Coastal Hazards & Sea-Level Rise Asset Vulnerability Assessment Protocol: Preserving our national heritage

Program for the Study of Developed Shorelines, Western Carolina University

- NPS – Park Facility Management Division - Sustainable Operations Branch
- NPS – Park Facility Management Division - Facilities Planning Branch
- NPS – Climate Change Response Program

NATIONAL PARK SERVICE

Western Carolina University

PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES

Assets in coastal parks exposed to 1 m of SLR: 103 coastal parks analyzed.

	Total Assets Analyzed		High Exposure Results				
Region	**# Assets**	**CRV**	**# Assets**	**% of Total Assets**	**CRV**	**% of Total CRV**	**% Historic[1]**
NER	3,683	$12,558,630,579	1,151	31%	$5,840,064,747	47%	19%
SER	3,455	$37,097,656,761	2,762	80%	$13,493,524,509	36%	14%
PWR	5,074	$10,373,481,532	481	9%	$1,609,426,190	16%	11%
IMR	242	$127,074,693	30	12%	$41,775,751	33%	0%
AKR	316	$219,444,614	3	1%	$107,831	0%	0%
NCR	2,578	$10,422,456,372	214	8%	$2,277,767,920	22%	4%
All Units	**15,348**	**$70,798,744,551**	**4,641**	**30%**	**$23,262,666,948**	**33%**	**15%**

Mission

- The Program for the Study of Developed Shorelines serves as a nexus between coastal science and policy. The PSDS applies innovative approaches to studying and understanding coastal processes, as well as translating new coastal science into sensible, science-based management recommendations. The center also seeks to communicate this science to the general public through traditional and non-traditional outlets.

Beach Nourishment

beachnourishment.wcu.edu

mac screen capture

WCU Phonebook | Hotline | USAA | RCP | Image of the Day | Flash Earth | lacoastpost | NC Policy Watch | Science Daily | Bookmarks

Beach Nourishment | Taking Screenshots in Mac OS X...

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Beach Nourishment Viewer

Program for the Study of Developed Shorelines @ Western Carolina University

Western Carolina University

Click on the state of interest or select it from the list:

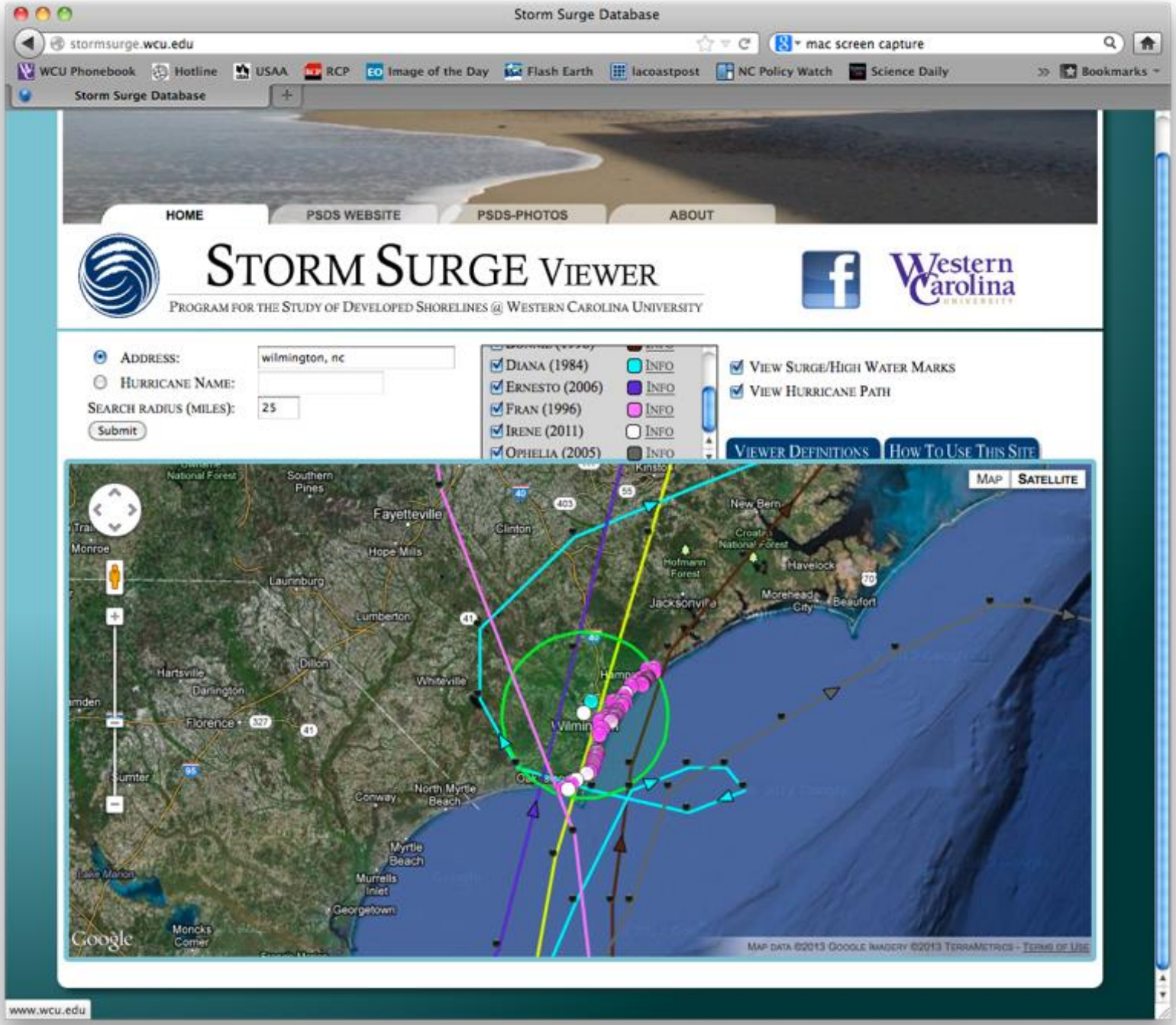
Select a state

"A Never-Ending Commitment": The High Cost of Preserving Vulnerable Beaches

In the wake of hurricanes like Florence, the U.S. government pays to dump truckloads of sand onto eroding beaches, in a cycle that is said to harm ecosystems and disproportionately benefit the rich.

by Lisa Song and Al Shaw, Sept. 27, 2018, 5 a.m. EDT

A beach replenishment project underway at Rockaway Beach in New York in 2014, following Hurricane Sandy. (Carolyn Cole/Los Angeles Times via Getty Images)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WCU Phonebook
Hotline
USAA
RCP
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PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES @ WESTERN CAROLINA UNIVERSITY
Western Carolina
ADDRESS:
wilmington, nc
HURRICANE NAME:
SEARCH RADIUS (MILES):
25
Submit
DIANA (1984)
ERNESTO (2006)
FRAN (1996)
IRENE (2011)
OPHELIA (2005)
INFO
VIEW SURGE/HIGH WATER MARKS
VIEW HURRICANE PATH
VIEWER DEFINITIONS
HOW TO USE THIS SITE
MAP
SATELLITE
Fayetteville
Clinton
New Bern
Havelock
Jacksonville
Morehead City
Beaufort
Hope Mills
Laurinburg
Lumberton
Dillon
Hartsville
Darlington
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Whiteville
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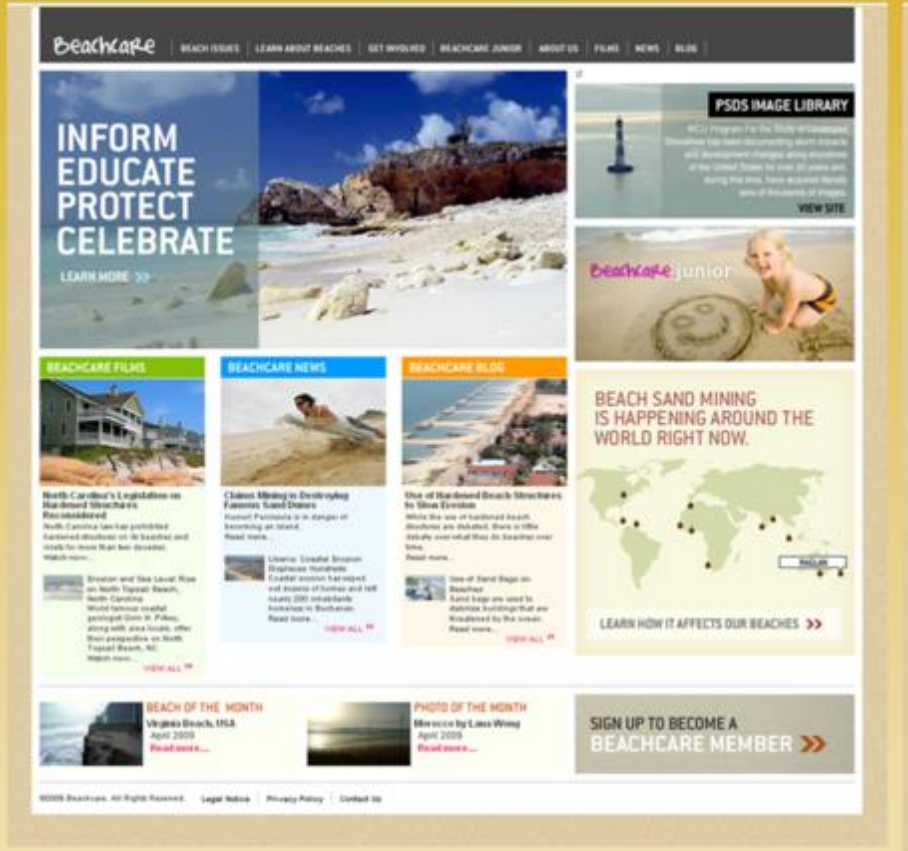
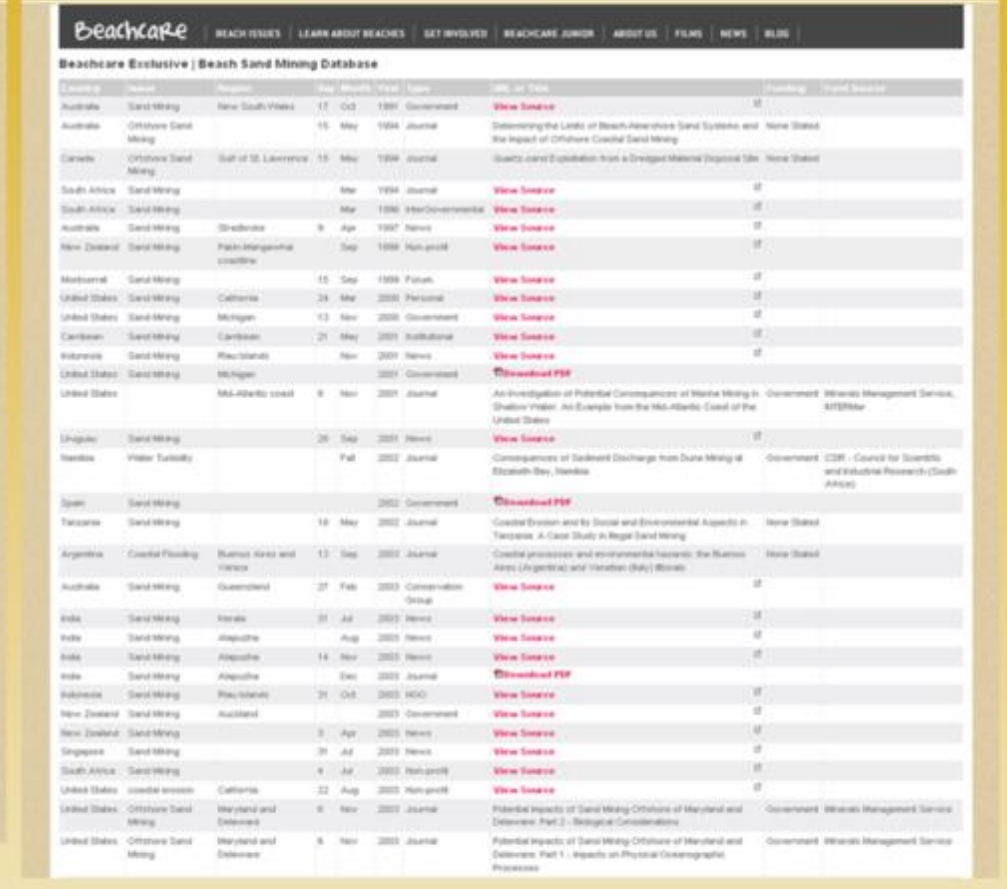
www.wcu.edu

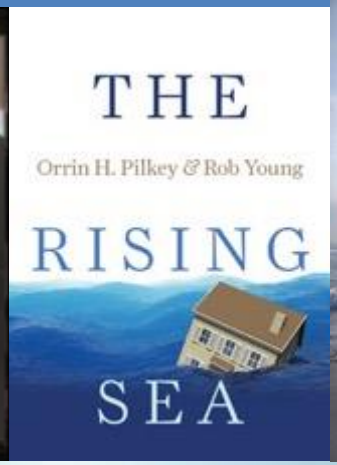
www.beachcare.org
sand mining database

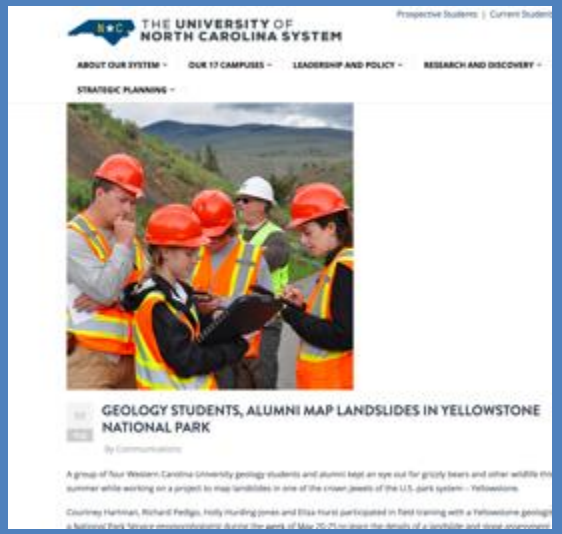




Program for the Study of Developed Shorelines

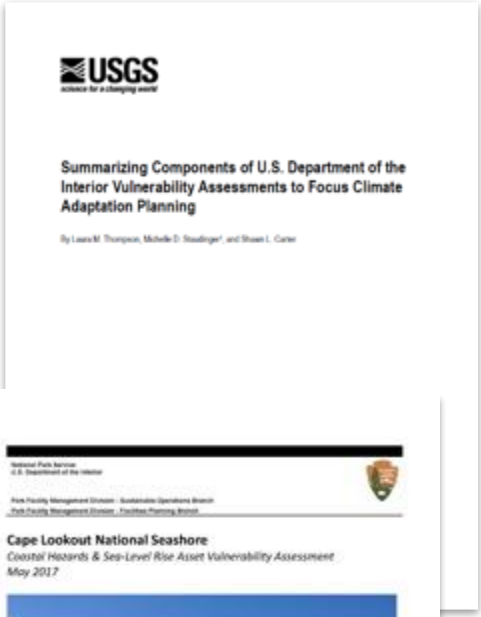
It's all about communicating



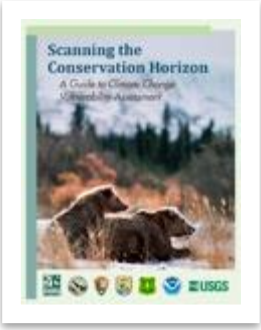


PRIMARY GOALS

- Asset level protocol: Create methodology for assessing vulnerability of NPS assets to coastal hazards & SLR (structures + transportation assets)
- Standardize methodology to allow comparison across regions
- Use consistent data sources: established & reliable data, universal & georeferenced, likely to be updated & maintained
- Provide actionable information!!! Decision-makers don't need a bunch of additional hazard maps to look through.
- Integrate the VA scoring into all park planning, short- and long-term



CONCEPTUAL DESIGN



METRICS OF VULNERABILITY: NATURAL RESOURCES

VULNERABILITY = EXPOSURE + SENSITIVITY + ADAPTIVE CAPACITY

Exposure
if a resource is located in an area experiencing climate change & coastal hazards

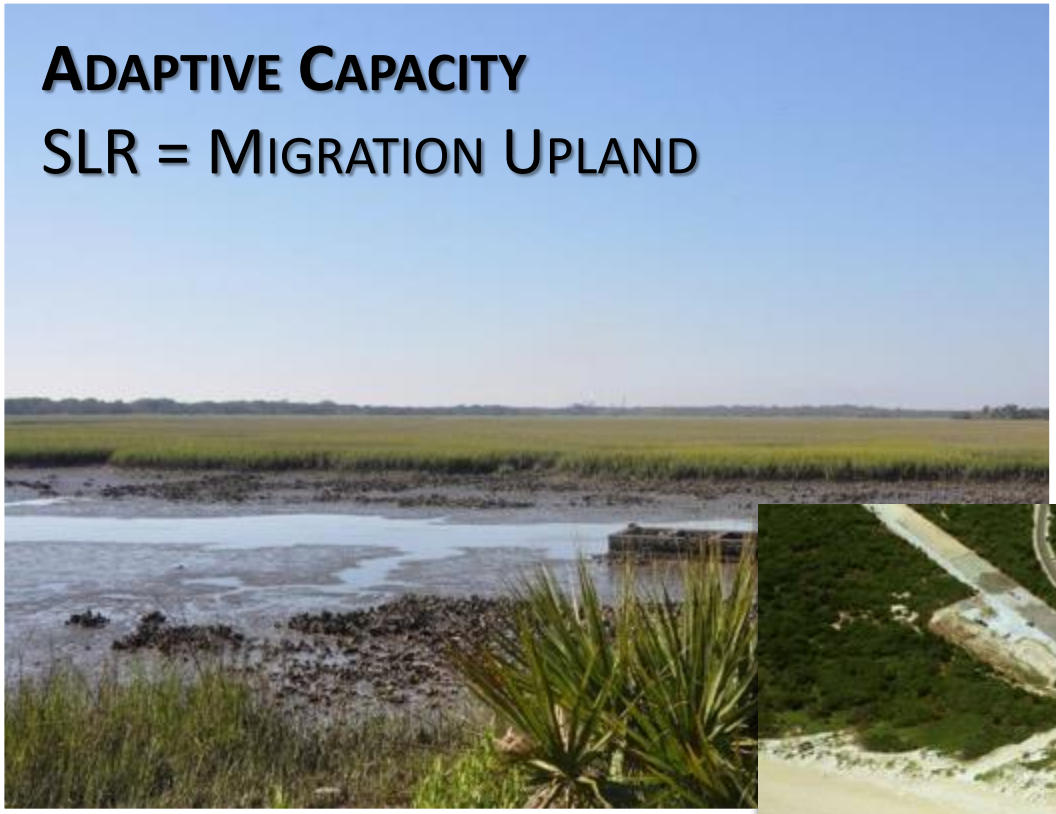
Sensitivity
how a resource fares when exposed to an impact

Adaptive capacity
the ability of the resource to adjust or cope with impacts

Conceptual Design

Adaptive Capacity

SLR = Migration Upland



Adaptive Capacity

SLR = Depends

CONCEPTUAL DESIGN

METRICS OF VULNERABILITY: INFRASTRUCTURE

Adaptive Capacity

- ✓ Still significant, but addressed separately
- ✓ Not part of vulnerability formula/score
- ✓ **Adaptation actions are developed at the end of the assessment**

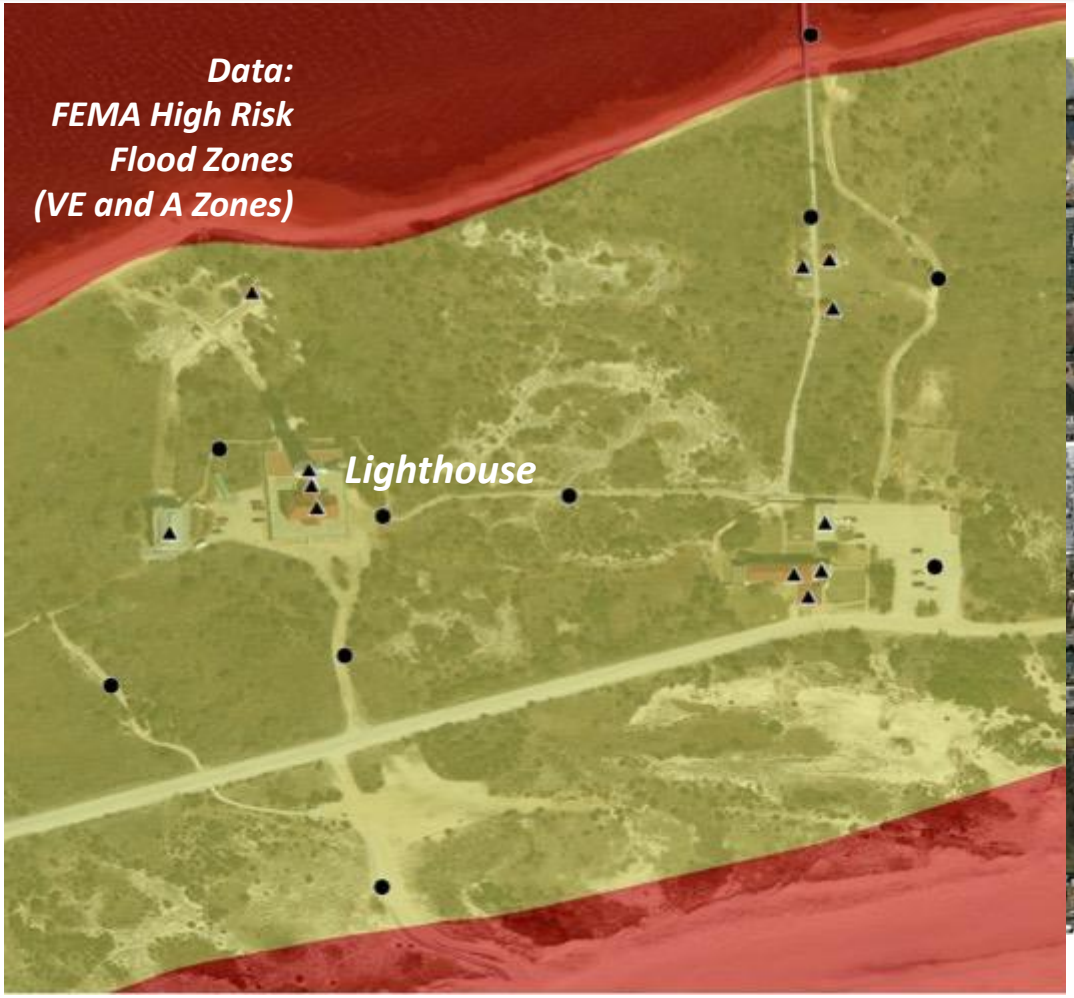
Coastal Hazard & SLR Exposure Indicators

Indicators: Factors/data to Consider When Analyzing Exposure of an Asset

Indicator	Data Sources
Flooding Potential 1% annual flood chance ± velocity/waves	• FEMA Flood Zones (VE or AE); LiDAR DEM or other elevation model
Extreme Event Flooding storm surge, tsunami, extreme high water	• NPS-specific SLOSH model; tsunami models; tide gage recorded extreme high water data
Sea-Level Rise Inundation 2050 projection	• NPS-specific SLR modeling; LiDAR DEM or other elevation model
Shoreline Change erosion, coastal proximity, cliff retreat	• State or USGS erosion rate buffers; cliff retreat rate buffers; shoreline proximity buffers
Reported Coastal Hazards historic flooding, visible slope instability	• Park surveys/questionnaire results; storm imagery & reconnaissance

- ***Goal:*** *consistent data sources across parks (when possible)*
- ***Exposure time frame:*** *2050*

Flooding Potential Indicator Data



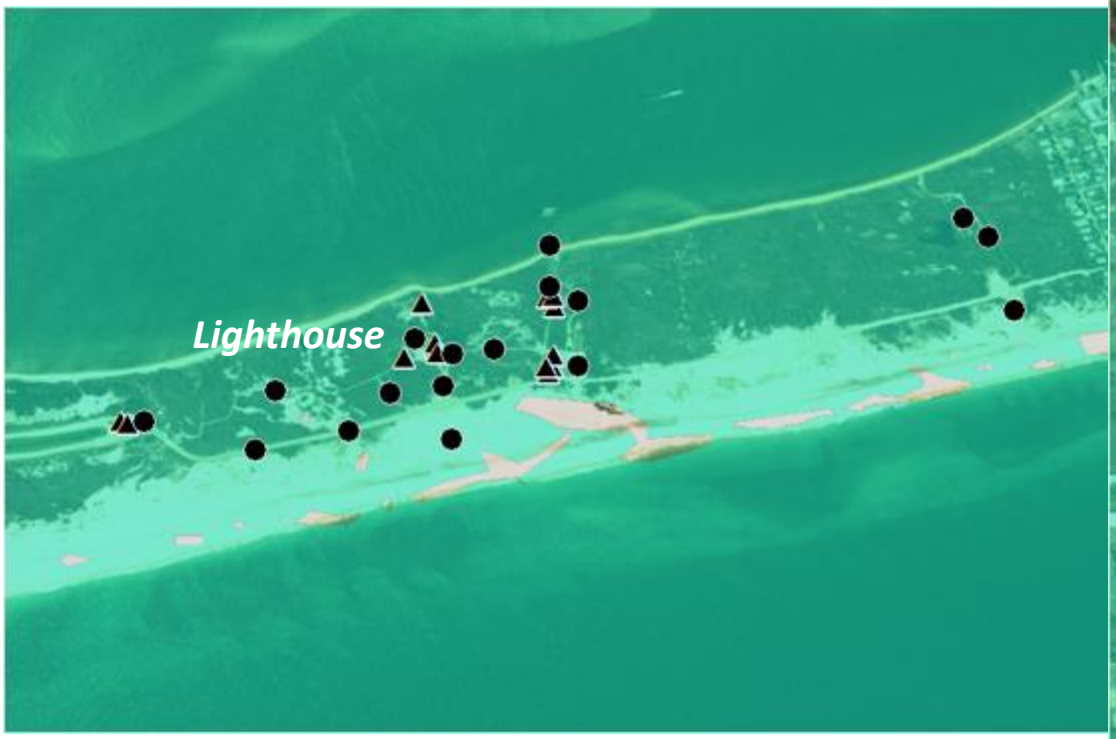
Data Source: *FEMA*

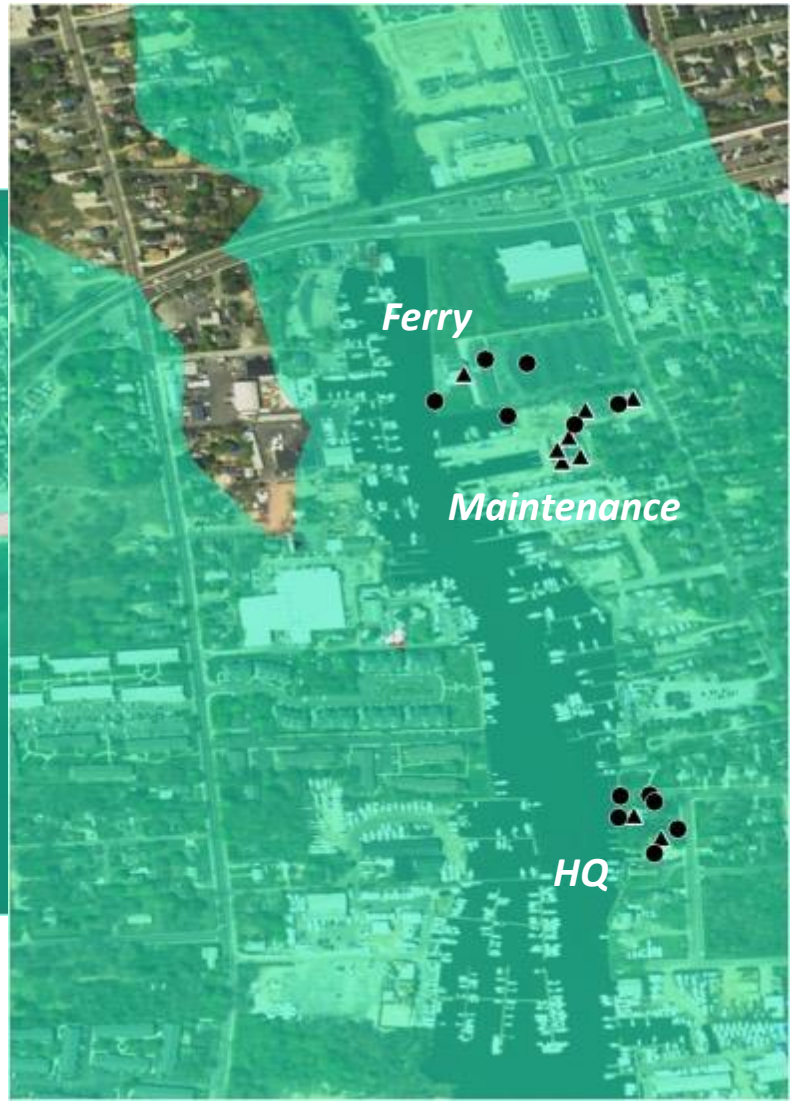
VE (Highest Hazard): Areas subject to inundation by the **1-percent-annual-chance flood event with additional hazards due to storm-induced velocity wave action**. Base Flood Elevations (BFEs) derived from detailed hydraulic analyses are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.

AE (or other A): Areas subject to inundation by the **1-percent-annual-chance flood event** determined by detailed methods. Base Flood Elevations (BFEs) are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.

Extreme Event Flooding Indicator Data

Data:
Storm Surge Cat 3 SLOSH Model





Data Source: *NPS CCRP*

SLR Inundation Indicator Data

Data:
Sea-level rise (SLR)

Data Info: *NPS-specific SLR models 2050 Intermediate Projection (obtained from NPS Climate Change Response Program)*

Shoreline Change Indicator Data

Data: 35-year erosion buffer zones & coastal proximity buffers

Data Source: USGS Erosion Rates

Coastal Hazards Field Data from Past Events

Data Sources: Historical Flooding Reports (Questionnaire) & Storm Imagery

Historical Flooding Data

https://arcg.is/1Gq0yy

Has the SITE or LAND AREA near any of the following assets been flooded in previous storm events?

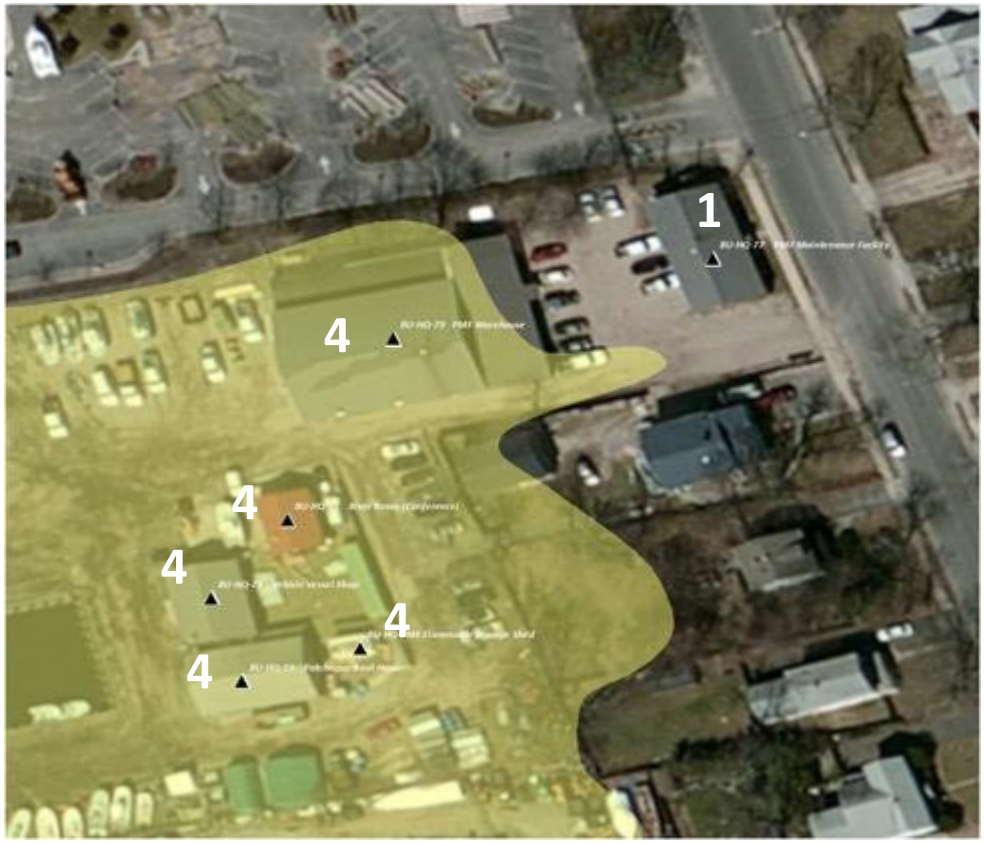
* This question is referring to the ***site or land area*** around an asset. Even if the asset was not built during a particular storm, we would like to know if that location has been flooded in the past. Please note in the comments if the flooding is non-coastal (e.g., heavy rainfall, ponding, or drainage issues).

FMSS Asset Information					Record Answers (add x)	Comments (clarifictions, unsure, unfamiliar with asset, etc.)
#	Asset Code	Year Built	FMSS Code	Asset Description	Yes	
1	4100	1964	111677	BU-BB-Sun Shelter		Click here to add any comments
2	4100	1964	105369	BU-BB-Snack Bar		Click here to add any comments
3	4100	1964	105370	BU-BB-Restrooms/Utility Room		Click here to add any comments

Exposure Scoring & Results

Flooding Indicator
Surge Indicator
SLR Indicator
Erosion/Coastal Proximity Indicator
Historical Flooding Indicator

Total Exposure Score



Exposure Scoring

# of Exp Zones	Raw Score	Final Score	Rank
4-5	17-20	4	High
2-3	11-14	3	Moderate
1	8	2	Low
0	5	1	Minimal

Exposure Scoring & Rank Definitions

Overall: This methodology is meant to assess the exposure of each asset to multiple coastal hazards and climate change factors combined (i.e., erosion, flooding, storm surge, sea-level rise, and historical flooding)

High: A ranking of "high" means that an asset is in a location that intersects at least 4 exposure indicators. This means the asset may not be within 1 of the 5 coastal hazard and SLR exposure indicator zones.

Moderate: A ranking of "moderate" means that an asset is in a location that intersects 2 or 3 exposure indicators. This means the asset may not be within 2 or 3 of the coastal hazard and SLR exposure indicator zones.

Low: A ranking of "low" means that an asset is in a location that intersects only 1 exposure indicator hazard zone. This means the asset is only within 1 of the 5 coastal hazard and SLR exposure indicator zones; the asset could still be seriously impacted by one hazard.

Minimal: A ranking of "minimal" means that an asset is not in ANY of the coastal hazard and SLR exposure indicator zones. This does not mean that the asset has no exposure, but instead, that the current data does not overlap with the location of the asset.

Exposure Scoring & Draft Results

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Exposure Analysis Data Results

Definitions of WCU Columns on Next Sheet (Click Here to View)

ID	Location	Area	Step 1: Score for Exposure Indicator Zones						Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	
			1a. FEMA VE Zone Score	1b. FEMA A Zone Score	1c. Erosion Proximity Score	1d. SLR Score	1e. Surge Cat 3 Score	1f. Historic Flooding Score	Raw Score from Step 1	Binned Score Raw	VE Zone Auto High Score	Exposure Score Unmod	WCU Flagged Asset	Exposure Score	Exposure Rank
1	Q-00000154-HO-TA-154 Ocean Qtrs	TA	4		1	1	4	1	11	3	4	4		4	high
2	BU-HQ-76 Park Headquarters	HQ		4	4	1	4	4	17	4		4		4	high
3	BU-HQ-72 Headquarters Annex	HQ		4	4	1	4	4	17	4		4		4	high
4	Q-00000103-HO-SH-103 Sailors Haven Housing Unit	SH		4	1	1	4	1	11	3		3		3	moderate
5	BU-HQ-73 Patchogue Boat House	HQ		4	4	1	4	4	17	4		4		4	high
6	BU-HQ-77 PMF Maintenance Facility	HQ		1	1	1	4	1	8	2		2		2	low
7	BU-HQ-78 Vehicle Vessel Shop	HQ		4	4	1	4	4	17	4		4		4	high
8	Q-00000006-HO-WH-06 Qtrs #6	WH		4	1	1	4	1	11	3		3		3	moderate
9	Q-00000002-HO-WH-02 Qtrs #2	WH		4	1	1	4	1	11	3		3		3	moderate
10	BU-HQ-79 PMF Warehouse	HQ		4	1	1	4	4	14	3		3		3	moderate
11	Q-00000003-HO-WH-03 Qtrs #3	WH		4	1	1	4	1	11	3		3		3	moderate
12	Q-00000004-HO-WH-04 Qtrs #4	WH		4	1	1	4	1	11	3		3		3	moderate
13	Q-00000005-HO-WH-05 Qtrs #5	WH		4	1	1	4	1	11	3		3		3	moderate
14	Q-00000007-HO-WH-07 Qtrs #7	WH		4	1	1	4	1	11	3		3		3	moderate
15	BU-HQ-81 River Room (Conference)	HQ		4	1	1	4	4	14	3		3		3	moderate
16	Q-00000008-HO-WH-08 Qtrs #8	WH		4	1	1	4	1	11	3		3		3	moderate
17	Q-00000009-HO-WH-09 Qtrs #9	WH		4	1	1	4	1	11	3		3		3	moderate
18	Q-00000010-HO-WH-10 Qtrs #10	WH		4	1	1	4	1	11	3		3		3	moderate
19	Q-00000011-HO-WH-11 Qtrs #11	WH		4	1	1	4	1	11	3		3		3	moderate
20	Q-00000012-HO-WH-12 Qtrs #12	WH		4	1	1	4	1	11	3		3		3	moderate
21	Q-00000001-HO-WH-01 Qtrs#1	WH		4	1	1	4	1	11	3		3		3	moderate
22	BU-WF-224 Curatorial Storage	WF		1	1	1	4	1	8	2		2		2	low
23	BU-LS-219 Single Story Connector Bldg	LS		4	1	1	4	1	11	3		3		3	moderate
24	Q-00000151-HO-CA-151 Carrington House	CA	4		1	1	4	1	11	3	4	4		4	high
25	BU-LS-93a Comfort Station	LS		4	1	1	4	1	11	3		3		3	moderate
26	Q-00000152-HO-CA-152 Carrington Cottage	CA		4	1	1	4	1	11	3		3		3	moderate
27	Q-00000104-HO-SH-102 Qtrs#102	SH		4	1	1	4	1	11	3		3		3	moderate
28	BU-SH-107 Comfort Station	SH		4	1	1	4	1	11	3		3		3	moderate
29	BU-SH-104 Visitor Center	SH		4	4	1	4	1	14	3		3		3	moderate
30	BU-OP-51 Wilderness Visitor Center	OP	4		1	1	4	1	11	3	4	4		4	high
31	BU-TA-156 Maintenance Shop	TA		4	1	1	4	1	11	3		3		3	moderate
32	BU-TA-157 Comfort Station	TA		4	4	1	4	1	14	3		3		3	moderate
33	BU-TA-158 Pump House	TA	4		1	1	4	1	11	3	4	4		4	high

Exposure Maps

Exposure Maps

Coastal Hazard & SLR Sensitivity Indicators

Indicators: Factors/Data to Consider When Analyzing Sensitivity of an Asset

Indicator		Common Data Sources
☑	**Flood Damage Potential**	• **Direct field measurement: threshold elevation, park personnel surveys/interviews**, field surveys
☑	**Storm Resistance & Condition**	• **Park personnel surveys/interviews,** FMSS
☑	**Historical Damage**	• **Park personnel surveys/interviews,** park documents/reports
☑	**Protective Engineering**	• **Park personnel surveys/interviews,** coastal engineering inventory (WCU/OSU), field surveys

SENSITIVITY INFORMATION – PARK QUESTIONNAIRE

Are any of the following assets elevated at least 5 feet above local ground level (including critical utilities)?

Examples include: 1) assets on stilts or pilings, or 2) assets built on artificial fill material above local ground level. NOTE: If elevated, but not quite 5 feet, indicate in comments

FMSS Asset Information					Record Answers (add x)	Comments (clarifications, unsure, unfamiliar with asset, etc.)
#	Asset Code	Year Built	FMSS Code	Asset Description	Yes	
42	4100	1964	15935	Q-00000154-HO-TA-154 Ocean Qtrs		Click here to add any comments
7	4100	1950	18216	BU-HQ-76 Park Headquarters		Click here to add any comments

Are any of the following assets built to resist flood/wave storm damage?

Examples include: 1) assets built to specific storm-resistant standards/engineering codes, or 2) assets particularly or inherently resistant to other forms of damage or deterioration (e.g., fortifications). Do not consider the LOCATION of the asset in your response, but instead focus completely on construction.

FMSS Asset Information					Record Answers (add x)	Comments (clarifications, unsure, unfamiliar with asset, etc.)
#	Asset Code	Year Built	FMSS Code	Asset Description	Yes	
42	4100	1964	15935	Q-00000154-HO-TA-154 Ocean Qtrs		Click here to add any comments
7	4100	1950	18216	BU-HQ-76 Park Headquarters		Click here to add any comments

Are any of the assets listed below particularly vulnerable to flood/wave damage due to condition?

*In other words, is the asset in poor condition due to deterioration, lack of maintenance, etc.? DO NOT consider the location of the asset (even if it is near the water or commonly flooded), only consider the physical condition of the asset itself. The condition should be considered **independent** of the asset's location.

FMSS Asset Information					Record Answers (add x)	Comments (clarifications, unsure, unfamiliar with asset, etc.)
#	Asset Code	Year Built	FMSS Code	Asset Description	Yes	
1	4100	1964	15935	Q-00000154-HO-TA-154 Ocean Qtrs		Click here to add any comments
2	4100	1950	18216	BU-HQ-76 Park Headquarters		Click here to add any comments
3	4100	1964	15935	Q-00000154-HO-TA-154 Ocean Qtrs		Click here to add any comments

Have any of the following assets been significantly DAMAGED in previous storm/flooding events (water/wave damage only)?

* This question is focused on the actual damage to an asset from an event (the prior flooding question is about the LAND near the asset being inundated)

FMSS Asset Information					Record Answers (add x)	Comments (clarifications, unsure, unfamiliar with asset, etc.)
#	Asset Code	Year Built	FMSS Code	Asset Description	Yes	
42	4100	1964	15935	Q-00000154-HO-TA-154 Ocean Qtrs		Click here to add any comments
7	4100	1950	18216	BU-HQ-76 Park Headquarters		Click here to add any comments
6	4100	1964	15935	Q-00000154-HO-TA-154 Ocean Qtrs		Click here to add any comments

Are any of the following assets currently being protected by an engineered structure (e.g., seawall, bulkhead) or other major engineering (e.g. drainage, major landscape modification, major restored landscape)?

FMSS Asset Information					Record Answers (add x)	Comments (clarifications, unsure, unfamiliar with asset, etc.)
#	Asset Code	Year Built	FMSS Code	Asset Description	Yes	
42	4100	1964	15935	Q-00000154-HO-TA-154 Ocean Qtrs		Click here to add any comments
7	4100	1950	18216	BU-HQ-76 Park Headquarters		Click here to add any comments

COASTAL HAZARD & SLR SENSITIVITY INDICATORS

THRESHOLD ELEVATION DATA COLLECTION

NPS Resource Information Services Division (Brian Diethorn & Tim Smith)

WCU: Verifying Sensitivity Indicator (Q1: Elevated)

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			Sensitivity Analysis Data Results											
			Definitions of WCU Columns on Next Sheet (Click Here to View)								Step 2	Step 4		
ID	Location	Area	Flood Damage Potential (Elevated) (Q2)	BFE (ft, NAVD88)	Threshold Elev (ft, NAVD88)	Threshold Above or Below BFE	Storm Resist; Condition (Q3, Q4)		Historical Damage (Q5)	Protective Engineering (Q6)	Flagged Asset	Sensitivity Score	Sensitivity Rank
28	BU-SH-107 Comfort Station	SH	4	9.0	6.430	Below	4	1	1	4		3	moderate
29	BU-SH-104 Visitor Center	SH	1	8.0	12.467	Above*	4	1	1	1	Q2/BFE. & Q6. See Notes	2	low
30	BU-OP-51 Wilderness Visitor Center	OP	1	16.0			4	1	1	4	Q2/BFE. See notes	3	moderate
31	BU-TA-156 Maintenance Shop	TA	4	13.0	8.169	Below	4	4	1	4		4	high
32	BU-TA-157 Comfort Station	TA	4	10.0	8.465	Below	4	1	1	4		3	moderate
33	BU-TA-158 Pump House	TA	4	16.0	8.071	Below	4	1	1	4		3	moderate
34	BU-WH-13 Marina Store	WH	1	7.0	7.415	Above	4	1	1	1	Q2/BFE. & Q6. See Notes	2	low
35	BU-LS-94 Annex Garage	LS	4	9.0	3.707	Below	4	1	4	4		4	high
36	BU-LS-96 Store House	LS	4	8.0	5.217	Below	4	1	1	4		3	moderate
37	BU-LS-97 Oil House	LS	4	8.0	5.807	Below	4	1	1	4		3	moderate
38	BU-LS-98 Tool House	LS	4	8.0	5.840	Below	4	1					
39	BU-LS-99 Lighthouse Boat House	LS	1	7.0	8.924	Above*	4	1					
40	BU-WH-20 Maintenance Shop	WH	4	8.0	3.773	Below	4	1					
41	BU-WH-22 Flammable Storage Bldg.	WH	4	8.0	3.215	Below	4	1					
42	BU-LS-91 Fire Island Light House	LS	1	7.0	15.486	Above*	4	1					
43	BU-LS-92 Keepers Qtrs	LS	1	8.0	13.845	Above*	4	1					
44	BU-LS-93 Check Station	LS	4	9.0	8.235	Below	4	1					
45	Q-00SHBARN-HO-SH-105 Horse Barn	SH	4	13.0	4.035	Below	4	1					
46	BU-SH-106 Gift Shop & Snack Bar	SH	4	8.0	5.052	Below	4	1					
47	BU-SH-109 Maintenance Shop	SH	4	9.0	3.609	Below	4	1					
48	BU-SH-111 Garbage Bldg.	SH	4	9.0	2.100	Below	4	1					
49	BU-WF-222 Turf Equipment Storage Building	WF	4	-	20.112		4	1					
50	BU-WF-223 Fire Cache Storage Building	WF	4	-	19.324		4	1					
51	BU-WF-221 Flamable Storage Building	WF	4	-	17.848		4	1					
52	BU-WH-14 Dockmaster Office	WH	4	7.0	5.085	Below	4	1					
53	BU-WH-15 Storage Bldg	WH	4	7.0	2.854	Below	4	1					
54	BU-WH-16 Visitor Center	WH	1	7.0	7.087	Above	4	1					
55	BU-WH-17 Marina Restroom	WH	1	7.0	7.119	Above	4	1					
56	BU-WH-21 First Aid Room	WH	4	7.0	2.920	Below*	4	1					

Sensitivity & Vulnerability Scoring

Flood Damage Potential Indicator
Storm Resistance/Condition Indicator
Historical Damage Indicator
Adaptive Protection Indicator

Total Sensitivity Score

Exposure Score

Sensitivity Score

Total Vulnerability Score

**Formula for Structures (slightly different for bridges/transportation)*

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Sensitivity Analysis Data Results

Definitions of WCU Columns on Next Sheet (Click Here to View)

ID	Location	Area	Flood Damage Potential (Elevated) (Q2)	BFE (ft, NAVD88)	Threshold Elev (ft, NAVD88)	Threshold Above or Below BFE	Storm Resist; Condition (Q3, Q4)		Historical Damage (Q5)	Protective Engineering (Q6)	Step 2 Flagged Asset	Step 4 Sensitivity Score	Step 4 Sensitivity Rank
1	Q-00000154-HO-TA-154 Ocean Qtrs	TA	1	17.0	16.995	Above	4	1	1	4	Q2/BFE. See notes	3	moderate
2	BU-HQ-76 Park Headquarters	HQ	4	6.0	5.938	Below	4	1	4	1	Q6. See Notes	3	moderate
3	BU-HQ-72 Headquarters Annex												
4	Q-00000103-HO-SH-103 Sailors Haven Housi												
5	BU-HQ-73 Patchogue Boat House												
6	BU-HQ-77 PMF Maintenance Facility												
7	BU-HQ-78 Vehicle Vessel Shop												
8	Q-00000006-HO-WH-06 Qtrs #6												
9	Q-00000002-HO-WH-02 Qtrs #2												
10	BU-HQ-79 PMF Warehouse												

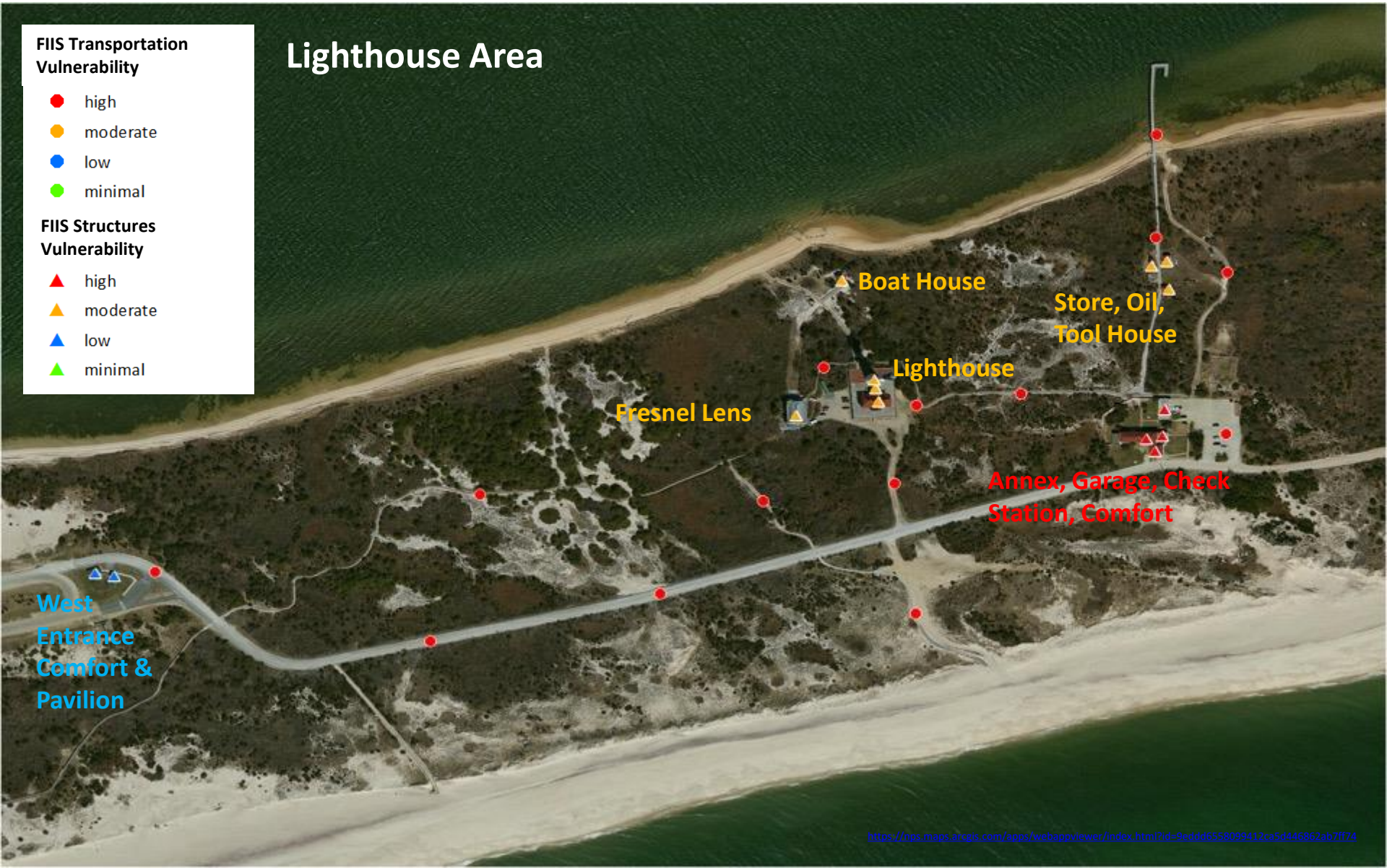
Next

Vulnerability Assessment Data Results

Definitions of WCU Columns on Next Sheet (Click Here to View)

ID	Location	Area	Metrics of Vulnerability: Exposure	Metrics of Vulnerability: Sensitivity	Vulnerability: Raw Score	Vulnerability: Final Score	Vulnerability: Final Rank	Geospatial Data: Latitude	Geospatial Data: Longitude	Location Code	Asset Code
1	Q-00000154-HO-TA-154 Ocean Qtrs	TA	4	3	7	4	high	40.671489	-73.042135	15935	4100
2	BU-HQ-76 Park Headquarters	HQ	4	3	7	4	high	40.755070	-73.017100	18216	4100
3	BU-HQ-72 Headquarters Annex	HQ	4	3	7	4	high	40.754854	-73.016833	18749	4100
4	Q-00000103-HO-SH-103 Sailors Haven Housing Unit	SH	3	4	7	4	high	40.656735	-73.103130	18750	4100
5	BU-HQ-73 Patchogue Boat House	HQ	4	4	8	4	high	40.758529	-73.017806	18751	4100
6	BU-HQ-77 PMF Maintenance Facility	HQ	2	4	6	3	moderate	40.759152	-73.017112	18752	4100
7	BU-HQ-78 Vehicle Vessel Shop	HQ	4	3	7	4	high	40.758651	-73.017852	18753	4100
8	Q-00000006-HO-WH-06 Qtrs #6	WH	3	3	6	3	moderate	40.690210	-72.990711	18756	4100

VULNERABILITY RESULTS & MAPS



DRAFT STATISTICS

FIIS Structures Summary & Statistics

Vulnerability Statistics	
Total # Structures Analyzed	98
# High Vulnerability	31
# Mod Vulnerability	38
# Low Vulnerability	13
# Minimal Vulnerability	16
% High Vulnerability	32%
% Moderate Vulnerability	39%
% Low Vulnerability	13%
% Minimal Vulnerability	16%

Exposure Statistics	
Total # Structures Analyzed	98
# High Exposure	15
# Mod Exposure	58
# Low Exposure	9
# Minimal Exposure	16
% High Exposure	15%
% Moderate Exposure	59%
% Low Exposure	9%
% Minimal Exposure	16%

Sensitivity Statistics	
Total # Structures Analyzed	82
# High Sensitivity	19
# Mod Sensitivity	58
# Low Sensitivity	5
excluded (min exposure)	16
% High Sensitivity	23%
% Moderate Sensitivity	71%
% Low Sensitivity	6%

# High or Moderate With API ≥ 70	3
% of Total Structures	3%
% of High/Mod Structures	4%

# High or Moderate With OB 1 or 2	10
% of Total Structures	10%
% of High/Mod Structures	14%

FIIS Transportation Summary & Statistics

Vulnerability Statistics	
Total # Structures Analyzed	88
# High Vulnerability	73
# Mod Vulnerability	11
# Low Vulnerability	0
# Minimal Vulnerability	4
% High Vulnerability	83%
% Moderate Vulnerability	13%
% Low Vulnerability	0%
% Minimal Vulnerability	5%

Exposure Statistics	
Total # Structures Analyzed	88
# High Exposure	36
# Mod Exposure	44
# Low Exposure	4
# Minimal Exposure	4
% High Exposure	41%
% Moderate Exposure	50%
% Low Exposure	5%
% Minimal Exposure	5%

Sensitivity Statistics	
Total # Structures Analyzed	84
# High Sensitivity	65
# Mod Sensitivity	16
# Low Sensitivity	3
excluded (min exposure)	4
% High Sensitivity	77%
% Moderate Sensitivity	19%
% Low Sensitivity	4%

# High or Moderate With API ≥ 70	7
% of Total Structures	8%
% of High/Mod Structures	8%

# High or Moderate With OB 1 or 2	5
% of Total Structures	6%
% of High/Mod Structures	6%

PROGRAM FOR THE STUDY OF DEVELOPED SHORELINES

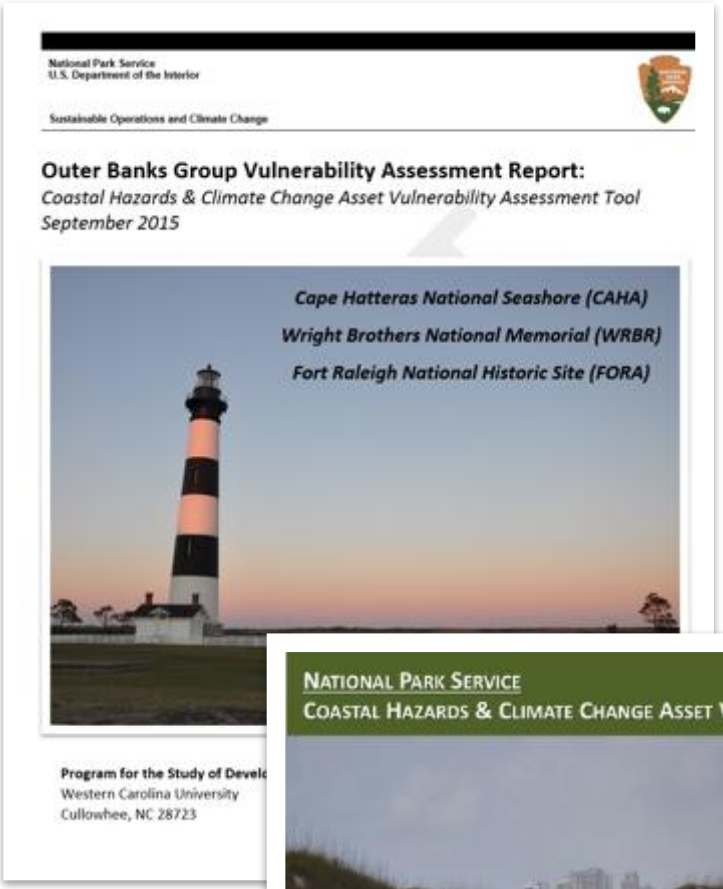
Western Carolina University

Adaptation Strategies

- ✓ Taking **adaptation actions** can reduce an asset's **exposure** and/or **sensitivity,** which in turn, lowers its overall **vulnerability.**

Adaptation Action	Asset Type	Effect on Vulnerability & Rationale
☑ **Elevate**	Structures & Transportation	Reduces the **sensitivity** of the asset; elevating an asset (pilings or artificial fill) reduces the risk of flood damage.
☑ **Relocate**	Structures & Transportation	Reduces the **exposure** of the asset; relocating the asset to a lower risk area reduces the likelihood that it will experience impacts from coastal hazards/SLR.
☑ **Protect/Engineer**	Structures & Transportation	Reduces the **exposure** and/or **sensitivity** of the asset; protecting the asset by an engineered structure (e.g., seawalls) or landscape modifications (e.g., drainage, nourishment, restoration) can reduce the likelihood that the asset will experience, or obtain damage from, coastal hazards/SLR.
☑ **Decommission & Remove**	Structures & Transportation	Eliminates the vulnerable asset
☑ **Storm-Resistant Redesign**	Structures & Transportation	Reduces the **sensitivity** of the asset; redesigning the asset to be more storm-resistant can reduce the likelihood of damage from coastal hazards/SLR.
☑ **Engineering Downgrade**	Transportation	Reduces the **sensitivity** of the asset; downgrading the amount of engineering (i.e., replacing paved parking lot with shell material lot) can reduce the cost of rebuilding after damage and give more flexibility for replacement.

FINAL PRODUCTS


National Park Service
U.S. Department of the Interior

Sustainable Operations and Climate Change

Outer Banks Group Vulnerability Assessment Report:
Coastal Hazards & Climate Change Asset Vulnerability Assessment Tool
September 2015

Cape Hatteras National Seashore (CAHA)
Wright Brothers National Memorial (WRBR)
Fort Raleigh National Historic Site (FORA)

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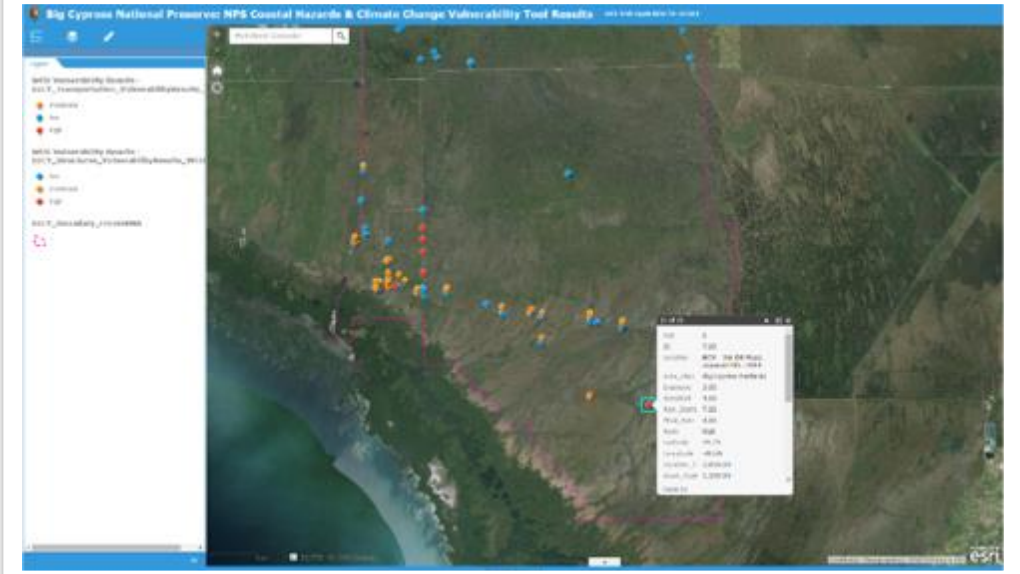
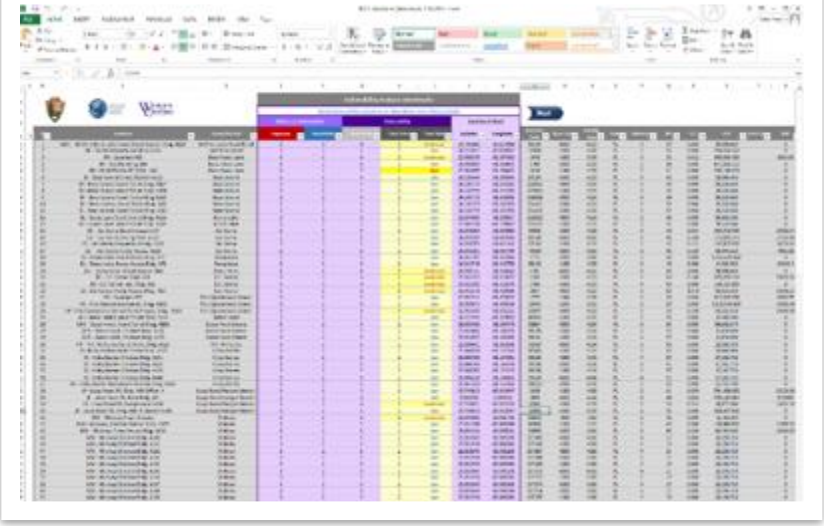
Western Carolina University
Cullowhee, NC 28723





Application

- It's not just where the water will be, but what happens when it gets there.
- Provides details at the asset level embedded within existing asset-management database
- These data are being used in multiple ways:
  - Short-term planning, spending, maintenance
  - Post-storm rebuilding
  - Long-term planning for cultural resources (e.g. Portsmouth Village, Cape Lookout, NS)

Benefits

- Clear, science-base guidance for the allocation of limited funding for maintenance, improvement, and rebuilding of park infrastructure.
- Data to support the funding of adaptation/resilience projects for infrastructure and historic structures that are mission critical.
- The best way to protect natural resources in coastal parks is to make very wise decisions about your infrastructure.

Coastal Hazards Infrastructure Vulnerability Assessment

Duck, North Carolina

February 2020

Program for the Study of Developed Shorelines
Western Carolina University
Cullowhee, NC 28723

Figure 7. Coastal hazard vulnerability results for roads and select buildings in south Duck, near the town commercial center. Select assets are labeled.

Questions?

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  - Holli Thompson. Program Manager

  - Rob Young, Director
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