CLIMATE CHANGE Vulnerability Assessment & Pilot Project

Photo: Aldaron Laird

Prepared for:

Caltrans
Del Norte Local Transportation Commission
Humboldt County Association of Governments
LAKE APC
MCOG

Prepared by:

ESA PWA
GHD

Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I
Chapter 1: Why Study Climate Change Impacts on Transportation?

1.0 Why Study Climate Change Impacts on Transportation?

Lead Authors: Robert C. Hyman, Joanne R. Potter, Michael J. Savonis, Virginia R. Burkett, and Jessica E. T

Transportation is such … States that few pause to
consider its importanc … public
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depend on reliable t
their customers; a r
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Transportation pr
specialists, ecolog
communities have

Given the ongoin
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the future

Four key

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The world is not on track to meet the target agreed [upon] by governments to limit the long-term rise in the average global temperature to 2° Celsius. Global greenhouse emissions are increasing rapidly and, in May 2013, carbon-dioxide levels in the atmosphere exceeded 400 parts per million for the first time in several hundred millennia.

—Executive Summary
Redrawing the Energy-Climate Map
International Energy Agency
June 2013


Courtesy of CALTRANS

Photo: Brian Birke, Creative Commons Attribution License

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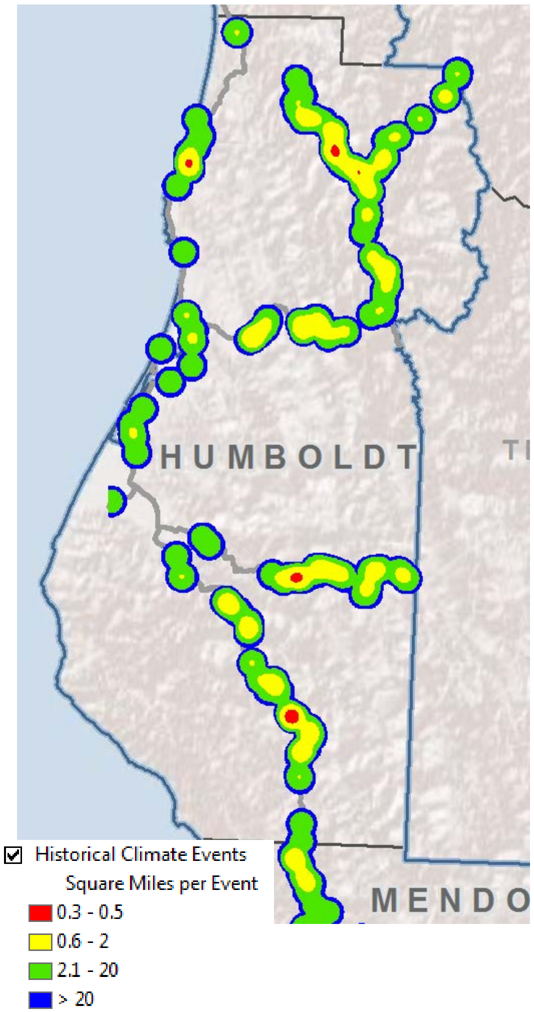
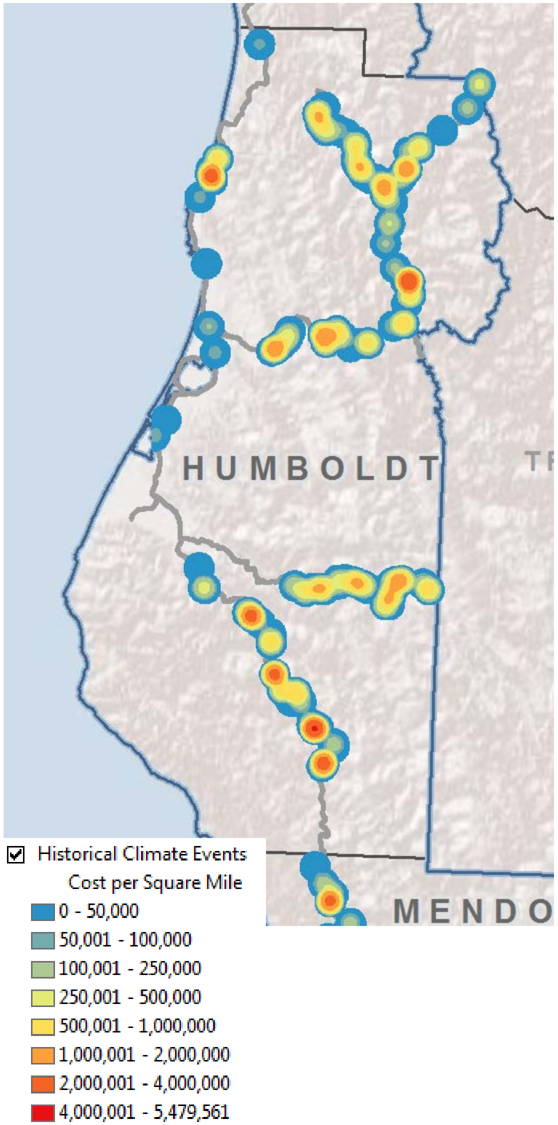
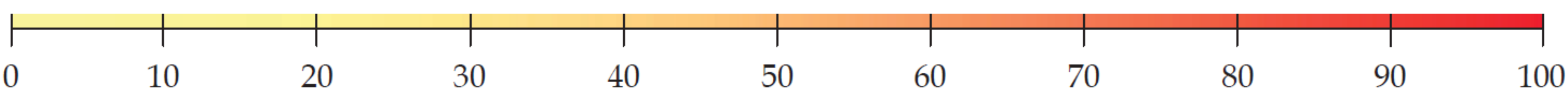
Historic Maintenance Events



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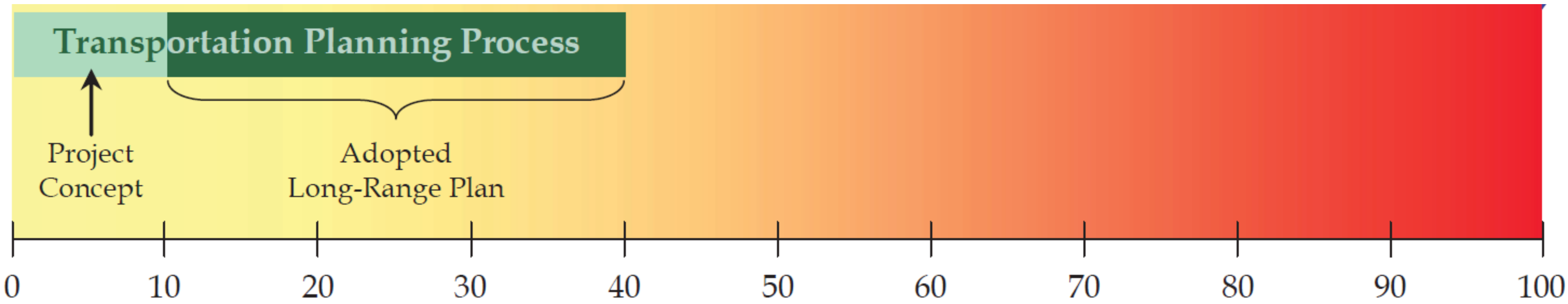
Transportation Planning Process
Project Concept
Adopted Long-Range Plan
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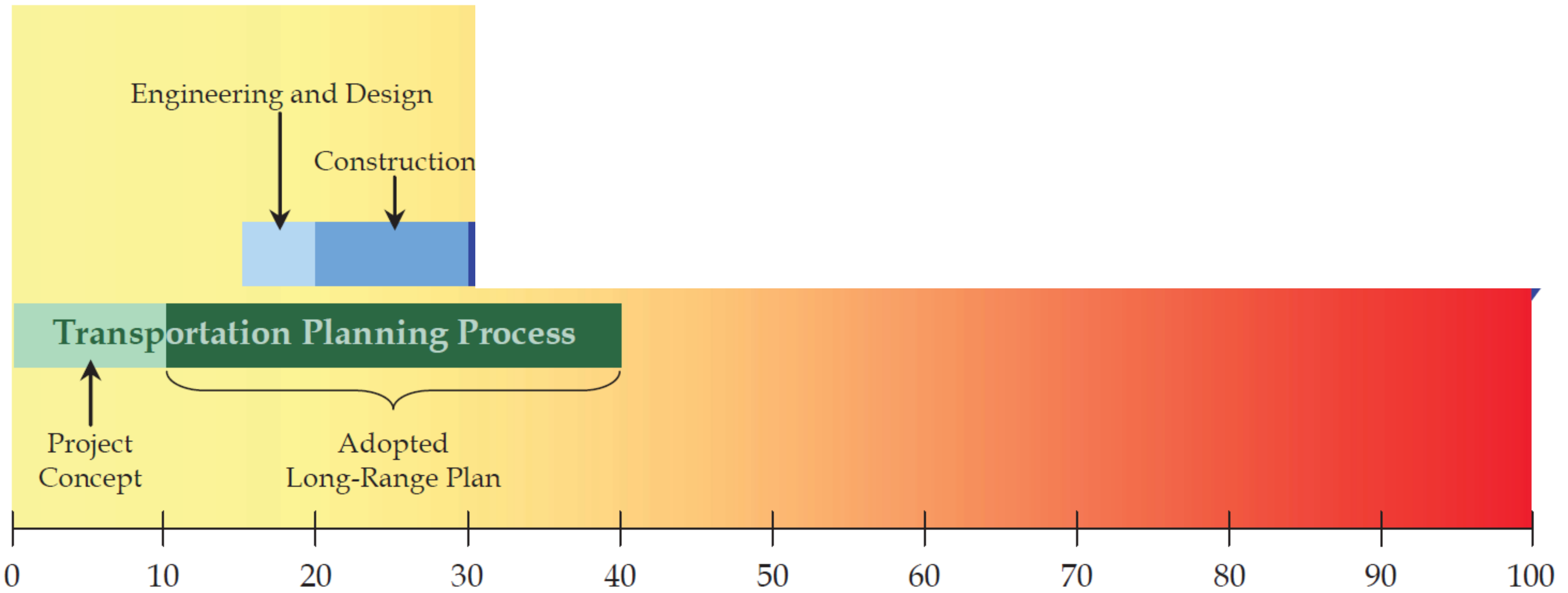

Engineering and Design
Construction
Transportation Planning Process
Project
Concept
Adopted
Long-Range Plan
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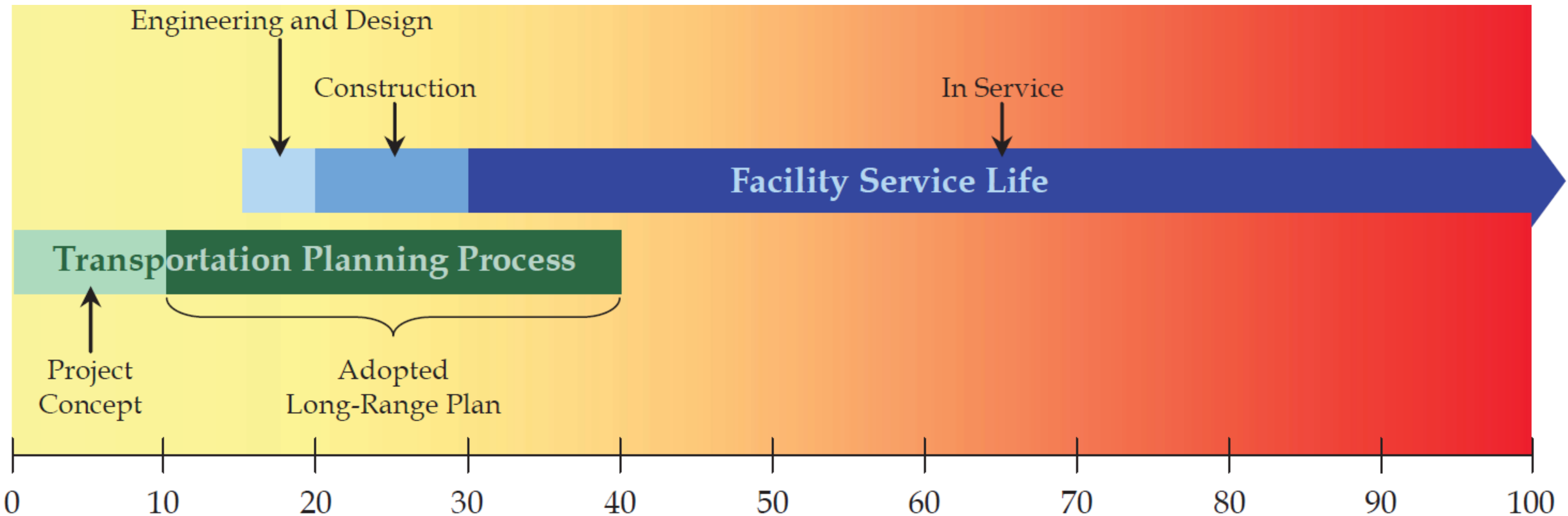
Engineering and Design
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In Service
Facility Service Life
Transportation Planning Process
Project
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Adopted
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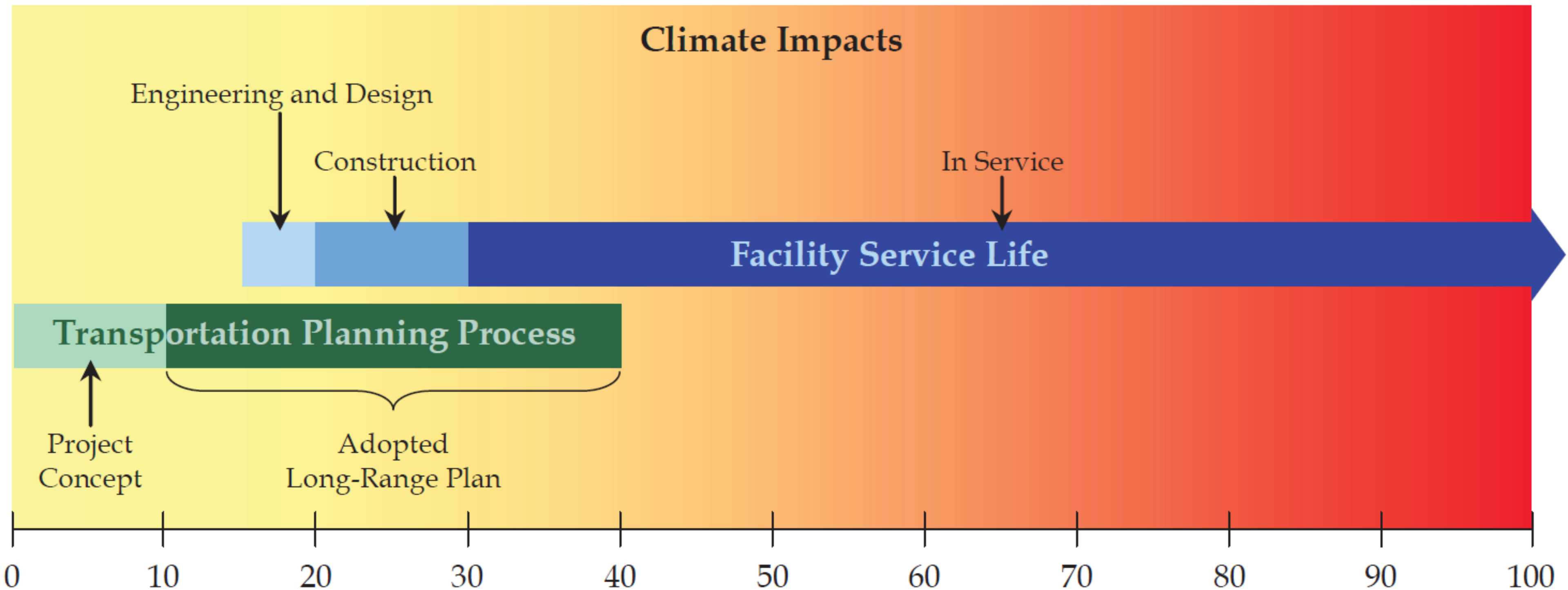

Climate Impacts
Engineering and Design
Construction
In Service
Facility Service Life
Transportation Planning Process
Project Concept
Adopted Long-Range Plan
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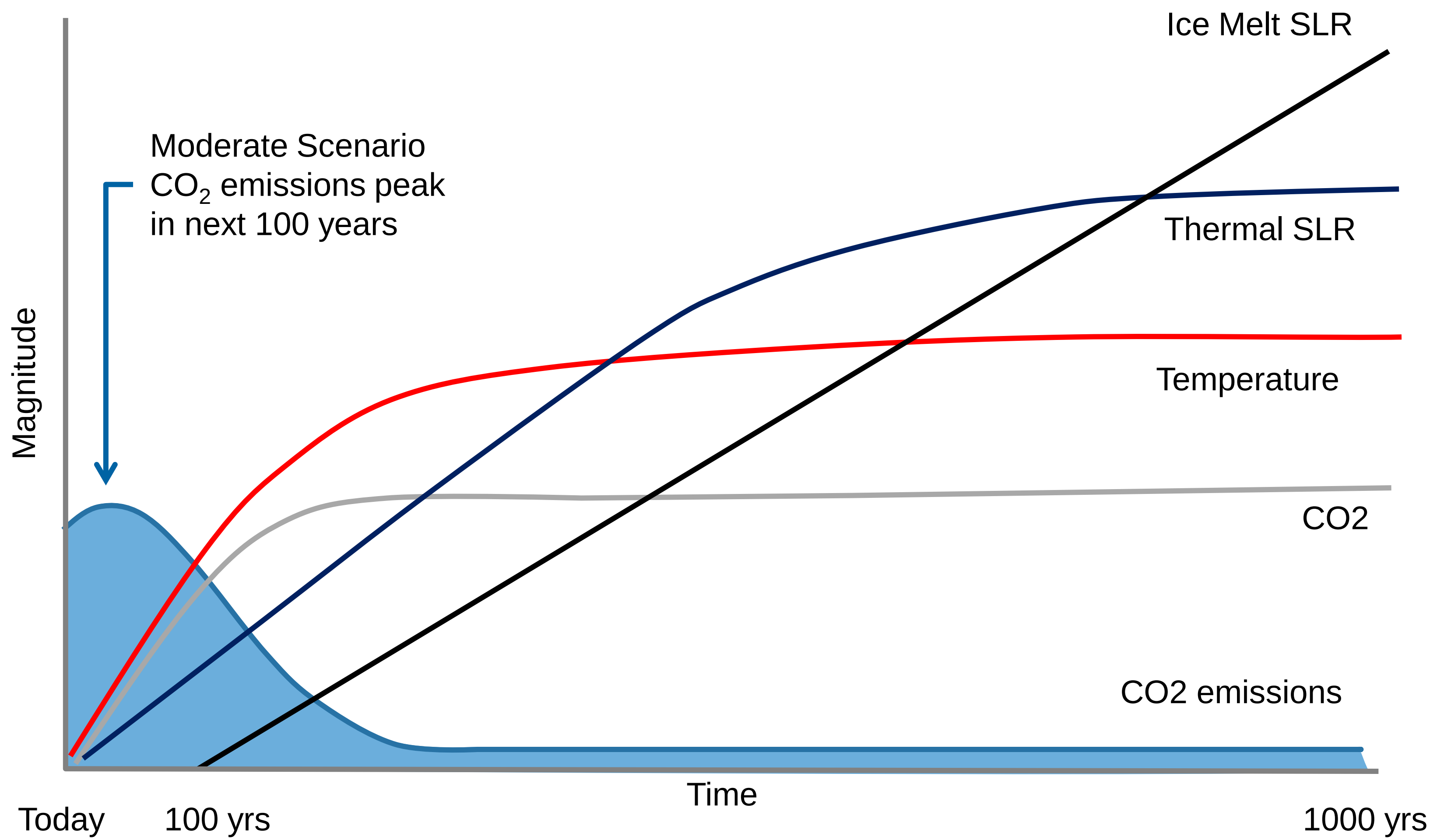
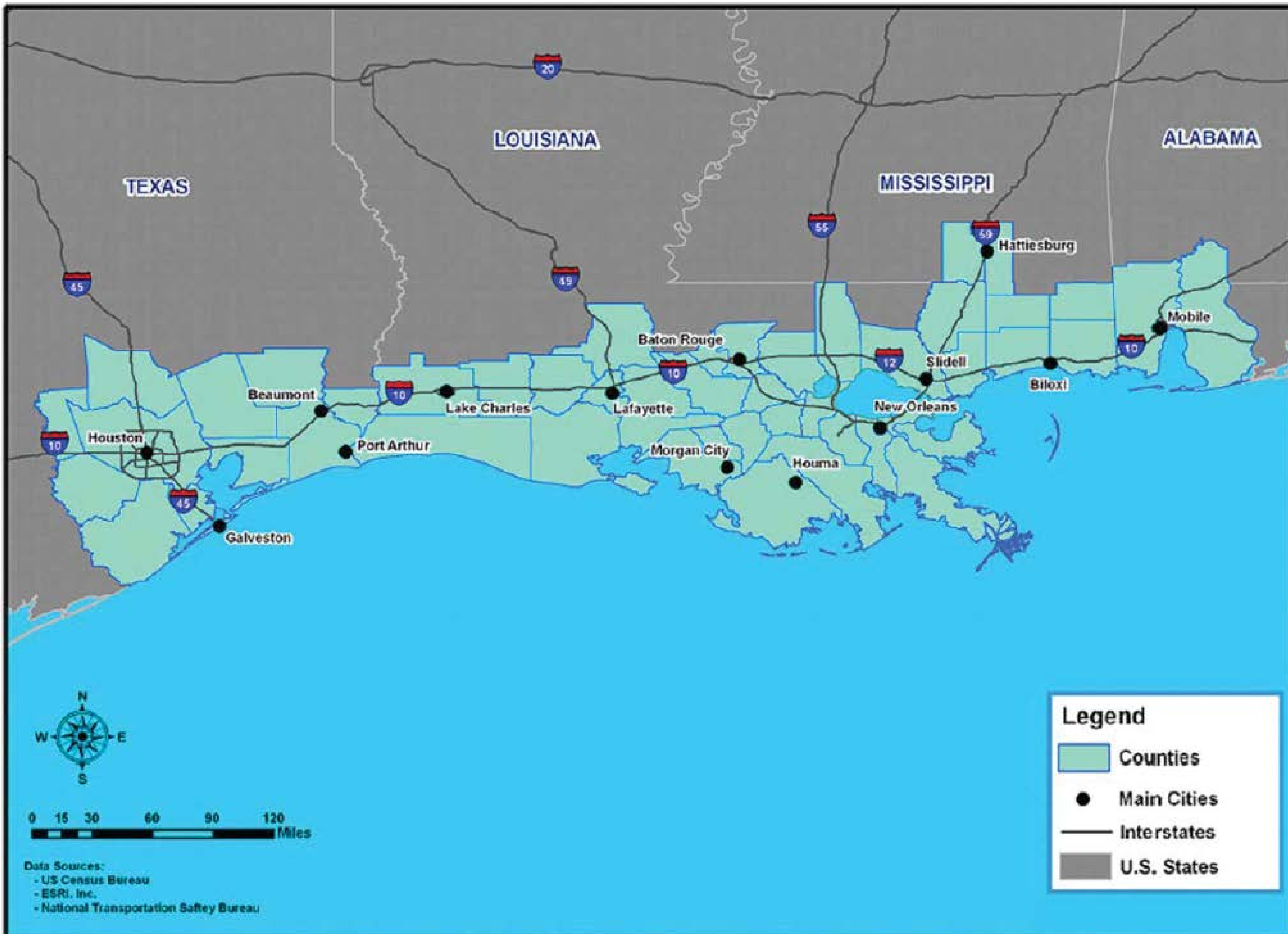

Ice Melt SLR
Moderate Scenario
CO_2 emissions peak
in next 100 years
Thermal SLR
Magnitude
Temperature
CO2
CO2 emissions
Time
Today
100 yrs
1000 yrs

Climate Change Scenarios

2050

Extreme Climate Change Models

Moderate Climate Change Models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Hattiesburg
Mobile
Baton Rouge
Slidell
Biloxi
New Orleans
Beaumont
Lake Charles
Lafayette
Houston
Port Arthur
Morgan City
Houma
Galveston
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E
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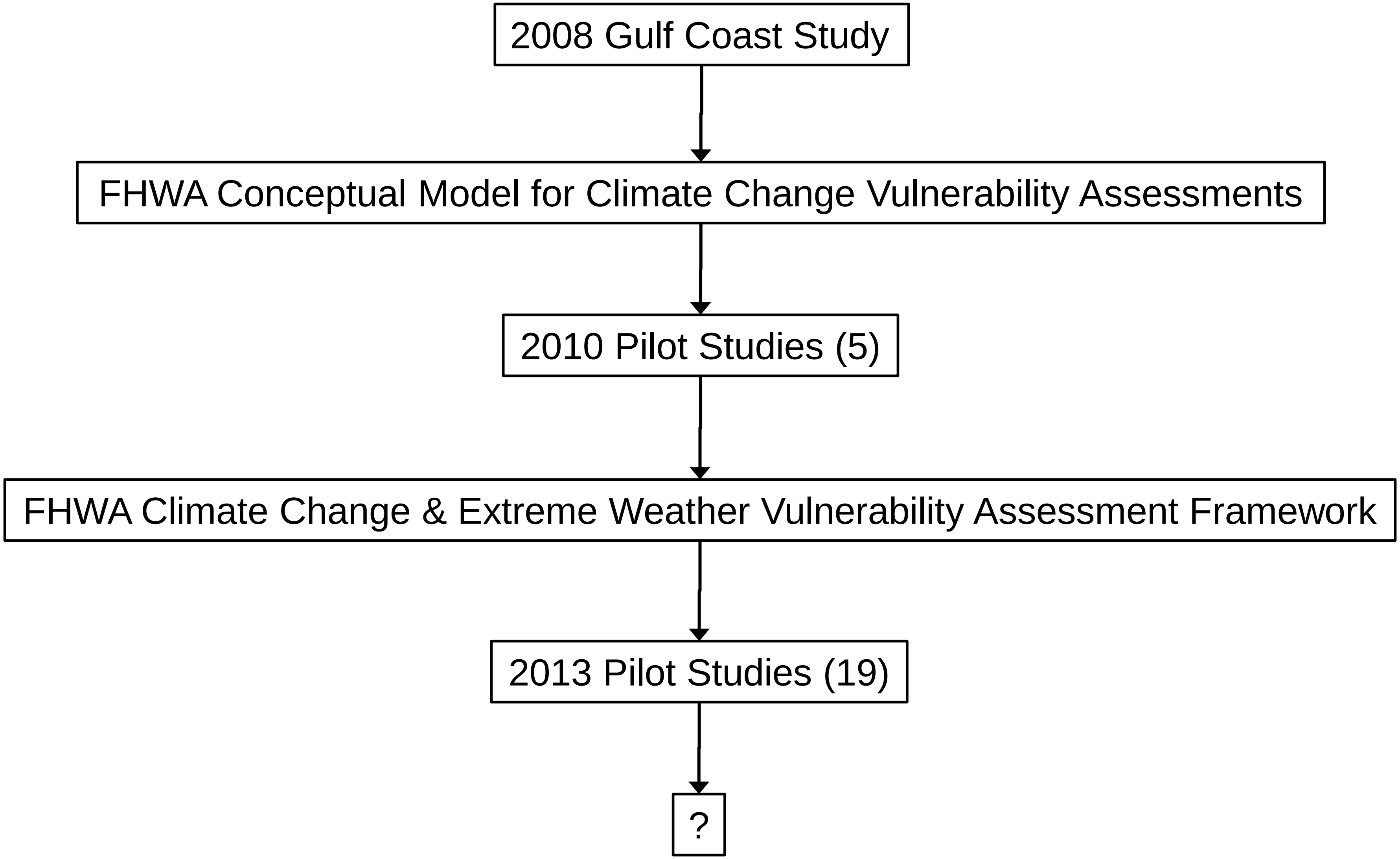
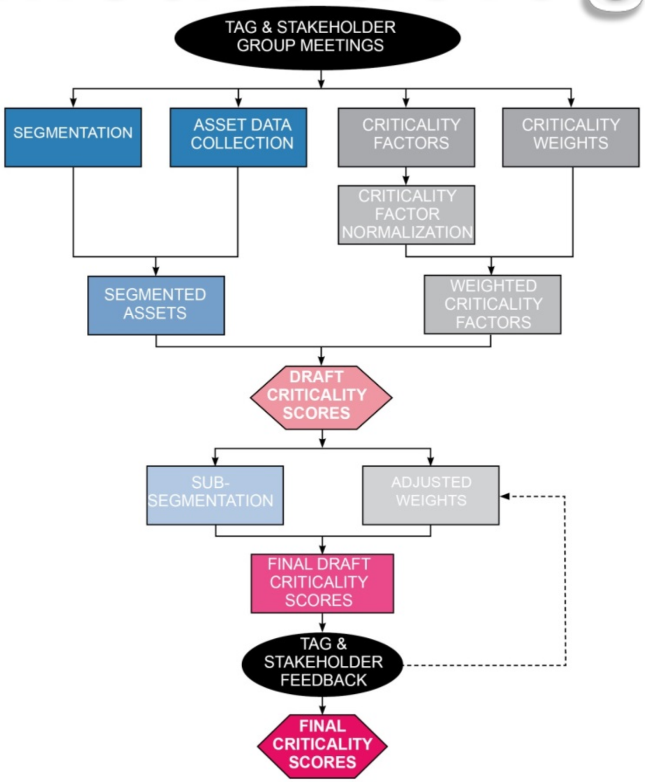
0 15 30 60 90 120
Miles
Data Sources:
- US Census Bureau
- ESRI, Inc.
- National Transportation Saftey Bureau
Legend
Counties
Main Cities
Interstates
U.S. States

PROJECT HISTORY



D1CCPS Project: Process vs. Product

Methodology

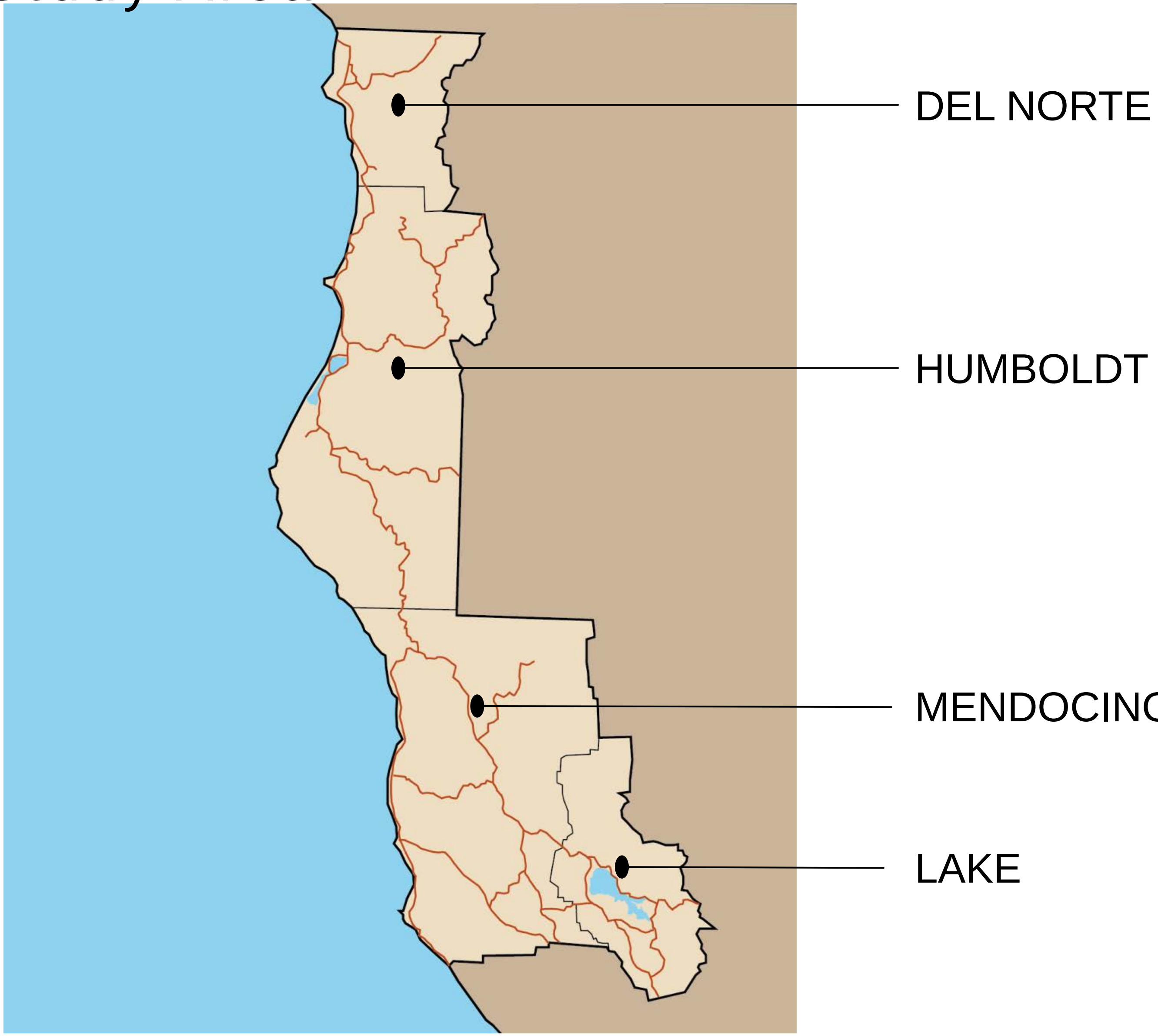


Project Objectives

1. Identify **Vulnerabilities**

2. Analyze **Adaptation Options**

Study Area



Identify vulnerabilities

What is *vulnerability?*

Criticality How critical is this facility?

+

Exposure What is the impact affecting it?

+

Sensitivity How does it handle the impact?

=

Vulnerability

What is “Criticality”

Photo: Google Earth

What is “Criticality”

Photo: Google Earth

What is “Criticality”

Photo: Google Earth

What is “Criticality”

Photo: Google Earth

What is "Criticality"

Photo: Google Earth

What is “Criticality”

Photo: Google Earth

Exposure

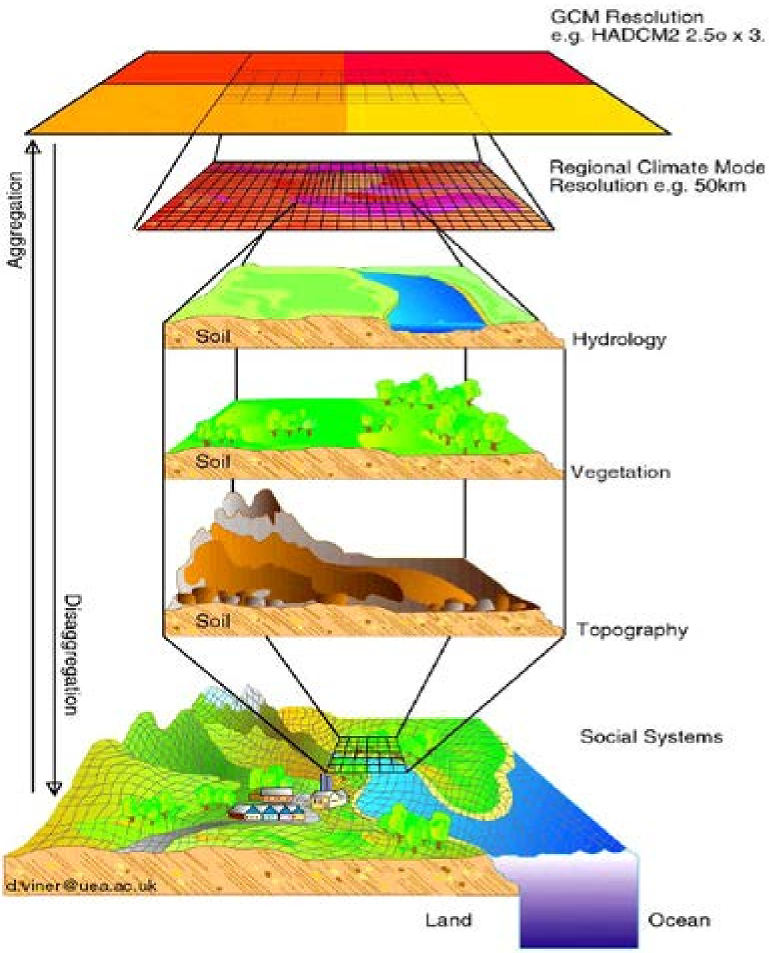
Climate Change Effects

- Temperature
- Precipitation
- Runoff
- Sea level rise
- Coastal erosion hazards
- Wildfire

Moderate & Extreme changes at 2050 and 2100

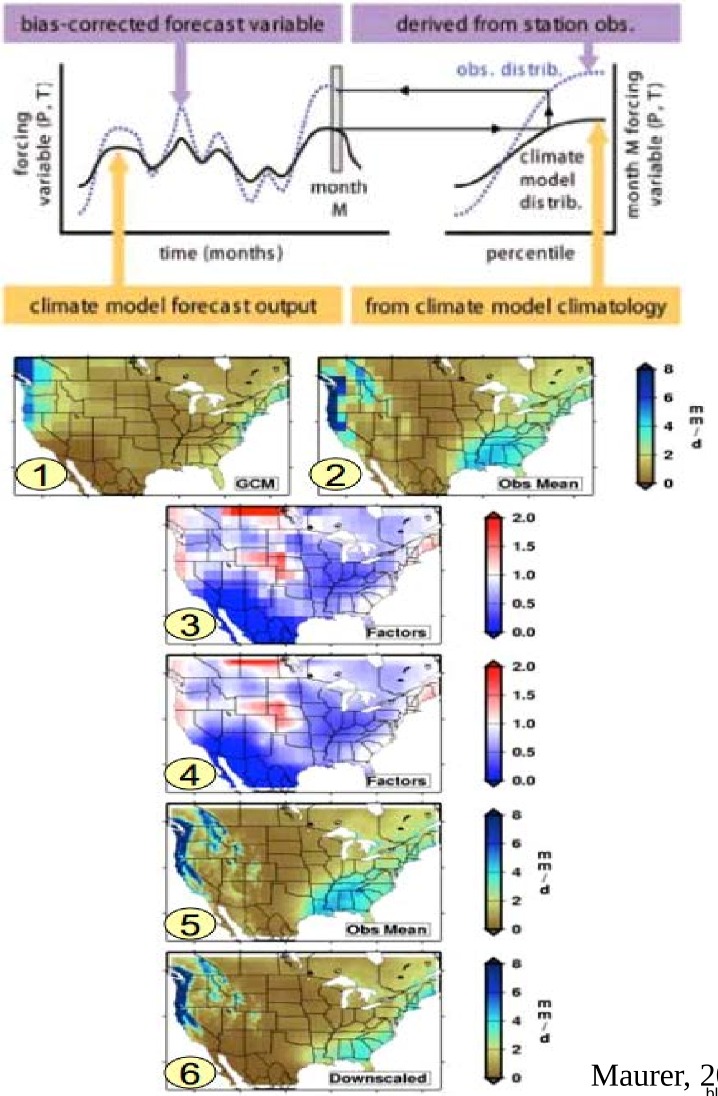
How do we know?

Dynamical



David Viner, Climatic Research Unit, University of East Anglia, UK

Statistical



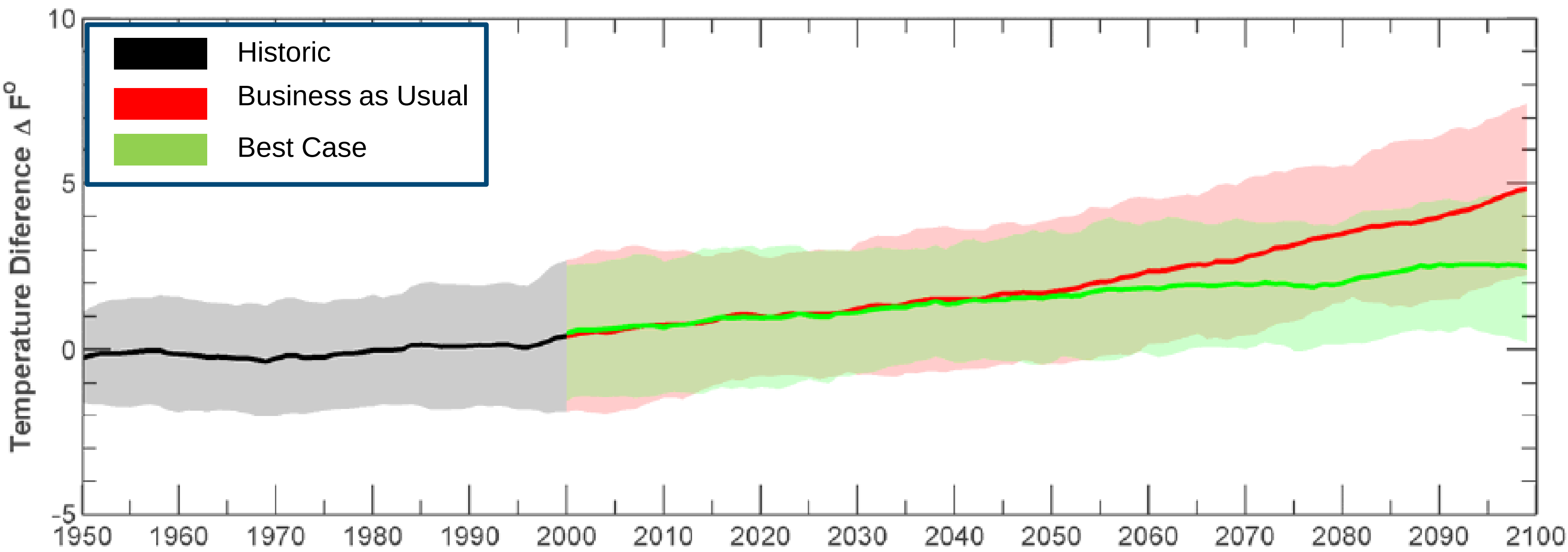
Maurer, 2008

blic Meeting

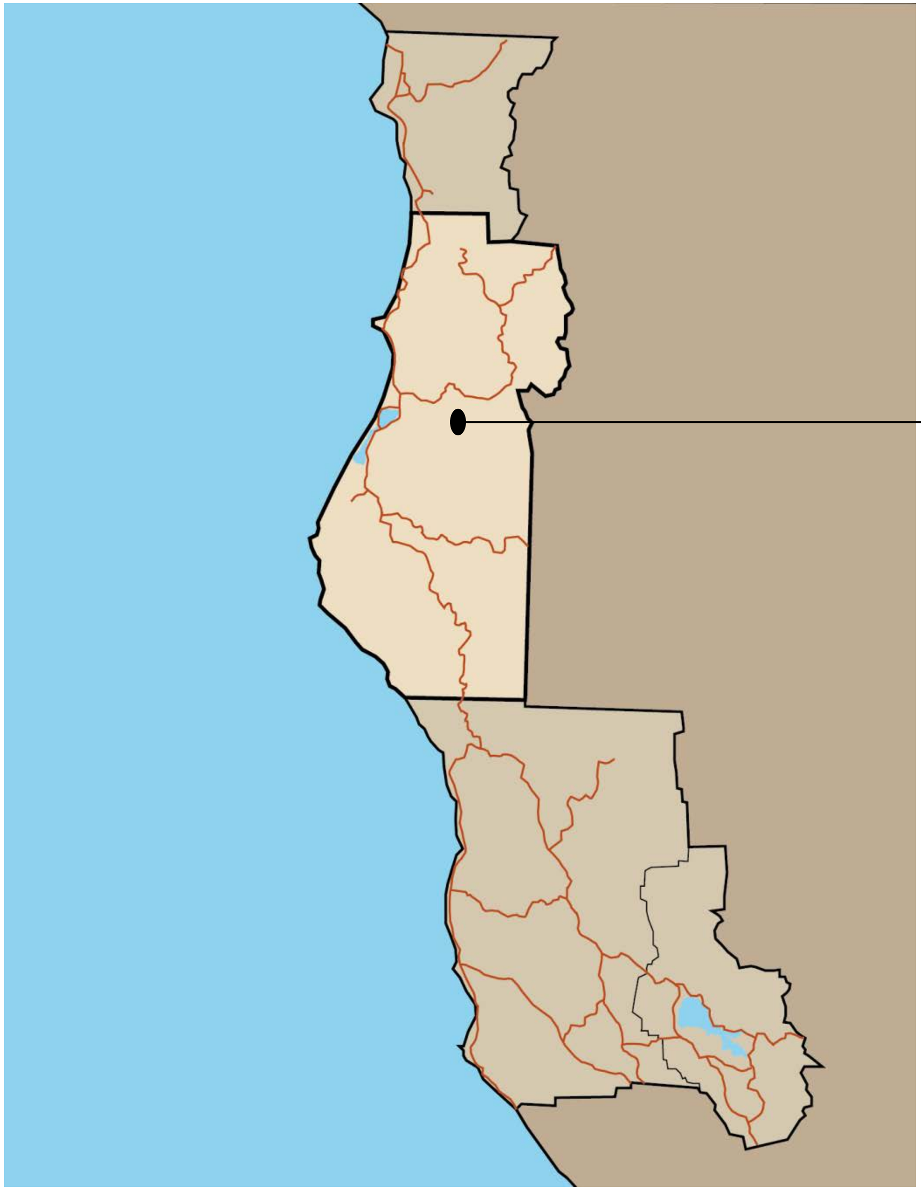
RESULTS OF EXPOSURE ANALYSIS

Climate Change Effects

Changes in Average Daily Maximum Temperature



Humboldt County



HUMBOLDT

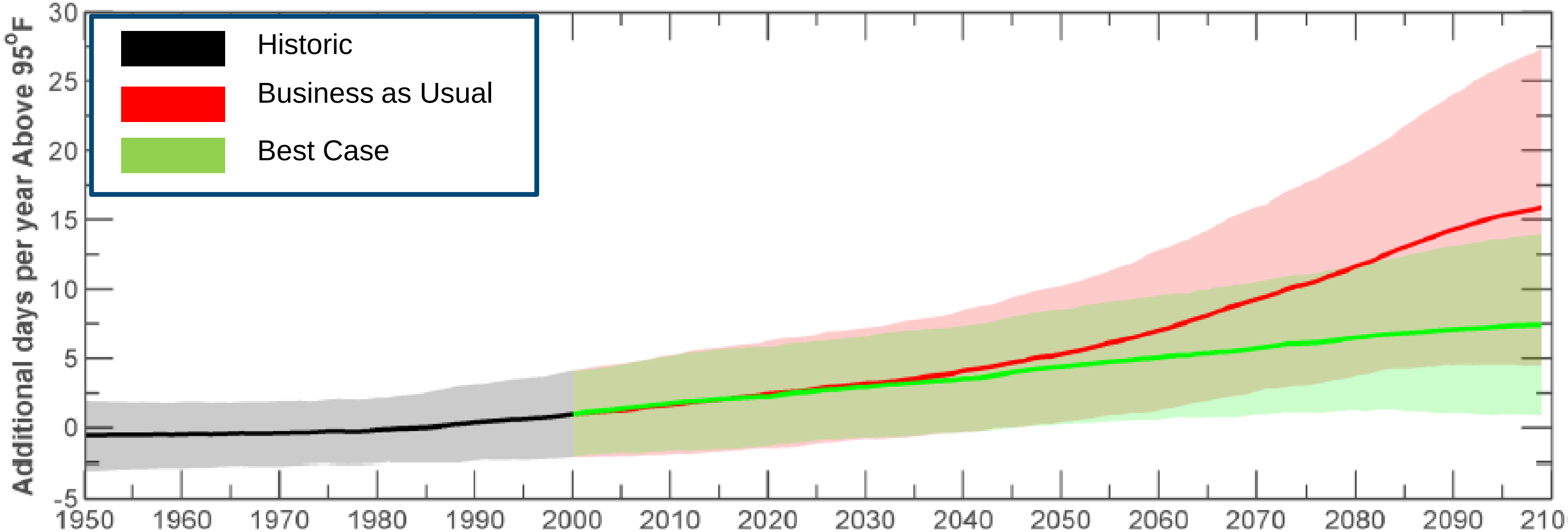
+2.9 to 3.3°F - 2050

+4.0 to 6.7°F – 2100

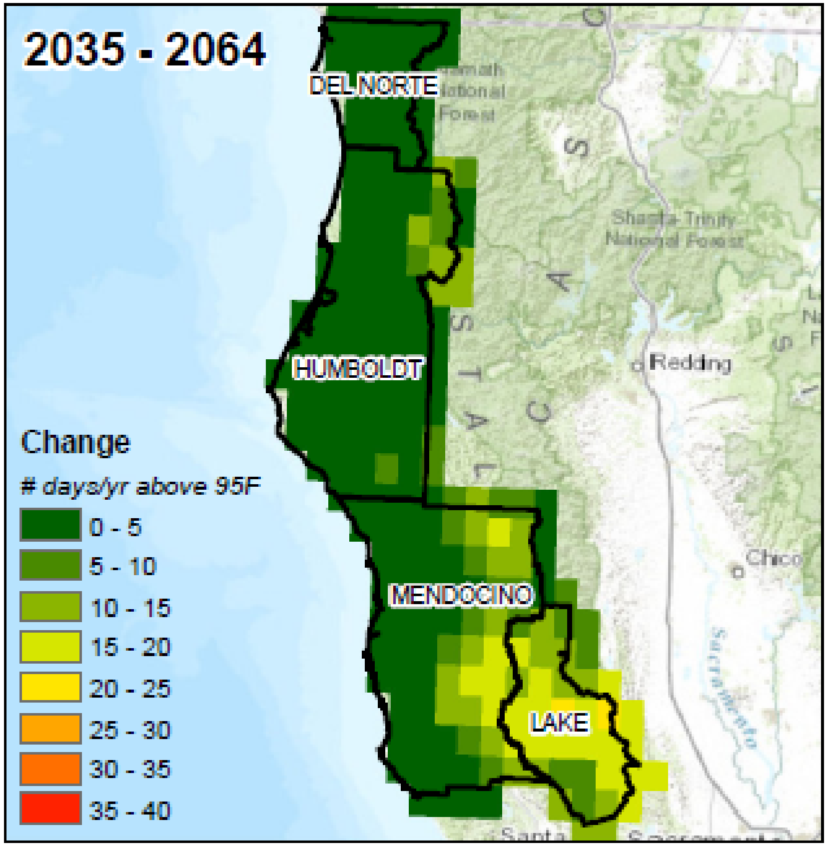
Increased average temperature

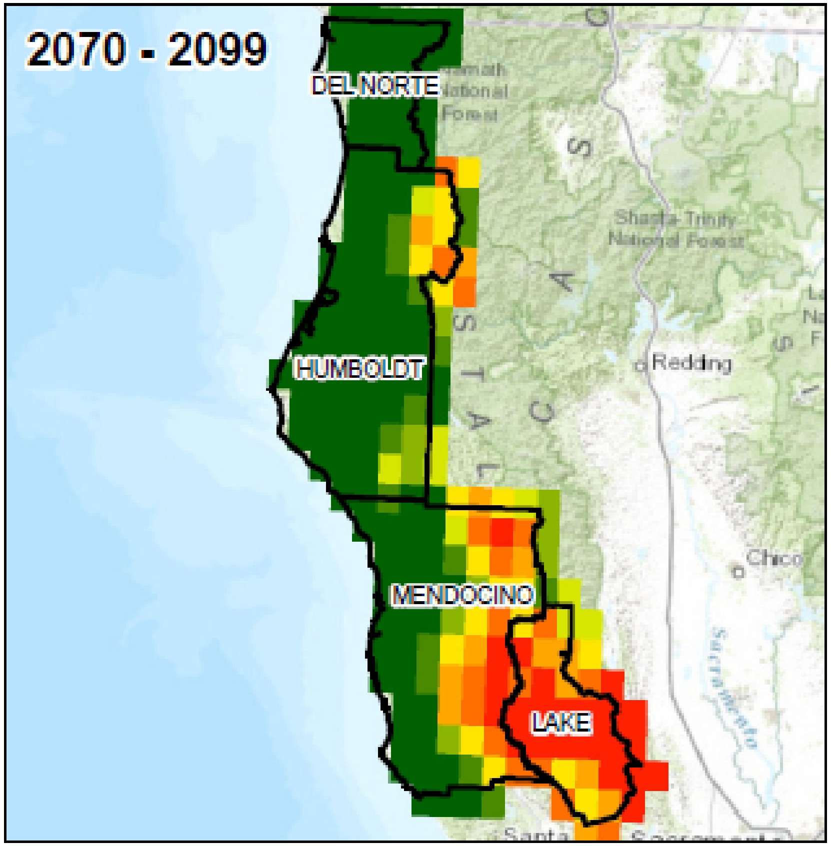
Climate Change Effects

Extreme Temperature
(additional days above 95F)



Extreme Temperatures





Increased days above 95°F.

Sea Level Rise

King Tides Rising

Sea Level Rise

2000 0 in

2050

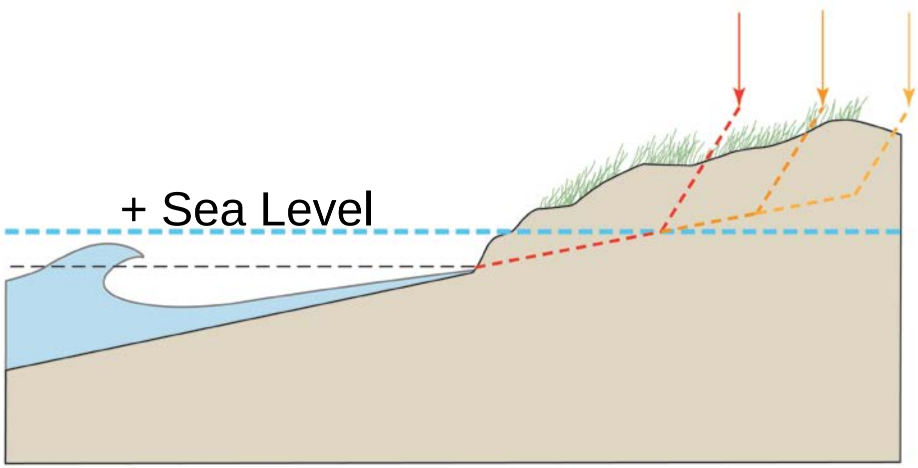
12-14 in

2100
36-55 in

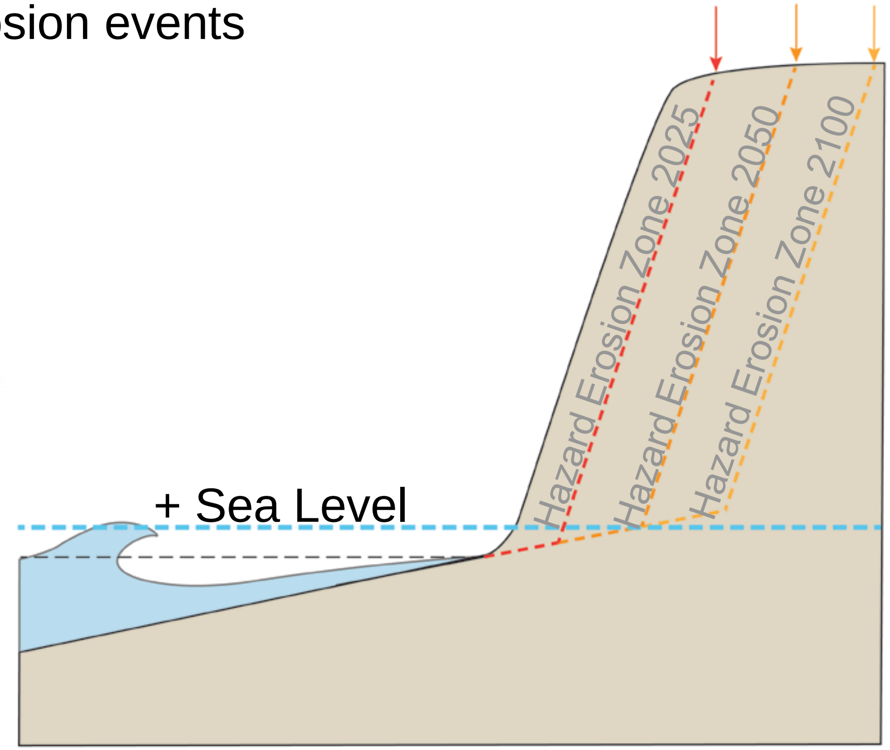
2100+ ?? in

Coastal Erosion

Erosion is episodic
Acceleration of background erosion events

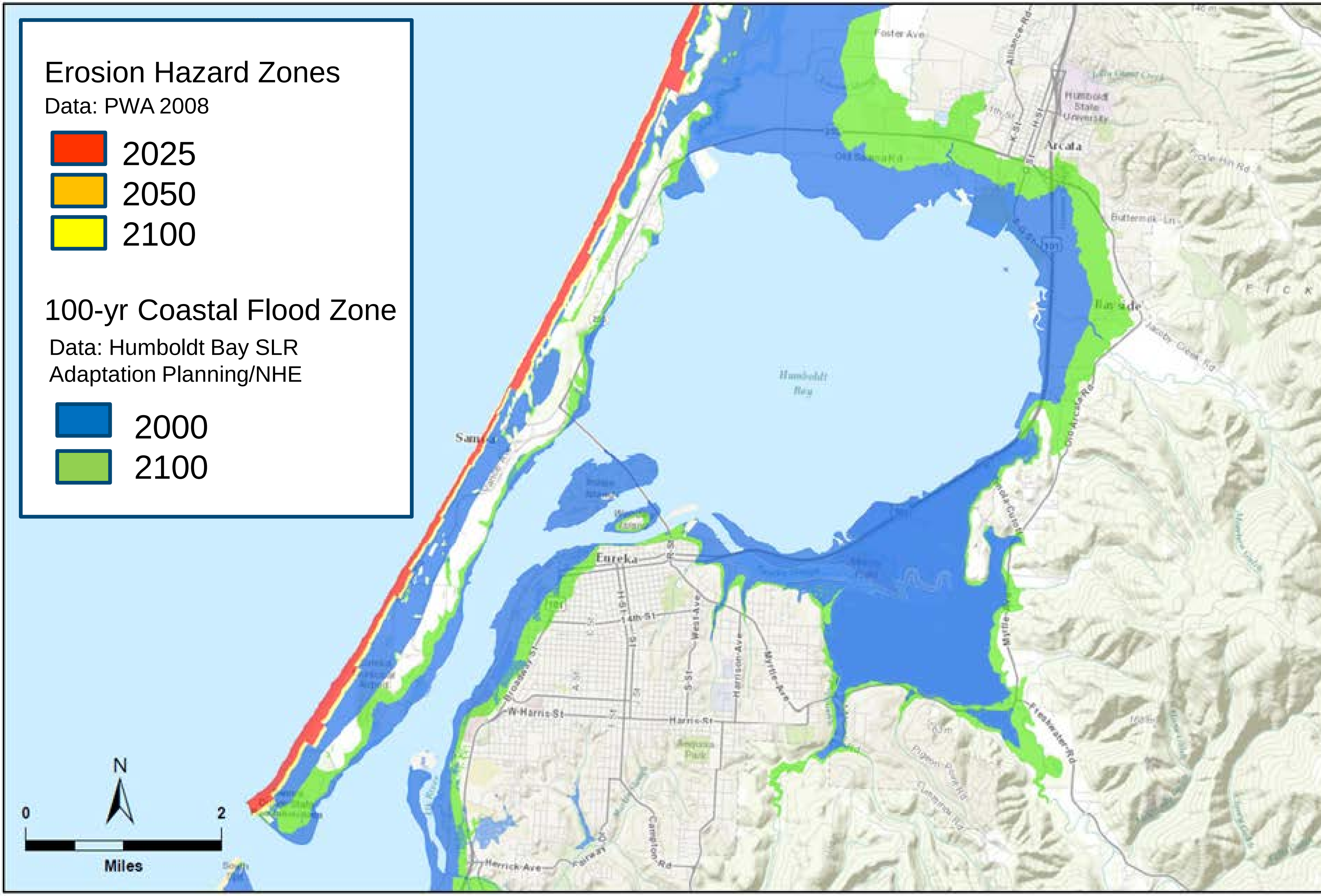


Dunes



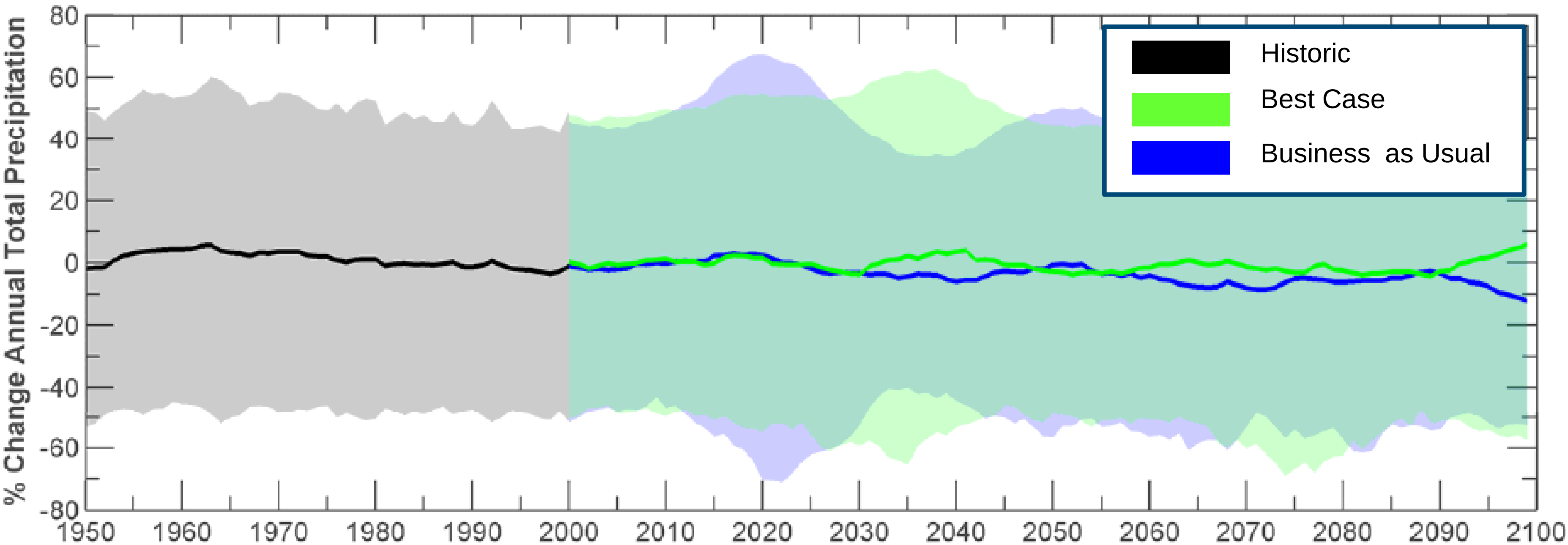
Bluffs

Coastal Hazards

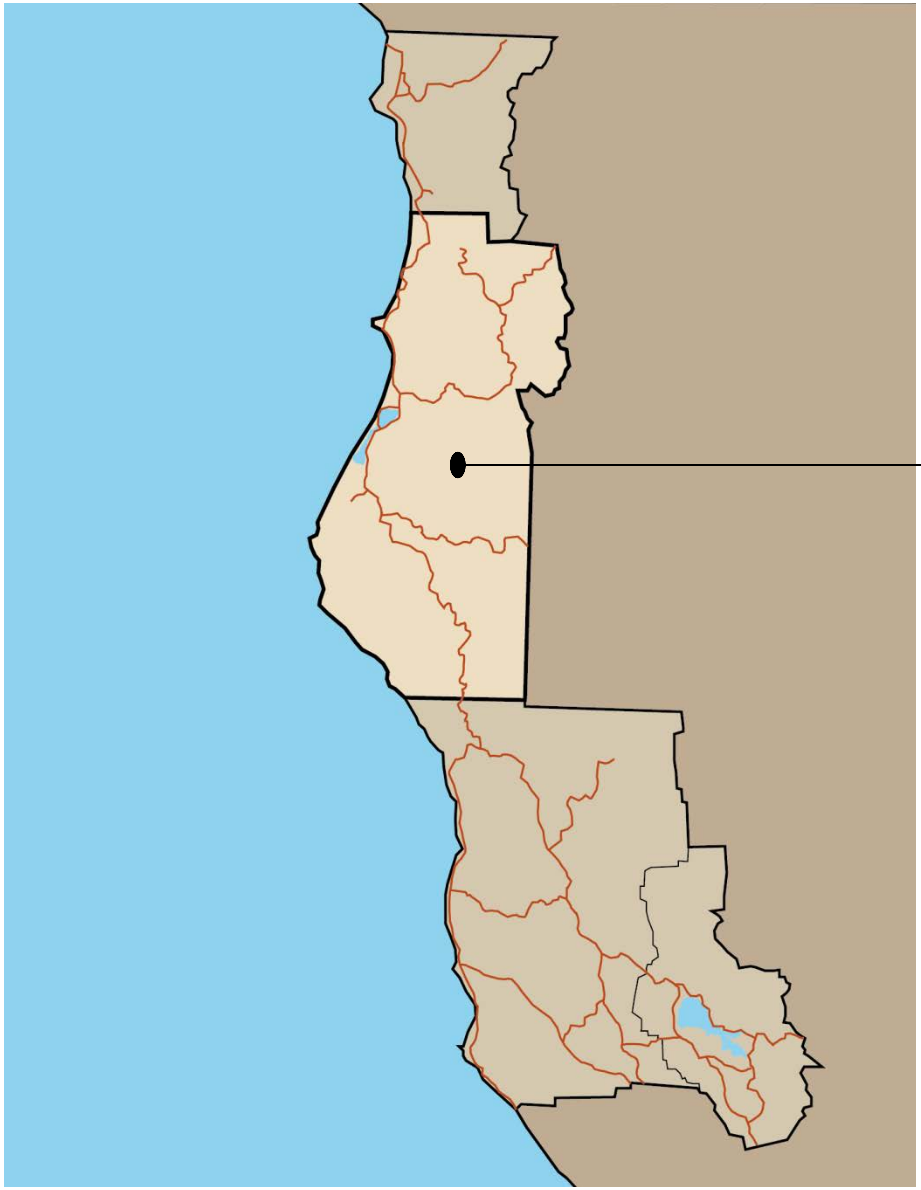


Coastal Hazards

Rainfall change



Humboldt County

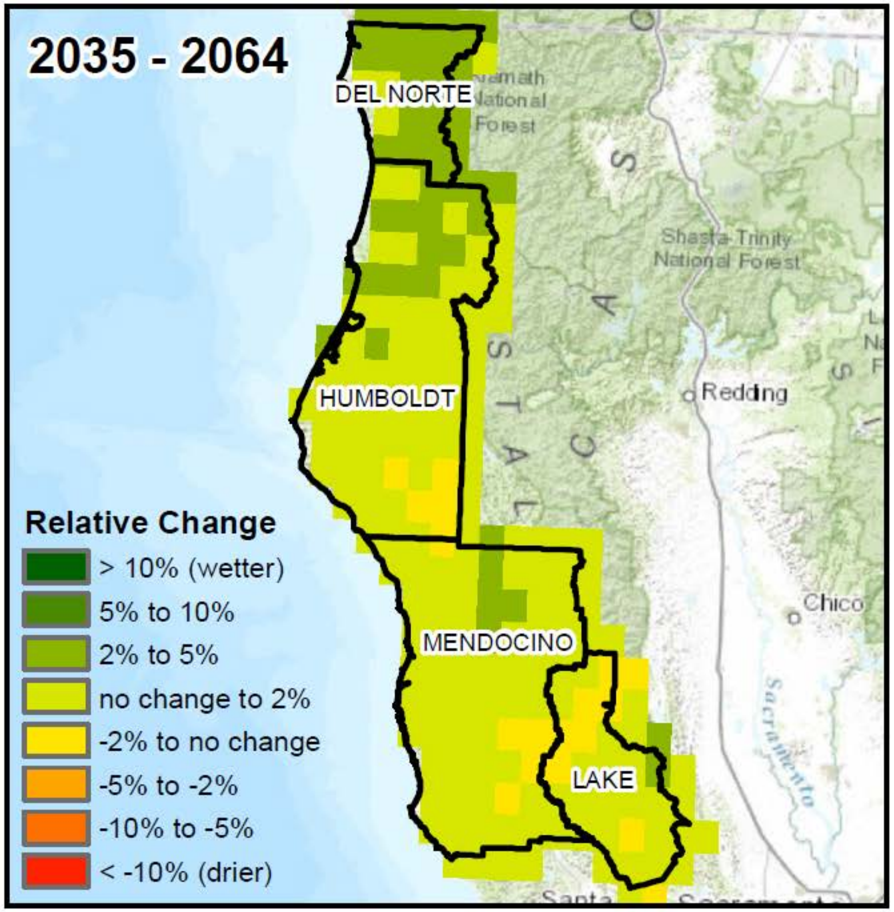


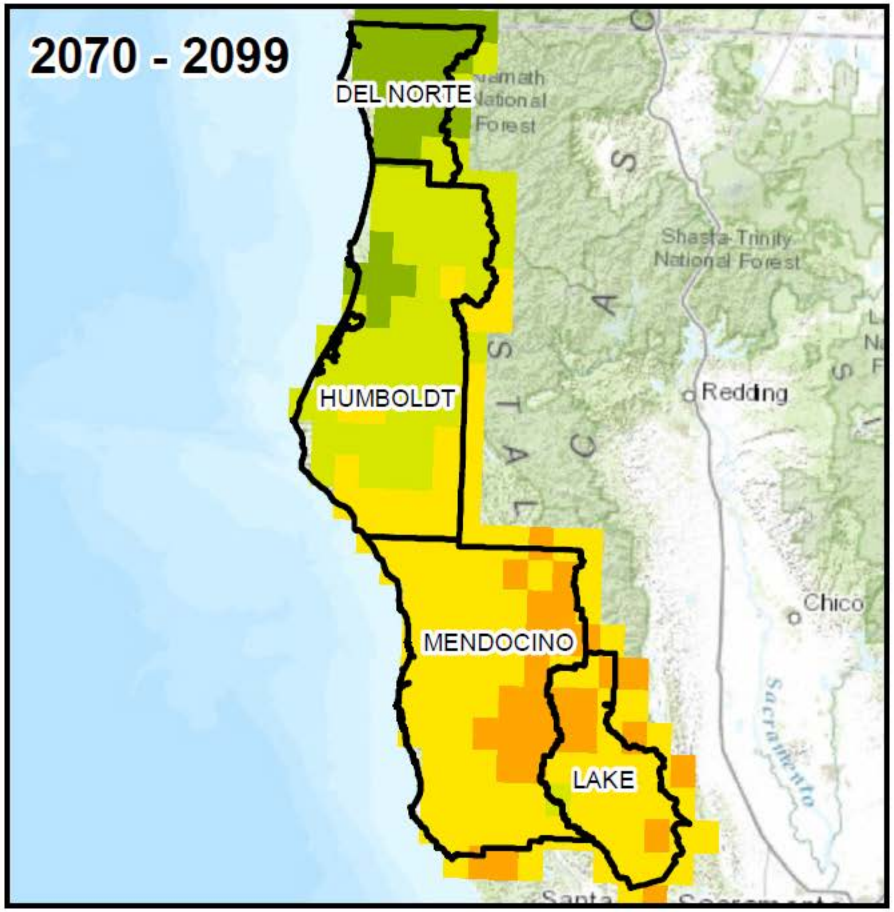
HUMBOLDT
-3.9% to -0.4%   2050
-6.5% to -1.8%   2100

Changes in average rainfall

Extreme Precipitation

Moderate Scenario

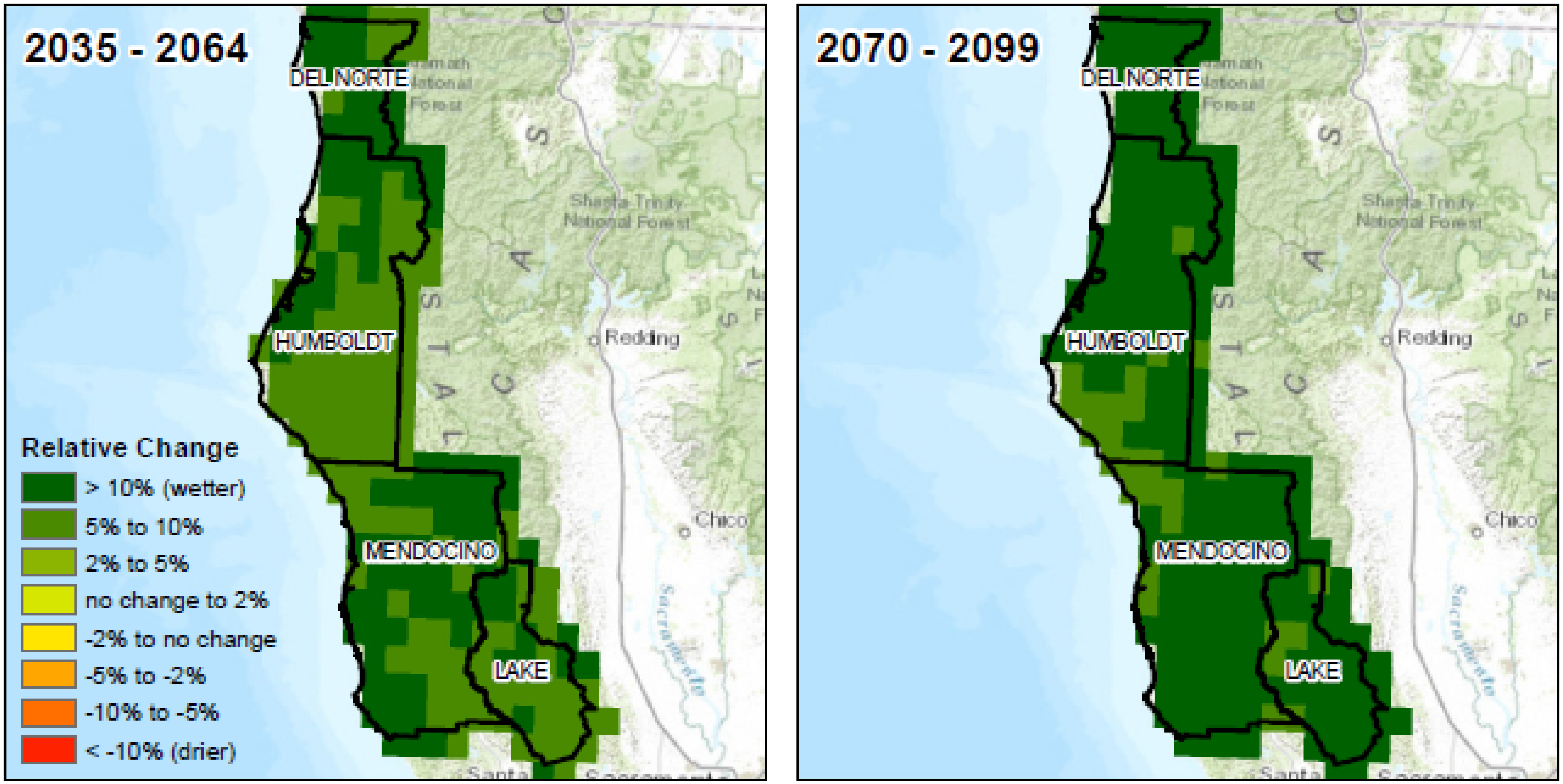




Changes in extreme rainfall

Extreme Precipitation

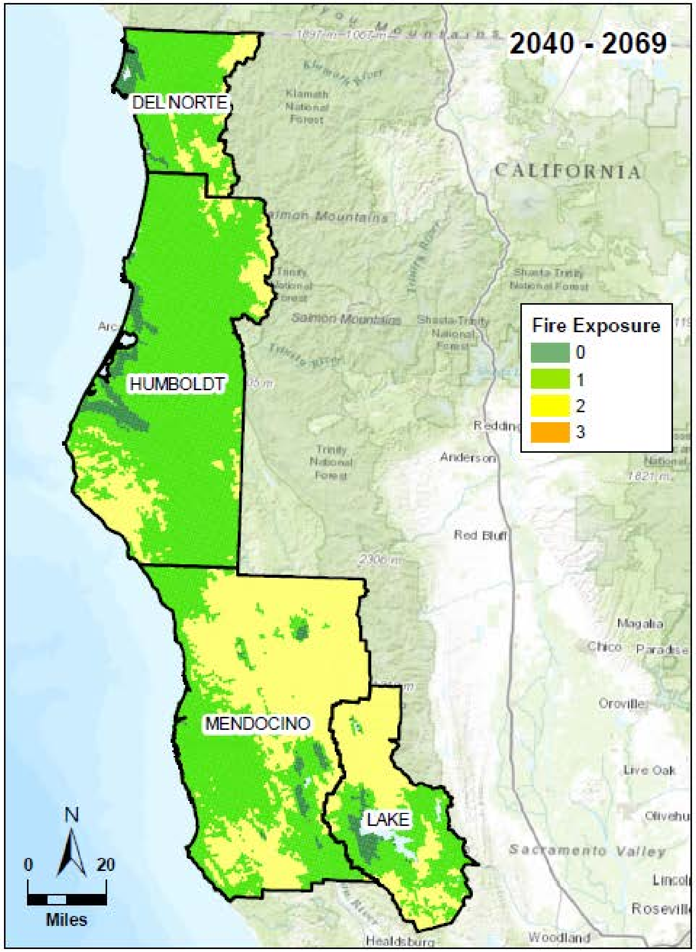
Wet scenario

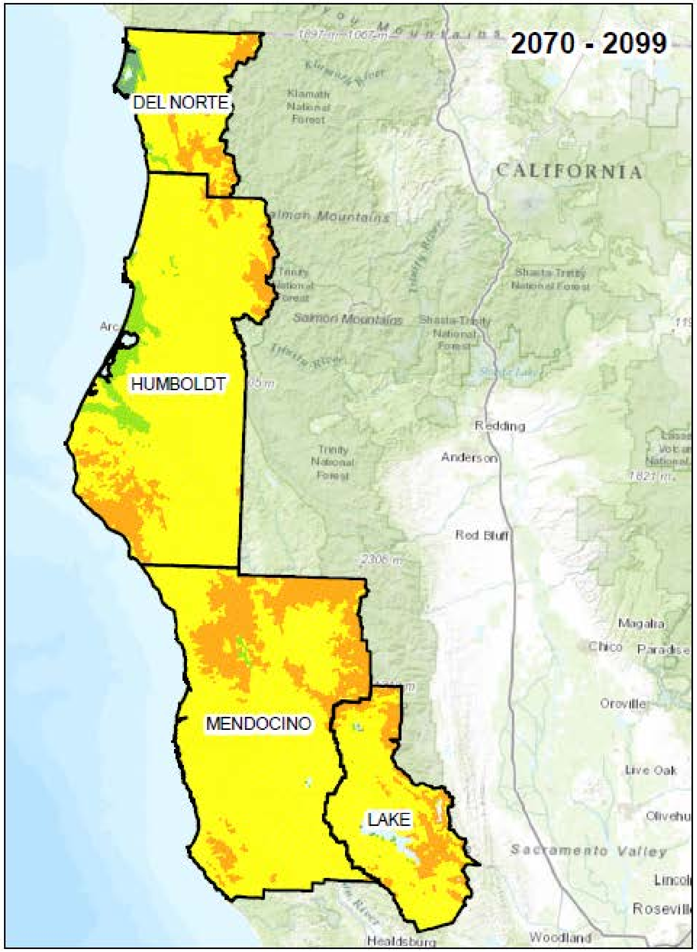


Changes in extreme rainfall

Wildfire Exposure

Moderate Scenario





Data: DWR, 2014

Changes wildfire risk

What is “Potential for Impact”

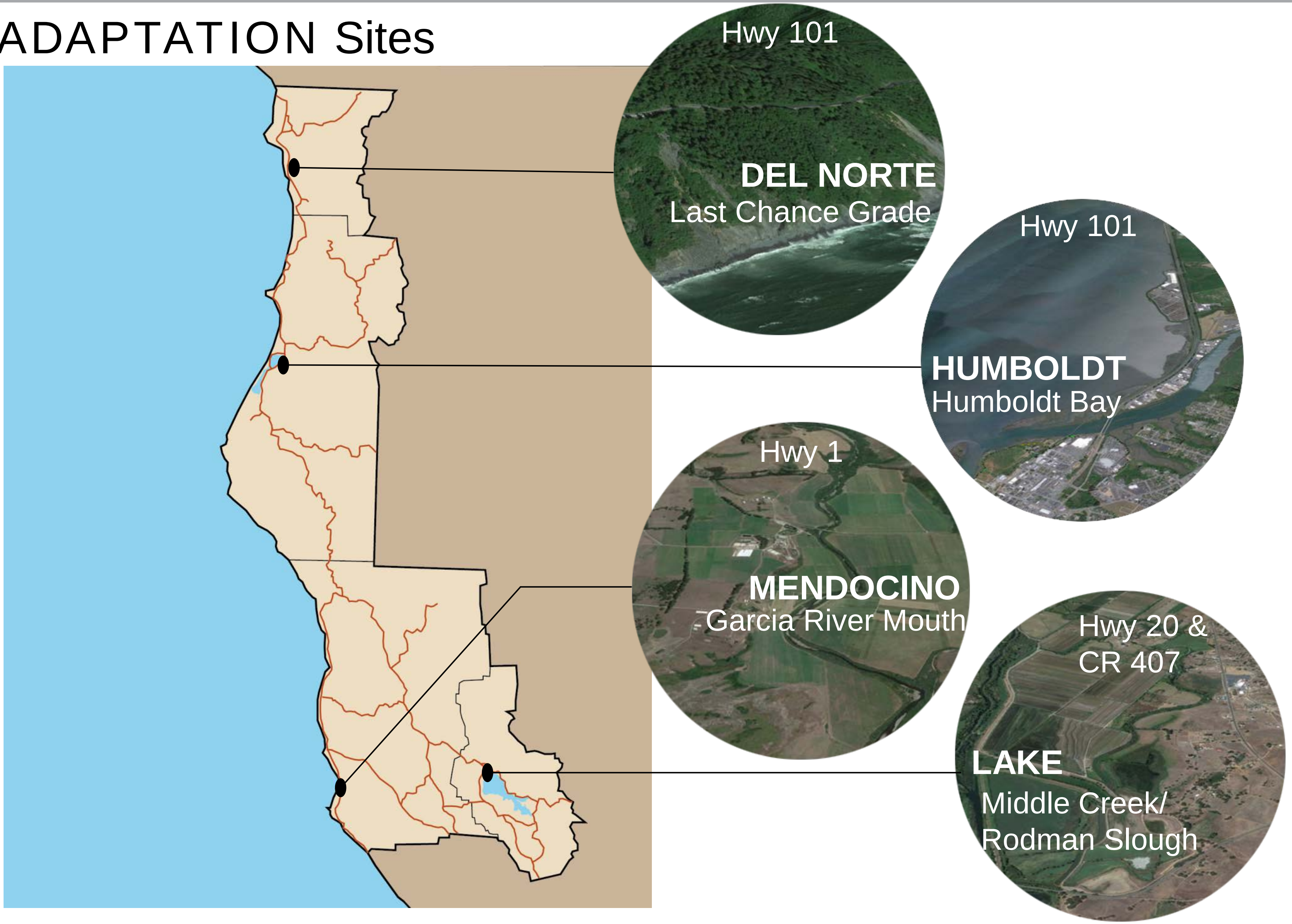
Delay

Temporary Closure – Damage

Failure

ADAPTATION Prototype Sites

ADAPTATION Sites



ADAPTATION Sites

Humboldt County

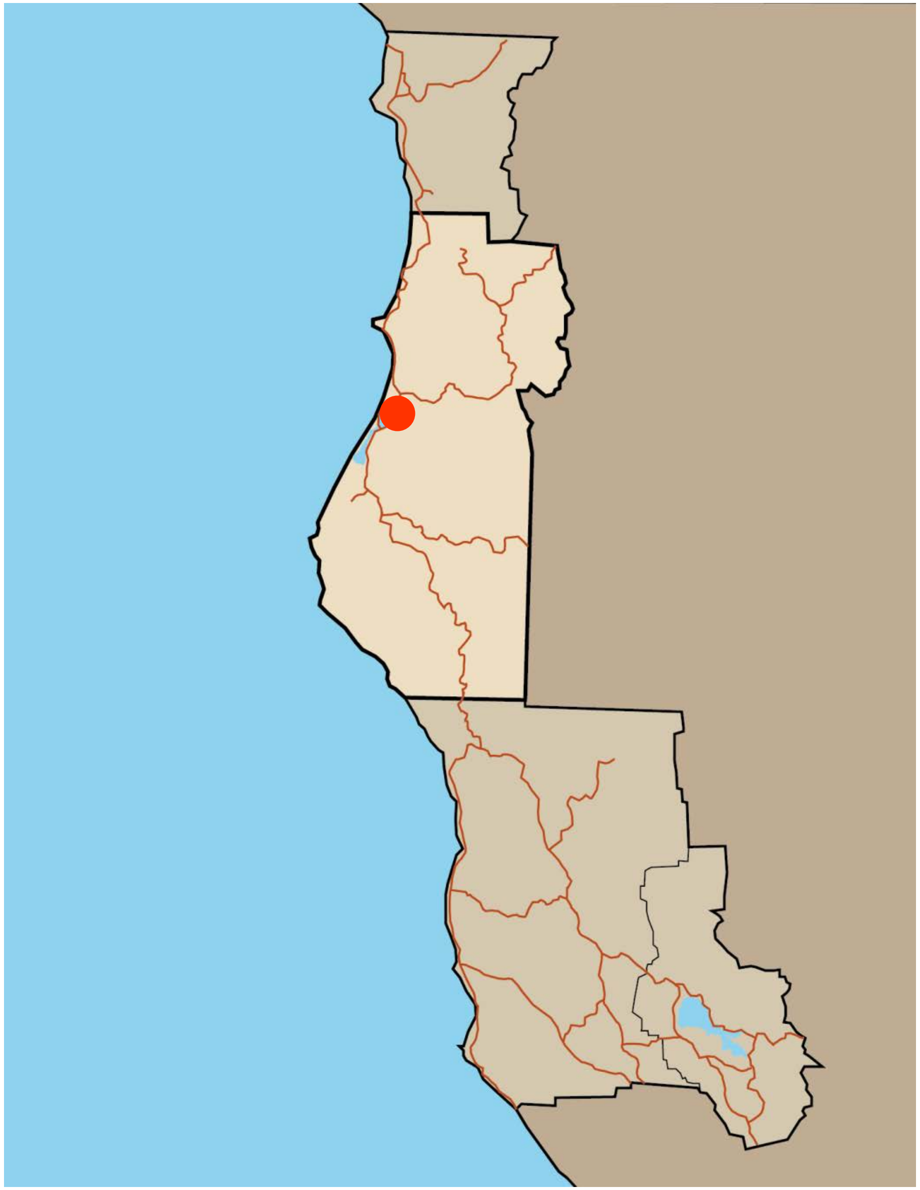
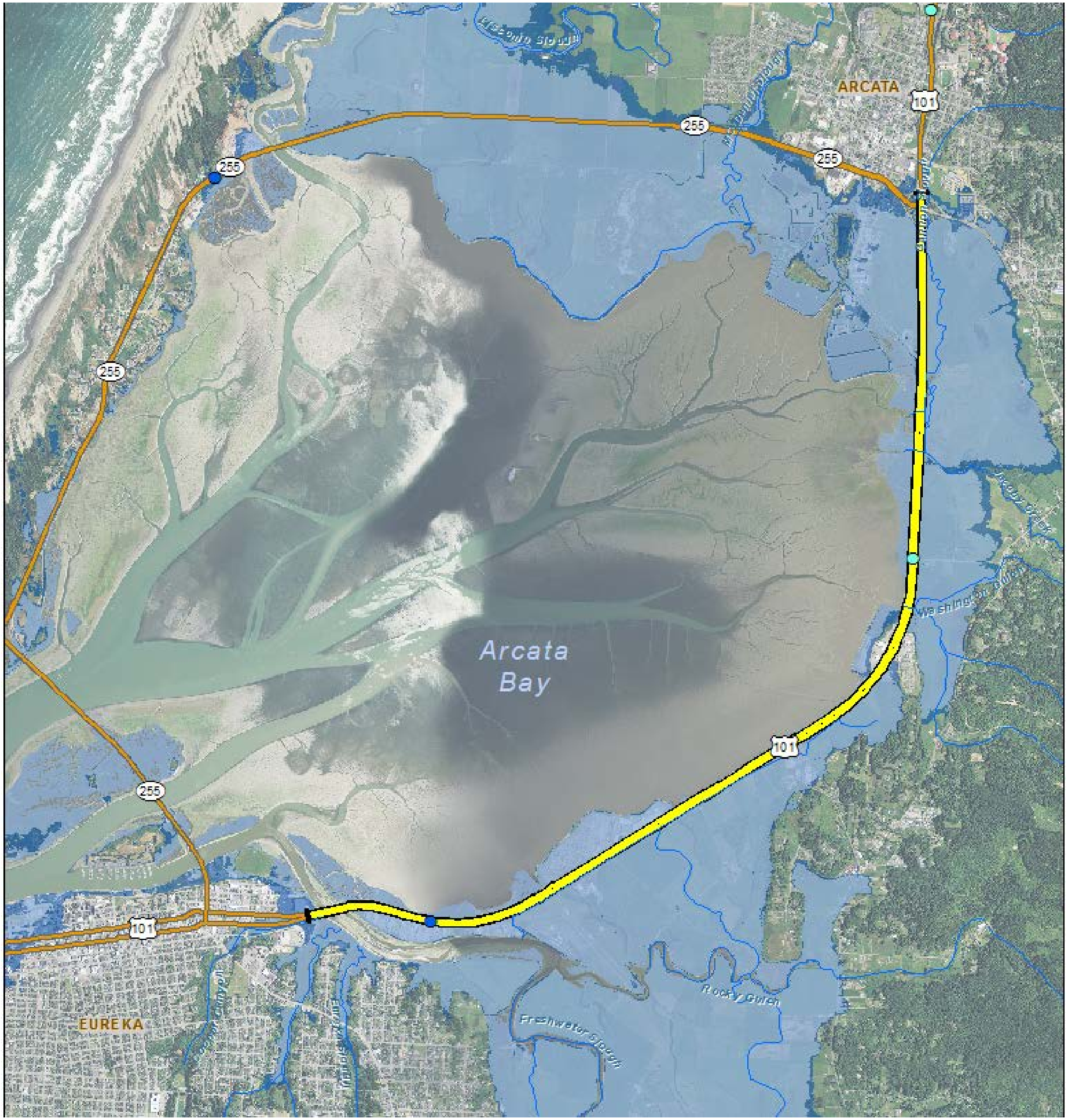


Photo: GoogleEarth

Humboldt Bay

Humboldt County



2100

Legend

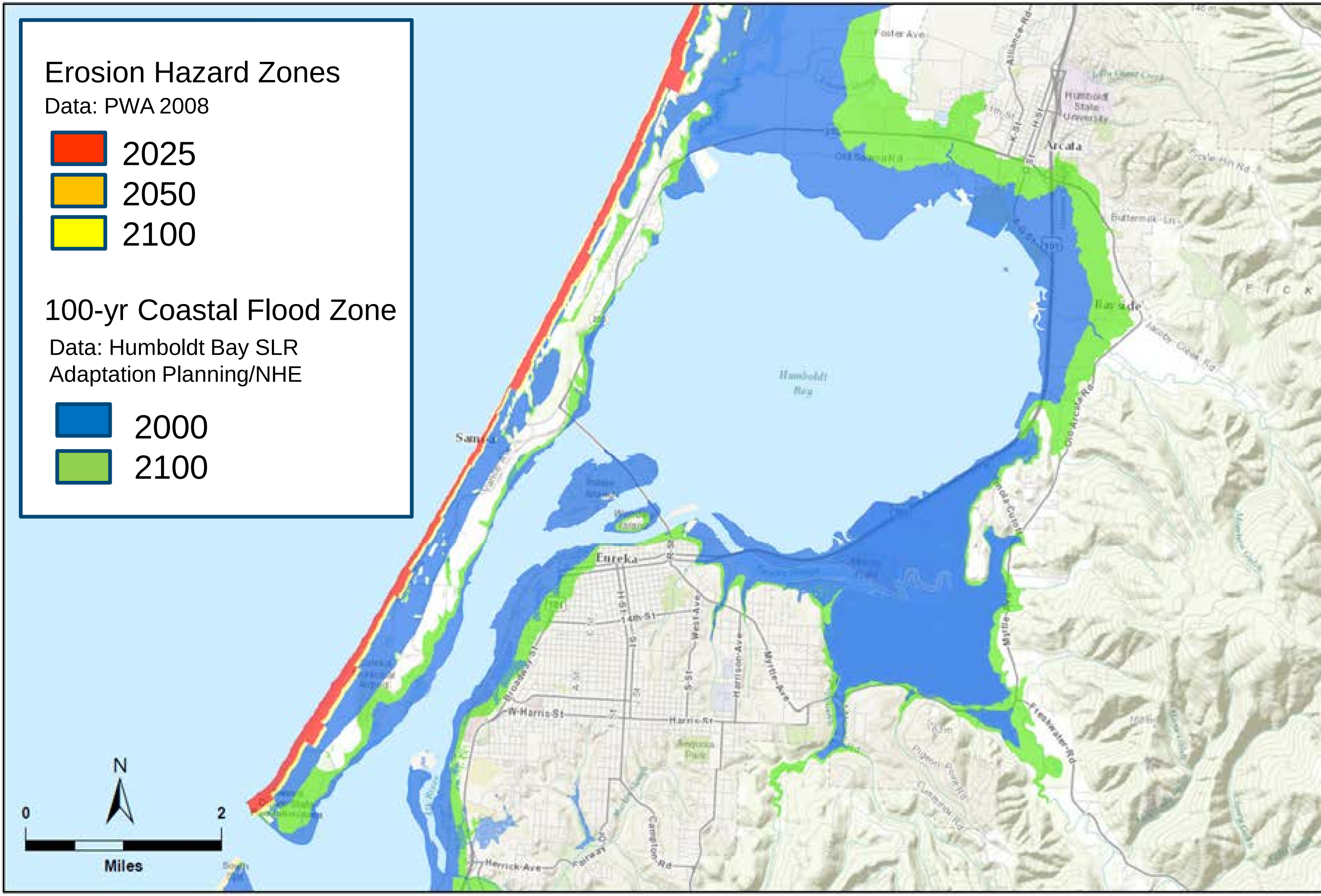
SYMBOL

- Chronic Drainage Issue Area
- Chronic Sea Level Issue Area
- Prototype Limits
- Streams
- Prototype Location
- Roadways
- Projected Daily High Tide due to Sea Level Rise
- Projected Annual High Tide due to Sea Level Rise

Humboldt Bay

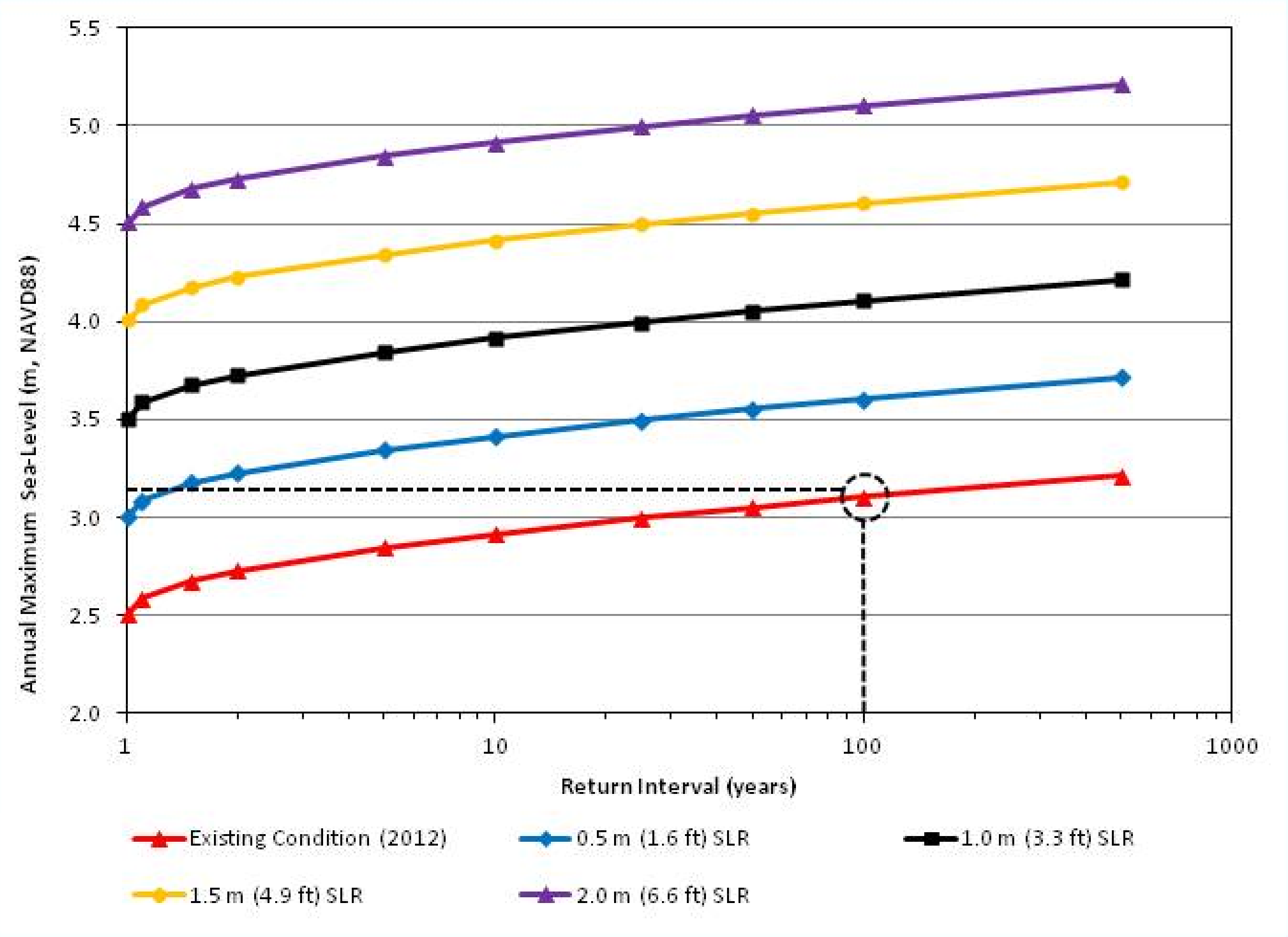
Findings in the Eureka/Arcata Corridor

Humboldt County



Humboldt Bay North Spit Sea-Levels

Extreme Sea-Levels with Sea-Level Rise



Why should we be concerned with Sea-Level Rise

- Immediate concerns are related to coastal flooding
- Sea-level rise gradually increases extreme water levels (not static like 100-yr riverine flood levels)
- For example, the 100-yr extreme sea-level becomes the 1-yr level with 0.5 m SLR
- To put this into perspective, since 1912 the North Spit Tide Gauge has seen about 0.47 m of SLR
- So what was a 100-yr extreme sea-level in 1912 is today the 1-yr level or about the mean monthly high tide

West of Highway 101-Un-Maintained Agricultural Di

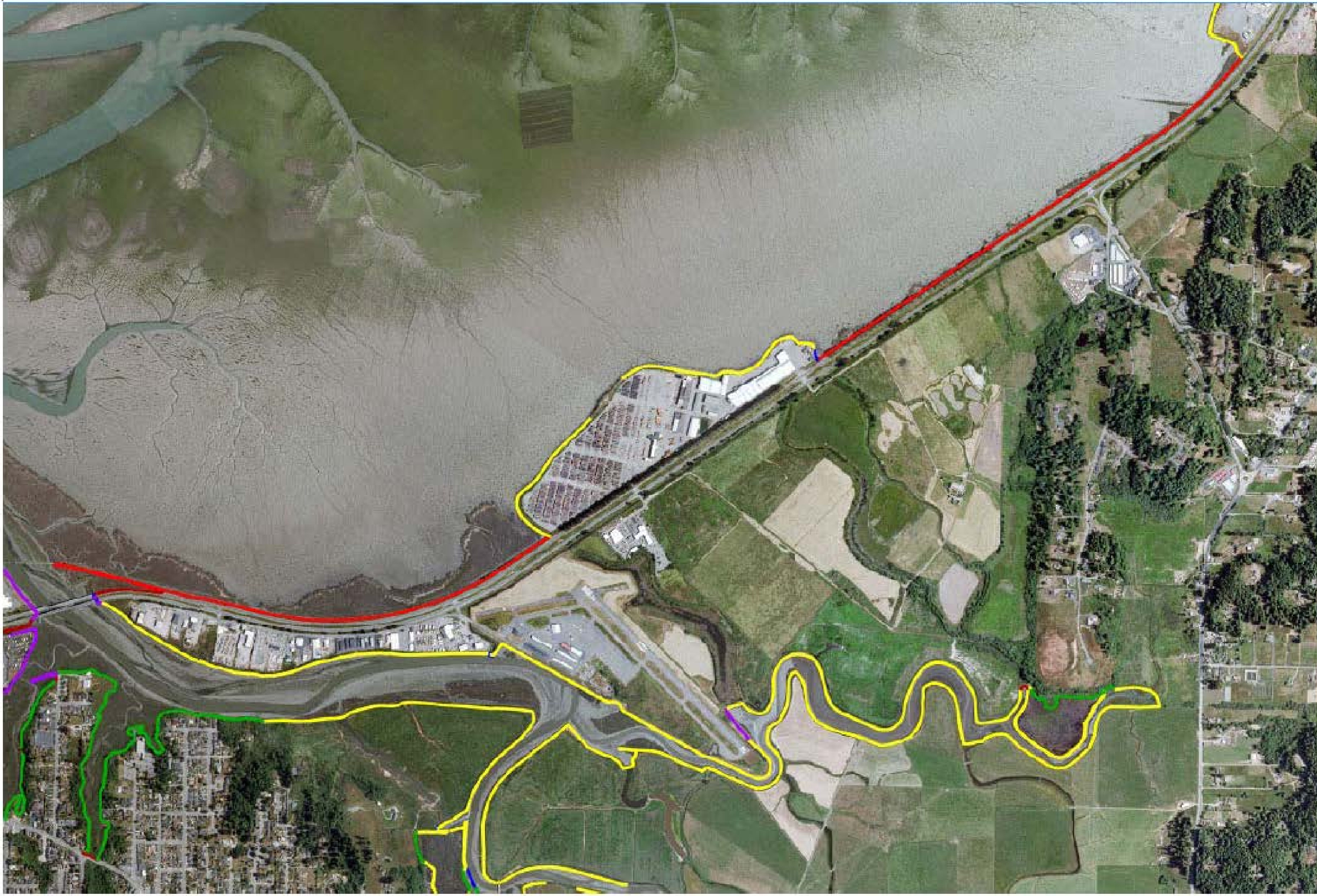


Figure 3. Shoreline structure of the lower reach of Highway 101: railroad (red), dike (yellow), fortified (purple), and natural (green) (Laird 2013).

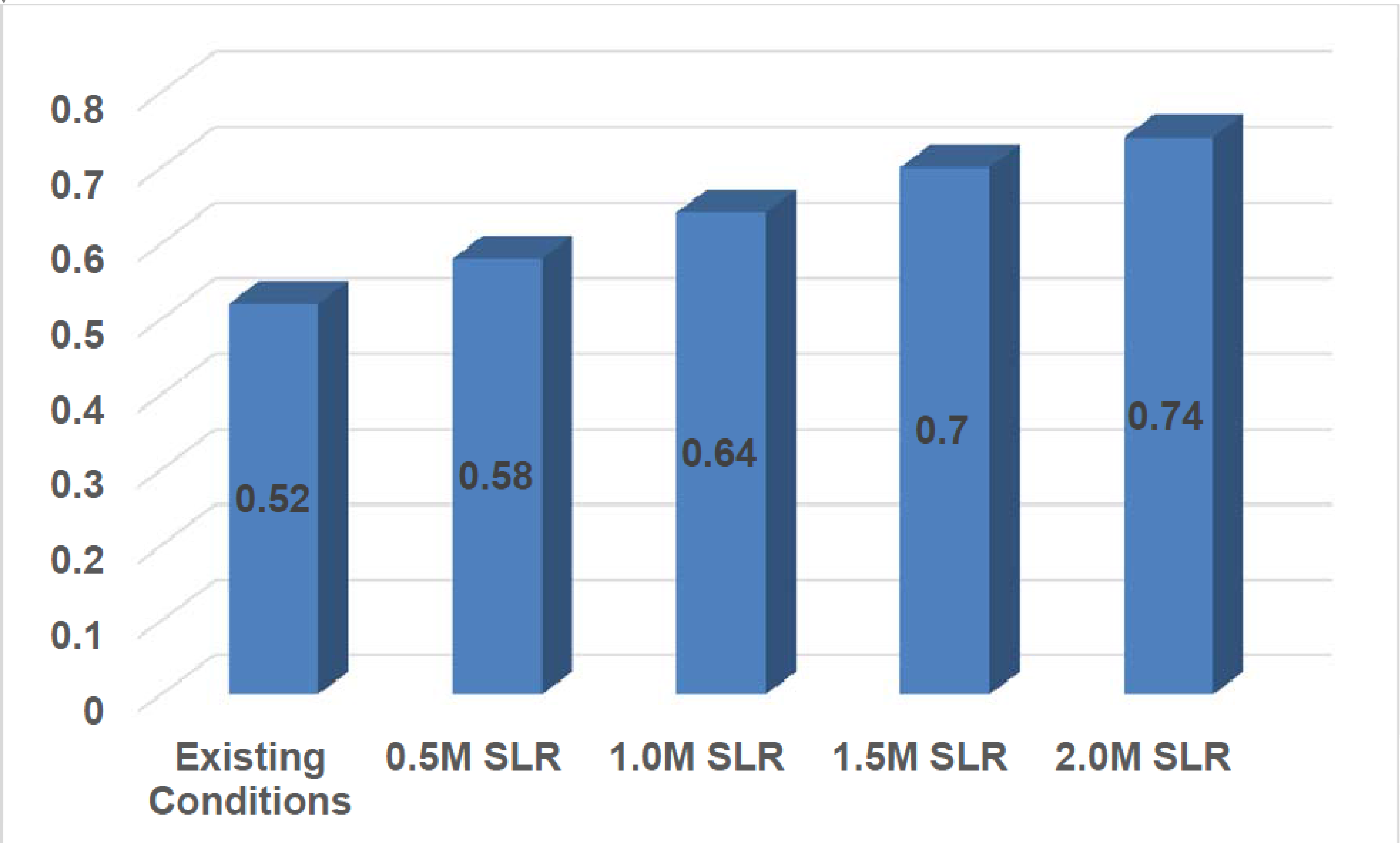
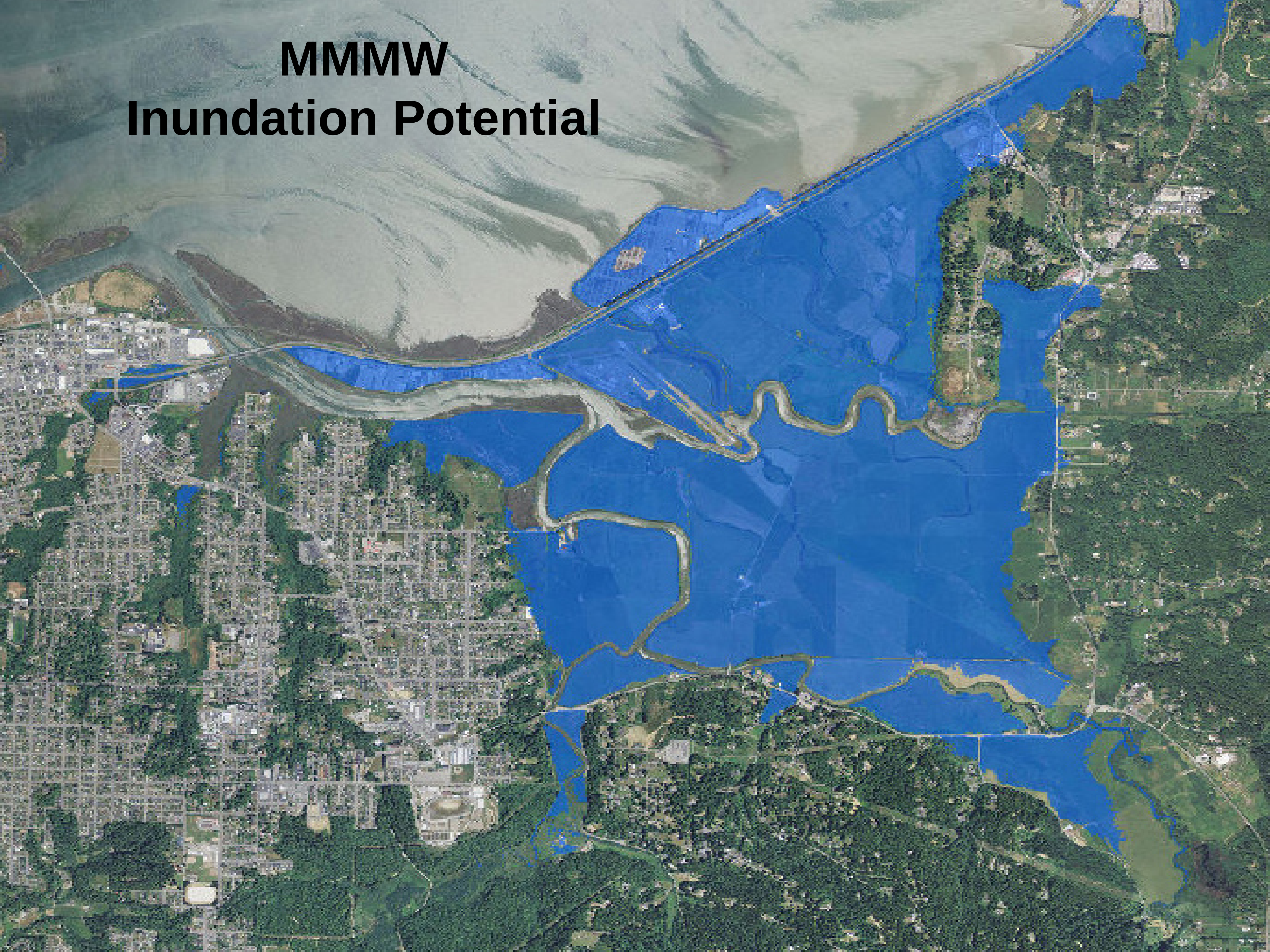
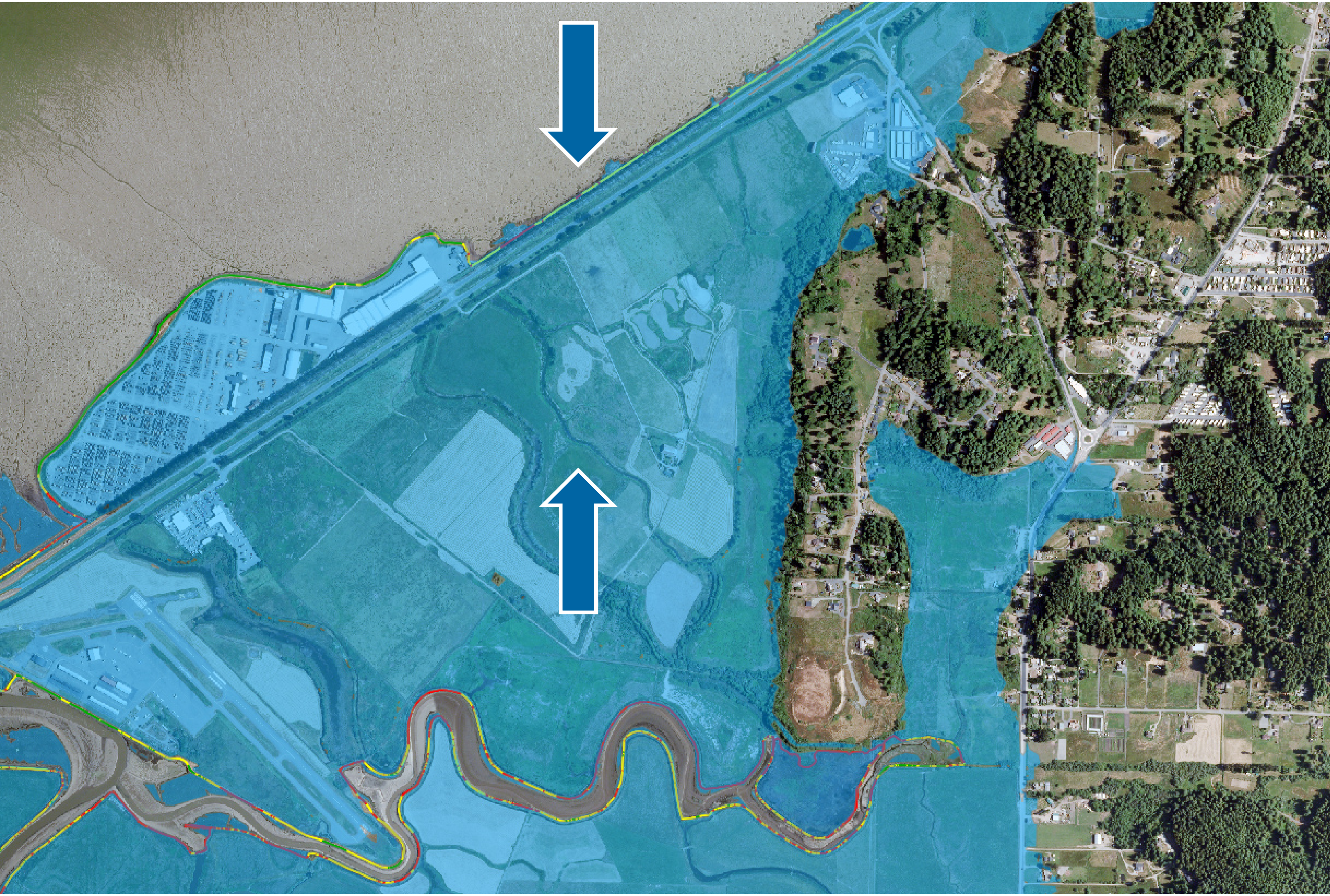


Figure 10. Percent increase in Bay footprint as result of shoreline failure and sea level rise.


MMMW
Inundation Potential




MMMW
Inundation Potential

West of Highway 101-Unmaintained NWP Railroad Grade

East of Highway 101-King Tide Flooding-Bayside Cut-off

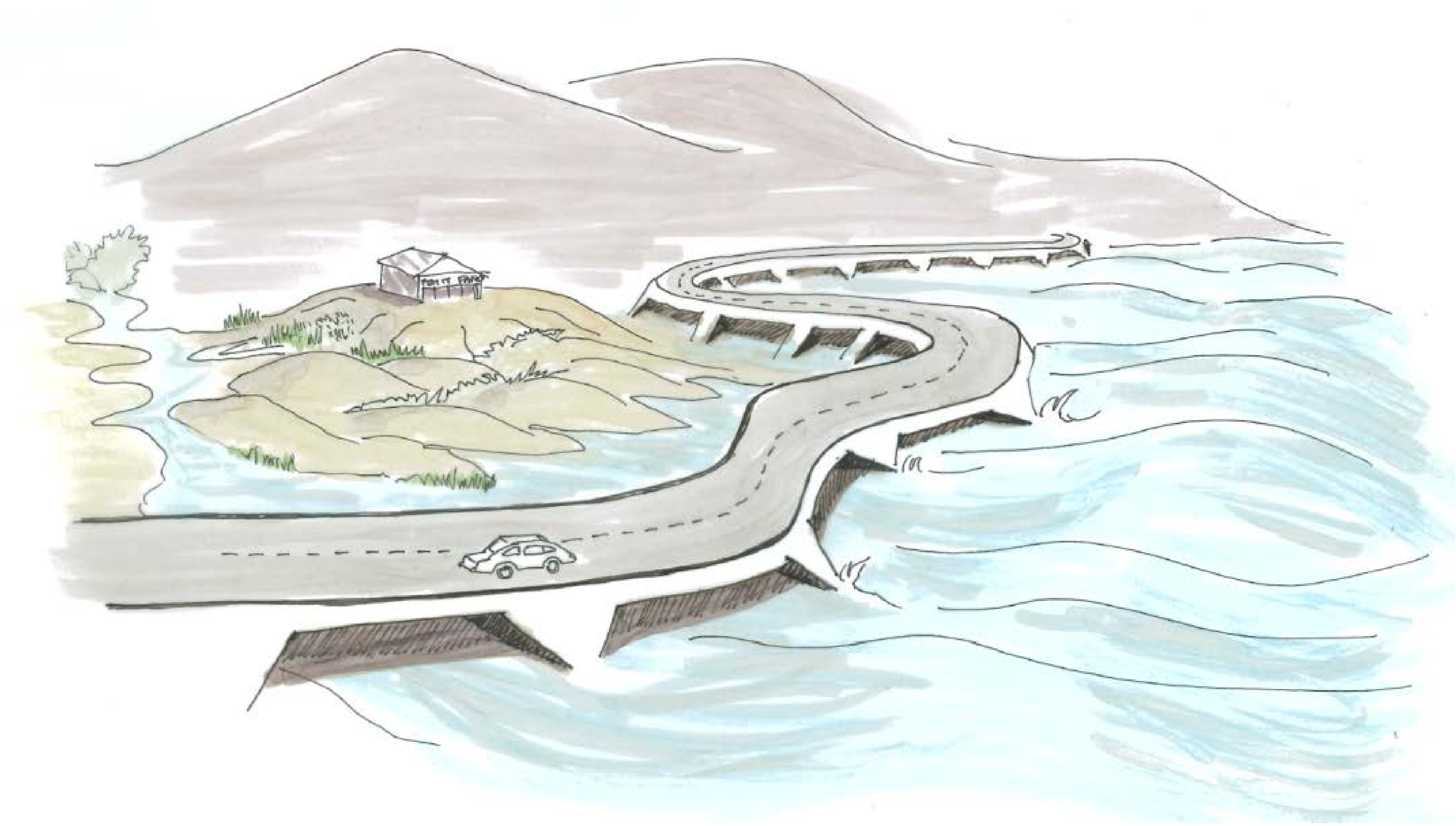
ADAPTATION Options

Existing

Adaptation approaches

Adaptation approaches

Defend



Adaptation approaches

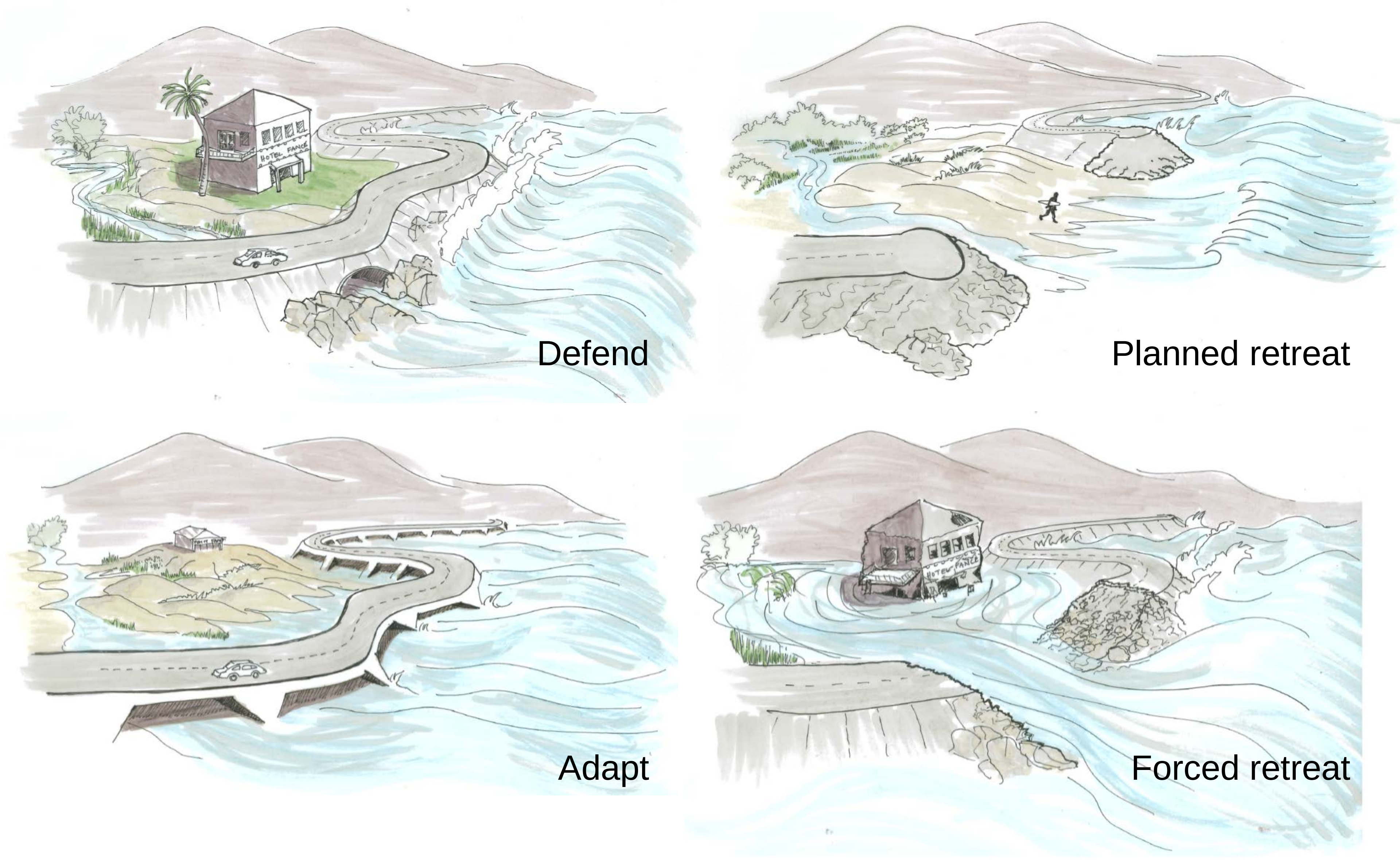
Adapt

Adaptation approaches

Planned Retreat

Adaptation approaches

Forced Retreat



Adaptation approaches

Adaptation approaches

Defend

Adaptation approaches

Flood Walls
Sea Walls
Levees
Dikes

Living shoreline

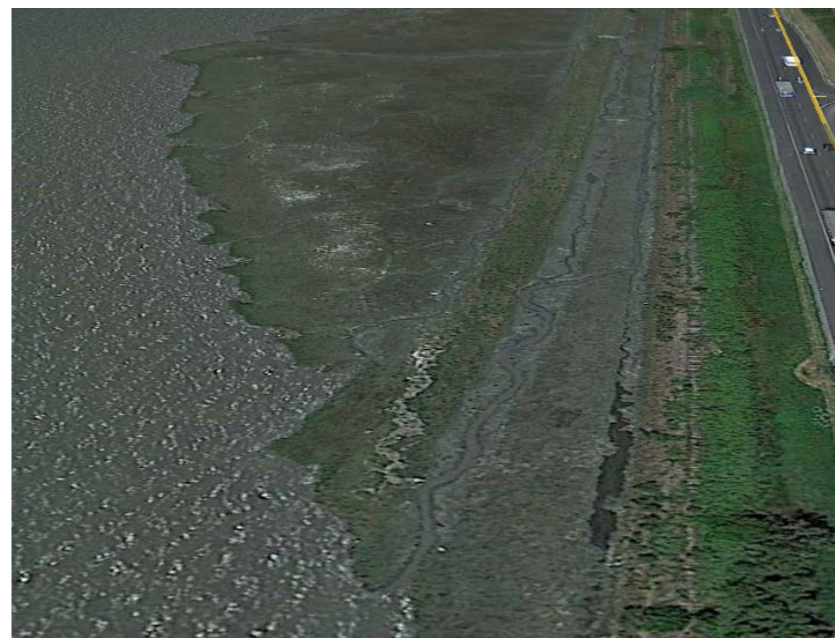
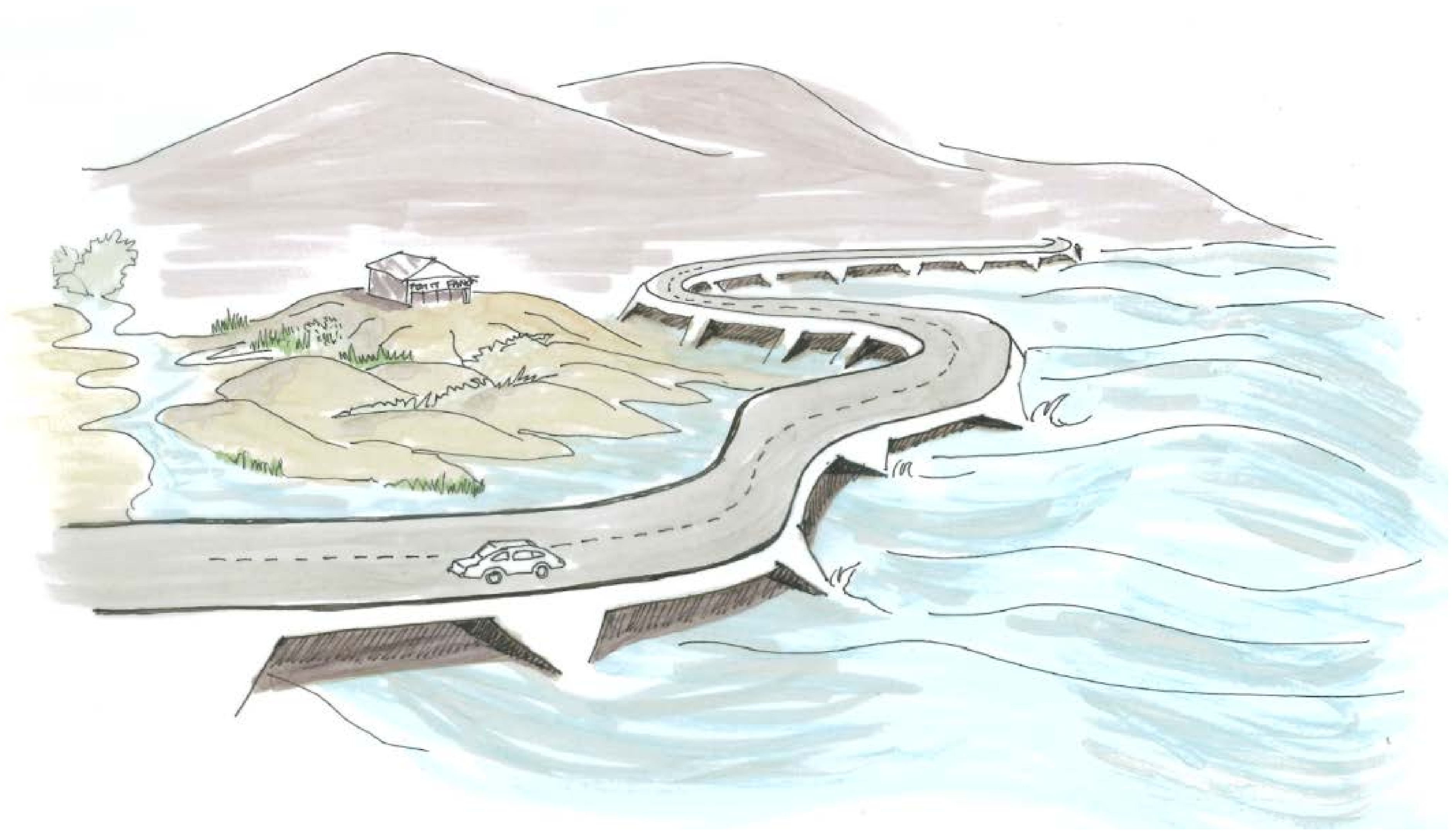


Photo: GoogleEarth



Adaptation approaches

Adapt

Adaptation approaches

Causeways

Photo: California Coastal Records Project

Floodable Bridges

Photo: Google Earth

Adaptation approaches

Raise bridges & roads

Photos: Peter Dobbins/Friends of the Garcia River (FrOG)

Armor roads

Photo: MoBikeFed, , Creative Commons Attribution License

Adaptation approaches

Planned Retreat

Adaptation approaches

Photo: Google Earth

Image: Ocean Beach Master Plan

Re-route & Retreat

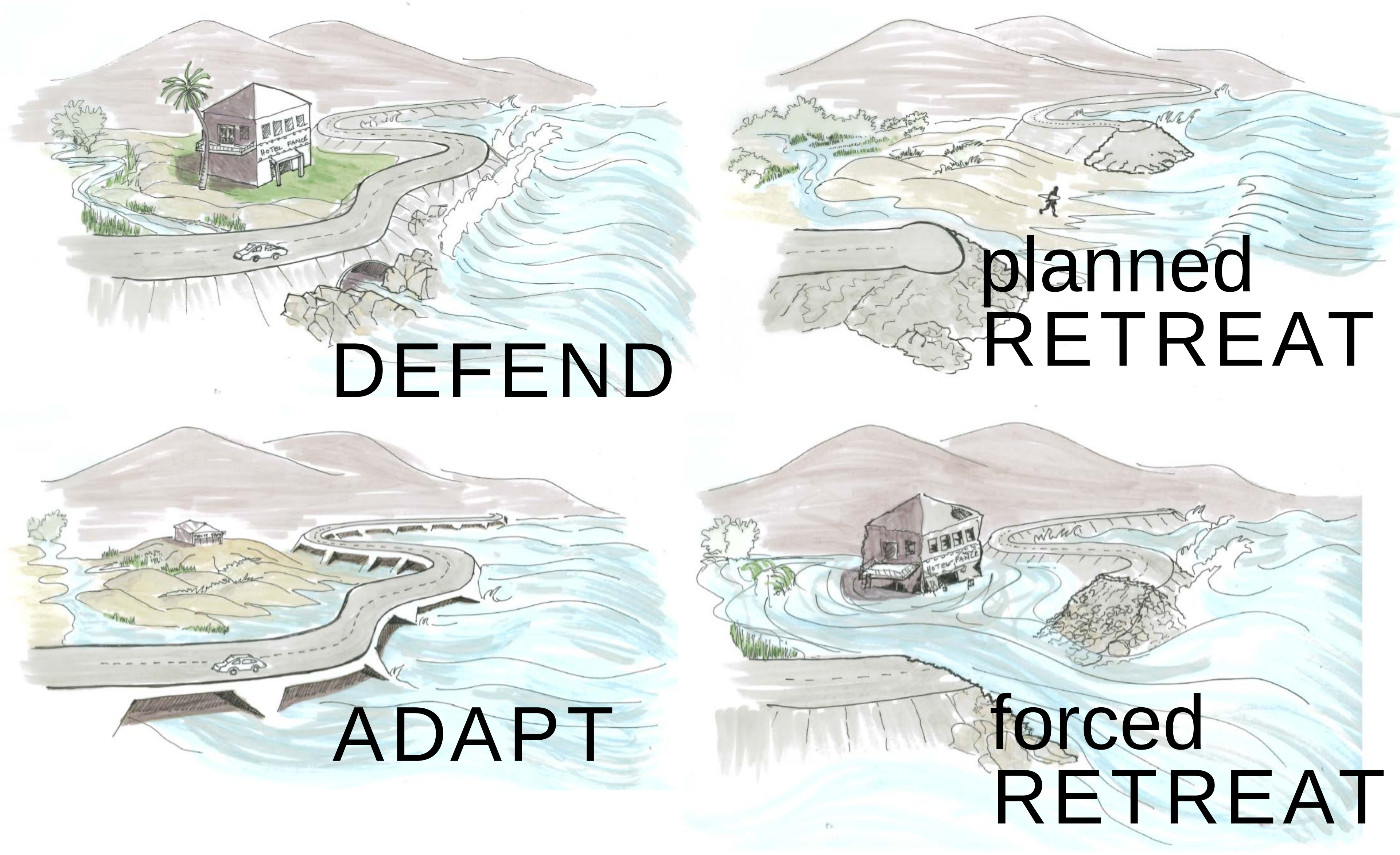
Adaptation approaches

Forced Retreat

Adaptation approaches

No Action:

Flooding & Road Closures



Adaptation approaches

Adaptation Assessment Criteria

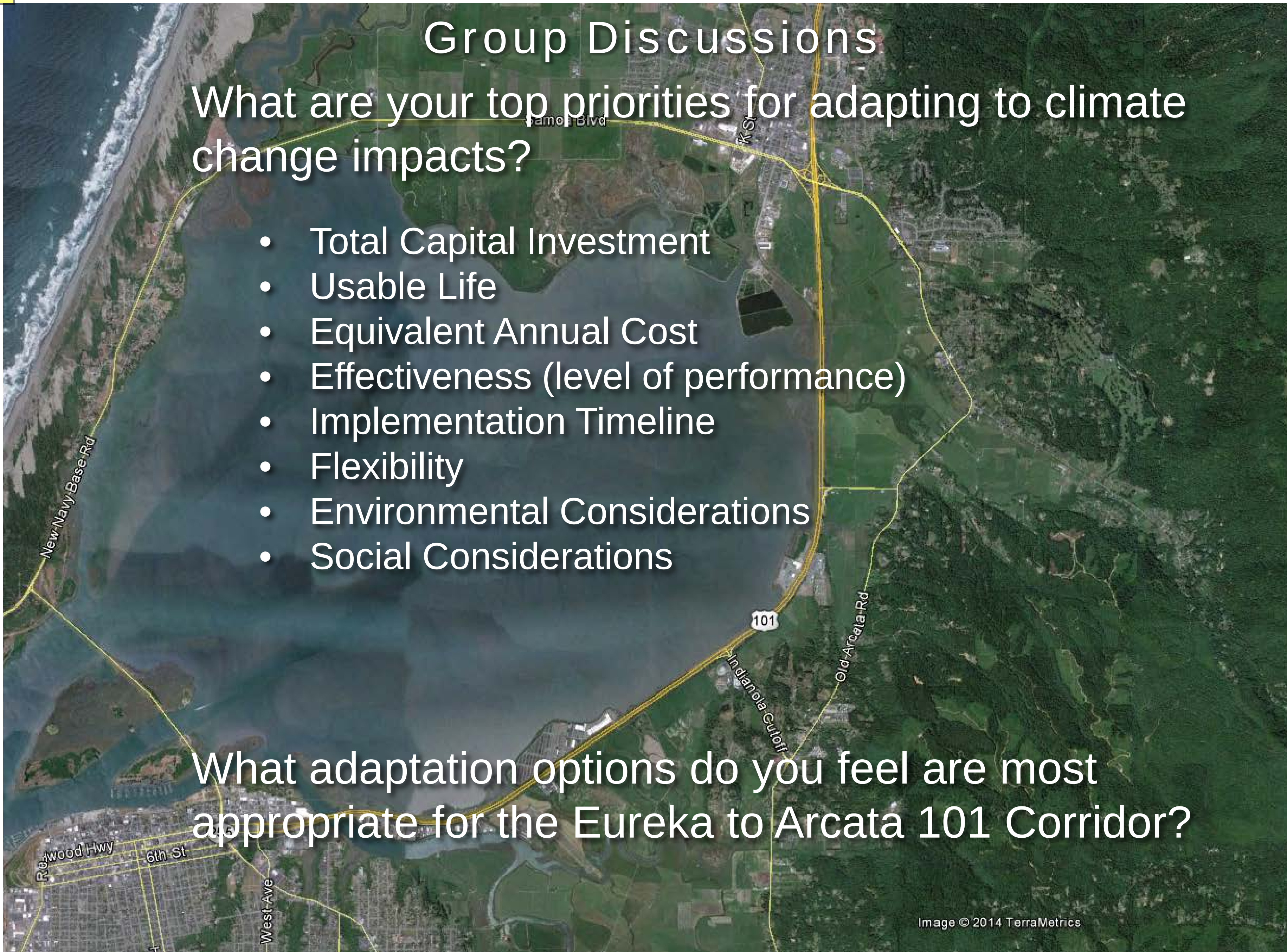
- Total Capital Investment
- Usable Life
- Equivalent Annual Cost
- Effectiveness (level of performance)
- Implementation Timeline
- Flexibility
- Environmental Considerations
- Social Considerations

Group Discussions

What are your top priorities for adapting to climate change impacts?

- Total Capital Investment
- Usable Life
- Equivalent Annual Cost
- Effectiveness (level of performance)
- Implementation Timeline
- Flexibility
- Environmental Considerations
- Social Considerations

What adaptation options do you feel are most appropriate for the Eureka to Arcata 101 Corridor?



Project website

http://www.northcoastclimatechange.com

DISTRICT ONE CLIMATE CHANGE PILOT STUDY

CLIMATE CHANGE ADAPTATION PILOT STRATEGY FOR CRITICALLY VULNERABLE ASSETS IN A NORTHWEST CALIFORNIA PROJECT

DISTRICT ONE – CLIMATE CHANGE – PILOT STUDY – (D1CCPS)

Project Background

The planning department of Caltrans District 1 applied for and received a grant from the Federal Highway Administration to study the potential vulnerabilities of transportation assets to climate change throughout District 1 (Del Norte, Humboldt, Mendocino, and Lake Counties), and to identify and evaluate a range of adaption options to address the identified vulnerabilities at four prototype locations.

The study will begin with an inventory of transportation assets in District 1 and a subsequent analysis to determine which assets are critically vulnerable. Following this task, four pilot sites ("prototype locations") will be selected for further analysis during the "adaptation assessment" phase of the project. The adaptation assessment will identify options for adapting Caltrans infrastructure to the various climate change factors and will evaluate the level of protection, flexibility, relative costs, acceptability, constraints, and benefits of those adaptation options. The adaptation methodology will include criteria