Stormwater Backup in the Chesapeake Region

Hit by Increasing Rainfall, Pennsylvania and Maryland Retreat in their Plans to Control Stormwater Pollution

FOR RELEASE:
August 17, 2020

EIP ENVIRONMENTAL INTEGRITY PROJECT

ACKNOWLEDGEMENTS:

This report was researched and written by Abel Russ, Mariah Lamm, Ari Phillips and Tom Pelton of the Environmental Integrity Project (EIP). Support for this report provided by the Campbell Foundation.

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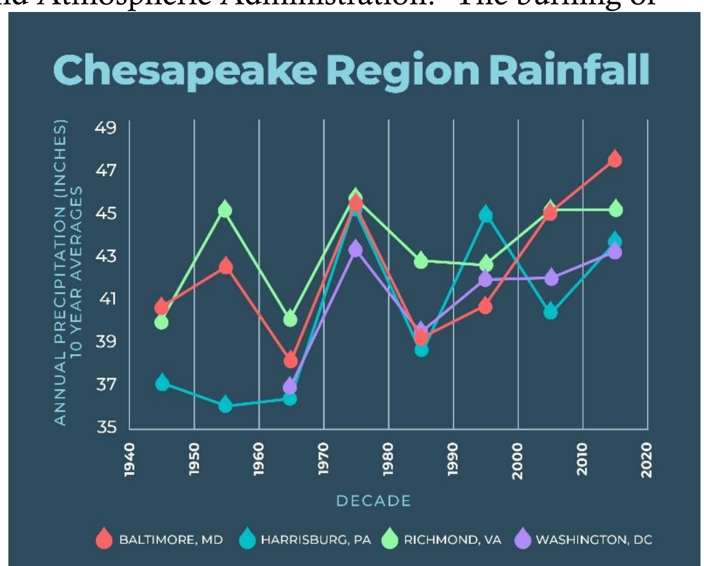
Stormwater Backup:

Despite Increasing Rainfall, PA and MD Retreat in their Plans to Control Stormwater Pollution

Executive Summary

In 2018, record-setting amounts of rain drenched the Chesapeake Bay region, including 72 inches in Baltimore – which was 75 percent more than the annual average stretching back to the 1940s.[1] Another 67 inches deluged Washington, D.C., 64 inches pummeled Richmond, and 62 inches flooded Harrisburg, among other locations. The amount of fresh water pouring into the nation's largest estuary in 2019 was by far the highest ever recorded, averaging 130,750 cubic feet per second, according to U.S. Geological Survey.[2] While many people think of rain as a cleansing force, in our modern world, because of all the fertilizers on lawns and farms and the oil and antifreeze on our roads and parking lots, increased precipitation sweeps more pollution off of these surfaces and into our waterways. This results in more sediment clouding the Bay's waters and more nitrogen and phosphorus fueling algae blooms and fish-killing low-oxygen "dead zones."

Both of these recent high-water years dealt blows to Chesapeake cleanup efforts.[3] But they were not freakish events. In fact, the amount and intensity of rainfall across the whole region has been gradually creeping upward for the last century, according to data from the National Oceanic and Atmospheric Administration.[4] The burning of fossil fuels has wrapped an insulating blanket of greenhouse gases around the Earth, heating the atmosphere. Warmer air retains more moisture, leading to more precipitation in some areas, including the Chesapeake Bay watershed.



Ten year average rainfall totals from National Oceanic and Atmospheric Administration (NOAA).

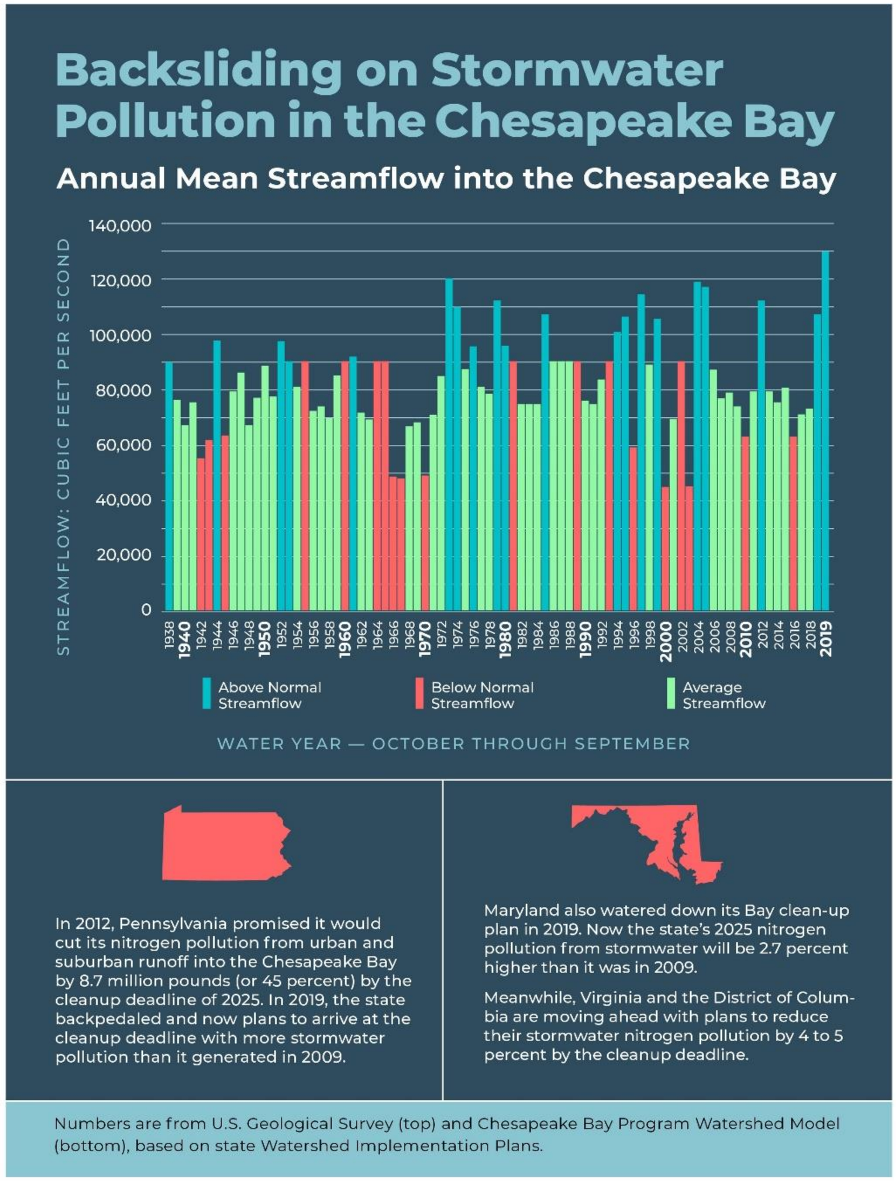
This increased runoff has created an additional challenge to the most recent Chesapeake Bay cleanup plan, launched by the U.S. Environmental Protection Agency and Bay region states in 2010, called the Bay Total Maximum Daily Load (or TMDL). The Bay TMDL requires states to implement plans by 2025 that will reduce nitrogen, phosphorus, and sediment flowing into the Bay by about a quarter. Cleanup progress has been erratic. Effluent from wastewater plants and some other sources has declined substantially. However, pollution from urban and suburban stormwater runoff has been increasing – up 5 percent for nitrogen between 2009 and 2019, up 3 percent for phosphorus and sediment over this time period, according to numbers from the EPA-led Chesapeake Bay Program.[5] In 2019, stormwater from developed land contributed 40 million pounds of nitrogen to the Bay (16 percent of the total nitrogen pollution), 2.6 million pounds of phosphorus (17 percent of total), and 1.7 billion pounds of sediment (9 percent of total).[6]

The growth of suburban sprawl and parking lots have increased the amount of runoff pollution fouling the Chesapeake Bay.

One reason for the increase in urban and suburban runoff pollution is continued real-estate development and suburban sprawl – and the failure of states to control this growth in impervious surfaces. Since 2009, the amount of developed land in the Bay watershed has increased by about 300,000 acres, or about 6 percent – an area six times the size of the District of Columbia -- adding more blacktop, roofs, and roads that accelerate runoff pollution.[7] But the other reason – as mentioned earlier – is the increase in rainfall from climate change. The Chesapeake Bay Program projects that climate change will increase annual nitrogen pollution in the Bay by 9 million pounds (or 3.6 percent) between 2018 and 2025, and increase annual phosphorus loads by 489,000 pounds (or 3 percent).[8]

Given those warnings of an increasing pollution load, the Bay region states should have incorporated more aggressive pollution control measures into their Bay cleanup plans, but two of the largest states did not. In their most recent pollution reduction plans submitted to EPA in August 2019—their Phase III "Watershed Implementation Plans" or WIPs – Pennsylvania and Maryland failed to incorporate the added pollution load attributable to climate change. Virginia, to its credit, has built the additional load from climate change into its plan and is moving forward with more projects to meet more stringent stormwater planning targets.

In contrast, Pennsylvania and Maryland retreated in their proposed efforts to reduce urban and suburban runoff. This is significant because Pennsylvania, Maryland and Virginia account for about 90 percent of the urban and suburban runoff pollution fouling the Bay. Overall, due largely to backsliding by Maryland and Pennsylvania, the Bay states' pollution reduction goals for 2025 have been scaled back significantly. The prior (Phase II) WIPs called for a watershed-wide stormwater nitrogen reduction of 7.9 million pounds by 2025, relative to the 2009 baseline. The current (Phase III) WIPs only call for a reduction of 0.5 million pounds.[9] In other words, the states have given up on 7.4 million pounds of nitrogen reductions from urban and suburban runoff. Similarly, the states have given up on 340,000 pounds of phosphorus pollution from stormwater and 382 million pounds of sediment.[10]



Meanwhile, at the local level, many cities and counties – like the states of Maryland and Pennsylvania – are not adequately planning for the increased volume of rainfall and stormwater already inundating their communities and causing flash flooding and erosion problems. As one planning consultant in Prince George's County warned: stormwater control projects "designed for current conditions will most likely fail to sufficiently treat and reduce runoff from the projected larger and more intense storm events."[11]

For this report, the Environmental Integrity Project (EIP) analyzed federal, state and county records and pollution control plans (including Phase II and III WIPs), as well as data from the Chesapeake Bay Program, U.S. Geological Survey, and other sources.

Among this report's conclusions are the following:

- Maryland and Pennsylvania's 2019 Bay cleanup plans (Phase III WIPs) set goals for nitrogen pollution entering the Bay from urban and suburban stormwater in 2025 that are *higher* than the loads back in 2009.This means these states are accepting increases in this pollution over this time period instead of planning reductions.

- Maryland's 2019 plan would allow an increase in the amount of nitrogen pollution flowing into the Bay from stormwater runoff by 249,000 pounds per year by 2025, compared to the 2009 baseline, according to the EPA-led Bay Program. Back in 2012, by contrast, Maryland had been planning for a 1.3 million-pound annual reduction.[12] Combined, that's a retreat of more than 1.5 million pounds of pollution per year.
- Compared to its 2012 plan, Maryland is now planning to build fewer stormwater-filtering projects called rain gardens (zero instead of 34,716 acres) by 2025. The state also plans to create less pavement permeable to water (zero acres instead of 350), and plant fewer forested acres along urban streams (zero instead of 26,430), among other retreats.[13]
- Pennsylvania's 2019 Bay cleanup plan will allow nearly 7 million more pounds of nitrogen pollution from urban and suburban runoff by the 2025 cleanup deadline than its 2012 plan. The new plan will increase the amount of nitrogen flowing into the bay from developed areas by 250,000 pounds by 2025, compared to the baseline of 2009, instead of decreasing it by 6.7 million pounds.
- Among other changes, the Keystone state's new plan would include replacing only replacing 202 acres of parking lots and other "impervious surfaces" instead of the 2,300 acres planned by the state back in 2012. Pennsylvania's 2019 plan would create 203,265 acres of stormwater control ponds, wetlands and other projects by 2025, instead of the 1.5 million acres of stormwater control practices planned back in 2012.[14]

Pennsylvania is dialing back its plans to build stormwater control ponds, wetlands, and permeable parking lots that would reduce flash flooding and stormwater pollution.

- By contrast, Virginia's most recent Bay cleanup plan (Phase III WIP) would reduce nitrogen pollution from urban and suburban stormwater by 408,000 pounds by 2025. Virginia would also reduce the amount of sediment flowing into the Bay from urban areas by 66 million pounds.
- To achieve these reductions, Virginia would plant 30,000 trees to absorb runoff (38 times more than the 799 trees in its last plan), and install 4,564 acres of pavement permeable to rain (instead of the 52 acres of permeable pavement proposed back in 2012), among other changes.

At the local level, EIP examined stormwater planning documents for 11 large counties in the Chesapeake Bay watershed – including Baltimore and Montgomery counties in MD; Lancaster and York counties in Pennsylvania; and Fairfax and Loudon counties in Virginia – and found all of them are planning for past rainfall averages, rather than for current and future rainfall volumes caused by climate change. We also scrutinized the plans of four cities with outdated combined sewage and stormwater systems that are planning upgrades to reduce sewage discharges and found that all of them are planning infrastructure based on outdated assumptions about rainfall. The worst case was in Cumberland, Maryland, which is planning on only 37 inches of annual rainfall as it designs an upgraded pipe system, when in reality 48 inches have been falling on that city each year over the last five years (a 27 percent difference). Washington, D.C., has a 21 percent gap between its planning for overflows and reality; Harrisburg, Pa., 15 percent; and Lynchburg, Va., 13 percent. Inadequate planning and infrastructure in some of these cities is contributing to severe local water quality problems. In Harrisburg, for example, bacteria monitoring by the Lower Susquehanna Riverkeeper in June and July of 2020 found *E. coli* bacteria concentrations in the river that averaged more than 2.5 times safe levels for swimming or water contact recreation, including just downstream from outfalls leading from the Governor's Residence and State Capitol Complex.[15]

This report looks briefly at all four of these cities, and then provides detailed case studies about what two communities – Washington, D.C., and Ellicott City, Maryland – are doing to manage increasing volumes of stormwater.

What are the solutions to the problem of rising runoff pollution and flash floods caused by climate change? EIP makes the following recommendations:

1) Broadly speaking, we should be planning for the future, not the past. There is no question that rainfall in the Bay region is increasing in both total volume and intensity. Planning at all levels – from the federal government down to the county and city level – must take these trends into account. All levels of government should start calibrating their planning and stormwater control projects and infrastructure to reflect likely future rainfall patterns, not historic averages from decades ago.
2) EPA must take a more active leadership role and require Pennsylvania and Maryland to strengthen their stormwater control plans and account for climate change. Instead of backtracking, Pennsylvania and Maryland should expand the stormwater pollution projects in their Phase III Watershed Implementation Plans.
3) EPA should require Pennsylvania to commit substantially more resources to its Bay cleanup effort, which has been far behind the other states. Federal actions could include the denial of permit approvals for major construction projects in Pennsylvania and a demand that the Commonwealth upgrade its leaky combined stormwater and sewage systems, including in Harrisburg.
4) States and municipalities across the Chesapeake region should invest more in stormwater control projects, such as the construction of artificial wetlands, ponds, rain gardens and the conversion of parking lots and other impervious surfaces to

green areas that absorb rain. These projects not only control runoff pollution, they also help address environmental justice issues by creating parks in urban areas that are often dominated by blacktop.

5) Because stormwater control projects are expensive, EPA and Congress should provide substantial federal funds to state and local governments to help pay for these projects, which create jobs. Such federal investments would be a healthy economic stimulus package to help the nation rebound from the COVID-19 recession.

With a problem as sweeping as climate change impacting all other environmental issues in the Bay watershed – from water pollution to flooding – it makes more sense to plan for their interconnectedness than to pretend they exist in isolation. Building more stormwater control infrastructure is also an ideal way to put American construction workers back to work during an economic downturn. Planting trees and building parks and green roofs on buildings to absorb rainwater also helps poorer neighborhoods in cities like Baltimore, Harrisburg, and the District of Columbia. These cities are often starved of green space and act as concrete frying pans in the summer, with temperatures several degrees hotter than wealthier and leafier suburban neighborhoods.[16] Adding greenspaces and trees will help alleviate environmental injustices, give urban neighborhoods more room to breathe, and help hold down temperatures in a warming world.

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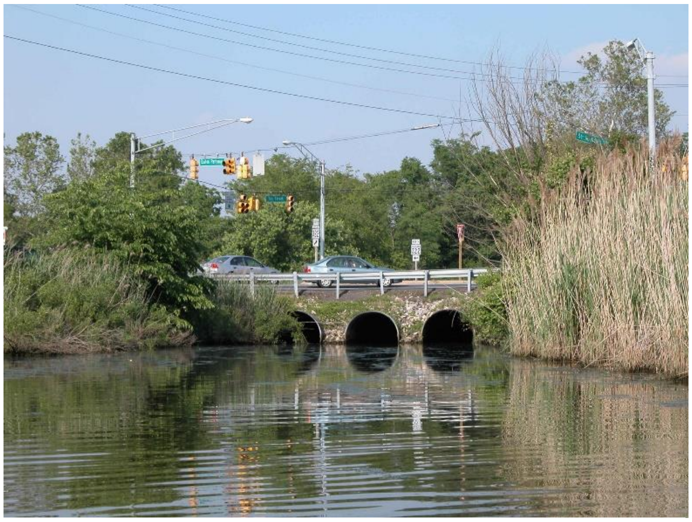
I. Background: Growing Rainfall and Suburban Sprawl

Climate change is causing increases in both total precipitation *volume* and precipitation *intensity*, or high-rainfall events. This is largely because warmer air holds more moisture.[17] As described in more detail below, the Chesapeake Bay watershed is uniquely vulnerable to these trends for three reasons. First of all, the Bay is already impaired, so there is no "buffer" that could help absorb the adverse impacts of climate change. Second, the Bay watershed is located in the northeastern United States, where precipitation intensity is increasing faster than anywhere else in the country. Third, the overall impact of climate change on the Bay includes much more than precipitation and stormwater (the focus of this report). As noted in the most recent National Climate Assessment, "[t]he Chesapeake Bay watershed is experiencing stronger and more frequent storms, an increase in heavy precipitation events, increasing bay water temperatures, and a rise in sea level."[18]

The historical trends for the northeastern United States are clear. Since 1900, total annual precipitation in the region has increased by roughly 1 cm per decade – twice as fast as the country as a whole.[19] In the Chesapeake Bay region, record-setting amounts of rain fell in 2018 in Baltimore (72 inches), Harrisburg (62 inches), Richmond (64 inches), and Washington DC (67 inches), among other locations, according to data from the National Oceanic and Atmospheric Administration (NOAA) dating back to the 1940s.[20] The upward trend has been fairly consistent over the decades, suggesting that 2018 was not a freakish year but possibly a reflection of a new normal. For example, in Baltimore, the annual average precipitation from 2010 to 2019 was 47 inches – 24 percent higher than the 38 inches per year from 1960 to 1970.[21] In Harrisburg, the 2010-2019 average was 44 inches, 22 percent more than the 36-inch average during the 1960s.[22]



Stormwater culverts discharge into a marsh along Maryland's Avon River, which empties into the Chesapeake Bay.

Beyond the sheer amount of rainfall, trends in precipitation *intensity* have been described in a variety of ways. For example, one study observed that, in the northeastern United States between 1979 and 2013, the frequency of "very wet days," and the total annual volume of precipitation falling on very wet days, increased by about 10 percent per decade.[23] Another study observed that, in the northeastern United States between 1958 and 2016, the amount of precipitation falling on the wettest days increased by 55 percent.[24] It is also worth noting that precipitation intensity has been increasing faster in the northeastern United States than anywhere else in the country.[25]

As a result, the Chesapeake Bay has been experiencing unprecedented volumes of fresh water pouring into the estuary from streams and rivers. According to data from U.S. Geological Survey, 130,750 cubic feet per second of fresh water flowed into the Bay in 2019. This was by far the highest on record since monitoring began in the 1930s.[26]

All of this extra water is washing more pollutants off parking lots, roads, suburban lawns and farm fields into the Bay, harming the estuary's health. As the amount of runoff into the bay jumped in 2018 and 2019, for example, the overall health of the Bay, as measured by the University of Maryland Center for Environmental Science's annual report card, declined from a 54 out of 100 in 2017 to a 44 out of 100 in 2019. That was a lower health score than the 52 rating in 2009, before EPA and states launched the Bay pollution diet (the TMDL cleanup process) in 2010.[27] Not coincidentally, the year with the Bay's best health on record – 2002, when it rated a 55 out of 100 – was also the year with the lowest amount of fresh-water flow into the estuary on record.[28] The trends toward increased rainfall, stormflow and runoff are expected to continue or accelerate because of climate change. According to one set of climate models, the northeastern United States will experience a faster increase than any section of the country, with a four or five-fold increase in heavy precipitation events (more than one inch of precipitation) by 2100.[29] Perhaps most troubling is the fact that we will see many more very wet days, but also more very dry days, with fewer days that we would consider normal.[30] The new reality will be, quite literally, "when it rains, it pours" – with higher levels of pollution as a result.

The combined impact of growing rainfall and increased precipitation intensity on erosion and sediment runoff was succinctly summarized by a group of Bay-area scientists ten years ago:

> *Annual sediment loading to the Chesapeake Bay is a non-linear function of annual streamflow, indicating an increase in total suspended sediment concentration as flow increases, which likely results from enhanced erosion and resuspension of sediments in the streambed. Even if the mean discharge were to remain unchanged, erosion could increase if precipitation intensity were to increase, a projection that is more certain than annual streamflow discharges.*[31]

All of this is undisputed – the EPA-led Chesapeake Bay Program and the Bay states have readily acknowledged these trends in their respective planning documents.[32] In short, everyone knows that climate change is already causing increased pollution loads, and everyone knows that the problem is going to get worse.

On top of this problem is the challenge of the growing amount of blacktop and other impervious surfaces because of suburban sprawl. Every year, development spreads over an additional roughly 32,000 acres across the Chesapeake Bay watershed.[33] This means that every year an area of land about three quarters the size of Washington, D.C. is converted to parking lots, roofs, roads, lawns, and buildings from fields and forests.[34] That means less rain is being absorbed by natural land cover and filtered by trees, and more is being funneled into Bay tributaries.

These trends make the goals of the Chesapeake Bay cleanup (the TMDL) more difficult to attain. The Bay region states will have to adjust their targets and ramp up their levels of effort. This may be especially true for the stormwater sector, which is uniquely vulnerable to changes in precipitation intensity.

A 2018 EPA analysis provides a detailed illustration of how climate change and increased rainfall in the Chesapeake Bay watershed will require local governments to build significantly more stormwater control projects than they are currently planning. EPA's National Center for Environmental Assessment wanted to estimate how climate change-induced changes in precipitation would affect the performance of stormwater pollution control projects, also known as Best Management Practices (BMPs), such as stormwater detention basins, in a variety of settings. The 2018 analysis looked at five types of developed land use in five geographic locations, and modeled BMP performance under both current precipitation patterns and projected future (mid-21st century) scenarios. Overall, EPA found that "BMPs designed for current conditions will not mitigate increases in stormwater runoff and associated downstream channel erosion and flooding under projected future conditions."[35] To accommodate future precipitation, "current practices will need greater temporary volume storage and/or reconfiguration of outlet structures to mitigate flooding and channel erosion risk."[36]

One of EPA's case studies was a hypothetical 20-acre mixed-use development site in Harford County, Maryland. EPA first determined that precipitation in this region will change dramatically by mid-century. Total annual precipitation volume will increase by 12.8 percent compared to current conditions, and the hourly precipitation volume for large storm events will increase by roughly 50 percent.[37] Perhaps most vividly, storms that now happen every ten years, on average, will be recurring every two years under future conditions.[38] Today's "ten-year storm" will be tomorrow's "two-year storm." EPA next looked at how various combinations of stormwater BMPs would perform under present and future conditions at this Maryland site. Under future conditions, the runoff volume and pollution loads using "conventional" BMPs (sand filters and dry detention basins) would increase by 50-70 percent.[39] To accommodate the added precipitation, EPA estimated that this hypothetical 20-acre site would have to add 1-2 acres of additional pollution control projects (BMP space).[40]

The rest of this report looks at whether the Bay region states are making adequate course corrections at the state level, at the county level, and at the level of individual stormwater permits. The answers, unfortunately, are not reassuring.

1. Failing the "Pollution Diet."

The Chesapeake Bay Total Maximum Daily Load (TMDL) is often described as a "pollution diet" for the Bay. If this is a diet, then the urban stormwater sector is overweight and eating ice cream.

A. TMDL Progress to Date

Since 2009, stormwater pollution loads have been increasing.[41] The Bay states have made a small amount of progress in reducing per-acre stormwater loads, but not enough to keep up with new growth and the expansion of developed acres. As a result, total stormwater nitrogen loads have increased by almost 5 percent since 2009, phosphorus has increased by about 3 percent, and sediment by almost 2 percent. The following table shows trends at the watershed scale.

Table 1: Developed Land and Stormwater Pollution in the Chesapeake, 2009-2019

	2009	2019	Change (%)
Developed acres	5,157,202	5,478,731	+6.2%
Pollution Loading Rate (pounds per developed acre)			
Nitrogen	7.36	7.26	-1.3%
Phosphorus	0.49	0.48	-3.5%
Sediment	326	315	-3.5%
Delivered Load (millions of pounds)			
Nitrogen	38.0	39.8	+4.8%
Phosphorus	2.5	2.6	+2.5%
Sediment	1,683	1,725	+2.5%

NOTE: All pollution estimates are "edge of tide," or delivered loads of pollution into the tidal Chesapeake Bay.

Appendix A shows state-level trends and reveals some state-to-state variability. For example, West Virginia has done more than enough to offset new growth, and the state's stormwater pollution loads have declined since 2009. Maryland, by contrast, has seen about the same level of growth in developed land as West Virginia (about 5 percent per year), but has also seen an increase in the per-acre loading of nitrogen and sediment. This means that nitrogen and sediment pollution in Maryland are increasing faster than new development. It is important to keep in mind that these estimates were generated using a model that assumes weather patterns from 1991-2000. See Section 3, Planning for Climate Change, below). Given changes in precipitation over the past twenty years, it's likely that the increase in stormwater loads has been even greater than the Bay program estimates.

We now turn to the Bay states' planning goals for the sector.

B. Relaxing the Goals

As part of the TMDL, the states periodically complete "Watershed Implementation Plans," or WIPs, which lay out numeric pollution reduction targets and strategies. The "Phase II" WIPs were completed in 2012. The "Phase III" WIPs were completed in 2019.[42] Each WIP provides targets in the form of loads that the states expect to see in 2025.

The following Table (Table 2, below) compares the nitrogen reductions that would have been achieved under the Phase II WIPs to the reductions that the states are now aiming for under the Phase III WIPs. This table shows that the two of the largest sources of stormwater pollution – Maryland and Pennsylvania – are backsliding on their commitments and are now planning to end the TMDL process with stormwater loads that are *higher* than when they started. As a result, and despite the fact that the other states are setting slightly more ambitious targets, the total Bay-wide stormwater load in 2025 is now expected to be higher than it would have been under the states' 2012 plans, and only about 1 percent lower than it was in 2009.

Appendix A provides parallel tables for phosphorus and sediment, which show the same thing – Maryland and Pennsylvania have dramatically relaxed their planning goals, and as a result the Bay-wide stormwater pollution loads in 2025 are now expected to be greater than they would have been under the state's 2012 plans, and not much lower than they were in 2009.

Since 2009, Bay states have made a small amount of progress in reducing per-acre stormwater loads, but not enough to keep up with new growth and the expansion of developed acres.

Table 2: Stormwater Nitrogen Pollution from Developed Land

State	2009 pollution (millions of pounds)	2025 targets (millions of pounds)		Planned change in pollution, 2009-2025	
		2012 plan	*2019 plan*	*2012 plan*	*2019 plan*
DE	0.66	0.70	0.65	+6.9%	-1.3%
DC	0.17	0.17	0.16	-4.4%	-4.8%
MD	9.01	7.69	9.26	-14.6%	+2.7%
NY	1.94	1.90	1.40	-2.0%	-28.0%
PA	14.76	8.06	15.06	-45.4%	+2.0%
VA	10.14	10.26	9.72	+1.1%	-4.1%
WV	1.23	1.23	1.17	+0.1%	-4.7%
TOTAL	**37.92**	**30.01**	**37.43**	**-20.9%**	**-1.3%**

NOTE: Pink cells above indicate a reduced level of effort. All load estimates are "edge of tide," or delivered loads of pollution. "2012 plan" and "2019 plan" loads represent the loads associated with Phase II and Phase III WIP commitments, respectively, as shown by the Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST).[43]

The following subsections look more closely at the evolving stormwater pollution strategies in Maryland, Pennsylvania, and Virginia, which together account for roughly 90 percent of the urban stormwater pollution affecting the Bay.[44]

i. Maryland's Implementation Plans

Maryland is effectively giving up and walking away from its stormwater commitments. According to the state's Phase III WIP:

> *The slower pace of restoration progress in the urban stormwater sector relative to wastewater and agriculture means that stormwater discharges will make up a larger proportion of the State's nutrient loads by 2025 - approximately 20% and 19% of the nitrogen and phosphorus loads, respectively. Reduction opportunities outside the stormwater sector will concurrently decrease, and stormwater management will become a more important part of Maryland's nutrient reduction portfolio. The result is that maintaining the statewide target pollution levels after 2025 will require continuing stormwater management implementation.*[45]

And:

> *The stormwater strategies described in this section rely on a sustained pace of implementation, recognizing that the arc of restoration will need to continue well beyond 2025 and a single permit cycle.*[46]

This language is far from clear, but reading between the lines one might conclude that Maryland is deferring action on the stormwater sector until after the TMDL process concludes, and potentially giving up altogether.

This is confirmed by the numbers in Maryland's WIPs. The following table compares the Phase II and Phase III WIPs with respect to (a) target pollution loads, and (b) stormwater treatment practice targets for 2025. This table shows that Maryland's planning targets have collapsed to less than 10 percent of what they once were, across the board. The reality is even worse than Maryland's Phase III WIP targets suggest. According to the EPA-led Chesapeake Bay Program, the strategies outlined in Maryland's Phase III WIP would actually lead to nitrogen and sediment load *increases* relative to 2009 loads.

Table 3: Plans for Reducing Stormwater Pollution from Developed Land in MD[47]

	2012 Bay Cleanup Plan (Phase II WIP)	2019 Bay Cleanup Plan (Phase III WIP)
Changes in Annual Pollution 2009-2025, According to Maryland's Cleanup Plans[48]		
Nitrogen (lbs)	-2,200,000	-200,000
Phosphorus (lbs)	-232,000	-10,000
Sediment (lbs)	-205 million	-11 million
Changes in Annual Pollution, 2009-2025, According to EPA-led Chesapeake Bay Program[49]		
Nitrogen (lbs)	-1,316,935	**+247,238**
Phosphorus (lbs)	-218,847	-26,625
Sediment (lbs)	-104 million	**+5.5 million**
Pollution Control Project Goals		
Abandoned Mine Reclamation (acres)	1,843	425
Bioretention/Rain Gardens (acres)	34,716	0
Bioswale (acres)	15,518	15
Dry Detention Ponds (acres)	80,803	751
Impervious Surface Reduction (acres)	31,003	1,129[50]
Stormwater Treatment (acres)	232,629[51]	42,727[52]
Permeable Pavement (acres)	350	0
Urban Filtering Practices (acres)	322,842	0
Urban Forest Buffers (acres)	26,430	0
Urban Infiltration Practices (acres)	33,872	0
Urban Tree Planting acres (acres)	15,000	1,592
Vegetated Open Channels (acres)	28,290	0
Wet Ponds/Wetlands (acres)	73,504	3,115
Erosion and Sediment Control (acres/yr)	42,642	0
Forest Conservation (acres/yr)	91,111	0
Street Sweeping (acres/yr)	9,033	37,286
Urban Nutrient Management (acres/yr)	504,053	5,700

Urban Stream Restoration (feet)	818,473[53]	1,060,015
Urban Shoreline Erosion Control (feet)	1,273,852	40,444[54]

A closely related problem is that Maryland has changed its municipal stormwater control (MS4) permits. These permits used to require the restoration of twenty percent of a county's impervious surfaces. This requirement is still part of the permits, but with a big escape clause: counties can now buy credits for pollution load reductions as an alternative form of compliance. The restoration "requirement" is no longer a requirement at all, but simply one of two options. As the Environmental Integrity Project documented in a 2019 report,[55] pollution trading, particularly in Maryland, is a misguided shell game that often involves double-counting pollution reductions that have already been made – and credited to the state – by wastewater treatment plants. Pollution trading will not get Maryland any closer to its TMDL targets, and it will certainly not reduce urban stormwater pollution.

In response to questions from EIP, the Maryland Department of the Environment (MDE) defended "nutrient trading" as a legitimate pollution control strategy and said that Maryland is relying on runoff-control projects on farms and improvements to sewage treatment plants to achieve most of the state's pollution reduction goals for 2025.[56] "The Phase III WIP envisions that Wastewater Treatment Plant upgrades and agricultural Best Management Practices will be the primary nutrient reduction drivers to achieve 2025 goals," said MDE statement says (for the full text of Maryland's response, see Appendix B.) Unfortunately, many of these wastewater treatment plant upgrades have already occurred, and Maryland has already been credited with those reductions by the EPA-led Chesapeake Bay Program's computer modeling of progress. MDE's plans therefore amount to double-counting. Moreover, even in an ideal situation, trading does not generate additional pollution reductions – it only changes where planned reductions will come from. MDE asserted that it is not retreating or giving up on stormwater pollution controls, but said it is difficult to compare 2009 pollution levels in the Bay to the amount projected for 2025 because of changes in computer modeling used by the Chesapeake Bay Program. However, this is a problem that can easily be avoided. The model has changed over time, but each new version of the model re-calculates the 2009 baseline, the estimated loads for each year, and the 2025 targets of various state plans. The data the Environmental Integrity Project examined to calculate pollution loads for the Phase II and Phase III WIPs used the same version of model – and the data still shows significant backsliding.

ii. Pennsylvania's Implementation Plans

Pennsylvania's stormwater planning is going in the same direction as Maryland's. Although Pennsylvania's WIPs are less transparent about pollution reduction goals and strategies, the Chesapeake Bay Program provides the relevant data by compiling Pennsylvania's planned implementation of BMPs and converting those plans into pollution reductions. The following Table compares BMP goals under the Phase II and Phase III WIPs. The goals for a few BMPs – urban tree planting, urban stream restoration, and storm drain cleanout – have increased, which is undeniably a good thing. On the other hand, the goals for major categories of BMPs have been slashed to a small fraction of what they once were:

- Acreage targets for the group of BMPs known as "stormwater management" (i.e., wetlands, detention ponds, and infiltration practices) have declined by 86 percent.
- Impervious surface restoration goals have declined by more than 90 percent.
- Urban forest and grass buffer goals are 88 percent lower.

The cumulative effect of these changes is that stormwater pollution loads in 2025 are likely to be much higher than they would have been under Pennsylvania's Phase II plan:

- In its Phase II plan, Pennsylvania was committed to reducing 6.7 million pounds of nitrogen from the urban stormwater sector by 2025. Under the Phase III Plan, there will be no nitrogen reduction at all – nitrogen loads will be higher in 2025 than they were in 2009.
- Phosphorus reductions under the new plan will be just 2 percent of what they would have been under the old plan.
- Sediment reductions under the Phase III WIP will be 11 percent of what they would have been under the Phase II WIP.

Table 4: Plans for Reducing Stormwater Pollution from Developed Land in Pennsylvania[57]

Target for 2025	2012 Bay Cleanup Plan (Phase II WIP)	2019 Bay Cleanup Plan (Phase III WIP)
Changes in Annual Pollution Load, 2009-2025		
Nitrogen (lbs)	-6,700,947	**+301,360**
Phosphorus (lbs)	-248,648	-5,797
Sediment (lbs)	-388,413,228	-43,139,243
Pollution Control Project Goals		
"Stormwater Management Composite" (includes wet ponds, wetlands, dry ponds, infiltration practices, etc.) (acres)	1,470,001	203,265
Erosion and Sediment Control (acres)	5,411	5,417
Impervious Surface Reduction (acres)	2,300	202
Urban Forest or Grass Buffers (acres)	25,575	3,076
Urban Tree Planting[58] (acres)	1,444	4,089
Urban Nutrient Management (acres)	333,128	123,815

Urban Stream Restoration (feet)	55,000	606,295
Storm Drain Cleanout (pounds of sediment)	0	121,269
Street Sweeping (acres)	36,200	1,016

In response to questions from EIP about the changes in their Bay cleanup plans, the Pennsylvania Department of Environmental Protection (DEP) said that the state's Phase III plan is more realistic.[59] The new plan reflects a shift, given the limited amount of money Pennsylvania has set aside for pollution control projects, toward more cost effective strategies, especially reducing runoff from farm fields instead of more expensive projects in suburban and urban areas. "Pennsylvania decided that moving forward, we need to focus our limited resources on the pollutant load sectors where nitrogen control (projects) will have the greatest impact, such as agriculture," Deborah Klenotic, Deputy Communications Director for DEP, said in an email to EIP. For DEP's full statement, see Appendix C).

It should be noted that Pennsylvania has been promising to reduce runoff from agriculture for more than a decade, with little success, in part because industrial-scale hog and poultry operations continue to grow and state regulations are weak.[60] The political influence of the farm lobby on the Pennsylvania General Assembly is strong, with state lawmakers, for example, making it illegal for the state to require farmers to fence cattle out of streams to reduce water pollution.[61]

iii. Virginia's implementation plans

Virginia, in stark contrast to Maryland and Pennsylvania, is ramping up its commitments to stormwater pollution control. Virginia's Phase III WIP increases its planning goals for most urban BMPs, in some cases by dramatic margins (e.g., permeable pavement, with a Phase III goal of 4,564 acres, up from 52 acres in the Phase II WIP). Under its Phase II WIP, Virginia would have seen increased nitrogen and sediment loads in 2025, relative to the 2009 baseline. Under its newer Phase III WIP, both pollutants will decline, and sediment reductions will be significantly greater than they would have been under the 2012 plan.

Table 5: Plans for Reducing Stormwater Pollution from Developed Land in Virginia[62]

Pollutant	2012 Bay Cleanup Plan (Phase II WIP)	2019 Bay Cleanup Plan (Phase III WIP)
Change in Annual Pollution Load, 2009-2025		
Nitrogen (lbs)	*-111,902*	-419,336
Phosphorus (lbs)	*-16,352*	-51,383
Sediment (lbs)	-30 million	-67 million
Pollution Control Project Goals (in acres, unless otherwise noted)		
Street Sweeping	24,040	0

Urban Nutrient Management	517,058	553,470
E and S	32,922	22,346
Bioretention	22,352	33,730
Bioswale	1,144	8,764
Permeable Pavement	52	4,564
Vegetated Open Channel	3,283	3,486
Dirt and Gravel Road	1,738	0
Impervious Surface Reduction	26,138	36,303
Forest Buffer Urban	4,115	9,982
Forest Conservation	14,128	18,871
Urban Tree Planting	799	30,000
Urban Stream Restoration	122,052	n.a.[63]
Dry Ponds	85,554	97,265
Extended Dry Ponds	160,081	159,030
Wet Pond Wetland	177,773	227,512
Infiltration	69,127	73,037
Filtration	65,868	58,112
Storm Drain Cleaning (pounds of sediment)	0	385,757
Other BMPs not mentioned in Phase II WIP[64]	0	39,580

3. Planning for Climate Change

As discussed in the background section of this report, there is no question that climate change is going to make it harder to meet the goals of the Bay TMDL. Yet the EPA, the Chesapeake Bay Program, and the Bay states are still in the early stages of planning for climate change impacts.

Climate change will increase rainfall and flooding across the Chesapeake Bay region, creating new stormwater management challenges for cities like Annapolis, MD.

The Bay Program and the Bay states measure TMDL progress using a set of models, including a "watershed model," which estimates nitrogen, phosphorus and sediment loads to the Bay.[65] The watershed model is based on a set of input data and assumptions. One critical set of assumptions relates to weather patterns. When the Bay Program is using the model to assess progress, it wants to know how various land use changes and pollution control strategies will affect pollution load. In order to isolate that signal, weather patterns are held constant. Regardless of the model year (i.e., a simulation of 2009 loads, 2018 loads, or 2025 loads), the model assumes weather conditions from 1991-2000.[66]

The Bay Program recognizes that weather has changed since the 1990s and will change even more between now and 2025.[67] In 2018, the Bay Program's Principles' Staff Committee provided numeric estimates of the additional pollution loads that could be expected by 2025 as a result of climate change:

Table 6: Additional Annual Pollution Attributable to Climate Change, 2018 to 2025[68]

	Nitrogen (millions of pounds)	Phosphorus (millions of pounds)
DC	0.01	0.001
DE	0.40	0.006
MD	2.19	0.114
NY	0.40	0.014
PA	4.14	0.141
VA	1.72	0.193
WV	0.24	0.019
Total	9.09	0.489

The numbers in Table 6 reflect the additional amounts of nitrogen and phosphorus (in millions of pounds) that climate change is expected to bring to the Chesapeake Bay each year between 2018 and 2025, from all sources in each state. From the perspective of planning for TMDL compliance, these numbers represent additional reductions that each state will have to make in order to reach its TMDL targets.

For the Phase III WIP planning process, the Bay Program required "a narrative strategy describing the jurisdictions' current action plans and strategies to address climate change." The Bay Program strongly encouraged, but did not require, the states to build the additional loads shown in Table 6 into their Phase III WIPs.[69] Virginia did so, but Maryland and Pennsylvania did not. According to the Bay Program, the states will be required to account for the effects of climate change on pollution loads and on BMP performance, but not until 2021-2023.[70]

The following sections provide more detail on what each of these three states has said about planning for climate change, with respect to both statewide pollution loads and the urban stormwater sector in their Phase III WIPs.

A. Climate Change in Maryland's Phase III WIP

Maryland's WIP acknowledges the climate change problem but fails to address it. As the WIP explains, "climate change impacts, including increased precipitation and storm events, are causing increased nutrient and sediment loads."[71] The WIP also acknowledges that climate change is likely to reduce the effectiveness of Best Management Practices (BMPs). For example, page 53 of the WIP states that "[t]he BMPs used to control water pollution will likely become less effective at controlling extreme storm events and be subject to damaging stresses of climate change."[72] Yet the WIP ignores the additional load that climate change will almost certainly cause, and it does not make any adjustments to its assumptions about BMP effectiveness.

The additional climate change-related loads from Maryland are expected to be 2.2 million pounds of nitrogen and 114,000 pounds of phosphorus.[73] Maryland's WIP states that the state will address these loads in 2021 and 2022.[74] This seems unwise. Deferring pollutant load adjustments will only increase the difficulty associated with planning for and meeting the adjusted targets in the future.

B. Climate Change in Pennsylvania's Phase III WIP

The Pennsylvania Department of Environmental Protection (PA DEP) acknowledges that climate change will make TMDL compliance much more difficult. An April 2020 report prepared for PA DEP by the Environment & Natural Resources Institute noted that average annual precipitation in Pennsylvania has increased by 10 percent over the past century, "heavy precipitation" has increased by 55 to 78 percent in the northeastern United States, and these trends will continue in Pennsylvania into the late 21st Century.[75] The authors of this report, like the authors of Maryland's WIP, concluded that climate change will pack a double punch. Increased precipitation intensity will increase pollution loads, and it will also decrease the effectiveness of pollution control BMPs.[76]

Yet Pennsylvania has not started planning for climate change. Its Phase III WIP does not adjust its planning targets to account for the additional climate change-related load,[77] postponing that basic step until 2022.[78] The WIP does have a section entitled "climate change and climate resiliency," but that section mainly deals with steps Pennsylvania is taking to reduce carbon emissions.[79] The WIP commits to studying the issue further, but does not commit to practical steps that might further reduce pollution.[80]

C. Climate Change in Virginia's Phase III WIP

Virginia, unlike Maryland and Pennsylvania, has explicitly accounted for the additional load attributable to climate change in its WIP:

The modeling estimates indicate that across the Bay watershed an additional 9 million pounds of nitrogen and 0.5 million pounds of phosphorus reductions are needed to offset the effects of climate change by 2025. Virginia's share of that additional load reduction is 1.72 million pounds of nitrogen and 0.19 million pounds of phosphorus. . . . Virginia's Phase III WIP includes sufficient practices and policies that when fully implemented account for these additional load reductions.[81]

Virginia's WIP adjusts targets for each basin to quantitatively account for the additional load due to climate change. For example, the following table appears on page 91 of Virginia's plan:

Table 7: Potomac River Basin WIP III Final Pollution Targets and Reductions

Potomac River Basin	2007 Progress Load	2025 Basin Target Load	Reductions Needed to Meet Target	Additional Reductions Needed to Address Climate Change	Reductions Identified in WIP III Final
Nitrogen (pounds)	17,109,000	16,000,000	1,109,000	620,000	1,729,000
Phosphorus (pounds)	1,976,000	1,892,000	84,000	82,000	302,500

Overall, Virginia's WIP states that "the sum of the regulated sectors and the [local area planning goal] loads, together with any resulting state initiatives, is expected to meet the State-Basin planning targets on 2025 base conditions and account for additional loads due to climate change."[82]

Virginia, unlike Maryland and Pennsylvania, is planning for climate change.

D. Climate Change at the County Level

We reviewed stormwater planning documents for 11 counties in the Chesapeake Bay watershed with large volumes of stormwater pollution: Anne Arundel, Baltimore, Frederick, Montgomery, and Prince George's Counties in Maryland; Lancaster and York Counties in Pennsylvania; and Augusta, Fairfax, Loudon, and Rockingham Counties in Virginia. All of these counties are planning important and commendable work to control stormwater that will provide real benefits to local communities, local ecosystems, and the Bay. However, all of the county plans are based on one critical flaw, which is that they plan for the past, rather than the future. More specifically, they assume that future rainfall patterns will resemble past rainfall patterns, when we know that the future will see more rain and more heavy rain events.

Most stormwater infrastructure design standards adopt local precipitation assumptions from a National Oceanic and Atmospheric Administration atlas of precipitation frequency across the U.S.[83] The problem with using this document, called "Atlas 14," and the data it contains, is neatly spelled out in a 2015 peer review comment:

> *The reality is that public and private infrastructure sized using the new Atlas 14 may become undersized at some point in the future . . . because Atlas 14 only represents current climate, not future climate. Also, the effort to update Atlas 14 will likely not happen again in the near future given potential lack of federal and state funds. Providing a sister tool to predict future design storm intensity … would allow states and engineers engaged in land development the opportunity to design to future conditions, versus current conditions, to extend the longevity of public and private infrastructure.*[84]

In response, NOAA basically said: we don't know if it's a good idea, but we'll look into it. As of the latest progress report in 2019, the agency was still studying the problem.[85] (NOAA's words were "we still do not have a definite answer to whether a non-stationary approach is advantageous for the NA14 process," and "we continue the investigation on this topic.")[86]

To take another example, Maryland's stormwater pollution control permits for counties and cities ("MS4 permits") require "environmental site design" to the "maximum extent practicable."[87] That's legalese for providing treatment (meaning filtration and absorption capacity) for stormwater from the maximum 24-hour rainfall that can be expected once a year.[88] The problem is that these design storm estimates are based on past data, not predictions of future rainfall. In 2025, the amount of rain falling over a 24-hour period once per year will likely be much greater than it was in, for example, the late 20th Century.

Or consider a typical county annual stormwater report, and how that report presents monitoring data. The 2019 annual report (MS4 report) for Baltimore County includes a detailed discussion of a stream, the Scotts Level Branch in the Gwynns Falls watershed.[89] At one monitoring location (site SL-01), the report indicates that the total phosphorus pollution load was 3,002 pounds in 2018. However, the report adjusts that number to what the pollution load *would have been* if the area had seen "average rainfall." Adjusted, the load was only 1,751 pounds.[90] The reality was far different. In fact, 2018 was a year of rainfall totals that were far above average, and therefore pollution loads that were also far above average. That truth becomes obscured by the adjustment to "average" rainfall. The report goes on to compare pollution in 2018 to what the EPA-led Chesapeake Bay Program's computer modeling predicted that year for the same watershed. For monitoring location SL-01, the model predicted a phosphorus load of 1,215 pounds.[91] The real 2018 load was therefore at least 2.5 times greater than the model assumes.[92] Yet one could easily miss that fact by only looking at the "adjusted" load.[93]

As explained earlier this in this report, 2018 was a year of record-breaking rainfall across the Bay watershed. As measured at Baltimore Washington International Airport, the precipitation total that year was higher than it had ever been since rainfall data were first collected in 1871. This leads to an important policy question. Should the record-setting 2018 rainfall be treated as an aberration, or as something that Baltimore County and other jurisdictions should be planning to accommodate more often in the future? When counties adjust their pollution reporting to reflect the amounts in "average" rainfall years, they are embedding an assumption into their plans, and the assumption is that future rainfall patterns will be similar to what they were in the past.

Ironically, the counties in the Bay watershed do frequently think about the future – just not future precipitation. In Virginia, for example, Fairfax County's Watershed Management Plan contemplates "future conditions," but that only refers to future land cover.[94] For precipitation and weather, the plan uses historic data.[95]

Only rarely do counties assume a more forward-looking posture toward the climate and rainfall. Montgomery County, Maryland, for example, is in the midst of a community-based climate workgroup process that should lead to a "climate action and resilience plan" sometime in 2021.[96] Although this process is generally focused on greenhouse gas emissions reduction, it does specifically identify the problem of basing forward-looking stormwater plans on backward-looking rainfall data. The goals and recommendations developed by the climate workgroups include:

- "Reduce risks and impacts of more intense storms."[97]
- "Improve hydrological and meteorological data collection and analysis of wet weather and storms, considering climate change over the next 30 to 100 years, and incorporating trends in land use/land cover change."[98]
- "Work with Maryland and NOAA to ensure that NOAA's outdated and inadequate Atlas 14 precipitation statistics for Maryland are updated and recalculated, and ensure that Maryland update and revise stormwater, floodplain, and other codes and regulations."[99]

And a consultant for Prince George's County said the following:

> *Although average annual precipitation in Maryland has increased by approximately 5 percent in the past century, precipitation from extremely heavy events has increased in the eastern United States by more than 25 percent since 1958 (USEPA 2016). The amount and frequency of precipitation is projected to continue increasing, which could lead to more flooding such as past flooding in Upper Marlboro. Average precipitation is expected to increase during winter and spring, which will cause snow to melt earlier and intensify flooding during those seasons.*[100]
>
> *BMPs designed for current conditions will most likely fail to sufficiently treat and reduce runoff from the projected larger and more intense storm events. That failure could cause stormwater to overflow or damage BMPs; the BMPs would not treat all the*

runoff and would not reduce runoff volume reaching the County's water bodies. That situation, in turn, could result in downstream channel erosion and flooding.[101]

Unfortunately, these salient observations were buried in a sediment restoration plan for the Patuxent River watersheds, and are not reflected in county-level policy.

There is no question that the counties should be planning for more rain, more storms, and more flooding. One path forward, given the complexity and breadth of climate modeling, is to advocate for better federal guidance, such as a forward-looking replacement for NOAA's "Atlas 14" guide on rainfall frequency across the U.S. Another strategy – one that would be much easier to implement – would be to use available resources (such as Atlas 14), but to plan for the storms that we used to think of as rare. It's well-known that high-precipitation storms are becoming more common. Southern New Hampshire recently saw 100-year floods three years in a row.[102] (These are floods that are supposed to have a one in one hundred chance of happening in any given year.) Ellicott City, Maryland experienced two 1,000-year storms in three years (see page 28).[103] An EPA modeling exercise for Harford County, Maryland estimated that today's ten-year storm will be tomorrow's two-year storm.[104] If that's the case, then perhaps it would be wise for counties (and states) to simply replace references to "two-year storms" in their planning documents with references to "ten-year storms." This way, they would be planning for the 2-year storms of the future. More generally, it may be time to start building capacity for 1,000-year storms.[105]

There is no question that counties and cities can and should be planning for larger storms. But local governments – on their own, without state and federal assistance – cannot be expected to unilaterally take responsibility for the added impacts of climate change on the Chesapeake Bay. A typical county or city is already working to prioritize and implement stormwater management policies within the constraints of tight budgets that have become more strained because of the Covid-19 economic crash. The EPA and the Bay region states set the Bay cleanup targets for the counties. So the federal and state governments should also take responsibility for leading counties and cities in planning for how climate change will affect Bay cleanup progress.

When planning for stormwater capacity needs, counties too often look backward at historical rainfall patterns when they should be looking ahead.

Beyond the progress of the Bay cleanup, another area where planning for increased rainfall from climate change is important is sewage overflows, which is more of a local public health issue than a major source of nitrogen and phosphorus pollution in the Chesapeake. Sewage overflows are not the same as the stormwater problem we have been discussing, but they are related in cities that have combined sewage and stormwater systems.

Growing Rainfall and Sewage Overflows in Cities

More than 50 cities and towns in the Chesapeake Bay watershed have antiquated, combined sewage and stormwater systems. This means the same pipes that were built under the streets to carry human waste to sewage treatment plants were also designed – whenever there is a significant rainstorm – to carry rainwater runoff mixed with human waste into nearby rivers and streams.[106] Thirty-one of these old-fashioned, leaky systems are in Pennsylvania, including the state capital, Harrisburg.

EPA and state environmental agencies require cities with combined sewer and stormwater systems to comply with the Clean Water Act by creating and following what are called Long-Term Control Plans.[107] These plans lay out improvements and procedures to reduce and minimize their sewage overflows, which often contain fecal bacteria and dangerous pathogens that can render local waterbodies unsafe for contact and recreation.

More than 50 cities and towns in the Chesapeake Bay watershed have antiquated, combined sewage and stormwater systems in need of major overhaul.

Long-Term Control Plans often use studies of past rainfall conducted by the city or precipitation data from state or federal sources to calibrate the size of their pipes and infrastructure improvements for future storm events. EIP gathered and analyzed these plans for four cities in the Chesapeake Bay watershed – Harrisburg, Pa; Cumberland, Md., Washington, D.C., and Lynchburg, Va. -- to determine if their long-term plans account for increases in rainfall that have been happening in recent years and reasonably project future increases in precipitation and storm intensity due to climate change.

Methods for determining typical year precipitation vary between cities. Some rely on complex modelling, national weather data, local monitoring, or a combination of these methods. EIP identified the typical year of rainfall assumption for each city's long-term control plan and compared it to the most recent five-year average calculated using data from the National Oceanic and Atmospheric Administration (NOAA). The results are below:

Table 8: Rainfall Assumptions in Long-Term Control Plans for Cities with Combined Sewage and Stormwater Systems

City, State	Annual Rainfall in Plan (inches)	Actual Annual Rainfall from 2015-2019	% Difference
Cumberland, MD	36.5	47.73	27%
Washington, DC	38.95	48.14	21%
Harrisburg, PA	39.8	46.22	15%
Lynchburg, VA	42.35	48.45	13%

Table 1: Annual rainfall in plan reflects rainfall depth in inches derived from the combined sewage and stormwater Long Term Control Plans for Washington, D.C., Harrisburg, Pa., and Lynchburg, Va. Rainfall depth assumptions for Cumberland are from the City's 2013 Comprehensive Plan. Harrisburg's rainfall depth has a standard deviation of 8.08. Rainfall depth is a parameter included in the calibration of a city's sewer system and used as a means to make assumptions comparable for the purposes of this report. Actual annual rainfall numbers are NOAA five-year averages, and are calculated from Global Summary of the Year precipitation records for 2015-2019.

As can be seen in the chart above, the cities' long-term plans are based on outdated rainfall assumptions, and underestimate recent rainfall by between 13 and 27 percent, meaning that their infrastructure improvements and stormwater controls were designed for less precipitation than has been falling – and much less than will fall in the future as climate change impacts grow.

Cumberland, Maryland: The greatest discrepancy between assumptions in a city's long-term plan and recent data was in Cumberland. In 2018, the city released 103 million gallons of sewage mixed with stormwater into tributaries to the Potomac River and Chesapeake Bay.[108] To help deal with this problem, the city had planned improvements for their combined sewage and stormwater system, including boosting the capacity of their pumping stations and building a stormwater retention facility that could hold 10 million gallons of overflow per day.[109] However, the city's plans were based on smaller annual rainfall projections than have been actually hitting the region in recent years. Cumberland used climatological data that assumes that the city receives 36.5 inches of rainfall per year.[110] This is 27 percent less than the most recent five-year average, which is 47.73 inches of rain per year, according to NOAA (see table above).[111,112] EIP sent written questions to Cumberland officials about this planning gap, but did not receive a response.[113]

Washington, D.C.: The nation's capital has invested far more to control stormwater and solve its sewage overflow problems than most cities (see detailed discussion on pages 25-28). The city's nearly $3 billion[114] in construction projects include the construction of two massive underground stormwater storage tunnels (with capacities of 77 million and 49 million gallons). DC Water is also separating sewage and stormwater outfalls, building new pumping stations, constructing a major sewer line, and installing rain gardens and other rain-absorbing "green" infrastructure. Some of these projects were completed by March 2018, others are still under construction, and the building of green infrastructure will continue through 2030.[115] As a result, discharges of stormwater mixed with sewage to the Potomac and Anacostia rivers have fallen substantially, including from 180,000 gallons in 2018 to 32,000 gallons through the first 10 months of 2019.[116]

However, even DC's massive project was based on rainfall data and projections that are no longer accurate. The city's 2002 long term control plan, which has a 40-year implementation timeline, used rainfall data from the monitoring station at Ronald Reagan National Airport and 1988-1990 as the forecast period. The average amount of rainfall during that period was 38.95 inches,[117] which is 21 percent lower than the most recent five-year average (2015-2019) using NOAA data.[118] This means almost ten inches more rain per year is entering the system than expected.[119] DC Water said that their rainfall assumptions were "developed in accordance with EPA guidelines."[120] This highlights the need for updated EPA guidelines that take climate change into account, as articulated in the conclusion of this report. (For DC Water's full response, see Appendix D.)

Harrisburg, Pennsylvania: Pennsylvania's state capital last year released 902 million gallons of sewage mixed with stormwater into the Chesapeake Bay's biggest tributary, the Susquehanna River, and 1.4 billion gallons in 2018, according the reports of the local water authority, called Capital Region Water.[121] This overflow – driven in part by growing rainfall and resulting stormwater – is causing severe local water quality problems. Bacteria monitoring by the Lower Susquehanna Riverkeeper along the Harrisburg waterfront in June and July of 2020, for example, found *E. coli* bacteria concentrations in the Susquehanna that averaged more than 2.5 times safe levels for swimming or water contact recreation, including just downstream from outfalls leading from the Governor's Residence and State Capitol Complex.[122]

To address the sewage and stormwater overflow problem, Capital Region Water signed a partial consent decree with the Pennsylvania Department of Environmental Protection (DEP) in 2015 that required more stormwater planning. Capital Region Water in 2018 released a plan that proposes for Harrisburg area residents to pay $315 million over 20 years improve the maintenance of the long-neglected combined sewage and stormwater pipes. The Harrisburg plan also includes the upgrade of a pumping plant, the repair and rehabilitation of sewer lines, improvements to outfall regulation devices, as well the planting of trees and rain gardens and the creation of other "green infrastructure" to help soak up rainwater.[123] Since Capital Region Water signed its limited consent decree with the state, however, the amount of effluent being piped into the river has increased from what had been an average of about 800 million gallons a year.[124] Harrisburg's control plan uses a median expected annual rainfall of about 40 inches per year, based on historic figures in a 57-year record from Harrisburg's two airport gauges.[125] But that is about 15 percent less than the average 46 inches of rain the region has experienced from 2015 to 2019, based on NOAA data. However, it should be recognized that Harrisburg's plan states that their annual rainfall predictions could vary by as much as 8 inches. That would suggest that its estimates of precipitation totals might be within an acceptable range of reality.[126] In response to questions sent by EIP, Harrisburg Capital Region Water said it was following EPA guidelines when it created its plan.[127] For the full text of Harrisburg's response see Appendix E.)

Lynchburg, Virginia: Lynchburg's combined sewer and stormwater system has 132 outfalls that released 65 million gallons of overflows in 2019.[128] To address the problem, the city has a long term control plan that includes closing 87 percent of the outfalls, increasing the capacity of the local wastewater treatment plant, building a storage tank and installing "green" infrastructure.[129] Many of these projects are either under construction or complete. However, this whole plan, updated in 2014, was created with what are now outdated annual estimates of rainfall. The plan used the period of 1993-1995 to create a "typical year" rainfall assumption of 42.35 inches. That's about 13 percent less than the average of 48.45 inches that fell from 2015-2019, according to NOAA data. Lynchburg's Director of the Department of Water Resources, Timothy Mitchell, defended the city's use of older rainfall averages as being "fully in accordance with applicable EPA guidance."[130] As mentioned earlier, this underscores the need for updated federal guidance that takes into account increasing rainfall from climate change. (For his full statement, see Appendix F.)

Looking to the future across the whole Chesapeake region, rainfall has turned out to be much higher than predicted, and in some recent years double historic averages. A 2020 report by NOAA states that this trend is expected to continue.[131] With this growing volume of rainfall in mind, many cities with combined sewage and stormwater systems may be unprepared for current rainfall conditions, much less the dramatic increases that could occur in the future.

In the next section of this report, we look at two case studies of local governments. One has been struggling mightily with stormwater and flash flooding: Ellicott City, Maryland. The other has been building larger and more expensive stormwater control facilities than almost any other city: Washington, D.C.

Examples of Cities Dealing with Stormwater Control Issues

CASE STUDY: ELLICOTT CITY, MARYLAND

250-year-old Mill Town Confronts Rising Flood Vulnerability

Founded in 1772, Ellicott City's historic downtown is home to the oldest surviving train station in the country. But while this quaint city on the edge of the Baltimore metropolitan area may be ideally situated for a railroad track, it's in a highly inopportune spot when it comes to flooding. The historic district is nestled within steep, rocky valleys and is part of a three-and-a-half-square-mile watershed that includes four tributaries — the Tiber, Hudson, Autumn Hill, and New Cut rivers — that empty into the Patapsco River, which runs straight through downtown. When it rains, it pours.

Flood damage along Main Street in Ellicott City on August 10, 2016. The suburban developments that have sprung up all around the town over the last 50 years have heightened flood risk during storm events by preventing natural drainage.

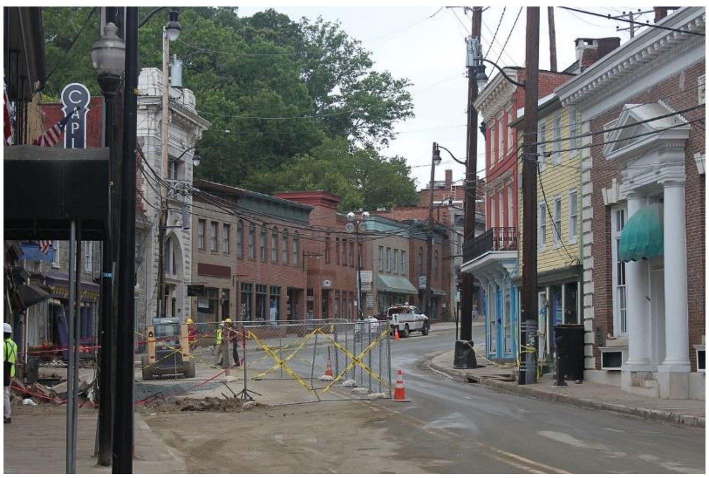
In the last decade, rainfall in the valley has been hitting new highs, as predicted by climate change models showing increased precipitation across the Northeast. The town was slammed by two 1,000-year storms in the span of two years — the first on July 30, 2016, and the second on May 27, 2018. Storms as intense as these are only supposed to have a 1 in 1,000 probability of occurring in any year. But climate change appears to be rewriting this math. Both these devastating downpours released flash floods upon the city's dense center, causing extensive damage and three deaths. During these heavy rains, torrents of water rushed downhill along Main Street, toward the Patapsco River.

Many of the same businesses were damaged by both floods and the same residents displaced. This caused uncertainty among community members about whether rebuilding and remaining in the town was a wise decision. While the town, which is built entirely in a 100-year floodplain, has had at least 18 major floods since it started recording them in 1789, something about the intensity and frequency of these two floods, as well as another major 2011 flood during Tropical Storm Lee, felt like a new kind of crisis.[132]

In March 2020, the Maryland General Assembly approved more than $8 million for additional stormwater control projects in Ellicott City. The money will fund a multi-year "Safe and Sound" plan that includes the construction of new stormwater tunnels to divert water away from Ellicott City's Main Street. The plan also features expanded culverts and new retention ponds higher up the watershed to reduce flooding. The Howard County government is purchasing all but one of ten flood-prone buildings around Main Street, at least four of which will be torn down due to their extreme susceptibility to flooding.[133]

County Executive Calvin Ball said he wants the "Safe and Sound" plan to be recognized as dealing with the realities of climate-driven precipitation increases and flood risks, and to be viewed as an example of how to preserve the character of a small city while prioritizing public health.[134]

The plan not only addresses aging infrastructure lacking adequate drainage, but also more recent suburban sprawl that's greatly expanded the impervious paved environment. All this pavement upends natural systems and directs more water into already overflowing rivers and stormwater channels. The unincorporated community's population has exploded in recent decades to over 75,000, and around two-thirds of the watershed's land is developed, with more than a fifth being covered by pavement, rooftops, and other hard, impervious surfaces.[135]



Recovery efforts along Main Street in Old Ellicott City during the summer of 2016. Before the 2016 flood, more than 100 businesses lined Main Street and generated some $200 million in annual revenue.

Stormwater regulations within the watershed today only require new developments to be capable of handling runoff from 100-year storms, which means eight inches in 24 hours. A 1,000-year storm such as the one in May 2018 released eight inches in just three hours,[136] and nearly double that over the course of the day.[137]

David Wood, the stormwater coordinator for the Chesapeake Stormwater Network, which is based in Ellicott City, said even the most drastic improvement to the town's local infrastructure would only solve part of the flooding problem.

"Topography, past development practices, and other factors play a big role," he said. "While improving the design of stormwater infrastructure will mitigate the impacts of somewhat more frequent flooding events—up to 100-year storms—the historically large events will likely remain beyond the control of typical stormwater infrastructure."

With two 1,000-year storms occurring within the space of three years, it's clear that the solution to the town's flooding problem must include much more than just adjustments to the city's stormwater tunnels and culverts. As the city continues to secure financing, build support for its current plans, and envision even bolder future actions, stopgap measures are underway. These include clearing debris out of stormwater channels and making sure stormwater management requirements are met and enforced without exception. The city has also installed a public-alert system with loud beeping to indicate imminent or likely flooding along with signs pointing the way toward higher ground.

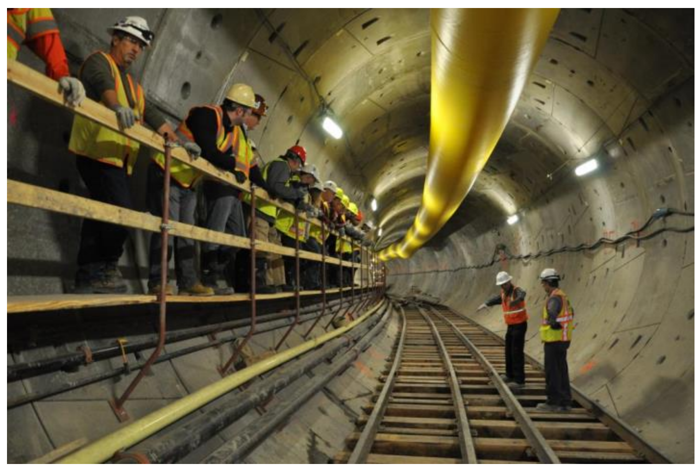
Wood said cities and counties across the Bay watershed, including Ellicott City, are just beginning to plan for the expected increases in rain volume and intensity due to climate change.

"Communities are often balancing budgets on a shoestring while trying to achieve both quantity and quality objectives," he said. "Understanding the changing climate conditions has a significant impact on future stormwater planning and design."

CASE STUDY: WASHINGTON, DC

From Massive Tunnels to Curbside Planters: A Complete Stormwater Infrastructure Overhaul

Washington, D.C., is in the midst of an ambitious and expensive stormwater infrastructure project that is designed to drastically reduce sewage overflows into the Anacostia and Potomac rivers.



When the entire DC Clean Rivers Project is completed in 2030, average combined sewage discharges to the three major District waterways—Anacostia and Potomac rivers and Rock Creek—will be reduced by 96 percent overall.

The goal is to make the waterways – once infamous for their contamination – healthy enough for swimming. Known as the Clean Rivers Project,[138] the construction project hinges on three massive underground tunnels that will be able to accommodate large rainfalls and prevent damaging nuisance flooding across the city, the result of a dated and overburdened drainage system based on 19th-century technology.

According to DC Water, the project will reduce combined sewer overflows by 96 percent overall and will essentially remove overflows of the city's combined sewage and stormwater system – called combined sewage overflows, or "CSOs" -- as a source of pollution to the Potomac.[139] The project will also reduce peak flows to wastewater treatment plants, making nutrient removal more effective and thus reducing pollution into the Chesapeake Bay. The first phase of the tunnel system went into operation in March 2018. By May of 2020, it had prevented over 7.7 billion gallons of sewage and stormwater from running into the District's waterways.

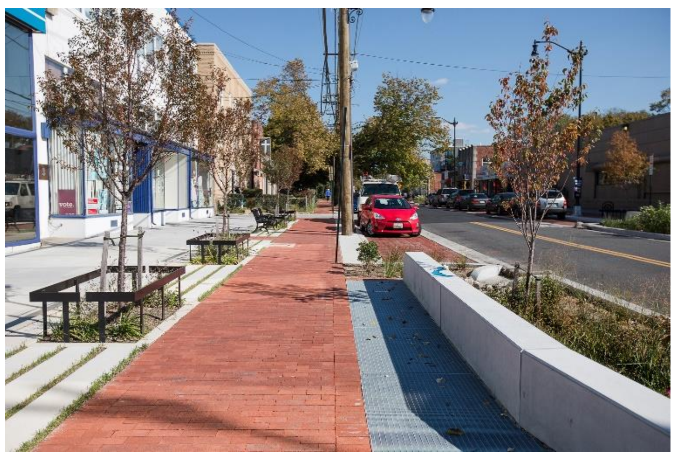
The overhaul of the system is the result of a twenty-year-old lawsuit filed by the Anacostia Watershed Society against DC Water over sewage pollution. DC Water agreed to build the massive sewer tunnels as part of a 2005 consent decree with the Environmental Protection Agency.[140]

More than 700 other cities around the country have similarly antiquated combined sewage and stormwater systems in need of major updating. Many of these cities must not only address dated infrastructure unable to accommodate today's sprawling urban landscapes dominated by impermeable surfaces, which exacerbate flooding, but also increased rainfall and other long-term weather changes driven by climate change.

Kimberly Isom, DC Clean Rivers Project Program Coordinator, said projects like DC's are long-term, expensive, and difficult to implement. With a price tag approaching $3 billion, the project is one of the largest and costliest building projects in the region's history.

"It's important that a comprehensive and defensible plan is developed at the beginning to establish schedule, budget, and performance," she said. "It is equally critical to obtain buy-in on the plan from the start from key stakeholders including regulators, environmental groups, and agency and political leaders."

Getting environmentalists' buy-in necessarily means addressing the storm on the horizon: climate change. The Washington region is forecast to get warmer and wetter.[141] Washington experienced its wettest year on record[142] in 2018, and its wettest 365-day stretch[143] from mid-2018 to mid-2019. More than 71 inches of rain fell between May 12, 2018, and May 12, 2019; almost five inches more than the record-setting 2018 calendar year total of 66.3 inches. Isom said Blue Plains Advanced Wastewater Treatment Plant, where DC's water is pumped out and treated, can be expanded in the future to increase the system's performance in the face of climate change, increasing growing rainfall, or other factors. She also said the tunnel system has been extended to provide additional storm conveyance capacity to historically flood-prone neighborhoods such as Bloomingdale and LeDroit Park.



The Kennedy Street revitalization project in northwest Washington added more than 13,000 square feet of green space to a city block. It will help reduce combined sewer overflows into nearby Rock Creek Park during major rainfall events.

The Clean Rivers Project consists of many different coordinated elements. Aside from the 18 miles of tunnels, dug deep underground at a rate of 50 feet per day, there's also a vast network of smaller green infrastructure projects to help mitigate rainfall and prevent overflows.

One of these efforts along the 100 block of Kennedy Street in the city's northwest quadrant won the Chesapeake Stormwater Network's award for "Best Ultra-Urban BMP (Best Management Practice) in the Bay in 2019.[144] The one-block project entails 33 green infrastructure projects, including enhanced tree canopy, permeable pavement (including along parking lanes), bioretention ponds, and curb extensions and planters that store water. Combined, these elements create three "lines of defense"—above-ground rainfall capture by the trees, street-level landscape enhancements and permeable pavements, and below-ground storage drywells.

By designing the infrastructure elements to work in a series, the overall system becomes even more resilient. When stormwater overwhelms one infiltration element it overflows to another, and then to another. This conveyance greatly slows the flow of the water, making it easier to capture before it spills over and causes flooding. The system removes 9,000 square feet of impervious surface from the 1.14-acre site and can accommodate nearly 60,000 gallons of stormwater, enough to mitigate a rainfall event of over two inches.

At the ribbon cutting for the Kennedy Street Project in June 2018, Washington Mayor Muriel Bowser celebrated the project for not only addressing chronic flooding issues, but improving public safety and making the city more beautiful.[145]

"We are proud to celebrate this tremendous revitalization," Mayor Bowser said. "Projects like this one are how we build a safer, stronger DC, and ensure that our neighborhoods continue to meet the needs of a growing city."

Isom pointed to the revitalization happening along Anacostia River waterfront as another example of a major civic improvement made possible in part by the stormwater upgrades.

"After decades of pollution from a variety of sources, the Anacostia River is being reclaimed as the community centerpiece that it can and should be," she said.

"These same benefits are also being experienced by wildlife," she continued. "DC Water has received numerous reports from river users of a surge in aquatic life since commissioning of the tunnel system. Adequate sewer infrastructure, including the tunnel system, is critical to achieving the goal of making the District's waterways fishable and swimmable."

Conclusion and Recommendations:

Even without the effects of climate change, state and local governments across the Chesapeake Bay region have been struggling with the challenge of urban and suburban runoff pollution. As some communities – like Washington, D.C. – have started to invest in permeable pavement and stormwater pollution control devices like bioretention ponds, others have moved in the opposite direction by continuing to allow sprawling developments with acres of blacktop. Since the most recent Bay cleanup agreement was signed in 2009, the amount of developed land in the Bay watershed has increased by about 291,629 acres – an area six times the size of the District of Columbia -- adding more blacktop, roofs, and roads that accelerate runoff pollution. As a result, while many types of pollution into the Chesapeake Bay have declined – notably, from sewage treatment plans – runoff of nitrogen and phosphorus from urban and suburban areas has increased.

On top of this urban planning problem is the much broader crisis of a global climate that's been thrown out of balance by the burning of fossil fuels. Record-breaking rainfall pummeled most of the Chesapeake region in 2018, and the next year, a record-setting volume of fresh water flowed into the Bay – carrying with it runoff pollution from subdivisions, cities and farms.

As the Chesapeake region states try to execute an ambitious 2010 Bay cleanup agreement, one might think that they would be motivated to address this growing rainfall problem and redouble their plans to build stormwater pollution control systems. These projects, after all, not only soak up the rainwater flushing over parking lots, but also create greenspace in urban areas – including through the planting of trees and the conversion of parking lots to parks. Virginia and the District of Columbia are taking this forward-looking approach. By contrast, Pennsylvania and Maryland are moving in the opposite direction. In their most recent Watershed Implementation Plans, they retreated by weakening their urban and suburban stormwater pollution targets and scaling back their plans for implementing pollution control projects. This is unacceptable, especially at a critical time when a 2025 deadline for the Bay cleanup is just around the corner.

State and federal environmental agencies have also failed to provide enough guidance and grant money to county and city governments struggling with the problem of increased and more intense precipitation.

This report recommends the following solutions:

1) Broadly speaking, we should be planning for the future, not the past. There is no question that rainfall in the Bay region is increasing in both total volume and intensity. Planning at all levels – from the federal government down to the county and city level – must take these trends into account. All levels of government should start calibrating their planning and stormwater control projects and infrastructure to reflect likely future rainfall patterns, not historic averages from decades ago.

2) EPA must take a more active leadership role and require Pennsylvania and Maryland to strengthen their stormwater control plans and account for climate change. Instead of backtracking, Pennsylvania and Maryland should expand the stormwater pollution projects in their Phase III Watershed Implementation Plans.
3) EPA should require Pennsylvania to commit substantially more resources to its Bay cleanup effort, which has been far behind the other states. Federal actions could include the denial of permit approvals for major construction projects in Pennsylvania and a demand that the Commonwealth upgrade its leaky combined stormwater and sewage systems, including in Harrisburg.
4) States and municipalities across the Chesapeake region should invest more in stormwater control projects, such as the construction of artificial wetlands, ponds, rain gardens and the conversion of parking lots and other impervious surfaces to green areas that absorb rain. These projects not only control runoff pollution, they also help address environmental justice issues by creating parks in urban areas that are often dominated by blacktop.
5) Because stormwater control projects are expensive, EPA and Congress should provide substantial federal funds to state and local governments to help pay for these projects, which create jobs. Such federal investments would be a healthy economic stimulus package to help the nation rebound from the COVID-19 recession.

During a time when people are especially concerned about public health and employment, there's no better investment than putting American laborers to work transforming parking lots to parks, installing gardens in our cites, planting wetlands and trees, fixing pipes and culverts, and cleaning sewage out of our rivers, streams, and Chesapeake Bay. Controlling stormwater also creates greenspaces that absorb heat and improve the quality of life in densely-packed urban areas. This helps to alleviate environmental injustice by making cities more livable during an era of climate change.

APPENDIX A: Additional Tables

Table A1: Developed land and stormwater loads from **Delaware**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Change (%)
Developed acres	57,457	60,133	+4.7%
Loading rate (pounds per developed acre)			
Nitrogen	11.40	10.99	-3.6%
Phosphorus	0.43	0.40	-8.2%
Sediment	27.17	27.27	+0.4%
Delivered load (pounds)			
Nitrogen	654,975	660,945	+0.9%
Phosphorus	24,840	23,877	-3.9%
Sediment	1,561,310	1,640,009	+5.0%

NOTE: All load estimates are "edge of tide," or delivered loads.

Table A2: Developed land and stormwater loads from the **District of Columbia**, 2009-2019.

	2009	2019	Rate of change (% per year)
Developed acres	31,312	32,621	+4.2%
Loading rate (pounds per developed acre)			
Nitrogen	5.45	5.30	-2.7%
Phosphorus	0.47	0.44	-6.0%
Sediment	689	642	-6.9%
Delivered load (pounds)			
Nitrogen	170,637	172,914	+1.3%
Phosphorus	14,652	14,347	-2.1%
Sediment	21,586,001	20,941,874	-3.0%

Table A3: Developed land and stormwater loads from **Maryland**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Rate of change (% per year)
Developed acres	1,240,341	1,302,377	5.0%
Loading rate (pounds per developed acre)			
Nitrogen	7.26	7.28	+0.3%
Phosphorus	0.55	0.54	-3.1%
Sediment	313	323	+3.4%
Delivered load (pounds)			
Nitrogen	9,007,360	9,484,662	+5.3%
Phosphorus	685,400	697,536	+1.8%
Sediment	388,067,503	421,219,826	+8.5%

Table A4: Developed land and stormwater loads from **New York**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Rate of change (% per year)
Developed acres	338,546	366,185	+8.2%
Loading rate (pounds per developed acre)			
Nitrogen	5.74	5.71	-0.5%
Phosphorus	0.22	0.21	-5.2%
Sediment	341	322	-5.6%
Delivered load (pounds)			
Nitrogen	1,942,778	2,091,431	+7.7%
Phosphorus	73,450	75,283	+2.5%
Sediment	115,389,621	117,781,261	+2.1%

Table A5: Developed land and stormwater loads from **Pennsylvania**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2018	Rate of change (% per year)
Developed acres	1,562,739	1,646,813	+5.4%
Loading rate (pounds per developed acre)			
Nitrogen	9.48	9.29	-2.0%
Phosphorus	0.28	0.26	-6.4%
Sediment	337	298	-11.7%
Delivered load (pounds)			
Nitrogen	14,811,711	15,301,338	+3.3%
Phosphorus	433,501	427,701	-1.3%
Sediment	526,727,009	489,980,766	-7.0%

Table A6: Developed land and stormwater loads from **Virginia**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Rate of change (% per year)
Developed acres	1,759,898	1,895,626	+7.7%
Loading rate (pounds per developed acre)			
Nitrogen	5.76	5.74	-0.3%
Phosphorus	0.70	0.69	-1.8%
Sediment	308	309	+0.4%
Delivered load (pounds)			
Nitrogen	10,131,975	10,885,541	+7.4%
Phosphorus	1,237,305	1,309,242	+5.8%
Sediment	541,559,575	585,890,045	+8.2%

Table A7: Developed land and stormwater loads from **West Virginia**'s portion of the Chesapeake Bay watershed, 2009-2019.

	2009	2019	Rate of change (% per year)

Developed acres	166,910	174,975	+4.8%
Loading rate (pounds per developed acre)			
Nitrogen	7.38	6.78	-8.2%
Phosphorus	0.44	0.33	-24.1%
Sediment	529	499	-5.7%
Delivered load (pounds)			
Nitrogen	1,232,166	1,185,806	-3.8%
Phosphorus	73,023	58,072	-20.5%
Sediment	88,292,675	87,255,613	-1.2%

Table A8. Stormwater phosphorus loads from developed land (highlighted cells indicate a reduced level of effort)

	2009 load (millions of pounds)	2025 targets (millions of pounds)		Planned change in load, 2009-2025	
		2012 plan	*2019 plan*	*2012 plan*	*2019 plan*
DE	0.02	0.03	0.02	+8.4%	+0.1%
DC	0.01	0.01	0.01	-0.9%	-10.6%
MD	0.69	0.47	0.66	-31.9%	-3.9%
NY	0.07	0.07	0.05	-6.5%	-34.8%
PA	0.43	0.18	0.43	-57.6%	-1.3%
VA	1.24	1.26	1.19	+1.3%	-4.1%
WV	0.07	0.06	0.05	-23.6%	-30.5%
TOTAL	**2.55**	**2.07**	**2.41**	**-18.5%**	**-5.2%**

NOTE: *All load estimates are "edge of tide," or delivered loads. "2012 plan" and "2019 plan" loads represent the loads associated with Phase II and Phase III WIP commitments, respectively, as shown by the Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST).*[146]

Table A9. Stormwater sediment loads from developed land (highlighted cells indicate a reduced level of effort)

	2009 load (millions of pounds)	2025 targets (millions of pounds)		Planned change in load, 2009-2025	
		2012 plan	*2019 plan*	*2012 plan*	*2019 plan*
DE	1.57	1.77	1.67	+13.2%	+6.7%
DC	22.19	19.47	19.77	-12.3%	-10.9%

MD	388.26	284.04	393.79	-26.8%	+1.4%
NY	115.39	95.41	67.94	-17.3%	-41.1%
PA	524.52	136.11	481.38	-74.1%	-8.2%
VA	542.33	511.89	475.68	-5.6%	-12.3%
WV	88.30	97.94	88.47	+10.9%	+0.2%
TOTAL	**1,682.56**	**1,146.63**	**1,528.72**	**-31.9%**	**-9.1%**

NOTE: *All load estimates are "edge of tide," or delivered loads. "2012 plan" and "2019 plan" loads represent the loads associated with Phase II and Phase III WIP commitments, respectively, as shown by the Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST).*[147]

APPENDIX B: Statement from the Maryland Department of the Environment

In response to questions from the Environmental Integrity Project, Jay Apperson, Deputy Director in the Office of Communications for the Maryland Department of the Environment, emailed the following statement on July 29, 2020:

"Maryland's commitment to reducing polluted urban and suburban stormwater runoff is unwavering. It is important to understand the importance of this being done not in a vacuum but in coordination with work to reduce nutrient and sediment pollution from all sectors for the best results as part of the broad Chesapeake Bay restoration plan. The numbers attached to this work may evolve due to changes reflected in improved modeling, an increasing use of calculations that consider growth and the effects of climate change and an understanding that this work does not end in 2025 and must be sustainable for the long run. Maryland's Phase III WIP includes nutrient targets that represent a substantial increase in effort over the Phase II WIP, with an additional million pounds of nitrogen reductions required by 2025. To reduce stormwater runoff It is crucial that the state gain the buy-in of stakeholders – including local governments that are responsible for planning, paying for and installing BMPs -- by helping them to understand the opportunities for restoration and the opportunities to solve multiple problems (for co-benefits such as reduced flooding, for example) to justify the costs. As a state, Maryland continues to be a leader in reducing nutrient and sediment pollution to our waterways and in restoring the Chesapeake Bay.

Question 1. In Maryland's Phase III Watershed Implementation Plan (WIP), submitted to EPA in August 2019, Maryland promised to do less to control stormwater from urban and suburban areas than it pledged back in 2012 in its Phase II WIP. Why the retreat on concrete commitments and projects to reduce urban and suburban stormwater pollution into the bay?

Response 1: The Phase III WIP envisions that WWTP upgrades and agricultural BMPs will be the primary nutrient reduction drivers to achieve 2025 goals and that stormwater restoration will need to continue in the future to maintain the 2025 Bay nutrient caps, offset the impact of climate change and to restore local rivers and streams.

The Phase III WIP expects to maintain a pace of restoration of impervious surfaces that would lead to 30% cumulative restoration by 2025 and almost 40% by 2030. There has been no retreat. Restoration of impervious surfaces with little or no stormwater management is largely implemented through the MS4 permits, which regulate more than 90% of the impervious surfaces in the state. In the last decade, the MS4 jurisdictions combined impervious surface restoration (concrete commitments on impervious surfaces with little or no stormwater management) has averaged about 2% per year or 20% by 2019. Continuing at this 2% pace represents a continuation of the most challenging and expensive component of Bay restoration goals in Maryland.

Question 2: Maryland's Phase III WIP set numeric goals for nitrogen pollution entering the Bay from urban and suburban stormwater in 2025 that are higher than the nitrogen loads from this sector back in 2009. The Phase III WIP would increase the amount of nitrogen pollution flowing into the Bay from stormwater runoff each year by 247,000 pounds by 2025, compared to the 2009 baseline. This suggests the state is not planning to make any net reductions at all in nitrogen from urban and suburban stormwater by 2025 and is instead accepting increases from this sector. Why?

Response 2: With respect to the 2009 comparison, as a result of Chesapeake Bay model changes, improvements in data reporting, load estimates are not comparable. The Phase III WIP reports that between 2017 and 2025 stormwater nitrogen, phosphorus and sediment pollution is expected to decrease. This will result from the combined effect from pollution mitigation and land conservation strategies on future development in addition to restoration of developed land with little to no existing stormwater management practices. The Phase III WIP, unlike the previous WIPs, accounts for growth to 2025 by factoring in the future population and land use (See Section VI). As land is developed, it is subject to many state laws, such as Environmental Site Design, Forest Conservation, Critical Area, Program Open Space, Tier II Waters, and wetland mitigation as well as local ordinances.

Question 3. Compared to Maryland's Phase II WIP (back in 2012), Maryland is now planning in its Phase III WIP to build fewer rain gardens (zero acres of rain gardens instead of 34,716 acres) by 2025. The state also plans to create less permeable pavement (zero acres instead of 350 acres), and plant fewer forested buffers along urban streams (zero new acres instead of 26,430 acres), among other retreats in urban and suburban stormwater commitments. Why?

Response 3: In the Phase III WIP, the stormwater restoration is estimated using different parameters than the Phase II WIP, thus a direct comparison is flawed. The change reflects that implementation of the strategies, or specific practices, occurs through the MS4 permits. Thus, the MS4 jurisdiction has the flexibility to determine the best practices given the land use, geology and environmental priorities of the county or city, while still meeting the restoration requirements in the WIP and the permit. In the draft MS4 permit expected out later this year, permit incentives have increased for forest buffers, green infrastructure and capturing and treating more runoff volume. These incentives will support growth of green infrastructure that align with local needs and Bay restoration goals.

Question 4: Is Maryland essentially giving up on the urban/suburban stormwater sector because of its high cost, compared to other strategies for reducing pollution in the Bay?

Response 4: Maryland has strengthened its effort on stormwater restoration in the Phase III WIP and recognizes that restoration will continue past 2025 to restore local streams and rivers and the Chesapeake Bay. This is a long-term commitment. Stormwater restoration is expensive but local communities also invest in co-benefits including increasing flood resiliency, increasing groundwater supplies and greenspace, to name a few.

Maryland's large and medium MS4 jurisdictions have established themselves as national leaders by collectively investing $685 million in clean water infrastructure. As a result, 35,000 impervious acres have been restored, reducing more than 67,000 pounds of phosphorus, 270,000 pounds of nitrogen, and 30,000,000 pounds of sediment annually to local waters and the Chesapeake Bay. The Chesapeake Bay Trust has awarded $36.5 million in grants to MS4 programs that are ensuring a cleaner, greener, and healthier Chesapeake Bay. MDE's Water Quality Finance Administration guaranteed $107 million in low-interest loans for MS4 restoration projects and another $135 million in low-interest loans are pending for additional projects.

To suggest we are giving up is absurd. We are as committed as ever to our nationally acclaimed stormwater permitting program. We continue to successfully defend it against challenges by governments and regulated entities who believe it's too aggressive or costly all the way up to the US Supreme Court and we continue to insist on greater environmental results to meet our Clean Water Act commitments.

Question 5: Is Maryland deferring action on the urban/suburban stormwater sector until after 2025? If so, why?

Response 5: Maryland is preparing to issue five Phase I Large MS4 permits by the end of this calendar year. These permits will result in a cumulative restoration of 30% by 2025, successfully meeting our phase III WIP Goals. Further, the permits represent a significant effort to engage with local governments. Local support is the key to long term success of restoration goals since planning, funding and execution of BMPs is a local responsibility.

Question 6: Maryland has changed its MS4 stormwater permits, which used to require counties and cities to restore 20 percent of a municipality's impervious surfaces. Counties and cities can now buy pollution trading credits as an alternative to restoring 20 percent of their impervious surfaces. Why? Is this switch to the pollution trading option one of the reasons Maryland's Phase III WIP contains fewer commitments for urban and suburban stormwater projects?

Response 6: Urban and suburban stormwater projects are as high a priority as ever, and we are doing more than ever to encourage and support the multiple co-benefits of such projects including climate adaptation and resiliency.

No matter how many times you say it, our nutrient and sediment credit trading programs are not "pollution trading," a misleading label to imply pollution is only getting spread around. Nutrient and sediment credit trading is an increasingly important tool in the Chesapeake Bay watersheds around the country to accelerate the pace of actual restoration and bring more partners to the table without letting polluters off the hook. It can increase cost effectiveness and stronger partnerships to meet our Bay restoration goals. In addition to permit compliance, trading done right provides permittees with incentives to explore more cost effective, innovative solutions to achieve their pollution reduction goals, and incorporate other co-benefits into their implementation goals. It's an important tool that can help the Bay and local water quality as long as regulatory accountability, transparency, and public support are joined with it.

APPENDIX C: Statement from Pennsylvania Department of Environmental Protection

In response to questions from EIP, Deborah Klenotic, Deputy Communications Director for the Pennsylvania Department of Environmental Protection, emailed the following answers on July 24, 2020:

"Question: In its Phase III Watershed Implementation Plan (WIP), submitted to EPA in August 2019, Pennsylvania promised to do less to control stormwater from urban and suburban areas than it pledged back in 2012 in its Phase II WIP. Why the retreat on concrete commitments to reduce urban and suburban stormwater pollution into the bay?

Answer: The Phase 3 WIP is based on updated and far more sophisticated technical analyses than were possible in 2012, which allows DEP to focus on pursuing the most impactful as well as implementable pollution reduction efforts. The primary difference between the Phase 2 and 3 WIPs is the level of certainty Pennsylvania has with respect to implementation. We are certain we'll accomplish more in urban stormwater load reductions in 2020-2025 than occurred in 2012-2019. The urban stormwater pollutant load reduction goals in the Phase 3 WIP are based on multiple planned actions: stormwater best management practices (BMPs) specified by Municipal Separate Storm Sewer System (MS4) municipalities in the Pollutant Reduction Plans (PRPs) and Total Maximum Daily Load (TMDL) Plans they have submitted for National Pollutant Discharge Elimination System (NPDES) permit requirements; the establishment of forest buffers in urban environments; ongoing efforts to manage post-construction stormwater runoff for development projects; and reductions in illicit discharges to MS4s as required by NPDES permits. These planned actions were simulated in the EPA Phase 6 Chesapeake Bay Model to determine reductions in the Phase 3 WIP and will play a crucial part in meeting our 2025 goals.

That said, while nitrogen is the critical pollutant of concern to the Bay, urban areas generate low concentrations of nitrogen and urban stormwater BMPs are generally inefficient at removing nitrogen. It would serve no purpose to continue using load reduction goals proposed in the past that weren't based on accurate technical understanding, realistic data, or regulatory mechanisms. Pennsylvania decided that moving forward, we need to focus our limited resources on the pollutant load sectors where nitrogen control BMPs will have the greatest impact, such as agriculture.

The focus of the MS4 program is to address the local water quality impairments caused by impervious urban areas. The rate and flow from these areas causes gullies and erodes stream banks and beds. Pollutants wash off because runoff cannot infiltrate the ground. Reduced groundwater recharge causes urban streams to dry up and/or have increased temperatures in the summer. Illicit discharges (e.g., oil, chemicals and sewage from leaky pipes) hurt aquatic life. These are the issues that our urban water quality programs are addressing. In developing Pennsylvania's MS4 General NPDES Permit (PAG-13) in 2015-2016, DEP also anticipated that more would be expected of the urban stormwater sector as part of its Phase 3 WIP. This is why PAG-13 requires PRPs and TMDL Plans. The focus of these plans is on attaining millions of pounds of sediment reductions to improve local waterways, but hundreds of thousands of pounds of nitrogen reductions will also occur to assist our efforts to clean up the Chesapeake Bay. It is true that it's not cost-effective for urban stormwater management to treat exclusively for nitrogen, but nitrogen is also reduced as sediment is reduced.

Pennsylvania's Phase 3 WIP was developed by over 1,000 Pennsylvanians. Farmers, local municipal and community leaders, foresters, academic experts, environmental organizations, and state government agencies contributed their expertise. This process produced a plan that is realistic, grounded in data and technical knowledge, and is actually going to reduce nitrogen, phosphorus, and sediment in the watershed.

Additionally, DEP is delegated the NPDES Construction Stormwater program from EPA, and we work directly with conservation districts in implementing this program. Our state regulations require that erosion and sediment control and post-construction stormwater management (PCSM) BMPs are implemented and maintained for earth disturbance activities where there is an NPDES permit requirement (equal to or greater than one acre of disturbance). Our state regulations require that the net change in rate, volume, and water quality (pollutant loading), comparing pre-construction to post-construction conditions, is addressed through PCSM. The data submitted quarterly by conservation districts and through our triennial review of the program were analyzed as part of the Phase 3 WIP development process.

Question: Pennsylvania's Phase III WIP set numeric goals for nitrogen pollution entering the Bay from urban and suburban stormwater in 2025 that are higher than the nitrogen loads from this sector back in 2009. The Phase III WIP would increase the amount of nitrogen pollution flowing into the Bay from stormwater runoff each year by Pennsylvania's by 301,360 pounds by 2025, compared to 2009. Back in 2012, in the state's Phase II WIP, Pennsylvania committed to decreasing nitrogen pollution from urban and suburban stormwater into the Bay by 6.7 million by 2025. Why the change?

Answer: Efforts to curb nitrogen loading to the Bay from urban and suburban stormwater sources will yield smaller results than pursuing nitrogen reductions in other sectors. The Phase 3 WIP will achieve a reduction of 34 million pounds of nitrogen loading by 2025 while accounting for changes in strategy. See above for additional details.

Among other changes, Pennsylvania's Phase III WIP would replace only 202 acres of impervious surfaces instead of the 2,300 acres planned by the state back in 2012 in the Phase II WIP. Pennsylvania's Phase III WIP would create 203,265 acres of stormwater control ponds, wetlands and other projects by 2025, instead of the 1.5 million acres of stormwater control practices planned in the Phase II WIP back in 2012. Is Pennsylvania backing away from these urban/suburban stormwater projects because of their high cost, compared to other strategies for reducing pollution in the Bay?

The Phase 3 WIP provides a more credible estimate of reductions to be achieved from real stormwater projects identified in MS4 Pollutant Reduction Plans and TMDL plans, as well as industrial stormwater projects.

Question: Is Pennsylvania essentially deferring action on the urban/suburban stormwater sector until after 2025? If so, why?

Answer: DEP is not deferring action on the urban stormwater sector. Quite the opposite. The 2018 MS4 General Permit established a challenging pollutant load reduction requirement for hundreds of Pennsylvania MS4-permitted municipalities. Those municipalities are actively implementing PRPs now, in many cases at substantial cost. Their required BMPs must be operational, and their pollutant load reductions attained, within 5 years after their plans were approved. Those are today's requirements for the urban sector, and they are significant. The nutrient load reductions we'll achieve through the MS4 permit requirements put in place starting in 2018 will be orders of magnitude greater than any nutrient load reductions achieved through prior MS4 permits (which were essentially none), regardless of what load reduction goals were proposed in prior WIPs.

APPENDIX D: Statement from DC Water

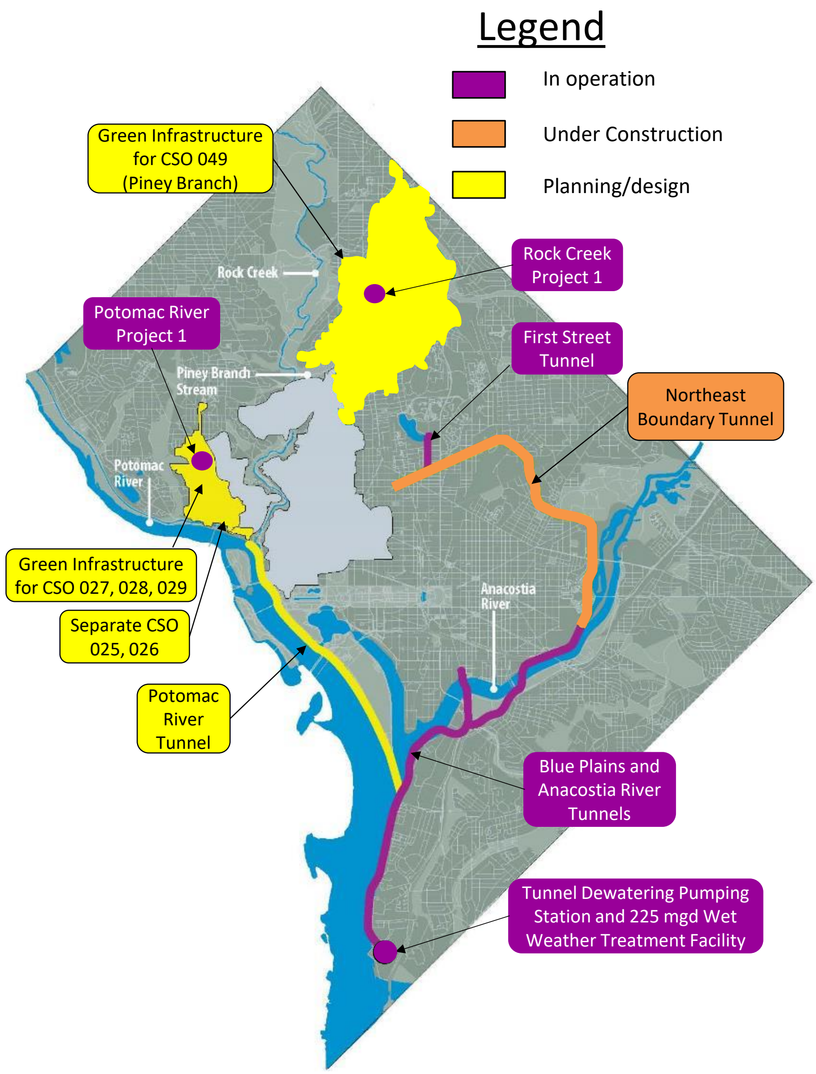
In response to written questions from the Environmental Integrity Project, Tamara Stevenson, Senior Manager of Marketing, Production and Operations at DC Water, emailed the following statement on July 24, 2020:

[Question 1: In DC's 2002 long term control plan, why does the city assume an average amount of rainfall of 38.95 (the average of the forecast period of 1988-1990), when the most recent five-year average from NOAA is significantly higher, 48.14?]

Answer: As rainfall depths can vary widely from year to year, the Long-Term Control Plan (LTCP) was developed in accordance with EPA guidelines for CSO planning using "system-wide annual average" rainfall conditions. In preparation of the LTCP, DC Water reviewed 50 years of rainfall data at Ronald Reagan National Airport. The average rainfall over this 50 period was 38.95" per year. The rainfall for the periods 1988-1990 was selected as representative of average conditions for use in evaluation of CSO controls. This three-year period averaged 40.97" per year, and included one year each drier than, approximately equal to, and wetter than the long-term average, allowing for evaluation of CSO control performance across a variety of climatic conditions.

[Question 2: Was the construction of the two underground stormwater storage tunnels (capacities of 77 million and 49 million gallons) outlined in the 2002 long term control plan completed? If not, what is their status? In addition, where is DC in the building of additional pumping stations, a new interceptor, green infrastructure, and separating sewage and stormwater outfalls?]

Answer: DC Water is completing the LTCP projects in accordance with the schedule stipulated in its federal consent decree, amended in 2016. Completion of the entire LTCP is required by 2030. The figure below shows the status of the major elements of the program.



DC Clean Rivers Project Status

[Question 3: If the above construction projects have been completed, when?]

Answer: The status and completion dates for each project associated with the LTCP is available in the DC Water's Long Term Control Plan Consent Decree Status Report. The most recent report (Q1 2020), is available here.

APPENDIX E: Statement from Harrisburg Capital Region Water

In response to written questions from the Environmental Integrity Project, Harrisburg Capital Region Water External Affairs Manager Rebecca J. Laufer sent the following statement via email on July 29, 2020:

"Question 1: In Capital Region Water's long term control plan for CSO's, why does the plan use a median expected annual rainfall of about 40 inches per year, based on historic figures in a 57-year record from Harrisburg's two airport gauges? That's about 15 percent less than the annual average of 46 inches of rain the region actually experienced from 2015 to 2019, based on NOAA data. Given that climate change is increasing rainfall across the region – and scientists expect those increases to continue into the future – why didn't Capital Region Water use more recent and higher rainfall averages to plan for its infrastructure improvements?

Answer 1: CRW's City Beautiful H2O Program Plan (CBH2OPP) follows the EPA guidance requirement to establish a "typical rainfall year" that is calculated from the historical rainfall record at the Harrisburg airport (dating back to 1948). The analysis is an averaging process that includes both wetter- and drier-than average years within the historical record. While it is true that 2017 and 2018 rainfall totals were higher than average, their incorporation would not significantly impact the typical year calculation results. Refer to CRW's Combined Sewer System Characterization Report, Section 2 Characterization of Precipitation Patterns, for CRW's EPA approved "Typical Year" statistical evaluation methodology and conclusion (https://capitalregionwater.com/wp-content/uploads/2018/01/CSS-Characterization-Report_v.2.0-FINAL-FOR-WEBSITE.pdf).

Question 2: Capital Region water's long-term plan calls for the upgrade of a sewage pumping plant, improvements to CSO outfall regulation devices, the lining and repair of long-neglected combined sewage and stormwater pipes, as well the planting of trees and rain gardens and the creation of other "green infrastructure" to help soak up rainwater. For which of these specific projects has construction already begun?

Answer 2: See attached document from Capital Region Water.

Question 3: Specifically which of these projects are now complete? And on what dates were they finished?

Answer 3: The attached tables summarize projects undertaken by CRW since submission of CBH2OPP. Each entry includes a brief description and an estimated date of completion. If the project has been completed, it is so noted (and italicized).

APPENDIX F: Statement from Lynchburg Department of Water Resources

In response to written questions from the Environmental Integrity Project, Timothy A. Mitchell, Director Lynchburg's Department of Water Resources, emailed the following statement on July 21, 2020:

"We very proud of our efforts on our award winning CSO Program. We have aggressively worked for over 3 decades to reduce and eliminate CSO overflow points, volume, and pollutants. To date, since 1993, the City has spent and/or appropriate over $400 million on CSO and Water Quality projects (over $20,000 per household). We anticipate being fully complete with our program within the next 5 years. Of the 10 LTCP Priority Projects identified in the 2014 LTCP, the first 6 are either complete or under construction. It is important to note that prior to the 2014 LTCP Update, we were doing massive separation projects. Specifically, answers to your questions follow:

[Question 1: In Lynchburg's long term control plan, why does the city assume an average amount of rainfall of 42.35, using the period of 1993-1995 as "typical year", when the most recent five-year average from NOAA is significantly higher, 48.45?]

Answer 1: According to the CSO Policy, CSO control alternatives should be assessed on a "system-wide, annual average basis". Our 2014 LTCP complies with this guidance by using a typical hydrologic period for all model applications during the long-term control plan (LTCP) development. The typical hydrologic period used for the 2014 LTCP was selected in 2012 to represent the average hydrologic condition in Lynchburg based on a comprehensive analysis of 63 years (1949-2011) of historical rainfall data and other hydrologic parameters (such as receiving water body flows), as described in detail in Section C.6 of Appendix C of the LTCP. In addition to annual average rainfall depth, rainfall intensity, duration and number of back-to-back events were also considered during the selection process. This standard methodology is widely accepted across the country for CSO LTCPs.

For comparison, the historical annual average rainfall depth from 1949 to 2011 is 40.52 inches, whereas the selected three-year period (1993-1995) has an annual average rainfall depth of 42.35 inches, which provides a conservative representation of the average condition. Even with the more recent rainfall from 2012-2019 included, the annual average rainfall from 1949-2019 is 40.82 inches, still below the annual average rainfall of 42.35 inches for the selected three year period. Similarly, the most recent 30-year annual average rainfall (1990-2019) is 41.68 inches, also below the annual average rainfall of 42.35 for the selected three year period. Therefore, the selected three-year period used in our LTCP is fully in accordance with applicable EPA guidance for LTCP development.

[Question 2: Has the city begun construction of the new storage tank, green infrastructure, and increase in capacity for the local wastewater treatment, as outlined in the long term control plan?]

Answer 2: Yes, all the projects at the WWTP including the storage and pumping facility are currently under construction. It is anticipated that construction will be complete and these facilities online in early 2021. Green infrastructure was fully evaluated but in our situation determined not to be a cost effective alternative due to the steep terrain and limited public area in which it could be implemented. That said, green infrastructure is incorporated into any municipal project when possible but is not part of our LTCP strategy.

[Question 3: If the above construction projects have been completed, when?]

Answer 3: See above.

END NOTES

[1] Data from National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information website, accessed 6/5/2020. Link: https://www.ncdc.noaa.gov/cag/city/time-series/USW00093738/pcp/12/12/1920-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000

[2] U.S. Geological Survey streamflow data from USGS "Freshwater Flow into Chesapeake Bay" web page, accessed 6/1/20. Link: https://www.usgs.gov/centers/cba/science/freshwater-flow-chesapeake-bay?qt-science_center_objects=0#qt-science_center_objects

[3] University of Maryland Center for Environmental Science annual "ECOCHECK" report cards on the Chesapeake Bay's health show an overall health rating falling from 54 out of 100 in 2017 to a 44 out of 100 in 2019. Link: https://ecoreportcard.org/report-cards/chesapeake-bay/bay-health/

[4] Data from National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information website, accessed 6/5/2020. Link: https://www.ncdc.noaa.gov/cag/city/time-series/USW00093738/pcp/12/12/1920-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000

[5] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/

[6] Ibid.

[7] Ibid.

[8] Chesapeake Bay Program, 2025 Chesapeake Bay Climate Change Load Projections (Apr. 30, 2018), https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwieqtXxzeHqAhUXoHIEHbT1CpYQFjAAegQIBhAB&url=https%3A%2F%2Fwww.naturalresources.virginia.gov%2Fmedia%2Fgovernorvirginiagov%2Fsecretary-of-natural-resources%2Fpdf%2F2025-Chesapeake-Bay-Climate-Change-Load-Projections.pdf&usg=AOvVaw0z4vRZfDQvZUnwhgW9dRvn.

[9] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/

[10] Ibid.

[11] Tetra Tech, Restoration Plan for Nontidal Sediment in the Patuxent River Lower and Middle Watersheds at 2-3 (July 31, 2019).

[12] Pollution projections from Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/ Maryland Phase III Watershed Implementation Plan (WIP) available at: https://mde.maryland.gov/programs/Water/TMDL/TMDLImplementation/Pages/Phase3WIP.aspx . Maryland has different projections for pollution impact of its WIP than the Bay Program. These numbers reflect the EPA-led Bay Program's estimates.

[13] Numbers compare Maryland's Phase II Watershed Implementation Plan (WIP), approved in 2012, to the state's Phase III WIP, approved in 2019

[14] The pollution control project goals in this category of Pennsylvania's Phase III WIP are "Stormwater Management Composite" includes wet ponds, wetlands, dry ponds, infiltration practices, etc.

[15] Water quality monitoring performed by Susquehanna Riverkeeper on 20 dates in June and July of 2020. Analysis for E coli bacteria performed by ALS Environmental in Middletown, PA.

[16] EPA website, "Learn About Heat Islands," accessed August 5, 2020. Link: https://www.epa.gov/heatislands/learn-about-heat-islands

[17] *See, e.g.*, D.R. Easterling et al., Precipitation change in the United States, pages 218 – 219. In: Climate Science Special Report: Fourth National Climate Assessment, Volume 1. U.S. Global Change Research Program, Washington DC (2017).

[18] *See, e.g.*, L.A. Dupigny-Giroux et al., Northeast, page 705. In: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. U.S. Global Change Research Program, Washington DC (2018).

[19] Environment & Natural Resources Institute, Pennsylvania Climate Change Impacts Assessment Update at 132 (April 2020), prepared for PA DEP, available at http://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/ClimateChange/2020ClimateChangeImpactsAssessmentUpdate.pdf.

[20] Data from National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information website, accessed 6/5/2020. Link:

https://www.ncdc.noaa.gov/cag/city/time-series/USW00093738/pcp/12/12/1920-2020?base_prd=true&begbaseyear=1901&endbaseyear=2000

[21] Ibid. Precipitation numbers from Baltimore from Baltimore Washington International Airport (BWI).

[22] Ibid.

[23] M. Hoerling et al., Characterizing Recent Trends in U.S. Heavy Precipitation, 29 Journal of Climate 2313, 2319, 2328 (Apr. 2016). "Very wet days" are defined as "days exceeding the 95th percentile of precipitation falling on a wet day precipitation occurrence exceeding 1 mm." *Id*. at 2315. The northeastern United States, for purposes of this study, included all of the Chesapeake Bay states other than Virginia.

[24] D.R. Easterling et al., Precipitation change in the United States, page 212, Fig. 7-4. In: Climate Science Special Report: Fourth National Climate Assessment, Volume 1. U.S. Global Change Research Program, Washington DC (2017). "99th percentile" days are defined as "daily events that exceed the 99th percentile of all non-zero precipitation days." The northeastern United States, for purposes of this study, included all of the Chesapeake Bay states other than Virginia.

[25] *Id*.

[26] U.S. Geological Survey streamflow data from USGS "Freshwater Flow into Chesapeake Bay" web page, accessed 6/1/20. Link: https://www.usgs.gov/centers/cba/science/freshwater-flow-chesapeake-bay?qt-science_center_objects=0#qt-science_center_objects

[27] University of Maryland Center for Environmental Sciences annual ECOHEALTH report card on the Bay, accessed 6/08/20. Link: https://ecoreportcard.org/report-cards/chesapeake-bay/bay-health/

[28] Ibid.

[29] J.M. Thibeault and A. Seth, Changing Climate Extremes in the Northeast United States: Observations and Projections from CMIP5, 127 Climatic Change 273-287, 275 (2014).

[30] D.R. Easterling et al., Precipitation change in the United States, page 221, Figure 7.8. In: Climate Science Special Report: Fourth National Climate Assessment, Volume 1. U.S. Global Change Research Program, Washington DC (2017).

[31] R.G. Najjar et al., Potential climate-change impacts on the Chesapeake Bay, 86 Estuarine, Coastal and Shelf Science 1, 5 (2010).

[32] *See, e.g.*, Chesapeake Bay Program Principals' Staff Committee, 2025 Chesapeake Bay Climate Change Load Projections at slides 3 and 6 (Mar. 2, 2018) (showing "increased precipitation volume and intensity"); Maryland 10 ("Impacts of climate change, including increased precipitation and storm events, are causing heightened nutrient and sediment loads to the Chesapeake Bay").

[33] Chesapeake Bay Program numbers

[34] Ibid.

[35] U.S. EPA, Improving the Resilience of Best Management Practices in a Changing Environment: Urban Stormwater Modeling Studies, EPA/600/R-17/469F at xix (May 2018).

[36] Id.

[37] Id. at 32.

[38] Id.

[39] Id. at 36. Runoff and pollution loads associated with a mix of both "conventional" BMPs and "green infrastructure" such as permeable pavement and infiltration basins would more than double under future conditions, but they would be starting from a much lower baseline than the conventional BMPs alone. For example, runoff volume using conventional BMPs would increase from 7.04 inches/year (current conditions) to 10.96 inches/year (future conditions), while runoff volume from the green infrastructure BMP mix would increase from 1.52 to 3.40 inches per year.

[40] Id. at 39.

[41] As of 2018, stormwater loads from developed land represented at least 16 percent of total nitrogen loads, 18 percent of total phosphorus loads, and 9 percent of total sediment loads. CAST, May 7, 2020. We say "at least" a certain percentage of total loads because the Chesapeake Bay Program's model outputs attribute part of the stormwater load to the "natural" category. To be more specific, the models assume that some amount of stormwater pollution will settle out in streams and rivers, and then be re-suspended and carried to the Bay. These re-suspended pollution loads are attributed to the "streams" category, which is part of the broader natural source category, even though the pollution originally came from developed land. See Environmental Integrity Project, The

State of Chesapeake Bay Climate Modeling at 24-27 (July 25, 2019), available at https://environmentalintegrity.org/reports/the-state-of-chesapeake-bay-watershed-modeling/ .

[42] U.S. EPA, Chesapeake Bay Watershed Implementation Plans, https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-watershed-implementation-plans-wips.

[43] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/. Accessed May 7, 2020. 2009 and Phase III WIP values have changed slightly with the introduction of the 2019 version of CAST. However, the new version of CAST no longer includes load estimates associated with 2012 WIP II planning targets. In order to maintain an apples-to-apples comparison, this table uses CAST estimates as of May 2020.

[44] Id. In 2018, Maryland, Pennsylvania and Virginia accounted for 90 percent of the urban stormwater nitrogen load, 93 percent of the phosphorus load, and 87 percent of the sediment load.

[45] Maryland Phase III WIP at B-32.

[46] Maryland Phase III WIP at B-33.

[47] Nutrient targets were taken from pages 27-33 of the Phase II WIP and pages 24-25 of the Phase III WIP. BMP implementation estimates were taken from Table 10 of the Phase II WIP and Appendix C of the Phase III WIP.

[48] Maryland Phase II WIP, page 27; Maryland Phase III WIP, page 24.

[49] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/. Accessed May 7, 2020. 2009 and Phase III WIP values have changed slightly with the introduction of the 2019 version of CAST. However, the new version of CAST no longer includes load estimates associated with 2012 WIP II planning targets. In order to maintain an apples-to-apples comparison, this table uses CAST estimates as of May 2020.

[50] "Runoff Reduction" in the Phase III WIP. Again, Maryland's WIP conflicts with Chesapeake Bay Program model outputs, which show Maryland's 2025 load as being greater than the 2009 load, for a net increase of roughly 5 million pounds. See Table A9 below.

[51] "MS4 Permit Stormwater Retrofit" and "Stormwater Management Generic BMP" in Phase II WIP.

[52] "Stormwater Treatment" in Phase III WIP.

[53] Described as "Urban Stream Restoration (interim" in Phase II WIP.

[54] "Urban Shoreline Management" in Phase III WIP

[55] Environmental Integrity Project, Pollution Trading in the Chesapeake Bay (Aug. 19, 2019), available at https://environmentalintegrity.org/reports/pollution-trading-in-the-chesapeake-bay/.

[56] Email to EIP from Jay Apperson, Deputy Director of the Office of Communications for the Maryland Department of the Environment on July 29. 2020.

[57] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/. Accessed May 7, 2020. 2009 and Phase III WIP values have changed slightly with the introduction of the 2019 version of CAST. However, the new version of CAST no longer includes load estimates associated with 2012 WIP II planning targets. In order to maintain an apples-to-apples comparison, this table uses CAST estimates as of May 2020.

[58] Includes both "Urban Tree Planting" and "Urban Forest Planting" BMPs.

[59] Email from Deborah Klenotic, Deputy Communications Director from the Pennsylvania Department of Environmental Protection to EIP on July 24, 2020.

[60] Environmental Integrity Project report, "Unsustainable Agriculture: Pennsylvania's Manure Hot Spots and their Impact on Local Water Quality and the Chesapeake Bay," August 31, 2017. Link: https://environmentalintegrity.org/wp-content/uploads/2017/08/Unsustainable-Agriculture_revised.pdf

[61] Chesapeake Bay Commission Report, "Healthy Livestock, Healthy Streams," May 2015, p. 17. Link: https://www.chesbay.us/library/public/documents/Policy-Reports/Healthy-Livestock-Healthy-Streams.pdf

[62] Chesapeake Bay Program, Chesapeake Assessment and Scenario Tool (CAST), https://cast.chesapeakebay.net/. Accessed May 7, 2020. 2009 and Phase III WIP values have changed slightly with the introduction of the 2019 version of CAST. However, the new version of CAST no longer includes load estimates associated with 2012 WIP II planning targets. In order to maintain an apples-to-apples comparison, this table uses CAST estimates as of May 2020; BMP implementation targets from Virginia's Phase II WIP (Table A.1) and Phase III WIP (Appendix D).

[63] VA's Phase III WIP commits to over one million feet of stream restoration, but places that BMP within the "natural" land use category.

[64] These include "stormwater performance standard" BMPs (21,796 acres), "advanced grey infrastructure nutrient discovery program" (17,306 acres), "floating treatment wetland" (377 acres), and "filter strip runoff reduction" (100 acres). Virginia Phase III WIP Appendix D.
[65] Chesapeake Bay Program, Watershed Model Documentation, Overview at 1-4, https://cast.chesapeakebay.net/Documentation/ModelDocumentation.
[66] *Id*. at 12-1.
[67] *See, e.g.*, Chesapeake Bay Program, Draft Climate Change Analysis, Documentation of Methods and Decisions for 2019-2021 Process, 2, ("The averaging period [1991-2000] and critical period [1993-1995] represent long-term climate norms that will no longer be representative of average conditions or a 10-year recurrence interval condition").
[68] Chesapeake Bay Program, Principals' Staff Committee, 2025 Chesapeake Bay Climate Change Load Projections (Mar. 2, 2018), https://www.chesapeakebay.net/channel_files/26045/v._2025_chesapeake_bay_climate_change_load_projections_explanation_revised_02.28.18.pdf.
[69] Chesapeake Bay Program, Draft Climate Change Analysis, Documentation of Methods and Decisions for 2019-2021 Process, 2.
[70] Chesapeake Bay Program, Draft Climate Change Analysis, Documentation of Methods and Decisions for 2019-2021 Process, 3.
[71] WIP at 9.
[72] WIP at 53.
[73] Chesapeake Bay Program Principals' Staff Committee, 2025 Chesapeake Bay Climate Change Load Projections (Mar. 2, 2018), https://www.chesapeakebay.net/channel_files/26045/v._2025_chesapeake_bay_climate_change_load_projections_explanation_revised_02.28.18.pdf; *see also* WIP at 39.
[74] See WIP at 43 ("Maryland is committed to adopting improved climate science by including refined nutrient reduction goals in 2021, and BMP efficiency into a future WIP addendum, and/or two-year milestone commitments in 2022.
[75] Environment & Natural Resources Institute, Pennsylvania Climate Change Impacts Assessment Update at 132-133 (April 2020), prepared for PA DEP, available at http://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/ClimateChange/2020ClimateChangeImpactsAssessmentUpdate.pdf.
[76] *Id*. at 3-4.
[77] Phase III WIP at 28.
[78] Id. at 180.
[79] Id. at 182-185.
[80] Id. at 185-186.
[81] Commonwealth of Virginia, Chesapeake Bay TMDL Phase III Watershed Implementation Plan at 24-25 (Aug. 23, 2019).
[82] Id. at 31.
[83] NOAA Atlas 14, Precipitation-Frequency Atlas of the United States, vol. 10, version 3.0, Northeastern United States at A.4-12 (2015). *See also, e.g.*, Virginia Stormwater Management Program regulations, 9 VAC 25-870-72; Virginia Runoff Reduction Method at 66 (May 2, 2016), https://www.swbmp.vwrrc.vt.edu/vrrm/; York County, Pennsylvania Model Stormwater Ordinance at pages 12 to 13, https://www.ycpc.org/320/Water-Quality-Stormwater-Management; Prince George's County, Maryland Stormwater Management Design Manual at Section 8.2 and Appendix 8-8 (Sep. 2014), https://www.princegeorgescountymd.gov/1478/Design-Manuals. Many local and state regulations also refer to U.S. Department of Agriculture precipitation planning tools, but those tools just incorporate NOAA Atlas 14 data. *See, e.g.*, USDA NRCS, TR-55 DOS version, TR-55 Documentation Appendix B, https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/home/?cid=stelprdb1042925.
[84] NOAA Atlas 14, Precipitation-Frequency Atlas of the United States, vol. 10, version 3.0, Northeastern United States at A.4-12 (2015).
[85] Hydrometeorological Design Studies Center, Progress Report for Period October 2018 to March 2019 (Apr. 2019), available at https://www.nws.noaa.gov/oh/hdsc/current_projects.html.

[86] Ibid.
[87] These permits are called MS4 or Municipal Separate Storm Sewer System permits.
[88] *See, e.g.*, Maryland Department of the Environment, Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Appendix J (Dec. 2019).
[89] Baltimore County, NPDES – Municipal Stormwater (MS4) Discharge permit, 2019 Annual Report at 9-3 (Jan. 22, 2020). The report notes that the Chesapeake Bay TMDL requires 29 percent nitrogen and 45.1 percent phosphorus load reductions for the that the Scotts Level Branch in the Gwynns Falls watershed.
[90] Id. at 9-11.
[91] Id. at 9-24.

[93] Id.
[94] *See, e.g.*, Fairfax County, Difficult Run Watershed Management Plan at 2-15.
[95] *See, e.g.,* Accotink Watershed Management Plan at 2-5 ("Based on many years of rainfall data collected, storms of varying strength have been established based on the duration and probability of that event occurring within any given year").
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