# Camden Harbor Storm Surge Risk & Mitigation

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# Topics

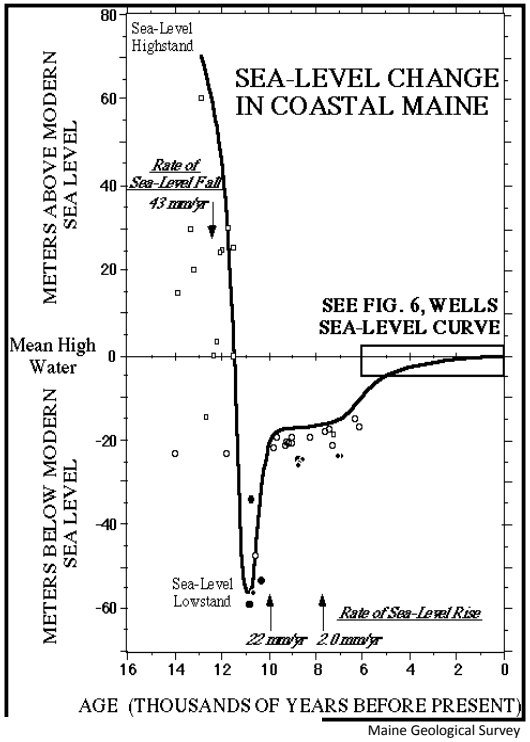
- Maine Sea Level History
- Increasing Storm Frequency
- 23 December 2022 Storm Event
- Risk Assessment
- Mitigation
- Next Steps

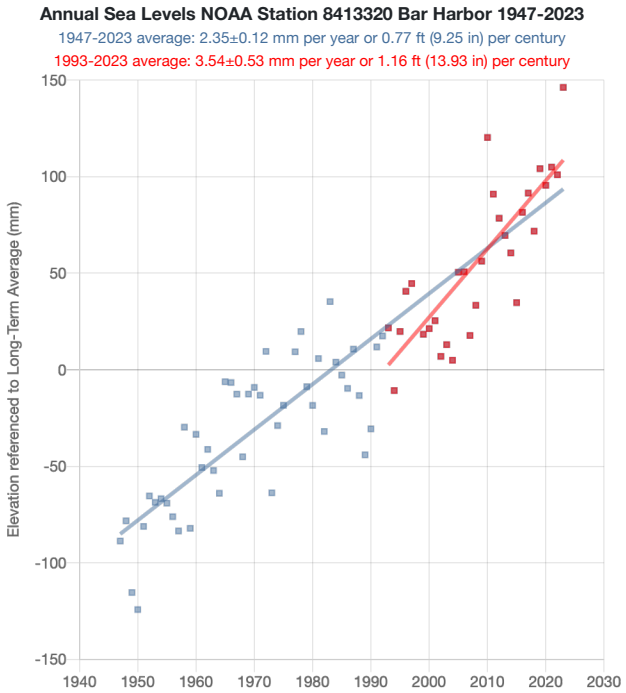
# Maine Sea Level History

**Current rise**

**3.5mm/yr**

## Immediate Issue: Frequency & Intensity of Storms



Recent
6 X Increase
in Severe
Storm
Frequency

**6 Storms**
**4 years**
**1.2/Yr**

**16 Storms**
**86 years**
**0.2/yr**

## Upper 10% Storm Surges in Camden Maine[1]

(Units in feet)

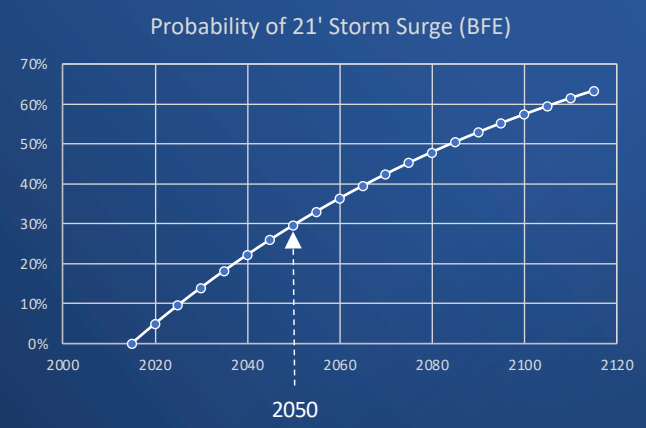
| Date | Predicted[2] | Measured[2] | Height Abv MSL[3] | Freeboard[4] | Rank |
|---|---|---|---|---|---|
| 2022-12-24 | 12.58 | **12.89** | 7.47 | 2.71 | 20 |
| 2022-12-23 | 12.37 | **14.19** | 8.76 | 1.41 | 5 |
| 2022-01-17 | 10.54 | **12.81** | 7.39 | 2.79 | 21 |
| 2020-11-16 | 12.96 | **13.30** | 7.87 | 2.30 | 17 |
| 2020-04-10 | 12.64 | **14.09** | 8.67 | 1.51 | 6 |
| 2018-01-04 | 12.69 | **14.26** | 8.84 | 1.34 | 3 |
| 2007-04-16 | 11.96 | 13.44 | 8.02 | 2.16 | 15 |
| 1990-12-04 | 12.62 | 13.88 | 8.45 | 1.72 | 8 |
| 1987-01-02 | 12.44 | 13.81 | 9.08 | 1.79 | 9 |
| 1979-01-28 | 12.78 | 14.02 | 9.29 | 1.58 | 7 |
| 1978-02-07 | 12.50 | 14.35 | 9.63 | 1.25 | 2 |
| 1978-01-09 | 12.46 | 14.46 | 9.74 | 1.14 | 1 |
| 1976-03-16 | 12.22 | 12.98 | 8.26 | 2.62 | 19 |
| 1972-02-19 | 11.33 | 12.50 | 7.78 | 3.10 | 22 |
| 1963-01-27 | 11.70 | 13.57 | 8.85 | 2.03 | 12 |
| 1959-12-29 | 12.72 | 14.20 | 9.48 | 1.40 | 4 |
| 1958-04-07 | 11.92 | 13.04 | 8.31 | 2.56 | 18 |
| 1953-02-16 | 12.03 | 13.50 | 8.78 | 2.10 | 14 |
| 1945-12-20 | 12.60 | 13.69 | 8.97 | 1.91 | 11 |
| 1944-11-30 | 12.03 | 13.74 | 9.02 | 1.86 | 10 |
| 1940-04-21 | 12.19 | 13.43 | 8.70 | 2.17 | 16 |
| 1931-03-04 | 11.86 | 13.51 | 8.79 | 2.09 | 13 |

1. Still water levels
2. Interpolated from NOAA recorded water levels at Bar Harbor and Portland https://tidesandcurrents.noaa.gov/datums.html?id=8418150
3. MSL = Mean Sea Level
4. Relative to USGS benchmark at Camden Yacht Club wharf

# 23 December, 2022
# Still water level 14.2’
# Wave amplitude 2’-4’ ($h^{1/3}$)

| Buoy | | Speed kts | Gust kts | Press hPa |
|---|---|---|---|---|
| MIMS1 | Matinicus | 28.2 | 33.6 | 982.9 |
| 44032 | Mid Maine Shelf | 33.4 | 45.9 | 980.7 |

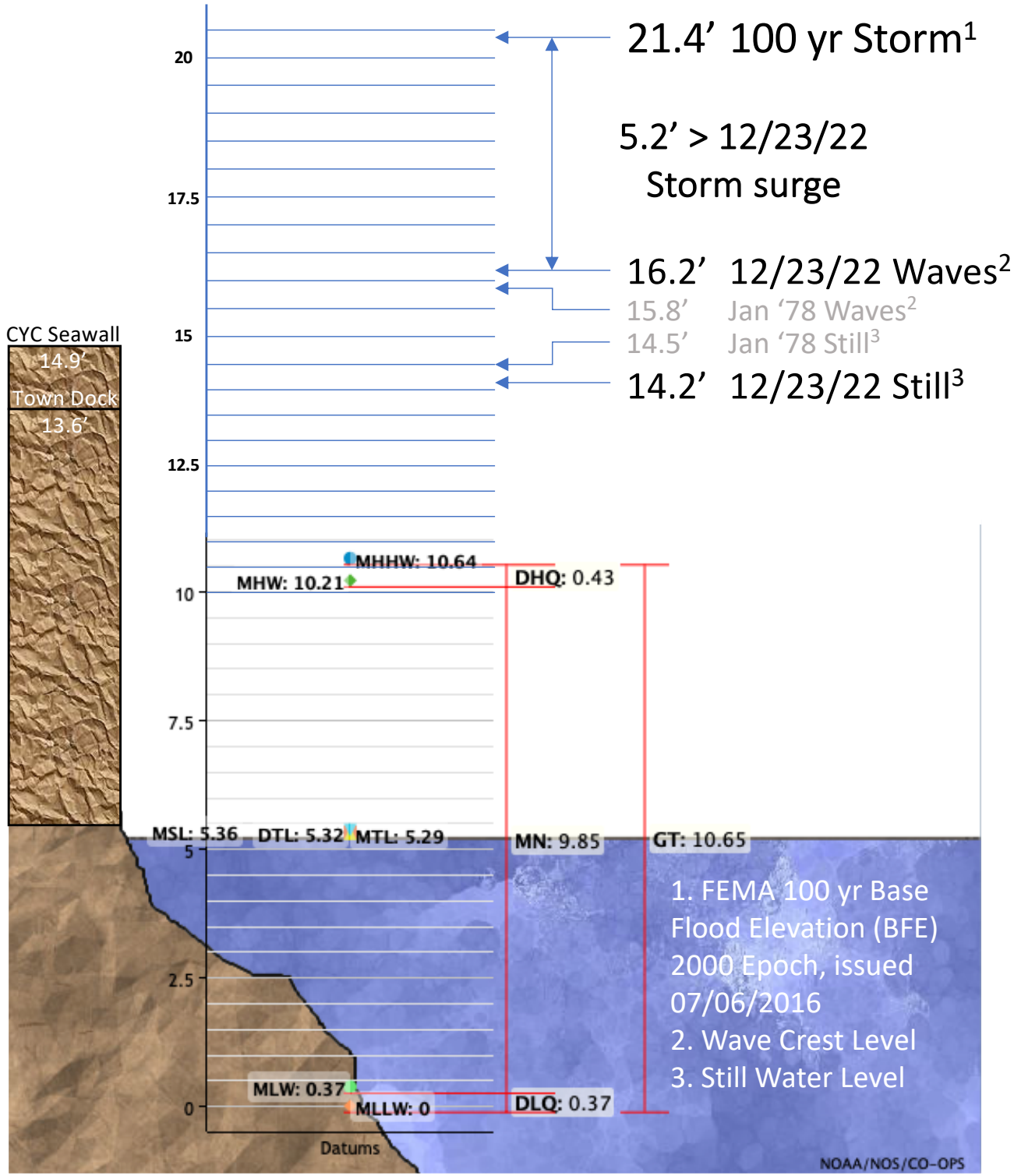
# Property Damage – Municipal $305K, Private $??




# 2050 Risk:

30% chance of exceeding Dec 23 Storm surge by 5.2’

Dec ‘22 Storm 8 hrs
Jan ‘78 Storm 48 hrs



# FEMA 100 Yr Storm Event

**Coastal A Zone**

BFE: Base Flood Elevation

**17.4' abv MLLW**

BFE 12'

Waves 1.5 to 3.0 feet

**Coastal V Zone**

BFE: Base Flood Elevation

**21.4' abv MLLW**

BFE 16'

Waves >= 3.0 feet

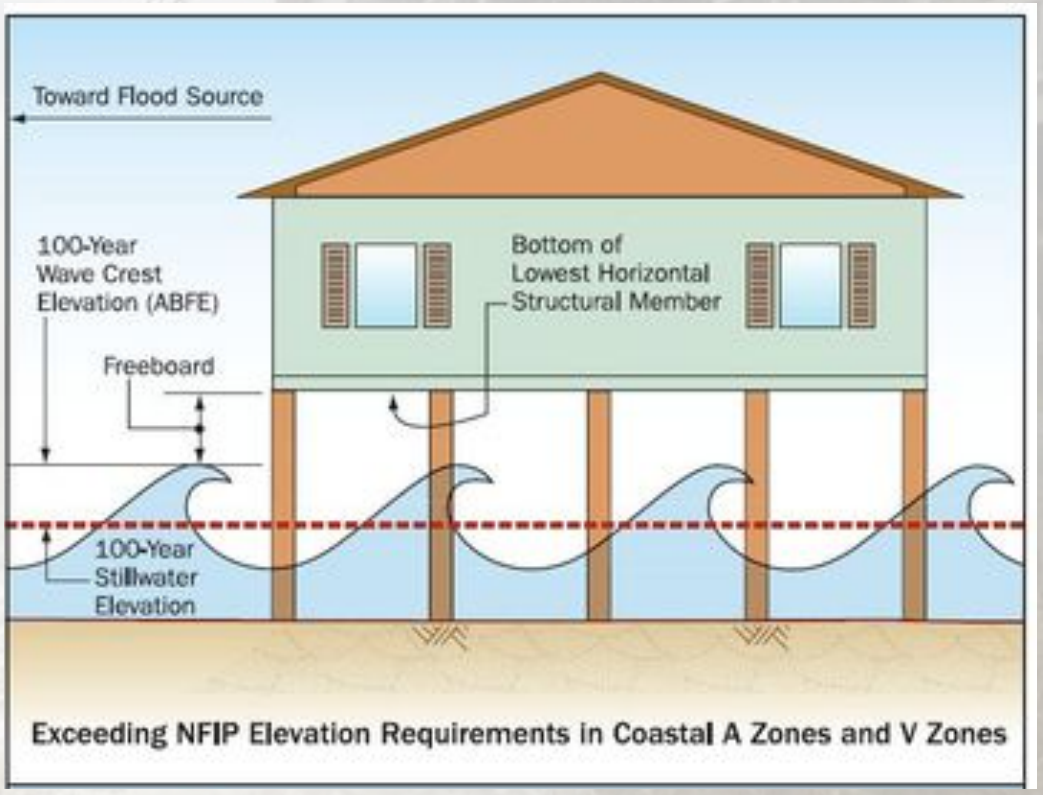
# Consequences

- Property Damage
  - Wave impact
  - High velocity flow erosion and scour
  - Floating debris
- Direct Economic Impact
  - Lost revenue
  - Repair cost
  - Downtime
- Lost Economic Opportunity
  - Deferred investment
  - Disruption of commerce
  - Cost of reconstruction

- Reduced Revenue
  - 75 downtown merchants
  - 100 waterfront properties
  - 12 charter sailing vessels
  - 15 commercial fishing vessels
  - 10,000+ tourist visits
  - 2,000+ regional jobs
- $220M waterfront valuation
- $1,750M Town valuation

# Mitigation

- Individual Actions
  - Harden
    - Reinforce
    - Deflect/Absorb
  - Raise Up
  - Retreat
- Community Action
  - Coordinated Planning
  - **Breakwater for Outer Harbor**



# Next Steps

- Public awareness
  - Energize Public Support
- Town Manager/Select Board support
  - Public Statements
  - Petition
- Develop Harbor Resiliency Plan
  - State grant?
- Fund breakwater feasibility study - $500K
  - State, Federal?
  - Private funding?
- Funding: Water Resources Development Act[1] (WRDA)
  - Build off feasibility Study
  - Target FY 2024 WRDA
  - Meet with Congressional Representatives
  - Develop Funding Proposal(s)

1. https://www.epw.senate.gov/public/index.cfm/the-water-resources-development-act-of-2022

# Back-Up

# Breakwater Status

- 1st attempt 1946
- 2nd attempt 1969
- 3rd attempt 2017
- U.S. Army Corps of Engineers (ACOE) Continuing Authorities Program (CAP)
  - Capped at $10 million
  - Authorized by ACOE
  - Federal Interest Determination Completed
- Camden project deauthorized 2022
- Recourse AOCE General Investigations (7001) Program
  - Authorized by Congress
  - Not capped
- Requirements:
  - Federal interest
  - Economically justified
  - Environmentally acceptable
  - Locally Sponsored – Town of Camden

Significant wave height (HS) at Camden Harbor is approximately 2 meters or 6.6 feet. Rounding this wave height up results in a of 7.0 feet. It must be kept in mind that these were significant wave heights and by wave statistics the Hmax would be nearly double Hs so 14 feet, and the H1/10 would be 1.27 X Hs or 8.9 feet. Once again rounding up the H1/10 wave height is 9.0 feet. H1/10 is typically used for calculating stable armor stone size and Hmax is used for calculating design forces on rigid structure type protection.

As can been seen in Figure 3-1... wave heights at the project site are dominated by wave energy propagating in from the ocean.

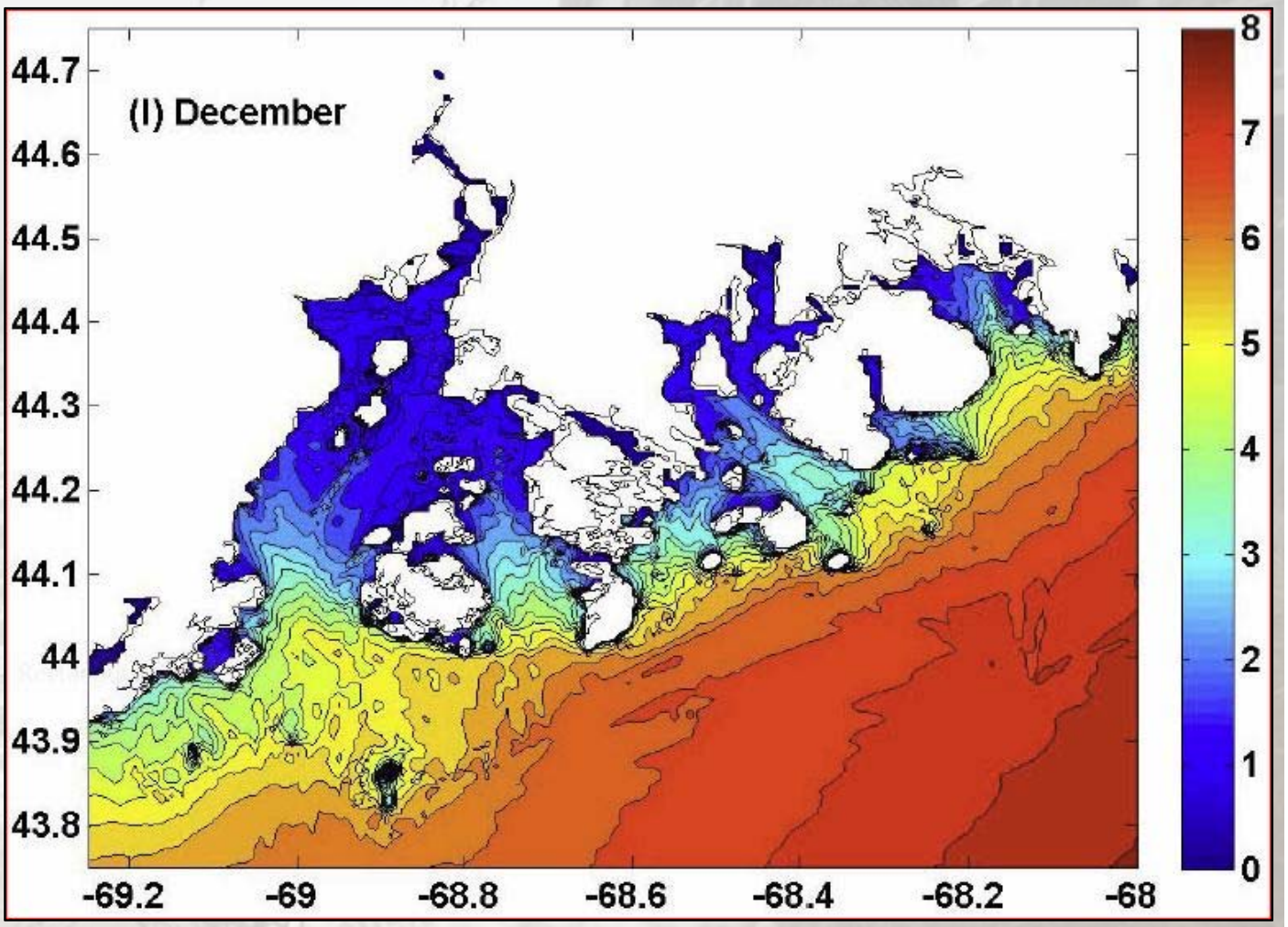



Figure 3-1. Maximum monthly significant wave height plot (meters) – December

# 1959 Breakwater Layout

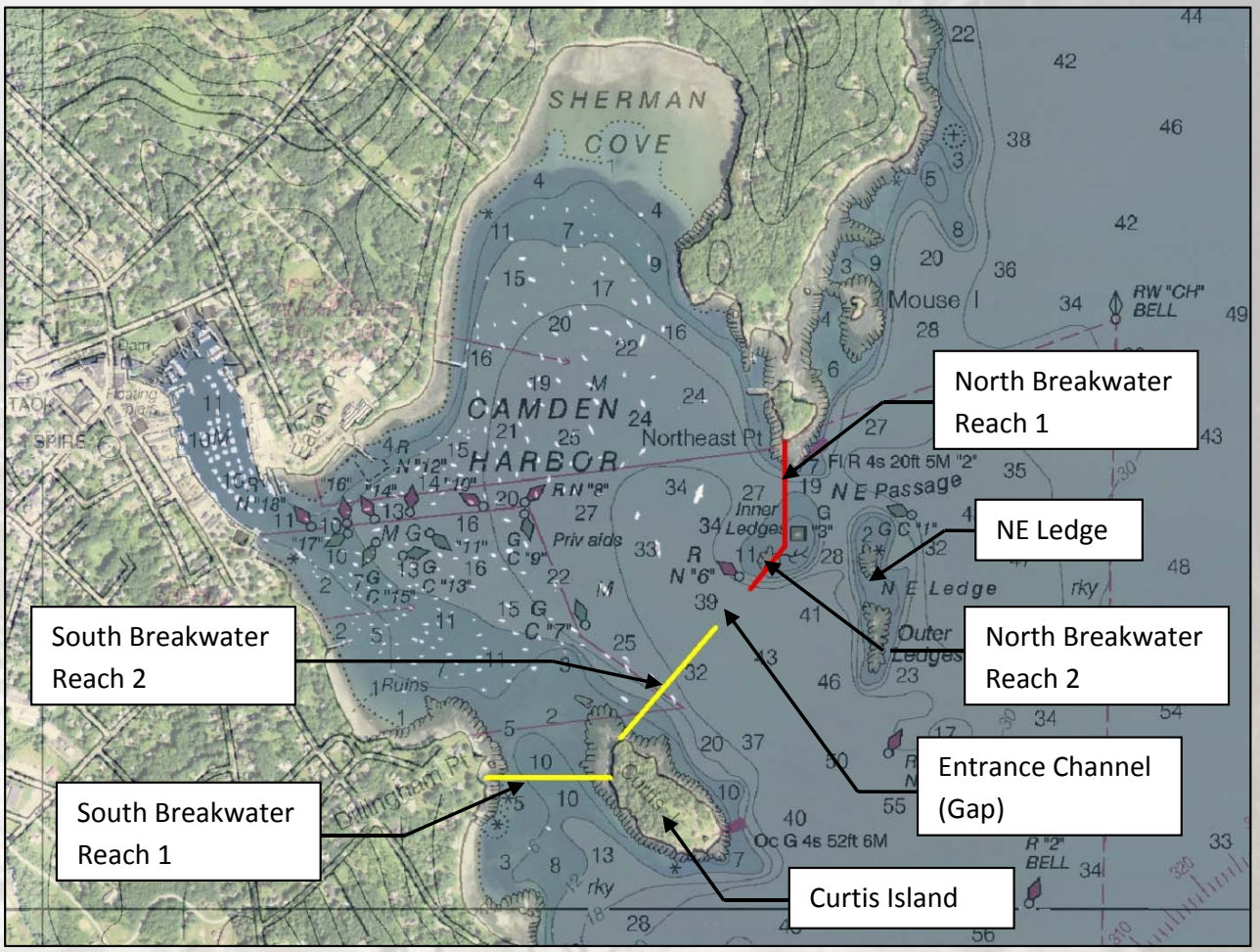



Figure 4-2. Breakwater layout – 1959

# 1959 Breakwater Wave Pattern

Figure 4-3. Gap diffraction diagram overlay – 1959 plan.

# 2012 Breakwater Layout

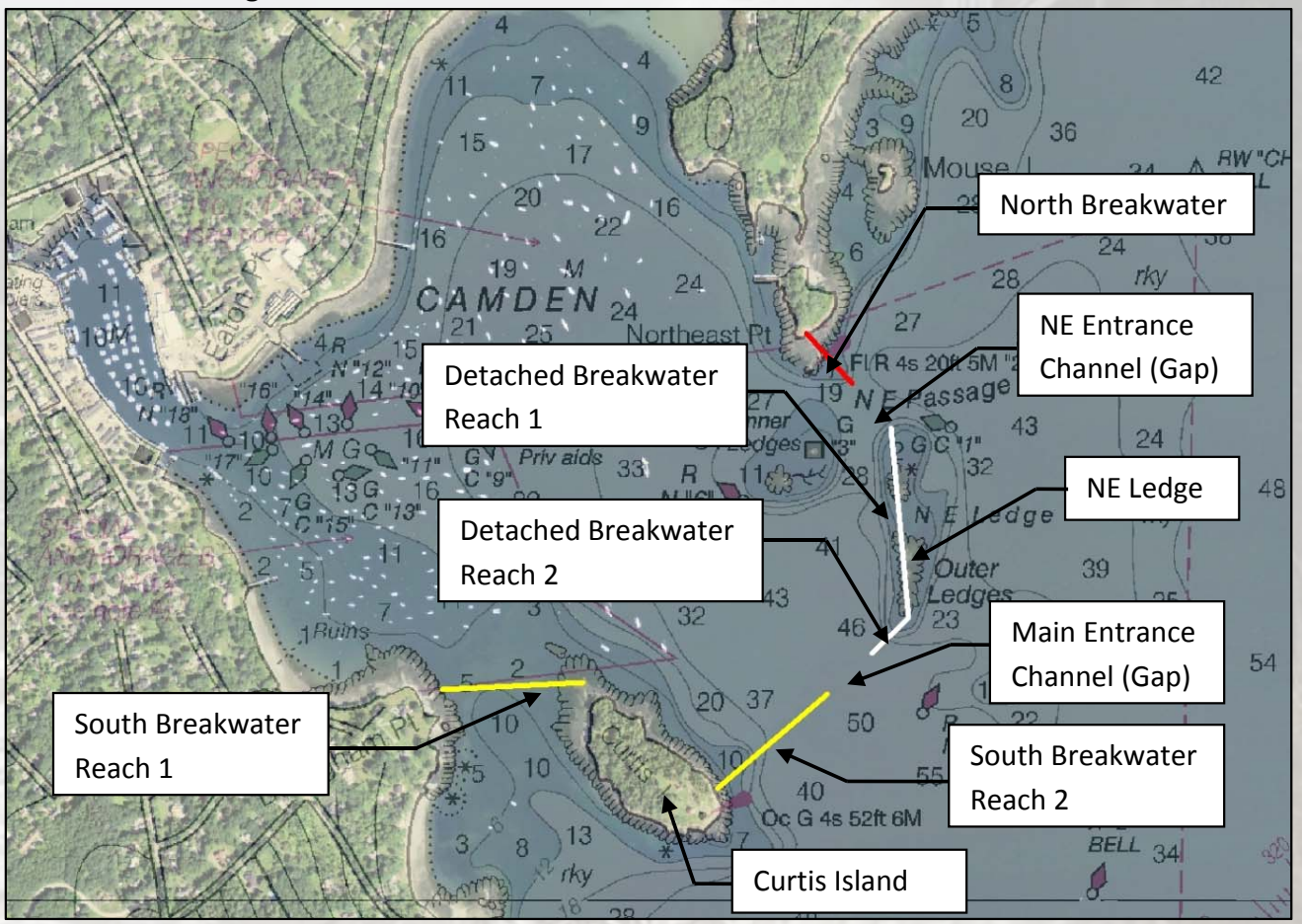



Figure 4-5. Breakwater layout – 2012

# 2012 Breakwater Main Entrance Wave Pattern

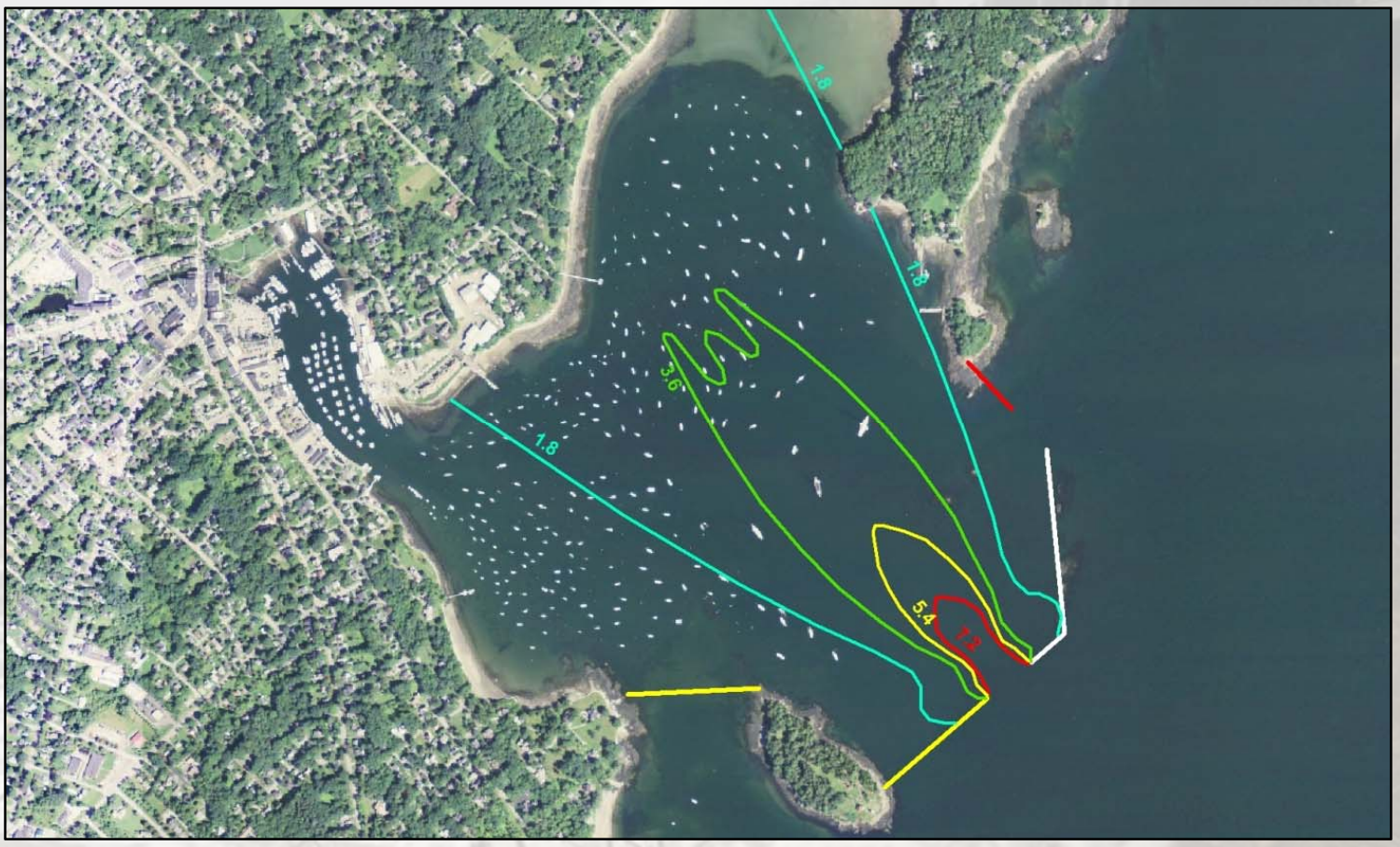



Figure 4-7. Gap diffraction wave contour map (feet) Main Entrance – 2012 (incoming wave $H_{1/10}$ = 9 feet)

# 2012 Breakwater NE Entrance Wave Pattern

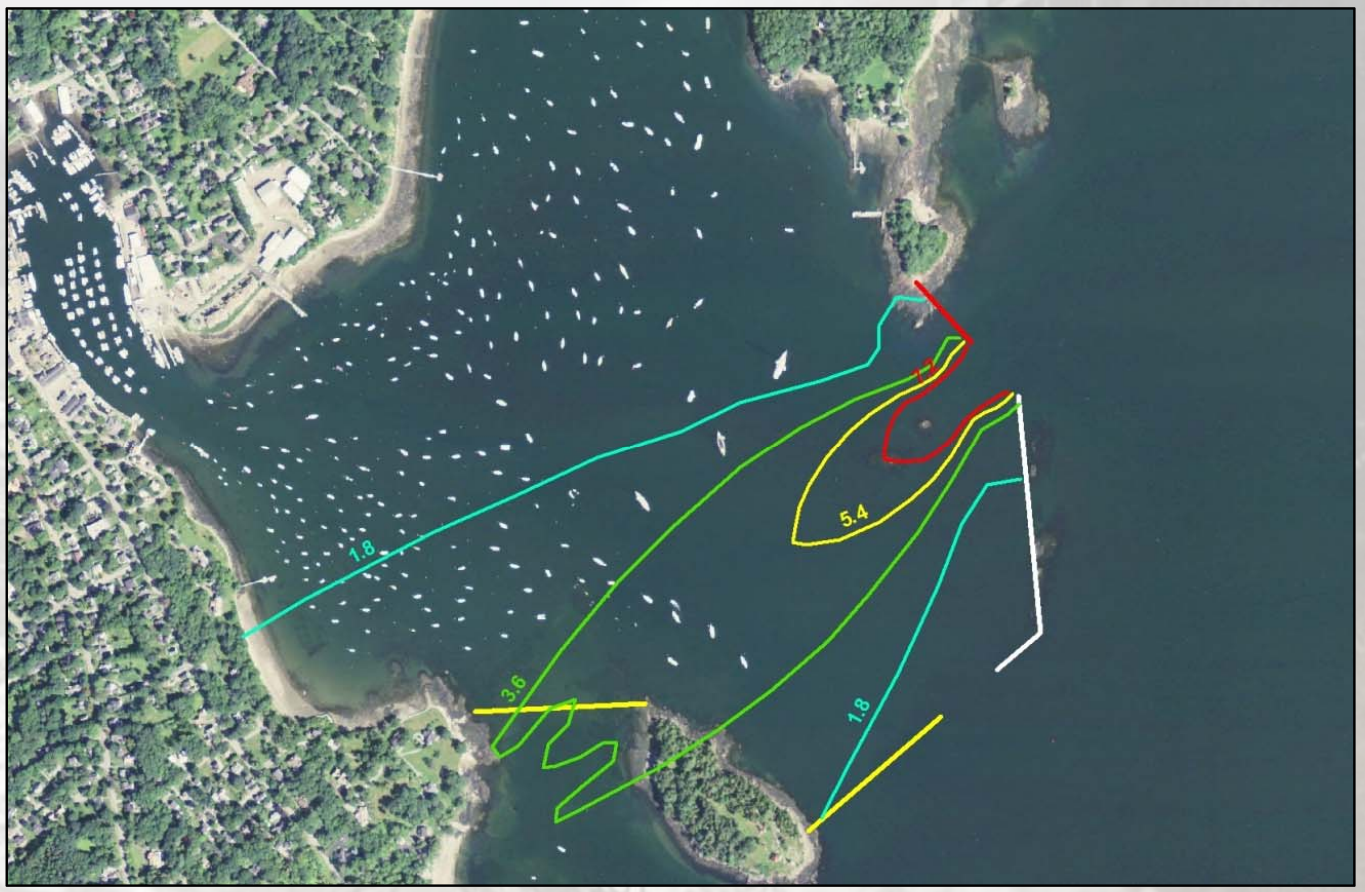



Figure 4-9. Gap diffraction wave contour map (feet) NE Entrance – 2012 (incoming wave $H_{1/10}$ = 9 feet)

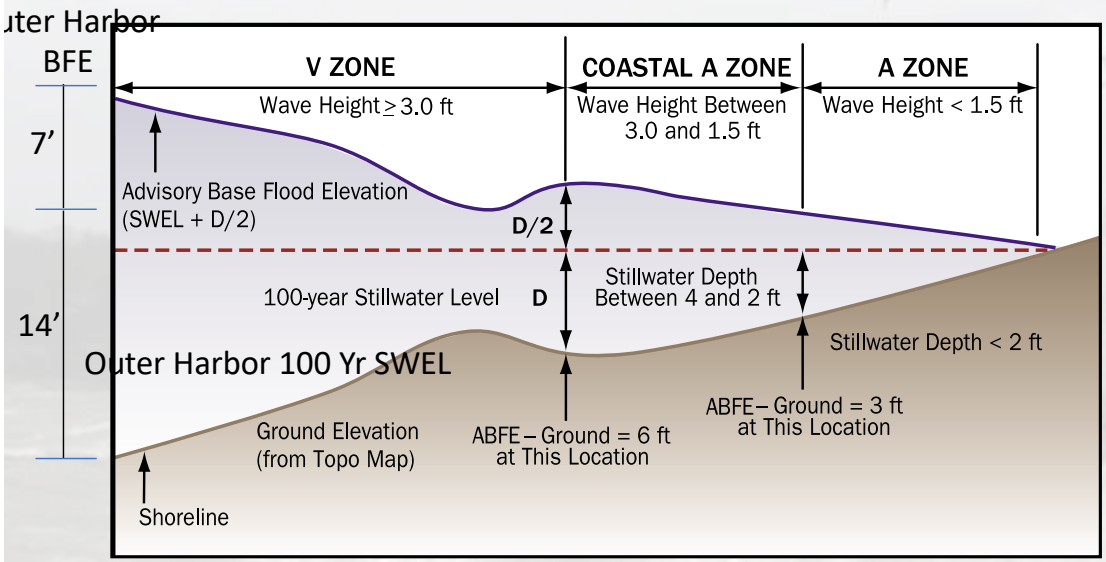
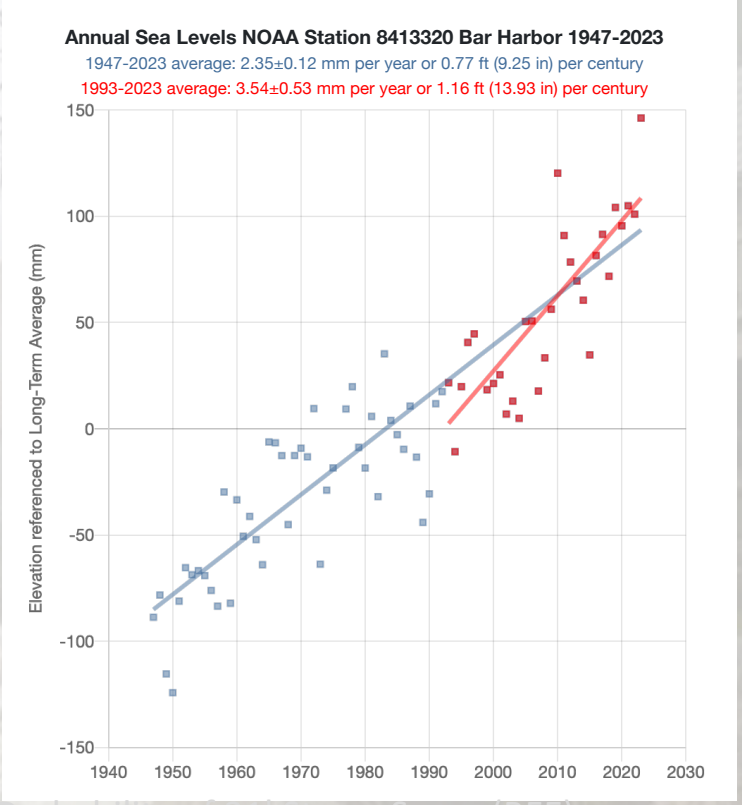
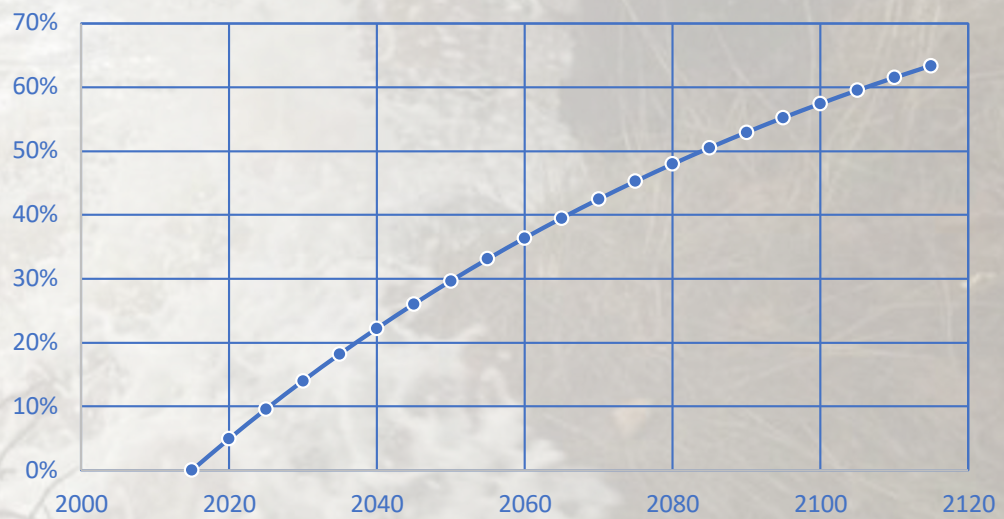



***Figure 9. Cross-section showing 1 percent annual chance stillwater elevation, stillwater depth and ABFE, and inland limits of V Zone and Coastal A Zone.***




Probabili[illegible] 24 Storm Surge (BFE)



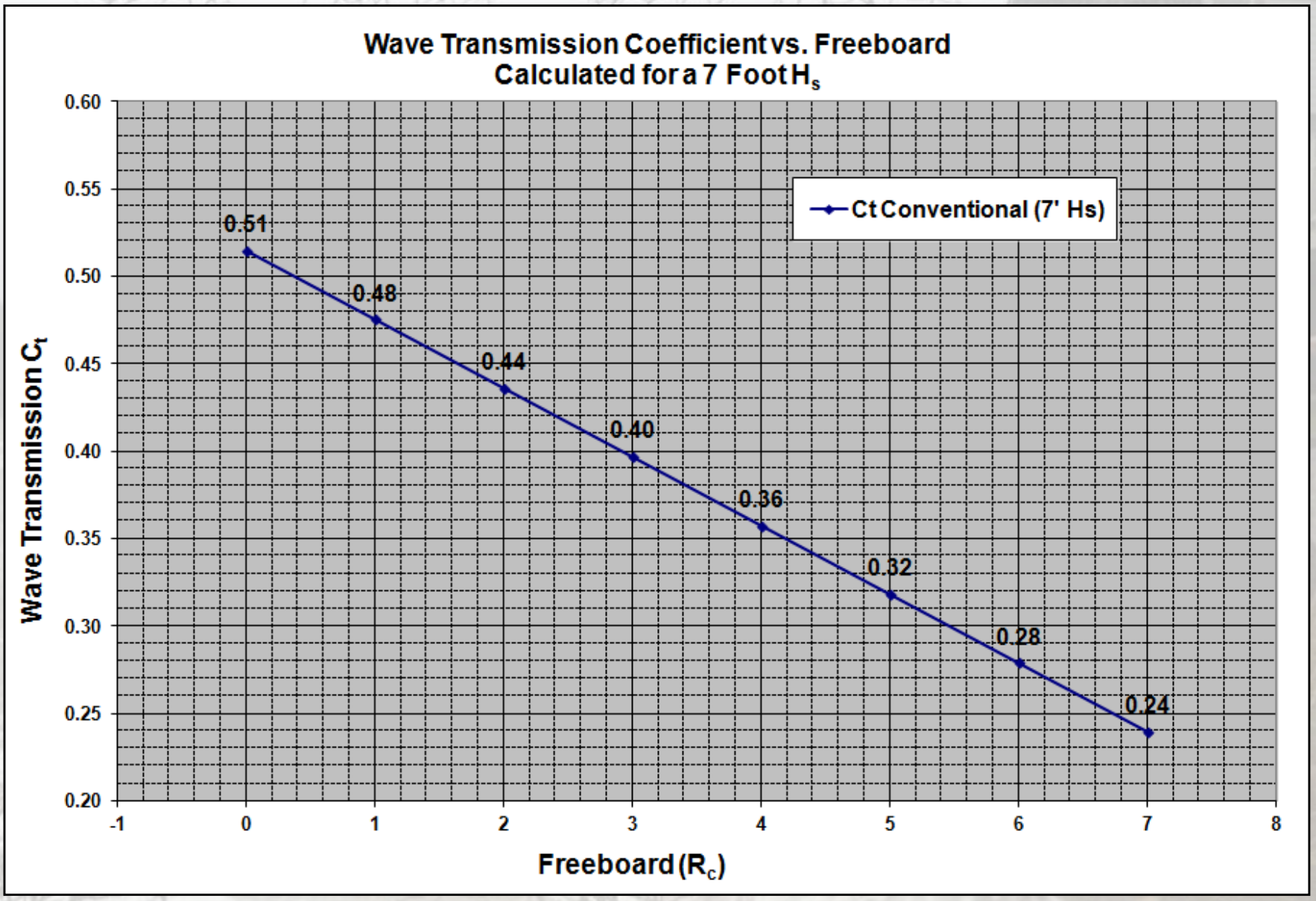



Figure 5-3. Wave transmission coefficients for wave height of 7 feet ($H_s$)