

U.S. Army Corps
of Engineers
Wilmington District

Model Development Case: Bogue Banks

Mike Wutkowski
Wilmington District



U.S. Army Corps
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Morehead City Harbor 933

Morehead City Harbor Ocean Bar

Ft. Macon

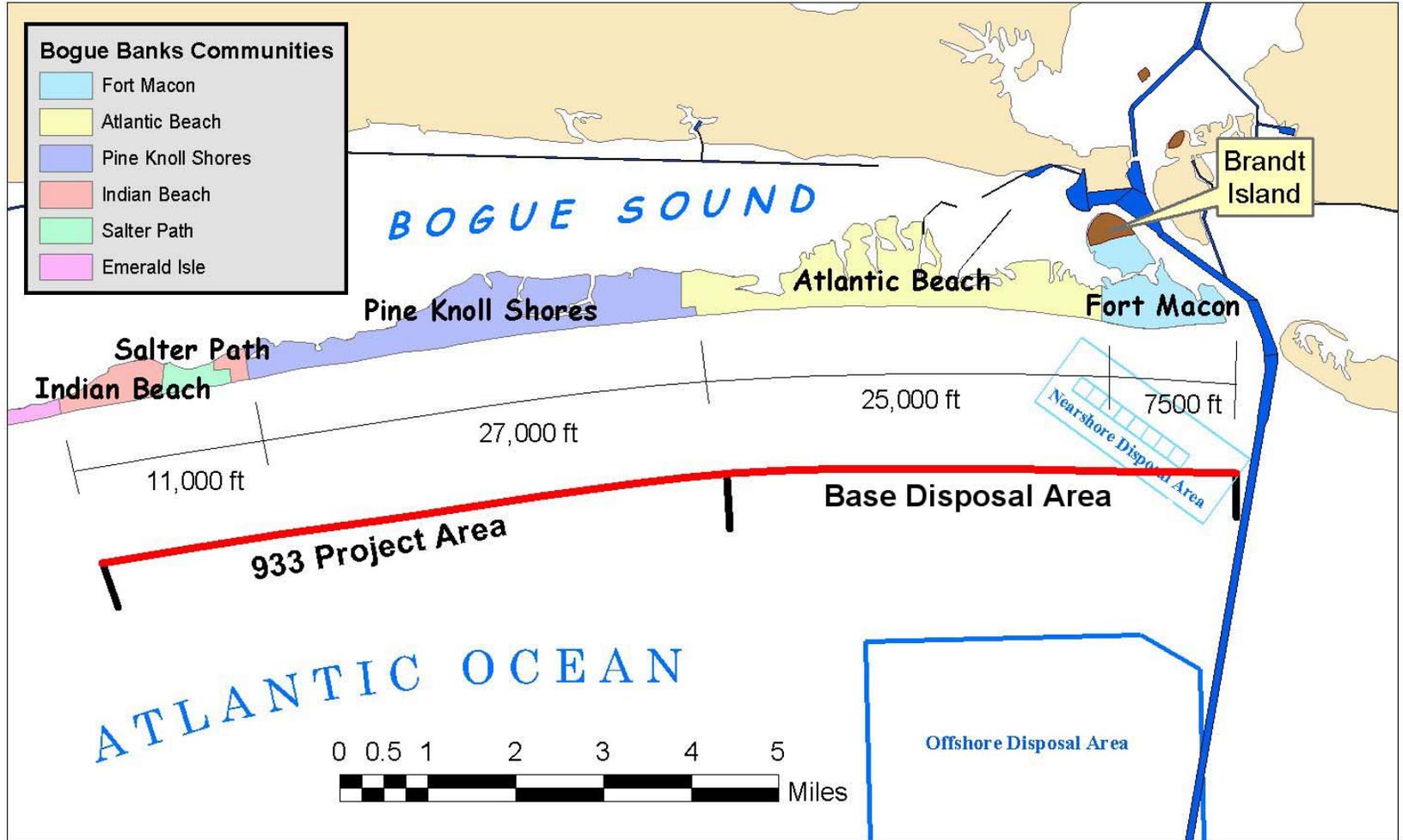
1.5 Million Cubic Yards

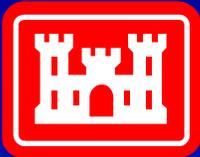
Brandt Island

4.8 Million Cubic Yards

Inner Harbor





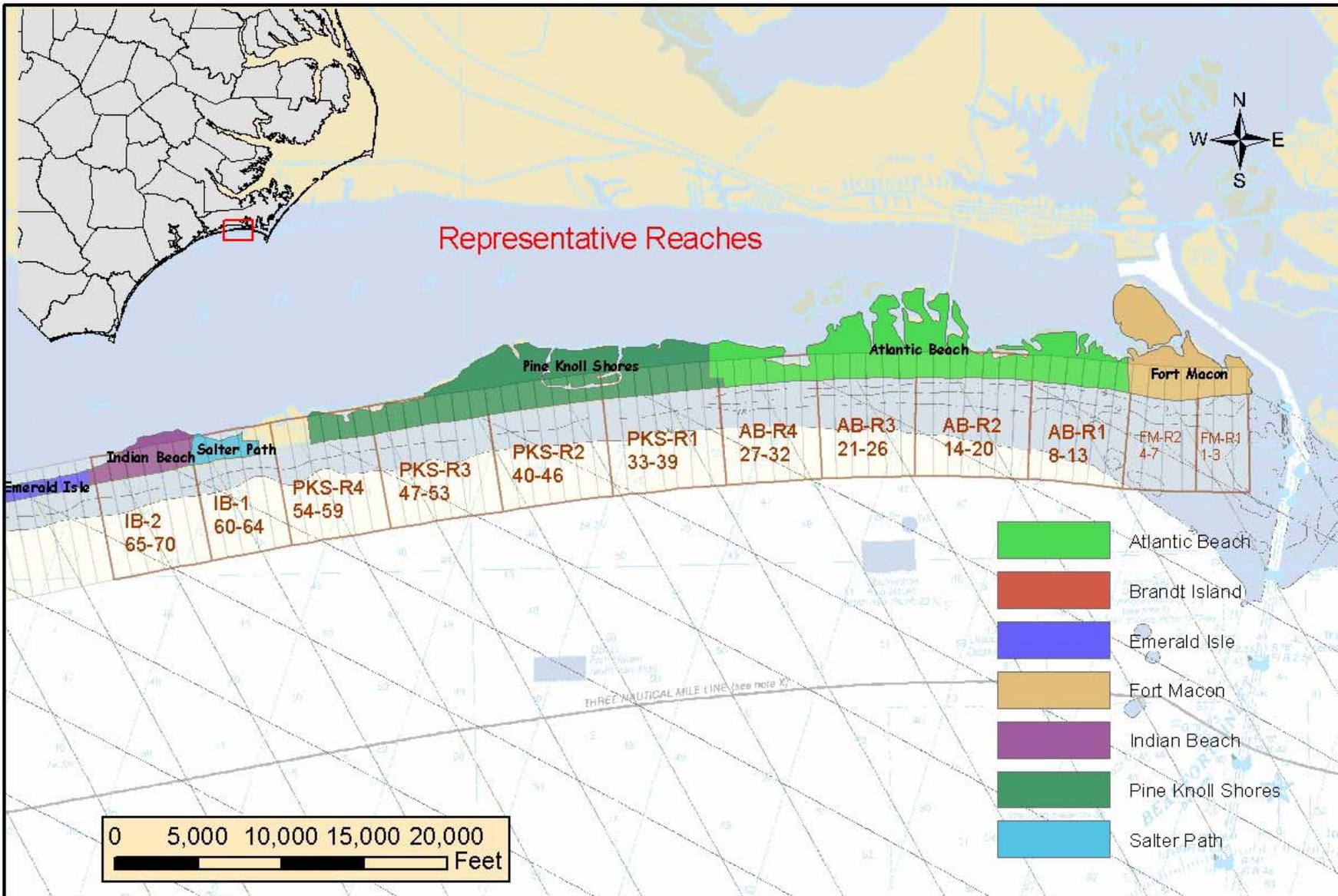


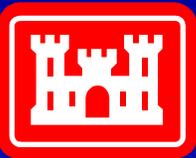
U.S. Army Corps
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DATA

WHAT'S OUT THERE?

Morehead City Section 933 Alternatives

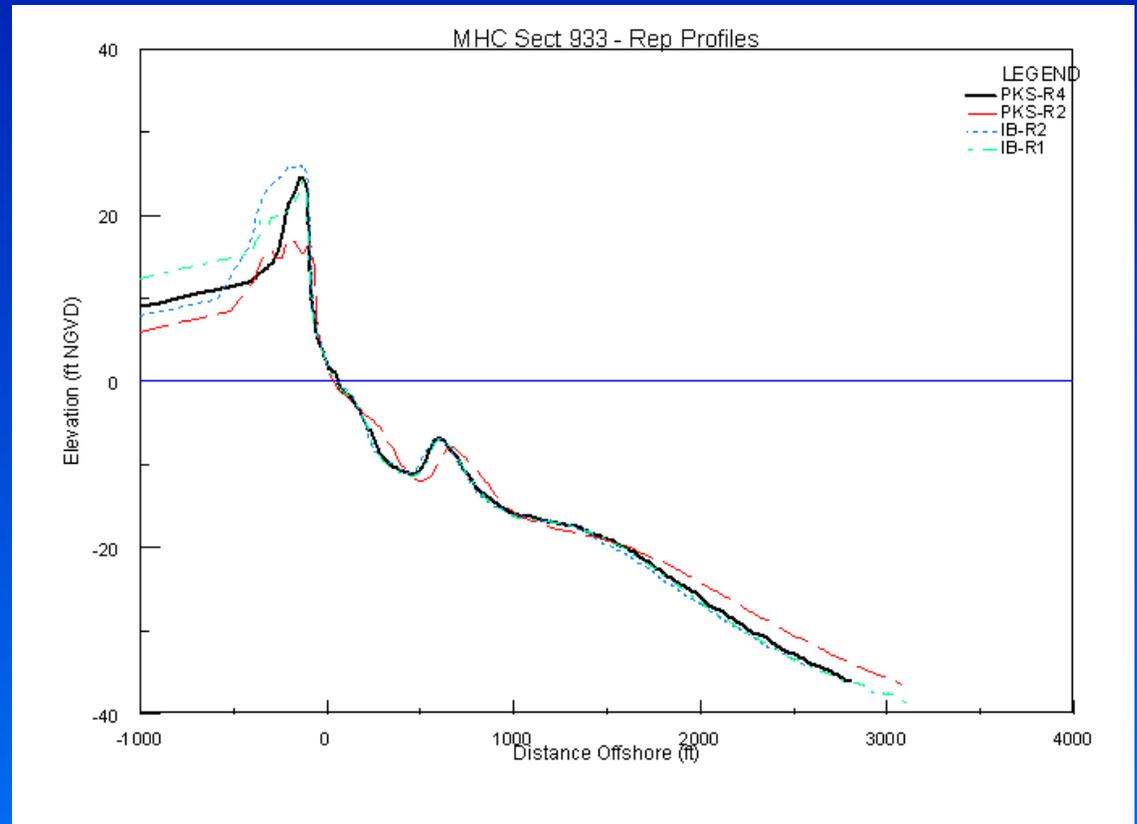


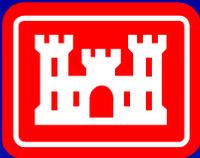


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Representative Beach Profiles

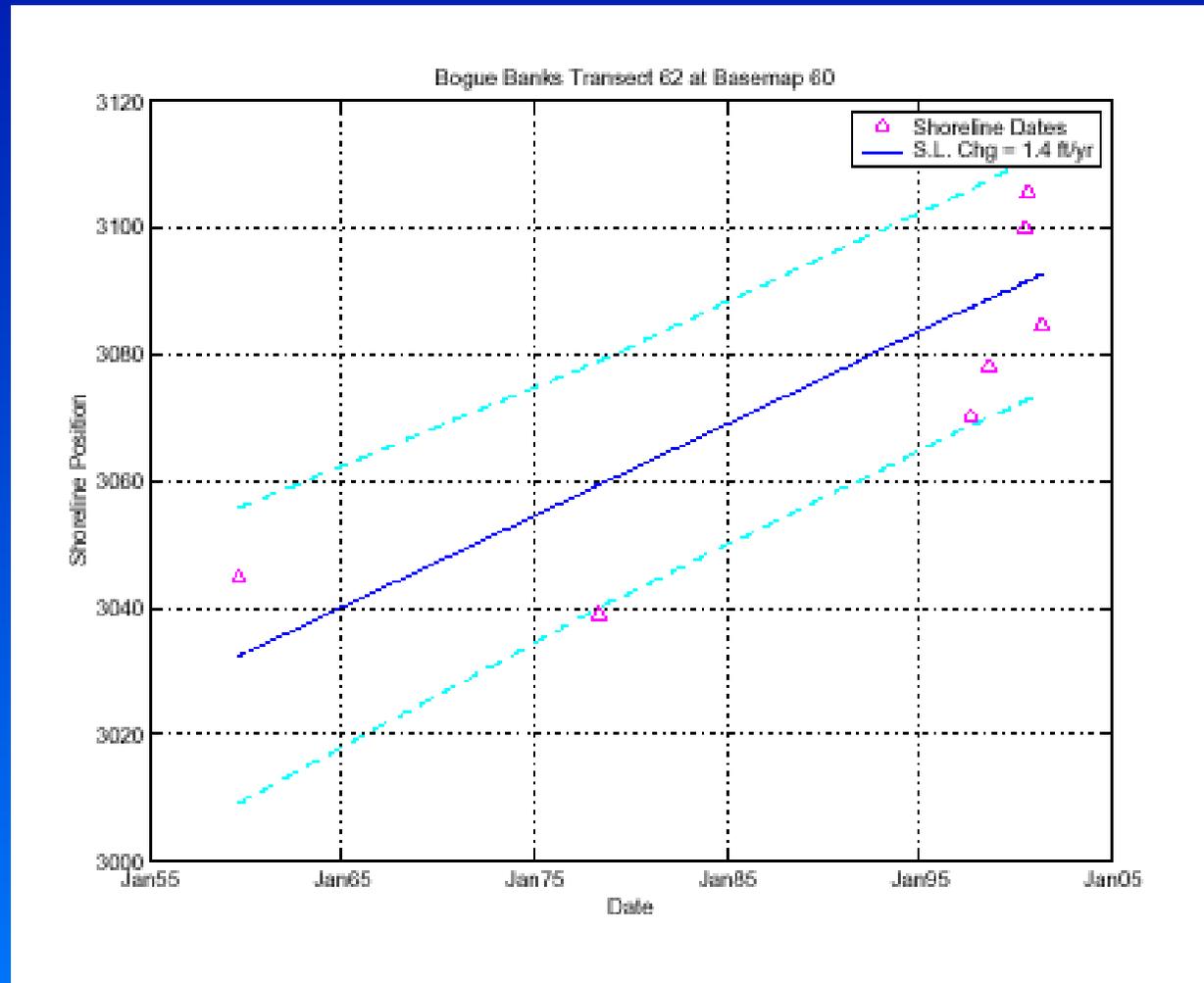
- 12 Profiles
- Consistent Bar
- Variable Dune Elevation and Volume





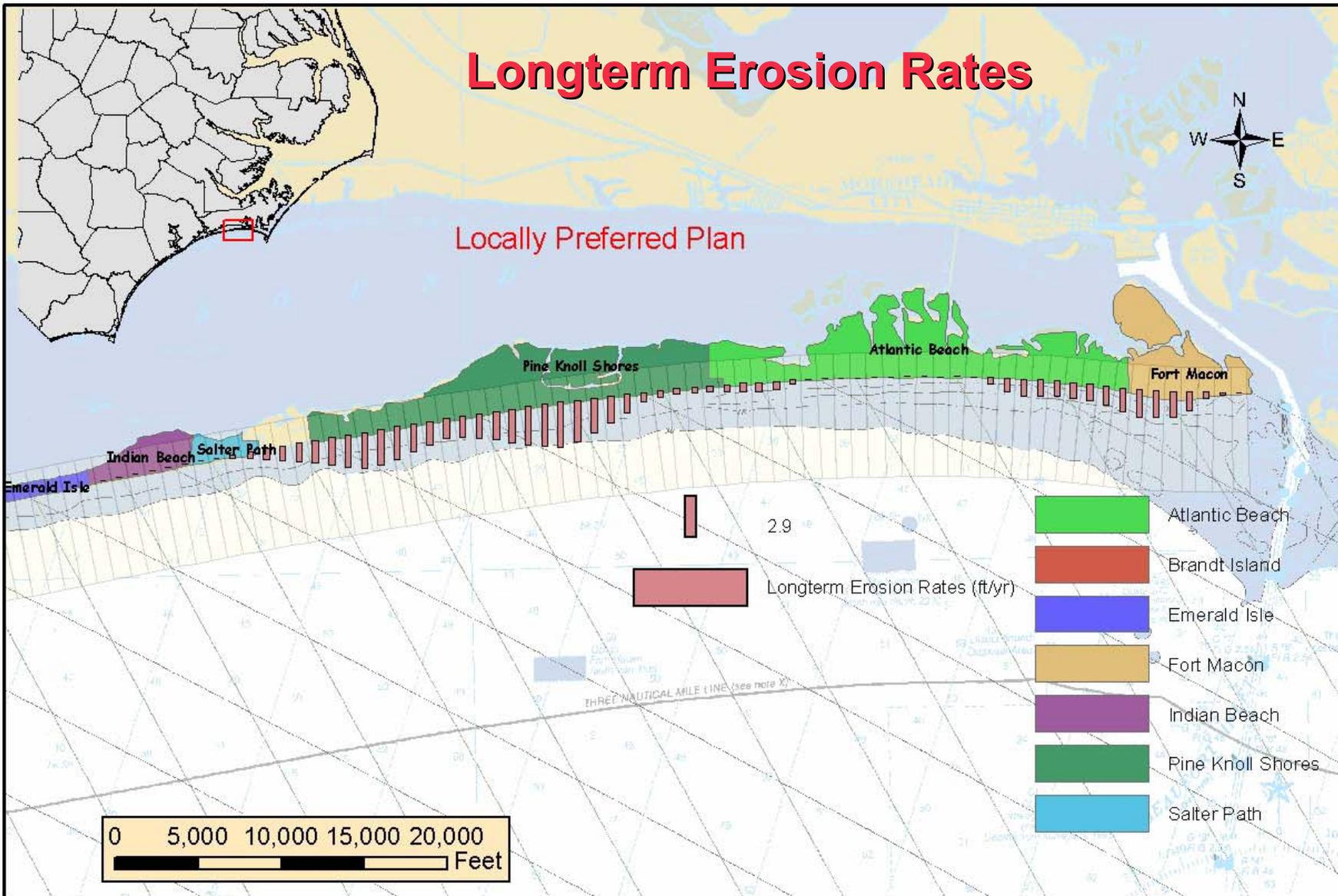
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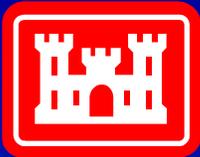
Longterm Erosion Rates



Longterm Erosion Rates

Locally Preferred Plan

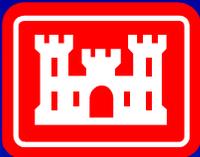




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DATA

WHAT'S DRIVES THE ANALYSIS?



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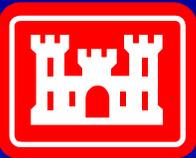
Storm Events

Water Levels

- Tropicals
 - Norm's Dbase (ADCIRC)
 - Updated 90's Storms
 - 37 Storms over 106 yrs
- Extratrops
 - Norms's Dbase (1976-1993)

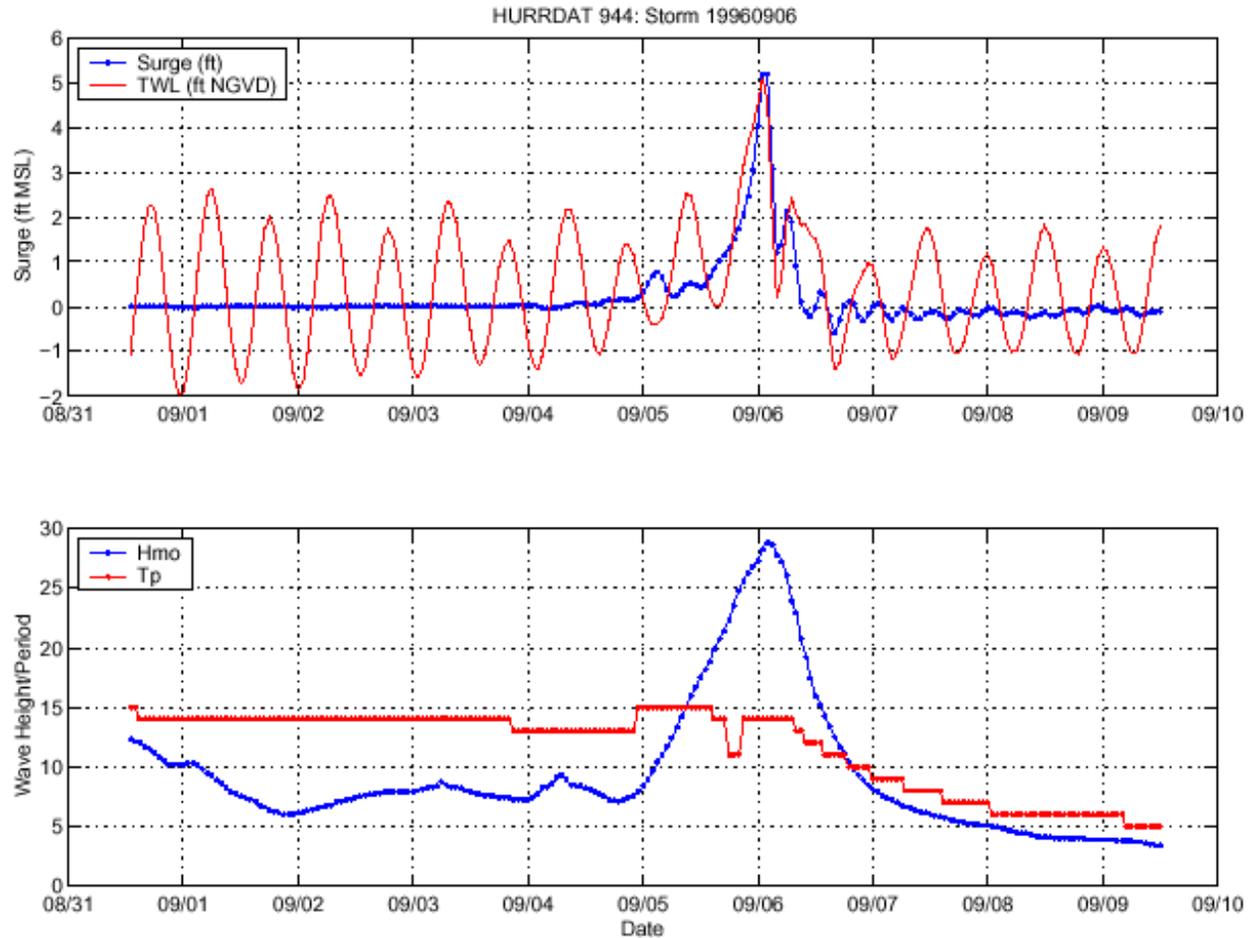
Waves

- Tropicals
 - Recent WIS (1990's)
 - WIS (1975-1995)
 - Emperical Hindcast Model for pre-1975
- Extratrops
 - Recent WIS (1990's)
 - WIS (1975-1995)



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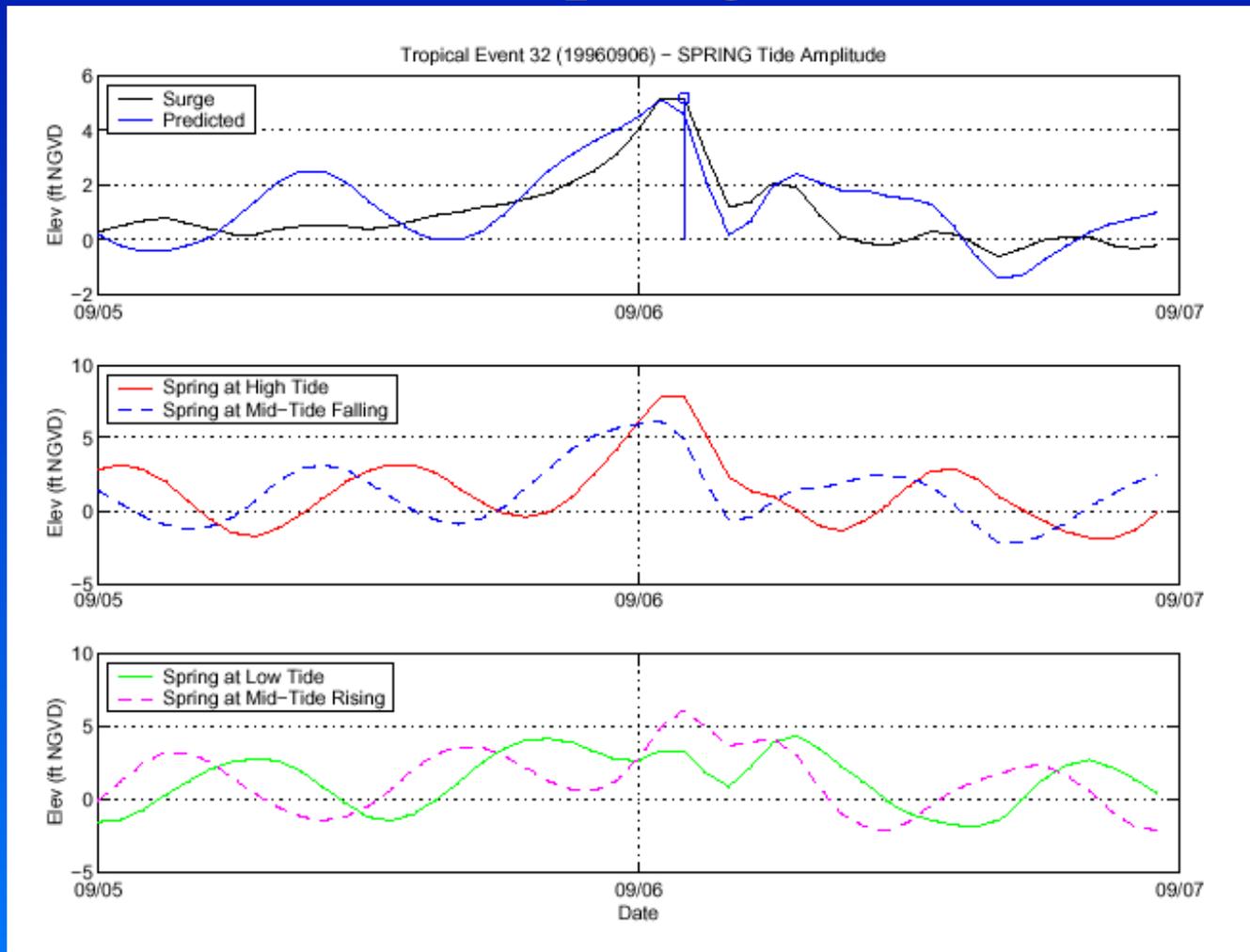
Storm Time Series





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Water Level Permutations Spring

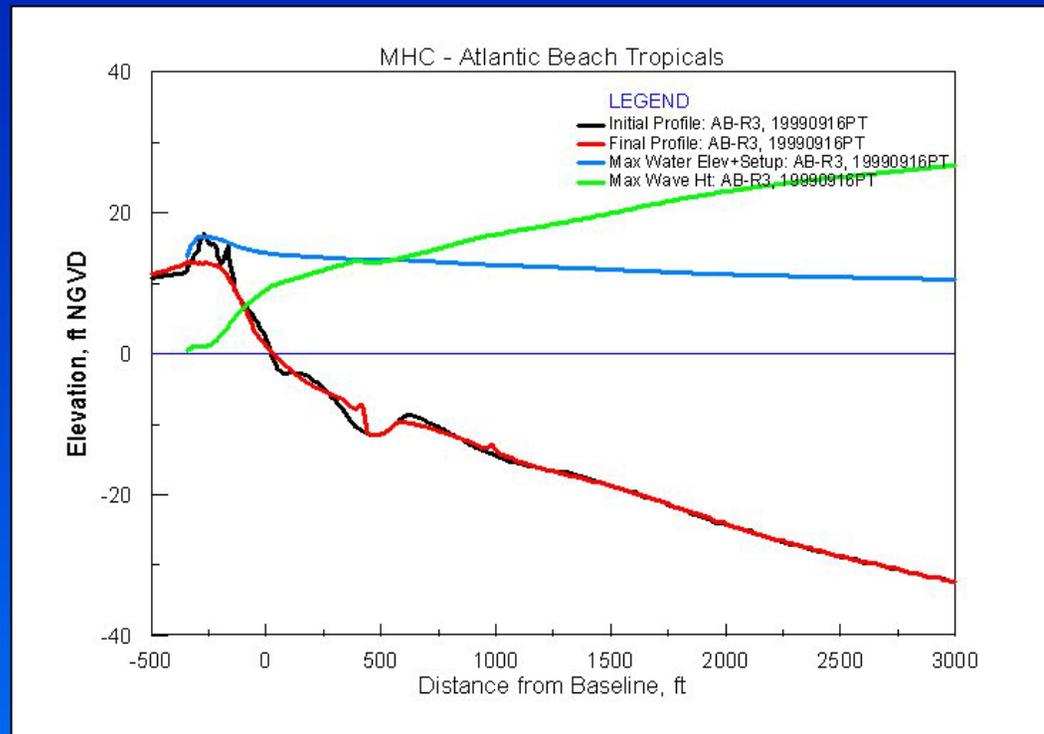




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SBEACH Parameters

- Erosion Indicators
- Dune Elevation
- Wave Height
- TWL
- TWL+Setup
- Setup
- Runup





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EST Analysis

- Input/Response Parameters
- Frequency
- Lifecycles
- Frequency-of-Occurrence

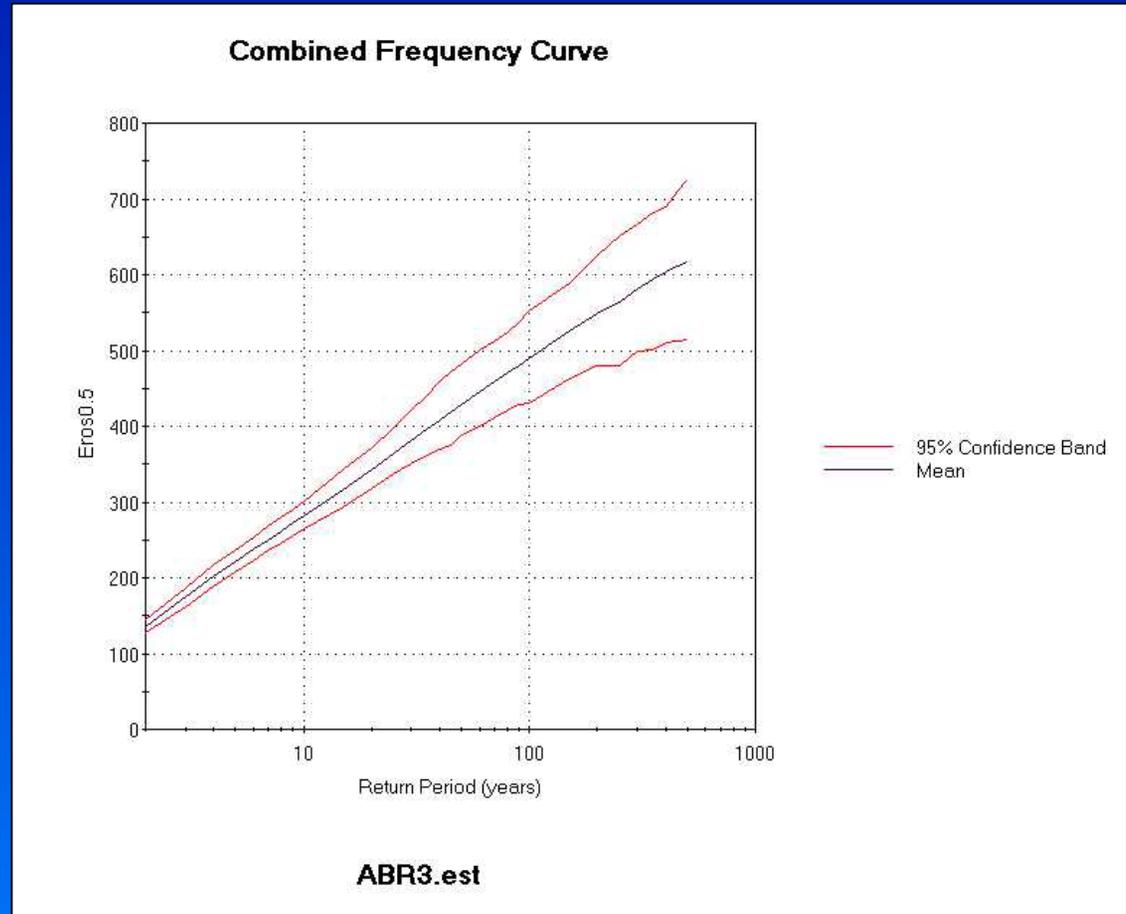
EVENT Label	Input Parameters				Response Parameters										
	Hmo	Tp	Surge	TWL	TWL	TWL+Setup	Surge	Setup	Runup	Eros0.5	Eros2.0	Eros4.0	DuneEI	DunePos	Volume
19931003PT	27.3	12.9	3.4	5.3	5.3	7.4	3.4	2.1	14.5	152.0	0.0	0.0	0.0	265.0	5.5
19101020PT	27.3	13.0	10.4	8.5	8.5	10.6	10.4	2.1	19.4	270.0	179.0	168.0	0.4	275.0	10.4
19280918PT	27.3	11.8	5.5	7.0	7.0	8.4	5.5	1.4	15.8	178.0	171.0	0.0	0.0	265.0	7.4
19291002PT	27.3	12.6	2.2	3.8	3.8	6.0	2.2	2.2	11.1	105.0	0.0	0.0	0.0	265.0	5.0
19300912PT	16.8	8.7	1.7	4.2	4.2	5.5	1.7	1.3	8.2	88.0	0.0	0.0	0.0	265.0	3.8
19350905PT	27.3	17.4	7.5	6.6	6.6	8.8	7.5	2.2	18.6	276.0	184.0	172.0	0.8	280.0	16.3
19440802PT	15.4	8.4	2.4	4.2	4.2	5.4	2.4	1.2	10.0	82.0	0.0	0.0	0.0	265.0	2.9
19441019PT	27.3	12.7	2.1	3.9	3.9	6.2	2.1	2.3	10.1	105.0	0.0	0.0	0.0	265.0	4.4
19470924PT	27.3	12.7	2.2	3.1	3.1	5.3	2.2	2.2	8.7	110.0	0.0	0.0	0.0	265.0	4.5
19530927PT	27.3	12.2	3.2	3.4	3.4	4.7	3.2	1.3	8.1	79.0	0.0	0.0	0.0	265.0	3.0
19541015PT	20.5	9.7	12.6	13.9	13.9	15.0	12.6	1.1	22.9	329.0	299.0	277.0	4.4	305.0	19.1
19550812PT	27.1	11.1	3.1	3.1	3.1	4.2	3.1	1.1	7.2	63.0	0.0	0.0	0.0	265.0	2.5
19550817PT	11.4	7.2	4.4	6.0	6.0	7.5	4.4	1.5	10.2	88.0	0.0	0.0	0.0	265.0	3.4
19550919PT	27.3	12.5	2.3	3.6	3.6	6.0	2.3	2.4	10.4	94.0	0.0	0.0	0.0	265.0	3.6
19560927PT	26.6	11.0	2.7	4.2	4.2	6.4	2.7	2.2	12.1	144.0	0.0	0.0	0.0	265.0	7.2
19600911PT	24.6	10.6	16.2	16.6	16.6	17.5	16.2	0.9	19.2	284.0	172.0	0.0	1.5	245.0	7.3
19660611PT	21.1	9.8	1.6	3.0	3.0	4.7	1.6	1.7	8.6	74.0	0.0	0.0	0.0	265.0	2.6
19680612PT	21.8	10.0	2.2	4.8	4.8	6.6	2.2	1.8	12.4	106.0	0.0	0.0	0.0	265.0	4.0
19681019PT	11.0	7.1	2.3	3.4	3.4	5.0	2.3	1.6	7.3	71.0	0.0	0.0	0.0	265.0	2.4
19710827PT	17.4	8.9	3.2	3.7	3.7	4.4	3.2	0.7	8.1	76.0	0.0	0.0	0.0	265.0	2.5
19720621PT	27.3	12.8	3.2	3.5	3.5	5.7	3.2	2.2	11.2	111.0	0.0	0.0	0.0	265.0	4.7
19790905PT	12.5	14.0	1.4	3.9	3.9	4.7	1.4	0.8	12.8	94.0	0.0	0.0	0.0	265.0	3.8
19810820PT	12.8	9.0	3.8	5.9	5.9	7.8	3.8	1.9	11.7	76.0	0.0	0.0	0.0	265.0	2.2
19820619PT	17.1	11.0	4.5	3.7	3.7	5.5	4.5	1.8	10.8	67.0	0.0	0.0	0.0	265.0	2.2
19840912PT	25.6	14.0	5.2	7.1	7.1	9.3	5.2	2.2	17.2	227.0	177.0	166.0	0.3	275.0	9.2
19850927PT	28.2	19.0	1.6	3.6	3.6	6.2	1.6	2.6	12.0	131.0	0.0	0.0	0.0	265.0	5.5
19851123PT	12.5	11.0	3.3	4.5	4.5	5.1	3.3	0.6	9.5	54.0	0.0	0.0	0.0	265.0	2.0
19890922PT	18.0	15.0	4.5	6.3	6.3	8.3	4.5	2.0	17.1	178.0	171.0	0.0	0.0	265.0	6.5
19950606PT	16.1	12.0	2.0	3.7	3.7	5.2	2.0	1.5	9.8	75.0	0.0	0.0	0.0	265.0	2.4
19960619PT	12.3	9.0	0.3	2.5	2.5	3.2	0.3	0.7	6.5	55.0	0.0	0.0	0.0	265.0	1.7
19960712PT	28.3	14.0	1.9	2.7	2.7	5.2	1.9	2.5	9.7	98.0	0.0	0.0	0.0	265.0	4.6
19960906PT	28.8	15.0	5.2	5.1	5.1	7.3	5.2	2.2	14.3	158.0	0.0	0.0	0.0	265.0	6.2
19961008PT	17.4	11.0	4.7	5.3	5.3	7.0	4.7	1.7	13.7	85.0	0.0	0.0	0.0	265.0	2.9
19980826PT	29.4	18.0	3.7	5.7	5.7	8.0	3.7	2.3	16.3	179.0	171.0	0.0	0.0	265.0	11.5

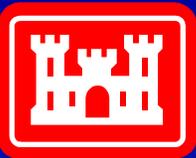


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EST Analysis

- Input/Response Parameters
- Frequency
- Lifecycles
- Frequency-of-Occurrence

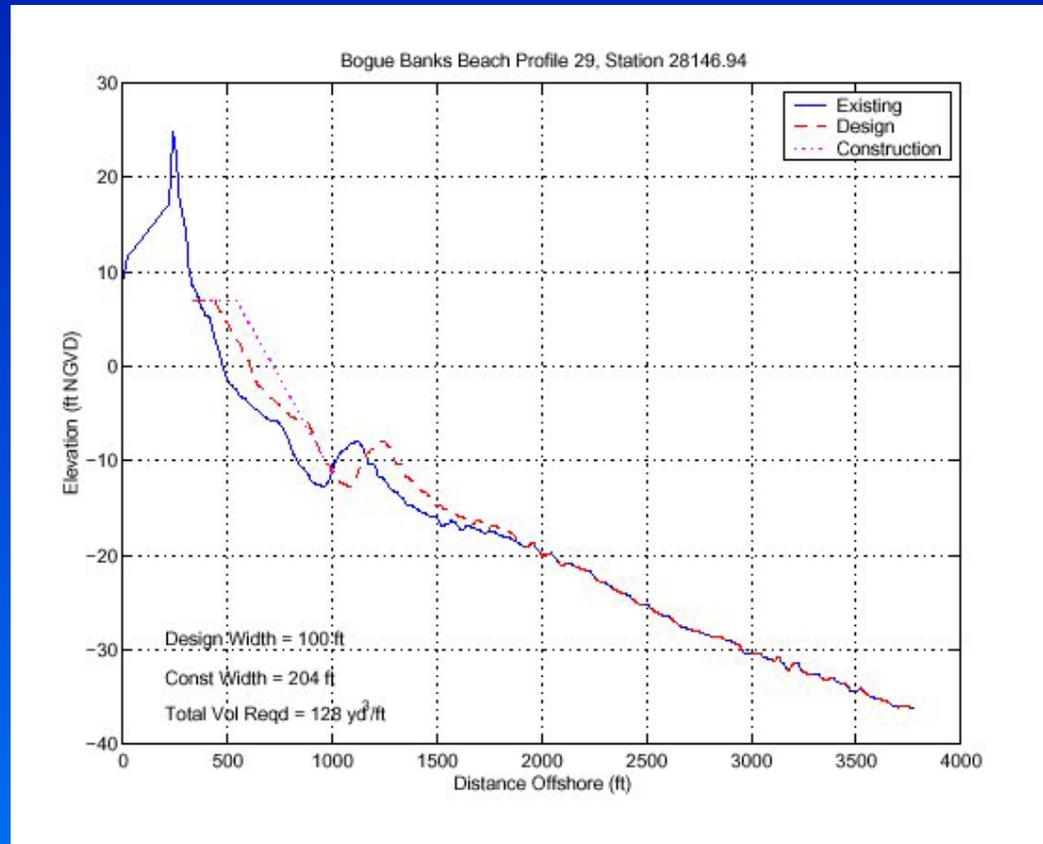




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Wilmington District

Plan Profiles

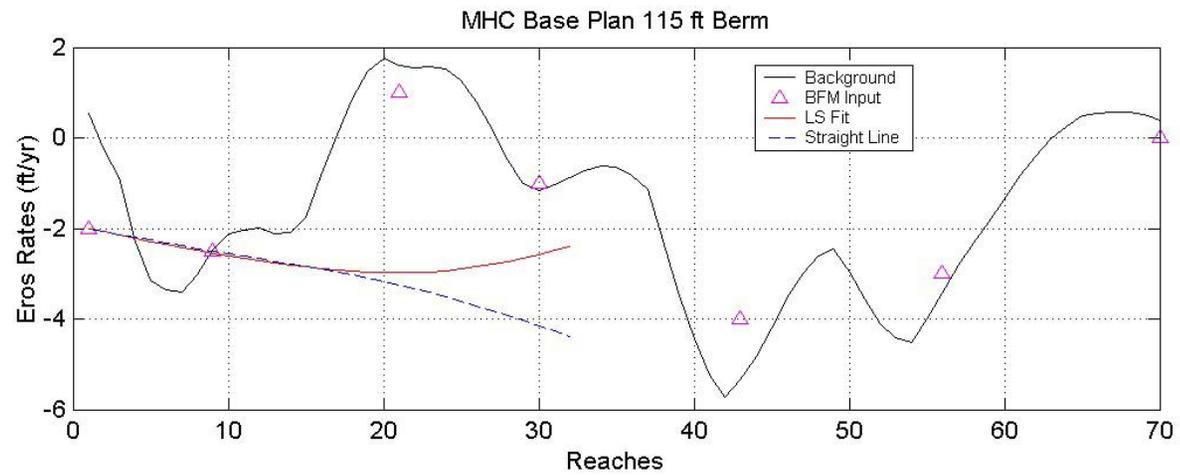
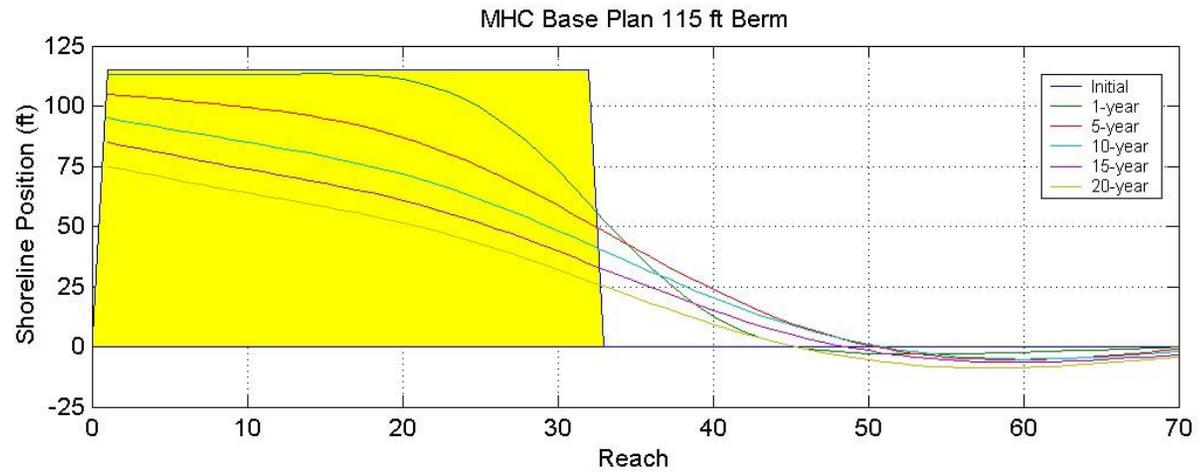
- Berm Only
- Active Profile
- Volume/ft
- Design vs Construction Profile





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Wilmington District

Plan Erosion Rates

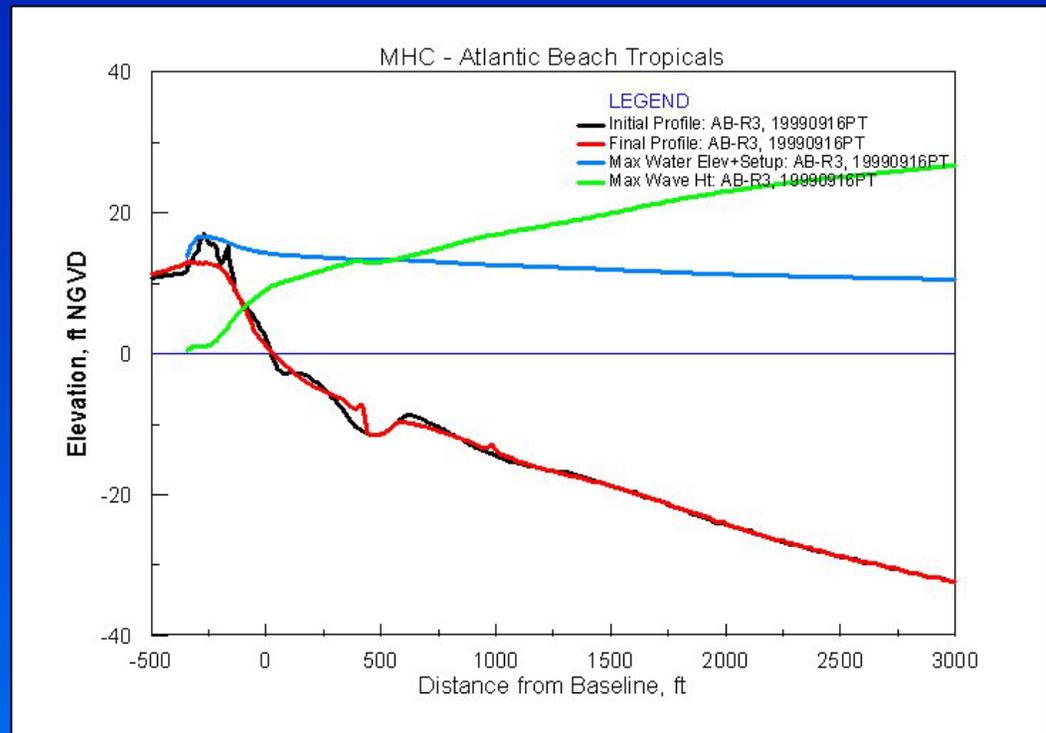




U.S. Army Corps
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SBEACH Parameters

- Erosion Indicators
- Dune Elevation
- Wave Height
- TWL
- TWL+Setup
- Setup
- Runup



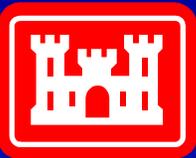


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Plan EST Analysis

- Input/Response Parameters
- Frequency
- Lifecycles
- Frequency-of-Occurrence

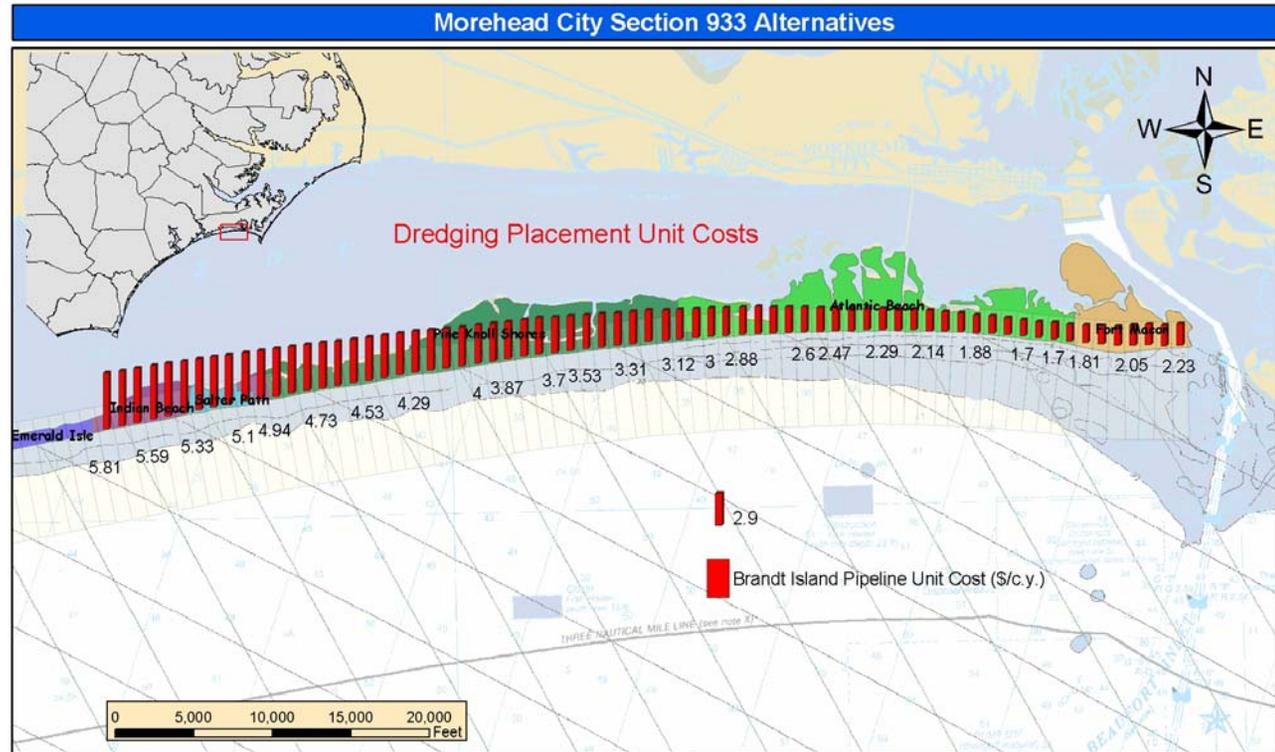
EVENT Label	Input Parameters				Response Parameters										
	Hmo	Tp	Surge	TWL	TWL	TWL+Setup	Surge	Setup	Runup	Eros0.5	Eros2.0	Eros4.0	DuneEI	DunePos	Volume
19931003PT	27.3	12.9	3.4	5.3	5.3	7.4	3.4	2.1	14.5	152.0	0.0	0.0	0.0	265.0	5.5
19101020PT	27.3	13.0	10.4	8.5	8.5	10.6	10.4	2.1	19.4	270.0	179.0	168.0	0.4	275.0	10.4
19280918PT	27.3	11.8	5.5	7.0	7.0	8.4	5.5	1.4	15.8	178.0	171.0	0.0	0.0	265.0	7.4
19291002PT	27.3	12.6	2.2	3.8	3.8	6.0	2.2	2.2	11.1	105.0	0.0	0.0	0.0	265.0	5.0
19300912PT	16.8	8.7	1.7	4.2	4.2	5.5	1.7	1.3	8.2	88.0	0.0	0.0	0.0	265.0	3.8
19350905PT	27.3	17.4	7.5	6.6	6.6	8.8	7.5	2.2	18.6	276.0	184.0	172.0	0.8	280.0	16.3
19440802PT	15.4	8.4	2.4	4.2	4.2	5.4	2.4	1.2	10.0	82.0	0.0	0.0	0.0	265.0	2.9
19441019PT	27.3	12.7	2.1	3.9	3.9	6.2	2.1	2.3	10.1	105.0	0.0	0.0	0.0	265.0	4.4
19470924PT	27.3	12.7	2.2	3.1	3.1	5.3	2.2	2.2	8.7	110.0	0.0	0.0	0.0	265.0	4.5
19530927PT	27.3	12.2	3.2	3.4	3.4	4.7	3.2	1.3	8.1	79.0	0.0	0.0	0.0	265.0	3.0
19541015PT	20.5	9.7	12.6	13.9	13.9	15.0	12.6	1.1	22.9	329.0	299.0	277.0	4.4	305.0	19.1
19550812PT	27.1	11.1	3.1	3.1	3.1	4.2	3.1	1.1	7.2	63.0	0.0	0.0	0.0	265.0	2.5
19550817PT	11.4	7.2	4.4	6.0	6.0	7.5	4.4	1.5	10.2	88.0	0.0	0.0	0.0	265.0	3.4
19550919PT	27.3	12.5	2.3	3.6	3.6	6.0	2.3	2.4	10.4	94.0	0.0	0.0	0.0	265.0	3.6
19560927PT	26.6	11.0	2.7	4.2	4.2	6.4	2.7	2.2	12.1	144.0	0.0	0.0	0.0	265.0	7.2
19600911PT	24.6	10.6	16.2	16.6	16.6	17.5	16.2	0.9	19.2	284.0	172.0	0.0	1.5	245.0	7.3
19660611PT	21.1	9.8	1.6	3.0	3.0	4.7	1.6	1.7	8.6	74.0	0.0	0.0	0.0	265.0	2.6
19680612PT	21.8	10.0	2.2	4.8	4.8	6.6	2.2	1.8	12.4	106.0	0.0	0.0	0.0	265.0	4.0
19681019PT	11.0	7.1	2.3	3.4	3.4	5.0	2.3	1.6	7.3	71.0	0.0	0.0	0.0	265.0	2.4
19710827PT	17.4	8.9	3.2	3.7	3.7	4.4	3.2	0.7	8.1	76.0	0.0	0.0	0.0	265.0	2.5
19720621PT	27.3	12.8	3.2	3.5	3.5	5.7	3.2	2.2	11.2	111.0	0.0	0.0	0.0	265.0	4.7
19790905PT	12.5	14.0	1.4	3.9	3.9	4.7	1.4	0.8	12.8	94.0	0.0	0.0	0.0	265.0	3.8
19810820PT	12.8	9.0	3.8	5.9	5.9	7.8	3.8	1.9	11.7	76.0	0.0	0.0	0.0	265.0	2.2
19820619PT	17.1	11.0	4.5	3.7	3.7	5.5	4.5	1.8	10.8	67.0	0.0	0.0	0.0	265.0	2.2
19840912PT	25.6	14.0	5.2	7.1	7.1	9.3	5.2	2.2	17.2	227.0	177.0	166.0	0.3	275.0	9.2
19850927PT	28.2	19.0	1.6	3.6	3.6	6.2	1.6	2.6	12.0	131.0	0.0	0.0	0.0	265.0	5.5
19851123PT	12.5	11.0	3.3	4.5	4.5	5.1	3.3	0.6	9.5	54.0	0.0	0.0	0.0	265.0	2.0
19890922PT	18.0	15.0	4.5	6.3	6.3	8.3	4.5	2.0	17.1	178.0	171.0	0.0	0.0	265.0	6.5
19950606PT	16.1	12.0	2.0	3.7	3.7	5.2	2.0	1.5	9.8	75.0	0.0	0.0	0.0	265.0	2.4
19960619PT	12.3	9.0	0.3	2.5	2.5	3.2	0.3	0.7	6.5	55.0	0.0	0.0	0.0	265.0	1.7
19960712PT	28.3	14.0	1.9	2.7	2.7	5.2	1.9	2.5	9.7	98.0	0.0	0.0	0.0	265.0	4.6
19960906PT	28.8	15.0	5.2	5.1	5.1	7.3	5.2	2.2	14.3	158.0	0.0	0.0	0.0	265.0	6.2
19961008PT	17.4	11.0	4.7	5.3	5.3	7.0	4.7	1.7	13.7	85.0	0.0	0.0	0.0	265.0	2.9
19980826PT	29.4	18.0	3.7	5.7	5.7	8.0	3.7	2.3	16.3	179.0	171.0	0.0	0.0	265.0	11.5

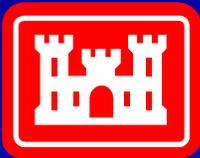


U.S. Army Corps
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Wilmington District

Generate Project Costs

- Brandt Island Pipeline
- Entrance Channel Pipeline
- Entrance Channel Hopper





U.S. Army Corps
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Wilmington District

GRANDUC

● INPUT

- Project Lifecycle
(Distributions of
Damage Parameters)
- Structure Conditions
- Damage Curves
- Plan Volumes/Costs
- Erosion Rates
- ...

● OUTPUT

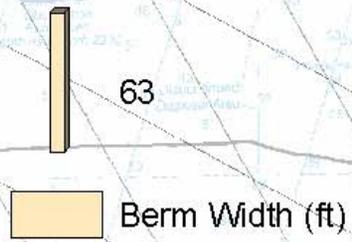
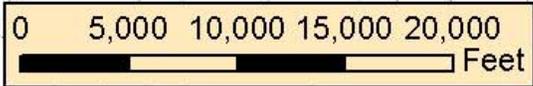
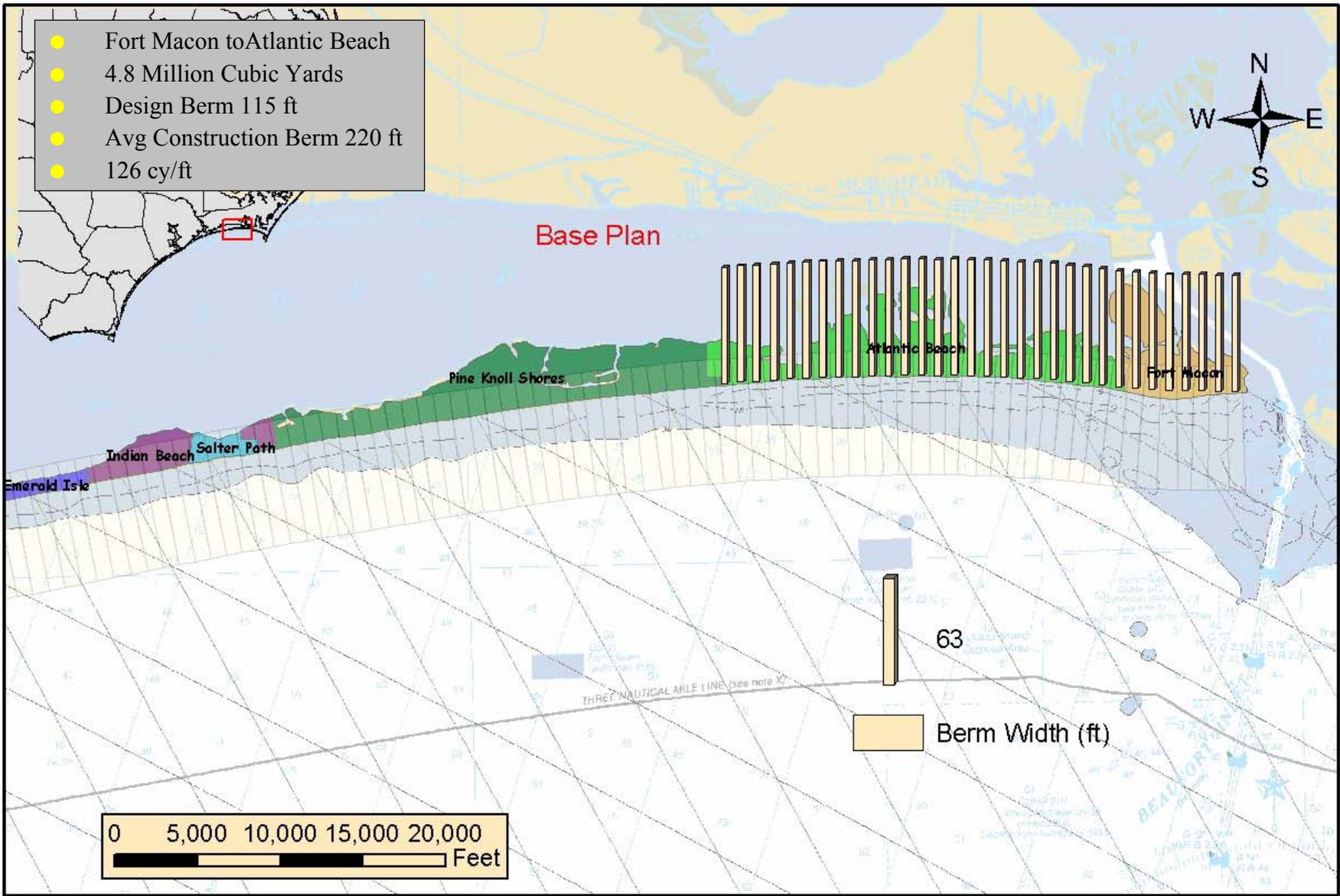
- Present-Value
Damages
- Present-Value Costs
- Damage Reduction for
Compared Plans
- Totals, Reach,
Structure
- ...

Morehead City Section 933 Alternatives

- Fort Macon to Atlantic Beach
- 4.8 Million Cubic Yards
- Design Berm 115 ft
- Avg Construction Berm 220 ft
- 126 cy/ft



Base Plan

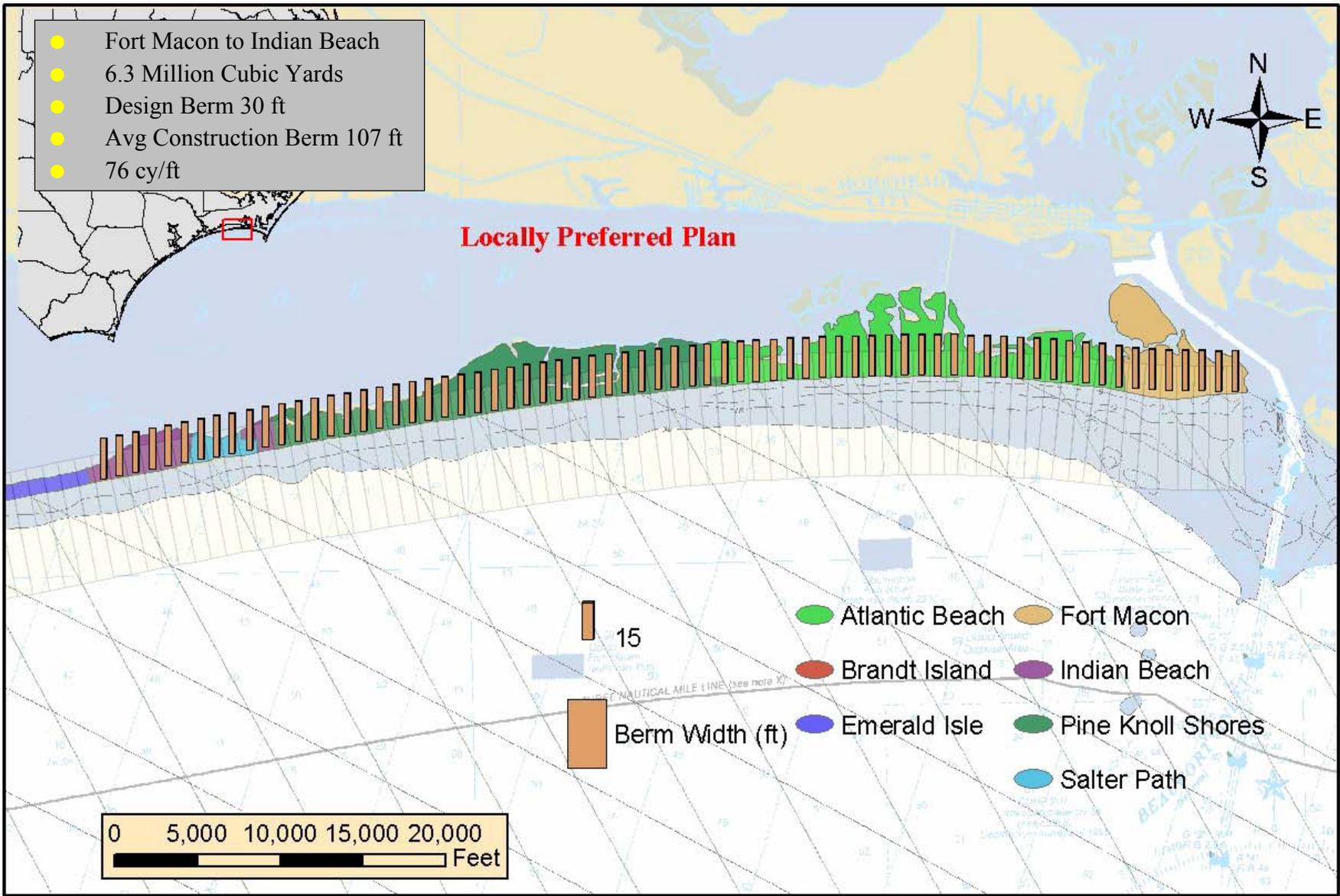


Morehead City Section 933 Alternatives

- Fort Macon to Indian Beach
- 6.3 Million Cubic Yards
- Design Berm 30 ft
- Avg Construction Berm 107 ft
- 76 cy/ft



Locally Preferred Plan

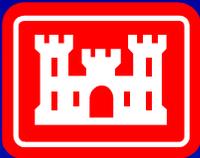


15

Berm Width (ft)

- Atlantic Beach
- Brandt Island
- Emerald Isle
- Fort Macon
- Indian Beach
- Pine Knoll Shores
- Salter Path

0 5,000 10,000 15,000 20,000 Feet



U.S. Army Corps
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DATA

Annual Total Benefits	\$10,655,000
Annual Total Costs	\$2,208,000
Benefit-to-Cost Ratio	4.8