NER Urban Landscapes Capability Team

Urban landscapes commonly are impacted in many ways, including degraded water quality, fragmented habitats, invasive species, contaminant spills and transport, reduced groundwater recharge, increasing streamflow flashiness, and others. Urban development disrupts native biological communities, particularly the loss of sensitive biota. Every aquifer or stream can be degraded by inputs of nutrients, contaminants and/or sediments. In addition, stormwater runoff is a major problem in urban areas, increasing flooding or contaminant loads in local streams and rivers and costing cities millions of dollars to mitigate. The USGS Northeast Region has been an active participant in the Urban Waters Federal Partnership (UWFP), which is a White House sponsored program designed to reconnect urban communities, particularly those that are overburdened or economically distressed, with their waterways by improving coordination among Federal agencies and collaborating with community-led revitalization efforts to improve our Nation's water systems and to promote their economic, environmental, and social benefits. Through the Urban Waters Federal Partnership, the Northeast Region is working with many Federal, state and local partners to improve and protect water quality, restore urban watersheds, create recreational opportunities, and improve social and economic conditions in unserved urban communities. Understanding the processes controlling urban impacts on ecosystems is not only a critical focus of the White House through the UWFP, but also of the USEPA, the Great Lakes Restoration Initiative, and many State and local stakeholders.

GOALS

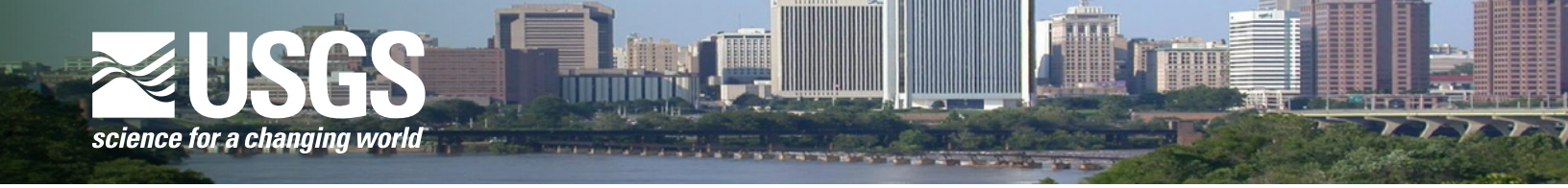
The Northeast Region Urban Landscapes Capability Team will advance the Northeast Region as a leader in urban science and decision support programs. The Team will be a resource to assist the Region and its Science Centers to develop and maintain science programs that provide information on impacts of urban development on ecosystems, aquifer systems, streams and other waterbodies and implications for watershed management. Specific areas for technical collaboration will include:

- Impacts on streams and other waterbodies;
- Effects on terrestrial and aquatic ecosystems;
- Effects on flood discharge and frequency;
- Green infrastructure and ecosystem services;
- Impact on communities;
- Ways to minimize impact on urban waters quality and quantity from urban development

MAJOR OBJECTIVES

Major objectives for the Northeast Region Urban Landscapes Capability Team will include:

- Build and maintain urban science program for Northeast Region SCs and assist the Northeast Region Headquarters staff with regional program development through technical support.
- Work with Northeast Region scientists to develop a technical vision for new urban waters science work and decision making tools.
- Keep Region technical staff aware of urban waters science related developments through Webinars and face-to-face meetings. Maintain forums for Region SCs to share technical problems and ideas.
- Interface with other USGS Regions, particularly the Midwest Region (since it is also developing an emphasis on urban science), to draw upon their expertise and foster information exchange.
- Support the UWFP by providing the necessary science to advance the initiative.
- Develop expertise to support communities in understanding and addressing the impacts from a changing climate, (e.g., more frequent and intense storms, increasing coastal events, sea-level rise) and building a more resilient community.
- Build expertise in understanding the unique impacts from natural disasters on urban areas and develop tools and resources to help communities recover from those impacts.



Northeast Region—Urban Landscapes Capability Team

Contaminants in Urban Waters—Science Capabilities of the U.S. Geological Survey

Streams and estuaries with urban watersheds commonly exhibit increased streamflow and decreased base flow; diminished stream-channel stability; excessive amounts of contaminants such as pesticides, metals, industrial and municipal waste, and combustion products; and alterations to biotic community structure. Collectively, these detrimental effects have been termed the "urban-stream syndrome." Water-resource managers seek to lessen the effects on receiving water bodies of new urban development and remediate the effects in areas of existing urbanization. Similarly, the scientific community has produced extensive research on these topics, with researchers from the U.S. Geological Survey (USGS) leading many studies of urban streams and the processes responsible for the urban-stream syndrome. Increasingly, USGS studies are evaluating the effects of management and restoration activities to better understand how urban waters respond to the implementation of management practices. The USGS has expertise in collecting and interpreting data for many physical, chemical, and ecological processes in urban waters and, thus, provides holistic assessments to inform managers of urban water resources.

Expertise and Resources

The USGS scientists of the Northeast Region Urban Landscapes Capability Team share expertise and resources to provide and interpret data on a wide range of urban-related issues at local, regional, and national levels. Monitoring contaminants in urban waters is one such area of expertise. The USGS develops and uses nationally-consistent methods for sampling and continuous monitoring. Scientists with the USGS work with stakeholders and industry to develop specialized sampling equipment, such as automated and passive samplers, for use in rivers, streams, estuaries, and groundwater. The USGS laboratories have developed state-of-the-art analytical methods for environmental samples such as the methods used to detect pharmaceuticals and pesticides and to operate at production levels supportive of USGS activities nationwide. Data generated by these monitoring and analytical programs are retained by the USGS National Water Information System database (http://dx.doi.org/10.5066/F7P55KJN). Scientists and statisticians of the USGS develop and utilize cutting-edge modeling and statistical analysis tools to interpret the data that result from these monitoring activities. This combination of nationally-consistent data-collection methods, centralized laboratory services, and advanced interpretive capabilities are unparalleled outside of the USGS. These capabilities have been relied on by resource managers to determine the effectiveness of stormwater-management infrastructure (including green infrastructure effectiveness), evaluate improvements in wastewater-treatment processes, and evaluate the feasibility of water reuse.

Nutrients

The overenrichment of nutrients in an ecosystem, which is termed eutrophication, creates a detrimental imbalance of the ecosystem. Though often associated with agricultural watersheds, eutrophication is common in urban streams and also in receiving water bodies. Eutrophication is the result of over-application of fertilizers on urban turf, leaking municipal sewer infrastructure, increased density of septic systems, and other nutrient sources. The USGS has expertise in monitoring nutrients and in modeling loads and trends using a combination of traditional methods and advanced technologies. Additional USGS expertise pertaining to nutrient cycles in the urban environment includes identifying nutrient sources and assessing the effectiveness of management mitigation actions.

A U.S. Geological Survey scientist collecting a water-quality sample in an urban stream in Virginia. Photograph by U.S. Geological Survey.

Suspended Sediment

Sediment loads can increase dramatically in watersheds undergoing urbanization because of increased sediment-laden runoff and because of aggravated erosion of stream channels that have more frequent high-energy stormflow events. Increases in sediment loads are often associated with destabilization of stream channels and degradation of habitat quality and also increases in the transport of sediment-associated contaminants. The USGS expertise in sediment-generation and transport

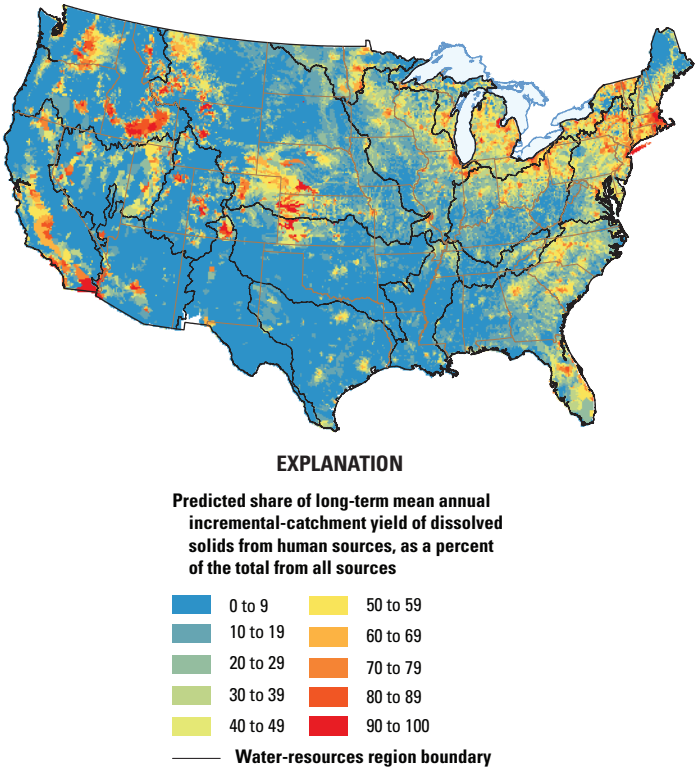
Banner photograph: Richmond, Virginia, skyline by the U.S. Geological Survey.

Fact Sheet 2016–3024
April 2016

related issues in urban streams includes geomorphic watershed assessment and monitoring; suspended sediment and sediment-associated contaminant loads, yields, and trends monitoring; and application of state-of-the-art continuous monitoring technologies.

Toxic Substances

Anthropogenic activities in urban areas release a broad range of chemical substances to the environment. Contamination by these substances, which include pesticides; pharmaceuticals; detergents and surfactants; fire suppressants; polychlorinated biphenyls; metals; and biological constituents such as bacteria, viruses, and other pathogens, can result in environmental degradation as well as effects to human health. Through programs such as the Toxic Substances Hydrology Program (http://toxics.usgs.gov/), the USGS has developed extensive expertise in characterizing the processes that control contaminant transport and degradation in aquatic environments, including methods of measuring and modeling these contaminants and their transport and fate.



The U.S. Geological Survey spatially referenced regressions on watershed model (also known as SPARROW) has been used to predict the percentage of dissolved solids yields contributed from human sources throughout the conterminous United States. Percentages represented by the color gradient from 0 to 100 percent of contribution. Note the widespread areas of greater human sources throughout the densely populated northeastern United States. From Anning and Flynn (2014).

Contaminants of Emerging Concern

Contaminants of emerging concern are natural or synthetic chemicals that commonly have been monitored in the environment but have the potential to enter the environment and are known or suspected to cause adverse environmental or human health effects. This class of contaminants includes potential endocrine disrupting compounds such as hormones, pharmaceuticals, personal-care products, pesticides, and other compounds that are associated with human activity and, therefore, commonly are detected in many densely populated urban areas. The USGS has pioneered many of the methods used for sample collection and analyses of these compounds in natural waters.

Examples of Current USGS Studies of Urban Water Quality

Scientists with the USGS are currently (2016) studying water quality in urban waters in the following areas:

- Fairfax County, Virginia—http://va.water.usgs.gov/fairfax
- Hampton Roads Region, Virginia—http://va.water.usgs.gov/HRstormwater
- Anacostia River, Maryland—http://md.water.usgs.gov/projects/qw/anacostia_nebranch
- Paint Branch, Maryland—http://md.water.usgs.gov/projects/qw/paint_branch
- Bronx and Harlem Rivers, New York—http://ny.cf.er.usgs.gov/nyprojectsearch/projects/LK00-DU700.html

Partnering Opportunities

The USGS is committed to expanding studies of urban streams. Access to USGS expertise, such as that described herein, is possible through numerous partnering opportunities. State and local agencies may partner with the USGS and access matching funds through the Cooperative Water Program (http://water.usgs.gov/coop/). Federal agencies, educational institutions, nonprofit organizations, and other entities may partner with USGS through a variety of programs.

Reference Cited

Anning, D.W, and Flynn, M.E., 2014, Dissolved-solids sources, loads, yields, and concentrations in streams of the conterminous United States: U.S. Geological Survey Scientific Investigations Report 2014–5012, 101 p., accessed April 12, 2016, at http://dx.doi.org/10.3133/sir20145012.

By John D. Jastram and Kenneth E. Hyer

For more information about these USGS projects and about partnering opportunities, contact:

USGS Northeast Region Urban Landscapes Capability Team

Email: GS-NE_ULCT@usgs.gov

or contact your local USGS office
https://www.usgs.gov/contact_us

ISSN 2327-6932 (online)
http://dx.doi.org/10.3133/fs20163024

Northeast Region—Urban Landscapes Capability Team

Urban Development and Stream Ecosystem Health—Science Capabilities of the U.S. Geological Survey

Urban development creates multiple stressors that can degrade stream ecosystems by changing stream hydrology, water quality, and physical habitat. Contaminants, habitat destruction, and increasing streamflow variability resulting from urban development have been associated with the disruption of biological communities, particularly the loss of sensitive aquatic biota. Understanding how algal, invertebrate, and fish communities respond to these physical and chemical stressors can provide important clues as to how streams should be managed to protect stream ecosystems as a watershed becomes increasingly urbanized. The U.S. Geological Survey (USGS) continues to lead monitoring efforts and scientific studies on the effects of urban development on stream ecosystems in metropolitan areas across the United States.

Expertise and Resources

The USGS scientists of the Northeast Region Urban Landscapes Capability Team share expertise and resources to provide and interpret data on a wide range of urban-related issues at local, regional, and national levels. Data collected from traditional water and bed-sediment samples are complemented with ecological toxicity and bioassay analyses to assess the exposure and vulnerability of organisms living in stream water and bed sediments. The ecological condition of streams and lakes are assessed by surveying fish, invertebrate, and algal communities and by analyzing biological tissues for contaminants.

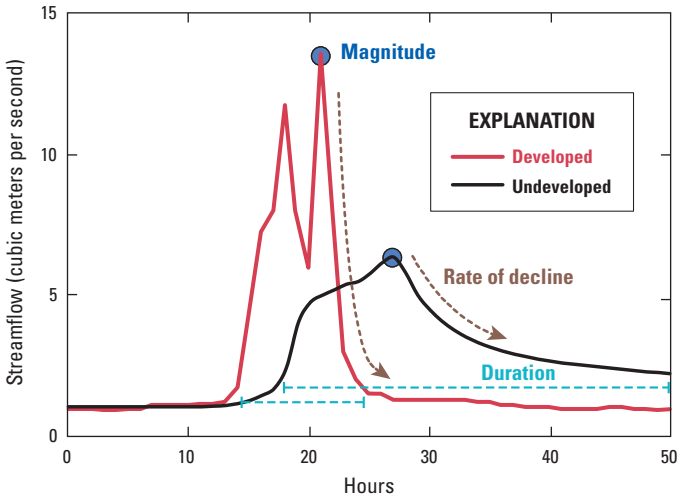
Streamflow Variability and Loss of Sensitive Species

Natural fluctuations of flows are critical to stream health because they build and maintain physical habitats, influence physical and chemical characteristics of water, and provide important life-stage cues for aquatic organisms. Urban development typically modifies streams by altering the magnitude, duration, frequency, and timing of streamflow. As the percentage of impervious surfaces and levels of stormwater-management controls increase with urban development, the amount of runoff entering streams frequently results in higher flows that can alter stream habitat from channel erosion. Additionally, rapid runoff reduces soil infiltration and aquifer recharge, which often results in lower sustained streamflows during summer. These changes generally result in a shift in the species composition of the biological communities, specifically with losses of fish species diversity and sensitive invertebrate species. As a result, the biological community shifts to a higher percentage of species more tolerant to physical and chemical stressors. Understanding how stream ecosystems change with increasing urban development can assist in the development of protective and rehabilitative management actions. Results from USGS studies (http://water.usgs.gov/nawqa/urban/html/publications.html) document the pervasiveness and severity of streamflow modification across the Nation and provide water-resources managers with regional-scale perspectives on the importance of maintaining natural streamflow to preserve biological communities and stream health.

Chemical Stressors and Ecosystem Health

Urban development may increase the inputs to streams of complex chemical mixtures typically present in runoff from impervious surfaces in industrial and suburban areas. These mixtures may include pesticides, nutrients, chloride, metals, organic wastewater compounds, and other chemicals that have deleterious biological effects. These effects of toxicity on the biological communities may be defined in terms of

Photograph of a brown bullhead (Ameiurus nebulosis) with lip tumors that was collected from the Presque Isle Bay Area of Concern in Erie, Pennsylvania. Bullhead species dwell and feed near bottom sediments; therefore, they are often used as an indicator species of environmental health (Blazer and others, 2014). Photograph by Vicki Blazer, U.S. Geological Survey.



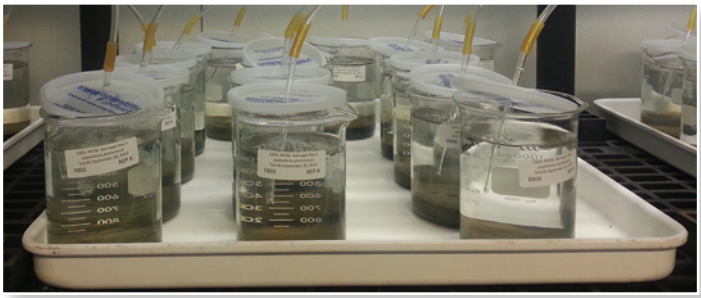
A common effect of urbanization on stream hydrology is that the frequency and magnitude of high flows generally increase and flow durations generally decrease as a result of rapid runoff from impervious surfaces. Figure from Coles and others (2012).

Banner photograph: Boston skyline by Bill Damon, Creative Commons Attribution 2.0 Generic license.

Fact Sheet 2016–3026
April 2016

limited survival, growth, and reproduction. Minor amounts of some compounds commonly present in urban streams may have immediate or long-term effects on ecosystem community structure, diversity, and productivity. For example, endocrine disruption (U.S. Geological Survey, 2009) and reproductive effects have been documented for fish (Blazer and others, 2013) from contaminants of emerging concern such as hormones, estrogenic pesticides (U.S. Geological Survey, 2012), and wastewater compounds. The bioaccumulation of trace elements, such as mercury, has been indicated to have reproductive and behavioral effects on fish and their higher level predators. Large increases in stream chloride concentrations in watersheds with increased urban development have been observed throughout the Northeastern United States where road salt and deicing chemicals are used extensively and may affect the survival of sensitive aquatic species.

In urban environments, increased stormwater runoff can introduce contaminants to the streams and alter streambed sediment chemistry and, thereby, increase the associated toxicity to biological communities. Flushing of urban streams during flood events can then resuspend and redistribute these contaminated sediments along the streambed and into downstream estuaries. The USGS stream assessment capabilities include identifying the presence of specific contaminants in water, sediment, and biological tissue, and evaluating ecosystem health by testing ecological toxicity.



Ecological toxicity tests provide data on the lethal and sublethal (reproductive, developmental, and behavior) effects of the chemical composition of the bed-sediment samples to which the organisms are exposed. Photograph by Jacob K. Stanley, U.S. Army Corps of Engineers.

Examples of USGS Urban Ecology Studies

USGS National Water Census

Tributaries in the Delaware River Basin are currently [2016] being studied to define relations that exist among major components of streamflow (magnitude, durations, frequency, timing, and rate of change) and the response of aquatic biological communities. This information will assist managers in making decisions about meeting human water needs while maintaining a healthy stream. http://water.usgs.gov/watercensus/delaware.html

Northeast Region Stream Quality Assessment

The goal of the Northeast Stream Quality Assessment study is to assess the quality of streams in the region by characterizing multiple water-quality factors that are stressors to aquatic life and evaluating the relation among these stressors and biological communities. The Northeast Stream Quality Assessment will focus on the effects of urbanization and agriculture on stream quality in New England, New York, and the northernmost parts of New Jersey and Pennsylvania. http://txpub.usgs.gov/RSQA/

USGS Environmental Health Program

Contaminants of emerging concern can have natural or synthetic sources that are present in the environment but are not commonly monitored. The USGS has ongoing environmental health research in the Northeast Region and nationally on these contaminants because these chemical compounds have the potential to cause adverse ecological or human health effects, or both. The primary goals of the research program are to develop analytical methods to detect these contaminants at low concentrations and to provide information on the frequency of detection, sources, transport and fate, and ecological effects of a variety of emerging contaminants. http://toxics.usgs.gov/regional/emc/index.html

USGS Regional Studies on the Effects of Urbanization on Stream Ecosystems

As part of the USGS National Water Quality Assessment, researchers studied the relation between varying levels of urban intensity and stream water quality, as measured by physical, chemical, and biological factors in 11 metropolitan areas. For these studies, stream water quality was considered a composite of physical, chemical, and biological characteristics influenced by natural factors and by human activities. Biological communities reflect the integration of these influences. http://water.usgs.gov/nawqa/urban/index.html

Partnering Opportunities

The USGS is a leader in monitoring the effects of urban development and land-use change on stream ecosystems. Ecosystem studies led by the USGS use standardized protocols and analytical procedures to integrate data from multiple biological communities so that assessments of stream health and its relation to urbanization can be compared nationally and locally. Access to USGS expertise is possible through numerous partnering opportunities. State and local agencies may partner with the USGS and access matching funds through the Cooperative Water Program (http://water.usgs.gov/coop/). Federal agencies, educational institutions, nonprofit organizations, and other entities may partner with the USGS through a variety of programs.

References Cited

Blazer, V.S., Mazik, P.M., Iwanowicz, L.R., Braham, R.P., Hahn, C.M., Walsh H.L., and Sperry, A.J., 2014, Assessment of the fish tumor beneficial use impairment in brown bullhead (Ameiurus nebulosus) at selected Great Lakes areas of concern: U.S. Geological Survey Open-File Report 2014–1105, 17 p., accessed April 12, 2016, at http://dx.doi.org/10.3133/ofr20141105.

Blazer, V.S., Pinkney, A.E., Jenkins, J.A., Iwanowicz, L.R., Minkkinen, Steven, Draugelis-Dale, R.O., and Uphoff, J.H., 2013, Reproductive health of yellow perch Perca flavescens in selected tributaries of the Chesapeake Bay: Science of the Total Environment, v. 447, p. 198–209, accessed April 12, 2016, at http://www.sciencedirect.com/science/article/pii/S0048969712016452.

Coles, J.F., McMahon, Gerard, Bell, A.H., Brown, L.R., Fitzpatrick, F.A., Scudder Eikenberry, B.C., Woodside, M.D., Cuffney, T.F., Bryant, W.L., Cappiella, Karen, Fraley-McNeal, Lisa, and Stack, W.P., 2012, Effects of urban development on stream ecosystems in nine metropolitan study areas across the United States: U.S. Geological Survey Circular 1373, 138 p., accessed April 12, 2016, at http://pubs.usgs.gov/circ/1373/.

U.S. Geological Survey, 2009, Tackling fish endocrine disruption: U.S. Geological Survey Environmental Health Web page, accessed April 12, 2016, at http://toxics.usgs.gov/highlights/fish_endocrine_disruption.html.

U.S. Geological Survey, 2012, Pyrethroid insecticide contamination of streams increases with urbanization: U.S. Geological Survey Environmental Health Web page, accessed April 12, 2016, at http://toxics.usgs.gov/highlights/pyrethroids_in_streams.html.

By Pamela A. Reilly, Zoltan Szabo, and James F. Coles

For more information about these USGS projects and about partnering opportunities, contact:

USGS Northeast Region Urban Landscapes Capability Team

Email: GS-NE_ULCT@usgs.gov

or contact your local USGS office
https://www.usgs.gov/contact_us

ISSN 2327-6932 (online)
http://dx.doi.org/10.3133/fs20163026

Northeast Region—Urban Landscapes Capability Team

Urban Hydrology—Science Capabilities of the U.S. Geological Survey

Urbanization affects streamflow characteristics, coastal flooding, and groundwater recharge. Increasing impervious areas, streamflow diversions, and groundwater pumpage are some of the ways that the natural water cycle is affected by urbanization. Assessment of the relations among these factors and changes in land use helps water-resource managers with issues such as stormwater management and vulnerability to flood and drought. Scientists with the U.S. Geological Survey (USGS) have the expertise to monitor and model urban hydrologic systems. Streamflow and groundwater data are available in national databases, and analyses of these data, including identification of long-term streamflow trends and the efficacy of management practices, are published in USGS reports.

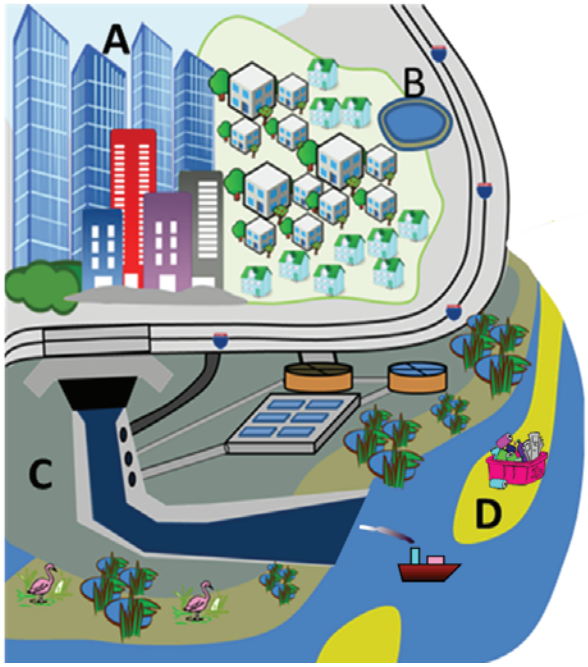
Expertise and Resources

The USGS scientists of the Northeast Region Urban Landscapes Capability Team share expertise and resources to provide and interpret data on a wide range of urban-related issues at local, regional, and national levels. These scientists use state-of-the-art monitoring, modeling, and laboratory methods to better understand hydrologic processes and their impacts on aquatic organisms and human life in urban environments. Examples of these efforts include operating continuous streamflow monitoring stations coupled with alert systems in flash-flood prone areas to provide the public with real-time warnings about flooding (http://waterwatch.usgs.gov/), generating data critical to refining inundation and storm surge forecasting models and maps, and providing emergency personnel with early warning of coastal flooding (http://water.usgs.gov/floods/swath/). Assessing the interactions between surface water and groundwater using advanced monitoring technologies and modeling applications informs urban planners and stakeholders about water resources. See http://ny.water.usgs.gov/projects/SOTA/ and Provost and others (2009) for more details.

Cement-lined stream in Queens County, New York. Photograph from U.S. Geological Survey.

Urban Streams

The USGS currently operates a network of over 8,000 streamgages (http://waterdata.usgs.gov/nwis/rt) as part of its cooperative water program, which is used by local, state, and Federal cooperators; stakeholders; and other government agencies. Increases in stormwater runoff from impervious surfaces (roads, parking lots, and roofs) increase peak flows during rain events, which can degrade stream channel stability. Advanced monitoring equipment, such as noncontact radar-stage sensors and acoustic Doppler velocimeters, are used to understand rapidly-changing hydrodynamic conditions in streams and estuaries in real time (http://ny.cf.er.usgs.gov/nyprojectsearch/projects/LK00-FKD-0300.html). The USGS modeling program, Stochastic Empirical Loading and Dilution Model (also known as SELDM), was created in cooperation with the Federal Highway Administration to determine the risk of adverse effects of storm runoff, the potential need for mitigation measures, and the effectiveness of management measures for reducing these risks (https://pubs.er.usgs.gov/publication/tm4C3). Information about how stream and coastal flooding are affected by land use helps municipal officials manage their current and future vulnerability to floods. Scientists with the USGS also work with urban planners and community groups to study the effects of stream restoration such as daylighting (uncovering buried streams) and dam removal.



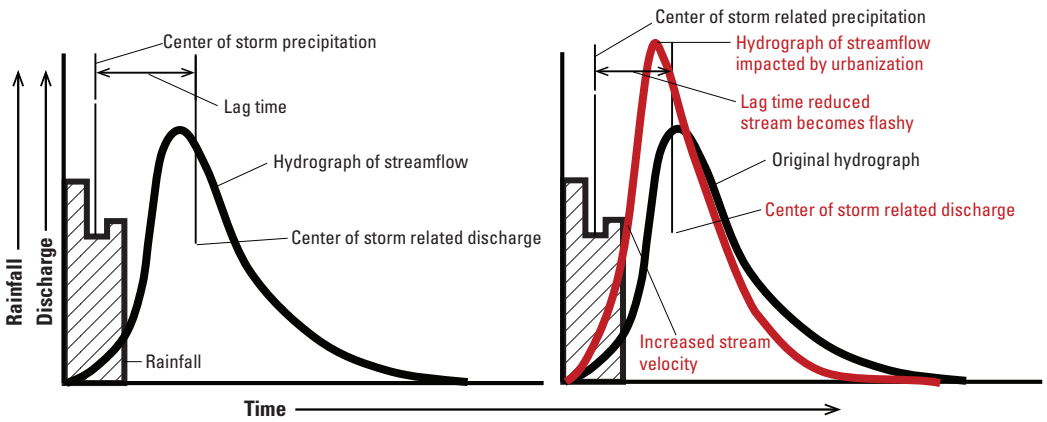
Urban hydrology qualifies and quantifies effects of *A*, impervious surfaces, *B*, groundwater sourcing, *C*, stream response time and sewage overflow, and *D*, waterway impairment.

Groundwater in Urban Areas

The USGS operates an extensive network of groundwater wells that can be used to assess groundwater level and quality and aquifer properties. Urbanization can affect groundwater resources in many ways. Impervious surfaces in an

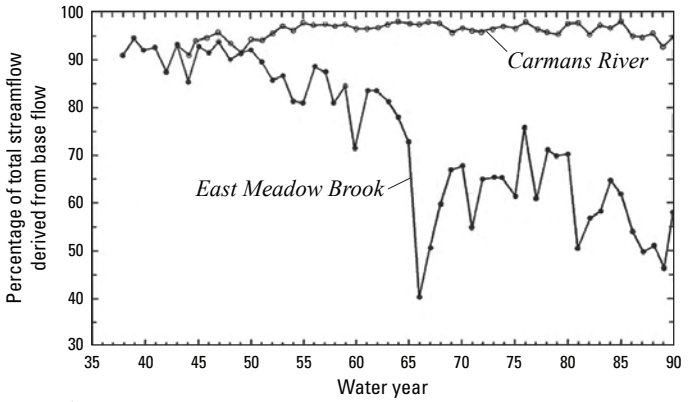
Banner photograph: Washington, D.C., skyline by Ad Meskens, Creative Commons Attribution-Share Alike 3.0 Unported license https://commons.wikimedia.org/wiki/File:Washington_dc_skyline.jpg.

Fact Sheet 2016–3023
April 2016



Conceptual model showing how a discharge hydrograph is altered by increases in impervious areas throughout a watershed. Water runs off faster from streets and roofs than from natural vegetated areas. The construction of parking lots, artificial channels, and storm sewers reduce the time required for a given amount of water to run off into neighboring streams. Effects of decreasing lag time are higher in-stream velocities, increased erosion, higher instantaneous discharge, and increased potential for flash flooding. Image modified from Leopold, 1968.

urban landscape alter groundwater recharge. Sanitary infrastructure alters the natural water budgets. Groundwater withdrawal for public supply removes water from storage and can decrease base flows to streams. Above-normal precipitation events, rising sea level, and climate change may exacerbate current infrastructure flooding issues by increasing groundwater levels. Conversely, droughts and supply withdrawals can lower groundwater levels and may lead to land subsidence or saltwater intrusion. To better understand complex aquifer systems and their potential response to changes in precipitation, urbanization, wastewater recharge, or withdrawal, the USGS has developed numerous groundwater flow models in urban areas using computer programs such as MODFLOW. Models such as these greatly improve the understanding of groundwater processes and groundwater response to stressors such as intensive supply pumping.



(Water year is the 12-month period of October 1, for any given year through September 30, of the following year. The water year is designated by the calendar year in which it ends.)

Percentage of streamflow derived from base flow at two streams in Long Island, New York; East Meadow Brook at Freeport, N.Y., and Carmans River at Yaphank, N.Y. Decreased streamflow in East Meadow Brook, N.Y., is attributed to sewering in the urbanized watershed, which exacerbated the low streamflows during drought conditions in the 1960s. Streamflow at the Carmans River, which is in a rural setting that is not sewered, was sustained by base flow during the same period of record (Scorca, 1996).

Examples of USGS Urban Hydrologic Studies

http://pubs.usgs.gov/sir/2014/5058/
http://pubs.usgs.gov/fs/fs07603/
http://pubs.usgs.gov/sir/2014/5036/pdf/sir2014-5036.pdf
http://pubs.usgs.gov/of/2014/1184
http://pubs.usgs.gov/circ/1968/0554/report.pdf
http://pubs.usgs.gov/wri/1996/4187/report.pdf

Partnering Opportunities

As the Nation's largest hydrologic, geologic, and biologic science and mapping agency, the USGS provides scientific understanding about natural resource conditions, issues, and problems. The diversity of our scientific expertise enables us to carry out large-scale, multi-disciplinary investigations and provide impartial scientific information to resource managers, planners, and other cooperators. The USGS Northeast Region Urban Landscape Capability Team is committed to continuing and expanding urban hydrologic studies needed to manage water resources of the United States. The USGS has a long history of collaborative science with a diversity of partners including local, state, Federal, and Tribal agencies; nonprofit organizations; academic institutions; watershed groups; and other water resources entities. Opportunities for jointly funded programs are available through the Cooperative Water Program (http://water.usgs.gov/coop/).

References Cited

Granato, G.E., 2013, Stochastic empirical loading and dilution model (SELDM) version 1.0.0: U.S. Geological Survey Techniques and Methods, book 4, chap. C3, 112 p., accessed April 12, 2016, at http://pubs.usgs.gov/tm/04/c03/.

Leopold, L.B., 1968, Hydrology for urban land planning—A guidebook of the hydrologic effects of urban land use: U.S. Geological Survey Circular 554, 18 p., accessed April 12, 2016, at http://pubs.usgs.gov/circ/1968/0554/report.pdf.

Provost, A.M., Reilly, T.E., Harbaugh, A.W., and Pollock, D.W., 2009, U.S. Geological Survey groundwater modeling software—Making sense of a complex natural resource: U.S. Geological Survey Fact Sheet 2009–3105, 4 p., accessed April 12, 2016, at http://pubs.usgs.gov/fs/2009/3105/pdf/2009-3105.pdf.

Scorca, M.P. and Ku, H.F.H., 1997, Urbanization and recharge in the vicinity of East Meadow Brook, Nassau County, New York, Part 3—Ground-water levels and flow conditions, 1988–93: U.S. Geological Survey Water-Resources Investigations Report 96–4265, 39 p., accessed April 12, 2016, at https://pubs.er.usgs.gov/publication/wri964265.

By Joseph M. Bell, Amy E. Simonson, and Irene J. Fisher

For more information about these USGS projects and about partnering opportunities, contact:

USGS Northeast Region Urban Landscapes Capability Team

Email: GS-NE_ULCT@usgs.gov

or contact your local USGS office
https://www.usgs.gov/contact_us

ISSN 2327-6932 (online)
http://dx.doi.org/10.3133/fs20163023

Northeast Region—Urban Landscapes Capability Team

Urban Infrastructure and Water Management—Science Capabilities of the U.S. Geological Survey

Managing the urban-water cycle has increasingly become a challenge for water-resources planners and regulators faced with the problem of providing clean drinking water to urban residents. Sanitary and combined sanitary and storm sewer networks convey wastewater to centralized treatment plants. Impervious surfaces, which include roads, parking lots, and buildings, increase stormwater runoff and the efficiency by which runoff is conveyed to nearby stream channels; therefore, impervious surfaces increase the risk of urban flooding and alteration of natural ecosystems. These challenges will increase with the expansion of urban centers and the probable effects of climate change on precipitation patterns. Understanding the urban-water cycle is critical to effectively manage water resources and to protect people, infrastructure, and urban-stream ecosystems. As a leader in water-supply, wastewater, and stormwater assessments, the U.S. Geological Survey (USGS) has the expertise and resources needed to monitor, model, and interpret data related to the urban-water cycle and thereby enable water-resources managers to make informed decisions.

Expertise and Resources

The USGS scientists of the Northeast Region Urban Landscapes Capability Team share expertise and resources to provide and interpret data on a wide range of urban-related issues at local, regional, and national levels. The USGS has been studying the effects of urbanization on natural resources—groundwater and surface-water quality, ecosystems, and geologic resources—throughout the United States for more than a century. Continuous water-quality monitoring is used to assess trends in water quality and to detect potential problems before an entire water-supply system is impacted. Groundwater monitoring and modeling are used in a variety of aquifer settings to assess the effects of groundwater pumping for public supply and infrastructure dewatering (for example, pumping groundwater to prevent flooding of subways). Scientists with the USGS evaluate groundwater and surface-water responses to changes in water management. Advanced geophysical equipment is used to understand the effects of compromised underground water-supply infrastructure (such as aqueducts), to understand the potential for geothermal development, and to understand the capacity for artificial storage and recovery of gray water. Advanced geophysical equipment also is used to guide the development of water-supply and wastewater conveyance systems in heavily developed areas. The expertise of USGS scientists also is applied when water quality and quantity is monitored to assess the effectiveness of various stormwater control measures (SCMs), including green infrastructure.

Water Supply Infrastructure

Monitoring water quality and quantity are critical for maintaining safe and reliable drinking water supplies. Contaminants (such as sediment, nutrients, metals, and chloride) can compromise water supplies and require expensive treatment systems. Scientists with the USGS frequently work with water purveyors and municipalities to develop strategies for evaluating the water-supply system, including not only the quality of water but also the infrastructure by which water is retained and transported.

Automated influent and effluent sampling at a wastewater treatment plant as part of a regional assessment of water quality. Photographs by Tia-Marie Scott, U.S. Geological Survey.

Wastewater Treatment Infrastructure

Without proper treatment, contaminants (such as nutrients, organic and inorganics compounds, pharmaceuticals and personal care products, and pathogen) may be discharged to receiving waters causing poor water quality, mutations to aquatic organisms, and beach advisories or closures. The effects of damaged or underperforming wastewater treatment plants, combined sewer overflows, and leaking and misconnected infrastructure can be difficult to determine without a properly devised monitoring program. Through influent/effluent monitoring and contaminant-source tracking, the USGS provides the near real-time data necessary for urban watershed assessments to aid water-resources managers in determining the effectiveness of wastewater treatment and in their work with sewer authorities to identify infrastructure problems.

Stormwater Infrastructure

Traditional engineering methods, grey infrastructure, are designed to rapidly convey storm runoff from developed areas to nearby stream channels or estuary. Green infrastructure is designed to reduce stormwater runoff through nontraditional control measures such as rain gardens and bioswales. Both types of infrastructure help protect cities from flood-related property damage and in some cases, decrease the contaminant loads in storm runoff. Green infrastructure is designed to help restore the natural water cycle by enhancing stormwater infiltration and evapotranspiration. Understanding whether the stormwater infrastructure is contributing to or mitigating the adverse effects of urbanization on nearby waterways is important. The USGS combines proven field methods with state-of-the-art technology to assess the effectiveness of SCMs at multiple scales. Whether monitoring the volumetric and contaminant mass balance of a single rain garden at the plot scale or the cumulative effect of several SCMs dispersed throughout an urban catchment, the USGS can provide the data necessary to help water-resources managers make informed decisions to achieve compliance with local and State contaminant reduction goals.

Banner photograph: New York City skyline by Tony Jin,
Creative Commons Attribution-Share Alike 3.0 Unported license.

Fact Sheet 2016–3025
April 2016

The USGS makes use of hydrologic and contaminant loading models so that information learned from grey and green infrastructure field measurements can be extrapolated into the surrounding urban landscape as a way to simulate the spatial and temporal influence of SCMs on stormwater quantity and quality compared to some baseline condition. For example, a calibrated contaminant loading model is being used to predict the potential benefit of street cleaning on sediment loads from stormwater runoff to nearby waterways.

Examples of USGS Urban Infrastructure Studies

Regional Climate Variability and Patterns of Urban Development

Effects on the urban water cycle and nutrient export.—USGS scientists have established and maintained discharge stations at several urban watersheds in Maryland. http://md.water.usgs.gov/projects/sw/water-sustainability.html

Determination of the Natural Resiliency of Critical Infrastructure in Response to Flooding Events

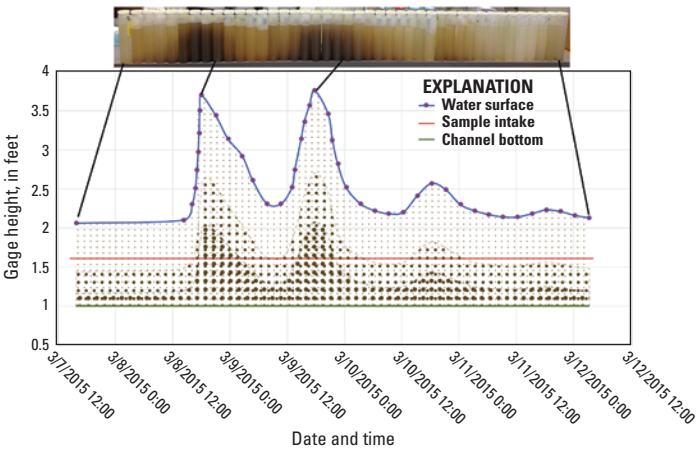
This project seeks to identify where key investments in green infrastructure may increase resiliency to intensified coastal storms, rising relative sea levels, and flooding in the Baltimore, Md., region. http://md.water.usgs.gov/projects/sw/green-infrastructure.html

Rockland County Water-Resource Assessment

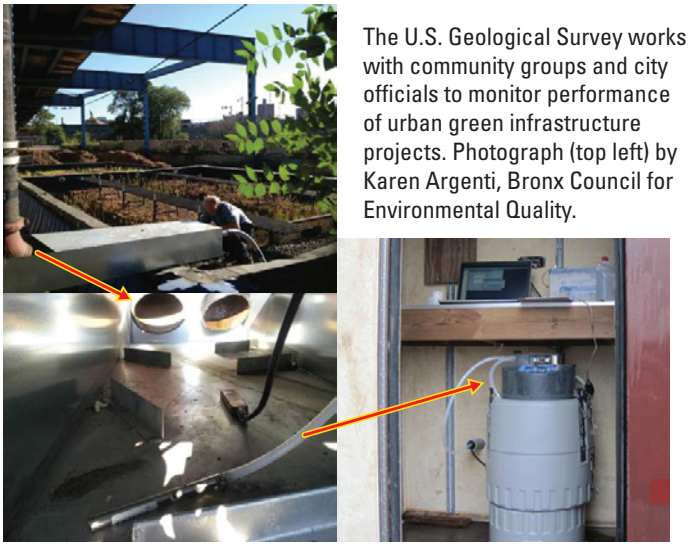
USGS scientists have assessed public water supply sources for viability and sustainability in Rockland County, New York. Surface-water impoundments, fractured bedrock, and glacial aquifers were monitored, along with sewer outfalls, to determine differences in supply versus treatment relative to potential use. http://ny.water.usgs.gov/projects/rockland/index.html

Effectiveness of Three Best Management Practices for Highway-Runoff Quality Along the Southeast Expressway, Boston, Mass.

The USGS has studied the effectiveness of three best management practices in reducing suspended-sediment loads and related constituents along the Southeast Expressway in Boston, Mass. http://pubs.er.usgs.gov/publication/wri024059



The Depth Integrated Sample Arm (DISA; above center) is an example of a state-of-the art technology that the U.S. Geological Survey is developing to obtain a true representation of sediment concentration and loads. The technology is especially useful in flashy systems where sediment concentrations vary substantially with water flow and depth such as stormwater and sewer tunnels (above right) or ephemeral streams (above left). The DISA solves the problem of collecting too much stratified sediment when using a fixed-point sample intake as seen in the above hydrograph and sample collection jars (https://pubs.er.usgs.gov/publication/70133842). Photographs by William Selbig, U.S. Geological Survey.



The U.S. Geological Survey works with community groups and city officials to monitor performance of urban green infrastructure projects. Photograph (top left) by Karen Argenti, Bronx Council for Environmental Quality.

Partnering Opportunities

As the Nation's largest hydrologic, geologic, and biologic science and mapping agency, the USGS provides scientific understanding about natural resource conditions, issues, and problems. The diverse scientific expertise of USGS scientists enables the USGS to carry out site-scale or large multiscale, multidisciplinary investigations and provide impartial scientific information to resource managers, planners, and other customers. The Northeast Region Urban Landscapes Capability Team is committed to expanding urban infrastructure studies needed to manage the water resources of the United States, including the infrastructure used to convey potable water, wastewater, and stormwater. The USGS has a long history of collaborative science with diverse partners including local, State, Federal, and Tribal agencies; nonprofit organizations; academic institutions; watershed groups; and other water resources entities. Opportunities for jointly funded programs are available through the Cooperative Water Program (http://water.usgs.gov/coop/).

References Cited

Selbig, W.R., 2015, Characterizing the distribution of particles in urban stormwater—advancements through improved sampling technology: Urban Waters Journal, v. 12, issue 2, p. 111–119, accessed April 12, 2016, at https://pubs.er.usgs.gov/publication/70133842.

Smith, K.P., 2002, Effectiveness of three best management practices for highway-runoff quality along the Southeast Expressway, Boston, Massachusetts: U.S. Geological Survey Water-Resources Investigations Report 2002–4059, 62 p. [Also available at http://pubs.er.usgs.gov/publication/wri024059.]

By Shawn C. Fisher, Rosemary M. Fanelli, and William R. Selbig

For more information about these USGS projects and about partnering opportunities, contact:

USGS Northeast Region Urban Landscapes Capability Team

Email: GS-NE_ULCT@usgs.gov

or contact your local USGS office
https://www.usgs.gov/contact_us

ISSN 2327-6932 (online)
http://dx.doi.org/10.3133/fs20163025