Climate Change: Assess, Design, Act

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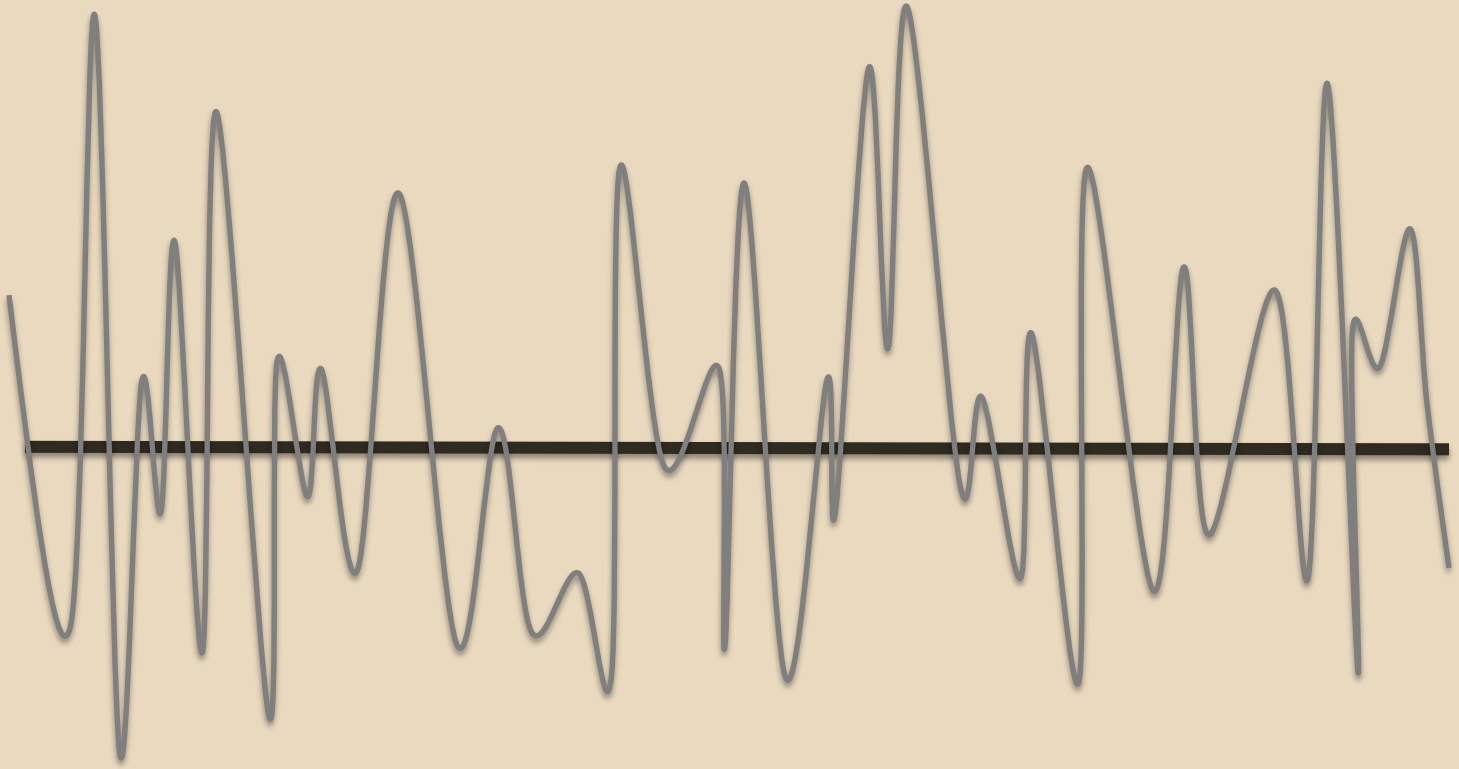
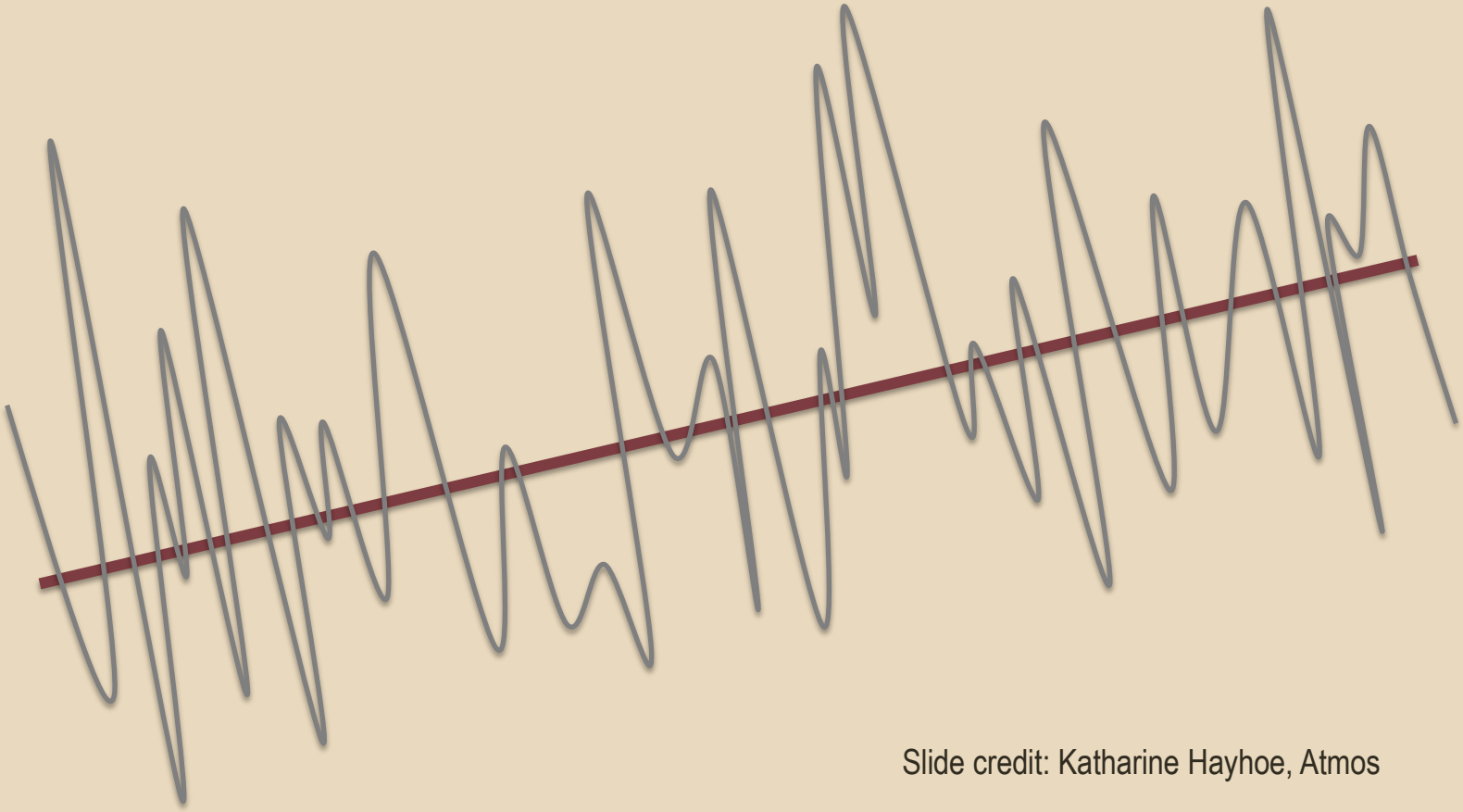
Our civilization is built on the assumption of a stable climate



Slide credit: Katharine Hayhoe, Atmos

What happens if that climate isn't stable any more?



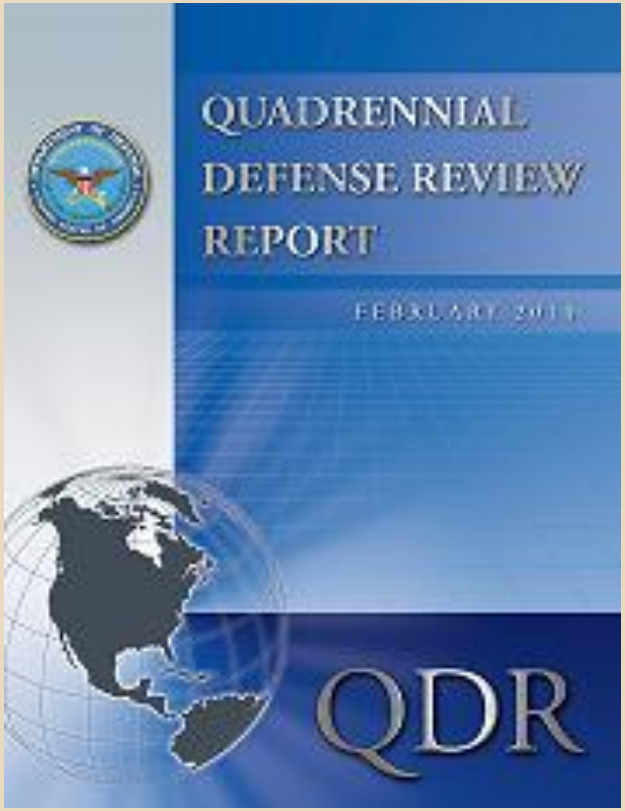
Slide credit: Katharine Hayhoe, Atmos

Climate Change and Risk

Geopolitical Implications

Photo credit: AP

Climate Change and Security



" … climate change could have significant geopolitical impacts around the world…further weakening of fragile governments.

Climate change will contribute to food and water scarcity, will increase the spread of disease and may spur or exacerbate mass migration."

"…In 2008, the National Intelligence Council judged that more than 30 U.S. military installations were already facing **elevated levels of risk from rising sea levels**.

DOD to complete a climate change assessment of all installations to assess impact on mission and adapt accordingly

Roadways

Transit

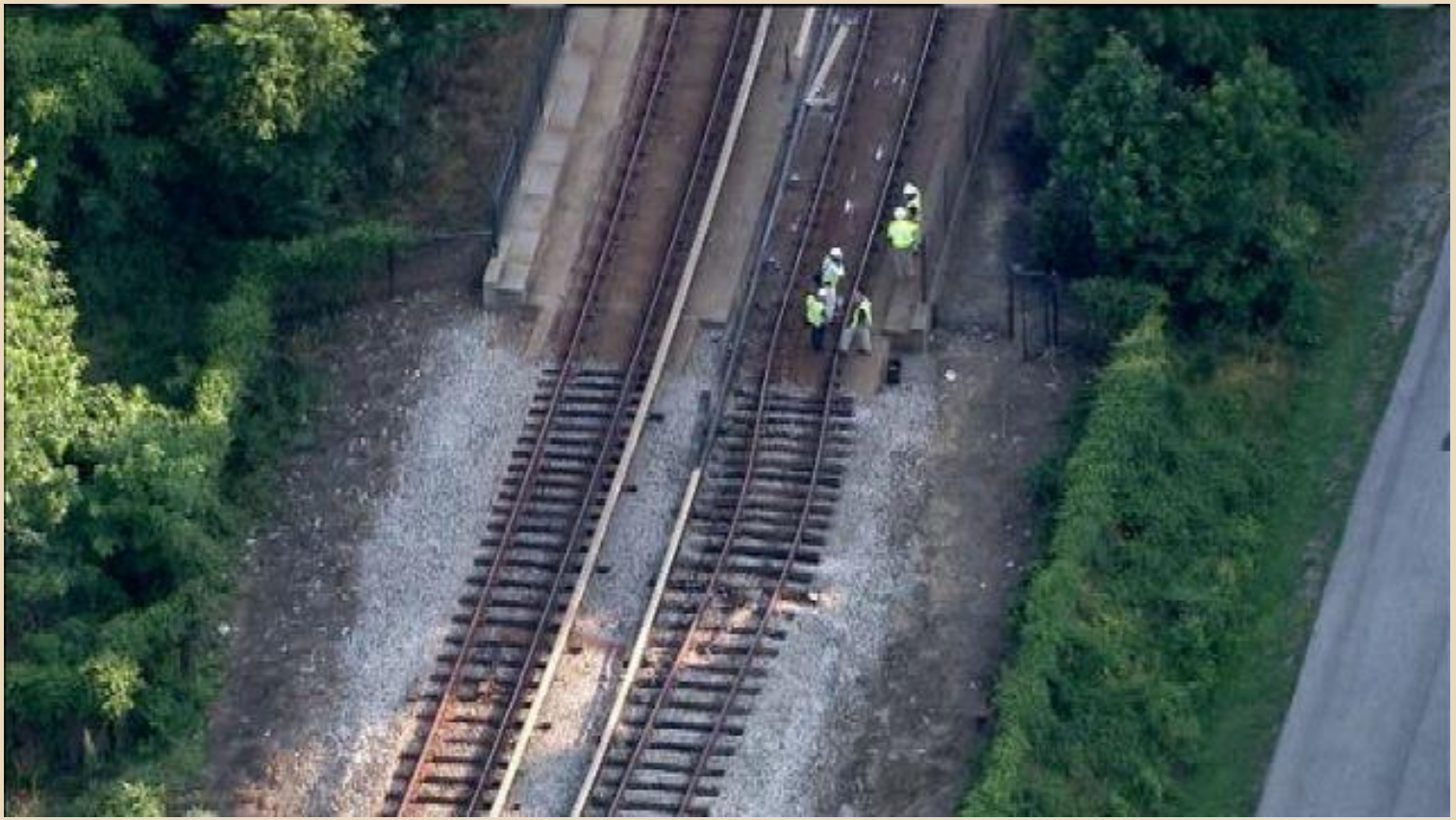
Roads

- Roads buckled. At least 17 buckles in MI on July 4th.

Airlines

- Caused soft spot in run way at Regan National Airport.

Railroads



- Tracks warped (“heat kink”) in Maryland, causing derailment.

Flooding in subway after rain event

Climate Change Threatens U.S. Energy Infrastructure

Average temperatures will continue to rise. Energy demand is directly impacted by these temperature increases. A recent study estimates that rising temperatures could increase demand for electricity by 40% by 2030

Drought (Water Scarcity)

85% of U.S electricity generated by power plants that rely heavily on water for cooling

Extreme Weather Events

11 weather events causing more than $1B in damages – Hurricane Sandy + Nor'easter = > 8M people lost power

Rising Sea Levels

8-inch rise in global sea levels over last century – 280 power plants and O&G refineries on low-lying lands

Climate Change Challenges Transportation Infrastructure

Making transportation infrastructure more resilient will be expensive. Aging highways, bridges, trains and buses already are in need of repair or replacement and no longer can handle peak traffic demands.

Superstorm Sandy

Severe damage to NY sub-way, halted rail service to City, and forced cancellation of thousands of flights

Flooding In Omaha, NE

Saturated ground beneath airfield caused about 100 Sinkholes and "soil boils" – airport spared through Installation of 70 dewatering wells and sandbags

Record Smashing Heat

Caused train tracks to bend and roadway pavement to buckle

Source: "Climate Change Challenge Transportation System in the U.S.". 11/22/2012

Climate Change Changing the Calculus of Water Sector

Causing poor water quality and scarcity and putting significant stress on our water infrastructure, climate change is having a profound effect on how communities can reliably access clean water as well as its treatment, distribution and collection.

Source Water

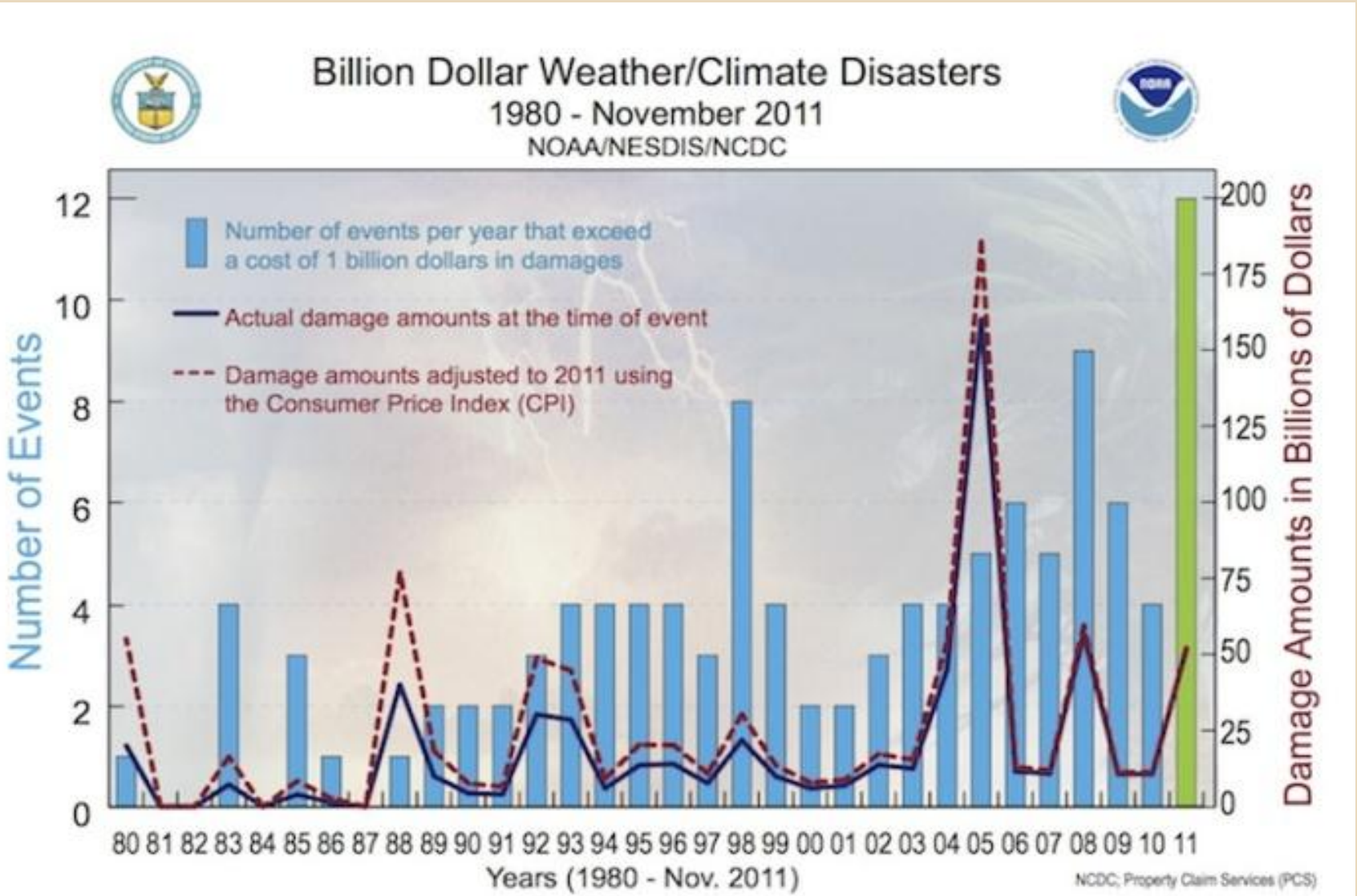
- Regional drought
- Intake elevations
- Water quality issues
- Evaporation
- Groundwater depletion

Water Treatment

- Sedimentation
- Addition water treatment requirements
- Siting elevations
- Water quality issues
- Infrastructure flooding

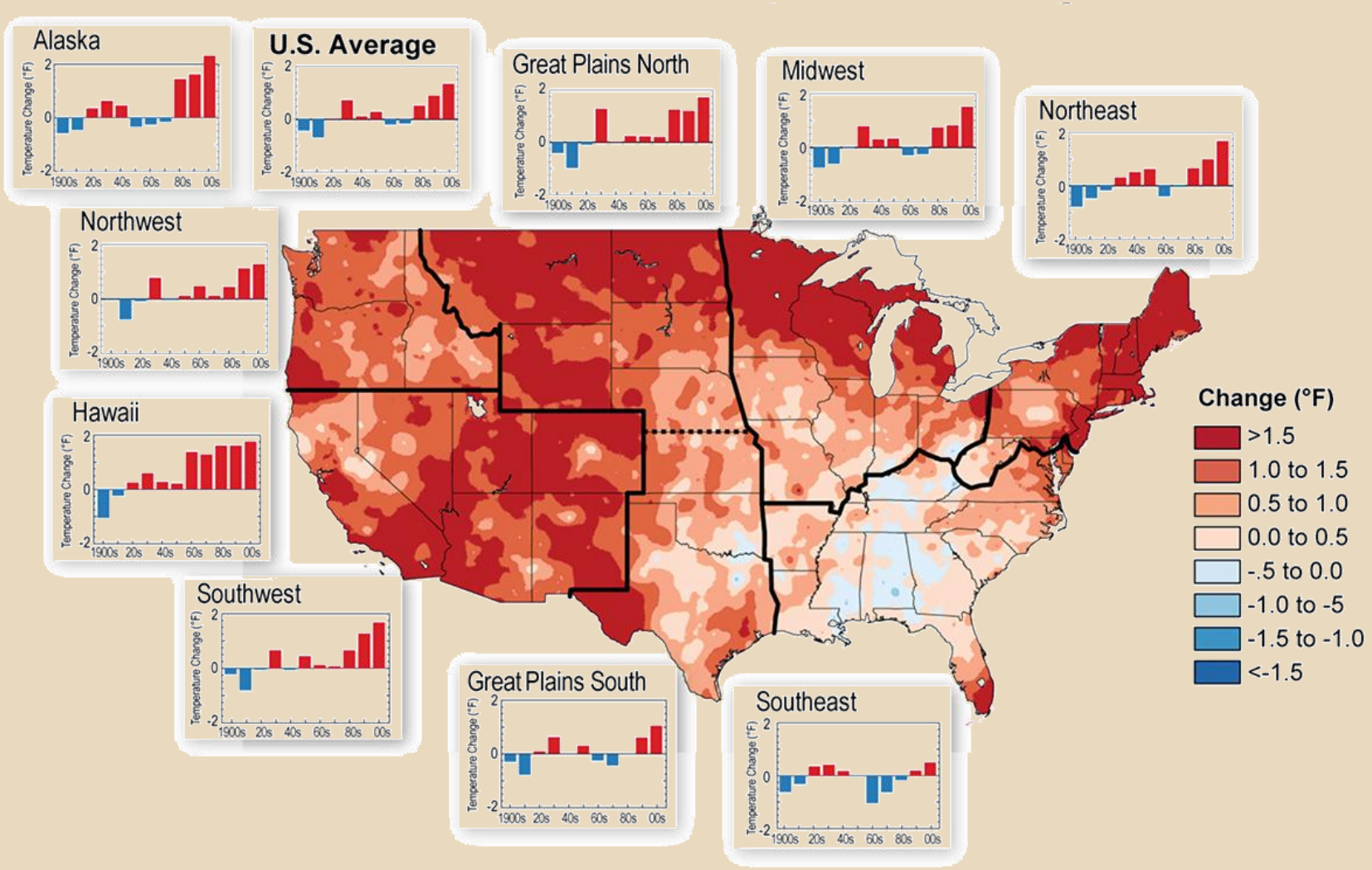
Wastewater Treatment

- Site elevations
- Outfall elevations
- SSO frequency
- Temperature-dependent processes
- Receiving water quality
- Infrastructure flooding


Billion Dollar Weather/Climate Disasters
1980 - November 2011
NOAA/NESDIS/NCDC
Number of events per year that exceed a cost of 1 billion dollars in damages
Actual damage amounts at the time of event
Damage amounts adjusted to 2011 using the Consumer Price Index (CPI)
Number of Events
Damage Amounts in Billions of Dollars
0 2 4 6 8 10 12
0 25 50 75 100 125 150 175 200
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11
Years (1980 - Nov. 2011)
NCDC; Property Claim Services (PCS)

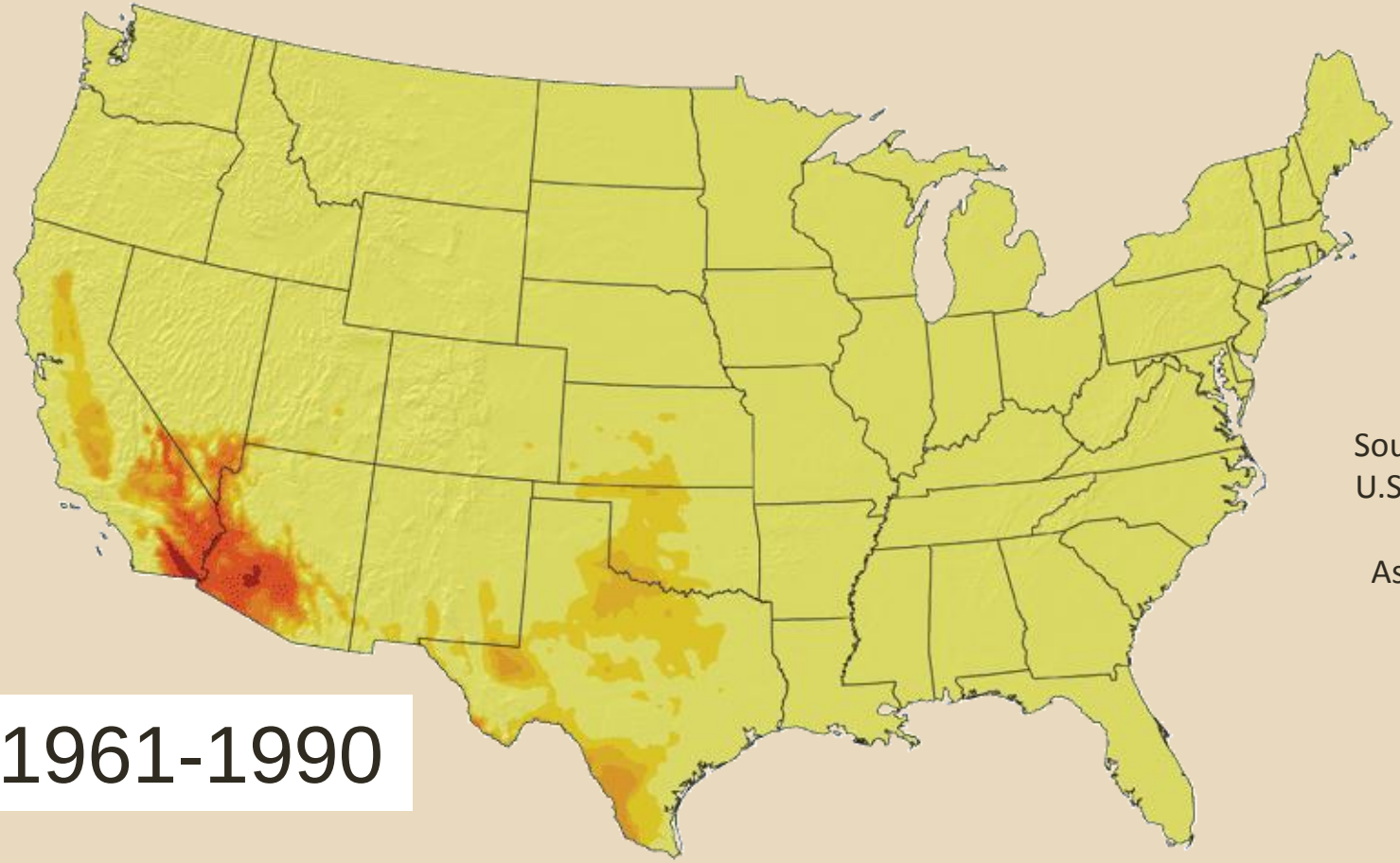
Climate Change predictions for the U.S.

The U.S. is getting warmer



Source: 2014 U.S. National Climate Assessment

Extreme heat becoming more common

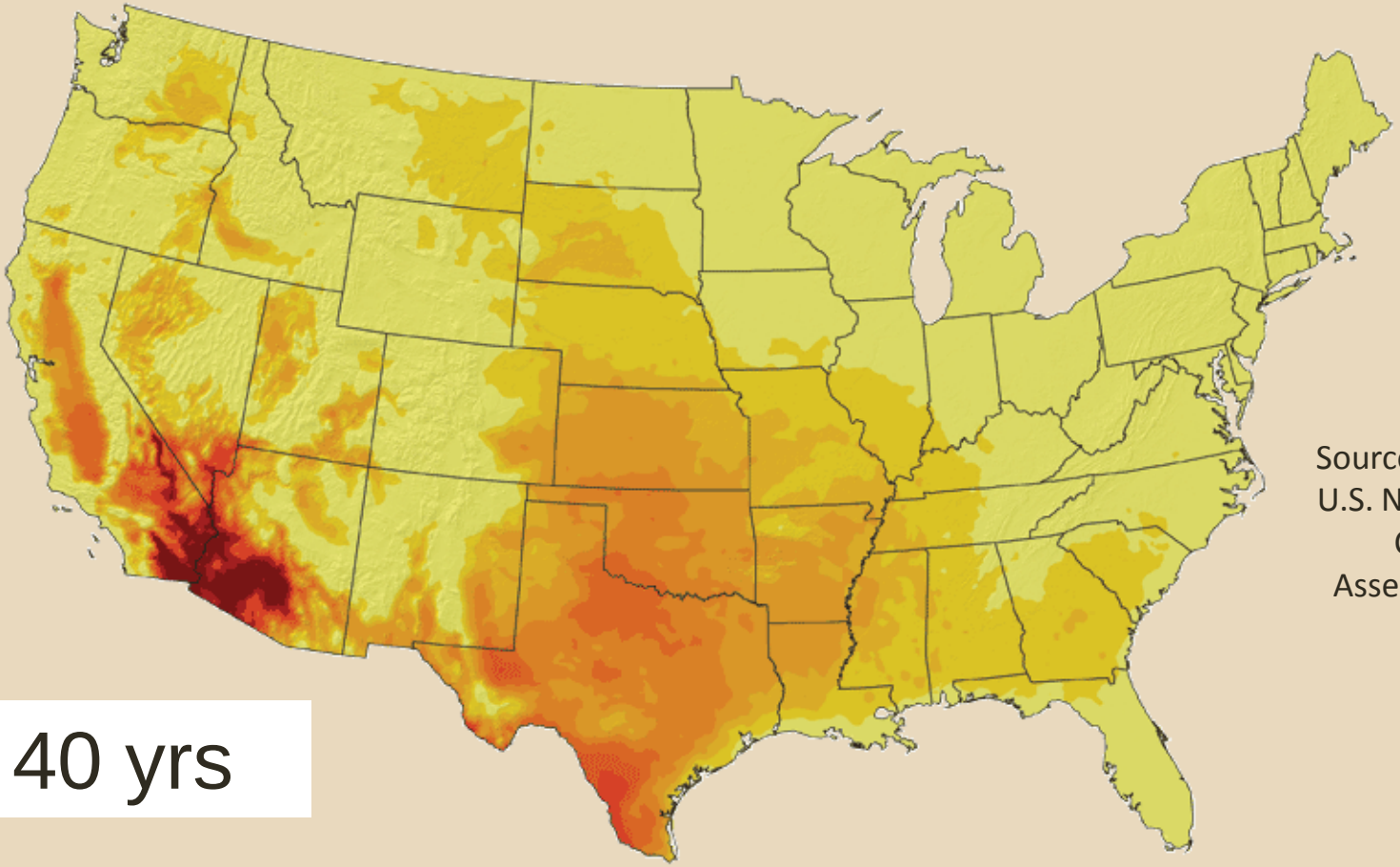


1961-1990

Source: 2009 U.S. National Climate Assessment

Days per year over 100°F

Extreme heat becoming more common



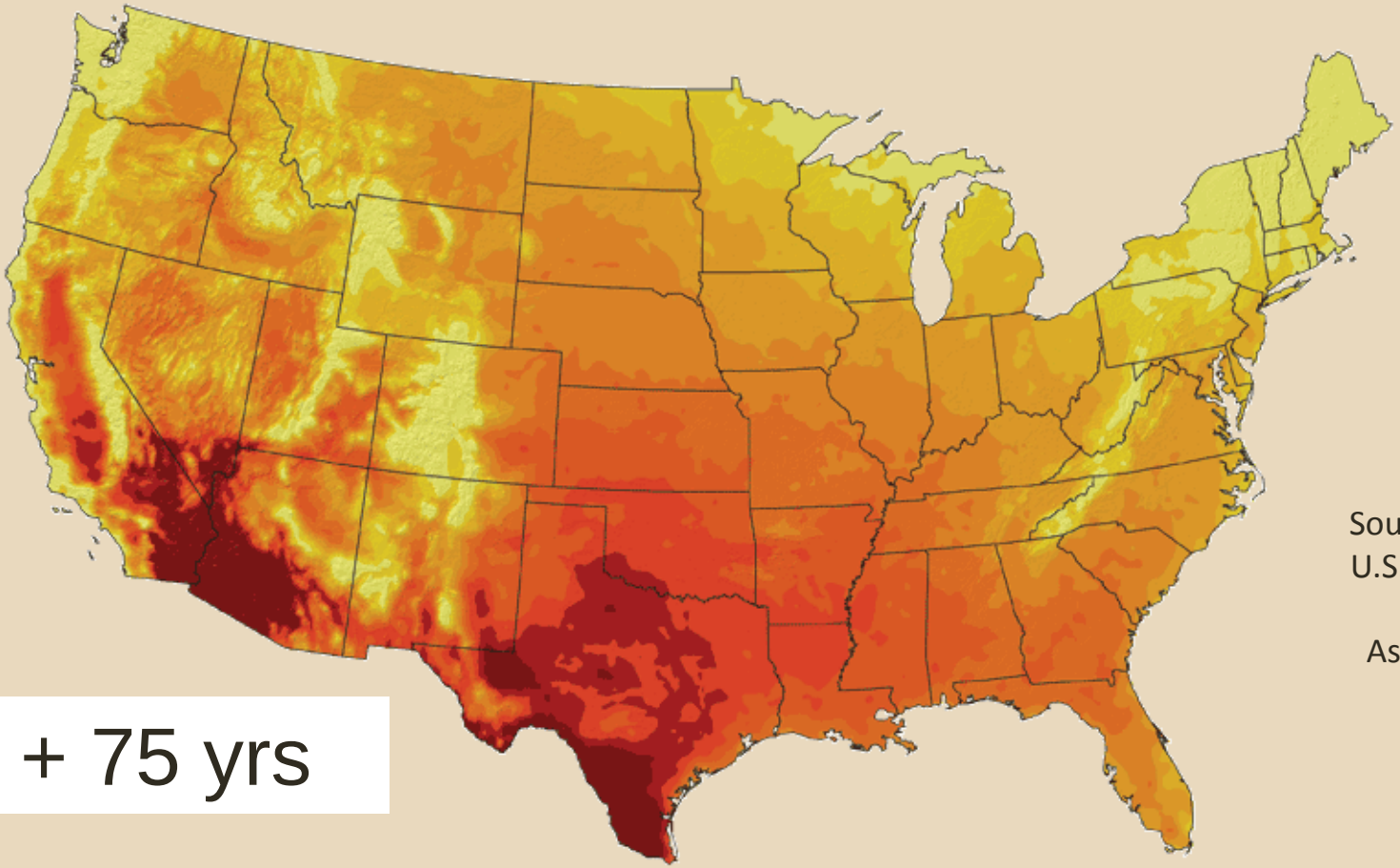
Source: 2009 U.S. National Climate Assessment

+ 40 yrs

Days per year over 100°F

<10 20 30 45 60 75 90 105 >120

Extreme heat becoming more common



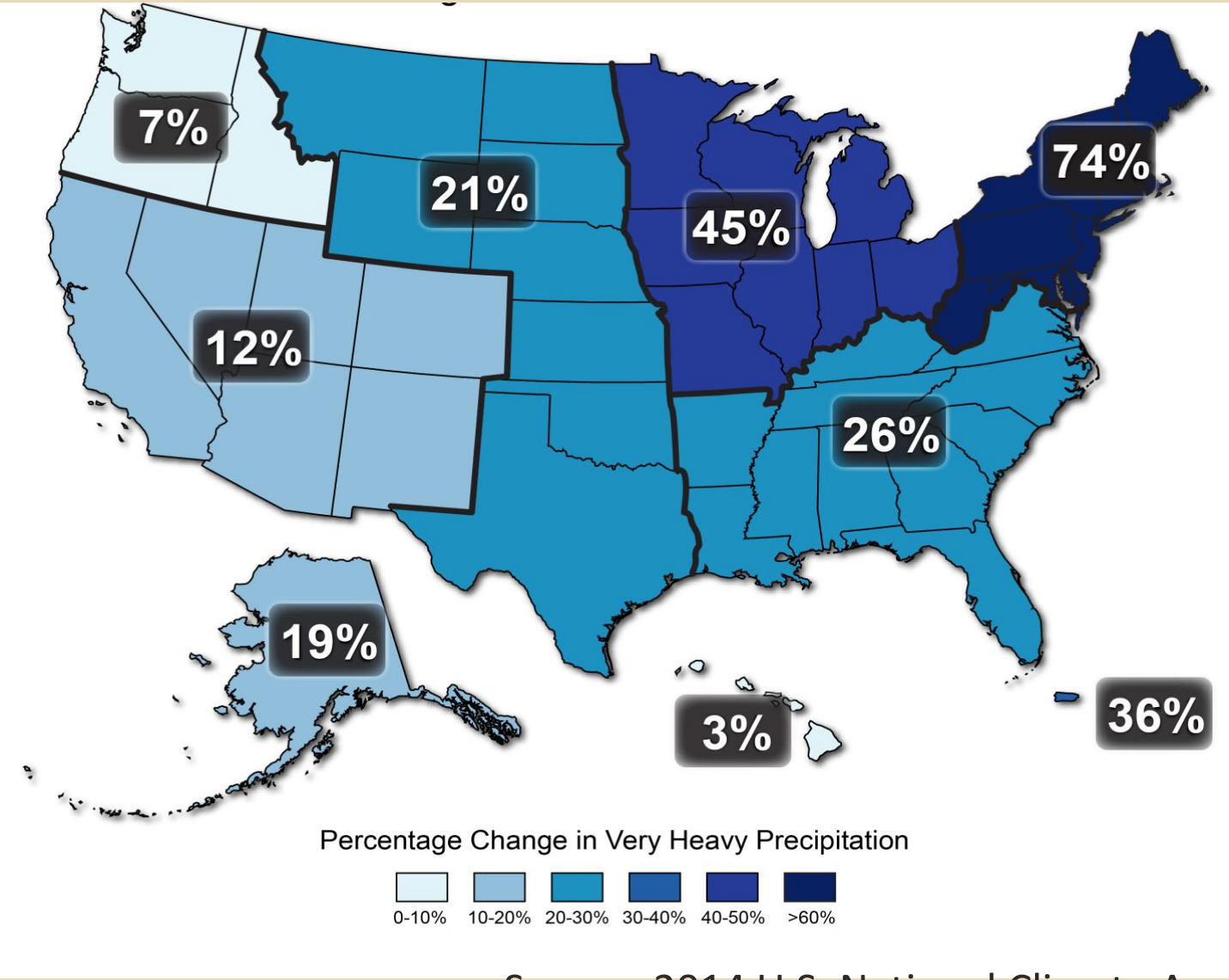
Source: 2009 U.S. National Climate Assessment

+ 75 yrs

Days per year over 100°F

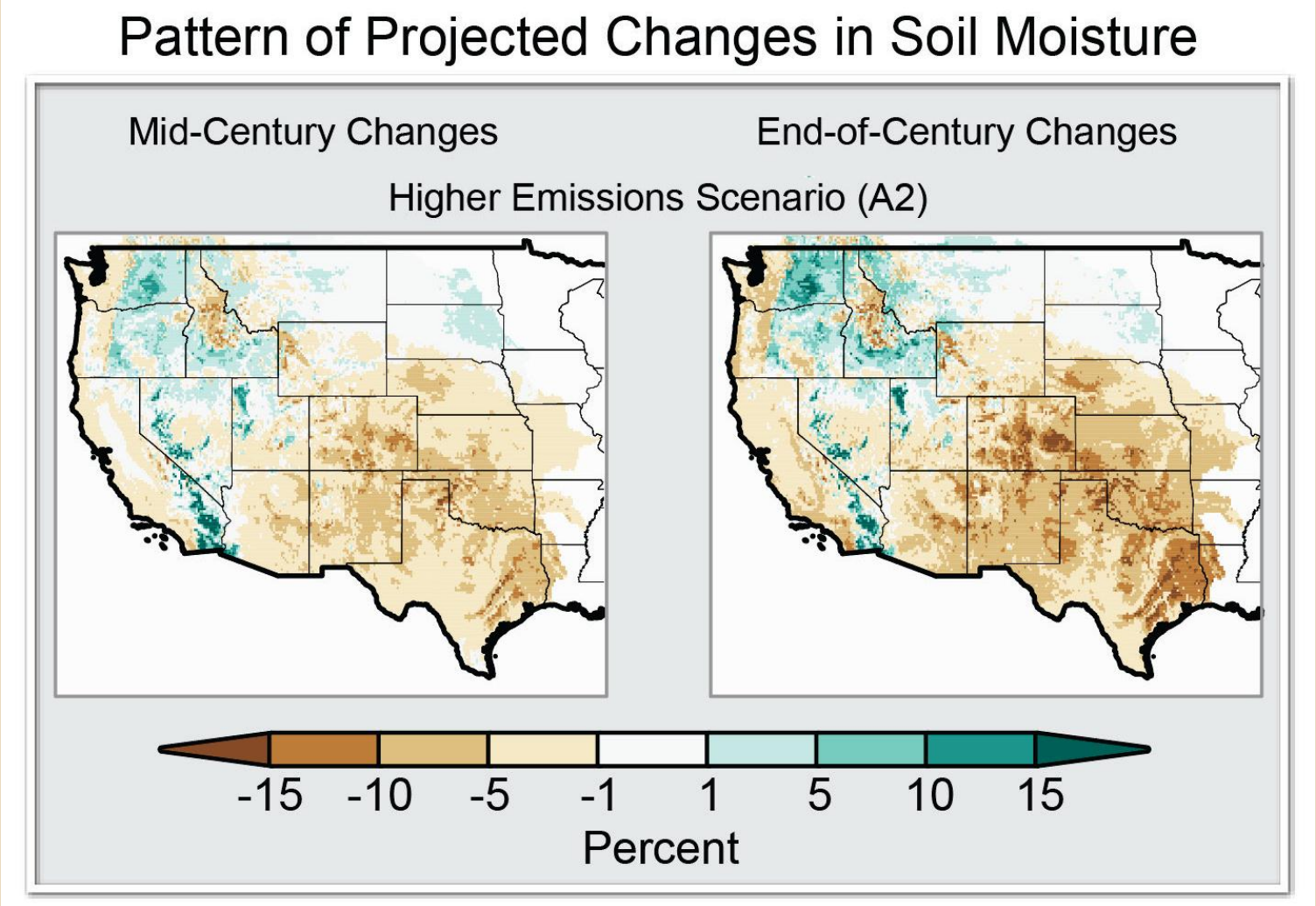
<10 20 30 45 60 75 90 105 >120

Heavy rainfall is more frequent, too



Source: 2014 U.S. National Climate Assessment

Droughts projected to become more intense



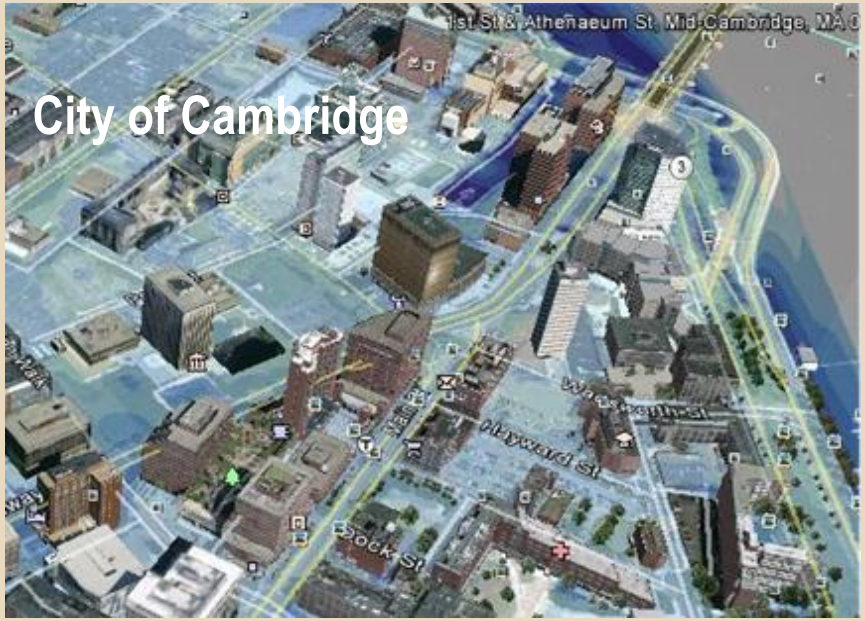
Source: 2014 U.S. National Climate Assessment

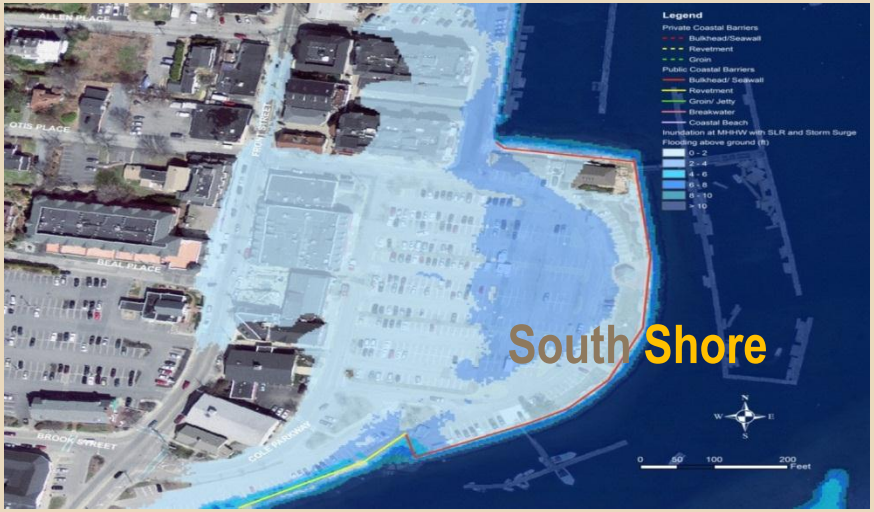
Climate Change Projections - overview

- Increasing temperatures – fastest in the winter
- Increasing frequency of extreme heat days and multi-day heat wave events
- Increase in heavy rainfall but NOT an increase in annual average rainfall volumes
- Increase in number of dry days
- As temperatures increase, every drought will become more severe – higher evaporation rates

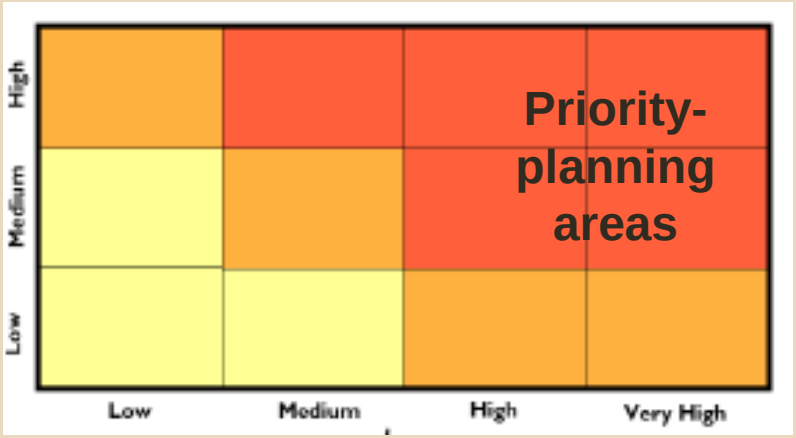
Climate Change Approach

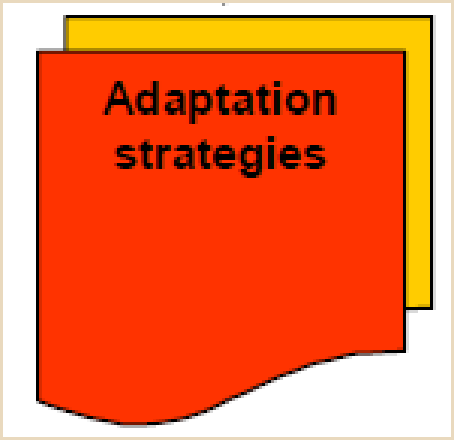
Climate Change Experience





Climate Change Approach





Step 1

Climate Projections

Scenario Development

Step 2

Vulnerability Assessment

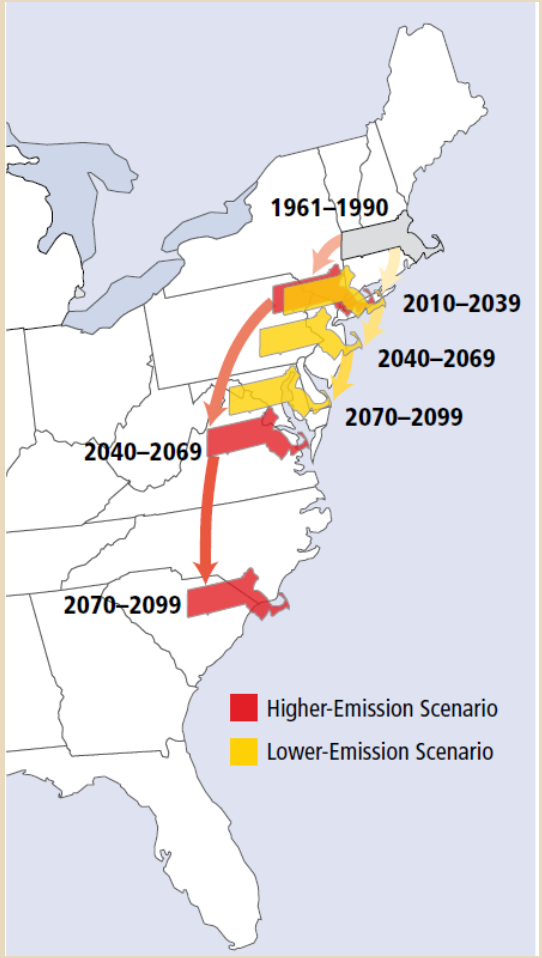
Risk Assessment

Step 3

Adaptation Planning and Design

Step 1a: Climate Projections

Temperature



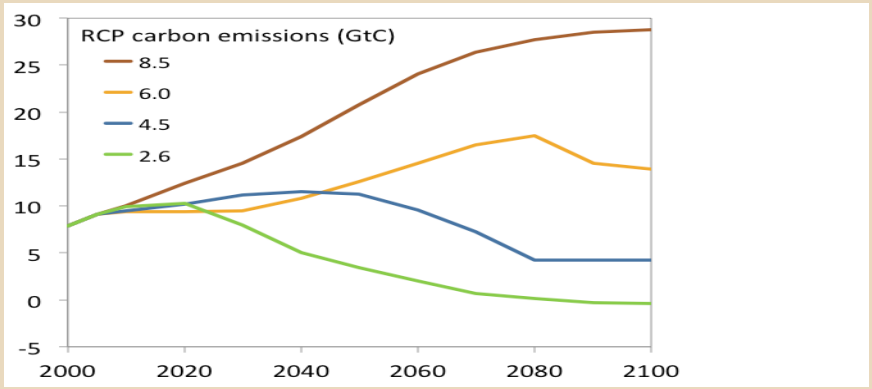
Precipitation

Extreme events

Sea Level Rise

Step 1b: Scenario Planning

Possible futures

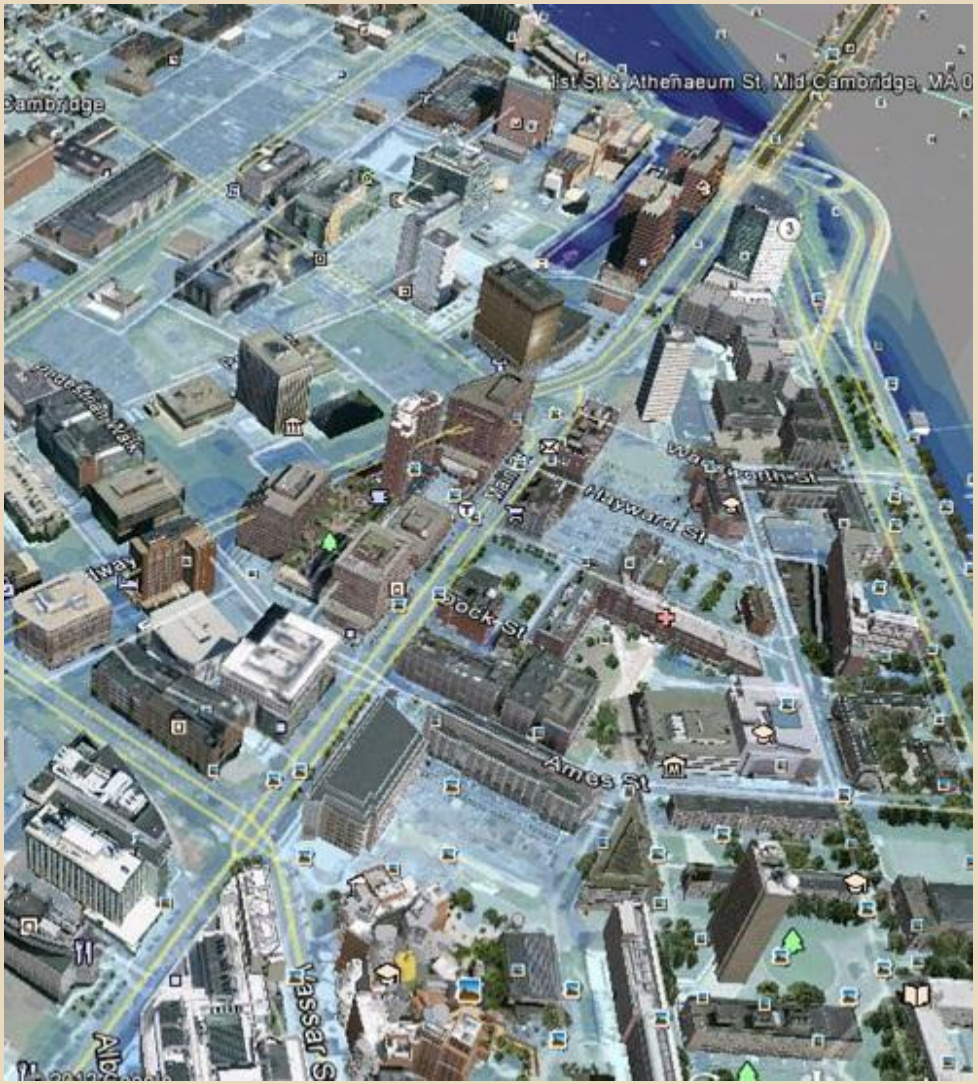


GHG emission scenarios

Climatic parameters

Step 2: Identify the Targets

- Infrastructure
- Critical Services
- Public Health
- Economic
- Natural Systems
- Insurance/Legal
- Social Resiliency



Potential Targets

Infrastructure

Energy
- Electricity & gas

Public Works and Transportation
- Highways, bridges, & roads)
- Local roads including pathways
- Stormwater system
- Transit: subways, buses, and commuter rails
- Parking

Water & Wastewater
- Water supply & distribution
- Wastewater collection
- Water/Wastewater treatment

Critical Services
- Public safety
- Hospitals
- Child care & elderly center

Telecom/ IT

Public Health
- Heat/temperature vulnerabilities
- Air quality
- Disease vectors

Economic
- Economic indicators/activity
- Retail goods and services
- Ridership at relevant transit stations (who can get to work)
- Number of employees
- Assessed real estate value
- Property tax collections

Natural systems
- Urban forestry
- Habitat

Public Facilities

Step 2a: Vulnerability Assessment

		Sensitivity: Low → High				
		S0	**S1**	**S2**	**S3**	**S4**
Adaptive Capacity Low ↓ High	**AC0**	V2	V3	V4	V5	V5
	AC1	V1	V2	V3	V4	V5
	AC2	V1	V1	V2	V3	V4
	AC3	PO	V1	V1	V2	V3
	AC4	PO	PO	PO	V1	V2

Analysis of individual assets

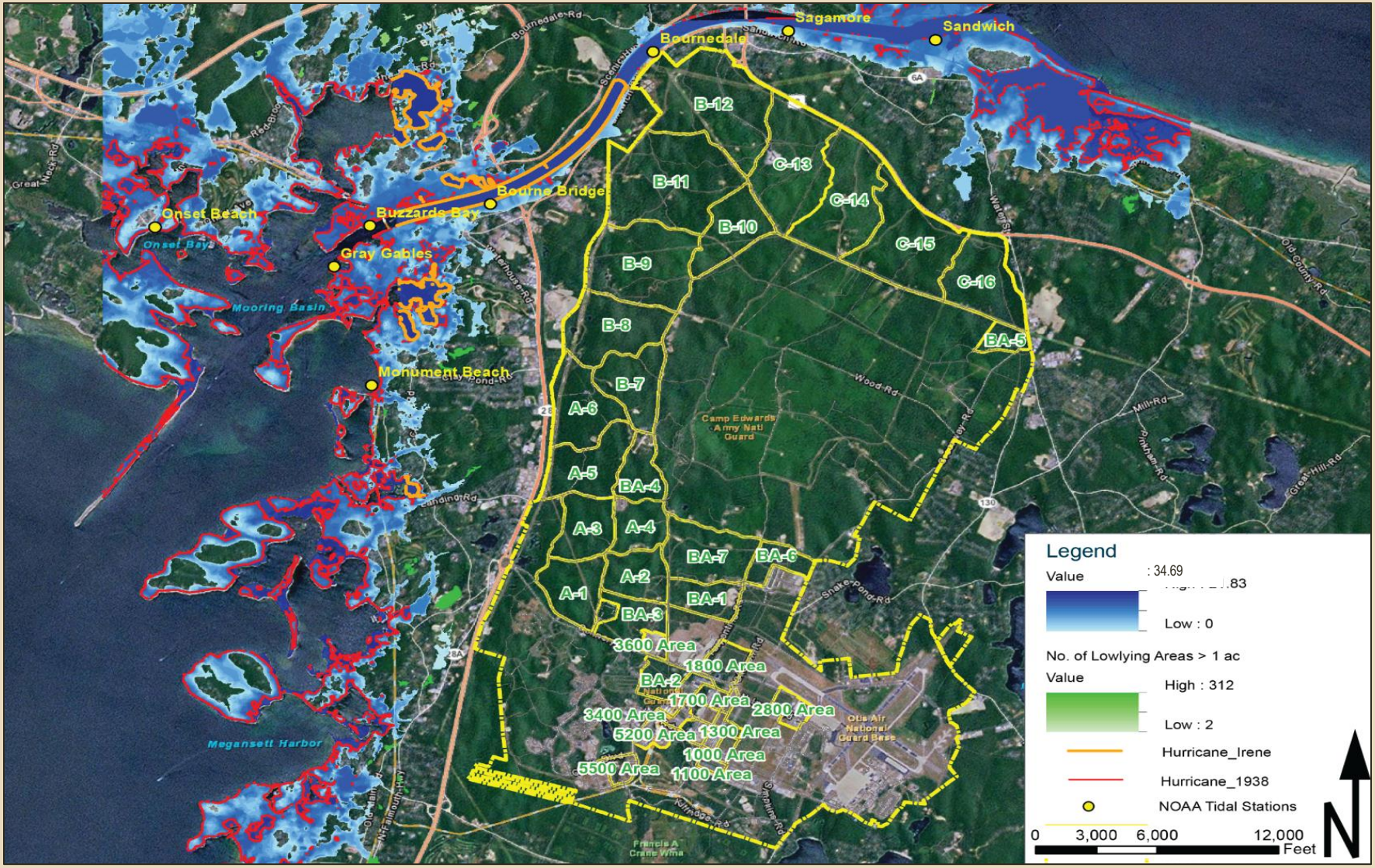
Step 2b: Risk Assessment

I = Infrastructure Consequence, T = Training Consequence, O = Operations Consequence.

Magnitude of Consequence	More likely than not	Likely	Very likely	Extremely likely
High	Aviation (O)	Power plant (I)	Electrical Utilities (I) Heat exhaustion for training (T) Heat exhaustion for operations (O) Storm damage for infrastructure (I)	Transportation system (I) Evacuation (O) Access (O)
Medium	Structural damage to Railroad bridge (I)	Wastewater treatment (I) Storm damage for operations (O)	Electrical utility cost (I) Infrastructure flooding for operations (O)	Damage to physical infrastructure from flooding (I)
Low	Water quality (I)	CSO discharge (I)		

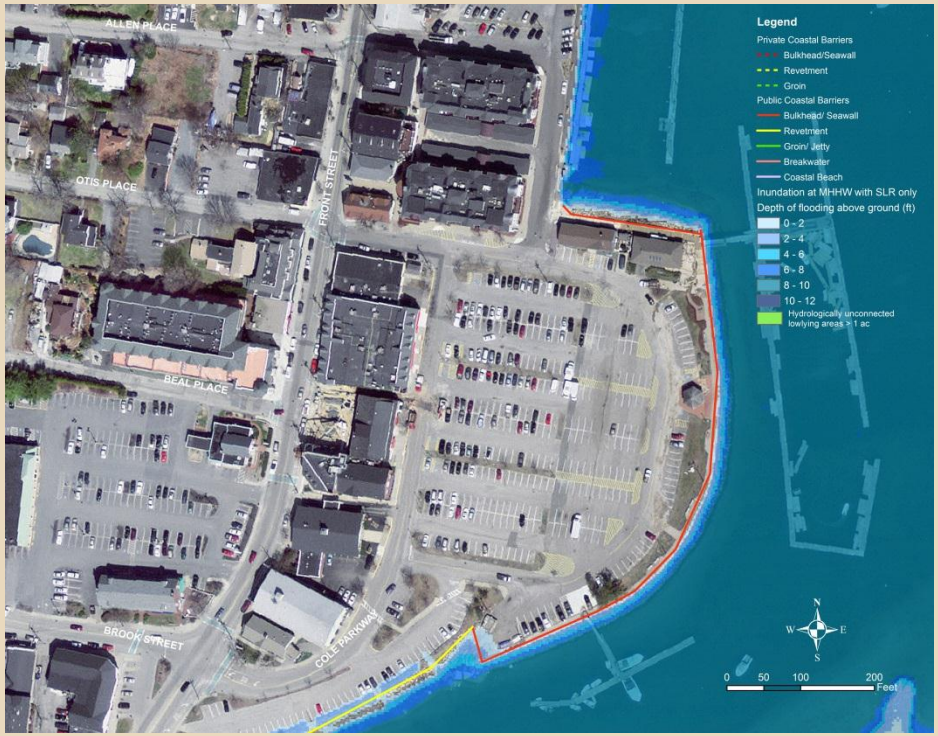
Probability/Likelihood of Occurrence of Consequence →

SLR with Storm Surge in 2020



Storm Surge

Sea Level Rise Only



SLR of 1.08 ft by 2038

Sea Level Rise and Storm Surge

SLR of 1.08 ft by 2038 and
Storm Surge from Category 1 Hurricane

Scituate Harbor

SLR with Storm Surge in 2020

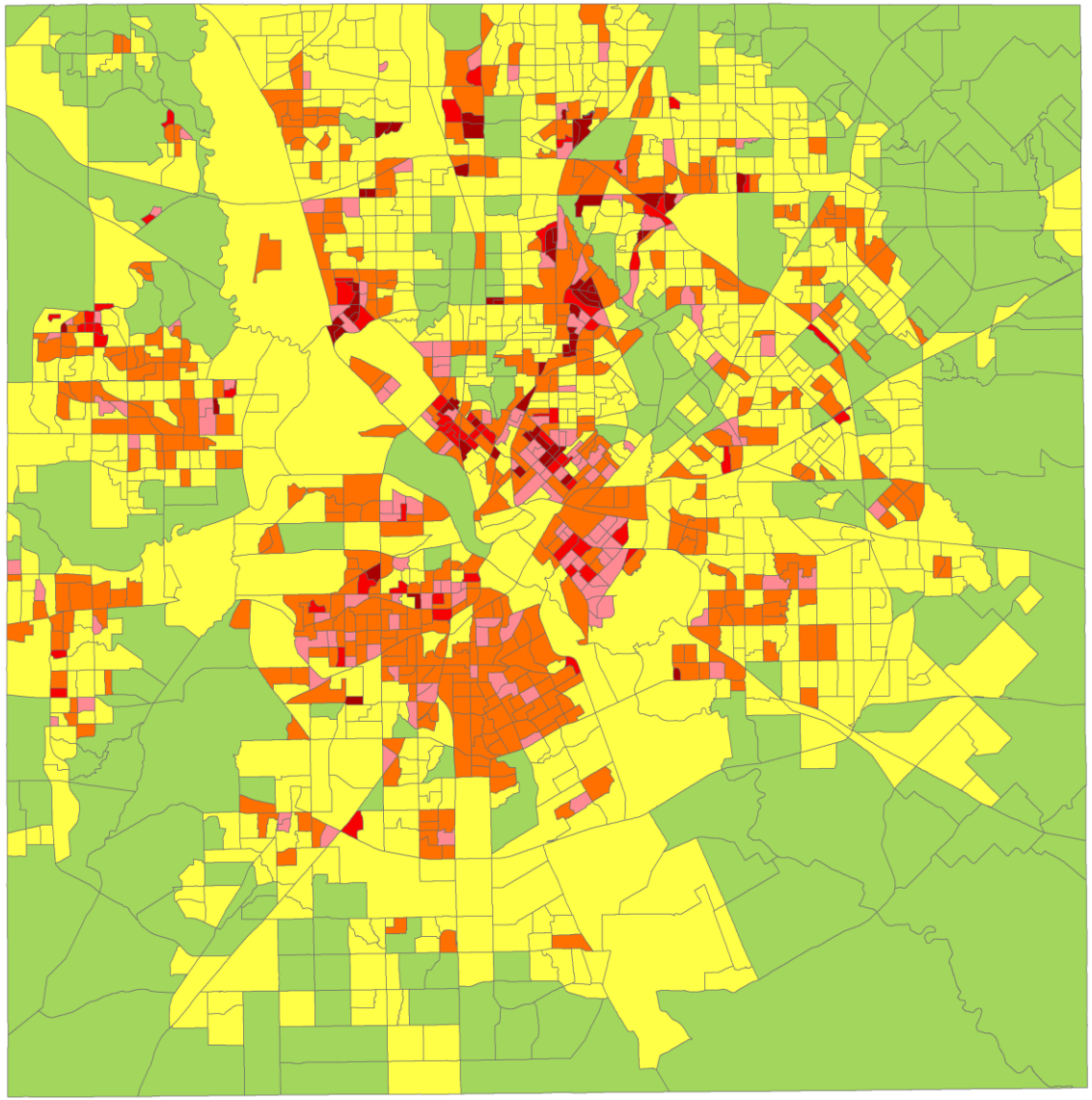
Railroad Bridge across the Canal

Present

2020

SLR with Storm Surge in 2075

Existing Heat Wave Vulnerability



Dallas County Heat Wave Vulnerability

By Census Block Group

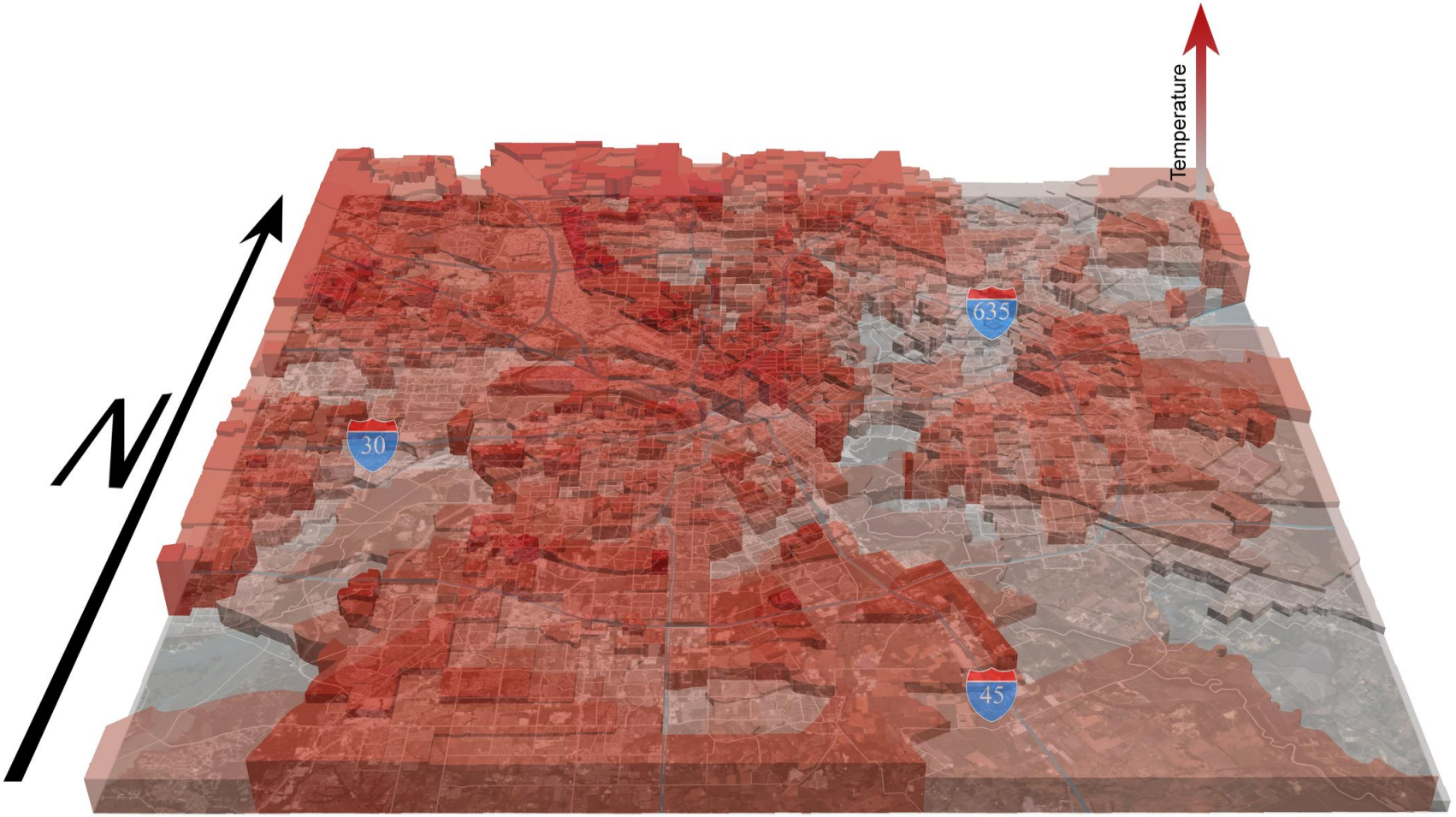
- Low
- Moderately Low
- Moderate
- Moderately High
- High
- > 2 Standard Deviations Above Mean Vulnerability

N

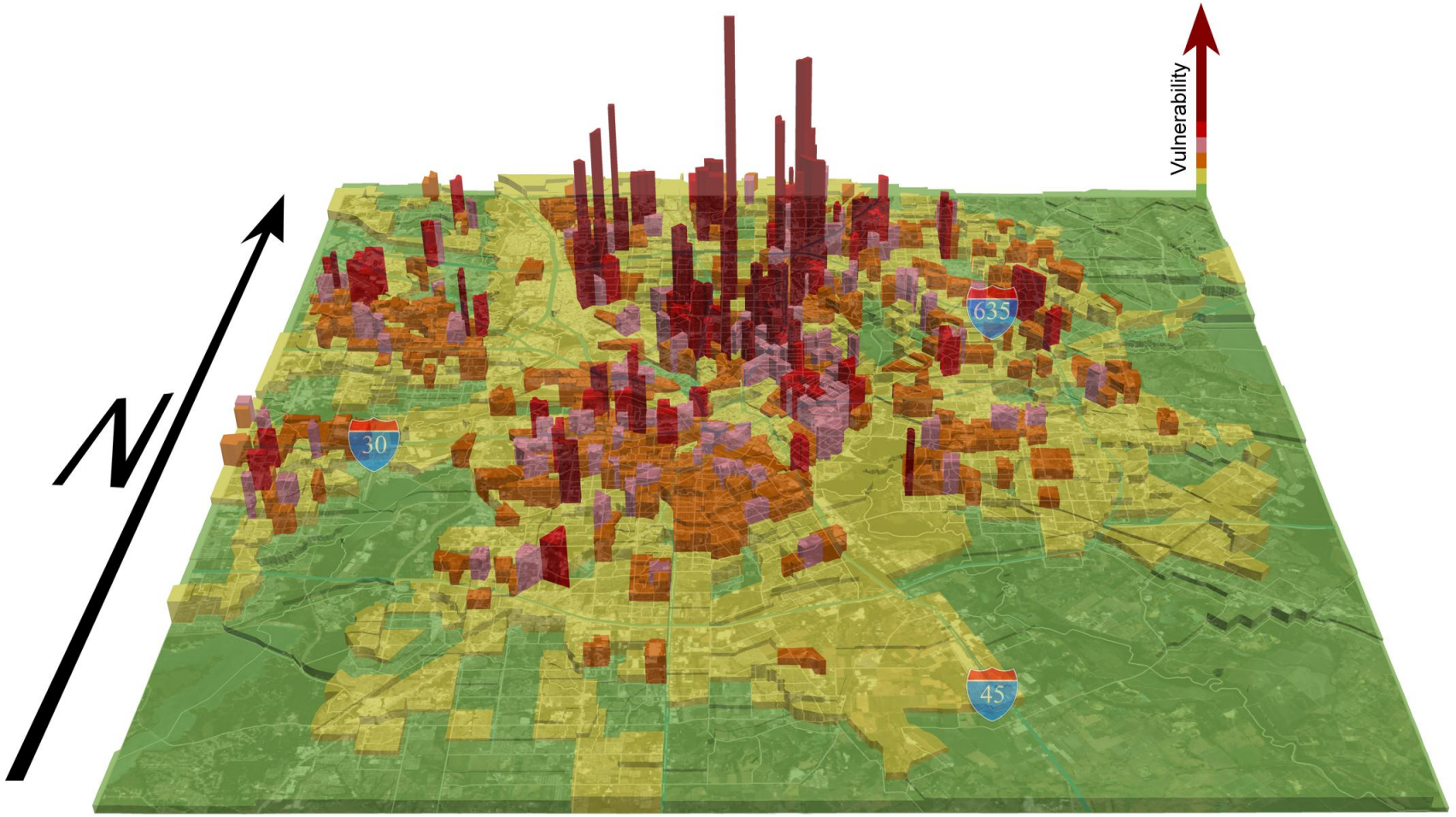
0 2.5 5 10

Miles

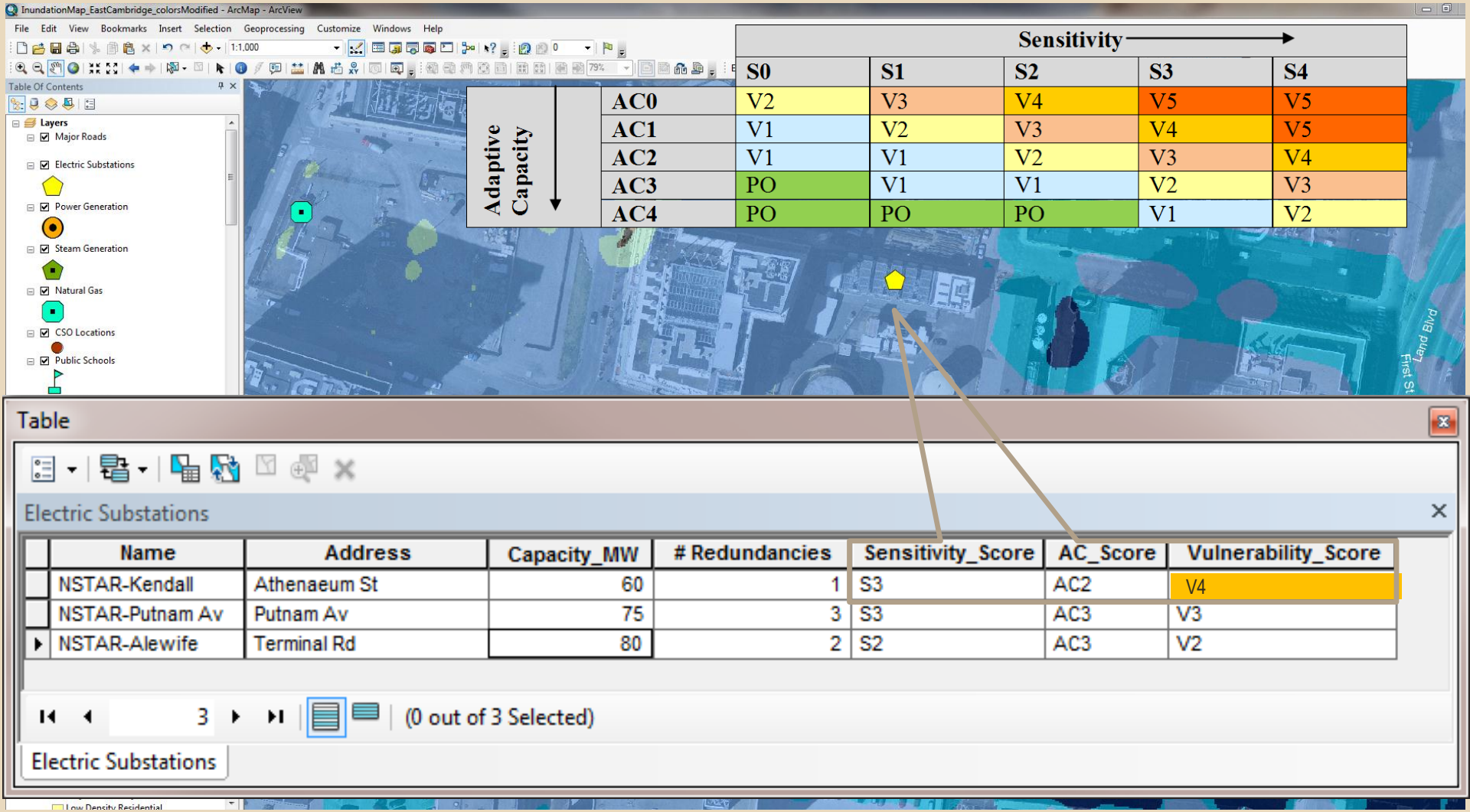
Existing Heat Island



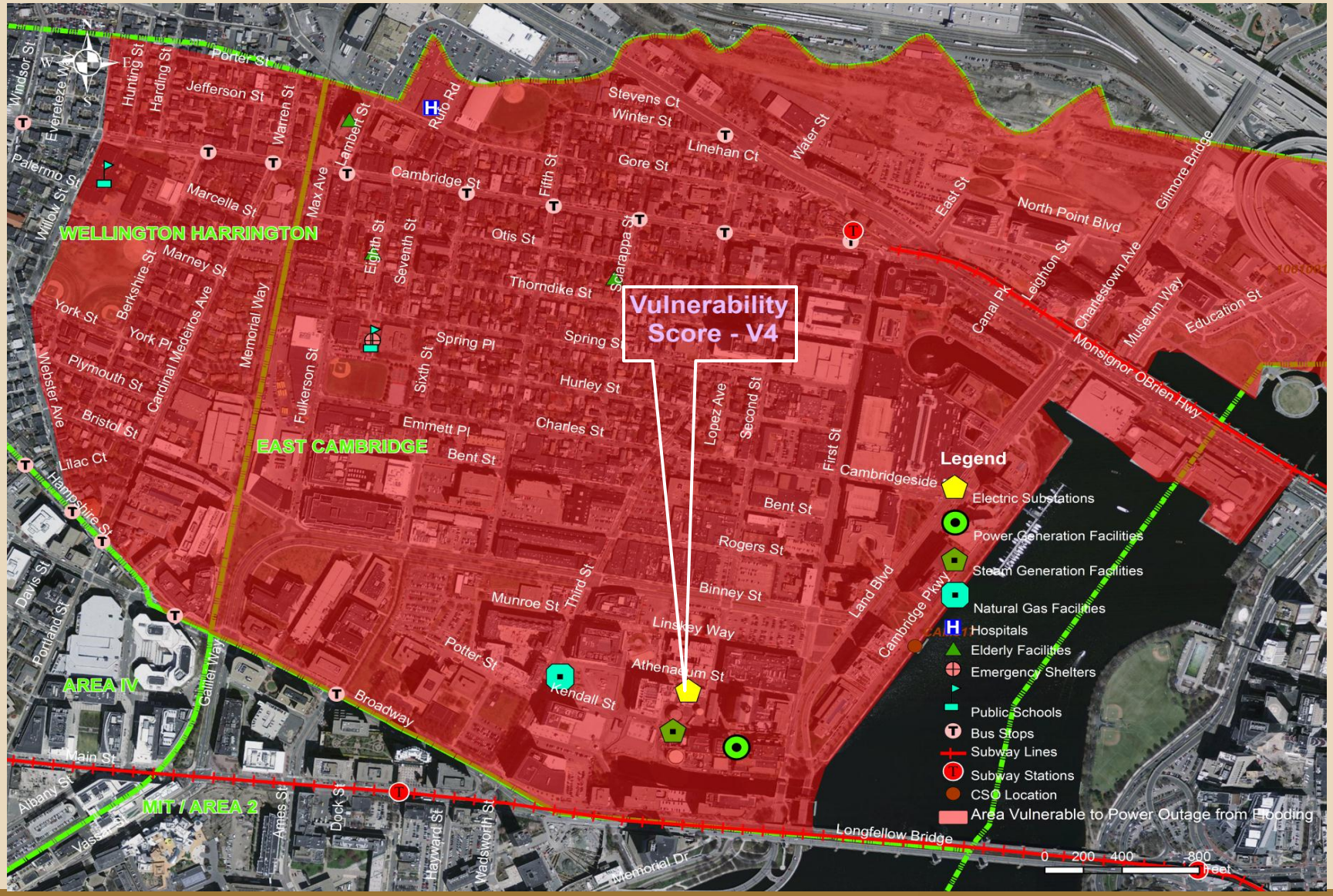
Existing Heat Wave Vulnerability



Linking GIS and Vulnerability



Risk Assessment



Adaptation Strategies

- Protect
- Retreat
- Accommodate

The Rub

- Current design criteria based on past events
- Past is no longer a reliable indicator of present or future conditions

How do you translate uncertainty in climate models into usable design criteria?

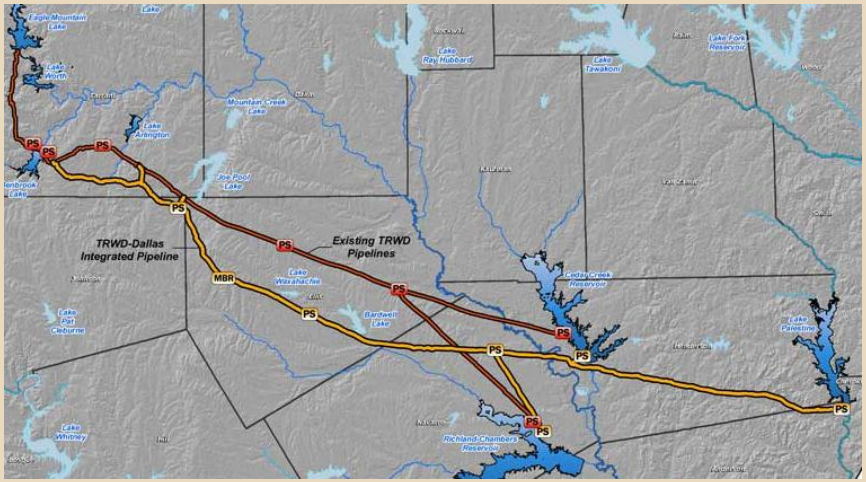
Design Considerations - Transportation

- Pavement design
- Drainage issues – 100 year storm may now be the 10 year storm
- Sizing of culverts/bridge openings
- Evacuation routes (coastal areas)
- Expansive clays
- Fuel flashpoints

Modifying Ventilation Grates

Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaption. FTA 2011

Design Considerations - Water

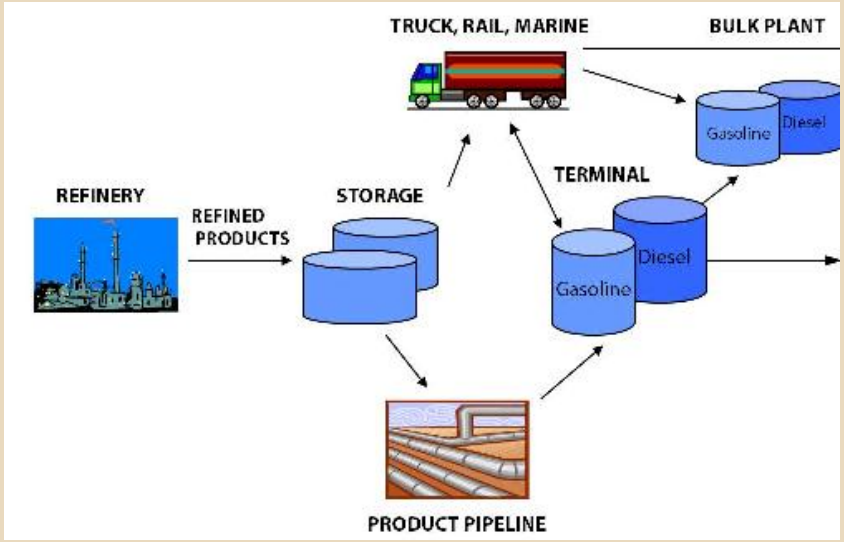


- Connect regional water system
- Develop new groundwater sources
- Consider aquifer storage and recovery
- Increase capacity of reservoirs by raising dam heights

Design Considerations - Wastewater

- Flood control barriers (levee certification)
- Shielding digesters
- Adequately sizing energy demand
- Reuse of treated effluent
- Design equalization basins for climate change considerations
- Alternative piping material

Design Considerations - Energy

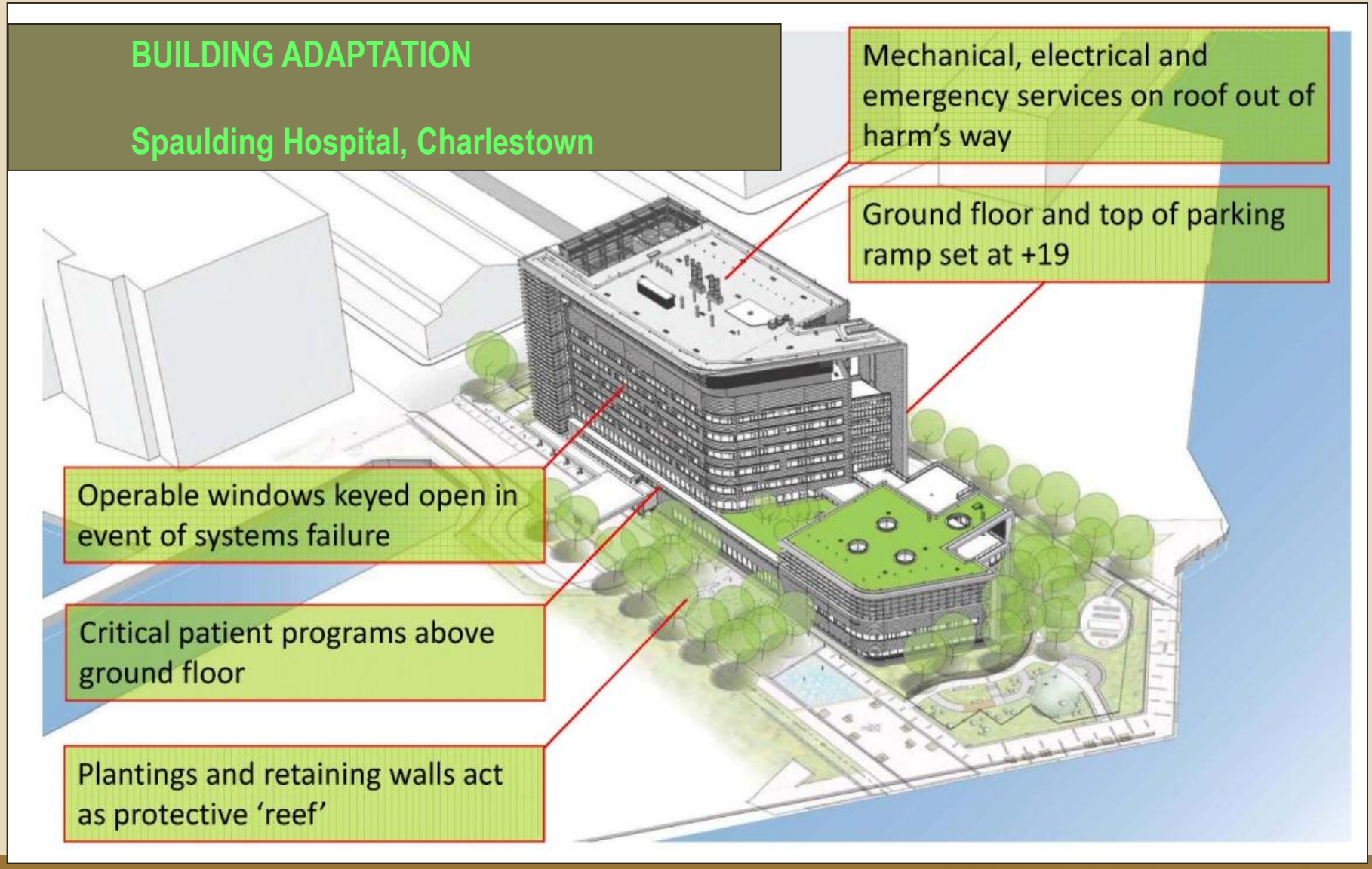


- Understanding competition for water resources and impacts of drought on energy production
- Redundancy in Fuel Distribution system
- Using less weather-sensitive components

Design Considerations - Facilities

BUILDING ADAPTATION

Spaulding Hospital, Charlestown

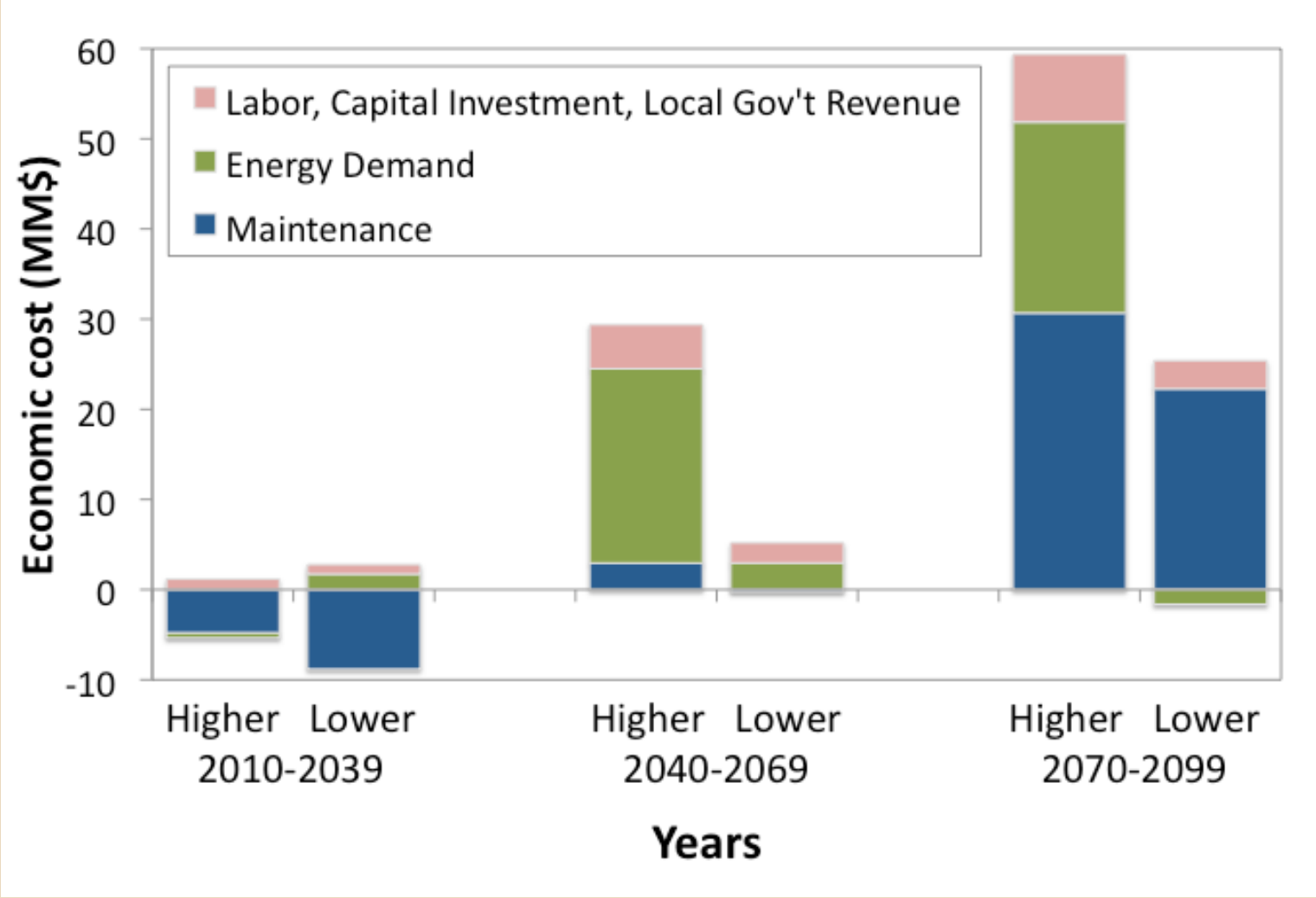


Design Considerations - Facilities

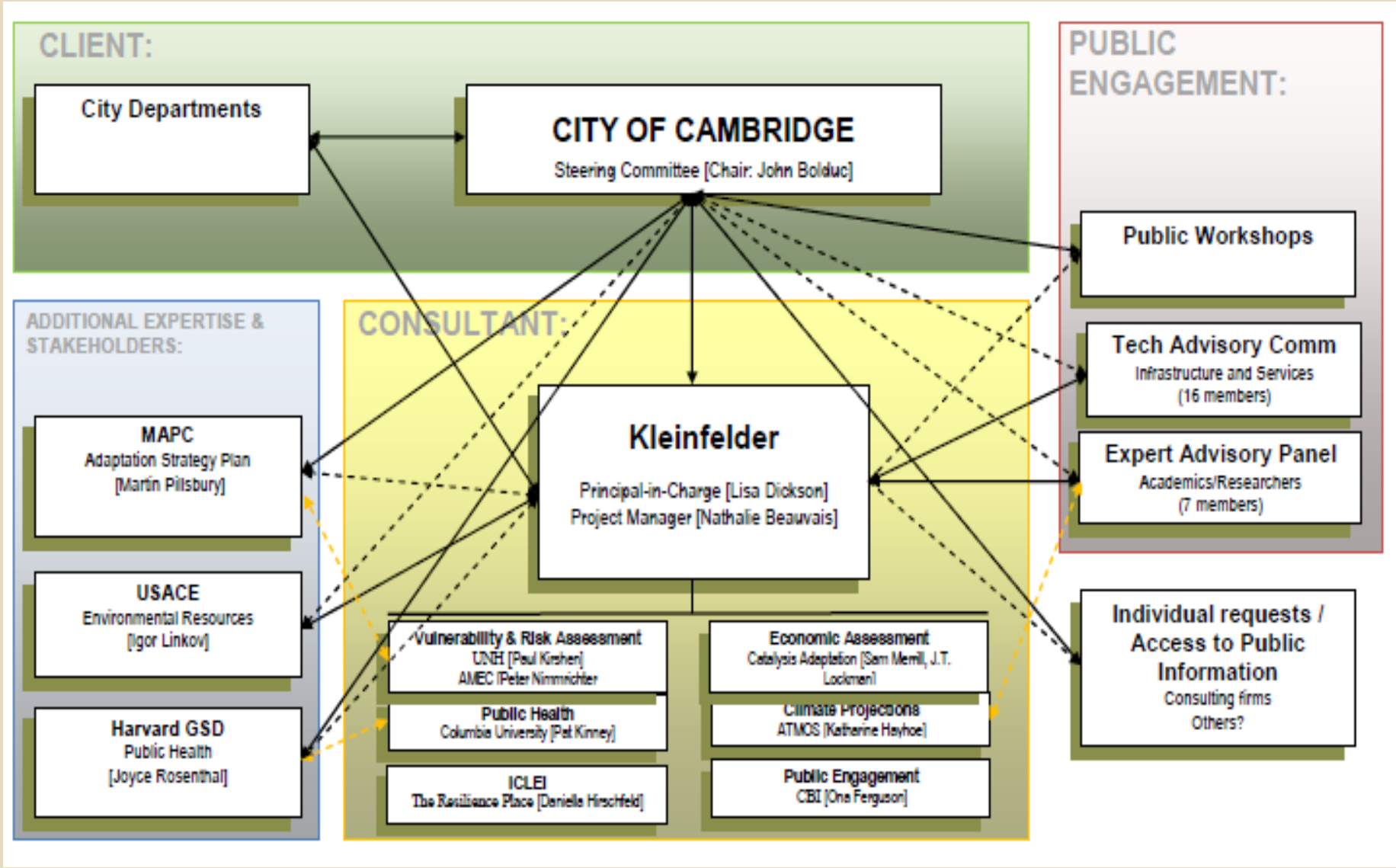
- Green roof minimizes heat retention
- Sun shades on south exposures that minimized solar heat
- Thermal rated low-E tinted windows with argon gas reduce heat
- PV cells provide energy for cooling and heating
- Water management includes
  - bioswales &inlets
  - bio-retention basins
  - undeground infiltration chambers

USACE Middletown JFHQ

Cost of Climate Change to City of Chicago



Stakeholder Engagement



Contact Information

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