

# *STAC Workshop*

***MONITORING AND ASSESSING IMPACTS OF CHANGES  
IN WEATHER PATTERNS AND EXTREME EVENTS ON  
BMP SITING AND DESIGN***



*September 7-8, 2017*  
*Crown Plaza Hotel, Annapolis, MD*



**Chesapeake Bay Program**  
*Science. Restoration. Partnership.*

# Session I: Introduction



## **PURPOSE OF WORKSHOP –**

MARK BENNETT, USGS; ZOE JOHNSON, NOAA

**STATE OF THE SCIENCE: IMPACTS ON THE  
CHESAPEAKE BAY – RAY NAJJAR, PENN STATE**

**BMP PERFORMANCE: LITERATURE REVIEW –  
JON BUTCHER, TETRA TECH**

# 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*

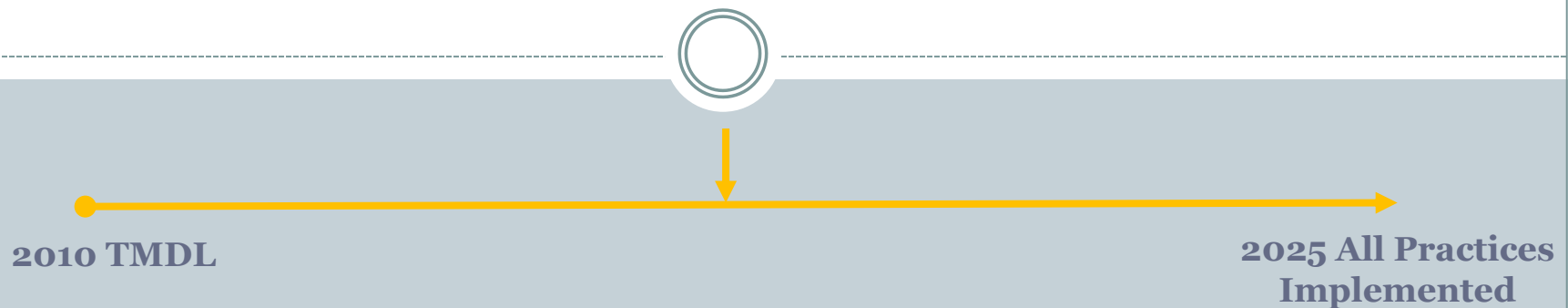
**Climate Resiliency Outcomes Management Strategy 2015–2025, v.1**

**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.

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# Chesapeake Bay TMDL: 2017 Mid-Point Assessment



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

# 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.
8. ***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.

# Qualitative Policy Option



## Optimize Phase III WIP Development and Adaptively Manage BMP Implementation

- *Element A:* During the development of Phase III WIPs, jurisdictions will consider and prioritize BMPs that are more resilient to future climate impacts over the intended design life of the proposed practices.
- *Element B:* Within a practical time-period applicable to an individual source sector, initiative or action, the Partnership will consider new information on the performance of BMPs, including the contribution of seasonal, inter-annual climate variability, and weather extremes. Jurisdictions will assess this information and their support programs and adjust plans through the two-year milestone process to implement their Phase III WIPs to better mitigate anticipated increases in nitrogen, phosphorus, or sediment due to climate change.
- *Element C:* Jurisdictions will provide a narrative consistent with the Guiding Principles that describes their programmatic commitments to address climate change in their Phase III WIPs.

# 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



Management Practice	Nutrient Benefit	Resilience Benefit				
		Temperature Reduction	Storm Buffer	Drought Buffer	Sea Level Rise Buffer	Wildlife Corridor
Wastewater Treatment Plant	✓			✓		
Stream Restoration	✓					✓
Forest Buffer	✓	✓	✓			✓
Wetlands	✓		✓	✓	✓	✓
Infiltration	✓		✓	✓		
Shoreline Erosion Control	✓		✓		✓	
Vegetated Open Channel	✓		✓			

# 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.

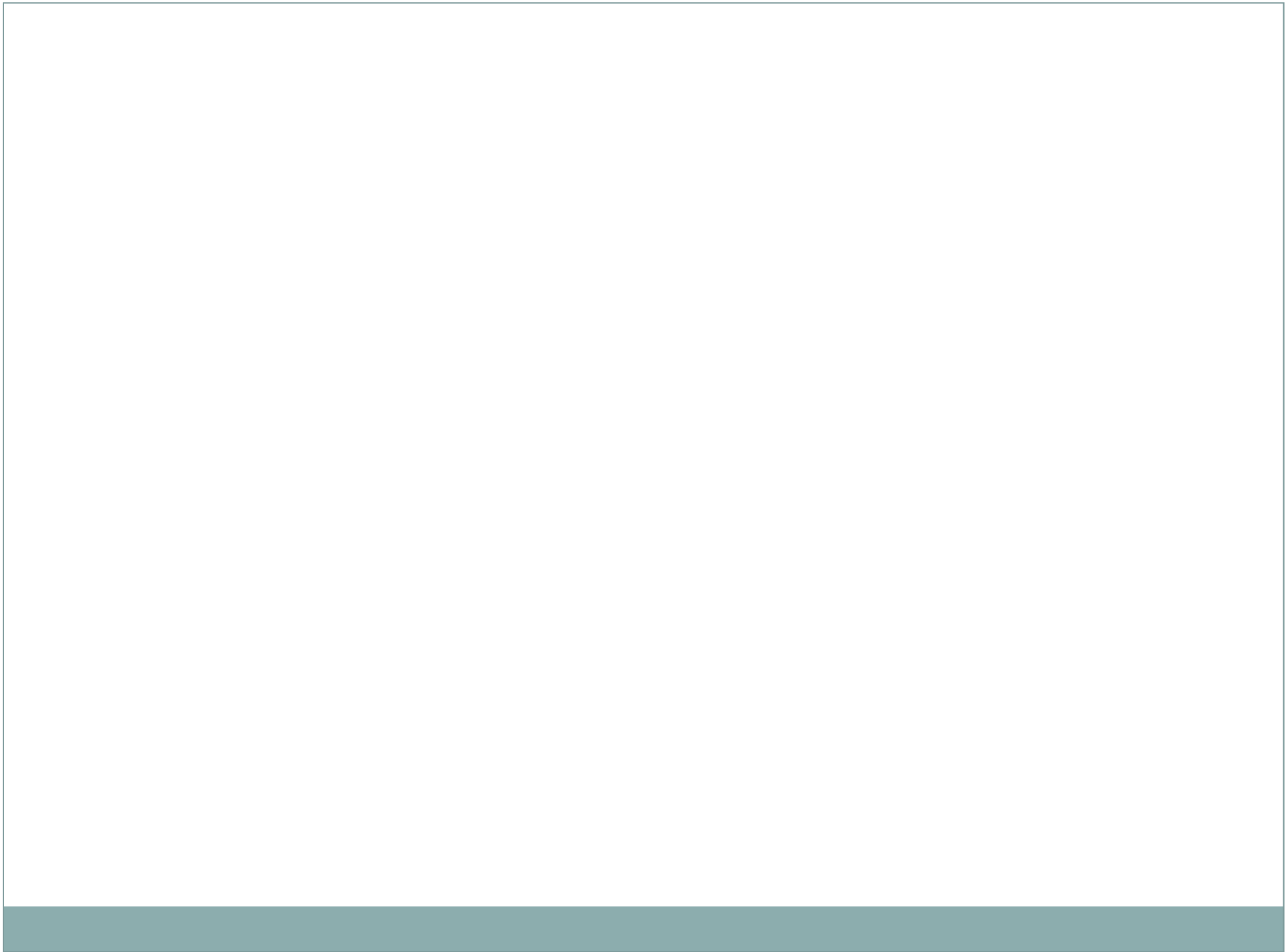
The chart shows how rainfall volumes are projected to increase across the relevant design storm events, especially for the more extreme (100 and 200 year) events.

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 ( $\pm < 1$ )
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 ( $\pm < 0.1$ )	2.6 (2.6 - 2.7)	3 ( $\pm < 1$ )
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 ( $\pm < 0.1$ )	10 (8 - 11)
80 <sup>th</sup> Percentile storm (in)	0.8	0.9 (0.1)	0.9 (0.1)	0.95 (0.1-0.15)
90 <sup>th</sup> 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)
95 <sup>th</sup> 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)

# STAC Workshop : 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 suite of BMPs 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?



# Session I: Discussion



**WHAT CAN WE DRAW  
FROM LITERATURE  
REVIEW ABOUT  
SITING AND DESIGN  
PRINCIPLES?**

# Session II: Discussion



**WHAT ARE SPECIFIC  
CHARACTERISTICS (FLEXIBILITY,  
ADAPTABILITY, ROBUSTNESS) OF  
BMP DESIGN TO ADDRESS  
EXTREME EVENTS AND PROVIDE  
CO-BENEFITS?**

# Session III: Discussion



**WHAT ARE THE REMAINING GAPS  
AND HIGHEST PRIORITY NEEDS  
(TOOLS AND RESOURCES) TO BETTER  
INFORM BMP DEVELOPMENT AND  
IMPLEMENTATION?**

# Session IV: Discussion



**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?**

Thank you.

