HARBOUR TOWN GOLF LINKS
18TH GREEN SHORELINE RESTORATION AND MARSH RESTORATION PROJECT

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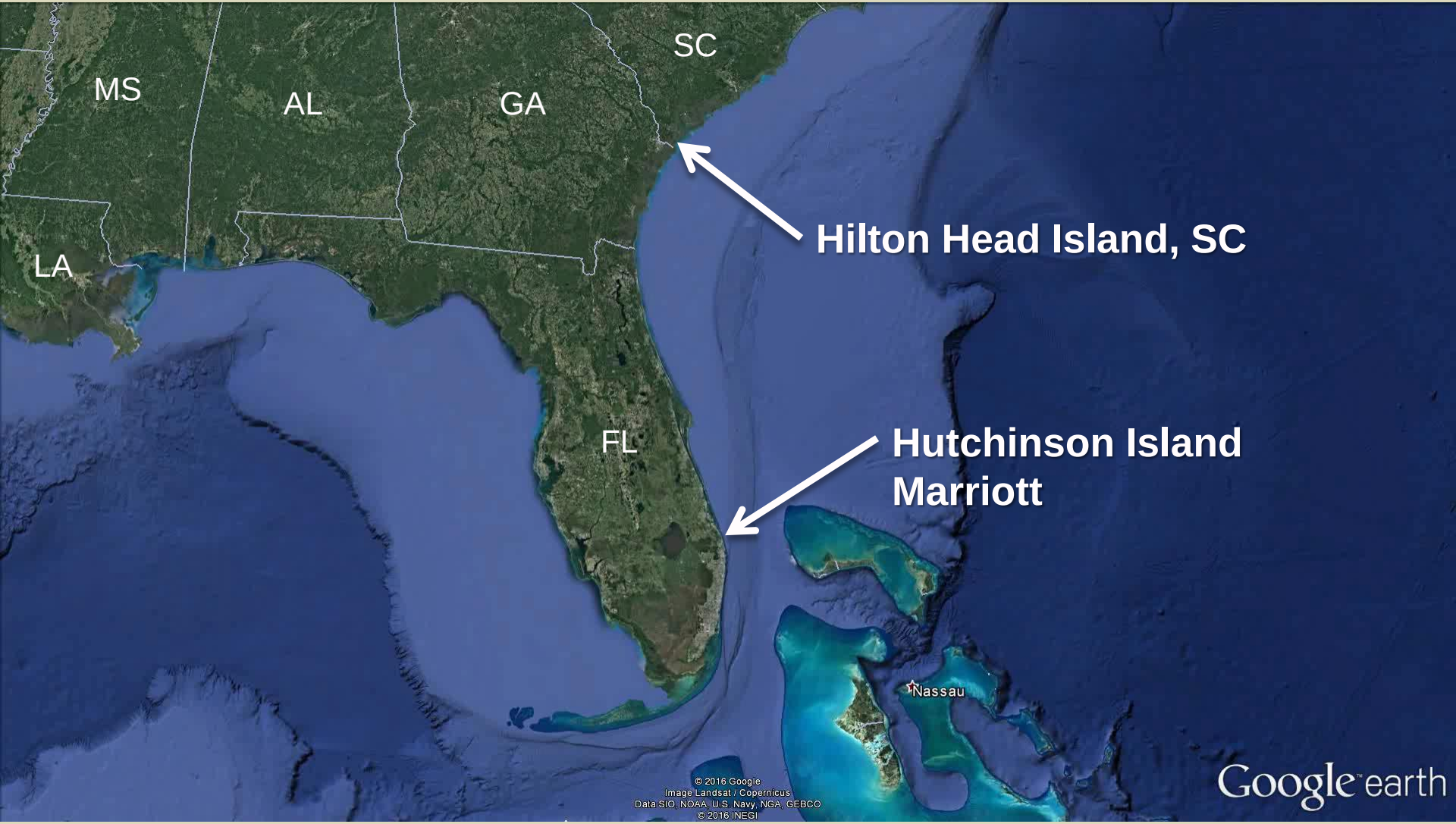
Coastal Engineering



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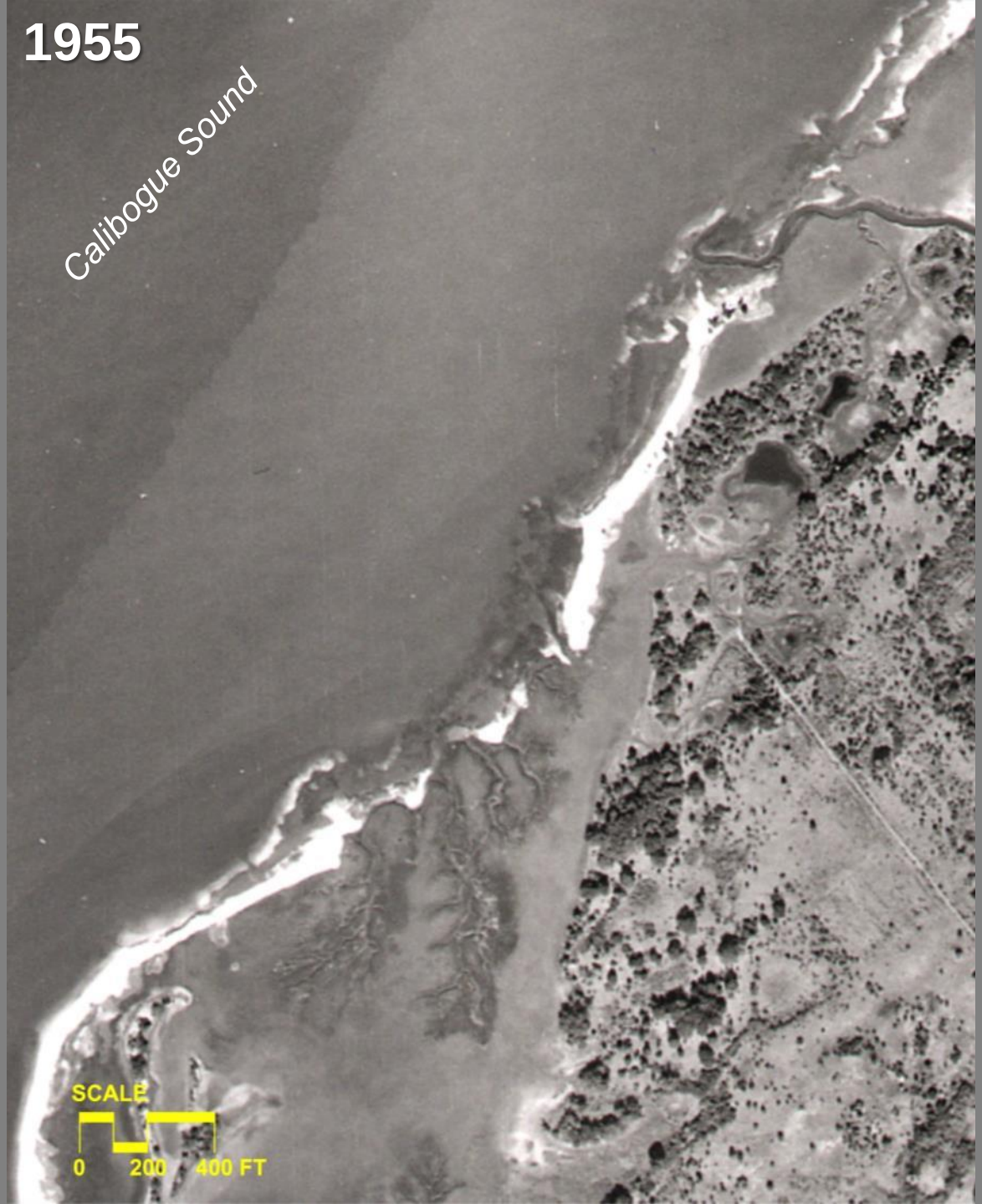
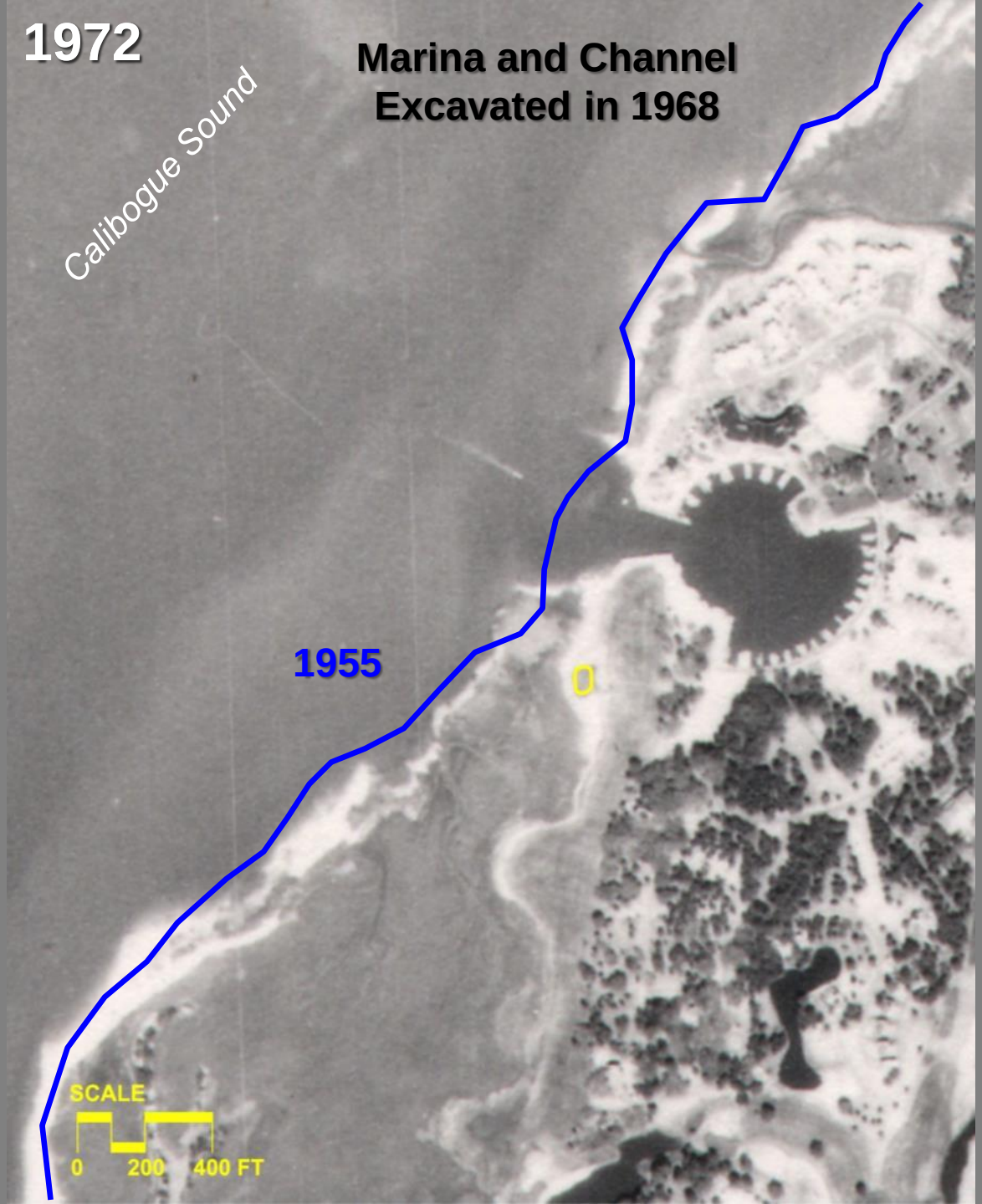

1955
Calibogue Sound
SCALE
0
200
400 FT


1972
Marina and Channel
Excavated in 1968
Calibogue Sound
1955
SCALE
0
200
400 FT

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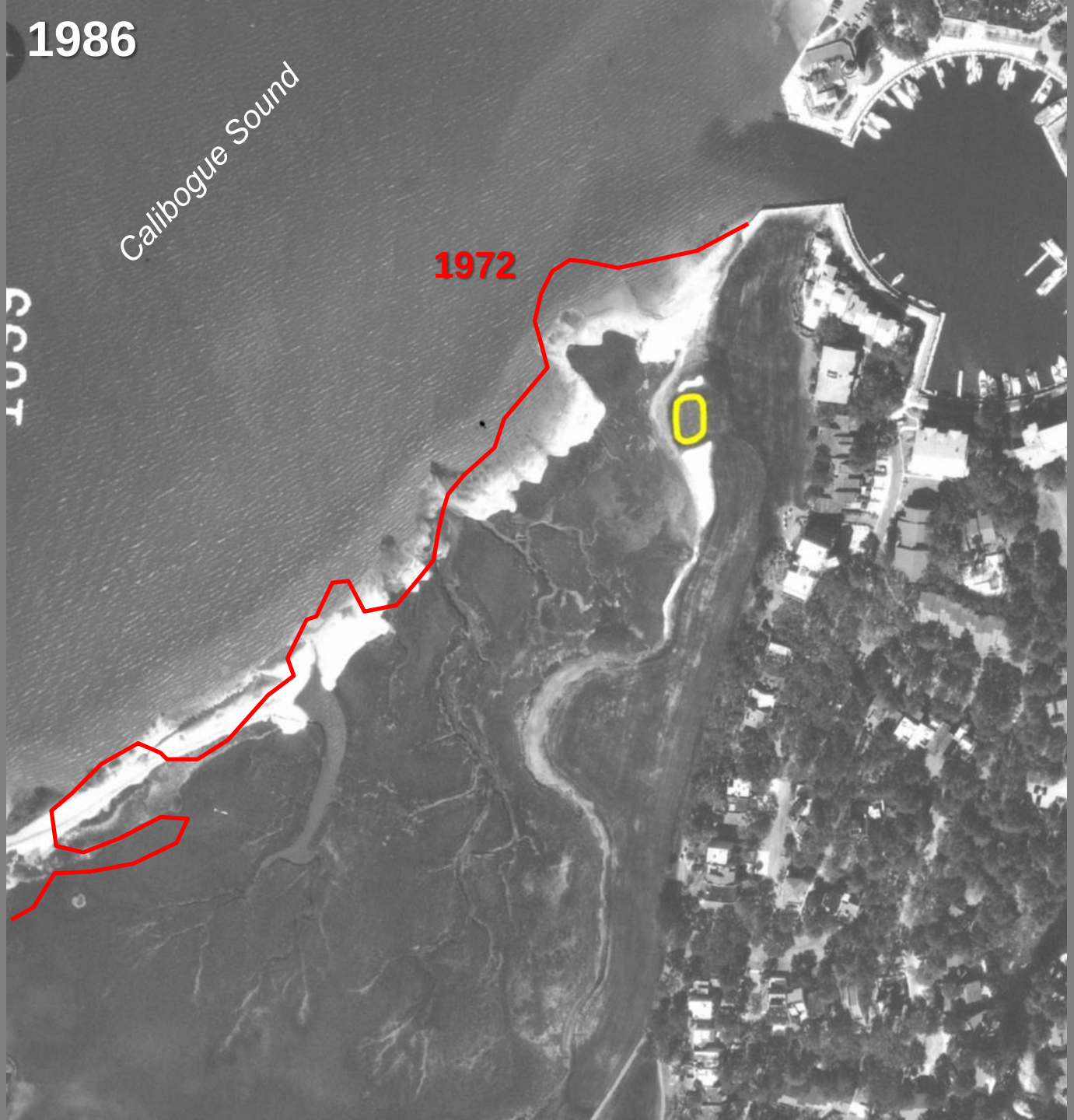

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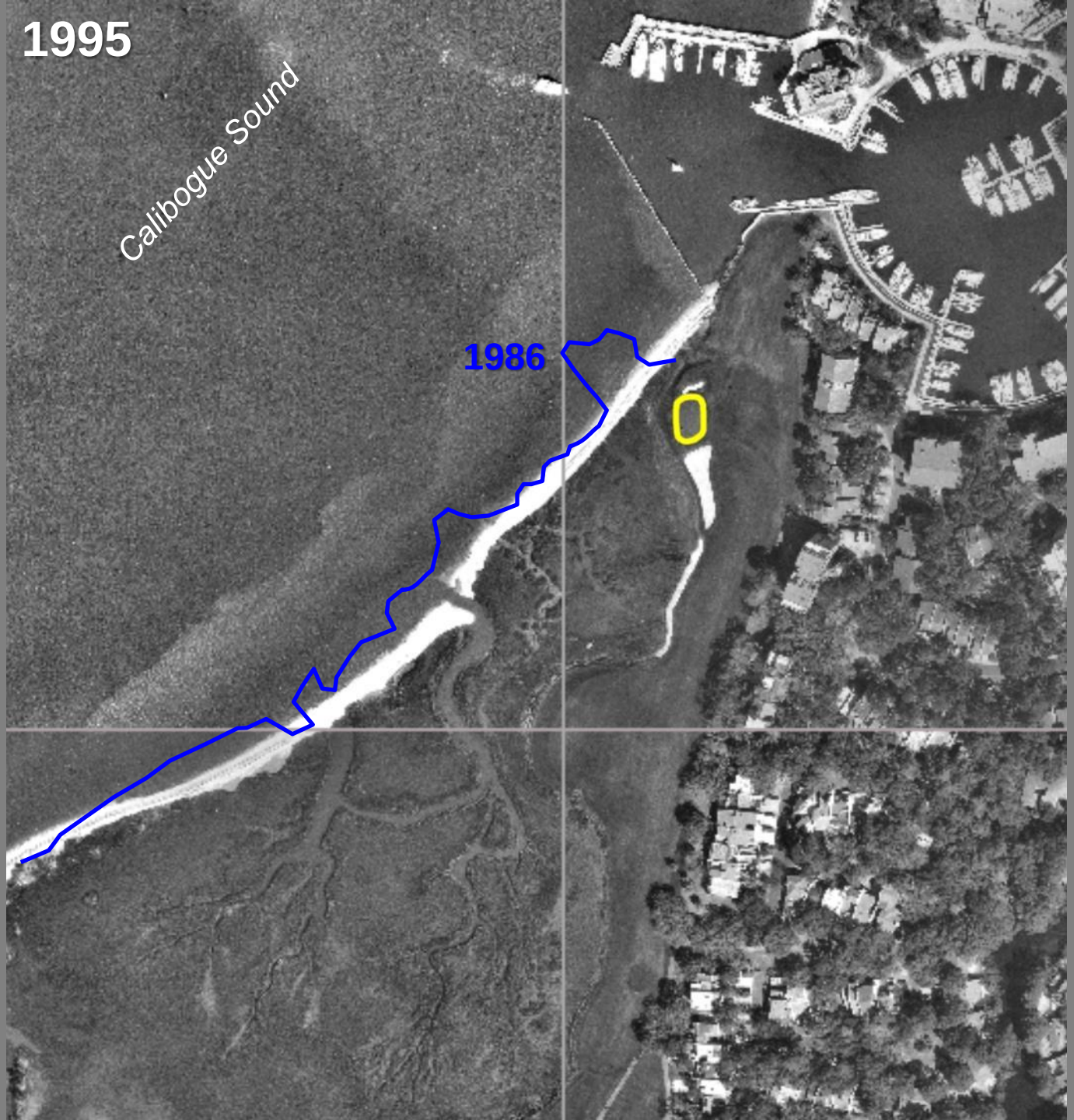

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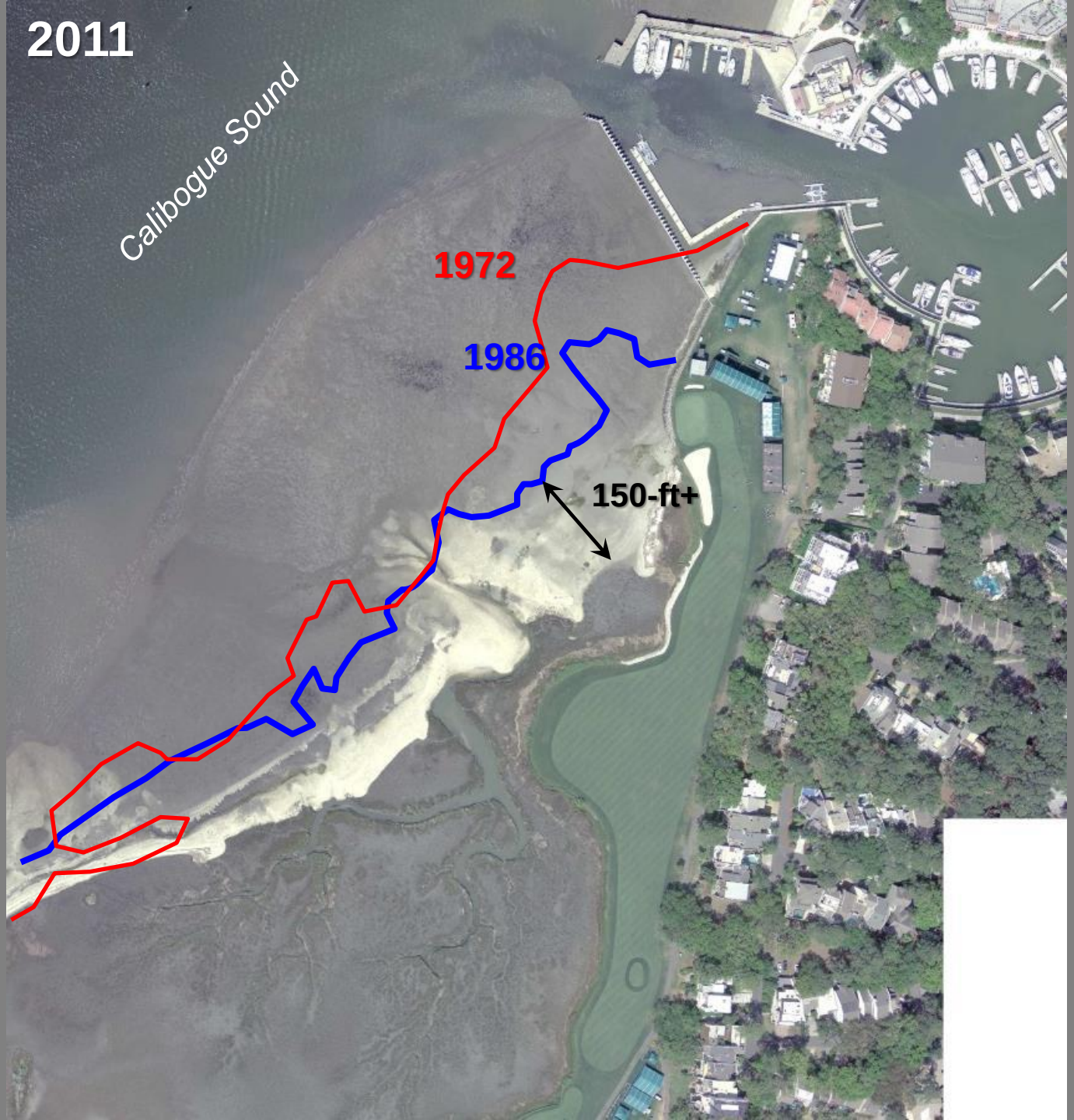

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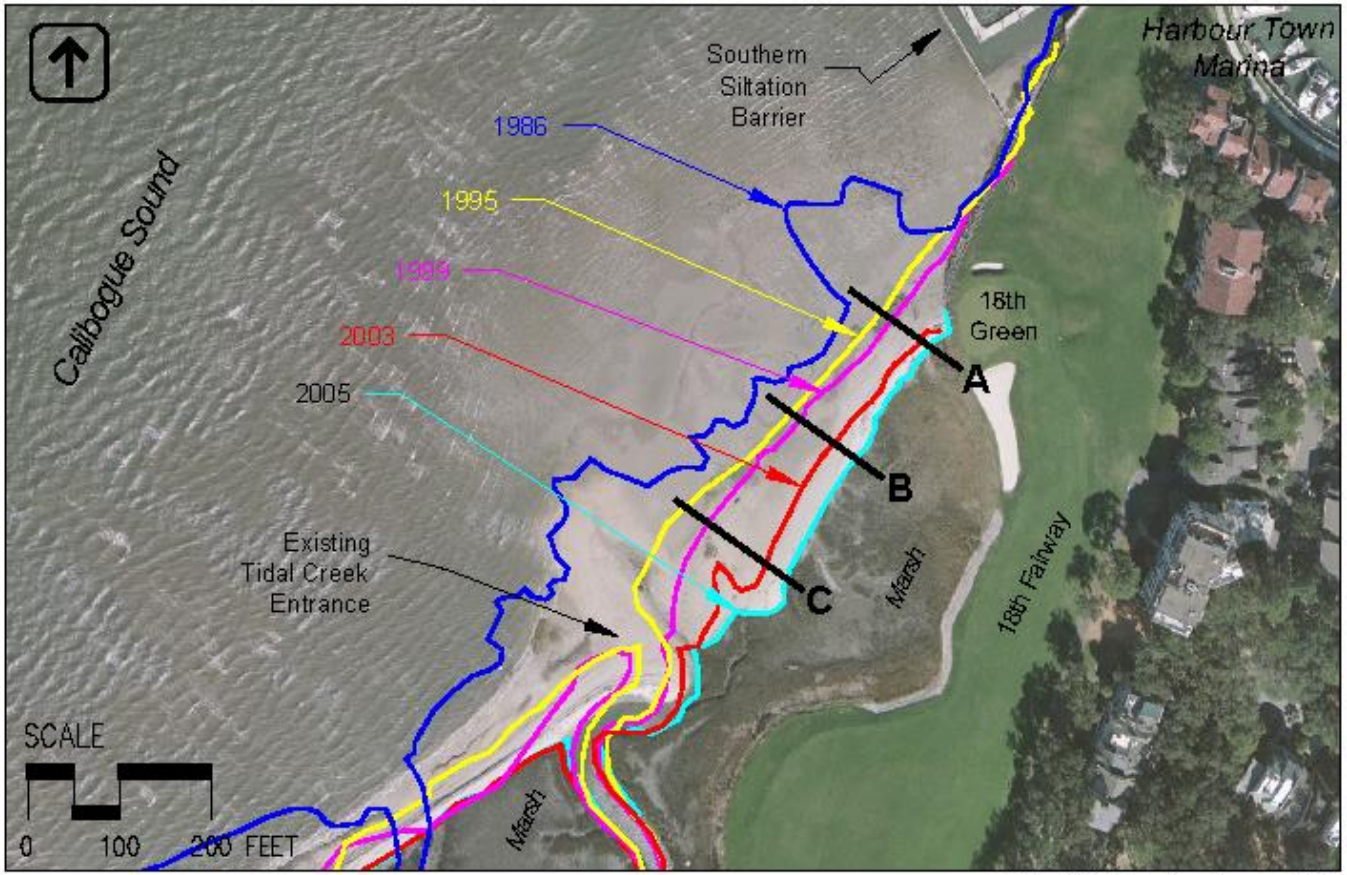

Date of Photography: January 2005

Representative Dates for Shoreline Locations		Time (yrs)	Recession Rate (ft/yr)			
			Transect A	Transect B	Transect C	Average
Jan-95	Jan-99	4.0	-3.6	-3.1	-7.5	-4.7
Jan-99	Dec-03	4.9	-7.5	-9.2	-13.8	-10.2
Dec-03	Jan-05	1.1	-13.7	-27.0	-34.0	-24.9
Average			-8.2	-13.1	-18.5	-13.3

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Why did the marsh leave…?

- **Development**
  - **Establishment of Marina and Associated Infrastructure**
- **Interruption of Littoral Drift**
  - **General Trend of Sand is from North to South**

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2.3 miles
2.0 miles
3.5 miles
Hilton Head Island
Daufuskie Island
Calibogue Sound
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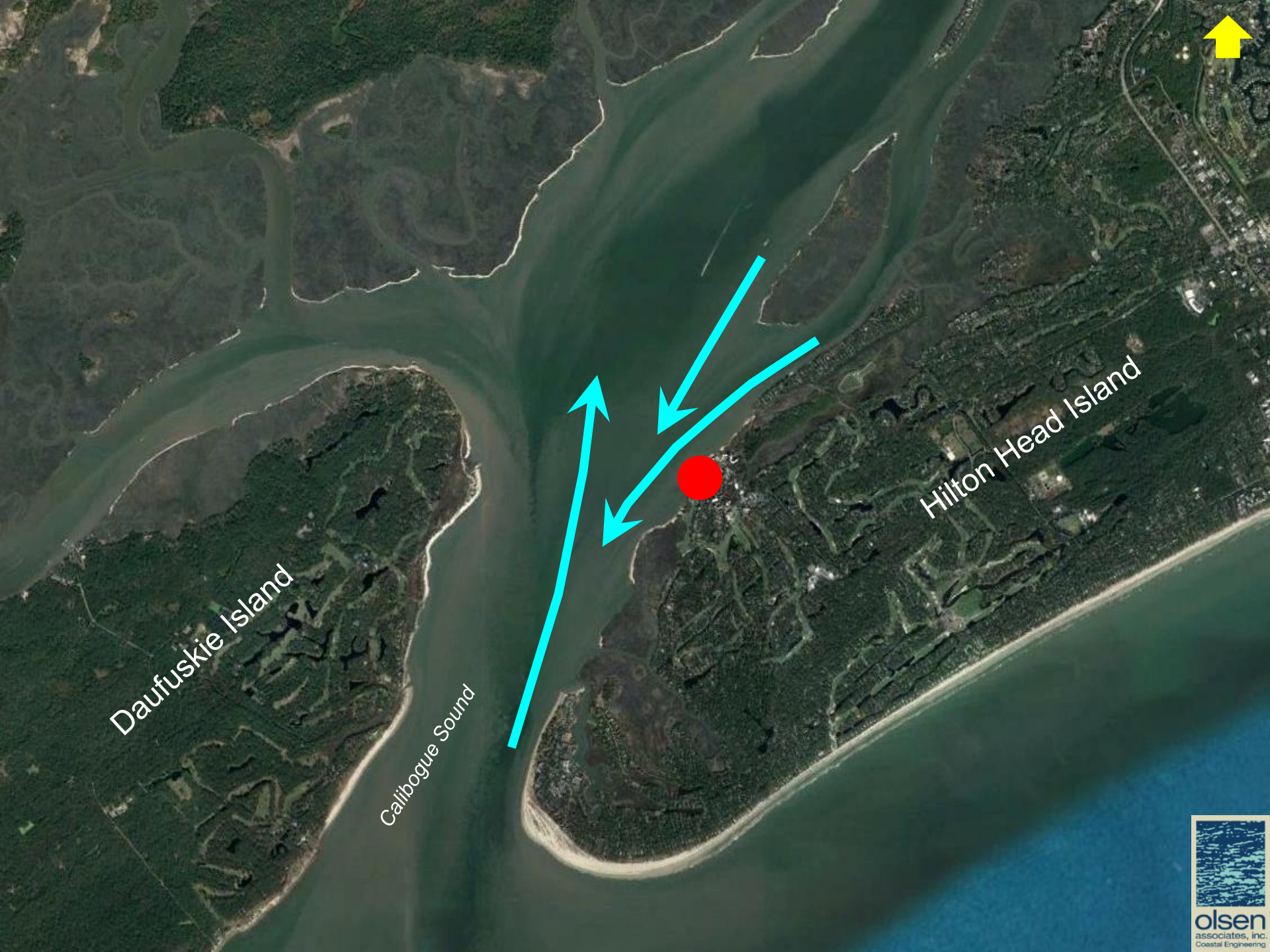
Daufuskie Island
Calibogue Sound
Hilton Head Island


Daufuskie Island
Calibogue Sound
Hilton Head Island

Why did the marsh leave…?

- **Development**
  - Establishment of Marina and Associated Infrastructure
- **Interruption of Sand Littoral Processes**
  - General Trend of Sand Transport is from North to South
    - Wave and Tidal Current Transport
- **Increased Wave Heights**
  - Introduction of Vertical Inlet Structures
    - Increased Wave Heights Due to Reflection
  - Sea Floor Deepening Seaward of Marsh
    - Navigation Channel Dredging/Maintenance

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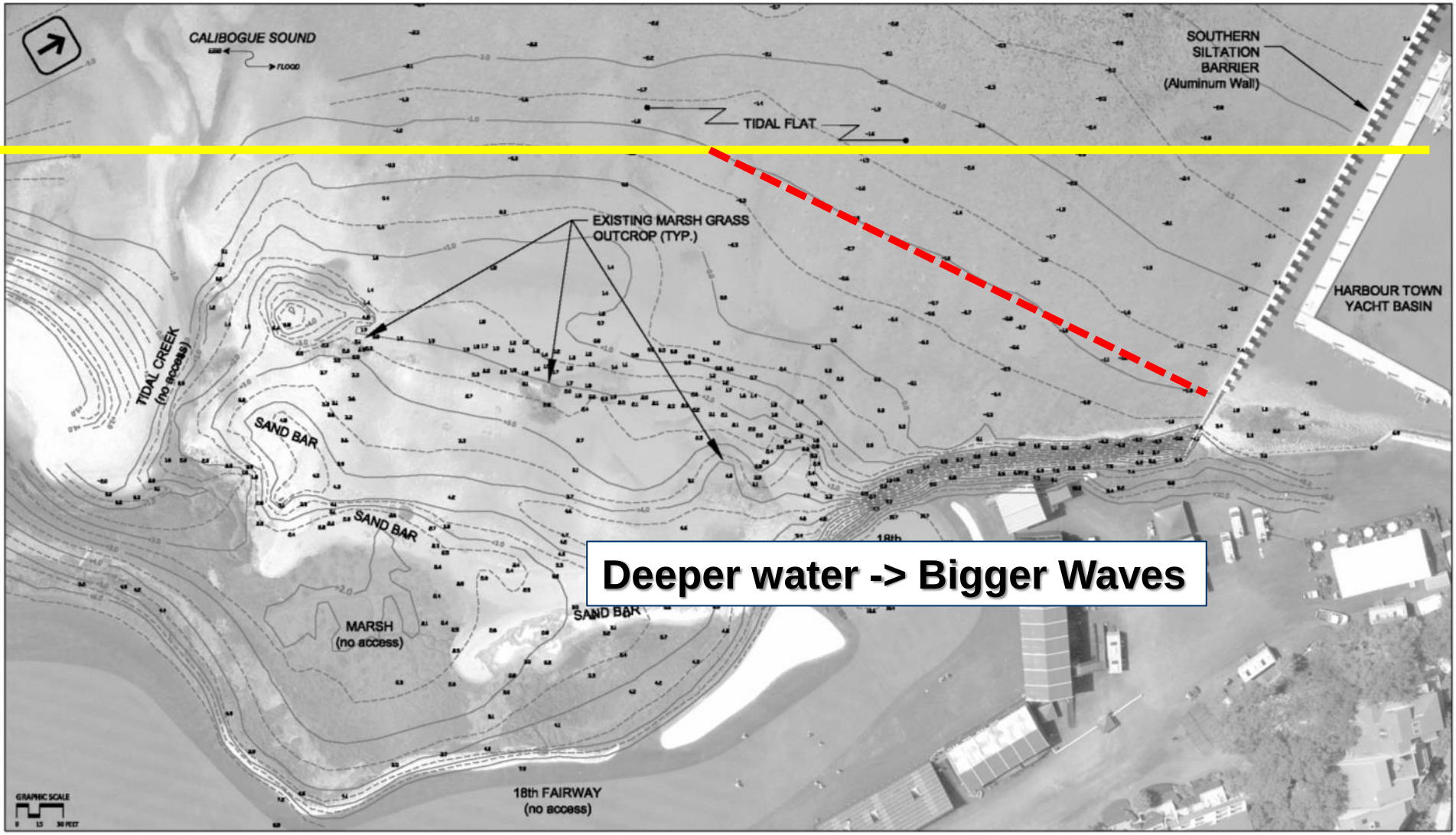

Sea Floor Deepening Seaward of Marsh

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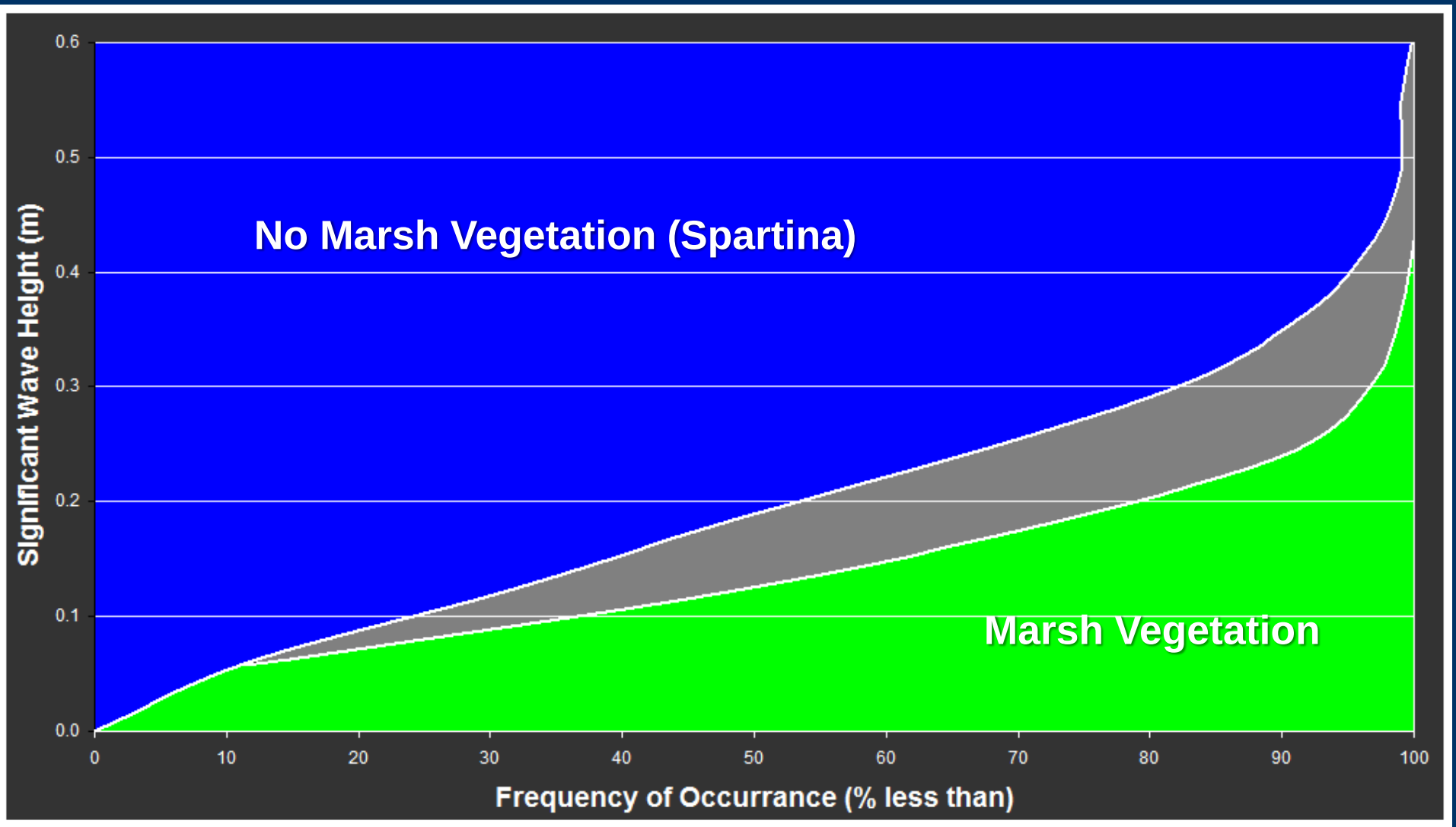

Roland and Douglass (2005)

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Project Goals

- **Protect the 18th Green from Erosion**

- **Return original aesthetics and playing conditions of the iconic 18th hole and green**
  - **Broad marsh buffer between hole/green and Calibogue Sound**
  - **Consistent water hazard to left of green**

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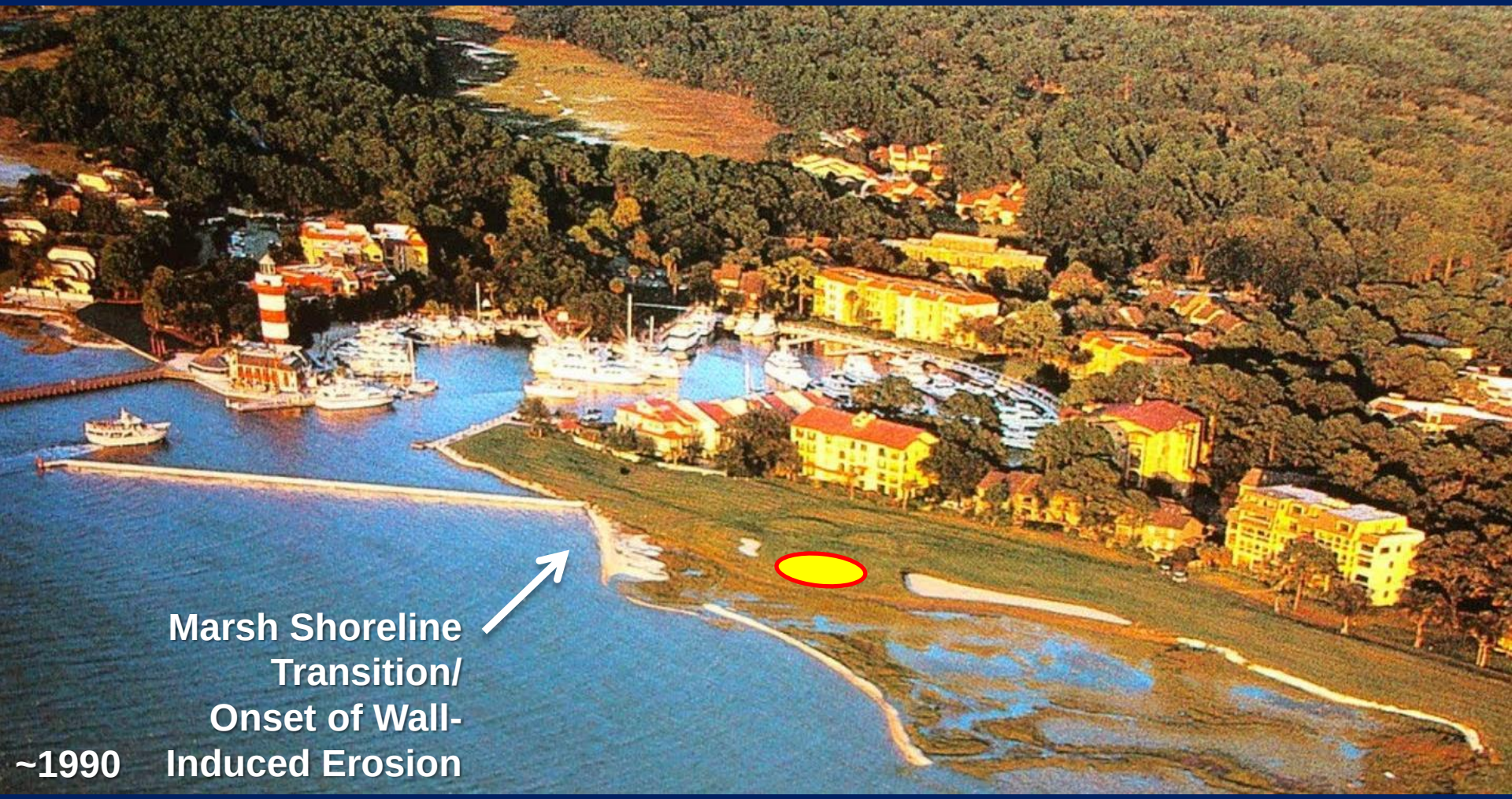
Marsh Shoreline
Transition/
Onset of Wall-
Induced Erosion
~1990

Design Precepts

- **Reduce Wave Energy**
  - **Consider wave reflection from adjacent vertical wall**
- **Restore suitable elevations and substrate for marsh reestablishment and sustainability**
  - **Replicate conditions found along adjacent healthy marshes**
- **Provide for adequate water exchange**
- **Replace marsh grasses**

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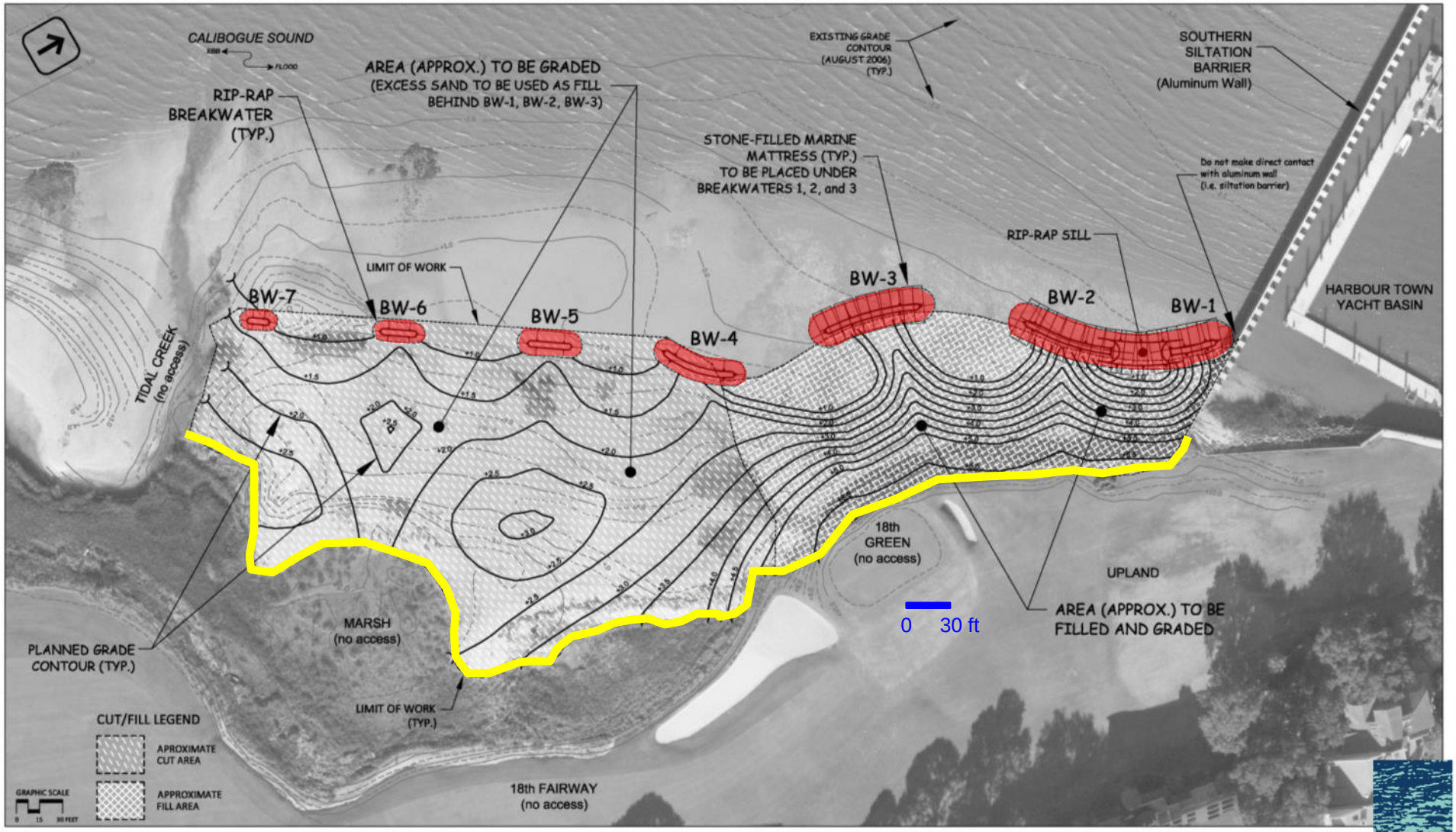
Design Concept

Implementation



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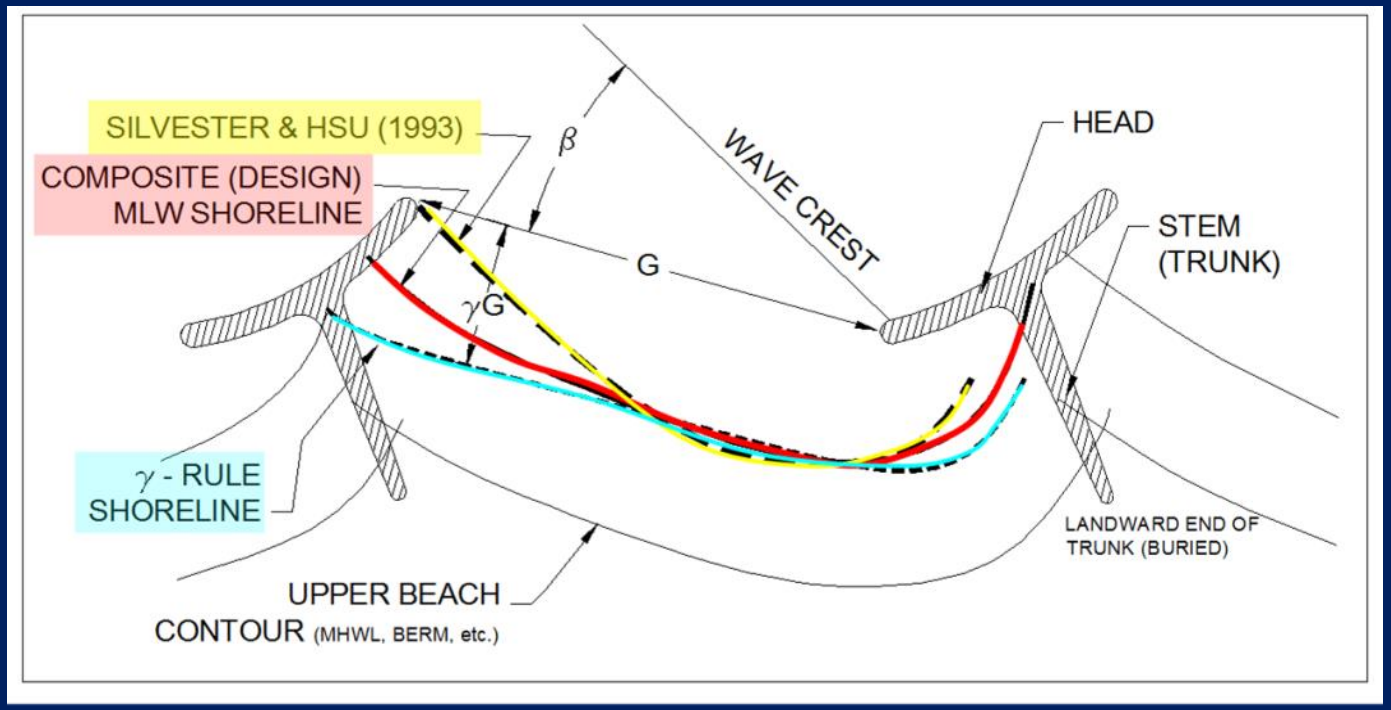
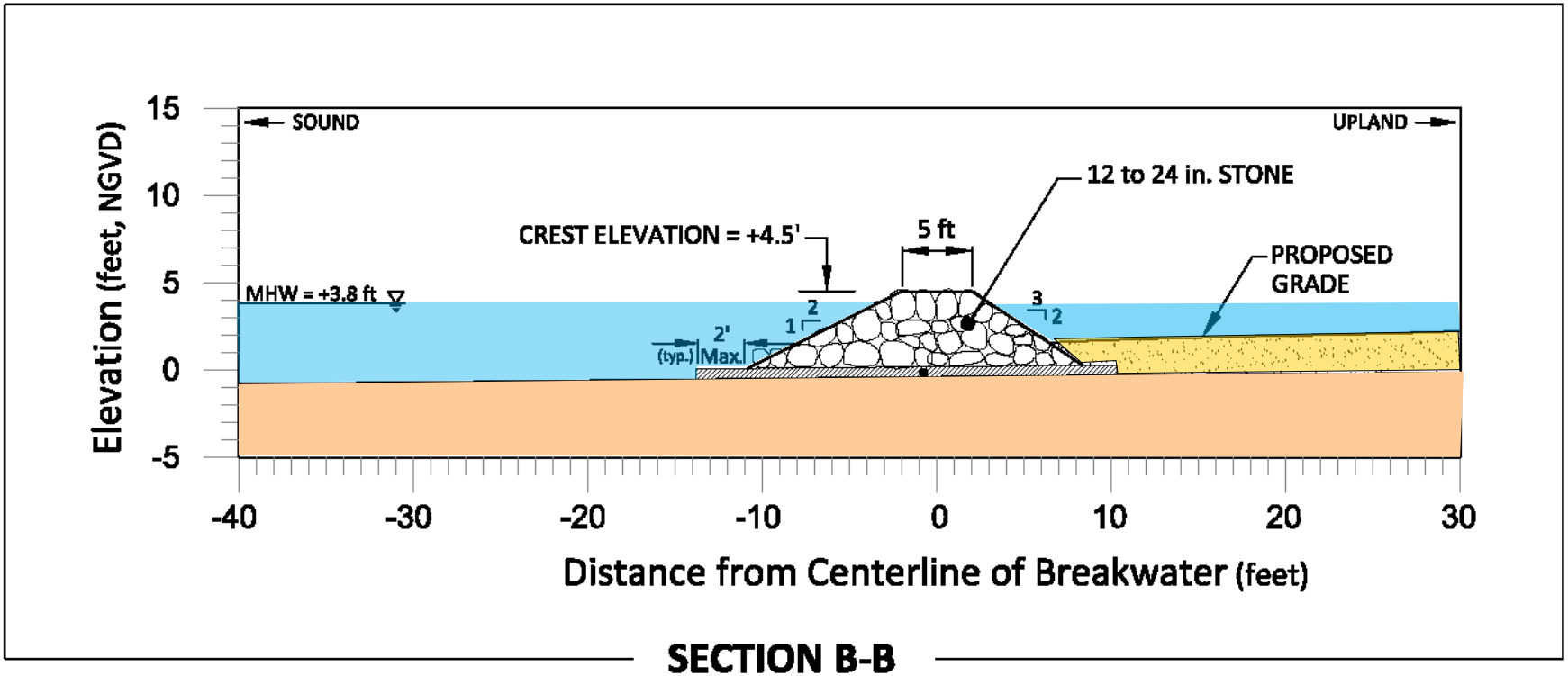
T-head groins and “pocket” beaches





SECTION B-B

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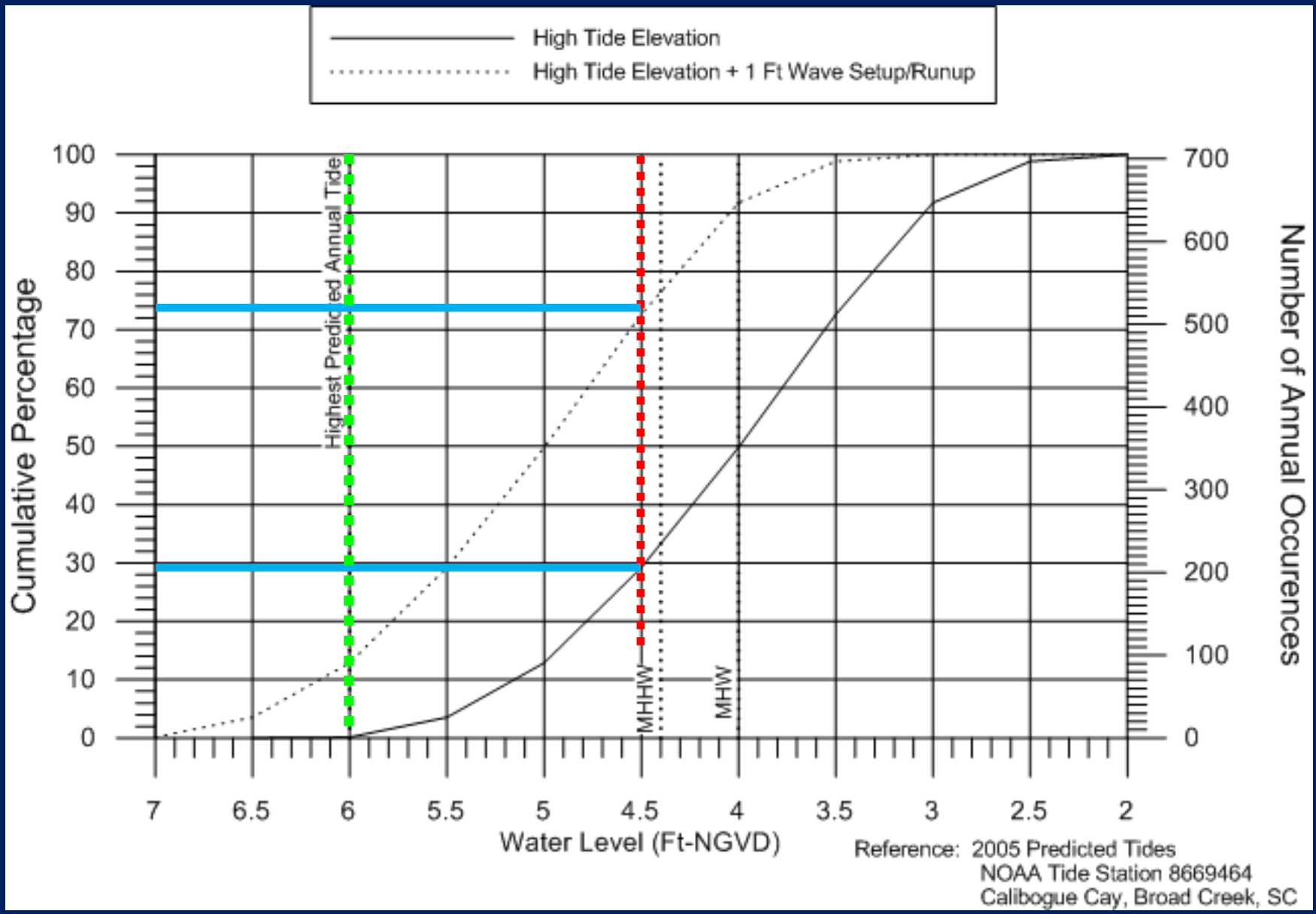
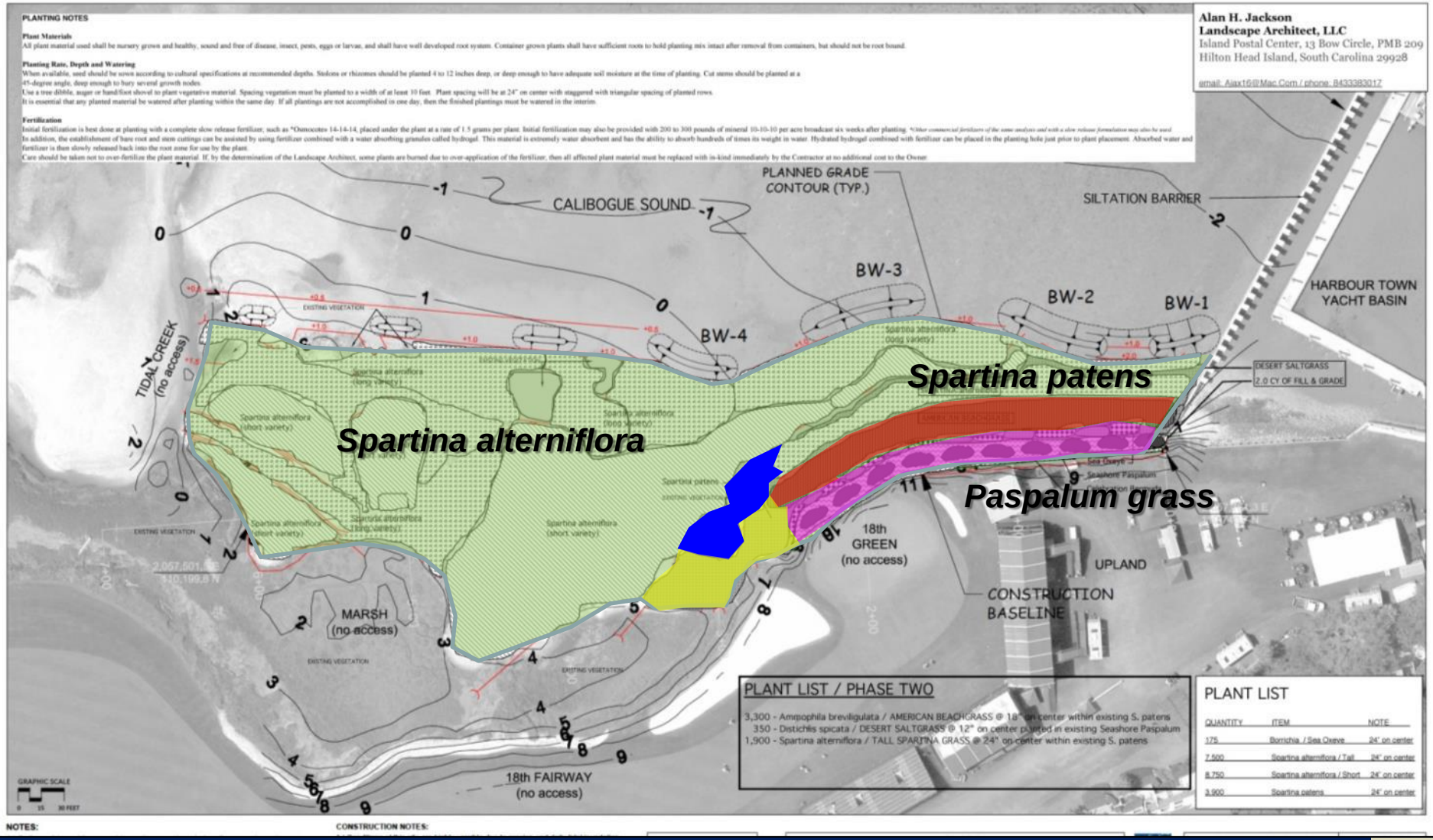

High Tide Elevation
High Tide Elevation + 1 Ft Wave Setup/Runup
Cumulative Percentage
Number of Annual Occurences
Highest Predicted Annual Tide
MHHW
MHW
Water Level (Ft-NGVD)
Reference: 2005 Predicted Tides
NOAA Tide Station 8669464
Calibogue Cay, Broad Creek, SC


PLANTING NOTES
Plant Materials
All plant material used shall be nursery grown and healthy, sound and free of disease, insect, pests, eggs or larvae, and shall have well developed root system. Container grown plants shall have sufficient roots to hold planting mix intact after removal from containers, but should not be root bound.
Planting Rate, Depth and Watering
When available, seed should be sown according to cultural specifications at recommended depths. Stolons or rhizomes should be planted 4 to 12 inches deep, or deep enough to have adequate soil moisture at the time of planting. Cut stems should be planted at a 45-degree angle, deep enough to bury several growth nodes.
Use a tree dibble, auger or hand/foot shovel to plant vegetative material. Spacing vegetation must be planted to a width of at least 10 feet. Plant spacing will be at 24" on center with staggered with triangular spacing of planted rows.
It is essential that any planted material be watered after planting within the same day. If all plantings are not accomplished in one day, then the finished plantings must be watered in the interim.
Fertilization
Initial fertilization is best done at planting with a complete slow release fertilizer, such as *Osmocotes 14-14-14, placed under the plant at a rate of 1.5 grams per plant. Initial fertilization may also be provided with 200 to 300 pounds of mineral 10-10-10 per acre broadcast six weeks after planting. *Other commercial fertilizers of the same analyses and with a slow release formulation may also be used.
In addition, the establishment of bare root and stem cuttings can be assisted by using fertilizer combined with a water absorbing granules called hydrogel. This material is extremely water absorbent and has the ability to absorb hundreds of times its weight in water. Hydrated hydrogel combined with fertilizer can be placed in the planting hole just prior to plant placement. Absorbed water and fertilizer is then slowly released back into the root zone for use by the plant.
Care should be taken not to over-fertilize the plant material. If, by the determination of the Landscape Architect, some plants are burned due to over-application of the fertilizer, then all affected plant material must be replaced with in-kind immediately by the Contractor at no additional cost to the Owner.
Alan H. Jackson
Landscape Architect, LLC
Island Postal Center, 13 Bow Circle, PMB 209
Hilton Head Island, South Carolina 29928
email: Ajax16@Mac.Com / phone: 8433383017
PLANNED GRADE CONTOUR (TYP.)
CALIBOGUE SOUND
SILTATION BARRIER
HARBOUR TOWN YACHT BASIN
BW-1
BW-2
BW-3
BW-4
TIDAL CREEK (no access)
Spartina patens
Spartina alterniflora
Paspalum grass
DESERT SALTGRASS
2.0 CY OF FILL & GRADE
18th GREEN (no access)
UPLAND
CONSTRUCTION BASELINE
MARSH (no access)
18th FAIRWAY (no access)
PLANT LIST / PHASE TWO
3,300 - Ampophila breviligulata / AMERICAN BEACHGRASS @ 18" on center within existing S. patens
350 - Distichlis spicata / DESERT SALTGRASS @ 12" on center planted in existing Seashore Paspalum
1,900 - Spartina alterniflora / TALL SPARTINA GRASS @ 24" on center within existing S. patens
PLANT LIST
QUANTITY | ITEM | NOTE
175 | Borrichia / Sea Oxeye | 24" on center
7,500 | Spartina alterniflora / Tall | 24" on center
8,750 | Spartina alterniflora / Short | 24" on center
3,900 | Spartina patens | 24" on center
GRAPHIC SCALE
NOTES:
CONSTRUCTION NOTES:

Permitting

- **Significant concerns by resource and regulatory agencies**
  - **Fill in the Critical Area**
  - **Questioned success expectations**
- **No examples in the state of South Carolina**
  - **Used examples from Palm Beach County to provide agencies reasonable assurance**
- **Strict Monitoring and Mitigation Plan**

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Project Summary

- **Six shore-stabilizing structures**
  - **1,200 tons of armor rock**
  - **40 stone-filled marine mattresses**
  - **1,500 cy of grading**
  - **3,000 cy (+/-) of sand fill from upland source**
- **Grade existing material (1,500 cy) and import 2,000 cy (+/-) of sand fill from upland source to recreate marsh substrate**
- **~1.5 acres of marsh grasses (20,000+ plants)**

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August 2, 2011
olsen
associates, inc.
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August 5, 2011
olsen
associates, inc.
Coastal Engineering


August 23, 2011
olsen
associates, inc.
Coastal Engineering

September 9, 2011

olsen associates, inc.
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September 29, 2011
olsen
associates, inc.
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October 18, 2011

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November 30, 2011
olsen
associates, inc.
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December 5, 2011
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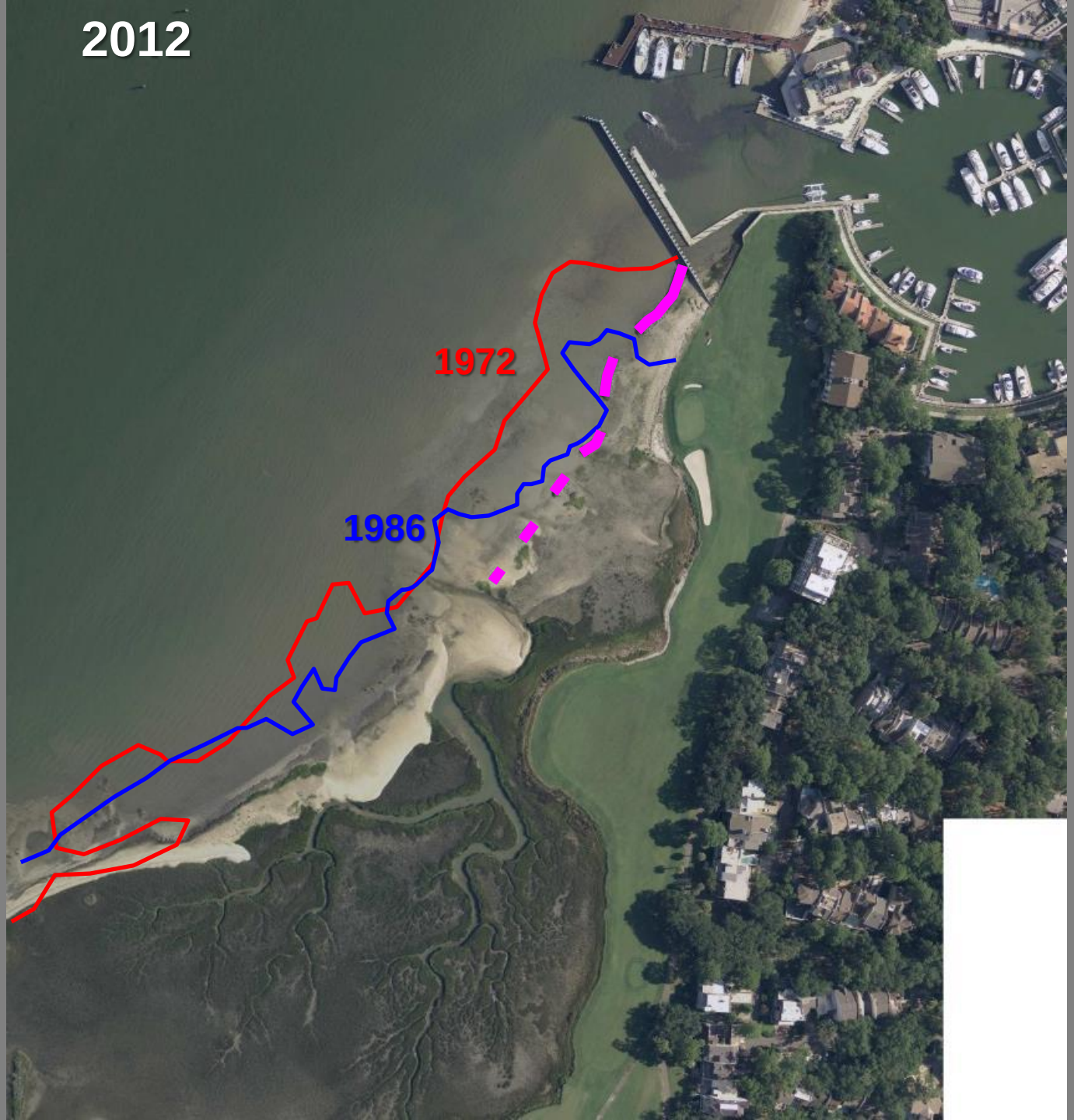

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Contractor: Cape Romain Contractors, Inc., Wando, SC

Construction Cost: $635,000.00, including planting

Pre-Project (2010)

Immediate Post-Construction (January 2012)

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Project Timeline…

2005:	**Erosion and project feasibility study**
2006-08:	**Permit acquisition period**
2008:	**State and Federal Permits are Issued.**
2008:	**Bids solicitation. Proposed prices exceed project budgets and project implementation is delayed.**
2010:	**Value Engineering study to evaluate design modification to reduce construction costs.**
2011 :	**Re-bid. 30% reduction is proposed costs relative to 2008 bids.**
2011:	**Shore-stabilizing structures and marsh grade complete.**
2012:	**Plant installation complete.**

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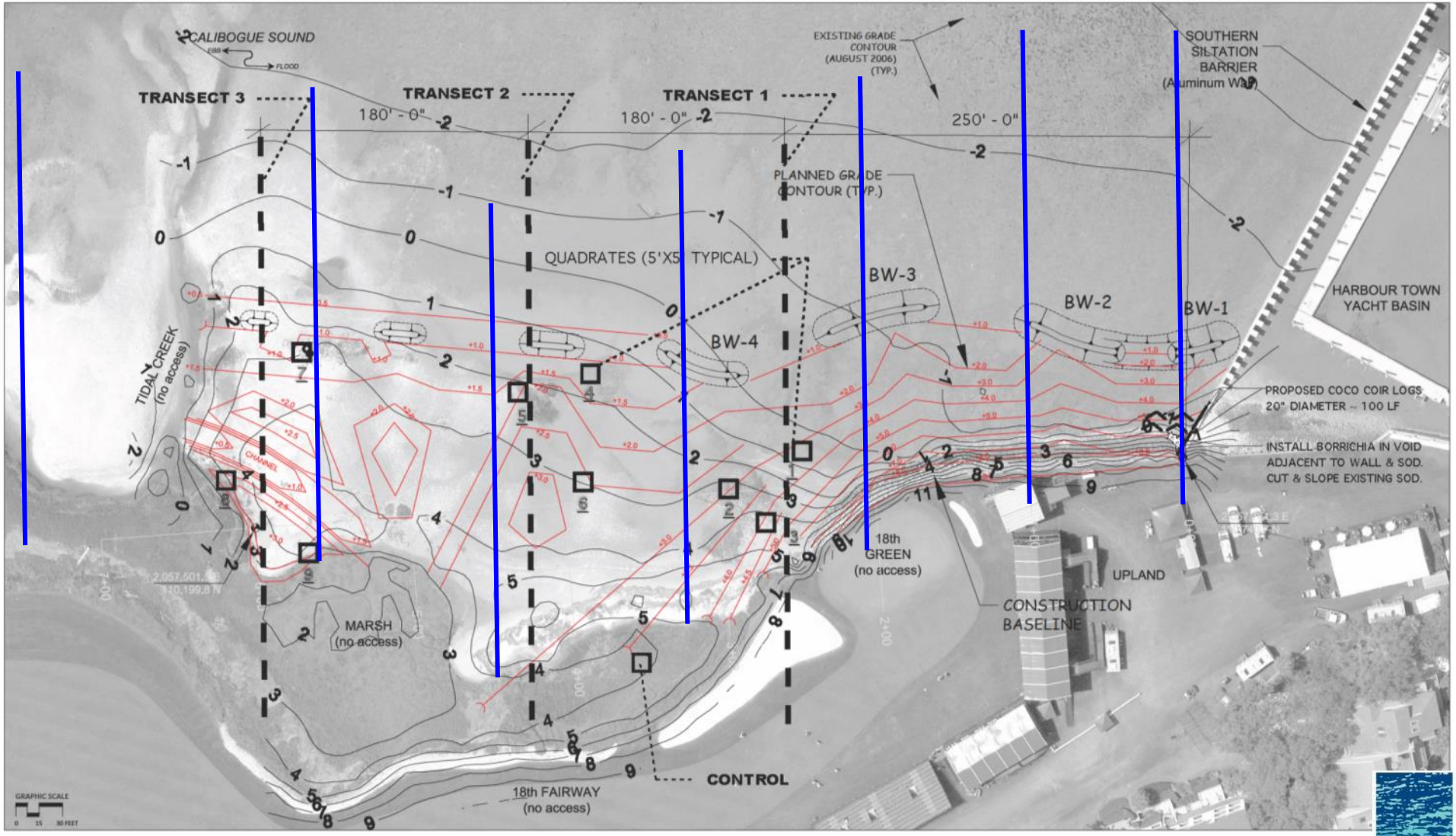
Monitoring and Performance

- **Evaluate the stability of the recreated marsh elevations and grades.**
- **Evaluate the stability of the stabilizing structures.**
- **Evaluate physical condition of the adjacent tidal creek, tidal flats and downdrift shoreline.**
- **Maintain adequate tidal flooding and drainage to facilitate marsh grass survival and development.**
- **Establish approximately 75 percent planted marsh grass plants at the end of the first 12 months.**
- **Provide marsh grass densities similar to adjacent areas within 3-5 years.**

Monitoring Plan



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October 2010
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July 2011 (Pre-construction)


November 30, 2011


December 22, 2011 (~1 month)


August 15, 2012 (~9 months)


May 7, 2014 (~30 months)


May 24, 2016 (~54 months)
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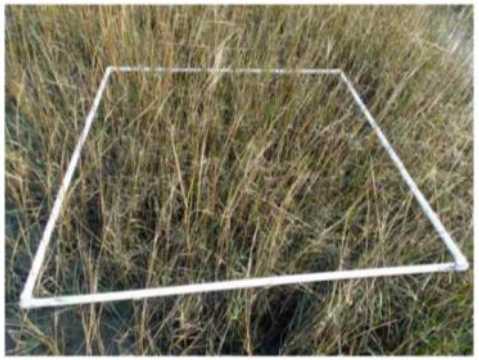
Jan. 2017 (60-months)

Plant Density

Quadrant # 7
contained accreted oyster shells
within existing Spartina density of 50%

Quadrant # 8
contained marsh periwinkles
within planted Spartina density of 100%



Quadrant # 9
contained marsh periwinkles within
existing Spartina density of 100%

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Plant Density

Biological Survey Date	Spartina Density (Percentage)									
	Transect 1			Transect 2			Transect 3			
	1	2	3	4	5	6	7	8	9	Average
September 2011 Pre-Planting	0%	50%	95%	10%	45%	0%	75%	100%	90%	52%
July 2012 6 Months Post	25%	50%	50%	10%	30%	50%	75%	100%	100%	54%
December 2012 1 Year Post	25%	50%	25%	10%	25%	10%	25%	90%	25%	32%
July 2013 1.5 Years Post	75%	25%	25%	25%	95%	5%	25%	100%	25%	44%
December 2013 2 Years Post	95%	75%	10%	25%	75%	50%	50%	95%	95%	63%
November 2014 3 Years Post	95%	100%	25%	25%	90%	90%	10%	100%	100%	71%
December 2015 4 Years Post	75%	90%	95%	50%	60%	90%	50%	100%	100%	79%

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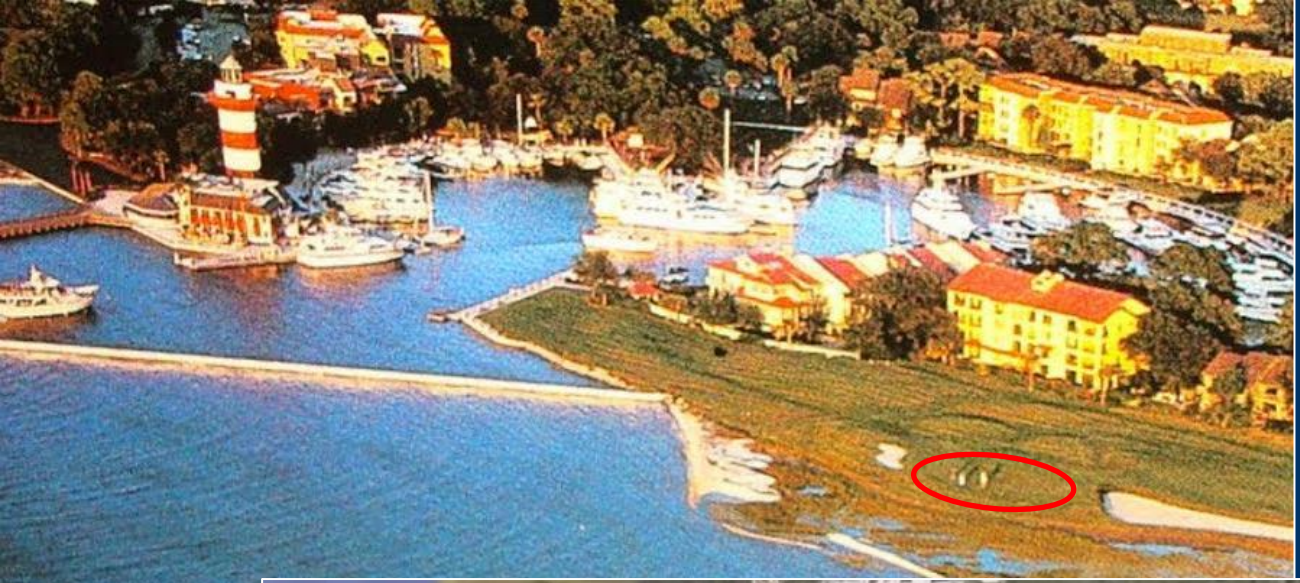
Monitoring and Performance

- No measurable change to marsh elevations and grades
- No change to stabilizing structures
- Tidal creek and downdrift shoreline have continued to evolve
- Tidal flooding and drainage to marsh area remains unconstrained
- 90 percent marsh grass survival at 12 months
- Average grass densities in restored are similar to adjacent areas
- Only notable area with poor grass survival is within 75 feet of siltation barrier


2015
Hurricane Matthew

October 2016 (Post-Matthew)



~1990

2016 (Post-Matthew)

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