



STATES AT
RISK     

OVERFLOW: CLIMATE CHANGE, HEAVY RAIN, AND SEWAGE

Alyson Kenward, Nicole Zenes, James Bronzan,
Jennifer Brady, Kasturi Shah

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ABOUT STATES AT RISK

States at Risk is aimed at showing how Americans in all 50 states are experiencing the impacts of climate change. Our work focuses on five threats -- extreme heat, wildfires, inland flooding, coastal flooding, and drought -- and the states most affected by those threats. In 2015, States at Risk evaluated how prepared each of the 50 states are for their current and future climate threats in its Preparedness Report Card.

This report was prepared by Climate Central.

Climate Central surveys and conducts scientific research on climate change and informs the public of key findings. Our scientists publish and our journalists report on climate science, energy, sea level rise, wildfires, drought, and related topics. Climate Central is not an advocacy organization. We do not lobby, and we do not support any specific legislation, policy or bill. Climate Central is a qualified 501(c)3 tax-exempt organization.

Climate Central scientists publish peer-reviewed research on climate science; energy; impacts such as sea level rise; climate attribution and more. Our work is not confined to scientific journals. We investigate and synthesize weather and climate data and science to equip local communities and media with the tools they need.

Princeton: One Palmer Square, Suite 330 Princeton, NJ 08542

Phone: +1 609 924-3800

Toll Free: +1 877 4-CLI-SCI / +1 877 425-4724

www.climatecentral.org

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SUMMARY

Record rainstorms across the U.S. in the past year have continued to make national news, causing billions of dollars of flood damage and killing dozens. But what has barely made headlines are that these floods often cause massive overflows of untreated sewage into streams, rivers, bays, canals, and even streets and homes.

Climate Central has investigated the extent of these sewage overflows. In most cases, we found reports that millions of gallons of untreated sewage were released into streets and waterways. These overflows can have devastating consequences for public health and the environment: they can trigger dangerous outbreaks of waterborne diseases and are often linked to fish kills. And when sewage overflows into homes and businesses, expensive remediation and decontamination is needed to make them safe again.

Worse was the discovery that the true extent of sewage overflow is often undocumented and largely unknown.

From the 70 sewage overflows we identified that had occurred in the past 20 months, overflows of more than one billion gallons combined were reported, triggering health warnings in dozens of cities. Local officials confirmed that these reported volumes are likely underestimating the true extent of overflows; during these flooding emergencies, there is typically no reliable way to determine how much untreated sewage gets into the waterways.

With a backdrop of antiquated and overpopulated sewer systems, the increase in rain and heavy downpours in recent decades -- one of the ongoing impacts of climate change -- continues to trigger overflows that affect millions of Americans every year.

While many cities are working toward upgrading their sewer systems, they can't eliminate their sewage overflow risks entirely. Climate models project that both overall precipitation, and the amount of rain falling in heavy downpours, will continue to increase this century with continued climate change, which could cause even more overflows.

According to the National Oceanic and Atmospheric Administration (NOAA) and Climate Central's World Weather Attribution project, the epic rains in Louisiana in August 2016 that flooded 60,000 homes and killed 13, were made nearly [twice as likely](#) due to carbon pollution in the atmosphere. Climate Central's analysis of more than 3,000 rain gauges nationwide shows that heavy downpours are happening more frequently than they did in the 1950s. We found that all but two of the Lower 48 states have seen an increase in the number of heavy downpours happening each year, on average, compared to the 1950s, and 28 states have seen at least a 25 percent increase in these heaviest events. With downpours projected to be even more frequent and intense as the world continues to warm, we can expect more of these costly and dangerous overflows for many years to come.

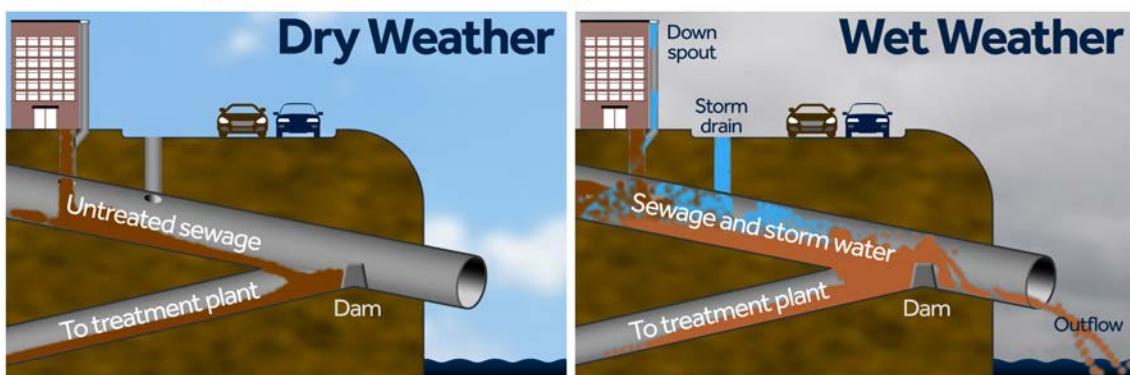
VULNERABILITY OF COMBINED SEWAGE SYSTEMS

Combined sewer systems exist in about [860 communities](#) across the country, and are located primarily in the Northeast and Midwest, in both large and small cities. They were largely introduced before the 20th century and at that time, it was a technological advancement to keep untreated wastewater out of the streets, combining these sewer pipes with stormwater drainage systems. Under normal circumstances, the combined sewer system sends sewage to wastewater treatment plants where it is treated and disinfected before it is mixed back into the water system. When it rains, water is kept off the streets by easily washing into the same drainage system.

During heavy rain, however, the extra stormwater can flood the system. In some cases, the combination of untreated sewage and storm runoff overflows into nearby waterways via outfall pipes or backs up into the streets, flowing up through storm drains or manholes.

How Heavy Rain Causes Sewage Overflows

CLIMATE  CENTRAL



Source: EPA

Wastewater treatment plants are also vulnerable to inundation from storms. Treatment plants are usually located beside the shores of rivers, bays, or the coastline so that treated sewage can be easily released back into the water system. However, when the water levels rise at the shore, they can flood treatment plants, forcing the facilities to bypass untreated or partially treated sewage directly into a river or bay.

Our previous analysis of [sewage overflows during Hurricane Sandy](#) illustrated how coastal treatment plants are threatened by the combination of sea level rise and storm surge. But inland treatment plants face a similar hazard of rapidly rising river waters during intense rainfall or upstream flooding.

Sanitary sewer systems are ones where sewage and stormwater run through separate pipes. While they are less susceptible to massive overflows from heavy downpours, they can still suffer similar problems under extreme conditions. During intense flooding, water can still infiltrate the sewer systems and lead to overflows, and the EPA has estimated that there could be tens of thousands of sanitary sewer overflows happening every year in the U.S.

The extent to which sewage overflows plague the U.S. is likely underestimated. While the EPA requires that sewage overflows be reported, there are no regulations in place for monitoring overflows in most states, so reporting is largely voluntary. The result is that most cities face chronic underreporting of their sewage overflows, as several other studies have found.

With continued population growth, the demands on our combined sewer systems have increased. We send ever more wastewater through the system, and more paved surfaces in our cities and towns can increase the volume of runoff when it does rain. In many parts of the country, precipitation has also increased in the past several decades, and heavy downpours are on the rise in nearly all of the Lower 48 states. In the absence of major improvements to our sewer infrastructure, these dangerous overflows will increase. And even with adaptation measures in place, no city is completely immune from the types of overflows that happen during the kinds of intense rainstorms that are projected to happen more frequently.

HEAVY RAIN CAUSES DANGEROUS OVERFLOWS NATIONWIDE

To understand the extent that heavy rain triggers dangerous sewage overflows across the country, we conducted a survey of news reports of rain-related overflows from January 2015 through August 2016. For each of these events, we confirmed how extreme the rain was, and in the case of several record-breaking rain events, we further examined the volume of sewage that was reported.

Of the 70 rain-related sewage overflows that we identified, nearly 30 percent were overflows of more than 1 million gallons – nearly 2 Olympic-sized swimming pools – and 70 percent were of at least 10,000 gallons. Filling an Olympic-sized swimming pool is equivalent to covering a football field in 1.5 feet of sewage.

Table 1. Ten largest overflows identified in news reports between January 2015 -September 2016

Rank	Location	Overflow volume (gallons)	Rainfall amount (inches)	Rainfall dates
1	Milwaukee	681 million	3.7	April 7-9, 2015
2	Memphis	350 million	4.2	March 30-31, 2016
3	St. Louis	100-200 million	9.2	December 26-28, 2015
4	St. Petersburg, Fla.	151 million	9.2	August 31-Sept. 5, 2016
5	Portland, Ore.	91 million	2.2	January 17-18, 2015
6	Topeka, Kan.	50 million	4.4	July 6-7, 2015
7	Ellicott City, Md.	25 million	8.8	July 29-31, 2016
8	St. Petersburg, Fla.	15 million	9.6	July 24-August 3, 2015
9	Baltimore	12 million	3.1	February 23-24, 2016
10	Duluth, Minn.	5.7 million	2.6	March 15-16, 2016

Among all the rain-related sewage overflows we identified, the biggest events – those at least 10 million gallons – were all linked to intense downpours, when several inches of rain fell in just several hours.

For example, this past summer, in Ellicott City, Md., where more than 6 inches of rain fell in just 2 hours, the resulting flash floods were linked to more than 25 million gallons of sewage overflow.

In late March 2016, more than 350 million gallons of sewage flowed into Mississippi tributaries when Memphis received 4.2 inches of rain in one day. This followed an incredible 10.6 inches of rain over 4 days just a few weeks earlier. A major sewer pipe collapsed in the midst of the latter downpour, spilling 50 million gallons of sewage every day for a week. Within weeks, another pipe had burst when the nearby ground gave away from rain-induced erosion, sending several million more gallons of untreated sewage into the Loosahatchie River, which flows into the Mississippi.

In April 2015, when nearly 4 inches of rain fell over two days in Milwaukee, the Metropolitan Milwaukee Sewerage District was forced to bypass an estimated 681 million gallons of sewer overflow into Lake Michigan and the Milwaukee River.

We also found that in dozens of cases, the reported values most certainly underestimate the extent of the overflow; the true volumes are simply unknown, but could be on the order of hundreds of millions of gallons, when compared to other floods of similar sizes their associated sewage overflows.

For example, in the midst of a record-breaking rainfall in December 2015, when more than 9 inches of rain fell in St. Louis, causing river levels to swell and inundate sewage treatment plants, at least 100 million gallons of sewage overflows were reported by the Metropolitan St. Louis Sewer District. However, two sewage treatment plants were flooded and were out of service for weeks. At normal capacity these plants treat a combined volume of 20 million gallons of sewage every day, so it is possible that upwards of 200 million gallons of sewage was bypassed into the Meramec River during this time.

In South Carolina, where last October a 1-in-a-1,000 year rainstorm dumped as much as 16 inches in three days, the resulting sewage overflows were tallied to be 2.5 million gallons. Officials from the South Carolina Department of Health warned us that they had no reliable way of estimating or reporting the real overflow and wastewater treatment plant bypass volumes. A heroic effort by workers at Columbia's wastewater treatment facility prevented a bypass of hundreds of millions of gallons of untreated sewage, but even the identified 2.5 million gallon overflow triggered health warnings for the local population.

Our analysis of news reports of sewage overflows shows that, as an exceptionally conservative estimate, heavy downpours triggered more than a billion gallons of sewage across the U.S. in just 20 months. Our investigations also reveal that the true volume is likely much larger and that the circumstances surrounding these emergency flooding situations means it is nearly impossible to accurately evaluate the true scale and impact of these sewage contaminations.

It is also worth pointing out that our analysis is limited to those overflows that made headline news. Yet, sewage overflows are so commonplace in some parts of the country that they don't ever make headline news. For example, in Pennsylvania, the Allegheny County Sanitation Authority has issued [dozens of overflow advisories](#) along its waterways this summer, and yet we were unable to find any news stories about any of these specific overflows and their health and environmental consequences.

Methodology: We conducted a nationwide web search for news articles reporting on rain-related sewage overflows from January 2015 to present. In the cases where overflow volumes were unknown or reported early, and in cases of record rainfall, we reached out to local authorities for further information on overflows and sewage bypass estimates. Rainfall dates and amounts were then corroborated using station records supplied by the [Applied Climatology Information System](#).

RAIN-RELATED SEWAGE OVERFLOWS IN MARYLAND

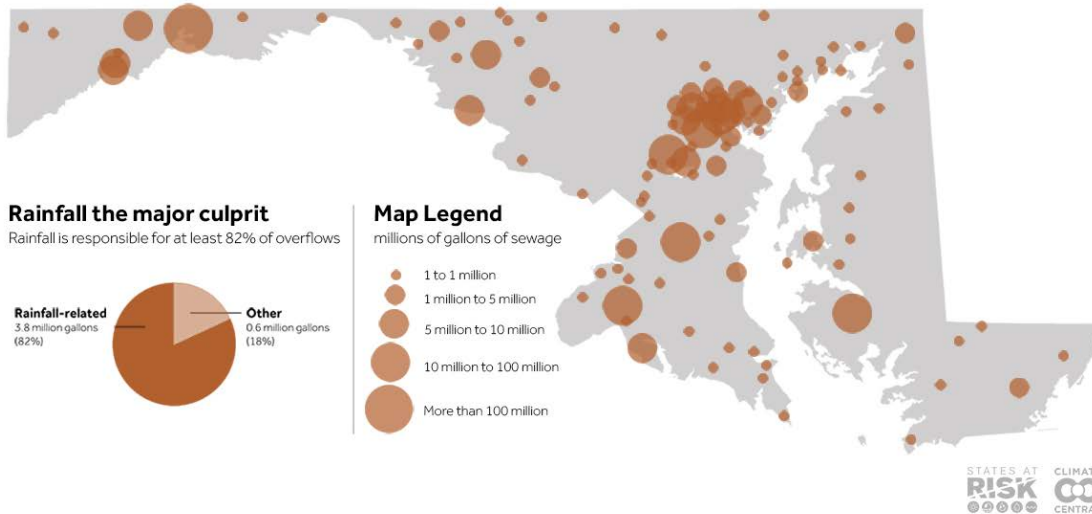
In Maryland, for example, which has one of the best state-level reporting systems for overflows, an additional analysis of nearly 20,000 recorded sewage overflows since 2005 shows that 82 percent of the total volume was from rain-related overflows. And of this 3.6 billion gallons of rain-related overflows, 23 percent were triggered by heavy rain.

To better understand the long-term relationship between sewage overflows and both rain and heavy downpours, we also did a focused analysis on 11 years of data from Maryland. The state's Department of the Environment maintains a database of sewer overflow events dating back to 2005. It is one of the most complete databases of its kind in the country; the system relies on municipalities to report accurately though fines for failure to report are rarely issued. Even with a higher-than-average reporting of overflows, it's likely that this database doesn't capture every overflow, and it is hard to estimate what kind of sewage volumes might consistently be going unreported.

Our analysis of more than 18,000 reported overflows since 2005 revealed that rainfall is a major driver of these events. 82 percent (3.6 billion gallons) of the total volume of all overflows were triggered by rainfall. That is equivalent to more than 5,468 Olympic-size swimming pools of sewage contamination over 11 years in Maryland, or an average of more than 495 pools' worth each year.

Eleven Years of Sewage Overflows Caused by Rainfall in Maryland

Precipitation-related sewage overflows from 2005 to 2015



Of these 3.6 billion gallons, 23 percent (870 million gallons) are linked to heavy downpours. In the three days before these sewage overflows were reported, the nearest rain gauge registered one of its top 10 percent heaviest rain events. However, this number almost surely underestimates the role of heavy precipitation because it does not capture overflows happening downstream of a major rainfall event, where high waters can also cause floods that cause sewage spills.

Two towns in northwestern Maryland accounted for a staggering 3 billion gallons of precipitation-caused sewage overflows, about 79 percent of all rain-related overflows in Maryland's database. While it is clear that these towns face an outsized challenge from sewer overflows, this figure also likely reveals the limitations of this database and more consistent reporting from other jurisdictions. Nevertheless, this means that more than 4,535 Olympic-size swimming pools of sewage have overflowed into the Potomac River and its tributaries over an 11-year period.

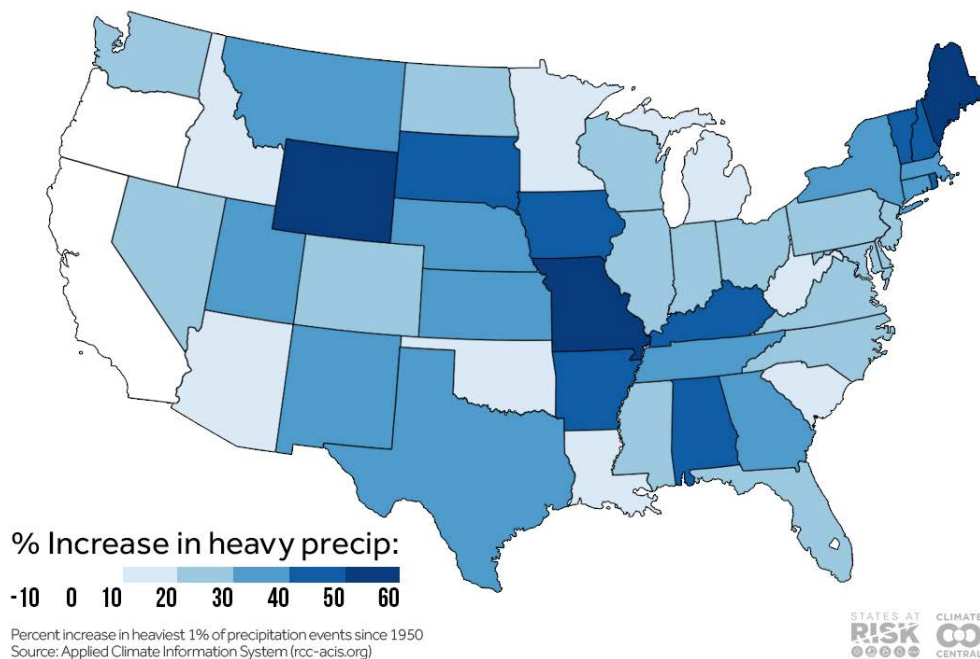
Methodology: Maryland's Department of Environment maintains a publicly accessible database of all reported sewage overflows since 2005 (more than 18,000 overflows). However, this database most certainly underestimates the true volume of all overflows because the compliance department of the Department of Environment regularly municipalities for failing to report overflows. For our analysis, we focused on a subset of overflows with causes related to precipitation. To determine whether overflows were related to heavy rain events, we used the precipitation records of the nearest weather station with at least 80% of its daily data present over the 30-year period 1986 to 2015. (22 weather stations in Maryland met this standard.) We compared the total precipitation in the 72 hours leading up to the date an overflow was discovered to the top 10% of 72-hour rainfall totals at that station. An overflow was deemed caused by "heavy precipitation" if its 72-hour rainfall was in the top 10% of 72-hour rainfalls over the 30-year record.

HEAVY DOWNPOURS ON THE RISE

Our analyses of both news-reported sewage overflows and routine overflows in Maryland show that while even modest amounts of rain can produce sewage overflows from combined sewer systems, it is the heaviest downpours that typically instigate massive sewage spills.

Climate Central's analysis of more than 3,000 rain gauges nationwide shows that heavy downpours are happening more frequently than they did in the 1950s. We found that all but two of the Lower 48 states have seen an increase in the number of heavy downpours happening each year, on average, compared to the 1950s, and 28 states have seen at least a 25 percent increase in these heaviest events.

More Heavy Downpours



Consistent with [previous work](#), the biggest increases in heavy rain are seen in the Northeast and Midwest. The analysis is based on the heaviest downpours – those days when the total precipitation exceeded the top 1 percent of all rain and snow days at each individual rain gauge – over the period 1950-2015. These state averages are based on area-weighting of local rain gauges, but because intense bouts of rain can be highly localized, there are some areas that have seen even more dramatic increases in these downpours over this 65-year period.

As temperatures warm, the air can hold more water vapour, and global analyses already show that atmospheric water vapor has increased. With more water vapor in air, when it rains there is more moisture available to fall as precipitation. Climate scientists predict the increasing trends in [heavy downpours will continue](#) this century, particularly if greenhouse gas emissions keep increasing.

The methodology for this analysis of heavy downpours was as described in our [previous report](#), updated to include 2015.

SEWER UPGRADES HELP BUT CAN'T PREVENT ALL OVERFLOWS

Ongoing and increasing sewage overflow problems have already prompted several cities to begin costly upgrades to their combined sewer systems. For example, Chicago is in the midst of an overhaul of its sewer system, one that has, for decades, suffered from constant overflows into its streets, canals, and Lake Michigan. Minneapolis and Washington, D.C. have also recently completed major improvements to their sewer systems. Upgrades can include improvements like larger and newer pipes, increasing the capacity at wastewater treatment plants, and even converting combined sewage systems to separate sewer systems, where stormwater runs through a completely separate set of pipes. These upgrades are costing taxpayers hundreds of millions, and sometimes billions, of dollars, but along with other adaptation measures, they can help offset the impacts of heavy downpours.

However, no sewer system upgrade will prevent all overflows; even the most advanced sewer systems will still face the threat of damage from heavy rains. More pipes and increased sewer capacity can help contain more stormwater, but intense storms can still inundate the system. That was this case this past spring in Duluth, where unusually heavy rain caused overflows into Lake Superior, even after a systemwide \$160 million improvement. And if rivers breach their banks at the site of treatment plants -- or storm surge inundates coastal plants -- facilities may have no choice but to bypass untreated sewage. In many cases, large overflows result when pipes burst after the soil around them washes away during heavy storms, and even upgraded pipes may not be able to withstand the effects of these washouts.

Princeton: One Palmer Square, Suite 330 Princeton, NJ 08542
Phone: +1 609 924-3800
Toll Free: +1 877 4-CLI-SCI / +1 877 425-4724
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