

Coastal Resilience

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US Army Corps of Engineers
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Overview

1. Motivation: Chief of Engineers' Charge to Coastal Engineering Research Board (CERB)
2. Definitions of Resilience
 - a) Engineering
 - b) Ecological
 - c) Communities
3. Best Practices to Manage Resilient Coastal Systems
4. Calculation of a Resilience Metric
5. Summary



Motivation: Chief of Engineers' Charge to the Coastal Engineering Research Board (CERB)*, Sep 13

Identify a research and implementation strategy to:

- ...integrate risk reduction and resilience practices within USACE coastal planning, engineering, operations, and construction communities.
- ...provide specific guidance on expected research outcomes that will provide the technical basis for sound engineering capability
- ...to quantify, predict and manage risk reduction and increased resilience for coastal infrastructure.

**Established by law in 1963 to advise USACE on Coastal Engineering Research needs*



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Motivation

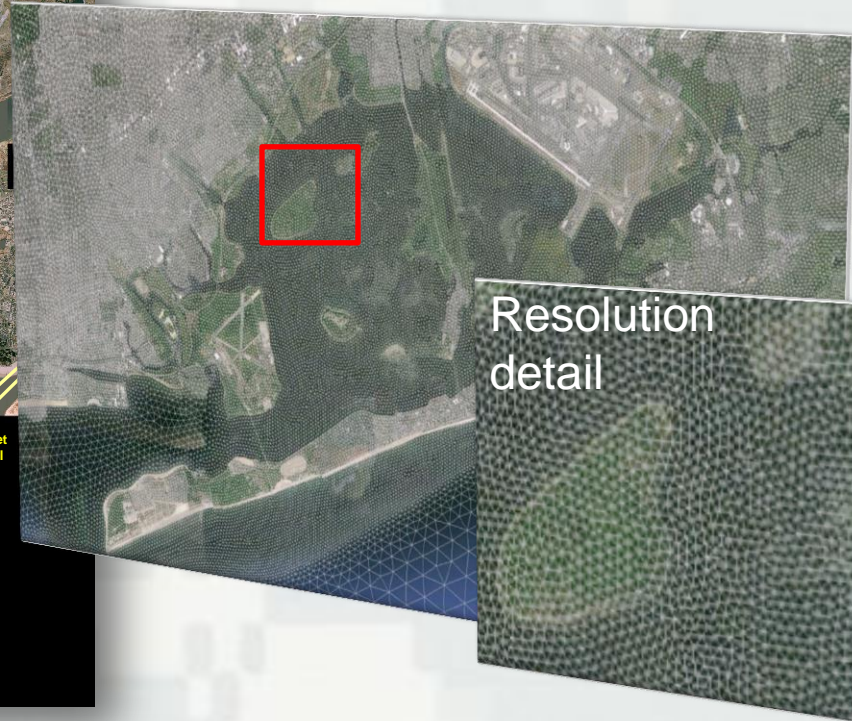
Definitions

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Chief's Charge: Pilot Demonstration at Jamaica Bay, NY



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Test, Validate, Inform R&D and Policy Needs

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Definitions of Resilience

Study	Definition
American Society of Civil Engineers (2006) http://www.asce.org/Content.aspx?id=8478	"Resilience refers to the capability to mitigate against significant all-hazards risks and incidents and to expeditiously recover and reconstitute critical services with minimum damage to public safety and health, the economy, and national security."
National Disaster Recovery Framework, Strengthening Disaster Recovery for the Nation (FEMA 2011) http://www.fema.gov/media-library/assets/documents/24647?fromSearch=fromsearch&id=5124	A resilient community has ... "an improved ability to withstand , respond to and recover from disasters."
The Infrastructure Security Partnership and Society of Military Engineers (SAME). "Understanding Resilience – Disaster Resilience Begins with Understanding the Threat" (2012) http://tisp.org/tisp/file/PROOF_121820_SAME_Booklet.pdf	... and the capability, to recover rapidly with limited
Disaster Resilience – A National Imperative (National Academies of Sciences, Engineering, and Medicine) (2012) http://www.nap.edu/catalog.php?record_id=13457	... and plan for, absorb , recover from , and more successfully
Hurricane Sandy Rebuilding Strategy: Stronger Communities, A Resilient Region (2013) http://portal.hud.gov/hudportal/documents/huddoc?id=HSRebuildingStrategy.pdf	... pt to changing conditions and withstand and recover
Infrastructure Rebuilding Principles (2013) http://coastalmanagement.noaa.gov/resources/docs/infsysrebuildingprinciples.pdf	... tions and withstand and rapidly recover from disruption
Coastal Risk Reduction and Resilience: Using the Full Array of Measures (U.S. Army Corps of Engineers) (2013) http://www.corpsclimate.us/docs/USACE_Coastal_Risk_Reduction_and_Resilience_S_2013-3.pdf	... or, respond to, and adapt to changing conditions and to disruptions with minimal damage."
Urban Land Institute, "After Sandy: Advancing Strategies for Long-term Resilience and Adaptability" (2013) http://www.uli.org/wp-content/uploads/2013/08/AfterSandy.pdf	... recover after a disaster and to return to its state before the
Presidential Executive Order on Climate Change, Preparing the United States for Impacts of Climate Change (2013) http://www.whitehouse.gov/the-press-office/2013/11/01/executive-order-preparing-united-states-impacts-climate-change	... anticipate, prepare for, and adapt to changing conditions and withstand , respond to, and recover rapidly from disruptions."
Rockefeller Foundation (2013) http://www.rockefellerfoundation.org/blog/city-resilient	"The capacity of individuals, communities and systems to survive , adapt , and grow in the face of changes, even catastrophic incidents."
Community and Regional Resilience Institute (CARRI) (2013) http://www.resilientus.org/wp-content/uploads/2013/08/definitions-of-community-resilience.pdf	"Community resilience is the capability to anticipate risk, limit impact , and bounce back rapidly through survival, adaptability , evolution , and growth in the face of turbulent change"
U.S. Army Corps of Engineers Safety of Dams, Policy and Procedures, ER 1110-2-1156 (2014) http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-2-1156.pdf	"The ability to avoid , minimize, withstand , and recover from the effects of adversity, whether natural or manmade, under all circumstances of use."
Intergovernmental Panel on Climate Change Fifth Assessment Report, "Climate Change 2014: Impacts, Adaptation, and Vulnerability" (2014) http://ipcc-wg2.gov/AR5	"The capacity of a social-ecological system to cope with a hazardous event or disturbance, ... entity, and transformation "

Key words:

Prepare

Resist

Recover

Adapt

Engineering Resilience

prepare, resist, recover, adapt

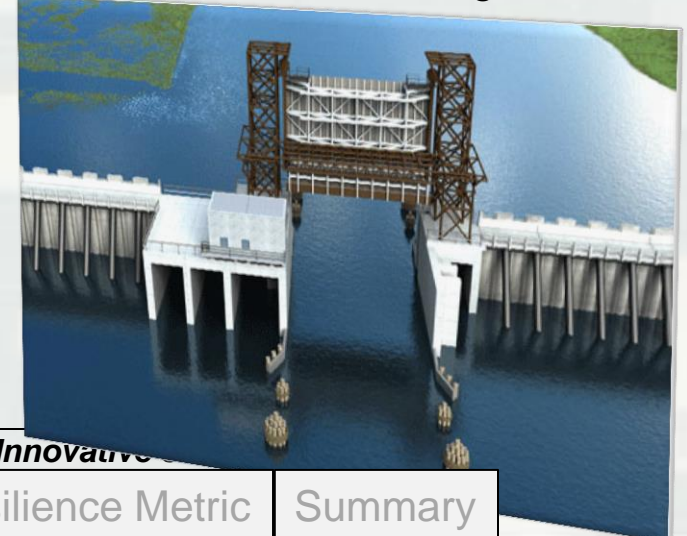
The ability of a *system* to anticipate, resist, recover, and adapt to achieve *functional* performance under the stress of disturbances.

Engineering Resilience:

- Reliable, predictable performance
- Range of design stresses

Most engineered systems do not naturally adapt

New Orleans Storm Surge Barrier



Schultz, M. T., McKay, S. K., and Hales, L. Z. (2012) "The Quantification and Evolution of Resilience in Integrated Coastal Systems," ERDC TR-12-7, U.S. Army Engineer Research and Development Center, Vicksburg, MS.



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Ecological Resilience

prepare, resist, recover, adapt

The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks

Ecological Resilience:
In general, changes must be gradual for successful adaptation



Walker, B., Holling, C. S., Carpenter, S. R., Kinzig, A. (2004). "Resilience, adaptability and transformability in social–ecological systems". *Ecology and Society* 9 (2): 5.

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Community Resilience

prepare, resist, recover, adapt

Capability to anticipate risk, limit impact, and bounce back rapidly through survival, adaptability, evolution, and growth in the face of turbulent change.

Community Resilience:
Humans have the capacity to learn and make conscious decisions to avoid future losses



Community and Regional Resilience Institute (CARRI) (2013).

“Definitions of Community Resilience: An Analysis,”

<http://www.resilientus.org/wp-content/uploads/2013/08/definitions-of-community-resilience.pdf>



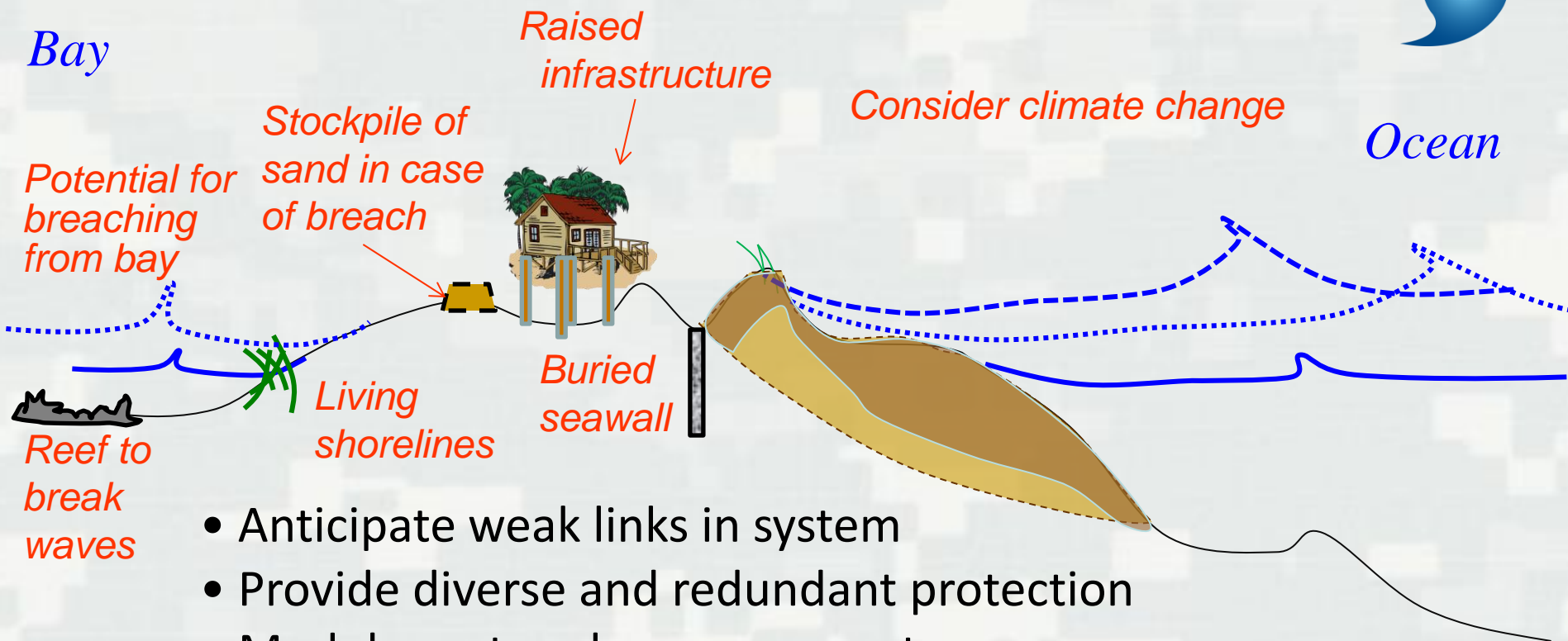
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Best Management Practices for Resilience

- Anticipate “weak links” in system
- Provide diverse and redundant protection
- Ensure the system has modular networks, with components that are independent of, and complement each other
- Consider unknowns associated with extended planning horizons (century-scale)
 - May evaluate 1000s of alternatives
 - Rapidly develop insights and group outcomes via tradespace analytics and big data mining
- Provide readily-available information for decision-making at local, state, and national levels



Example of Resilient Coastal Risk Reduction



- Anticipate weak links in system
- Provide diverse and redundant protection
- Modular networks –components are independent of, and complement each other.
- Information is accessible for decision-making



Calculation of a Resilience Metric*

Define...

1. System temporal and spatial scales
2. Critical elements of the system
3. Disturbance(s) (Storms, Relative Sea Level Rise, Tsunamis...)
4. Objectives:
 - ▶ Functional performance of system, $F \rightarrow$ prepare, resist
 - ▶ Recovery of system, $R \rightarrow$ recover, adapt
 - *Recovery can be natural or managed*
5. Weighting coefficients, W , for system elements (total=1)
6. Were objectives met for each element? (1=yes, 0=no)
7. Calculate Resilience Metric =
$$\frac{\sum (F*W+R*W)}{2} (\%)$$



*Schultz, et al. 2012.

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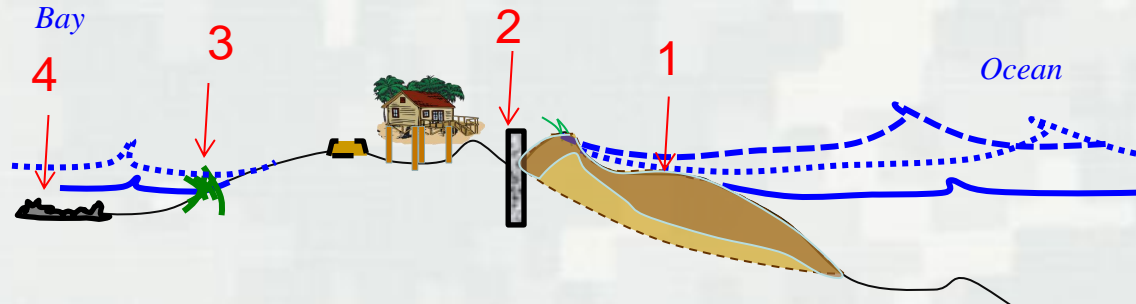
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Example Calculation: Resilience Metric



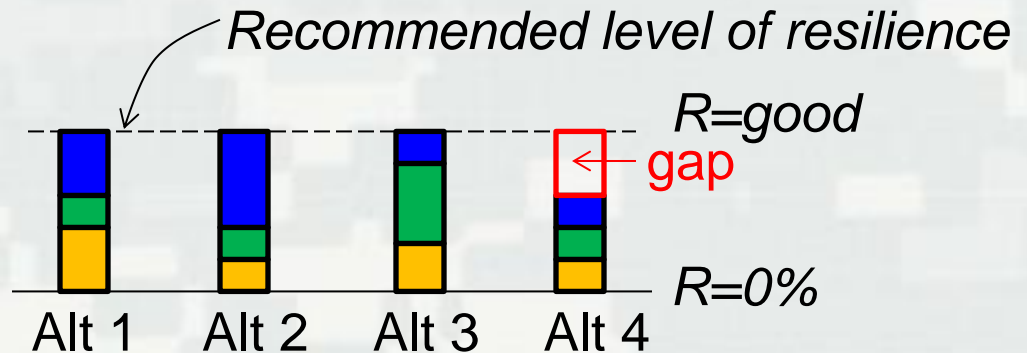
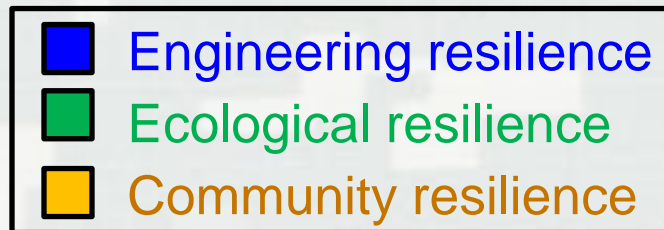
Critical Element	Functional Obj, F	Recovery Obj, R	Was F met?	Was R met?	F+R	Weighting, W
1. Beach & Dune	No surge/waves on infrastructure	3 mos	1	1	2	0.5
2. Seawall	No sand on roads	1 week	1	1	2	0.1
3. Living Shoreline	Reduce bayshore erosion by 50%	3 mos	0	0	0	0.2
4. Bay Reef	Reduce bayshore waves by 30%	3 mos	0	1	1	0.2
Resilience Metric = $\{(2)*0.5+(2)*0.1+(0)*0.2+(1)*0.2\}/2=$						70%



Resilience Metric

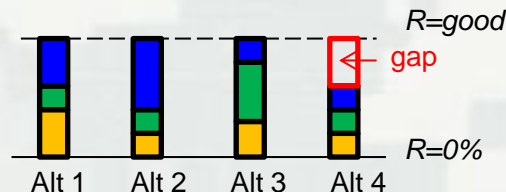
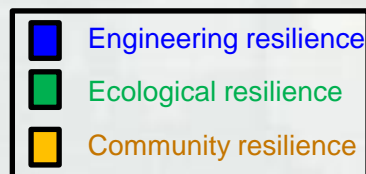
Can Integrate:

- Engineering Projects
- Ecology -- Natural and Nature-Based Features
- Community Systems



Summary

- Chief of Engineers recognized significance of resilience and Charged CERB:
 - ▶ Integrate risk and resilience into coastal practice
 - ▶ Develop Coastal Resilience R&D needs
- Many definitions of resilience!
 - ▶ Key words: **prepare**, **resist**, **recover**, **adapt**
- Method to calculate resilience metric based on:
 - ▶ Achieving Functional and Recovery objectives for each element
 - ▶ Weighting Factors that define relative importance of element
- Resilience Calculation Method can be applied to Engineering, Ecological, and Community Systems



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