Innovative Living Shoreline Practices in Maryland

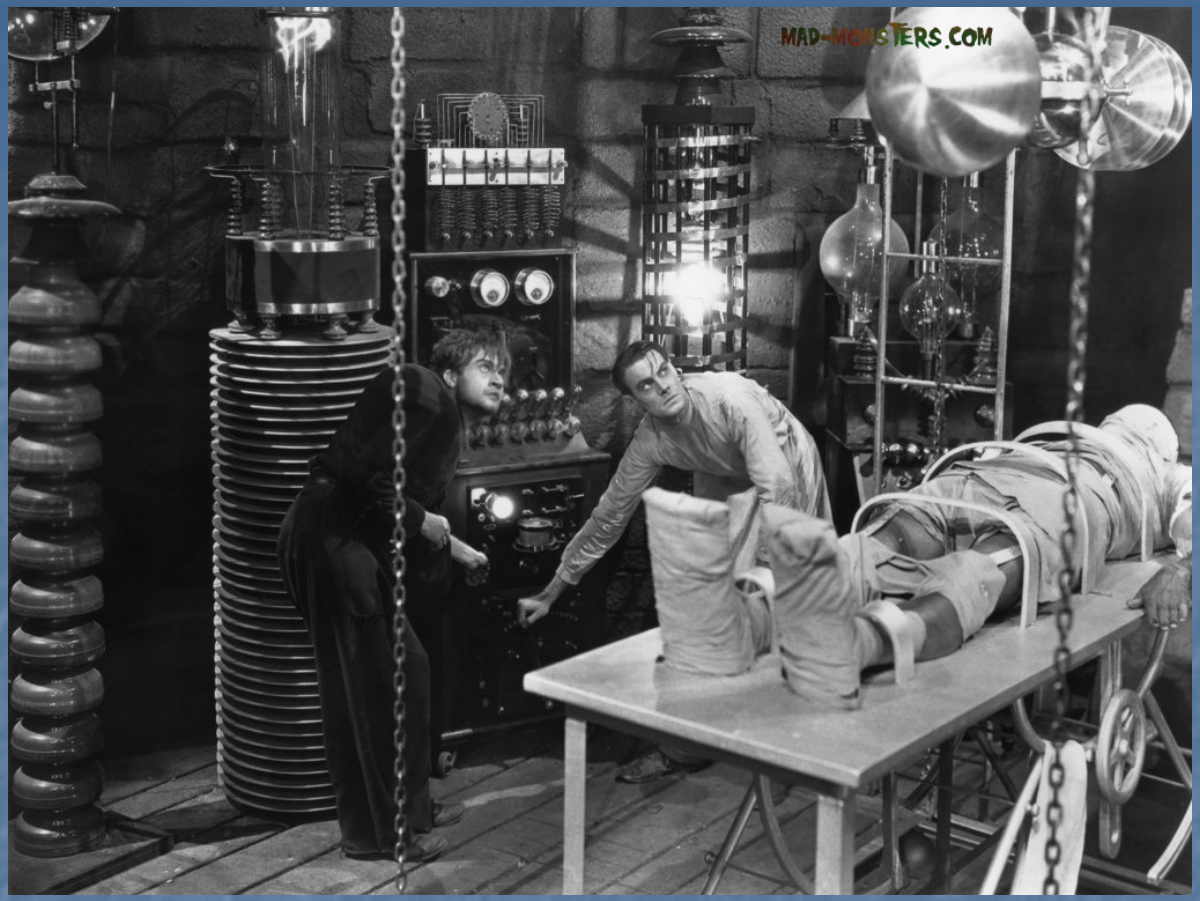
Evolving Living Shorelines: Techniques and Performance

Living Shoreline Summit
Cambridge, Maryland
December 10th, 2013

Albert McCullough
Sustainable Science LLC

Fundamental Design Questions

- Where has the shoreline been?
- Where is the shoreline now?
- Where should the shoreline go?



What are the living shoreline design factors?

- *PAST LIFE:* Historical shoreline erosion rate & trend
- *SKELETON:* Structure geometry, orientation & location from shore
- *FLESH:* Planting substrate, vegetation type & tolerance
- *ENERGY:* Wave height, period and approach angle

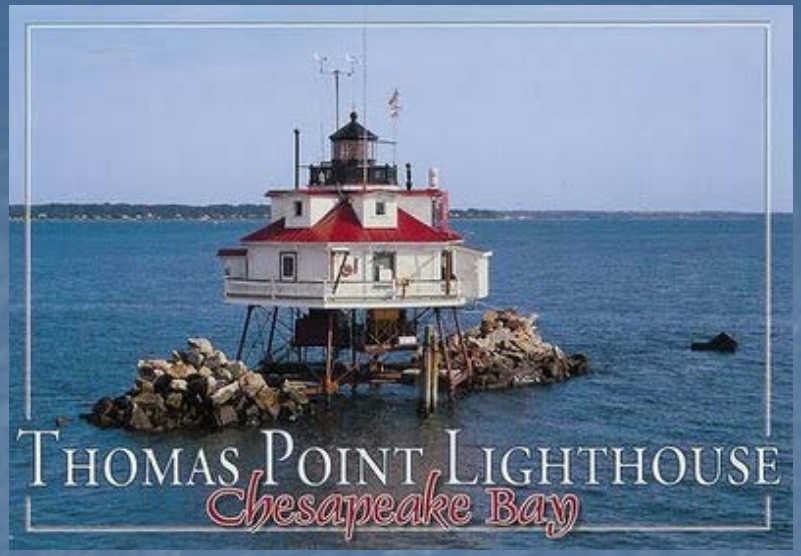
Nature's Coastal Protection & Man's Counterparts

Nature	Man
Shore rock	Armored shore
Oyster reef	Submerged breakwater
Bay island	Offshore breakwater
Rock headland	Headland breakwater
Rock perpendicular to shore	Groin
Submerged aquatic vegetation	Bottom mattresses
Floating aquatic vegetation	Floating breakwater
Dune	Dike
Material transfer to shore by: -Wind drift -Rivers -Shore erosion -Longshore littoral drift -Sea bottom transfer	Artificial nourishment from land sources
Natural by-passing of drift at tidal inlets	Artificial nourishment from offshore sources or mechanical by-passing of drift at tidal entrances

Most Commonly Applied Nature Counterpart Practice

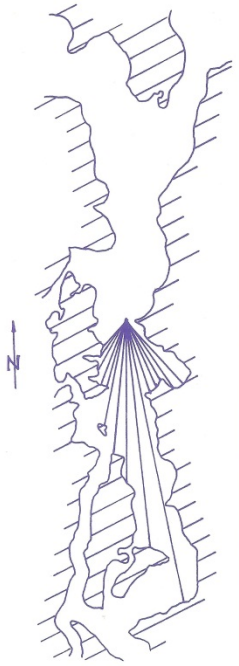
Waves *(Thy Friend & Hopefully Not Foe)*

- Wind generated defined by wind duration, speed and direction over open water
- Boat generated waves dependent upon hull shape, vessel displacement, speed and direction



- Wind records from Thomas Point Lighthouse
- Wave prediction using limited open water method
- NW Winter Winds & S Summer Winds

US Army Corps of Engineers



COASTAL ENGINEERING RESEARCH CENTER

MISCELLANEOUS PAPER CERC-91-2

WIND-WAVE GENERATION ON RESTRICTED FETCHES

by

Jane M. Smith

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

May 1991
Final Report

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Under Work Unit 31592

Boat Wake Wave Analysis

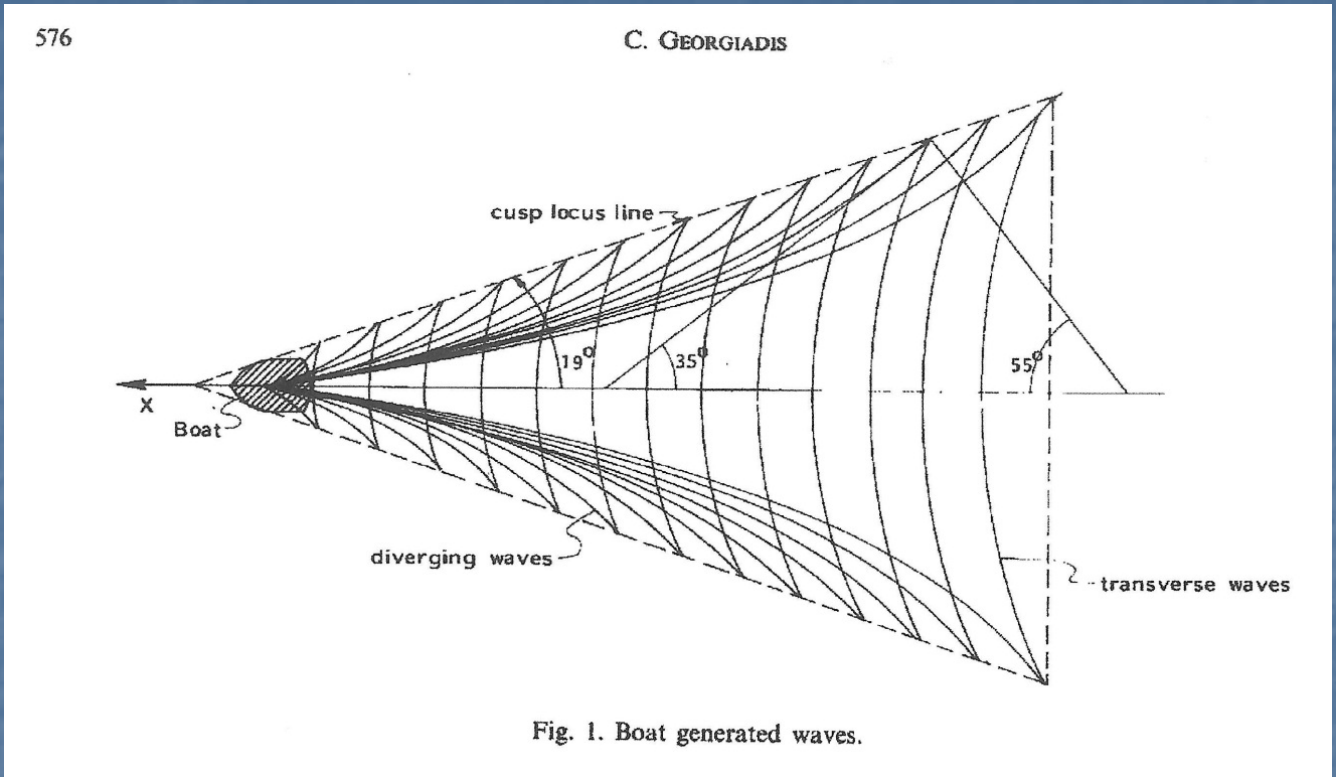


Fig. 1. Boat generated waves.

- Fully developed boat wake waves propagate 35 degrees from boat centerline
- Use straight line between channel markers
- For errant boaters use four (4) shoreline wave approach conditions namely 25 & 45 degree to port & to bay

Wave Transformation

- Waves behave similar to light by diffracting, refracting and reflecting when encountering an object

Stable Bay Wave Crest Relation

EM 1110-2-1100 (Part V)
31 Jul 2003

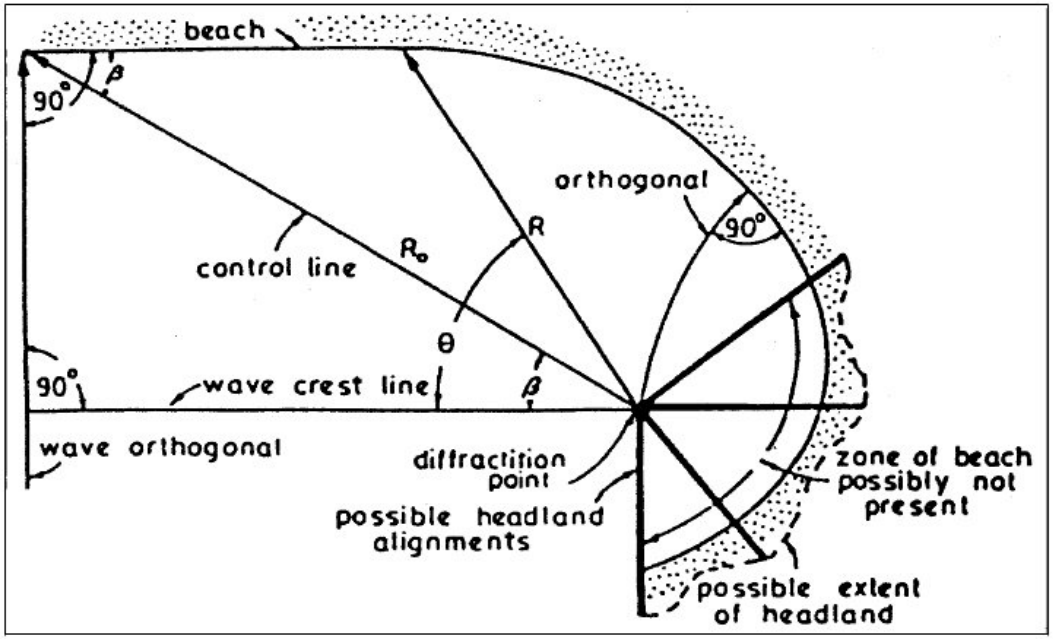


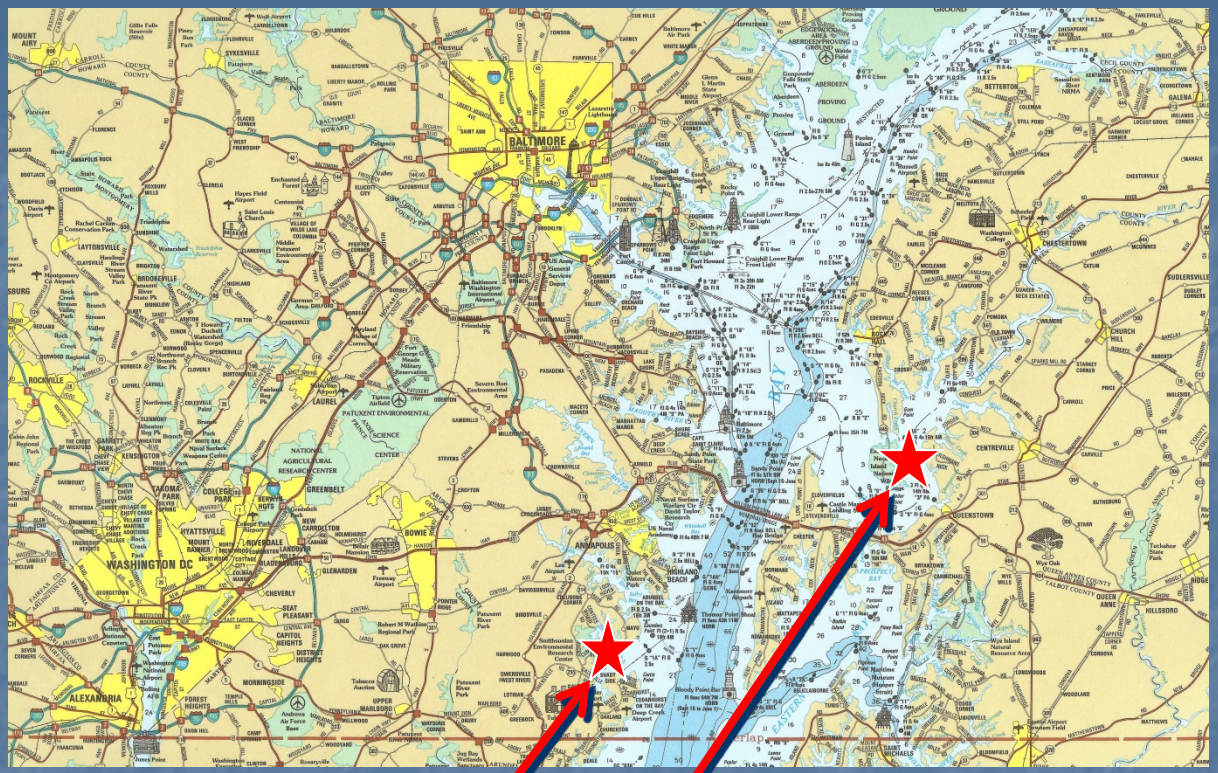
Figure V-3-13. Definition sketch of parabolic model for planform shape

Y	Distance of breakwater from nourished shoreline
Y_{min}	Minimum distance from base (reference) line to mhw shoreline after design storm event
B	Minimum beach width at mhw after nourishment
W	Width of design beach nourishment
Z_s	Backshore elevation at baseline
F_B	Breakwater freeboard, mhw to crest
Q_{net}	Net longshore sediment transport rate
Q_{gross}	Gross longshore sediment transport rate
$Q_{offshore}$	Offshore sediment transport rate for design storm

What Does The Present Shoreline Tell Us?

- Areas of shoaling and erosion provide clues to correlate with long term trends
- Does it line up with design predictions?
- Each shoreline has a unique story!

A TALE OF TWO LIVING SHORELINES



SERC Living Shoreline

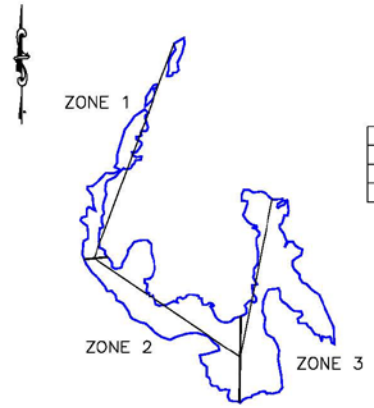
- Located at Smithsonian Environmental Research Center
- Shoreline Length = 3,850 ft.
- Longest Fetch = 14.5 mi. NE

ENNWR Living Shoreline

- Located at Eastern Neck National Wildlife Refuge
- Shoreline Length = 3,180 ft.
- Longest Fetch = 6.1 mi. NNE

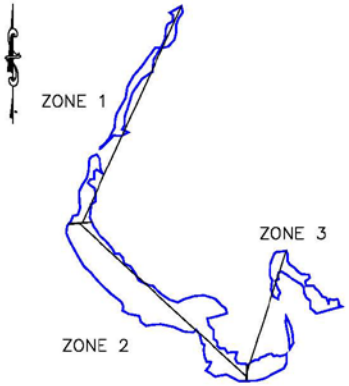
ENNWR Living Shoreline Project

- Within the National Wildlife Refuge is Hail Cove which separates the Chester River from Hail Creek (regarded as one of the five best waterfowl habitats in Maryland) by a narrow isthmus .
- Aerial surveys over 10 years before project was constructed revealed the isthmus actively eroding.
- Main project goal was to prevent breaching of Hail Cove to preserve the Hail Creek submerged aquatic vegetation that is so critical to migratory waterfowl.



ZONE	LENGTH (ft)	AREA (ac)	AVE. WIDTH (ft)	RECESSION RATE (ft/yr)
1	724 ft.	0.62 ac.	37.5 ft.	5.4 ft./yr.
2	557 ft.	1.67 ac.	130.3 ft.	18.6 ft./yr.
3	509 ft.	1.91 ac.	163.2 ft.	23.3 ft./yr.
	TOTAL:	4.20 ac.		
	LOSS PER YEAR:	0.60 ac.		

1957 to 1964 Shoreline Recession



ZONE	LENGTH (ft)	AREA (ac)	AVE. WIDTH (ft)	RECESSION RATE (ft/yr)
1	753 ft.	0.45 ac.	25.8 ft.	1.0 ft./yr.
2	717 ft.	1.56 ac.	94.9 ft.	3.8 ft./yr.
3	404 ft.	0.48 ac.	51.5 ft.	2.1 ft./yr.
	TOTAL:	2.49 ac.		
	LOSS PER YEAR:	0.10 ac.		

1964 to 1989 Shoreline Recession

COVE SHORELINE RECESSION EVALUATION

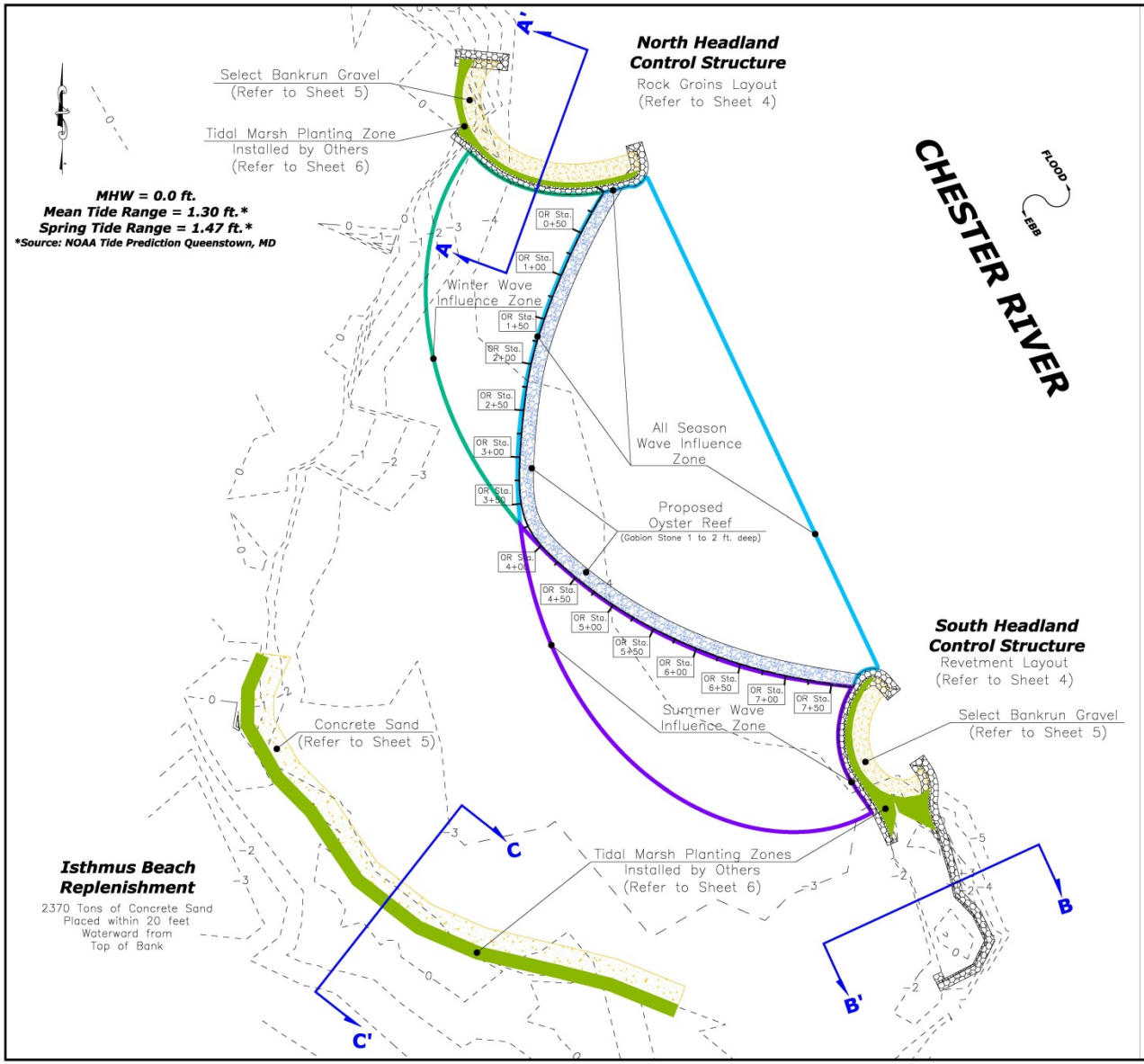
Hail Point Living Shoreline Project
Eastern Neck National Wildlife Refuge

Kent County, Maryland

SUSTAINABLE SCIENCE LLC
Ecological Engineering Services
410 S. Second Street
Denton, Maryland 21629
Phone: (410) 924-4316
www.sustainablescience.com

SCALE:	1 inch = 400 feet
DRAWN BY:	A. McCullough
DATE:	January 24th, 2009
LAST REVISION:	NONE
SS PROJECT NO:	08006
SHEET NUMBER	1 OF 1

Living Shoreline Design



CONSTRUCTION SEQUENCE:

1) Notify Mr. Jonathan Priday of U.S. Fish & Wildlife Service Eastern Neck National Wildlife Service two (2) weeks prior to site mobilization @ (410) 639-7056.

2) Notify Mr. John Smack of Vulcan Materials two (2) weeks before site mobilization @ (410) 459-3598 to coordinate revetment material delivery.

3) Mobilize construction equipment & materials to the project site.

4) Place concrete sand in Isthmus Beach Replenishment in accordance with plans and specifications.

5) Construct North & South Headland Control Structure revetment in accordance with plans and specifications.

6) Place oyster reef stone in accordance with plans and specifications.

7) Place washed bankrun gravel within North & South Headland Control Structures in accordance with plans and specifications.

8) Demobilize construction equipment & clean project area.

9) Allow a minimum of two (2) weeks of tidal influence after placement of beach materials to adjust headland and isthmus beaches.

10) Plant areas (by others) in accordance with plans & specifications. No planting shall be performed until all construction activities have been completed & demobilized.

OYSTER REEF LAYOUT (OR): 15 ft. Wide by 1.5 ft. Deep

OR Sta. No.	Landward Northing (feet)	Landward Easting (feet)
0+00	494,374.01	1,538,055.82
0+25	494,352.57	1,538,042.98
0+50	494,330.51	1,538,031.23
0+75	494,308.03	1,538,020.28
1+00	494,285.21	1,538,010.10
1+25	494,262.06	1,538,000.65
1+50	494,238.62	1,537,991.95
1+75	494,214.87	1,537,984.16
2+00	494,190.70	1,537,977.82
2+25	494,166.12	1,537,973.26
2+50	494,141.34	1,537,969.97
2+75	494,116.46	1,537,967.53
3+00	494,091.52	1,537,965.86
3+25	494,066.53	1,537,965.30
3+50	494,041.63	1,537,967.20
3+75	494,017.86	1,537,974.58
4+00	493,997.30	1,537,988.68
4+25	493,979.67	1,538,006.38
4+50	493,963.38	1,538,025.34
4+75	493,948.09	1,538,045.11
5+00	493,933.83	1,538,065.64
5+25	493,920.66	1,538,086.89
5+50	493,908.61	1,538,108.79
5+75	493,897.60	1,538,131.23
6+00	493,887.64	1,538,154.16
6+25	493,878.70	1,538,177.50
6+50	493,870.81	1,538,201.22
6+75	493,864.03	1,538,225.29
7+00	493,858.40	1,538,249.64
7+25	493,853.57	1,538,274.17
7+50	493,849.13	1,538,298.78
7+72	493,846.09	1,538,320.39

NOTES:
1) Northing and Easting values relate to Maryland State Plane Coordinate System (feet).

2) Select bankrun gravel shall have less than ten percent (10%) passing No. 100 sieve by weight. Material gradation to be approved prior to project delivery.

3) Revetment layouts provided on Sheet 4 with cross-sections shown on Sheet 5.

DATE:	February 28th, 2009	SCALE: 1 inch = 50 feet
REVISION DATE:	April 16th, 2009	DESIGN BY: A. McCullough
REVISION TYPE:	Revised oyster reef	DRAWN BY: A. McCullough
REVISION DATE:	April 20th, 2009	CHECKED BY: A. McCullough
REVISION TYPE:	Oyster reef layout	SS PROJECT NO: 08008
REVISION DATE:	NONE	SHEET NUMBER: 3 OF 6
REVISION TYPE:		

SUSTAINABLE SCIENCE LLC
Ecological Engineering Services
#105 Second Street
Denton, Maryland 21629
Phone: 410-479-1446
www.sustainablescience.com

HAIL COVE LIVING SHORELINE PLAN

Hail Cove Living Shoreline Project
Eastern Neck National Wildlife Refuge
1730 Eastern Neck Road
Kent County, Maryland

Living Shoreline Construction

- Construction from 3rd week of July to 3rd week in August, 2009
- Planted in 2nd week of September, 2009

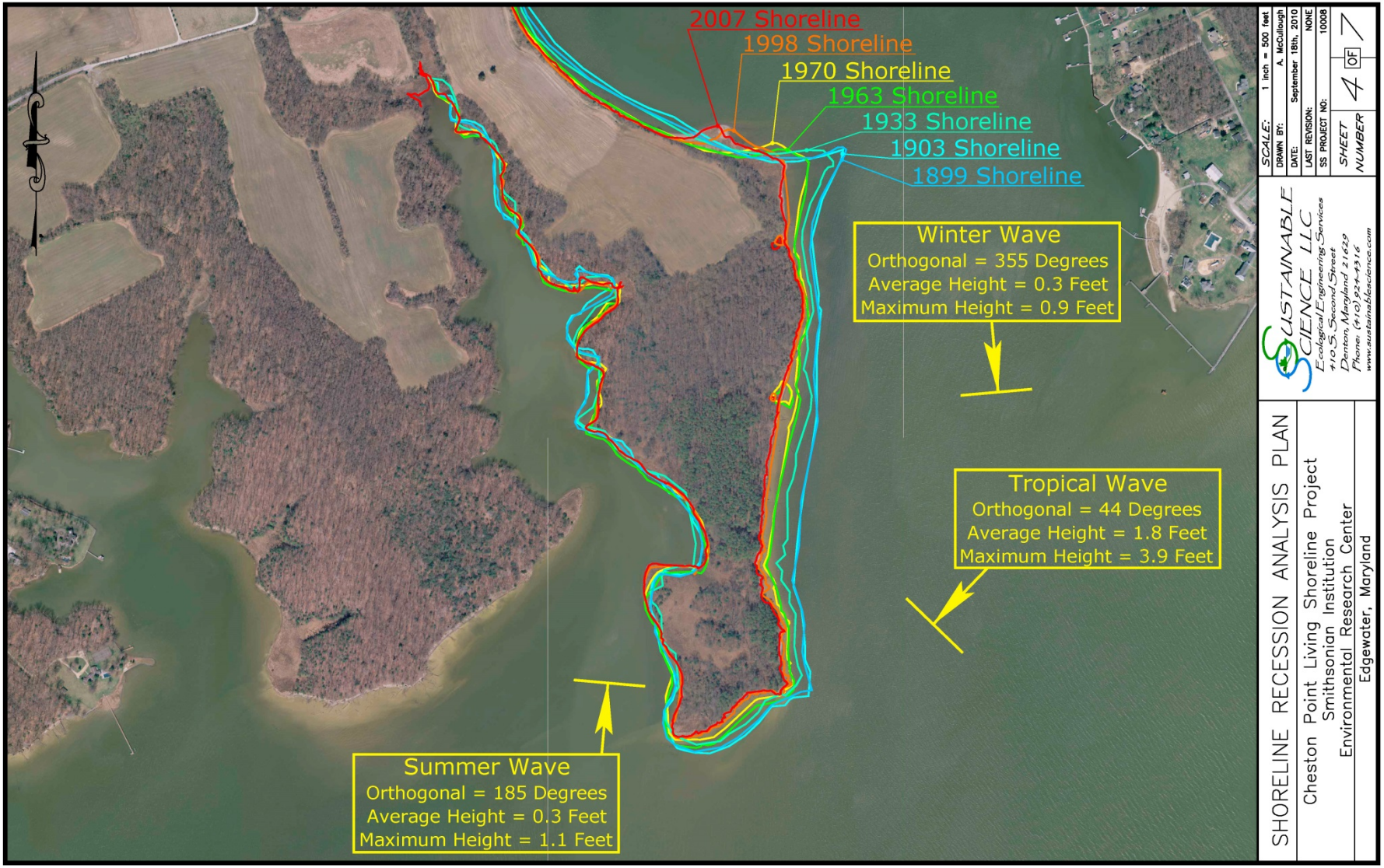
Hail Cove Living Shoreline Lessons Learned

- Stable beach shape lined up well with design prediction
- Reef extensively colonized with mussels & oysters (initially seeded)
- Diversity of fish species increased with SAV colonized behind the island
- Planting executed too early with some replanting required
- Total construction cost $445K for 3,180 feet of shoreline protected equating to $140 per linear foot

SERC Living Shoreline Design Process

- Step 1: Perform historical shoreline recession analysis to identify erosion rates & trends
- Step 2: Execute wind wave analysis to determine stable bay shapes and compare to historical shoreline erosion
- Step 3: If comparison correlates well use stable bay method. If poor correlation use Hardaway method (1.65 opening to 1.0 embayment radius ratio).

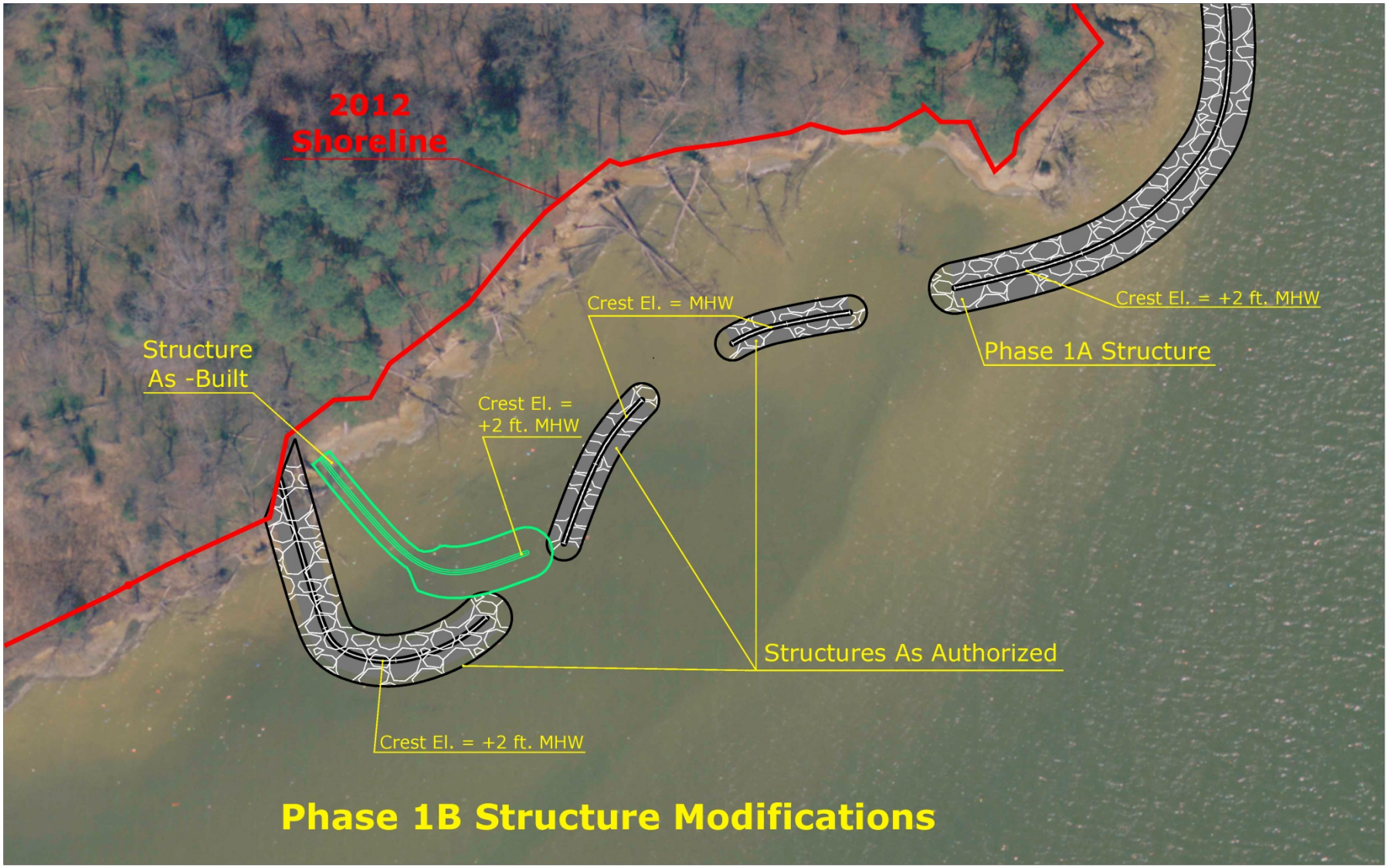
SERC Shoreline Predicted Vs. Observed Perplexion



SERC Living Shoreline Construction

- Project divided into two (2) phases with first phase subdivided into three sections & prioritized
- Phase 1A construction commenced on 5/6/12 with placed materials trended to determine what could potentially be built for Phase 1B
- Boat wake wave analysis completed by 5/9/12 to determine how stable the Phase 1B cove would be without any middle structures
- After Phase 1A was completed, the remaining sand & rock for Phase 1B revealed that only a revised end rock structure to contain the remaining sand could be constructed

Boat Wake Wave Results



SERC Living Shoreline Lessons Learned

- Western shorelines more boat wave dominated then by wind
- Measured shoreline lines up well with stable embayment boat wake wave prediction
- Top of sand bank becoming colonized by seed rain from adjacent trees.
- Total construction cost $637K for 1,100 feet of shoreline protected equating to $579 per linear foot

Thanks!

Albert McCullough
(410) 924-4316
albert@sustainablescience.com