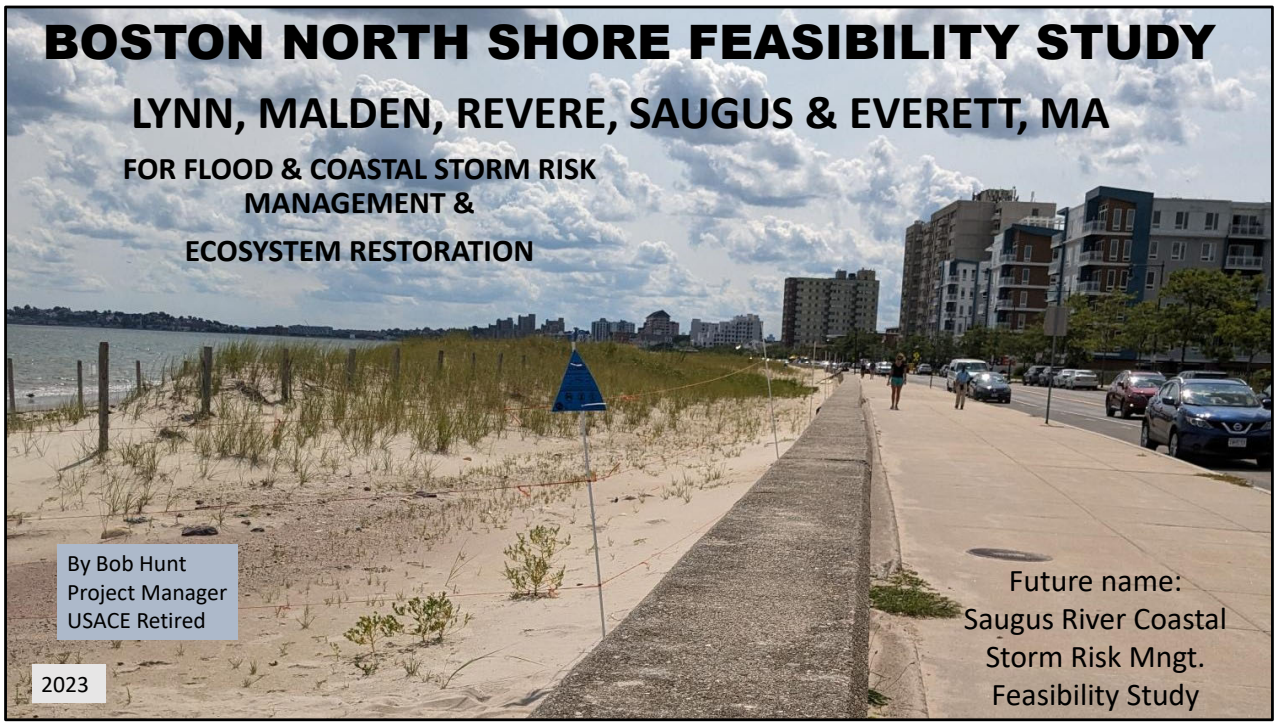


Boston North Shore Feasibility Study: The study was authorized by President Biden in Dec. 2022; however as of Nov. 2023, no Federal funds have been provided. Besides evaluating plans for the USACE's 5-foot sea level rise by 2100 to provide SPN protection, the feasibility study would evaluate plans at other levels of protection including, for example, CZMs adopted rise of 7.8-feet by 2100. USACE advised that the future name for the study may change to "Saugus River Coastal Storm Risk Management Feasibility Study" to eliminate confusion with two other on-going Boston flood studies, which has already caused some confusion.

DEVELOP & EVALUATE NEW PLANS TO PROTECT AGAINST 5 FEET OF SEA LEVEL RISE BY 2100 WITH PROTECTION AGAINST THE STANDARD PROJECT NORTHEASTER. The following slides supplement the original project features, e.g. the Floodgate details are similar, so not repeated here.

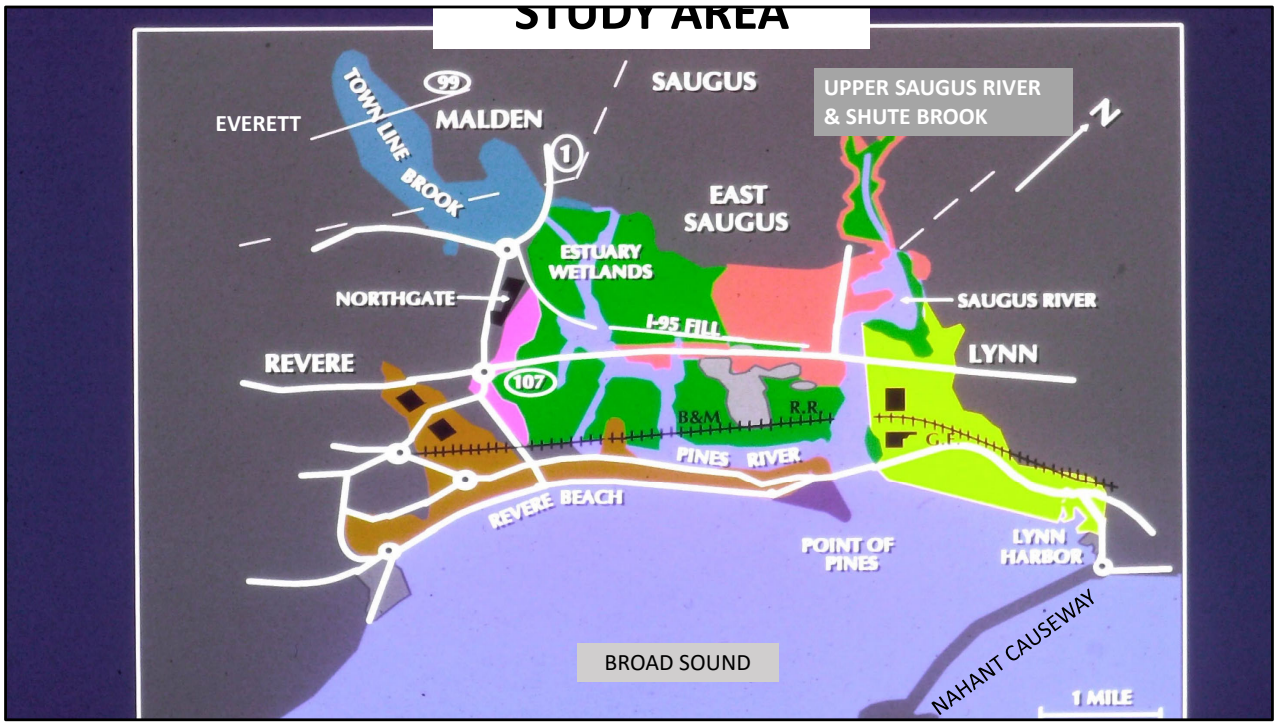
Develop and Evaluate New Plans: New plans must be developed since accelerated sea level rise has been adopted by both the USACE and MA Coastal Zone Management Office. Sea level rise is increasing rapidly every decade which makes a significant difference in forecasting flood levels, future damages, and plans to protect the region.

OVERVIEW

- Blizzard of ’78: **3,100 Buildings flooded,** $332M Damages *
- 4 Year Feasibility Study, 5-Steering Committees**, $6.8 million.***
- 1990: Recommend $250M Regional Saugus River Floodgate Project, **Protect Entire Region & Estuary,** w/ Shore Features in Lynn & Revere.
- After NEPA/MEPA Process, **Positive Envir Certificate, State Sponsor.**
- Congress Authorized Project, **$15.6 Million design effort** (75%).*
- **New Environ. Secretary opposed construction, Project on-hold 1993.**
- 2020: 5-Towns **Request Corps for “Boston North Shore Study”**
- **Authorized by President Biden Dec. 2022, NEED FUNDS**
- **Accelerated Sea Level Rise, Project @ $485M to prevent $4B damages**

*** All costs updated to 2023 price level.**

Overview: This slide summarizes the history of investigations and direction of the new study.

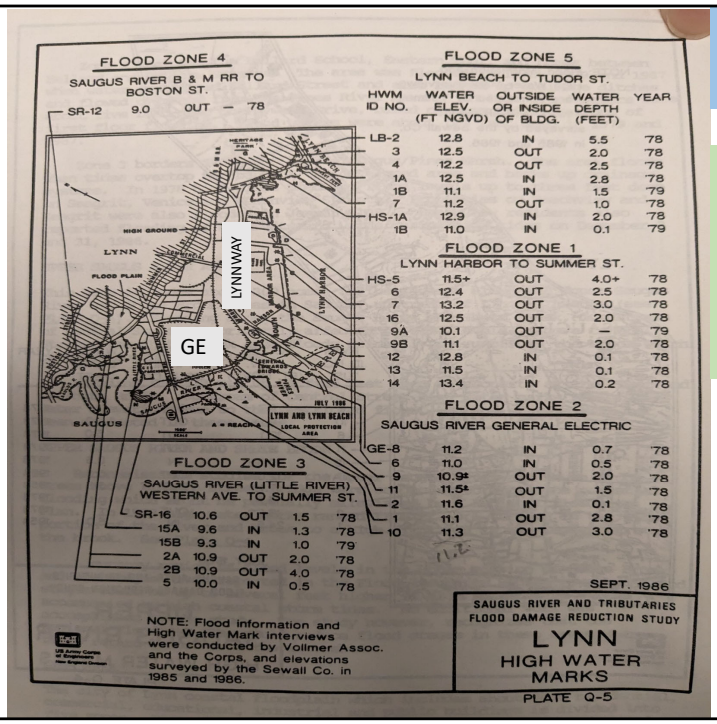


Study Area: The Study Area encompasses the floodplains of the Cities of Revere, Lynn, Malden and Everett and the Town of Saugus. The original study identified the floodplain thirty years ago up to the Standard Project Northeaster (SPN) or El. 12 feet, NGVD with 5,100 buildings, 21,000 residents and 8,300 housing units. The SPN is the worst coastal storm likely to occur. The floodplain would now encompass an area up to about El. 22 ft.,NGVD by the year 2130, or 10 feet higher with accelerated sea level rise. By 2030 the floodplain may reach 8,000 buildings, 35,000 residents with 13,000 housing units affected, but studies are needed.

ESTUARY FLOOD LEVELS VS. BOSTON TIDE GAUGE

500 Interviews determined flood levels for ‘78 Blizzard, 100-yr flood et.al.
Sustained winds “piled-up” Estuary tides flooding 0.5 to 4 feet higher than Boston Gauge, a similar effect for 10-year storms, e.g. ‘79, ‘87 & ‘91.

Estuary Flood Levels vs. Boston Tide Guage: A wide variation in flood levels occurred during the Blizzard of 1978 when compared to the Boston Gauge. Flood levels ranged from 0.5 to 4 feet higher than the Boston gauge in areas exposed to the open Estuary. The following slides depict the significant differences between the Boston Guage as compared to the USACE surveys with information reported by residents following the Blizzard of 1978, the 100 year frequency storm, and several 10-year storms.



CORPS OF ENGINEERS' 1990 FEASIBILITY REPORT PLAN FORMULATION APDX.

CITY OF LYNN 1978 100 YEAR FLOOD HIGH WATER MARKS & 1979 10 YEAR FLOOD HWMs

SAMPLE AREA

Lynn's 100-year High Water Marks: This plate from the USACE's Plan Formulation Appendix, Final 1990 Feasibility Report summarizes the Blizzard of '78, 100-year and other 10-year events' high water marks locations surveyed in the City of Lynn. This is just a sample.

1978 Recorded Levels & Damages

USACE REPORTS
1978, 100-Year Event,
Boston Tide Gage El. 10.3 Ft., NGVD

Location	Flood Depth Avg.	Outside Avg.	Above Gage
Lynn Harbor, Lynnway	2.9 Feet	El. 12.4	2.1 Ft.
Lynn-General Electric *	2.3 Feet	El. 11.2	0.9 Ft.
Saugus, Ballard St. * .	2.1 Feet	El. 11.3	1.0 Ft.
Above Lincoln Ave. Bridge *	3.2 Feet	El. 14.2	3.9, **Say 4 Ft.**
Northgate, Revere *	----	El. 10.9	0.6 Ft.
Wonderland & Ocean Ave.	6.4 Feet	El. 10.4	0.1, O.T.
Town Line Bk., Revere & Malden	3-4 Feet	El. 7-8	(2-3 Ft.)
Riverside, Pines River, Revere *	1-3.7 Feet	El.9-12.5	(1.3) 2.2 Ft.
Kelley's Meadow, Revere	5.7 Feet	El. 8.3	(2 Ft.)

1978 DAMAGES — $ 332-Million (60% of Buildings)
Updated prices to '23 P.L.

All total about 25 different hydraulic or flooding zones, show complexity of floodplain! (Only 18 zones evaluated.)

As sea levels rise so will these flood levels, e.g. a 5-foot rise in sea level would raise flood levels about 5-feet.

A refined coastal model, if it can reproduce 1978 flood levels, may show whether higher flood events result in even a higher surge above the Boston Gage.

* Areas open to Estuary. Other areas subject to overtopping of walls.

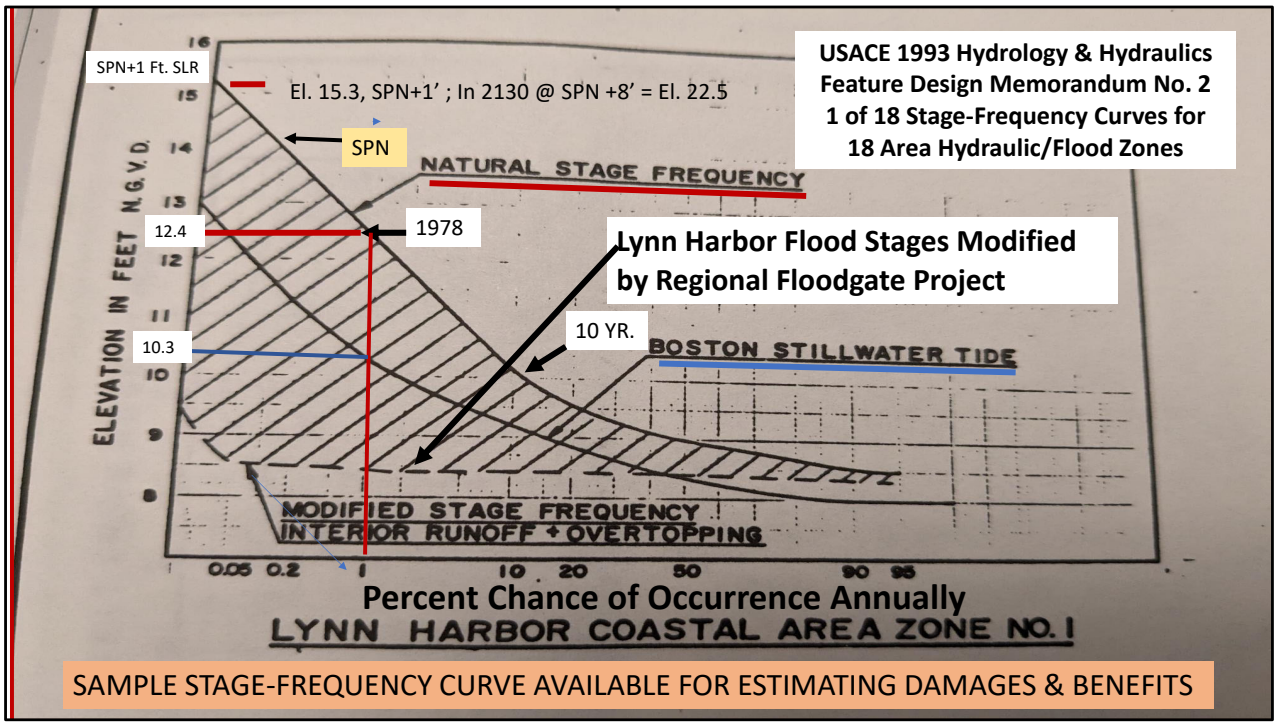
1978 Recorded Levels & Damages: Actual flood levels are compared to the Boston Gauge for 1978. Note that the areas exposed to the open Estuary's flood levels range from 0.6 feet to 4 feet higher than the Boston gauge.

STANDARD PROJECT NORTHEASTER

THE SPN IS THE WORST COASTAL STORM REASONABLY LIKELY TO OCCUR IN THE REGION AND WOULD CAUSE DAMAGES OVER 4 TIMES WORSE THAN IN 1978, BASED ON OVER 2,000 INTERVIEWS OF ACTUAL FLOOD LEVELS, AND DAMAGE SURVEYS OF 3,700 BUILDINGS.

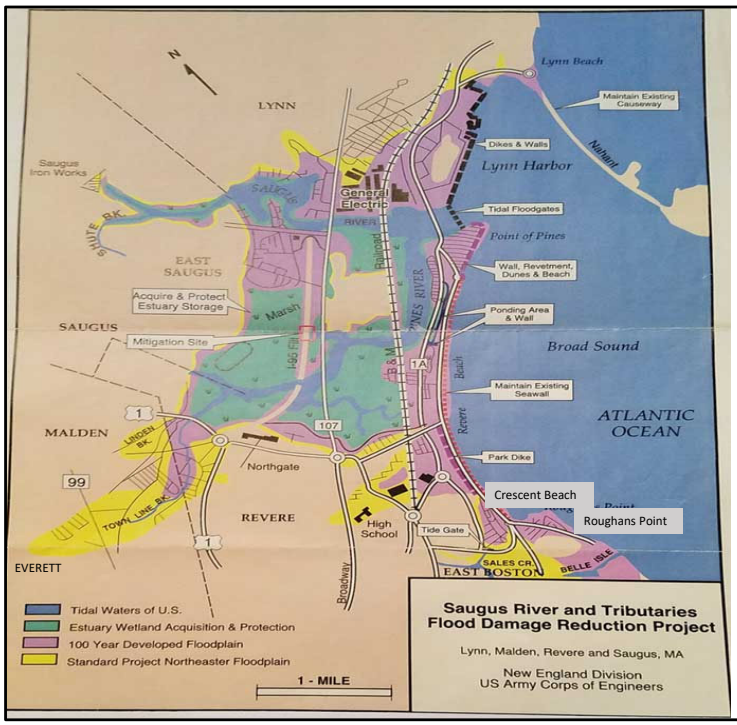
SPN = HIGH SPRING TIDE + STORM SURGE OF RECORD (5 FEET)

Standard Project Northeaster: the SPN is the highest level of flooding likely to occur, generally with a stillwater level at 1.7 feet higher than a 100 year storm tide. Sea level rise preliminary plans are being formulated for SPN protection.



Lynn Harbor Stage vs. Frequency Curve: This S-F curve shows the frequency of storms compared to the elevation/stage of flooding for Natural flooding conditions for land behind Lynn Harbor, and for conditions modified by the Regional Saugus River Floodgate Project. The Boston Tide curve is provided for reference, and identifies the Blizzard of '78, 100-year tide level at El. 10.3 ft. NGVD for the gauge, while the Lynn Harbor Natural level is El. 12.4 which is 2.1 feet higher than the Boston Gauge, primarily from overtopping of the Harbor's bulkhead and shorefront. This is one of 18 S-F curves which shows the results of high-water marks and hydrologic analysis in each flood zone for the region and should be used for damage analysis. Other zones

not yet evaluated include the Town Line and Linden Brook floodplains, the Upper Saugus River and Shute Brook areas, and the area behind Lynn Beach. These S-F curves will generally rise one foot vertically for each foot of sea level rise to show future flood levels.



1978 (100 YEAR) FLOODPLAIN IN PURPLE

SPN FLOODPLAIN: YELLOW + PURPLE

Flood levels in the open Estuary reach up to 0.5 to 4 feet higher in the Estuary and in Communities than the Boston Gage.

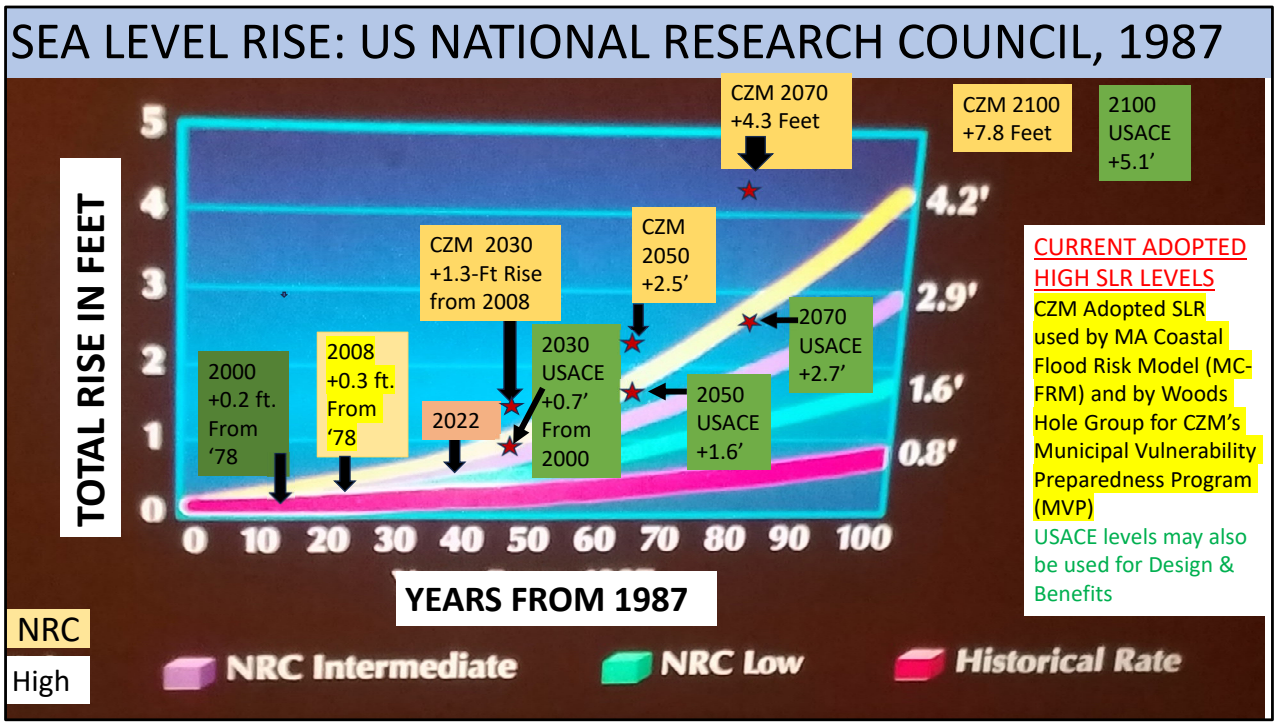
5 COMMUNITIES: SPN +1Ft. SLR OVER 6,000 BUILDINGS, 8,000+ HOUSING UNITS, MAJOR ARTERIES: US #1, 1A, 107, MBTA BLUE LINE & B&M COMMUTER RAIL

Study Area Map: the Study Area Map shows the area of the Blizzard of ’78 flooding for the 100-year flood in purple and the Standard Project Nor’easter floodplain (set at El. 12 ft. NGVD contours) extended in yellow. Not shown is how far the floodplain would extend to the El. 22 ft. NGVD contour for the year 2130’s approximate SPN floodplain with flood levels about 10-feet higher than the 1978 SPN level (or about 15 feet above the start of damages).

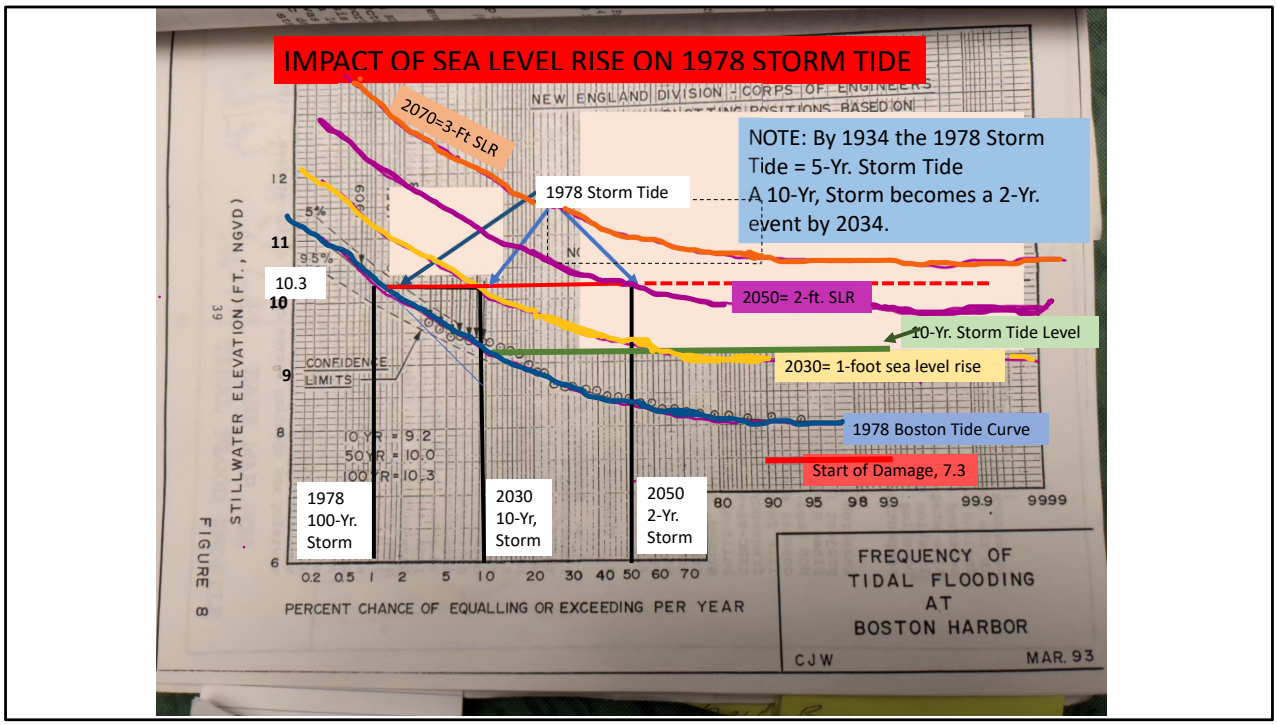
ACCELERATED SEA LEVEL RISE

- Feb. 2022—NASA, NOAA & USGS: "..over the **next 30 years, by 2050, sea levels** on the East Coast **will rise 10 to 14 inches**.." ---historically seen over 100 Years! And **cause catatrophic flooding, accelerating**.
- Also reported: ".. by the mid-2030s every U.S. coast **will experience more intense high-tide floods** due to a wobble in the Moon's orbit..this.. in conjunction with rising sea level, is projected to worsen the impacts of high-tide flooding during the 2030s and 2040s."
- June 2023—Scientists: "**Oceans warming at unprecedented rate..Surge threatens to raise sea levels**; just totally shocking.."
- Oct. 23, 2023, "Nature Climate Change": Rapid melting in..Antarctica is 'unavoidable',with **potential disastrous consequences for sea level rise..**
- **2023: USACE adopts their "High Rate" for sea level rise, CZM is higher!**

Accelerated Sea Level Rise: These quotes depict statements warning of the danger and extent of sea level rise, and the fact that higher levels have been adopted by the USACE and Commonwealth of Massachusetts for planning projects.

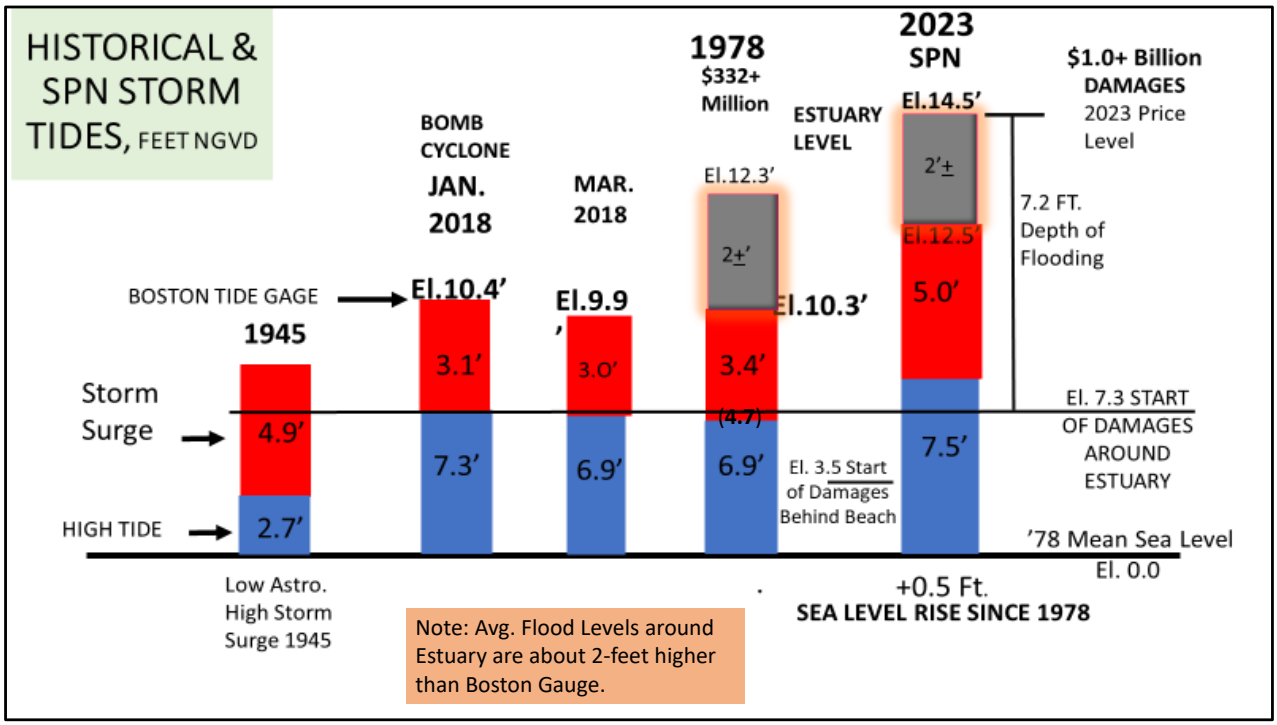


Sea Level Rise: The 1987 graph shows the Historical Rate of sea level rise at 0.8 ft. in 100-years with other rates forecasted at that time. Now the NRC "High Rate" seems to be adopted by the USACE, but CZM has adopted higher rates.



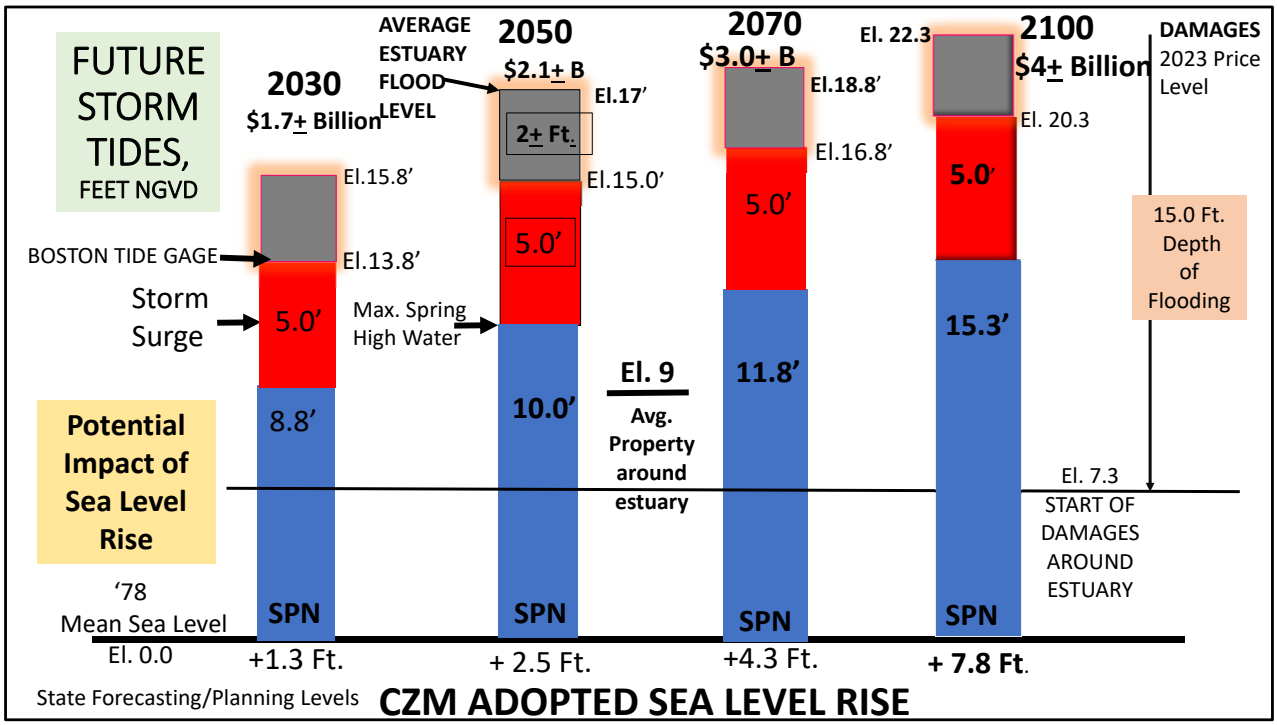
Impact of Sea Level Rise on 1978 Storm Tide: The Boston Tide Level-Frequency is shown on the bottom curve which was in effect during the initial investigation and has only risen since then at about the historical rate of 0.1 foot per decade. The left side of the grid is the elevation of the tide and bottom grid line is the frequency when the tide occurs. For example, the Blizzard of 1978 had a peak tide elevation of 10.3 feet, NGVD at a frequency of 1% chance of occurring each year or a 100 year Storm. The curves above it are for each foot of sea level rise (SLR). By 2030 with about 1-foot of SLR the El. 10.3 level becomes a 10% chance or a 10-year storm event. By 2050 with 2-feet of SLR, the El. 10.3 level has a 50% chance of occurring each year or a 2-

year storm. Then before 2070 the El. 10.3 tide level (dashed red line) becomes an annual event. By the time a project could be built about 2034 the Blizzard of 78 tide level of El. 10.3 has a 20% chance of occurring each year or a 5-year storm event. For reference, see the “Start of Damage” at El. 7.3 around the Estuary. Over the past several decades we’ve seen many 10-year storm floods with an El. 9.2 (green line) tide level. By 2034 those floods will occur about every 2-years. The Blizzard of 78 was a normal 2-day Nor’easter with a frequent 3.4-foot storm surge, but it occurred on a high spring tide. Many more of these events will devastate the region as sea levels rise.

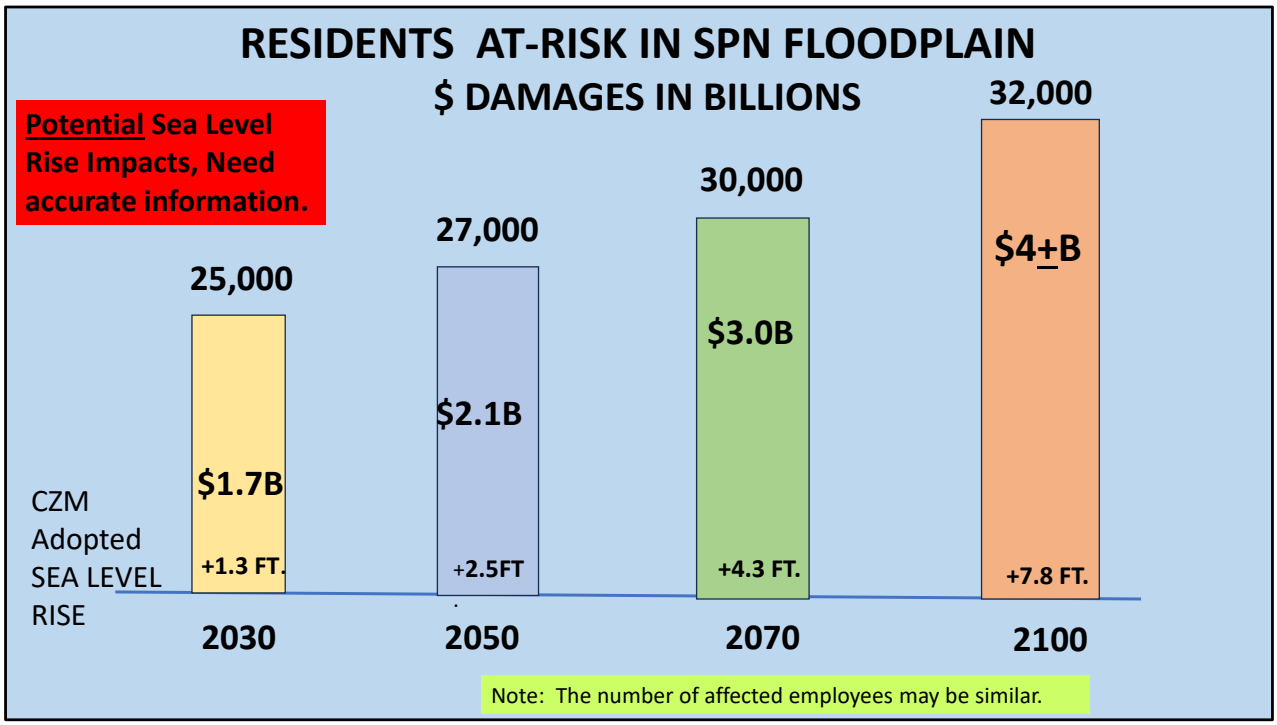


Historical & SPN Storm Tides: The astronomic or predicted tides and storm surge is shown for historical storms. The "3 foot" surge shown for several historical storms is an average annual storm surge for Boston storms. What makes these storms unique is they occur during a high predicted water level, or high monthly tide. In the case of the Blizzard of '78, the highest surge was 4.7 feet on Feb. 6th with a lower tide, which occurred the day before the highest recorded level the next day of 10.3 ft. NGVD with only a 3.4 foot surge. In 2023 with a higher astronomic level of 7.5 feet, if accompanied today by the historical storm surge of 5 feet, the catastrophic SPN storm would produce a flood depth of 7-feet above the start of damage. A "2-foot" water level is

added to the top of the SPN and ’78 storm to reflect the average surge height in the Estuary of 0.6 to 4 feet above the Boston Gauge which occurred in ’78.



Future Storm Tides: This chart represents the height of SPN storms using CZM's adopted levels of sea level rise. Again, a 2-foot water level is added for the increased surge in the Estuary above the Boston Gauge. A more refined model may show that as higher flood events occur, so also the height of the surge above the Boston Gauge may increase as well, beyond the average 2-foot shown.



This graph reflects only the potential impact of sea level rise on the residents in the floodplain. It was developed by extending a curve of known impacts up to a 1-foot sea level rise. This information needs to be developed as it's critical for characterizing the need for the study as a selection criterion for assigning funds at the Washington level.

PLANS TO EVALUATE

OPTION #1: LOCAL WALLS AROUND ESTUARY & SHOREFRONT

DEVELOPED AREAS AROUND ESTUARY TO BE PROTECTED WITH DIKES, WALLS, REVETMENTS & SAND DUNES/BEACH

OPTION #2: NON-STRUCTURAL PLAN/RAISE BUILDINGS

INDIVIDUAL BUILDINGS TO BE RAISED OR FLOOD PROOFED \
WITH A WARNING SYSTEM

OPTION #3: REGIONAL SAUGUS RIVER FLOODGATE PLAN & ESTUARY WALLS

TO PROTECT THE ENTIRE REGION USING A FLOODGATE, WALLS, DIKES, BEACH & DUNES ALONG THE SHOREFRONT, PURCHASE & PROTECT THE ESTUARY FOR RUNOFF STORAGE & NON-STRUCTURAL MEASURES

DETAILED STUDIES NEEDED FOR THESE OPTIONS. Preliminary analysis follows.

Plans to Evaluate: These three options are generally plans which are assumed should be evaluated for sea level rise. Others may be suggested by agencies or communities. Option #3, the Regional Saugus River Floodgate Project was originally selected; however, significant changes are made here due to accelerated sea level rise which may either enforce or change their support for the project.

Preliminary PLANNING CRITERIA AGAINST SEA LEVEL RISE

1. *2034 is the estimated year a project could be completed.*
2. *In 2034 frequent property flooding occurs 4 times per month & max. monthly high water is half a foot higher than today reaching El. 8.7 ft. NGVD, 1.4 ft. above start of damage El. 7.3.*
3. *Coastal storms are more intense w/ higher flood stages, '78 storm becomes a 10 yr. event.*
4. *By 2100 in 77 Yrs the USACE 's adopted rise in sea level is 5.1 feet & CZM adopted 7.8 feet.*
5. *Original authorized project was optimized for the SPN and thus adopted here for the level of protection for this initial/preliminary evaluation of plans; versus CZM's level @ 100 year.*
6. *Since the surge in the estuary is 0.5 to 4 feet higher than the Boston gauge, a 2-foot increase is added to the Boston Gauge SPN 2100 water level to El. 19 (12 feet above start of damage).*
7. *A 2-foot height is added for wall freeboard (dikes 3' FB) w/ a top of wall at El.21 in 2100.*
8. *With an average ground elevation on back yards and edge of roads at El. 9 (in each of 3 towns), the average wall height viewed by residents is 12 feet in 2100 for SPN protection.*
9. *A Floodgate built in 2034 would prevent damages with 4 closures per month.*
10. *Low walls around the Estuary could reduce closures to 2 / year, shown on the following chart.*
11. *Costs are based on updated price levels from the 1993 General Design Report.*
12. *Details, impacts and economic feasibility of plans are yet to be determined, although damages and thus benefits are expected to increase significantly with accelerated sea levels.*

Planning Criteria: The text provides some of the assumed planning criteria in developing or formulating plans for protecting against sea level rise.

WALL HEIGHT AROUND ESTUARY W/O & W/ FLOODGATE & CLOSURES

YEAR	Boston Tide Elev FT.,NGVD w/ USACE Rise 100 Yr.	SPN	HIGH SEA LEVEL RISE USACE	Estuary SPN Elev.	Estuary Walls SPN Without Floodgate Option #1 +2'FB Top El.	Height Above Avg. Yard/Rd El. 9	Estuary Walls WITH Floodgate, SPN Option #3 +2'FB Top El.	Height Above Avg. Yard/Rd El.9	Floodgate Closures per Month / Hrs. Each Without Walls
1978	10.3	12.0	0	+2'Surge					0.2/2 Hr. in 1978
2000	10.5	★ 12.2	+0.2	14.2	Rounded		Min. Gate Close 2/Yr.		
2030	11.2	12.9	★ +0.7	14.9	El. 17	**8 Ft.**	El. 10.5 Water El 8.5	**1.5 Ft.**	**3/2.5** '34 **4/3 1.8%**
2050	12.1	13.8	★ +1.6	15.8	El. 18	**9 Ft.**	El. 11.5	**2.5 Ft.**	**10/4 5.6%**
2070	13.2	14.9	★ +2.7	16.9	El. 19	**10 Ft.**	El. 12.5	**3.5 Ft.**	**23/5**
'90	14.7	16.4	★ +4.2	18.4	El. 20	**11 Ft.**	El. 14	**5 Ft.**	**49 / 6**
2100	15.6	17.3	★ +5.1	19.3	El. 21	**12 Ft.**	El. 15	**6 Ft.**	
2120	17.4	19.1	★ +6.9	21.1	El. 23	**14 Ft.**	El. 17	**8 Ft.**	
2130	18.4	20.1	★ +7.9	22.1	El. 24	**15 Ft.**	El. 18	**9 Ft.**	

Wall Height Around Estuary: This table shows the development of the height of walls around the Estuary required to protect the region as sea levels rise. Columns 2 & 3 show the Boston Gauge readings for both the 100-year storm and SPN storm levels. Column 3 includes the USACE adopted sea level rise, which when each is added to the Boston Gauge SPN level in 2000, the base year, gives the SPN Boston level for each of the years for sea level rise. Column 5 adds the 2-foot surge to establish the average SPN level in the Estuary. Col. 6 adds 2-feet of freeboard for wave runup to determine the top of wall elevation needed around the Estuary to protect against the SPN for that year. Col. 7

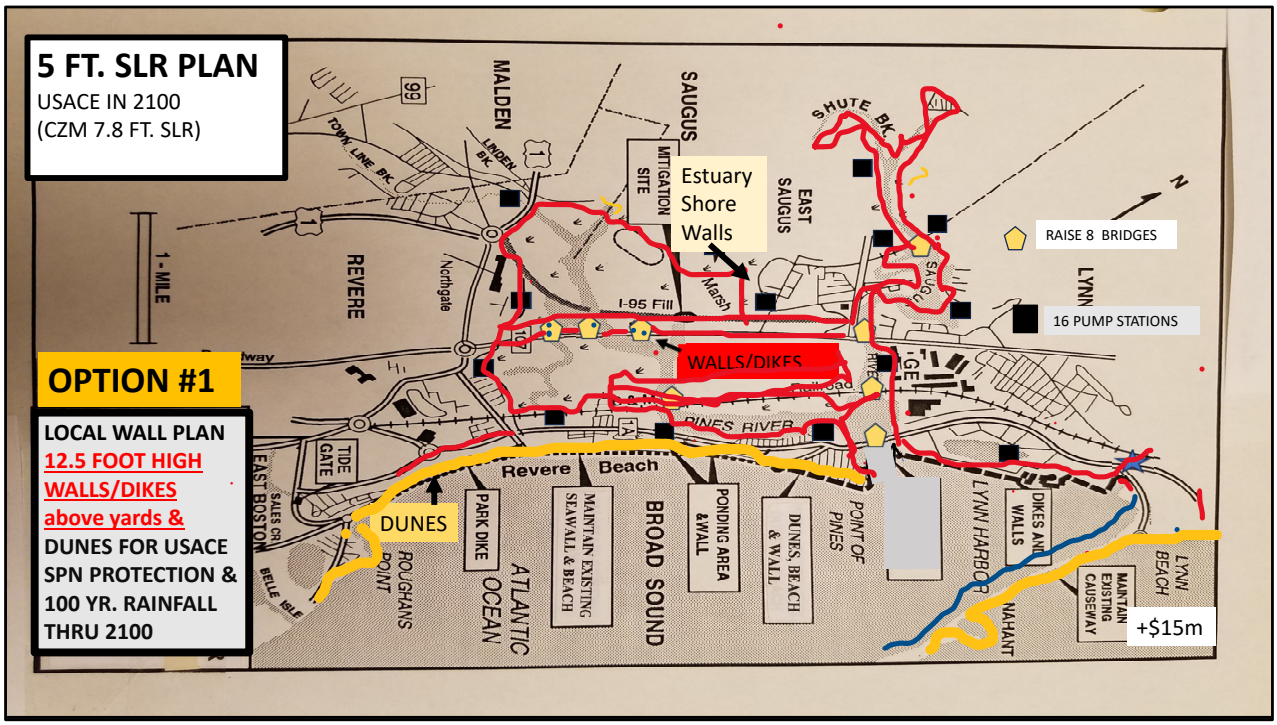
(Yellow) subtracts the average ground in the three bordering communities of El. 9 ft. NGVD to show the height of walls above the backyards of bordering residents and above Route 107.

Columns 8-10 were determined with the help of the operating engineers in the Corps' Water Control Branch who determined that in the 1980 time frame with the Saugus River Floodgate installed, the average gate closure to prevent damages at about El. 7.5 ft.NGVD would be about 2 closures per year. When sea levels rose 1-foot, closures would increase to 40 per year, or say 3 per month (Col. 10). Since the goal is to limit: the impact on flushing and tide levels in the Estuary; impacts on navigation; and reduce operating and maintenance costs, closures should not significantly exceed about 2 to 12 per year. Thus, by 2030 seas would have risen about 1-foot approaching 3/month. Therefore, the water level in the Estuary should be allowed to rise one additional foot to El. 8.5, thus returning closures to 2 per year. The wall height with a 2-foot freeboard would be El. 10.5 (Col. 8), or 1.5 feet (Col. 9, green) above the average ground El. 9. Thereafter, Estuary water levels and wall heights would increase 1-foot for each foot of sea level rise. So, planning ahead would require raising walls more than the minimum 1.5 feet above ground, possibly to 2050 levels of 2.5 feet. Note that Col. 10 lists the total number of closures if no walls were built.

Preliminary Option #1 LOCAL WALLS

1. *The estuary's perimeter, including sides of roads and RR, is 25 miles.*
2. *Entire shore needs to be raised with walls or dikes to a height of 12 feet.*
3. *Walls & dikes provide SPN protection in 2100 for 5.1-feet of sea level rise.*
4. *Route 107 and Rail transportation raised & 8-bridges raised.*
5. *Sand dunes and beaches built along Revere Beach and Point of Pine.*
6. *Walls and dikes built along Lynn Harbor.*
7. *Maintain Nahant Causeway which reduces wave action in Lynn Harbor.*
8. *About 16 pumping stations built with interior drainage to pump out rain water.*
9. *Plan could be built in two phases. In 2034, 9 feet of the walls built to protect thru 2050 when the remaining 3 feet is added for a total 12 feet above the average back yard or road level for SPN protection.*
10. *Although CZM's adopted rates of sea level rise are higher than USACE's, CZM applies their rate to the 100-year storm, compared to the higher SPN flood. Thus, CZM's level of protection is either equal to or a foot higher than USACE's.*

Option #1 Local Walls: Option #1 is similar to Local Protection Projects, except walls and dikes are continuous around the Estuary due to the significant height of flood waters and widespread damages from inundating the floodplain. All areas would be protected, but the height of walls reaching 12 feet above most back yards and edge of Route 107 would likely be less acceptable than Option 3 with lower walls. Both plans would protect against the SPN with 5-feet of sea level rise by 2100. With water levels in Option #1 at 10-feet above average ground levels, tide gates on culverts or wall openings which malfunction or not closed properly would see a rapid flow of ocean water entering the floodplain.



Option #1 Plan: This plan shows the location of walls or dikes around the Estuary for Option #1 and the potential location of pump stations and bridges to be raised. The yellow lines are locations of proposed dune/beach systems. The Nahant Causeway must be protected since it substantially reduces wave action in Lynn Harbor and the north end of Point of Pines. This causeway needs to be investigated to determine exactly what will be needed to protect it.

Preliminary Option #2- NONSTRUCTURAL, RAISE BUILDINGS

1. *Raise 6000 + buildings up to 12 feet high for SPN protection*
2. *By 2034 properties & streets flood 4 times per month.*
3. *By 2050 properties flood 10 times per month & max. monthly high water at El. 9.5.*
4. *Continually flooding side streets, Rt. 107 & RR at El. 4 – 9.*
5. *Impractical to raise roads & streets to 12 feet high.*
6. *Roads and streets submerged continuously.*
7. *Nonstructural plans appear impractical against rising seas.*
8. *Total evacuation from floodplain would cost $3-6 billion±.*

Option #2 Nonstructural Plan/Raise Buildings: It's difficult to formulate a nonstructural plan realizing that residential streets and arteries would be submerged most of the time and then continuously. For comparison, the cost to raise or floodproof 6,000 buildings up to 12-feet high is shown. The cost is based on the updated cost to raise a home from the Plan Formulation Appendix. The cost to raise or floodproof commercial and industrial buildings would be much higher. Also, there are far more buildings in the 2100 SPN floodplain than 6000 buildings which may reach 8,000, but the exact number needs to be determined.

Preliminary OPTION #3A – FLOODGATE PLAN & WALLS

1. *Phase #1 2034 build Floodgate, raise 2-feet for SLR, Closures 4 per month@3Hrs.*
2. *Build 2.5-foot high walls along estuary's 12 miles, reduce closures to 2 per year.*
3. *Lynn Harbor & Revere features raise 2-ft for SLR above originally design.*
4. *Use 2/3rd of I- 95 Embankment for dunes & beaches,*
5. *Restore 2/3rd 41 acres of wetlands & flushing to 500 acres after Floodgates built.*
6. *Build 2/3rd of sand dunes and beach along Revere Beach & Point of Pines.*
7. *Purchase & protect the 1,650-acre estuary.*
8. *Build 5 pumping stations & maintain Nahant Causeway.. (Walls along higher ground, such as the Upper Saugus River & Shute Brook, delayed to Phase #2.)*
9. *Phase #2 in 2070: Raise Floodgate, Lynn Harbor & Revere's features 3-feet.*
10. *Remaining 3.5 feet added to Phase #1 walls.*
11. *Use I-95 for dunes & beaches & Restore wetlands.*
12. *Build remaining walls about 4-feet high around rest of Estuary's 13 miles.*
13. *Raise 8 bridges, build 11 pumping stations, & maintain Nahant Causeway.*

Option #3A Floodgate Plan & Walls: This plan requires construction of the Saugus River Floodgates, walls & dikes along Lynn Harbor, sand dune/beach systems along the Point of Pines and Revere Beach shoreline, and purchase and protection of the 1,650-acre Estuary for flood water storage when gates are closed. When built, gate closures would approach 3 times per month which is likely more than the acceptable impacts on the Estuary, navigation or operation and maintenance of the Floodgates. Therefore, walls would be required around the 25 miles of Estuary to reduce the number of closures which could be accomplished in several phases. If it is acceptable to later raise walls rather than build them at full height, the foundation of walls would be

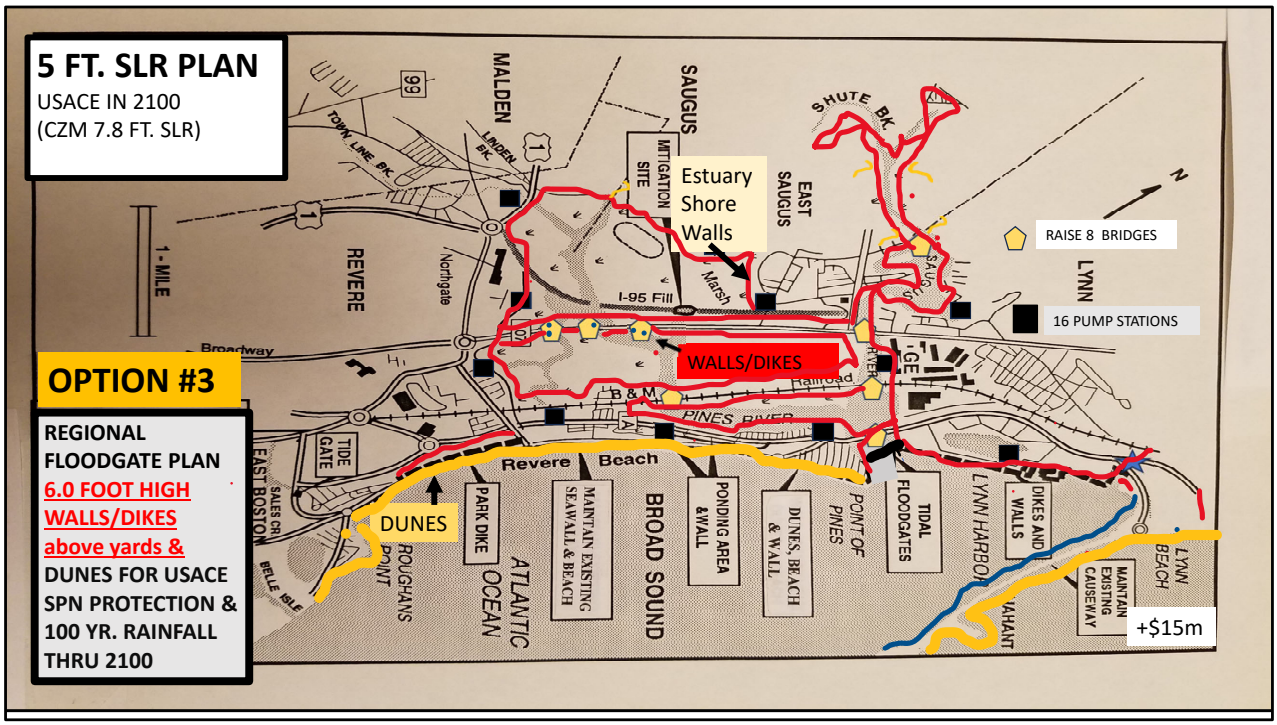
built to accommodate raising or capping later.

Preliminary OPTION #3B– FLOODGATE PLAN & DELAY WALLS

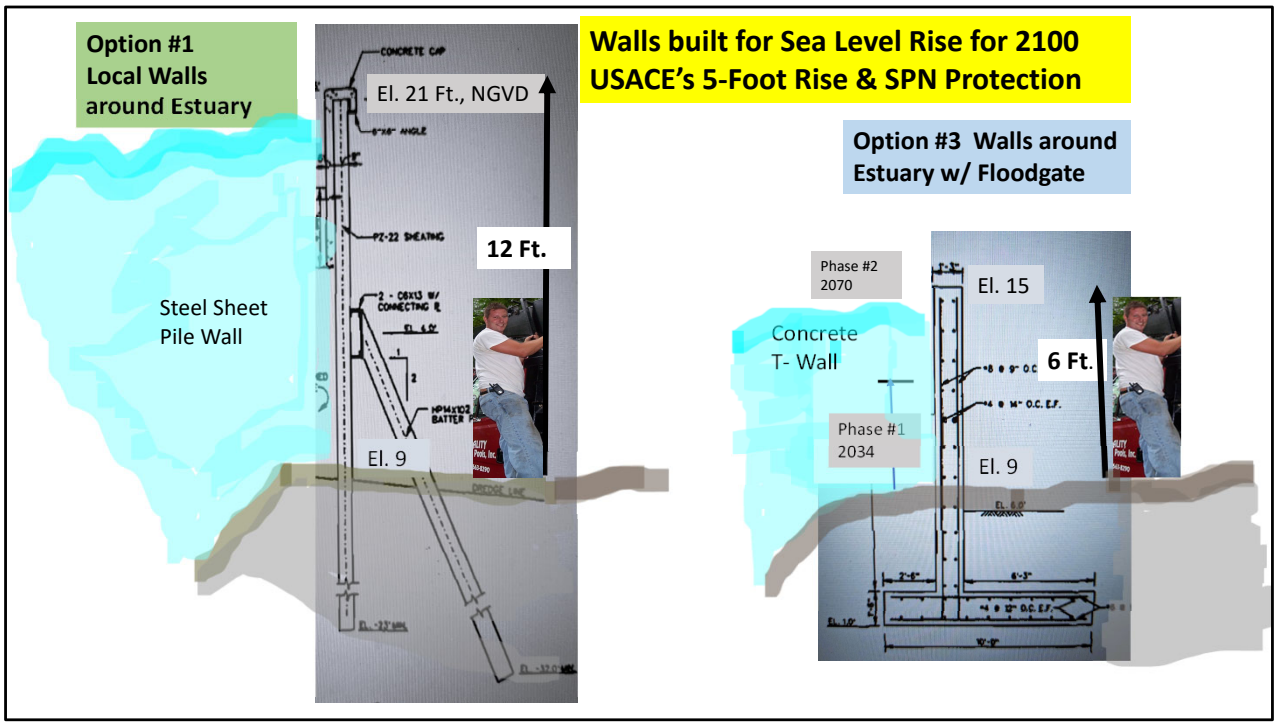
1. ***D****elay raising estuary shorefront until 2050, closures reach 10 times a month.*
2. *Phase #1 in 2034, Floodgates & shorefront structures raised 2-feet.*
3. *Remove 1/3rd of sand from the I-95 embankment.*
4. *Restore 1/3rd of 41 acres of wetlands and flushing to 500 acres.*
5. *Build 1/3rd of sand dunes & beach along Revere Beach and Point of Pines.*
6. *Purchase & protect the 1,650-acre estuary.*
7. *Maintain Nahant Causeway.*
8. *Phase #2 in 2050: Raise Floodgate, Lynn Harbor & Revere's features 3-feet.*
9. *Remove remaining sand from I-95 embankment & restore wetlands.*
10. *Build 25 miles of walls & dikes to 6 feet above average yard and road levels.*
11. *Raise Rt. 107 & RR & 8 bridges.*
12. *Build 16 pumping stations; and maintain the Nahant Causeway.*

Option #3B: Not likely acceptable w/ 10 closures/ month @ 4-hours each due to impacts on navigation & Estuary.

Option 3B Floodgate Plan & Delay Walls: This plan is similar to Option 3A however the construction of walls around the Estuary is delayed until about 2050 when closures approach 10 times per month for about 4 hours each closure. This could reduce the initial investment in a project by about 50% while more information determines the exact rate of sea level rise. The impact may be too unacceptable with the anticipated closures.



Option 3 Plan: the plan's map is similar to Option #1 except Floodgates are located at the mouth of the Saugus River, and walls around the Estuary are lower.



Walls Built for Sea Level Rise: The graphic shows a comparison of wall heights between Options #1 versus Option #3. For Option #1, the 10-foot head or force of water requires a heavily reinforced 12-foot wall to sustain the pressure, more so than the 4 foot head of water against the 6-foot wall with the Floodgates. The lower wall is very likely to be much more acceptable for the residents, especially if built in two phases of 2.5 feet in 2034, then capped in 2070 for 3-feet for a total of 6 -feet.

POTENTIAL LOCATION FOR TIDAL FLOODGATES

FLOODGATES REDUCE HEIGHT TO RAISE
25 MILES OF SHOREFRONT FROM 12 FEET HIGH TO 6 FT. BY 2100 &
PROVIDE AN IMPROVED HARBOR OF REFUGE FOR 400 AREA VESSELS.

Floodgate Alignment: The alignment of the Saugus River Floodgate at the mouth of the Saugus River underwent both physical and numerical modeling at this location and final design including extensive subsurface borings and surveys. The alignment may need to move 200 feet east to avoid the planned installation of the MWRA 20-inch pipeline.

Photo of Floodgate Alignment: Viewing the Floodgate alignment from the oceanside with Revere on the left and Lynn on the right.

MAJOR FLOODGATE DESIGN CRITERIA

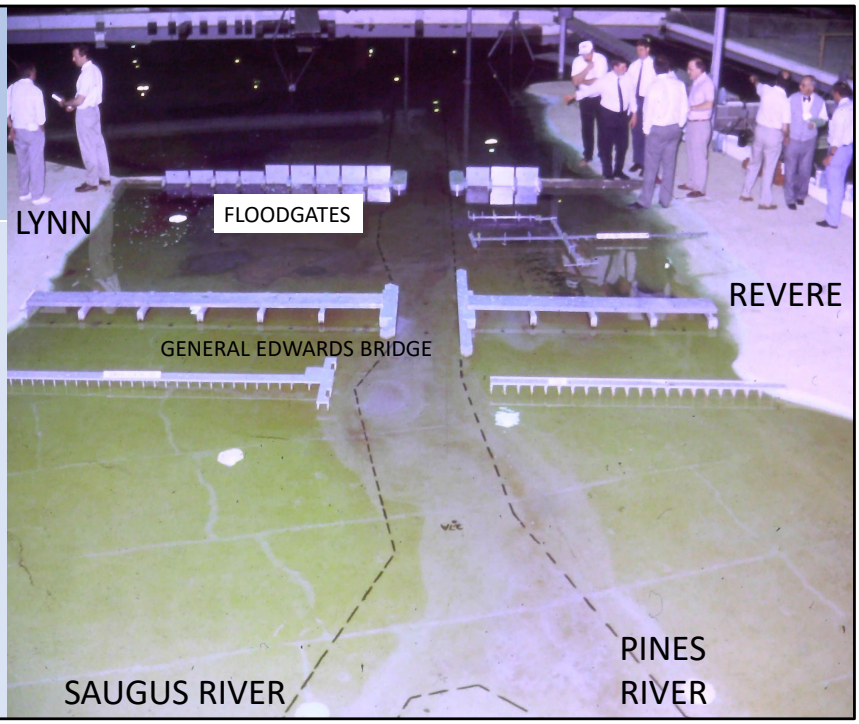
1. DESIGN FOR SPN STORM TIDE + SEA LEVEL RISE
2. SAFE PASSAGE FOR NAVIGATION AND
3. PROVIDE FOR NO IMPACT ON TIDE LEVELS AND FLUSHING IN THE 1650 ACRE SALT-WATER ESTUARY

Floodgate Design Criteria: These three design criteria were used to design the Floodgates.

FLOODGATE PHYSICAL MODEL

BEING VIEWED BY MEMBERS OF CITIZEN STEERING COMMITTEES AND TECHNICAL GROUP

NUMERICAL MODEL ALSO BUILT BY CORPS OF ENGINEERS' WATERWAYS EXPERIMENT STATION IN VICKSBURG , MS



Floodgate Physical Model: The physical model was constructed at the Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi. Members of the steering committees visited the model and operated a lobster boat and a GE oil tanker through the gates.

AVERAGE ANNUAL PROJECT BENEFITS

BENEFIT	SAMPLE	2019 Price Level
Flood Damage Reduction	**64%**	$18,370,000 (60% of Buildings)
1 Ft. Sea Level Rise	**9%**	2,940,000 **60% "**
Damage to Shorefront Structures		2,510,000
Reduced Damage to Piers		1,810,000
Reduced Damage to Town Line Bk Project		200,000
Emergency Costs		420,000
Future Development		370,000
Affluence		630,000
Flood Insurance Overhead		150,000
Recreation Benefits		1,080,000
Total Average Annual Benefits		$28,480,000 (Say $28,500,000)

"1-Ft. Sea Level Rise" Benefit reflects damages at historical rate of rise, 1 Ft. in 100 years, Benefits will escalate with accelerated rise.

Project Benefits: This is a sample of the type of benefits assigned to the Regional Floodgate Project. Note that only benefits for a 1-foot rise in sea level over 100-years was allowed at the time. Now with plans designed for accelerated sea level rise, benefits will escalate for sea level rise.

Sec. of Envir. Affairs Certificate MAJOR ISSUES

#1 Marsh at El. 6 should be submerged when Floodgates are closed at El. 7 thus minimizing wetland impacts.

#2 Sand source for estuary should not change by assuring no significant change in Estuary flushing.

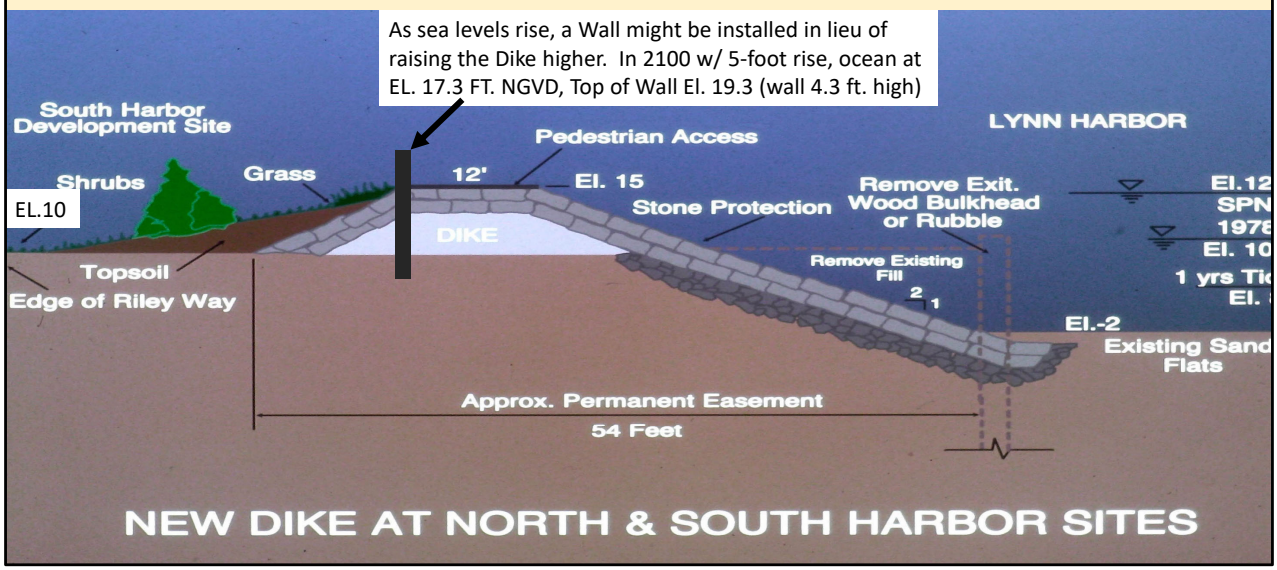
#3 Structures should be designed to accommodate up to 4 ft. rise in sea level.

#4 Flooding events in this Estuary are difficult to predict in time to allow orderly evacuation (now about 30,000 to 50,000 people).

#5 Land acquisition of the Estuary must be included with a Regional Floodgate Plan.

Environmental Affairs Certificate: These five items were major concerns of resource agencies and private interest groups. All five concerns were satisfied with the project.

LYNN HARBOR SHOREFRONT DIKE TO REPLACE BULKHEAD

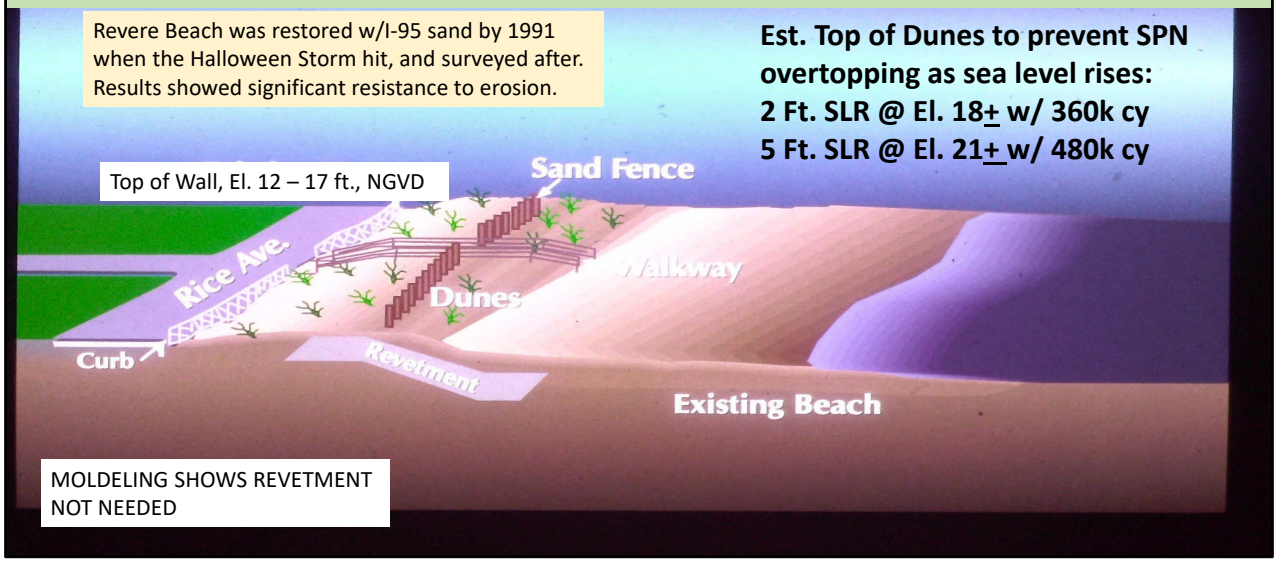


Lynn Harbor Dike: The original alignment of the dike was oceanside of the bulkhead but moved inland following objections by state wetland agencies. As sea levels rise either the dike could be raised about 5-feet, or a wall could be built above it about 4-feet high to meet SPN protection in 2100.

Point of Pines: The shorefront of Point of Pines was originally designed for armor stone revetments. However beach surveys on the effectiveness of the I-95 embankment sand at Revere Beach following the 1991 Halloween storm proved the sand was very resistant to erosion. Further modeling of the revetment proved ineffective against severe storms such as the 1978 and SPN storms. Evaluation of sand dunes and beach combinations proved very effective against even the worst storms and is recommended to be further evaluated in lieu of revetments.

Point of Pines Sand Dune Restoration, 3,150 Feet:

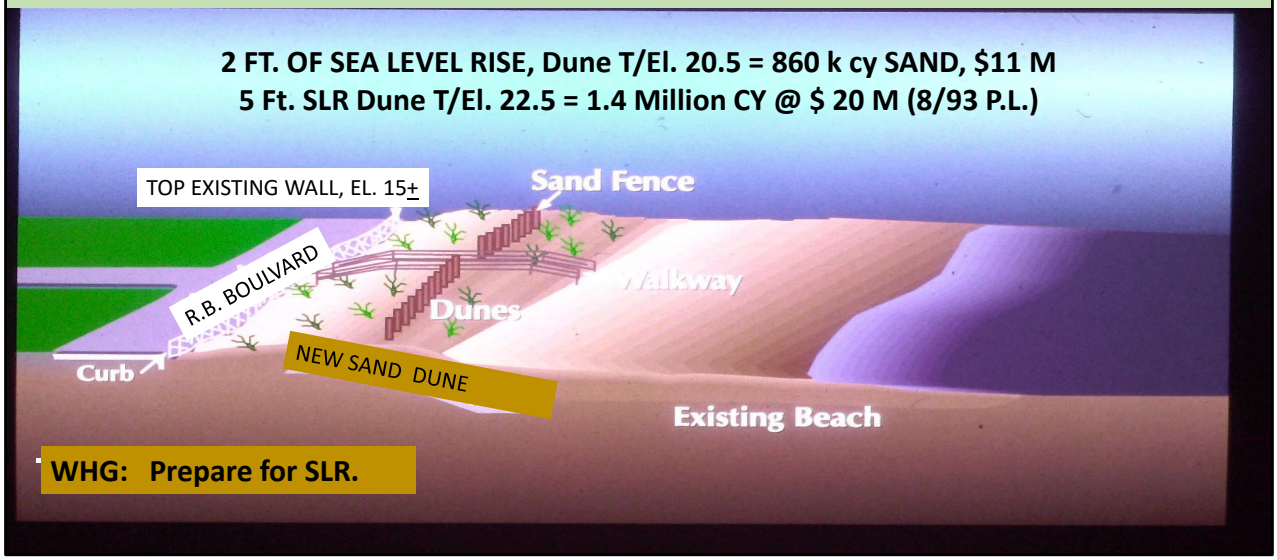
Physical Model & Surveys showed Dunes very effective for SPN



Point of Pines Sand Dune: The potential sand dunes and beach at Point of Pines would not require a revetment at the north end of the shoreline where sand dunes exist based on model studies. The potential height of dunes along the shorefront to provide SPN protection through 2100 would be about 3 to 6-feet above existing seawalls.

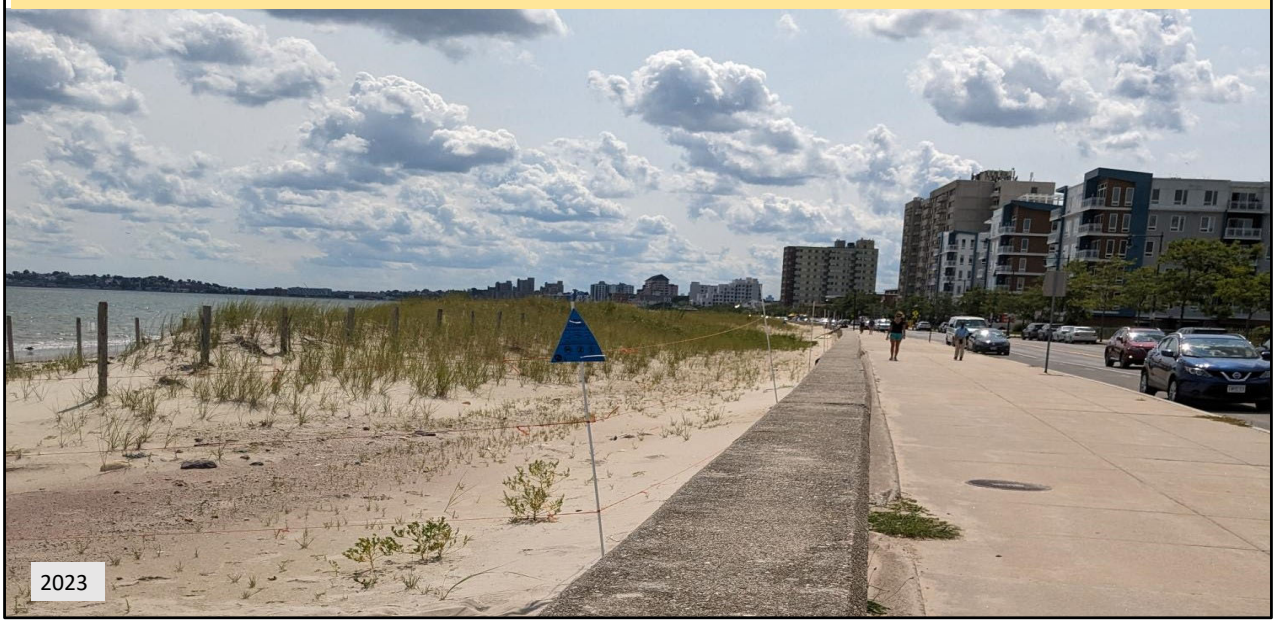
Revere Beach Park Dike: The original plan to prevent flooding behind the vulnerable area of Revere Beach near the former MDC police Station required raised parkland which would stop overtopping water and return it over the seawall. However, model studies confirmed the effectiveness of a dune/beach system to prevent overtopping, and the parkland may not be needed for sea level rise plans.

Revere Beach Sand Dunes, 13,000 Feet: Est. to Protect against SPN in 2100 @ 5 Ft. SLR

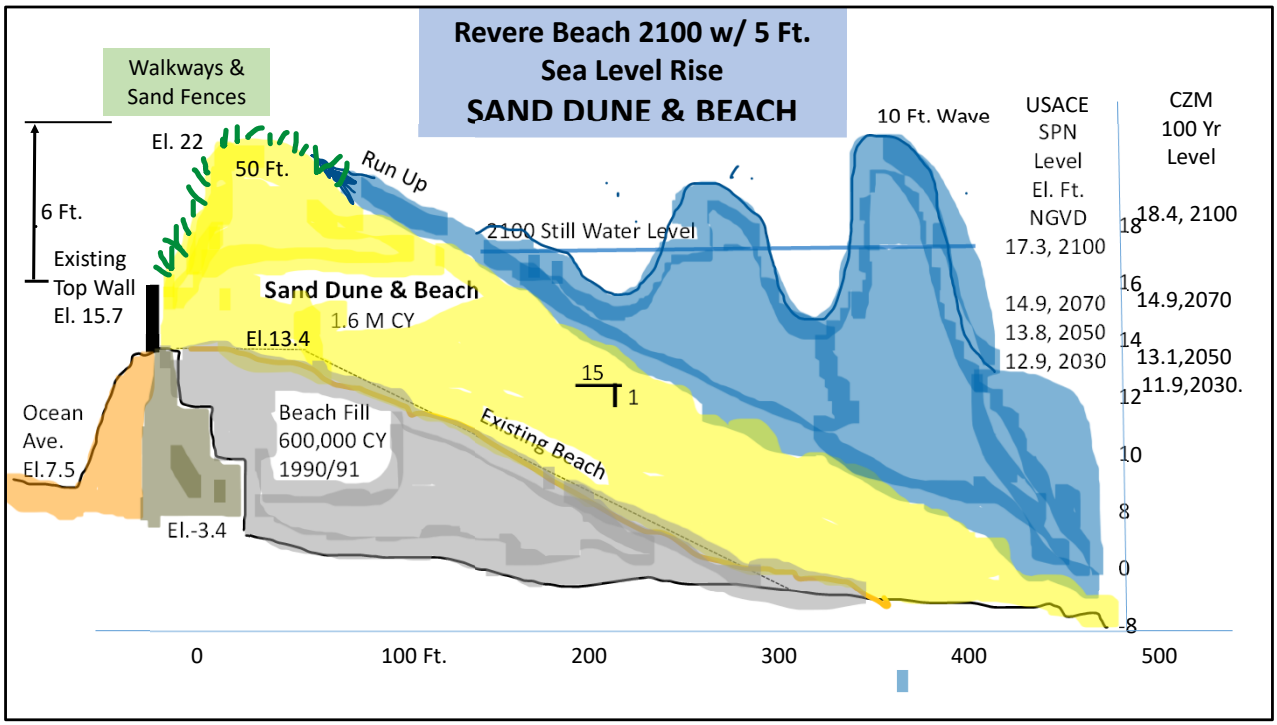


Revere Beach Sand Dunes: Sand dunes along Revere Beach would need to be about 6-feet above existing walls to provide SPN protection against 5-feet of sea level rise by 2100,

REVERE BEACH SAND DUNES
Bird Nesting Habitat



Existing Revere Beach Sand Dunes: For the past few years sand dunes were established at the north end of Revere Beach which provides bird nesting habitat.

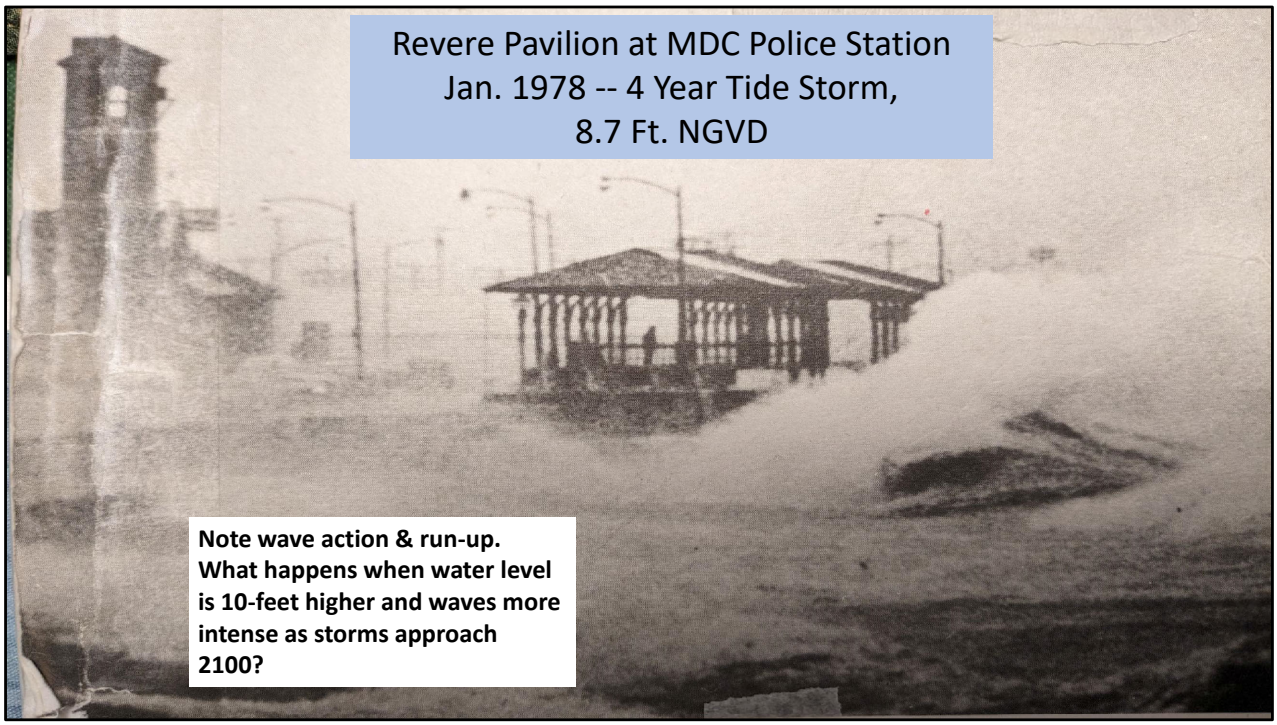


Revere Beach Sand Dune & Beach: This diagram of Revere Beach cross-section shows the height and depth of a sand dune/beach system at Revere Beach. Note the beach material would extend about 500 feet out into the ocean to start breaking waves before reaching and running up the sand dunes!

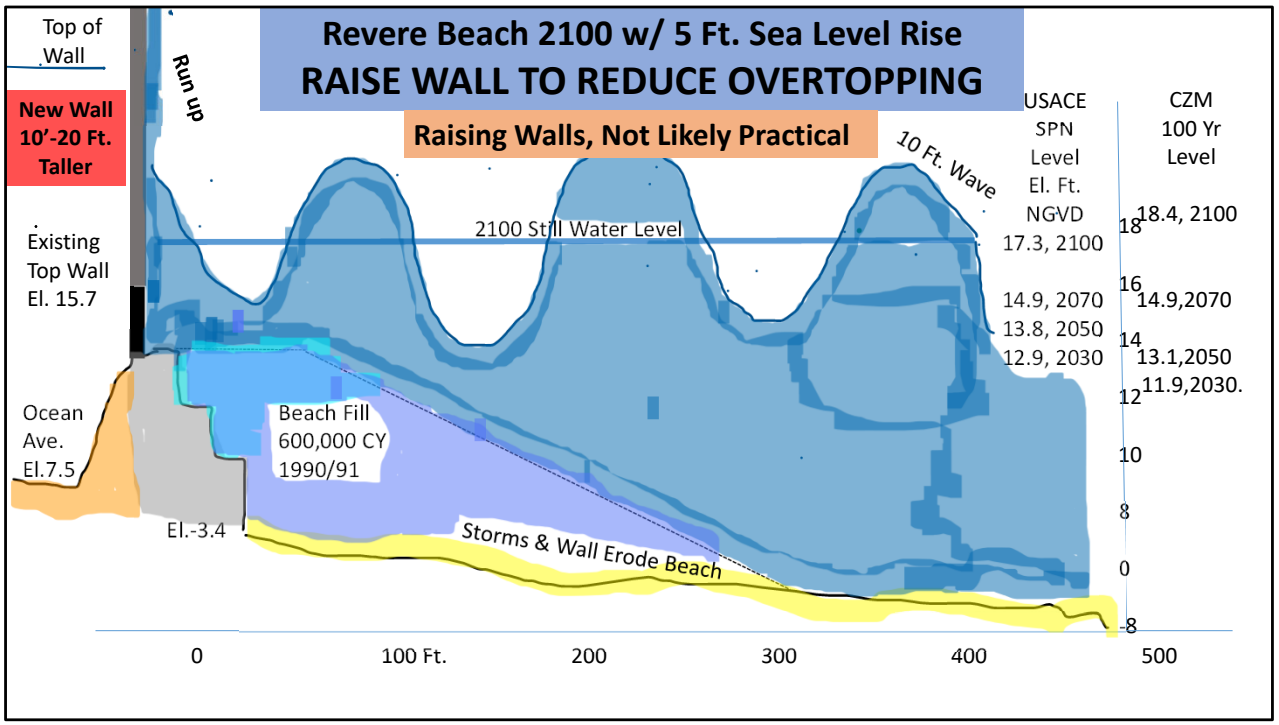
ESTUARY STORAGE PROTECTION PROGRAM

1,650 SALT WATER ESTUARY:
Purchase in Fee
Full Time Manager
Regulatory / Enforcement
Education

Estuary Storage Protection Program: While the Floodgates are closed, the Estuary needs to provide storage for interior runoff. The original project was required to have and was authorized to protect the Estuary with acquisition in fee and a full-time manager to oversee enforcement and education.



Revere Pavilion: This photo of a 4-year frequency storm one month before the Great Blizzard of 1978 at the Revere Pavilion shows the power of waves hitting the wall fronting the pavilion. It is provided to help visualize what could happen if water levels are about 10-feet higher and waves 2 to 3 times that size pounding the Pavilion.



Raise Wall at Revere Beach: This diagram is intended to show the height of water run-up and power of 9- to 10-foot-high waves hitting the pavilion walls. The likely run-up which could reach 10 to 20 feet higher than existing walls reinforces the recommendation to provide the dune/beach system to provide protection against 5-feet of sea level rise and SPN protection in 2100. Such a wall height of 15 to 25 feet to prevent overtopping is likely unpractical.

Preliminary OPTION #3, Saugus River Floodgate Plans

ESTIMATED COSTS: 2023 P.L. for 5 Ft. Sea Level Rise, SPN Protection

	PHASE # 1 CONSTRUCTION o/a 2034	**Options: 3A**	**3B**
1.	Floodgates, Lynn Harbor, Pt. of Pines & Estuary, GDR 6/93 $102.6 M x 2.45 =	$ 250 M	$250 M
2.	Raise Floodgates, Lynn Harbor & Pt. of Pines shore 2 Feet @ $2.6 M/Ft. =	5 M	5 M
3.	Estuary Walls & Dikes, 12 Miles, Built 2.5 Ft. high, 2/3 cost @ $1,395/LF =	60 M	0
4.	Revere Beach Dunes/Beach, 13,000 LF @60% 860k cy from I-95,restore wetlands =	11 M	9 M
5.	Pump Stations, 5 Ea. @ $ 2M =	10 M	0
6.	Stabilize Nahant Causeway, T-Wall or Dunes, 1.5 miles @ $1,900/LF, 2/3 of cost =	10 M	5 M
7.	TOTAL PHASE #1 =	$ 346 M	$ 269 M

PHASE # 2 CONSTRUCTION o/a 2070 for Option 3A ; o/a 2050 for Option 3B

1.	Raise Floodgate, Lynn Harbor, & Pt. of Pines shore, 3 Feet @ $ 2.6 M/Ft. =	$ 8 M	$ 8 M
2.	Raise Phase #1 Walls & Dikes 3.5 Ft, 12 Miles @ remaining 1/3 cost, $1,395/LF =	29 M	89 M
3.	Upper Saugus River & Shute Bk, Walls & Dikes, 5 Miles, @ 890/LF =	24 M	24 M
4.	Estuary RR., Rt 107, Other higher ground, 8 Miles, $1,000/LF, about 4 ft. high above yards/rd =	42 M	42 M
5.	Revere Beach Dunes/Beach place remaining 40% of I-95 cy @ 13,000 LF, restore wetlands =	9 M	11 M
6.	Pump Stations, 11/16 Ea. @ $2M =	22 M	32 M
7.	Nahant Causeway , 1.5 Miles at 1/3 remaining cost, $1,900 /LF =	5 M	10 M
8.	TOTAL PHASE # 2 =	S 139 M	$ 216 M

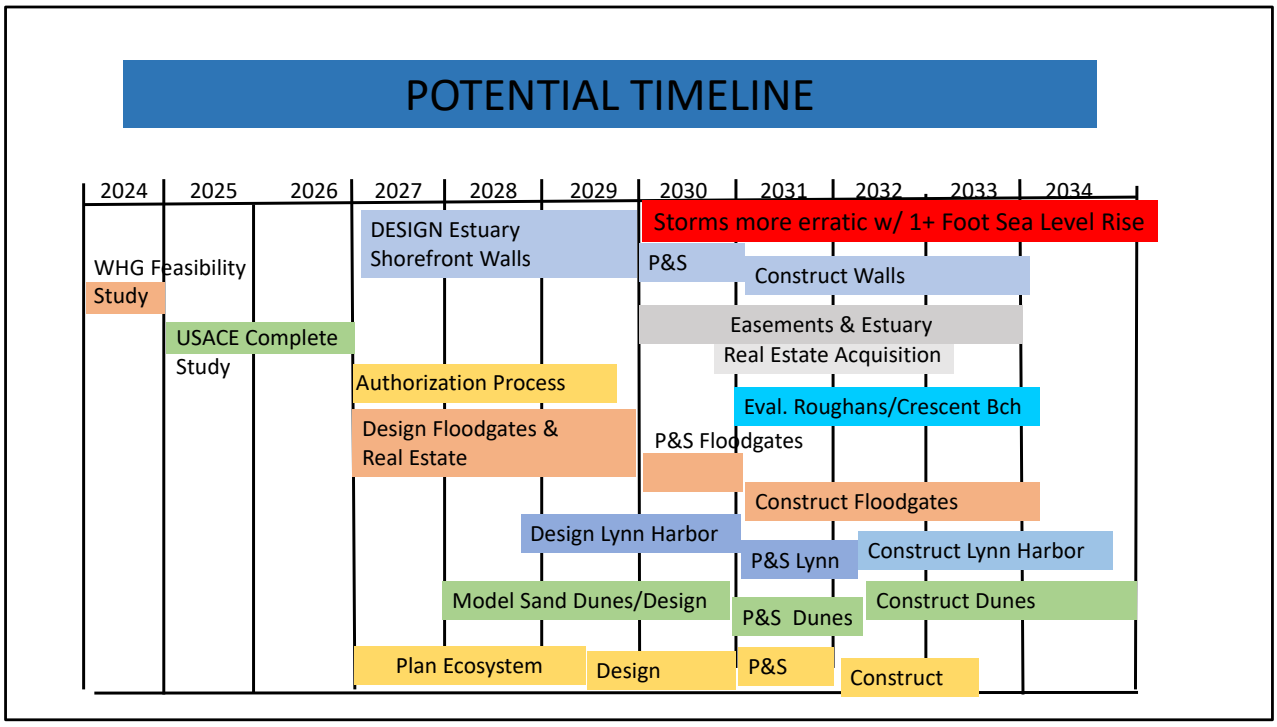
TOTAL OPTIONS #3A & 3B, PHASE #1 & #2 FIRST COST = $ 485 MILLION

Option #3 Estimated Costs: This table summarizes the estimated cost for the Option #3 alternatives. Although very preliminary, the order of magnitude for these costs reveals the investment which may be required to protect the region. The first major cost for the Floodgates, Lynn and Point of Pines features was developed in the General Design Report, and the costs are updated to 2023 prices. Most other costs were based on similar features in the GDR report or planning reports and updated to ’23 prices.

MARSH IMPACTED BY I-95 EMBANKMENT

Marsh Impacted: The Estuary photo reflects damage to the Estuary from the I-95 embankment cutting off the natural flow of salt water. If the embankment is removed for use of the sand, flushing would be restored to the upper 500-acres of the Estuary and improve the wetlands.

I-95 Fill: There is an estimated 1-million cubic yards of fill available to be screened for sand above the marsh surface. In addition, about 9-feet below the base of fill is about 6oo thousand CY of potential sand but with environmental issues which would need to be resolved. Other areas of the fill are also potential sources of sand.



Potential Timeline: The schedule assumes the maximum length of time which the USACE may need for the Feasibility Study. The design and construction schedules are based on a detailed schedule previously developed for specific features of the project.

Preliminary PLAN COMPARISON WITH 5 FT. OF SLR

Options 1 & 3 Protect to SPN & 5 Feet of SLR for Over 6,000 Buildings

PRELIMINARY ESTIMATE	OPTION 1 Local Walls	Option 2 Raise Buildings	Op.3A Reg. Floodgate Plan Walls: 2034	Op. 3B 2050
'34 Lynn Harbor & Revere Shorefront	Yes	No	Yes + Floodgate	
'34 Estuary Wall Height above El. 9,Ph#1	9 Ft.	12 Ft.	2.5 Ft.	0
'70 Estuary Wall Raised/ **Total**, Ph.#2	3/ **12 Ft**.	ALL	3.5/ **6 Ft**.	6 Ft. '50
'34 Aprox. Length of Wall/Dike, Ph.#1	25 Miles	ROADS	12 Miles	0
'70 Length Raised to full Height,Ph. #2	25 Miles	SUBMERGED	25 Miles	25 Mi. '50
'34 Build Pumps Sta./Raise Bridges,Ph#1	11/8	n/a	5/0	0/0
'70 Build Pump/ Raise Bridges, Ph.#2	0	n/a	11/8	16/8
Wetlands Lost/ I-95 Gain + 500 (Ac)	90/41	----	70/41	70/41
Loss of Views, Height of Walls,Ph #1/2	High 9/12 Ft.	Yes	Low: 3.5/6 Ft.	0/6Ft.
'34 First Cost, excl bridges, Ph #1	$ 390 M	---	$ 346 M	$269 M
'70 First Cost, excl bridges, Ph #2	$ 190 M	Buildings Only	$ 139 M	$ 216 M
Total First Cost 2023 P.L.	**$ 580 M**	**$ 540 M+**	**$ 485 M**	**$ 485M**

Plan Comparison: The Plan Comparison table summarizes a few of the pertinent features of each option. Option #3 is about $100 million less than other options, however, costs are very preliminary.

ECOSYSTEM RESTORATION

Restore Tidal Flushing to 500 acres /Remove I-95 Fill
Restore up to 156 acres in restrictive channels.
Remove up to 67 acres of fill to restore wetlands.
Use I-95 sand for sand dunes & beach restoration.

Ecosystem Restoration: The Boston North Shore Feasibility Study was authorized to investigate areas where ecosystems might be restored. There are over 200 potential acres impacted by restricted channels or land fill around the Estuary which could be investigated.

CRESCENT BEACH/ GARFIELD SCHOOL AREA
Plan Protects to El. 10.3 Ft., NGVD
Evaluate for Sea Level Rise

Crescent Beach: The initial authorized project could only provide protection to this Crescent Beach/Garfield School area at the south end of Revere Beach, outside of the Saugus River watershed, to the 100-year level of protection. Now with accelerated sea level rise it should be investigated for higher protection.

ROUGHANS POINT Coastal Flood Protection Project, 1987
USACE Built Armour Stone Revetment, 500 Year Protection to El. 11.2 Ft. NGVD

Evaluate for Sea Level Rise

Roughans Point: This previously constructed flood control project by the USACE protected to a 500-year storm level. Now with accelerated sea level rise it should be investigated for higher protection.

ACTION NEEDED

- **State/communities fund Engineering firm ASAP to develop information for Feasibility Study with technical assistance from Corps of Engineers.**
- **Encourage Delegation to obtain Federal funds for authorized study with 50% State cost share.**
- **Max. $3M Funds needed for max. 3-year Feasibility Study.**
- **Justified project proceeds directly to design.**

Current Status: The Boston North Shore Feasibility Study has yet to be funded and the region is fast running out of time before flooding intensifies. The Commonwealth should consider funding the first year or two of the study with technical assistance from the Corps of Engineers. Details of the project and all planning and design documents are included on the project's web site including photographs of the area, correspondence, and history.

CURRENT STATUS

- **Dec '22 Pres. Biden authorized study.**
- **Max. $3M Funds needed & State (50%).**
- **Accomplish feasibility study.**
- **Justified project proceeds directly to design.**
- **See "saugusriverfloodgates.com"**
- **Project Manager would modify slide presentation for any town, agency or legislator.**