Chesapeake Bay Climate Projections and Stormwater Vulnerabilities

Climate change is expected to alter the volume and intensity of precipitation across the Chesapeake Bay watershed in the coming years. These changing hydrologic conditions, coupled with ongoing development, rising sea levels, and warmer temperatures pose a risk to stormwater infrastructure and public safety. Understanding local climate projections and the vulnerabilities of our current design principles will help inform more resilient approaches moving forward.

MAIN IDEAS:

- **Temperature, sea level,** and **precipitation intensity** are all increasing across the Chesapeake Bay watershed.
- **Current stormwater design relies on historic precipitation data that are likely to underestimate future precipitation**, leading to undersized practices with risks ranging from catastrophic failure to diminishing pollutant removal performance.
- The **age, location, design**, and **maintenance condition** of a given practice influence its vulnerability.
- Updated stormwater design criteria and floodplain management regulations should be considered in the context of projected climate change impacts and BMP vulnerabilities.

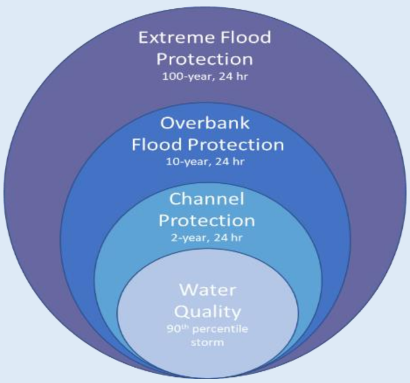


Figure 1. Example Unified Sizing Criteria for Stormwater Management

Climate Projections and Stormwater Design: The design of past and current stormwater infrastructure relies on historic rainfall data from NOAA's Atlas 14. Atlas 14 tells us the local rainfall intensity, duration, and frequency (IDF) that must be captured and safely conveyed to meet a range of management objectives (See Figure 1). By using historic data, we risk under-sizing our practices, as climate change projections suggest they are no longer a reliable proxy for future conditions. To build more resilient practices, we need to understand how these "IDF curves" will look throughout a practice's design life. Global and regional climate models are downscaled to local monitoring stations across the watershed, so that the projections can be converted into actionable datasets and tools for stormwater infrastructure sizing at a finer scale. Using these projected IDF curves, policy decisions can be made about acceptable levels of risk and uncertainty for each community.

Median Projected Precipitation Depths (In.) for 2050-2100, compared to Atlas 14 values. Source: MARISA

	2 year			10 year			100 year		
	Atlas 14	2050- 2100*	Change	Atlas 14	2050- 2100*	Change	Atlas 14	2050- 2100*	Change
Virginia Beach	3.65	4.12	13%	5.63	6.08	8%	9.44	10.67	13%
Annapolis, MD	3.23	3.67	14%	5.02	5.87	17%	8.66	9.44	9%
Harrisburg, PA	2.9	3.31	14%	4.36	5.06	16%	7.48	8.53	14%

*Projection under RCP 4.5 (Conservative, Low Emissions Scenario)

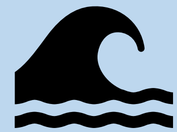
Summary Climate Projections: While stormwater managers will likely first focus on rainfall and runoff characteristics, climate change projections for temperature, stream flow and sea level rise will factor significantly into local investment and resilience decisions. Watershed planning and BMP implementation efforts should consider the full range of changes projected for the region.

SUMMARY OF CHESAPEAKE BAY WATERSHED CLIMATE PROJECTIONS:

PRECIPITATION

- More intense downpours and longer dry periods between rain events
- Intensity to increase by 5-35% by 2050
- Volume of annual rainfall to increase in the watershed by approximately 6.5% by 2055
- The 20-year, 24-hour precipitation event could become the 10-year, 24-hour event by 2100

TEMPS/STREAMS/SEA LEVELS



- Approx. 2 feet of sea level rise across the Mid-Atlantic by 2100
- Annual streamflow to increase by 4.5% by 2055
- Temperatures across the watershed to increase by 3.7°F by 2050
- Blue-sky flooding to exceed 30 days per year in over 20 cities in the Northeast by 2050

Infrastructure failure: Although the eventual degradation and failure of infrastructure is inevitable in the absence of consistent maintenance, climate change is an added obstacle that will exacerbate already-present design flaws and vulnerabilities. Climate change-induced risk occurs on a spectrum ranging from diminished pollutant removal to catastrophic failure. Along this spectrum are varying levels of risk based upon the type of best management practice (BMP), its position in the urban landscape, and the ultimate management objectives the practice is intended to address. While specific vulnerabilities differ between the BMP types, the most common include more **frequent overflow and bypass of runoff, loss of treatment capacity due to sedimentation or high groundwater tables, and increased erosion where runoff enters and exits the practices.** These are the most common vulnerabilities for certain BMP design components:

Capacity Loss

Spillway Failure

Inlet Erosion

Inlet Erosion

Clogged Filter Bed

Stressed Vegetation

Key variables to consider when assessing infrastructure:

Age:
Era of stormwater management

Stormwater design in the Bay watershed has advanced through a series of distinct eras. A typical timeline begins prior to the 1960s, when the focus was solely on stormwater **conveyance**. From the 1960s-80s, **quantity** control via large ponds dominated the landscape. Since 2010, we have entered an era of water quality and **Low Impact Development (LIDs).** Communities can generally predict the era, and therefore, flood risk based on the average age of urban development in a local watershed.

<u>Older practices</u> are more likely to be:

- Designed using **outdated** precipitation data and design guidelines
- Experiencing **natural wear and tear**, therefore increasing their vulnerability to extreme events.

Condition:
Of design and maintenance

Regardless of climate change, many stormwater BMPs throughout the watershed are already at risk of failure due to a wide variety of design and construction flaws, as well as insufficient maintenance. Climate change is likely to **exacerbate design flaws**, speeding up structural and performance failures, while demanding more routine maintenance to preserve water quality performance.

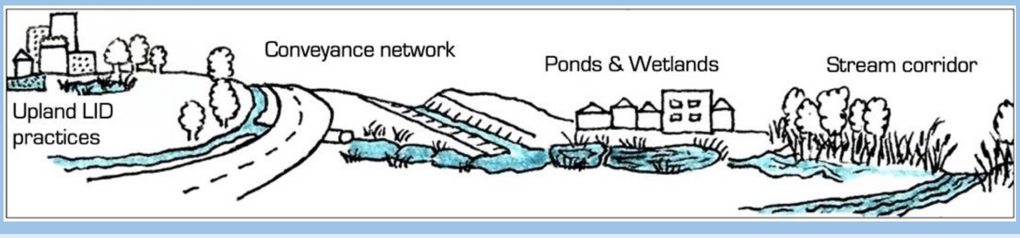
<u>Design flaws exacerbated by climate change:</u>

- Design elevation
- Undersized inlet/outlet
- Insufficient bypass measures
- Preferential flow paths
- Insufficient pre-treatment

Location: Within the urban stormwater drainage network

Examples of BMPs in each level:

Upland LIDs	Conveyance	Ponds & Wetlands	Stream corridor
Bioretention	Vegetated swale	Wet/dry pond	Stream restoration
Permeable pavement	RSC	Stormwater wetland	Shoreline management
Green roof	Storm drain pipe	Legacy pond	



As runoff moves through the urban drainage network, it becomes more concentrated and the practices that capture, infiltrate, or convey that runoff must handle increasingly larger volumes of water. Where a practice is located in the watershed may determine whether its risks are primarily related to increased maintenance costs, pollutant removal performance, or public safety. This path begins with small and dispersed **upland LIDs**, followed by the **conveyance network**, then **stormwater ponds and wetlands**, before eventually joining the **stream corridor**.

For more details, including references, please visit the following CSN memos:
Memo 1: Summary of Stakeholder Concerns, Current Management and Future Needs for Addressing Climate Change Impacts on Stormwater Management
Memo 2: Review of Current Stormwater Engineering Standards and Criteria for Rainfall and Runoff Modeling in the Chesapeake Bay
Memo 3: Review of Recent Research on Climate Projections for the Chesapeake Bay Watershed
Memo 4: Vulnerability Analysis and Resilient Design Considerations for Stormwater Best Management Practices MARISA: Projected Intensity-Duration-Frequency (IDF) Curve Data Tool for the Chesapeake Bay Watershed and Virginia