Implementation of ASCE 7-22, 500-Year Flood Standard Revisions in Rhode Island

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Presentation to:
EC4 Science and Technology Advisory Board (STAB)

January 10, 2024



ASCE 7-22 Flood Standards Updated



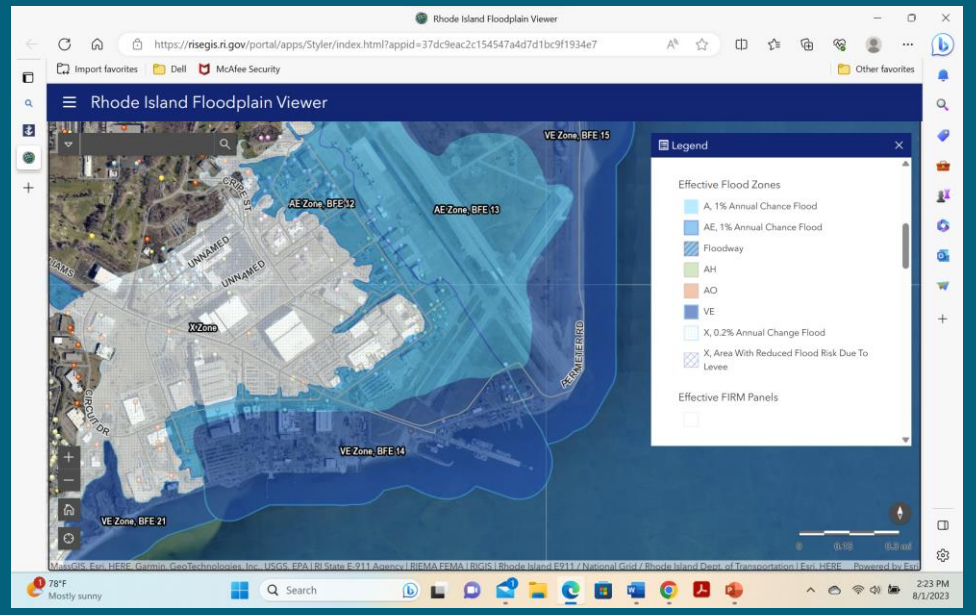
New flood standard requires ASCE 7-22 class II (residential homes) to use 500 yr FEMA FIRM flood maps (for class (I, III, & IV) structures, mean return intervals(MRI) are 100, 750, and 1000 yr, respectively) and to consider sea level rise(SLR) over the design life of the structure.

Updated ASCE 7-22 standard now available | ASCE

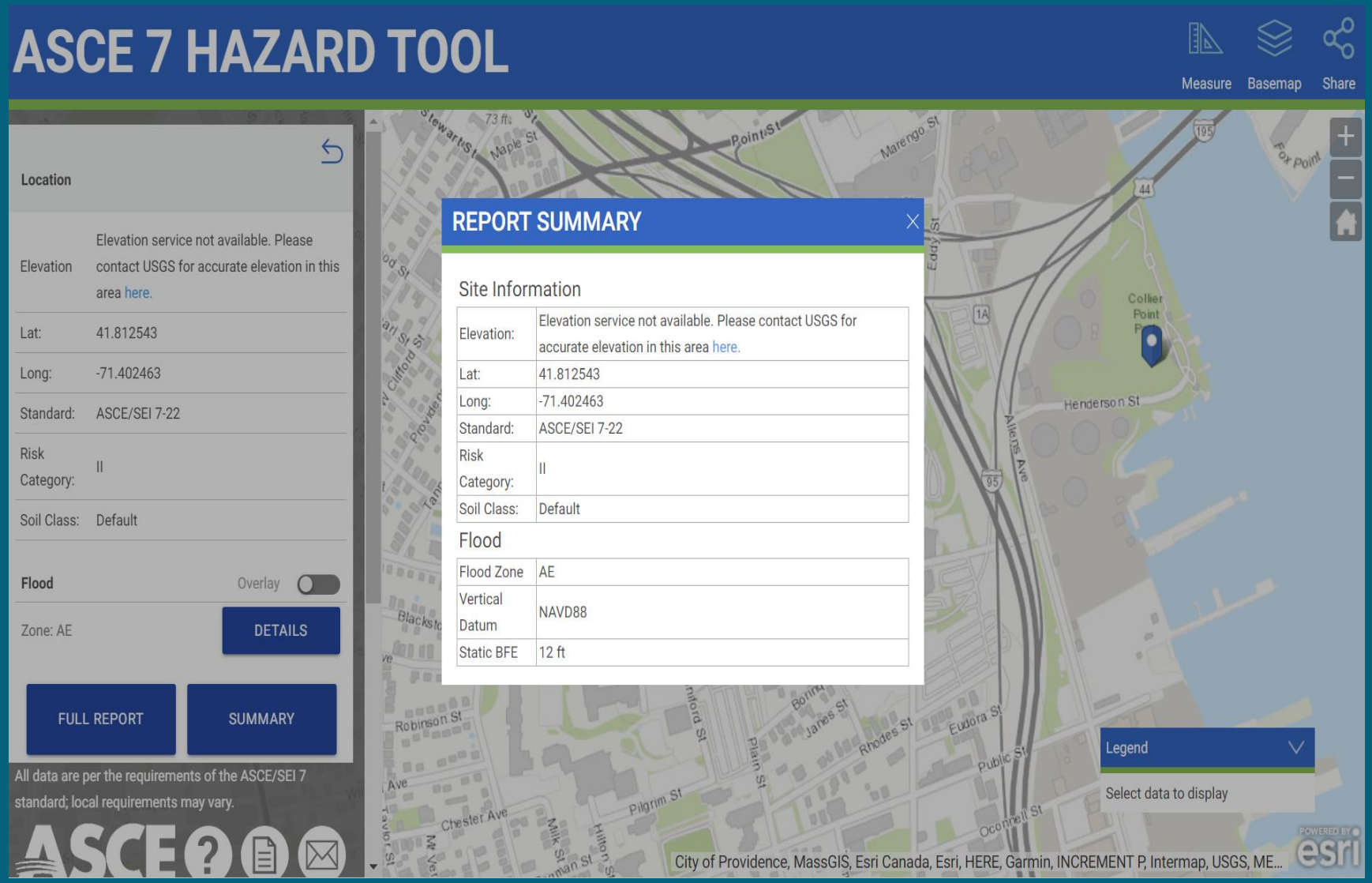
New ASCE 7-22 supplement on flood loads now available as free download | ASCE

Impact of updates (May 2023) to ASCE 7-22 on hazard analysis

- New standard for flooding is 500 yr (0.2%, X event) for Class II (residential structures), including correction for sea level rise (SLR). For other classes: Class I (warehouse), III (apartment bldg.), and IV(hospital) - 100, 750, and 1000 yr, respectively.
- Current FEMA flooding maps show 1 and 0.2%, (X zones) but don't provide BFEs for 0.2% case, just show surge levels. Need to add SLR and determine wave conditions.
- X zone values are available from FEMA Flood Insurance Studies(FIS) but show significant spatial inconsistencies in Narragansett Bay
- Need to generate SDE maps 500 yr with SLR for state.



ASCE 7 HAZARD TOOL



https://asce7hazardtool.online/

Example from ASCE Hazard Tool

Location: Collier Point, Providence, RI

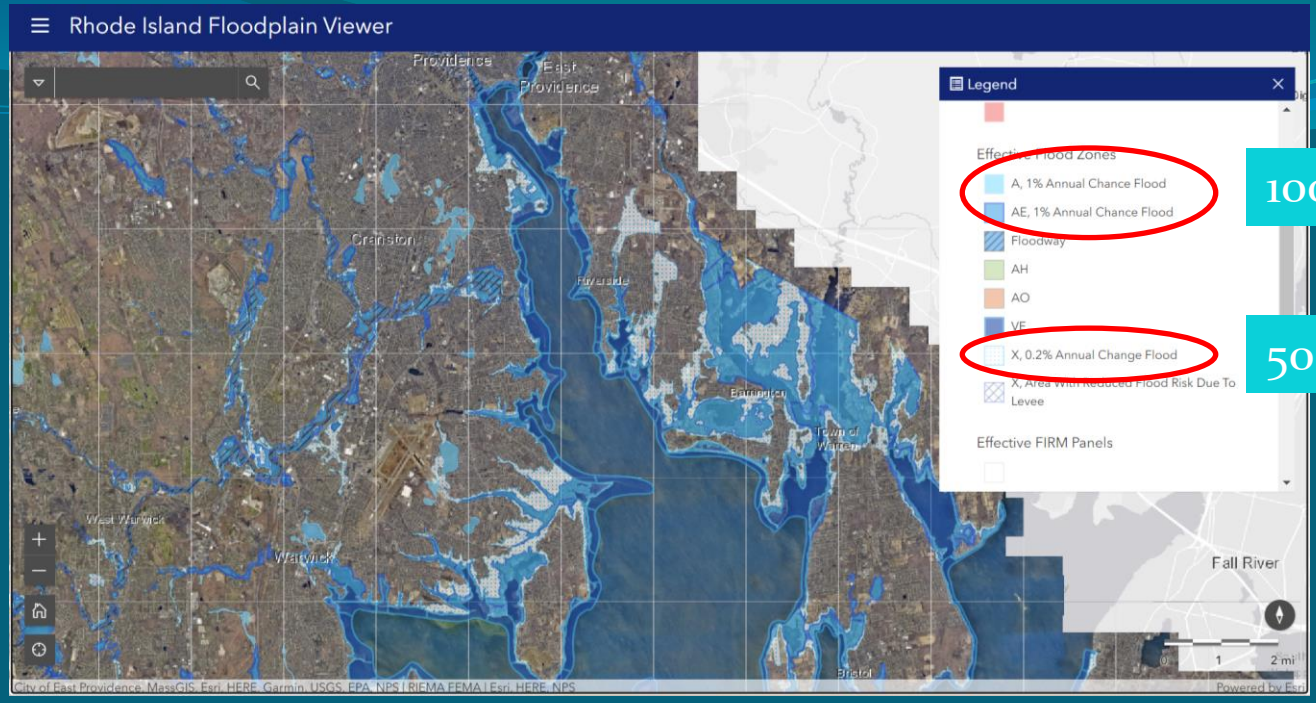
Summary is based on FEMA FIRM zone and BFE: AE and 12 ft NAVD88.

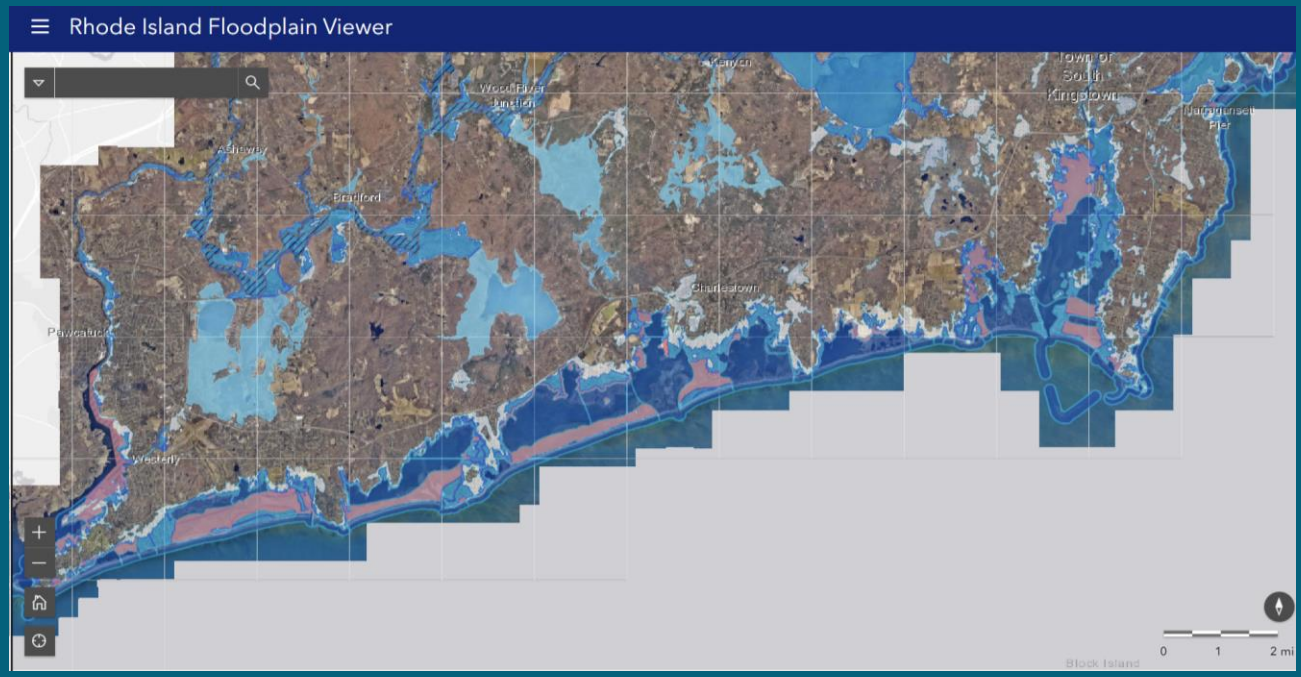
No mention of 500 yr flood levels

RI Emergency Management Agency (RI EMA) Flood Plain Maps

Impact of 0.2% (500 yr) vs 1% (100 yr) return period on flooding in RI

[Rhode Island Floodplain Viewer (ri.gov)]

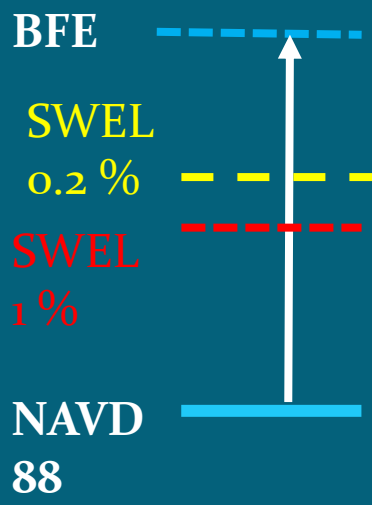


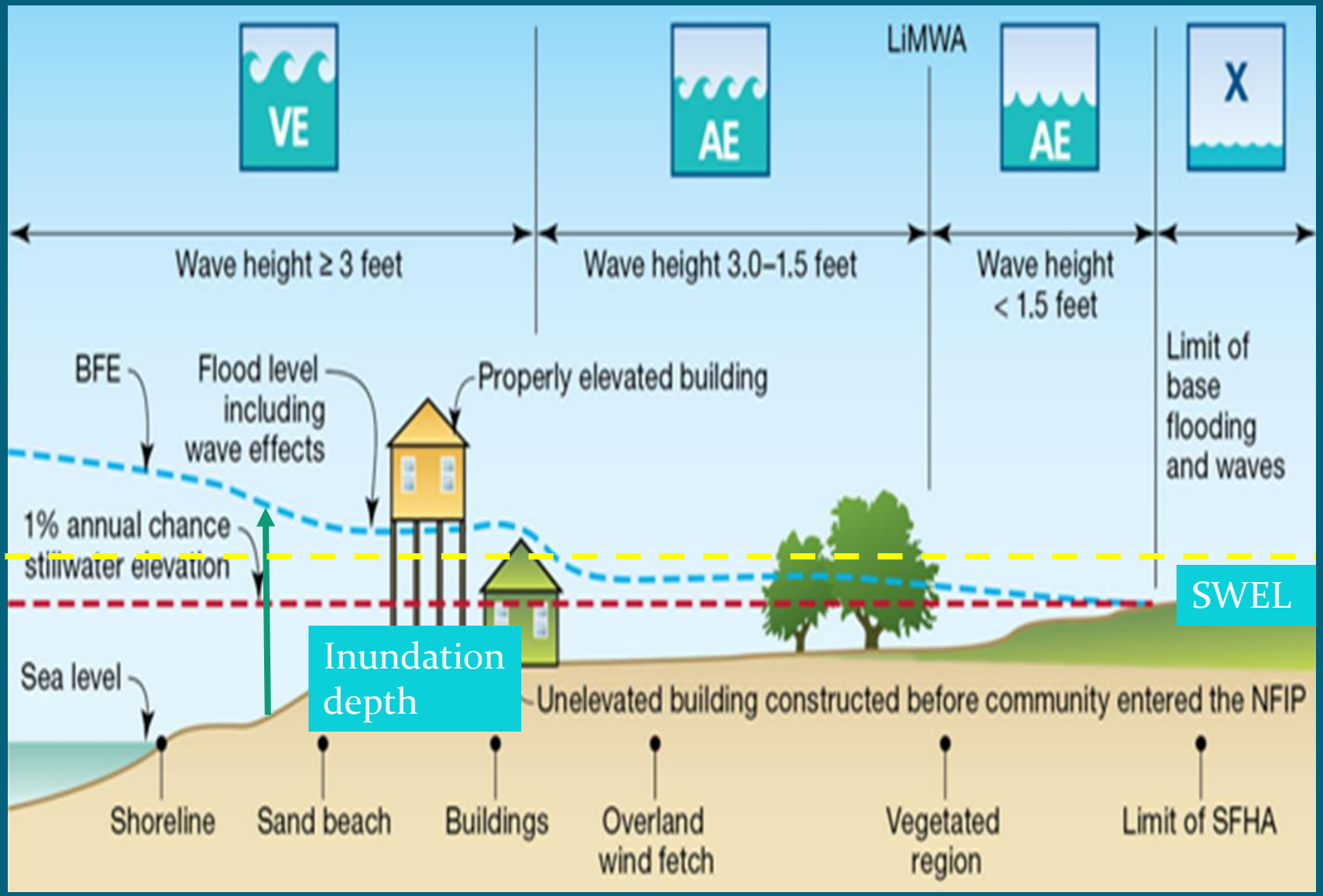


FEMA flood zones associated water levels and waves

BFE: referenced to NAVD88

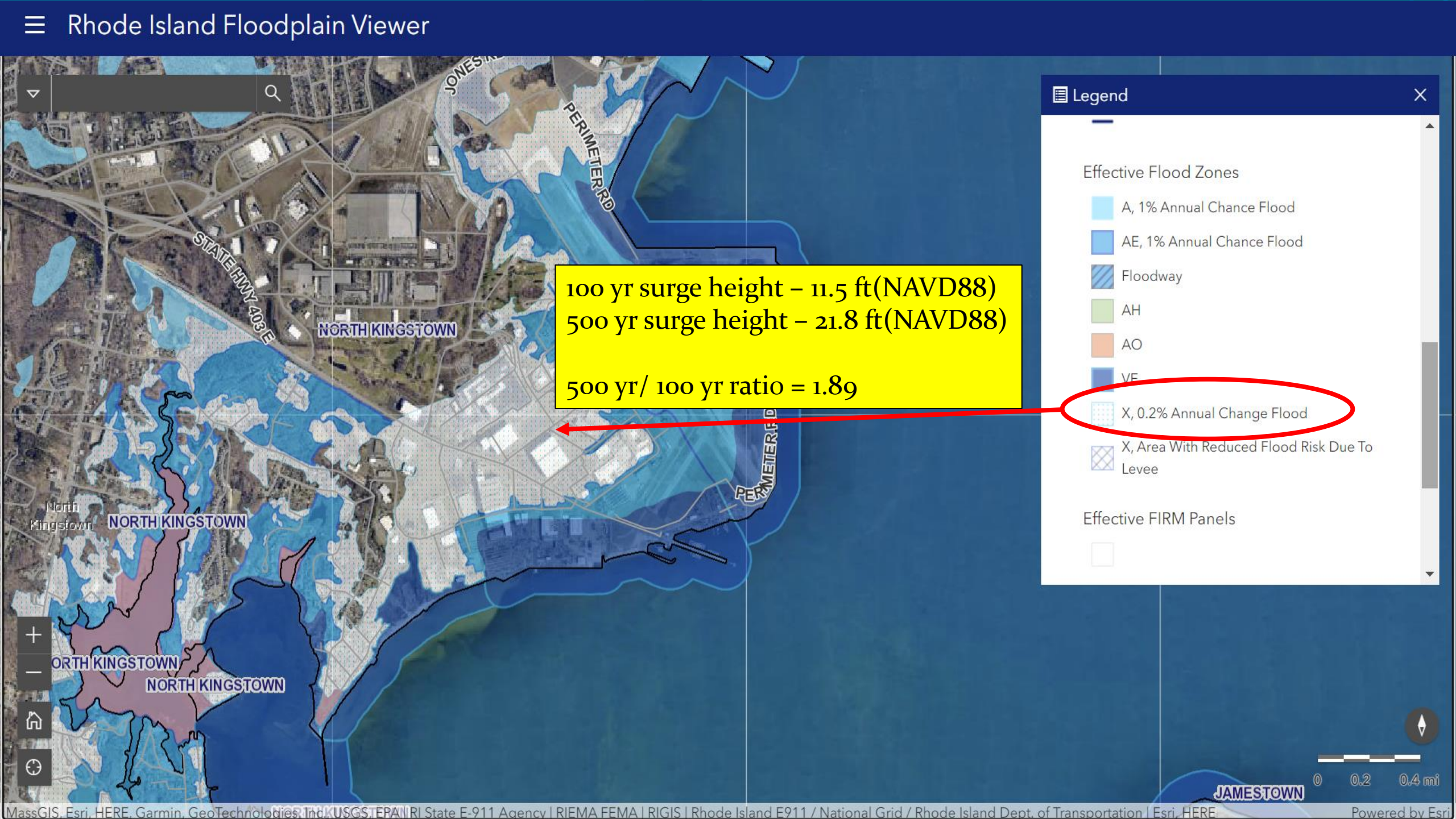
Depth of inundation, referenced to grade elevation

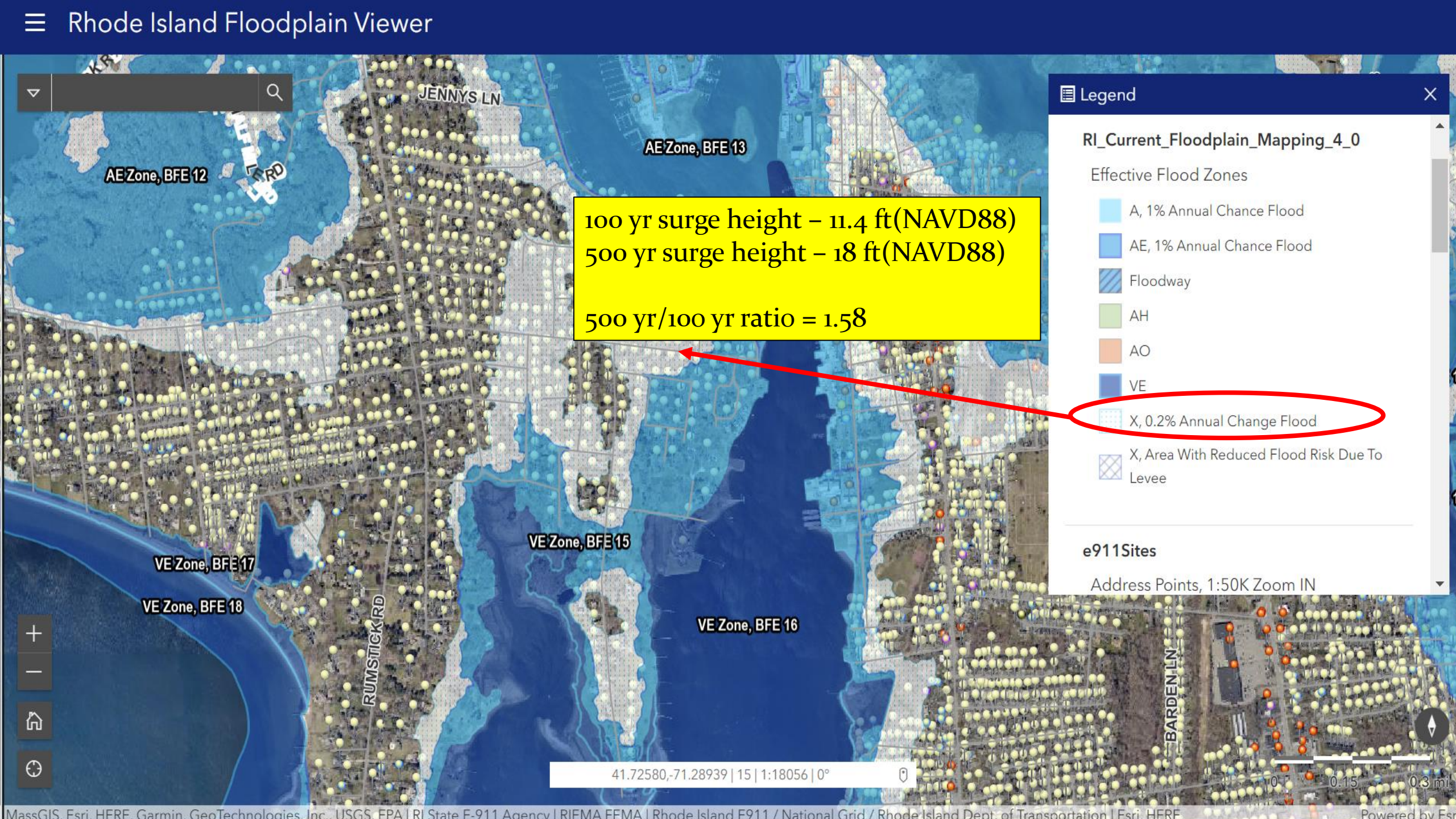


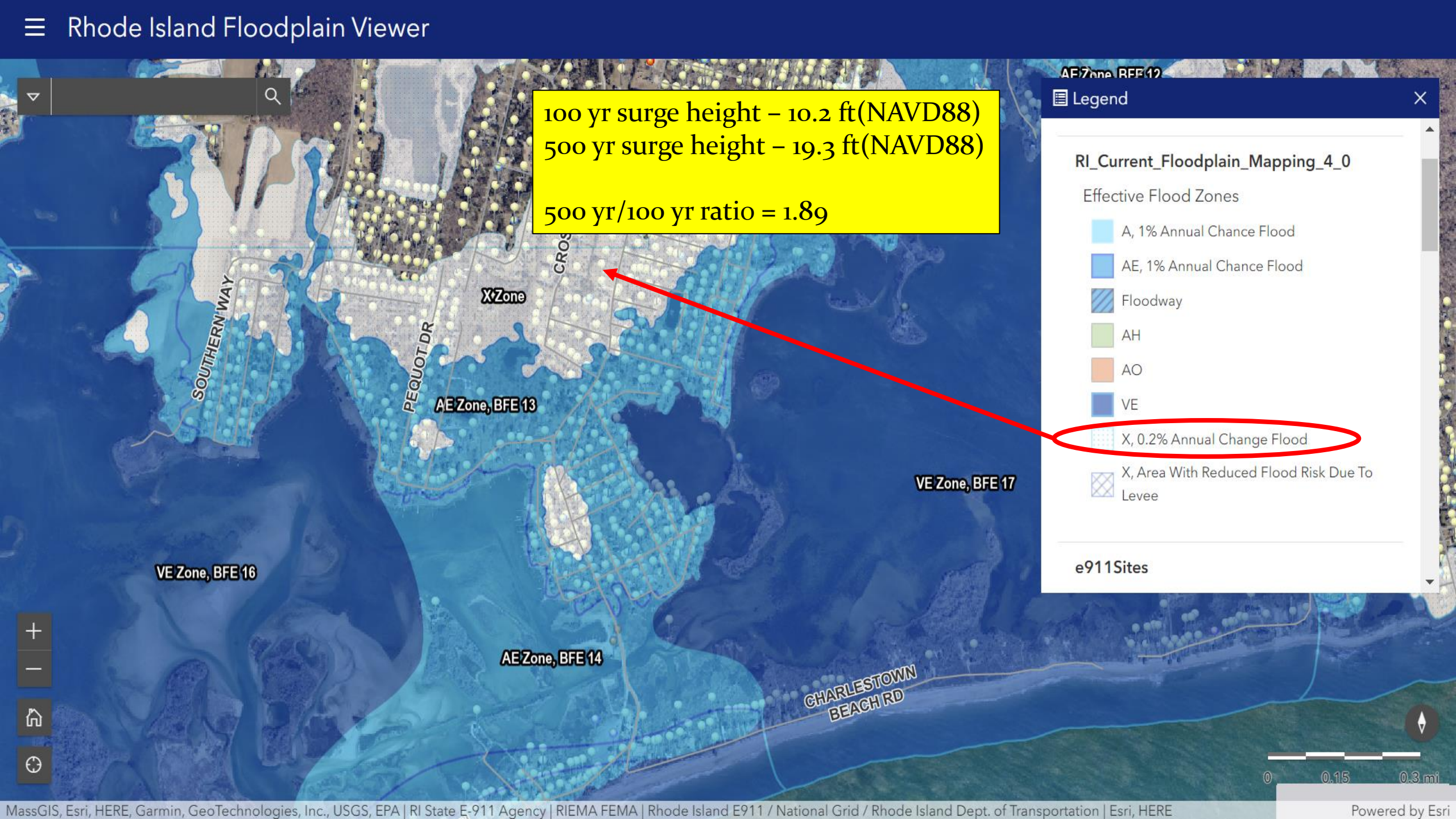


FEMA FIRMS 100 and 500 yr events, do not consider sea level rise or change in precipitation.


Rhode Island Floodplain Viewer
Legend
Effective Flood Zones
A, 1% Annual Chance Flood
AE, 1% Annual Chance Flood
Floodway
AH
AO
VE
X, 0.2% Annual Change Flood
X, Area With Reduced Flood Risk Due To Levee
Effective FIRM Panels
e911Sites
100 yr surge height – 12 ft (NAVD88)
500 yr surge height – 19 ft(NAVD88)
500 yr/100 yr ratio = 1.58
VE Zone, BFE 14
AE Zone, BFE 12
X Zone
AE Zone, BFE 17
VE Zone, BFE 17
VE Zone, BFE 26
SHIPYARD ST
SAVE THE BAY DR
SQUANTUM RD
I95 S
I95 N
0
0.15
0.3 mi


Rhode Island Floodplain Viewer
Legend
Effective Flood Zones
A, 1% Annual Chance Flood
AE, 1% Annual Chance Flood
Floodway
AH
AO
VE
X, 0.2% Annual Change Flood
X, Area With Reduced Flood Risk Due To Levee
Effective FIRM Panels
100 yr surge height – 11.5 ft(NAVD88)
500 yr surge height – 21.8 ft(NAVD88)
500 yr/ 100 yr ratio = 1.89
NORTH KINGSTOWN
PERIMETER RD
STATE HWY 403 E
JAMESTOWN
0
0.2
0.4 mi
MassGIS, Esri, HERE, Garmin, GeoTechnologies, Inc, USGS, EPA | RI State E-911 Agency | RIEMA FEMA | RIGIS | Rhode Island E911 / National Grid / Rhode Island Dept. of Transportation | Esri, HERE
Powered by Esri


Rhode Island Floodplain Viewer
JENNYS LN
AE Zone, BFE 12
AE Zone, BFE 13
100 yr surge height – 11.4 ft(NAVD88)
500 yr surge height – 18 ft(NAVD88)
500 yr/100 yr ratio = 1.58
Legend
RI_Current_Floodplain_Mapping_4_0
Effective Flood Zones
A, 1% Annual Chance Flood
AE, 1% Annual Chance Flood
Floodway
AH
AO
VE
X, 0.2% Annual Change Flood
X, Area With Reduced Flood Risk Due To Levee
e911Sites
Address Points, 1:50K Zoom IN
VE Zone, BFE 15
VE Zone, BFE 17
VE Zone, BFE 18
VE Zone, BFE 16
RUMSTICK RD
BARDEN LN
41.72580,-71.28939 | 15 | 1:18056 | 0°
0 0.15 0.3 mi
MassGIS, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, EPA | RI State E-911 Agency | RIEMA FEMA | Rhode Island E911 / National Grid / Rhode Island Dept. of Transportation | Esri, HERE
Powered by Esri


Rhode Island Floodplain Viewer
100 yr surge height – 10.2 ft(NAVD88)
500 yr surge height – 19.3 ft(NAVD88)
500 yr/100 yr ratio = 1.89
Legend
RI_Current_Floodplain_Mapping_4_0
Effective Flood Zones
A, 1% Annual Chance Flood
AE, 1% Annual Chance Flood
Floodway
AH
AO
VE
X, 0.2% Annual Change Flood
X, Area With Reduced Flood Risk Due To Levee
e911Sites
X Zone
AE Zone, BFE 13
VE Zone, BFE 17
VE Zone, BFE 16
AE Zone, BFE 14
SOUTHERN WAY
PEQUOT DR
CHARLESTOWN BEACH RD
0
0.15
0.3 mi
MassGIS, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, EPA | RI State E-911 Agency | RIEMA FEMA | Rhode Island E911 / National Grid / Rhode Island Dept. of Transportation | Esri, HERE
Powered by Esri

ASCE 7-22 Flood Design Scaling Factors

Table 5.3-1. Design Flood MRI Scaling Factors.

Risk Category	MRI (year)	Annual Exceedance Probability (AEP)	C_{MRI} Gulf of Mexico Coastal Sites[1]	C_{MRI} All Other Coastal Sites[1]	C_{MRI} Great Lakes Sites[2]	C_{MRI} Riverine Sites
I	100	1.00%	1.00	1.00	1.00	1.00
II	500	0.20%	1.35	1.25	1.15	1.35
III	750	0.13%	1.45	1.35	1.20	1.45
IV	1,000	0.10%	1.50	1.40	1.25	1.50

[1]Gulf Coast site scale factors are for coastlines of Texas, Louisiana, Mississippi, Alabama, and Florida west of 80.75 degrees W. All other coastlines shall be taken as Other.

- ASCE, Risk Category II- 500 yr Scaling (North Atlantic - 1.25), Risk Category III (1.35) IV(1.4)

FEMA, Risk Category II – 500 yr scaling - 1.5 to 1.9

ASCE Risk Categories

I – Warehouse
II- Residential structures
III- High occupancy structures
IV- Hospital, fire stations

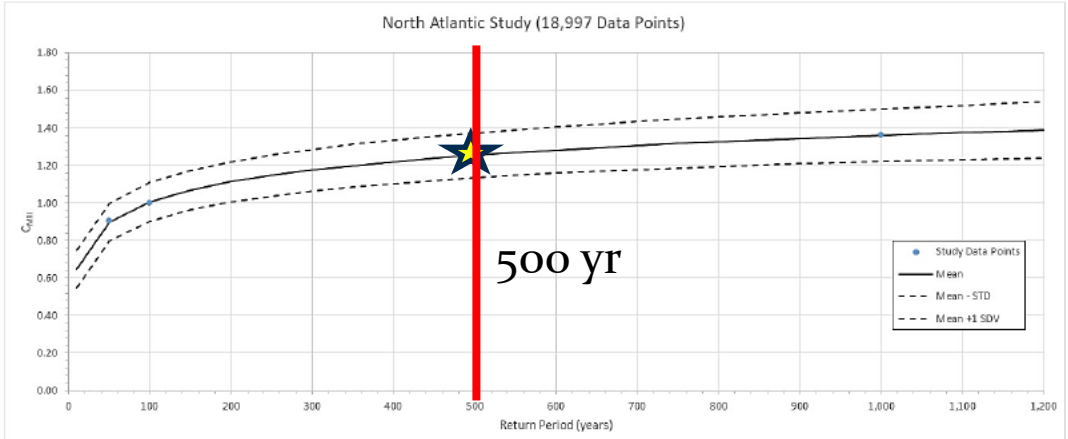


Figure C5.3-2. C_{MRI} Curve for North Atlantic Based on USACE Data.

Summary of 100 yr and 500 yr SWEL for all transects, each county in RI, FEMA FIS

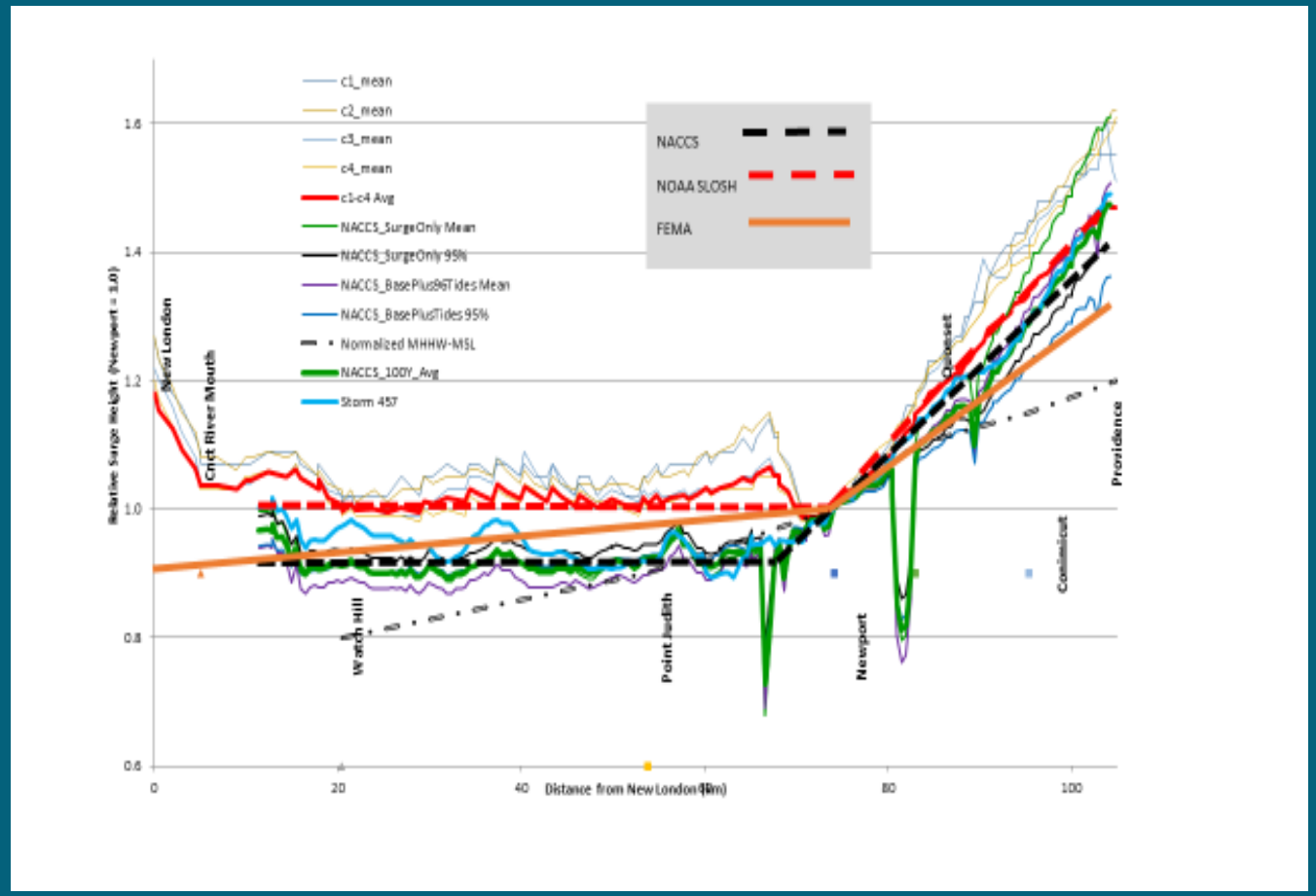
County	100 yr	500 yr	Ratio 500/100 yr
	ft	ft	
Washington	10.48	19.82	1.89
Newport	11.09	20.92	1.89
Bristol	11.26	17.75	1.58
Kent	12.02	17.68	1.47
Providence	12.34	18.81	1.52

Amplification (500 yr/100 yr)

FEMA - 1.47 to 1.89

ASCE - 1.25

FEMA method gives decrease in 500 yr surge levels from mouth to head of bay (0.94), 100 yr estimate shows the opposite (1.17)



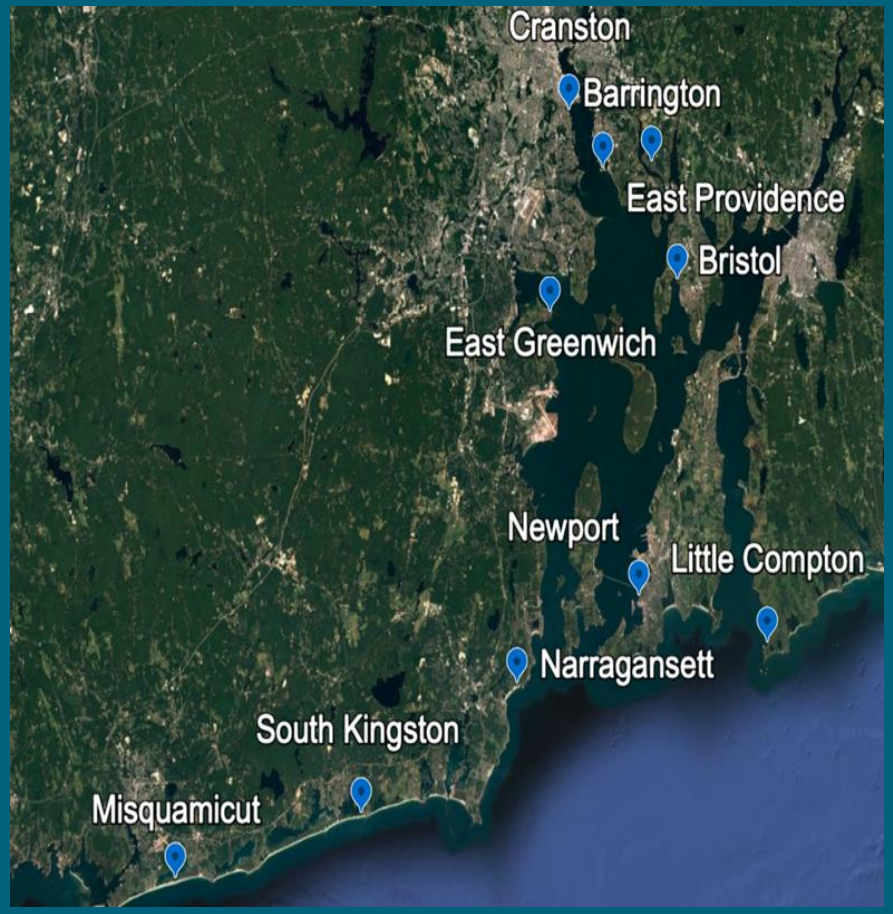
(Spaulding et al, 2014)

Simplified scaling SDE maps from 100 yr to 500 yr, with sea level rise(SLR)

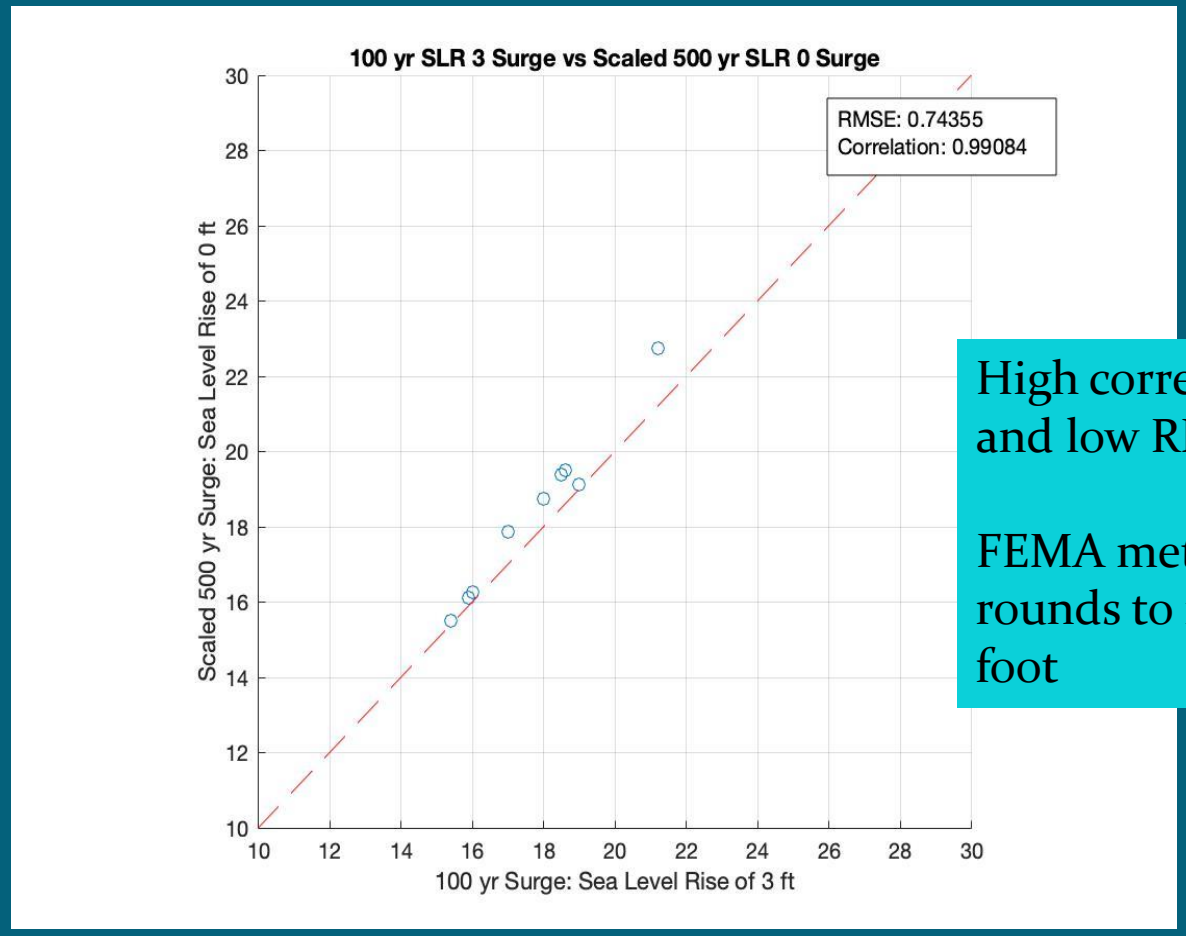
Approach (Simplified): (interim solution)

* Multiply 100 yr surge level by 1.25 to determine 500 yr surge level (SWEL- still water elevation).
* Add sea level rise(SLR) value (SWEL+SLR).
* Determine ratio of wave crest to surge height referenced to grade elevation for 100 yr plus surge for all SLR cases. Determine avg value.
* Use this ratio to scale wave crest heights for 500 yr cases with SLR.
*Add scaled waves to surge levels to generate BFE (Base Flood Elevation) 500 yr with SLR rise values.
* Perform regression of 100 yr with SLR to 500 yr with SLR to determine which gives best fit. Perform for both surge only and BFE.

Location of evaluation sites

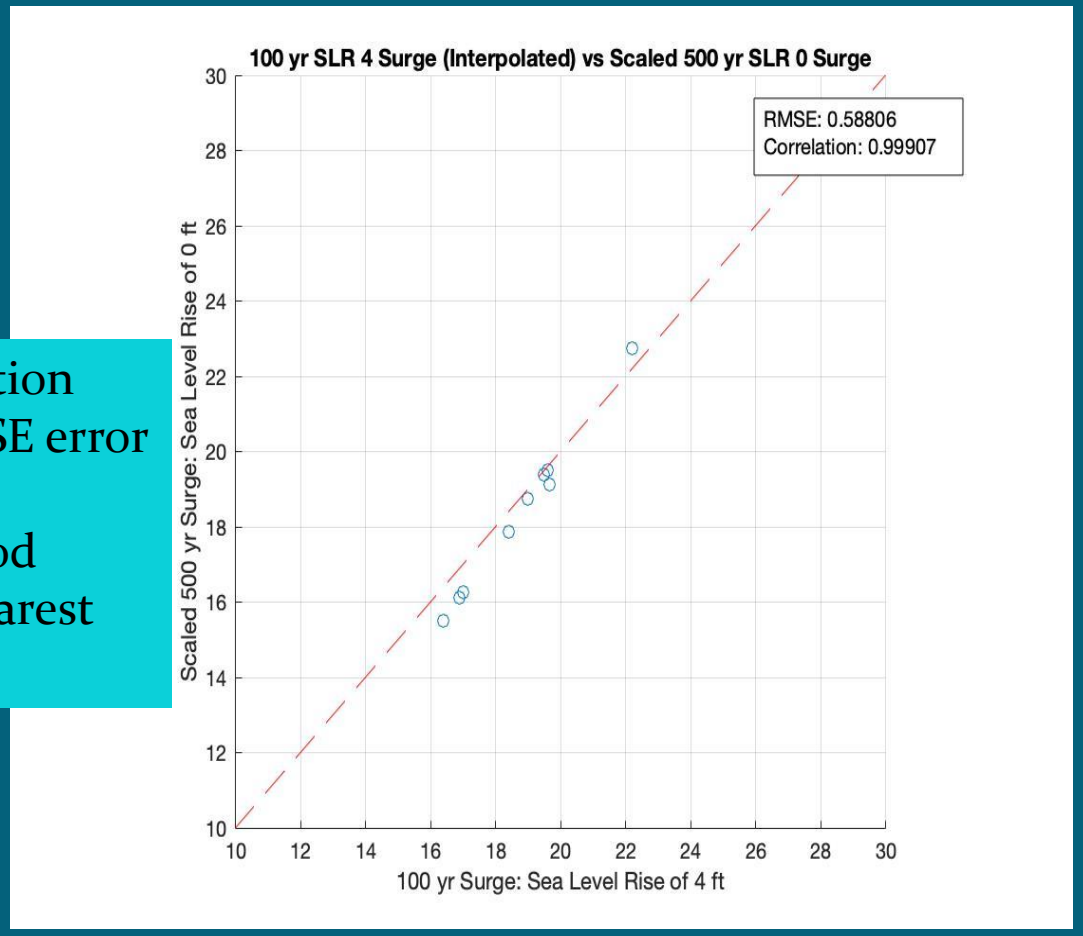


Regression *Surge Only* 500 yr no SLR to 100 yr with 3 or 4 ft SLR

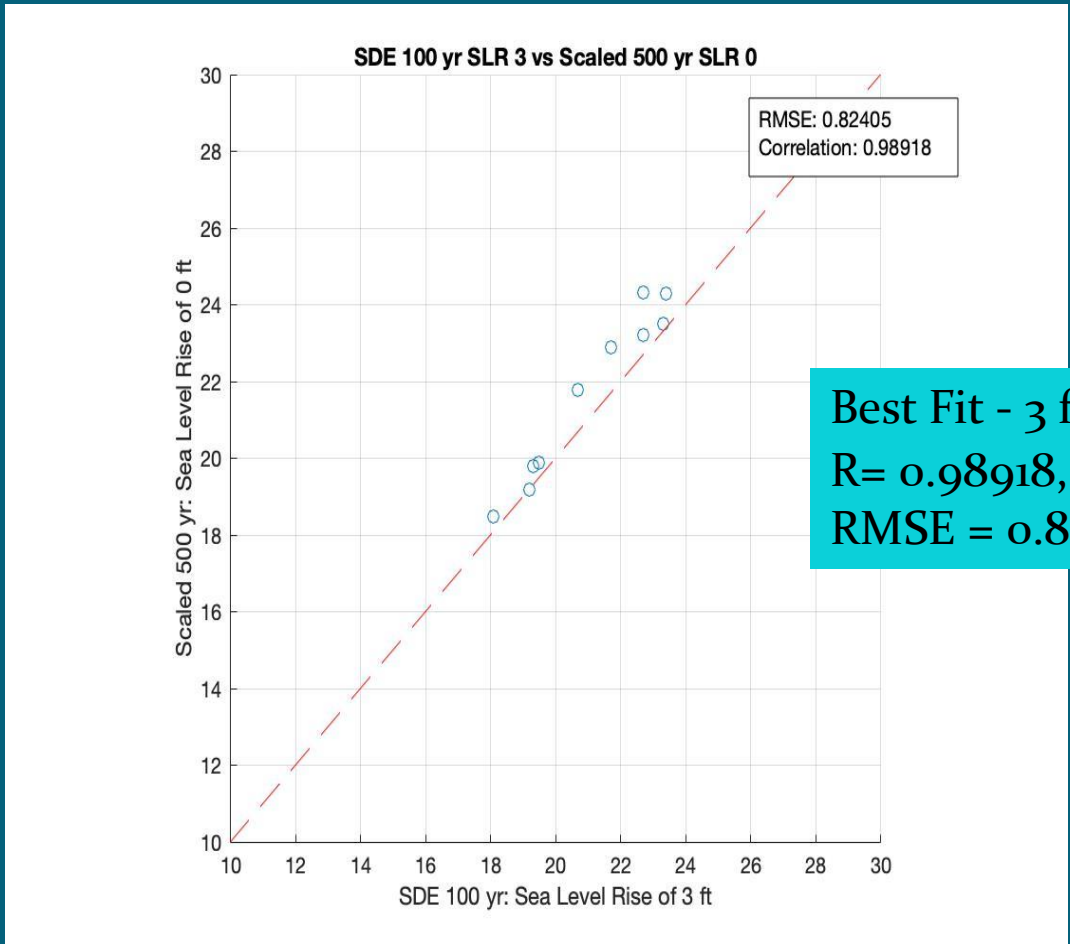


High correlation and low RMSE error

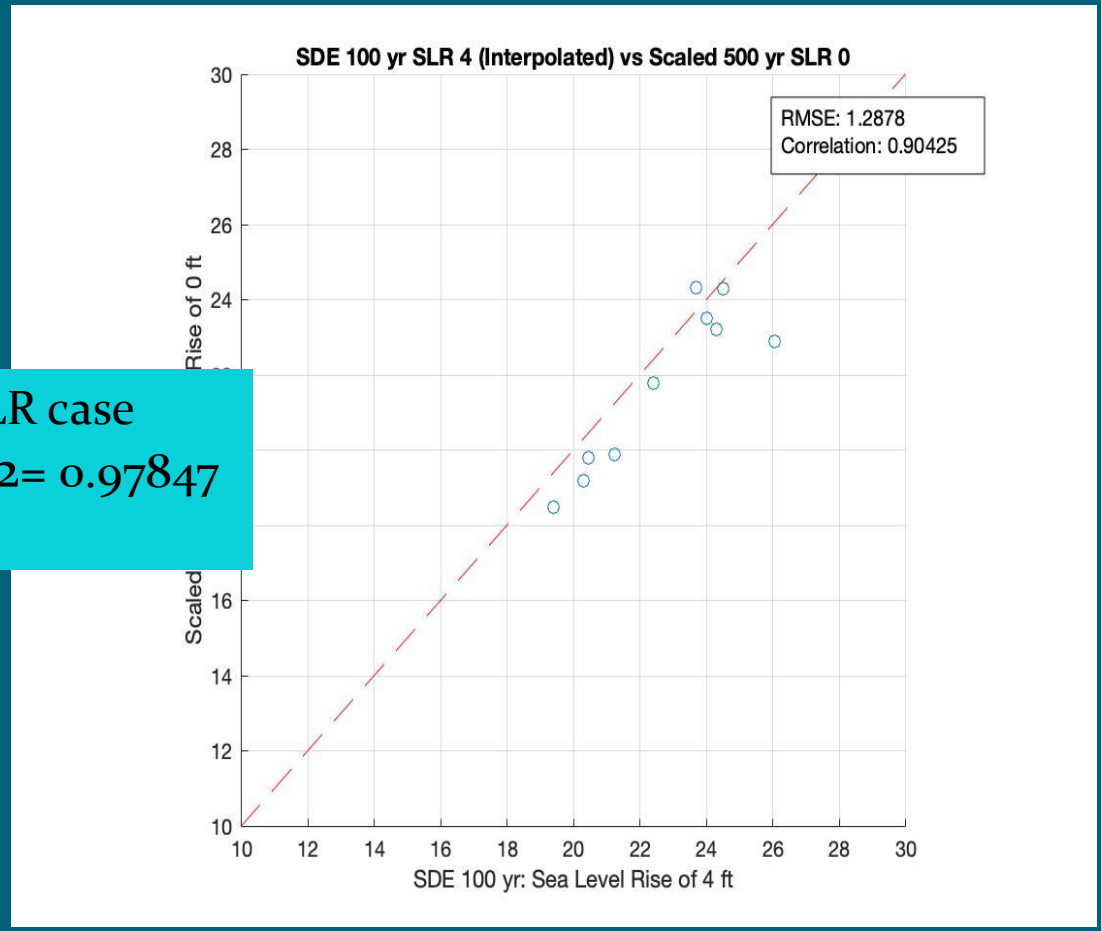
FEMA method rounds to nearest foot



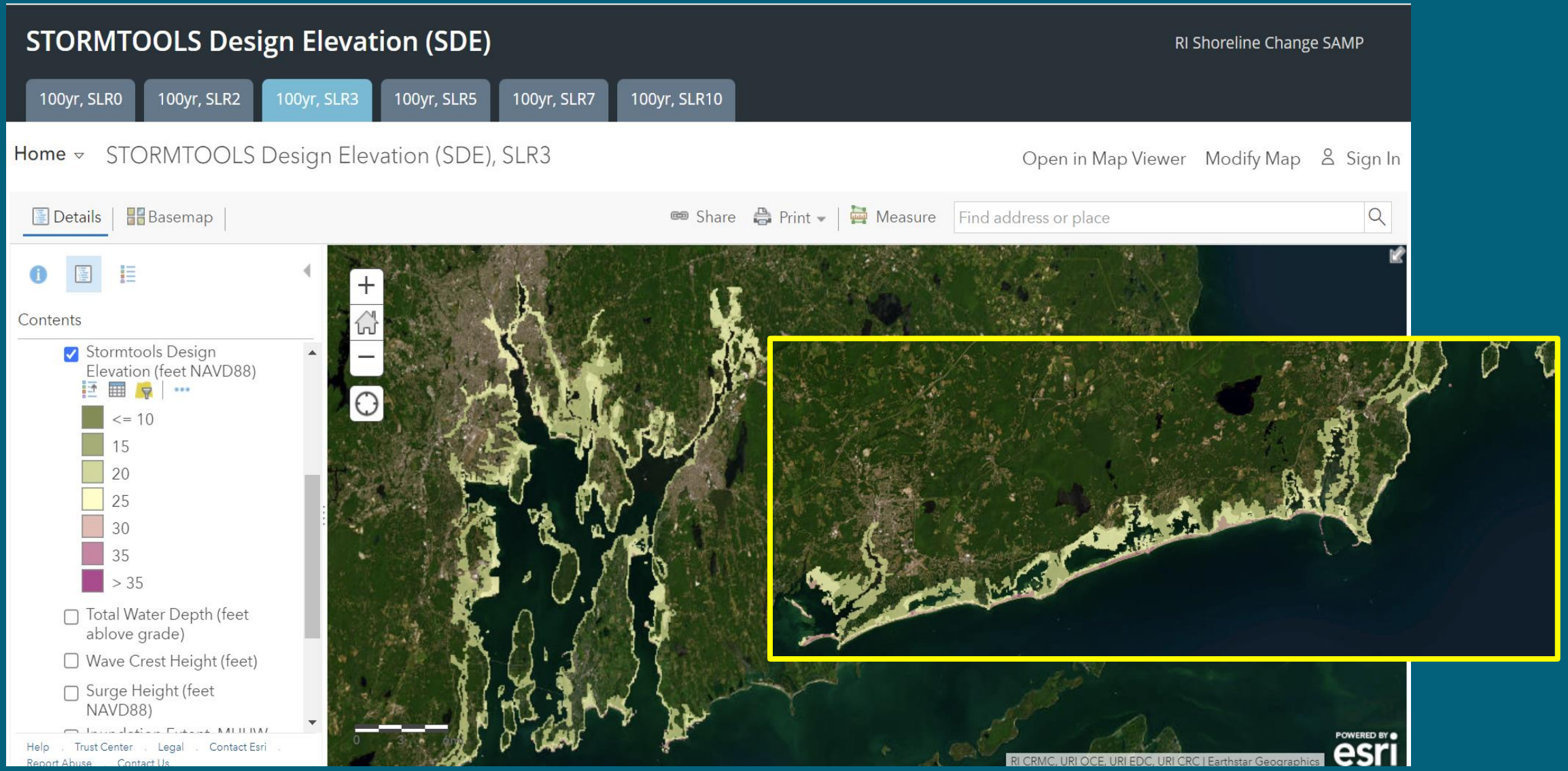
Regression SDE BFE 500 yr no SLR to 100 yr with 3 or 4 ft SLR



Best Fit - 3 ft SLR case
R= 0.98918, R^2= 0.97847
RMSE = 0.8245

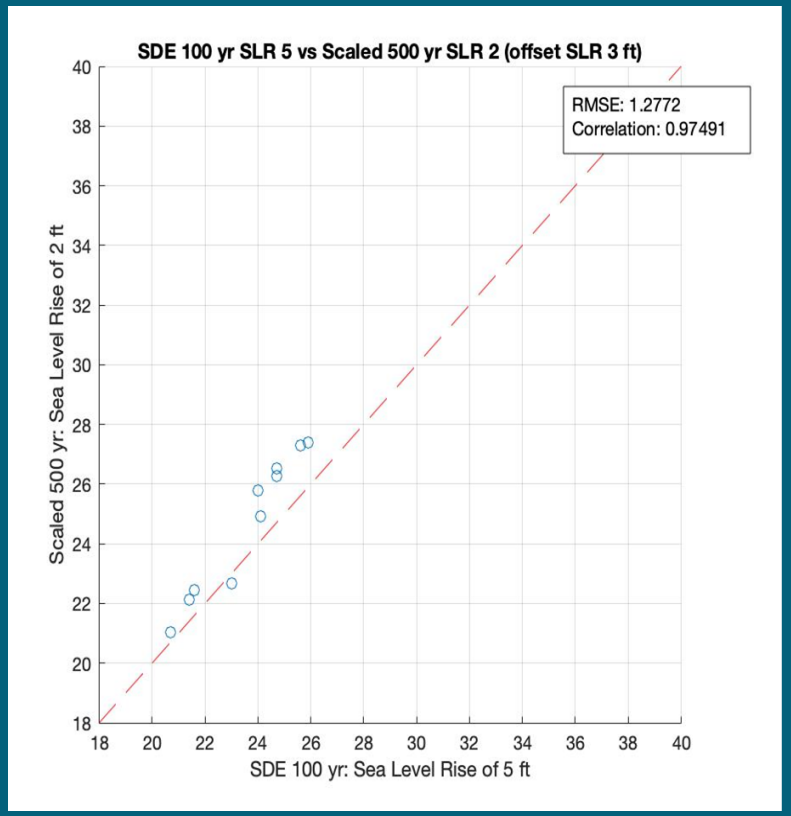


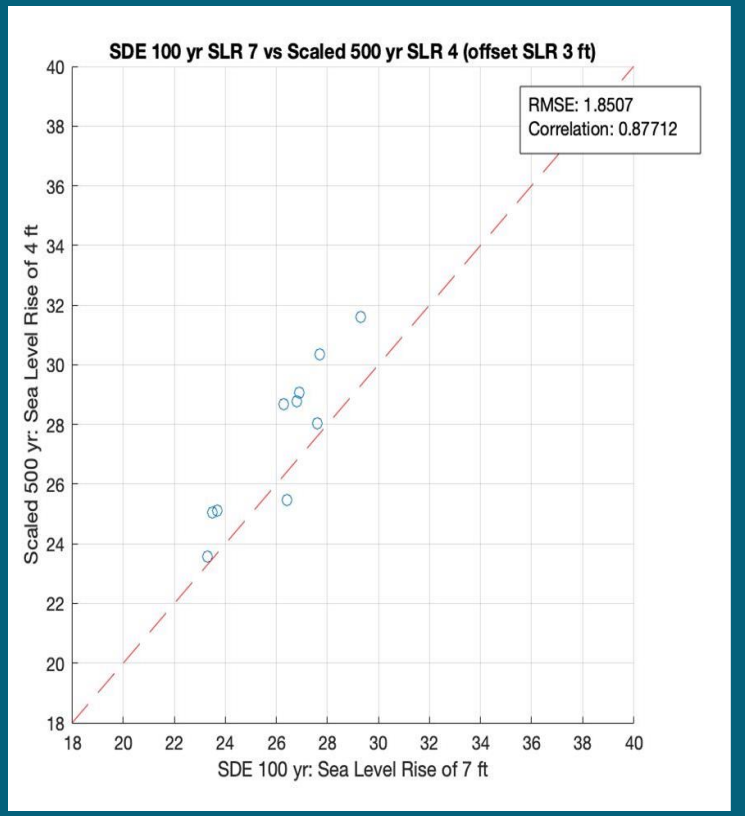
SDE map 500 yr, 0 SLR = 100 yr, 3 ft SLR

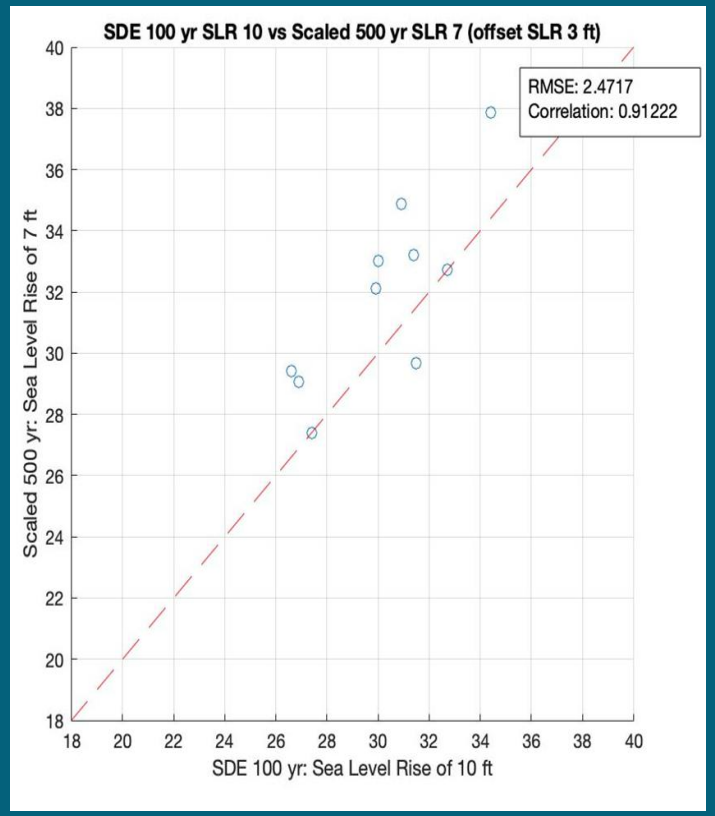


Regression SDE 500 yr: 2, 4, and 7 ft SLR to 100 yr: 5, 7, and 10 ft SLR (offset 3 ft)

Correlation generally good, R > 0.877, R^2 >0.769
RMSE however increases - 1.27 to 2.47 ft







Perform analysis following strategy for development of SDE maps, 500 yr, with SLR: 0, 2, 3, 5, and 7 ft.

Journal of *Marine Science and Engineering*

MDPI

Article

Stormtools Design Elevation (SDE) Maps: Including Impact of Sea Level Rise

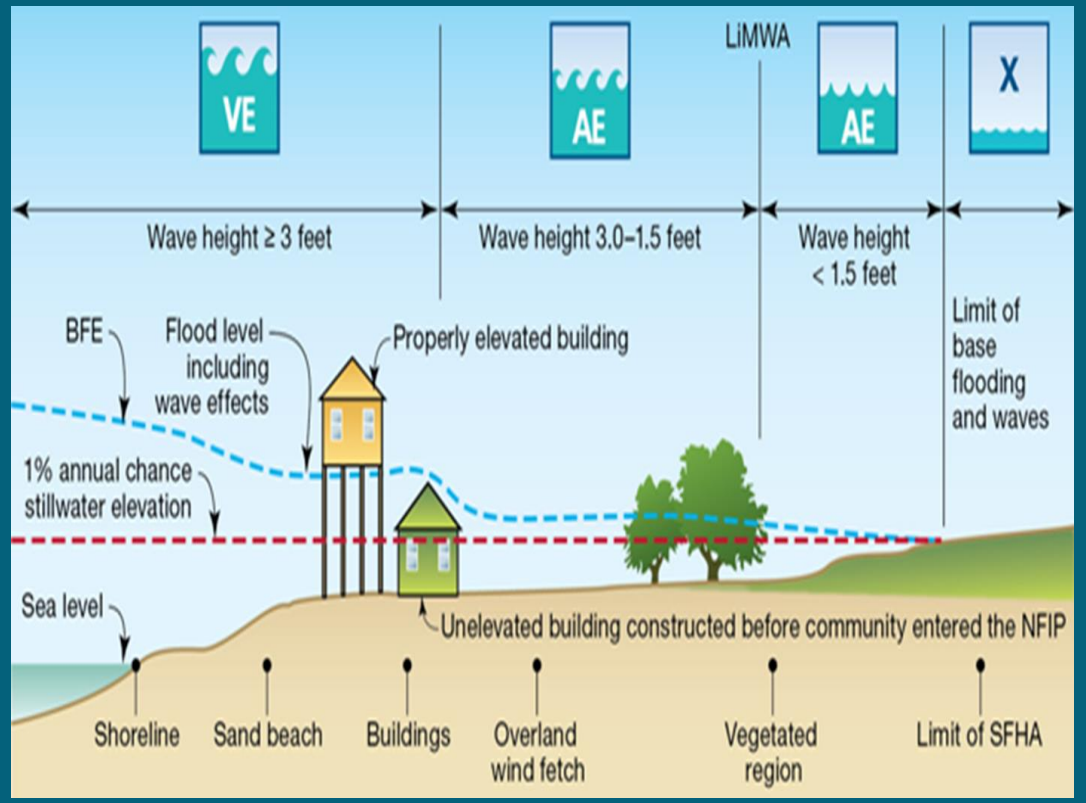
Malcolm L. Spaulding [1,*], Annette Grilli [1], Chris Damon [2], Reza Hashemi [1], Soroush Kouhi [1] and Grover Fugate [3]

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2 Environmental Data Center, University of RI, Kingston, RI 02881, USA; cdamon@uri.edu
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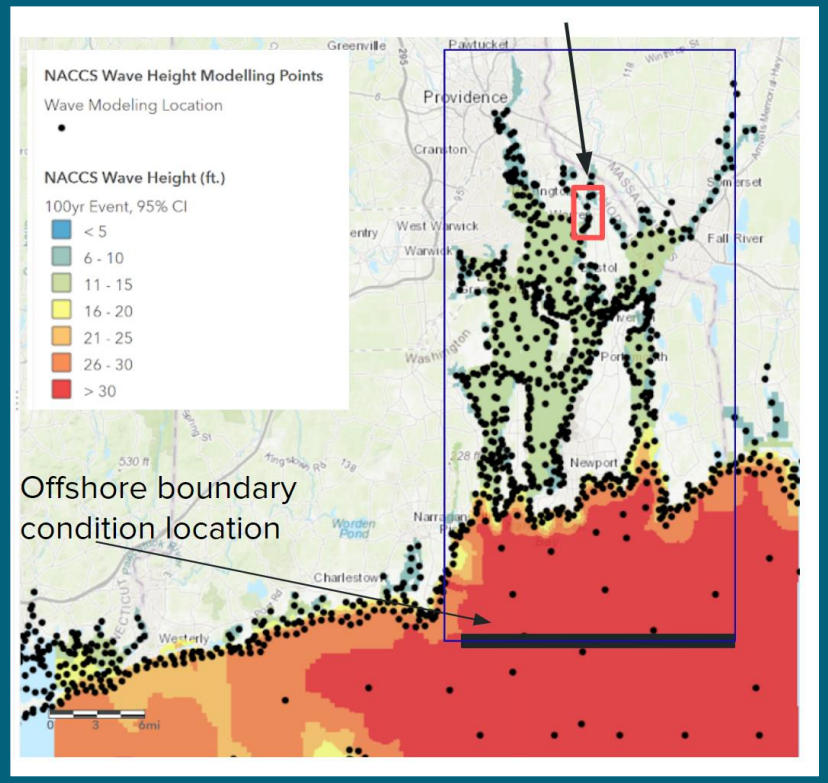
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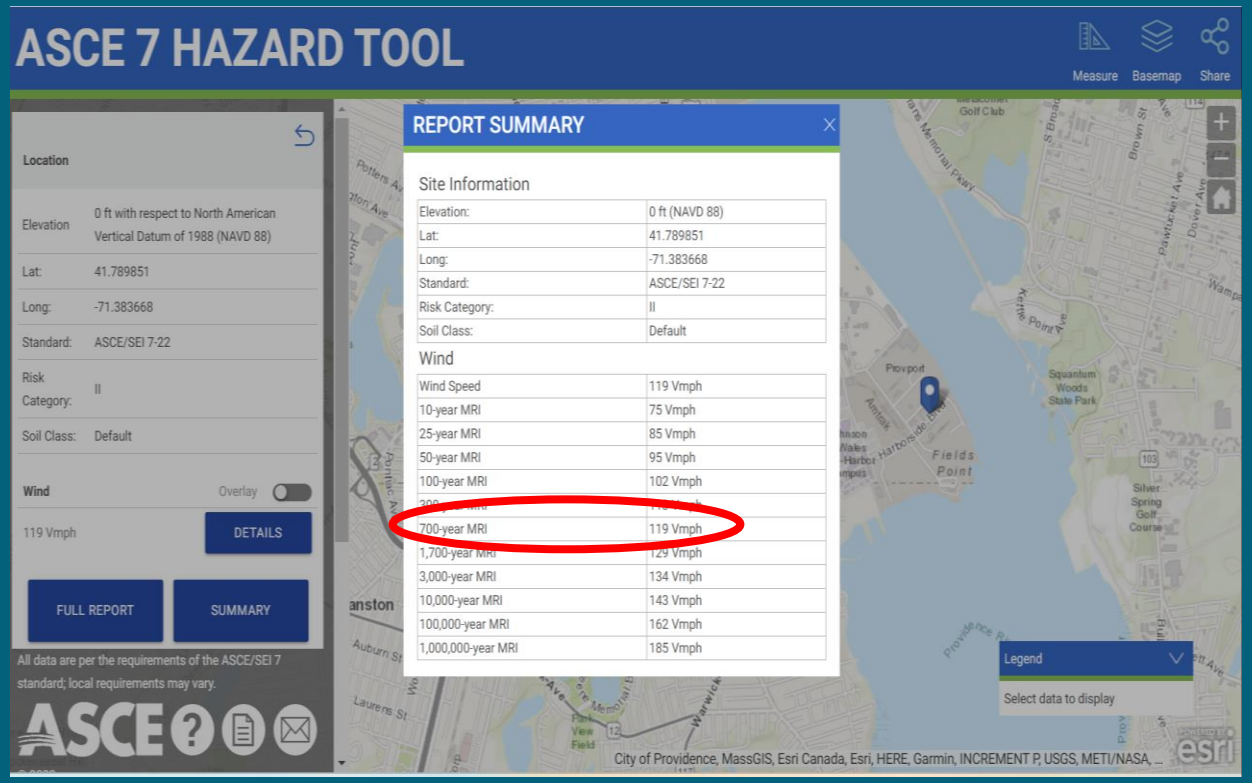
Abstract: Many coastal communities in the US use base flood elevation (BFE) maps for the 100-year return period, specified on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs), to design structures and infrastructure. The FIRMs are increasingly known to have serious problems in accurately specifying the risk coastal communities face, as most recently evidenced during hurricanes Harvey and Irma in 2017 and Florence and Michael in 2018. The FIRM BFE maps also do not include the impact of sea level rise, which clearly needs to be considered in the design of coastal structures over the next several decades given recent National Oceanic and Atmospheric Administration (NOAA) sea level rise (SLR) projections. Here, we generate alternative BFE maps (STORMTOOLS Design Elevation (SDE) maps) for coastal waters of Rhode Island (RI) using surge predictions from tropical and extratropical storms of the coupled surge-wave models from the US



Approach: Narragansett Bay

*Apply STWAVE to Narragansett Bay using 500 yr winds and water levels using ASCE scaling method, with SLR. Predict significant wave height & estimate wave crest height, determine SDEs 500 yr; 0, 2, 3, 5 and 7 ft SLR.



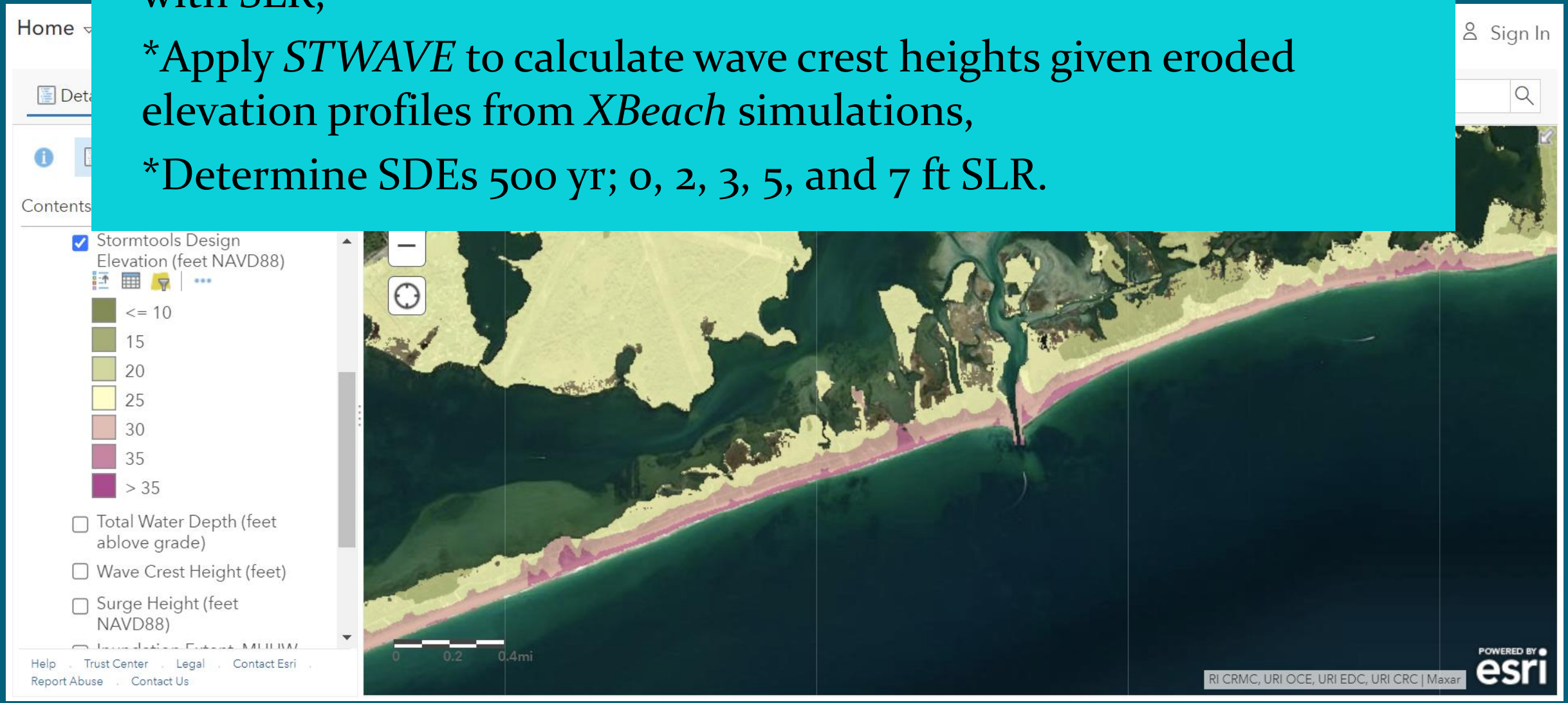


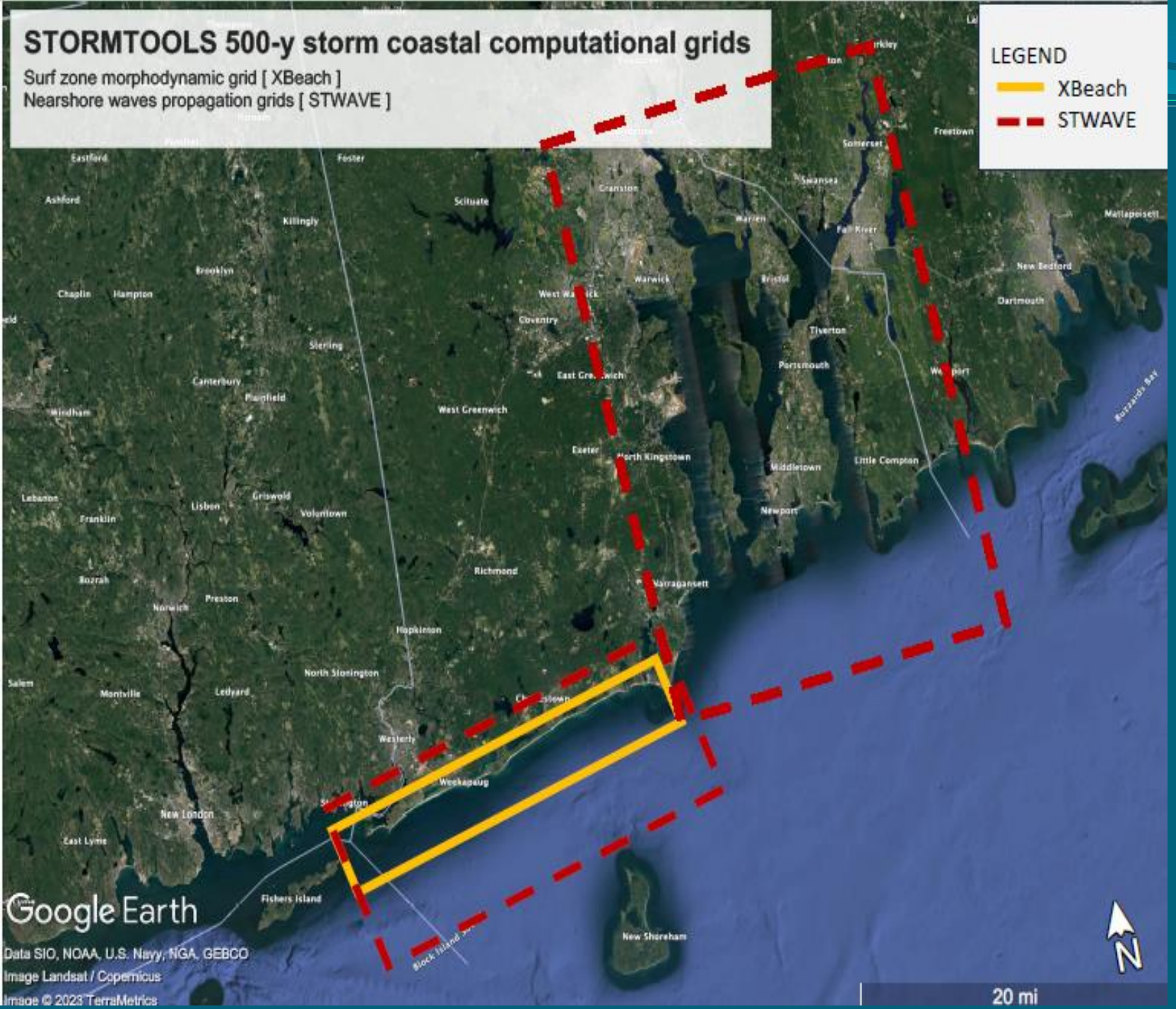
Approach: Southern RI Shoreline

*Apply *XBeach* to calculate shoreline erosion for 500 yr surge levels with SLR,

*Apply *STWAVE* to calculate wave crest heights given eroded elevation profiles from *XBeach* simulations,

*Determine SDEs 500 yr; 0, 2, 3, 5, and 7 ft SLR.





Computational Domains

STWAVE - - -

nearshore wave propagation

XBeach ——

surf zone morphology

STORMTOOLS Design Elevation (SDE)

RI Shoreline Change SAMP

500yr,SLR0 | 500 yr SLR2 | 500yr SLR3 | 500 yr SLR5 | 500yr SLR7

Sample of SDE maps
500 yr with SLR



Outreach

- Kickoff presentation on project to key state officials, town planners, and engineering community. Introduction of simplified maps.
- Update SDE maps and allow access to revised maps via STORMTOOLS Hub (https://stormtools-mainpage-crc-uri.hub.arcgis.com/).
- Prepare paper summarizing the development of 500 yr with SLR, SDE maps
- Hold training sessions at the conclusion of study to introduce revised maps to the community and regulators.