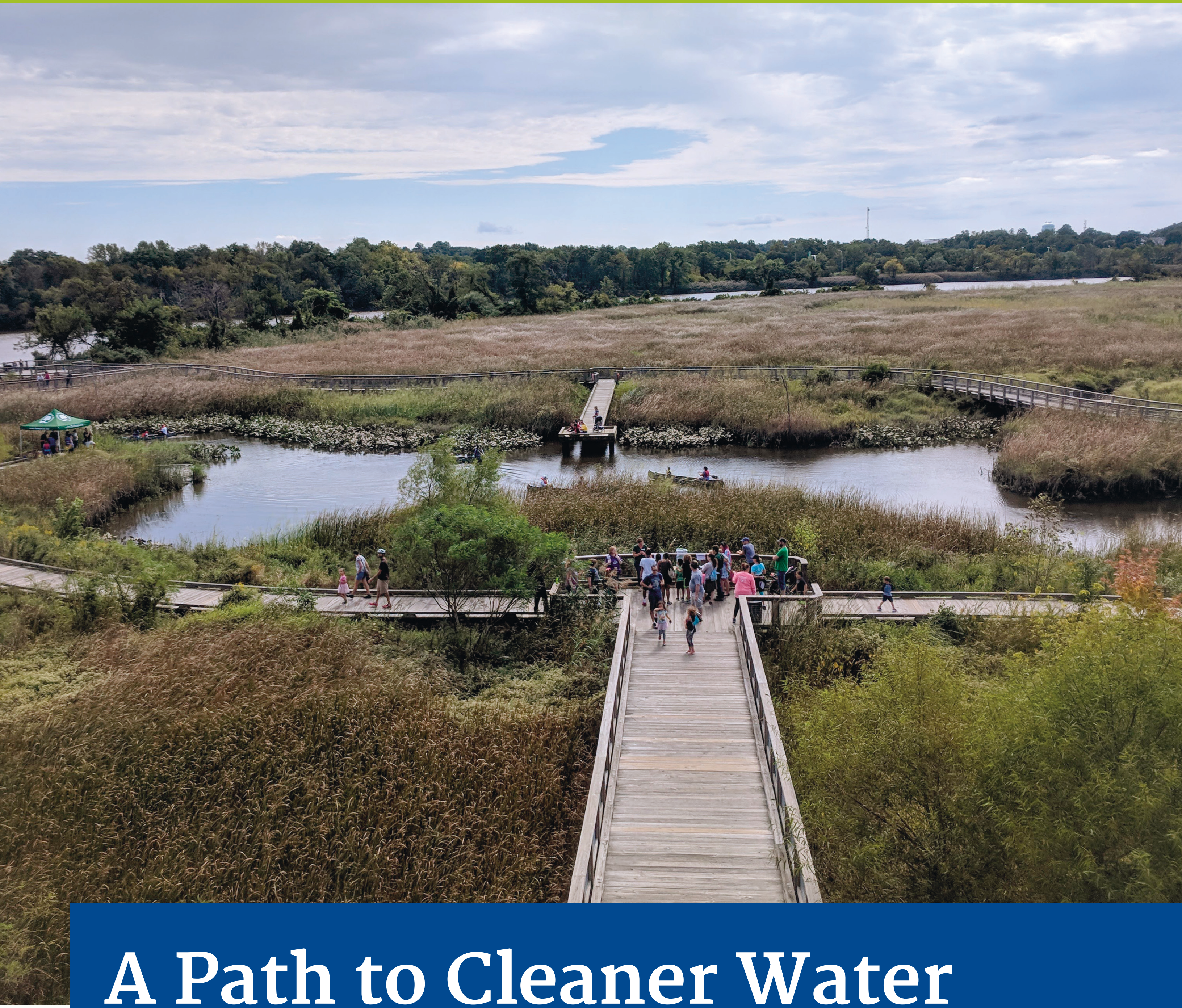

A Path to Cleaner Water

How investments in America's water infrastructure are protecting waterways

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Layout: Alec Meltzer/meltzerdesign.net
Cover: Wetlands of Christina River, DE. Credit: Laura Miller

Table of contents

Executive summary

America's waterways are a national asset. They are the places we swim on hot summer days, kayak with friends and family, spend a relaxing day fishing, and so much more. Yet billions of gallons of stormwater runoff and sewage overflows continue to pollute our rivers, lakes and coastal waters. As a result, all too often our beaches are unsafe for swimming, communities are flooded with sewage, and toxic algal outbreaks threaten wildlife and public health. Absent strong action from our leaders, these pollution problems will worsen in coming years, as overdevelopment and more intense storms put greater burdens on our fraying water infrastructure systems.

Stormwater and wastewater management systems are part of America's water infrastructure; when properly maintained they can prevent pollution. But as a nation, we have failed to keep our water infrastructure in working order. The American Society of Civil Engineers gave U.S. wastewater infrastructure a D+ grade in 2017.[1]

If we want clean water, our nation will have to make a substantial investment in repairing and updating our infrastructure. The U.S. Environmental Protection Agency (EPA) estimates that wastewater and stormwater systems will require an investment of $271 billion over the next 20 years to meet demands.[2] This is likely a conservative estimate for actual investment requirements in the coming years.

With investment in clean water, America can deploy nature-based or green infrastructure—such as vegetated buffers, rain barrels, and constructed wetlands—to help prevent combined sewage overflows and capture stormwater before it sweeps pollutants into our waterways. Simply fixing and updating our aging and often outdated sewage infrastructure will also reduce this pollution.

In every EPA Region across the country, there are success stories. Documented cases of communities fixing and/or greening their water infrastructure exist nationwide, creating cleaner waterways as a result:

- **Rhode Island**—Green infrastructure and septic replacement helped eliminate beach closures from bacteria at Bristol's Town Beach on Narragansett Bay.
- **Vermont**—Green stormwater infrastructure is protecting the Passumpsic River and St. Albans Bay on Lake Champlain from runoff pollution.
- **Maine**—By upgrading its treatment plant, separating sewer lines and increasing stormwater storage, Portland is on track to end sewage overflows into Casco Bay by 2030.
- **Connecticut**—Stormwater redirected to an existing wetland, and new vegetation restored the Edgewood Park Pond as a clean and treasured feature of the park.
- **New Jersey**—Underway green stormwater infrastructure projects in Hoboken and the Camden area are projected to dramatically reduce pollution into the Hudson and Cooper rivers, respectively.
- **Delaware**—A soon-to-be completed stormwater wetland park and stormwater and wastewater sewer separation will eliminate sewer overflows and reduce stormwater pollution into the Christina River.

- **Maryland**—Green infrastructure and conservation landscaping around the MedStar Harbor Hospital is trapping and filtering 18 acres of runoff before it reaches the Patapsco River.
- **Florida**—Updates to sewer and stormwater infrastructure is keeping runoff pollution from Robert's Bay and the surrounding white sand beaches.
- **North Carolina**—Forthcoming sewer improvements will keep sewage pollution from entering the Flat Swamp and flowing into the Pamlico Estuary.
- **Alabama**—Green infrastructure soaks up nutrients, making Mill Creek clean and accessible to Auburn University and local residents.
- **Illinois**—A world-class stormwater tunnel and reservoir system eliminated combined sewer overflows in 2018 from the Calumet river systems in the Chicago region.
- **Ohio**—Green stormwater infrastructure projects around Cleveland are keeping 46 million gallons of combined sewer overflows out of Lake Erie.
- **Wisconsin**—An in-the-works green stormwater park will prevent an estimated 293,000 gallons of stormwater runoff from Interstate 794 from contaminating Lake Michigan.
- **Texas**—Wastewater treatment system updates keep fecal bacteria out of the Guadalupe River, and nature-based infrastructure incorporated into a road redesign now protects the San Marcos River from stormwater pollution.
- **Missouri**—Green infrastructure and a stream restoration project is preventing stormwater runoff pollution and other threats from contaminating the Blue River and South Creek.
- **Montana**—Wastewater treatment system upgrades are helping protect Hebgen Lake for wildlife and recreation.
- **California**—An ongoing project to switch residents from failing septic systems to a new wastewater treatment facility will help make Malibu Lagoon State Beach safe for swimming and surfing.
- **Washington**—Wastewater treatment plant upgrades greatly reduce nitrogen levels and eliminate combined sewer overflows into the Puget Sound.
- **Oregon**—Gray and green stormwater infrastructures are working together to reduce combined sewer overflows into the Willamette River and Columbia Slough by 94 percent and 99 percent, respectively.

These examples show investments in water infrastructure providing tangible clean water results.

Policy makers must invest in America's water infrastructure and innovative gray and green infrastructure to prevent stormwater runoff pollution and sewage overflows from reaching waterways. By investing now, the nation can begin improving its water management systems before the problem worsens and becomes harder to address.

Introduction

Effective water infrastructure protects America's beaches, drinking water sources, and vital waterways. It ensures that polluted stormwater and sewage don't flood the streets when it rains or contaminate the waters in which we swim, fish, and boat.

Systems that manage water can be conventional, such as pipes and treatment plants, and natural, such as wetlands and rain gardens. Due to a lack of funding to install or upgrade these systems, our country is failing to keep waterways clean.

In 2017, the American Society of Civil Engineers gave U.S. wastewater infrastructure a D+ grade.[3] The U.S. Environmental Protection Agency (EPA) estimates that wastewater systems will require an investment of $271 billion over the next 20 years to meet current and future demands.[4] This estimate is for system repairs and maintenance, and does not mention the need to remove emerging contaminants nor the impacts of climate change on water infrastructure.[5] Therefore, it is likely an underestimate of the expected cost to protect American waterways.

Not only is the need for funding great, but overall federal investments in water infrastructure have declined since the 1980s. The federal government's investment in water and wastewater utilities declined from 63 percent in 1977 to only 9 percent in 2014.[6] Cash-strapped state and local governments pay significantly more than the federal government on water infrastructure.[7] Strain on state and local government budgets often cause water infrastructure needs to fall behind other priorities, leading to unsafe water, particularly in communities with smaller budgets and reduced capacity. This strain will worsen due to the economic impacts of COVID-19. Continuing to fund clean water at the current level is insufficient for the nation's needs.

Without proper investment, the impact of failing water infrastructure and stormwater runoff pollution is evident. In 2020, dead fish washed ashore in Biscayne Bay in Florida[8] and the Pamlico River in North Carolina[9] as pollution made the water uninhabitable. In the last decade, the frequency of algal outbreaks in the Great Lakes rose dramatically[10] due in part to sewage overflows and stormwater runoff pollution.[12] Many swimming spots, such as Juanita Beach in Washington state,[13] can be deemed unsafe for swimming after potentially hazardous levels of contaminants, such as fecal matter bacteria, are detected.

Contaminants that threaten our waterways often come from sources that effective water infrastructure could prevent. Without action to update our water systems, more fish kills, harmful algal outbreaks, and beach closures can be expected in years to come.

Excessive stormwater carries pollution to our waterways

Rainfall, snow melt, floodwaters, and other types of stormwater flowing over urban and suburban areas can pick up contaminants and carry them to nearby waterways. Stormwater runoff can contain nutrients and bacteria from fertilizer, and fecal waste from yards and failing sewer systems. This polluted stormwater runoff can contaminate waterways directly, or after passing through storm drains that do not remove pollutants.

Impervious surfaces—such as parking lots, highways, and malls—prevent stormwater from percolating naturally through the soil. Instead, stormwater flows along these surfaces and picks up oil, grease, fecal matter, and toxic chemicals, and then all too often sweeps these pollutants into nearby waterways.. Additionally, overdevelopment often destroys or degrades natural areas like wetlands that protect waterways by filtering out pollutants.

In recent history, developed areas in the U.S. have rapidly expanded. From 1996 to 2010, 3.6 million acres of coastal areas in the U.S. were developed, while 982,000 acres of wetlands and millions of acres of forests were destroyed in that region.[14]

A 2014 study from the journal Hydrological Processes found that an "increase in impervious surfaces will intensify current undesired impacts of development by converting even more rainfall to stormwater runoff" and "[c]oncentrations of indicators of water quality degradation (e.g. chemicals, nutrients, bacteria, viruses) increase in waterways as development increases."[15]

As over-development increases volumes of runoff, heavy precipitation events are also worsening stormwater runoff pollution. Research shows that climate change is increasing the frequency and intensity of rain events in many parts of the country. The Northeast and Midwest regions are experiencing the greatest increases in heavy precipitation, 71 percent and 37 percent respectively.[16]

Each region is unique, therefore intensifying storm events are impacting stormwater runoff volumes differently. But an increase in severe storms will increase runoff volume and the peak rate of stormwater flow.[17] For example, precipitation data over Lake Ontario between 1954-1983 and 1984-2013 show an increase in precipitation of 3.5 percent. During that period, runoff into Lake Ontario increased by 9.8 percent [18] adding pollution stress to the lake.[19]

As intensifying storms and expanding development increase stormwater runoff pollution, the need for clean water solutions such as updated water infrastructure and clean water funding grows as well. Without immediate action, stormwater runoff pollution will worsen, our waterways will grow dirtier, and water infrastructure will require larger, more expensive fixes.

Failing sewage systems threaten waterways with fecal contamination

In the U.S. there are tens of thousands of sewage system leaks or overflows every year,[20] spilling human fecal waste into the environment and contaminating rivers, lakes, and coastal waters.

Some of the worst sewage spills are caused by combined sewer systems, outdated systems that combine stormwater and sewage in a single pipe. During storm events, the increase in stormwater overwhelms the system and causes an overflow of excess sewage and stormwater into a nearby waterway. This overflow event is called a Combined Sewer Overflow (CSO).

There are approximately 860 communities and 40 million people served by combined sewer systems in the U.S., most of which can be found in Northeast and Great Lakes regions.[21] In 2014, EPA reported that in the Great Lakes region alone, CSOs discharged 22 billion gallons of sewage and stormwater into the Great Lakes.[22] For communities using these systems, aging wastewater infrastructure and increased stormwater volumes will lead to an increase in CSO events.

Sanitary sewers, unlike combined sewer systems, carry only sewage and are less prone to spills if maintained.[23] However, they overflow as many as 75,000 times a year in the U.S.,[24] and spills occur either when a pipe leaks sewage or water enters the pipe causing an overflow. Storm events with heavy rainfall, and sanitary sewers places in locations with high water tables can increase the chance for these systems to be overwhelmed.

Septic systems are another major source of sewage pollution, with a failure rate between 5 and 35 percent.[25] When used and maintained properly, septic systems can effectively treat wastewater at the source. But if installed in a location prone to flooding or if they are not properly maintained, these systems can leak sewage and contaminate ground and surface water.

Stormwater runoff and wastewater pollution threaten public health and the environment

Fecal contamination makes water unsafe for swimming. Human contact with water contaminated by fecal matter can result in gastrointestinal illness, respiratory disease, ear or eye infection, and skin rash.[26] In fact, each year in the U.S. an estimated 57 million swimmers in oceans, lakes, rivers, and ponds suffer from recreational waterborne illness.[27]

The 2020 edition of Environment America Research & Policy Center's report Safe for Swimming? highlighted stormwater runoff pollution and sewage overflows as major threats to beach safety across the country. In an analysis of water quality data from 3,172 sites across 29 coastal and Great Lake states and Puerto Rico, they found that over half the sites tested were potentially unsafe for swimming on one day in 2019[28] due to levels of fecal indicator bacteria above EPA's "Beach Action Value."[29] Nearly one in every eight beaches surveyed were potentially unsafe on at least 25 percent of sampling days in 2019.[30]

The effects of stormwater runoff and sewage pollution are visible across the country. Signs for beach closures warn swimmers of potential fecal matter contamination in their lakes and coastal waters. Harmful algal outbreaks caused by excess nutrients from stormwater runoff can lead to fish kills.[31] Sewer infrastructure from the mid-1900s or earlier is failing, releasing partially treated or untreated wastewater into our communities or waterways during rain and storm events, such as those seen throughout 2019 in Cleveland, Ohio.[32]

In summary, after decades of underinvestment, aging and failing water infrastructure is being overwhelmed by an increase in development and heavier stormwater loads from a changing climate. As a consequence, our waterways are plagued with high volumes of pollution that threatens public health and our environment.

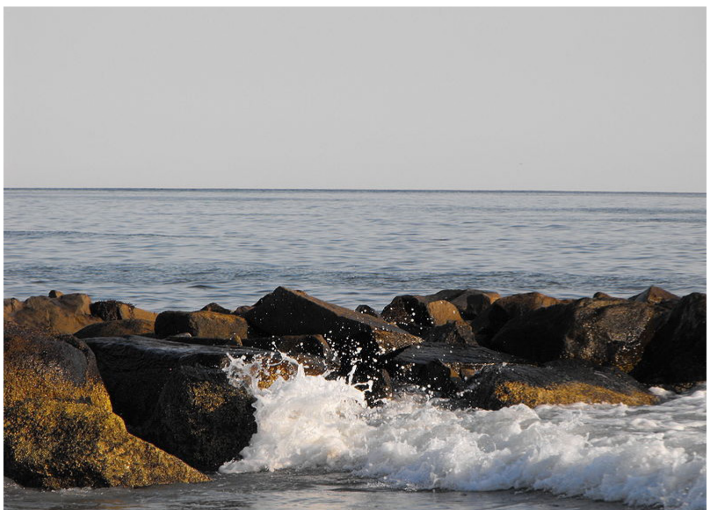
Water Infrastructure Works

Fortunately, this water pollution can be dramatically reduced when we devote the resources to repairing and updating our water infrastructure. Green and natural infrastructure—including restored wetlands, rooftop gardens, and vegetated buffers—recreate nature's capacity to absorb stormwater onsite, and thereby prevent runoff pollution and curb CSOs. Replacing leaky wastewater pipes and broken or inadequate treatment works likewise prevents the flow of sewage pollution into our waterways.

The efficacy of these clean water solutions is evidenced by the actual experience of communities across the country. This report documents the success of 23 water infrastructure projects from every U.S. EPA Region across the country.

EPA Region 1: (CT, ME, MA, NH, RI, VT, and 10 Tribal Nations)

Rhode Island: Green infrastructure makes Bristol beach safe for swimming



Narragansett Bay. Credit: Flickr, Boliyou

Problem

Narragansett Bay is considered the heart of Rhode Island, providing for thousands of plants, fish, and wildlife species and welcoming two million residents and ten million tourists every year.[33] Town Beach in Bristol is a classic example of what the Bay brings to Ocean State residents—swimming, recreation classes, summer camps, and more. Unfortunately, it was often closed due to pollution from bacteria in stormwater runoff.

Between 2000 and 2012, Town Beach experienced 72 beach closure days[34] due to water contamination. Likely sources of contamination included four stormwater discharges, fecal matter from geese, runoff from the beach's parking lot, and failing septic systems.[35]

Solution

In addition to removing and replacing two nearby septic systems with a sewer line,[36] green infrastructure was installed to trap and filter stormwater runoff as it flowed toward the beach.

To reduce wildlife fecal matter, 125 trees were planted to deter Canada Geese from lingering and dropping their waste. These trees also manage stormwater by capturing and storing rainfall and promoting its infiltration into soil where it will filter nutrients and other pollutants by tree root systems.[37]

The beach parking lot was rebuilt with a vegetated stormwater channel to collect and treat stormwater, and six rain gardens and three vegetated stormwater basins were built into the parking lot and adjacent play areas.[38] All of these systems are designed to slow stormwater runoff as it flows towards the beach, filter it of contaminants using a variety of techniques, and discharge it slowly into the Bay. They collect and treat stormwater from a total of 95 acres from surrounding neighborhoods, roads, and parking lots.[39]

Additionally, marsh grasses and other native plants were planted as a buffer to filter runoff along the beach's north side.[40]

Green Stormwater Infrastructure in Town Beach Parking Lot, Bristol Rhode Island. Credit: Rhode Island Department of Environmental Management

Result

The new green infrastructure protects Town Beach by removing pollutants from roughly 12 million gallons of stormwater (on average) each year.[41] After the project's completion, beach closures were eliminated in 2013, resulting in an estimated $50,000 increase in revenue from the beach over five years.[42]

With water that is safe for swimming, Town Beach is once again open to neighbors and visitors, and even offered outdoor summer camps and physically distanced group fitness classes during the COVID-19 pandemic.[43]

While this project has shown outstanding results, much more work is needed to protect Narragansett Bay and its tributaries, which still suffer from 2.2 billion gallons of sewage overflows each year.[44]

Funding

The Town Beach retrofit cost $1,404,620 and was paid for by a $1 million Rhode Island State Revolving Fund loan as well as EPA and local funding.[45]

Vermont: Green infrastructure helps protect the Passumpsic River from sewage overflows

Problem

The Passumpsic River in northeastern Vermont offers anglers a chance to catch rainbow and brown trout,[46] swimmers a place to cool off on hot days, and beautiful scenery for all that visit its waters. Despite its healthy fish populations in early spring and use for swimming in the summer, the river is not always clean enough for fishing and swimming. A section of the river is impaired by fecal bacteria due to St. Johnsbury's combined sewer overflows.[47]

Solution

As part of a long-term plan to reduce combined sewer overflows required by the state, St. Johnsbury is implementing green stormwater infrastructure. Oak Street runs along the banks of the impaired portion of the Passumpsic River and was targeted to reduce stormwater runoff. A traditional, or gray, water infrastructure project was planned to replace a water main and install new sewer and stormwater collection systems that would

Aerial view of St. Johnsbury and the Passumpsic River. Credit: iStock photos, Joshua Conover reduce combined sewer overflows. To further reduce runoff pollution, green infrastructure practices were installed at the project site, including a vegetated stormwater basin and road grading to direct runoff towards the green infrastructure for treatment and storage. These natural systems collect and treat stormwater runoff from over seven acres of the surrounding area before it reaches the Passumpsic River.[48]

Results

Completed in 2019, the green stormwater infrastructure project along Oak Street provides 5,550 cubic feet of stormwater storage and treatment capacity. The system is capable of capturing the first three inches of rainfall with no discharge into the Passumpsic.[49]

This project, along with the other efforts by St. Johnsbury to reduce combined sewer overflows, will preserve the Passumpsic River for anglers, swimmers, paddlers, and nature lovers for years to come. It is a long-term project that has been in the works since 1993, with limited funding drawing out the project's timeline. Additional funding would speed up the city's remediation efforts and bring clean water to the area as soon as possible.[50]

Funding

The green stormwater management project on Oak Street cost $600,000[51] and was funded in part by the Clean Water State Revolving Fund.[52]

Vermont: Gravel wetland reduces runoff into St. Albans Bay

Lake Champlain. Credit: Pixabay

Problem

The town of St. Albans, on the shores of Lake Champlain, is home to St. Albans Bay which offers stunning views of mountain peaks, and a chance to swim, boat, or fish. But the Bay, like many other parts of Lake Champlain, suffers from harmful algal outbreaks due to an excess of the nutrient phosphorus from urban and agricultural runoff.[53] These outbreaks are potentially hazardous to humans and pets swimming in the lake, and are a target of cleanup efforts for local, state, and national agencies. Several streams carry phosphorus to the St. Albans Bay, including Stevens Brook, which flows through St. Albans and carries stormwater runoff containing phosphorus and other contaminants to the St. Albans Bay.

Solution

In addition to agricultural best management practices, urban stormwater management is being implemented to reduce phosphorus levels and harmful algal outbreaks in the Bay. To address stormwater runoff pollution in Stevens Brook, the Vermont Agency of Transportation installed a gravel wetland to capture and treat stormwater runoff from the adjacent Park and Ride and roadway. Catch basins direct stormwater into the wetland, where it is filtered through microbe-rich gravel beneath the surface. Native plants above the gravel and along the wetland's slopes absorb additional stormwater and

St. Albans Gravel Wetland after completion. Credit: Watershed Consulting

nutrients.[54] During storm events, the wetland holds excess water, and filters and releases it slowly into Stevens Brook to prevent erosion and flooding[55] that may cause additional pollution.

Result

The St. Albans Park and Ride gravel wetland successfully traps and treats stormwater before releasing it into Stevens Brook and eventually Lake Champlain, and serves as an example for other green stormwater projects throughout Vermont. The Vermont Department of Environmental Conservation's Stormwater Treatment Standards expects gravel wetlands, when properly constructed and maintained, to remove 60-80 percent of total phosphorus.[56]

Despite the success of this project, St. Albans Bay still requires additional investment in water infrastructure and other best management practices to reduce phosphorus pollution causing harmful algal outbreaks.

Funding

This project cost approximately $44,000 and was paid for by Vermont's Clean Water Initiative Program[57] which receives funding from state and federal sources.

Maine: Wastewater treatment plant upgrade reduces pollution into Casco Bay

Problem

Casco Bay, off the coast of Portland, is a gem of the northeast coast known for fresh seafood, its beautiful rocky coastline, and water recreation opportunities.[58] However, combined sewer overflows from its failing wastewater treatment systems threaten the prized coastal waters and beaches.[59] As of 2014, Portland's 31 combined sewage systems release 414 million gallons of untreated stormwater and sewage into the Bay.[60] Excess nitrogen from these overflows and other common sources can cause algal outbreaks, like those in 2017,[61] and put the health of Casco Bay at risk.

Solution

As part of a long term plan for Portland to reduce pollution into the Bay as required by a consent decree, the city is separating sewer lines, creating stormwater storage facilities,[62] implementing green infrastructure to trap and treat stormwater,[63] and upgrading wastewater treatment plants. The East End Wastewater Treatment Plant was upgraded in 2018 to increase capacity and reduce nitrogen discharges from the facility.[64]

Portland Lighthouse. Credit: Pixabay

Results

The East End Wastewater Treatment Plant reduced its nitrogen discharges into Casco Bay in 2018 by 72 percent.[65]

However, ensuring clean water in Casco Bay will require much more work, including a $170 million plan to end all of Portland's remaining CSOs.[66]

Funding

The East End Wastewater Treatment Facility upgrade cost $11.4 million, and was funded by the Clean Water State Revolving Fund. It also received a $200,000 grant from Efficiency Maine for its energy efficiency.[67]

Connecticut: Green solutions restore New Haven's Edgewood Park Pond

Problem

Edgewood Park Pond in New Haven once offered visitors a chance to birdwatch, canoe, or fish. By 1990 it was shallow and at risk of becoming a marsh. Nutrients caused algae outbreaks, which "transformed the pond into a pool of green muck and unpleasant odors."[68]

Erosion of slopes near the pond delivered sediment during storms, made worse by a stormwater discharge pipe embedded in these slopes. This storm pipe, as well as pet and wildlife waste, were possible sources of bacteria and nutrients.[69] The pond was too polluted for wildlife or for swimming.[70]

Image of Edgewood Park Pond after project completion. Credit: U.S. EPA

Solution

The storm pipe was redirected to a nearby wetland where that stormwater would be trapped and filtered. Vegetation was planted along the nearby slopes to reduce erosion and discourage resident waterfowl from accessing the pond and dropping waste where it would run into the water. Additionally, the pond was deepened and fish habitat was created.[71]

Results

By 2006, reductions in nutrient pollution made the pond clean enough to support fish and wildlife again.[72] The pond was removed from the U.S. EPA's list of impaired waterways for bacteria in 2014.[73] The pond was not relisted, and is once again a treasured feature of Edgewood Park. The park is now used for educational programs by local school groups, canoeing and kayaking, and is open for fishing.[74]

Funding

The pond's restoration project cost $393,000, supplied by EPA Clean Water Act section 319 program, state, and local funding.[75]

EPA Region 2: (NY, NJ, PR, USVI, and 8 Tribal Nations)

New Jersey: Resiliency Park to protect the Hudson River from sewer overflows

Problem

While the upper reaches of the Hudson River have been cleaned up enough for boating, fishing, and swimming, sewage overflows and runoff pollution continue to make the river unsafe for swimming in the Hudson Harbor Estuary[76] on which the city of Hoboken is located.

In addition to being located on a polluted waterway, Hoboken experiences chronic flooding. Following Superstorm Sandy, around 75 percent of the city was inundated with many areas inaccessible for nearly a week.[77] Floodwaters overwhelm the city's combined sewer system, causing discharges of sewage and stormwater into the Hudson, or can back up into city streets and basements during severe floods. The city experienced an average of 49 sewage overflows per year, as of 2017.[78]

Solution

Hoboken is incorporating green infrastructure into its overflow mitigation plan. Their green infrastructure will increase the city's resilience during wet weather while capturing and treating stormwater at its source.[79]

The Northwest Resiliency Park, to be completed in 2022, is part of the city's green infrastructure plan. Once constructed, it will be the largest stormwater park in Hoboken to date. To capture and filter stormwater, the design plans for the park include several stormwater gardens and gravel storage under athletic fields. Additionally, plans for the park include an underground stormwater detention system to trap stormwater to prevent flooding and sewage overflows.[80]

Graphic rendering of the Northwest Resiliency Park design. Credit: City of Hoboken.

Results

The 6-acre park will store up to two million gallons of stormwater during intense rain using the stormwater storage and green infrastructure systems.[81] It is expected to alleviate chronic flooding in the surrounding neighborhoods and greatly reduce combined sewer overflows.

Funding

The total cost of the Northwest Resiliency Park is currently slated to be $90 million.[82] It was funded by the New Jersey Environmental Infrastructure Program which draws funding, in part, from the Clean Water State Revolving Fund.[83]

New Jersey: Green infrastructure helps open the Cooper River for recreation[84]

Problem

The Cooper River in southwestern New Jersey offers locals a chance to fish, birdwatch, and paddle in Camden County. Heavy development caused an increase in urban land use and impervious cover, severely limiting the amount of stormwater that can soak into the ground. High levels of urban stormwater runoff caused severe streambank erosion and deposited a variety of pollutants into the river. The Cooper River was listed as impaired in 2006 due to poor water clarity, water quality too poor for many water dwelling animals, and phosphorus and fecal bacteria contamination.

Solution

In 2006 the Camden County Soil Conservation District created a watershed-based plan to restore the Cooper River. It prioritized stormwater best management practices and reducing stormwater runoff pollution.

Implementation began in 2007, and as of October 2018 approximately 42 rain gardens, one stream restoration, a floating island pond treatment unit, a biofilter wetland, a vegetated stream buffer, and 14 stormwater basins to slow and filter stormwater have been implemented. These systems use native plants to trap and treat stormwater before it reaches the Cooper River.

Rain Garden at Subaru of America in Cherry Hill, NJ. Credit: U.S. EPA

Results

These green infrastructure systems greatly reduced untreated stormwater runoff from impervious surfaces by allowing rain to soak into the ground. In 2014, a section of the Cooper River was delisted for water clarity. Progress is still underway and the river remains listed as impaired for several contaminants.[85]

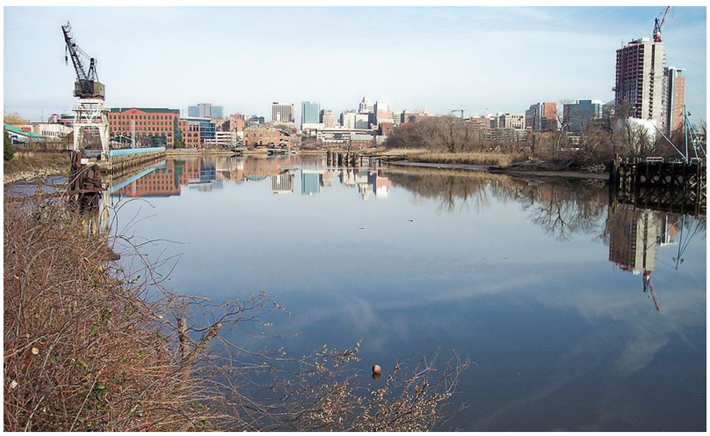
As water quality improves, community members are enjoying increased access to the river, and take advantage of fishing and boating opportunities when it is safe to do so.[86]

Funding

Between 2007 and 2011, a federal grant from the Clean Water Act provided around $1.1 million for restoration projects. Local partners such as Rutgers and local school districts also contributed to the restoration.

EPA Region 3: (DE, DC, MD, PA, VA, WV, and 7 Tribal Nations)

Delaware: Wetlands and sewer separation protect the Christina River



Christina River from the Riverfront Trail across from South Wilmington. Credit: Tim Kiser

Problem

The Christina River in Wilmington reminds residents of the city's rich shipping, transportation, and industrial history, while providing residents a place to walk along the tidal river. Southbridge, a historically Black community in Wilmington on the banks of the Christina River, also often associates the river with chronic flooding and sewage overflows backing up into residents' basements.[87]

The city utilizes a combined sewer system, prone to overflows during rain events, which contributes to neighborhood and residential flooding. During severe events, 12.6 acres of Southbridge experience flooding, and approximately 2.1 million gallons of combined sewage and stormwater overflow into the neighborhood.[88]

Solution

To address these flooding and pollution problems, the city of Wilmington is restoring 14 acres of wetlands and separating 36 acres of combined sewer pipes.[89]

The wetlands reduce pollution threats by replacing one of the largest contaminated sites in the city.[90] After safely removing contaminated soil and invasive species, introducing native species to fill the wetland park with vibrant marsh, meadow, and forest habitats.[91] These native species are more effective than invasive plants at trapping and filtering stormwater before it is released into the Christina River.

Additionally, the city is separating 36 acres of combined sewer pipes to direct stormwater to the new wetland park.[92]

Result

The stormwater wetland is expected to reduce acres of neighborhood flooding by 96 percent[93] and the CSO separation will eliminate combined sewage and stormwater backups.[94] The park will also provide a recreational trail through the wetland for residents to walk and bike.

Local nonprofit organizations are already utilizing the park to educate Southbridge residents on the importance of wetlands in their ecosystem, youth activities in nature, and youth employment opportunities.[95] These programs are designed to increase community appreciation of the Christina River as pollution levels decrease and more outdoor recreation opportunities become available.

Funding

The projected total cost of this project is $25 million,[96] with funding from local, state, and federal sources.[97]

Maryland: Hospital green infrastructure to reduce pollution in Chesapeake Bay watershed

Problem

Home to blue crabs and bald eagles, the Chesapeake Bay is the most productive estuary in North America and provides endless opportunities for boating, fishing, swimming, and hiking along its shores. Unfortunately, an overload of nutrient pollution causes a perennial dead zone to form in the bay, putting the ecosystem at risk.

The MedStar Harbor Hospital (MHH) sits on the banks of the Middle Branch of the Patapsco River in Baltimore, MD. Its 18-acre campus of impervious surfaces once sent 20 million gallons of nutrient-laden stormwater runoff into the Patapsco, which flows into the Bay.[98]

Solution

MHH and its partners developed a green infrastructure master plan to reduce the amount of polluted stormwater runoff it contributed to the river.[99] The project, completed in 2018 by Blue Water Baltimore, retrofitted four of the hospital's major parking lots with green stormwater management. Two rain gardens, 12 vegetated stormwater basins, 81 new trees, and over 16,000 square feet of conservation landscaping using native plants[100] trap and filter stormwater before it drains into the Patapsco. The parking lots and driveways were fitted with drains and ditches, some vegetated, to help divert stormwater into these systems.[101]

Result

This green infrastructure park traps and filters stormwater from the hospital's campus before it reaches the river.[102] The project is estimated to annually prevent 39 pounds of nitrogen, six pounds of phosphorus, and 1.2 tons of sediment from entering the river.[103]

In addition to managing stormwater runoff, the project improved pedestrian safety and accessibility.[104] The redesigned waterfront area attracts large crowds during Baltimore events such as Independence Day fireworks, and is easily accessible from the Middle Branch Park bike trail that crosses the MHH campus.

Conservation landscaping using native plants before bloom. Credit: Blue Water Baltimore

Funding

The total cost of implementation was $1.2 million. Funding sources include two Chesapeake Bay Trust grants and funding from the Maryland Department of Natural Resources'[105] Chesapeake and Atlantic Coastal Bays Trust Fund.

Vegetated stormwater basin in parking lot after planting. Credit: Blue Water Baltimore

EPA Region 4: (AL, FL, GA, KY, MS, NC, SC, TN, and 6 Tribal Nations)

Florida: Green infrastructure protects Roberts Bay[106]

Aerial view of Roberts Bay. Credit: Amanda Dominguez

Problem

Roberts Bay in northwest Sarasota County flows out towards the area's white sand beaches and is prized for boating, fishing, and wildlife viewing.[107] The surrounding 65 acre basin drains into the bay and is predominantly urbanized and residential.

In 1998 Roberts Bay was listed as impaired for nutrients. Likely sources of pollution included four domestic wastewater treatment plants in the region, septic systems, and surface water runoff. In 2005 Roberts Bay was verified as impaired for excess nutrients.

Solution

To reduce nutrients, filtration systems known as baffle boxes were installed along storm pipes to trap trash and sediment-rich nutrients before the stormwater is discharged into the bay. Additionally a pump station, sewer enlargements, and inlet traps were installed to trap trash and organic debris.

Results

The water infrastructure improvements resulted in an estimated annual reduction of 267 pounds of nitrogen, 186 pounds of phosphorus, and 53,892 pounds of total suspended solids.

After this project was completed in 2006, water quality data showed nutrient reduction, leading to Roberts Bay's removal from the list of impaired waterways in 2010.

Yet more infrastructure investment is needed to make Roberts Bay clean. It was relisted for excess nitrogen in 2013,[108] and the county needs to improve its wastewater treatment systems to reduce sewage pollution from unauthorized discharges.[109]

Reduction in stormwater runoff pollutants is especially critical in areas that flow out to popular beaches for swimming and recreation locations such as Roberts Bay. Clean water at Roberts Bay and around Florida is essential for public health and a thriving natural environment.

Funding

Project implementation, monitoring, and education was funded by $1.6 million in Clean Water Act section 319(h) funds and $5.2 million in local funds.

North Carolina: Sanitary sewer improvements to prevent sewer overflows

Problem

Parmele sits along the Flat Swamp waterway, part of the Tar-Pamlico River watershed, which feeds into the Pamlico estuary known for its highly productive commercial and recreational fishing.[110] Unfortunately, Flat Swamp receives contaminants from sewer overflows from a failing sewer system and septic systems. Aging sewer lines in the town overflow and discharge sewage near a Flat Swamp tributary.[111] Additionally, several residents rely on failing septic systems, or septic systems placed in low-lying, flood prone areas,[112] which discharge untreated sewage into the environment.

Like so many small, rural towns with shrinking population, limited utility customer base, and poorer status,[113] Parmele struggles to pay for operations and maintenance of its water infrastructure. Additional funding in the form of grants facilitated remediation of sewage overflows and water pollution near Flat Swamp.[114]

Solution

To eliminate sewer overflows, Parmele is undertaking three sewer improvement projects. The first two projects will rehabilitate the existing sewer system to stop sewer infiltration that causes overflows. This project includes pump station renovations, sewer line rehabilitation to reduce the amount of water entering the pipes, and manhole renovations to prevent sewage from escaping in the case of pipe backups or overflows.[115]

The third project to remediate failing septic systems will get underway once the first projects are completed and the sewer system can accommodate new hookups.[116] It will extend the existing sewer system to reach 23 new homes to resolve the problem of failing septic systems and those in flood prone areas.[117]

Groundbreaking ceremony, Parmele, 7/27/2018. Congressman G. K. Butterfield, State Senator Erica Smith, State Representative Shelly Willingham and DEQ's Division of Water Infrastructrue Director Kim Colson joined Parmele Mayor Jerry McCrary and several other Parmele-area leaders to celebrate sewer system rehabilitation and renovation in Parmele. Credit: North Carolina Department of Environmental Quality

Result

These projects are expected to remediate contamination from the failing sewer system and flood-prone septic systems. Keeping E. coli out of the Flat Swamp tributary will preserve water quality and protect public health.

Funding

These three sewer improvement projects cost over $2.8 million dollars, with funding provided by two North Carolina Wastewater State Reserve Grants and a Community Development Block Grant for infrastructure. These projects were made possible through the availability of grant funding for communities with a limited customer base and economically distressed status.[118]

Alabama: Green infrastructure restores Mill Creek[119]

Problem

Mill Creek is a waterway in eastern Alabama that runs through Auburn University's campus and discharges into the Chattahoochee River in Phenix City. Its predominantly urban watershed was experiencing an increase in development and loss of riparian buffers, leading to increased stormwater runoff pollution of nutrients, sediments, and pathogens. By 2010, Mill Creek was listed on the Clean Water Act (CWA) section 303(d) list as too polluted to fully support fish and wildlife.

Solution

From 2011 to 2016, the Alabama Cooperative Extension System and Auburn University coordinated a two-phased remediation plan that employed natural infrastructure to trap and filter stormwater before it reached the creek. This green infrastructure included vegetated stormwater basins and channels, rain gardens, and wetlands designed to absorb stormwater.

Additionally, a septic tank pump-out program and a stormwater education program were implemented to further reduce water pollution.

Results

Thanks to these projects, Mill Creek is once again clean enough to support fish and wildlife. The green infrastructure implemented around Mill Creek increased the amount of stormwater able to soak into the ground and decreased the volume of urban runoff. Vegetation in these projects takes in nutrients from the stormwater, therefore decreasing nutrients and organic matter in the creek.

In 2018, Mill Creek was removed from the CWA 303(d) list upon meeting water quality standards. Now, the creek is accessible and better appreciated by the community. It now serves as an outdoor classroom at Auburn University[120] and a local nonprofit, Friends of Mill Creek, hosts cleanups and native planting workshops.[122]

Mill Creek erosion control. Credit: EPA

Funding

More than $500,000 of federal funding for this project came from Clean Water Act section 319(h) grants and a National Fish and Wildlife Foundation grant, and watershed partners provided matching funds.

EPA Region 5: (IL, IN, MI, MN, OH, WI, and 33 Tribal Nations)

Illinois: Stormwater storage helps restore the Chicago River

Problem

The Chicago and Calumet River Systems that flow through Chicago helped turn the city into the metropolis it is today. However, given its history of pollution, including from the city's untreated wastewater, Chicago has been working to clean up these river systems since at least 1855 when the city constructed one of the country's first sewer systems.[123]

Around 100 years later, the river systems regularly received runoff pollution and untreated sewage from the combined sewer systems the city then relied on. Combined sewer overflows occurred 50-100 times per year beginning in the 1960s into the Chicago River.[124] Chicago's sewage and stormwater overflows would flood highway underpasses and basements unless the water was discharged into the river untreated. Metropolitan Water Reclamation District of Greater Chicago (MWRD) may release this contaminated flood water into Lake Michigan during severe floods, which forced swimming bans and threatened drinking water due to high fecal bacteria levels.[125]

Solution

As part of a consent decree to limit sewer overflows, MWRD created the Tunnel and Reservoir Plan (TARP), which included tunnels and the Thornton Composite Reservoir to transport and store excess stormwater and sewage. In 2006, 109 miles of tunnels were constructed under the Chicago region, providing 2.3 billion gallons of water storage.[126]

The Thornton Composite Reservoir can hold 7.9 billion gallons of storage in the retired portion of an old quarry.[127] It is the largest portion of TARP completed to date, and the largest combined sewer reservoir in the world as of 2016.[128]

TARP Reservoir,. Credit: MWRD

The reservoir collects water from tunnels before pumping it to the Calumet Water Reclamation Plant for treatment when capacity allows. This plant was upgraded to disinfect the water it treats in order to protect public health and allow a variety of recreational uses in the Chicago Area Waterway System where it discharges.

Result

As of 2017, the Thornton Composite Reservoir has prevented more than 38 billion gallons of sewage from polluting local waterways.[129]

The reservoir and adjoining tunnels captured more than 99 percent of combined sewer overflow discharges.[130] In 2018, there were no combined sewer overflows into the Calumet River Systems. To further reduce water pollution, MWRD plans to expand TARP and install green infrastructure.[131]

Thanks to TARP and other steps, cleaner water has helped the recovery of fish and wildlife in Chicago waterways.[132] Cleaner water is also bringing new life to Chicago's downtown riverwalk:

> "Today, on a sunny summer day, local families and tourists vie for space in kayaks, yachts, and rented pontoons on the river's Main Branch, while along the shore, fishermen cast their lines, and groups of friends sip wine, sitting close enough to dip their toes in the water. Further from downtown, great blue herons, muskrats, and river otters leap in and out of the river."[133]

Perhaps with further investments in green infrastructure, Chicagoans will one day even be able to safely swim in this recovering river.

Funding

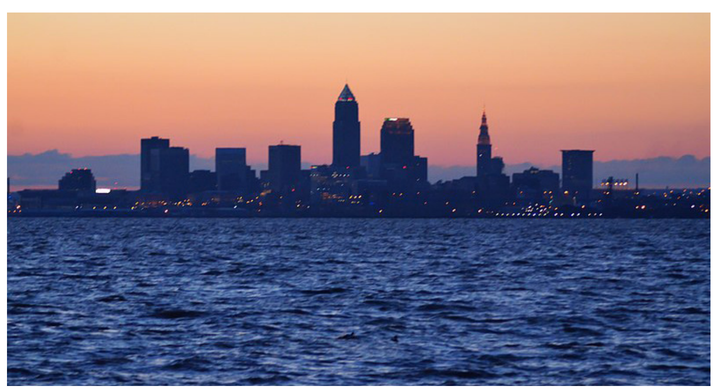
TARP will cost a projected $3.8 billion upon completion, including the cost for tunnels, the Thornton Reservoir, and the new McCook Reservoir currently underway.[134]

Kayakers along the Chicago Riverwalk. Credit: Don Harder via Flickr

Ohio: Cleveland's green infrastructure helps prevent pollution of Lake Erie

Problem

Cleveland sits on the shores of Lake Erie, the fourth largest Great Lake and a destination for residents and visitors to boat, fish, and swim. The Cuyahoga River, which flows through Cleveland before discharging into Lake Erie, famously caught fire in 1969. And while this incident helped spur adoption of the federal Clean Water Act in 1972, Cleveland's combined sewer system continued to pollute the Cuyahoga and Lake Erie for decades. Cleveland discharged an estimated 9 billion gallons of combined sewage into Lake Erie in the 1970s. In 2015, there were still 4.1 billion gallons of combined sewage discharged annually into the lake.[135]



Cleveland skyline over Lake Erie. Credit: Erik Drost

Solution

Then, the Clean Water Act came back to rescue the Cuyahoga River (and Lake Erie), as the U.S. Environmental Protection Agency used the law to compel the Northeast Ohio Regional Sewer District (NEORSD) to create Project Clean Lake, a 25-year plan to greatly reduce its combined sewage discharges.[136] The plan includes a combination of green infrastructure, stormwater storage tunnels, and wastewater treatment plant upgrades and expansion. Nine green infrastructure projects were designed to reduce combined sewer overflows by at least 44 million gallons.[137]

As one of the nine projects, the Fleet Avenue Green Infrastructure project converted vacant land into a rain garden.[138] Using sand already on the project site and native plants, the garden allows stormwater from the surrounding 15 acres of mostly impervious surfaces to soak into the ground.[139]

Result

The rain garden at Fleet Avenue removes 4.8 million gallons of stormwater from the combined sewer system every year.[140] Altogether, the nine green infrastructure projects in Cleveland capture an estimated 121.2 million gallons of stormwater per year, which currently prevents 59.1 million gallons of combined sewer overflows. However, the volume captured is expected to decrease to 15.7 million gallons per year after completion of a storage tunnel.[141]

Project Clean Lake will reduce pollution into Lake Erie by 4 billion gallons every year.[142]

Funding

Project Clean Lake's green infrastructure projects (including the Fleet Avenue rain garden) cost $57.7 million.[143]

TARP Reservoir. Credit: MWRD

Wisconsin: Milwaukee is turning to green infrastructure to protect Lake Michigan

Milwaukee from Lake Michigan. Credit: Pixabay

Graphic rendering of Milwaukee Underpass green stormwater infratructure park design. Credit: Human Nature and Stand Associates

Problem

Milwaukee sits on Lake Michigan, which offers surfing, sailing, and strolling along the RiverWalk.[144] But like many cities in the Great Lakes region, Milwaukee still uses some combined sewer systems, which are prone to overflow.[145] Since 1994, the Milwaukee Metropolitan Sewerage District (MMSD) substantially reduced its sewage overflows by upgrading its water infrastructure,[146] but more work is needed. In 2018 and 2020, the district reported spikes in overflows— 1.2 and 21.7billion gallons, respectively.[147] Intensifying storms and increased rainfall are driving this spike. MMSD is now looking to completely eliminate overflows by 2035.[148]

Solution

Having spent considerable sums on grey "end of pipe" solutions, MMSD is now turning to green infrastructure to meet its goal of eliminating overflows. One project is being designed to turn a 16-acre site beneath Interstate 794 into a green stormwater management park that will trap and filter runoff from the freeway's bridges.[149] The project's preliminary master plan includes a pre-treatment and treatment vegetated basins, and a meadow with native vegetation.[150]

Result

When finalized, the park is expected to be capable of capturing 293,000 gallons of stormwater from six acres of the above freeway[151] that would otherwise add to the combined sewer system.

And Milwaukee aims to go further. Mayor Tom Barrett's Green Infrastructure Plan has a goal of absorbing 36 million gallons of stormwater by 2030. Reaching that laudable goal will require further investment.[152]

Funding

The current budget for construction of this green infrastructure project is approximately $2.26 million.[153]

EPA Region 6: (NM, TX, OK, AR, LA, and 66 Tribal Nations)

Texas: Guadalupe River restored following wastewater infrastructure upgrade[154]

Guadalupe River. Credit: Jonathan Cutrer via Wikimedia

Problem

Swimming and tubing on the Guadalupe River above Canyon Lake is an essential summer activity in central Texas, but in 2002 the river was often unsafe due to excessive levels of E. coli threatening the health of people enjoying the river.

A 3.5-mile stretch of the Guadalupe in the City of Kerrville had too much bacteria for safe swimming, and so it was listed on the state's Clean Water Act (CWA) 303(d) list of impaired waterways. Stormwater runoff and sewage leaks from failing septic and municipal wastewater systems are the primary sources of pollution, according to the Texas Commission on Environmental Quality (TCEQ).

Solution

To prevent the overflows contributing to bacterial pollution, aging and failing wastewater collection infrastructure was repaired or replaced throughout the city. Improvements included 42,675 feet of degraded sewer line, 16 lift stations to transport sewage without leakage, and 100 manholes through which sewage would overflow when the sewer pipes flooded. Tree roots were removed from the vicinity to prevent future damage to the sewer pipes that would cause excess water to enter the pipes and lead to sewage backups and overflows.

In addition to wastewater infrastructure, best management practices such as pet waste stations and bird deterrent structures were used to further reduce runoff contaminants.

Results

These changes sufficiently reduced bacterial pollution to make this section of the Guadalupe River safe for swimming again. With the return of clean water, Kerrville is once again inviting people to the Guadalupe River to cool off through swimming, paddling, and relaxing by the shores at annual music festivals and celebrations that draw both locals and tourists.[155]

Funding

The wastewater improvement projects cost the City of Kerrville $22 million, and $329,000 from federal clean water programs helped fund best management practices.

Texas: Stormwater infrastructure protects San Marcos River

Problem

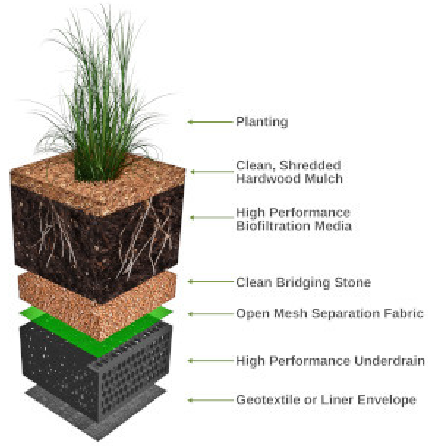
The headwaters of the San Marcos River headwaters are a prized feature of the city of San Marcos. The waters are a place for swimming and fishing, as well as habitat for endangered species such as the Fountain Darter and the Texas Blind Salamander.[156]

This central Texas city understands the value of its waterway, and strives to prevent stormwater runoff pollution from reaching the river to protect its clean water. Stormwater runoff can contain pollutants such as excess sediments, bacteria, and nutrients, which could make the water unsafe for swimming or destroy the habitats of its endangered species.

Solution

The CM Allen Parkway in San Marcos runs parallel to the San Marcos River. When the parkway required updates[157] the city used the construction as an opportunity to protect the river's clean water.

CM Allen Parkway after completion. Credit: City of San Marcos



Focal Point biofiltration system. Credit: Convergent Water Tech

The road's redesign included nature-based stormwater management features. Traditional vegetated stormwater management and FocalPoint filtration systems were installed along road medians and edges. Using native plants and soil that allowed rainwater to soak into the ground, these features filter stormwater runoff from the roadway and downtown area before it reaches the river.[158]

Additionally, the Hutchinson stormwater pond that sits between CM Parkway and the San Marcos River was repaired to maximize nutrient uptake to further reduce pollution to the river.[159]

Results

These filtration systems along CM Parkway along with the Hutchinson stormwater pond are estimated to remove approximately 10,840 pounds of suspended solids every year.[160] They will also significantly reduce E. coli levels, nitrogen, and phosphorus.[161]

Due to continuous efforts to protect water quality, the San Marcos River in San Marcos remains a point of pride for locals, and attracts tourists to paddle, boat, and learn about the region's history.[162]

Funding

The CM Allen Parkway project, including road improvements and green infrastructure, cost the City of San Marcos approximately $3.35 million.[163]

EPA Region 7: (IA, KO, NE, KS, and 9 Tribal Nations)

Missouri: Kansas City green solutions to clean up the Blue River

Problem

Blue River is a tributary to the Missouri River that runs through Kansas City, Missouri and Kansas City, Kansas and has miles of walking and biking trails along its banks. Unfortunately, the river is polluted by stormwater runoff and failing sewer treatment plants. At times the lower reaches of the Blue River are "so grossly polluted" by sewage that fish cannot survive.[164]

The sewage system of Kansas City, Missouri is one of the largest in the country—featuring 7 treatment plants, 38 pumping stations and nearly 3,000 miles of sewer lines over 420 square miles.[165] Between 2002 and 2010, the city experienced thousands of sewage spills from the combined sewers and other failing sewer systems. These overflows resulted in an estimated 7 billion gallons of raw sewage into local waterways, including Blue River and the Missouri River.[166]

Vegetated stormwater retention basin, curb extension. Credit: Kansas City Water Services

Solution

The Middle Blue River Basin Green Solutions Pilot Project was the first green infrastructure project in Kansas City's Overflow Control Program, an effort to reduce combined sewer overflows as required by a consent decree.[167] The project, implemented in 2012, included approximately 135 vegetated best management practices (BMPs) included 81 rain gardens, 53 vegetated stormwater basins, and one 2,000 square foot vegetated stormwater channel.[168] All of these systems utilize soil and native plants to trap and filter stormwater runoff. It also included 27,490 square feet of permeable and porous sidewalks and gutters to reduce stormwater runoff by allowing it to soak into the ground.[169]

Additionally, the Overflow Control Program repaired, lined, or cleaned out more than 20,000 linear feet of sewer pipes to prevent overflows.[170]

Result

After project completion, there was a measured reduction of 292,000 gallons of stormwater reaching the project area's combined sewer outflow, which curbed peak flow by 76 percent.[171] This effectively keeps stormwater out of the combined sewer system to reduce the chance of sewage overflows.

Local residents were engaged throughout the project, and residents described a surge in community pride following the project, and an increase in community engagement on actions to continue to improve their neighborhood.[172]

Funding

The total cost of design and construction was $10.4 million,[173] with funding from local and federal sources.[174]

Missouri: South Creek restored using natural solutions

South Creek before restoration. Credit: City of Springfield and James River Basin Partnership

South Creek after restoration, with vegetated stormwater filtration systems at outfalls along creek. Credit: City of Springfield and James River Basin Partnership

Problem

South Creek in Springfield was a favored fishing spot for bluegill and sun-perch in the 1970s. Just one decade later, one mile of the creek was paved into a straight, concrete channel that received stormwater discharge from approximately 40 outlets.[175] South Creek contributed an annual 15.2 million pounds of sediment, 13,800 pounds of phosphorus, and 60,000 pounds of nitrogen to rivers downstream, according to the James River Basin Partnership (JRBP).[176] Monitoring of South Creek showed inadequate aquatic life, indicating poor water quality or lack of habitat.[177]

Solution

The city of Springfield completed a restoration project for the channelized stretch of stream.[178] In addition to removing concrete and adding features of natural Ozarks streams, sections of the stream below stormwater discharge pipes were excavated and seeded to slow stormwater runoff and filter pollutants. Around eight acres of native species were planted to provide water filtration services. One hundred native trees were planted along the stream corridor to provide shade and a riparian buffer.[179]

To complement this project, Springfield Public Works planted native species in the median of a major road that runs along South Creek.[180] This will further trap and filter stormwater.

Results

These improvements led to cleaner water. Aquatic life monitoring data for two of the three testing sites along the project area improved to "good" or "excellent."[181] As water quality improves, fish once common to the creek are returning.[182]

Volunteers who value the restored river returning to life participate in volunteer clean ups throughout the year to reduce litter. The creek now serves as an educational tool for tours and those recreating on the adjacent greenway trail. JRBP continues aquatic life monitoring at five sites along South Creek to survey water quality twice a year as part of a Missouri Department of Natural Resources 319 Nonpoint Source Project Grant.[183]

Funding

The total cost of the project was approximately $140,000 for design, and $1.1 million for construction. Funding sources include a Clean Water Act section 319 grant, and state and local funds.[184]

EPA Region 8: (CO, MT, ND, SD, UT, WY, and 28 Tribal Nations)

Montana: Wastewater system improvements protect Hebgen Lake

Hebgen Lake. Credit: Michael Matti via Flickr

Problem

Hebgen Lake is a premier stillwater fishing lake in Montana featuring brown, cutthroat, and rainbow trout. It is also a popular vacation spot near Yellowstone Park and attracts swimmers, boaters, and paddlers.[185]

However, the lake was at risk for being unsafe for swimming due to contamination from sewage overflows. In 2003 the Montana Department of Environmental Quality (DEQ) found excessive nitrates in nearby wells, indicating a sewage leak from the Hebgen Lake Water and Sewer District (the District).[186] In the early 2010s, the District was one of eight wastewater treatment systems in the county discharging fecal bacteria and nitrate pollution to ground and surface water in the county.[187]

Solution

To prevent groundwater pollution, sewage discharges, and reduce human exposure to raw wastewater, the District made several system improvements. In response to the leaks found by DEQ, the station that pipes sewage to the treatment plant was replaced to reduce leakage and increase reliability of wastewater collection. Two man-holes and 60 feet of sewer line were replaced to reduce potential sewage leaks from these outdated structures. The wastewater treatment system was also upgraded to remove a greater amount of nitrogen.[188]

Results

The equipment improvements made through this project were anticipated to reduce the risk of sewage backups and spills to protect public health from bacteria in sewage. They were also expected to contribute to surface water quality improvement in Hebgen Lake as well as groundwater quality by eliminating pollution leaking from the source. Safer recreation opportunities and healthier fish populations were additional anticipated benefits of the project.[189]

Funding

The total cost of this project was $1,958,000 from several sources, including state funds, a Water Resources Defense Act Allocation, and three Water Pollution Control State Revolving Fund loans (Montana’s Clean Water State Revolving Fund program)[190, 191]

EPA Region 9: (AZ, CA, HI, NV, Pacific Islands, and 148 Tribal Nations)

California: New wastewater treatment center to protect Malibu Lagoon State Beach from fecal bacteria

Problem

Malibu Lagoon State Beach is a treasured coastal area known nationally for its beauty and world-class surfing opportunities. However, swimmers and surfers must check that beaches are safe for swimming before heading out.

Very recently, many Malibu residents managed their wastewater using septic systems, which regularly leaked untreated sewage into the Malibu lagoon and overflow during storms.[192] When sewage contaminants reached Malibu's famous Surfrider beach, surfers have suffered from waterborne illnesses such as gastrointestinal or respiratory issues, or ear and eye infections.[193]

Solution

To reduce pollution from septic systems and comply with a resolution from the Los Angeles Regional Water Quality Board prohibiting septic discharges[194] Malibu began constructing a new wastewater treatment facility: the Malibu Civic Center Water Treatment Facility. Once complete, the city will convert the community's 6,000 septic tanks to the sewer system.[195] The project is designed to address local water conservation concerns as well by including a recycled water distribution system and groundwater recharge wells.[196]

Result

The first phase of the project was completed in Oct., 2018. The new plant treats an average of 50,000 to 70,000 gallons of wastewater per day, and supplies up to

Malibu Lagoon. Credit: Ellen M. via Flickr

66,500 gallons per day of recycled water.[197] During phase two, scheduled for completion in 2022, the facility's capacity will be nearly doubled to accommodate more residents converting from septic to sewer system.[198]

This project will remove a major pollution source from a valuable coastal area by treating local wastewater to remove harmful nutrients and bacteria. The system is expected to clean up one of the nation's most famous surfing destinations and keep surfers and swimmers healthy while enjoying the water.

Funding

Phase one of this project cost nearly $60.3 million. Funding sources included a loan from the Clean Water State Revolving Fund for just over $26 million, and separate loan from the Clean Water State Revolving Fund Drought Response program of over $24.6 million.[199]

Surfer in Malibu. Credit: Terrell Woods

EPA Region 10: (WA, OR, ID, AK, and 271 Tribal Nations)

Washington: LOTT wastewater plant eliminates sewage overflows to Puget Sound

Budd Inlet. Credit: Matthew Kowal

Problem

The Puget Sound offers vacationers and locals a wide variety of outdoor activities, such as kayaking and a chance to spot iconic wildlife like Southern Resident orcas and the salmon they rely on. Unfortunately, sewage wastewater is contributing excessive nutrients to the Sound, reducing dissolved oxygen in the water that fish need to survive. Approximately 20% of the greater Puget Sound does not meet dissolved oxygen standards due to nitrogen pollution.[200] This causes periodic dead zones and fish kills throughout the Sound.[201,202] With increased population growth and climate change, the region risks enlarging the dead zone and worsening conditions in the sound.

Solution

LOTT, a partnership between the governments of Lacy, Olympia, Tumwater, and Thurston County, manages a sewage treatment plant at Budd Inlet originally built in 1952. The facility upgraded in the 1990s to add nitrogen removal and ultraviolet disinfection to produce cleaner wastewater. LOTT now also produces Class A Reclaimed Water to restore groundwater supplies, conserve water in the region,[203] and reduce the amount of treated wastewater discharged by the plant.[204]

Like many coastal treatment plants, LOTT is vulnerable to sea level rise and flooding. To increase resilience and ensure the facility will function for years to come, LOTT engaged in a joint planning effort to prepare the Olympia Sea Level Rise Response Plan in 2018-2019 with the city of Olympia and port of Olympia and is now participating in efforts to implement the plan.[205]

Budd Inlet wastewater treatment plant. Credit: LOTT Clean Water Alliance

Result

The LOTT treatment plant now regularly removes more than the required level of nitrogen from its discharge, releasing only 52 percent[206] of permitted nitrogen during the summer, and is a model for what is possible in the region.[207] With one possible exception LOTT has had no combined sewer overflows into Budd Inlet since 2009.[208]

While LOTT is a model for nitrogen removal, many wastewater treatment plants in the region are failing to address their nitrogen pollution and contribute to degraded water quality. Stormwater remains the number one source of toxic pollution to Puget Sound.[209] Strengthening Clean Water Act permits, controlling combined sewer overflows, and controlling stormwater are all important parts of improving the health of the sound. This work requires significant investment in clean water infrastructure, and Washington needs federal support to help protect clean water.

Funding

Advanced nitrogen removal upgrades to the LOTT treatment plant were paid for in part by two loans totalling over $33 million from the state of Washington Water Pollution Control Revolving Fund, which receives funding through federal State Revolving Fund allocations.[210]

Special thanks to Alyssa Barton of Puget Soundkeeper Alliance for her support researching and drafting this case study.

Oregon: Portland's waterways restored by Big Pipe Project and green infrastructure

Problem

Portland is a place of convergence of two major waterways, the Willamette River and Columbia River, and the Columbia Slough—a tributary of the Willamette River prized by Portlanders for recreation. Despite their value to wildlife and people, the Willamette and the Columbia Slough suffered from a long history of industrial and wastewater pollution that made them unsuitable for fish and human recreation. Even as recently as 1990, Portland's combined sewer systems dumped an annual average of six billion gallons of overflow into the Willamette River and Columbia Slough.[211] A local resident recalls seeing "floaters" from sewage in the Willamette due to the regular combined sewer overflows.[212]

Solution

In response to a legal order to limit combined sewer overflows, in 1991 Portland began a two-part project to reduce and manage stormwater runoff.

One part, the Cornerstone Projects, used green infrastructure to reduce stormwater before reaching the combined sewer system. Projects included downspout disconnections, 3,000 stormwater catch basins, and local stream diversions from the combined system. In addition, the city separated the sewer system in some neighborhoods with new pipes.[213]

Downspout disconnection as part of the Cornerstone Projects. Credit: City of Portland

The second part of the project built three “Big Pipes” to convey and pump stormwater and sewage to the city’s main treatment plant. This treatment plant was updated to treat the increase in stormwater from captured overflows.[214]

Results

The Cornerstone Projects greatly reduced stormwater entering the combined sewer system. Stream diversion removed around 165 million gallons of stormwater annually.[215] Downspout disconnections removed more than 1.2 billion gallons annually from the system. The creation of stormwater catch basins and sewer separations further reduced combined sewer overflows, for a total reduction of about 35 percent.[216]

Altogether, the Cornerstone and Big Pipe Projects reduced combined sewage discharges into the Willamette River and Columbia Slough by 94 percent and 99 percent, respectively.[217]

Today, the Willamette River and Columbia Slough are much safer for all types of recreation.[218] A local nonprofit, Human Access Project, hosts an annual “Big Float” to celebrate the Willamette’s restoration with residents swimming, floating, boating, and relaxing on its shores.[219] The City of Portland Bureau of Environmental Services conducts weekly bacteria tests in the Willamette River in the summertime to ensure it is safe for swimming.[220] Resident now paddle on the Columbia Slough, where wildlife—including coho and chinook salmon—now thrive.[221]

Swimmer dives into the cleaner Willamette River. Credit: Diane Dulken of with City of Portland

While these results are impressive, it is also sobering that these projects were not begun until 1991, and it took 20 years to complete them. With more robust federal funding for water infrastructure, hopefully waters like the Willamette can be cleaned up much sooner, before entire generations of children miss out on safely swimming or floating in a local river or stream.

Funding

Portland’s Big Pipe Project, including the green infrastructure Cornerstone Projects, cost $1.4 billion.[222]

Policy Recommendations

Nearly fifty years ago, our nation set a goal in the Clean Water Act of having all our waterways clean and safe for swimming. To reach this goal, America's water infrastructure must effectively protect water quality, communities, and public health. It should manage stormwater and wastewater, and must rise to the challenges that growing populations, increased development, and extreme weather will put on these systems. Unfortunately, this is often not the case.

Protecting clean water by updating and improving our infrastructure requires significant resources. With current strains on state and municipal budgets, it is more important now than ever for federal policy makers to invest in clean water.

Investing in water infrastructure makes dramatic improvements in water quality, decreases in sewage overflows, and flood reduction possible. To ensure long term improvements, policy makers must provide clean water funding that addresses common pollution sources. This funding should prioritize green infrastructure that not only reduces sewer overflows but also prevents pollutants from directly running off into our waterways.

Policymakers should:

Prevent stormwater runoff pollution

- Dramatically increase federal investment in natural and green infrastructure practices— such as rain gardens, permeable surfaces, and urban greenspace— that prevent bacteria-laden pollution from reaching waterways.
- Protect and restore natural infrastructure, including riparian areas and wetlands that can filter bacteria, sediment, and nutrients.
- Support increased capacity of stormwater systems, water and energy conservation, and nature-based or green infrastructure to promote resilience, the ability to continue functioning successfully, to manage changing weather patterns and rising sea levels.
- Require new development and redevelopment to prevent runoff pollution.

Prevent sewage pollution

- Dramatically increase investment in fixing aging sewage systems to end sewage overflows, flooding and other pollution harmful to our waterways.
- Support and prioritize the use of green infrastructure to prevent sewage overflows.
- Set standards for municipal wastewater treatment strong enough to prevent overflows and keep our waterways clean, and ensure compliance with those standards.
- Upgrade wastewater facilities that are in danger of overflowing during storms and floods to ensure that they are resilient, or still functioning properly, amid changing weather patterns and sea level rise.
- Ensure more frequent inspections and proper maintenance of residential septic systems.

Policy makers must also take steps to ensure that clean water funding is accessible to all communities. Current barriers to clean water funding can prevent smaller, more rural communities from implementing projects and practices that protect their residents and water from harmful pollutants. Rural or urban, large or small, all communities play a critical role in the health of our waterways.

However, even dramatic increases in water infrastructure funding will be for naught if we do not also provide our waterways with strong protections against pollution and degradation. Federal policymakers should set policies that dramatically curtail pollution from other sources—including power plants, factory farms, and oil and gas operations. And as an immediate priority, U.S. EPA and the Army Corps of Engineers must restore Clean Water Act protections for our streams, which feed our larger waterways, and for our wetlands, which filter out pollutants and prevent flooding.

If we invest boldly and wisely in water infrastructure and curb pollution from other sources, we can finally make all of America's waterways safe and clean.

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