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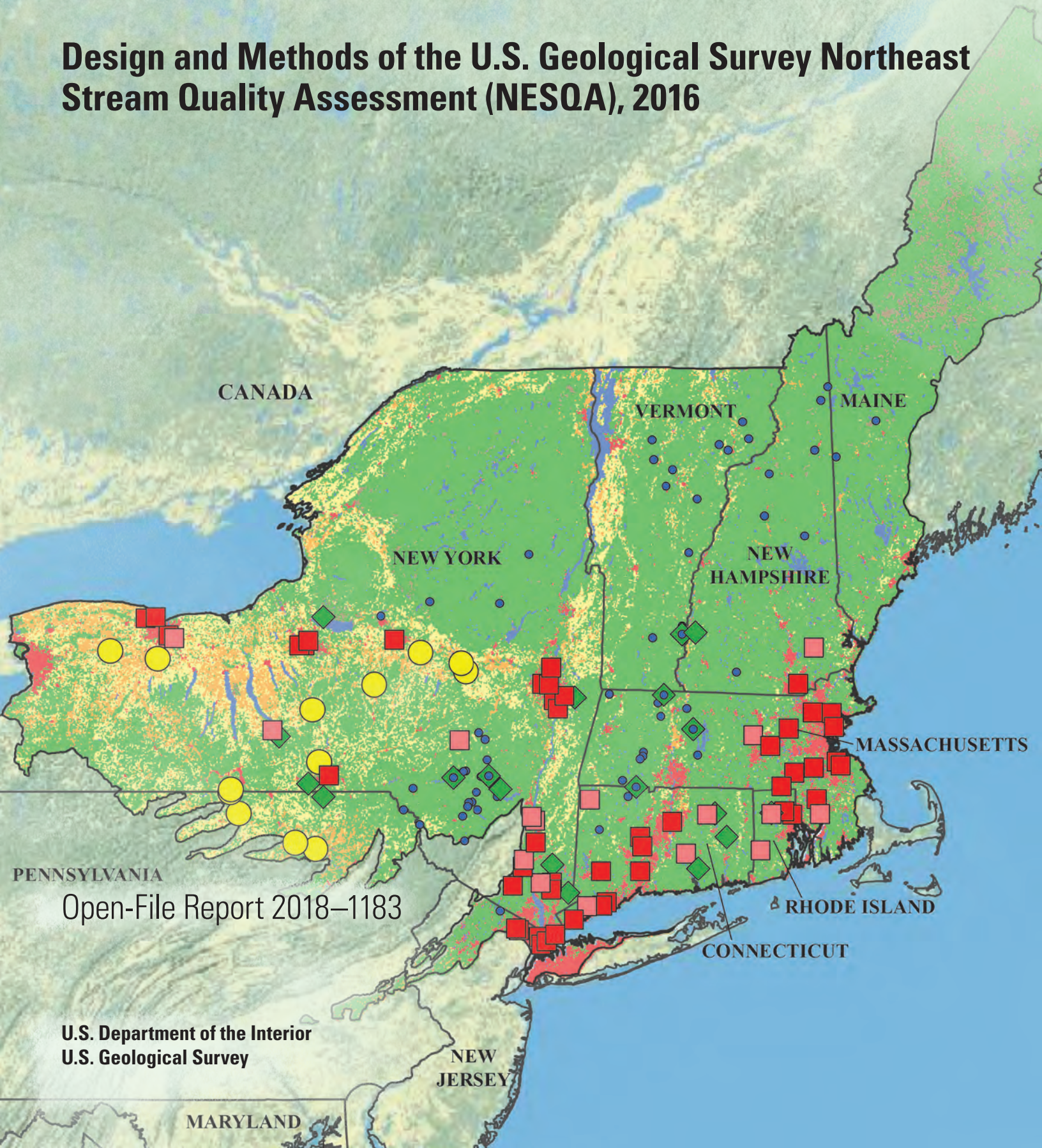
Design and Methods of the U.S. Geological Survey Northeast Stream Quality Assessment (NESQA), 2016



Open-File Report 2018–1183

U.S. Department of the Interior
U.S. Geological Survey

Cover. Map of the Northeast Stream Quality Assessment study area, modified from figure *2A* of this report.

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By James F. Coles, Karen Riva-Murray, Peter C. Van Metre, Daniel T. Button, Amanda H. Bell, Sharon L. Qi, Celeste A. Journey, and Richard W. Sheibley

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DAVID BERNHARDT, Acting Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2019

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
micrometer (µm)	3.937×10^{-5}	inch (in.)
nanometer (nm)	3.937×10^{-8}	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
meter (m)	1.094	yard (yd)
	Area	
square meter (m^2)	0.0002471	acre
square meter (m^2)	10.76	square foot (ft^2)
square centimeter (cm^2)	0.1550	square inch (ft^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
microliter (µL)	2.642×10^{-7}	gallon (gal)
milliliter (mL)	0.0002642	gallon (gal)
liter (L)	0.2642	gallon (gal)
liter (L)	61.02	cubic inch (in^3)
microliter (µL)	6.102×10^{-5}	cubic inch (in^3)
	Flow rate	
meter per second (m/s)	3.281	foot per second (ft/s)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
nanogram (ng)	3.527×10^{-11}	ounce, avoirdupois (oz)
gram per square meter (g/m^2)	0.0002048	pound per square foot (lb/ft^2)
milligram per square meter (mg/m^2)	3.277×10^{-6}	ounce, avoirdupois, per square foot (oz/ft^2)
	Pressure	
kilopascal (kPa)	0.1450	pound-force per inch (lbf/in [or psi])

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as

$$°F = (1.8 \times °C) + 32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as

$$°C = (°F - 32) / 1.8.$$

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L), micrograms per liter (µg/L), or nanograms per liter (ng/L). Concentrations of chemical constituents in bed sediment are given in micrograms per kilogram (µg/kg).

Abbreviations

ASE	accelerated solvent extraction
ASR	analytical service request
CEC	Commission for Environmental Cooperation
CERC	Columbia Environmental Research Center
DAI	direct aqueous injection
DOC	dissolved organic carbon
ELISA	enzyme-linked immunosorbent assay
EPA	U.S. Environmental Protection Agency
ESI	electrospray ionization
GC/MS	gas chromatography mass spectrometry
GC–MS/MS	gas chromatography-tandem mass spectrometry
GIS	geographic information system
INSTAAR	Institute of Arctic and Alpine Research
LC–MS/MS	liquid chromatography tandem mass spectrometry
MRM	multiple reaction monitoring
NAWQA	National Water-Quality Assessment Project
NESQA	Northeast Stream Quality Assessment
NHDPlus	National Hydrography Dataset Plus
NLCD	National Land Cover Database
NWIS	National Water Information System
NWQL	National Water Quality Laboratory
NYWSC	New York Water Science Center
OGRL	Kansas Organic Geochemistry Research Laboratory
OPP	Office of Pesticide Programs
OTU	operational taxonomic unit
PAH	polycyclic aromatic hydrocarbon
PAR	photosynthetically active radiation

PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PCFF	Personal Computer Field Form
POCIS	polar organic chemical integrative sampler
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QW	quality of water
QWDATA	Water-Quality System within NWIS
QWDX	Water Quality Data Exchange
RP	reference point
RSQA	Regional Stream Quality Assessment
RTH	richest targeted habitat
TERL	Trace Elements Research Laboratory
THg	total mercury
USGS	U.S. Geological Survey
UVA	ultraviolet absorbance
WSC	Water Science Center

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Abstract

During 2016, as part of the National Water-Quality Assessment Project (NAWQA), the U.S. Geological Survey conducted the Northeast Stream Quality Assessment (NESQA) to investigate stream quality in the northeastern United States. The goal of the NESQA was to assess the health of wadeable streams in the region by characterizing multiple water-quality factors that are stressors to aquatic life and by evaluating the relation between these stressors and the condition of biological communities. Urbanization, agriculture, and human modifications to streamflow are anthropogenic changes that greatly affect water quality in the region; consequently, the study design primarily selected sites and targeted stressors associated with these activities. The NESQA built on a prior NAWQA study conducted in the region in 2014, the Atlantic Highlands flow-ecology study, which investigated the effects of anthropogenically modified flows on aquatic biological communities in primarily forested watersheds. Land-cover data for the NESQA were used to identify and select sites within the region that had watersheds ranging in levels of urban and agricultural development. A total of 95 sites were selected: 67 on streams in watersheds representing a range of urban land use, 13 on streams in watersheds with some degree of agricultural land use, and 15 on streams in predominantly forested watersheds with little development. Depending on land-cover characteristics, sites were sampled weekly for metal and organic contaminants, nutrients, and sediment for either a 9-week period that began the week of June 6, 2016, or a 4-week period that begin the week of July 11, 2016. Beginning August 1, 2016, and for about 2 weeks, an ecological survey was conducted at every site to assess stream habitat, and algal, benthic invertebrate, and fish communities. Additional samples collected during the ecological surveys were streambed sediment for chemical analysis and toxicity testing, and fish tissue for mercury analysis. This report describes the various study components and methods of the NESQA and describes a precursor effort for the Atlantic Highlands flow-ecology study. Details are presented for measurements of water quality, sediment chemistry, streamflow, and ecological surveys of stream biota and habitat, as well as processes of sample analysis, quality assurance and quality control, and data management.

Introduction

Many natural and anthropogenic stressors can affect stream ecosystems, and often the stressors that degrade streams are associated with the predominant land use in a region. Variations in streamflow, habitat, temperature, and levels of sediment and nutrients are essential characteristics of natural stream ecosystems, but deviation from the natural patterns of streams can substantially alter their biological condition and ecological function (Lenat and Crawford, 1994; Gregory and Calhoun, 2006; Nagy and others, 2011). Contaminants differ from other stressors in that most are derived from human activities and, through various modes of action and toxicity, are potentially detrimental to aquatic life as well as to humans who use water resources. In order to efficiently manage water resources, it is important to understand the conditions under which stressors—individually or in combinations—adversely affect the biological condition of streams and the water resources valued by people.

Multistressor effects are often assessed in the laboratory under controlled conditions or in the field at small-catchment scales. At these small scales, biogeochemical processes and complex environmental interactions can be manipulated and monitored; however, results of such studies are not readily extended over larger spatial scales. Alternatively, by characterizing the conditions of multiple streams over a broad spatial area, specific stressors and biological conditions can be evaluated on regional and national scales (U.S. Environmental Protection Agency, 2006; Herlihy and others, 2008); from such studies, empirical models have been developed to predict metrics of biological condition and environmental stressors across national-scale disturbance gradients (Waite and others, 2000; Klemm and others, 2003; Herlihy and others, 2006; Coles and others, 2012). To date, however, most regional- and national-scale studies have not included a thorough characterization of stressors but have limited their evaluations to relations between land use and biological condition.

The U.S. Geological Survey (USGS), through the National Water-Quality Assessment Project (NAWQA), is conducting studies to bridge this gap, through extensive stressor characterizations at large spatial scales that include multiple sampling sites to promote development of empirical models. As such, the studies are intended to provide communities and

policymakers with information about the human and environmental factors that have the greatest effects on stream quality by addressing these objectives:

1. Determine the status of stream quality across the region on the basis of contaminants, nutrients, sediments, toxicity of the bed sediments, streamflow, habitat, and biological communities.

2. Evaluate the relative influence of contaminants, nutrients, sediment, toxicity, streamflow, and habitat on biological communities in the streams.

3. Evaluate how the natural and anthropogenic characteristics of the watersheds are related to stressors measured at the stream-reach scale and how the condition of biological communities can be explained by these stressors.

4. Develop statistical models and management tools to predict the ecological health of wadeable streams throughout the region and how it is associated with concentrations of contaminants, nutrients, and sediment.

Background

The USGS launched Cycle III of the NAWQA in 2013, which marked the beginning of NAWQA's third decade of water-quality assessments for the Nation. In 1992, Cycle I of NAWQA began investigations with an emphasis on characterizing the Nation's streams and aquifers through a routine monitoring program to establish baseline conditions. A decade later, NAWQA transitioned to Cycle II, which emphasized trends and modeling and included five "topical" studies designed to improve our understanding of environmental processes. The topical studies addressed (1) the fate and transport of agricultural chemicals, (2) effects of urbanization on stream ecosystems, (3) effects of nutrient enrichment on stream ecosystems, (4) transport of contaminants to public-supply wells, and (5) bioaccumulation of mercury in stream ecosystems. Cycle III is built on 20 years of NAWQA studies that describe linkages between contaminant sources and their transport to receiving waters and the effects of land use on stream quality and ecological condition.

Among the major objectives in Cycle III is to assess the occurrence and effects of multiple instream stressors on stream quality. Termed Regional Stream Quality Assessment (RSQA) studies, these studies are characterizing watershed and stream water-quality stressors and aquatic biological conditions to improve understanding of stressor-effects relations at regional scales (https://webapps.usgs.gov/RSQA/). Each RSQA study is a short-term assessment of wadeable streams within a targeted, multistate region, generally delineated by U.S. Environmental Protection Agency (EPA) ecoregions (Omernik and Griffith, 2014). About 100 streams are sampled in each RSQA study to investigate stream ecology and the influences of multiple physical and chemical stressors that are primarily associated with urban development and agricultural land use. Wadeable streams are selected across gradients in urban or agricultural land use or both, depending on the dominant land uses in the region. Weekly water sampling was conducted for 4 to 12 weeks (depending on region and site) for a wide range of chemical constituents, as well as continuous monitoring of flow or stage and temperature in the streams. The timing of this water-quality "index period" is designed to capture the spring and early summer growing season when pesticide and fertilizer applications are highest. The water-quality index period culminates with collection of streambed sediment for extensive chemical analyses and toxicity testing, and with an ecological survey to assess stream habitat and algal, invertebrate, and fish communities.

In 2016, an RSQA study was conducted as part of the NAWQA to assess stream quality across the Northeast region of the United States. Designated as the Northeast Stream Quality Assessment (NESQA), this study was the fourth of the five NAWQA Cycle III regional studies (fig. 1); others were the Midwest Stream Quality Assessment in 2013 (U.S. Geological Survey, 2012), the Southeast Stream Quality Assessment in 2014 (Van Metre and Journey, 2014), the Pacific Northwest Stream Quality Assessment in 2015 (Van Metre, and others, 2015), and the California Stream Quality Assessment in 2017 (Van Metre, Egler, and May, 2017). The study area for the NESQA included 95 watersheds in 8 States: Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont (fig. 2*A*; table 1, in back of report). Like the preceding RSQA studies, the 2016 NESQA primarily investigated stressors associated with urban development, which is particularly intense along the corridor from Boston, Massachusetts, to New York City, New York, and agriculture, which is concentrated mainly in watersheds across the southwestern area of the NESQA region (New York and Pennsylvania).

A related NAWQA study, on which the 2016 NESQA study was built, was the Atlantic Highlands flow-ecology study conducted in 2014 at 66 sites in the Atlantic Highlands ecoregion to assess how flow alterations affected biological communities. The Atlantic Highlands is a Level II ecoregion that is based on ecoregion designations by the Commission for Environmental Cooperation (CEC) in North America (Omernik and Griffith, 2014), and it closely corresponds to the EPA Level III Northeastern Highlands ecoregion. The Atlantic Highlands (and thus Northeastern Highlands) includes the higher elevation sections in the NESQA study area, mainly across the more northern latitudes (fig. 2B); this area is generally less developed and more heavily forested than other ecoregions in the Northeast, and it has many streams whose flow has been anthropogenically altered to create water supplies, hydropower, recreational areas, and flood controls. Consequently, the Atlantic Highlands flow-ecology study was conducted to assess how biological communities were affected specifically by stressors associated with altered streamflows in otherwise low-disturbance streams. To help provide a context with the 2016 NESQA study, an overview of the Atlantic Highlands flow-ecology study is provided in a separate section near the end of this report.

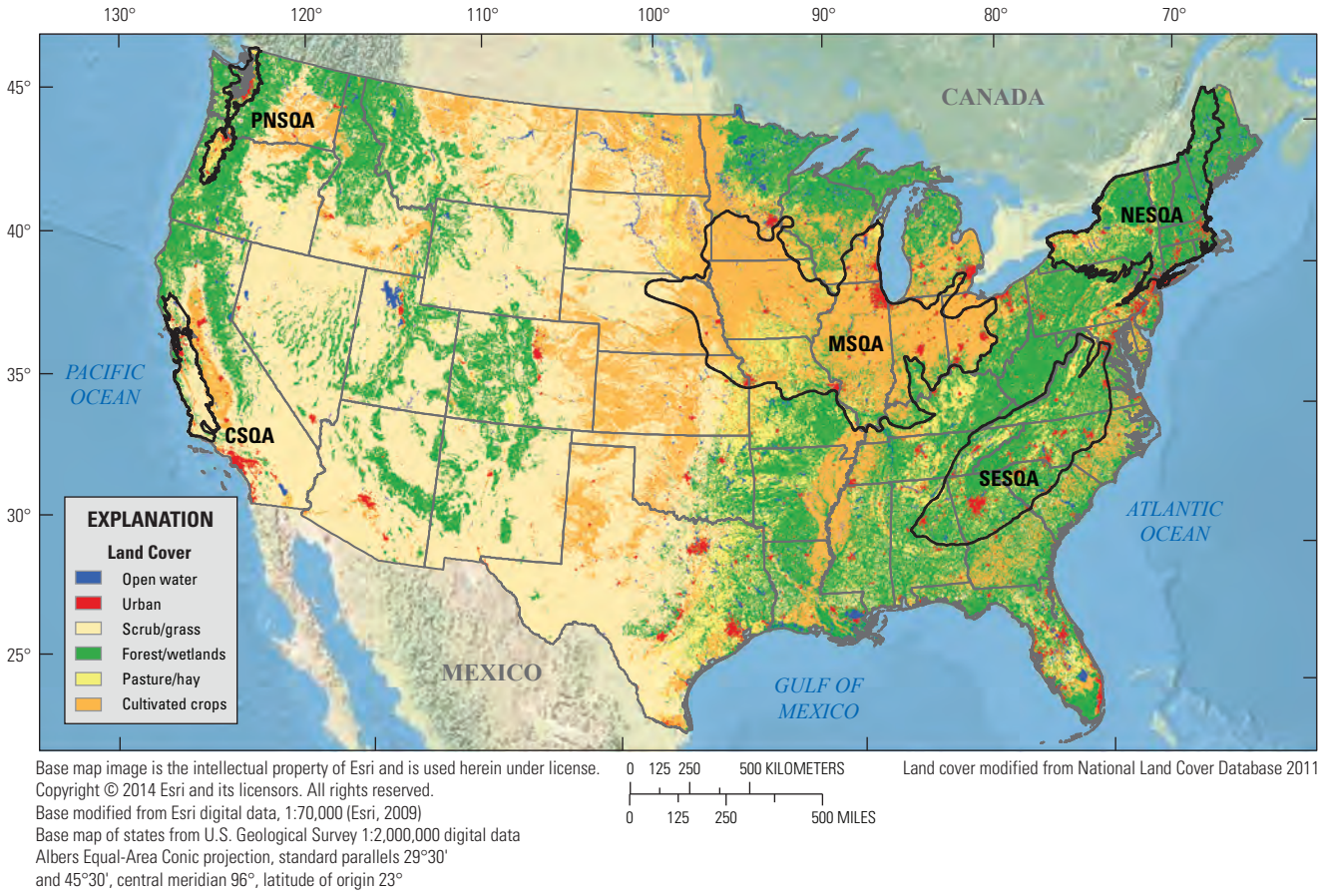


Figure 1. Locations of the Regional Stream Quality Assessment studies across the United States. CSQA, California Stream Quality Assessment; MSQA, Midwest Stream Quality Assessment; NESQA, Northeast Stream Quality Assessment; PNSQA, Pacific Northwest Stream Quality Assessment; SESQA, Southeast Stream Quality Assessment.

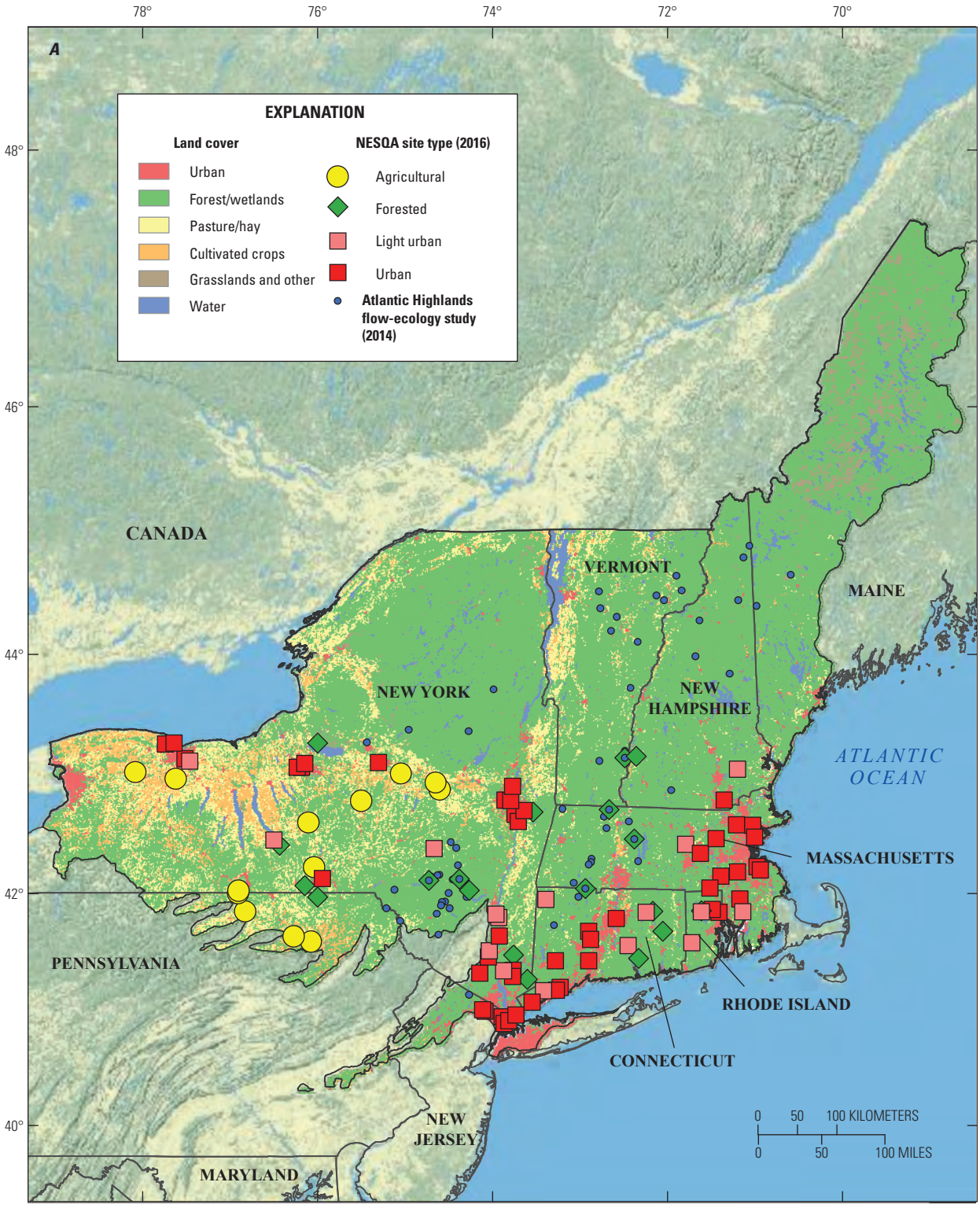
Purpose and Scope

This report describes the design and methods of the NESQA, a study in the northeastern United States incorporating a network of 95 stream sites sampled over several weeks during late spring and summer of 2016 to evaluate stream conditions related to water quality, sediment quality, biological communities, streamflow, water temperature, and habitat characteristics. The methods described include the collection and processing of several kinds of water-quality samples and ancillary data, the discussion of which is divided into three parts: comprehensive data collected at all sites, data collected at selected sites as part of focused studies, and data collected in the ecological surveys that took place at the end of the study period. The report also describes methods of laboratory analysis and other data processing, quality assurance and quality control procedures, and data management procedures. A precursor study in the Northeast that was completed in 2014, the Atlantic Highlands flow-ecology study, is summarized near the end of the report.

Study Area Description

The 95 NESQA streams sampled in 2016 were initially selected, in part, to constrain natural variably among sites to the extent practicable. A map of the CEC Level II ecoregion designations was used for this purpose because land-cover delineations at this level are based on environmental characterizations assessed at a broad regional scale (Wiken and others, 2011). As a result, the watersheds of the NESQA streams were in three CEC Level II ecoregions: 76 stream sites were in Mixed Wood Plains, 17 sites were in Atlantic Highlands, and 2 sites were in the northernmost part of Southeastern USA Plains. The NESQA sites were also categorized by EPA Level III ecoregions so that the streams could be defined in environmental terms with greater precision (table 1, in back of report; fig. 2*B*). Much of the following information that describes the EPA Level III ecoregions within the NESQA study area is summarized from Wiken and others (2011), and further details are in that publication.

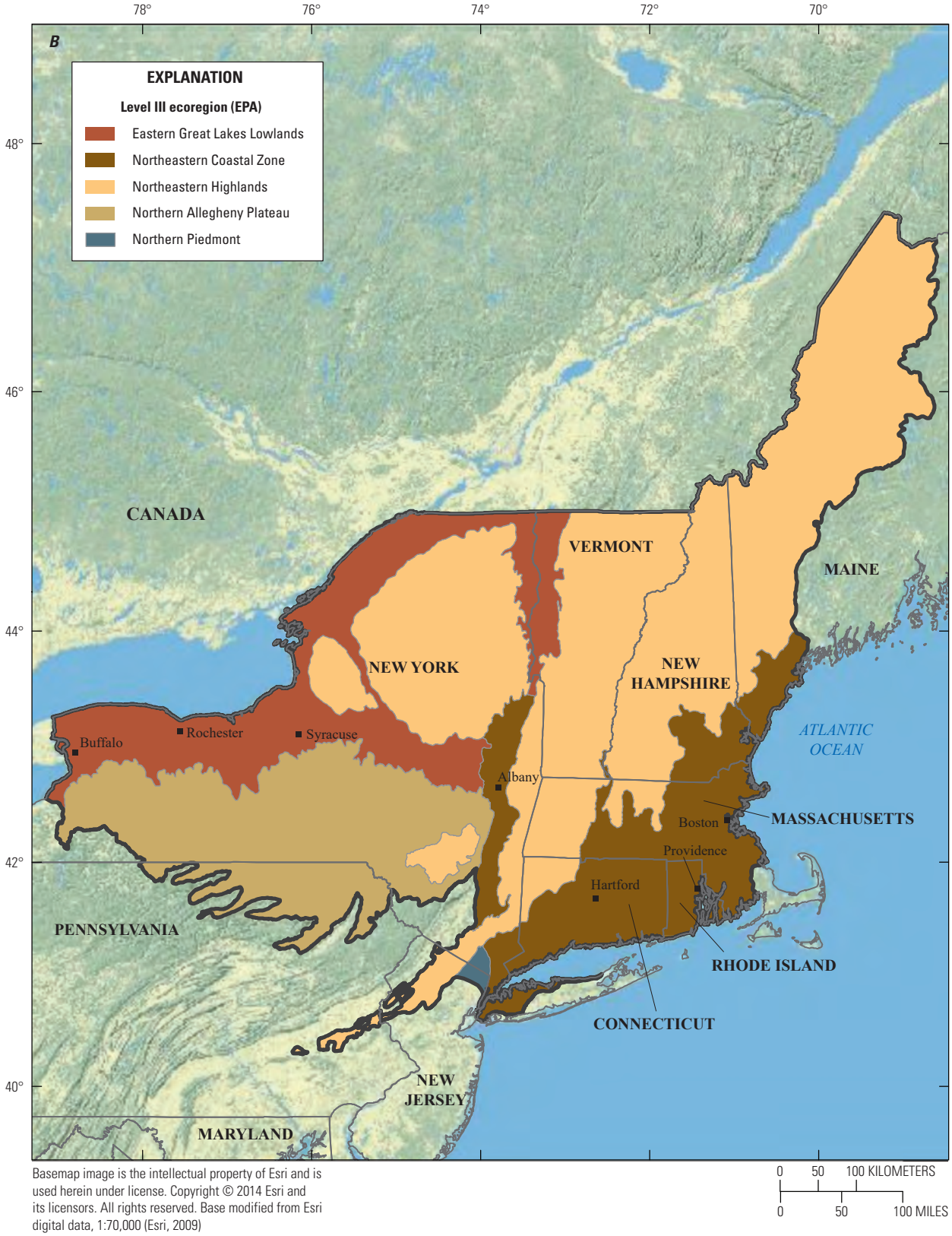
The Northeastern Coastal Zone had 52 NESQA sites, generally defines the eastern and southern boundaries of the



Base map image is the intellectual property of Esri and is used herein under license. Copyright © 2014 Esri and its licensors. All rights reserved. Base modified from Esri digital data, 1:70,000 (Esri, 2009) Web Mercator Projection World Geodetic System of 1984 (WGS 84)

Land cover modified from National Land Cover Database 2011

Figure 2. The Northeast Stream Quality Assessment (NESQA) study area. *A*, sampling locations and generalized land cover. *B*, U.S. Environmental Protection Agency (EPA) Level III ecoregions. In 2016, 95 streams in urban, agricultural, and forested settings were sampled. As part of the Atlantic Highlands flow-ecology study in 2014, 66 streams in forested settings were sampled; 6 of these streams were also part of the NESQA site network, which are indicated by a green diamond with a blue dot. Site types are defined in table 1, footnote 3.



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NESQA region, and encompasses the urban corridor of Boston, Mass., Providence, Rhode Island, Hartford, Connecticut, and New York City, N.Y. This ecoregion has much greater concentrations of human population than does the westerly adjacent ecoregion, the Northeastern Highlands. Attempts were made to farm much of the Northeastern Coastal Zone after the region was settled by Europeans, but land use now mainly consists of urban and suburban development, regrowth forests and woodlands, and only small areas of pasture and cropland.

The Eastern Great Lakes Lowlands had 14 NESQA sites and extends over the lowlands centered on the lower reaches of the St. Lawrence and Hudson Rivers. This ecoregion, being characterized by lowlands, surrounds sections of the Northeastern Highlands ecoregion in New York and defines the western boundary of the NESQA region. Although some urban centers are in this ecoregion, such as Syracuse, Rochester, and Buffalo, N.Y., 60 percent of the ecoregion is intensively cultivated farmland with the dominant farming systems being mixed, dairy, and cash crops. Major crops include grains, corn, soybeans, hay, and fruits and vegetables; orchards and vineyards are also important for the region.

The Northern Allegheny Plateau had 14 NESQA sites, defined the southwest boundary of the NESQA region, and included parts of southern New York and northern Pennsylvania. The terrain is glaciated upland plateau, which contains rolling hills, open valleys, and low mountains, and the geology is mostly shales, siltstones, and sandstones. Urban development is relatively low in this ecoregion, although it does have multiple towns and small cities. Much of this ecoregion can be characterized generally as a mosaic landscape that has farms interspersed with areas of woodlands and forest. The principal crops of the farms are pasture, hay, and grain for beef and dairy cattle.

The Northeastern Highlands had 13 NESQA sites, 6 of which were also sampled for the 2014 Atlantic Highlands flow-ecology study. This Level III ecoregion covers most of the northern and mountainous parts of New England, as well as the Adirondack and Catskill Mountains in New York State. More forest-covered than the adjacent ecoregions, it has considerable variety in its tree species and has many moderate-to-high-gradient perennial streams. A primary reason sites were chosen in this ecoregion is that it has many streams with forest-dominated watersheds that are minimally disturbed by human land use. The streams in this ecoregion that were used in the Atlantic Highlands flow-ecology study collectively represented a gradient of low to high levels of flow alteration. However, the 2016 NESQA sites in this ecoregion were at the low end of the flow-alteration gradient and, therefore, were among the least disturbed sites in the NESQA study.

Two NESQA sites in New Jersey were in the Northern Piedmont. This ecoregion extends as far north as northern New Jersey and extends through that State as a narrow band bordered on the west by the Northern Appalachian Plateau ecoregion and on the east by the Atlantic Maritime Highlands and the Northeastern Coastal Zone ecoregions; thus, the Northern Piedmont generally is situated between mountain ranges and the coastal plain. The climate in this area of the Northern Piedmont generally is marked by hot summers and cold winters, it has low to moderate gradient perennial streams, and topography can be characterized as having low, rounded hills. Pre-Columbian vegetation was predominately Appalachian oak forests but now includes chestnut oak, white oak, red oak, hickories, ash, elm, and yellow-poplar; eastern red cedar is common on abandoned farmland. Mostly agriculture and urban, suburban, and industrial uses prevail, but in the vicinity of the NESQA sites, land cover is primarily developed, including urban and suburban land uses.

Study Design

The NESQA study was designed to assess differences in stream quality that were associated with urban development and agriculture in the region and to identify and measure specific stressors linked to those land uses. The NESQA study expanded on the 2014 Atlantic Highlands flow-ecology study that assessed changes in the quality of Northeast streams relative to the type and extent of flow-regime modifications.

Of the 95 NESQA stream sites that were sampled during 2016, 63 were primarily selected to characterize the effects of urban development and associated stressors on stream health, and 17 were selected to characterize the effects of agriculture and associated stressors on stream health; additionally, 15 sites were predominantly forested, with less than 1 percent of urban and less than 5 percent agricultural land use in their watersheds, and these sites were used to help establish “least developed” conditions for most stressors examined here. The network of 67 urban-development sites represented a gradient design, in which the watersheds represented a range of urban development from near zero to 99 percent. The 13 agricultural sites were incorporated in a group design, which grouped sites in 1 of 3 categories based on the relative percentage of agricultural land use in the watershed (1 to 5, greater than 5 to 15, and greater than 15 percent). The forested sites were used in conjunction with both the urban and agricultural sites, either to characterize the least developed end of the urban gradient or near-reference conditions for the agricultural gradient.

Site Selection

Only wadeable streams were considered for the study because they generally had a depth of about 1 m or less during low flow, which is shallow enough to be sampled by wading. In selecting streams for the NESQA study, candidate sites were identified first from active and historical (inactive) USGS streamgages, then from other USGS sampling sites and from monitoring sites used by State and local agencies. Several sites that had not been previously sampled were also selected to fill gaps in the distribution of land-use settings relative to design objectives. A geospatial database was created that included

land-cover characteristics for the watersheds of all candidate sites. Watershed delineations and characteristics were available for active USGS streamgages; however, for other candidate sites, catchment boundaries from the National Hydrography Dataset Plus were used as the watershed boundaries by selecting all upstream catchments from the segment on which the candidate site was located (NHDPlus Version 2; U.S. Environmental Protection Agency, 2012). Nationally available, digital geographic information systems (GIS) data layers (for example, the National Land Cover Database [NLCD], Homer and others, 2015) were overlain on the catchment-derived watersheds, and then characteristics of the watersheds were assessed and summarized from these data layers.

Initially, 630 sites were identified in the NESQA region. These were subsequently evaluated with the use of Google Earth satellite imagery (https://www.google.com/earth/) for general watershed characteristics related to land cover and geomorphology, potential stressor sources (for example, water treatment plants, industrial complexes, golf courses), and sampling reach locations. From this procedure, 178 sites were selected as potential sampling streams that collectively represented forest, agricultural, and urban development land uses. An instream reconnaissance of these sites was conducted by USGS staff during the summer of 2015; field observations for each site included evaluating the site for access and safety, assessing general stream characteristics to determine a water-sampling location, and identifying a 150-meter (m) stream reach with riffle habitat suitable for conducting ecological surveys. Information that was documented included stream accessibility, location and description of the nearest bridge for water-chemistry sampling during high flows, stream-reach wadeability, streambed substrate, instream habitat complexity, presence of discharge pipes and other obvious point sources, potential landowner contacts, and photographs of the stream. Field notes and photography were recorded onsite by using field-reconnaissance forms on an electronic tablet; afterwards, information from these forms was compiled into spreadsheets for use in site review for final selection.

Land-Use Designations

The designations of the three types of NESQA sites—urban development, agricultural, and forested undeveloped—were based on percentages of land cover in their watersheds (fig. 3). Candidate urban-development sites were selected on the basis of the percentage of urban land use and lack of substantial (about 5 percent or less) agricultural row-crop land use from the 2011 NLCD data (U.S. Geological Survey, 2014; Homer and others, 2015). To ensure that the network of urban-development sites characterized a gradient of urbanization from low to high levels, sites were selected to fit within one of five categorical "tiers" that each represented a different range of watershed urban land cover: tier 1, 1–10 percent (considered "light urban"); tier 2, greater than 10–20 percent, tier 3, greater than 20–37.5 percent; tier 4, greater than 37.5–50 percent; and tier 5, greater than 50 percent (table 1, in back of report). The 67 sites selected for the urban-development gradient were distributed across the 5 tiers so that incremental levels of urban development were represented. Urban development in the region is concentrated along the southern corridor of the NESQA region that included the metropolitan areas of Boston, Mass., Providence, R.I., Hartford, Conn., and New York City, N.Y. (fig. 2*B*), but urban centers located elsewhere in the region were also included (for example, Albany, Syracuse, and Rochester, N.Y.). In addition, the predominantly forested sites along this section of the NESQA region were used in the urban-development gradient to represent least developed conditions.

Agricultural sites were selected to represent the major crop-producing areas in the western NESQA region (fig. 2*A*), and priority was given to sites in watersheds where agricultural chemical use was expected to be high on the basis of the crop type grown. Unlike the gradient design used to characterize increasing levels of urban development among sites, the agricultural network of 13 sites included 2 categories that each represented a range of land-use percentages in cultivated row crops: low Ag, 5 to 15 percent agriculture, and Ag, greater than 15 percent agriculture (table 1, in back of report). In addition, 4 of the 15 "Forested" sites had very low agriculture, 1 to 5 percent, and these supplemented the agricultural site groups (forming a third agricultural group). The balance of land use in the watersheds of most of these sites with very low agriculture was primarily forest with very little urban development. Additionally, the remaining 11 of the 15 NESQA forested sites helped to characterize least disturbed stream conditions for comparison with conditions of the agricultural sites and to help approximate predevelopment conditions along the urban gradient (fig. 3). It is important to note that the categorical designations used for selecting the sites were based on cursory reviews of watershed features and that more rigorous GIS procedures were used later to more accurately characterize and define the sites.

Sample Collection and Processing

To allocate resources effectively among the 95 NESQA sites, the frequency of water-quality sampling varied by the intensity of development in the watershed. The predominately forested sites were sampled weekly during the 4-week period that began on July 11, 2016. All 45 urban sites and 6 of the 22 light urban sites were sampled weekly for the 9-week period that began on June 6, 2016; 16 of light urban sites that were sampled only during the 4-week period. Of the 13 agricultural sites, the 8 representing the highest level (greater than 15 percent row crop) were sampled weekly over the 9-week period, whereas the sites representing the low levels (5 sites) of agriculture were sampled weekly only during the 4-week period. Further information about the sampling frequency at each site is provided in tables 2 (in back of report) and 3.

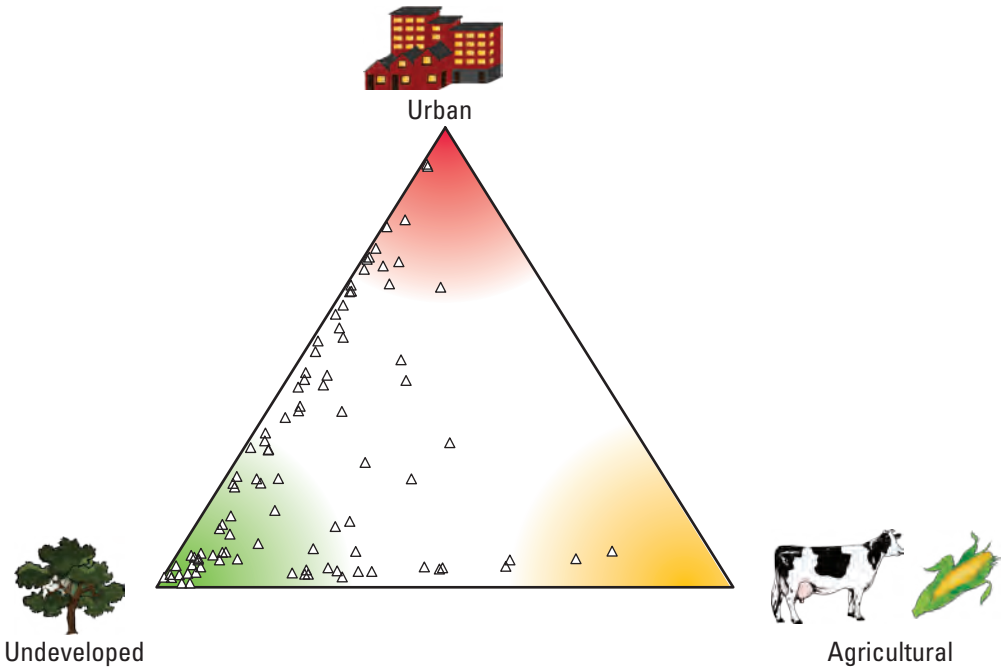

Figure 3. The relative percentages of undeveloped (mostly forested), urban, and agricultural land cover in watersheds of the 95 streams investigated for the Northeast Stream Quality Assessment (NESQA) in 2016. Each of the three points of the diagram represents 100 percent of the respective land-cover type. If a site had equal amounts of urban, agriculture, and undeveloped land cover, it would be centered in the diagram. Colors are for visual effect.

The types of data and the intervals at which samples were collected varied among the NESQA sites according to land-cover type and associated potential stressors. Data collection routines were categorized nominally by three study-design components (table 2, in back of report). The comprehensive stream water data component began the week of June 6, 2016 (at 59 sites), or the week of July 11, 2016 (at 36 sites), and continued through the week of August 8, 2016. During the sampling period, water temperature and streamflow were recorded at all sites (by data-logging instrumentation, typically on a 1-hour interval), and water-quality samples were collected weekly. The focused studies component included several investigations at subsets of NESQA streams that were focused on the occurrence and timing of specific stressors that could affect the condition of those streams; these studies are described below. The ecological survey component occurred within a 2-week period that began August 1, 2016: at each stream along a 150-m sampling reach during, assessments were made of the physical habitat and biological communities, and samples were collected for chemical analysis of sediment and mercury contamination in fish.

In addition to being characterized by study-design component, data were defined by the time interval at which they were collected: discrete, integrated, or continuous, depending on the parameter being measured (table 2, in back of report). Discrete data characterized conditions at a given date and time and could be collected once, as represented by streambed sediment samples collected during the ecological survey, or at discrete intervals, as represented by water-quality samples collected weekly. Integrated data represented "average" conditions over the time period the sampler was deployed, as was the case with the polar organic chemical integrative sampler (POCIS), described in the section "Polar Organic Compound Integrative Samplers." Continuous data were water-quality parameters recorded at short but regular time intervals throughout a sampling period, as was the case with stream temperature, which was recorded hourly.

USGS staff who participated in the NESQA study received intensive training prior to any data collection activities, including instructions specific to water-quality sampling, the focused studies, and ecological surveys. For example, the use of low-level analytical methods necessitated that water samples be collected according to "parts-per-billion" protocols (U.S. Geological Survey, 2006). During weeks when water-quality data were collected at all 95 sites, as many as 10 two-person teams of USGS staff were deployed. Thus, to ensure consistency among the water-quality teams, training for the collection and processing of water-quality samples occurred in May 2016 for all personnel involved with sample collection. Classroom water-quality training was followed by field-training exercises to work through all sampling and processing procedures in the field prior to the start of sampling. The sample collection timelines (table 3), sample types collected at sites, and sample collection, processing, and handling procedures are summarized in appendix 1 and described briefly here.

Table 3. Timeline of the sample collection by site type for the U.S. Geological Survey Northeast Stream Quality Assessment in 2016.

[Timing is shown only for sampling that took place at all sites, not for components of the focused studies. %, percent; POCIS, polar organic chemical integrative sampler]

Site type	Sampling type	Week of									
		June 6	June 13	June 20	June 27	July 4	July 11	July 18	July 25	August 1	August 8
9-week sites											
Urban: All 45 Tier 2–5 sites, 6 of 22 Tier 1 sites **Agriculture**: All 8 sites with greater than 15% row crop	Water chemistry, sampled weekly	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	
	POCIS			Deployed						Retrieved	
	Aquatic biota Physical habitat									Ecological surveys	
	Mercury in fish tissue Sediment contaminants										
4-week sites											
Forested: All 15 sites **Urban**: 16 of the 22 Tier 1 sites **Agriculture**: All 5 sites with less than 15% row crop	Water chemistry, sampled weekly						Week 6	Week 7	Week 8	Week 9	
	POCIS			Deployed						Retrieved	
	Aquatic biota Physical habitat									Ecological surveys	
	Mercury in fish tissue Sediment contaminants										

Comprehensive Stream Water Data

To help characterize stream conditions in a consistent manner among NESQA sites, a comprehensive suite of samples and ancillary data were collected at each location over several weeks during the course of the NESQA study. Discrete water-quality samples were collected for a 9-week QW (quality of water) sampling period at 59 sites and a 4-week QW sampling period at 36 sites (tables 2, in back of report, and 3 and appendix 1, table 1.1). Continuous readings of water temperature and streamflow were collected at all sites for up to a year (including the QW and ecological sampling periods). Discharge was recorded at sites that had active USGS streamgages, and pressure transducers were installed to record stream stage during the QW and ecological sampling periods (or longer) at sites without active streamgages (table 2, in back of report). Polar organic chemical integrative samplers (POCISs) were deployed at all sites for about 6 weeks during the QW sampling period; the POCISs provided estimates of the average concentrations of certain organic chemicals over the deployment period. These samples and how they were collected are described in more detail in the following sections.

Discrete Water-Quality Samples

Weekly discrete water-quality samples were collected according to the following basic laboratory schedules: nutrients, major ions, dissolved organic carbon, pesticides, glyphosate by immunoassay, and suspended-sediment concentration. This group of schedules is referred to as BASIC for the weekly sampling routines, whereas additional chemical parameter groups were sampled on selected weeks (appendix 1, table 1.1). The parameter groups included in a sampling event and frequency of sample collection varied by site type so that potential stressors could be associated with land-use characteristics, such as timing of pesticide applications.

Samples were collected and processed by following standard USGS protocols described in the National Field Manual (Wilde and others, 2009). Prior to collecting samples from the field, all field equipment was cleaned according to USGS protocols and was rinsed with native water immediately before samples were collected. In general, discrete water samples were collected for most analytes by an isokinetic, equal-width increment method (U.S. Geological Survey, 2006), where subsamples were collected at 10 increments across the stream with either a DH–81 or DH–95 sampler (Davis, 2005). The sampler had a precleaned Teflon cap and nozzle assembly that fitted a 1-liter (L) Teflon bottle (U.S. Geological Survey, 2006). Each incremental sample was placed immediately into a precleaned, acid- and methanol-rinsed Teflon churn for compositing prior to processing. When stream conditions did not meet the requirements for collection of a representative equal-width increment sample (velocity greater than 1.5 foot per second [ft/s]), samples were collected either by a multivertical grab (velocity less than 1.5 ft/s, width greater than 10 feet), or by a grab from the centroid of flow (velocity less than 1.5 ft/s, width less than 10 feet, depth less than 1 foot). Water was collected directly into sample bottles for unfiltered constituents and into a precleaned 1-L Teflon sample bottle for filtered constituents; samples were subsequently filtered from that bottle into sample bottles (appendix 1, table 1.3).

Much of the Northeast experienced a drought during the summer of 2016, with little or no rain for much of the QW sampling period; as a result, many streams were sampled by collecting grab samples near the end of the QW sampling period when streamflows were particularly low. In addition, however, dissolved organic carbon (DOC) samples were collected by a center grab regardless of flow conditions.

Field properties of specific conductance, pH, dissolved oxygen, and water temperature were measured at the time of sampling with a field-calibrated multiparameter sonde (Wilde, variously dated). The measurements were made at five locations within the water-quality sampling transect. When the stream width was less than 3 m, parameters were collected from the centroid of flow. In addition to constituents sampled in all weekly visits previously noted, samples for other water-quality constituents were collected on selected weeks during the QW sampling periods: isotopes of nitrate (^{15}N and ^{18}O), organic wastewater indicators and pharmaceuticals, algal toxins, mercury (total and methyl), and ultraviolet absorbance (specific weeks when constituents were sampled are identified in appendix 1, table 1.1). Ultratrace-concentration clean-sampling procedures and equipment were used to collect samples for low-concentration total mercury and methylmercury analysis (U.S. Environmental Protection Agency, 1996; Lewis and Brigham, 2004). These were grab samples collected at about 0.3 m below the water surface in a Teflon bottle; five samples were collected at the 9-week sites, and three samples were collected at the 4-week sites, (table 2, in back of report; appendix 1, table 1.1).

Continuous Water Temperature and Streamflow

Digital temperature data loggers were used to continuously monitor water temperature at all stream sites. The devices recorded temperature at 1-hour intervals and were deployed during the early fall of 2015 and retrieved about a year later, in order to provide a water temperature dataset inclusive of all NESQA sampling activities. (Exceptions were several sites with USGS streamgages where continuous temperature loggers had been previously installed.) Where possible, loggers were deployed approximately 10 centimeters (cm) above the streambed, out of direct sunlight, and attached to rebar anchored into the streambed or to stable parts of streamgage infrastructure (for example, orifice pipe). In most cases, the HOBO Water Temp Pro v2 U22 loggers were deployed (device specifications are in appendix 1, table 1.2). Guidance from the manufacturer and the U.S. Forest Service concerning deployment, calibration, and maintenance generally was followed (Dunham and others, 2005; Onset Computer Corporation, 2012).

USGS streamgages were active at 54 NESQA sites and provided stream stage and streamflow discharge at 15-minute intervals (table 2, in back of report). Water-level loggers were deployed at the 41 sites where streamgages did not exist; these loggers recorded stream stage (and water temperature) at hourly intervals. The NESQA study used the HOBO U20–001–04 digital water level loggers (specifications are in appendix 1, table 1.2). In most cases, the units were deployed during the spring of 2016, prior to the start of the QW sampling periods, and remained deployed until the fall of 2016. Guidance from the manufacturer and the USGS for deployment, calibration, and maintenance was followed (Onset Computer Corporation, 2014; Sauer and Turnipseed, 2010).

Deployment included the installation of two water-level loggers per site: one mounted in the water column to measure changes in water pressure as the water level changed, and one mounted in the air to measure barometric pressure to provide a correction factor for calculating stream stage. The loggers were mounted inside a vertical 2-inch polyvinyl chloride (PVC) pipe mounted to a bridge support or directly to a metal post driven into the streambed. The water-pressure loggers were mounted at a depth where the unit would remain continually submerged, and the barometric-pressure loggers were typically mounted in the air at the top of the pipe or post; both were programmed to record on hourly intervals for the duration of the study.

Establishing a baseline water-level was necessary immediately after installation of the water level loggers so that logger readings in water pressure could be converted to actual water level. A reference point (RP), on which changes in water level were based, was established above the pool that held the submerged water-level logger. Typically, the RP was a mark scribed on a permanently fixed structure adjacent to the attached logger, such as a bridge support or wing wall; a measurement from the RP to the water surface was the "tape down" distance. An arbitrary datum was then established that was greater than the distance between the RP and the channel bottom, and this datum would cover all low stages and ensure no negative stage values; typically, 10 feet was used. The distance from the RP to the surface of the water at time of deployment was used to establish the initial stream stage. In addition, measurements from the RP to water surface were made during at least one of the site visits by the water-quality sampling crew so that these values could be used to check the data for consistency and quality.

Polar Organic Compound Integrative Samplers

The POCISs are designed to accumulate water-soluble (polar or hydrophilic) organic compounds from surface water. These integrative samplers were deployed at all NESQA sites during the week of June 20 and retrieved during the last water-quality sampling visit during the week of August 1 (tables 2, in back of report, and 3). Four POCISs containing the sorbent Oasis HLB (Waters, Milford, Mass.) (Alvarez, 2010) were deployed in a single canister at each of the 95 sites. Oasis HLB is considered a universal sorbent in environmental analyses and has been used to extract a wide assortment of chemical classes from water. The use of Oasis HLB in the POCIS provided a mechanism to estimate time-weighted average concentrations of target chemicals, pharmaceuticals, and pesticides. The POCIS extracts were analyzed for concentrations of pesticides and pharmaceuticals by using modified versions of the water methods for these chemical groups (Van Metre, Alvarez, and others, 2017).

Field deployment followed the guidelines provided in Alvarez (2010). Successful deployment required a stream location with sufficient depth (about 15 cm) for the sampler to remain submerged during the deployment period and be protected from excessive sediment accumulation and flood debris and from vandalism. Effective anchoring systems were adopted on the basis of site-specific characteristics (for example, sandy versus rocky substrate, streamflow variability, and so forth). The POCIS was attached coincident with the temperature data logger at many sites, either on the rebar or on the orifice pipe. Field records were maintained that included the site name, date and time of deployment and retrieval, and observations of streambed substrate, streamflow conditions, and water clarity.

About 10 percent of the POCISs were accompanied by field blanks that were used to assess any accumulation of target and nontarget compounds from the air during shipment and deployment. The POCIS field-blank protocol specified that the blank canisters be open to the air at the same time and place as the field POCISs were exposed to air during deployment and retrieval. Between deployment and retrieval of the field POCISs, the POCIS blank canisters were kept sealed and stored between −20 and 0 °C. All field POCISs and blank canisters were stored on ice during transport to and from the field location. After the 6-week deployment period, the POCISs were retrieved from the sites and immediately sealed in their respective canisters; the POCISs, field blanks, and log sheets were shipped to the USGS Columbia Environmental Research Center (CERC) in coolers with wet ice.

Focused Studies

Three types of focused studies were conducted at selected NESQA sites. Small-volume pesticide automated samplers were deployed at seven sites to collect daily-composited water samples for pesticide analysis. Walling tubes were deployed at 14 sites to collect integrated samples of suspended sediment. Algal productivity was evaluated at five sites with the use of nitrate, dissolved oxygen, pH, and conductivity data that were collected continuously and chlorophyll *a* samples that were collected monthly from April through September.

Sampling Pesticides With Small-Volume Pesticide Automated Samplers

A small-volume pesticide autosampler (hereafter, "pesticide autosampler") was designed and built at Portland State University to collect fixed-point, small-volume samples for analysis of pesticides in water using newly developed direct aqueous injection (DAI) methods. The samplers were used in the NESQA study to help determine if increasing sampling frequency would improve the accuracy of characterizations of instream pesticide stressor conditions to which biota were subjected, in particular short-duration but acutely toxic events. Although weekly discrete samples of pesticides were collected at all sites during the QW sampling periods (with some exceptions, described in a later section, "Sample Analyses"), discrete samples might not detect short-term "spikes" in high concentrations that are potentially acutely toxic. Pesticide autosamplers were deployed at one agricultural site and six urban sites (greater than 50 percent agriculture or urban, respectively) to collect daily and weekly composite samples over the 9-week QW sampling period (table 2, in back of report).

The pesticide autosamplers were programmed to collect multiple aliquots to form daily and weekly composite samples of stream water over successive 1-week periods. An aliquot of stream water was collected every 6 hours into daily-composite vials (four aliquots per vial, with the "day" typically starting around noon) and every 12 hours into the weekly composite vial. Thus, eight vials were filled per week for seven daily samples and one weekly sample. In addition, a ninth vial containing a known pesticide spike mixture in native stream water was included to assess the potential for compound degradation during the weekly collection period. A 6-mL aliquot of a 1:1 methanol-water mixture was added, as a preservative, to each of the nine vials before deployment.

Over the 9 weeks of operation, the pesticide autosamplers were serviced each week on either Monday or Tuesday. Two units were available for each of the seven sites so that one unit could be serviced in the laboratory and exchanged in the field for the deployed unit. This arrangement minimized interruption by allowing ample time to remove and replace sample vials, charge batteries, clean tubing, and replace consumable components such as filters. Prior to deployment, each vial was labeled with the station identification number, vial number, date, and initial weight. Daily-composite samples (vials 1 through 7) were analyzed for pesticide concentrations by the EPA Office of Pesticide Programs (OPP). Sample splits of the weekly composite sample (vial 9) and the spike sample (vial 8) were analyzed for pesticide concentrations by the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, and the OPP laboratory. Analytical service request (ASR) forms (USGS) and cooler inventory forms (USGS and EPA) were included with sample shipments, and barcodes were affixed to each vial as an auxiliary data identifier and tracking method.

Sampling Suspended Sediment With Walling Tube Samplers

Suspended-sediment samples were collected from 14 sites by using time-integrating passive samplers, referred to in this report as Walling tubes (Phillips and others, 2000; Gellis and others, 2017). The sediments were analyzed for major and trace elements and radionuclides to assess sources and ages of sediment in the stream. The network of Walling-tube sites comprised 10 urban sites, 3 agricultural sites, and 1 forested site (table 2, in back of report). The Walling tube sampler was made from commercially available PVC pipe (98-millimeter [mm] inner-diameter) cut to a length of approximately 1.0 m. The end facing upstream was affixed with a funnel that had a 4-mm stem facing outward; the downstream end of the tube was fitted with an endcap with a hole drilled in the center with a 4-mm plastic tube inserted. As water passed into the tube through the small opening in the funnel stem, the velocity decreased in the larger diameter tube, allowing suspended sediment to settle, and relatively clear water passed out of the 4-mm tube at the back. The tubes were attached to metal posts that were driven into the streambed and were oriented so that the funnel end faced into the flow. Typically, four tubes were deployed within the 150-m reach of a site, where two tubes were installed at each of two locations by placing one tube above the other on the metal posts. To ensure that samples consisted of suspended sediment and not bed sediment, the bottom tube was positioned at least 15 cm above the channel bed when it was deployed. If base flows were especially low at the time of deployment, the top tube was allowed to be out of water; in such cases, the top tubes would only collect sediment samples at higher flows.

Deployment of Walling tubes centered around late April, and the tubes remained deployed for approximately 20 weeks, through early October (inclusive of the 9-week QW sampling period); sediment was retrieved about every 4 weeks so that sufficient sediment could accumulate for analyses of major and trace elements and radionuclides. To collect the sediment samples, the tubes were removed from their posts, the end caps were opened, and the water and sediment were poured into a 5-gallon plastic bucket. A spray bottle filled with deionized water was used to rinse any remaining sediment from the tubes. After collecting the samples, the tubes were cleaned with a brush and deionized water, then rinsed with native water. The water-sediment mixture was stored at room temperature in the 5-gallon bucket until the sediment settled to the bottom (usually 3–7 days), then the water was siphoned off and discarded, and the remaining sediment was transferred to a sample jar and shipped on wet ice to the laboratory.

Assessing Algal Productivity

A focused investigation was conducted at five NESQA sites to assess nutrient dynamics at a high temporal resolution and to evaluate how algal productivity responds to changes in

water quality (table 2, in back of report). Data were collected as time-series measurements and included algal biomass, nitrate, and water-quality parameters. Three urban sites (two tier 1, one tier 3) and two agricultural sites were selected to incorporate a range of expected nutrient conditions. Sites were operated from April through September 2016 and were instrumented with an Onset photosynthetically active radiation (PAR) meter and YSI EXO2 and Sea-Bird SUNA continuous water-quality monitors, with the exception that a SUNA was not used to record nitrate at one site (Salmon River near East Hampton, Conn. [CT_SalmonHam]; although this site is categorized as tier 1 urban, the land cover is less than 4 percent urban, so the presumption was made that the stressor levels such as nitrate concentrations would be relatively low).

Continuous, discrete, and reach-level data were collected at the algal productivity sites. The following parameters were measured continuously (15-minute intervals) during the study: water temperature, dissolved oxygen, pH, specific conductance, turbidity, fluorescent dissolved organic matter (a proxy for carbon concentration), nitrate, and PAR. Discrete samples for nutrients, suspended sediment, and DOC were collected monthly at each site over the course of the study. During each monthly visit, data also were collected along a 90-m reach of the channel that encompassed 10 equally-spaced transects (10 m apart), established by using the methods described in Fitzpatrick and others (1998). Field readings for dissolved oxygen, specific conductance, pH, and water temperature were recorded at five points along a transect across the stream channel. Macrophyte coverage was estimated at 5 locations along each of the 10 transects, and canopy density was estimated with a spherical densiometer at the center of each transect. Periphyton samples (assumed to be dominated by benthic algae) were collected at the 10 transects (right, middle, or left portions of each transect) and were composited; subsamples were extracted from the composited sample and filtered onto 0.47-µm glass-fiber filters for chlorophyll *a* and ash-free dry mass (AFDM) analysis (appendix 2.1–table 2.10) (Britton and Greeson, 1987; Arar and Collins, 1997).

Ecological Surveys

The data collected during the ecological surveys characterize aquatic biota, mercury in fish tissue, sediment contaminants, and physical habitat along a 150-m sampling reach of each site (tables 2, in back of report, and 3). Six teams, each consisting of six USGS employees, were deployed across the region to complete the sampling at all sites during August 1–10, 2016, which was considered the shortest timeframe practical. The ecological surveys were timed to coincide with the end of the QW sampling period so that monitored water-quality conditions could be related to the biological condition. Some exceptions were made at a few sites, identified in table 2 (in back of report), where certain ecological-survey components were delayed until October 2016 because of either very low-flow or storm events during the normal ecological sampling period. Although the data collected during the ecological surveys were based on discrete samples, biological and habitat data generally represent integrative conditions over some period of time. For example, sediment chemistry is influenced by erosional processes and contaminant persistence; the species structure of aquatic biological communities depends on water-quality conditions that occur over life cycles of the organisms; and the physical habitat of a stream reach is strongly affected by many years of hydrologic events and human actions.

To ensure consistency in collecting the biological samples and conducting the physical habitat surveys, most personnel on the sampling teams were experienced in applying the methods described in USGS ecological sampling protocols and had participated in previous RSQA sampling. Algal, invertebrate, and fish community samples were collected, and habitat was assessed along a 150-m ecological assessment reach at each stream, according to the methods described in Moulton and others (2002). All field data were recorded on electronic forms by using hand-held tablet computers. Field data collected from the fish and habitat surveys, and field records for the algal and invertebrate samples destined for laboratory analysis were loaded into the USGS BioData database, the USGS repository for aquatic bioassessment data (U.S. Geological Survey, 2016).

Aquatic Biota

Algal and invertebrate communities were sampled according to standard USGS richest targeted habitat (RTH) protocols (Porter and others, 1993; Moulton and others, 2002; Hambrook and Canova, 2007). RTH samples are intended to represent the habitat features having the greatest potential diversity of organisms within a given stream reach. All NESQA sites had sampling reaches with at least one riffle zone, the assumed RTH habitat, and algal and invertebrate samples were collected from these riffles.

The algal sample was collected by scraping the periphyton biofilm from rocky substrate (for example, flat cobbles) to obtain a targeted area of 150 cm^2. The substrate was scraped with a brush in a defined area and flushed into a 500-mL bottle with native water. Typically, 11 scrapes of equal size were taken from rocks that were collected among the RTH riffles and combined into a single composited algal sample to represent the site. A total of seven aliquots were removed from the sample for various analyses. Four aliquots were filtered onto glass-fiber filters with 0.47-µm pore size for analysis at the NWQL of chlorophyll *a* and ash-free dry mass (two filters), and for backups in the event of sample loss or damage (two filters). The fifth aliquot was filtered onto a precombusted glass-fiber filter with 0.47-µm pore size for analysis of carbon and nitrogen stable isotopes ($\delta^{13}C$ and $\delta^{15}N$, respectively) and C:N ratios at the Cornell University Stable Isotope Laboratory in Ithaca, N.Y. The sixth aliquot was processed in the same manner and served as a backup in the event of sample damage or loss, or of need for additional material for analysis. The

seventh aliquot was put into a 2-mL vial and shipped to the Institute of Arctic and Alpine Research (INSTAAR) Diatom Laboratory at the University of Colorado Boulder for environmental DNA (eDNA) analysis. The remainder of the sample was preserved with buffered formalin at a concentration of approximately 5 percent and sent to the INSTAAR Laboratory for taxonomic identification and enumeration of diatoms.

A periphyton sample also was collected to ascertain if microcystins were present in the stream. Microcystins are a group of algal toxins produced during harmful algal blooms. The sample was collected in the same manner as the primary algal sample, except that only five scrapes were taken from rocks. The collected material was composited in a 125-mL bottle and shipped on dry ice to the USGS Kansas Organic Geochemistry Research Laboratory (OGRL) for analysis of microcystin concentrations.

Invertebrate samples were collected from RTH riffles, using a modified Surber sampler with 500-micrometer (µm) mesh net that samples a 0.25-m^2 area of substrate (Moulton and others, 2002). The total invertebrate sample area was targeted at 12,500 cm^2 (1.25 m^2), the sum of a composite of five modified Surber samples each collected from a different section of riffle. The samples were sieved through a 500-µm sieve, large organic and inorganic debris was removed, and then samples were transferred to a 1-L bottle and preserved with 10-percent buffered formalin. Large or rare invertebrates, such as crayfish and large mollusks, were photographed and released in accordance with collection permit procedures. Identification and enumeration of invertebrate taxa (generally to either genus or species taxonomic levels) were completed by the NWQL.

A fish-community survey was conducted at each site by using a pulsed direct current backpack electrofishing unit in conjunction with generally two staff persons netting the fish. Two electrofishing passes of the sampling reach were made. Fish were collected by two crew members using 6-mm mesh nets, and fish from the first pass were held in live wells until the completion of the second pass. All fish were identified to species and counted in the field, then released back to the stream, except for some individuals that were retained either as voucher specimens or for analysis of mercury concentrations in fish tissue.

Fish Mercury Samples

Mercury concentrations in fish tissue were analyzed at 92 of the 95 sites (table 2, in back of report), and mercury isotopes (indicators of potential Hg sources and environmental processing) were analyzed at 23 of the sites (table 2, in back of report). The 92 fish-tissue sites were not preselected; rather, the intent was to collect targeted fish species from every site where they were found; subsequently the targeted species were collected at 92 of the 95 sites. The 23 mercury isotope sites were selected on the basis of potential differences in mercury sources. Three general site types were selected: largely forested sites that were expected to receive Hg mainly from atmospheric deposition from distant sources, urban-industrial sites that were expected to have industrial (including legacy) Hg contamination, and urban-residential sites that were expected to have a mixture of sources. Mercury isotopes were analyzed in fish tissues and bed sediment samples collected from these 23 sites.

During the fish community survey (described previously), specimens of targeted species were retained for laboratory analysis of total mercury (THg) concentrations and stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) and, at the 23 isotope sites, mercury isotopes. The primary species that were targeted were small, midtrophic level, invertivorous fishes that are widely distributed across the NESQA study area, such as blacknose dace (*Rhinichthys atratulus),* longnose dace *(R. cataractae),* creek chub (*Semotilus atromaculatus)*, and small-sized sunfish species (*Lepomis* spp.). Multiple target species were collected where possible. Each sample consisted of a single-species composite of 1 to 24 (median 10) similarly sized individual whole specimens. Secondarily, predatory game fish such as brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), largemouth bass (*Micropterus salmoides*), and large specimens of sunfish species (*Lepomis* spp.) were retained when encountered. Each game fish sample consisted of an individual skinless fillet. Multiple samples of one or more game fish species were collected where possible.

Field processing was minimal for both the composite samples of whole midtrophic specimens and the fillet samples of individual game fish. Specimens that were retained for mercury and stable isotope analysis were field-rinsed in deionized water or native stream water (if deionized water was not available), placed in a plastic zip-lock bag (either individually or with other conspecifics), and frozen (on dry ice or in a field freezer). Samples were delivered to the USGS New York Water Science Center (NYWSC) laboratory where they were kept frozen until further processing. At the NYWSC laboratory, specimens were thawed, rinsed thoroughly in deionized water, and measured (total length). Game fish specimens were individually weighed, and a skinless fillet was removed as described in Scudder and others (2008). The fillet was triple-rinsed in deionized water, patted dry, weighed, placed in a fresh zip-lock bag, labeled, double-bagged, and frozen. Midtrophic-level fish specimens from each site were sorted into single-species composites (containing similarly sized individuals), rinsed thoroughly in deionized water, and batch-weighed (that is, all individuals in a composited sample were weighed together). All specimens in a composite sample were placed into a fresh zip-lock bag, labeled, double-bagged, and frozen.

Samples were shipped frozen on dry ice to either the Trace Elements Research Laboratory (TERL) at Texas A&M University in College Station, Texas (340 samples), or the USGS Mercury Research Laboratory (USGS Mercury Lab) in Middleton, Wisconsin (69 samples), for analysis of THg and percent moisture. The 69 samples submitted to the USGS Mercury Lab also were analyzed for stable isotopes of THg ($\delta^{202}Hg$, $\Delta^{199}Hg$, and $\Delta^{201}Hg$). Upon completion of processing and analysis at the TERL and the USGS Mercury

Lab, the remaining tissue (freeze-dried and homogenized) for each sample was sent to the Cornell University Stable Isotope Laboratory in Ithaca, N.Y., for analysis of stable isotopes of carbon ($d^{13}C$) and nitrogen ($d^{15}N$).

Sediment Samples

At each site during the ecological survey, sediment samples were collected from the streambed and the stream banks. At 14 sites prior to the start of the ecological surveys, two streambed sediment samples were collected during the second and sixth weeks of the 9-week QW sampling period. These additional samples were identified as "temporal bed sediment samples" and, in combination with results from samples collected during the ecological survey, were to be used to evaluate how sediment chemistry varied over the 9-week sampling period. These 14 sites are identified with "2" in the column labeled "Sediment Chemistry," under "Ecological Surveys," table 2 (in back of report).

Depending on the site, one or two streambed sediment samples were collected. A bulk sediment sample was collected at all sites for analysis of multiple constituents, including certain organic compounds, trace elements, organic carbon, and grain size. At 23 sites (mercury isotope sites), a second sediment sample was collected for analysis of total, methyl, and isotopic mercury. The bulk sediment sample collected at all sites and analyzed for multiple constituents was collected by following established USGS protocols (Shelton and Capel, 1994; Radtke, 2005) with several collection method variations. Four-inch (about 10-cm) stainless steel cylinders and stainless steel spatulas were used to collect the sediment. Multiple collections of sediment were made from depositional areas along the 150-m ecological assessment reach, targeting locations where fine-grained sediments accumulated. Depositional zones across the reach were sampled in approximate proportion to their bottom surface area. The collection method required pushing the stainless steel cylinder into the streambed to a depth of 2 cm, then sliding the spatula under the cylinder to support the enclosed streambed core. Each streambed core was lifted gently out of the water to minimize the loss of fine material, and all cores were composited in a large plastic bucket; approximately 6 to 10 L of streambed material was collected for the sample. Samples were sieved in the field by using a 2-mm stainless steel sieve that rested on top of the bucket.

The bulk sediment sample was placed on ice in the field and transported to a central processing facility at the USGS office in Troy, N.Y., where samples were homogenized and split into aliquots for various analyses. Each sample was homogenized by using a kitchen mixer with a stainless steel bowl and a bread-dough-style paddle operated at low speed. Prior to the NESQA sampling, testing was done with several streambed sediment samples to determine minimum mixing time to achieve a reasonably homogeneous sample; about 30 seconds was used for initial mixing and then about 15 seconds for additional mixing between removal of aliquots. Sample aliquots were shipped chilled to various laboratories for toxicity testing and chemical analyses. Not all constituents were analyzed for all samples (appendix 1, table 1.1). Major and trace elements, organic carbon, radionuclides, and grain size were measured in samples from all sites. In samples from 72 sites, polycyclic aromatic hydrocarbons (PAHs) and other semivolatile compounds were measured. For 52 sites, among the 72 sites for which PAHs were measured, sediments were analyzed for organic wastewater indicators, organochlorine insecticides, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and current-use pesticides. Sediment from those 52 of the sites was tested by using standard whole-sediment toxicity tests with amphipod crustaceans (*Hyalella azteca*; 28-day exposures), midge larvae (*Chironomus dilutus*; 10-day exposures), and freshwater mussels (*Lampsilis siliquoidea*; 28-day exposures) to measure potential effects of contaminants on survival and growth. Toxicity testing was conducted at the USGS Columbia Environmental Research Center (CERC).

Aliquots for assessing the concentration of THg at all sites were taken from the bulk sediment samples, as described above. Sediment samples for Hg isotopes were collected separately at 23 sites with a cut-off 50-mL plastic syringe to extract plugs of sediment. The plugs were collected from 6 to 10 depositional locations within and (or) near the stream reach and were placed into a wide-mouth plastic jar. Large pieces (such as twigs, leaves, and rocks) were removed from the sample by gloved fingers, and samples were immediately frozen. Samples were kept frozen and were shipped to the USGS Mercury Research Laboratory for analysis of total mercury concentration and mercury isotope analysis (the latter only in samples from the subset of 23 sites).

The bank sediment sample was collected from 5 to 10 locations along the ecological sampling reach where an exposed or eroding bank was observed on either side of the stream. At each location, sediment was collected by using a precleaned plastic trowel to scrape a vertical furrow from above the water line to the top of the exposed bank (about 1-cm depth into the bank). The bank scrapes were composited as a single sample in a 1-L plastic jar, which was stored on wet ice and shipped to the USGS Maryland-Delaware-D.C. Water Science Center in Baltimore, Maryland, for further processing and analysis of elements and radionuclides.

Physical Habitat

The physical habitat of the reach was characterized generally by following USGS protocols (Fitzpatrick and others, 1998). The 150-m sampling reach was segmented with 11 primary transects that were set apart every 15 m along the reach and with 10 secondary transects that were set approximately midway between the primary transects. Descriptive and quantitative measurements were collected across each primary transect and included geomorphic channel unit type (that is, pool, riffle, or run), stream depth, substrate size at five locations (right and left edges of water, the center of the channel, and midway between channel edges and channel midpoint),

stream wetted width, bank height, canopy cover at mid-transect, macrophyte coverage, and the presence of bars, islands, and potential fish habitat features. Measurements made across the secondary transects were wetted width and substrate size at the five locations described above. The surface water gradient was measured over the entire 150-m reach and indicated the average slope from the top to the bottom of the reach.

Sample Analyses

Most of the analyses of water, sediment, and invertebrate samples were conducted by the NWQL (appendix 2, tables 2.1 to 2.10), and the methods are briefly described in this section. Analytical results from the NWQL were uploaded to the Water-Quality System (QWDATA) database within the National Water Information System (NWIS) of the USGS for storage and archiving. Results of each sample in QWDATA were uniquely identified by station identification number, date, time, and medium code. Additionally, each NESQA sample was labeled with a unique barcode as a backup sample-tracking identifier. Real-time data recorded by data-logging instruments and by USGS staff in the field, such as streamflow, temperature, and biological-community data, are also discussed in this section; no laboratory analyses were required to generate these data, so they were processed at the USGS water science centers that operated the instruments or made the measurements.

Continuous Water Temperature and Streamflow

Discharge data collected at active USGS streamgages (54 sites) were continuously uploaded to and made available through the USGS NWIS database. For sites where pressure transducers were installed (41 sites), the raw stage data were processed with the HOBOware graphing and analysis software (Onset Computer Corporation, Bourne, Mass.). This process included applying corrections to the stage values with barometric pressure readings and comparing tape-down measurements from the reference point to the water surface to ensure that the instruments functioned consistently and reliably while they were in service.

The water temperature data were also processed with the HOBOware software; values were checked for outliers that could indicate that the data logger was out of water, such as with very low-flow conditions. This evaluation was particularly important because of the drought conditions that existed over much of the NESQA region during the summer of 2016. The general procedure used to assess the validity of temperature readings that appeared inordinately high was to first review streamflows at the site to determine if the high temperature values corresponded to minimal stage values, then compare these temperature values with those of nearby sites to assess if the data logger was reading air rather than water temperature. Erroneous water temperature data were subsequently deleted from the data file.

Chemical Analyses of Water, Sediment, and Fish

Discrete Water-Quality Samples

Water-quality samples collected over the 9- and 4-week QW sampling periods were analyzed for nutrients, major ions, DOC/ultraviolet absorbance (UVA), and pesticides by the NWQL with the exception that pesticides were analyzed in only the last sample collected (week 9) at eight of the forested and three of the tier 1 urban sites. Samples for major ions and nutrients were analyzed by the NWQL as specified in appendix 2 (tables 2.1 and 2.2). Total phosphorus concentrations were determined by colorimetry according to EPA method 365.1 (O'Dell, 1993). Dissolved ammonia, nitrite, and orthophosphate colorimetric analyses are described by Fishman (1993). Dissolved nitrate-plus-nitrite concentrations were determined by low-level enzyme reduction colorimetry with an automated discrete analyzer, as described by Patton and Kryskalla (2011). Concentrations of dissolved cations were determined by inductively coupled plasma-atomic emission spectroscopy (Fishman, 1993), and concentrations of dissolved anions were determined by ion chromatography, as described by Fishman and Friedman (1989).

Pesticides were analyzed by direct aqueous injection (DAI) liquid chromatography tandem mass spectrometry (LC–MS/MS) (appendix 2, table 2.3; Sandstrom and others, 2015). The pesticide analytical method quantified 225 pesticides and pesticide degradates in filtered water samples. The targeted pesticides represent a broad range of chemical classes and were selected on the basis of criteria such as current-use intensity, probability of occurrence in streams and groundwater, toxicity to humans or aquatic organisms, and precision of analytical methods. The method uses direct aqueous injection of a 100-microliter (µL) sample onto the LC–MS/MS without any sample preparation other than filtration. Samples were analyzed with two injection modes—positive electrospray ionization (ESI) and negative ESI—using dynamic multiple reaction monitoring (MRM) conditions and with two MRM transitions for each analyte. Recoveries for most analytes ranged from 80 to 120 percent in the water types tested, with relative standard deviations of less than 30 percent. The method detection limits ranged from 1 to 103 nanograms per liter (ng/L) for 182 analytes analyzed in the ESI positive mode and from 2 to 106 ng/L for 42 analytes analyzed in the ESI negative mode. The remaining analytes (five) had method detection limits between 100 and 250 ng/L.

Human-use pharmaceuticals and organic wastewater indicator compounds were analyzed three times at the 9-week sites and once at the 4-week sites (appendix 1, table 1.1). Pharmaceutical samples were syringe-filtered into 20-mL vials, and organic waste indicator samples were collected as whole water samples into a 1-L baked amber glass bottle. Samples were analyzed for 112 pharmaceuticals by DAI LC–MS/MS

(appendix 2, table 2.4; Furlong and others, 2008, 2014) and for organic wastewater indicator compounds by gas chromatography mass spectrometry (GC/MS) (appendix 2, table 2.5; Zaugg and others, 2006).

Stable nitrogen (^{15}N) and oxygen (^{18}O) isotopes of nitrate were analyzed in two of the weekly samples collected from the 9-week sites and in one of the weekly samples collected from the 4-week sites (appendix 1, table 1.1). Samples were filtered into bottles and frozen until nitrate concentration data were received and then shipped to the USGS Reston Stable Isotope Laboratory in Reston, Virginia. Isotopic analyses were done by following the method of Coplen and others (2012). Dissolved nitrate in water is converted to nitrous oxide (N_2O) by denitrifying bacteria, and the nitrous oxide is analyzed for nitrogen and oxygen isotopic abundance by continuous-flow isotope-ratio mass spectrometry.

Methylmercury and THg concentrations in whole water were analyzed at the USGS Mercury Research Laboratory in Middleton, Wis., in five of the weekly samples collected from the 9-week sites and in three of the weekly samples collected from the 4-week sites. Methylmercury was analyzed by gas chromatographic separation with cold vapor atomic fluorescence spectrometry (DeWild and others, 2002); THg was analyzed by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry (method 1631, revision E; U.S. Environmental Protection Agency, 2002). The USGS Mercury Lab also analyzed DOC in samples collected weekly, as well as ultraviolet absorbance at 254 nanometers (UVA_{254}) in the samples collected concurrently with the mercury samples.

Weekly filtered water samples were analyzed for glyphosate by using an enzyme-linked immunosorbent assay (ELISA) at the USGS Texas Water Science Center (Mahler and others, 2017). Glyphosate also was sampled during weeks 2 (at 59 sites) and 9 (at all sites) and analyzed at the Kansas OGRL by using an online solid-phase extraction and liquid chromatography/tandem mass spectrometry (Meyer and others, 2009). These data were used to evaluate quality control of the data analyzed by the ELISA method.

Weekly discrete whole-water samples were analyzed for suspended-sediment concentrations at the USGS Kentucky Sediment Laboratory in Louisville, Kentucky. Methods for processing suspended-sediment concentrations are described in Guy (1969) and Knott and others (1993) and included use of wet-sieving filtration.

A separate water sample was collected at all sites during week 8 to survey across the region for the concentrations of microcystin in streams (appendix 1, table 1.1). These samples were processed and analyzed by the Kansas OGRL following methods outlined in Loftin and others (2016). Unfiltered samples were lysed by three sequential freeze-thaw cycles at −20 degrees Celsius and 25 degrees Celsius and then syringe filtered through 0.7-micrometer glass fiber filters and frozen until analysis. Algal toxins were quantified by using the microcystin ELISA method with a minimum reporting level of 0.10 micrograms per liter.

Pesticides From the Small-Volume Pesticide Automated Samplers

Daily-composite samples from the pesticide autosamplers (vials 1 through 7) were analyzed for pesticide concentrations by the EPA Office of Pesticide Programs (OPP) Analytical Chemistry Laboratory in Fort Meade, Md. Sample splits of the weekly composite sample (vial 9) and the spike sample (vial 8) were analyzed for pesticide concentrations by the NWQL in Denver, Colo., as well as the OPP laboratory. The NWQL analyzed the sample for current-use pesticides (appendix 2, table 2.3) following the methods described above (Sandstrom and others, 2015). The OPP laboratory used the same direct aqueous-injection LC–MS/MS method and instrument (Agilent Model 6460) used by the NWQL with similar detection levels

Polar Organic Compound Integrative Samplers

The POCISs were processed for analysis of pesticides and pharmaceuticals by the methods described in Alvarez (2010) and in Van Metre, Alvarez, and others (2017). The CERC eluted the concentrated extract from the field and blank POCIS using methanol and concentrated the extracts to 1 milliliter (mL). Concentrated extracts were sealed in 1-mL amber glass ampules, stored at −20 °C, and shipped to the NWQL in Denver, Colo., for analysis. At the NWQL, the extracts were transferred to analytical vials and diluted 1:100, which was required to prevent ionization suppression or enhancement of internal standards by the POCIS extracts during LC–MS/MS analysis. Laboratory blank and lab-fortified spike samples were prepared by using comparable volumes of methanol and processed with the POCIS extracts. The extracts were analyzed for concentrations of current-use pesticides (appendix 2, table 2.3) and pharmaceuticals (appendix 2, table 2.4) by LC–MS/MS by following the methods described previously for the discrete water samples.

Sediment Samples

An aliquot of each composited streambed sediment sample was analyzed for organic wastewater indicator compounds by using accelerated solvent extraction (ASE), solid-phase extraction cleanup, and GC/MS (appendix 2, table 2.6; Burkhardt and others, 2006). Sixteen parent PAHs were analyzed at RTI Laboratories (Livonia, Michigan, http://rtilab.com/), following EPA method 8270D (U.S. Environmental Protection Agency, 2014) with extraction by ASE and analysis by GC/MS with selected ion monitoring (appendix 2, table 2.7). A custom method was used for selected organohalogens in sediment (chlorinated and brominated compounds including insecticides, PCBs, and PBDEs), which extracted the sample by ASE, followed by solid-phase extraction cleanup and analysis by electron-capture negative ionization mode GC/MS with selected ion monitoring (appendix 2, table 2.8;

reported in Mahler and others, 2009; Wagner and others, 2014). Streambed sediment was analyzed for 118 current-use pesticides at the USGS Organic Chemistry Research Laboratory (Sacramento, California) by gas chromatography-tandem mass spectrometry (GC–MS/MS) (Hladik and McWayne, 2012). Hormone compounds in sediment were analyzed with the use of GC–MS/MS (appendix 2, table 2.9; Foreman and others, 2012).

Major and trace elements were analyzed in an aliquot of the streambed sediment sample (2-mm sieve) and in an aliquot sieved to less than 63 micrometers (<63 µm). Bank sediment samples and Walling tube samples also were sieved to <63 µm, and the fine fraction was analyzed for major and trace elements. The samples were analyzed by AGAT Laboratories (Mississauga, Ontario, Canada, http://www.agatlabs.com/index.cfm), using inductively coupled plasma-optical emission spectroscopy and inductively coupled plasma-mass spectrometry following dissolution in a mixture of hydrochloric, nitric, perchloric, and hydrofluoric acids (similar to the method documented in Smith and others, 2013). Aliquots of the streambed, bank, and Walling tube samples sieved to <63 µm were analyzed for radionuclides (lead-210, radium-226, cesium-137, and beryllium-7) at a USGS Sediment Radioisotope Laboratory in Menlo Park, Calif. Radionuclides were analyzed by using a high-resolution gamma spectrometer with an intrinsic germanium detector following methods described in Van Metre and others (2004).

Bed sediment samples from all sites were analyzed for THg and organic carbon at AGAT Laboratories. The mercury analysis was done by continuous flow-cold vapor-atomic fluorescence spectrometry (Hageman, 2007). Bed sediment samples that were collected from depositional zones from the 23 isotope sites were analyzed for THg by the USGS Mercury Lab by direct combustion and atomic absorption detection following EPA method 7473 (U.S. Environmental Protection Agency, 1998). Loss-on-ignition was analyzed by the USGS Mercury Lab by the method in Fishman and Friedman (1989). Bed sediment samples from 23 isotope sites also were analyzed by the USGS Mercury Lab for Hg isotopes by the same methods as described previously for fish ("Fish Mercury Samples" subsection of "Sample Collection and Processing"), except that the bed sediment samples were digested in aqua regia (3:1 HCl:HNO_3; Estrade and others, 2010; Lepak and others, 2015).

Periphyton Samples for Assessing Algal Productivity

Periphyton samples that were collected from five algal-productivity sites and processed in the field onto 0.47-µm glass-fiber filters were shipped to the NWQL for analysis of chlorophyll *a* and ash-free dry mass (AFDM). These samples were analyzed by using USGS method B–3520–85 and EPA method 445.0, respectively (appendix 2, table 2.10; Britton and Greeson, 1987; Arar and Collins, 1997). Ancillary data for assessing algal productivity were collected continuously by the PAR meter, YSI EXO2, and Sea-Bird SUNA continuous water-quality monitors and were processed into data records by the USGS water science centers that operated the instruments.

Ecological Surveys

Aquatic Biota

Periphyton samples for chlorophyll *a*, pheophytin *a*, and algal ash-free dry mass were collected during the ecological survey and processed in the field by filtering onto 0.47-µm glass-fiber filters. The filters were analyzed by using USGS method B–3520–85 and EPA method 445.0, respectively, by the NWQL (appendix 2, table 2.10; Britton and Greeson, 1987; Arar and Collins, 1997).

Periphyton samples preserved with formalin were analyzed for diatom community composition and abundance at the INSTAAR laboratory, at the University of Colorado Boulder, following NAWQA protocols (Charles and others, 2002) with the following modification. Four replicate slides of the diatoms were made by using Battarbee chambers to obtain random distribution of cells on cover slips (Battarbee, 1973). A precount collection of voucher flora was created based on examination of 80 percent of the algal slides. The voucher flora included images of all taxa encountered, with a greater number of images for rare and previously unknown taxa. The images were sorted into operational taxonomic units (OTUs) and assigned OTU codes. Samples and their order of analysis were randomly assigned to two analysts. Ten percent of samples were reanalyzed by each analyst, and 10 percent of samples were analyzed in cross comparison. Finally, OTU codes were translated into formal scientific names following the taxonomy in the USGS BioData program and Diatoms of the United States (Spaulding and others, 2010). Voucher slides, digested material, and the voucher flora were archived at INSTAAR. The soft algae fractions of the samples were stored at INSTAAR for possible analysis at a later time.

Benthic invertebrate samples were processed by the Biological Unit of the NWQL using the quantitative fixed count method (Moulton and others, 2000). Briefly, the sample is sorted to attain a minimum of 300 organisms, which are then identified to the lowest possible taxonomic level (generally the species or genus level), which is similar to the method described in the EPA Rapid Bioassessment Protocol III (Barbour and others, 1999). Additionally, the biomass of arthropods and mollusks in the sample was estimated by measuring each of these organisms to the nearest millimeter and calculating their mass with the use of length-mass regressions for the various taxa. Quality assurance was verified in both the sorting step and the taxonomic step by a second person repeating these steps for 10 percent of the organisms. Taxonomic and enumeration results were uploaded to BioData (MacCoy, 2011).

Fish community data were based on species identification and counts made in the field, and the data were uploaded to BioData. Although most fish were returned to the streams, some individuals were retained either as voucher specimens for identification or for tissue samples that would be analyzed for Hg concentrations. In some cases, photographs were taken for verification of the field identification. Voucher specimens were submitted to the Biological Survey Laboratory of the New York State Museum in Troy, N.Y., for verification of field identifications and for archiving.

Sediment Toxicity Testing

Methods used for sediment toxicity testing are described in Moran and others (2017). For sediment testing, methods in U.S. Environmental Protection Agency (2000) and in American Society for Testing and Materials International (2014b) were followed; for mussel testing, methods in American Society for Testing and Materials International (2014a) were followed. Whole sediment toxicity tests were conducted with the amphipod *Hyalella azteca* (28-day exposures), with the midge *Chironomus dilutus* (10-day exposures), and with the mussel *Lampsilis siliquoidea* (28-day exposures). Up to 1.8 L (assuming a 50/50 split of solids and liquids) of the composited streambed sediment was used for toxicity testing. Testing for each species included endpoints of survival, weight, and biomass of test organisms. Exposures were conducted at 23 °C in 300-mL beakers containing 10 test organisms fed daily and 100 mL of sediment with two volume additions per day of overlying water.

Physical Habitat

Data collected from habitat surveys were recorded on electronic field forms; these data were reviewed in the office by USGS staff. Any values on the field forms that were suspect (such as typographical errors) were resolved, and the data were loaded into the USGS BioData biological database (https://aquatic.biodata.usgs.gov).

Quality Assurance and Quality Control

This section primarily describes details of the quality assurance (QA) and quality control (QC) procedures for the collection of environmental water samples that were processed by the NWQL. QA/QC of project data is an iterative process that begins when samples are collected and continues through the establishment of sample records in NWIS and until the final acceptance of data as reviewed and approved or, in rare cases, rejected. This process allows for a continuous review of records by field personnel, RSQA data managers, lab analysts, team QW specialists, and team leads for both sample data (results) and metadata. Specific database scripts were developed to check sample coding logic and to generate data tables in multiple formats for data review and conformation. For sediment and fish samples, QA/QC procedures generally were simpler and included the use of replicates and standard reference materials during sample analyses in the laboratory. For samples analyzed at laboratories other than the NWQL, general QA/QC procedures may be found in the methods descriptions of publications cited previously in the “Sample Analyses” section and in the standard operating procedures maintained by the laboratories.

QA/QC procedures maintain the integrity, accuracy, and legal defensibility of results from data collection and assessment. Documented USGS QA/QC policies and procedures for environmental sampling were implemented in the NESQA study to ensure that the data can be interpreted properly and are scientifically defensible (Mueller and others, 1997; U.S. Geological Survey, 2006). QC samples were collected to identify, quantify, and document bias and variability in data that result from the sampling procedure (through field QC sampling) and laboratory procedures (through laboratory QC sampling). Field QC sampling captures bias and variability from sample collection, processing, shipping, and handling of samples. Laboratory QC sampling documents the variability of analytical methods and sample preparation in the laboratory. The QA/QC methods used by the NWQL for stream water analyses are described here. Methods used by the other laboratories that analyzed other NESQA samples may be found on the laboratory websites.

To ensure that all field crews followed consistent sample collection and processing procedures, classroom training was held for field personnel prior to the sampling period. In addition, all personnel worked through a full suite of sample collection and sample processing procedures at one of the NESQA sites prior to the start of the weekly sampling period. To minimize potential confusion in the field, all sampling scheduling, creation of analytical services request forms (ASRs) and bottle labels, and preparation of bottle kits (all sample containers needed for each site for a given visit) were handled centrally by USGS personnel who had provided similar support to previous RSQA studies.

The QC samples for constituents measured in water included field blanks, matrix spikes, and replicates (table 4; appendix 1, table 1.1). The QC plan was designed not only to meet or exceed 5 percent QC samples for inorganics and 10 percent for organics but also to ensure that QC was distributed across the region evenly and that every field crew was assigned QC samples at an appropriate interval. Field blanks were used to test if cleaning procedures would adequately remove any sampling equipment contamination introduced by samples obtained at previous sites and ensure that sample collection, processing, handling, and shipping did not result in contamination (Mueller and others, 1997; U.S. Geological Survey, 2006). Field replicates were used to test the precision of analyses at the laboratory and were prepared by dividing a single volume of water into two samples in the field. When these samples were collected from the churn, either filtered or not, two containers were filled sequentially. When grab

Table 4. Summary counts of environmental, field blank, replicate, and spike samples of stream water from the 95 stream sites sampled in the Northeast Stream Quality Assessment of the U.S. Geological Survey National Water-Quality Assessment Project in 2016.

[Recommended percentages are from Mueller and others (1997). QA, quality assurance; KS OGRL, U.S. Geological Survey Kansas Organic Geochemistry Research Laboratory; N/A, not applicable; --, no data]

Laboratory schedule	Type of sample	Sample counts	Ratio of QA to environmental samples (percent)	
			Actual	Recommended
Major ions	Environmental	675	N/A	N/A
	Blank	23	3.4	[a]1.6
	Replicate	30	4.4	[a]1.6
	Spike	0	0	0
Nutrients	Environmental	693	N/A	N/A
	Blank	23	3.3	[a]1.6
	Replicate	29	4.2	[a]1.6
	Spike	0	0	0
Dissolved organic carbon	Environmental	682	N/A	N/A
	Blank	22	3.2	[a]1.4
	Replicate	28	4.1	[a]1.4
	Spike	0	0	0
Pesticides	Environmental	640	N/A	N/A
	Blank	24	3.8	[a]1.4
	Replicate	28	4.4	[a]1.4
	Spike	62	9.7	[b]9.1
Glyphosate (immunoassay)	Environmental	671	N/A	N/A
	Blank	23	3.4	--
	Replicate	28	4.2	--
	Spike	0	0	--
Pharmaceuticals	Environmental	212	N/A	N/A
	Blank	10	4.7	--
	Replicate	11	5.2	--
	Spike	10	5	--
Organic wastewater indicators	Environmental	211	N/A	N/A
	Blank	10	4.7	--
	Replicate	10	4.7	--
	Spike	11	5.2	--
Glyphosate (KS OGRL)	Environmental	118	N/A	N/A
	Blank	6	5.1	--
	Replicate	7	5.9	--
	Spike	6	5.1	--
Mercury	Environmental	401	N/A	N/A
	Blank	21	5.2	[a]1.4
	Replicate	23	5.7	[a]1.4
	Spike	0	0	0
Isotopes	Environmental	153	N/A	N/A
	Blank	0	0	--
	Replicate	14	9.2	--
	Spike	0	0	--

[a]Mueller and others (1997) recommend substituting 1 of the indicated sample types per month if many environmental samples are collected in a short period of time rather than a set of 1 per 30 (3.3 percent) or 1 per 20 (5 percent). Therefore, for the Northeast Stream Quality Assessment study, weekly samples were collected at 59 sites for 9 weeks, so the recommended percentage was computed as 1 monthly quality control sample at 59 sites, or 1.4 percent.

[b]Recommended amount is one per site.

samples were collected, replicates were collected sequentially directly from the stream. These replicates provided a measure of the variability introduced during sample processing and analysis (Mueller and others, 1997; U.S. Geological Survey, 2006). Field and laboratory matrix spikes were used to assess the potential bias for analytes in a particular sample matrix. Bias is estimated from spiked samples by calculating the percentage of the added analyte (spike material) measured (recovered) in the sample at the laboratory (Mueller and others, 1997; U.S. Geological Survey, 2006). Recovery can be either greater than or less than 100 percent, so the bias can be either positive or negative; however, matrix interference and analyte degradation generally result in a negative bias.

Field blanks were collected once from 22 to 24 sites for each of the basic laboratory schedules (major ions, nutrients, dissolved organic carbon, pesticides, and glyphosate by immunoassay) sampled weekly (table 4). For QA/QC samples collected as part of NAWQA, Mueller and others (1997) recommend 1 field blank or replicate per every 30 (3.3 percent) or 20 (5 percent) environmental samples for the previously mentioned constituents when sampling at long-term sites; however, if many environmental samples are collected in a short period of time, as was the case in the NESQA study, it is recommended to lower the QC sample frequency to 1 per month. Therefore, for the NESQA study, the recommended percentage was computed as 1 monthly QC sample at 59 sites, or 1.4 percent. Actual field blanks represented 3.2 to 3.8 percent of the environmental samples, and split replicates for the same analyses represented 4.1 to 4.4 percent of the environmental samples, which met the frequency recommendation (table 4; Mueller and others, 1997).

No recommendation for QA/QC samples was provided for the organic compounds of emerging concern (pharmaceuticals and organic wastewater indicators) in Mueller and others (1997); therefore, we applied the same approach as used for pesticides. For pharmaceutical and organic wastewater indicator analyses, field blanks represented 4.7 percent of the environmental samples, and split replicates represented 5.2 and 4.7 percent of the environmental samples, respectively (table 4). Matrix spikes were performed on all analyses for organic compounds, with the exception of glyphosate analysis by immunoassay. The frequency of these spikes ranged from 5 to 5.2 percent, depending on the analyte (table 4).

Quality assurance included maintaining standardized sample collection and handling protocols among all field personnel as described in the National Field Manual (U.S. Geological Survey, variously dated) for water and sediment sampling and in Moulton and others (2002) for ecological sampling. All sampling and handling protocols were reviewed by field personnel involved in the NESQA study during training courses prior to field work. Additionally, several programs exist within the USGS Quality Systems Branch to help document the quality of project results. For laboratory analyses conducted by the NWQL, documented QC included double-blind analyses of blanks for organic and inorganic constituents and provision of graphical and tabular control data for the analytical lines. Field personnel involved in the NESQA study are tested annually to verify their proficiency in collecting field data, including temperature, pH, dissolved oxygen, alkalinity, and specific conductance.

Water-quality data from each sampling event were reviewed for completeness, precision, bias, and transcription errors when received from the laboratory as part of the QA/QC procedures. Water-quality and sediment-quality data were stored in the NWIS database. Quality-assured water-quality and sediment-quality data are available for retrieval at https://waterdata.usgs.gov/nwis/sw and through the data retrieval application at the RSQA project website (https://webapps.usgs.gov/RSQA/). The NWQL provides all QA/QC documentation for their analytical services at http://nwql.usgs.gov/Public/quality.shtml.

Water-Quality Data-Management Procedures

An important goal of data management for the NESQA study is to have the data reviewed, approved, and stored in a USGS approved database that is appropriate for the specific type of data (for example, water quality, streamflow, biological). Because NESQA sampling sites were located in multiple States, data entry and retrieval for sites in a particular State were managed by the USGS water science center (WSC) for that State. The NWIS station number that is used to identify a site (table 1, in back of report) is the master indexing and retrieval element for accessing data specific to the site. The NWIS database is the repository for most of the water-quality and streamflow data, which are the majority of the NESQA data, and is composed of separate distributed databases that are each hosted by the WSC for the State in which the site is located. Thus, the WSC responsible for managing NESQA data in NWIS depends on the State in which the NESQA site was located. Additionally, a data-management team was created to include both national RSQA staff and regional NESQA staff to facilitate the data-management process. Centralization of the data-management process was adopted to ensure consistency among the WSCs for each RSQA study and among all RSQA study areas. Nine main steps were implemented for the data-management process:

1. Sampling matrix and sample coding design
2. Electronic field form use, including barcoding
3. Sample status checks at all laboratories
4. NWIS sample record checks
5. Data transfer from laboratory to NWIS
6. Establishment of project networks
7. Sample coding and field parameter checks

8. Data quality checks
9. Approval of data in NWIS and other databases, as appropriate

Sites selected for the NESQA study were assigned the appropriate network designations in NWIS ProjectNetworks (Dupré and others, 2013) which allows integration with similar sites across many regions and designation of the site type in NWIS. These network designations were obtained from the project planning documents and, where possible, kept consistent with other network designations that may have been used in previous regional studies. ProjectNetworks documentation was provided to local WSC personnel so they could establish their sites in NWIS ProjectNetworks.

Prior to the start of sampling, the manager of the data-management team prepared a matrix that would be the sampling design and coding plan for all aspects of the field activities. The sampling matrix distributed QC samples approximately equally across sites, sample teams, and time periods for optimum coverage. The matrix also served as a summary diagram for the type, frequency, and location of environmental and QC samples to be collected (appendix 1, table 1.1). A sample coding scheme was developed by the data manager that was used by the NESQA sampling teams to ensure a well-structured and manageable dataset. Additionally, training and written guidelines for sampling coding were made available to sampling teams prior to the start of sampling.

Weekly sample bottle packs were assembled at a central location by a USGS staff person designated as the field-supply manager. The bottle packs consisted of the necessary bottles, filters, preservatives, labels, and analytical service requests (ASRs) for each stream site; the packs were shipped to the local WSC at least one week prior to sampling. Centralizing the distribution of sample bottle packs helped ensure that correct sample coding, sample schedules, and timing of QC samples matched the proposed sample plan and reduced errors in the sample login process at the analytical laboratories.

Most of the NESQA sampling teams used the Personal Computer Field Form (PCFF) version 7.2 software created by the USGS, which provides electronic field forms for data collection at sampling sites. However, the use of PCFF did not preclude the use of all paper field forms when sampling; a two-page standardized form for NESQA water-quality field notes was routinely used at all sites to record basic site conditions when samples were collected and to affix bar codes that identified the samples. The bar codes were unique identifiers used to associate specific sample types with a site and the sampling event. The PCFF software streamlines the process of uploading (logging in) field data and sampling codes to NWIS by automatically generating the batch load files required by NWIS (qwsample and qwresult), thereby improving the efficiency of data flow from field and laboratory to database. The information uploaded to NWIS for each sample is stored under a unique number associated with that sample, as are later results received from the laboratory. In addition, the automation of data upload to NWIS limits the incidence of transcription errors that may occur during the manual entry of data into NWIS. Although PCFF can be used to generate the NWQL ASR documents for samples being submitted to the NWQL, the field-supply manager provided ASRs to the sampling teams each week along with the corresponding bottle sets. Some field teams did not use the PCFF; in these cases, field data were recorded on paper field forms and then transferred onto electronic digital forms in the office.

Sample shipment schedules were established prior to the start of sampling for NESQA, and generally shipments were made twice per week (appendix 1, table 1.4). Sampling teams and other WSC personnel were responsible for the shipment process. The data manager continuously tracked the shipments to verify that the shipped samples were received at each laboratory (1) within the correct holding times, (2) in the proper condition (for example, chilled samples received at the appropriate temperature of 4 °C or less), and (3) with proper documentation. The data manager worked with the laboratories to correct problems with mislabeled samples or ASRs in a timely manner and to communicate problem-resolution approaches to WSC personnel. During this process, the data manager also established the connection between the USGS Laboratory Information Management System used to transfer sample results and the NWIS database used to receive and store sample results.

During sampling and the corresponding establishment of sample records in NWIS, the data manager inspected sample coding and procedures to ensure that sample records were established properly and in a consistent manner. Sample coding or procedures were modified if found to be inaccurate or inconsistent. These modifications involved changes or corrections to sample time offsets, sample type coding, or other documentation at the laboratory or in NWIS. Modifications in sample coding or procedures related to data management or sample submittal were communicated immediately to sampling teams to ensure that appropriate adjustments were made before the next sampling.

Most of the laboratories used for NESQA sample analysis transmitted sample results through the Water Quality Data Exchange (QWDX) for automatic upload into the NWIS database. For those laboratories without the ability to use QWDX, sample results were loaded into NWIS by using manually created batch files. Batch files were created by the data manager upon receipt of electronic data from the laboratory and were loaded into the respective WSC NWIS host by the data manager or the local database administrator for the WSC. The data manager verified that the batch files of data were properly loaded into NWIS. Data files provided through email by laboratories and data not applicable to NWIS (for example, CERC toxicity data) were stored electronically in the RSQA team database rather than NWIS. These data, and data such as quality assurance sample results not publicly available through NWIS, will be made available using the ScienceBase digital data repository supported by the USGS.

After sampling was completed, the data manager inspected the NWIS sample records for completeness

regarding field data collection, including stream measurements (streamflow, stage, sampling points, stream width, and so forth), field parameters (pH, air and water temperature, specific conductance, dissolved oxygen), and sample coding (sample purpose, purpose of site visit, sampling method, sampler type, and multiple QC-related sample codes). Manual checks were made for each sample, and any corrections were communicated to WSC personnel; the data manager, WSC personnel, or database administrator made any needed changes in NWIS.

National RSQA staff scientists reviewed the water-quality and sediment-quality results received from the laboratory. The water-quality data reviews included identification and review of extremes in the data (outliers); inconsistencies or unexpected results in the data; and major differences between environmental samples and replicates, detected values in blanks, and analyte recoveries in spike samples. The RSQA staff scientists communicated requests for reruns, reloads, and verification of results from the laboratory; they worked closely with the data manager to verify completeness of sample results, and a final dataset was established in NWIS as well as in a central RSQA database.

Upon completion of the data review process by the RSQA staff scientists, the data manager provided tables of the data-review results to the respective analysts for internal reviews. WSC personnel who were responsible for data quality at the WSC changed the data quality indicator (DQI) code for each individual water-quality parameter, on the basis of the results of the review, to reviewed and accepted (R) or reviewed and rejected (Q). Any data that were rejected at the WSC level were not used in data analysis or publications. In addition to NWIS and ScienceBase, water quality, sediment, biological tissue, and ecological survey data are also made available at the RSQA mapping and data application website, which allows mapping, querying, and data downloads (https://webapps.usgs.gov/RSQA/#!/download).

Atlantic Highlands Flow-Ecology Study

Prior to the NESQA, a study was conducted in 2014 to investigate the effects of flow alteration on the ecological condition of streams in the Northeast. Specific objectives were to (1) quantify the extent of flow alterations at USGS gaged streams across the Atlantic Highlands ecoregion; (2) identify streams where flow alterations likely have resulted in thermal regime shifts; and (3) describe how flow alterations are related to the health of aquatic ecosystems, as indicated by changes in the thermal regime, physical habitat, water chemistry, and aquatic biota. Unlike the NESQA study that was conducted as a multistressor investigation, the Atlantic Highlands flow-ecology study was primarily focused on flow alteration as a single stressor; thus, a different set of criteria was used for site selection that resulted in the study being more constrained in spatial extent and sampling elements.

To identify a network of sites for the study, a preliminary list of candidate streams was developed that met specific criteria: the streams were in the Atlantic Highlands ecoregion, were in primarily forested watersheds with less than 20 percent developed land, were outfitted with an active USGS streamgage, and had at least 10 years of antecedent streamflow data. A total of 190 candidate sites met these criteria. Geospatial data from the USGS GAGES–II dataset were used to identify the extent of flow alteration for the candidate sites with the use of an index of hydrologic alteration calculated from variables in the dataset (Falcone, 2011); sites then were selected to represent a gradient of hydrologic alterations from essentially unaltered (forested watersheds with no known streamflow modifications upstream from site) to highly altered (for example, immediately downstream from a large impoundment with regulated flows). Site reconnaissance was conducted during 2013 to identify a 150-m sampling reach, identify riffle habitat along the reach, evaluate access to the reach for sampling, and ascertain the absence of point sources and other human-related factors that could potentially confound verifying streamflow alteration as the primary stressor. After results from the reconnaissance were assessed, 66 gaged sites across the Atlantic Highlands ecoregion were deemed suitable for the study. Habitat was surveyed, and invertebrates and algae samples were collected at 60 “full ecology sites,” but only invertebrate samples were collected at 6 “invertebrate only sites” (table 5).

All 66 sites were instrumented with a water temperature data logger that was installed in the water column in the manner described previously for the NESQA study, except in cases where water temperature was already being collected as part of the data collection routine for a site; additionally, an air temperature data logger was installed at all sites near the stream reach (typically in a tree). The data loggers were programmed to collect data at hourly intervals and were deployed in August 2013. They were removed in the fall of 2014, after ecological sampling was completed, in order to characterize at least a full year of air and water temperature regimes at each site. Also, a bed sediment sample was collected from fine-grained depositional zones within the stream reach of 41 sites during the visits when temperature sensors were deployed (table 5, see footnote). Sediment from the upper 2 cm of depositional substrate was collected from multiple locations by using an inverted glass petri dish and small Teflon square, a technique similar to that used for NESQA sediment sampling. Sediment from multiple locations in the reach was composited in a glass bowl and mixed thoroughly. Subsamples were then removed and placed into vials and jars appropriate to each intended analysis. Frozen subsamples were submitted to the USGS Mercury Research Laboratory for analysis of total mercury, methylmercury, and loss on ignition. Chilled (wet ice) subsamples were submitted to the NWQL for analysis of PAHs and halogenated compounds, to the USGS Crustal Geophysics and Geochemistry Laboratory for analysis of major and trace elements, and to the USGS Sediment Radioisotope Laboratory for analysis of radionuclides. Methods for each of

Table 5. Stream watersheds that were included in the Atlantic Highlands flow-ecology study, conducted by the U.S. Geological Survey as part of the National Water-Quality Assessment Project in 2014.

[Full ecology sites included habitat surveys and algal and invertebrate samples, whereas the invertebrate-only sites did not include habitat surveys and algal samples. Sites with NWIS station numbers shaded were also part of the Northeast Stream Quality Assessment site network. Latitude and longitude are referenced to the North American Datum of 1983 and shown in decimal degrees. States are abbreviated with two-letter postal codes; for example, NH is New Hampshire. NWIS, U.S. Geological Survey National Water Information System database; km^2, square kilometer]

NWIS station number	NWIS station name	Field identifier	Latitude (NWIS)	Longitude (NWIS)	Drainage area (km^2)
	Full ecology sites				
01052500	DIAMOND RIVER NEAR WENTWORTH LOCATION, NH	NH_DIAMO_WL	44.8774	-71.0575	384
01054200	WILD RIVER AT GILEAD, MAINE	ME_WILDR_GI	44.3904	-70.9796	181
01055000	SWIFT RIVER NEAR ROXBURY, MAINE	ME_SWIFT_RO	44.6427	-70.5888	251
01064801	BEARCAMP RIVER AT SOUTH TAMWORTH, NH	NH_BEARC_ST	43.8301	-71.2878	173
01075000	PEMIGEWASSET RIVER AT WOODSTOCK, NH	NH_PEMIG_WO	43.9762	-71.6795	504
01082000	CONTOOCOOK RIVER AT PETERBOROUGH, NH	NH_CONTO_PE	42.8626	-71.9592	175
01133000	EAST BRANCH PASSUMPSIC RIVER NEAR EAST HAVEN, VT	VT_EBPAS_EH	44.6339	-71.8976	138
01134500	MOOSE RIVER AT VICTORY, VT	VT_MOOSE_VI	44.5117	-71.8373	195
01135150	POPE BROOK (SITE W-3) NEAR NORTH DANVILLE, VT	VT_POPEB_ND	44.4762	-72.1245	10
01135300	SLEEPERS RIVER (SITE W-5) NEAR ST. JOHNSBURY, VT	VT_SLEEP_EF	44.4353	-72.0389	111
01137500	AMMONOOSUC RIVER AT BETHLEHEM JUNCTION, NH	NH_AMMON_BJ	44.2687	-71.6304	229
01139800	EAST ORANGE BRANCH AT EAST ORANGE, VT	VT_EORAN_EO[1]	44.0928	-72.3357	23
01153550	WILLIAMS RIVER NEAR ROCKINGHAM, VT	VT_WILLI_RO[1]	43.1917	-72.4851	290
01154000	SAXTONS RIVER AT SAXTONS RIVER, VT	VT_SAXTO_SA[1]	43.1376	-72.4881	187
01155500	WEST RIVER AT JAMAICA, VT	VT_WESTR_JA	43.1090	-72.7754	460
01158600	OTTER BROOK BELOW OTTER BROOK DAM, NEAR KEENE, NH	NH_OTTER_KE[1]	42.9459	-72.2368	122
01164000	MILLERS RIVER AT SOUTH ROYALSTON, MA	MA_MILLE_SR	42.6298	-72.1504	492
01166500	MILLERS RIVER AT ERVING, MA	MA_MILLE_ER[1]	42.5976	-72.4381	966
01169000	NORTH RIVER AT SHATTUCKVILLE, MA	MA_NORTH_SH[1]	42.6384	-72.7251	231
01169900	SOUTH RIVER NEAR CONWAY, MA	MA_SOUTH_CO[1]	42.5420	-72.6937	62
01170100	GREEN RIVER NEAR COLRAIN, MA	MA_GREEN_CO[1]	42.7034	-72.6706	107
01174565	WEST BRANCH SWIFT RIVER NEAR SHUTESBURY, MA	MA_WBSWI_SH[1]	42.4551	-72.3818	33
01175500	SWIFT RIVER AT WEST WARE, MA	MA_SWIFT_WW[1]	42.2679	-72.3326	490
01179500	WESTFIELD RIVER AT KNIGHTVILLE, MA	MA_WESTF_KN[1]	42.2879	-72.8643	422
01180500	MIDDLE B WESTFIELD RIVER AT GOSS HEIGHTS, MA	MA_MBWES_GH[1]	42.2587	-72.8726	137
01181000	WEST BRANCH WESTFIELD RIVER AT HUNTINGTON, MA	MA_WBWES_HU[1]	42.2373	-72.8957	244
01185500	WEST BRANCH FARMINGTON RIVER NEAR NEW BOSTON, MA	MA_WBFAR_NB	42.0793	-73.0729	237
01186000	WEST BRANCH FARMINGTON RIVER AT RIVERTON, CT	CT_WBFAR_RI[1]	41.9629	-73.0176	334
01187300	HUBBARD RIVER NEAR WEST HARTLAND, CT	CT_HUBBA_WA	42.0373	-72.9390	54
01202501	SHEPAUG RIVER AT PETERS DAM AT WOODVILLE, CT	CT_SHEPA_WO[1]	41.7193	-73.2929	100
01315500	HUDSON RIVER AT NORTH CREEK, NY	NY_HUDSO_NC[1]	43.7009	-73.9835	2,059
01321000	SACANDAGA RIVER NEAR HOPE, NY	NY_SACAN_HO[1]	43.3528	-74.2704	1,264
01333000	GREEN RIVER AT WILLIAMSTOWN, MA	MA_GREEN_WI[1]	42.7090	-73.1968	112
01336000	MOHAWK RIVER BELOW DELTA DAM NEAR ROME, NY	NY_MOHAW_RO[1]	43.2645	-75.4363	386
01343060	WEST CANADA CREEK NEAR WILMURT, NY	NY_WCANA_WI[1]	43.3662	-74.9577	610

Table 5. Stream watersheds that were included in the Atlantic Highlands flow-ecology study, conducted by the U.S. Geological Survey as part of the National Water-Quality Assessment Project in 2014.—Continued

[Full ecology sites included habitat surveys and algal and invertebrate samples, whereas the invertebrate-only sites did not include habitat surveys and algal samples. Sites with NWIS station numbers shaded were also part of the Northeast Stream Quality Assessment site network. Latitude and longitude are referenced to the North American Datum of 1983 and shown in decimal degrees. States are abbreviated with two-letter postal codes; for example, NH is New Hampshire. NWIS, U.S. Geological Survey National Water Information System database; km^2, square kilometer]

NWIS station number	NWIS station name	Field identifier	Latitude (NWIS)	Longitude (NWIS)	Drainage area (km^2)
	Full ecology sites—Continued				
01349810	WEST KILL NEAR WEST KILL, NY	NY_WESTK_WK[1]	42.2304	-74.3929	74
01350080	MANOR KILL AT WEST CONESVILLE NEAR GILBOA, NY	NY_MANOR_GI[1]	42.3770	-74.4129	84
01350140	MINE KILL NEAR NORTH BLENHEIM, NY	NY_MINEK_NB[1]	42.4290	-74.4729	44
013621955	BIRCH CREEK AT BIG INDIAN, NY	NY_BIRCH_BI[1]	42.1090	-74.4518	33
01362200	ESOPUS CREEK AT ALLABEN, NY	NY_ESOPU_AL[1]	42.1170	-74.3801	169
01363382	BUSH KILL BLW MALTBY HOLLOW BK AT WEST SHOKAN, NY	NY_BUSHK_WS[1]	41.9656	-74.2929	44
01374581	W BR CROTON RIVER BELOW DAM NEAR KENT CLIFFS, NY	NY_WBCRO_KC[1]	41.4498	-73.7365	58
01384500	RINGWOOD CREEK NEAR WANAQUE, NJ	NJ_RINGW_WA[1]	41.1275	-74.2656	44
01413398	BUSH KILL NEAR ARKVILLE, NY	NY_BUSHK_AR[1]	42.1509	-74.6013	121
01413408	DRY BROOK AT ARKVILLE, NY	NY_DRYBR_AR[1]	42.1468	-74.6232	213
01414000	PLATTE KILL AT DUNRAVEN, NY	NY_PLATT_DU[1]	42.1331	-74.6954	90
01414500	MILL BROOK NEAR DUNRAVEN, NY	NY_MILLB_DU[1]	42.1062	-74.7304	64
01427510	DELAWARE RIVER AT CALLICOON, NY	NY_DELAW_CA	41.7568	-75.0574	4,725
01434017	EAST BR NEVERSINK RIVER NR CLARYVILLE, NY	NY_EBNEV_CL[1]	41.9254	-74.5402	60
01434025	BISCUIT BK ABOVE PIGEON BK AT FROST VALLEY, NY	NY_BISCU_FV	41.9954	-74.5010	10
01434498	WEST BRANCH NEVERSINK R AT CLARYVILLE, NY	NY_WBNEV_CL[1]	41.9204	-74.5746	88
01435000	NEVERSINK RIVER NEAR CLARYVILLE, NY	NY_NEVER_CL	41.8901	-74.5899	172
01436000	NEVERSINK RIVER AT NEVERSINK, NY	NY_NEVER_NE	41.8201	-74.6354	241
01436690	NEVERSINK RIVER AT BRIDGEVILLE, NY	NY_NEVER_BR	41.6381	-74.6169	443
01439500	BUSH KILL AT SHOEMAKERS, PA	PA_BUSHK_SH	41.0882	-75.0377	306
01440400	BRODHEAD CREEK NEAR ANALOMINK, PA	PA_BRODH_AN[1]	41.0848	-75.2146	175
01447800	LEHIGH RIVER BLW FRANCIS E WALTER RES NR WHITE HAVEN, PA	PA_LEHIG_WH[1]	41.1048	-75.7321	753
04287000	DOG RIVER AT NORTHFIELD FALLS, VT	VT_DOGRI_NF[1]	44.1828	-72.6404	199
04288230	RANCH BROOK AT RANCH CAMP, NEAR STOWE, VT	VT_RANCH_ST[1]	44.5039	-72.7818	10
04289000	LITTLE RIVER NEAR WATERBURY, VT	VT_LITTL_WA[1]	44.3701	-72.7693	287
	Invertebrate-only sites				
01053500	ANDROSCOGGIN RIVER AT ERROL, NH	NH_ANDRO_ER	44.7826	-71.1287	2,702
01054000	ANDROSCOGGIN RIVER NEAR GORHAM, NH	NH_ANDRO_GO	44.4358	-71.1902	3,528
01055500	NEZINSCOT RIVER AT TURNER CENTER, MAINE	ME_NEZIN_TC	44.2695	-70.2296	440
01144000	WHITE RIVER AT WEST HARTFORD, VT	VT_WHITE_WH[1]	43.7142	-72.4181	1,790
04285500	NORTH BRANCH WINOOSKI RIVER AT WRIGHTSVILLE, VT	VT_NBWIN_WR[1]	44.2995	-72.5787	182
04288000	MAD RIVER NEAR MORETOWN, VT	VT_MADRI_MO	44.2773	-72.7426	364

[1]A bed sediment sample was collected at these sites.

these analyses are described previously (section "Chemical Analyses of Water, Sediment, and Fish").

Each of the 66 sites was visited twice during the summer of 2014 for data collection, generally using methods described for the NESQA study. The first visit, in August, consisted of the following at the 60 full ecology sites: measuring specific conductance, dissolved oxygen, pH, and water temperature with YSI field meters; collecting a grab water sample from a well-mixed portion of the stream (one sample per site, two additional QA samples at three sites); collecting invertebrate and periphyton samples from riffle habitats; and measuring the water-surface gradient along the reach. During the August 2014 visit at the six invertebrate only sites, an invertebrate sample was collected from riffle habitats, but no other sampling was done. The second site visit was made in late September or early October and consisted of the following: removing the temperature data loggers from the reach and downloading the data at all sites, and conducting a habitat assessment at the full ecology sites.

Water samples were kept on wet ice in the field and transferred to a refrigerator at the NYWSC laboratory. Samples were then shipped overnight to the NWQL and analyzed at the NWQL for major ions, dissolved organic carbon, acid-neutralizing capacity, filtered aluminum, and inorganic monomeric aluminum, according to methods detailed in Lawrence and others (1995). Algal samples were preserved in formalin as previously described and were shipped to INSTAAR and analyzed as previously described. Invertebrate samples were field-processed and preserved as previously described. The samples were analyzed by a contract laboratory (Rhithron Associates, Inc., Missoula, Montana), and the data were uploaded into the USGS BioData biological database (https://aquatic.biodata.usgs.gov).

Summary

This report summarizes the design and methods used during an intensive regional study to assess stream quality in the northeastern United States: the Northeast Stream Quality Assessment. Ninety-five wadeable stream sites were selected throughout five Level III ecoregions to determine the occurrence and levels of multiple stressors and to assess the conditions of aquatic biological communities. Water quality was measured during a 4- or 9-week period from June to August 2016, followed by an ecological survey to assess the biological communities (algal, invertebrates, fish), contaminants in sediment, mercury in fish tissue, and the physical habitat of the stream, as well as other aspects of stream condition such as indicators of harmful algal blooms. Multiple parameters covering a wide variety of potential stressors to aquatic life were measured during the Northeast Stream Quality Assessment and included both discrete and continuous data collected over the course of the assessment at all 95 sites and in special focused studies conducted at subsets of sites. Procedures are described that were used for sample analyses, quality assurance and quality control, and data management. The overall goal of the assessment is to improve our understanding of multiple water-quality stressors that affect wadeable streams throughout the region by evaluating relations between these stressors and indicators of stream health.

A related study on which the Northeast Stream Quality Assessment was built was the Atlantic Highlands flow-ecology study conducted during 2014 that investigated 66 streams and focused on effects of flow alteration on stream ecosystems. The design of the Atlantic Highlands flow-ecology study, which consisted of a subset of the many variables considered in the 2016 multistressor assessment, is also summarized here.

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Tables 1–2

Table 1. Characteristics of stream watersheds in the northeastern United States that were assessed as part of the U.S. Geological Survey Northeast Stream Quality Assessment in 2016.

[Latitude and longitude of water-quality-sample locations are based on the North American Datum of 1983 and shown in decimal degrees. Urbanization is represented as a gradient, from tier 1 (least) to tier 5 (greatest). States are abbreviated with two-letter postal codes; for example, NH is New Hampshire. Sites with NWIS station numbers highlighted were also part of the Atlantic Highlands flow-ecology study. U.S. Environmental Protection Agency Level III ecoregions: NCZ, Northeastern Coastal Zone; NEH, Northeastern Highlands; EGLL, Eastern Great Lakes Lowlands; NP, Northern Piedmont; NAP, Northern Allegheny Plateau. Agriculture categories: Ag, agriculture; LowAg, low agriculture; VLowAg, very low agriculture; Ref, reference. NWIS, U.S. Geological Survey National Water Information System; km^2, square kilometer]

NWIS station number	NWIS station name	Field identifier	Latitude (NWIS)	Longitude (NWIS)	Ecoregion	Drainage area (km^2)	Urban category[1]	Agriculture category[2]	Site type[3]
01073319	LAMPREY RIVER AT LANGFORD ROAD, AT RAYMOND, NH	NH_Lamprey	43.0414	-71.2017	NCZ	144.4	Tier 1	Ref	Light urban
01095220	STILLWATER RIVER NEAR STERLING, MA	MA_Stillwater	42.4109	-71.7912	NCZ	78.7	Tier 1	Ref	Light urban
01096710	ASSABET RIVER AT ALLEN STREET AT NORTHBOROUGH, MA	MA_Assabet	42.3294	-71.6300	NCZ	77.9	Tier 3	Ref	Urban
01097270	FORT POND BROOK AT RIVER ROAD NEAR SOUTH ACTON, MA	MA_FortPond	42.4594	-71.4428	NCZ	51.3	Tier 2	Ref	Urban
01100600	SHAWSHEEN RIVER NEAR WILMINGTON, MA	MA_Shawsheen	42.5681	-71.2148	NCZ	95.9	Tier 5	Ref	Urban
01101500	IPSWICH RIVER AT SOUTH MIDDLETON, MA	MA_Ipswich	42.5695	-71.0270	NCZ	113.7	Tier 4	Ref	Urban
01102345	SAUGUS RIVER AT SAUGUS IRONWORKS AT SAUGUS, MA	MA_Saugus	42.4695	-71.0070	NCZ	64.4	Tier 5	Ref	Urban
01103280	CHARLES RIVER AT MEDWAY, MA	MA_Charles	42.1398	-71.3895	NCZ	169.0	Tier 3	Ref	Urban
01105000	NEPONSET RIVER AT NORWOOD, MA	MA_Neponset	42.1776	-71.2009	NCZ	90.3	Tier 3	Ref	Urban
01105583	MONATIQUOT RIVER AT EAST BRAINTREE, MA	MA_Monatiquot	42.2209	-70.9781	NCZ	74.3	Tier 4	Ref	Urban
01105600	OLD SWAMP RIVER NEAR SOUTH WEYMOUTH, MA	MA_OldSwamp	42.1904	-70.9448	NCZ	12.0	Tier 5	Ref	Urban
01109000	WADING RIVER NEAR NORTON, MA	MA_Wading	41.9476	-71.1767	NCZ	111.7	Tier 3	Ref	Urban
01109070	SEGREGANSET RIVER NEAR DIGHTON, MA	MA_Segreganset	41.8404	-71.1428	NCZ	27.4	Tier 1	Ref	Light urban
01112262	MILL RIVER AT SUMMER STREET NEAR BLACKSTONE, MA	MA_MillSummer	42.0408	-71.5156	NCZ	74.0	Tier 2	Ref	Urban
01114000	MOSHASSUCK RIVER AT PROVIDENCE, RI	RI_Moshassuck	41.8340	-71.4106	NCZ	59.2	Tier 5	Ref	Urban
01114500	WOONASQUATUCKET RIVER AT CENTERDALE, RI	RI_Woonasqua	41.8590	-71.4873	NCZ	97.8	Tier 3	Ref	Urban
01115110	HUNTINGHOUSE BK AT ELMDALE RD AT N SCITUATE, RI	RI_Hunting	41.8468	-71.6117	NCZ	16.1	Tier 1	Ref	Light urban
01115114	RUSH BROOK NEAR ELMDALE RD NEAR NORTH SCITUATE, RI	RI_Rush	41.8376	-71.6120	NCZ	12.2	Tier 1	Ref	Light urban
01117800	WOOD RIVER NEAR ARCADIA, RI	RI_Wood	41.5740	-71.7206	NCZ	91.2	Tier 1	Ref	Light urban
01121000	MOUNT HOPE RIVER NEAR WARRENVILLE, CT	CT_Hope	41.8437	-72.1690	NCZ	75.1	Tier 1	Ref	Light urban
01121330	FENTON RIVER AT MANSFIELD, CT	CT_Fenton	41.8332	-72.2428	NCZ	49.7	Tier 1	Ref	Light urban
01123000	LITTLE RIVER NEAR HANOVER, CT	CT_LHanover	41.6718	-72.0523	NCZ	77.6	Tier 1	Ref	Light urban
01154000	SAXTONS RIVER AT SAXTONS RIVER, VT	VT_Saxtons	43.1376	-72.4881	NEH	186.7	Ref	Ref	Forested
01154950	COLD RIVER AT HIGH STREET, AT ALSTEAD, NH	NH_Cold	43.1494	-72.3617	NEH	193.2	Ref	Ref	Forested
01170100	GREEN RIVER NEAR COLRAIN, MA	MA_Green	42.7034	-72.6706	NEH	106.5	Ref	Ref	Forested

Table 1. Characteristics of stream watersheds in the northeastern United States that were assessed as part of the U.S. Geological Survey Northeast Stream Quality Assessment in 2016.—Continued

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NWIS station number	NWIS station name	Field identifier	Latitude (NWIS)	Longitude (NWIS)	Ecoregion	Drainage area (km^2)	Urban category[1]	Agriculture category[2]	Site type[3]
01174565	WEST BRANCH SWIFT RIVER NEAR SHUTESBURY, MA	MA_WBSwift	42.4551	-72.3818	NEH	32.9	Ref	Ref	Forested
01187300	HUBBARD RIVER NEAR WEST HARTLAND, CT	CT_Hubbard	42.0375	-72.9393	NEH	53.5	Ref	Ref	Forested
01189000	PEQUABUCK R AT FORESTVILLE, CT	CT_Pequabuck	41.6732	-72.9007	NCZ	118.3	Tier 3	Ref	Urban
01192500	HOCKANUM RIVER NEAR EAST HARTFORD, CT	CT_Hockanum	41.7832	-72.5873	NCZ	190.8	Tier 3	VLowAg	Urban
01193500	SALMON RIVER NEAR EAST HAMPTON, CT	CT_SalmonHam	41.5523	-72.4493	NCZ	260.5	Tier 1	Ref	Light urban
01194000	EIGHTMILE RIVER AT NORTH PLAIN, CT	CT_Eightmile	41.4417	-72.3327	NCZ	52.4	Ref	Ref	Forested
01195490	QUINNIPIAC RIVER AT SOUTHINGTON, CT	CT_Quinnipiac	41.6035	-72.8832	NCZ	46.1	Tier 4	Ref	Urban
01196620	MILL RIVER NEAR HAMDEN, CT	CT_MillHamden	41.4204	-72.9027	NCZ	63.6	Tier 2	Ref	Urban
01199050	SALMON CREEK AT LIME ROCK, CT	CT_SalmonLime	41.9423	-73.3910	NEH	76.1	Tier 1	Ref	Light urban
01203510	POOTATUCK RIVER AT SANDY HOOK, CT	CT_Pootatuck	41.4193	-73.2821	NCZ	64.5	Tier 2	Ref	Urban
01208869	ROOSTER RIVER NEAR FAIRFIELD, CT	CT_Rooster	41.1887	-73.2212	NCZ	19.4	Tier 5	Ref	Urban
01208925	MILL RIVER NEAR FAIRFIELD, CT	CT_MillFair	41.1655	-73.2700	NCZ	74.0	Tier 2	Ref	Urban
01209700	NORWALK RIVER AT SOUTH WILTON, CT	CT_Norwalk	41.1638	-73.4195	NCZ	77.5	Tier 1	Ref	Light urban
01209901	RIPPOWAM RIVER AT STAMFORD, CT	CT_Rippowam	41.0661	-73.5493	NCZ	88.6	Tier 2	Ref	Urban
010965852	BEAVER BROOK AT NORTH PELHAM, NH	NH_Beaver	42.7829	-71.3537	NCZ	123.1	Tier 3	Ref	Urban
01342730	STEELE CREEK AT ILION, NY	NY_Steele	43.0066	-75.0417	EGLL	68.0	Ref	Ag	Agriculture
01349150	CANAJOHARIE CREEK NR CANAJOHARIE, NY	NY_Canajoharie	42.8761	-74.6031	EGLL	152.8	Tier 1	Ag	Agriculture
01356190	LISHA KILL NORTHWEST OF NISKAYUNA, NY	NY_LishaKill	42.7836	-73.8567	NCZ	41.9	Tier 3	VLowAg	Urban
01359135	PATROON CREEK AT ALBANY, NY	NY_Patroon	42.6634	-73.7462	NCZ	35.7	Tier 5	VLowAg	Urban
01362200	ESOPUS CREEK AT ALLABEN, NY	NY_Esopus	42.1169	-74.3803	NEH	165.0	Ref	Ref	Forested
01362497	LITTLE BEAVERKILL AT BEECHFORD NEAR MT TREMPER, NY	NY_LBeaver	42.0194	-74.2664	NEH	43.2	Ref	Ref	Forested
01372040	CRUM ELBOW CR AT HYDE PARK, NY	NY_Crum	41.7906	-73.9302	NCZ	47.0	Tier 1	Ref	Light urban
01374559	WEST BRANCH CROTON RIVER AT RICHARDSVILLE, NY	NY_WBCroton	41.4706	-73.7600	NEH	28.5	Ref	Ref	Forested
01374890	CROSS RIVER NEAR CROSS RIVER, NY	NY_Cross	41.2602	-73.6019	NCZ	44.2	Tier 1	Ref	Light urban
01374930	MUSCOOT RIVER AT BALDWIN PLACE, NY	NY_Muscoot	41.3381	-73.7687	NCZ	34.3	Tier 2	Ref	Urban
01374960	HALLOCKS MILL BROOK AT YORKTOWN HEIGHTS, NY	NY_Hallocks	41.2845	-73.7740	NCZ	25.0	Tier 3	Ref	Urban

Table 1. Characteristics of stream watersheds in the northeastern United States that were assessed as part of the U.S. Geological Survey Northeast Stream Quality Assessment in 2016.—Continued

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NWIS station number	NWIS station name	Field identifier	Latitude (NWIS)	Longitude (NWIS)	Ecoregion	Drainage area (km^2)	Urban category[1]	Agriculture category[2]	Site type[3]
01376500	SAW MILL RIVER AT YONKERS, NY	NY_SawMill	40.9364	-73.8861	NCZ	66.1	Tier 4	Ref	Urban
01390500	SADDLE RIVER AT RIDGEWOOD, NJ	NJ_Saddle	40.9850	-74.0906	NP	54.4	Tier 2	VLowAg	Urban
01391000	HOHOKUS BROOK AT HO-HO-KUS, NJ	NJ_Hohokus	40.9978	-74.1119	NP	43.3	Tier 3	Ref	Urban
01414500	MILL BROOK NEAR DUNRAVEN, NY	NY_MillBrook	42.1061	-74.7306	NEH	65.0	Ref	Ref	Forested
01513550	CHOCONUT CREEK NEAR CHOCONUT, PA	PA_Choconut	41.9628	-76.0014	NAP	48.1	Ref	VLowAg	Forested
01513725	NANTICOKE CREEK AT AMES ROAD NEAR MAINE, NY	NY_Nanticoke	42.2155	-76.0394	NAP	120.7	Ref	LowAg	Agriculture
01513820	APALACHIN CREEK AT APALACHIN, NY	NY_Apalachin	42.0623	-76.1488	NAP	111.4	Ref	VLowAg	Forested
01531250	NB SUGAR CREEK TRIB NEAR COLUMBIA CROSS ROADS, PA	PA_NBSugar	41.8404	-76.8269	NAP	23.0	Ref	LowAg	Agriculture
0422026250	NORTHRUP CREEK AT NORTH GREECE, NY	NY_Northrup	43.2536	-77.7422	EGLL	26.3	Tier 2	LowAg	Urban
04229700	SPRING BROOK AT MORAN CORNER, NY	NY_Spring	42.9601	-77.6194	EGLL	58.7	Tier 1	Ag	Agriculture
04232050	ALLEN CREEK NEAR ROCHESTER, NY	NY_Allen	43.1303	-77.5186	EGLL	79.7	Tier 3	LowAg	Urban
04233300	SIXMILE CREEK AT BETHEL GROVE, NY	NY_Sixmile	42.4031	-76.4350	NAP	100.1	Ref	VLowAg	Forested
04240105	HARBOR BK AT HIAWATHA BLVD., SYRACUSE, NY	NY_Harbor	43.0561	-76.1850	EGLL	31.8	Tier 3	VLowAg	Urban
04240253	GEDDES BROOK AT FAIRMOUNT, NY	NY_Geddes	43.0573	-76.2338	EGLL	21.8	Tier 3	LowAg	Urban
04245840	SCRIBA CREEK NEAR CONSTANTIA, NY	NY_Scriba	43.2597	-76.0028	EGLL	103.0	Ref	VLowAg	Forested
405242073521001	BRONX RIVER AT WOODLAWN CEMETERY AT BRONX, NY	NY_Bronx	40.8784	-73.8695	NCZ	138.1	Tier 4	Ref	Urban
405409073485501	HUTCHINSON RIVER AT COLONIAL AVE AT PELHAM, NY	NY_Hutchinson	40.9026	-73.8155	NCZ	18.6	Tier 5	Ref	Urban
405708073440301	MAMARONECK RIVER AT WARD AVE AT MAMARONECK, NY	NY_Mamaroneck	40.9524	-73.7343	NCZ	58.9	Tier 3	Ref	Urban
411844074085601	RAMAPO RIVER AT RIVER ROAD AT HARRMAN, NY	NY_Ramapo	41.3122	-74.1489	NEH	26.6	Tier 3	Ref	Urban
411959073522901	PEEKSKILL HOLLOW CREEK AT LAKE PEEKSKILL, NY	NY_Peekskill	41.3331	-73.8747	NCZ	104.8	Tier 1	Ref	Light urban
412715074030101	SILVER STREAM AT VAILS GATE, NY	NY_Silver	41.4544	-74.0503	NCZ	17.2	Tier 3	LowAg	Urban
413020074022001	GIDNEYTOWN CREEK AT RT52 AT NEWBURGH, NY	NY_Gidneytown	41.5057	-74.0390	NCZ	24.9	Tier 1	VLowAg	Light urban
413453076041101	LITTLE MEHOOPANY CREEK AT NORTH MEHOOPANY, PA	PA_LMehoopany	41.5815	-76.0698	NAP	27.9	Ref	Ag	Agriculture
413735076162701	SUGAR RUN NEAR WILMOT, PA	PA_SugarRun	41.6264	-76.2744	NAP	86.9	Ref	Ag	Agriculture
413758073552401	CASPER CREEK AT BRIDGEWATER RD NR WAPPINGERS FALLS, NY	NY_Casper	41.6330	-73.9236	NCZ	27.5	Tier 4	Ref	Urban
414904073575201	BLACK CREEK ABOVE RTE 9W BRIDGE AT ESOPUS, NY	NY_BlackEsopus	41.8181	-73.9645	NCZ	87.3	Tier 1	VLowAg	Light urban

Table 1. Characteristics of stream watersheds in the northeastern United States that were assessed as part of the U.S. Geological Survey Northeast Stream Quality Assessment in 2016.—Continued

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NWIS station number	NWIS station name	Field identifier	Latitude (NWIS)	Longitude (NWIS)	Ecore-gion	Drainage area (km^2)	Urban cat-egory[1]	Agri-culture category[2]	Site type[3]
415929076544401	HAMMOND CREEK NEAR WELLS, PA	PA_Hammond	41.9963	-76.9074	NAP	75.1	Ref	LowAg	Agriculture
420103076540701	MUDLICK CREEK AT SEELEY CREEK, NY	NY_Mudlick	42.0175	-76.9022	NAP	60.0	Ref	Ag	Agriculture
420722075565001	LITTLE CHOCONUT CR AT ST JOHN'S CH AT JOHNSON CITY, NY	NY_LittleChoco	42.1228	-75.9473	NAP	32.7	Tier 2	LowAg	Light urban
422223074400201	WEST BRANCH DELAWARE R AT CORNELL AVE BRIDGE, HOBART, NY	NY_WBDelaware	42.3731	-74.6673	NAP	41.1	Tier 1	LowAg	Light urban
422644076300001	CASCADILLA CREEK AT ITHACA, NY	NY_Cascadilla	42.4458	-76.5003	NAP	34.1	Tier 1	LowAg	Light urban
423533076062101	TROUT BROOK AT CORTLANDVILLE, NY	NY_Trout	42.5928	-76.1059	NAP	93.0	Ref	LowAg	Agriculture
423613073422001	MILL CREEK AT EAST GREENBUSH, NY	NY_MillGreen	42.6036	-73.7057	NCZ	26.3	Tier 1	Ref	Light urban
424059073322501	POESTEN KILL AT BLUE FACTORY RD AT BARBERVILLE, NY	NY_Poesten	42.6832	-73.5405	NEH	93.0	Ref	Ref	Forested
424143073382901	WYNANTS KILL AT RUSSEL AVE AT WYNANTSKILL, NY	NY_Wynants	42.6955	-73.6414	NEH	75.1	Tier 1	VLowAg	Light urban
424633075300701	SANGERFIELD RIVER AT POOLVILLE, NY	NY_Sangerfield	42.7760	-75.5022	NAP	137.0	Ref	LowAg	Agriculture
424643073472901	SHAKERS CREEK AT RIVER ROAD NEAR LATHAM, NY	NY_Shakers	42.7787	-73.7915	NCZ	30.0	Tier 4	VLowAg	Urban
425358073462301	DWAAS KILL SOUTH OF USHERS, NY	NY_Dwaas	42.8997	-73.7731	NCZ	45.8	Tier 2	LowAg	Urban
425540074384801	OTSQUAGO CREEK NEAR FORT PLAIN, NY	NY_Otsquago	42.9277	-74.6467	EGLL	155.7	Ref	Ag	Agriculture
430056078044801	BLACK CREEK AT MORGANVILLE, NY	NY_BlackMorgan	43.0156	-78.0802	EGLL	56.6	Tier 1	Ag	Agriculture
430524076084201	LEY CREEK AT LEMOYNE AND FACTORY AT MATTYDALE, NY	NY_LeyCreek	43.0901	-76.1451	EGLL	61.7	Tier 5	Ref	Urban
430557075181801	MUD CREEK AT NEW YORK MILLS, NY	NY_MudCreek	43.0992	-75.3050	EGLL	29.1	Tier 2	LowAg	Urban
430629077274701	THOMAS CREEK AT EAST ROCHESTER, NY	NY_Thomas	43.1082	-77.4633	EGLL	76.5	Tier 2	LowAg	Urban
431542077382401	SLATER CREEK AT HOJACK INDUSTRIAL PARK IN ROCHESTER, NY	NY_Slater	43.2617	-77.6400	EGLL	10.7	Tier 5	Ref	Urban

[1]Urban categories represent ranges of percentages of urban land use in a watershed, computed as the total percentages of developed land as defined by the 2006 National Land Cover Database (sum of classes 22, 23, 24; Fry and others, 2011): Ref, 0–1 percent; tier 1, >1–10 percent; tier 2, >10–20 percent; tier 3, >20–37.5 percent; tier 4, >37.5–50 percent; and tier 5, >50 percent.

[2]Agriculture categories represent percent row crop land use in a watershed: Ref, 0–1 percent; VlowAg, >1–5 percent; LowAg, >5–15 percent; and Ag, >15 percent.

[3]Site type based on joint designations in the categories of Urban (Urb-cat) and Agriculture (Ag-cat). Forested: Urb-cat = Ref and Ag-cat = Ref or VLowAg; Light Urban: Urb-cat = Tier 1 and Ag-cat = Ref, VLowAg, or LowAg; Urban: Urb-cat = Tier 2, 3, 4, or 5 and Ag-cat = Ref, VlowAg, or LowAg; Agriculture: Urb-cat = Ref and Ag-cat = LowAg or Ag, or alternatively Urb-cat = Tier 1 and Ag-cat = Ag.

Table 2. Summary of data collected at each of the Northeast Stream Quality Assessment sites in 2016.

[Parameters are categorized by the Northeast Stream Quality Assessment study-design components: comprehensive stream water data, focused studies, and ecological surveys. Numerical values in the table indicate the number of times samples were collected/analyzed for each parameter type. "**I**" indicates an integrated sample. "C" indicates a continuous sample. "D" indicates sites where components of ecological surveys were delayed from August until October 2016. "1*iso*" indicates that mercury isotopes were also analyzed. States are abbreviated with two-letter postal codes; for example, NH is New Hampshire. POCIS, polar organic chemical integrative sampler; PAH, polycyclic aromatic hydrocarbon; --, not sampled.]

Site information		Comprehensive stream water data															Focused studies			Ecological surveys					
Field identifier	Primary land-use type	Major ions	Nutrients	Pesticides	Glyphosate	Suspended sediment	Dissolved organic carbon	Mercury	Nitrate isotopes	Organic waste indicators	Pharmaceuticals	Algal toxins	POCIS	Stream discharge	Stream stage	Temperature	Pesticide autosampler	Walling tube sediment	Algal productivity	Aquatic biota	Mercury in fish	Sediment chemistry	Sediment PAH	Sediment toxicity	Physical habitat
NH_Lamprey	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	--	1
MA_Stillwater	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	1	--	1
MA_Assabet	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	**I**	--	1	1	1	1	1	1
MA_FortPond	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	--	1
MA_Shawsheen	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	2	1	1	1
MA_Ipswich	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	**I**	--	1	1*iso*	1	1	1	1
MA_Saugus	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	--	1	1	1	1
MA_Charles	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	**I**	**I**	--	1	1*iso*	2	1	1	1
MA_Neponset	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	**I**	--	1	1*iso*	2	1	1	1
MA_Monatiquot	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	2	1	1	1
MA_OldSwamp	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	1	1	1
MA_Wading	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	1	1
MA_Segreganset	Light urban	2	2	2	2	2	2	1	1	0	0	0	**I**	C	--	C	--	--	--	--	--	--	--	--	--
MA_MillSummer	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	1	1
RI_Moshassuck	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	**I**	**I**	--	1	1	2	1	1	1
RI_Woonasqua	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	1	1D
RI_Hunting	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	1	1
RI_Rush	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	--	1
RI_Wood	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	--	1D
CT_Hope	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	--	--	1
CT_Fenton	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	--	1
CT_LHanover	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	--	--	1
VT_Saxtons	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	--	--	1
NH_Cold	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	--	--	1
MA_Green	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1D	1	1	1	1	1
MA_WBSwift	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	--	--	1
CT_Hubbard	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	--	--	1
CT_Pequabuck	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	C	1D	1	1	1	1	1D
CT_Hockanum	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	**I**	--	--	1	1	1	1	1	1
CT_SalmonHam	Light urban	4	4	4	4	4	4	4	1	3	3	1	**I**	C	--	C	--	--	C	1	1	1	1	--	1
CT_Eightmile	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	--	--	1
CT_Quinnipiac	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1D	1	1	1	1	1D

Table 2. Summary of data collected at each of the Northeast Stream Quality Assessment sites in 2016.—Continued

[Parameters are categorized by the Northeast Stream Quality Assessment study-design components: comprehensive stream water data, focused studies, and ecological surveys. Numerical values in the table indicate the number of times samples were collected/analyzed for each parameter type. "**I**" indicates an integrated sample. "C" indicates a continuous sample. "D" indicates sites where components of ecological surveys were delayed from August until October 2016. "1*iso*" indicates that mercury isotopes were also analyzed. States are abbreviated with two-letter postal codes; for example, NH is New Hampshire. POCIS, polar organic chemical integrative sampler; PAH, polycyclic aromatic hydrocarbon; --, not sampled.]

Site information		Comprehensive stream water data															Focused studies			Ecological surveys					
Field identifier	Primary land-use type	Major ions	Nutrients	Pesticides	Glyphosate	Suspended sediment	Dissolved organic carbon	Mercury	Nitrate isotopes	Organic waste indicators	Pharmaceuticals	Algal toxins	POCIS	Stream discharge	Stream stage	Temperature	Pesticide autosampler	Walling tube sediment	Algal productivity	Aquatic biota	Mercury in fish	Sediment chemistry	Sediment PAH	Sediment toxicity	Physical habitat
CT_MillHamden	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	--	1
CT_SalmonLime	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	--	1
CT_Pootatuck	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	1	1
CT_Rooster	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	2	1	1	1
CT_MillFair	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	1	--	1
CT_Norwalk	Light urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	C	1	1	2	1	1	1
CT_Rippowam	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	1	1	1
NH_Beaver	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	1	1	1
NY_Steele	Agriculture	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	--	--	1
NY_Canajoharie	Agriculture	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	**I**	**I**	C	1	1	2	1	1	1
NY_LishaKill	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1D	1D	2D	1D	1D	1D
NY_Patroon	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	**I**	**I**	--	1D	--	2D	1D	1D	1D
NY_Esopus	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	--	--	1
NY_LBeaver	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	--	--	1
NY_Crum	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	--	1
NY_WBCroton	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	1	1
NY_Cross	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	--	--	1
NY_Muscoot	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	1	1	1
NY_Hallocks	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1*iso*	1	1	--	1
NY_SawMill	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1*iso*	1	1	1	1
NJ_Saddle	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	1	1
NJ_Hohokus	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	--	1
NY_MillBrook	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	--	--	1
PA_Choconut	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	--	--	1
NY_Nanticoke	Agriculture	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	--	--	1
NY_Apalachin	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	--	--	1
PA_NBSugar	Agriculture	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	1	1
NY_Northrup	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	1	1
NY_Spring	Agriculture	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	1	1
NY_Allen	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	1	1	1
NY_Sixmile	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	--	--	1
NY_Harbor	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	C	--	C	--	--	--	1	1	1	1	1	1

Table 2. Summary of data collected at each of the Northeast Stream Quality Assessment sites in 2016.—Continued

[Parameters are categorized by the Northeast Stream Quality Assessment study-design components: comprehensive stream water data, focused studies, and ecological surveys. Numerical values in the table indicate the number of times samples were collected/analyzed for each parameter type. "**I**" indicates an integrated sample. "C" indicates a continuous sample. "D" indicates sites where components of ecological surveys were delayed from August until October 2016. "1*iso*" indicates that mercury isotopes were also analyzed. States are abbreviated with two-letter postal codes; for example, NH is New Hampshire. POCIS, polar organic chemical integrative sampler; PAH, polycyclic aromatic hydrocarbon; --, not sampled.]

Site information		Comprehensive stream water data															Focused studies			Ecological surveys					
Field identifier	Primary land-use type	Major ions	Nutrients	Pesticides	Glyphosate	Suspended sediment	Dissolved organic carbon	Mercury	Nitrate isotopes	Organic waste indicators	Pharmaceuticals	Algal toxins	POCIS	Stream discharge	Stream stage	Temperature	Pesticide autosampler	Walling tube sediment	Algal productivity	Aquatic biota	Mercury in fish	Sediment chemistry	Sediment PAH	Sediment toxicity	Physical habitat
NY_Geddes	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	**I**	--	1	1	1	1	1	1
NY_Scriba	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	C	--	C	--	--	--	1	1*iso*	1	1	1	1
NY_Bronx	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	**I**	**I**	--	1	1*iso*	2	1	1	1
NY_Hutchinson	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	**I**	--	--	1	1	2	1	1	1
NY_Mamaroneck	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1*iso*	1	1	1	1
NY_Ramapo	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	1	1
NY_Peekskill	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	--	1
NY_Silver	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	1	1
NY_Gidneytown	Light urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	1	1
PA_LMehoopany	Agriculture	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	--	--	1
PA_SugarRun	Agriculture	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	1	1
NY_Casper	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	**I**	--	1	1*iso*	1	1	1	1
NY_BlackEsopus	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	--	--	1
PA_Hammond	Agriculture	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	--	--	1
NY_Mudlick	Agriculture	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	--	--	1
NY_LittleChoco	Light urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	--	1
NY_WBDelaware	Light urban	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	--	--	1D	1	1	1	--	1
NY_Cascadilla	Light urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	--	1
NY_Trout	Agriculture	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	--	--	1
NY_MillGreen	Light urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	**I**	--	1D	1D	1D	1D	1D	1D
NY_Poesten	Forested	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	**I**	--	1D	1D	1D	--	--	1D
NY_Wynants	Light urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	--	1
NY_Sangerfield	Agriculture	4	4	4	4	4	4	3	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	--	--	1
NY_Shakers	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	1	1
NY_Dwaas	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1D	1	1	1	1	1
NY_Otsquago	Agriculture	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	**I**	C	1	1	1	--	--	1
NY_BlackMorgan	Agriculture	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	**I**	--	1	1	2	1	1	1
NY_LeyCreek	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1*iso*	2	1	1	1
NY_MudCreek	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	--	1
NY_Thomas	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1*iso*	1	1	1	1
NY_Slater	Urban	9	9	9	9	9	9	4	1	3	3	1	**I**	--	C	C	--	--	--	1	1	1	1	1	1

Appendixes 1–2

Appendix 1. Description of the Sampling Timelines, Matrix, Collection, and Processing for Water, Sediment, and Ecological Samples

[Appendix tables are available for download at https://doi.org/10.3133/ofr20181183]

Tables

Appendix 2. Description of the U.S. Geological Survey National Water Quality Laboratory Schedules Used for Water, Sediment, and Periphyton

[Appendix tables are available for download at https://doi.org/10.3133/ofr20181183]

Tables

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