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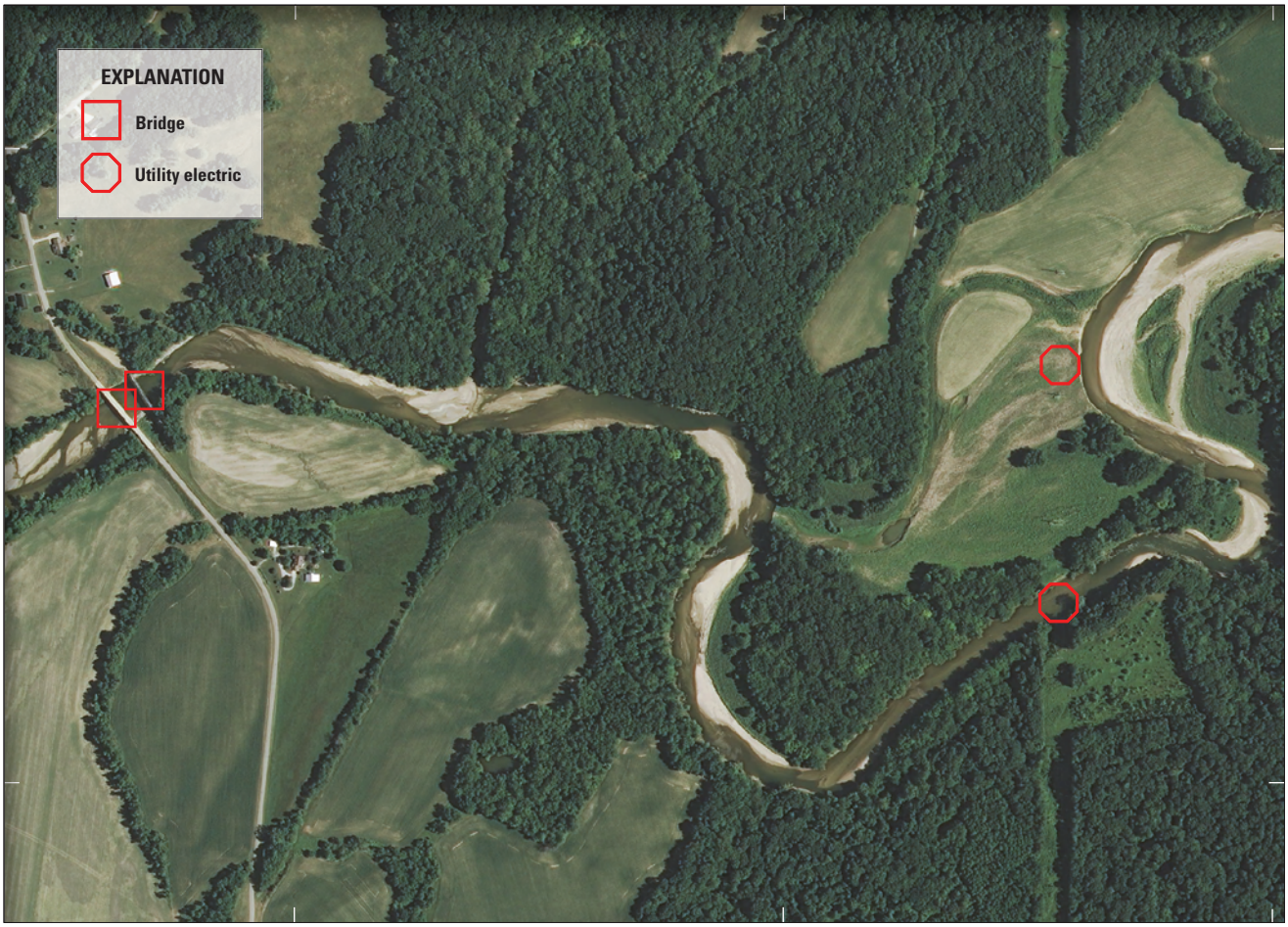
Vulnerable Transportation and Utility Assets near Actively Migrating Streams in Indiana



Data Series 1068

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

Cover image. Digital orthophoto showing aerial perspective of vulnerable transportation and utility assets near an actively migrating reach of Sugar Creek in Parke County, Indiana. (Orthophotography from U.S. Department of Agriculture-FAS Aerial Photography Field Office, 2012.)

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RYAN K. ZINKE, Secretary

U.S. Geological Survey
William H. Werkheiser, Acting Director

U.S. Geological Survey, Reston, Virginia: 2017

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Migration rate	
foot per year (ft/yr)	0.3048	meter per year (m/yr)

Abbreviations

FEH fluvial erosion hazard

GIS geographic information system

NHD National Hydrography Dataset

Words presented in bold type are defined in the Glossary section of this report.

Acknowledgments

The author acknowledges the support of the Indiana Office of Community and Rural Affairs and members of the Indiana Silver Jackets, particularly Bret Robinson and Robert Barr, for their contributions to the fluvial erosion hazards program in Indiana. Work performed by fluvial geomorphologist Bret Robinson (retired) of the U.S. Geological Survey provided original data released with this report. His efforts are greatly appreciated.

Vulnerable Transportation and Utility Assets near Actively Migrating Streams in Indiana

By Benjamin J. Sperl

Abstract

An investigation was completed by the U.S. Geological Survey in cooperation with the Indiana Office of Community and Rural Affairs that found 1,132 transportation and utility assets in Indiana are vulnerable to **fluvial erosion hazards** due to close proximity to actively migrating streams. Locations of transportation assets (bridges, roadways, and railroad lines) and selected utility assets (high-capacity overhead power-transmission lines, underground pipelines, water treatment facilities, and in-channel dams) were determined using aerial imagery hosted by the **Google Earth** platform. Identified assets were aggregated by **stream reach**, county, and class. Accompanying the report is a polyline shapefile of the stream reaches documented by Robinson (2013a). The shapefile, derived from line work in the National Hydrography Dataset and attributed with channel **migration rates**, is released with complete Federal Geographic Data Committee metadata**.** The data presented in this report are intended to help stakeholders and others identify high-risk areas where transportation and utility assets may be threatened by fluvial erosion hazards thus warranting consideration for mitigation strategies.

Introduction

The June 7–9, 2008, flooding in central and southern Indiana caused extensive erosion-related damages to public and private infrastructure (Morlock and others, 2008). Following the flood, members of the Indiana Silver Jackets (https://silverjackets.nfrmp.us/State-Teams/Indiana), a multi-agency taskforce whose mission is to mitigate natural hazards in Indiana, recognized the need for a program that focuses specifically on fluvial erosion hazards (FEH). FEH is a term that collectively refers to "damages imparted by erosion and stream-channel migration processes" (Robinson, 2013b, p. 1). The FEH program (http://feh.iupui.edu/) was formed to help communities understand and reduce the risks associated with fluvial erosion. The program meets that goal through education and outreach as well as sponsorship of projects that produce tools and information to enhance awareness of the hazard (Indiana University-Purdue University Indianapolis, 2017). Projects sponsored by the FEH program have developed regional curves for bankfull-channel dimension for Indiana streams, measured the rates of channel migration, and delineated FEH-avoidance corridors along actively migrating stream reaches (Robinson, 2013a; Robinson, 2013b; Indiana Department of Natural Resources, 2016).

Rates of channel migration were measured along 42 stream reaches in Indiana between 1998 and 2011 (Robinson, 2013a). Of the 42 stream reaches examined, 16 were found to be actively migrating with a migration rate of greater than 1 foot per year, while 26 were found to be stationary, which is defined as having a migration rate of less than 1 foot per year, over the period of study (Robinson, 2013a).

Purpose and Scope

The purpose of this report is (1) to publish a table highlighting stream reaches and counties in Indiana where transportation and utility assets are at greater risk for damages by fluvial erosion based on the findings of Robinson (2013a) and (2) to document a geographic information system (**GIS**) dataset (Sperl, 2017) of those stream reaches which may serve as a resource to stakeholders and others in conducting their own independent risk analyses. The report focuses solely on transportation and utility assets, including bridges, roadways, railroad lines, high-capacity overhead power-transmission lines, underground pipelines, water treatment facilities, and in-channel dams.

Identification of Vulnerable Transportation and Utility Assets

The locations of vulnerable assets were determined visually using digital **orthophotography** hosted by the Google Earth platform. The availability of imagery provided in Google Earth varies by geographic area and date; therefore, assets were identified from multiple images covering different dates and areal swaths. When measuring distances between assets and eroding channel banks, an effort was made to use the most currently available imagery with respect to the time of the investigation in 2014. However, in many cases, images with older capture dates were used instead of the most currently available imagery because they offered finer ground resolution or leaf-off conditions making assets more visible. The sources and dates of imagery used to identify vulnerable assets are summarized in table 1. The identified assets are near or within the **fluvial plains** of the 16 active stream reaches documented in Robinson (2013a), as well as 38 tributaries where migration rates were not directly measured but also show signs of recent channel migration (fig. 1; table 2). To determine the degree of channel migration in tributaries, digital orthophotos from different capture dates were used to compare the position of stream channels relative to fixed landscape features. Through this method, many tributary channels were identified as static. However, 38 tributaries showed signs of observable channel movement in the time span between the capture dates of digital orthophotos. These 38 tributaries were noted as actively migrating but no measurements were completed to document their channel-migration rates as they were for main stem stream reaches in Robinson (2013a).

Tools provided in Google Earth were used to record the locations of assets and store their geographic coordinates in a placemark file (.kmz). Beginning at the most downstream point on a stream reach and panning over imagery in the upstream direction, locations of assets were recorded where their position relative to the banks of an actively migrating stream was considered a potential vulnerability. As a general rule, an asset was judged vulnerable if the shortest distance from its location to the nearest channel bank was approximately 300 feet or less. The locations of some buried pipelines that were not visible from imagery were identified with the aid of a GIS dataset containing polyline features that represent the pipes' underground pathways (Indiana Geological Survey, 2002). In some cases, the locations of pipelines could be inferred from vegetation clearings along utility easements, like the one shown for an electric utility in figure 2. Stream reaches that remained stationary over the period of study in Robinson (2013a) were excluded from the investigation for vulnerable assets, but they are included as features in the polyline shapefile (Sperl, 2017).

As locations of assets were recorded, so too were the following attributes: name of the nearby stream reach and its **main stem** stream reach, county where the asset was found, and the class of an asset (bridge, road, electric utility, etc.). These attributes were used to aggregate the data and summarize the results by stream reach, county, and class in table 3.

Table 1. Sources and dates of imagery used to locate transportation and utility assets.

[Date format mm/dd/yyyy, month/day/year; USDA, U.S. Department of Agriculture]

Image source[1]	Image date[2]	Number of assets
Google	10/10/2013	3
Google	10/11/2013	15
Google	2/26/2012	19
Google	4/4/2013	36
Google	5/14/2012	10
Google	5/5/2010	21
Google	8/29/2012	36
Google	9/1/2011	67
Google	9/13/2013	5
Google	9/22/2013	142
Google	9/25/2013	34
Indiana Map Framework Data	2/28/2005	703
USDA Farm Service Agency	6/18/2008	1
USDA Farm Service Agency	6/19/2010	25
USDA Farm Service Agency	9/14/2011	15

[1]Refers to ownership of imagery; sensor specifications are not provided.

[2]Date image was captured.

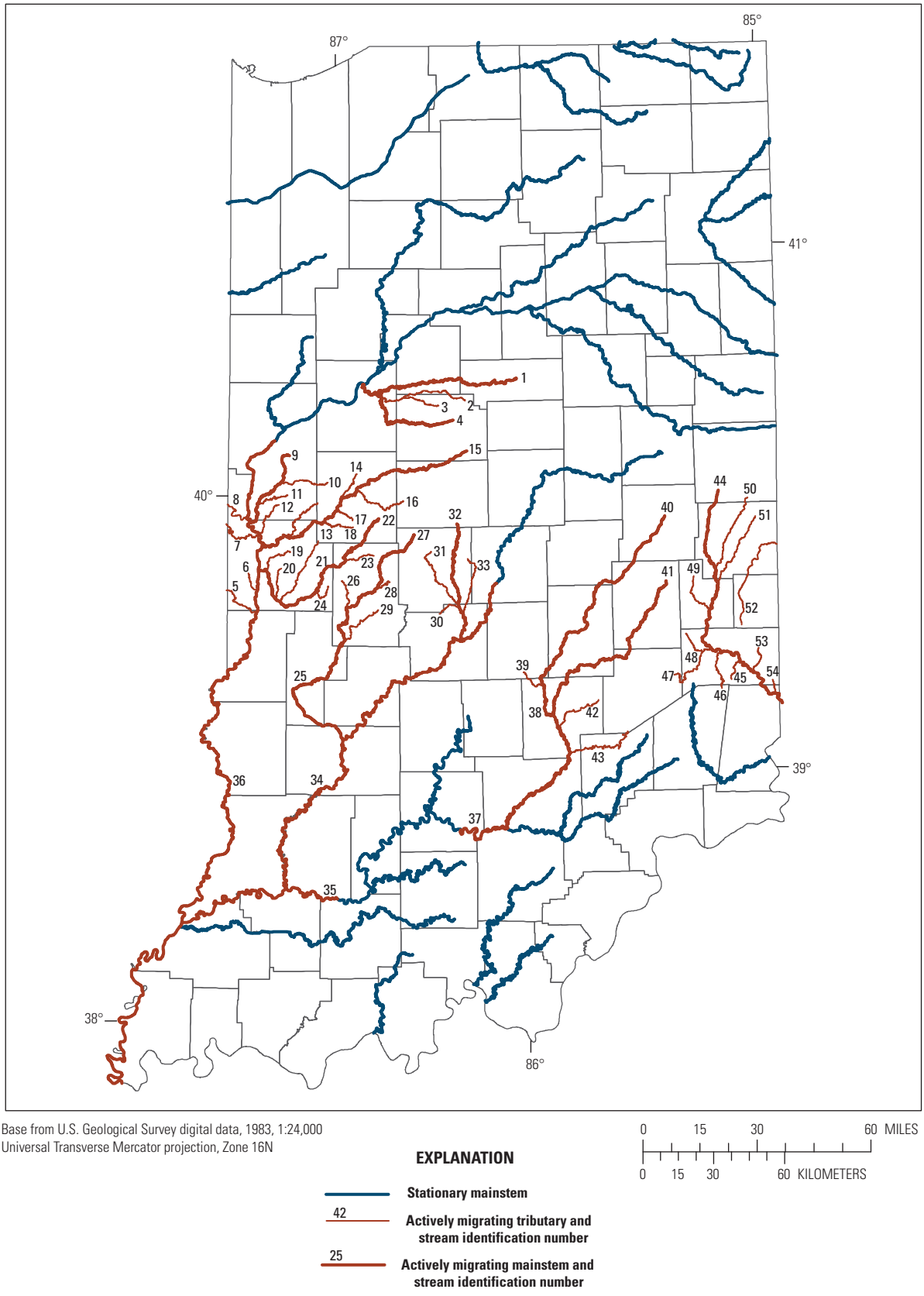

Figure 1. Map showing stream reaches identified as actively migrating or recently stationary. (Map labels 1–54 reference table 2).

Table 2. Actively migrating stream reaches in Indiana, main stem and tributary.

[mi, miles; ft/yr, feet per year; --, no data]

Map label (fig. 1)[1]	Reach name	Main stem	Length (mi)	Migration rate (ft/yr)[2]
1	Wildcat Creek	Wildcat Creek	68.9	5.1
2	Middle Fork Wildcat Creek	South Fork Wildcat Creek	33.8	--
3	Campbells Run	South Fork Wildcat Creek	13.2	--
4	South Fork Wildcat Creek	South Fork Wildcat Creek	44.9	8.0
5	Brouilletts Creek	Wabash River (lower)	15.4	--
6	Norton Creek	Wabash River (lower)	6.7	--
7	Little Vermilion River	Wabash River (lower)	21.4	--
8	Vermilion River	Wabash River (lower)	10.9	--
9	Coal Creek	Coal Creek	32.7	4.5
10	East Fork Coal Creek	Coal Creek	17.1	--
11	Prairie Creek	Coal Creek	13.1	--
12	Mill Creek	Wabash River (lower)	13.4	--
13	Sugar Mill Creek	Sugar Creek	20.8	--
14	Black Creek	Sugar Creek	9.7	--
15	Sugar Creek	Sugar Creek	87.7	6.4
16	Walnut Fork Sugar Creek	Sugar Creek	23.3	--
17	Rattlesnake Creek	Sugar Creek	8.4	--
18	Indian Creek	Sugar Creek	13.6	--
19	Leatherwood Creek	Big Raccoon Creek	12.5	--
20	Rock Run	Big Raccoon Creek	10.5	--
21	Little Raccoon Creek	Big Raccoon Creek	23.2	--
22	Big Raccoon Creek	Big Raccoon Creek	68.3	6.3
23	Ramp Creek	Big Raccoon Creek	10.3	--
24	Rocky Fork	Big Raccoon Creek	8.0	--
25	Eel River (south)	Eel River (south)	54.9	5.4
26	Little Walnut Creek	Big Walnut Creek	9.5	--
27	Big Walnut Creek	Big Walnut Creek	54.2	12.2
28	Clear Creek	Big Walnut Creek	6.8	--
29	Deer Creek	Eel River (south)	18.5	--
30	McCracken Creek	White Lick Creek	8.3	--
31	West Fork White Lick Creek	White Lick Creek	25.3	--
32	White Lick Creek	White Lick Creek	45.8	16.3
33	East Fork White Lick Creek	White Lick Creek	20.8	--
34	White River (lower)	White River (lower)	229.0	16.5
35	East Fork White River (lower)	East Fork White River (lower)	21.7	8.0
36	Wabash River (lower)	Wabash River (lower)	275.9	8.3
37	East Fork White River (upper)	East Fork White River (upper)	86.9	12.3
38	Driftwood River	Driftwood River	15.8	5.5
39	Nineveh Creek	Driftwood River	9.1	--
40	Big Blue River	Big Blue River	74.1	4.1
41	Flatrock River	Flatrock River	74.4	10.2
42	Clifty Creek	East Fork White River (upper)	19.1	--
43	Sand Creek	East Fork White River (upper)	31.1	

Table 2. Actively migrating stream reaches in Indiana, main stem and tributary.—Continued

[mi, miles; ft/yr, feet per year; --, no data]

Map label (fig. 1)[1]	Reach name	Main stem	Length (mi)	Migration rate (ft/yr)[2]
44	Whitewater River	Whitewater River	93.1	30.2
45	Blue Creek	Whitewater River	7.7	--
46	Pipe Creek	Whitewater River	15.3	--
47	Salt Creek	Whitewater River	23.6	--
48	Little Salt Creek	Whitewater River	9.5	--
49	Williams Creek	Whitewater River	15.0	--
50	Greens Fork	Whitewater River	26.5	--
51	Nolands Fork	Whitewater River	26.1	--
52	East Fork Whitewater River	Whitewater River	31.7	--
53	Big Cedar Creek	Whitewater River	10.1	--
54	Johnson Fork	Whitewater River	4.5	--

[1]Map labels reference figure 1.

[2]Channel migration rates were measured in a report by Robinson (2013a) for mainstem stream reaches only.

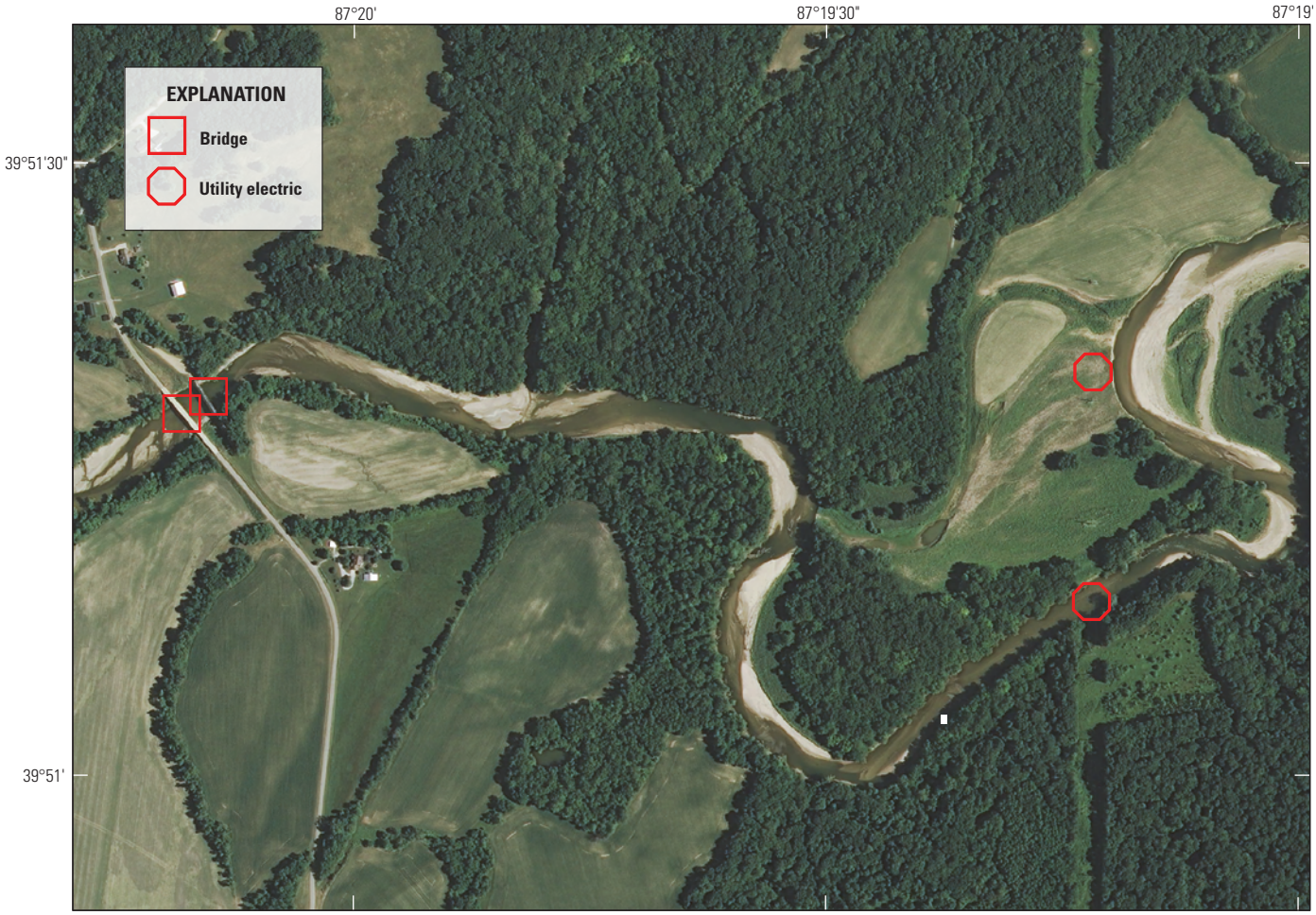

Figure 2. Digital orthophoto showing aerial perspective of vulnerable transportation and utility assets near an actively migrating reach of Sugar Creek in Parke County, Indiana.

Table 3. Summary of vulnerable transportation and utility assets by stream reach, county, and class.

[Values represent the number of vulnerable assets found, aggregated by stream reach, county, and class; --, no data]

Reach name	Main stem	Transportation				Utility					
		Road	Bridge	Railroad	Railroad bridge	Dam	Electric	Levee	Oil/gas	Water	Total
Bartholomew County											
Driftwood River	Driftwood River	2	5	--	--	--	1	--	3	--	11
Nineveh Creek	Driftwood River	--	4	--	--	--	--	--	--	--	4
Clifty Creek	East Fork White River (upper)	--	--	--	--	--	--	--	2	--	2
East Fork White River (upper)	East Fork White River (upper)	1	2	--	1	1	3	--	1	--	9
Flatrock River	Flatrock River	3	8	1	1	1	3	--	3	--	20
Carroll County											
Wildcat Creek	Wildcat Creek	--	2	--	--	--	--	--	--	--	2
Clay County											
Eel River (south)	Eel River (south)	16	8	--	--	--	2	--	2	--	28
Clinton County											
Campbells Run	South Fork Wildcat Creek	--	4	--	--	--	--	--	--	--	4
South Fork Wildcat Creek	South Fork Wildcat Creek	5	6	1	1	--	--	--	--	--	13
Daviess County											
East Fork White River (lower)	East Fork White River (lower)	--	2	--	1	--	3	--	1	--	7
White River (lower)	White River (lower)	--	--	3	2	--	--	--	--	--	5
Dearborn County											
Whitewater River	Whitewater River	12	4	3	--	1	--	--	--	--	20
Fayette County											
Nolands Fork	Whitewater River	--	1	--	--	--	--	--	--	--	1
Whitewater River	Whitewater River	4	4	1	2	--	3	--	--	--	14
Williams Creek	Whitewater River	3	2	--	--	--	--	--	--	--	5
Fountain County											
Coal Creek	Coal Creek	11	10	--	1	1	1	--	--	--	24
Prairie Creek	Coal Creek	3	7	--	--	--	3	--	--	--	13
Wabash River (lower)	Wabash River (lower)	1	2	--	1	--	--	--	--	--	4
Franklin County											
Big Cedar Creek	Whitewater River	6	3	--	1	--	1	--	--	--	11
Little Salt Creek	Whitewater River	--	1	--	--	--	1	--	--	--	2
Pipe Creek	Whitewater River	6	4	--	--	--	--	--	--	--	10

Table 3. Summary of vulnerable transportation and utility assets by stream reach, county, and class.—Continued

[Values represent the number of vulnerable assets found, aggregated by stream reach, county, and class; --, no data]

Reach name	Main stem	Transportation				Utility					
		Road	Bridge	Railroad	Railroad bridge	Dam	Electric	Levee	Oil/gas	Water	Total
Franklin County—Continued											
Salt Creek	Whitewater River	4	2	--	--	--	1	--	--	--	7
Whitewater River	Whitewater River	32	7	19	1	1	3	--	4	--	67
Gibson County											
Wabash River (lower)	Wabash River (lower)	--	1	--	3	--	--	--	9	--	13
White River (lower)	White River (lower)	1	--	--	--	--	--	--	--	--	1
Greene County											
Eel River (south)	Eel River (south)	--	1	1	--	--	1	--	3	--	6
White River (lower)	White River (lower)	3	3	1	3	--	7	--	2	--	19
Hancock County											
Big Blue River	Big Blue River	1	3	--	--	--	1	--	--	--	5
Hendricks County											
Big Walnut Creek	Big Walnut Creek	--	4	--	--	--	--	--	--	--	4
East Fork White Lick Creek	White Lick Creek	3	3	--	--	--	--	--	--	--	6
West Fork White Lick Creek	White Lick Creek	6	21	--	1	--	2	--	--	1	31
White Lick Creek	White Lick Creek	16	15	--	1	--	9	--	2	1	44
Henry County											
Big Blue River	Big Blue River	1	8	--	--	--	--	--	--	--	9
Jackson County											
East Fork White River (upper)	East Fork White River (upper)	8	16	6	2	1	3	--	2	1	39
Sand Creek	East Fork White River (upper)	--	2	--	--	--	--	--	--	--	2
Jennings County											
Sand Creek	East Fork White River (upper)	1	--	--	--	--	--	--	2	--	3
Johnson County											
Big Blue River	Big Blue River	--	4	--	1	1	3	--	4	1	14
Knox County											
Wabash River (lower)	Wabash River (lower)	--	4	--	1	--	--	1	9	--	15
White River (lower)	White River (lower)	6	8	--	2	--	7	3	14	1	41
Lawrence County											
East Fork White River (upper)	East Fork White River (upper)	6	2	2	--	--	1	--	3	--	14

Table 3. Summary of vulnerable transportation and utility assets by stream reach, county, and class.—Continued

[Values represent the number of vulnerable assets found, aggregated by stream reach, county, and class; --, no data]

Reach name	Main stem	Transportation				Utility					
		Road	Bridge	Railroad	Railroad bridge	Dam	Electric	Levee	Oil/gas	Water	Total
Marion County											
White River (lower)	White River (lower)	--	1	--	--	--	1	--	2	--	4
Montgomery County											
Black Creek	Sugar Creek	3	3	--	--	--	--	--	--	--	6
Indian Creek	Sugar Creek	--	--	--	--	--	--	--	1	--	1
Rattlesnake Creek	Sugar Creek	1	1	--	--	--	--	--	--	--	2
Sugar Creek	Sugar Creek	7	15	1	1	--	--	--	--	--	24
Morgan County											
East Fork White Lick Creek	White Lick Creek	4	6	--	1	--	--	--	1	1	13
McCracken Creek	White Lick Creek	--	2	--	--	--	--	--	--	--	2
White Lick Creek	White Lick Creek	4	7	--	1	--	7	--	3	--	22
White River (lower)	White River (lower)	6	5	1	2	1	10	--	6	--	31
Owen County											
Eel River (south)	Eel River (south)	1	2	--	--	--	--	--	--	--	3
White River (lower)	White River (lower)	6	5	9	--	--	3	--	1	--	24
Parke County											
Big Raccoon Creek	Big Raccoon Creek	11	17	--	--	3	3	--	6	--	40
Leatherwood Creek	Big Raccoon Creek	1	4	--	--	--	1	--	--	--	6
Little Raccoon Creek	Big Raccoon Creek	--	7	--	--	--	--	--	--	--	7
Rock Run	Big Raccoon Creek	--	2	--	--	--	1	--	--	--	3
Rocky Fork	Big Raccoon Creek	1	4	--	--	--	--	--	--	--	5
Coal Creek	Coal Creek	--	1	--	--	--	--	--	--	--	1
Sugar Creek	Sugar Creek	6	9	--	--	1	10	--	2	--	28
Sugar Mill Creek	Sugar Creek	2	4	--	--	--	--	--	--	--	6
Mill Creek	Wabash River (lower)	2	4	--	--	--	--	--	--	--	6
Wabash River (lower)	Wabash River (lower)	--	3	--	2	--	2	--	5	--	12
Pike County											
White River (lower)	White River (lower)	--	--	1	--	--	--	--	--	--	1
Posey County											
Wabash River (lower)	Wabash River (lower)	--	4	--	1	--	--	--	9	--	14

Table 3. Summary of vulnerable transportation and utility assets by stream reach, county, and class.—Continued

[Values represent the number of vulnerable assets found, aggregated by stream reach, county, and class; --, no data]

Reach name	Main stem	Transportation				Utility					
		Road	Bridge	Railroad	Railroad bridge	Dam	Electric	Levee	Oil/gas	Water	Total
Putnam County											
Big Raccoon Creek	Big Raccoon Creek	5	4	--	--	--	1	--	1	--	11
Ramp Creek	Big Raccoon Creek	3	5	--	--	--		--	2	--	10
Big Walnut Creek	Big Walnut Creek	26	27	--	3	1	3	--	8	--	68
Clear Creek	Big Walnut Creek	2	4	--	--	--	--	--	--	--	6
Little Walnut Creek	Big Walnut Creek	12	4	--	1	--	--	--	--	--	17
Deer Creek	Eel River (south)	--	2	--	--	--	--	--	--	--	2
Eel River (south)	Eel River (south)	--	--	--	--	--	1	--	--	--	1
Rush County											
Big Blue River	Big Blue River	6	4	--	1	--	--	--	--	--	11
Shelby County											
Big Blue River	Big Blue River	17	12	--	2	--	14	--	4	1	50
Flatrock River	Flatrock River	4	3	--	--	--	--	--	--	--	7
Sullivan County											
Wabash River (lower)	Wabash River (lower)	2	1	--	1	--	1	--	4	--	9
Tippecanoe County											
Middle Fork Wildcat Creek	South Fork Wildcat Creek	2	5	--	--	--	1	--	1	--	9
South Fork Wildcat Creek	South Fork Wildcat Creek	7	7	--	1	--	4	--	5	--	24
Wildcat Creek	Wildcat Creek	8	7	--	1	--	4	--	3	--	23
Union County											
East Fork Whitewater River	Whitewater River	3	3	--	1	--	--	--	--	--	7
Vermillion County											
Little Vermilion River	Wabash River (lower)	2	7	--	1	--	1	--	--	--	11
Vermilion River	Wabash River (lower)	3	5	--	--	--	1	--	--	--	9
Wabash River (lower)	Wabash River (lower)	--	3	1	--	--	1	--	--	--	5
Vigo County											
Brouilletts Creek	Wabash River (lower)	--	--	--	--	--	--	--	2	--	2
Wabash River (lower)	Wabash River (lower)	4	6	--	3	--	10	--	9	--	32
Wayne County											
East Fork Whitewater River	Whitewater River	1	--	--	--	--	--	--	--	--	1
Nolands Fork	Whitewater River	3	3	--	--	--	1	--	--	--	7

Polyline Shapefile of Investigated Stream Reaches

A polyline shapefile depicting both active and stationary stream reaches documented in Robinson (2013a), as well as 38 additional tributaries also showing signs of active migration, was derived from line work in the National Hydrography Dataset (NHD), which was downloaded as a statewide extract from The National Map (https://nhd.usgs.gov) on March 15, 2015 (U.S. Geological Survey, 2015). Segmented NHD flow lines were selected between the upstream and downstream points that bound each stream reach and exported from the NHD file geodatabase (.gdb) to shapefile (.shp) format. The names of flow lines in the dataset, sourced from the Geographic Names Information System (U.S. Board on Geographic Names, no date), were edited to be consistent with the names of stream reaches used in Robinson (2013a). After the flow lines were renamed, the dissolve command of **ArcInfo** was used to combine flow line segments into singlepart features based on contiguity and common names. Lastly, the attributes named main stem, **tributary**, active, rate_ft_yr, length_mi, and label were added to the attribute table of the shapefile Data_Series_2017_1068_Channel_Migration_Rates.shp (table 4) to support queries on the dataset.

Table 4. Names and descriptions of attributes in Data_Series_2017_1068_Channel_Migration_Rates.shp.

Attribute	Description	Data type
reach_name	Name of stream reach, as documented in Scientific Investigations Report 2013–5168 (Robinson, 2013a)	String
mainstem	Name of mainstem stream reach	String
tributary	Indicates whether a stream reach is considered a mainstem or tributary	Short integer
active	Indicates whether a stream reach is actively migrating or stationary	Short integer
rate_ft_yr[1]	Channel migration rate expressed in feet per year	String
length_mi	Length of stream reach expressed in miles along stream's path	Float
label	References map label in figure 1	String

[1]Channel migration rates were measured in a report by Robinson (2013a) for mainstem stream reaches only.

Accessing the Data

The products of this report are available through a data release at https://doi.org/10.5066/F7ZG6R49 (Sperl, 2017). The products include (1) a comma-delimited text file (.csv) of table 3, which provides numbers of vulnerable assets aggregated by stream reach, county, and class of asset; and (2) a polyline shapefile (.shp) of the stream reaches documented in Robinson (2013a) as well as 38 additional tributaries where recent channel migration was observed. Federal Geographic Committee metadata is provided for both files in the associated data release.

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Glossary

ArcInfo GIS software developed by Environmental Systems Research Institute.

Fluvial erosion hazard The suite of risks to structures, property, and infrastructure elements that are brought about by the natural processes of stream-bank erosion and stream-channel meandering.

Fluvial plain The valley-floor (or valley-flat) land that has been produced by fluvial processes and may include the flood plain and adjacent terraces.

Migration rate The rate at which a channel migrates laterally, expressed in units of feet per year.

Stream reach A section of a stream or river between two points.

Main stem A larger river or stream formed by a number of smaller tributaries.

Orthophotography Refers to aerial photographs that have been geometrically corrected to preserve true distances.

Tributary A smaller river or stream that flows into a larger river or stream.

GIS Geographic information system(s).

Google Earth A software application developed by Google with functionality to view imagery from different sources, times, and places.

For additional information contact:
Director, Indiana Water Science Center
U.S. Geological Survey
5957 Lakeside Boulevard
Indianapolis, IN 46278-1996

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