Prepared in cooperation with the Federal Highway Administration

Bridge Scour Countermeasure Assessments at Select Bridges in the United States, 2016–18

Open-File Report 2019–1008

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

Cover:
Banner:
T-LiDAR survey being conducted during the November 2015 site visit at the Grand River near McFall, Missouri (site ID 011). Photograph by Richard Huizinga.

Top left:
Conducting Wolman pebble count on riprap on left bank at the Wapsipinicon River near Wheatland, Iowa (site ID 031). Photograph by Richard Huizinga.

Top right:
Photograph showing singlebeam bathymetric survey being conducted during the June 2016 site visit using Trimble S6 total station scanner at the Blackfoot River near Bonner, Montana (site ID 016). Photograph by Taylor Dudunake.

Bottom:
High-resolution bathymetric point cloud and T-LiDAR data obtained by Richard Huizinga during the August 2018 site visit at the Upper Iowa River near Dorchester, Iowa (site ID 030).

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Conversion Factors

Inch/Pound to International System of Units

Multiply	By	To obtain
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).
Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).
Elevation, as used in this report, refers to distance above the vertical datum.

Abbreviations

AEP	annual exceedance probability
DOT	Department of Transportation
FHWA	Federal Highway Administration
MBES	multibeam echo sounder
NBI	National Bridge Inventory
NWIS	National Water Information System
OFR	Open File Report
RI	recurrence interval
RTK-GNSS	real-time kinematic-global navigation satellite system
SBES	singlebeam echosounder
T-LiDAR	terrestrial light detection and ranging technology
USGS	U.S. Geological Survey

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Abstract

In 2009, the Federal Highway Administration published Hydraulic Engineering Circular No. 23 (HEC-23) to provide specific design and implementation guidelines for bridge scour and stream instability countermeasures. However, the effectiveness of countermeasures implemented over the past decade following those guidelines has not been evaluated. Therefore, in 2013, the U.S. Geological Survey, in cooperation with the Federal Highway Administration, began a study to assess the current condition of bridge-scour countermeasures at selected sites to evaluate their effectiveness. Bridge-scour countermeasures were assessed during 2016–2018 after additional sites were added following a similar study. Site assessments included reviewing countermeasure design plans, summarizing the peak and daily streamflow history, and assessments at each site. Each site survey included a photo log summary, field form, and topographic and bathymetric geospatial data and metadata. This report documents the study area and site-selection criteria, explains the survey methods used to evaluate the condition of countermeasures, and presents the complete documentation for each countermeasure assessment.

Introduction

On April 5, 1987, 10 people lost their lives as a result of the failure of a New York State Thruway bridge over Schoharie Creek (Lumia, 1998). The cause of the failure was erosion of the channel bed material, or scouring, under pier 3, which supported two of the five bridge spans (National Transportation Safety Board, 1988). According to the Federal Highway Administration (FHWA), scouring around bridge foundations is the most common cause of bridge failure (Federal Highway Administration, 2012). This risk can be mitigated by implementing effective bridge-scour countermeasures.

Bridge-scour countermeasures minimize risk to public transportation infrastructure by reducing sediment scour at bridges. Countermeasures can be defined as structures incorporated into a highway-stream crossing system that control or minimize harmful stream instability and/or bridge-scour (Federal Highway Administration, 2009). In 2009, the FHWA published the Hydraulic Engineering Circular No. 23 (HEC-23; Federal Highway Administration, 2009) to provide specific design and implementation guidelines for bridge scour and stream instability countermeasures. However, the effectiveness of countermeasures implemented over the past decade following FHWA HEC-23 guidelines has not been evaluated. Therefore, in 2013, the U.S. Geological Survey (USGS), in cooperation with the FHWA, began a study to assess the current condition of bridge-scour countermeasures at 20 select sites across the United States. The FHWA will use these site-specific assessments to evaluate the effectiveness of bridge-scour countermeasures described in the HEC-23 design guidelines.

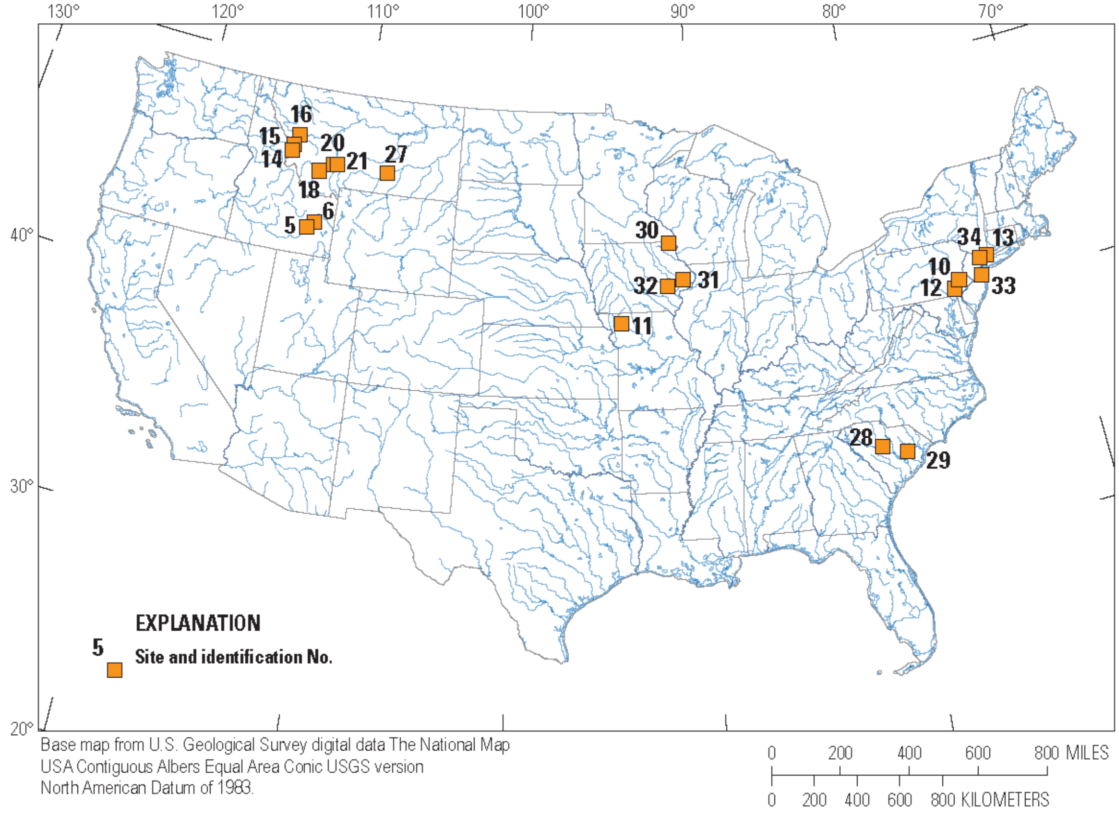
Purpose and Scope

This report summarizes countermeasure site assessments conducted in 2016 through 2018 at selected sites across the United States. Site assessments included reviewing countermeasure design plans, summarizing the peak and daily streamflow history, and a site survey to document the existing site and countermeasure. This report presents the complete documentation for each countermeasure assessment. Dudunake and others (2017) summarizes the initial phase of this project and included countermeasure assessments for 14 bridge sites. This report summarizes the second phase of a longer term study (Dudunake and others, 2017).

This report documents the study area and site-selection criteria, explains the survey methods used to evaluate the condition of countermeasures, and presents site assessments summarizing the countermeasure condition.

Description of Study Area

The study area in this report includes 20 bridge sites in 8 States: Connecticut, Idaho, Iowa, Missouri, Montana, New Jersey, Pennsylvania, and South Carolina (fig. 1, table 1). These bridge sites vary in river and bridge size, magnitude of flow, and type of countermeasures.



Base map from U.S. Geological Survey digital data The National Map
USA Contiguous Albers Equal Area Conic USGS version
North American Datum of 1983.

Figure 1. Map showing sites of the assessment of scour-related countermeasures at representative bridges throughout the United States, 2016–18.

Table 1. Description of approved sites, assessment category, and post-countermeasure hydrologic summary with collected data throughout the United States, 2016–18.

[**Year countermeasure installed:** Countermeasure installation data not documented for each day, month, or both. **Abbreviations:** NBI, National Bridge Inventory; dd, decimal degrees; ft^3/s, cubic feet per second; AEP, annual exceedance probability; CT, Connecticut; IA, Iowa; ID, Idaho; IL, Illinois; MO, Missouri; MT, Montana; NJ, New Jersey; PA, Pennsylvania; SC, South Carolina]

Site No.	NBI structure No.	Site name	Latitude (dd)	Longitude (dd)	Survey category	Representative streamgage	Year countermeasure installed	Peak-flow post-countermeasure (ft^3/s)	Year of peak flow post-countermeasure	Peak-flow, post-countermeasure, AEP (percent)
005	000000000019340	Snake River at Ferry Butte Road (W 500 S), Bingham County, ID	43.1269	-112.5133	1	13069500	2002	28,700	2011	[1]20
006	000000000019275	Snake River at Shelley West River Road (E 1250 N) near Shelley, ID	43.3767	-112.1694	1	13060000	2002	32,300	2011	[1]10
010	000000000047594, 000000000047595	Perkiomen Creek and Mill Race at Salford Station Road (SR 1024) near Perkiomenville, PA	40.2984	-75.4574	8	01473000	2012	26,600	2011	2
011	7583	Grand River at Rte-A (P0250) near McFall, MO	40.1128	-94.2975	4	06897500	2001	55,000	2007	1
012	000000000010536	West Branch Brandywine Creek at Strasburg Road (SR 3062) near Coatesville, PA	39.9467	-75.7800	8	01480617	2008	7,000	2014	10

Site No.	NBI structure No.	Site name	Latitude (dd)	Longitude (dd)	Survey category	Represent-ative streamgage	Year counter-measure installed	Peak-flow post-counter-measure (ft^3/s)	Year of peak flow post-counter-measure	Peak-flow, post-counter-measure, AEP (percent)
013	05018	Byram River at Sherwood Ave (05018) at Greenwich, CT	41.0609	-73.6775	8	01212500	2010	1,700	2011	10
014	P00007043+06661	Bitterroot River at US-93 near Hamilton, MT	46.1987	-114.1684	8	12344000	2004	12,000	2009	10
015	S00370000+05361	Bitterroot River at Bell Crossing near Victor, MT	46.4435	-114.1242	3	12350250	2004	13,700	2011	20
016	I00090110+01981	Blackfoot River at I-90 at Bonner, MT	46.8717	-113.8869	3	12340000	2004	17,200	2011	4
018	P00049027+05411	Beaverhead River at MT-41 at Twin Bridges, MT	45.5443	-112.3325	8	06023100, 06026500	2009	3,100	2011	[1]10
020	P00013093+06931	Jefferson River at MT-2 near Three Forks, MT	45.8969	-111.5963	8	06036650	2008	17,700	2011	4
021	I00090278+08571	Madison River at I-90 near Three Forks, MT	45.8986	-111.5237	8	06041000	2004	8,050	2011	10
027	L56788012+07001	Yellowstone River at Hwy 312 at Huntley, MT	45.9039	-108.3186	3	06214500	2008	73,700	2011	4
028	000000000009360	Smith Branch at S-126 (Clement Rd) at Columbia, SC	34.0350	-81.0600	6	02162093	1998	5,030	2015	<0.2

Site No.	NBI structure No.	Site name	Latitude (dd)	Longitude (dd)	Survey category	Represent-ative streamgage	Year counter-measure installed	Peak-flow post-counter-measure (ft^3/s)	Year of peak flow post-counter-measure	Peak-flow, post-counter-measure, AEP (percent)
029	000000000009547	Black River at US-52 at Kingstree, SC	33.6633	-79.8367	4	02136000	1998	83,700	2015	<0.2
030	000000000013660	Upper Iowa River at IA-76 near Dorchester, IA	43.4215	-91.5088	4	05388250	2001	38,000	2016	0.2
031	000000000020740	Wapsipinicon River at US-30 near Wheatland, IA	41.8296	-90.8119	4	05422000	2000	37,200	2014	1
032	000000000031680	Old Man's Creek at IA-1 near Iowa City, IA	41.6066	-91.6624	6	05455100	2007	13,900	2013	2
033	1308153	Yellow Brook at NJ-34 at Colts Neck Township, NJ	40.2950	-74.1746	8	01407290	2008	2,030	2011	0.2-1
034	0216157	Saddle River at NJ-17 at Ridgewood, NJ	40.9851	-74.0909	8	01390500	2009	6,770	2011	0.2-1

[1] Estimate affected to unknown degree by upstream regulation.

Methods

To date, there has been no comprehensive evaluation of the effectiveness of the long-term performance of bridge-scour countermeasures provided by Federal Highway Administration (2012). This study focused on collecting data to assess the current condition of different bridge-scour countermeasure types, mainly armoring structures (riprap, articulated blocks, concrete armor units, and gabion mattresses). Photographs, field forms, topographic surveys, and bathymetric surveys were collected at the selected sites. The following sections outline the methods used to complete these tasks.

Site Selection

The FWHA and the USGS selected 20 bridges for this study from the National Bridge Inventory (NBI) and State Departments of Transportation databases using the following criteria:

1. The site had bridge-scour countermeasures in place that were designed according to HEC-23 guidelines.
2. The site was near an existing USGS streamgage with a daily and peak streamflow record.
3. The site had experienced a significant streamflow event since the countermeasure was installed.

Criterion 1. Although the study objective was to assess the quality and overall effectiveness of countermeasures designed to FHWA HEC-23 guidelines, some exceptions were made for sites with installed countermeasures designed to earlier versions of FHWA guidelines. Site 031, Wapsipinicon River at US-30 near Wheatland, Iowa, is one example of this exception. The extensive details provided in the bridge-scour countermeasure plans and bridge structure plans for this site made it a sufficient candidate for this study. In addition, the riprap countermeasures installed at the site in 2000 remained present around main channel piers even though it experienced several substantial floods since installation.

Criterion 2. Daily and peak streamflow data were evaluated for a representative streamgage to review the flood history after countermeasures were installed. Drainage area adjustments described in Ries (2007) were used to better estimate at-site flow conditions when a USGS streamgage and bridge site were not colocated but were on the same stream. Historical streamflow observations and flood frequency statistics were obtained from the USGS National Water Information System (U.S. Geological Survey, 2016a) and the USGS StreamStats Web application (U.S. Geological Survey, 2016b). Annual peak flow and instantaneous data were reviewed to determine the three highest unique observed peak flows since scour countermeasures were installed. Criteria for selecting unique peak flows are described in Novak (1985).

Criterion 3. Peak flow frequency statistics were reviewed for the representative streamgage using published statistics to determine if the bridge site experienced a significant streamflow event since the countermeasure was installed. Sites that experienced streamflows exceeding the 4-percent annual exceedance probability (AEP) (25-year recurrence interval) since countermeasure installation were considered significant and were included in this study. As defined by the American Society of Civil Engineers, the recurrence interval (RI) is the average interval of time within which the given flood will be equaled or exceeded once (American Society of Civil Engineers, 1953). The published statistics for a colocated or nearby streamgage were used to determine the exceedance probability of each flood event after countermeasure installation. Peak-flow frequency statistics were determined using a weighted estimate from PeakFQ and StreamStats. Site 015, Bitterroot River at Bell Crossing near Victor, MT, is one example of when weighted estimates were used. Alternatively, at-site statistics were determined using PeakFQ and Bulletin 17B estimates when published statistics were not available (Veilleux and others, 2014) or when peak flows exceeded the published regression limits. This method was necessary for both sites in South Carolina due to extreme flooding in 2015. Drainage area adjustments were used for peak flow frequency statistics when the streamgage and bridge were not colocated (Ries, 2007). The flood history was particularly important when assessing the effectiveness of designed countermeasures.

An additional criterion for identifying significant streamflow events was considered for bridges located in mountainous regions because the stream power and complexity of hydraulics in high-gradient streams can cause scouring at streamflows less than the 4-percent AEP. A site was selected when the bankfull discharge (typically 1–2-year RI) produced scouring comparable to the 4-percent AEP event given a specific set of basin characteristics (Holnbeck and McCarthy, 2009). Most of the selected sites in Montana met this bankfull discharge criterion and were considered to have experienced a significant streamflow event.

Scour Countermeasure Assessments

Site Photographs and Field Form

All site surveys included collecting detailed site photographs and completing a field form summarizing site characteristics. The field team collected photographs of the bridge structure, surrounding floodplain, and visible countermeasures. Photographs were documented in an annotated photo log for each site. A field form derived from Cinotto and White (2000) were completed to describe the surrounding floodplain, channel characteristics, bridge substructure, and the countermeasures. These photographic and textual descriptions may assist in future modeling efforts and survey site analyses.

Bathymetric and Topographic Data

The 20 sites selected for countermeasure assessments represented hydraulically and geographically diverse environments (fig. 1, table 1) and were divided into 9 survey categories based on specific site characteristics including depth and turbidity of water and type of riparian vegetation (tables 1 and 2). Bathymetric and topographic data were collected at each site according to appropriate methods for the survey category (table 2).

Survey categories 1 and 2 include sites requiring a manned boat to survey across large bodies of water (table 2). At the time of survey, depths at these sites generally exceeded 15 ft, suitable for using a multibeam echosounder (MBES) to acquire bathymetric data. Category 1 survey sites had clear water at the time of survey; allowing a gridded camera to be used to collect underwater images around the countermeasure if needed. Category 2 survey sites generally had turbid water that was unsuitable for underwater images.

The MBES provides high-resolution bathymetry data around submerged countermeasures. Coupled with real-time kinematic global navigation satellite systems (RTK-GNSS), the MBES is more advantageous than a single-beam echosounder (SBES), acoustic Doppler current profilers (ADCP), or other sounding methods because it provides greater coverage of the streambed to capture the bathymetry of the waterbody (Weakland and others, 2011).

Table 2. References for various data-collection techniques of category 1–9 sites.

[MBES, multibeam echo sounder; T-LiDAR, terrestrial light detection and ranging technology; SBES, single beam echosounder; RTK-GNSS, real-time kinematic global navigation satellite system]

Category	Data collection technique	Reference
1/2	MBES	Wood and others, 2012; Fosness, 2013; Huizinga, 2015
	Gridded camera	Explained in report
	T-LiDAR	Kimbrow and Lee, 2013; Kimbrow, 2014; Brenner and others, 2016
3/4	SBES	Snyder and others, 2016
	MBES	Wood and others, 2012; Fosness, 2013; Huizinga, 2015
	Gridded camera	Explained in report
	T-LiDAR	Kimbrow and Lee, 2013; Kimbrow, 2014; Brenner and others, 2016
	Total station/RTK-GNSS	Rydlund and Densmore, 2012; Wood and others, 2012
5/6	Total station	Wood and others, 2012
	T-LiDAR	Kimbrow and Lee, 2013; Kimbrow, 2014; Brenner and others, 2016
7	T-LiDAR	Kimbrow and Lee, 2013; Kimbrow, 2014; Brenner and others, 2016
8	RTK-GNSS	Rydlund and Densmore, 2012
	Basic bathymetric survey	Mueller and Wagner, 2003
9	RTK-GNSS	Rydlund and Densmore, 2012
All	Basic countermeasure assessment field forms	Cinotto and White, 2000

Motion-compensated and tripod-based terrestrial light detection and ranging technology (T-LiDAR) captured high-resolution topography data for areas above the water surface and below the estimated peak flow stage. T-LiDAR technology uses rapidly moving laser pulses transmitted from the instrument. The pulses are reflected off the subject(s) and back to the instrument, which calculates the distance of the returned pulse based on the incoming velocity (Kimbrow and Lee, 2013). T-LiDAR data were generally collected around the super-structure, surrounding floodplain, bridge abutments, and piers that might be visible from the boat. Where vegetation was abundant in the area above water, RTK-GNSS topographical survey methods were used. The RTK-GNSS surveys followed the techniques and methods described in Rydlund and Densmore (2012).

Underwater gridded camera systems were used to collect photographs at gridded locations around the piers and other submerged countermeasures when possible. Visual samples were used to qualitatively assess the effects of aggradation, degradation, embeddedness, and the current condition of the countermeasure. This method excelled in deep-water conditions where SBES systems could not provide sufficient data resolution and MBES was not available. However, the camera systems were only useful in clear water conditions.

Category 3 and 4 survey sites (table 2) had water conditions that were shallower than categories 1 and 2 survey sites, roughly 5–14 ft deep. At these sites, bathymetric data were collected with SBES or ADCP mounted to boogie-boards, small boats, and/or by wading. MBES, T-LiDAR, and RTK-GNSS were used to obtain topographic data as applicable. Sidescan technology and (or) underwater gridded cameras also were used in similar situations as conditions allowed. Category 3 survey sites had clear water at the time of survey, whereas category 4 survey sites were turbid.

At categories 5 and 6 survey sites (table 2), the water depth was less than 4 ft and a boat could not be used, so wading techniques were used instead. Surveyors used RTK-GNSS and total station to obtain bathymetric data and T-LiDAR, RTK-GNSS, or total station scanner systems were used to acquire topographic data. Category 5 survey sites had no vegetation that disturbed data collection, whereas obstructing vegetation existed at category 6 survey sites.

If the stream channel was dry, the site was classified as category 7 (table 2) and T-LiDAR was used to obtain all data. Category 8 survey sites (table 2) were similar to categories 3 and 4 survey sites, but were generally shallower than 4 ft deep. Additionally, category 8 survey sites did not require detailed structural, bathymetric, or topographic surveys using T-LiDAR or MBES. Category 9 survey sites (table 2) were less than 4 ft deep and did not require a bathymetric survey. Similar to category 8 survey sites, category 9 sites did not require detailed structural, bathymetric, or topographic surveys using T-LiDAR or MBES. Base-level assessment data included photo documentation with cross-section bathymetry data and RTK-GNSS topography data (Mueller and Wagner, 2003). These basic cross-section and countermeasure survey data will provide sufficient detail to conduct countermeasure assessments.

Particle-Size Analyses

Particle-size analyses were conducted for 21 sites with riprap countermeasures (table 3). Twelve of those sites are from the present study and nine of those sites are from the first phase of the project, detailed in Dudunake and others (2017). These analyses included Wolman pebble counts or high-resolution bathymetric surveys to estimate above and below-water gradation of in-place riprap. Wolman pebble counts were conducted using methods developed for riprap by Federal Highway Administration (2008). Dimensions of riprap particles were measured to develop a grain-size distribution curve and will assist FHWA in verifying countermeasure design guidelines. High-resolution bathymetric surveys were conducted when wading techniques were not possible. By adjusting survey equipment settings, a high-resolution, centimeter-scale bathymetric survey output was produced to assist FHWA determine riprap extent, individual rock sizes, and riprap gradation.

Scour Countermeasure Assessment Data

Countermeasure assessment results were processed, compiled, and published in a USGS Data Release for 20 sites (table 1) in Connecticut, Idaho, Iowa, Missouri, Montana, New Jersey, Pennsylvania, and South Carolina (Dudunake, 2018, https://doi.org/10.5066/F7WW7G4W). Site information for each bridge included a compressed file containing countermeasure plans, a detailed photograph log, and completed field form. Geospatial data includes all topography and bathymetry data collected and associated metadata. Site survey data includes an additional particle-size analysis for the 21 sites described in table 3. A complete summary of geospatial data and countermeasure design plans, photo summaries, and field forms are available in Dudunake (2018).

Table 3. Survey sites and links to particle-size analysis data for the assessment of scour-related countermeasures at representative bridges in United States, 2014–2018.

Site No.	NBI structure No.	Site name	Particle-size analysis data available at https://doi.org/10.5066/F7WW7G4W
001[1]	500086, 500087	Apalachicola River at I-10 (SR 8), near Chattahoochee, FL	siteID-001_ApalachicolaRiver_I-10_highres_multibeam_bathymetry.zip
003[1]	K0932	Mississippi River at US-54, (K0932) at Louisiana, MO	siteID-003_MississippiRiver_US-54_highres_multibeam_bathymetry.zip
004[1]	1936	Mississippi River at I-155 (A1700), near Caruthersville, MO	siteID-004_MississippiRiver_I-155_highres_multibeam_bathymetry.zip
007[1]	33175 (097- 0003/0004)	Wabash River at I-64 (097- 0003/0004), near Grayville, IL	siteID-007_WabashRiver_I-64_highres_multibeam_bathymetry.zip
008[1]	A0906	Thompson River at MO-6 (A0906) near Trenton, MO	siteID-008_ThompsonRiver_MO-6_wolman_pebble_count.zip
009[1]	A4584	Fox River at US-61 (A4584) near Wayland, MO	siteID-009_FoxRiver_US-61_wolman_pebble_count.zip
010	000000000047594, 000000000047595	Perkiomen Creek and Mill Race at Salford Station Road (SR 1024) near Perkiomenville, PA	siteID-010_PerkiomenCreek_SR-1024_wolman_pebble_count.zip
011	7583	Grand River at Rte-A (P0250) near McFall, MO	siteID-011_GrandRiver_Rte-A_wolman_pebble_count.zip
012	000000000010536	West Branch Brandywine Creek at Strasburg Road (SR 3062) near Coatesville, PA	siteID-012_BrandywineCreek_SR-3062_wolman_pebble_count.zip
015	S00370000+05361	Bitterroot River at Bell Crossing near Victor, MT	siteID-015_Bitterroot_BellCrossing_wolman_pebble_count.zip
016	I00090110+01981	Blackfoot River at I-90 at Bonner, MT	siteID-016_Blackfoot_I90_wolman_pebble_count.zip
020	P00013093+06931	Jefferson River at MT-2 near Three Forks, MT	siteID-020_Jefferson_ThreeForks_wolman_pebble_count.zip
023[1]	P00081024+0.962	Judith River at MT-81 near Lewistown, MT	siteID-023_Judith_wolman_pebble_count.zip
024[1]	S00300000+0.2001	Musselshell River at S-300 at Ryegate, MT	siteID-024_Musselshell_wolman_pebble_count.zip
026[1]	P00003101+0.8001	Two Medicine River at US-89 near Browning, MT	siteID-026_TwoMedicine_wolman_pebble_count.zip
028	000000000009360	Smith Branch at S-126 (Clement Rd) at Columbia, SC	siteID-028_SmithBranch_S-126_wolman_pebble_count.zip
029	000000000009547	Black River at US-52 at Kingstree, SC	siteID-029_BlackRiver_US-52_wolman_pebble_count.zip
030[2]	000000000013660	Upper Iowa River at IA-76 near Dorchester, IA	siteID-030_UpperIowaRiver_IA-76_wolman_highres.zip
031	000000000020740	Wapsipinicon River at US-30 near Wheatland, IA	siteID_031_WapsipiniconRiver_US-30_wolman_pebble_count.zip
032	000000000031680	Old Man's Creek at IA-1 near Iowa City, IA	siteID_032_OldMansCreek_IA1_wolman_pebble_count.zip
034	0216157	Saddle River at NJ-17 at Ridgewood, NJ	siteID-034_SaddleRiver_NJ17_wolman_pebble_count.zip

[1] Site detailed in Dudunake and others (2017).

[2] Wolman pebble count and high-resolution bathymetry acquired.

Summary

With the completion of bathymetric and topographical data collection, FHWA will investigate the value of their countermeasure design guidelines by simulating conditions using computer modeling analyses and the acquired survey data. A final project report will be written to summarize documentation, interpretive details, and countermeasure assessment data following the completion of the project. With the use of these surveys and scour modeling, engineers will be able to design better bridge-scour countermeasures to withstand changing stream environments using new estimates of countermeasure effectiveness.

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