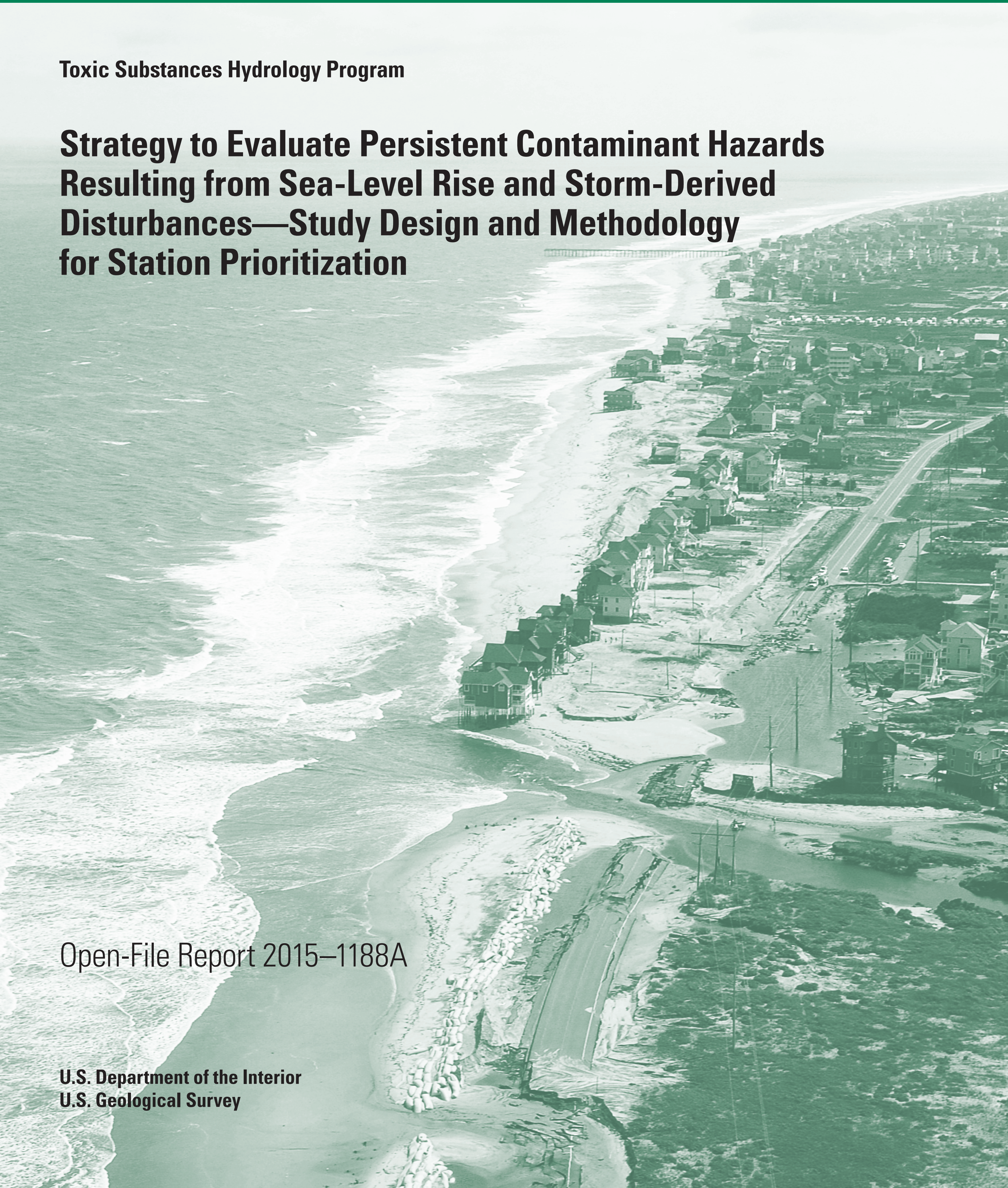
Toxic Substances Hydrology Program

Strategy to Evaluate Persistent Contaminant Hazards Resulting from Sea-Level Rise and Storm-Derived Disturbances—Study Design and Methodology for Station Prioritization



Open-File Report 2015–1188A

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

Cover. Breach in the coastline at Rodanthe, North Carolina, caused by Hurricane Irene in August 2011. Photograph by Karen Morgan, U.S. Geological Survey.

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SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2015

Suggested citation:
Reilly, T.J., Jones, D.K., Focazio, M.J., Aquino, K.C., Carbo, C.L., Kaufhold, E.E., Zinecker, E.K., Benzel, W.M., Fisher, S.C., Griffin, D.W., Iwanowicz, L.R., Loftin, K.A. and Schill, W.B., 2015, Strategy to evaluate persistent contaminant hazards resulting from sea-level rise and storm-derived disturbances—Study design and methodology for station prioritization: U.S. Geological Survey Open-File Report 2015–1188A, 20 p., http://dx.doi.org/10.3133/ofr20151188A.

ISSN 2331-1258 (online)

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Conversion Factors

International System of Units to Inch/Pound

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	0.0002471	acre
square kilometer (km^2)	247.1	acre

Datum

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

Acronyms

CAS	Chemical Abstracts Service
DNA	deoxyribonucleic acid
DOI	U.S. Department of the Interior
dPCR	digital PCR
EH	environmental health
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FRS	Facility Registry Service
FTIR	Fourier transform infrared spectroscopy
GC/MS	gas chromatography/mass spectrometry
HSDB	Hazardous Substances Data Bank
IBTrACS	International Best Track Archive for Climate Stewardship
LC/fluorescence	liquid chromatography fluorescence spectroscopy
LC/TOF MS	liquid chromatography/time-of-flight mass spectrometry
LC/UV-Vis	liquid chromatography/ultraviolet-visible spectroscopy
LIBS	laser-induced breakdown spectroscopy
MRSA	methicillin-resistant *Staphylococcus aureus*

NAWQA	National Water Quality Assessment
NOAA	National Oceanic and Atmospheric Administration
NTAS	National Target Analyte Strategy
NWS	National Weather Service
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PCR	polymerase chain reaction
pXRF	portable x-ray fluorescence
qPCR	quantitative-PCR
RNA	ribonucleic acid
SCoRR	Sediment-Bound Contaminant Resiliency and Response
SET-MH	Surface Elevation Table-Marker Horizon network
SFHA	special flood hazard area
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
SLR	sea-level rise
SOP	standard operating procedure
SWaTH	Surge, Wave, and Tide Hydrodynamic network
TRI	Toxic Release Inventory
USGS	U.S. Geological Survey
WSC	Water Science Center
WWTP	wastewater-treatment plant

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Abstract

Coastal communities are uniquely vulnerable to sea-level rise (SLR) and severe storms such as hurricanes. These events enhance the dispersion and concentration of natural and anthropogenic chemicals and pathogenic microorganisms that could adversely affect the health and resilience of coastal communities and ecosystems in coming years. The U.S. Geological Survey has developed a strategy to define baseline and post-event sediment-bound environmental health (EH) stressors (hereafter referred to as the Sediment-Bound Contaminant Resiliency and Response [SCoRR] strategy). A tiered, multi-metric approach will be used to (1) identify and map contaminant sources and potential exposure pathways for human and ecological receptors, (2) define the baseline mixtures of EH stressors present in sediments and correlations of relevance, (3) document post-event changes in EH stressors present in sediments, and (4) establish and apply metrics to quantify changes in coastal resilience associated with sediment-bound contaminants. Integration of this information provides a means to improve assessment of the baseline status of a complex system and the significance of changes in contaminant hazards due to storm-induced (episodic) and SLR (incremental) disturbances. This report describes the purpose and design of the SCoRR strategy and the methods used to construct a decision support tool to identify candidate sampling stations vulnerable to contaminants that may be mobilized by coastal storms.

Introduction

The U.S. Geological Survey (USGS) Hurricane Sandy Science Plan (Buxton and others, 2013) was designed and implemented in 2012 to supplement response activities that took place before and immediately after the storm struck the eastern coast of the United States. This plan was organized into five themes to characterize the forces and effects of Hurricane Sandy. The primary objective of the fourth theme (Impacts on Environmental Quality and Persisting Contaminant Exposures) was to determine the extent of potential long-term exposures of humans and ecosystems to contaminants in the nearshore marine and beach environments resulting from Hurricane Sandy (Buxton and others, 2013; Caskie, 2013). Specific activities included—

- Reconnaissance sampling of contaminants in sediments collected in nearshore environments. These samples underwent in vitro bioassay screening for toxicity and chemical activities, as well as a battery of legacy and emerging chemical contaminant analyses (Fischer and others, 2015).
- Comparison of contaminant occurrence before and after Hurricane Sandy.
- Assessment of major contaminant sources from compromised infrastructure, such as wastewater-treatment plants and on-site septic systems.
- Assessment of beach-dune replenishment activities that potentially present a hazard to humans through leaching of toxic metals or other contaminants from source materials such as previously anoxic back-bay sediments.
- Evaluation of ecological receptors, including potentially harmful levels of contaminants in bluefish and mussel tissue, consumption of which can be a concern for humans and wildlife.

Sufficient data were collected during this study from key areas that had been evaluated as part of current and past monitoring programs such that mapping of baseline contamination sources and receptors along the northeast coast of the United States could be initiated. The data will be evaluated to identify processes controlling contaminant exposure and dispersal, and initial assessments of contaminant conditions throughout the northeast coast will be provided as part of ongoing work. However, the lack of an existing multimetric sediment-quality assessment of integrated environmental health (EH) stressors forced reliance on historical data collected by the USGS and other agencies (particularly the U.S. Environmental Protection Agency [EPA] and National Oceanic and Atmospheric Administration [NOAA]) that lacked the density, extent, and analyses necessary to rigorously evaluate EH effects throughout the region.

A major limitation in conducting contaminant analyses after a storm and evaluating the resiliency of the environment and mitigation efforts is the lack of prestorm contaminant concentrations for comparative purposes. This data gap underscores the need for conducting baseline sediment-quality assessments in both nearshore and aquatic environments at locations relevant to human and ecological health. Resource managers also require assessment of ecosystem benefits associated with sediment quality for which no established methods of quantification are available. To be successful, these assessments and accompanying metrics require method development and carefully designed data-collection strategies to be completed to facilitate implementation and application in order to evaluate mitigation efforts.

Study Objectives

In order to appropriately measure the resiliency of the coastal environment to contaminant threats, a strategy for assessing the relation of contaminant changes and EH receptor effects is needed. The Sediment-Bound Contaminant Resiliency and Response (SCoRR) strategy addresses this need by establishing metrics for quantifying environmental change and associated threats to ecosystems and humans from sediment-bound contaminants (which include chemical and biological constituents capable of causing adverse effects on humans or biota), either through episodic events such as hurricanes or through incremental changes such as sea-level rise (SLR), in order to provide information critical to adaptive management strategies employed by the U.S. Department of the Interior (DOI) and other Federal and State agencies. The objectives of this study are to:

1. Develop a strategy to assess contaminant threats to humans and ecosystems induced by SLR and severe storms.
2. Demonstrate the strategy by conducting a pilot implementation in the northeastern United States.
3. Map, measure, and evaluate vulnerability of sampling stations relevant to ecosystem and human health to contaminant threats.

Purpose and Scope

This report describes the purpose and design of the SCoRR strategy and the methods used to develop the decision support tool that can be used to identify candidate sampling stations vulnerable to contaminants that may be mobilized by coastal storms.

Study Area

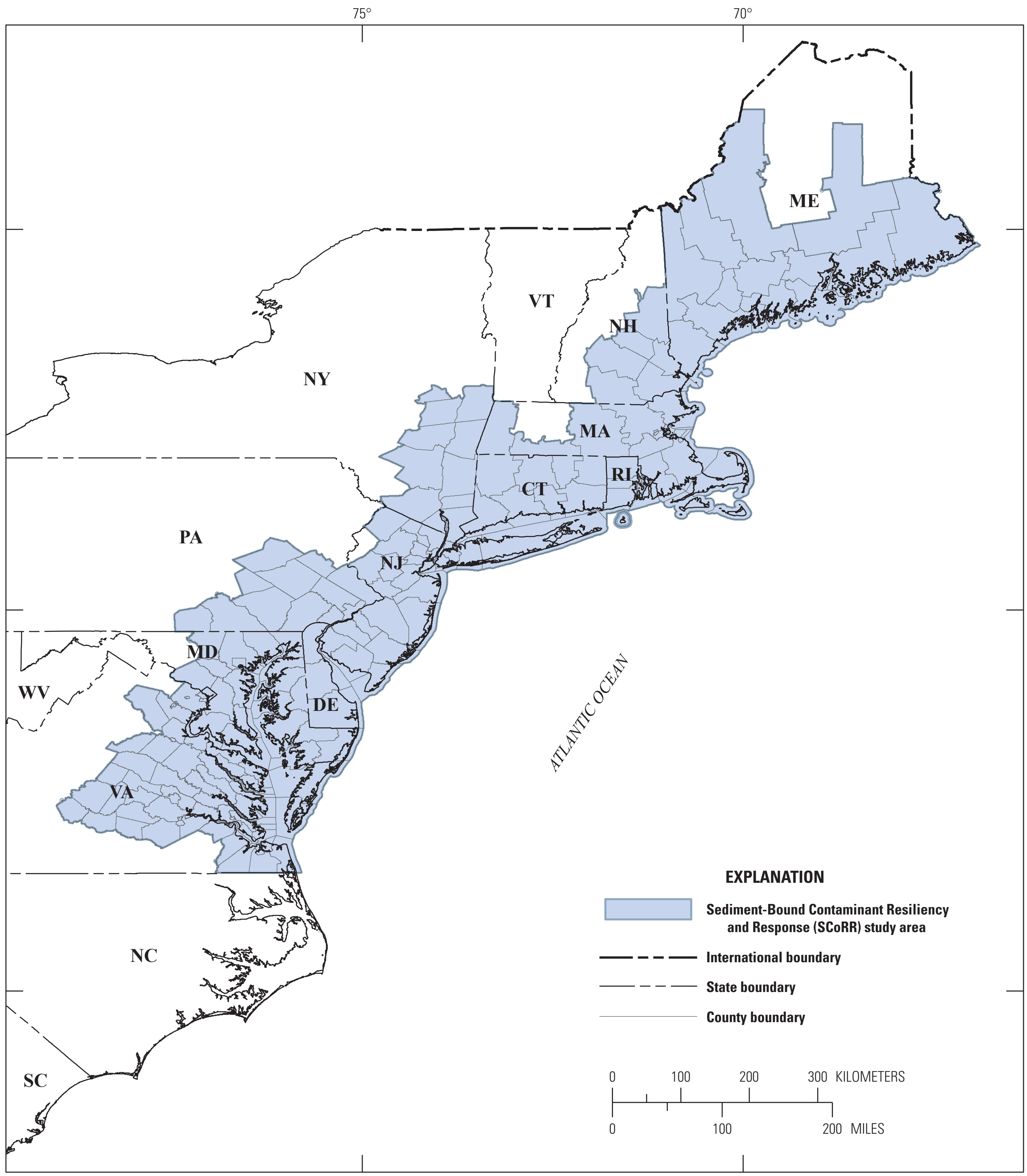
The study area for the demonstration of the SCoRR strategy encompasses the coastal watershed counties of Virginia, Maryland, Delaware, New Jersey, Pennsylvania, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine, as well as the District of Columbia (fig. 1). Coastal watershed counties are defined as counties in which at least 15 percent of the area drains to coastal watersheds as delineated by NOAA and the USGS, and represent areas where changes in land use and water quality most directly affect coastal ecosystems (National Oceanic and Atmospheric Administration, 2015). Once successfully demonstrated, this strategy can be implemented or integrated into existing USGS networks in the Northeast. The strategy could be extended to other regions by adapting protocols and metrics developed for the Northeast to address region-specific conditions and stressors.

Strategy Design

The SCoRR strategy has two operational modes, Resiliency Mode and Response Mode, each of which is defined by five key sequential tasks (prioritization, acquisition, analysis, reporting, and evaluation) (fig. 2).

Resiliency Mode

Under normal (non-event-related) conditions, SCoRR operates in Resiliency Mode to provide baseline sediment-quality data to document incremental changes (for example, SLR) and define and apply EH metrics based on sediment quality. Sampling stations within the study area are prioritized for sampling on the basis of their receptor-based EH relevance and systematic criteria that are used to evaluate proximal contaminant sources and storm vulnerabilities (described in detail farther on in this report). Samples are acquired in coordination with local USGS Water Science Center (WSC) staff on an established schedule. Collected samples are evaluated with a battery of qualitative chemical and biological activity screening tools reflective of a tiered analytical and data integration strategy that will identify vulnerable human and environmental receptors, the sediment-bound contaminants present, and the biological activity and potential effects resulting from exposure to characterized sediments. A subset of samples



Base from U.S. Geological Survey 1:24,000 scale digital data,
North American Datum of 1983 (NAD 83)

Figure 1. Sediment-Bound Contaminant Resiliency and Response (SCoRR) strategy demonstration study area, northeastern United States.

is subjected to additional quantitative analyses to verify and assure the quality of the results and to compare them to analytical results for Response Mode (post-event) samples. Resiliency Mode results will be reported through a SCoRR Web site by using map-based visualization tools and an online database. Interpretations of these results will be accessible to, and their availability will be communicated to, stakeholders and the scientific community.

Response Mode

When a severe storm (anticipated to be damaging to human or ecological communities and multistate in scale) is forecast to affect the study area, Resiliency Mode activities are suspended and Response Mode is initiated to characterize the EH effects of the event. During the demonstration of the SCoRR strategy, the decision to activate Response Mode activities is made by the SCoRR team lead on the basis of input from personnel from other USGS programs and networks with hazard-response duties and the SCoRR staff. Formal criteria for Response Mode activation will need to be defined once the strategy has been proven successful and established as an ongoing operational capacity. Stations prioritized during Resiliency Mode will be evaluated to ensure that adequate pre-event data exist within the projected storm track. If data are insufficient, pre-event samples will be collected from priority locations. Crews will be deployed post-event to resample these stations, allowing direct evaluation of effects, as well as redefining baseline sediment-quality conditions for these areas. During the demonstration of this strategy, stations will be resampled once. All samples collected will be analyzed by using qualitative screening tools and confirmatory quantitative analyses (discussed in detail below). Response Mode results will be distributed and reviewed internally as rapidly as possible for dissemination to health officials, wildlife managers, and other key decision makers, and then released to the public on the SCoRR Web site.

Both Resiliency and Response Mode data will be evaluated by using a series of EH metrics developed to allow for the identification of potentially harmful EH effects from episodic stressors. A plan for developing these metrics is

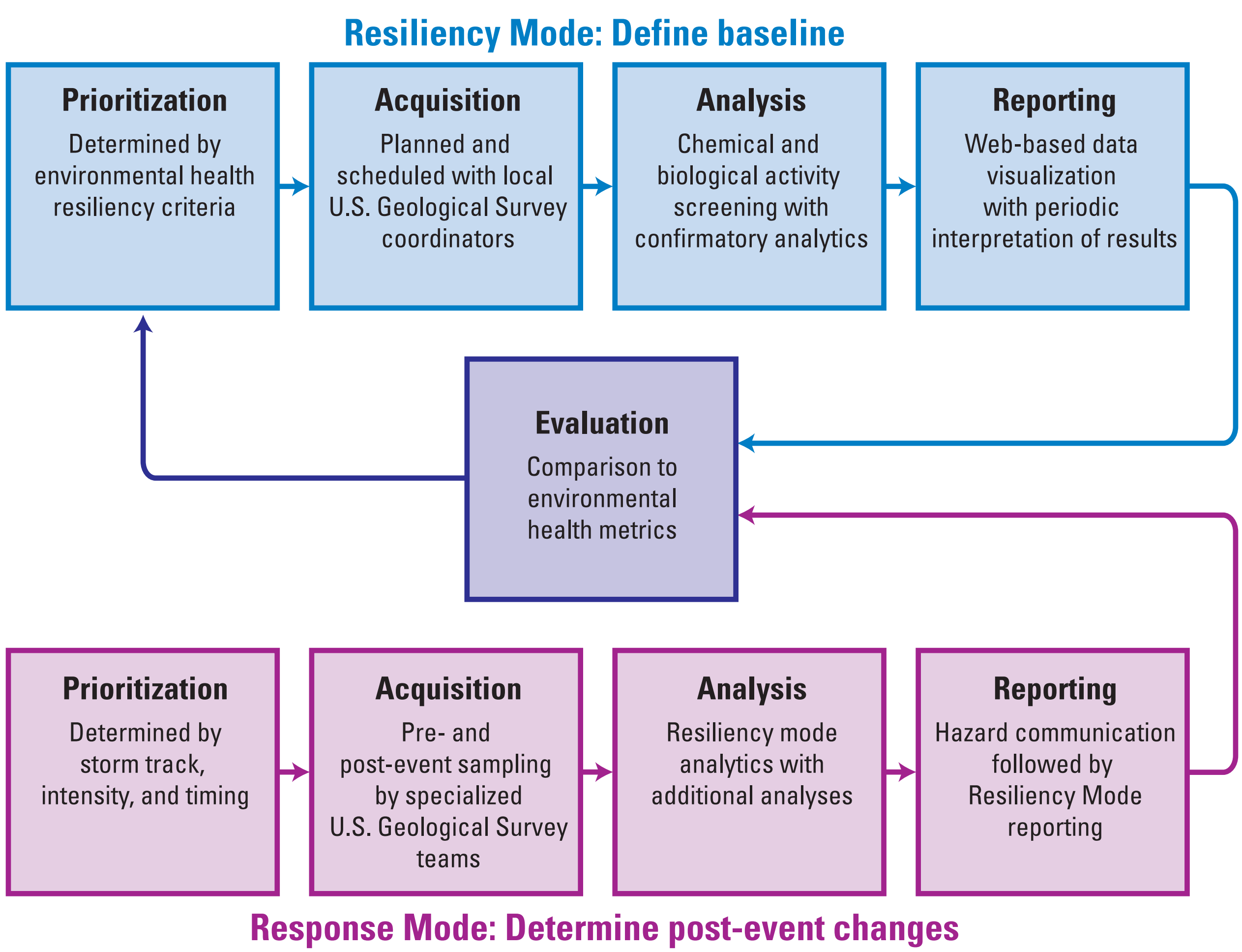


Figure 2. Conceptual design of the Sediment-Bound Contaminant Resiliency and Response (SCoRR) strategy.

included in the Metric Development section of this report. The scope of this demonstration of the SCoRR strategy is to collect one round of Resiliency Mode samples and to evaluate one storm in Response Mode. If the SCoRR strategy is implemented as an ongoing network, periodic resampling at locations after events in Resiliency Mode will inform evaluations of incremental influences such as SLR, natural attenuation of contaminants, mitigation practices, and other adaptive management strategies.

Analytical Approach and Site-Selection Criteria

A multimetric, tiered data integration and analytical approach (fig. 3) has been developed as part of SCoRR. This approach will be used to identify vulnerable human and environmental receptors, the presence or absence of sediment-bound contaminants, and the biological activity of and potential effects of exposure to sediments from these settings. It will demonstrate the linkage between the geospatial analyses used to identify potential sources of contamination, historical sediment contaminant data, and associated biological effects data (Tier 1), and will then be applied to the design of the SCoRR strategy. Subsequent qualitative (Tier 2) and quantitative (Tier 3) analytics will be used to document baseline (Resiliency Mode) and event-based (Response Mode) EH stressors. Subsequent biological uptake, fate, transport, and exposure studies (Tier 4) can be designed and prioritized on the basis of SCoRR strategy findings.

Thousands of candidate locations will be characterized and prioritized in the Tier 1 phase of the study. The following criteria will be used to identify potential sampling stations:

1. Environmental health relevance—contaminant sources and exposure pathways, presence of human and ecological receptors (for example, DOI trust lands, recreational areas, critical habitats), and historical sediment quality and (or) biological effects data;

2. Resiliency relevance—proximity to SLR mitigation efforts (for example, restored salt marshes, living shorelines) and critical infrastructure (for example, wastewater-treatment plants [WWTPs] and drinking-water intakes);

3. Leverage—connection to other USGS data-collection networks (for example, Surge, Wave, and Tide Hydrodynamic [SWaTH], Surface Elevation Table-Marker Horizon [SET-MH], local WSC streamgage and water-quality networks);

4. Stakeholder input—importance of the station to local and national stakeholder interests; and

5. Accessibility—can the station be sampled safely and rapidly during or soon after an event?

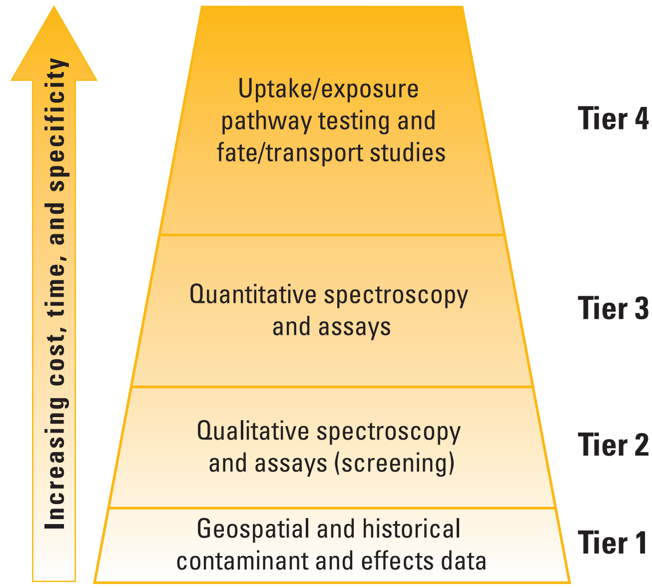


Figure 3. Sediment-Bound Contaminant Resiliency and Response (SCoRR) multimetric, tiered data integration and analytical strategy.

The vulnerability of these locations to coastal storms and contaminant threats will be assessed and attributed to each location by using a decision support tool described farther on in this report (see section called Decision Support Tool for Station Prioritization). The same criteria will be used during Response Mode, with each of the above criteria modified to consider storm track, intensity, and timing based on SWaTH network activity and National Weather Service (NWS) predictions.

Decision Support Tool for Station Prioritization

Background

As a result of the scale of the study area and the number of potential sampling stations, a methodology was required to categorize and evaluate potential stations in order to prioritize a representative subset of stations for sampling during Resiliency and Response Modes. Furthermore, the methodology had to remain flexible and adaptable given the broad array of geologic, land-use, and climatic variables encompassed by the SCoRR study region.

To prioritize sampling stations, a decision support tool was developed that assigns a prioritization value to each station on the basis of proximal contaminant sources and storm vulnerabilities. The tool uses public, nationally available data sources provided by the EPA, the Federal Emergency Management Agency (FEMA), and the NWS to define contaminant sources and storm vulnerabilities. Contaminant point sources are assigned an initial potential contamination hazard rank ranging from 1 to 4 on the basis of the perceived toxicity, volatility, and environmental or human exposure potential of the contaminant present. Historical and probabilistic storm vulnerability data are then used to weight the potential hazard ranks wherever the contaminant source and storm vulnerability datasets intersect. Proximity analyses are then used to identify nearby contaminant sources for each sampling location, and a final sampling-station priority value is determined by summing proximal storm-weighted potential contamination hazard ranks by using a distance weighting equation.

Methods

Data Sources

Two EPA data sources were used to define potential contaminant point sources: the Toxic Release Inventory (TRI) (U.S. Environmental Protection Agency, 2015b) and the Facility Registry Service (FRS) (U.S. Environmental Protection Agency, 2015a) databases. The TRI tracks the management of facilities with toxic chemicals that may pose a threat to human health and the environment. Each facility is required to report annually the quantities of each chemical stored, produced, and (or) released on- or offsite. The TRI includes facility coordinates, North American Industry Classification System (NAICS) codes, a list of the types and quantities of chemicals (contaminants) housed or released at each facility, Chemical Abstracts Service (CAS) numbers, and unique facility identification numbers that can be used to access additional facility information online (U.S. Environmental Protection Agency, 2014). The FRS database catalogs businesses, facilities, sites, or locations subject to environmental regulations or of interest to the EPA and the programs it administers and (or) enforces (U.S. Environmental Protection Agency, 2015a). The FRS database provides similar facility information to the TRI database, but includes additional facilities that do not fall under the TRI designation (for example, facilities that are not permitted to release toxic substances). Unlike the TRI, the FRS does not provide information about the types and quantities of chemicals housed, produced, or released at each facility. Instead, the FRS details any regulations associated with each facility entry, providing a means to identify additional facilities outside the TRI that may release contaminants in the event of a disaster.

Data Preparation

Substantial quality assurance of the TRI and FRS data was required to remove duplicate and (or) incomplete facility records prior to analysis. Datasets were organized into a spreadsheet and erroneous or incomplete records were removed by using Microsoft® Excel®. As a result of the large number of records and the self-reported nature of the data, however, it is likely that duplicate or erroneous records remain. While problematic, the inclusion of these records does not substantially affect the prioritization process because of the conservative (protective) assumptions (described below) used, and does not detract from the demonstration of the SCoRR strategy.

After each dataset was quality assured, contaminant rankings were applied to each facility record by following the methodology outlined below. Data tables of ranked facilities were then converted into point shapefiles on the basis of each facility's latitude and longitude coordinates for geospatial analyses. In the event that a facility reported multiple constituents and (or) programs of interest to the EPA, the highest ranking constituent or program was selected to represent the facility, thereby ensuring that the highest potential contaminant hazard ranking attributable to that facility was used.

Ranking of Contaminant Source Data

TRI and FRS facilities were assigned potential contaminant hazard ranks ranging from 1 to 4 on the basis of the contaminant hazard(s) present at each facility. Different ranking methods were required for the TRI and FRS data because of inherent differences in the facility information available from the two data sources (that is, the TRI details the type and quantity of chemicals, whereas the FRS details only the regulations applicable to each facility).

To rank the TRI records, a prioritization scheme developed by Olsen and others (2013) was modified and applied to each recorded constituent in the TRI database by matching CAS numbers. Olsen and others (2013) evaluated and prioritized 2,541 constituents for national- and regional-scale monitoring of water and sediment as part of the USGS National Water Quality Assessment (NAWQA) National Target Analyte Strategy (NTAS) work group (see appendix A [at end of report] for additional information). Constituents were prioritized on the basis of available information detailing physical and chemical properties, observed or predicted environmental occurrence and fate, and observed or anticipated adverse effects on human or aquatic health (Olsen and others, 2013). One of three prioritization tiers (hereafter referred to as Olsen tiers to distinguish them from the tiers associated with the SCoRR strategy) was assigned to each constituent (by CAS number) and separated into groups for sediment and water monitoring. Constituents listed in Olsen Tier 1 have the highest priority for monitoring because of the likelihood of their occurrence in the environment or the likelihood of potential adverse effects on human health or aquatic life. Constituents in Olsen Tier 2 have intermediate priority for monitoring because of lower environmental occurrence and (or) lesser effects on human health or aquatic life. Olsen Tier 3 is composed of constituents that have low or no priority for monitoring because of minimal to no environmental occurrence and (or) human or ecological health effects. Also included in Olsen Tier 3 are constituents for which evidence of occurrence or effects is insufficient to place them in Olsen Tier 2.

CAS numbers were used to apply prioritization values from Olsen and others (2013) to each listed constituent record in the TRI database (see appendix B [at end of report] for more information). Tier ranks from both the water and sediment categories were considered and adjusted to conform to a four-tier SCoRR ranking system detailed in tables 1 and 2. A four-tier system was used to accommodate the alternative ranking methodology used for the FRS data described below. A total of 91 additional constituents listed in the TRI were not included in Olsen's (2013) analysis. These additional constituents were evaluated following the Olsen (2013) methodology using constituent data found in material safety data sheets in the Toxnet Hazardous Substances Data Bank (HSDB) (http://toxnet.nlm.nih.gov/) provided by the U.S. National Library of Medicine. Solubility, mobility, toxicity, bioaccumulation/absorption, and decomposition characteristics were compiled from the HSDB and used to rank each constituent according to Olsen's (2013) methodology (see appendix B for more information).

Table 1. Olsen tiers for sediment and water and associated Sediment-Bound Contaminant Resiliency and Response (SCoRR) ranks.

[Olsen tiers defined in Olsen and others (2013); N/A, not available]

Olsen tier (water)	Olsen tier (sediment)	SCoRR rank
1	1	4
1	2	4
2	1	4
1	3	4
3	1	4
1	N/A	4
N/A	1	4
2	2	3
3	2	3
2	3	3
2	N/A	3
N/A	2	3
3	3	2
3	N/A	1
N/A	3	1

Table 2. Sediment-Bound Contaminant Resiliency and Response (SCoRR) contaminant hazard potential ranks, and their associated explanations and Olsen tier designations.

[Olsen tiers defined in Olsen and others (2013)]

SCoRR rank	Explanation
1	Little to no hazard risk to human/aquatic life; Olsen tier = 4
2	Mild effects on human/aquatic life; Olsen tier = 3
3	Slightly hazardous effects on human/aquatic life; Olsen tier = 2
4	Hazardous effects on human/aquatic life; Olsen tier = 1

The methodology of Olsen and others (2013) could not be applied to the FRS records because the FRS lacks specific information about the constituents stored, released, or produced by a given facility. Therefore, three attribute fields were used to assess the potential contaminant hazard rank of a facility:

1. Environmental Program Type (shown as "Program System Acronym" in the FRS database)—represents the names of information management systems at both the State and Federal levels that monitor each facility. Programs include the Assessment, Cleanup and Redevelopment Exchange System (ACRES), Base Realignment and Closure (BRAC), National Pollution Discharge Elimination System (NPDES), and the Toxic Substances Control Act (TSCA), among others.

2. Environmental Interest Type—represents the Federal environmental permit or regulatory program that applies to each facility. Interest types include Brownfields, Gasoline and Diesel Producers, Superfunds, and TRI Reporters, among others.

3. Site Type—represents the general attribute name for the type of site a facility occupies. Each facility is assigned a single site type from among eight options: Facility, Stationary, Monitoring Station, Potentially Contaminated Site, Contamination Addressed, Contaminated Site, Brownfield, or Water System.

Each possible value for each attribute field was assigned a potential contaminant hazard rank ranging from 1 to 4 on the basis of the following questions:

1. Does the program, interest, or site type indicate a regulated facility?

2. Does the program, interest, or site type indicate regular and direct releases (active or passive) of probable contaminants to sediment and (or) water?

3. Does the program, interest, or site type relate to regulation, remediation, regulatory compliance, or mitigation of probable contamination to/contaminants in sediments and (or) water?

4. Does the program, interest, or site type indicate that a facility's standard operations include the bulk storage and (or) production of nongaseous contaminants?

Each question was answered with a yes (1) or no (0), and then answers were summed to obtain the potential contaminant hazard rank ranging from 1 (minimal potential contaminant threat) to 4 (high potential contaminant threat). The maximum rank obtained from the resulting ranks across each of the three attribute fields was selected to represent the overall potential contaminant hazard rank for each facility. For example, if a facility had a rank of 4 for its Program Type, 2 for its Interest Type, and 2 for its Site Type, the overall potential contaminant hazard rank for the facility would be 4. (Note that multiple entries are possible for one facility for both the Program Type and Interest Type attributes.)

To minimize ranking bias, the questionnaire was administered to a panel of five experts (four internal to the project and one external) for their assessment. The experts were instructed to answer the questions using only the definitions specified in the EPA FRS documentation for each Environmental Program, Interest, or Site Type. Answers from all of the experts were pooled and a consensus rank was assigned on the basis of the most frequently given rank. Appendix C (at end of report) details the attribute values for each of the three fields, the results of the expert panel ranking exercise, and the final consensus rank for each attribute variable.

Definition of Storm Vulnerability

Storm vulnerabilities were defined by using an additive weighting approach based on the intersections between the location of the facility and the presence or absence of the facility within three storm vulnerability datasets:

1. FEMA 100-year flood zones derived from the Special Flood Hazard Area (SFHA), representing areas with a 1-percent annual chance of being inundated during a flood event (Federal Emergency Management Agency, 2015);
2. Historical storm-track data from the extended International Best Track Archive for Climate Stewardship (IBTrACS), modified to represent return intervals for inland tropical storms (Kruk and others, 2010); and
3. Sea, Lake, and Overland Surges from Hurricanes (SLOSH) CAT 1–5 inundation zones (Jelesnianski and others, 1992), simplified to polygons representing the inundation extent of a storm of each magnitude.

These datasets were selected because of their relative consistency across the SCoRR study region, and their specificity to coastal storm hazards. The inclusion of 100-year flood zones provides a means to extend the analysis inland, thereby capturing vulnerabilities to noncyclonic storm events such as “Nor’easters.”

Overlay analyses were used to identify facilities within each storm vulnerability zone (fig. 4). Initial potential contaminant hazard ranks for facilities within one or more storm vulnerability zones were then weighted using the following equation:

$$RF_x = RI_x \times 2^{S+\sum_{i=1} \frac{V_i}{r_i}}, \quad (1)$$

where
RF_x is the storm vulnerability-weighted potential contaminant hazard rank of contaminant source x,
RI_x is the initial potential contaminant hazard rank,
S is the binary “in or out” code for the 100-year flood zone,
V_i is the binary “in or out” code for each CAT zone i, and
r_i is the return interval of the magnitude storm associated with CAT zone V_i.

Resulting ranks represent the contaminant hazard potential and associated storm vulnerabilities of each facility location, with higher values indicating a greater hazard and (or) vulnerability than lower values (fig. 5).

Attribution of Contaminant and Storm Vulnerability to Stations

To prioritize sampling locations, proximity analyses were used to identify and accumulate nearby ranked TRI and FRS facilities. A 2-kilometer search radius was used to identify all facilities near each sampling location (fig. 6). Storm vulnerability-weighted ranks were then pooled for each facility, and a distance-weighted average was calculated from the pooled ranks for each sampling location:

$$R_x = \sum_{i=1}^{\pi K^2} \frac{RF_i}{d_i}, \quad (2)$$

where
R_x is the distance-weighted average rank for sampling location x,
K is the search radius,
RF_i is the storm vulnerability-weighted potential contaminant hazard rank for facility i, and
d_i is the distance between sampling location x and facility i.

This method was used to minimize computational requirements and to maintain a generalized framework that could be easily implemented across a broad spatial extent.

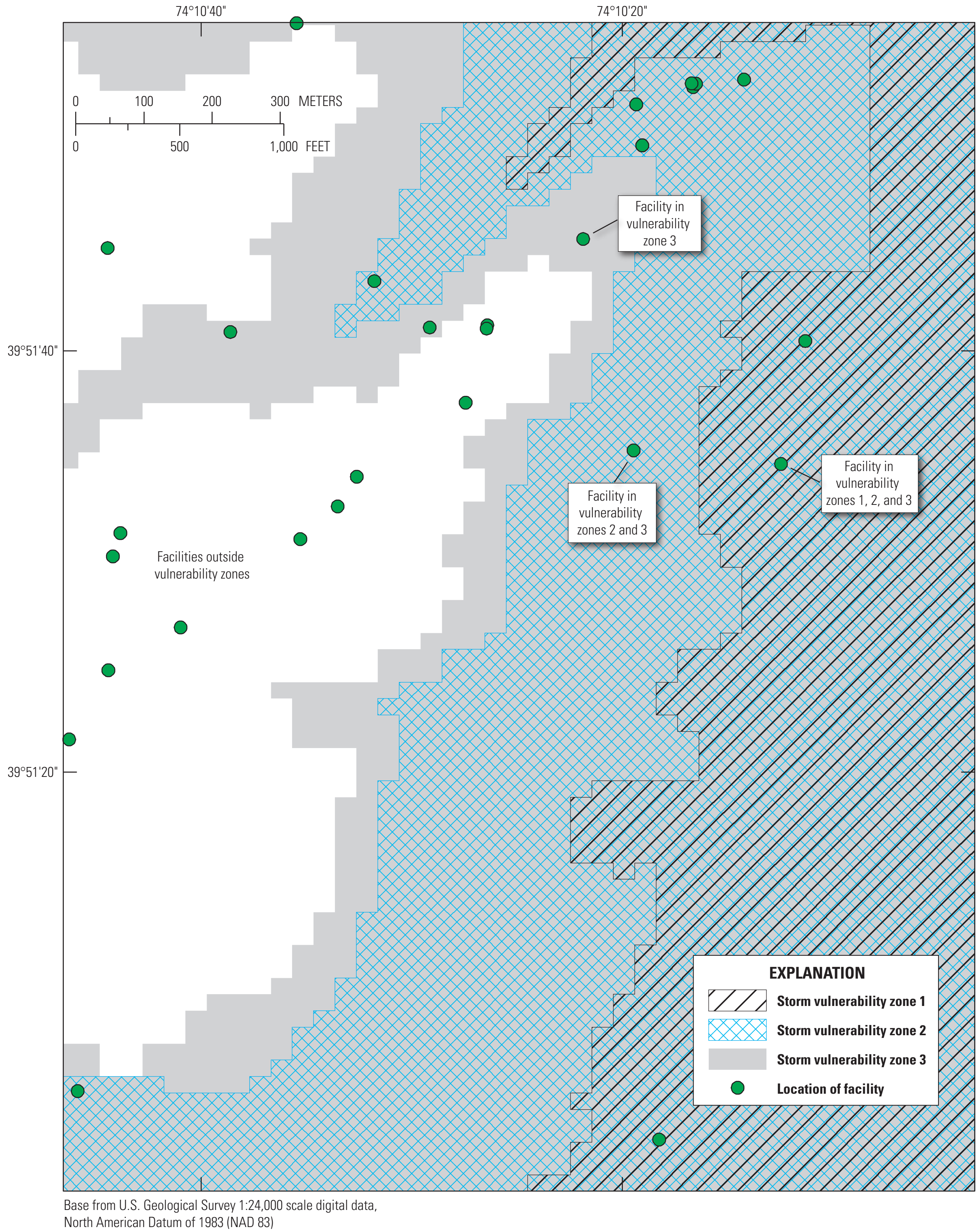


Figure 4. Intersection of contaminant sources and storm vulnerability data to weight potential contaminant hazard ranks.

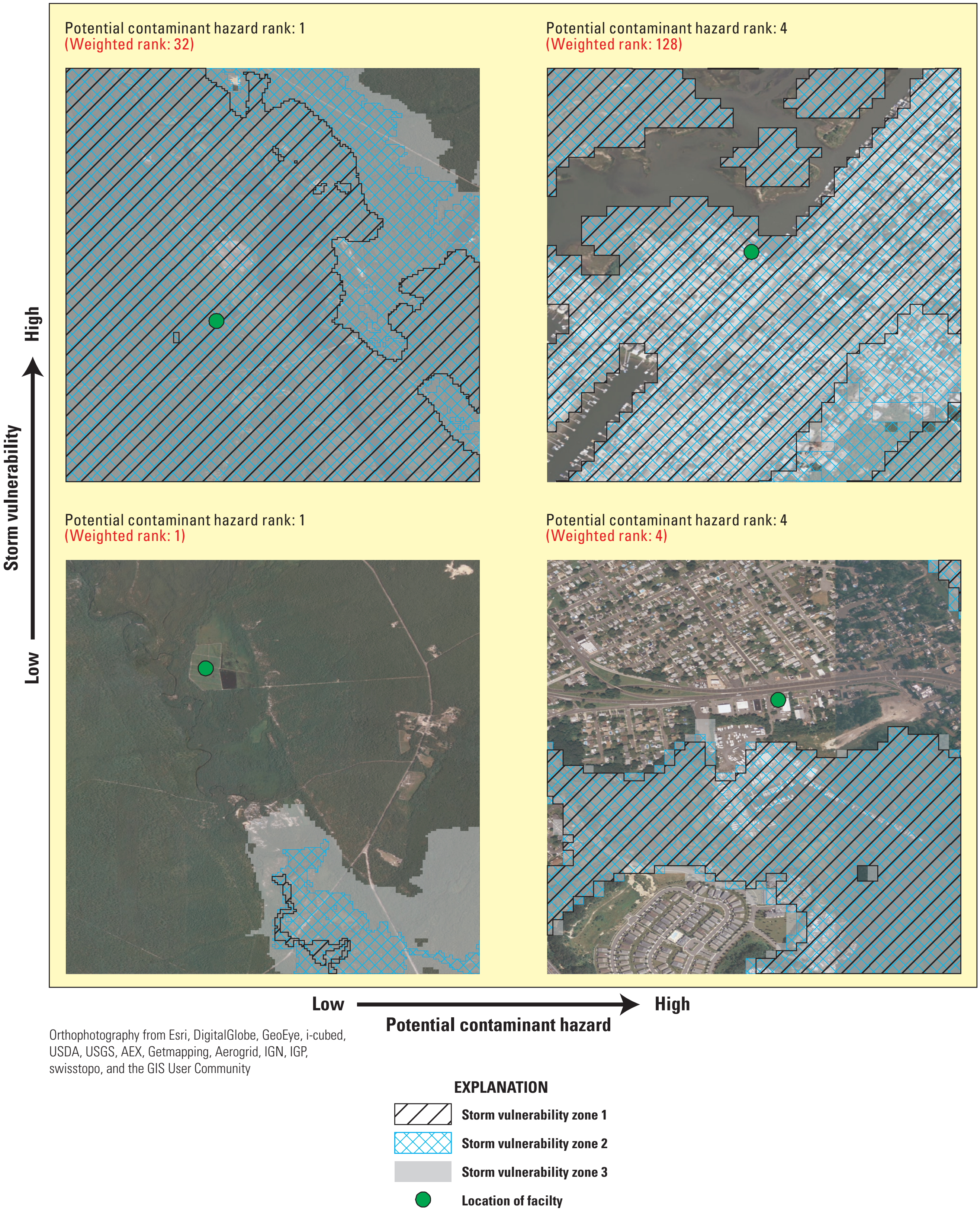


Figure 5. The four possible rank extremes applied to facilities in the Toxic Release Inventory and Facility Registry Service databases. (Potential contaminant hazard ranks for each facility ranging from 1 to 4 were weighted according to the facility's location relative to modeled and historical storm vulnerabilities.)

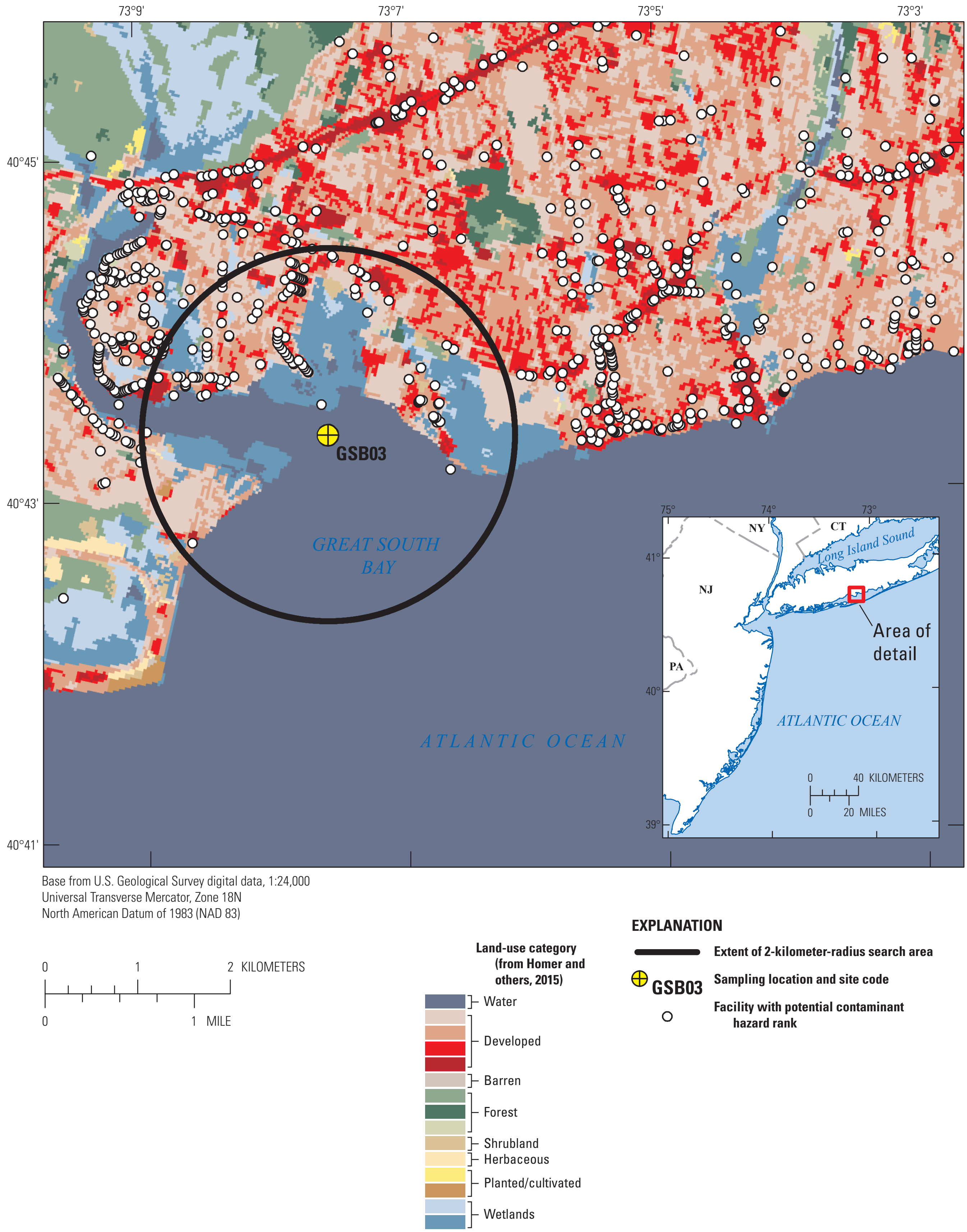


Figure 6. Attribution of storm-weighted potential contaminant hazard ranks to sampling locations in the Sediment-Bound Contaminant Resiliency and Response (SCoRR) network.

The resulting distance-weighted potential contaminant hazard ranks represent the contaminant and storm vulnerabilities associated with each sampling location. High prioritization values indicate an abundance of highly ranked contaminant sources near the sampling location that reside within one or more storm vulnerability zones. Low prioritization values represent sampling locations with few or no nearby contaminant sources that also may not reside within any storm vulnerability zones.

Sampling Methods

Sediment-quality samples will be collected using established sampling techniques that will be modified as needed on the basis of station characteristics (including but not limited to open water, flood plains, and recreational fields) and documented in a SCoRR standard operating procedure (SOP). The SOP will provide detailed instructions in a standardized format for sample collection tailored to each sample type (bed sediment, sand, soil, and marsh sediment). Supplies for Resiliency Mode sampling will be assembled into sampling kits containing all materials necessary to collect samples and will be staged at participating WSCs. Additional supplies will be provided to ensure capability for event response. Field notes (including digital images of habitat and critical structures) and location descriptions collected during site reconnaissance and sampling will be recorded by field staff into a custom electronic field form and stored in a project-specific database.

In Resiliency Mode, samples from a subset of stations selected on the basis of priorities determined by means of the Tier 1 prioritization process will be collected on an established schedule. In Response Mode, established sampling schedules throughout the network will be suspended and resources will be redirected to the portion of the network within the projected storm path. Available data for sampling stations in the projected storm path will be evaluated and pre-event samples will be collected if samples have not yet been collected at those stations during Resiliency Mode. Post-event samples will be collected to determine the EH and resiliency consequences of the event. Samples will be collected and shipped following protocols established for each analysis to USGS laboratories for further processing, analysis, and archiving. Additional sample volumes will be collected and archived to allow for re-analysis or subsequent research.

One round of Resiliency Mode samples will be collected from approximately 200 stations and approximately 50 stations will be sampled in Response Mode during at least one event in 2015 to demonstrate the SCoRR strategy. If this demonstration is successful and SCoRR is deployed as a long-term network, Resiliency Mode sampling ideally would be continued in a cyclical manner such that data will be refreshed on a time scale commensurate with the station's priority and dynamics (for example, a station located in an estuary experiencing SLR, containing sensitive/threatened species, and colocated with a SET-MH station may merit more frequent sampling than a station with similar EH relevance located outside the 100-year flood zone). This process will allow for evaluations of both incremental and episodic changes in EH stressors. These factors, as well as considerations for integrating changing stakeholder needs and implementation of new technologies, will be considered periodically during the "Evaluation" task (fig. 2).

Analytical Methods

Sediment samples collected during Resiliency and Response Modes will be evaluated by using a suite of screening techniques to provide a rapid, qualitative/semiquantitative characterization of the chemical composition and biological activity/inhibition of sediment-bound contaminants (Tier 2) (fig. 3). These are established methods that are commonly used in industrial, medical, and research applications—their use as a suite of assessment tools is an innovative approach to provide converging lines of evidence with an integrated, interdisciplinary evaluation of EH stressors. These results will be used to identify a subset of Resiliency Mode samples that will be subjected to detailed analysis to verify and quantify results using traditional, quantitative spectroscopy/spectrometry techniques and assays (Tier 3) (fig. 3).

Inorganic Geochemistry

The inorganic analysis of SCoRR sediment samples is designed to identify the mineral phases present in, and to characterize the particle-size distribution, inorganic and organic carbon content, and trace-element composition of, the sediment. These analyses include chemical compositional analyses such as x-ray fluorescence, inductively coupled plasma-mass spectrometry, mineralogy by x-ray diffraction, particle-size distribution by laser particle-size analyzer, and measurements of radioisotope activity by gamma spectroscopy. Well-established, published methods are available for all of these measurements in soil and marine sediment samples. These datasets will provide the necessary background information to identify where contaminants reside within the sample matrix (absorptive or reactive minerals and fine fractions). When appropriate, scanning electron microscopy will be used to characterize and verify contaminant residence and associations within the sediment matrix.

Method development associated with this strategy focuses on comparing laboratory (Tier 3) to field portable instrument data (Tier 2). The portable instrumentation includes radioisotope survey meters, portable x-ray fluorescence (pXRF), laser-induced breakdown spectroscopy (LIBS), and portable reflectance spectroscopy. In addition to the data comparison, these datasets will be evaluated in conjunction with other screening methods to assess their value in providing rapid, qualitative to semiquantitative evaluations of sediment quality.

Organic Geochemistry

Identification and understanding of fate and transport processes governing the occurrence and distribution of natural and anthropogenic organic chemicals are critical for the assessment of severe-weather-induced changes that link adverse effects on receptors back to contaminant sources. Screening (Tier 2) (fig. 3) provides a better opportunity to capture all environmental contaminants responsible for an adverse outcome than traditional targeted contaminant analysis (Tier 3) (fig. 3). When chemical screening data strongly indicate a contaminant-adverse outcome linkage, targeted contaminant analysis becomes more useful (Doyle and others, 2014). Two major objectives of the organic-chemistry component of this strategy focus on the assessment of severe-storm-derived change:

1. Identification of unknown environmental contaminants through multiple lines of evidence, and
2. Evaluation of organic chemical contributions to adverse biological effects.

Tier 2 analysis for polar contaminants includes chemical screening approaches of whole sediment and sediment extracts (as appropriate), based on Fourier transform infrared (FTIR), liquid chromatography/ultraviolet-visible (LC/UV-Vis), and liquid chromatography fluorescence (LC/fluorescence) spectroscopies (Abbas and others, 2008; Denis and others, 2012; Ferretto and others, 2014). These techniques will be used for functional group analysis and qualitative identification of chemicals above a threshold of concern. Tier 2 analysis for nonpolar chemicals will be evaluated by gas chromatography/mass spectrometry (GC/MS) for qualitative assessment above a threshold of concern (Bu and others, 2014). Tier 3 analysis for polar contaminants will focus on the use of liquid chromatography/time-of-flight mass spectrometry (LC/TOF MS) on a subset of samples collected pre- and post-storm for semiquantitative/quantitative assessment of contaminants and storm-derived changes (Ferrer and Thurman, 2012). Tier 3 analysis for nonpolar contaminants will include analysis by GC/MS on a subset of samples collected pre- and post-storm for quantitative assessment of contaminants and storm-derived changes. All Tier 3 analyses will be evaluated by using contaminant libraries and verifying tentative chemical identifications where possible. Contaminant classes being investigated include polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), a full range of pesticides and flame retardants, pharmaceuticals, endocrine disruptors, household and industrial additives, and algal toxins. Data-set interpretation will also include chemometric approaches to evaluate contaminant linkages with receptors (Altenburger and others, 2015).

Pathogens

Sediments will be screened for the prevalence of 15 antibiotic resistance genes and 19 bacteriophage and pathogenic viruses to determine microbial EH risk. Acquisition and maintenance of antibiotic resistance genes in eubacteria is typically associated with exposure to antibiotic sources (Mullany, 2014). These sources can be natural, but they are more typically found in areas affected by wastewater or sewage discharge (Bengtsson-Palme and others, 2014). Antibiotic-resistant infections caused by bacteria such as methicillin-resistant *Staphylococcus aureus* (MRSA) can present a substantial risk to human and other animal populations (native, domestic, livestock) (Casey and others, 2014; Seaton and others, 2014). The implementation of the Resiliency Mode of SCoRR will provide baseline biogeography for the distribution of these genes and how they are affected by climate change and storm events. The bacteriophage and human viral pathogen data will allow source tracking of pollutants and pathogens that affect SCoRR sample sites. Genetic targets include a number of viral pathogens (Enteroviruses, Influenza A and B viruses, Adenoviruses, Noroviruses, Dengue and Chikungunya viruses, etc.) and bacteriophage (F^+ coliphage) that have been used successfully in previous studies to determine sources of pollutants (human as opposed to other animals) (Griffin and others, 2000; Griffin and others, 2003; Lipp and others, 2007).

Deoxyribonucleic and ribonucleic acids (DNA and RNA, respectively) will be extracted from soil and sediment samples and used for polymerase chain reaction (PCR)-based analyses. The primary approach will be to screen all targets by using a presence/absence quantitative-PCR (qPCR) assay. Any targets that are positive with qPCR will then be quantified by using digital-PCR (dPCR), which is less susceptible to PCR inhibitors such as humic acids and provides absolute quantification at low copy range (fewer than 2,000 genetic copies) (Baker, 2012; Huggett and others, 2013; Morisset and others, 2013). Any samples that produce spike signals (more than 2,000 genetic copies) with dPCR analyses will be diluted and evaluated for more accurate enumeration. Systems that will be used to complete SCoRR microbiology objectives include Life Technologies (Carlsbad, California) StepOnePlus™ Real-Time PCR System and Life Technologies™ QuantStudio® 3D Digital PCR System. Tier 3 analyses will include the isolation and sequencing of the PCR amplicon for verification of selected target genes.

Biological Assays

Soils and sediments may contain complex mixtures of contaminants and toxicants associated with the solid phase, dissolved in interstitial (pore) water, or partitioned between the two. Sediment characteristics (for example, carbon content, mineralogy, pH, and salinity) can affect the availability of contaminants to biota and, therefore, affect their biological activity. Such mixtures of sediment characteristics may lead to vastly different biological effects in exposed biota that are not necessarily predictable by using chemical analyses alone. Bioassays offer a means to provide fast and relatively inexpensive determinations of the integrated biological effects of chemical mixtures and the specific activation of complex receptor signaling pathways. Endpoints such as acute and chronic toxicity are unambiguous outcomes of exposure and are of notable value for screening; however, subtle perturbations that do not lead to imminent death, but instead to other adverse outcomes, are likely to be more common in environmental matrices.

Sediments will be evaluated with a series of bioassays to test an array of endpoints and make use of commercially available and research-oriented assay platforms. Microtox® is an ecologically relevant, standardized toxicity test system that is rapid, sensitive, reproducible, and cost effective. The assay uses *Vibrio fischeri*, a bioluminescent marine bacterium, as the test organism. A considerable body of published data has demonstrated that the Microtox® system toxicity values for a wide range of compounds compare favorably with those determined by using whole organisms (Johnson, 2005). The SOS chromotest and Ames test are useful platforms for the determination of the genotoxic and mutagenic potential of a chemical mixture (Quillardet and Hofnung, 1993; Mortelmans and Zeiger, 2000). Yeast reporter assays that report activation of nuclear receptors, including estrogen receptor, androgen receptor, and glucocorticoid receptor, will also be used (Sanseverino and others, 2005; Fischer and others, 2015). Other nuclear-receptor-based assays include those that assess nuclear translocation (Stavreva and others, 2012). The RTH-149 cell line will be used to screen for heavy-metal-induced metallothionein expression (Kamer and others, 2003). Protein phosphatase inhibition will also be determined by using a commercially available Abraxis (Warminster, Pennsylvania) kit (Manubolu and others, 2014; Fischer and others, 2015).

Metric Development

EH metrics will be developed and used to compare SCoRR data collected during Resiliency and Response Modes to evaluate the potential EH consequences of alterations of sediment chemistry and associated biological activity caused by incremental and episodic stressors. Metrics will be developed by using two approaches:

1. Metrics specific to the stations included in the SCoRR network will be established by comparing the findings from Tiers 1 through 3 throughout the study area with established regulatory and literature-based criteria. This process will allow comparison among network stations in both Resiliency and Response Modes.
2. Metrics will be developed experimentally in the laboratory. Five or more soil reference materials representative of northeastern United States soils and sediments will be processed and characterized and then made available for other researchers. Metrics will be developed by spiking the standardized materials with selected contaminants and measuring the resulting biological activity. Results from sampled stations will be related to these metrics by principal component analysis on the basis of key traits (for example, mineralogy or organic carbon content).

Data Delivery and Communication of Results

Use of screening-level analytical methods and biological assays (Tier 2) is critical to the success of the SCoRR strategy. Collectively, these methods provide rapid, interdisciplinary results capable of informing the later phase of event response and the early phases of recovery when applied in Response Mode. Tier 2 results are also vital to the prioritization of stations for subsequent analyses (Tiers 3 and 4) in Resiliency Mode. Although individually they are not new technologies, the Tier 2 analyses yield a new class of data for the conventional databases of the USGS. These data relate to existing USGS methods, but are intended to provide qualitative or semiquantitative assessment of the chemical and biological contaminants present. Where possible and appropriate, guidance for defining the data standards and the appropriate use of Tier 2 results and their relation to the established USGS methods with which they are associated will be made publicly available.

Resiliency and Response Mode results will be reported in an online relational database hosted and visualized on a map-based SCoRR Web page. Each point location on the mapper will indicate corresponding assets (for example, tide gage, SET-MH, SWaTH deployments), sampling priority, and links to USGS provisional and approved data, as well as other site-relevant and regional information. The combined mapper and relational database will allow stakeholders to retrieve network data and ancillary information on demand and will serve as the primary data-reporting mechanism for the SCoRR network. The Web site will be designed to recognize users who employ mobile platforms and will allow station and (or) regional update alerts for subscribers. Links to the SCoRR work plan, SOPs, affiliated USGS and stakeholder networks, and any interpretive reports generated from the results obtained during Resiliency and Response Modes will be highlighted on the SCoRR Web page and in other public USGS forums.

For Response Mode, network response and interpreted results of analyses of the pre- and post-event samples will be described, and potential follow-up studies using Tier 3 analyses at existing stations and possible broader screening with

Tier 2 analytics (if appropriate) will be presented. Results will give decision makers access to timely information, with interpretations geared toward anticipated EH concerns. This plan will ensure that critical information is available to stakeholders and the USGS to help guide their response to future events.

The following products will be made publicly available through the SCoRR Web page (http://health.usgs.gov/scorr/) and other USGS information dissemination mechanisms as appropriate:

1. SOP documents for site prioritization, sample collection, and sample analysis for both Resiliency and Response Modes;
2. Prioritized map of SCoRR stations used for Resiliency Mode sampling;
3. Results of Tier 2 and 3 analyses generated in both Resiliency and Response Modes;
4. Documentation summarizing network response, findings, and potential further actions in Response Mode;
5. EH metrics based on Resiliency Mode results and analysis of standardized sediments; and
6. Publicly available documentation of the development and demonstration of the SCoRR strategy, including methodologies, data standards, and appropriate uses.

References Cited

Abbas, O., Rebufa, C., Dupuy, N., Permanyer, A., and Kister, J., 2008, Review: Assessing petroleum oils biodegradation by chemometric analysis of spectroscopic data: Talanta, v. 75, no. 4, p. 857–871.

Altenburger, R., Ait-Aissa, S., Antczak, P., Backhaus, T., Barceló, D., Seiler, T.-B., Brion, F., Busch, W., Chipman, K., López de Alda, M., de Aragão Umbuzeiro, G., Escher, B.I., Falciani, F., Faust, M., Focks, A., Hilscherova, K., Hollender, J., Hollert, H., Jäger, F., Jahnke, A., Kortenkamp, A., Krauss, M., Lemkine, G.F., Munthe, J., Neumann, S., Schymanski, E.L., Scrimshaw, M., Segner, H., Slobodnik, J., Smedes, F., Kughathas, S., Teodorovic, I., Tindall, A.J., Tollefsen, K.E., Walz, K.-H., Williams, T.D., Van den Brink, P.J., van Gils, J., Vrana, B., Zhang, X., and Brack, W., 2015, Future water quality monitoring—Adapting tools to deal with mixtures of pollutants in water resource management: Science of the Total Environment, v. 512, p. 540–551.

Baker, M., 2012, Digital PCR hits its stride: Nature Methods, v. 9, p. 541–544.

Bengtsson-Palme, J., Boulund, F., Fick, J., Kristiansson, E., and Larsson, D.G., 2014, Shotgun metagenomics reveals a wide array of antibiotic resistance genes and mobile elements in a polluted lake in India: Frontiers in Microbiology, v. 5, p. 648.

Bu, Q., Wang, D., Liu, X., and Wang, Z., 2014, A high throughput semi-quantification method for screening organic contaminants in river sediments: Journal of Environmental Management, v. 143, p. 135–139.

Buxton, H.T., Andersen, M.E., Focazio, M.J., Haines, J.W., Hainly, R.A., Hippe, D.J., and Sugarbaker, L.J., 2013, Meeting the science needs of the Nation in the wake of Hurricane Sandy—A U.S. Geological Survey science plan for support of restoration and recovery: U.S. Geological Survey Circular 1390, 26 p., http://pubs.usgs.gov/circ/1390/.

Casey, J.A., Shopsin, B., Cosgrove, S.E., Nachman, K.E., Curriero, F.C., Rose, H.R., and Schwartz, B.S., 2014. High-density livestock production and molecularly characterized MRSA infections in Pennsylvania: Environmental Health Perspectives, v. 122, p. 464–470.

Caskie, S.A., 2013, Hurricane Sandy Science Plan—Impacts of environmental quality and persisting contaminant exposures: U.S. Geological Survey Fact Sheet 2013–3091, 2 p., http://pubs.usgs.gov/fs/2013/3091/.

Denis, E.H., Toney, J.L., Tarozo, R., Anderson, R.S., and Roach, L.D., 2012, Polycyclic aromatic hydrocarbons (PAHs) in lake sediments record historic fire events: Validation using HPLC-fluorescence detection: Organic Geochemistry, v. 45, p. 7–17.

Doyle, E., Biales, A., Focazio, M., Griffin, D., Loftin, K., and Wilson, V., 2014, Effect-based screening methods for water quality characterization will augment conventional analyte-by-analyte chemical methods in research as well as regulatory monitoring: Environmental Science and Technology, ASAP article, December 18, 2014, http://pubs.acs.org/doi/abs/10.1021/es5053254.

Federal Emergency Management Agency, 2015, Flood zones: accessed May 1, 2015, at https://www.fema.gov/flood-zones.

Ferrer, I., and Thurman, E.M., 2012, Analysis of 100 pharmaceuticals and their degradates in water samples by liquid chromatography/quadropole time-of-flight mass spectrometry: Journal of Chromatography, v. 1259, p. 148−157.

Ferretto, N., Tedetti, M., Guigue, C., Mounier, S., Redon, R., and Goutx, M., 2014, Identification and quantification of known polycyclic aromatic hydrocarbons and pesticides in complex mixtures using fluorescence excitation-emission matrices and parallel factor analysis: Chemosphere, v. 107, p. 344–353.

Fischer, J.M., Phillips, P.J., Reilly, T.J., Focazio, M.J., Loftin, K.A., Benzel, W.M., Jones, D.K., Smalling, K.L., Fisher, S.C., Fisher, I.J., Iwanowicz, L.R., Romanok, K.M., Jenkins, D., Bowers, L., Boehlke, A., Foreman, W.T., Deetz, A.C., Carper, L.G., Imbrigiotta, T.E., and Birdwell, J., 2015, Estuarine bed-sediment-quality data collected in New Jersey and New York after Hurricane Sandy, 2013: U.S. Geological Survey Data Series 905, 42 p. plus CD-ROM, http://dx.doi.org/10.3133/ds905.

Griffin, D.W., Stokes, R., Rose, J.B., and Paul, J.H., 2000, Bacterial indicator occurrence and the use of an F^+ specific RNA coliphage assay to identify fecal sources in Homosassa Springs, Florida: Microbial Ecology, v. 39, p. 56–64.

Griffin, D.W., Donaldson, K.A., Paul, J.H., and Rose, J.B., 2003, Pathogenic human viruses in coastal waters: Clinical Microbiology Reviews, v. 16, p. 129–143.

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States—Representing a decade of land cover change information: Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345–354

Huggett, J.F., Foy, C.A., Benes, V., Emslie, K., Garson, J.A., Haynes, R., Hellemans, J., Kubista, M., Mueller, R.D., Nolan, T., Pfaffl, M.W., Shipley, G.L., Vandesompele, J., Wittwer, C.T., and Bustin, S.A., 2013, The digital MIQE guidelines: Minimum information for publication of quantitative digital PCR experiments: Clinical Chemistry, v. 59, no. 6, p. 892–902.

Jelesnianski, C.P., Chen, J., and Shaffer, W.A., 1992, SLOSH: Sea, lake, and overland surges from hurricanes: U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), NOAA Technical Report NWS 48, 71 p.

Johnson, B.T., 2005, Microtox® acute toxicity test, *in* Blaise, C., and Férard, J.-F., eds., Small-scale freshwater toxicity investigations—v. 1, Toxicity test methods: Dordrecht, the Netherlands, Springer, p. 69–105.

Kamer, I., Douek, J., Tom, M., and Rinkevich, B., 2003, Metallothionein induction in the RTH-149 cell line as an indicator for heavy metal bioavailability in a brackish environment: Assessment by RT-competitive PCR: Archives of Environmental Contamination and Toxicology, v. 45, no. 1, p. 86–91.

Kruk, M.C., Gibney, E.J., Levinson, D.H., and Squires, M., 2010, A climatology of inland winds from tropical cyclones for the Eastern United States: Journal of Applied Meteorology and Climatology, v. 49, p. 1538–1547.

Lipp, E.K., Futch, C.J., and Griffin, D.W., 2007, Analysis of multiple enteric viral targets as sewage markers in coral reefs: Marine Pollution Bulletin, v. 54, p.1897–1902.

Manubolu, M., Eklund, S., Dutta, P.C., and Mamlof, K., 2014, Variable exposure and responses to cyanotoxins in cattle grazing pastures in the coastal zone of the Baltic Sea: A field study: International Journal of Environmental Research, v. 8, p. 733–740.

Morisset, D., Stebih, D., Milavec, M., Gruden, K., and Zel, J., 2013, Quantitative analysis of food and feed samples with droplet digital PCR: PLoS One, v. 8, no. 5, http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0062583.

Mortelmans, K., and Zeiger, E., 2000, The Ames Salmonella/microsome mutagenicity assay: Mutation Research, v. 455, no. 1–2, p. 29–60.

Mullany, P., 2014, Functional metagenomics for the investigation of antibiotic resistance: Virulence, v. 5, p. 443–447.

National Oceanic and Atmospheric Administration, 2015, Spatial trends in coastal socioeconomics (STICS): Coastal county definitions: accessed May 1, 2015, at http://coast.noaa.gov/htdata/SocioEconomic/NOAA_CoastalCountyDefinitions.pdf.

Olsen, L.D., Valder, J.F., Carter, J.M., and Zogorski, J.S., 2013, Prioritization of constituents for national- and regional-scale ambient monitoring of water and sediment in the United States: U.S. Geological Survey Scientific Investigations Report 2012–5218, 203 p. plus supplemental tables, http://pubs.usgs.gov/sir/2012/5218/.

Quillardet, P., and Hofnung, M., 1993, The SOS chromotest: A review: Mutation Research, v. 297, no. 3, p. 235–279.

Sanseverino, J., Gupta, R.K., Layton, A.C., Patterson, S.S., Ripp, S.A., Saidak, L., Simpson, M.L., Schultz, T.W., and Sayler, G.S., 2005, Use of Saccharomyces cerevisiae BLYES expressing bacterial bioluminescence for rapid, sensitive detection of estrogenic compounds: Applied Environmental Microbiology, v. 71, no. 8, p. 4455–4460.

Seaton, R.A., Johal, S., Coia, J.E., Reid, N., Cooper, S., and Jones, B.L., 2014, Economic evaluation of treatment for MRSA complicated skin and soft tissue infections in Glasgow hospitals: European Journal of Clinical Microbiology & Infectious Diseases, v. 33, p. 305–311.

Stavreva, D.A., George, A.A., Klausmeyer, P., Varticovski, L., Sack, D., Voss, T.C., Schiltz, R.L., Blazer, V.S., Iwanowicz, L.R., and Hager, G.L., 2012, Prevalent glucocorticoid and androgen activity in US water sources: Scientific Reports, v. 2, p. 937.

U.S. Environmental Protection Agency, 2014, Toxic release inventory basic data file format documentation version 13: U.S. Environmental Protection Agency, Office of Environmental Information, Office of Information and Access, Toxics Release Inventory Program Division, Information and Outreach Branch, 17 p., accessed May 1, 2015, at http://www2.epa.gov/sites/production/files/2014-07/documents/tri_basic_data_file_format_v13_0.pdf.

U.S. Environmental Protection Agency, 2015a, Facility Registry Services (FRS): accessed May 1, 2015, at http://www.epa.gov/enviro/html/fii/index.html.

U.S. Environmental Protection Agency, 2015b, Toxic Release Inventory (TRI) Program: accessed May 1, 2015, at http://www2.epa.gov/toxics-release-inventory-tri-program.

Appendixes

Appendix A—National Target Analyte Strategy (NTAS) Constituent Database

(Available online at http://dx.doi.org/10.3133/ofr20151188A)

This appendix contains a Microsoft® Excel® workbook (NTASdatabase.xlsx) listing the constituents identified by Olsen and others (2013) prioritized for national- or regional-scale ambient monitoring of water or sediment in the United States. These data were used to apply potential contaminant hazard ranks to facilities identified in the U.S. Environmental Protection Agency (EPA) Toxic Release Inventory (TRI) database within the study area.

Reference Cited

Olsen, L.D., Valder, J.F., Carter, J.M., and Zogorski, J.S., 2013, Prioritization of constituents for national- and regional-scale ambient monitoring of water and sediment in the United States: U.S. Geological Survey Scientific Investigations Report 2012–5218, 203 p. plus supplemental tables, http://pubs.usgs.gov/sir/2012/5218/.

Appendix B—National Target Analyte Strategy (NTAS) Ranked Constituent Database

(Available online at http://dx.doi.org/10.3133/ofr20151188A)

This appendix contains two Microsoft® Excel® worksheets (TRI_ranks.xlsx). The first worksheet lists all constituents from the U.S. Environmental Protection Agency (EPA) Toxic Release Inventory (TRI) database that are also present in the National Target Analyte Strategy (NTAS) database. These constituents are ranked using the methods described in the “Ranking of Contaminant Source Data” section of this report. The second worksheet contains constituents from the database TRI that are not described in NTAS and are ranked following methods outlined in Olsen and others (2013) using constituent data found in material safety data sheets from the Toxnet Hazardous Substances Data Bank (HSDB) (http://toxnet.nlm.nih.gov/) provided by the U.S. National Library of Medicine.

Reference Cited

Olsen, L.D., Valder, J.F., Carter, J.M., and Zogorski, J.S., 2013, Prioritization of constituents for national- and regional-scale ambient monitoring of water and sediment in the United States: U.S. Geological Survey Scientific Investigations Report 2012–5218, 203 p. plus supplemental tables, http://pubs.usgs.gov/sir/2012/5218/.

Appendix C—U.S. Environmental Protection Agency (EPA) Facility Registry Service (FRS) Questionnaire used to Generate Potential Contaminant Hazard Ranks

(Available online at http://dx.doi.org/10.3133/ofr20151188A)

This appendix contains three Microsoft® Excel® worksheets (FRSQuestionnaire.xlsx). The first worksheet contains instructions and background material that were administered to a panel of five experts as described in the “Ranking of Contaminant Source Data” section of this report. The second worksheet contains the final consensus ranks as determined by the expert panel for each Facility Registry Service (FRS) attribute value. The third worksheet contains the individual potential contaminant hazard ranks provided by each expert panel member for a subset of FRS attribute values.

For additional information:
U.S. Geological Survey
Toxic Substances Hydrology Program
12201 Sunrise Valley Drive
Reston, Virginia 20192

Or visit the U.S. Geological Survey Environmental Health Web site at:
http://www.usgs.gov/envirohealth/

Document prepared by the West Trenton Publishing Service Center

Reilly and others—**Strategy to Evaluate Persistent Contaminant Hazards Resulting from Sea-Level Rise and Storm-Derived Disturbances—Study Design and Methodology for Station Prioritization**—Open-File Report 2015–1188A

ISSN 2331-1258 (online)
http://dx.doi.org/10.3133/ofr20151188A