

U.S. DOT Climate Adaptation and Mitigation Workshop

# Climate Resilience Planning:

*Baltimore's Combined All Hazards Mitigation and Climate Adaptation Process*



Kristin Baja  
Climate and Resilience Planner  
City of Baltimore, Office of Sustainability

# Overview

- Hazards
- Current Impacts
- Plan Development
- Implementation
- Integration



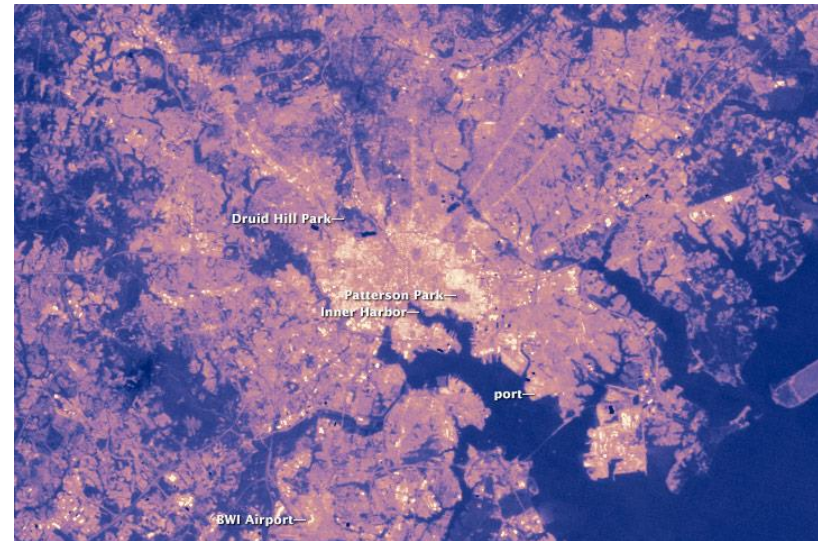
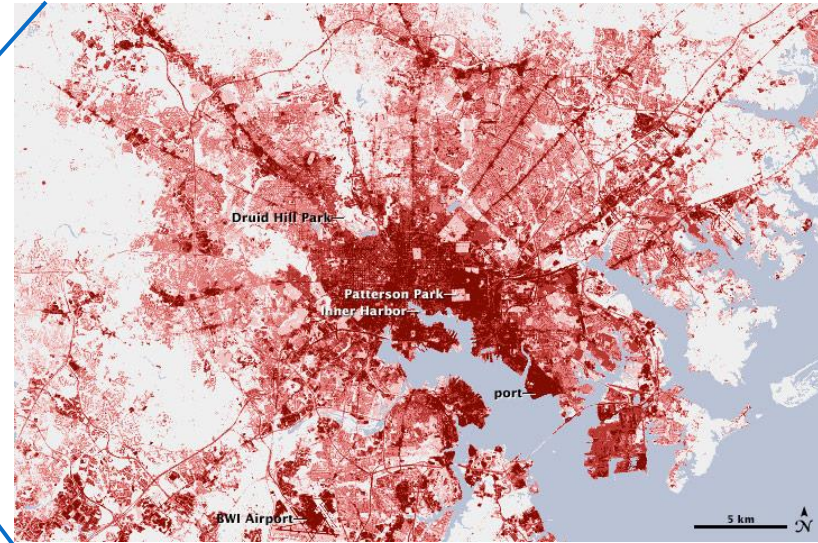
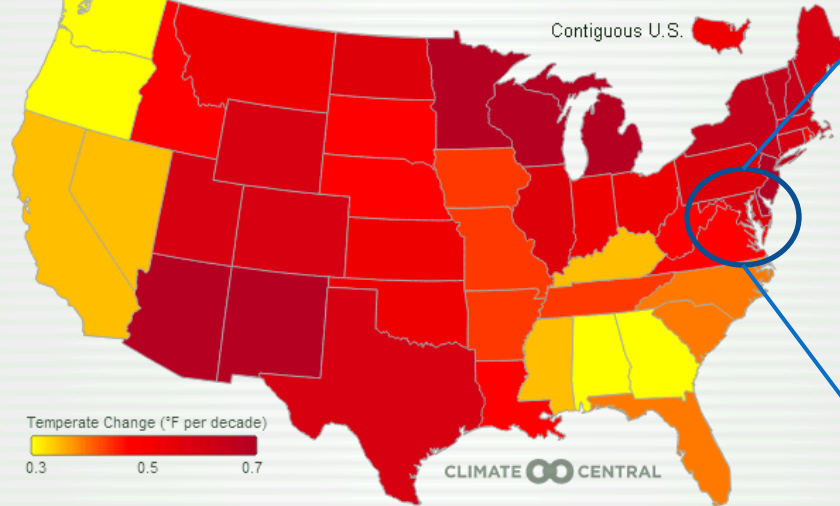
# Hazards



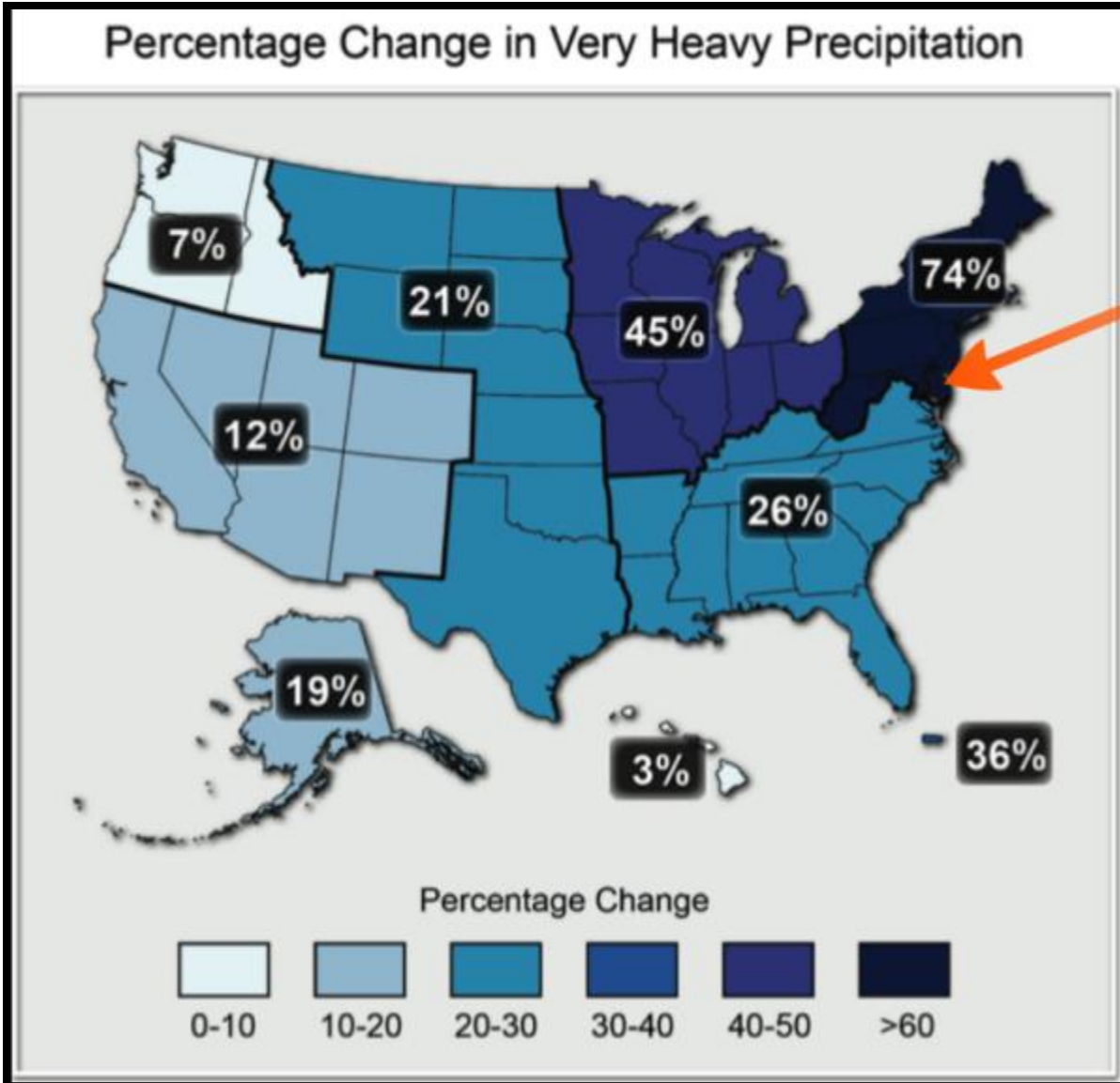
# Extreme Heat

## Some States Warming at Twice Global Rate

Click on a state to see annual temperature increase since 1970



# Precipitation Variability



# Coastal Storms

There has been a substantial increase in hurricane activity in the Atlantic since the 1970's.

Recent Tropical Storms/Hurricanes impacting Baltimore:

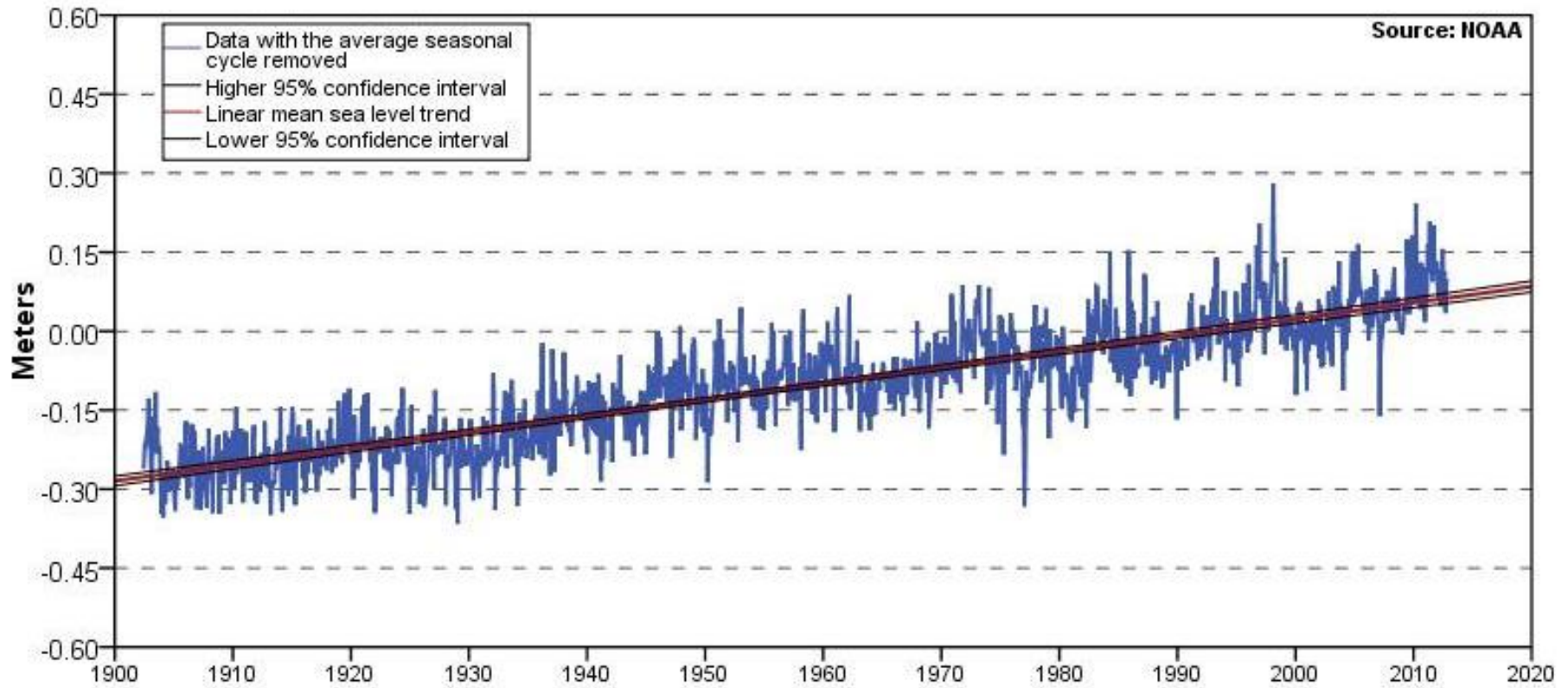
- 2013 Hurricane Sandy
- 2011 Tropical Storm Lee
- 2011 Hurricane Irene
- 2006 Tropical Storm Ernesto
- 2003 Hurricane Isabel



# Sea Level Rise



Baltimore, MD 3.08 +/- 0.15 mm/yr



# Quick Review of Hazards



**Coastal Storms**

**more severe**

**Floods**

**more extensive**

**Severe Thunderstorms**

**more severe**

**Wind**

**increase intensity**

**Winter Storms**

**less snow, more flooding**

**Extreme Heat/Drought**

**more severe and intense**

**Sea Level Rise**

**increased threat**

**Air Quality**

**lower quality and increase risk**



# Recent Impacts



# Roads



Baltimore DOT is responsible for planning, designing, building and maintenance of 2,000 miles of roadways



# Rail and Lightrail



In 2014, due to heavy precipitation, a retaining wall collapsed onto the CSX tracks below

In 1994 the Baltimore's lightrail froze to the tracks



# Bridges



Baltimore City has 298 bridges and culverts



# Port



About 2,800 ships a year enter the port, an average of 7.6 a day. The costs of delivery delays, as well as fuel and fees, mount quickly. Also affected are the tugboats that escort ships to the port, the bay pilots who steer the ships up the Chesapeake Bay, the shipping lines that carry the cargo, the longshoremen who handle the cargo and the terminal operators. Hurricane Isabel (Baltimore Sun, 2003)



# Planning



# Baltimore's Unique Approach



All Hazard Mitigation Plan

(Current and Historical Hazards)

+

Climate Adaptation Plan

(Adapt to new and predicted climate conditions)

= Resilience





## Risk Assessment



### Hazard Identification

- Hazard Identification
- Review Historical Impacts
- Conduct an Asset Inventory

### Vulnerability Assessment

- Determine likelihood
- Determine economic, social, legal & environmental consequence

### Impacts Assessment

- HAZUS Modeling
- Integrate projected climate conditions
- Identify weaknesses

### Plan Development

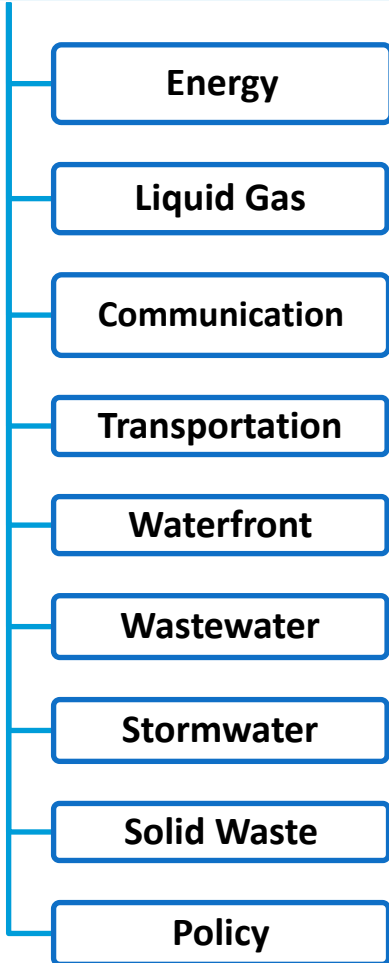
- Vision, Goals, Strategies, Actions
- Prioritization
- Integration
- Plan for implementation & monitoring



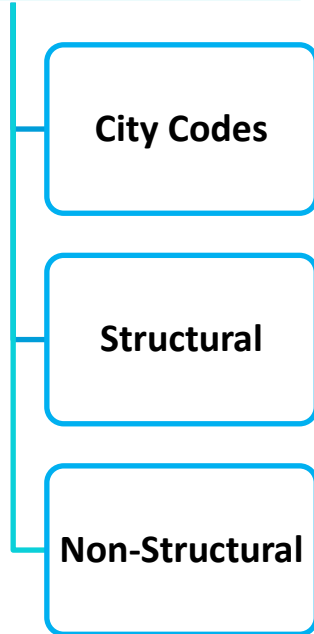
# Structure



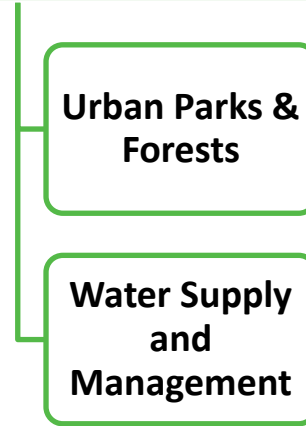
## Infrastructure



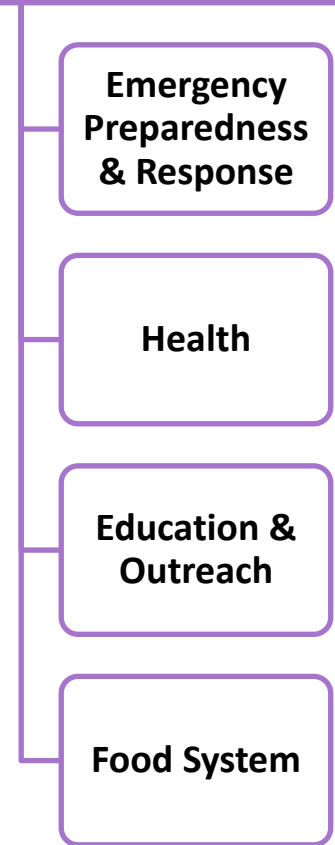
## Buildings



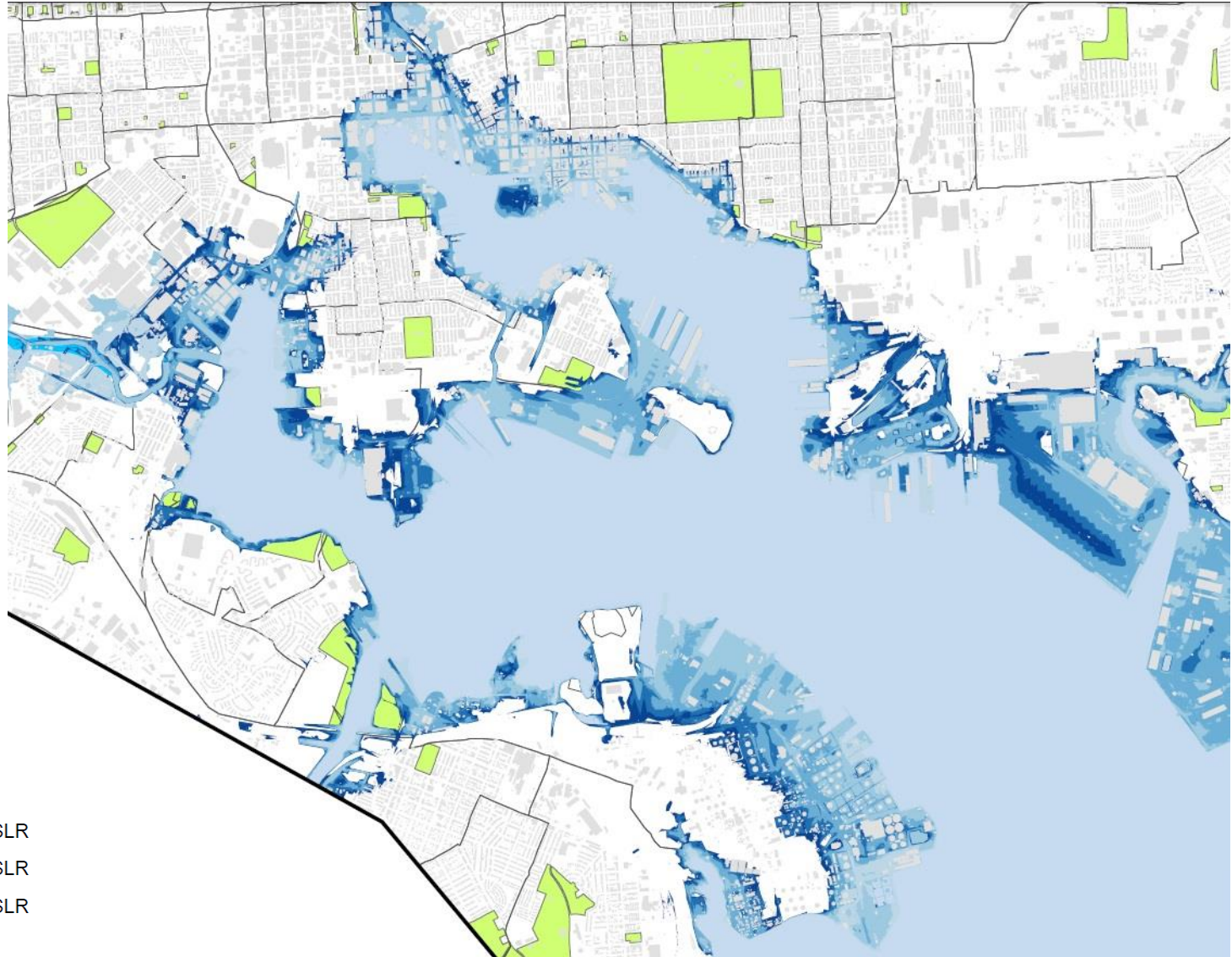
## Natural Systems



## Public Services



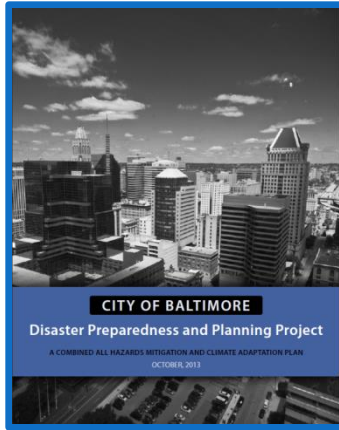
# Modeling



- Building
- Floodway
- 100 Year
- 500 Year
- 500 Year + 3 ft SLR
- 500 Year + 5 ft SLR
- 500 Year + 7 ft SLR
- Census Tracts

# Disaster Preparedness Plan

Adopted unanimously in October, 2013

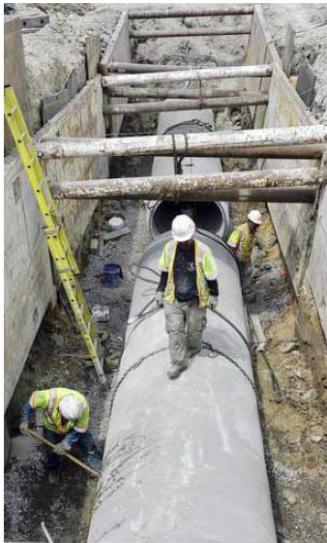


DESIGN AND PLANNING PROJECT

STRATEGIES AND ACTIONS 191

ment that evaluates and improves all pipes' ability to withstand cold

em is dated and in need of upgrades. It is important to build extreme weather resilience and disaster prevention into water and wastewater systems by using both adaptation and mitigation actions. Additionally, structural and infrastructural upgrades must be made to reduce loss of water supply from the distribution system.



Baltimore Water Pipe

Source: BaltimoreSun

1. Replace old and malfunctioning pipes with new pipes or retrofit existing pipes with new lining

Pipes that have already begun experiencing problems, or older pipes which are more vulnerable to the impacts of hazards, should be upgraded using the best available technology.

2. Evaluate and utilize new technology that allows for greater flexibility in pipes as they are replaced

It is essential to prepare for future changes in hazard events and proactively upgrade pipe systems to prevent cracking and bursting.

#### IMPLEMENTATION GUIDELINES

Lead Agency	DPW
Stakeholders	DOT, DPW, Water and Wastewater Utilities
Alignment with Goals	Goal 3
Connection with Existing Efforts	 CAP; CRS; MD DNR; ESF-3; ESF-4
Timeframe	

## STORMWATER

### IN-16 Enhance and expand stormwater infrastructure and systems

Future changes in precipitation frequency and intensity may require reconsideration of the design of existing stormwater infrastructure systems.

Increase resiliency and disaster prevention measures related to stormwater systems by enhancing drainage systems in stream corridors and improving and repairing stormwater conveyance pipes and outfalls.

1. Implement the requirements of Baltimore's MS4 (separate stormwater and sewer system) permit (S)
5. Review and revise storm drain design on a continuous basis, to accommodate projected changes in intense rainfall (O)

The City of Baltimore operates under a Municipal Separate Stormwater and Sewer System (MS4) permit, which protects water-quality and requires that Baltimore prevents pollution as much as possible. It is critical that the requirements of these permits are fully met.

The City's storm drains will require continual revision to incorporate new and projected changes in intense rainfall. This will ensure that the storm drains maintain adequate capacity.

2. Prioritize storm drain upgrades and replacement in areas with reoccurring flooding (S)

While proximity to a floodplain or floodway can increase vulnerability to flooding, certain measures can reduce this vulnerability. Inadequate or older pipes, which cannot accommodate the excessive amounts of stormwater, should be upgraded so as to handle extreme rainfall and storm surge events.

3. Install backflow-prevention devices or other appropriate technology along waterfront to reduce flood risk (M-L)

Backflow-prevention devices are used to ensure that water does not flow back through drainage infrastructure. Through the installation of backflow-prevention devices, the City can improve the performance of the drainage network and prevent risk of flooding impact along the waterfront.

4. Preserve and protect natural drainage corridors (S)

It is important to utilize natural drainage corridors and green infrastructure to capture more stormwater runoff and enhance the ability of the existing infrastructure to cope with environmental changes.

IMPLEMENTATION GUIDELINES	
Lead Agency	DPW
Stakeholders	Community Groups, DOT, DPW, MOEM, MDNR, NGOs, Private Developers, Stormwater Utility
Alignment with Goals	Goals 1, 3, and 6
Connection with Existing Efforts	 CRS; MD DNR
Timeframe	

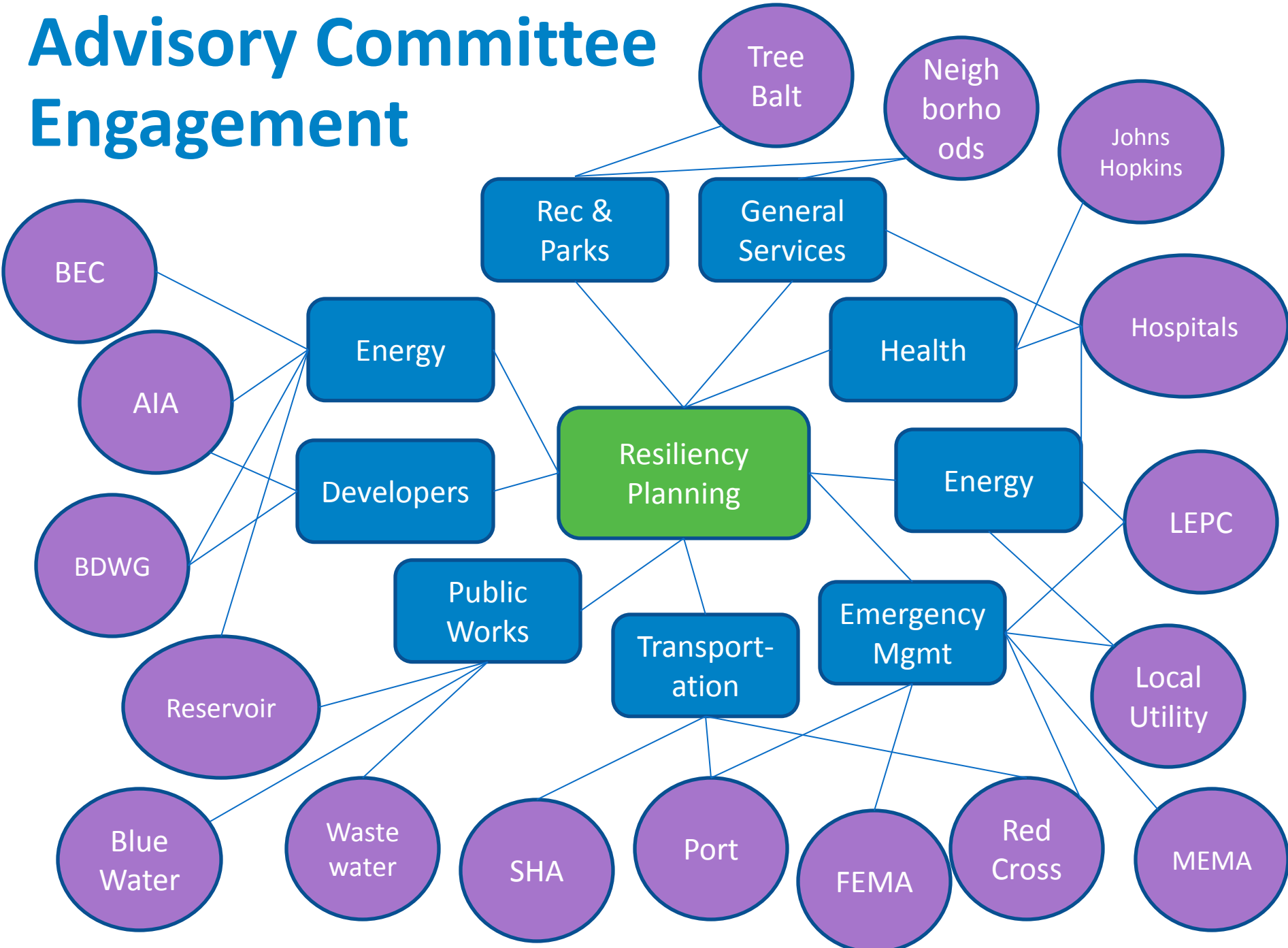


Backflow Preventer

Source: DemarPlumbingNYC



# Advisory Committee Engagement



# Community Engagement



## Small Staff Trainings and Community Meetings



## Large Town Halls and Interactive Community Meetings



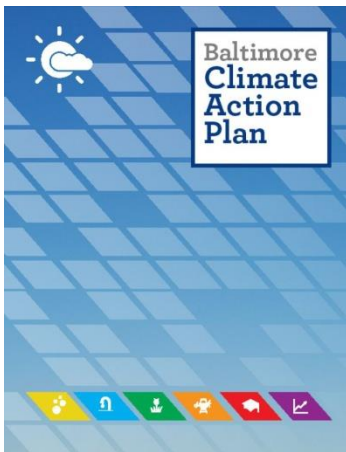


Implementation

# Prioritization



## MITIGATION



Energy Savings and Supply

Land Use and Transportation

Growing a Green City

## RESILIENT + SUSTAINABLE

Drinking water  
Renewable Energy  
Trees  
Building Codes  
Energy Grid  
Energy Efficiency  
Transportation Inf.

## ADAPTATION + HAZARD MITIGATION



Infrastructure

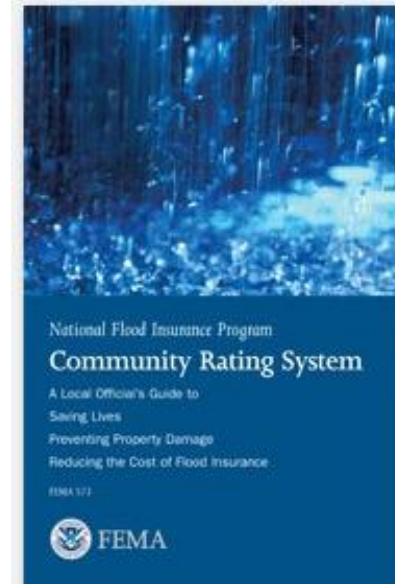
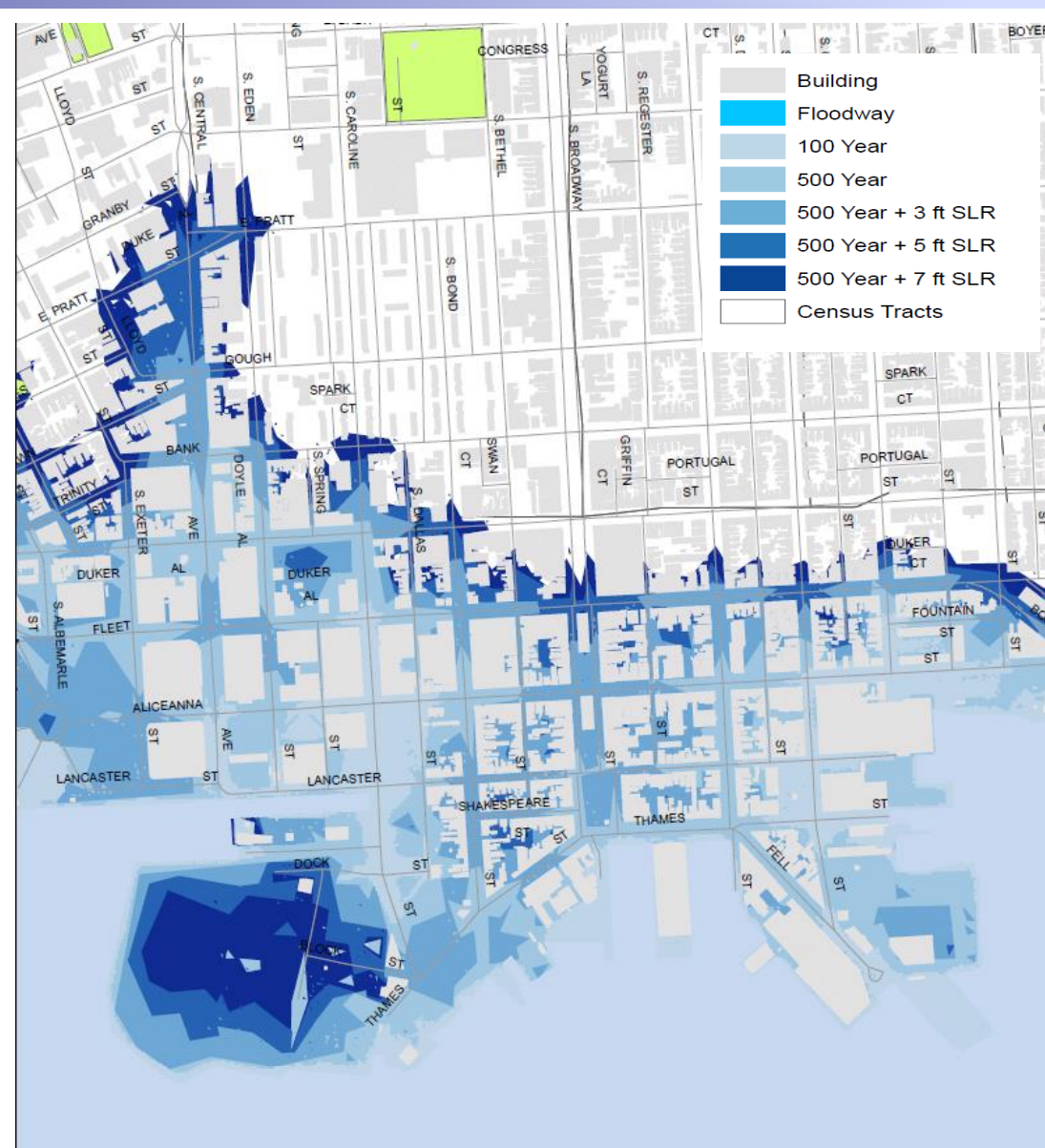
Buildings

Natural Systems

Public Services



# Floodplain



- Two foot freeboard
- Regulate 500-yr
- CRS
- Local, State, and Federal Partners

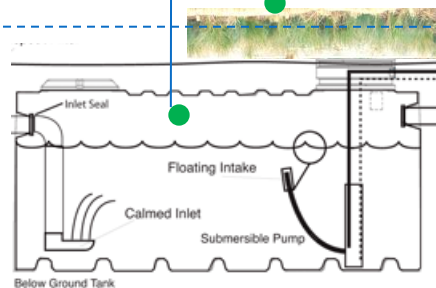
# Whole Block Approach

## Energy

- Cool Roofs
- Weatherization
- Energy Education

## Additional

- Trees and Greening
- Renewable Energy
- Stormwater
- Heat sensors



# Stormwater Management



## Issues:

- High percentage of impervious surface
- Lots of encroachments on stream channels (structures, bridges, railways)
- Inadequate storm sewer drains (wood pipes) and debris



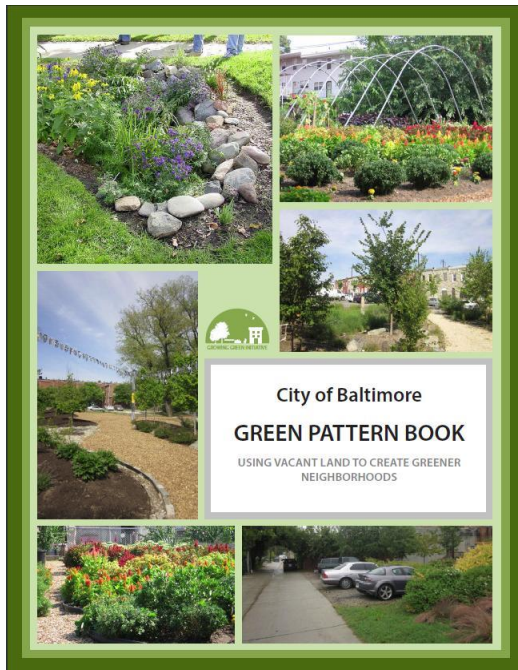
## Implementation:

- Blue alley projects
- Replacing and upgrading pipes
- Stormwater Remediation Fee

# Growing Green



Effort focused on re-using vacant land to green neighborhoods, reduce stormwater runoff, grow food, and create community spaces that mitigate the negative impacts of vacant properties



# Collaboration & Integration



# Federal and State



Floodplain

Community Rating System (CRS)



US Army Corps of Engineers®

Modeling and HAZUS

Engineering Studies

DP3

A more Sustainable and Resilient Baltimore City

Pre-Disaster Mitigation

Floodplain

Modeling

Coastal Adaptation

Community Preparedness



# Regional Collaboration



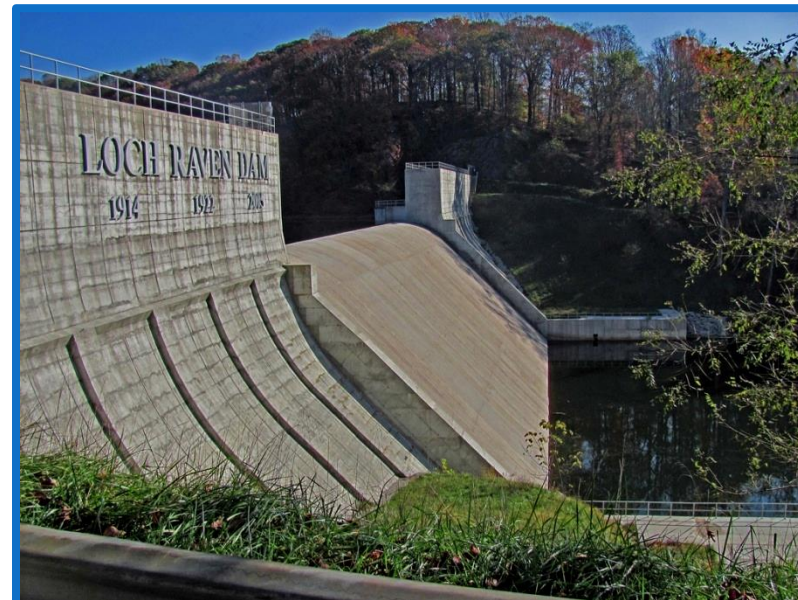
## Surrounding Counties:

- Dams
- Stormwater Management
- Emergency Management
- Critical Facilities
- Energy and Transportation



## Regional Partnerships:

- Other Cities (DC, Philly, NYC)
- Baltimore Wilderness Coalition
- Baltimore Urban Waters Partnership
- USDN Preparedness Group



# Local Partners



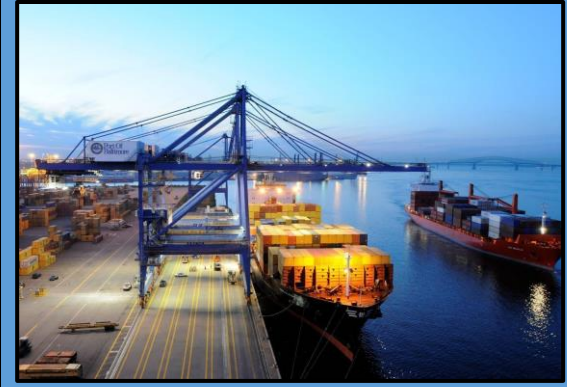
## Non-Profits



## Universities



## Business & Industrial





# Make a Plan, Build a Kit, Help Each Other



# Capital Improvement



- Department of Planning manages process
- Developed a Resiliency Checklist for projects
- Identify how each project will help reduce risk and improve the City's ability to adapt and respond to natural hazards
- Projects must take into account anticipated impacts from climate change
- Include extreme weather events, adaptation, SLR, floodplain considerations, and mitigation



**THANK YOU!**



Kristin Baja  
Climate and Resilience Planner  
[Kristin.baja@baltimorecity.gov](mailto:Kristin.baja@baltimorecity.gov)