Breakwater Approach to Living Shoreline Projects

Living Shoreline Professionals' Workshop
February 22nd, 2010

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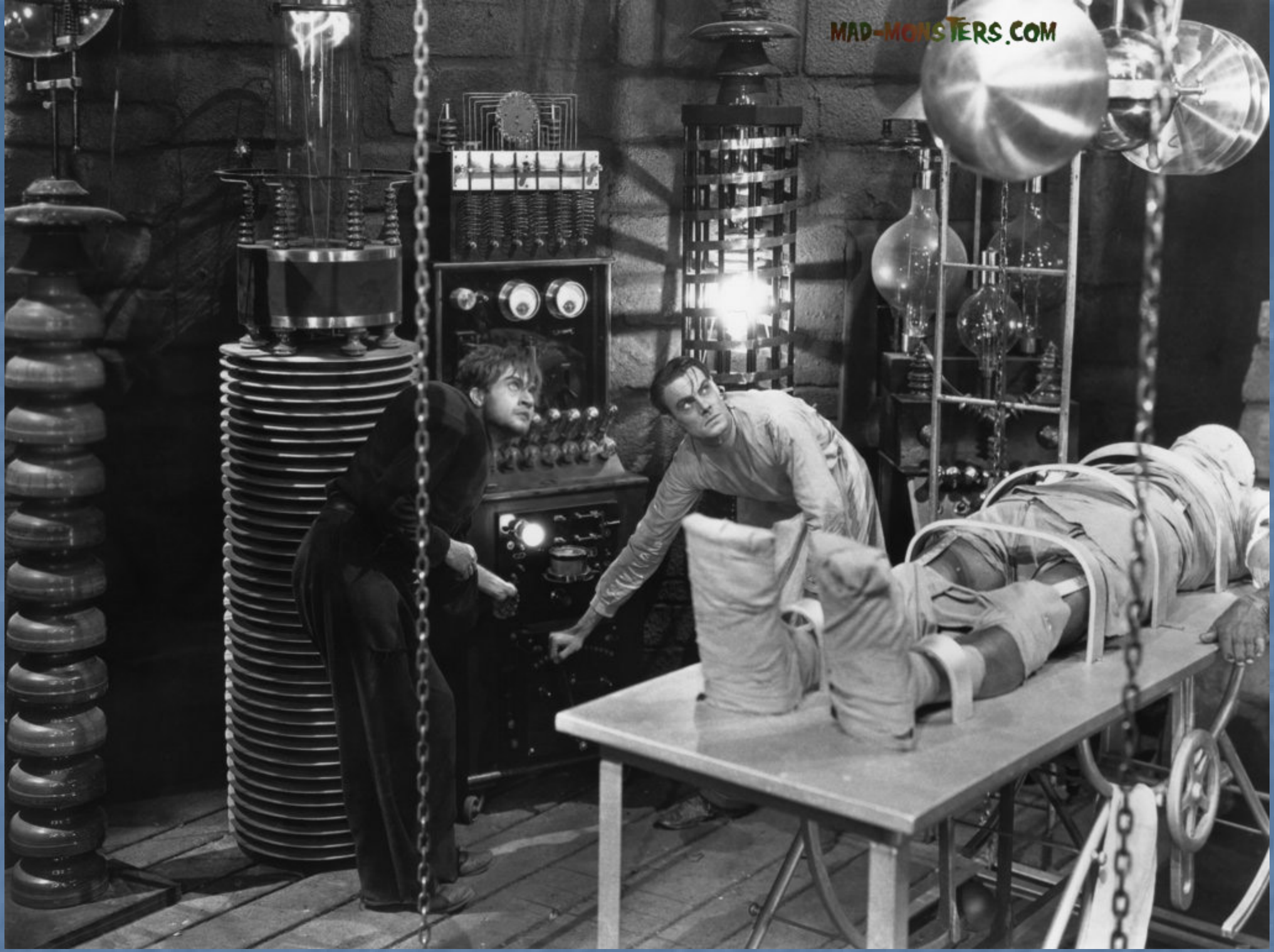
Sustainable Science LLC

Nature's Coastal Protection & Man's Counterparts

Nature	Man
Shore rock	Armored shore
Rock reef	Submerged breakwater
Rock island	Offshore breakwater
Rock headland	Headland breakwater
Rock perpendicular to shore	Groin
Sea floor vegetation	Bottom mattresses
Sea surface 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



What are the breakwater design factors?

- Wave height, period and approach angle
- Structure height, orientation & location from shore
- Historical shoreline recession trend & direction
- Vegetation type, tolerance and elevation range

Waves

- Prediction began in World War II to predict conditions for beach landings
  - Initial USA work by Sverdrup and Munk on significant wave height & period with initial England work by Longuet-Higgins on harmonic analysis
- Dependent on wind duration, speed and direction over open water

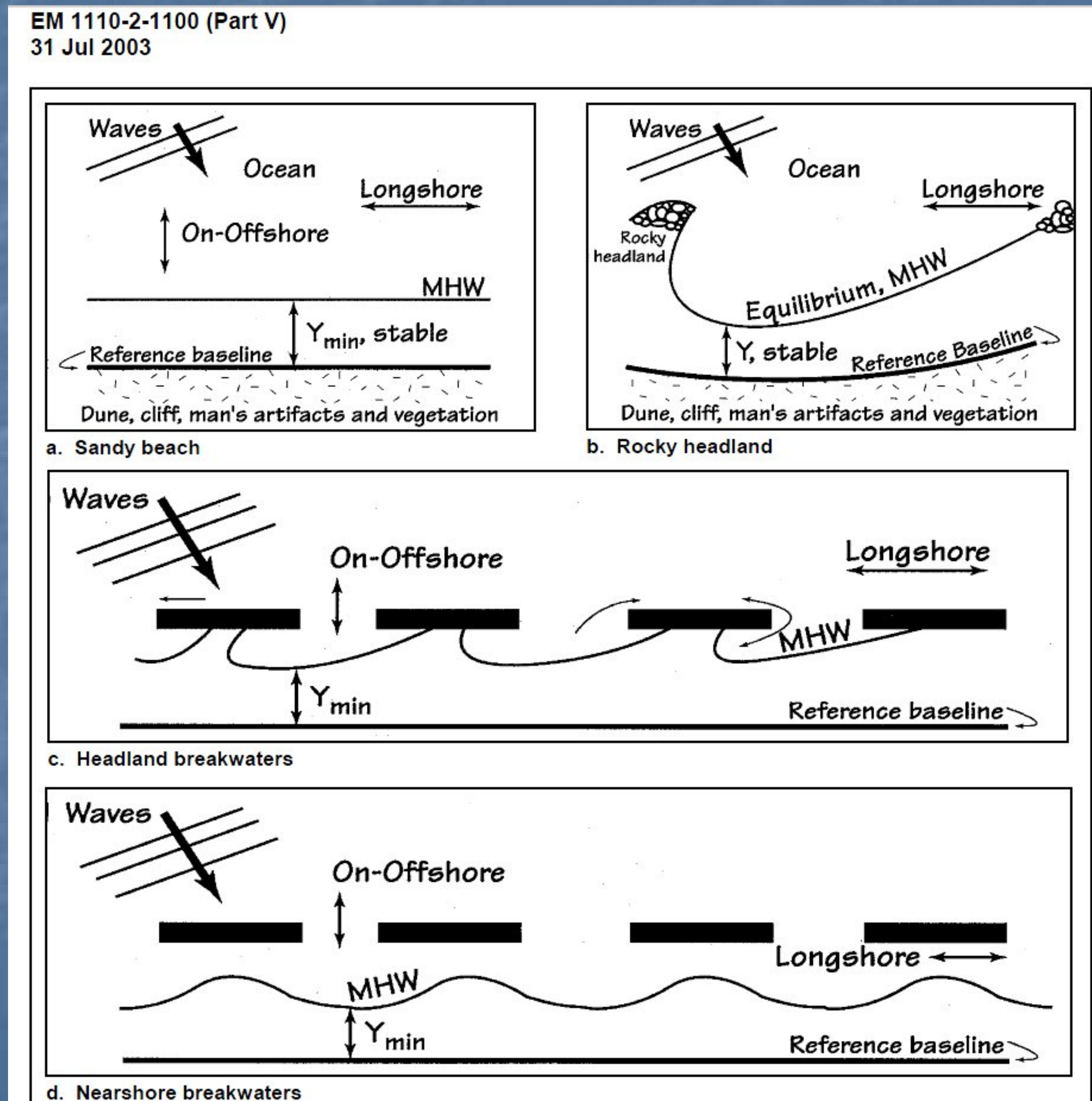
Wave Generation & Prediction

- Dependent upon prevailing winds over open water
- Due to irregular shoreline & seasonal variation each project has a unique wave climate that needs to be analyzed

Wave Transformation

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

Breakwater Types



Predicting Stable Bay Shape

- Stable beaches with rocky headlands have been used to predict bay shape versus wave climate

Parabolic Bay Relation

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

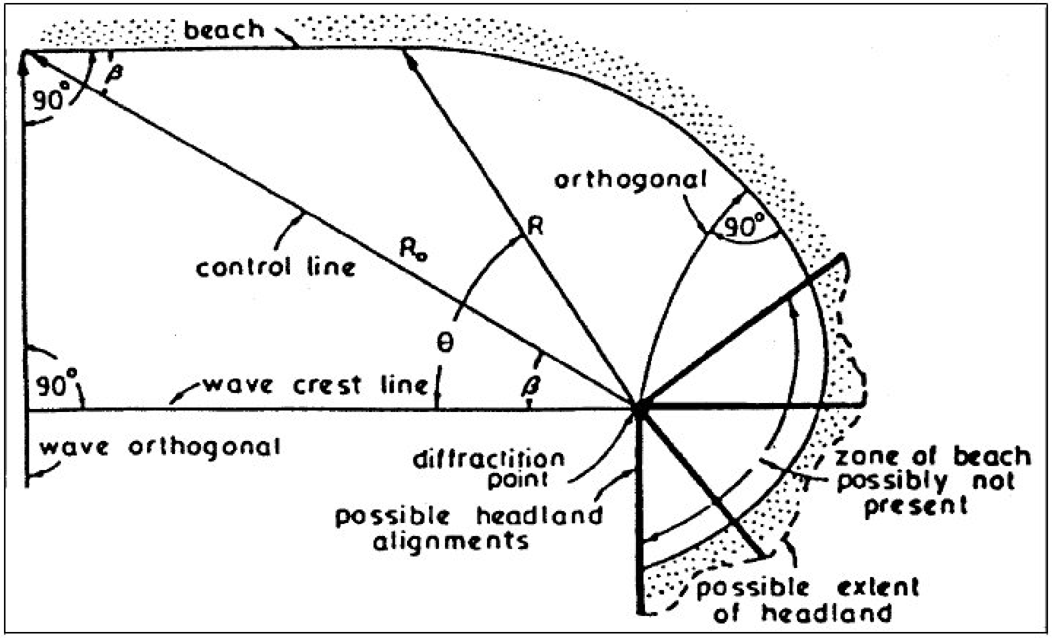


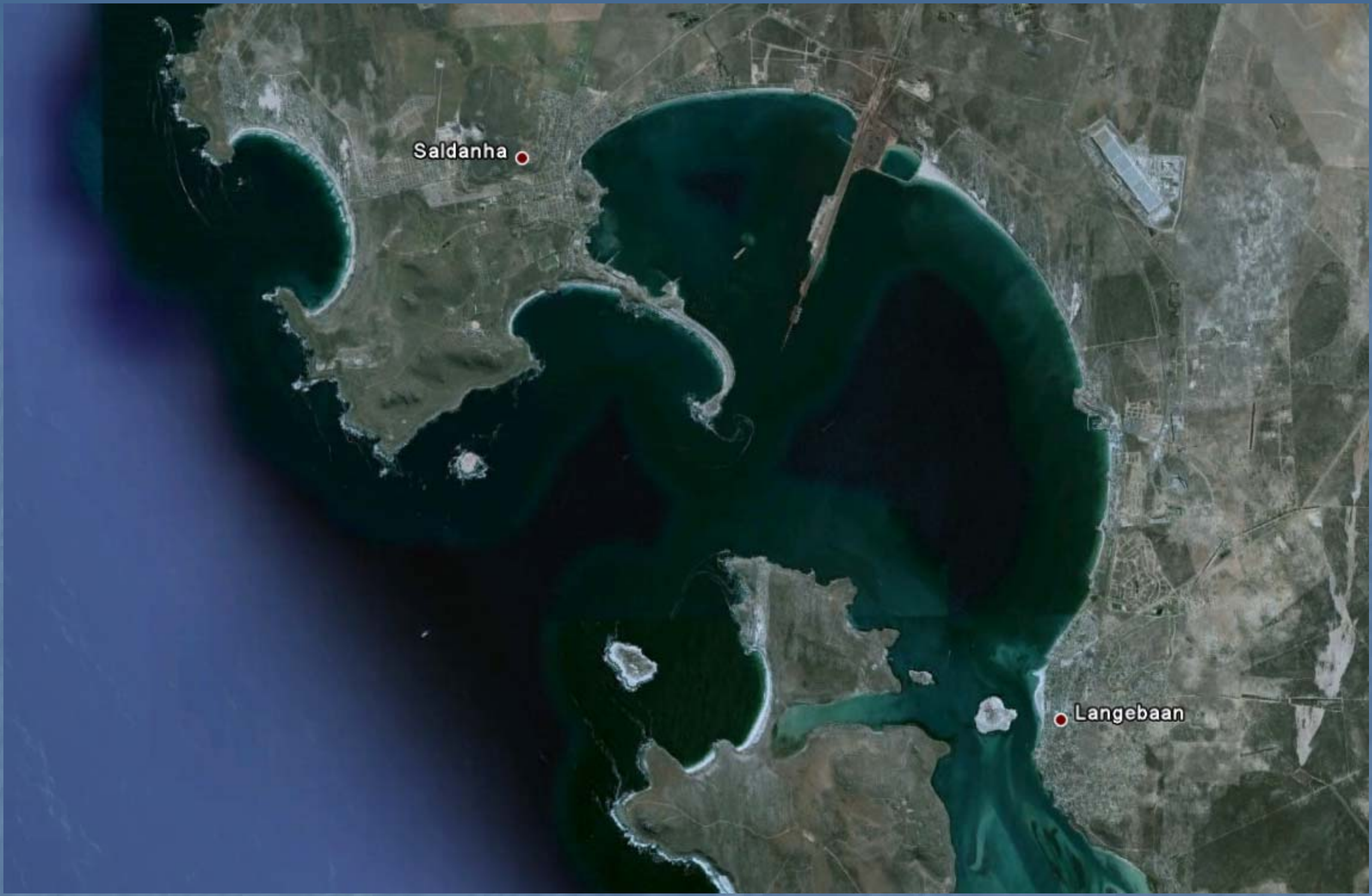
Figure V-3-13. Definition sketch of parabolic model for planform shape

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

Chesapeake Bay Shorelines

Singapore Headland Breakwaters

- Headland breakwaters used since 1970's for shore protection
- Early 2000's used to join two islands, Pulau Seringat (north) and Pulau Sakijang Pelepah (south).
- Predominant waves from South China Sea arriving from the east



South Africa Sand Breakwater

- Barrier beach breakwater used to protect ore handling facility in Saldanha Bay by connecting with Marcus Island
- Waves with periods 10 to 18 seconds from SSW were used to predict final refracted shape

Toronto, Canada Beach Headland Control

- Project to provide recreation and marina & port shelter areas
- Major wave input is from the east
- Project cost less than half of armored shoreline

Vegetation

- Similar in type, elevation and composition from adjacent shoreline
- Shore aspect and physical setting important
- Reference areas used to determine design guidelines
- In other words, beach zones should have beach vegetation (S. patens & A. breviligulata) with back of dune marsh with typical marsh vegetation (S. alterniflora)

Required Base Design Information

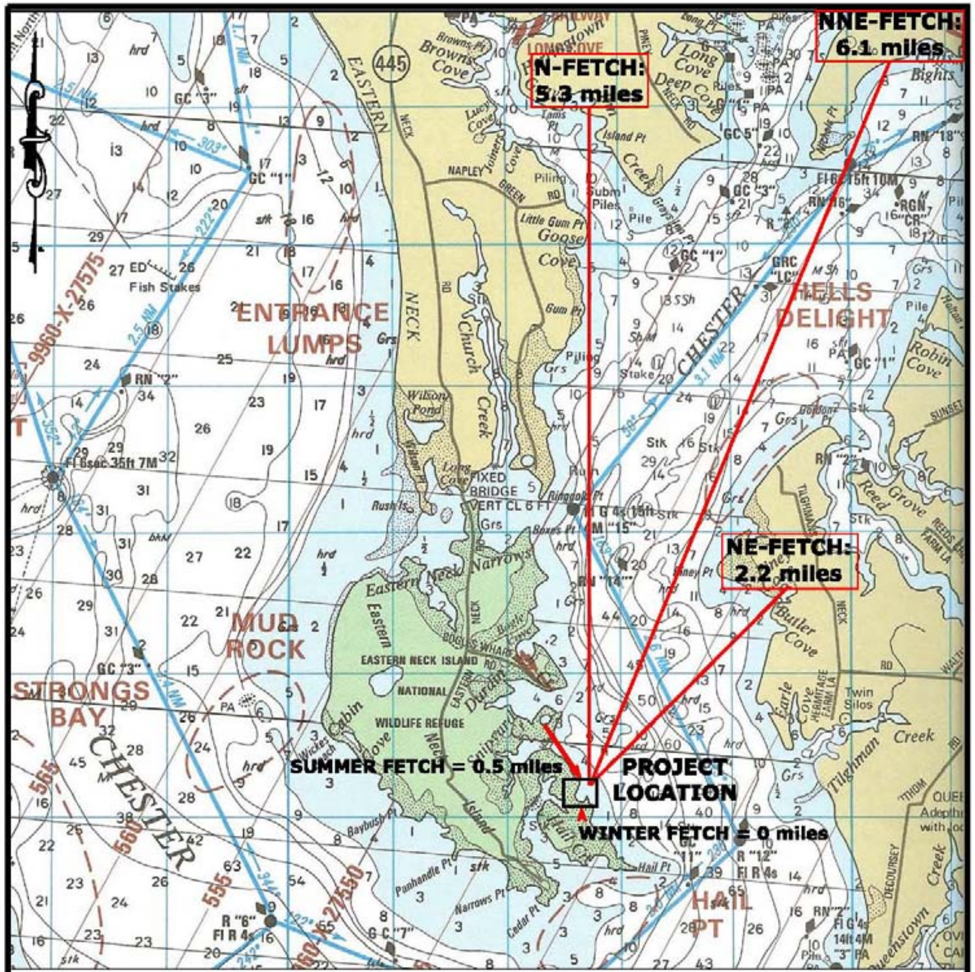
- Historical maps and aerial photography
- Navigation charts
- Long-term wind records
- Nearshore bathymetry & topography (1 ft. contours)
- Reference marsh survey
- Strong coffee & Visine

Project Cost Estimates

Item No.	*Description*	*Weight (tons)*	*Spartina Plant Plugs (no.)*	*Unit Cost ($)*	
1	*Mobilization*				
2	*Sediment & Erosion Control*				
3	*Rip Rap Placement*				
4	*Concrete Sand Placement*				
5	*Landscape Planting*				
6	*Goose Fencing*				
7	*Site Clean Up & Demobilization*				
				Subtotal Cost:	
				10% Contigency	
				10% Administration	
				Subtotal Cost:	

Hail Cove Living Shoreline Project

- The Hail Cove Living Shoreline Project, is located at Eastern Neck National Wildlife Refuge in Kent County, Maryland
- Eastern Neck National Wildlife Refuge is a 2,286-acre stopover area for migratory and wintering waterfowl at the mouth of the Chester River on Maryland's Eastern Shore.
- Within Eastern Neck is Hail Cove which separates the Chester River and Hail Creek. Hail Cove is regarded as one of the five best waterfowl habitats in Maryland.
- Aerial surveys over the past 10 years revealed the importance of protecting Hail Creek from damaging erosion due to prevailing winds.
- Protecting Hail Cove will preserve submerged aquatic vegetation that is so critical to migratory waterfowl.

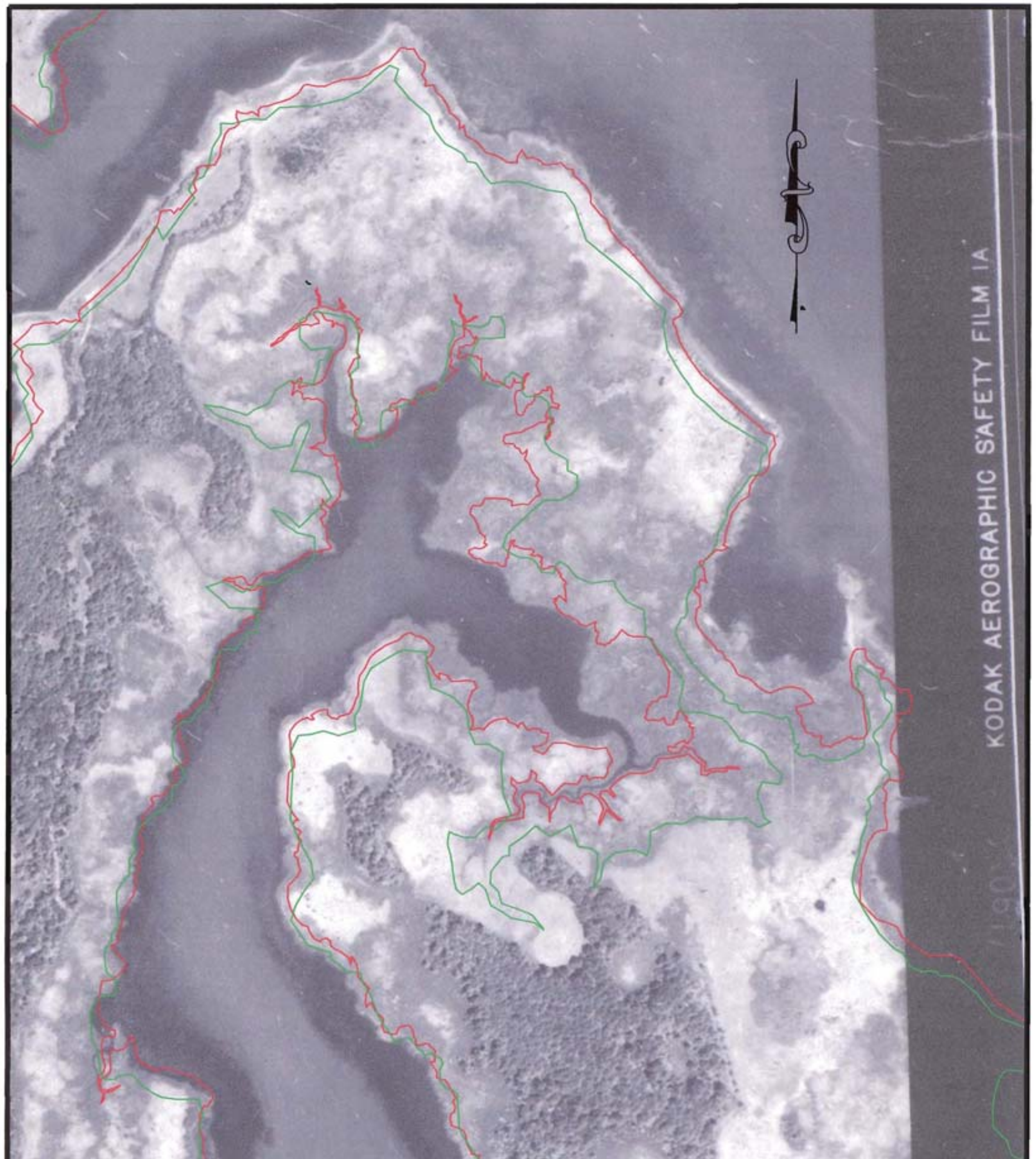


NOTES:

1) Base map obtained from navigation chart entitled Chart 4; Chesapeake Bay; Maryland & Virginia Chartbook by ADC The Map People dated 1998.

2) Fetch and wind direction analysis performed by Sustainable Science LLC.

VICINITY MAP	SUSTAINABLE SCIENCE LLC	SCALE:	1 inch = 1 mile
Hail Point Living Shoreline Project Eastern Neck National Wildlife Refuge 1730 Eastern Neck Road	Ecological Engineering Services 410 S. Second Street Denton, Maryland 21629 Phone: (410) 924-4316 www.sustainablescience.com	DRAWN BY:	A. McCullough
		DATE:	July 14th, 2008
		LAST REVISION:	NONE
		SS PROJECT NO:	08008
Kent County, Maryland		SHEET NUMBER	1 OF 4



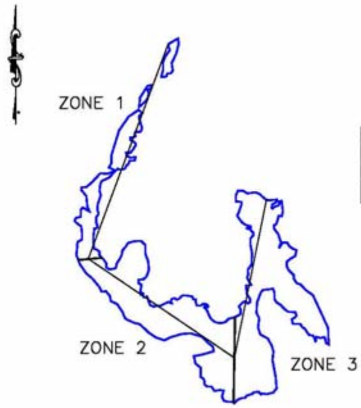
1957 AERIAL & 1964/1989 SHORELINES

Hail Point Living Shoreline Project
Eastern Neck National Wildlife Refuge

Kent County, Maryland

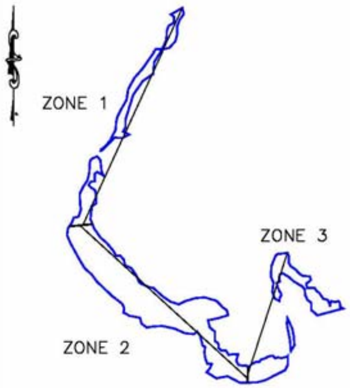
SUSTAINABLE SCIENCE LLC
Ecological Engineering Services
410 S. Second Street
Denton, Maryland 21629
Phone: (410) 924-4316
www.sustainablescience.com

SCALE:	1 inch = 500 feet
DRAWN BY:	A. McCullough
DATE:	January 23rd, 2009
LAST REVISION:	NONE
SS PROJECT NO:	08006
SHEET NUMBER	1 OF 7



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

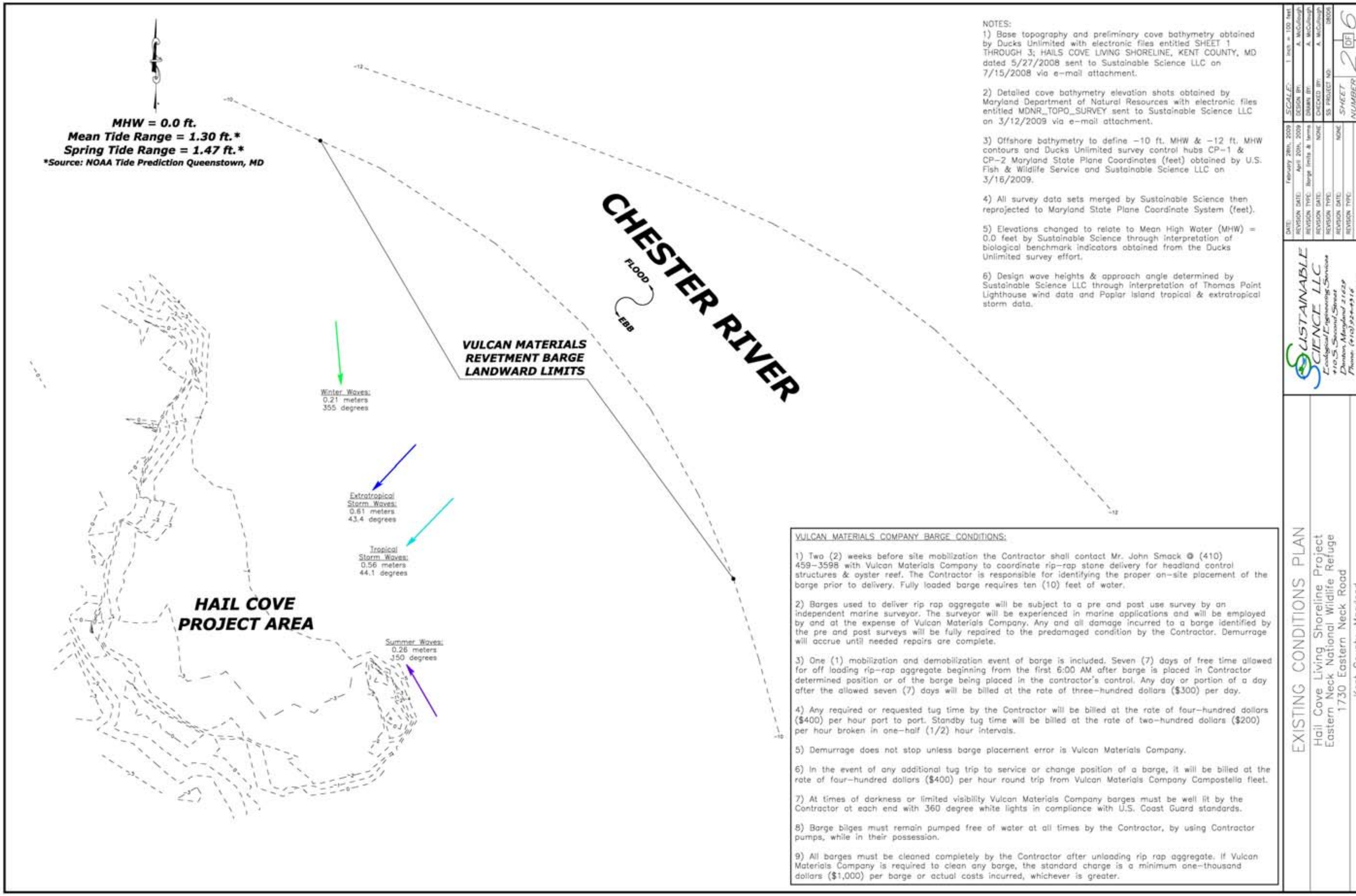
Hail Point Living Shoreline Project
Eastern Neck National Wildlife Refuge

Kent County, Maryland

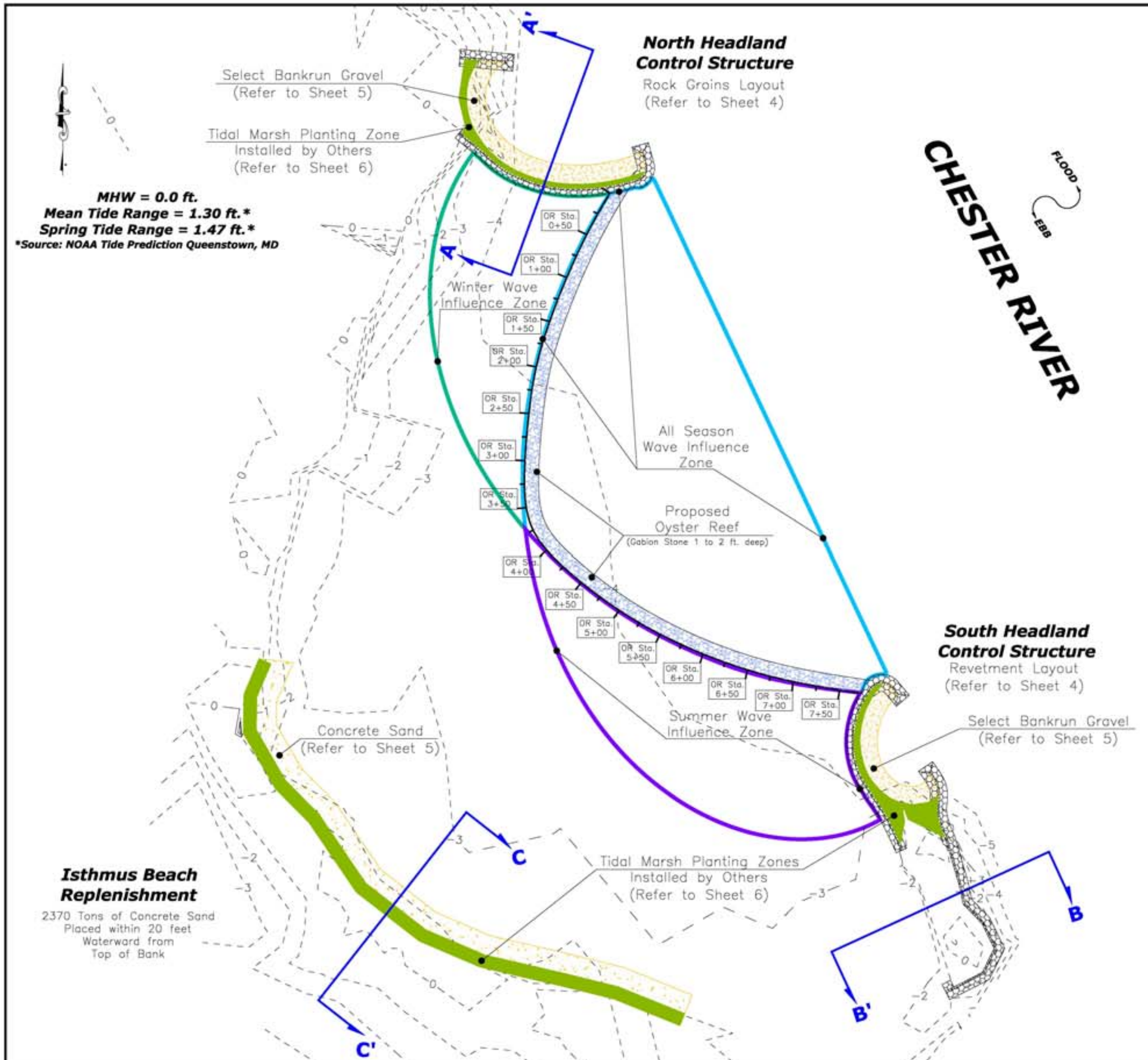
SUSTAINABLE SCIENCE LLC
Ecological Engineering Services
410 S. Second Street
Denton, Maryland 21629
Phone: (410) 924-4316
www.sustainablescience.com

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

Wave Analysis Results



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.

HAIL COVE LIVING SHORELINE PLAN

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

SUSTAINABLE SCIENCE LLC
Ecological Engineering Services

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:	08006
REVISION DATE:	NONE	SHEET NUMBER	3 OF 6
REVISION TYPE:			

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 Project Summary

- Seventeen project partners involved
- Total project cost $445K for 3,180 feet of shoreline protected equating to $140 per linear foot
- Typical high energy projects range from $400 to $500 per linear foot respectively equating to project costs from $1.27M to $1.59M
- Headland breakwater project costs range in the $150 to $250 per linear foot

Thanks!

Any Questions??

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

US Army Corps of Engineers Coastal Engineering Manual:
http://chl.erdc.usace.army.mil/cem