Joint Meeting of the Urban Stormwater Workgroup and Climate Resiliency Workgroup

October 18-19, 2021 | Meeting Minutes

Day 1 Event Calendar Page: Link

This meeting was recorded for internal use to ensure the accuracy of meeting notes.

Summary of Actions and Decisions Day 1

- ✓ Julie Reichert-Nguyen will follow up with Annie Neale to schedule a working meeting for CRWG to discuss how EnviroAtlas could help in their efforts.
- ✓ Julie Reichert-Nguyen will organize a small internal review committee for the BMP climate uncertainty report being drafted by Virginia Tech.

Meeting Minutes Day 1

1:30 Announcements, Introductions and Meeting Objectives – Norm Goulet (USWG Chair), Mark Bennett (CRWG Chair), Julie Reichert-Nguyen (CRWG Coordinator), and David Wood (USWG Coordinator)

Summary

David Wood summarized the presentations and discussions that will occur over the course of the meeting. Some of the presentations have already been recorded and linked in the agenda. Other presentations will be recorded for those unable to make it to some of the discussions. *Reminder:* The Water Quality Goal Implementation Team (WQGIT) is holding a Phase 7 development meeting on October 25- 26 and recommendations from this meeting will be brought in front of the WQGIT.

CBP prioritized climate change indicators:
https://www.chesapeakebay.net/channel_files/41939/list_of_climate_change_indicators_for_mgmt_board_discussion_final.pdf

1:45 EnviroAtlas – Annie Neale and Jessica Daniel (US EPA)

Annie and Jessica presented information on EnviroAtlas, and metrics related to flooding, precipitation, tree canopy, and carbon sequestration. EnviroAtlas provides geospatial data, easy-to-use tools, and other resources related to ecosystem services, chemical and non-chemical stressors, and human health. They discussed how EnviroAtlas could potentially be used to support the prioritized climate change indicators.

Summary

EnviroAtlas: https://www.epa.gov/enviroatlas
Interactive Map Homepage: https://www.epa.gov/enviroatlas/enviroatlas-interactive-map
Interactive Map: https://enviroatlas.epa.gov/enviroatlas/interactivemap/

Annie Neale gave a demonstration of how to use the EnviroAtlas interactive map. If participants need more tutorials on how to use this tool there are links on the interactive map homepage under *"need help getting started?"* EnviroAtlas designed to reach broad audience, including decision-makers and health

professionals. It provides data at multiple extents and scales and combines data layers. E.g., percent green space and households below poverty level. General work process for new data layers includes research to create data layer, publish in literature, and publish in EnviroAtlas.

Julie Reichert- Nguyen discussed how CRWG has worked on refining their climate change indicators. It would be great to have future conversations around this tool and how we could integrate this into our indicators/ how it could support this work. Potential connections include flooding, marsh migration, and sea level rise. CRWG could have Annie Neale come to a future meeting to do a working meeting to identify specific data layers in relation to featured resilience collections around prioritized climate change indicators. E.g., how close people live to flood zones related to transportation. Peter Tango suggested selecting a few options for metrics then review and discuss them on the EnviroAtlas and target discussion for adoption. Mark Symborski asked if data can be downloaded from EnviroAtlas by local jurisdictions for separate analysis? Need to follow-up for answer due to technical difficulties.

2:15 Chesapeake Bay BMP Climate Synthesis Report – Jeremy Hanson (CRC) and Zach Easton (Virginia Tech)

Jeremy and Zach provided an update on the BMP climate resilience assessment on nature-based, agriculture, and stormwater BMPs from their modified systematic literature review, sponsored by the CBP Scientific and Technical Advisory Committee (STAC) and NOAA. This review assisted the CRWG and other CBP workgroups to identify knowledge gaps to build into a research agenda as requested by the CBP Principal Staff Committee (PSC).

Summary

The project involved reviewing existing literature to assess BMP performance uncertainty under changing climate conditions. There was varying success in finding research on how climate change will affect BMP performance. Hardly any studies on oysters or sea level rise. Conflicting results in literature whether more surface runoff equates to more evapotranspiration. More research is needed in soil moisture effects. Overall BMPs will have to deal with greater variability.

Peter Tango asked about efficiencies and whether any of the BMPs had improved. Zach Easton stated that BMPs that rely on denitrification usually do well. Jeremy Hanson followed up that some of the more intense climate change BMPs perform better than the less intense ones. There is evidence to suggest that there are some mechanisms that perform better but it's harder to understand how they relate. Lew Linker said that the zonal approach was a good idea and asked if there will be information in the document that states what conditions would make cover crops efficient BMPs. Cover crop is a great example because it depends on when those functions are realized.

Kristen Saunders asked where forest buffers and wetlands fall in the processes zone categories. Jeremy Hanson stated that he has been placing forest buffers in zone 1 because they both are in that space where they use the hydrological landscape of the land. Wetland rehabilitation can go into a couple different zones. Tree planting is in Zone A (biological or chemical), currently. Denice Wardrop talked about how the variability in wetlands posed from climate change was going to be 5x as much as what we are used to managing and was wondering if in the report, if they will try to address variability. Zach Easton said there is a discussion on variability related to, for example, soil, but in terms of processes.

Yi Liu asked the impacts from sea level rise in the Chesapeake Bay. For sea level rise the short term is 0.3-0.6m and the long term is 0.5-1.7m. Lew Linker suggested that there should be a section on "next steps" which would take the long view on how the CBP needs to continue to wrestle with the science and understanding of BMPs and climate change and seconded Gary Shenk's suggestion that there should

be information on how to use the information in the report. Zach suggested that they could discuss performance and how it changes.

Julie Reichert-Nguyen reminded everyone that the report is planned to be released in December. Julie Reichert-Nguyen will be reaching out to participating CBP teams to organize an internal review committee for the report.

2:45 Break

2:55 Stormwater BMP Vulnerabilities to Climate Change -- David Wood (CSN)

David outlined the key findings from a series of four memos on maintaining the resilience of stormwater BMPs. The memos cover the current stormwater design standards across the Chesapeake Bay Watershed, a synthesis of local climate projections, and likely vulnerabilities in our stormwater infrastructure. Resilient design considerations were also covered.

An archived recording with an extended version of this presentation is available here.

Summary

Chesapeake Bay BMPs and stormwater infrastructure face a range of vulnerabilities based on their age, maintenance condition, and location in the watershed. While it appears that the 90th percentile storm is unlikely to increase significantly, green infrastructure practices designed to the 90th percentile storm are still vulnerable to performance losses due to increasing maintenance needs and runoff bypass/overflow caused by increasing storm intensities. There is uncertainty on how well infiltration BMPs will perform in tidal areas with more saltwater intrusion and rising water tables. Helpful to think about performance in terms of whether the change falls within the acceptable range the BMP is currently designed around. Pond practices are the oldest, handle the largest flows, and are likely undersized.

Peter Tango suggested that culvert designs that include living resource considerations for fish passage in addition to flood control adds other important design considerations into the equation. Were those living resource considerations part of the surveys? David Wood replied that living resource considerations were not a major part of their work, but they will be talking some more about flood control and floodplain management standards tomorrow and they can better integrate these conversations in the future.

3:15 Considerations and Next Steps for More Resilient Stormwater BMP Design – Dr. Jon Hathaway (University of Tennessee), David Wood and Tom Schueler (CSN)

Dr. Hathaway presented the latest research on climate change implications for stormwater BMP performance and design. Then, Tom and David proposed a framework for local adaptation strategies to promote urban watershed resilience.

Summary

Research looked at downscaled data to assess possible futures in relation to increases in large storm events and effects on green infrastructure. Evaluated how GCM-scaled historical data compare to observed data to correct model bias related to the drizzle effect (lots of small events influencing results). Observed more overflow—will only be able to partially treat with bioretention, but not at the same performance under baseline conditions (i.e., bioretention practice efficiency is at high risk under increased precipitation). Need to assess how strategies will change under climate change scenarios. For

instance, retrofitting versus new system designs. Factors to evaluate include height, soil thickness, conductivity, drainage area.

Research took a probabilistic approach (published research paper on this). Looked at design modifications based on ten climate projections. New builds, while they involve big modifications (i.e., increase in pond size/depth and surface area), gave the best result for adaptation. Local soil condition had a big effect. Hydrology and be connected to nutrients especially on dry days—more dry days between rain events can negatively impact microbial communities releasing nitrogen into the system. Lab and field results demonstrated that longer dry periods resulted in spikes of nitrate and nitrite in system. Overall, need to sort out the overall goal in urban watersheds—do we just want to maintain current efficiencies or do we want to further improve or accept a different outlook with water.

The question is where do we go from here, or what are the next steps? The fourth stormwater memo laid out different resilient BMP practices. But what is a resilient stormwater practice? An example is stormwater design for cloud-burst events (riverine event vs. pluvial event). Some next steps are continuing to gather data on BMP performance, including indicators and metrics for management of BMPs, creating tools for local governments (ex. guidance on how to interpret IDF curves).

John said that one of the things that is important is the resolution of climate projections (hourly precipitation). It's hard to route things through urban watersheds at an hour resolution. The other thing with the hydrological side is understanding the sizing of stuff. For instance, building retention areas that are 15% of the size. That system will be a dryer system overall; you change the dynamics of the system when you change the size of the bioretention area. David Wood said that when we look at sizing, we are limited by the urban area and so I think it's important to have wholistic discussions on what other options there are that would help us be better able to handle some of these storm events.

Lew Linker followed up and talked about how we have an immediate problem with efficiencies- can we do something like a look back scenario? Could we ask the change in Nitrogen, Phosphorous, and Sediment? If we change the hydrology, can we get a relative percent change? One of the issues we have is that we are better at modeling some things over others and the change in the hydrology and showing how different practices would affect that. Norm Goulet countered that there is just too much variability in the processes and rainfall to be able to do this. At least not until we start to monitor in the field. Jon's research is a prime example of something that we never thought about. We could make changes to the design storms and tweaks to the engineering, but we won't get the numbers you want. We would have so many generalities that it would create too much uncertainty.

In the chat Larry Sandford stated that one of the things David noted in his presentation, but did not discuss further, was interactions between rainfall and high tide events. For urban environments adjacent to tidal water bodies, intense rain accompanied by storm high tides are becoming more common. This can completely stop up stormwater drains (or reverse the flow), greatly exacerbating flooding. Any thoughts? Kevin Du Bois said it's interesting in your comments, you mentioned it's more than just bigger sizes but also that we should be using fewer smaller drainage and homeowner practices. There seems to be conflicting guidance for urban or other areas where land area is limited for BMP implementation. Nicole Carlozo said it's also important to think about cost effectiveness of retrofits versus building bigger, especially if bigger drier systems are not as efficient.

3:45 Discussion and Wrap Up

Participants discussed and provided input on the proposed urban watershed resilience framework, which includes developing pilot "next generation Bay-wide design specifications", as well as other topics from the day. Discussion will be used to draft recommendations for the WQGIT and MB.

Discussion Question: What is the best way to package resilient design specs to aid their "adoptability for state and local governments?

Thumbs up were given in the chat, but more time needs to be given for participants to think over the question. Will be discussed more fully during tomorrow's meeting.

Reminder for CRWG: There will be no November meeting. Instead there will be a joint meeting with the Wetlands WG on December 13th and 14th.

4:00 Adjourn

Day 1 Participants:
C. Hegberg, H. Gewandter, J. Carr, Alexander Gunnerson, Amy Goldfischer, Adrienne Kotula, Alana Hartman, Allan Brockenbrough, Allie Wagner, Allison Breitenother, Anna Hamilton Annie Neale, Arianna Johns, Ashley Gordon, Audra Lew, Ben McFarlane Bill Jenkins, Breck Sullivan, Brenda Morgan, Cecilia Lane, Cassie Davis, Christina Lyerly, Corey Miles, David Wood, Deb Cappuccitti, Derick Winn, Elaine Webb, Fredrika Moser, Gary Shenk, Ginger Ellis, Ginny Snead, James Dunbar, Jamie Eberl, Jeff Ratteree, Jeff Sweeney, Dinorah Dalmasy, James Martin, Jennifer Miller Herzog, Jennifer Smith, Jennifer Star, Jeremy Hanson, Jesse Maines, Jessica Rodriguez, Jim George, Jon Hathaway, Julie Reichert-Nguyen, Karl Berger, Kate Bennett, Katie Brownson, Katie Dyer, KC Filippino, Kevin Du Bois, Kevin Hess, Krista Brown, Kristin Saunders, Larry Sanford, Laura Bachle, Lew Linker, Marel King, Maria Mutuc, Mark Hoffman, Mark Symborski, Meg Cole, Megan Barniea, Meredith Neely, Mike Mertaugh, M. Bennet, Nancy Roth, Neely Law, Nick Lindow, Nicole Carlozo, Nora Jackson, Norm Goulet, Peter Tango, Amanda Poskaitis, Raymond Boo, Roxolana Kashuba, Sally Claggett, Sadie Drescher, Scott Crafton, Ted Brown, Zach Easton, Tom Schueler, Hilary Swartwood, Muktar Ibrahim

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Day 2 Event Calendar Page: Link

This meeting was recorded for internal use to ensure the accuracy of meeting notes.

Summary of Actions and Decisions Day 2

- ✓ DC DOEE will connect with Michelle Miro to look at how to implement larger storm sizes in their stormwater regulations based on IDF curves.
- ✓ Connect IDF tool with local planners - engage local leadership (Who is doing this? Kristin Saunders brought this up as an action item).
- ✓ All members to follow up with David Wood via email if they have further comments.
- ✓ Wetlands Workgroup will connect with Ward Oberholzer and Scott Lowe to explore floodplain reconnection and wetland creation in alignment with stream restoration efforts and resilient design.
- ✓ David Wood will send a survey to USWG/CRWG to get more responses/comments regarding priority research needs.

Meeting Minutes Day 2

10:00 Announcements and Recap of Day 1 – Norm Goulet (USWG Chair) and David Wood (USWG Coordinator)

Summary

Norm Goulet introduced the meeting. David Wood recapped yesterday's meeting, summarizing the main takeaways and actions. David emphasized that the goal of today's meeting is to come away with ideas for what the priority research recommendations are, and the priorities for advancing implementation of the resilient design principals being discussed given the Chesapeake Bay Program's increased focus on climate change and climate resilience.

Kevin DuBois commented in the chat asking for clarification on Jon Hathaway's presentation yesterday and whether we are likely to experience more bypass in addition to overflow. Norm responded he believes that is correct, using current design standards.

10:20 Chesapeake Bay Climate Change-Informed IDF Curves – Michelle Miro (RAND)

Michelle provided an overview of the newly completed climate change-informed intensity duration frequency (IDF) curves. She then provided a quick demo of the web tool and lead a discussion on next steps and continuing research to further refine the tools and make them more useful for design applications.

An archived recording with an extended version of this presentation is available here.

Summary

Projected Intensity-Duration-Frequency (IDF) Curve Data Tool for the Chesapeake Bay Watershed and Virginia

Michelle Miro explained that the main driver for this work was incorporating climate change into design. Michelle noted that there is more detail available in the recording of the longer talk, which is linked above. Michelle gave a demonstration of how to use the Projected Intensity-Duration-Frequency (IDF) Curve Data Tool for the Chesapeake Bay Watershed and Virginia. You can hover over a county and click on a station. Click on "Using the Tool" tab to learn more about how to use it. Michelle also gave an overview of future directions for research.

David asked given the different design criteria that are used across the watershed region, curves weren't developed for every return interval so if you wanted to get information on the 15-year 24-hour storm, is that something you can interpolate through the tool, or how would you handle that?

James Dunbar asked, are 15-year curves available as well? If not, is it something we can interpolate between curves given in the tool already?

Michelle responded it is ideal to derive the 15-year, 24-hour storm rather than interpolating it because those dynamics aren't necessarily linear and interpolating between the 10 year and the 20 year may not be the right approach. It's worth seeing how the shape of the curve at the particular station you use has held up between the 10 and 20 year up over time. They looked at the shape of the IDF curves to see how they were changing and found consistency across future projected data sets. They felt confident in how they applied 24-hour change factors. However, Michelle advises doing the analysis looking between the 10 and 20 year to see how different the 15-year is in the historic record first. If it looks linear you could interpolate, but the ideal method is to re-derive it.

Nick Lindow asked, can users simply convert the depth numbers to intensity according to the duration? Michelle replied yes, they can. They're all a depth per time so that is convertible; depth was chosen to mimic Atlas 14.

Kristin Saunders who the intended users of the tool are. David responded that the intended users of the tool are stormwater professionals and local managers. It can be referenced in Chesapeake Assessment Scenario Tool (CAST) but it is mostly a tool for local planners and managers.

Kevin DuBois asked, I understand the tendency to let jurisdictions choose the design standards that they are comfortable with, but without a statewide standard, are we creating community winners and losers regarding vulnerability? Doesn't that tend to reinforce the vulnerability of low-income communities with less resources to implement more expensive more resilient design features. What are the policy implications of that standard flexibility? This question was saved for discussion later.

David Wood asked about updates for the future version of the tool – how do updates of Atlas 14 influence future versions of the tool. Michelle Miro said some of this is in the tool itself in the "how to use the data" section. The tool, and the change factors were built on existing Atlas 14 data. They chose the period of 1950-2000 because it mimics the range of data used in existing Atlas 14. Those change factors wouldn't be directly applicable to any updates of Atlas 14, and this is a limitation of the work. For those stations they've projected values, you can compare future projected values (IDF curve in the tool plus change factor) to updates of Atlas 14 to see how different they are. That would be the extent of the applicability.

Lew Linker asked if we're updating Atlas 14, is there value in updating the analysis to the latest Atlas 14. Lew commented about future research directions, saying that whatever we choose we should aim for improving application and implementation. For the future research direction of developing guidance for range of uncertainty to consider for specific infrastructure types – at some point we start getting into public safety issues. Large impoundments, culverts that get backwater and cause flooding, large

stormwater facilities, etc. Would public safety and property protection be coming into the discussion? Norm Goulet responded to this question by saying this is a standard that's typically set by individual localities. Norm gave the example that many years ago there was a big push for stormwater ponds and there were a couple of drownings that occurred. Then there was a push to stop using ponds or put chain-link fencing around them. The liability aspects trickled down to various facilities. Once you start getting into liability, it gets out of the hands of scientists and into the hands of policy makers.

Lew Linker clarified on the question – he's thinking some applications of the future oriented IDF curves could involve aspects of public safety focused around flooding. Would this enter into the discussion around different infrastructure needs - would public safety be applied? Michelle Miro responded by saying that a critical extension of the work would be to work with policy makers and decision makers to understand this. On the science side we can't make these decisions for localities, we can just try to understand the different ranges of risk tolerance and use that to provide guidance. But this should be through a collaborative element.

Norm Goulet commented that the sub-hourly information is definitely needed. He said one of the methods used is looking at the change factors we come up with an acceptable percentage and asked if it is a valid method to take that Atlas plus 20% and use it for the sub-hourly numbers. Michelle Miro responded that this method is what they currently do in the tool. They have 15 minute and up durations with the change factors applied. The limitation is that there isn't sub hourly projected data available from climate models, so it is an estimate. According to what they looked at comparing a 24 hour to 3 hour to 1 hour change factor, those change factors hold so they were comfortable applying them to shorter duration events in Atlas 14 data. However, this is an area that needs future work to confirm its validity. In the absence of better information, it's appropriate now.

10:50 Resilient Stream Restoration Design – Ward Oberholzer (LandStudies) and Scott Lowe (McCormick Taylor)

David Wood introduced this presentation by saying this presentation will inform us on the state of resilient stream restoration design, which is one of the most popular and commonly utilized Best Management Practices (BMPs). David mentioned that they did talk about stream restoration practices in the 4th memo of their BMP vulnerability series. Stream restoration practices face a lot of potential risk. They have the largest contributing draining area. Historically they have been designed to withstand high flow events rather than reduce them, although there are some techniques to spread the water out and slow water down to prevent downstream impacts. There is potential for increased erosion etc. if the BMPs are not designed to the correct reference conditions. These can be exacerbated – similar to Low Impact Development (LID) practices - by design principals and poor references. One of the changes over past couple years is adoption of guidance for inspecting and verifying practices that are installed for the Bay Total Maximum Daily Load (TMDL) purposes. This is a major improvement, now we have criteria for loss of performance longer into the future. On the water quality side there is little research that links prevented erosion and factors around floodplain trapping in climate change scenarios. There is potential for improving reductions if we're expecting baseline to be greater bank erosion – by preventing that, we might see greater performance. But, we have to consider variability and offsets that can happen if you have a single extreme event that leads to a failure of your practice. What we are asking is how to think about resilient stream restoration and design if we expect to see an increase in 100 year 24 hour storms over the next 50 years. How does it impact overall project design and feasibility, sediment loading, floodplain reconnection, implications for more armoring, sediment/nutrient remobilization, and what are impacts on stream restoration and longevity of these projects?

This session focused on climate change impacts on stream restoration design. Scott and Ward used a hypothetical restoration scenario to discuss how increasing precipitation intensity may impact:

- Reach sediment loading in the absence of any restoration

- How the higher flows would influence overall project design and feasibility
- Prospects for floodplain reconnection
- The implications for more armoring
- Project longevity and possible sediment/nutrient remobilization
- And more…

Summary

Scott Lowe noted that they use the IDF tool. There is a gap in research relating climate and stream restoration. Noted public safety with floods is major concern, but there is a lack of public trust around the need for stream restoration. Scott noted that watersheds are not always connected linearly in time and space in terms of responses.

Scott Crafton commented that the Conowingo Dam on the Susquehanna River is a great mega-example of a sediment sink that becomes a source of downstream sediment delivery.

Kristin Saunders commented that the Wetlands Workgroup is still trying to gain a foothold in meeting their goals, and wants to explore floodplain reconnection and wetland creation in alignment with stream restoration efforts and resilient design.

Scott Crafton commented that the pushback to big projects (mitigation banks) being depended upon vs. smaller Storm Water Management Model (SWMM) BMPs is that with the bigger projects, the small, very vulnerable headwater and first order streams get sacrificed -- more likely to blow out and accumulate pollutants. Plus the smaller streams tend to be much more fundamental to the food chain and eco-health of the stream. Lisa Wainger responded asking if sites low in the watershed are too developed to leave room for big projects.

Scott replied, I agree about the smaller streams. I think the headwater channels have the most long-term benefit from a water quality standpoint (and they are often connected to wetlands). The difficulty from a resiliency standpoint is that it is harder to impact peak discharges and have much attenuation unless you are further downstream in the watershed.

Ward Oberholzer commented that one thing they are seeing is that wetlands that are primarily herbaceous are more resilient than wetlands dominated by trees such as willows, birches, and alders although not those dominated by sycamore. These trees quickly block out other vegetation, and the other vegetation tends to have more rooting depth and surface area covered by roots, and vegetation laying down. When that is removed because of shading and crowding from willows and birches, we end up with obstructions in the channel and a lot of open sediment. We still have vertical controls underneath, but we don't see that occurring when we end up with a large sedge type wetland as opposed to forested wetland.

11:20 Discussion and Morning Recap

Participants discussed potential next steps and research recommendations for future refinements to the climate-change informed IDF curves and associated tools. They also discussed how best to advance resilient stream restoration planning and design.

Summary

David Wood said at this point it seems like we have some theoretical frameworks in place, and asked are there any priority research needs understanding how these systems work that would support resilient designs? Things that we could push out to academic partners.

Scott Lowe replied that when you're in a suburban/urban environment, or an environment that will be facing development pressures, the interaction with infrastructure around conditions is critical. They interrupt floodplain control tremendously. The transitions between any restoration approach or natural approach or any manmade impediment is where the greatest risk is introduced. Similar to what Barbara Dowell (?) presented in North Carolina about how flood plains and stream channels are interacting with our infrastructure – from a watershed study, site selection process, we have work to do on how to select sites optimally to also address infrastructure issues simultaneously. It's difficult if you approach something like a wide floodplain system that has to come into a 10 by 20 box culvert. The transitions create issues. Vegetation dynamics (like Ward commented on) in flood plains – forested channels are wider than herbaceous channels. What's optimal, what do we want to replace – obviously trees are important for carbon sequestration and temp management. There are crossovers and potential conflicts between different wants and needs. Ward emphasized the importance of decision science and how we need good frameworks around this.

People commented in the chat about the tradeoffs between the potential water quality benefits of working in headwater channels and smaller order systems as opposed to the potential resilience benefits from a hydrologist standpoint of working with the larger systems downstream where you have a larger valley do work with. David Wood asked for the presenters' thoughts about decision making around this.

Ward Oberholzer commented that we'll try to apply the flood plain restoration process wherever we have the availability of the valley to do it. The valley restoration process doesn't have to correlate with legacy sediment removal. Some of the projects we've done in western Pennsylvania in the mountains were somewhat watershed wide – we'd end up with a larger system, cut what we needed out and end up filling side slopes with a material that was cut instead of hauling it off. We would have smaller tributaries and feeder streams coming into the larger waterway. We'd use material we're cutting out to build alluvial fans between the tributaries and mainstem. We'd use the material from the mainstem to fill gullies and get the width that we need to reduce the shear stress. We're not cutting anything out of feeder streams but we might fill 7 or 8 feet to get a gully formation up to a width of 20 to 25 feet which is what we feel that we might need to lower boundary stress. If we're in a larger system and you don't have enough valley width to do a floodplain restoration project without putting a lot of armoring in, you would have two options. One if we think the stresses are low enough that we can get vegetation establishment, might armor it with buried rocks or logs. But if we have high stress, then we won't try to do a valley restoration type project, we'll do an armoring project. Whether the watersheds are small and steep or large and flat, we rely on valley width and lowering shear stress.

Scott Lowe commented that from a decision standpoint for better or for worse the crediting has driven a lot of the decisions that have had to be made by jurisdictions. As a participant in that process it's been successful in prioritizing projects that are most impaired or have longest term of potential impairment process. When you look at the expert panel document that drives decisions you see: longer sites produce more credit (more cost effective) and wider/longer area has a beneficial outcome. The other component is that protocol 5 helps to prioritize areas with a tremendous amount of incision. These areas will continually produce erosion and trees will fall, they will be hard to armor. Identifying these areas to be restored are a huge priority because they produce lots of sediments, they don't store anything, and they are conduits for pollutants from upland. These two approaches are beneficial; should do both approaches because they impact watersheds at different locations and have different benefits. If you haven't looked at upstream reaches and you're doing restoration project downstream when there's a lot of gully erosion upstream, you're going to have issues managing sediment in the future. Need to look at watershed and see what stresses are and address them systematically. Need to look at things from full delivery model.

Put all site location on private entities who are looking for the most cost effective project and it might not necessarily fit in a watershed approach; there needs to be a balance with that type of procurement mechanism as well.

Norm Goulet commented that we are still learning more and more about stream restoration and undoubtedly there will be another expert panel in the next 2 years.

David Wood said what we're looking for is to identify highest priority research and design and maintenance considerations around stream restoration design and resilience related to higher flows. We have new guidance around crediting, new verification protocols. There might be ways to provide an addendum that speaks to high flow conditions and decision making and tradeoffs. David asked for comments on top priority research items.

Scott Lowe commented the research that's done on the hydrology estimates is critical for moving restoration along particularly from a regulatory standpoint. The overall goals have not always been identified. We are going to run into a lot of conflicting goals. Sometimes they'll overlap in a positive way. Looking at watersheds and developing targeted goals for landuse, watershed improvements, whether that's species specific or temperature specific, or more granular for restoration designers to shoot for is good. This would promote innovation from designers' perspective if there are specific targets for benefits or protection attributes. For example, if the goal is 10% forested land, how can we combine stream restoration and reforestation.

Jason Coleman commented – Scott talked about practitioners using 2D models. I think a lot of practitioners are using 2D models. If you take the 2D model and increase the discharge, forgetting about 100-year interval – add 20% to it, you can put a number in and test drive any design. Looking at larger discharges and what your project's doing for long term resiliency, you can evaluate the velocity and shear stress based on larger discharge. You can get a good feel of how resilient your stream will be to shear stress, carbon storage, sediment and carbon movement, even down to resilient ecosystems, ecology and biology. It's a quick way to test drive your site during design.

Scott Lowe replied that groundwater drives a lot of decision. Understanding how groundwater may be influenced during a period of climate change or in response to storm response is not understood. Priority on research around expectations for groundwater would be good.

Ward Oberholzer added that it would be best to prioritize the waters that are closest to the Bay. To create conditions where you get more processing of the nutrients before it goes to the Bay, and you get more sediment dropping out prior to entering the Bay. For doing restoration to the feeding streams, I'm not sure what the lag is before the Bay feels any effect. However, anything close to the Bay would be felt much quicker. Even if it's in state parks, county owned properties – see results and get more impact here than elsewhere.

Lisa Wainger asked, are we tracking the restorations that blow out and under what precipitation conditions so that we can better characterize risk? David Wood responded that we don't have a comprehensive dataset to look at that, but it is a good suggestion.

Scott Lowe commented that the jurisdictions that undertake stream restoration projects are required to monitor and report their effectiveness. They follow the expert panel guidance. So each Municipal Separate Storm Sewer System (MS4) should have the erosion % tracked in their geodatabases.

Julie Reichert-Nguyen commented that in regards to sediment loading it will be important to also consider what tidal marshes need in terms of building resilience - marshes need sediment inputs to maintain resilience in low-lying areas and options for migration. It would seem that a consideration of

groundwater and sea level rise would be needed if looking into connecting/ discharging excess water through floodplain management to not inadvertently speed up drowning of tidal marshes. Scott Lowe commented these were very good points about sediment delivery.

11:45 Break

12:15 Climate-Impacts to Restoration Practices – Jon Butcher (Tetra Tech)

Jon presented his work projecting climate change-informed IDF curves in Maryland. Jon also discussed the resulting analysis of the practical consequences of the predicted changes in precipitation and runoff including: future BMP performance, flood risk, and channel instability.

Summary

Jon Butcher's final report, fact sheet, and database posted on the Pooled Monitoring Initiative's website (see awarded projects and search for "butcher"): https://cbtrust.org/grants/restoration-research/

Pursuing related work on IDF curves but slightly different from Michelle's work. Interest in methodological questions and interpretation of how it effects practical results.

Norm Goulet commented he's been hearing with the new IPCC report there will be new runs with the RPCs. If that occurs, all of the work that Jon and Michelle have done is going to have to be rerun in order to see those effects. Do you know any more about this?

Jon Butcher replied, yes, results were delayed a year by covid. They are just starting to become available. Not many downscaling products available yet – those take a long time to run with dynamic downscaling. Jon talked with developers of MACA and they are running full analysis nationwide towards end of this year. As of beginning of this year only 50% of the global models were released. The consensus is that the ?6 models are more detailed although not necessarily more accurate. They do resolve cloud dynamics better so they may be better for looking at convection type storms. In terms of updating, our method is pretty much automated now. Assuming they don't change the data format in the MACA release which I don't think they will we could rerun all the IDF and accompanying analyses quite easily.

Norm Goulet responded that when Atlas 14 is updated sometime in the next 2-2.5 years it should be a matter of putting the new information in and hitting go.

Lew Linker commented that he was interested in the work just concluded using CMET 5 and LOCA that connected climate change to SWMM models. You said there was a generic developed landuse model that was used to look at management practices and how it changes under climate change. Is that work accessible?

Jon Butcher responded – that is not calibrated SWMM models of individual sites, this is generic representation of 10 acre urban landscape at various levels of modified urban soils. A method of accounting for evapotranspiration, various transport characteristics, and so on to give you runoff estimate that is comparable to a runoff duration frequency curve.

Lew said this is the sort of thing that could be adapted to look at relative differences of what management practices could do under different hydrologies.

Jon responded – we've been looking at retention-based products and practices, and green practices represented by bioretention.

1:00 Resilient Floodplain Management – Jason Coleman (RK&K), Tom Schueler, CSN,

Tom Schueler introduced the presentation by reading a quote from "The Flood Control Controversy" by LB Leopold and Thomas Maddock. Tom said hope to hold a coastal plain workshop either virtual or onsite in tidewater Virginia. If anyone is interested, let Tom know. There was interest expressed by several participants including Lew Linker and Allan Brockenbrough.

Jason and Tom discussed how the proposed changes in IDF curves would affect current and future flood boundaries from the perspective of floodplain managers. In this session, we covered the status of floodplain mapping efforts, the effect of current factors or safety on flooding, and possible floodplain management strategies may make sense to pursue.

Summary

Increases in rain does not necessarily mean same increase in flooding because engineering designed with overdesigns that can handle some additional flow. However, flooding could be exacerbated by increases in impervious cover; also higher risk of pluvial flooding—flooding in streets; aging patchwork of stormwater design. For insurance purposes, FEMA floodplains excludes headwaters. The flooding risk is often underestimated since not always the best science used, just the affordable science. FEMA doesn't account for changes in rainfall or headwater streams and the average floodplain map is about 18 years old. The flood mapping process is based on hydrologic study using regression equations based on stream gauge data or using a computer model to convert rainfall to runoff. FEMA encourages localities to have stricter standards than the FEMA standards. FEMA has a voluntary incentive program where a more proactive community has lower flood insurance rates.

Strategies to increase flood resiliency include looking both vertically and horizontally. E.g., freeboard just has requirements to build to a specified height; should also consider new development to build outside "future" floodplain. Another option is modeling future runoff conditions. Also design based on extreme storm duration outcomes. E.g., 2" rainfall in 3 hours produces similar discharge as 100-yr, 24-hr storm.

Floodplain management challenges include existing development and infrastructure, loss of natural floodplains, unidentified hazards, imperviousness, inadequate stormwater management, and lack of local technical resources. Needs include vulnerability assessments—most vulnerable neighborhoods, most vulnerable infrastructure (water and sewer lines, local roads and bridges), most vulnerable stormwater ponds (assess condition), most vulnerable habitats (streams, greenways, parks).

Norm Goulet commented that Northern Virginia Flood Insurance Rate Maps (NoVA FIRMs) being updated this year.

Kristin Saunders commented, I feel like there is a misconception that Federal Emergency Management Agency (FEMA) floodplain maps will be the best/default place to start for us to identify vulnerable areas. Given what Jason just told us, what data resource should we direct people to for the correct layers for vulnerability and targeting work? Norm added to this that given that the FIRMs maps don't use climate analysis and coastal flooding in their mapping products are there other products that are available.

Jason Coleman said in the chat that many times the community itself can provide the best data of problem areas as they are fielding calls from affected residents. Also, the community should have data on "repetitive flooding". In MD and VA this is typically handled at the County level. The state may also have data as well. Jason also commented - I don't think there is one place to go to that's better than

FEMA. Typically when FEMA does the studies they use the best available data. There are some websites starting to look at future conditions. Although they don't have things mapped out, they do look at future flood risk and you can look by zip code where the most risk is.

Laura Cattell Noll said in the chat that a possible example to replicate: Charles County, MD is planning to use American Rescue Plan Act Funds to step in for "zombie HOAs" and install/maintain stormwater BMPs in a few neighborhoods (identified based on flood risk and equity criteria).

Norm Goulet said that Virginia is taking a different approach and there is some statewide mapping that will happen because of that. It's something that's occurring now. Norm asked, is Maryland taking a similar approach?

Jason Coleman respond that MD has updated 80% of their FEMA maps over the last four years. Typically when you wanted to get a FEMA model you had to request it and pay for the data. But they made a website called https://mdfloodmaps.net/ and you can zoom in on an area, download models right from their website. Those models aren't perfect, but at least all the information is there and it's easier to go into something that's already been developed and update discharges, a bridge etc. I imagine Virginia will have something similar to that. New Jersey is going up to 30 acre watershed to map flood plains.

Corey Miles asked in the chat: Tom/Jason, have you looked at how to determine flood damages that have occurred outside of FEMA mapped floodplains?

Kristin Saunders commented in the chat: our GIS team is trying to populate their open data portal with the best and most representative data layers to be considered, and hoping to get that into the hands of local planners and decision makers. Let's try to get the best recommendation of layers beyond FEMA to our GIS team @David Wood

Jon Butcher commented that how to integrate FEMA Flood Risk Information System (FRIS) with NOAA Sea, Lake and Overland Surges from Hurricanes (SLOSH) storm surge estimates seems still not resolved.

KC Filippino asked did any of the "most vulnerable" categories include impacts to water quality? Can we solve all of our water quality and quantity problems simultaneously or will we still have to do more? David Wood responded that we had to rush through some of that discussion yesterday afternoon, but it sort of falls under the "MVB - Most Vulnerable BMPs (non-pond)". Looking at Performance Enhancing Devices (PEDs), smart sensor tech, etc. are one way we're looking at reducing vulnerabilities to WQ impacts. I'll include it in the summary.

1:30 Moving Towards Implementing Resilient Design Principles – Michelle Miro (RAND), Alan Cohn (NYC DEP), Ben McFarlane (HRPDC)

This session focused on options for watershed managers interested in applying projected IDF curves in their stormwater programs or implementing alternative resilient design principles. This discussion featured case studies from Hampton Roads and New York City to set the stage for possible recommendations for other Bay managers.

Summary

https://www1.nyc.gov/site/orr/index.page
https://www1.nyc.gov/site/dep/environment/climate-resiliency.page

New York City looking at how green and gray infrastructure can be used together to minimize extreme rainfall events like those from Hurricane Ida. Assessing ideas based on strategies from Copenhagen related to green infrastructure and the storage of more water. They chose future 10-yr event as their goal for designing a series of practices emphasizing connectivity. E.g., proposing to lower basketball court to allow flooding there as last resort.

Hampton Roads utilized the RAND IDF product to calculate future precipitation values based on locality centroids and Atlas14. Also looked at existing impervious cover to figure out the percentile to choose. They equated high imperviousness with more risk based on 50^{th} and 75^{th} percentiles They recommended one multiplier for each locality (a bit different from what MARISA envisioned).

David Wood asked do you have a sense of the receptiveness of communities in terms of adopting some of this guidance?

Ben McFarlane responded that he thinks some communities will adopt. The state department of transportation is working on something similar. The timeline to modify a local ordinance can vary, however. For example, Virginia Beach worked on theirs for two years before adopting. Nobody has said no yet but uncertain about when. David Wood commented to keep in mind the goal of more communication and coordination with other groups and entities at different levels.

Derick Winn asked, are tide valve installations on outfalls in Hampton Roads common for preventing tidal flow into outfalls? Ben responded not sure how common they are, knows there are some and thinks they are becoming more common. KC Filippino agreed.

Lew Linker highlighted how comprehensive the challenge is. Not only more rainfall, more intensity, sea level rise. Lew commented on the plus side we have a very talented team coming up with innovative ways to deal with the problem.

Norm Goulet added that we haven't even discussed politics. Some of the most contentious work Norm experienced is updates to state stormwater standards and state stormwater BMP handbooks. James Martin added land subsidence as an issue. Norm says a lot of it needs to be top down from the states as there is only so much local government can do. Lew commented at least the Chesapeake Bay region and the Mid-Atlantic is leaning into these issues.

Elizabeth Feinberg asked if there are any examples of municipalities that have halted new land development while they figure how to manage these challenges? Ben McFarlane responded that Virginia Beach denied a rezoning application because of flooding. Alan Cohn said that NYC is downzoning some coastal areas to minimize population growth in some at-risk areas: https://www1.nyc.gov/site/planning/plans/flood-resilience-zoning-text-update/flood-resilience-zoning-text-update.page

Ben McFarlane commented that in the recommendations that we're developing we are consistent in telling our localities that the plan is to update these as appropriate. In terms of practice planning and engineering, we tend to do something and leave it alone for 20, 30 years. However, the rate of change is too fast to continue with previous practices where we waited longer intervals between evaluations. We're still waiting on the next tidal datum to come out from NOAA – the current one is from 1982-2001. We went with this more simplistic approach for change factors because we know Virginia is supposed to finish updating Atlas 14 by 2023-24. Went for something simple enough to be implemented at the local level. We don't have to be perfectly right but we need to be better than what we're doing right now. Lew Linker commented that things are changing fast and we'll be handing this problem to our kids. Remember the steps that we go through so it becomes more of the norm as we step through these next several decades.

Alan Cohn responded to the chat comment about MS4 compliance, saying that a lot of what we've been doing has been building off regulatory compliance. Anything we're doing in regards to green infrastructure came out of Combined Sewer Overflow (CSO) reduction efforts. The foundation of what we can do is available, but what we don't have is the guidance or push to move us to solutions that meet multiple objectives. We need help to not just to meet client goals but how we can design programs that are responsive to climate change.

Mark Hoffman commented that at our last Commission meeting in Easton we did a field visit to a stream restoration project. Although the project helped meet MS4 requirements - the reason the project was done was to address flooding in town and now that have more residents that want this done.

Michelle Miro added that a lot of these challenges are on the implementation side. Some of the challenges are further upstream on the science side. Talking about rapid changes and impacts on the ground – the science is catching up. For those of us in the research side who work in the applied space trying to translate and improve the climate science so it's useful on the ground, really needs open communications with those of you on the ground so we make sure the science and research we're producing is useful to you and meeting your needs.

2:15 Discussion, Wrap Up, and Next Steps

Participants discussed the afternoon presentations, with the goal of producing a series of recommended action items and next steps for the workgroups and other partners.

Summary

David Wood presented the final wrap up and a summary of research needs from days 1-2.

Day 1 Research needs:

- More long-term studies on BMP responses to climate change – especially for most vulnerable that combine biological and hydrological mechanisms (Type 1/A/4)
- Impact/Interaction of maintenance and upkeep with climate change functions on BMP performance
- Modeled Study that adjusts only hydrology to determine impacts on BMP removal efficiencies, along with uncertainty analysis
- Further advancements of temporal resolution of downscaled climate models. 1 hr resolution is not enough for most urban watershed modeling applications
- Study of impacts of increased sizing on other variables (ex. Larger BMPs will be dryer for longer)

Day 2 Research needs:

- Decision making frameworks and research on understanding how managers are operationalizing ranges of future climate changes
- Deeper dive into sub-hourly factors
- How are microbursts accounted for in sediment transport models
- More comprehensive assessment of risk and failure and the storm sizing/design/siting factors
- Real site examples of interactions between development (IC), ESD, and flooding/flows under climate conditions

Implementation support needs:

- More robust decision-making frameworks for SR siting and design, weighing variable objectives (including resilience)

    - Similar work to tie objectives to design considerations for GI
- Guidance on how to interpret range of uncertainty for different infrastructure types and locations
- Rapid community and asset vulnerability assessment tools
    - Priorities? Vulnerabilities that weren't discussed?
- Addressing equity implications of vulnerability assessments and voluntary adoption of resilience standards
- Updated model/pilot specs to demonstrate resilient design considerations, maintenance benchmarks etc.

Blended Research and Action:

- Mid-Atlantic Regional Integrated Sciences and Assessments (MARISA) team workshop recommendations
- More guidance and research on tidal/runoff interactions to provide better resources for coastal communities

David Wood asked of participants what stands out, any priorities or takeaways, what is the best way to package these tools for adoptability for state and local governments, what is the interest level from workgroup partners on engaging with development process?

KC Filippino commented that we also didn't talk about funding, VB has a Flood Protection Program bond referendum on their November ballot to decide whether or not they should increase real estate taxes to fund flood protection projects. David said that funding should be on the list in terms of the implementation side.

Julie Reichert-Nguyen shared a note she received from Jeremy Hanson yesterday clarifying the characterization (based on certainty): the Venn diagram is a useful way for us to organize our approximate sense of current "certainty" for the performance of BMPs [performance meaning nitrogen, phosphorous and sediment reduction], but it is NOT a representation of resilience of the practices. Just because a lot of the "complex" BMPs fall into zone 1, doesn't mean that those practices are the least resilient, it just means we have the hardest time to understand their much more complicated impacts and processes.

Derick Winn asked in the efforts to develop regional bank erosion rate curves for stream restoration projects has climate change impact been considered?

KC commented that more of a conversation on smart BMPs is needed. These will be very important in coastal area particularly.

David closed out by thanking all presenters, and that he'll be following up on some of the action items. He'll be giving a recap of these two days at the upcoming WQGIT meeting.

2:45 Adjourn

Day 2 Participants:
Elizabeth Feinberg, Jon.Butcher, Shana Stephens, Allan Brockenbrough, Alana Hartman, Adrienne Kotula, Martin Koch, Scott Crafton, David Wood, Yi Liu, Jennifer Smith, Dave Montali, Peter Clagget, Allison Breitenother, Alan Cohn, Jamie Eberl, C. Hegberg, Deb Cappuccitti, Lisa Ochsenhirt, James Martin, Allie Wagner, Lisa Wainger, Ginny Snead, Deborah Herr Cornwell, C.Lane, Alexander Gunnerson, Cassandra Davis, Taryn Sudol, Lew Linker, Paul Mayer, Sally Claggett, Josh Burch, Ted Brown, Marel King, Mark Symborski, Sadie Drescher Matt Meyers, Ward Oberholzer, Kate Bennett, Ashley Gordon, Brenda Morgan, Shana

Stephens, KC Filippino, Katie Brownson, Tom Schueler, Meredith Neely, Jeff Ratteree, Scott Lowe, Audra Lew, Katie Dyer, Ginger Ellis, Nick Lindow, Mark Voli, Hilary Swartwood, Heidi Bonnaffon, Mark Bennet, Stewart C., Khurhid Jahan, Nicole Carlozo, Mark Hoffman, Arianna Johns, Jeff Hartranft, Ben McFarlane, Earl Bradley, Jessica Rodriguez, Amy Goldfischer, Karl Berger, James Dunbar, Michelle Miro, Laura Cattell Noll, Corey Miles, Jason Coleman, Maria Mutuc, Normand Goulet, Matthew English, Jessica Krueger, D. Austin, Aaron Fisher, Michelle Crawford, Kristin Saunders, Robert Goo, Julie Reichert-Nguyen, H. Gewandter, Archana Sharma, Neely Law, Megan Barniea, Gary Shenk, Breck Sullivan, Jennifer Carr, Kevin Hess, Nora Jackson, Elaine Webb, Anna Hamilton, Jeff Hartranft, Derick Winn, Jesse Maines, Kate Bennett, Christina Lyerly, Shana Stephens, Alex Foraste, Gabrielle Bryson, Kevin Du Bois.