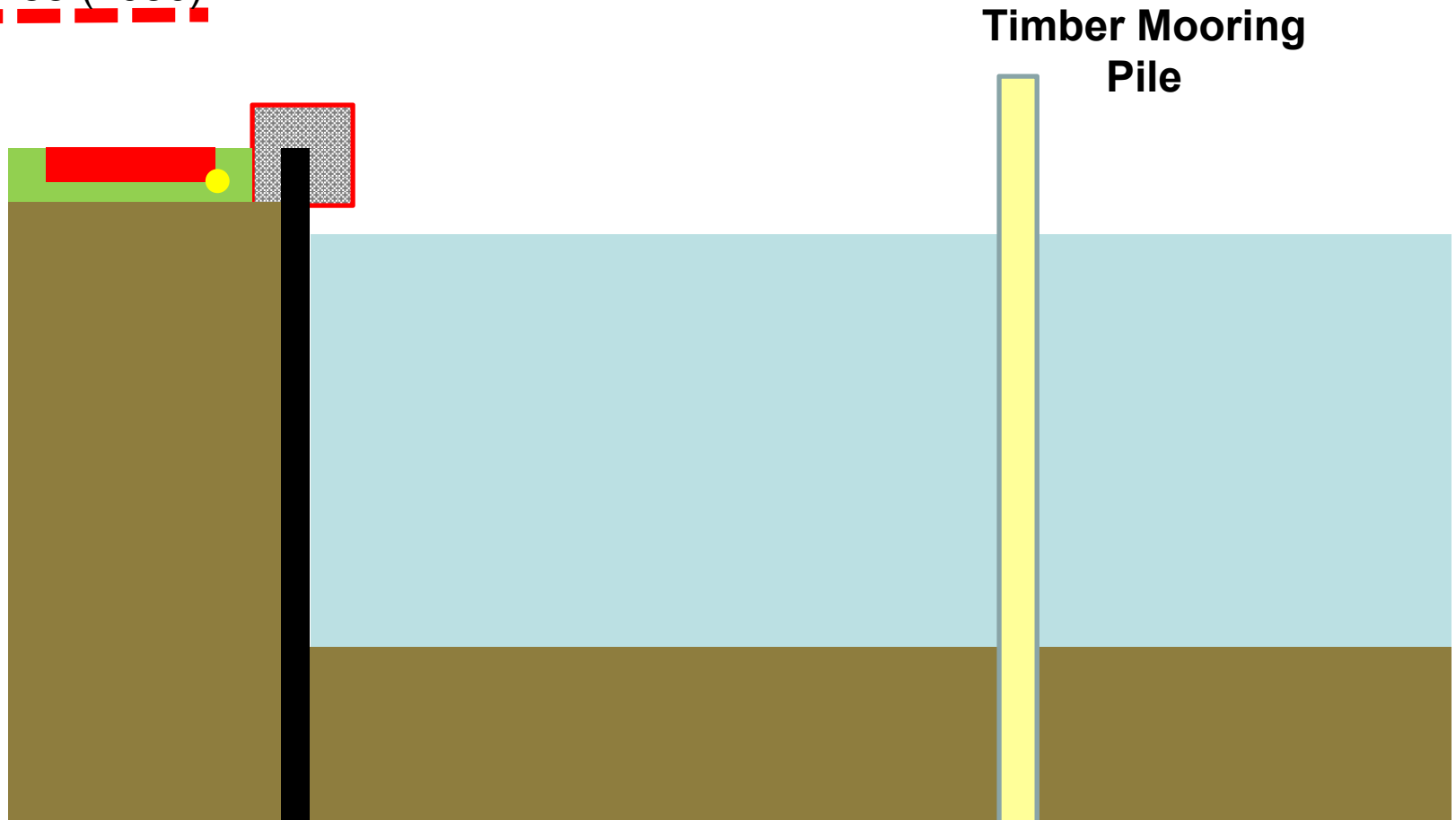
Harbor Bulkhead – Option A

No Storm – Passive Barrier Stored in Sidewalk

12.5 ft NAVD88 (2070)



9.7 ft NAVD88 (2030)

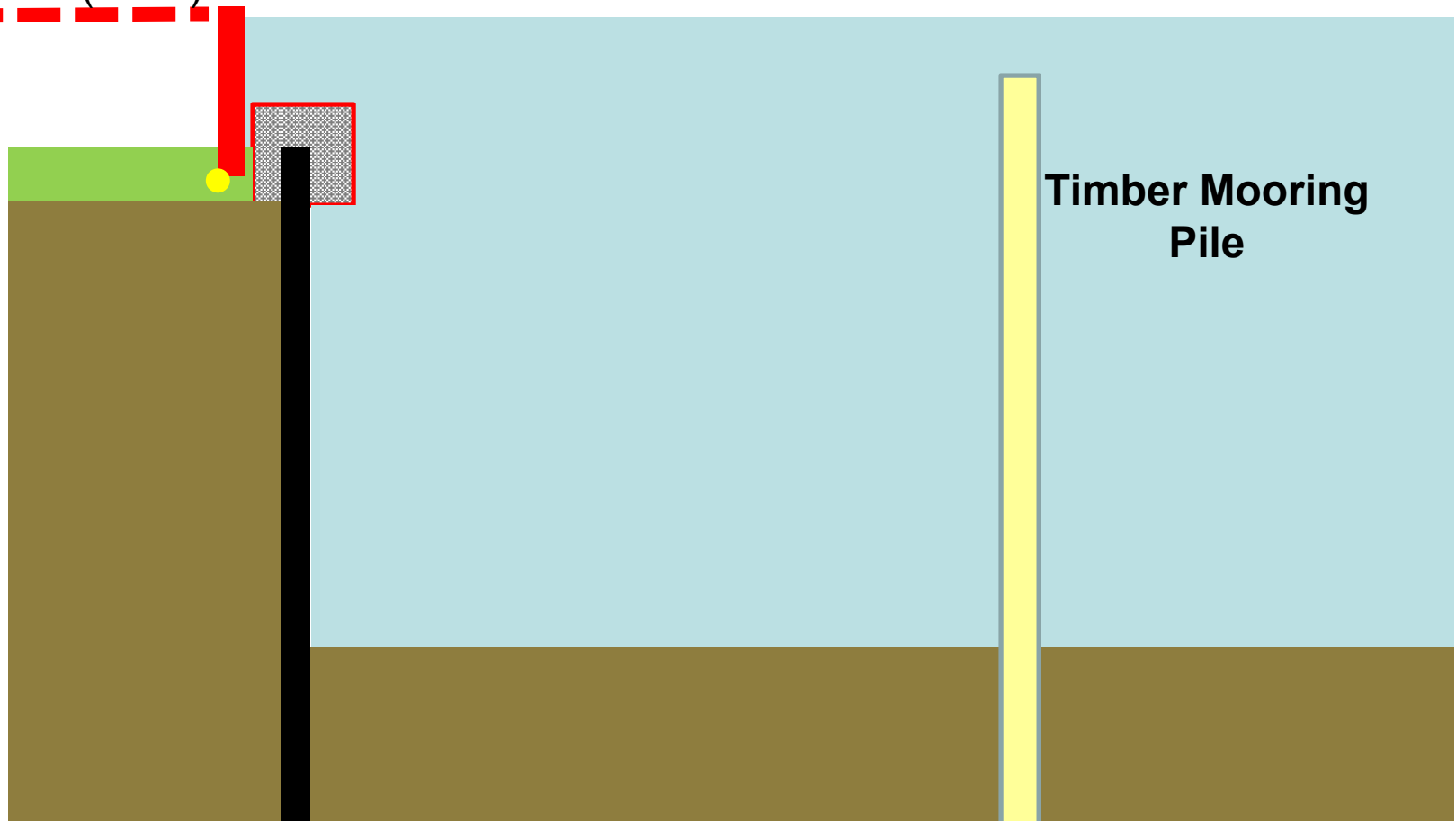


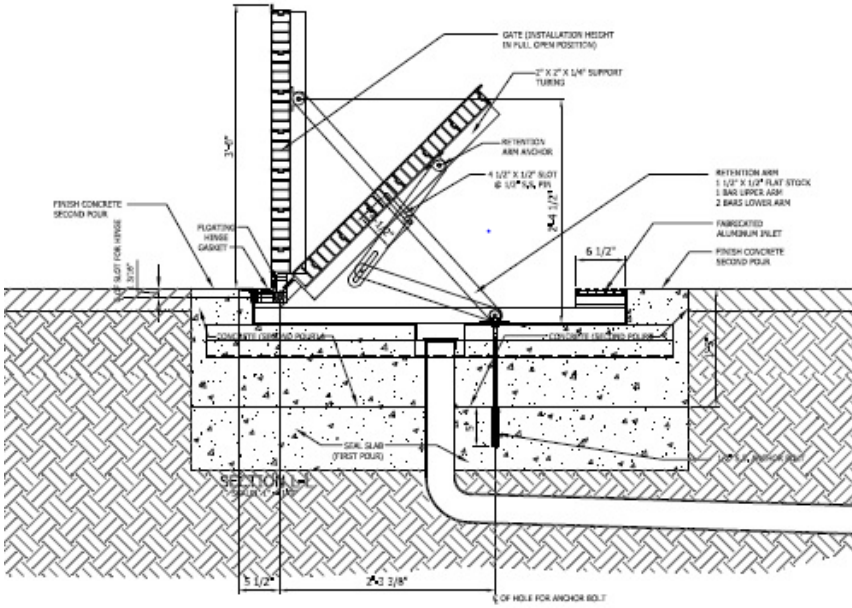
Harbor Bulkhead – Option A

Storm Event – Passive Barrier Rotated into Position

12.5 ft NAVD88 (2070)

9.7 ft NAVD88 (2030)





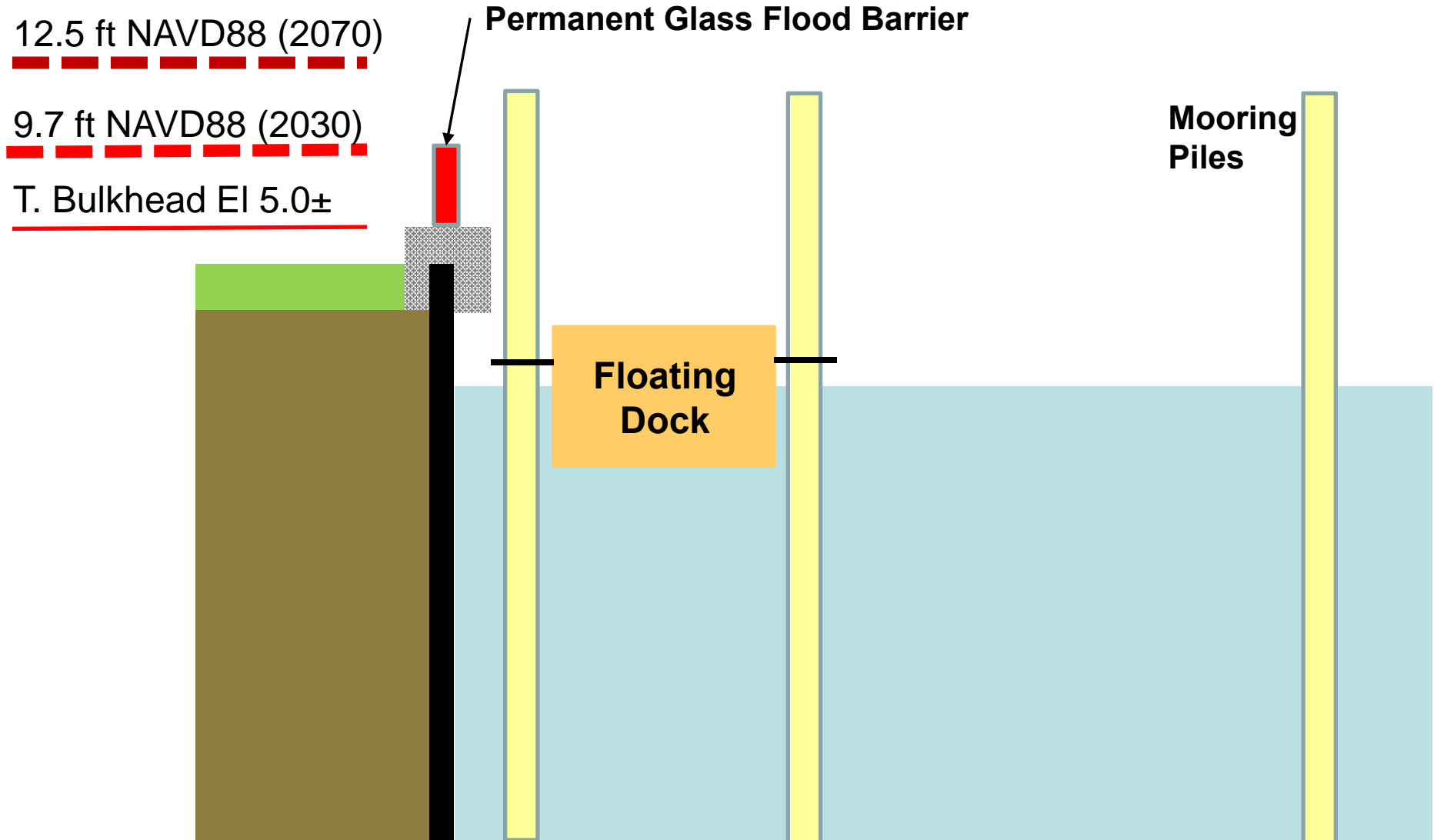
Typical Cross Section



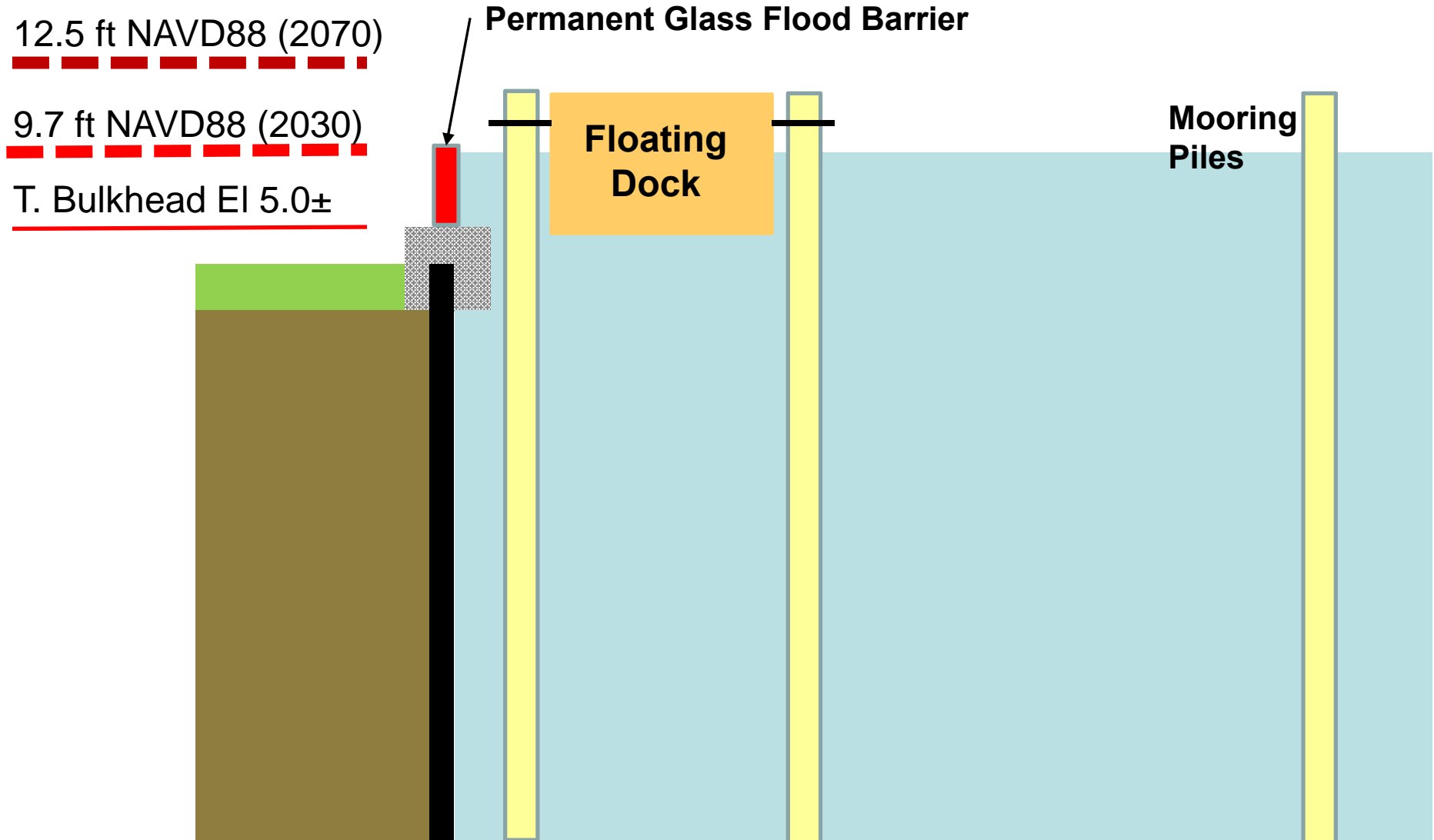
Lourdes Hospital, Binghamton, NY

Example of Passive Flood Barrier

Harbor Bulkhead – Option B

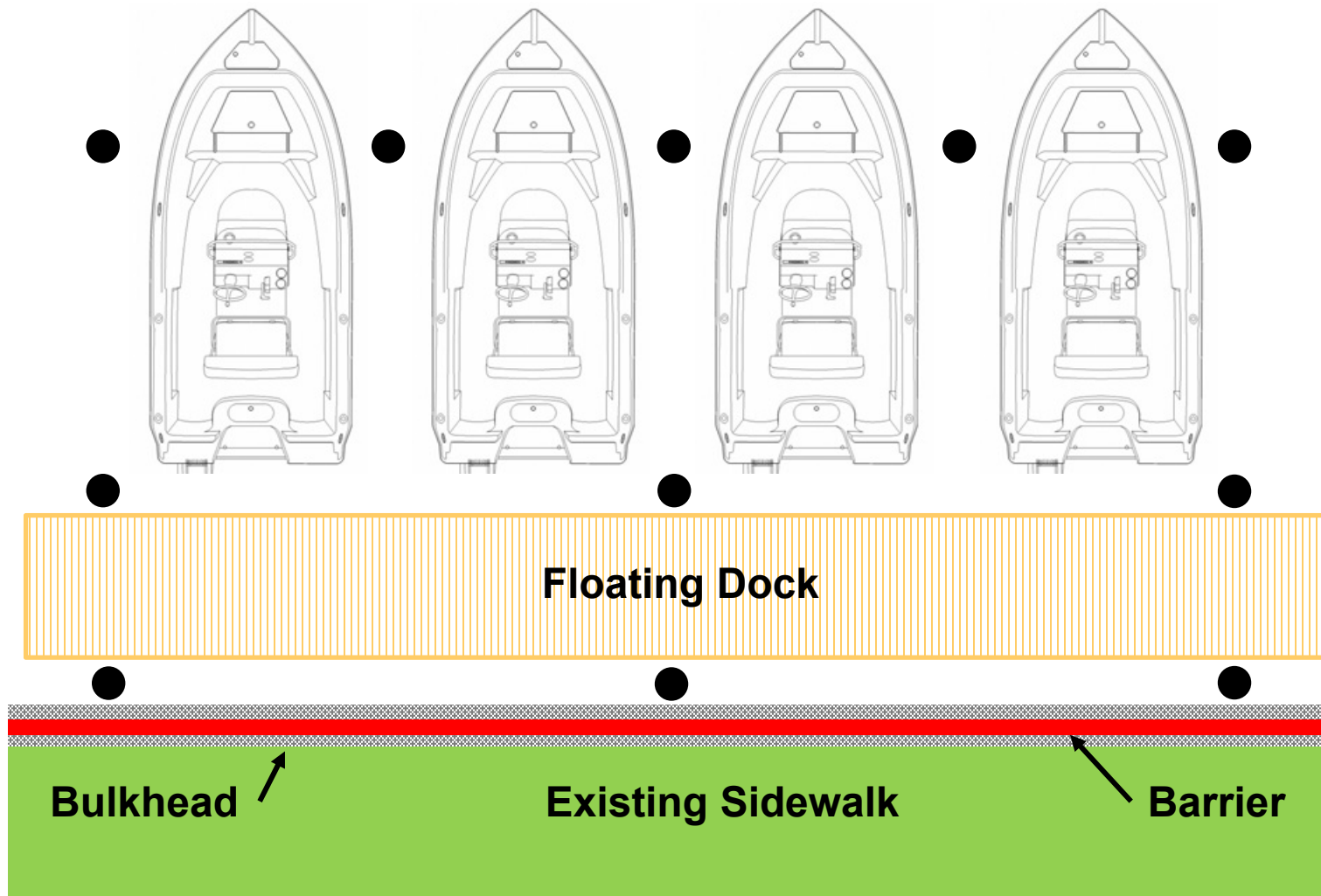


Harbor Bulkhead – Option B



Harbor Bulkhead – Option B

*Not drawn to scale, for illustrative purposes only





Example of Glass Flood Barrier



Infill Panel to be Installed to Fill Openings During Storm Events

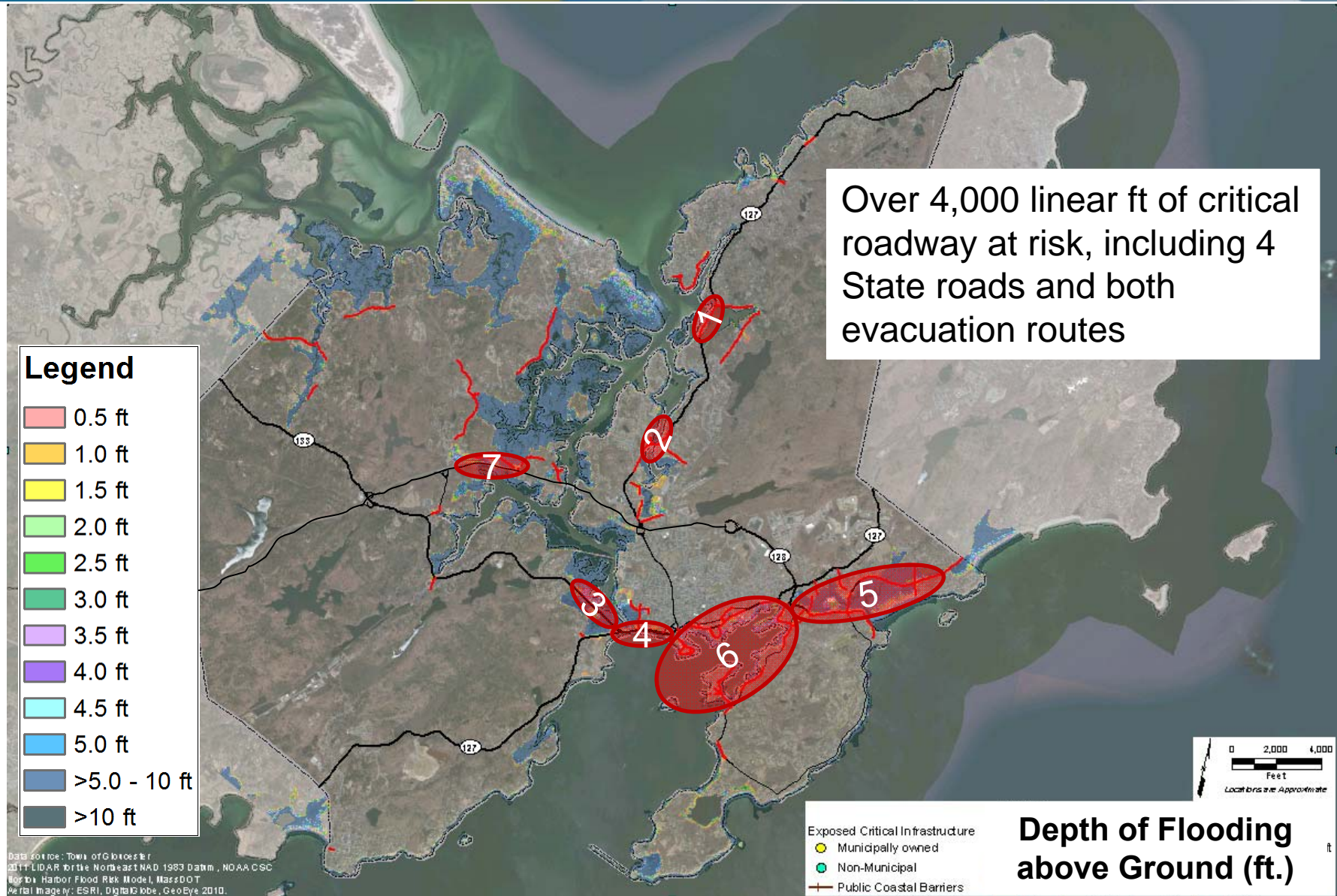




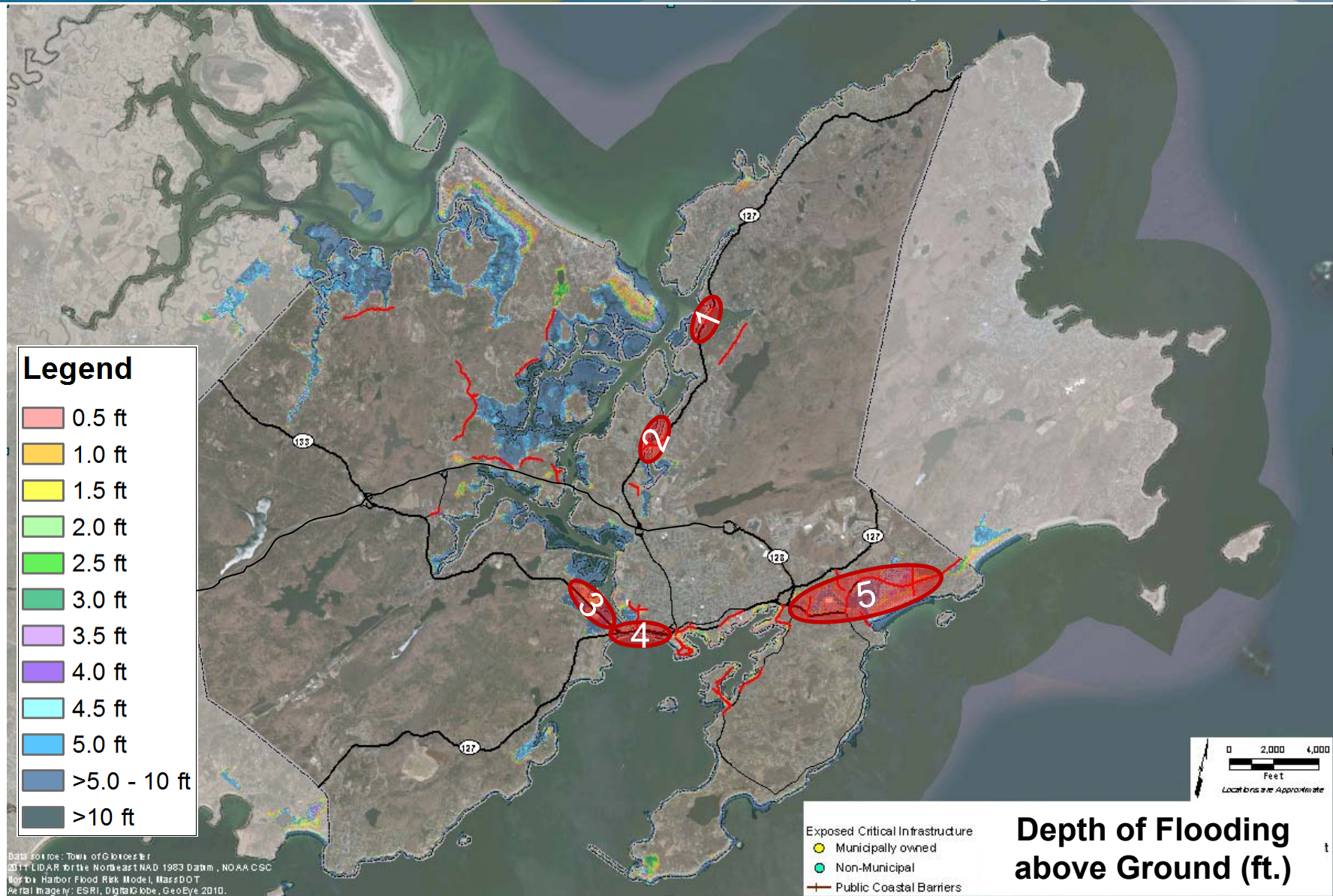
MAJOR ROADWAYS

Transportation infrastructure can be a major source of risk, but it can also be harnessed for resiliency

2070: 1% Annual Probability – Flooded Streets Gloucester (≈100 yr Recurrence)



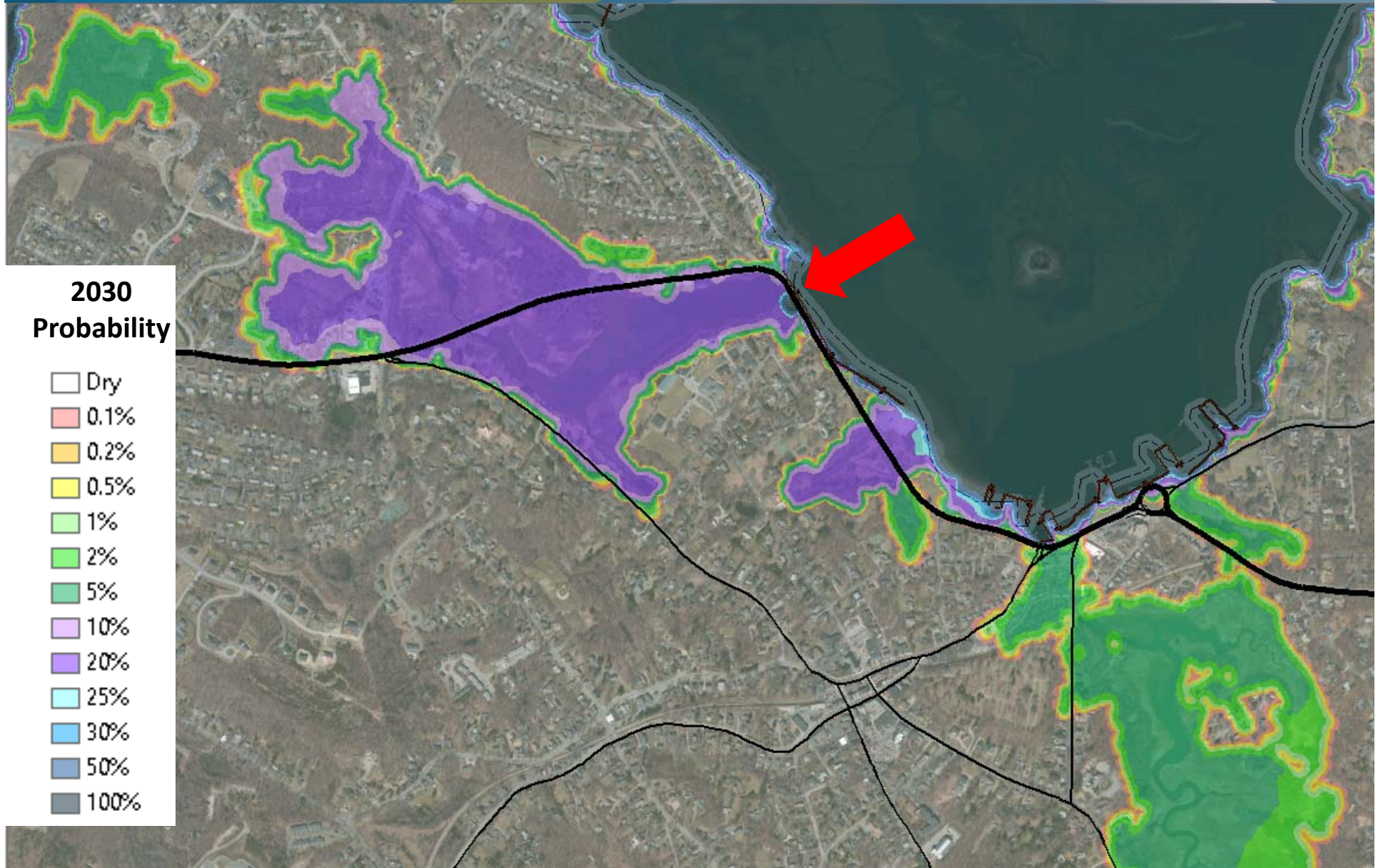
2030: 1% Annual Probability – Flooded Streets Gloucester (≈100 yr Recurrence)



Focus on addressing flood pathways with a high probability of exposing clusters of municipal assets

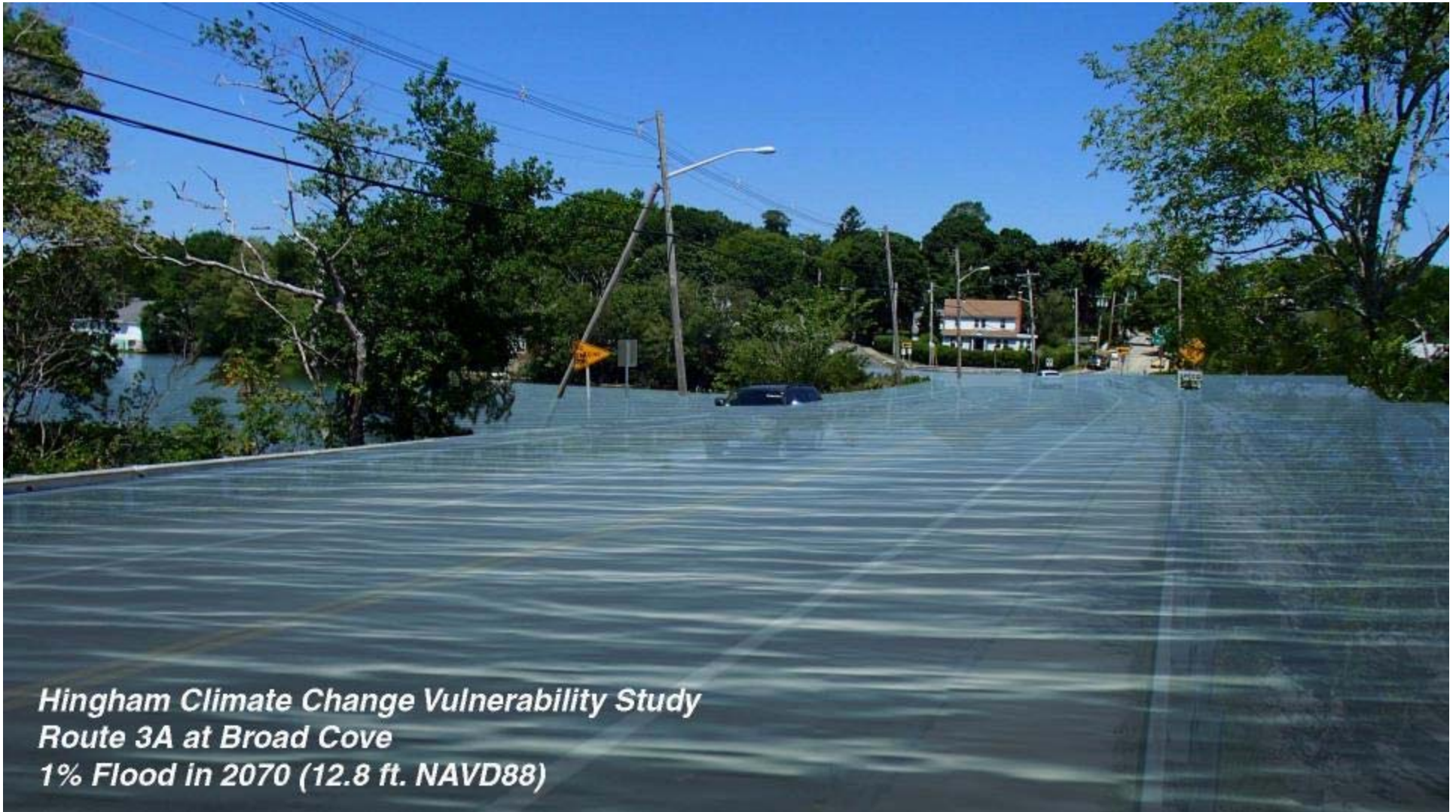
The costs may be higher than addressing each asset individually, but the co-benefits for the community are often vastly greater

Route 3A @ Broad Cove – Hingham



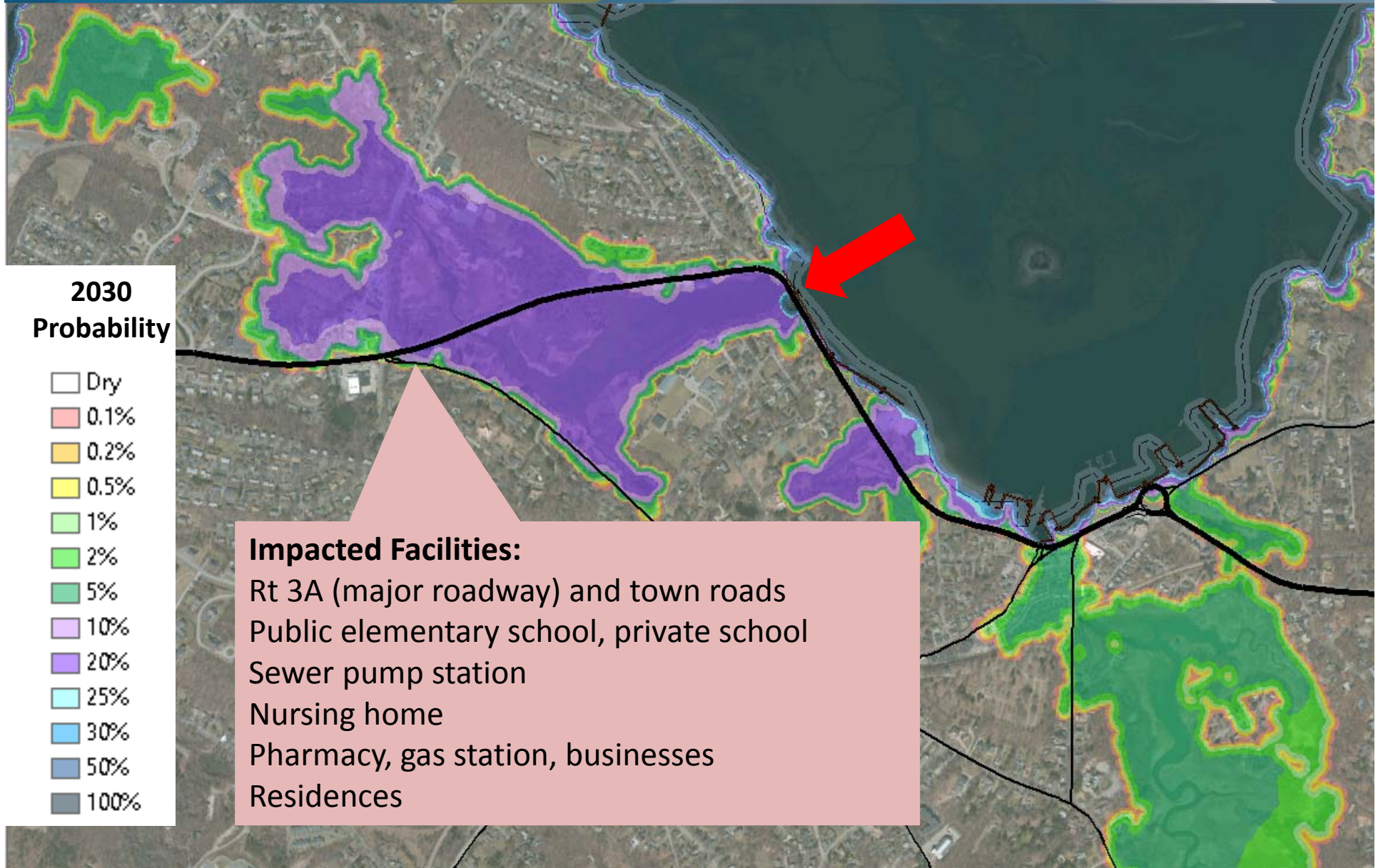


Rt. 3A at Broad Cove 2070 1% (100 YR)



*Hingham Climate Change Vulnerability Study
Route 3A at Broad Cove
1% Flood in 2070 (12.8 ft. NAVD88)*

Route 3A @ Broad Cove – Hingham

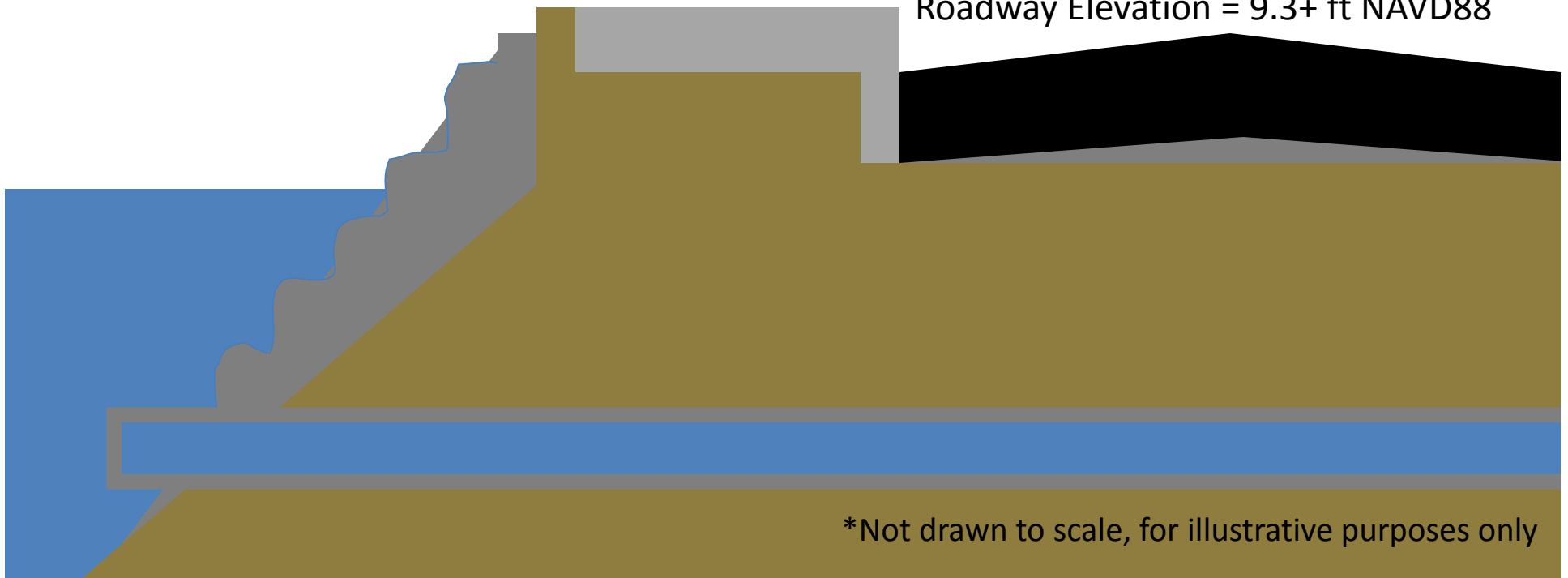


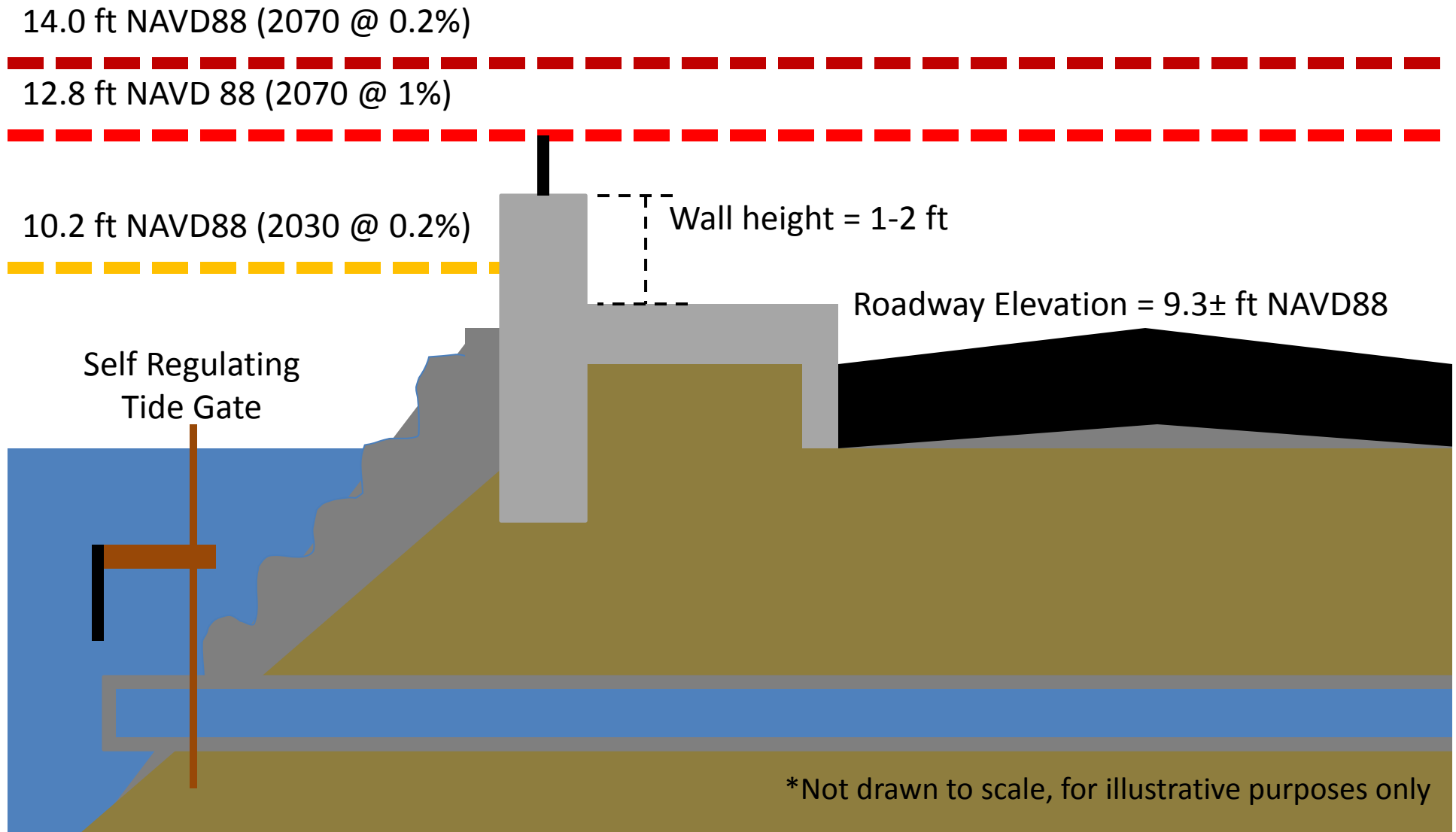
14.0 ft NAVD88 (2070 @ 0.2%)

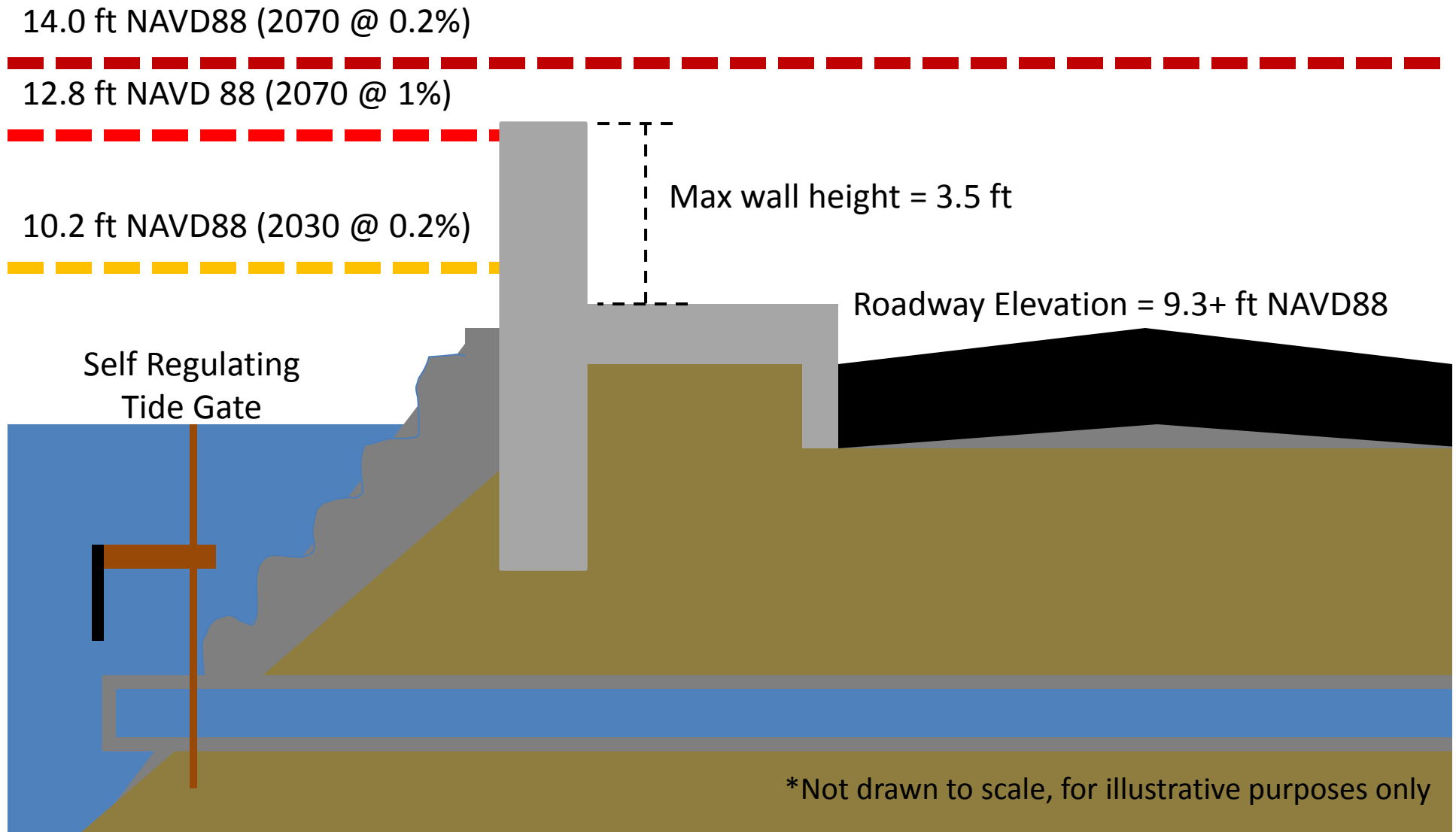
12.8 ft NAVD 88 (2070 @ 1%)

10.2 ft NAVD88 (2030 @ 0.2%)

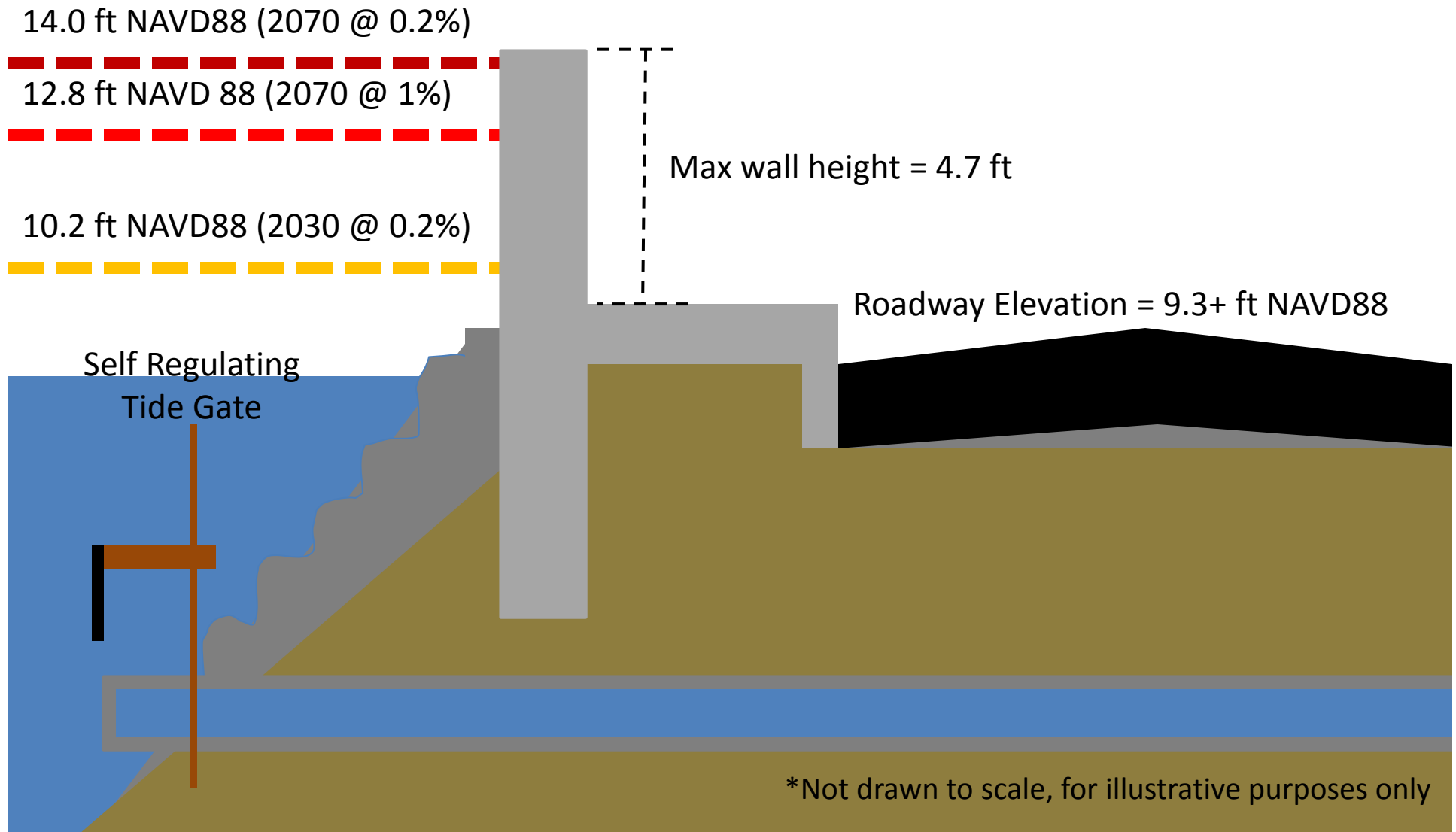
Roadway Elevation = 9.3+ ft NAVD88







Long Term Option: Over Long Term, Increasing Wall Height Unsustainable

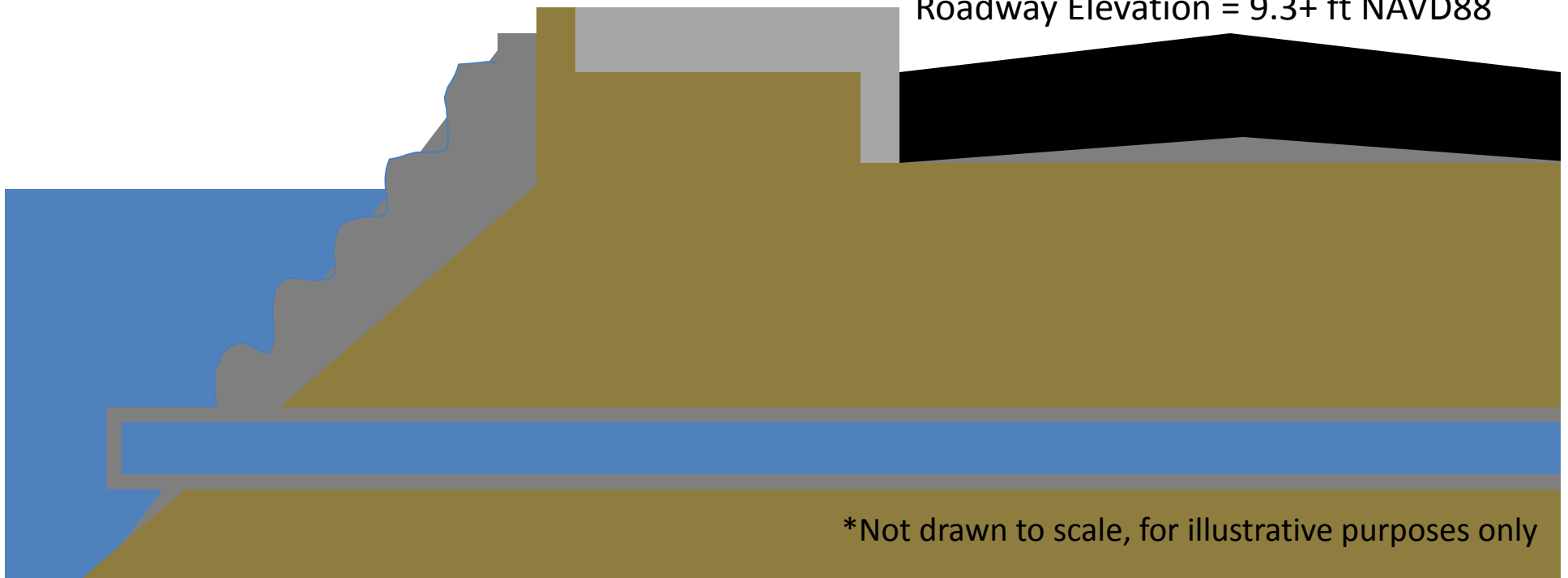


14.0 ft NAVD88 (2070 @ 0.2%)

12.8 ft NAVD 88 (2070 @ 1%)

10.2 ft NAVD88 (2030 @ 0.2%)

Roadway Elevation = 9.3+ ft NAVD88



*Not drawn to scale, for illustrative purposes only

Recommended Option / Medium Term: Raise Road and Sidewalk to 11 ft ± NAVD

14.0 ft NAVD88 (2070 @ 0.2%)

12.8 ft NAVD 88 (2070 @ 1%)

10.2 ft NAVD88 (2030 @ 0.2%)

Roadway Elevation = 11± ft NAVD88

Self Regulating
Tide Gate

Retaining Wall

*Not drawn to scale, for illustrative purposes only

Recommended Option / Medium Term: Provides Flexibility to Increase Level of Protection Later

14.0 ft NAVD88 (2070 @ 0.2%)

12.8 ft NAVD 88 (2070 @ 1%)

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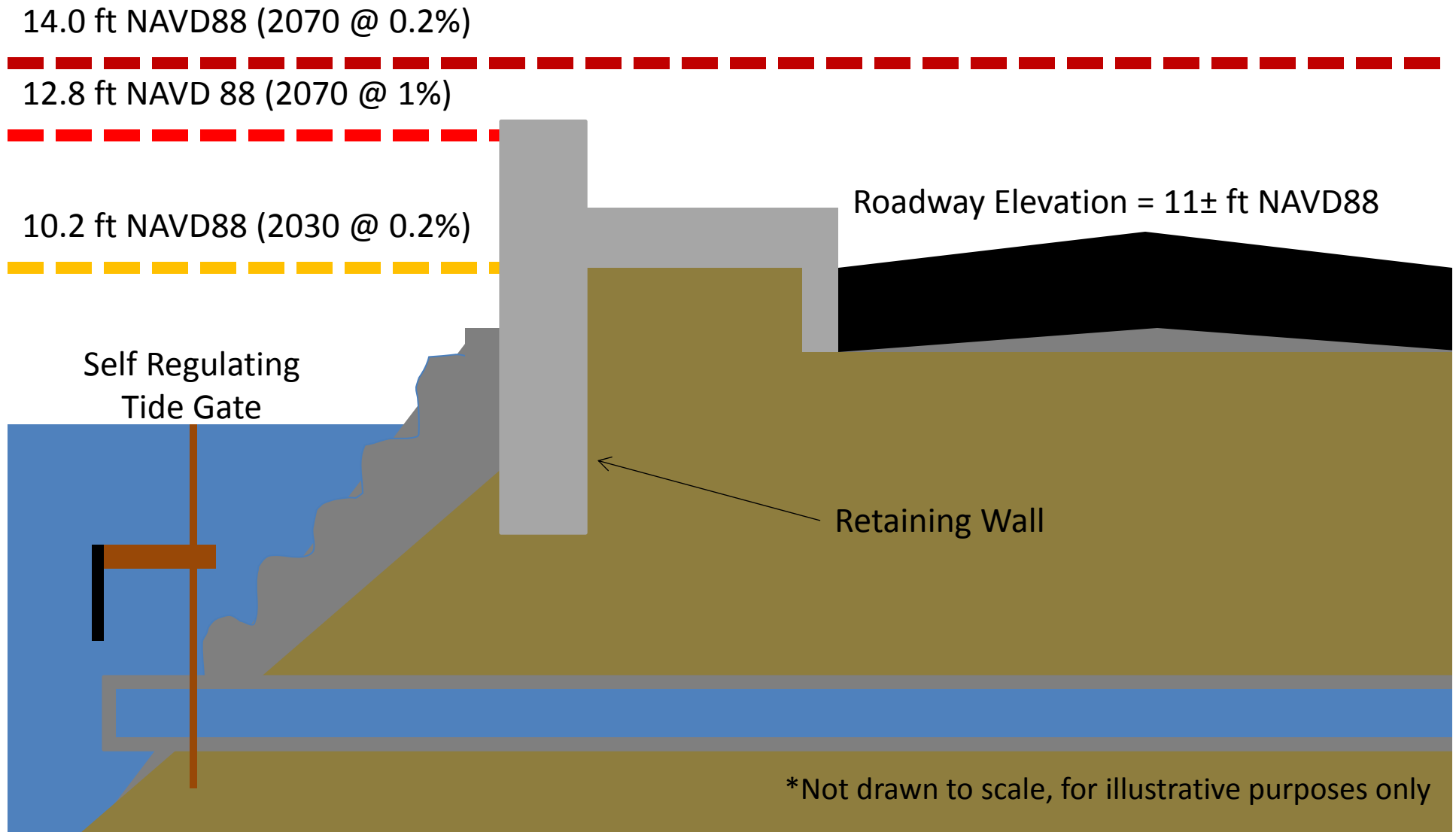
Roadway Elevation = 11± ft NAVD88

Self Regulating
Tide Gate

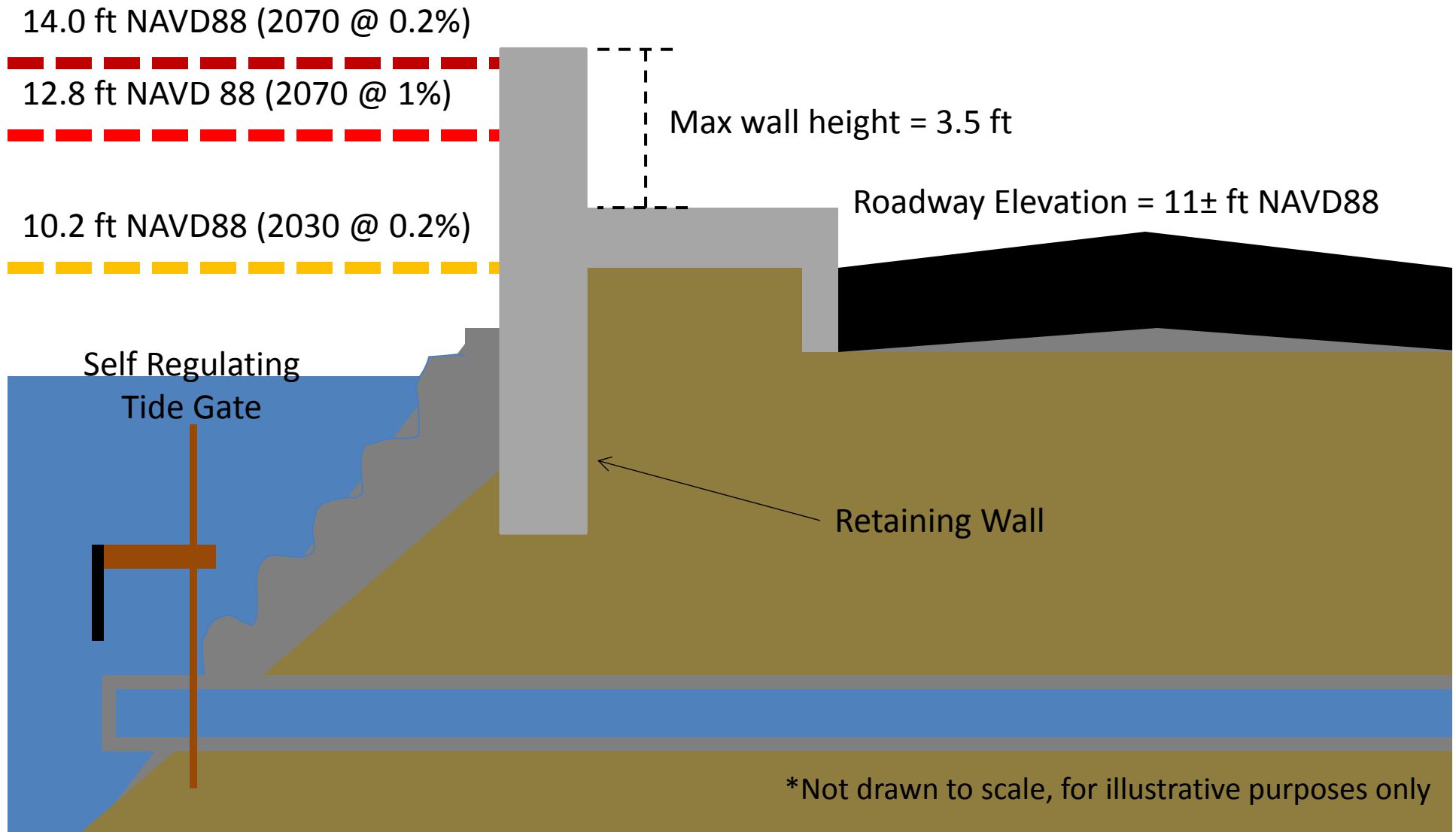
Retaining Wall

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Recommended Option / Long Term: Provides Flexibility to Increase Level of Protection Later



Recommended Option / Long Term: Provides Flexibility to Increase Level of Protection Later



Questions/Discussion



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