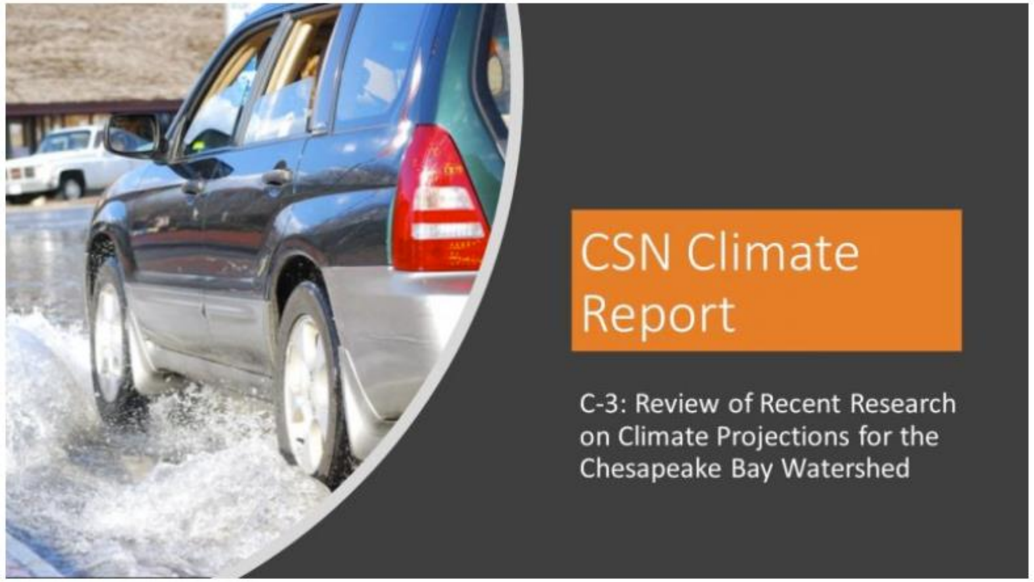
STORMWATER BMP VULNERABILITIES TO CLIMATE CHANGE

URBAN STORMWATER WG AND CLIMATE RESILIENCY WG

OCTOBER 18, 2021

CSN CLIMATE AND STORMWATER REPORTS

- **Reports & Fact Sheets:** https://chesapeakestormwater.net/climate-change-and-stormwater-management/
- **Webinar:** https://chesapeakestormwater.net/events/bmp_vunerability_resilience/



C-3: Synthesis of Chesapeake Bay Climate Projections

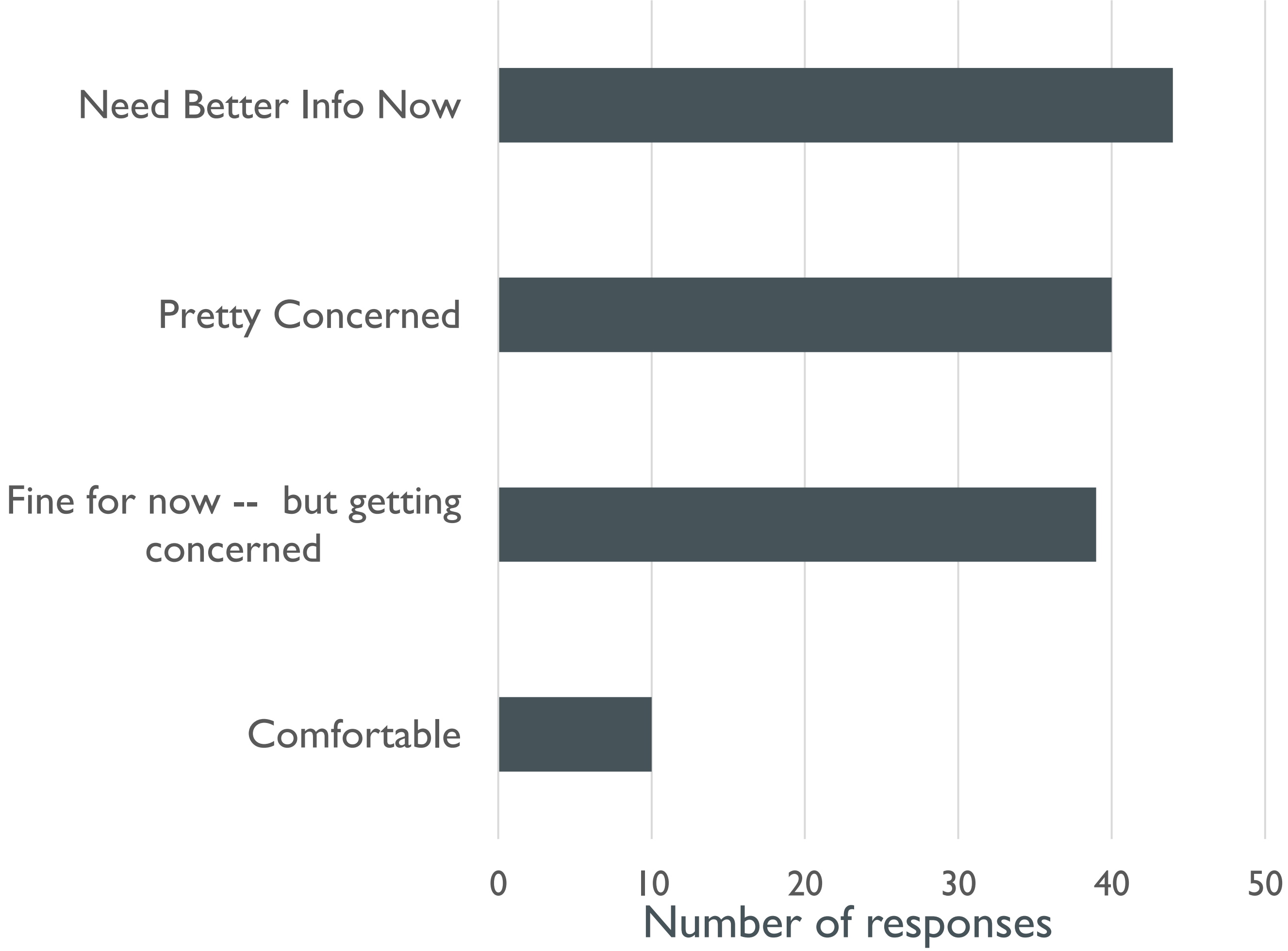
C-4: BMP Vulnerability Analysis and Resilient Design Considerations

MEMO 1 – STAKEHOLDER SURVEY

- Everyone is worried about damage to critical infrastructure during large storm events
- Particularly how to pay for both routine and non-routine maintenance
- The current stormwater design criteria aren't cutting it
- All tools are useful but they really want new design specs.

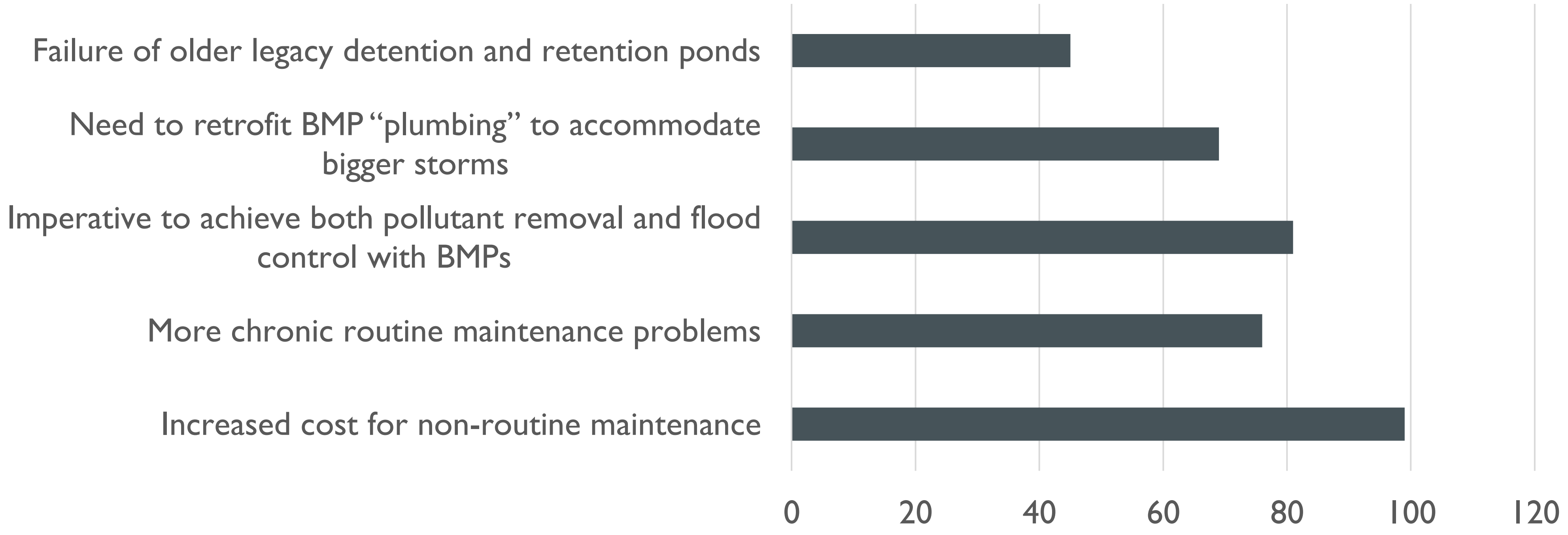
MEMO 1: STAKEHOLDER SURVEY

- Respondents are not comfortable with the current quality and utility of engineering design criteria on future rainfall intensity

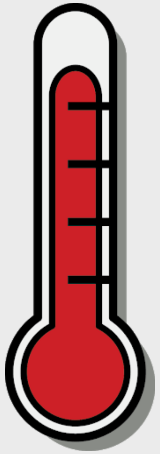


MEMO 1: STAKEHOLDER SURVEY

Everyone is concerned with how to pay for the necessary maintenance and upgrades, as well as to plan for future resilience.



Memo 3: Changing Conditions



2-3°F of warming

5-35% increase in precip intensity

1-2 feet of sea level rise

In 30 years, Bioretentions will see:

- Shifting vegetation palettes
- More sediment mobilization in CDA
- Additional rainfall volume in similar # of events
- Rising water tables in coastal areas
- Unknown impacts on pollutant removal efficiency

RISK IN THE URBAN BMP LANDSCAPE

Memo 4: Urban BMP Risk and Vulnerability

Catastrophic Failure	Complete failure of the practice to perform its design function, resulting in risk to human health and public safety
Structural Failure	Complete failure of the practice to operate as designed, but with no immediate risk to public safety
Water Quality Performance Failure / Water Quantity Performance Failure	Practice still exists and may perform some intended functions, but either no longer provides any pollutant removal or leads to impacts on downstream floodplain boundaries
Diminishing Performance	Practice still exists provides some pollutant removal function, at a diminished rate
Anticipated Failure	Some degree of failure or loss of performance was anticipated due to causes unrelated to climate change

Key Factors:

Age

Location in the Watershed

Maintenance/Design Condition

AGE AND MAINTENANCE CONDITION

Let’s not forget about the non-climate effects on BMPs:

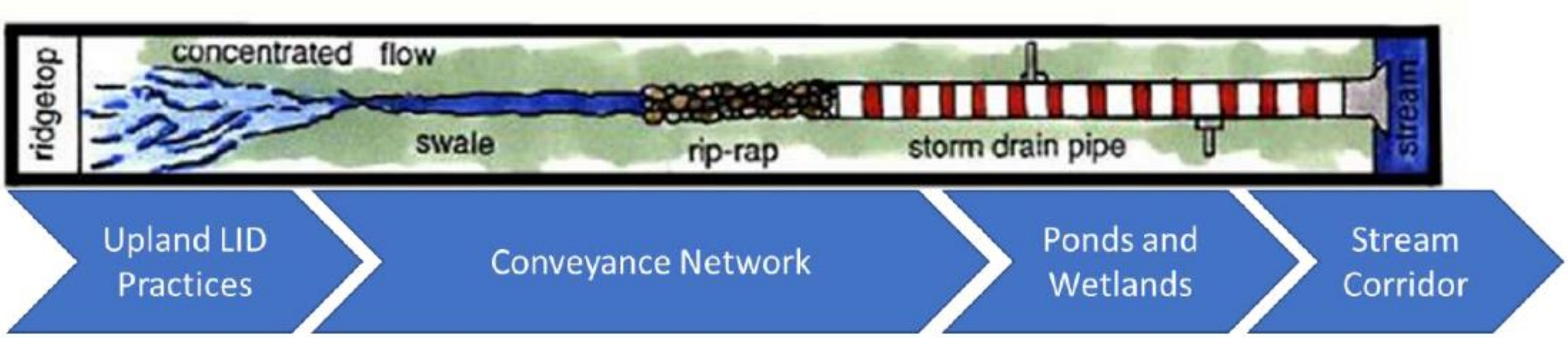
- Development/ Land Use Change
- Maintenance condition
- Natural wear and tear

Failure/Expiration rate near 5-15% of reported BMPs

"TYPICAL" TIMELINE FOR THE PROGRESSION OF STORMWATER INFRASTRUCTURE

- 1960's and before: Conveyance only (no detention storage)
- 1980's and before: Detention pond era (quantity control, no quality control)
- 1990's -2010: Quality and quantity control
- 2010 to present: LID era (and in recent years, the stream restoration era)

Figure 2. The Urban Stormwater Drainage Network



LOCATION IN THE WATERSHED

- Contributing Drainage Area
  - "On-line" vs. "offline"
    - Tidal influences

UPLAND LID PRACTICES

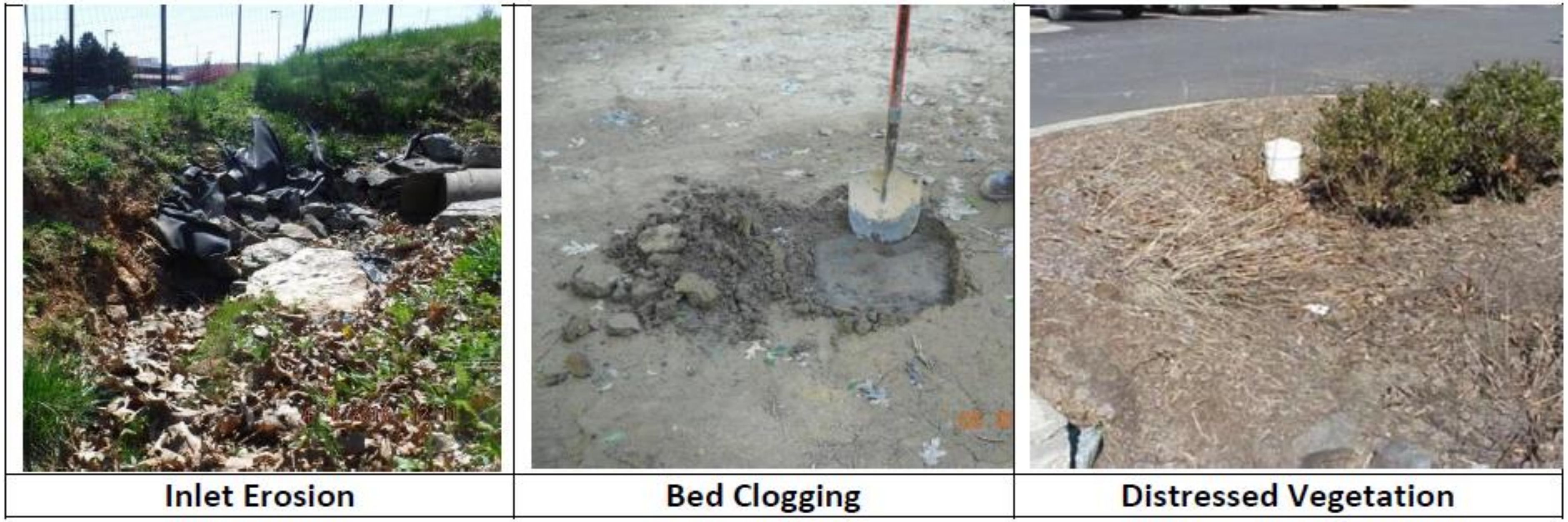
- Maintenance "needy",
- Primarily designed for water quality

- Vulnerabilities:
  - Erosion (in and out)
  - Bypass/Overflow
  - Clogged Filter Media
  - Distressed Vegetation

Vulnerabilities are often the result of flawed design or maintenance – climate change just makes it worse:

- Improper design elevations
- Preferential flow paths through the facility
- An undersized curb cut
- Insufficient pre-treatment
- Insufficient bypass measures for storms larger than the design storm

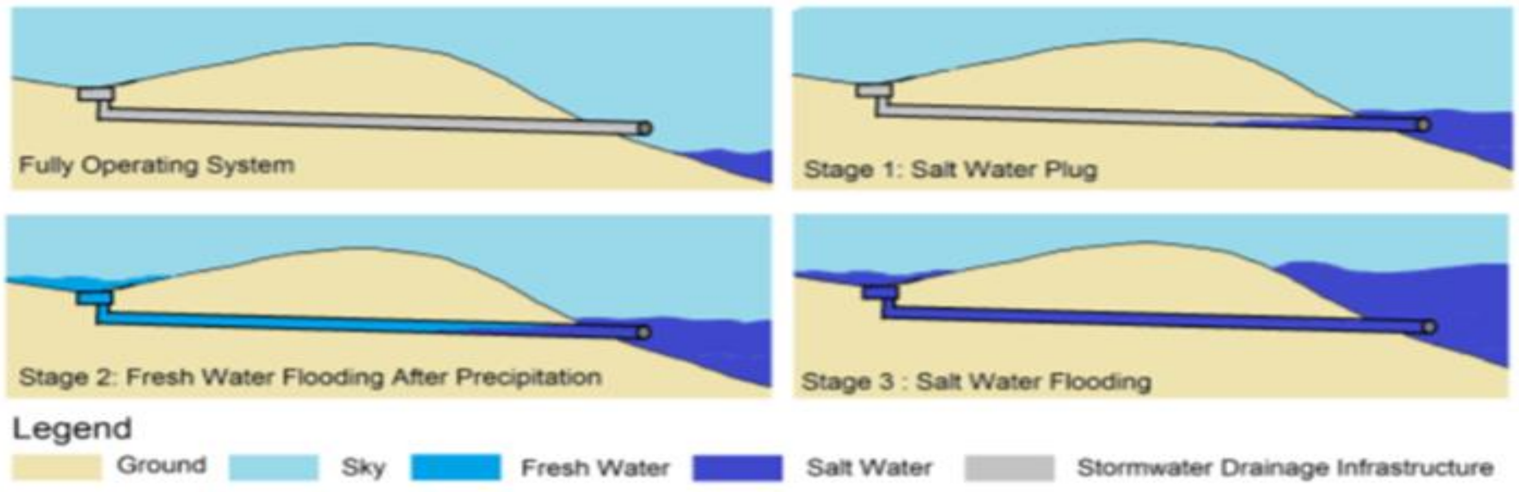
Figure 4. Examples of vulnerable design elements in upland LID practices.



TIDAL FLOODING IMPACTS

- Reduced infiltration capacity
- Submerged outlet structures resulting in back-up and loss of capacity
- Saltwater intrusion – vegetation and pollutant removal impacts

Figure 2.5: Stages of stormwater drainage failure due to sea-level rise. Graphic by Emily Niederman, Stetson University.



WATER QUALITY PERFORMANCE IMPACTS

The 90th percentile storm event hasn't changed much – and may not.

- The 90th percentile storm increased by ~ 6% from 1.14" to 1.21" in the last 15 years at Reagan National
- The predicted intensity of the 90th percentile, 24-hour event does not show a consistent increase at most Maryland stations under future conditions (Butcher, 2020)

But this doesn't mean there won't be water quality performance impacts on BMPs

WATER QUALITY PERFORMANCE IMPACTS

Table 1. Summary of Select Climate Change Pollutant Removal Impact Studies

Citation	**Type of Study**	**BMP**	**Performance Metric**	**Change in Performance**
Hathaway et al., 2014	Modeled	Bioretention (online)	Overflow volume	70-136% increase in overflow volume by 2055
Catalano de Souza et al., 2016	Field (extreme weather as proxy for climate change)	Bioretention (offline)	Bypass volume	40% bypass during extreme events vs 23% bypass during non-extreme events
Butcher, 2020	Modeled	Bioretention	Overflow volume	11% increase in overflow volume by 2055
Alamdari et al., 2020	Modeled	Mixed	BMP removal efficiency	6-11% decline (TSS) 7-12% decline (TN) 11-17% decline (TP)
U.S. EPA, 2018	Modeled	Mixed	BMP removal efficiency	0-10% decline (TSS) 0-6% decline (TN) 0-5% decline (TP)

CONVEYANCE PRACTICES

- Serve as choke point that can elevate risk elsewhere
- Impacts on transportation infrastructure
- Vulnerabilities:
  - Erosion (in and out)
  - Loss of Capacity
  - Damage at the Outfall

CONVEYANCE PRACTICES

- "Softer" conveyance practices and rural roadside ditches carry high risk of erosion/deposition
  - Undersized gray infrastructure
  - Interactions with tidal flooding

POND PRACTICES

- Potentially high impact on public safety
- Older practices

- Vulnerabilities:
  - Erosion
  - Sedimentation
  - Emergency Spillway
  - Leaching and Resuspension

Figure 6. Examples of vulnerable design elements for stormwater ponds.

	
Erosion at the Inlet	**Loss of Capacity – Full Pilot Channel**
	
Embankment Failure	**Damage to Emergency Spillway**

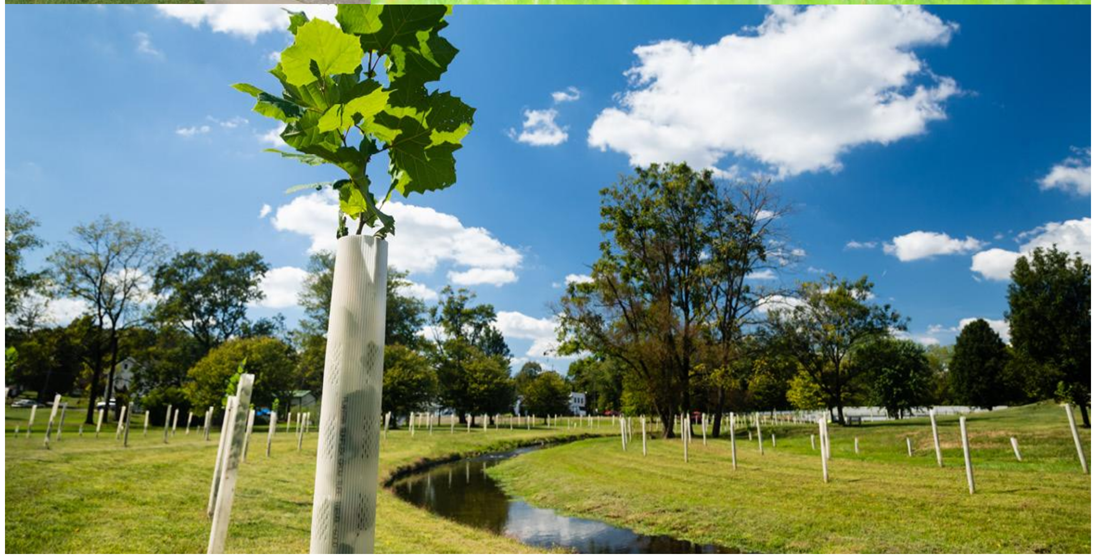
POND WATER QUALITY VULNERABILITIES

- High flows may disrupt the settling process and shorten the HRT of stormwater retention ponds during extreme conditions
- High flows also mean more inlet loads and less pond performance
- Overall, higher storm intensity is a bigger problem for ponds than more volume

OTHER URBAN PRACTICES

- Data is lacking for programmatic BMPs (Street sweeping, UNM, NDGI)
- Tree BMPs are somewhat better understood, but again lack data

- Vulnerabilities:
  - Shifting tree ranges
  - Tree mortality
  - Build-up wash off dynamics



QUESTIONS?

JON'S PRESENTATION

RESILIENT DESIGN AND NEXT STEPS

RESILIENT STORMWATER DESIGN PRINCIPLES

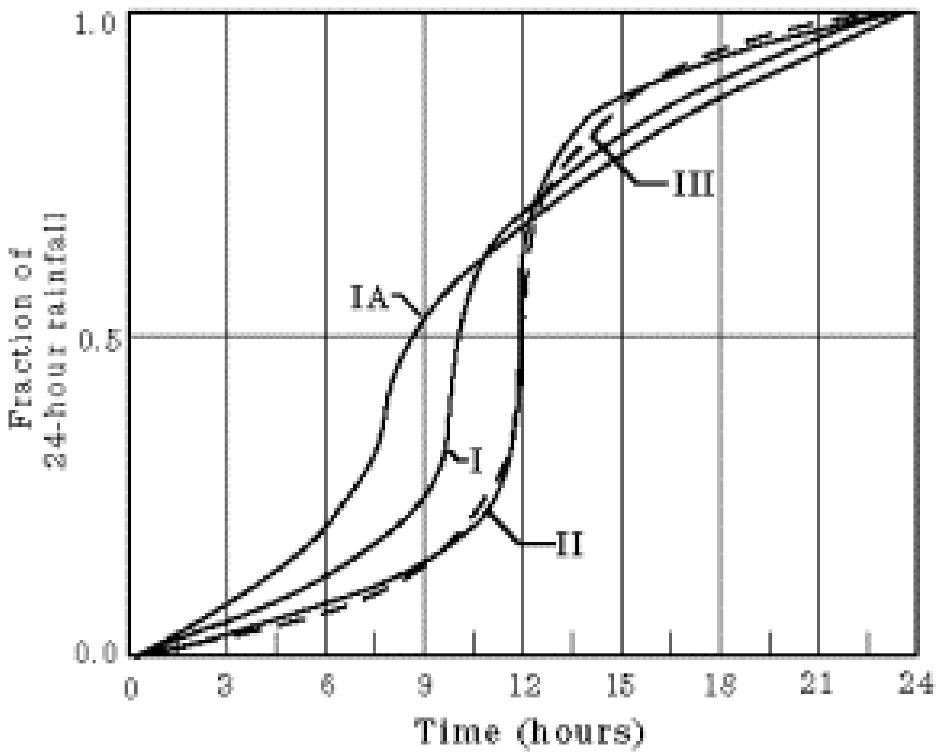
- Comprehensive Watershed Management
- Sizing for acceptable level of risk under future climate
- Flow-Plains
- Full Cycle Implementation
- Redundancies
- Performance Enhancers

WHAT IS A RESILIENT STORMWATER PRACTICE?

- More Than Just Bigger Sizing
- Reduced Maintenance Burden
- Fewer Small Drainage and Homeowner Erosion Complaints
- Extended Design Life
- Improved Pollutant Removal Performance

What is the best design storm for cloud-burst events?

Riverine Event: NRCS Type 2, 24 hour Storm Distribution

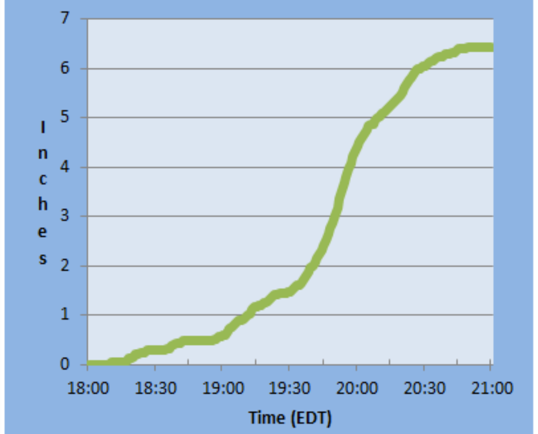


Pluvial Event: 1 to 3 hour micro-burst event Overwhelms stormwater conveyance system

Historic Rainfall in Ellicott City, Maryland – July 30, 2016

Duration	Max Rainfall in Duration	Time of Occurrence
1 minute	0.20"	7:52pm-7:53pm
5 minutes	0.80"	7:50pm-7:55pm
10 minutes	1.44"	7:50pm-8:00pm
15 minutes	2.04"	7:46pm-8:01pm
20 minutes	2.44"	7:44pm-8:04pm
30 minutes	3.20"	7:36pm-8:06pm
60 minutes	4.56"	7:30pm-8:30pm
90 minutes	5.48"	7:00pm-8:30pm
2 hours	5.96"	6:50pm-8:50pm

Total Rain in Ellicott City (ELYM2)



Storm Total Rainfall: 6.60 inches

Information obtained from the Ellicott City (ELYM2) rain gauge.
This gauge reports in 0.04" increments.

RESILIENCE IS A FULL CYCLE

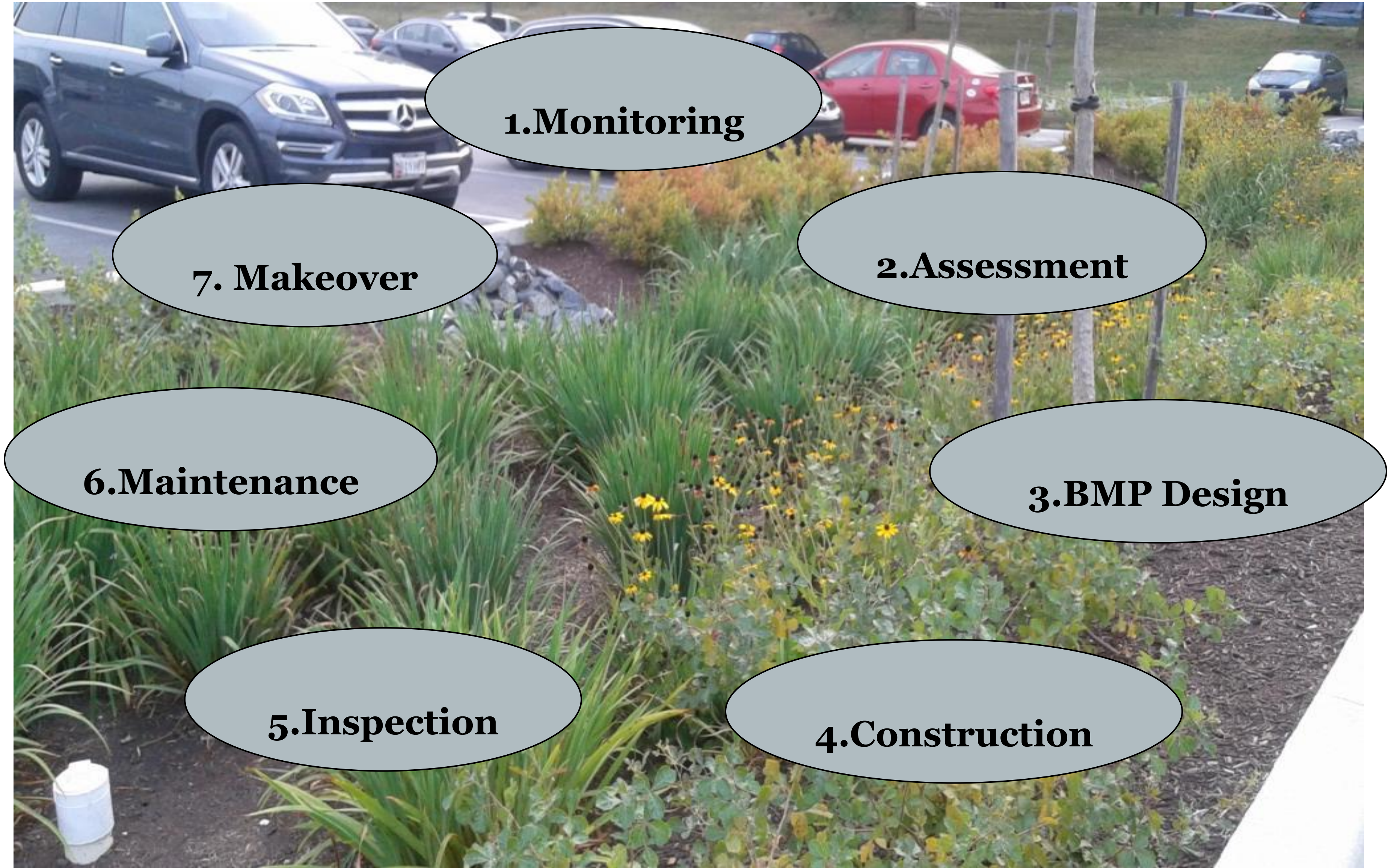
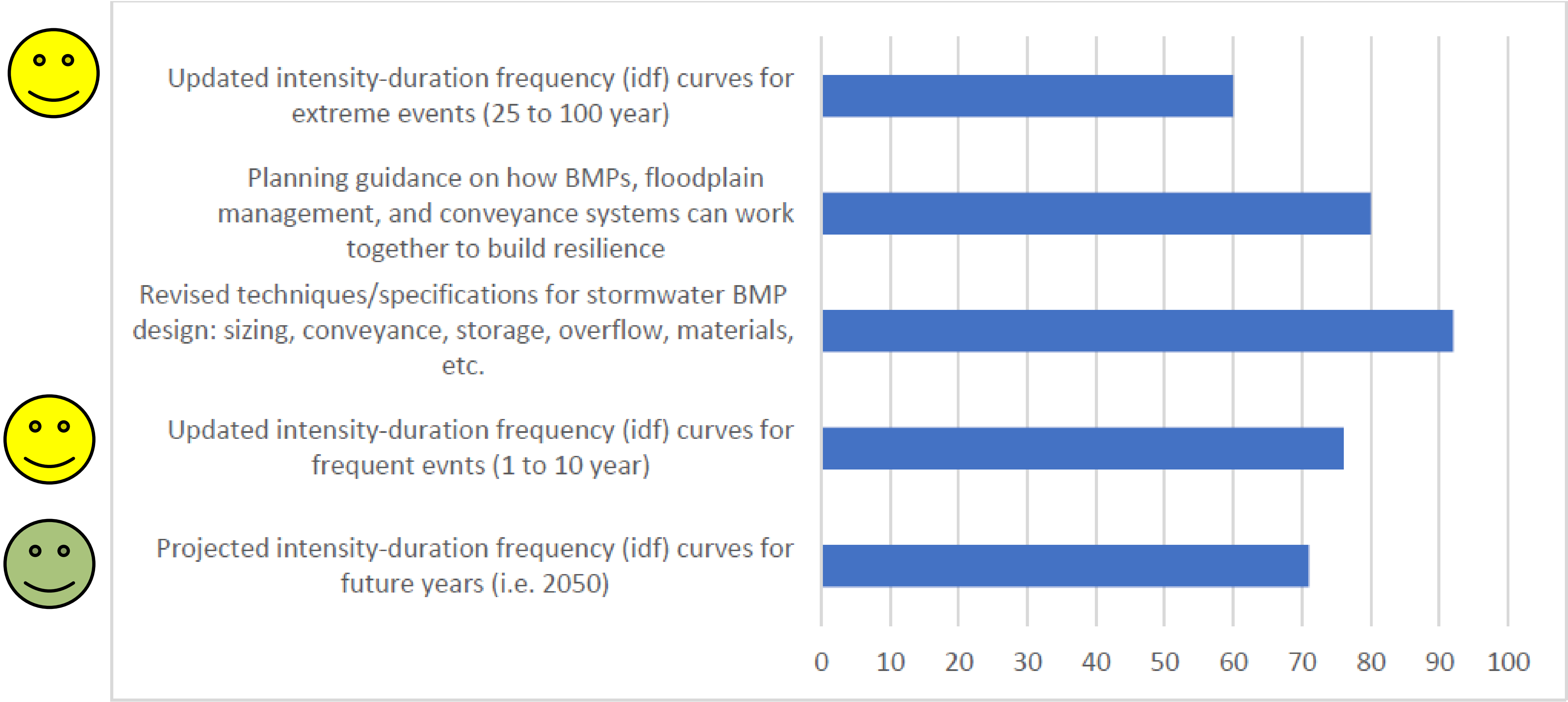


Figure 3. Top 5 tools rated as "useful" or "very useful" for communities with a need for better design specifications (n=124).



WHERE DO WE GO FROM HERE?

- Continue gathering data on BMP performance impacts and resilient design options

- Begin moving toward resilient implementation:

  - Develop effective new state or Bay-wide stormwater design standards and specifications
  - Coordinate between relevant agencies
  - Provide updated guidance for several impacted BMPs

TOOLS TO ID THE MOST VULNERABLE BMPS

- Rapid Risk Assessment Checklist for Stormwater Practices
- Considers Age, Location and Maintenance Condition
- Placed within the context of vulnerable communities, facilities, and habitats
- More details to come tomorrow…

BETTER SPECS

- Updated "plumbing" criteria to manage inflows and overflows to on-line LID practices
- Provide a range sustainable landscaping templates that are easy to maintain and require less mulch
- Incorporate maintenance benchmarks and indicators into design specifications
- Use performance enhancers like media amendments and Smart BMPs to offset performance losses
- Coastal design adaptations

SOME SIZING OPTIONS

- Replace existing IDF curves with projected IDF curves
  - Still lack temporal resolution needed for most design applications

- Factor of Safety – Add % to existing IDF curves based on projections

- Increase the design storm criteria (ex. design for the 15 year, 24 hr instead of the 10 year, 24 hr)

- Over-management criteria – (ex. release the 150-year post-development storm at the 100-year pre-development level)

POSSIBLE TOOLS FOR LOCAL GOVS

- Guidance on how to interpret projected IDF curves and options for applying climate-informed data in local requirements
- Pilot Bay-wide design specs that promote longevity, pollutant removal performance, handle increased extreme rainfall
- Establish landscaping maintenance criteria that reflect future climate conditions and provide opportunities for carbon reduction and improved BMP performance

DISCUSSION

- What is the best way to package resilient design specs to aid their "adoptability" for state and local govs?
- Is there interest from workgroup partners in engaging on the development process?
- What are the highest priority items to address through resilient design specs?