selected potential

Adaptation Approaches to Sea Level Rise

Jim O’Connell

University of Hawaii Sea Grant Program on Kauai

*** Shoreline Setbacks**

*** House Relocation**

*** Elevation: Freeboard**

*** Coastal A-Zones**

*** Real Estate Hazards Notification**

Beach/Dune Nourishment

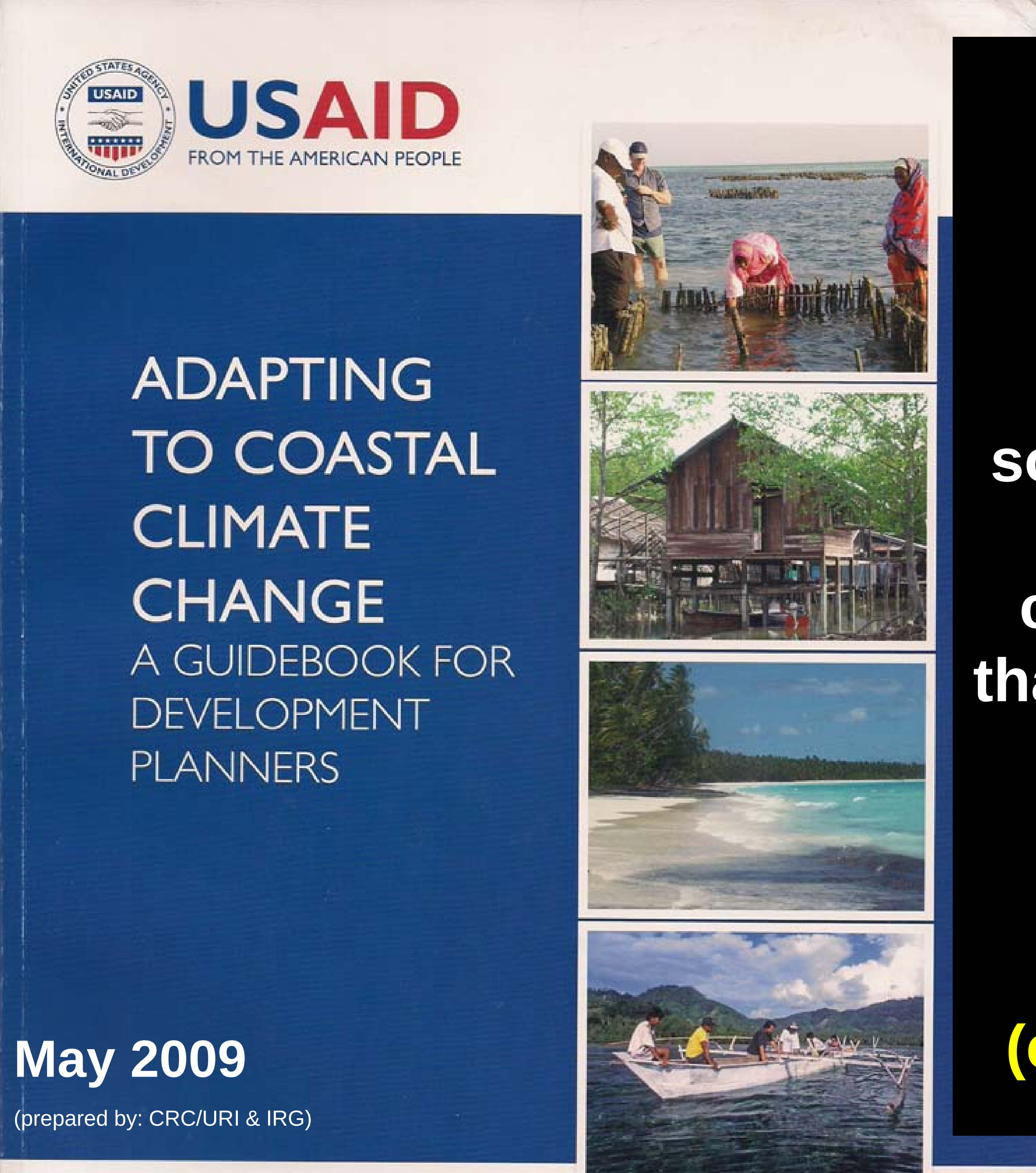
Coastal Engineering Structures

If a wall of moving water was coming right at you what would you do?

- **run the opposite direction (*setbacks or relocation*);**

- **get higher than the wall of water (Elevation or Freeboard)**

‘Adaptive Capacity’!!



May 2009

(prepared by: CRC/URI & IRG)

‘<u>Adaptive Capacity</u>’

‘the ability of society to plan for & respond to change in a way that makes it better equipped to manage its exposure and sensitivity to (climate change)

Climate Change consequences:

- Higher sea level -- accelerated rate of rise
- Increased flooding (vertically & horizontally)
- Accelerated coastal erosion & loss of land & property
- Saltwater intrusion (septic systems; ground water; salt/fresh water wedge)
- Decreased rainfall
- Decreased stream-flow
- More intense coastal storms & perhaps more frequent storms
- Increased runoff (less rainfall/less ground cover)
- Shift in distribution & abundance of marine habitats, species & biodiversity
- Accelerated spread of exotic & invasive species
- Coral bleaching & increased mortality (warmer ocean temp)
- Loss of coastal wetland ecosystems & fishing grounds, growth in the spread of marine dead zones.

only addressing **'SEA LEVEL RISE'**

(Jim O'Connell, UH Sea Grant Kauai)

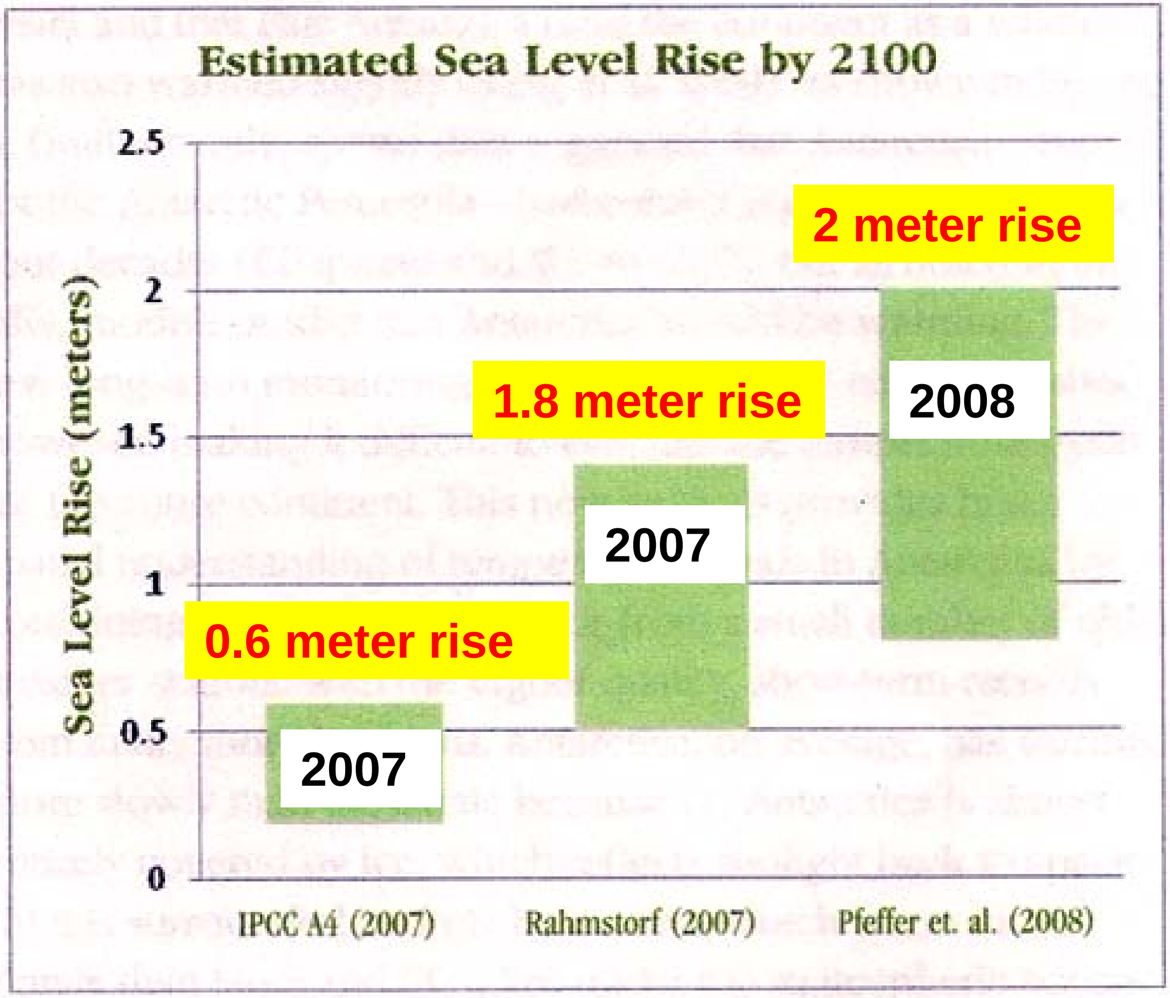


Figure 1. *Comparison of recent estimates of sea level rise in 2100, relative to 1990 levels.*

'Key Scientific Developments since the IPCC 4th Assessment Report'

(PEW Center on Global Climate Change, June 2009)

NOW considering thermal expansion of the ocean AND glacier melting

New estimates of average global Sea Level Rise by 2100

U.S. Army Corps of Engineers

Department of the Army
U.S. Army Corps of Engineers
Washington, DC 20314-1000

EC 1165-2-211

CECW-CE

Circular
No. 1165-2-211

1 July 2009

EXPIRES 1 JULY 2011
WATER RESOURCE POLICIES AND AUTHORITIES
INCORPORATING SEA-LEVEL CHANGE CONSIDERATIONS
IN CIVIL WORKS PROGRAMS

1. Purpose. This circular provides United States Army Corps of Engineers (USACE) guidance for incorporating the direct and indirect physical effects of projected future sea-level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level. Impacts to coastal and estuarine zones caused by sea-level change must be considered in all phases of Civil Works programs.

2. Applicability. This Circular applies to all USACE elements having Civil Works responsibilities and is applicable to all USACE Civil Works activities. This guidance is effective immediately, and supersedes all previous guidance on this subject. Districts and Divisions shall inform CECW of any problems with implementing this guidance.

3. Distribution Statement. This publication is approved for public release; distribution is unlimited.

4. References. Required and related references are at Appendix A. A glossary is included at the end of this document.

5. Geographic Extent of Applicability.

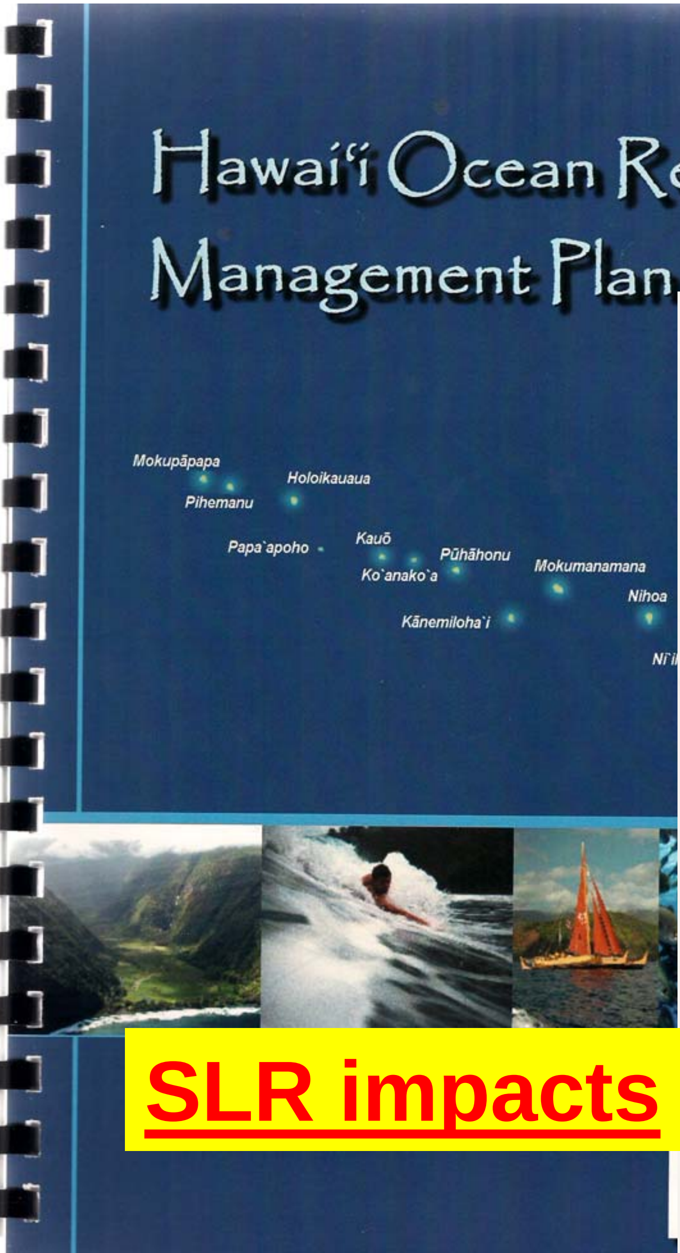
a. USACE water resources management projects are planned, designed, constructed and operated locally or regionally. For this reason, it is important to distinguish between global mean sea level (GMSL) and local (or "relative") mean sea level (MSL). At any location, changes in local MSL reflect the integrated effects of GMSL change plus changes of regional geologic, oceanographic, or atmospheric origin as described in Appendix B and the Glossary.

b. Potential relative sea-level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. Fluvial studies (such as flood studies) that include backwater profiling should also include potential relative sea-level change in the starting water surface elevation for such profiles, where appropriate. The base level of potential relative

U.S. Army Corps of Engineers SLR POLICY July 2009:

'Potential relative sea level rise must be considered in every COE activity'!

Latest version?



Hawai'i Ocean Resources Management Plan (December 2006)

Sea Level Rise and Other Coastal Hazards

Global warming is predicted to cause an increase in frequency and power of both storm surge and hurricanes. One study suggests that peak hurricane wind speeds will increase by 5 to 10 percent by the end of the 21st century. A 1-meter rise in sea level would enable a 15-year storm to flood areas that today are only flooded by a 100-year storm (IPCC 1998).

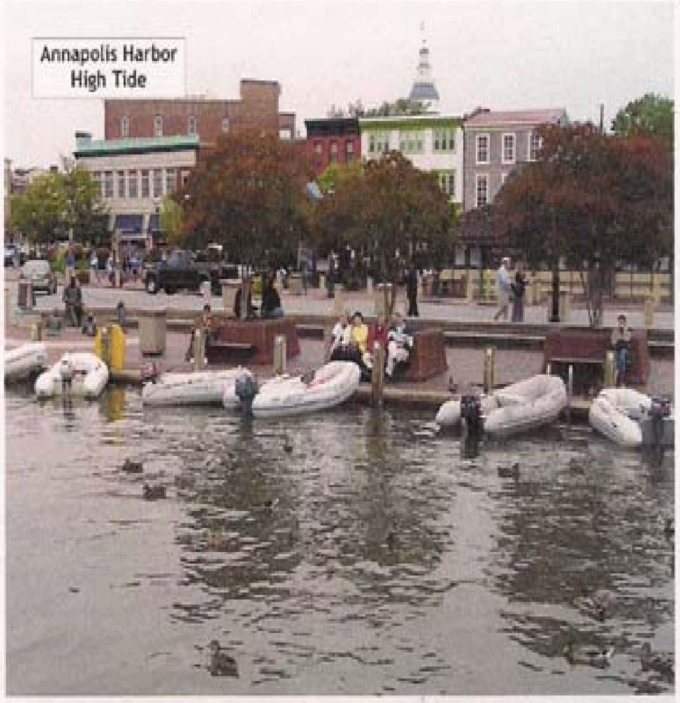
While the impacts of global climate change are largely beyond our control, proactive planning to mitigate their impacts is vital to our economy and the health and safety of our residents and visitors. The temperature of the Earth is predicted to increase between 2.0 to 6.3°F (1.1 to 3.5°C) by the end of the century (Meehl 2005), causing a wide range of increased threats to the coastal area and marine ecosystems. Global warming has also increased the ocean's temperature over the past few decades, which will likely increase the frequency and severity of coral bleaching events and cause sea level to rise (Barnett 2005). The Intergovernmental Panel on Climate Change (IPCC) predicts that worldwide sea level will rise 1.5 feet over the next 100 years, and has outlined numerous impacts from this rise on coastal communities:

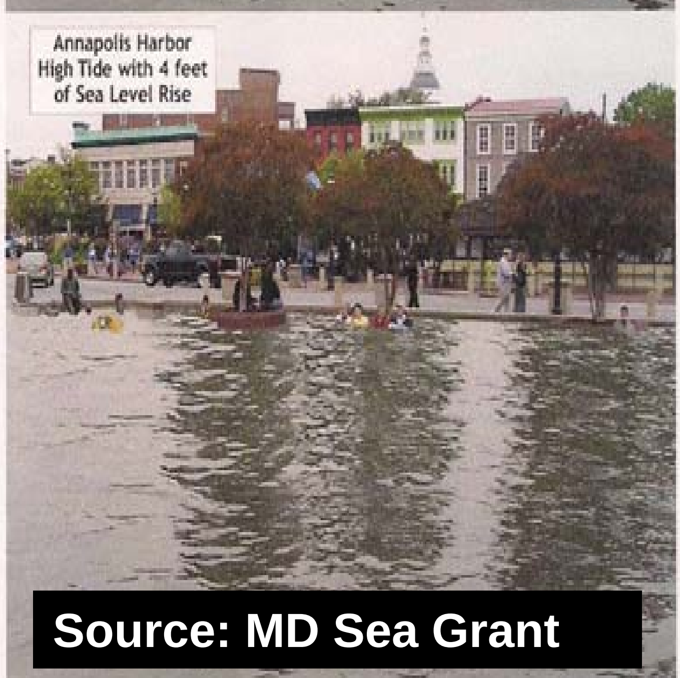
SLR impacts

- Beach erosion
- Inundation of land
- Increased flood and storm damage
- Saltwater intrusion into the freshwater lens aquifer
- Increased levels of land-based pollutants to coastal waters including sediments, nutrients and contaminants
- More frequent, longer, and more powerful El Niño and La Niña events

All of these impacts will contribute to a greater vulnerability of communities living in coastal areas, endangering life and property. Existing development and present coastal planning do not take this changing environment into account. Preventive or mitigative actions should not wait until a massive natural catastrophe (such as the Indian Ocean tsunami in 2004 or Hurricane Katrina in 2005) causes widespread destruction of the coastal zone.

MOVIE: Model of Sea-level rise, coastal erosion, and wave overtopping in Waimanalo, HI





Source: MD Sea Grant

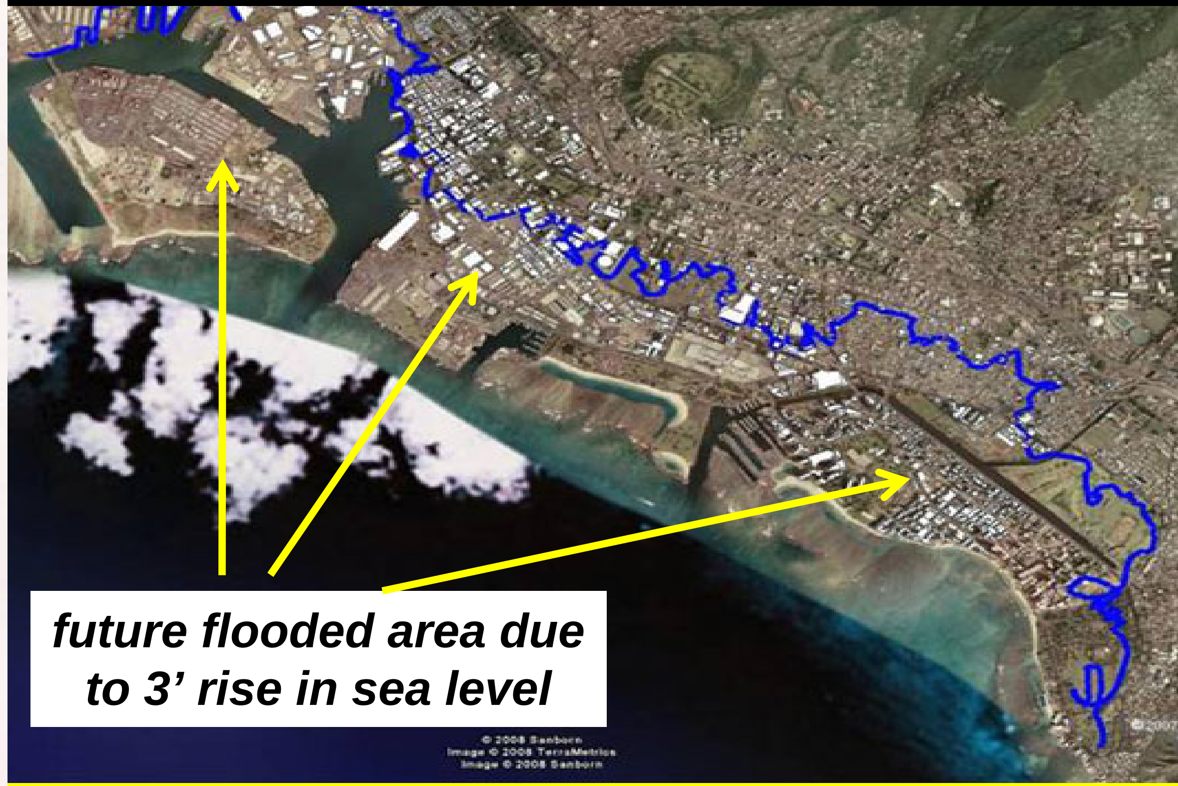


Figure 1. The blue line marks the contour of high tide when sea level is 1 m above present. Lands makai of the line are highly vulnerable to coastal hazards. These are targets for redevelopment to increase resiliency to natural hazards.

http://www.soest.hawaii.edu/coasts/sealevel/

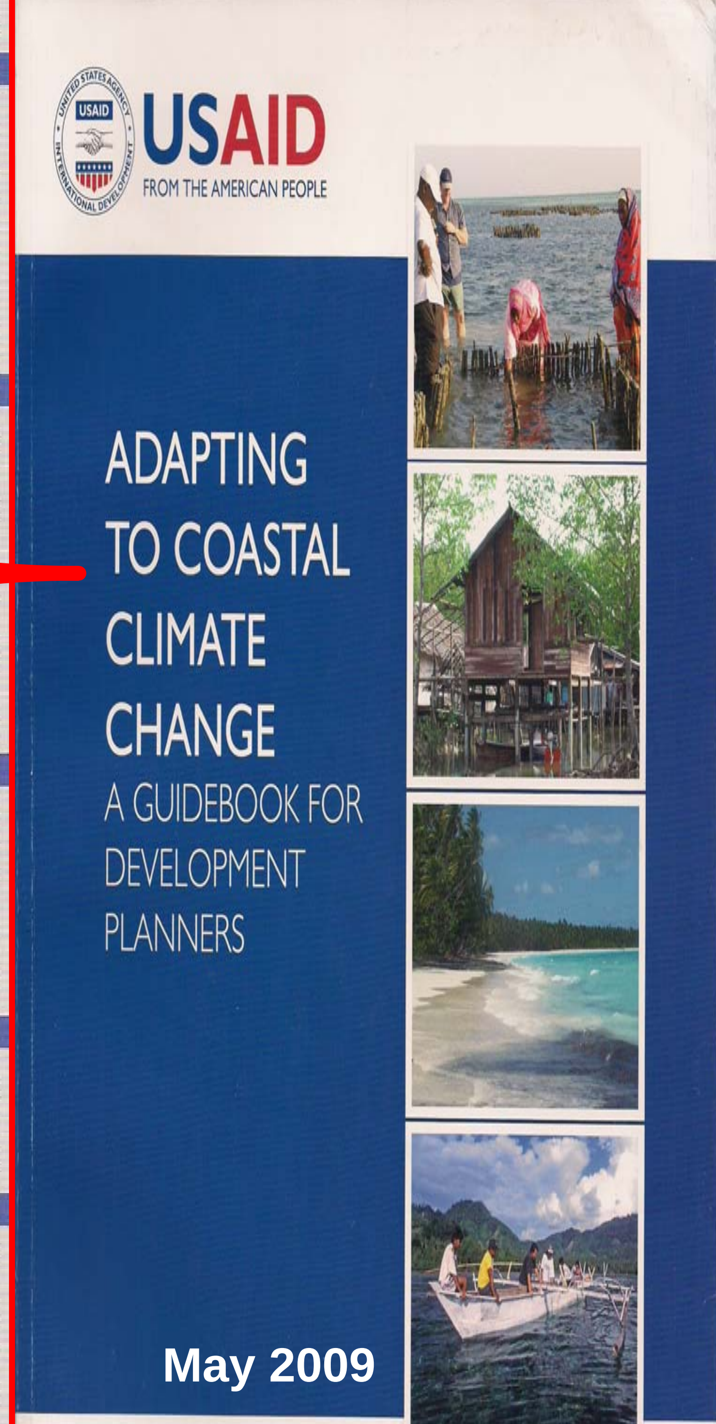
Adaptations to Sea Level Rise

1. Land use planning (by-law/zoning)

2. Building design practices

3. Control flood waters (levees; dikes; seawalls: beach/dune nourishment)

Adaptation Measures	Relevance to Climate Change	Page
Functioning & Healthy Ecosystems		
Coastal wetland protection and restoration	Acts as buffer against extreme weather events, storm surge, erosion, and floods; limits salt water intrusion.	89
Marine conservation agreements	Improves the resilience of coastal ecosystems to climate change and improves the economic and social conditions of coastal communities.	93
Marine protected areas	Maintains healthy and resilient coastal habitats and fisheries productivity; acts as "refugia" and critical sources of new larval recruits.	97
Payment for environmental services	Provides incentives to protect critical habitats that defend against damages from flooding and storm surges as well as coastal erosion.	101
Built Environment		
Beach and dune nourishment	Protects shores and restores beaches; serves as a "soft" buffer against flooding, erosion, scour and water damage.	105
Building standards	By incorporating climate considerations (e.g. effects of flooding, waves and wind) in building design, it reduces damages and human safety risks from climate change impacts, including extreme events, sea level rise, and flooding.	109
Coastal development setbacks	Reduces the infrastructure losses and human safety risks of sea level rise, storm surge, and erosion.	112
Living shorelines	Mitigates erosion and protects people and ecosystems from climate change impacts and variability in low to medium energy areas along sheltered coastlines (e.g. estuarine and lagoon ecosystems).	116
Structural shoreline stabilization	Temporary buffer against the impacts of erosion and flooding caused by factors such as sea level rise, storm surge, and wave attacks.	120
Diversified Livelihoods		
Fisheries sector good practices	...d security and marine biodiversity against the impacts of extreme climate events, precipitation change, ocean acidification, sea level rise and sea surface warming.	125
Mariculture best management practices	Integration of climate change considerations helps safeguard against extreme climate events, precipitation change, ocean acidification, sea level rise and sea surface warming.	130
Tourism best management practices	Integration of climate change concerns helps promote the sector's sustainability as well as safeguard against extreme climate events, precipitation change, sea level rise and sea surface warming.	133
Human Safety & Safety Enhanced		
Community-based disaster risk reduction	By proactive planning and capacity building that addresses the specific needs of local communities, increases their resilience and ability to respond to the effects of extreme climate events and flooding.	139
Flood hazard mapping	Informs coastal planning processes and policy, reducing the impact of flooding resulting from storm events, heavy rains, storm surges, and extreme tides.	143
Overarching Planning & Governance		
Coastal watershed management	Preserves estuaries, which act as storm buffers and protect against coastal groundwater salinization.	149
Integrated coastal management	Provides a comprehensive process that defines goals, priorities, and actions to address coastal issues, including the effects of climate change.	154
Special area management planning	Improves the management of discreet geographic areas where there are complex coastal management issues and conflicts, including issues related to extreme climate events, precipitation change, ocean acidification, sea level rise and temperature change.	160



Adaption Measure **Relevance to Climate Change**

Built Environment

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ANNEX A: Adaptation Measures

- **Coastal Development Setbacks**
- **Building Standards**
- Structural Shoreline Stabilization
- Beach & Dune Nourishment
- Living Shorelines

Honorable Mention

USAID: Adapting to Climate Change: A Guidebook for Development Planners, May

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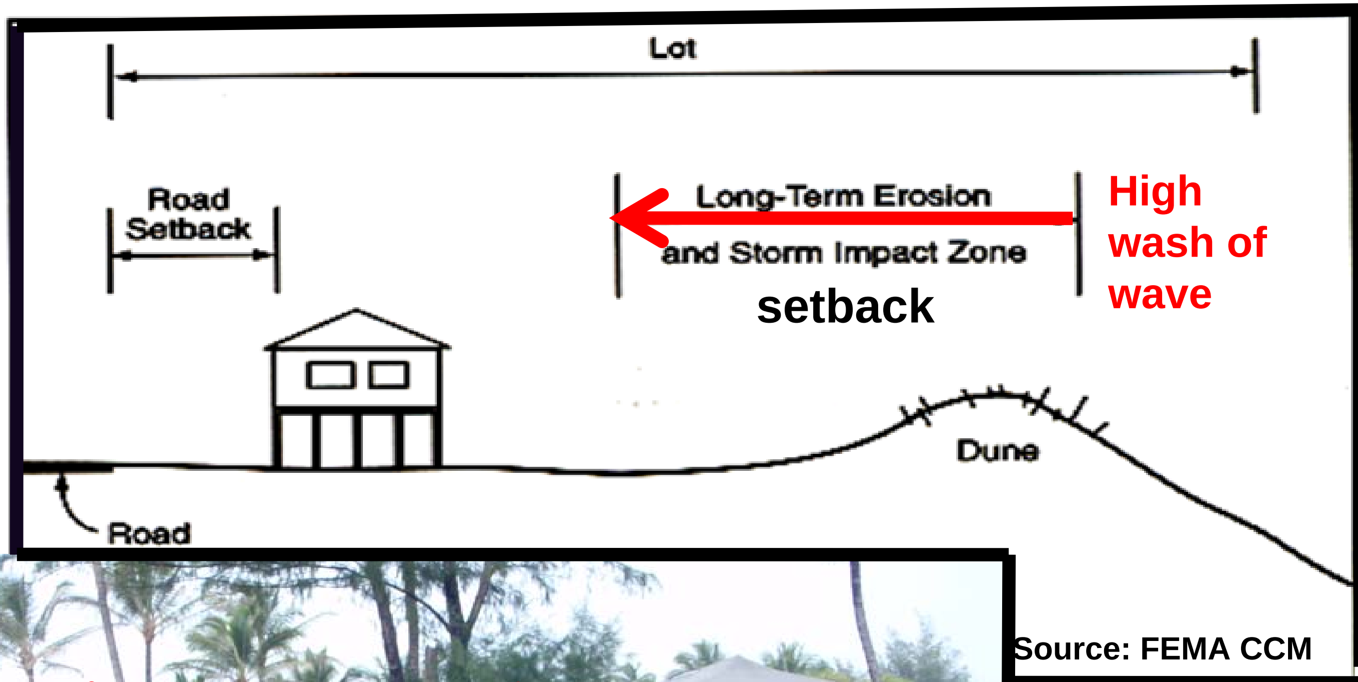
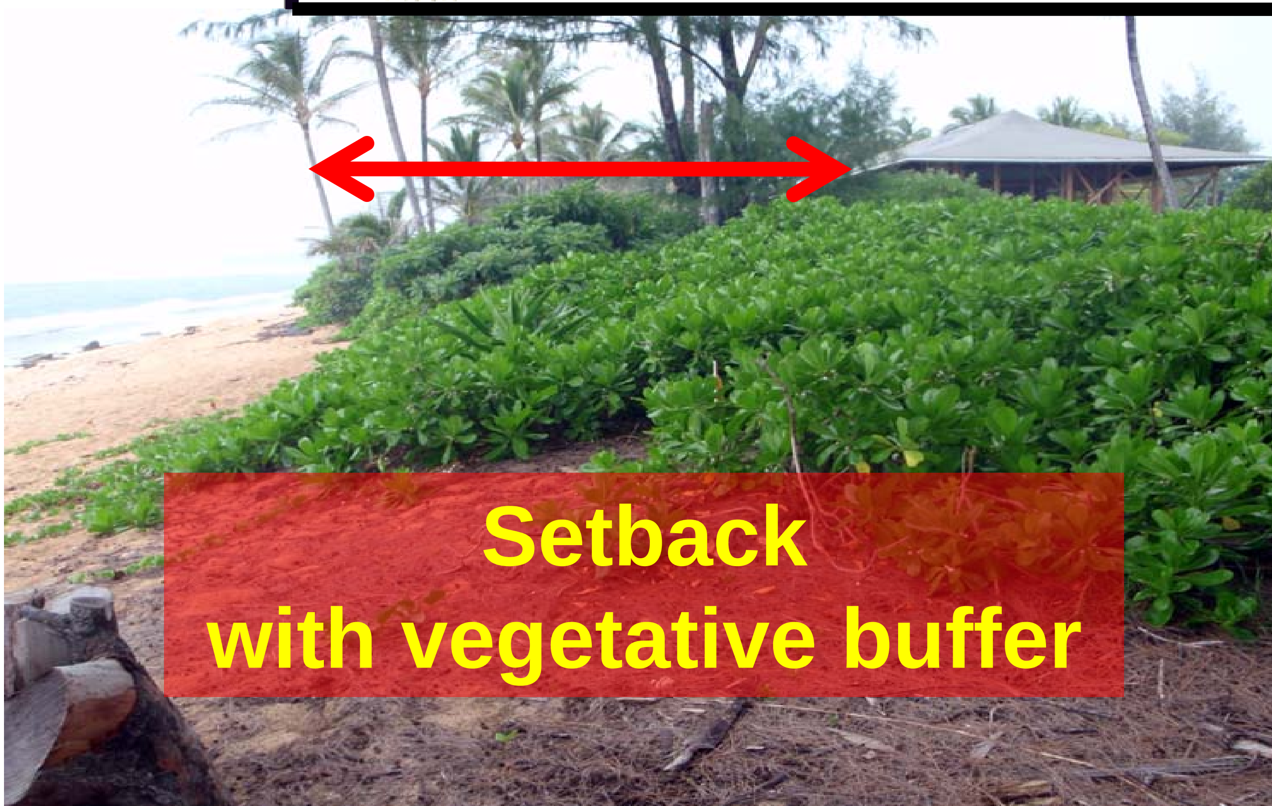
USAID: Adapting to Climate Change: A Guidebook for Development Planners (May 2009)

Figure 8-7
Recommended lot layout. Sufficient space is provided to comply with state/local setback requirements and avoid dune damage.





‘Forestalls’ the impacts of ‘sea level rise’

<u>Benefits of Setbacks:</u>

Avoid loss of shorefront dwellings

Protect infrastructure

**** <u>Avoid Shoreline Armoring</u>**

*** Preserve Beaches**

*** Preserve Shoreline Access**

*** Preserve Marine (beach/intertidal) Habitat**

23 states & territories shoreline setback policy
(Bernd-Cohen & Gordon, 1998)

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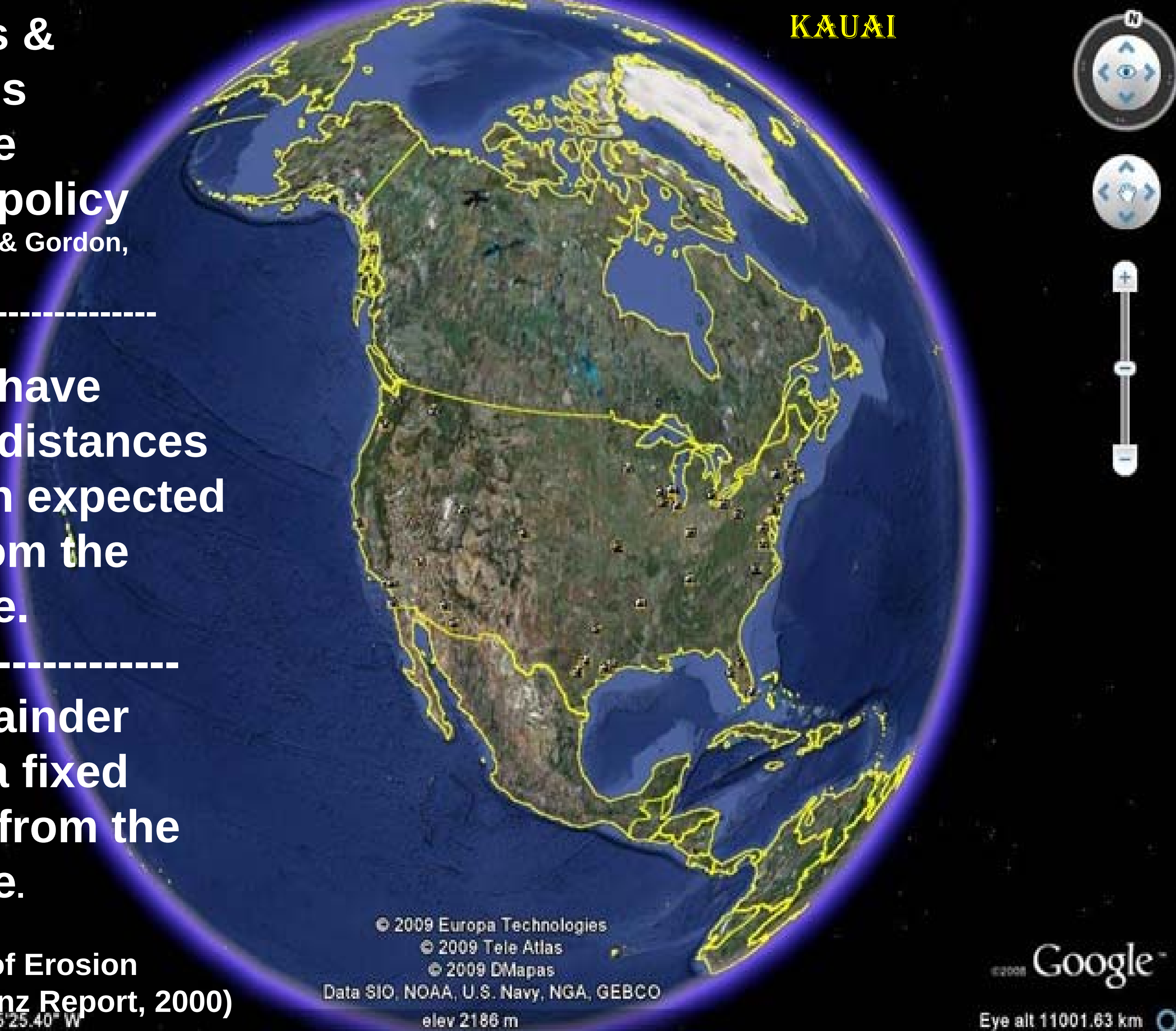
7 states have setback distances based on expected years from the shoreline.

The remainder specify a fixed setback from the shoreline.

(Evaluation of Erosion Hazards, Heinz Report, 2000)



HI CZM statewide setback:
not <20’ & not >40’
from a ‘Certified Shoreline’

Maui:
- **Average lot depth or**
- **(50 x erosion rate + 25’)**
  greater of two

Oahu: 40’ (20’ small lots)

Hawaii County: 40’

Kauai:
- **Average lot depth, or**
- **Building size + Erosion rate-based**
  (70 x erosion rate + 40’)
  (100 x erosion rate + 40’)

Exiting shoreline setbacks in Hawaii

(Jim O’Connell, UH Sea Grant Kauai)

‘*Shoreline Setback & Coastal Protection Ordinance*’ County of Kauai, HI

Jim O’Connell
UH Sea Grant, Kauai

Shoreline Setback and Coastal Protection Ordinance : Kauai, HI

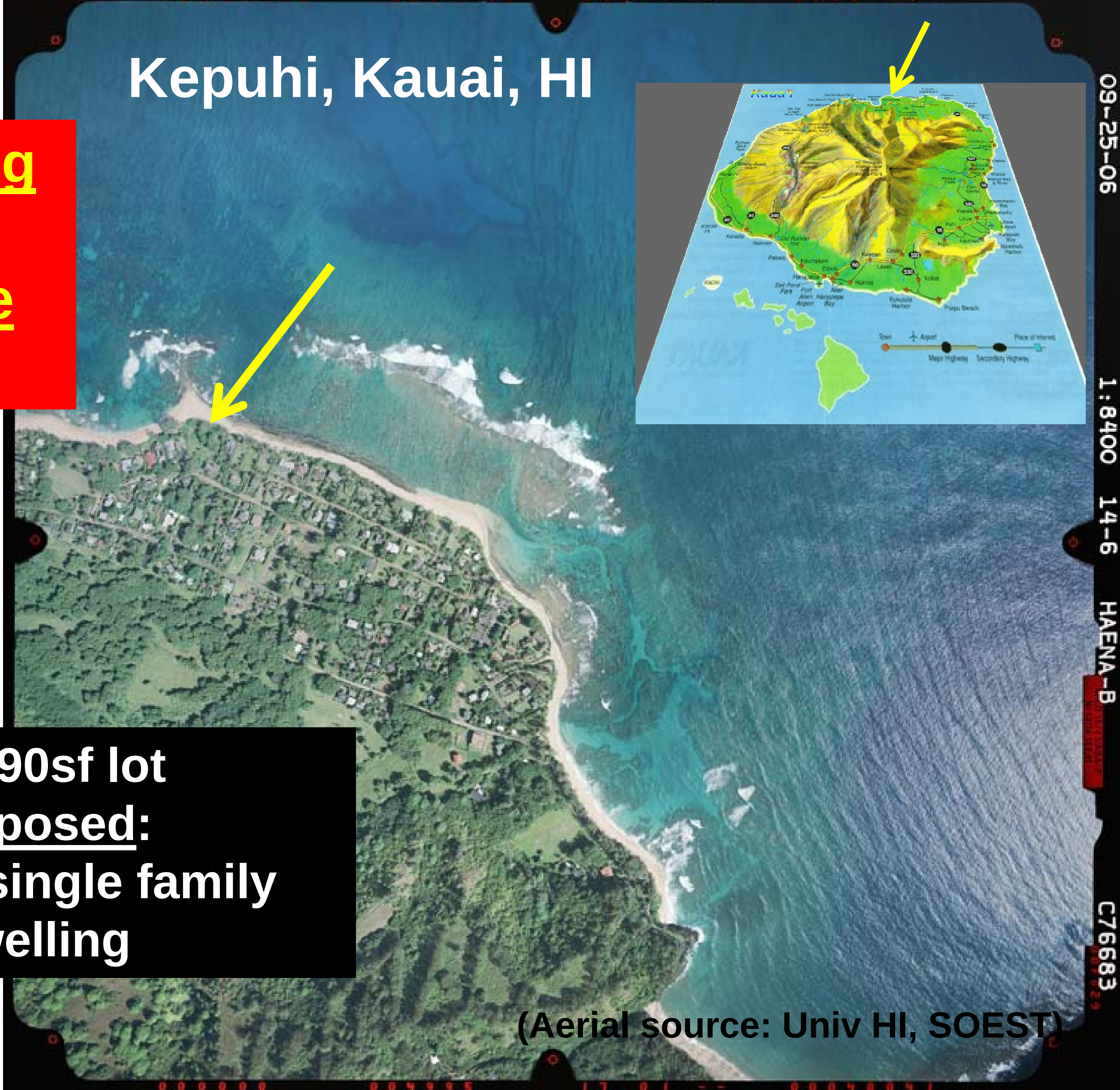
<u>Applicability</u> : a. Abutting the shoreline

b. Located within 500’ of the shoreline,

<u>UNLESS</u> ‘…applicant demonstrates to satisfaction of Director (Planning Department) that proposal will not be affected by coastal erosion

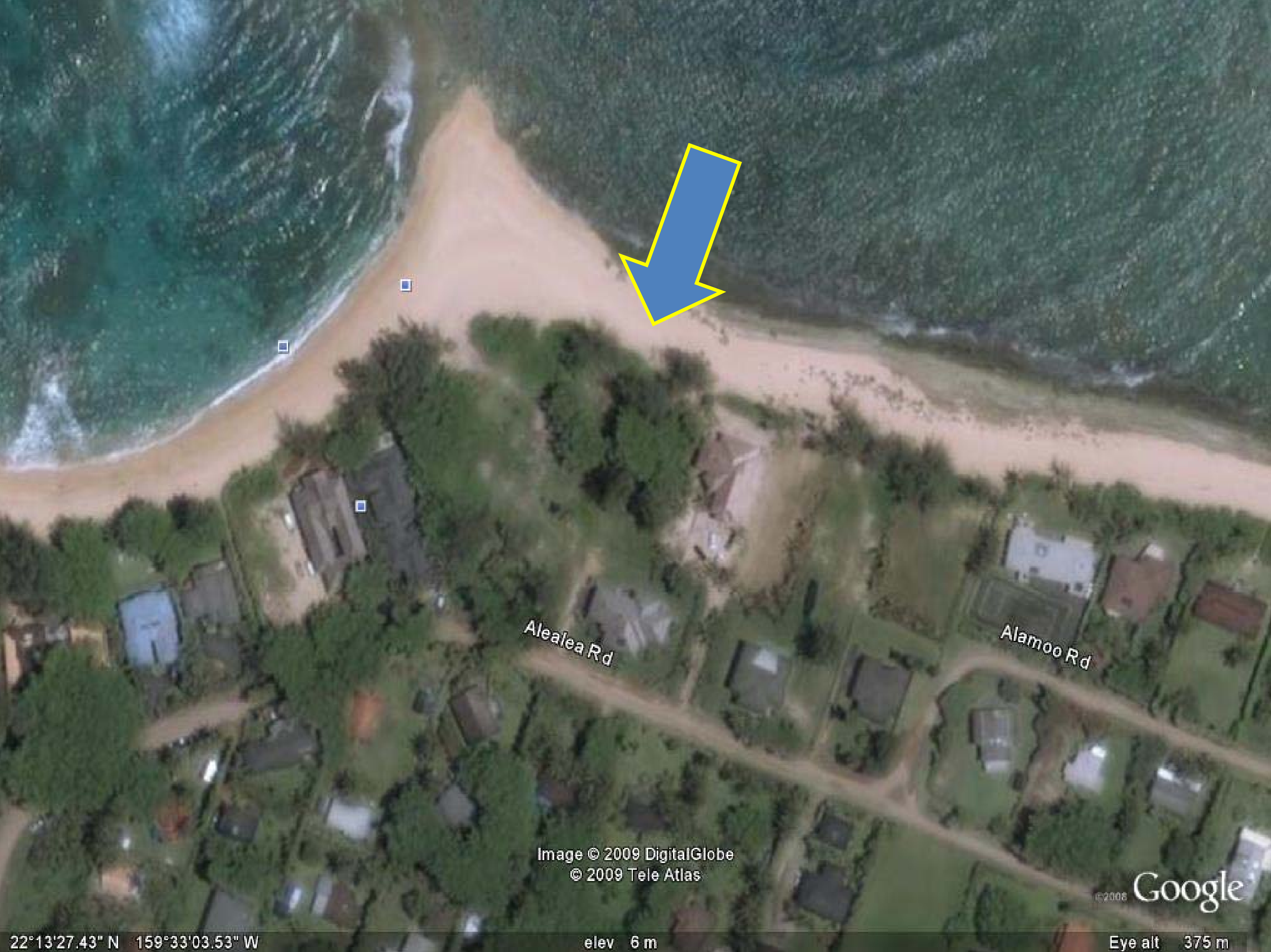
Kepuhi, Kauai, HI

calculating the shoreline setback



17,390sf lot
proposed:
2,485 sf single family dwelling

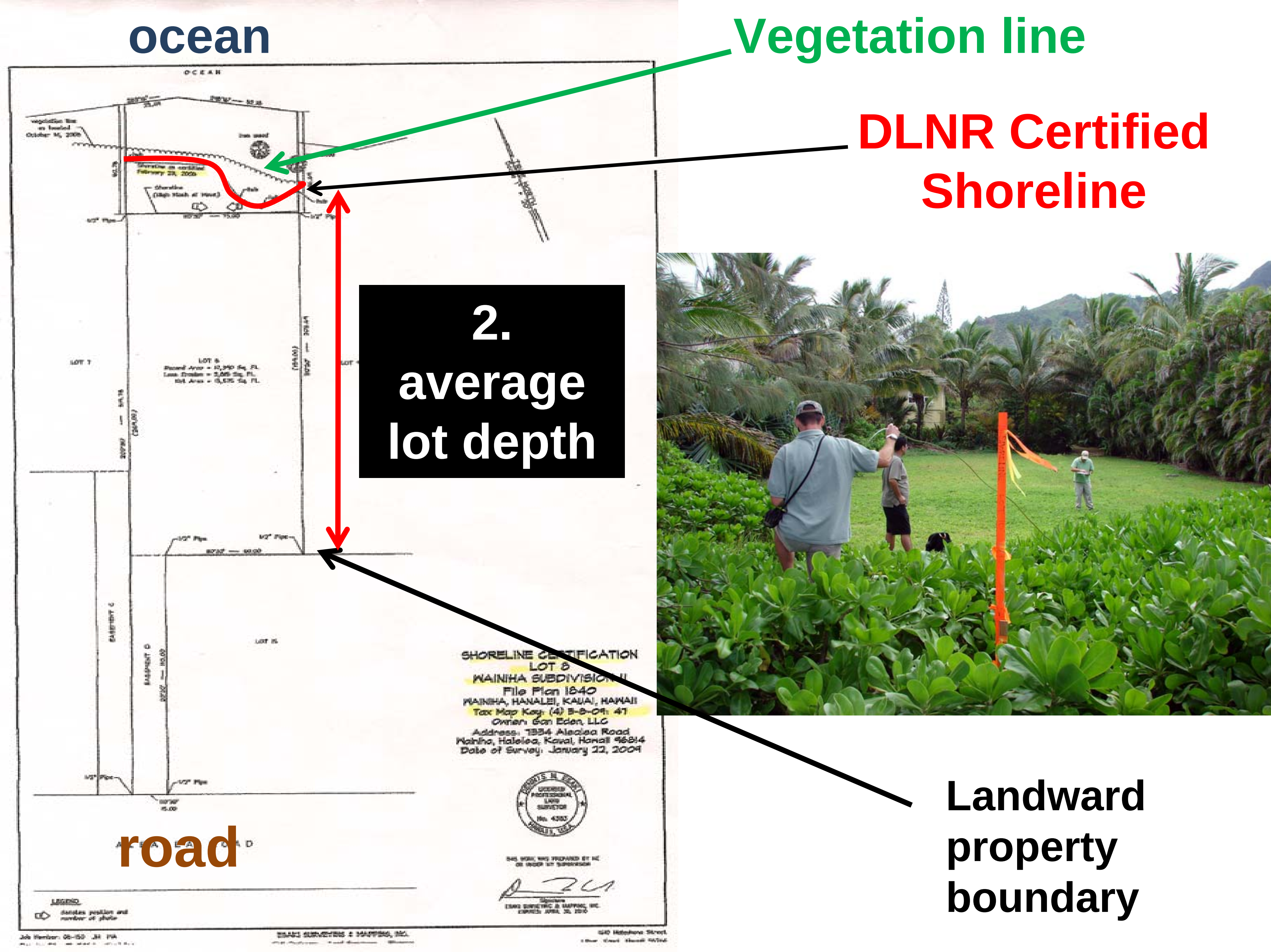
(Aerial source: Univ HI, SOEST)


Alealea Rd
Alamoo Rd
Image © 2009 DigitalGlobe
© 2009 Tele Atlas
Google
22°13'27.43" N 159°33'03.53" W
elev 6 m
Eye alt 375 m

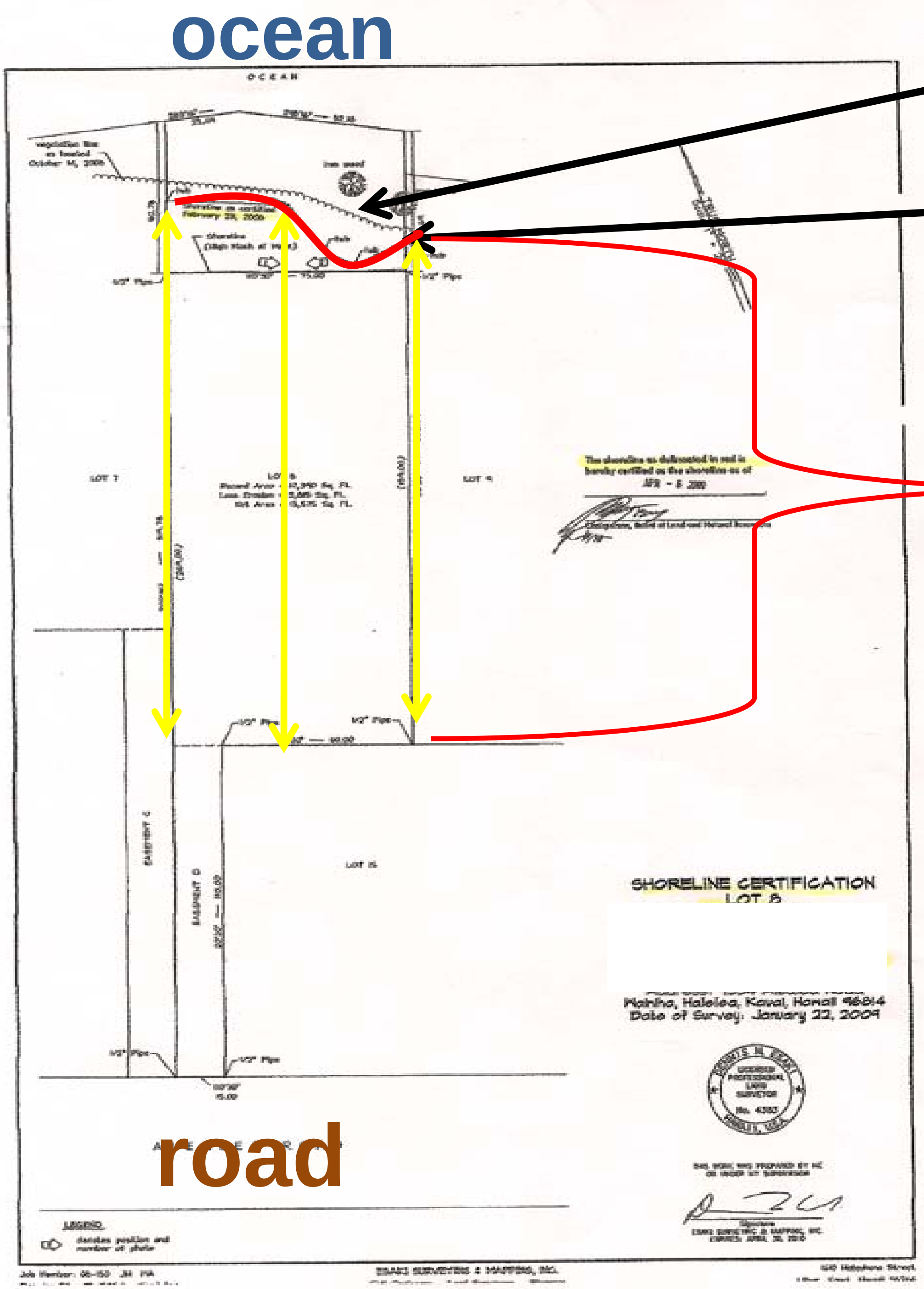
DLNR delineating a state *'Certified Shoreline'*

'Upper reaches of the wash of the waves, other than storms and seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by edge of vegetation growth, or the upper limit of debris left by the wash of the waves'

Certified Shoreline
approved by DLNR
PRIVATE PROPERTY
ocean
Private Land
Public Beach Area
beach
In addition:
'it's the line from which the shoreline setback is measured landward'.



ocean
Vegetation line
DLNR Certified Shoreline
2. average lot depth
Landward property boundary
road
OCEAN
LOT 7
LOT 8
LOT 15
File Plan 1840
WAINIHA, HANALEI, KAUAI, HAWAII
Tax Map Key: (4) 5-8-09: 47
Date of Survey: January 22, 2009



Vegetation line

Certified Shoreline

(x+x+x)/3 = 177’

‘Avg lot depth’
177’

Lot Survey

Kauai Shoreline Setbacks: Ordinance #863

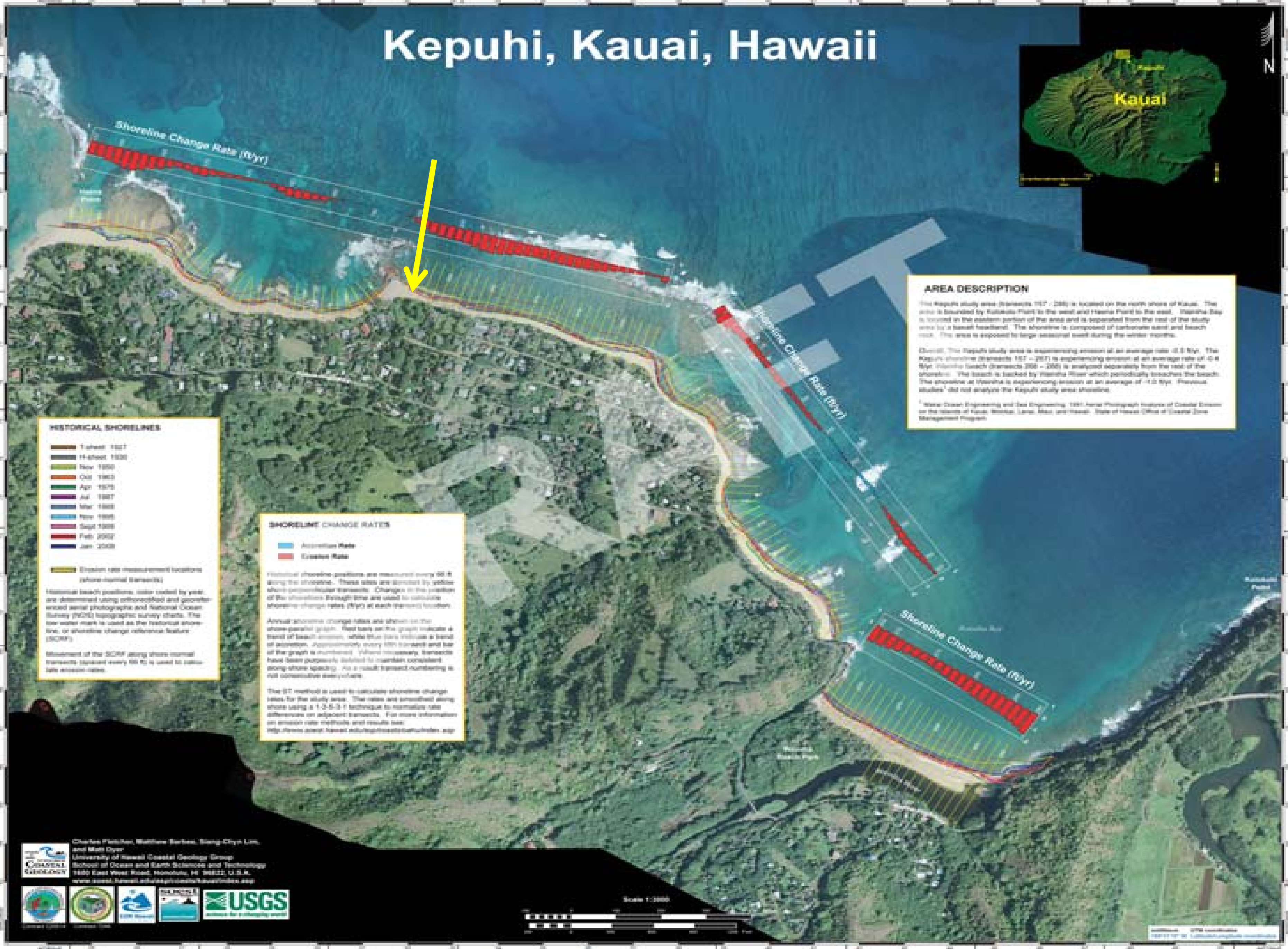
177’↓

If Average Lot Depth is:	< 100 ft or less	101-120 ft	121-140 ft	141-160 ft	161-180 ft	181-200 ft	>200 ft
Minimum Setback	40 ft	50 ft	60 ft	70 ft	80 ft	90 ft	100 ft

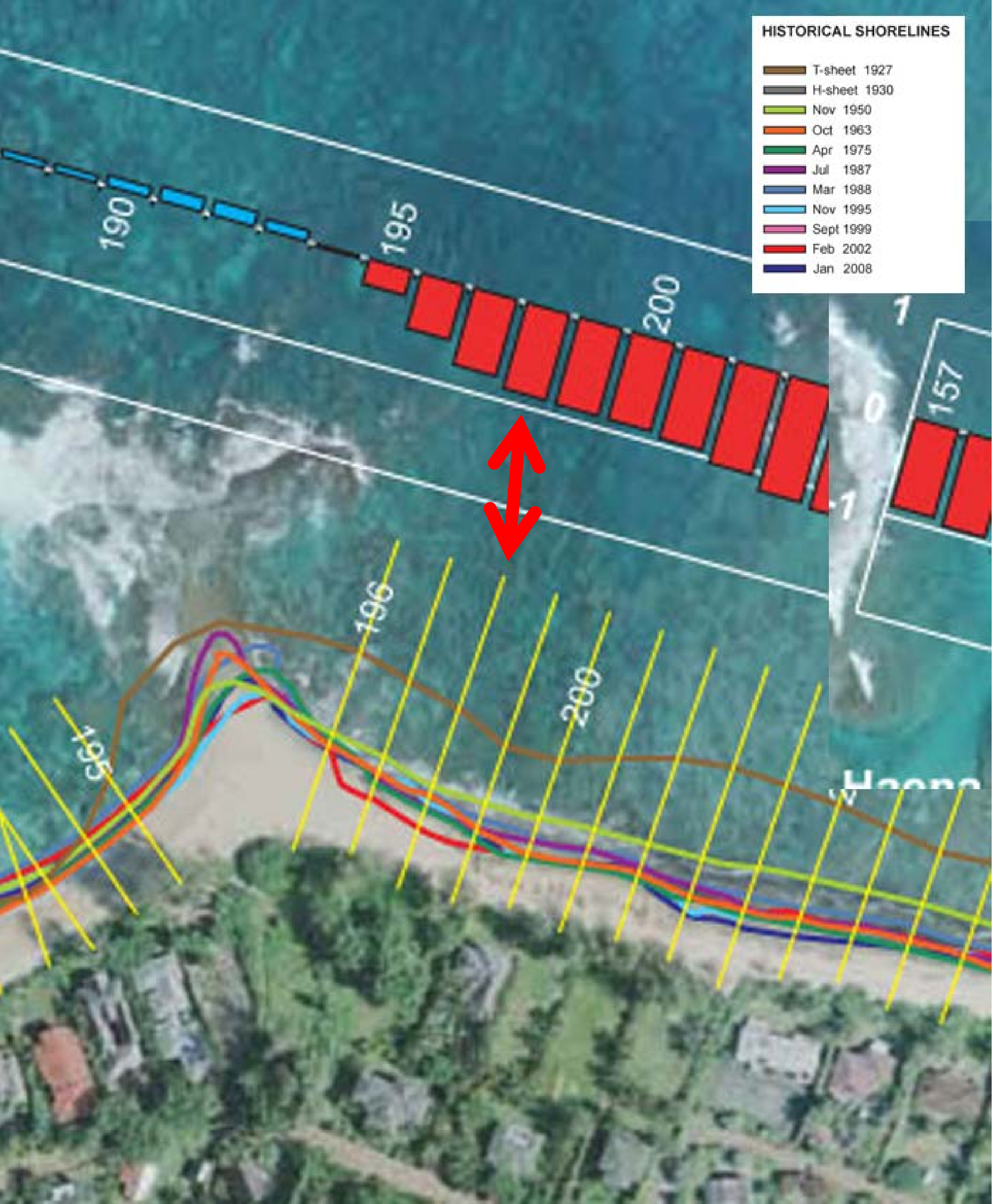
For lots >160 ft depth shoreline setback line set based on ‘coastal erosion study’ as provided in Table 2 below BUT no less than Table 1.

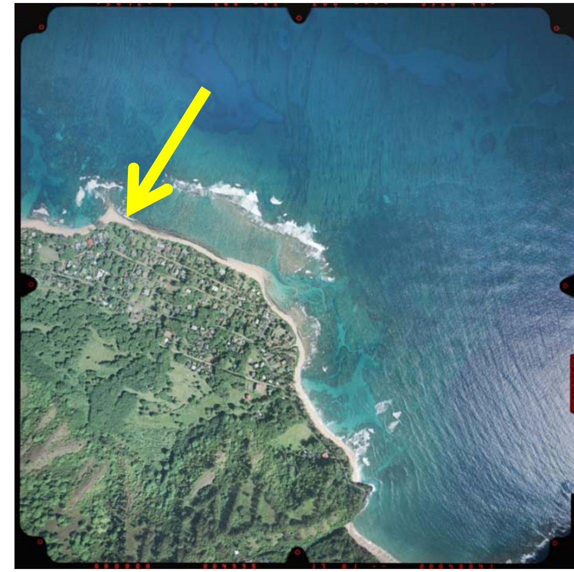
Structure with a Building Footprint that is:	Less than or equal to 5,000 ft² (proposed 2,485sf)	Greater than 5,000 ft²
The Setback Distance is:	40 feet plus 70 times the annual coastal erosion rate(?)	40 feet plus 100 times the annual coastal erosion rate

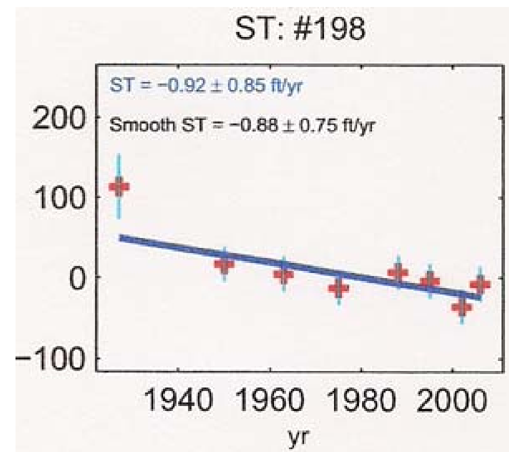
Jim O’Connell, UH Sea Grant on Kauai



Kepuhi, Kauai, Hawaii
Kauai
Shoreline Change Rate (ft/yr)
Shoreline Change Rate (ft/yr)
Shoreline Change Rate (ft/yr)
AREA DESCRIPTION
HISTORICAL SHORELINES
SHORELINE CHANGE RATES
Accretion Rate
Erosion Rate
USGS
N



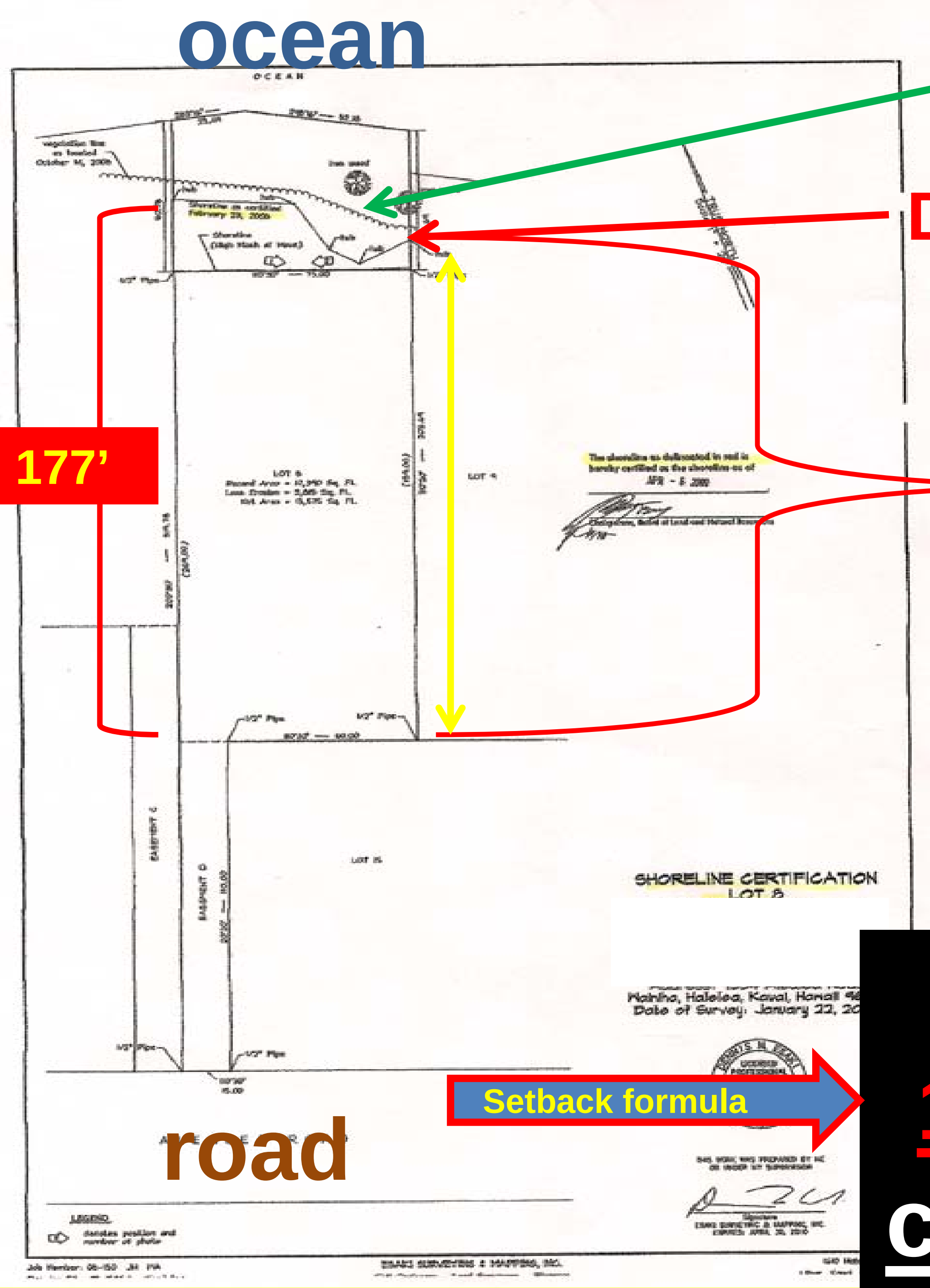




Erosion rate =

<u>-0.88'/yr</u>

(1927-2008)



Vegetation line

DLNR Certified Shoreline

Avg lot depth

(177')

>160' <180

2,485sf dwelling (<5000sf)

-0.88'/yr erosion rate

(70 x 0.88) + 40' =

102' setback from certified shoreline


Shoreline Setback,
Haena, Kauai
Setback = 102' from Certified Shoreline'
Certified Shoreline
Shoreline Setback = 102' from Certified Shoreline
(based on 'erosion study')
Jim O'Connell, UH Sea Grant Kauai


32,234 sq ft (Poipu)
Proposed single family house
For sale: $5,900,000
Setback = 100’
Kauai
Poipu
buildable area
Setback area
Dave Caylor, Kauai
Summer 2009
Avg lot depth = 264’ erosion rate-based setback(s): 54’ & 64’

How much setback will be enough as Sea Level approaches 1 meter above present ?

Estimate: L/D

L = distance offshore where waves affect the bottom
D = depth at that place

Typically the L/D ratio is 100 (varies between 50 - 200)
Currently, sea level rise is approx 0.12”/yr – translates to 1’/yr erosion
(close to the average on Kauai, Maui & Oahu)

SO: given an approximate 1 meter rise by 2100 = <u>shoreline retreat could exceed 300’</u>

(Source: Beach Erosion & Loss, Chapter 9, p. 2-3)

July 2008
Jim O’Connell,
UH Sea Grant Kauai

* RELOCATION House - Relocate Landward

(Photo from: HI Hazard Mitigation Guidebook, D. Hwang, 2006)

Figure 9-6 – Aliomanu Bay, Kauai – Erosion of the
and impacts water quality. These impacts can be
sand that meets the standards in Figure 9-5, inst
Dennis Fujimoto of Garden Island News (from:

Adaptive Capacity to respond to sea level rise in the Built Environment:

the ability AND planning to get the heck out of the way of on-coming storm and flood waters by either:

1. Moving in the opposite direction (landward);
2. Moving higher above waves & flood;
3. Protect it (dike/levee/seawall); or,
4. Don’t build in a flood-prone area.

Adaption Measure **Relevance to Climate Change**

BUILT ENVIRONMENT IS LESS EXPOSED AS A PRIMARY GOAL		
Beach and dune nourishment	Protects shores and restores beaches; serves as a "soft" buffer against flooding, erosion, scour and water damage.	105
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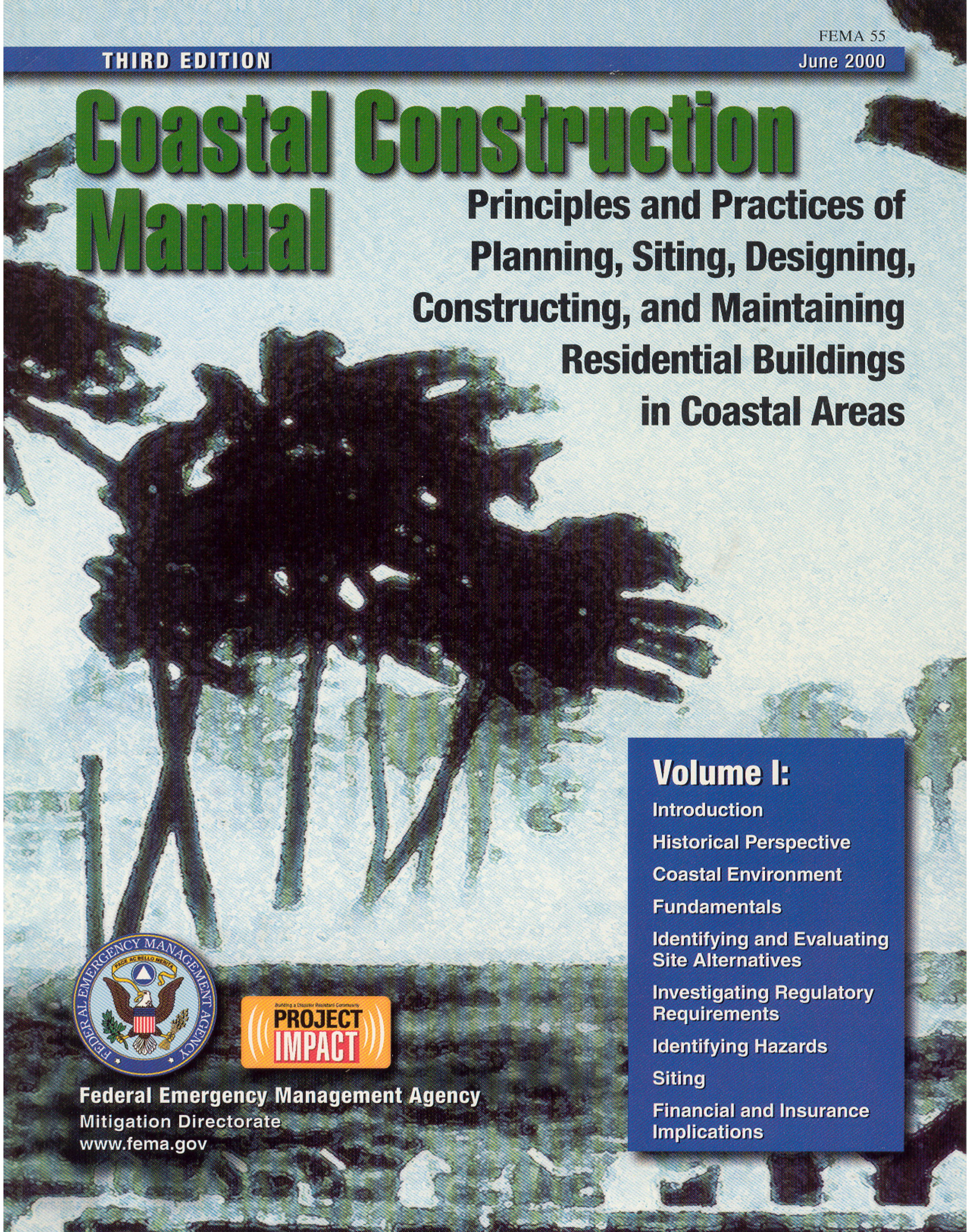
USAID: Adapting to Climate Change: A Guidebook for Development Planners (May 2009)



Federal Emergency Management Agency:

In light of <u>relative sea level rise,</u> <u>erosion,</u> & potential <u>map errors</u> need to be more protective – progressive!

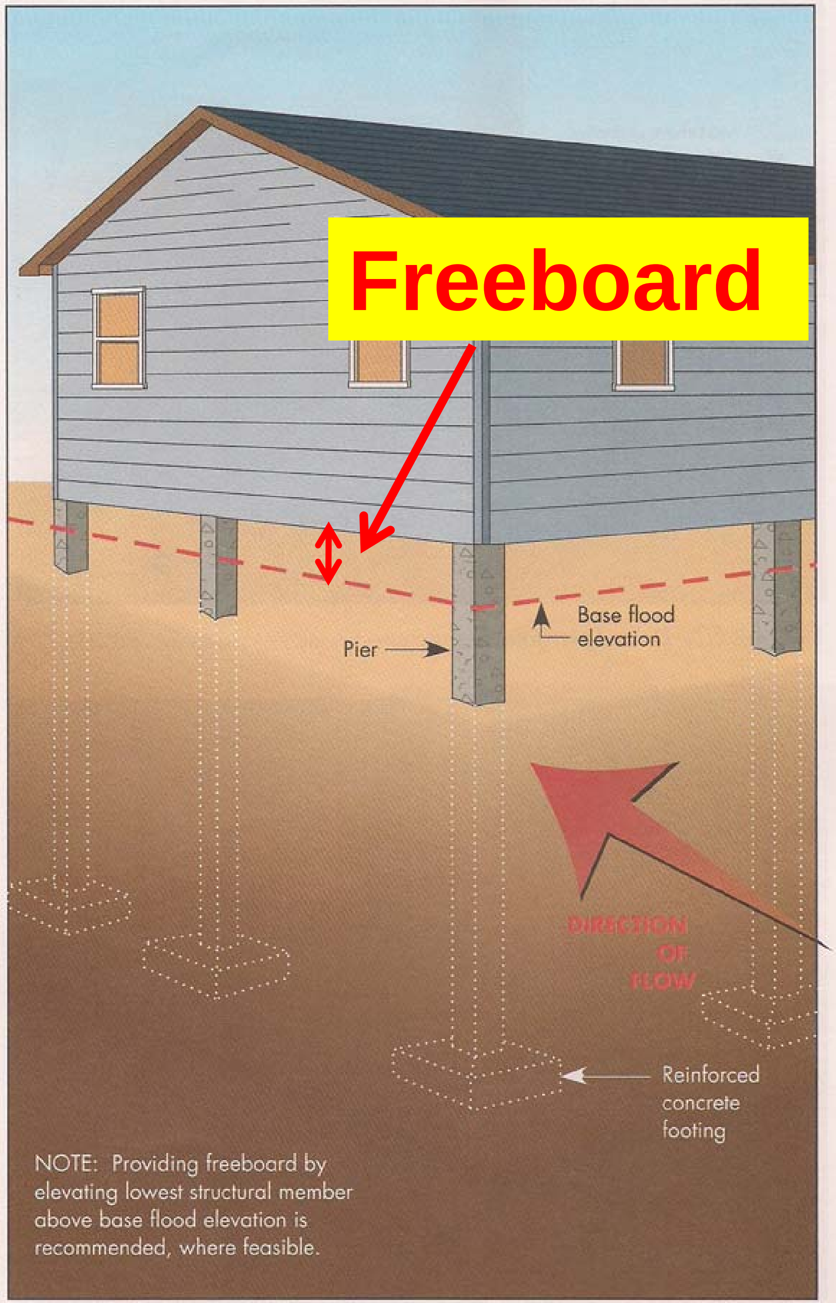


FIGURE 61. *One method of support for piers is a reinforced concrete footing.*

From: ‘Building Performance: Hurricane Iniki in Hawaii’

Observations, Recommendations and Technical Guide, FEMA, March 3, 1993

‘Providing freeboard by elevating lowest structural member above base flood elevation is recommended, where feasible.’

fact sheet 5

Freeboard

Better preparation for ongoing sea level rise

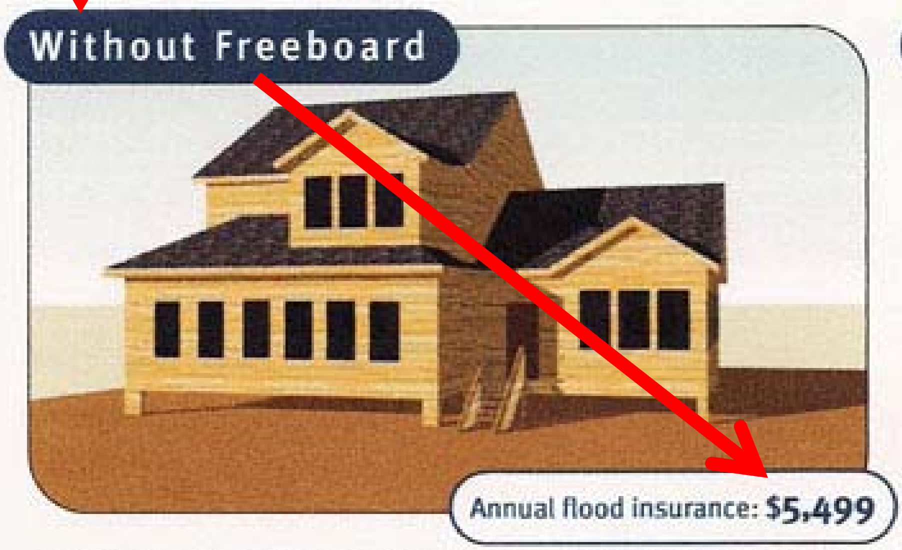
stormsmart coasts

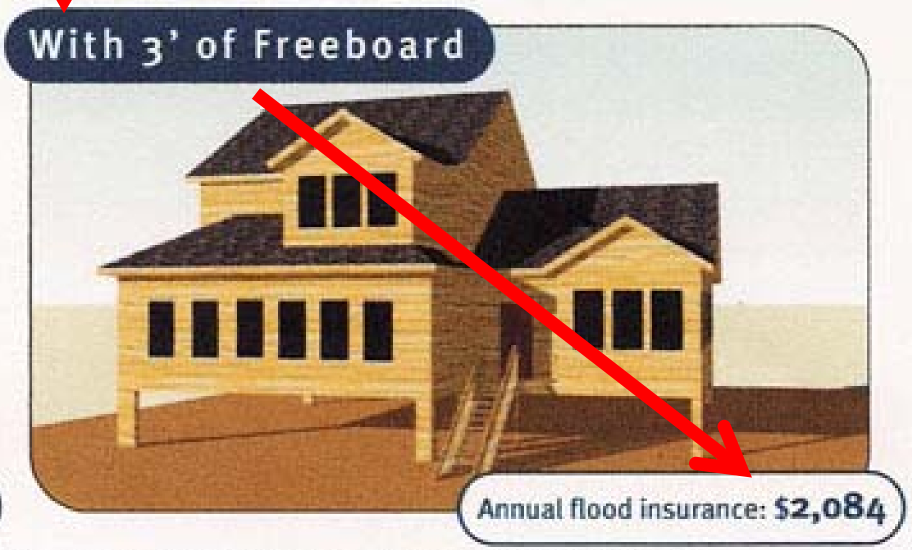
... savings on NFIP premiums[1] with freeboard

Zone		Annual savings in NFIP premiums	Savings over 30-year mortgage
V Zone[2]	1' freeboard	$1,360 (25%)	$40,800
V Zone[2]	2' freeboard	$2,730 (50%)	$81,900
V Zone[2]	3' freeboard	$3,415 (62%)	$102,450
A Zone[3]	1' freeboard	$502 (41%)	$15,060
A Zone[3]	2' freeboard	$678 (55%)	$20,340
A Zone[3]	3' freeboard	$743 (60%)	$22,290

Raise Your Home, Lower Your Monthly Payments

Protect buildings and reduce monthly expenses with freeboard





Elevating a home a few feet above legally mandated heights has very little effect on its overall look, yet it can lead to substantial reductions in flood insurance, substantially decrease the chances the home will be damaged by storms and flooding, and help protect against sea level rise.

http://www.mass.gov/czm/stormsmart/regulations/freeboard.htm

Raise Your Home, Lower Your Monthly Payments

Protect buildings and reduce monthly expenses with freeboard

Home at minimum legal height

Monthly mortgage payments	$1,580.17	
Monthly flood insurance	+ $458.25	
Total monthly cost	**= $2,038.42**	

Home with 3' of freeboard

Monthly mortgage payments	$1,599.13	(+$18.96)
Monthly flood insurance	+ $173.67	(-$284.58)
Total monthly cost	**= $1,772.80**	**(-$265.62)**

In this example, adding 3 feet of freeboard saves the homeowner $265.62 per month, or $95,623.67 over a 30-year mortgage. Benefits in A zones[3] are generally less dramatic, but still substantial. To determine NFIP premiums for a specific property, see a licensed insurance agent.

http://www.mass.gov/czm/stormsmart/regulations/freeboard.htm

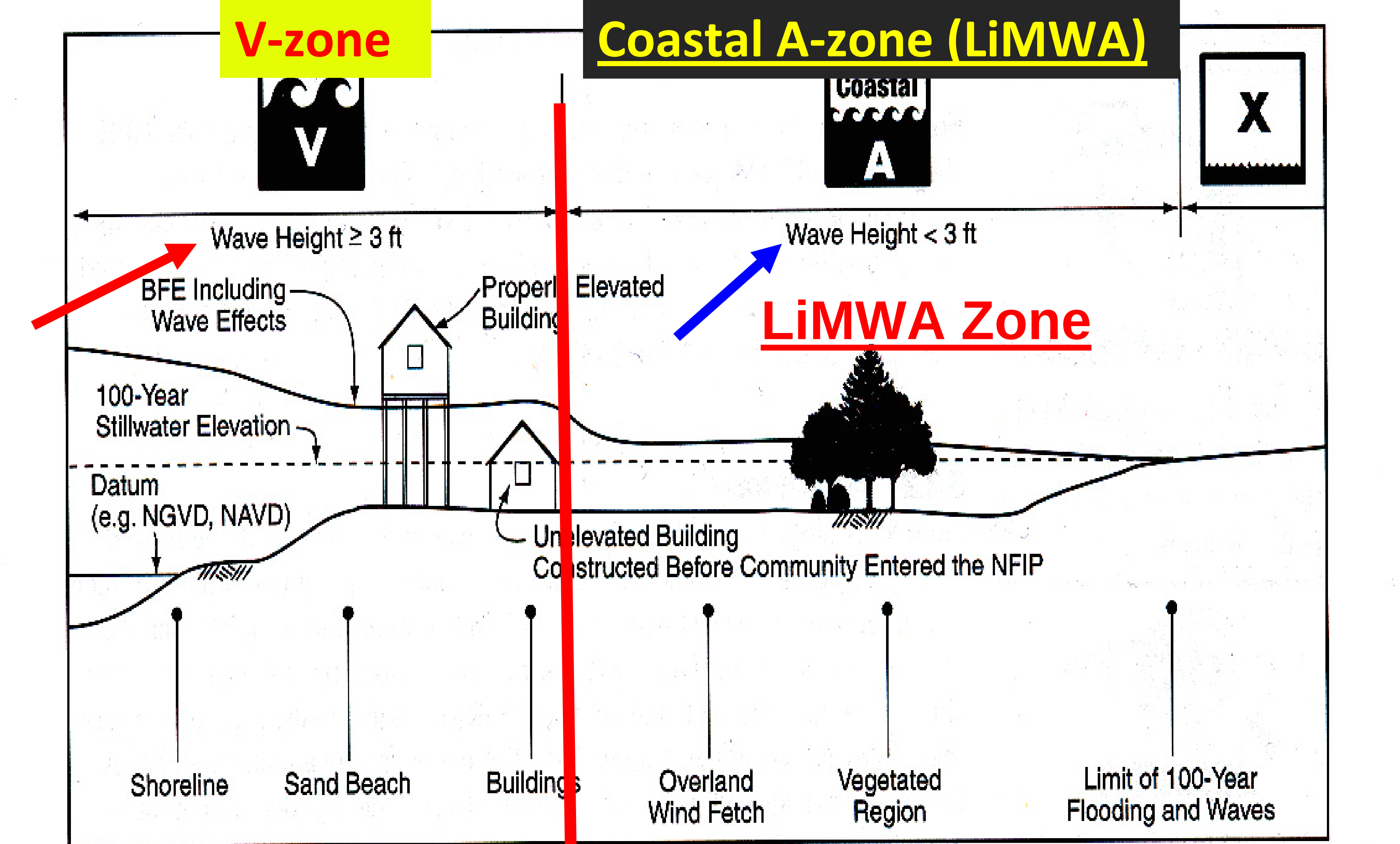


Figure 3-7

Typical shoreline-perpendicular transect used in the analysis of stillwater and wave crest elevations.

(FEMA's Coastal Construction Manual recommends distinguishing 'Coastal A-zones' & apply higher V-zone standards)

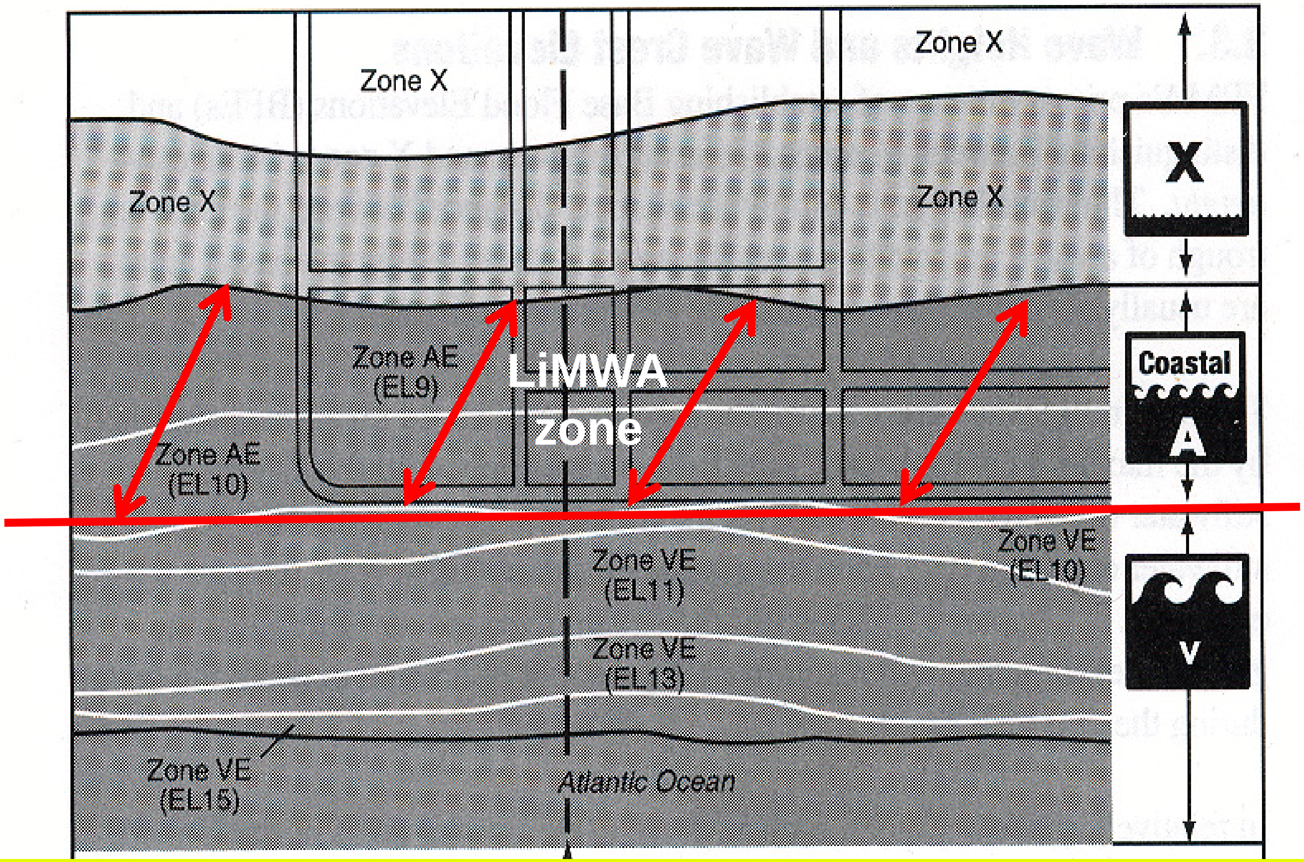
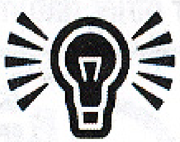


Figure 3-6
This portion of a FIRM shows a coastal Special Flood Hazard Area (SFHA) (dark gray), the 500-year flood hazard area (light gray), coastal Base Flood Elevations (BFEs) (numbers in parentheses), and flood insurance rate zones (AE and VE = SFHA, VE = Coastal High Hazard Area, X = areas outside the SFHA).



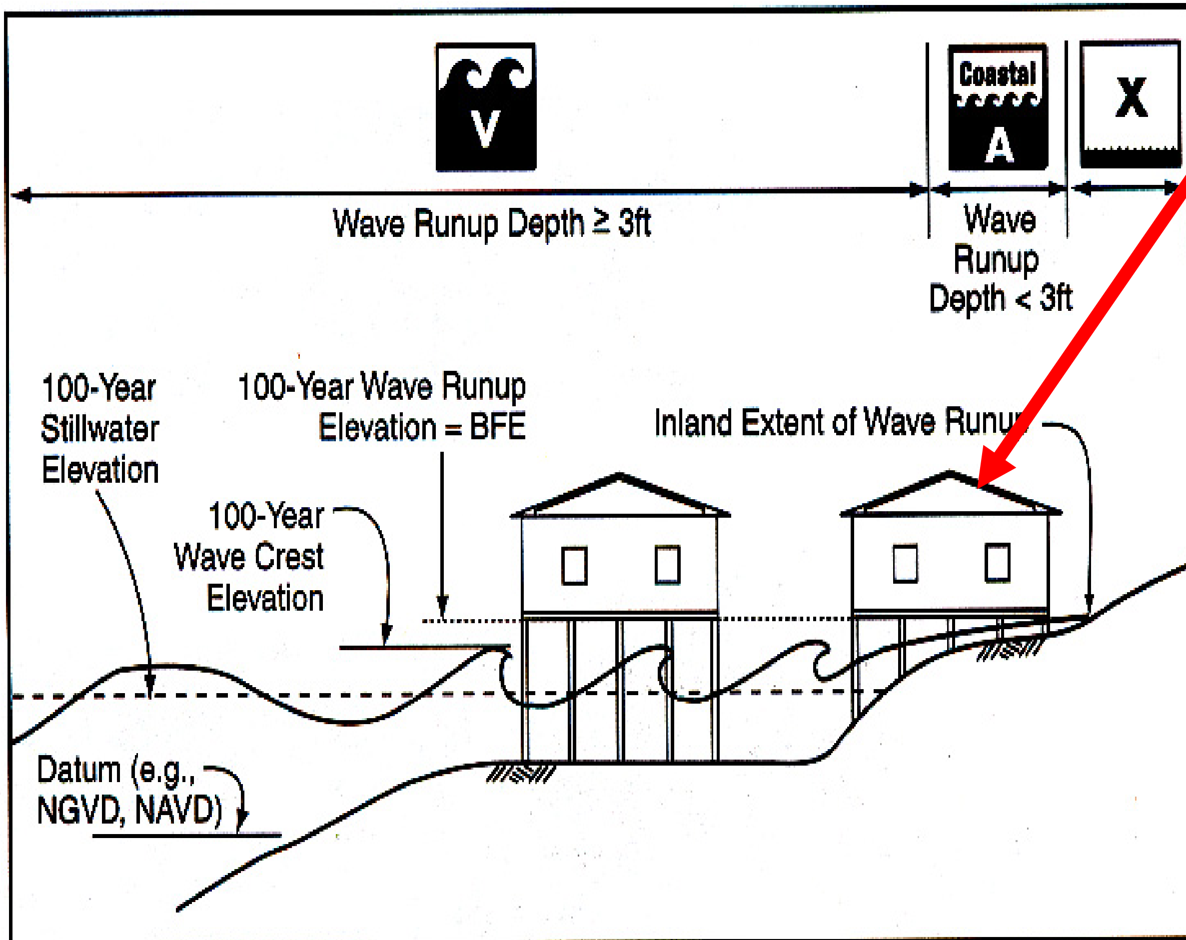
Coastal A-zone: **portion of SFHA landward of V-zone or landward of open coast w/o mapped V-zone; principal flood source tides, storm surge, (seiches, tsunamis).**

** **NOT RIVERINE FLOOD SOURCE!!** **

Figure 3-9

Where wave runup elevations exceed wave crest elevations, the BFE is equal to the runup elevation.

Elevate on open piles



DEFINITION

Wave runup elevation is the elevation reached by wave runup, referenced to the National Geodetic Vertical Datum of 1929 (NGVD) or other datum.

Wave runup depth at any point is equal to the maximum wave runup elevation minus the lowest eroded ground elevation at that point.

‘Real Estate Disclosure’ of site specific coastal hazards & Property Owner ‘Education’

Flood zone   Tsunamis zone   Erosion Rate   Set-back

RECOMMENDATIONS:

1. Map sea level rise inundation areas (3’);
2. Freeboard Advisory at Building Department
3. Institute Erosion Rate-based Setbacks;
4. Study: Costs & Logistics of Relocating Buildings in HI;
5. Shoreline Management Plan: Where to Allow Armoring (resorts?) & Loss of Coastal Resources vs. Where to Preserve Shoreline Areas in their Natural State
6. Real Estate Disclosure & Property Owner Coastal Hazards Education

(Jim O‘Connell, UH Sea Grant Kauai)

(1)

SEA GRANT

Helping Communities Adapt to Climate Change

May 2009

❖ Improve Understanding

❖ Increase Capacity

❖ Respond to Climate Change

See also web site:
UH Center for Island Climate Adaptation & Policy

(2)

Summary of Coastal Program Initiatives that address Sea Level Rise as a result of Global Climate Change

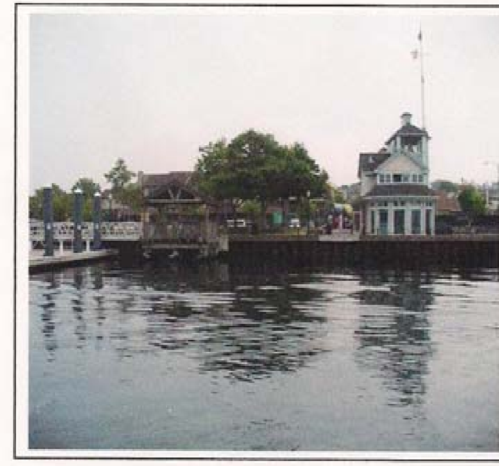
Table 1: Summary of State/Territory Sea-Level-Rise Policies and Initiatives

Sea-Level-Rise Policies and Initiatives by State/Territory					
State/ Territory	Working Groups, Commission, Committees	Outreach	Information for Decision Makers	Implementable Policy or Regulation	Plans, Strategies, Recommendations for Action
Alabama					
Alaska					
American Samoa					
California			X	X	X
Connecticut			X		X
Delaware	X	X	X		X
Florida			X		
Georgia					
Guam					
Hawaii			X		
Indiana					
Louisiana		X			
Maine		X	X	X	X
Maryland	X	X	X		X
Massachusetts			X	X	X
Mariana Islands					
Michigan			X		
Minnesota		X			X
Mississippi					
New Hampshire			X		X
New Jersey	X		X		X
New York	X		X	X	X
North Carolina	X		X		X
Northern Mariana Is.					
Ohio					
Oregon	X	X			X
Pennsylvania					
Puerto Rico	X				
Rhode Island	X	X		X	
South Carolina	X	X			
Texas			X	X	
Virginia	X		X		X
US Virgin Islands					
Washington	X		X		X
Wisconsin		X	X	X	X

Pamela Rubinoff
Nathan D. Vinhateiro
Christopher Piecuch

February, 2008

Rhode Island Sea Grant/Coastal Resources Center
University of Rhode Island



Hui O Mana Ka

Pu‘uwai

Outrigger Canoe Club

Jim O’Connell
UH Sea Grant Program on Kauai

(808) 241-4921
Jim.OConnell@hawaii.edu