Chesapeake Bay Program:
Water-Climate Impacts

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CHESAPEAKE BAY AND WATER RESOURCES POLICY COMMITTEE

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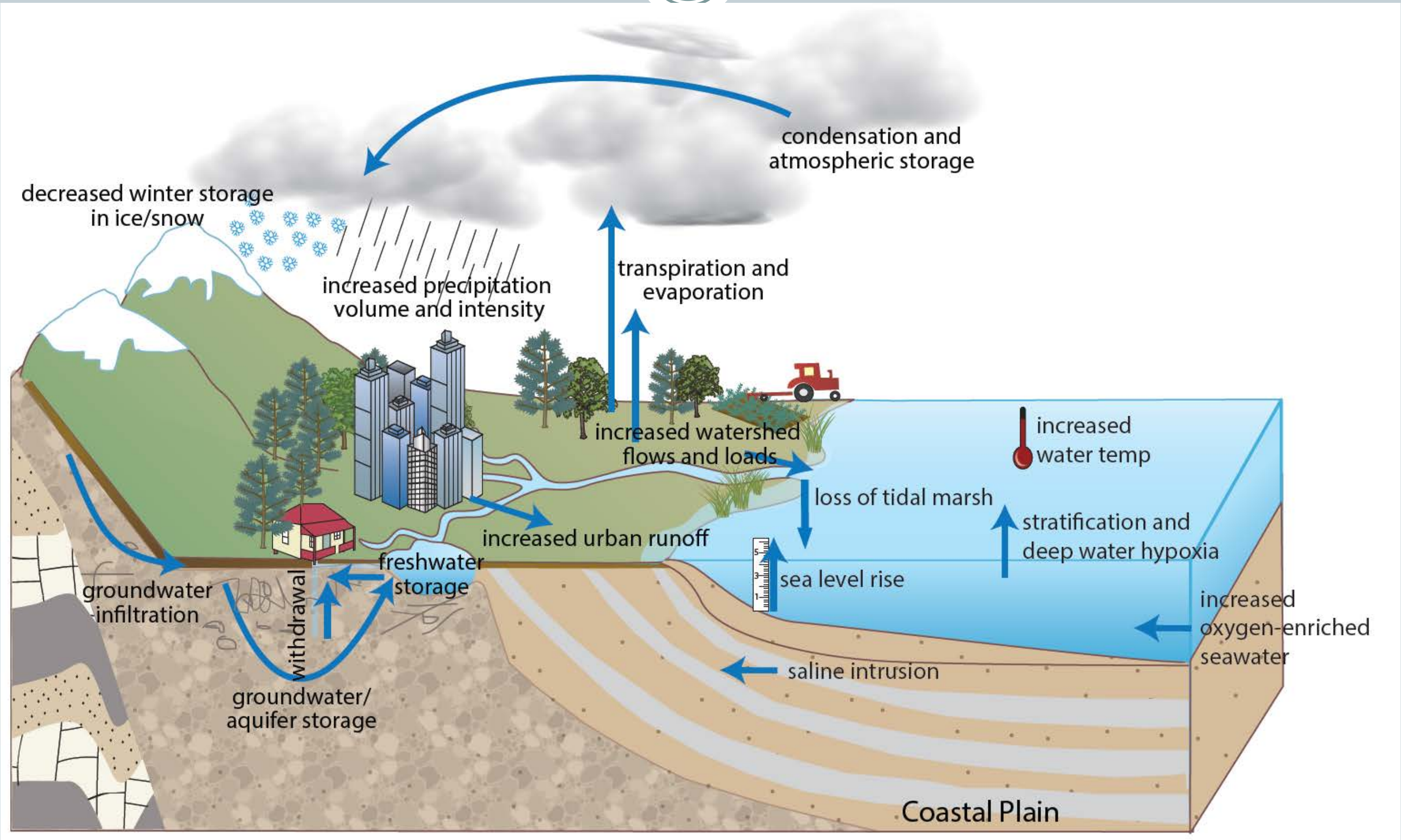
Climate Influence on the CB Watershed



Source: CBP Modified UMCES/ IAN graphic (2011)

2014 Chesapeake Bay Agreement

Climate Resiliency

2014 Chesapeake Bay Agreement

CLIMATE RESILIENCY

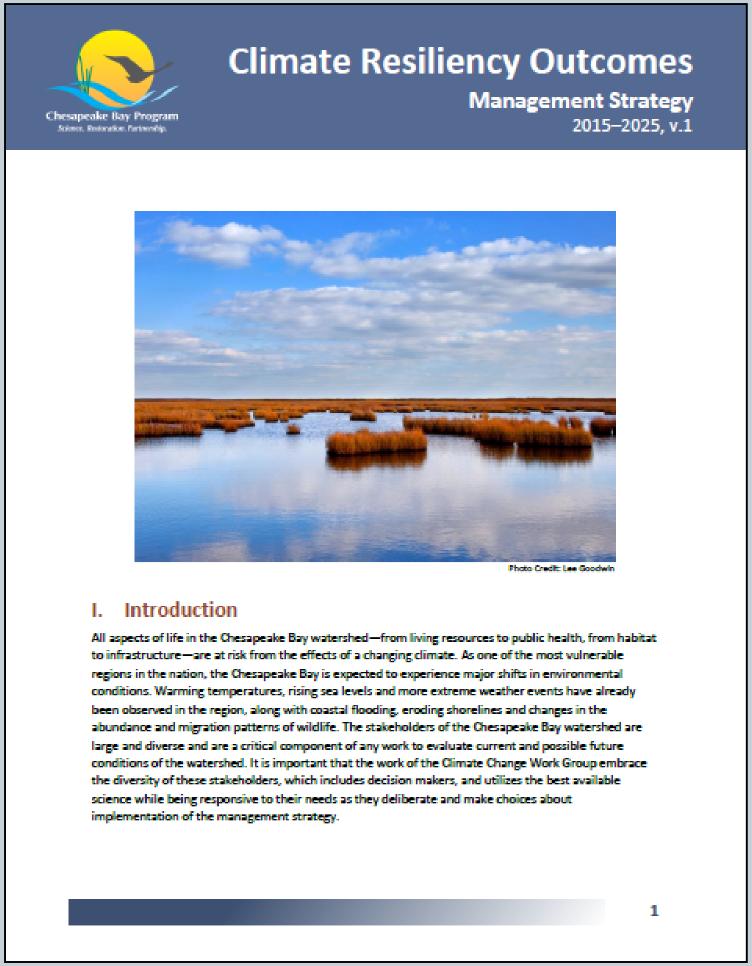
GOAL: Increase the resiliency of the Chesapeake Bay watershed, including its living resources, habitats, public infrastructure and communities, to withstand adverse impacts from changing environmental and climate conditions.

- **Monitoring and Assessment Outcome:** Continually monitor and assess the trends and likely impacts of changing climatic and sea level conditions on the Chesapeake Bay ecosystem, including the effectiveness of restoration and protection policies, programs and projects.

- **Adaptation Outcome:** Continually pursue, design and construct restoration and protection projects to enhance the resiliency of Bay and aquatic ecosystems from the impacts of coastal erosion, coastal flooding, more intense and more frequent storms and sea level rise.

Key Partnership Climate -Related Commitments and Recommendations

- *2010 Chesapeake Bay TMDL*
- *2010 Executive Order 13058: Strategy for Protecting and Restoring the Chesapeake Bay Watershed*
- *2014 Chesapeake Bay Watershed Agreement*



Chesapeake Bay Program
Science. Restoration. Partnership.

Climate Resiliency Outcomes

Management Strategy

2015–2025, v.1

Photo Credit: Lee Goodwin

I. Introduction

All aspects of life in the Chesapeake Bay watershed—from living resources to public health, from habitat to infrastructure—are at risk from the effects of a changing climate. As one of the most vulnerable regions in the nation, the Chesapeake Bay is expected to experience major shifts in environmental conditions. Warming temperatures, rising sea levels and more extreme weather events have already been observed in the region, along with coastal flooding, eroding shorelines and changes in the abundance and migration patterns of wildlife. The stakeholders of the Chesapeake Bay watershed are large and diverse and are a critical component of any work to evaluate current and possible future conditions of the watershed. It is important that the work of the Climate Change Work Group embrace the diversity of these stakeholders, which includes decision makers, and utilizes the best available science while being responsive to their needs as they deliberate and make choices about implementation of the management strategy.

1

Chesapeake Bay TMDL: 2017 Mid-Point Assessment

2010 TMDL

2025 All Practices Implemented

Goal: Determine whether the implementation the CBP Partnership's restoration strategies by 2025 will achieve water quality standards in the Bay.

Objective: Make this determination based on the best available science data, tools, Best Management Practices (BMPs), and lessons-learned.

Commitment: Conduct a more complete analysis of climate effects on nitrogen, phosphorus, and sediment loads and allocations in time for the mid-course assessment of Chesapeake Bay TMDL progress in 2017.

Climate Change & the TMDL Mid-Point Assessment

Assessment Procedures (approved)

Assess how climate change may affect current water quality standards (i.e., nutrient and sediment source loads over time and attainment)

- Precipitation change (increased volume and intensity)
- Temperature increase (air and water)
- Sea level rise (hydrodynamics and impacts to beneficial resources (i.e., wetlands)

Guiding Principles (approved)

- WIP Development
  - Capitalize on Co-Benefits
  - Reduce vulnerability
- WIP Implementation
  - Monitor performance
  - Adaptability

Policy Options (under consideration)

- Quantitative
  - Factor climate change impacts into Phase III WIP Base Conditions
- Qualitative
  - Optimize WIP Development and Adaptively Manage BMP Implementation

Approved
Climate Change Assessment Procedures

- Partition the influence of climate change into separate elements:

Watershed (WSM)

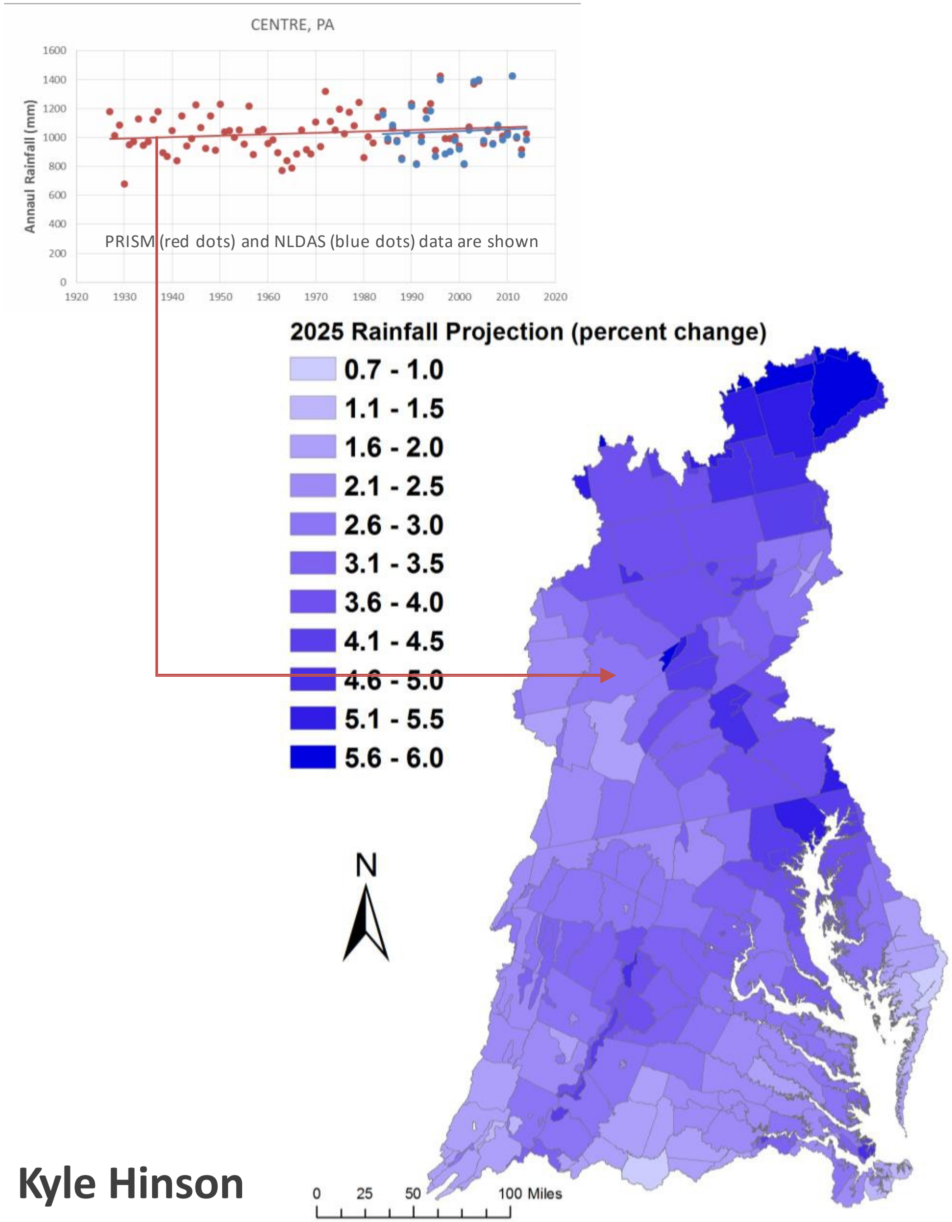
- Increased Precipitation
- Increased temperature
- Increased evapotranspiration
- Storm intensity
- **Modeling Results: Influence on watershed flows and loads**

Estuary (WQSTM)

- Changes in watershed loads
- Increased estuarine temperatures
- Increased sea level rise
- Loss of tidal wetlands
- **Modeling Results: Influence on water quality standards**

- Run climate change scenarios based on estimated 2025 and 2050 conditions
- Run a range of scenarios to bound the range of uncertainty

Rainfall projections using the trends in 88-years of annual PRISM[1] data



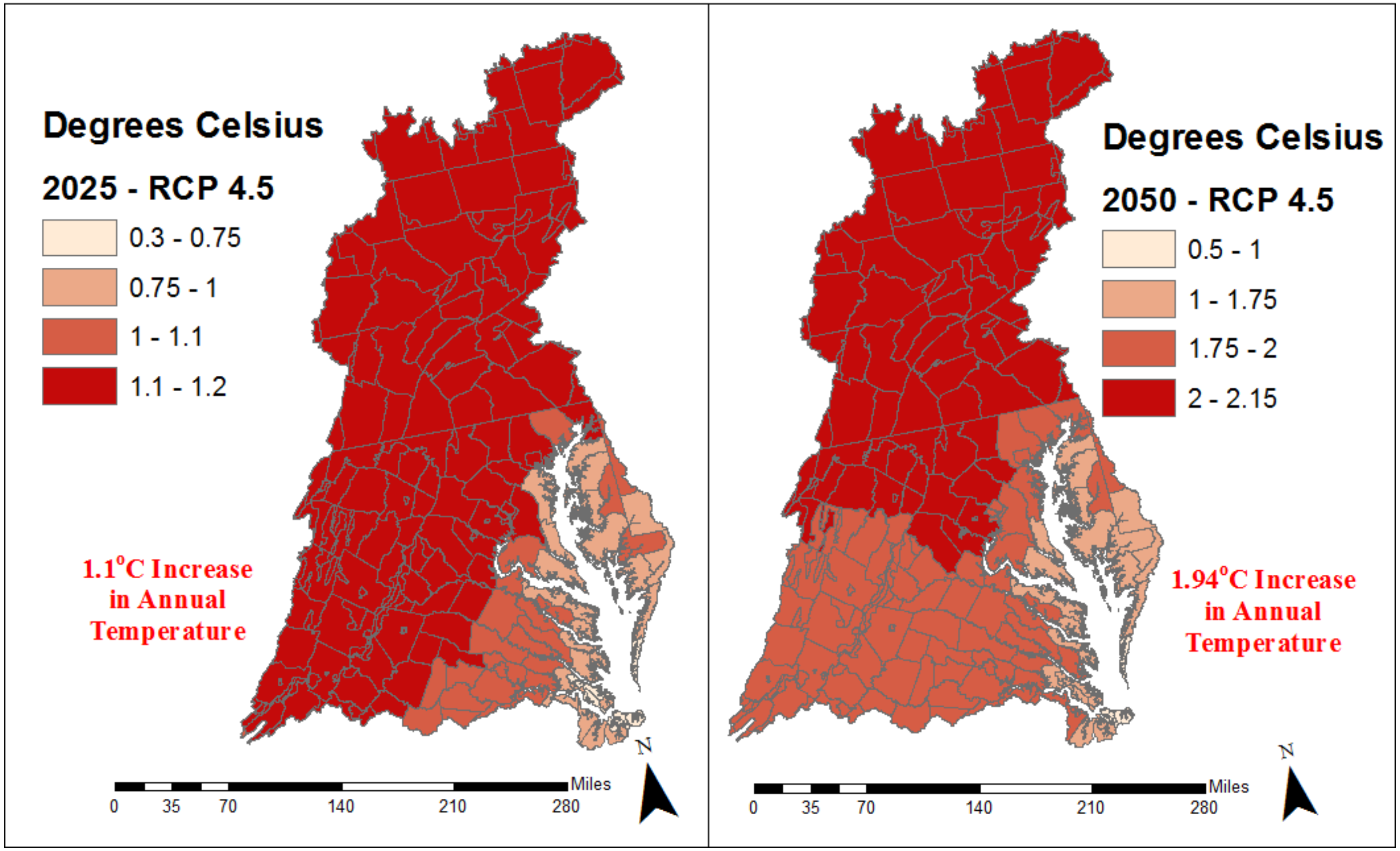
Change in Rainfall Volume 2021-2030 vs. 1991-2000

Major Basins	PRISM Trend
Youghiogheny River	2.1%
Patuxent River Basin	3.3%
Western Shore	4.1%
Rappahannock River Basin	3.2%
York River Basin	2.6%
Eastern Shore	2.5%
James River Basin	2.2%
Potomac River Basin	2.8%
Susquehanna River Basin	3.7%
Chesapeake Bay Watershed	**3.1%**

Kyle Hinson

[1] Parameter-elevation Relationships on Independent Slopes Model

Chesapeake Bay Watershed Annual Change in Temperature



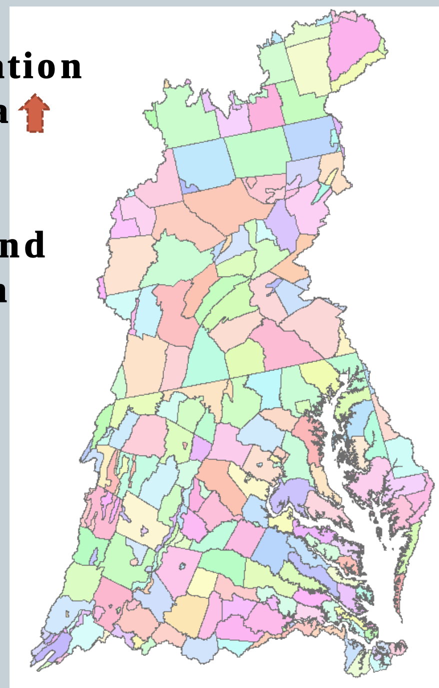
2025 Modeling Climate Inputs

Variable	Input	Modeling Run Completed	Uncertainty Analysis Component
CO_2	427 ppm	Watershed Model	No
Potential Evapotranspiration	Hargreaves-Samani	Watershed Model	Yes
	Hamon	Watershed Model	Yes
Temperature	RCP 2.6 Ensemble Median		Yes
	RCP 4.5 Ensemble Median	Watershed Model, WQSTM	Yes
	RCP 8.5 Ensemble Median		Yes
Precipitation	Historical Trend (+3.1%) with no Δ Intensity	Watershed Model	Yes
	Historical Trend (+3.1%) with Δ Intensity	Watershed Model	Yes
Sea Level Rise	0.17 meters		Yes
	0.3 meters	WQSTM	Yes
Wetland Loss	NWF SLAMM Model Runs (2008)	WQSTM	Yes
	NOAA SLR Viewer (Marsh Migration)		Yes

Preliminary Modeling Results

In the Watershed

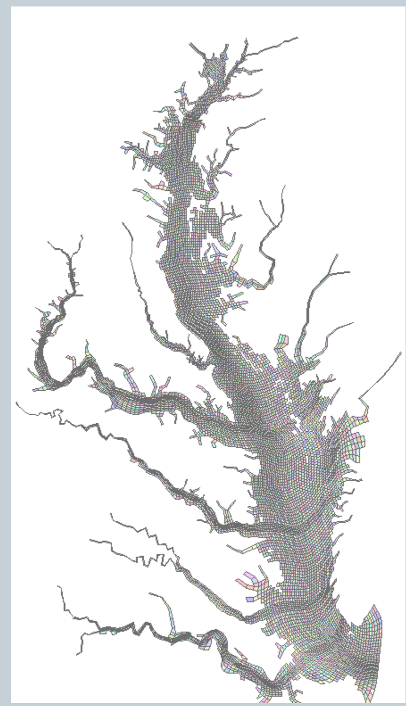
Increased Precipitation Volume = Hypoxia



Increased Precipitation Intensity = Hypoxia

Increase in Temp and Evapotranspiration = Hypoxia

In the Estuary



Increased WS Loads = Hypoxia

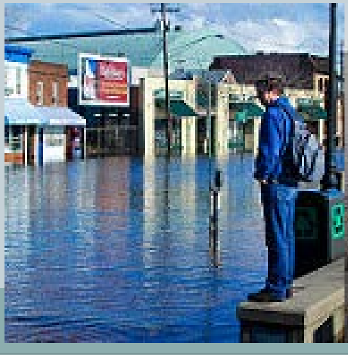
Increased WS Flows = Hypoxia

Increased Temperature = Hypoxia

Sea Level Rise = Hypoxia

So what does this mean?

- Preliminary modeling results suggest that changes in loads (N, P, S) are likely to be minimal; and, that the overall influence of estimated 2025 conditions is likely to have a small influence on water quality standard achievement.
- While expected load changes are small and more mixing due to SLR may offset watershed load increases by 2025, impacts beyond that date (e.g, 2050) are expected to intensify.
- Communities are already observing localized impacts of extreme precipitation events and coastal flooding on the performance of BMPs.
- Therefore, as many BMP's that are planned, or already in place, will remain beyond 2025, there is a need to focus on **<u>local impacts</u>** now.




Policy Options

Quantitative

- *Factor Climate Change into Phase III WIP' Base Conditions*:
  - Use either the 2025 or 2050 climate projection scenarios as base conditions (informed by CBWM climate modeling results) in the establishment of the jurisdictions' Phase III WIPs.
  - The climate change projection would be an added load that the jurisdictions would need to address in addition to their Phase III WIP planning targets, thereby increasing the level of effort.

Policy Option Language approved by PSC

Qualitative

- Optimize Phase III WIP Development and Adaptively Manage BMP Implementation:
  - During the development of Phase III WIPs, jurisdictions will prioritize BMPs that are more resilient to future climate impacts over the intended design life of the proposed practices.
  - During each two-year milestone development period, jurisdictions will consider new information on the performance of BMPs and the programs that support them, including the contribution of seasonal, inter-annual climate variability and weather extremes.
    - Jurisdictions will assess this information and adjust plans to implement their Phase III WIPs to better mitigate anticipated increases in nitrogen, phosphorus or sediment due to climate change.
  - Jurisdictions would provide a narrative consistent with the Guiding Principles that describes their programmatic commitments to address climate change in their Phase III WIPs.

Policy Option Language proposed by CRWG

Guiding Principles
WIP Development

1. ***Capitalize on "Co-Benefits"*** – maximize BMP selection to increase climate or coastal resiliency, soil health, flood attenuation, habitat restoration, carbon sequestration, or socio-economic and quality of life benefits.
2. ***Align with existing climate resiliency plans and strategies*** – align with implementation of existing greenhouse gas reduction strategies; coastal/climate adaptation strategies; hazard mitigation plans; floodplain management programs; fisheries/habitat restoration programs, etc.
3. ***Account for and integrate planning and consideration of existing stressors*** – consider existing stressors such as future increase in the amount of paved or impervious area, future population growth, and land-use change in establishing reduction targets or selection/prioritizing BMPs.
4. ***Manage for risk* and *plan for uncertainty*** – employ iterative risk management and develop robust and flexible implementation plans to achieve and maintain the established water quality standards in changing, often difficult-to-predict conditions.

Guiding Principles

WIP Implementation

6. ***Reduce vulnerability*** - use "Climate-Smart" principles to site and design BMP's to reduce future impact of sea level rise, coastal storms, increased temperature, and extreme events on BMP performance over time. Vulnerability should be evaluated based on the factor of risk (i.e. consequence x probability) in combination with determined levels of risk tolerance, over the intended design-life of the proposed practice.

7. ***Build in flexibility and adaptability*** - allow for adjustments in BMP implementation in order to consider a wider range of potential uncertainties and a richer set of response options (load allocations, BMP selections, BMP redesign). Use existing WIP development, implementation and reporting procedures, as well as monitoring results and local feedback on performance, to guide this process.

Engage Local Agencies and Leaders – work cooperatively with agencies, elected officials, and staff at the local level to provide the best available data on local impacts from climate change and facilitate the modification of existing WIPs to account for these impacts.

What is a “resilient” BMP?

1) **Assess vulnerability** of BMP’s to projected impacts over intended design life
2) **Incorporate** resilient **siting and design principles**
3) **Monitor performance** over-time and adjust implementation, as necessary
4) **Research changes in BMP efficiencies** in response to extreme events or changing conditions.

Resilient BMPs: Good Risk Management

- "Risk management is critical in any restoration project. Risks include those associated with climate patterns, such as more intense storms, as well as those associated with land use change, site selection, and design. Addressing these risks in conjunction with ongoing restoration efforts will prepare communities for greater variability and may result in cost savings and reduced risk. (MD DNR 2013)"

Resilient BMPs: Account for Uncertainty

Resilient BMPs: Capitalize on Co-Benefits

Sector	BMP Name	Climate Adaptation	Flood Control	Energy Efficiency
Urban	Urban Shoreline Management	4.0	1.0	0.5
Urban	Urban Forest Buffers	3.5	3.5	4.0
Urban	Dirt & Gravel Road Erosion & Sediment Control	2.5	1.5	0.0
Urban	Urban Stream Restoration	2.5	3.5	2.5
Urban	Bioretention/raingardens	2.0	3.5	3.0
Urban	Bioswale	2.0	3.5	3.0
Urban	Impervious Surface Reduction	2.0	3.0	1.0
Urban	Urban Grass Buffers	2.0	2.0	1.0
Urban	Urban Growth Reduction	2.0	3.0	1.0
Urban	Urban Tree Planting	2.0	2.0	4.5
Urban	Wet Ponds	2.0	3.0	1.0
Urban	Wetlands	2.0	3.5	1.0
Urban	Abandoned Mine Reclamation	1.0	3.0	3.0
Urban	Advanced Grey Infra.	1.0	0.0	1.0
Urban	Dry Detention Ponds	1.0	2.5	0.0
Urban	Dry Extended Detention Ponds	1.0	2.5	0.0
Urban	Erosion and Sediment Control	1.0	1.5	0.0
Urban	Filter Strip Runoff Reduction	1.0	3.0	0.0
Urban	Filter Strip Stormwater Treatment	1.0	3.0	0.0
Urban	Filtering Practices	1.0	1.0	1.0
Urban	Infiltration Practices	1.0	3.0	1.0
Urban	Vegetated Open Channels	1.0	3.0	1.0
Urban	Nutrient Management Plan	0.0	0.5	0.0

Source: Tetra Tech (2017)

Resilient BMPs: Reduce Vulnerability

Resilient BMPs: Siting & Design Guidance

Design Storm Events

Changes in rainfall volumes have a significant impact on infrastructure.

Design storms are the selected events that engineers use to design drainage infrastructure, bridges, culverts, etc.

Input from DC Water, DDOT and DDOE's Stormwater Management Division informed the selection of events that are used as standards for stormwater, wastewater, and transportation infrastructure.

The chart shows how rainfall volumes are projected to increase across the relevant design storm events, especially for the more extreme (100 and 200 year) events.

Design Storm	Baseline 1981-2000	2020s	2050s	2080s
1-yr 24 hr. storm (in)	1.6	1.7 (1.5 - 1.8)	1.7 (1.5 - 1.8)	2 (±<1)
2-yr 24 hr. storm (in)	3.2	3.4 (3.2 - 3.7)	3.7 (3.5 - 3.9)	4 (4 - 5)
15-yr 24 hr. storm (in)	5.5	6.8 (6.0 - 7.3)	7.1 (6.7 - 7.6)	8 (4 - 9)
25-yr 24 hr. storm (in)	6.3	7.9 (6.8 - 8.6)	8 (7.5 - 8.8)	10 (8 - 12)
100-yr 24 hr. storm (in)	8.1	10.5 (8.9 - 12.4)	10.3 (9.0 - 11.9)	14 (10 - 16)
200-yr 24 hr. storm (in)	9	12 (10.1 - 14.7)	11.7 (9.8 - 13.6)	16 (11 - 19)
2-yr 6 hr. storm (in)	2.3	2.4 (±<0.1)	2.6 (2.6 - 2.7	3 (±<1)
15-yr 6 hr. storm (in)	3.6	4.6 (4.3 - 4.8)	4.7 (4.6 - 4.8)	5 (4 - 6)
100-yr 6 hr. storm (in)	5.1	6.7 (6.5 - 6.8)	6.5 (6.4 - 6.7)	9 (7 - 10)
200-yr 6 hr. storm (in)	5.6	7.5 (7.2 - 7.7)	7.2 (±<0.1)	10 (8 - 11)
80th Percentile storm (in)	0.8	0.9 (0.1)	0.9 (0.1)	0.95 (0.1-0.15)
90th Percentile storm (in)	1.14	1.24 (0.1)	1.24 – 1.34 (0.1-0.2)	1.24 – 1.39 (0.1-0.25)
95th Percentile storm (in)	1.5	1.6 – 1.65 (0.1-0.15)	1.6 – 1.75 (0.1-0.25)	1.75 – 1.85 (0.15-0.35)

Source: DDOE (2016)

STAC Workshop (Fall 2017): Monitoring and Assessing Impacts of Changes in Weather Patterns and Extreme Events on BMP Siting & Design

- What are the general principles of BMP siting and design to reduce the vulnerability of urban, agriculture, and coastal BMP's to future impacts of sea level rise, coastal storms, increased temperature, and extreme events?
- How flexible or adaptable are BMPs to anticipated changes in weather patterns and extreme events and what types of adjustments (e.g., retrofits) in BMP design to maintain structural integrity?
- What <u>suite of BMPs</u> are most robust (e.g., mitigate the anticipated increased nitrogen, phosphorus, and sediment loads) to anticipated changes in weather patterns and extreme events?
- What are the remaining gaps and highest priority needs (i.e., research, monitoring measures, programmatic efforts) to address in order to better inform and improve BMP development and implementation?

PSC Decision-Making Timeline

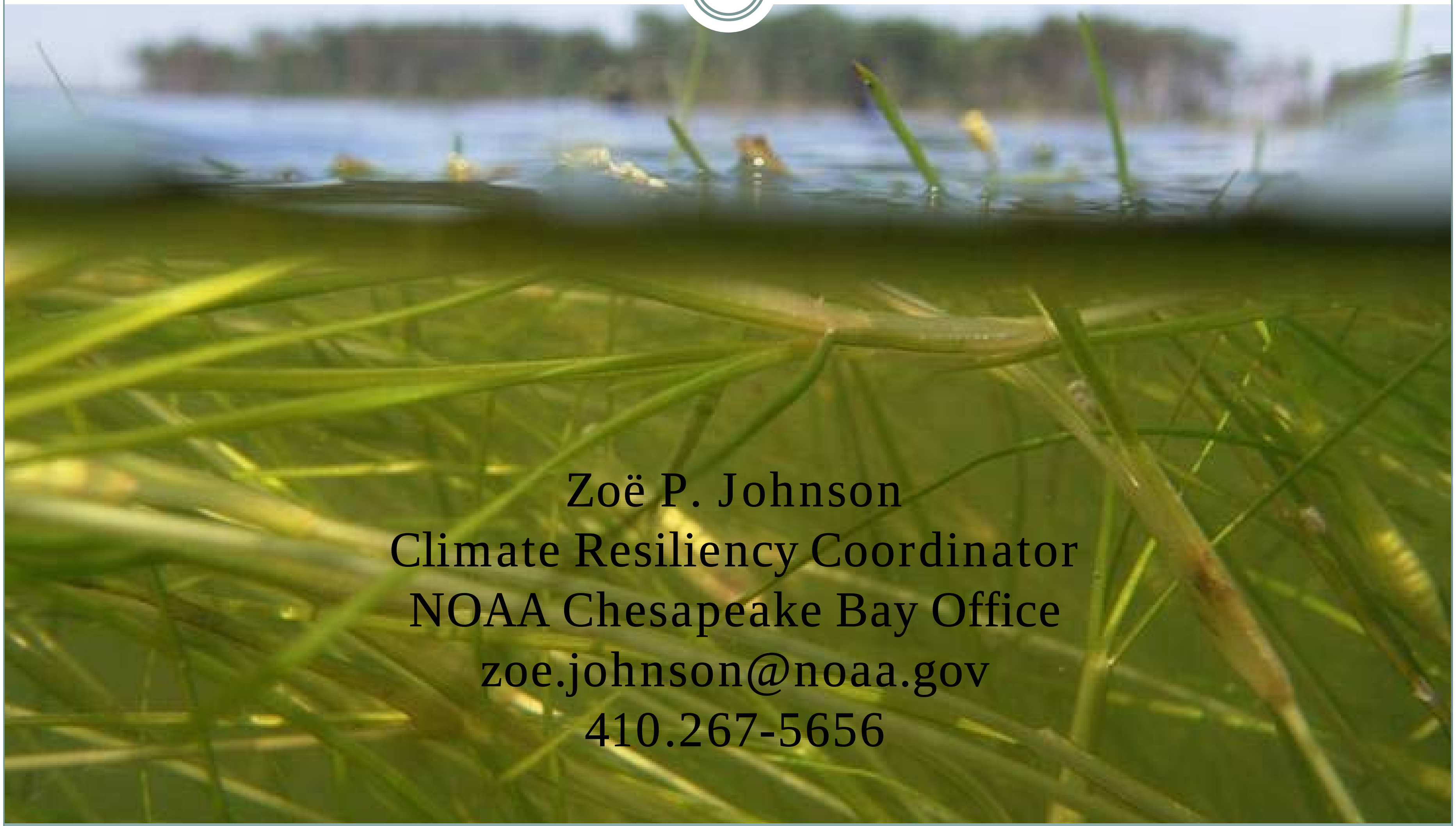
- **December 13, 2016**: Agreement on 1) climate change assessment procedures, 2) guiding principles, and 3) the range of options for how and when to factor climate change considerations into the jurisdictions' Phase III WIPs
- **Late October 2017**: How and when to incorporate climate change considerations into the Phase III WIPs
- **March 2018**: Final Phase III WIP planning targets fully reflecting Partnership decisions regarding how and when to incorporate climate change considerations

Chesapeake Bay And Water Resources Policy Committee

Areas for Future Engagement

- Engage in the policy dialog related to integrating climate change into the Mid-Point Assessment, Phase III WIPS, and beyond.
- Identify "Technical Assistance" needs (data, tools, resources and other information needs).
- Identify project(s) to showcase resilient BMP practices or which could serve as future demonstration sites (siting and design practices, implementation of monitoring protocols).

Questions?



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