

Prepared in cooperation with the city of De Soto, Missouri, and Jefferson County, Missouri

# Flood-Inundation Maps for Joachim Creek, De Soto, Missouri, 2018



Scientific Investigations Report 2019–5068

**Cover:** Flooding on Joachim Creek at De Soto, Missouri, looking west from East Miller Street toward West Miller and Main streets.

**Back:** Flooded cars and business at 519 East Main Street. Looking west to Hopson Field at newly constructed bridge. Photographs courtesy of Leader Publications, April 18, 2013. Ted Howell, photographer.

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By David C. Heimann, Jonathan D. Voss, and Paul H. Rydlund, Jr.

Prepared in cooperation with the city of De Soto, Missouri, and Jefferson County,  
Missouri

Scientific Investigations Report 2019–5068

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## Contents

Acknowledgments .....	iii
Abstract .....	1
Introduction.....	1
Purpose and Scope .....	3
Study Area Description.....	3
Previous Studies .....	3
Creation of Flood-Inundation-Map Library.....	4
Computation of Water-Surface Profiles.....	4
Hydrologic Data.....	4
Topographic and Bathymetric Data .....	5
Hydraulic Structures .....	5
Energy-Loss Factors.....	6
Hydraulic Model.....	6
Development of Water-Surface Profiles.....	7
Development of Flood-Inundation Maps .....	7
Flood-Inundation Map Delivery .....	7
Disclaimer for Flood-Inundation Maps .....	7
Uncertainties and Limitations Regarding Use of Flood-Inundation Maps .....	7
Summary.....	9
References Cited.....	9

## Figures

1. Map showing location of the study reach, elevation cross sections used in the hydraulic model, and location of the cooperative U.S. Geological Survey streamgage Joachim Creek at De Soto, Missouri .....
2. Flood-inundation map for Joachim Creek, De Soto, Missouri, corresponding to a stage of 17.0 feet at the U.S. Geological Survey streamgage 07019500 .....

## Tables

1. U.S. Geological Survey streamgage information for Joachim Creek at De Soto, Missouri.....
2. Peak discharges for selected annual exceedance probabilities for Joachim Creek at De Soto, Missouri.....
3. Estimated discharges for corresponding stages and water-surface elevations at the streamgage Joachim Creek at De Soto, Missouri, used in the hydraulic model for the study reach .....
4. Calibration of model to target in-channel water-surface elevations at U.S. Geological Survey streamgage Joachim Creek at De Soto, Missouri.....
5. Calibration of model to water-surface elevations at selected locations along Joachim Creek for the flood of April 18, 2013.....

## Conversion Factors

U.S. customary units to International System of Units

<b>Multiply</b>	<b>By</b>	<b>To obtain</b>
Length		
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi <sup>2</sup> )	2.590	square kilometer (km <sup>2</sup> )
Flow rate		
cubic foot per second (ft <sup>3</sup> /s)	0.02832	cubic meter per second (m <sup>3</sup> /s)

## Datum

Vertical coordinate information is referenced to (1) stage, the height above an arbitrary datum established at a streamgage, and (2) elevation, the height above the North American Vertical Datum of 1988 (NAVD 88).

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

# Flood-Inundation Maps for Joachim Creek, De Soto, Missouri, 2018

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## Abstract

Digital flood-inundation maps for a 6.7-mile reach of Joachim Creek, De Soto, Missouri, were created by the U.S. Geological Survey (USGS) in cooperation with the city of De Soto and Jefferson County, Missouri. The flood-inundation maps, which can be accessed through the USGS Flood Inundation Mapping Program website at <https://www.usgs.gov/mission-areas/water-resources/science/flood-inundation-mapping-fim-program>, depict estimates of the areal extent and depth of flooding corresponding to selected water levels (stages) at the USGS streamgage Joachim Creek at De Soto, Missouri (station number 07019500). Near-real-time stages at this streamgage may be obtained on the internet from the USGS National Water Information System at <https://waterdata.usgs.gov/nwis> or the National Weather Service Advanced Hydrologic Prediction Service at <http://water.weather.gov/ahps2/hydrograph.php?wfo=lsx&gage=desm7>, which also forecasts flood hydrographs at this site (site DESM7).

Flood profiles were computed for the stream reach using a one-dimensional model for simulation of water-surface profiles with steady-state (gradually varied) or unsteady-state flow computation options. The model was calibrated by using the theoretical stage-discharge relation at the USGS streamgage Joachim Creek at De Soto, Missouri (station number 07019500), and documented high-water marks from the flood of April 18, 2013.

The hydraulic model was then used to compute 10 water-surface profiles for flood stages at 1-foot (ft) intervals referenced to the streamgage datum. The profiles ranged from 8.0 ft, or near bankfull, to 17.0 ft, which exceeds the stage that corresponds to the estimated 0.2-percent annual exceedance probability flood (500-year recurrence interval flood). The simulated water-surface profiles were then combined with a geographic information system digital elevation model (derived from light detection and ranging data having a 0.60-ft vertical accuracy and 1.97-ft horizontal resolution) to delineate the area flooded at each water level.

The availability of these maps, along with internet information regarding current stage from the USGS streamgage and forecasted high-flow stages from the National Weather Service, will provide emergency management personnel and

residents with information that is critical for flood-response activities such as evacuations and road closures and for post-flood recovery efforts.

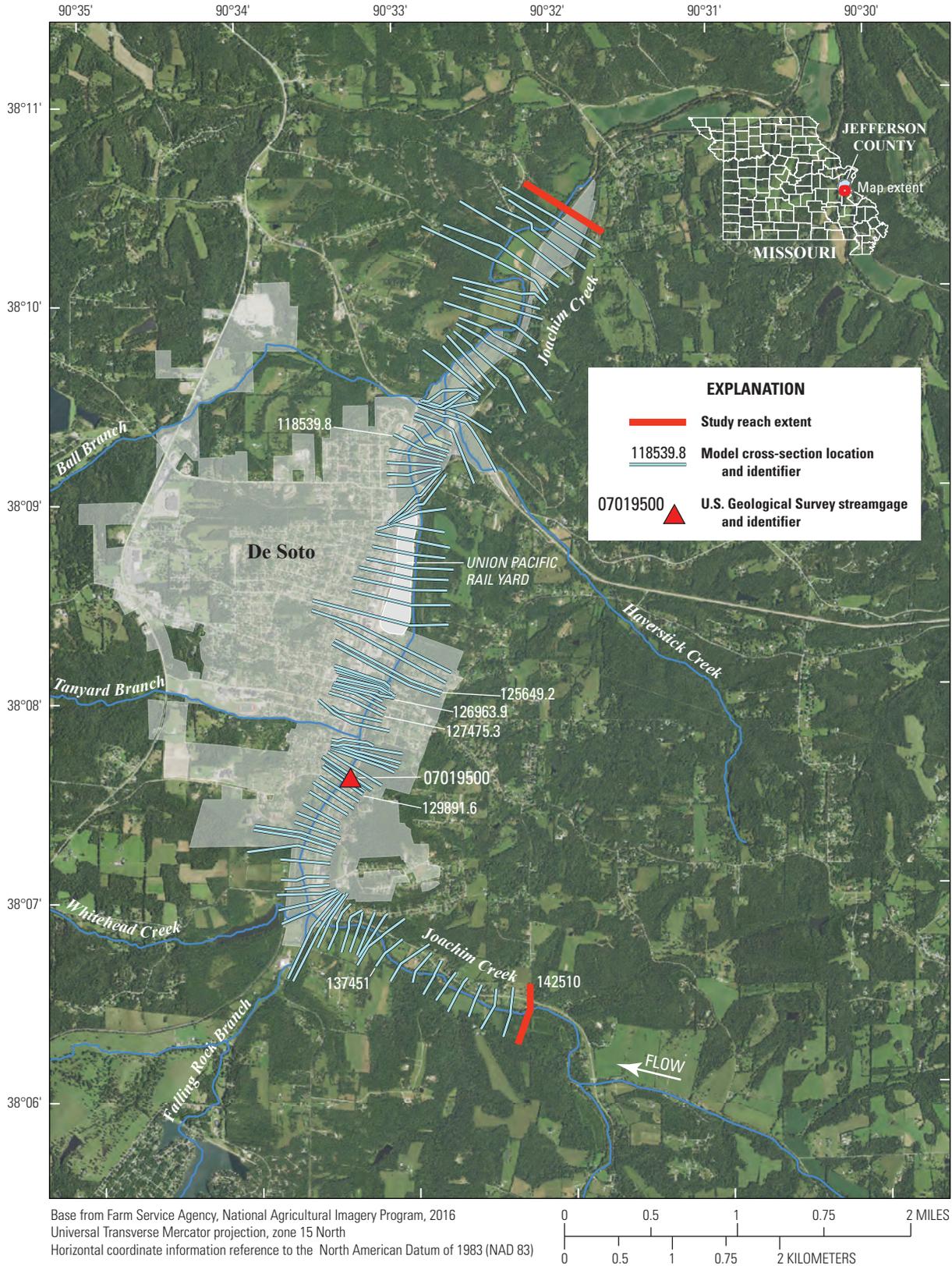
## Introduction

During April 2013, May 2013, August 2016, and April 2017, the residents of the city of De Soto, Missouri, population 6,380 (U.S. Census Bureau, 2019) have experienced substantial flooding from Joachim Creek (fig. 1). Flooding in April 2013 resulted in the death of one individual by drowning, and the first responders also are at direct risk because the rural firehouse is in the flood plain. The residents of De Soto lack the resources needed to determine the status and consequences of water levels (stages) and streamflows along Joachim Creek, including flood conditions that threaten lives and property.

Prior to this study, emergency responders in De Soto, Missouri, relied on several information sources (all of which are available on the internet) to make decisions on how to best alert the public and mitigate flood damages. One source is the Federal Emergency Management Agency (FEMA) flood insurance study (FIS) for De Soto, Missouri, dated April 2006 (FEMA, 2006). A second source of information is the U.S. Geological Survey (USGS) streamgage Joachim Creek at De Soto, Missouri, from which current (USGS, 2018a) and historical (since July 7, 2018) water levels and discharges can be obtained. A third source of flood-related information is the National Weather Service (NWS) Advanced Hydrologic Prediction Service (AHPS), which displays the USGS stage data from the streamgage and also issues forecasts of stage at the Joachim Creek at De Soto, Missouri, streamgage (NWS, 2018a).

Although the current stage at a USGS streamgage is particularly useful for residents in the immediate vicinity of a streamgage, the current stage is of limited use to residents farther upstream or downstream because the water-surface elevation is not constant along the stream reach. Knowledge of a water level at a streamgage is difficult to translate into depth and areal extent of flooding at points distant from the streamgage. One way to address these informational gaps is to

2 Flood-Inundation Maps for Joachim Creek, De Soto, Missouri, 2018



**Figure 1.** Location of the study reach, elevation cross sections used in the hydraulic model, and location of the cooperative U.S. Geological Survey streamgage Joachim Creek at De Soto, Missouri (station number 07019500).

produce a library of flood-inundation maps that are referenced to the stages recorded at the USGS streamgage. By referring to the appropriate map, emergency responders can discern the severity of flooding (depth of water and areal extent), identify roads that are or will soon be flooded, and make plans for notification or evacuation of residents in harm's way for some distance upstream and downstream from the streamgage. In addition, the capability to visualize the potential extent of flooding has helped to motivate residents to take precautions and heed warnings that they previously might have disregarded. In 2018–19, the USGS, in cooperation with the city of De Soto, Missouri, and Jefferson County, Missouri, led a project to produce a library of flood-inundation maps for Joachim Creek, De Soto, Missouri.

## Purpose and Scope

The purpose of this report is to describe the development of a series of estimated flood-inundation maps for Joachim Creek, De Soto, Missouri, to identify where the maps are on the internet, and how the ancillary data (geographic information system [GIS] flood polygons and depth grids) can be downloaded. The 6.7-mile study reach extends from 1.3 miles upstream from the De Soto, Missouri, city boundary downstream to the approximate boundary of De Soto (fig. 1). The maps were produced for flood levels referenced to the stage recorded at the USGS streamgage Joachim Creek at De Soto, Missouri (station number 07019500; table 1); the gage is approximately 2.4 miles downstream from the upstream extent of the study reach (fig. 1).

The maps cover a range in stage from 8.0 to 17.0 feet (ft), referenced to the streamgage datum. The 8.0-ft stage is approximately bankfull and is defined by the NWS (2018b) as the “action stage” or that stage, when reached by a rising stream, requires the NWS or a partner to take some type of mitigation action in preparation for possible significant hydrologic activity. The 17.0-ft stage exceeds the stage that

corresponds to the estimated 0.2-percent annual exceedance probability flood (500-year recurrence interval).

## Study Area Description

The Joachim Creek study reach is in east-central Missouri in Jefferson County and is within the city limits of De Soto, Missouri (fig. 1). The drainage area upstream from the USGS streamgage at De Soto is 42.4 square miles, and the drainage area at the downstream extent of the study reach is 60.8 square miles. The Joachim Creek study basin is in the Ozark Plateau physiographic region (Fenneman, 1938). Land slopes in the basin are generally 3 to 10 percent with local relief of 300 to 400 ft (Collier, 1955). The primary land cover of the study basin is forest (71 percent) followed by pasture (12 percent), based on 2011 National Land Cover Data (Homer and others, 2015). Less than 5 percent of the basin is classified as low- to high-intensity development. The study reach is 6.7 miles with an average top-of-bank width of 560 ft and average slope of 11.4 feet per mile based on channel cross-section data obtained from a hydraulic model of Joachim Creek (Alecia Williams, Wood Environment and Infrastructure Solutions, written commun., 2018). There are seven bridge crossings in the main-stem reach, which include one railroad, three state highway, and three county/city road crossings.

## Previous Studies

The hydrologic and hydraulic analyses for the latest published FIS for Jefferson County, Missouri, (FEMA, 2006) includes hydraulic analysis for Joachim Creek, De Soto, Missouri, which was completed by the U.S. Army Corps of Engineers (USACE), St. Louis District, in August 2002 (FEMA, 2002). A previous FIS for De Soto, Missouri, was completed in 1981 by Booker Associates, Inc., (FEMA, 1981) and revised by FEMA in 1998 (FEMA, 2006). An updated

**Table 1.** U.S. Geological Survey streamgage information for Joachim Creek at De Soto, Missouri.

[Station location is shown in figure 1. mi<sup>2</sup>, square mile; ft, foot; NAVD 88, North American Vertical Datum of 1988; ft<sup>3</sup>/s, cubic foot per second; °, degree; ', minute; ", second]

Station name	Station number	Drainage area (mi <sup>2</sup> )	Latitude	Longitude	Period of peak-flow record (water year) <sup>1</sup>	Maximum recorded stage, (ft), gage datum and elevation (ft, NAVD 88) and date	Maximum discharge (ft <sup>3</sup> /s) and date
Joachim Creek at De Soto, Missouri	07019500	42.4	38°07'36"	90°33'23"	2018	<sup>2</sup> 14.3 (506.2) April 18, 2013	<sup>3</sup> 15,000 April 18, 2013

<sup>1</sup>Water year is the 12-month period from October 1 of one year through September 30 of the following year and is designated by the calendar year in which it ends.

<sup>2</sup>Stage interpolated from observed high-water marks.

<sup>3</sup>Discharge estimated using hydraulic model and observed high-water marks.

hydraulic model was completed in July 2015 by Wood Environmental and Infrastructure Solutions (Alecia Williams, Wood Environment and Infrastructure Solutions, written commun., 2018) in an ongoing effort to revise the FIS for De Soto, Missouri.

The latest published FIS (FEMA, 2006) presents estimates of the peak discharges and associated annual exceedance probabilities (AEPs) and their associated water-surface elevations at several locations along Joachim Creek. Updated peak discharges for AEPs of 10, 2, 1, and 0.2 percent (table 2) at the Joachim Creek at De Soto, Missouri, streamgage were generated for this study using the USGS StreamStats application (USGS, 2018c).

## Creation of Flood-Inundation-Map Library

The USGS has standardized the procedures for creating flood-inundation maps for flood-prone communities (USGS, 2018c) so that the process followed and products produced are similar regardless of which USGS office is responsible for the work. Tasks specific to the development of the flood maps for this study included (1) installation of the streamgage Joachim Creek at De Soto, Missouri (table 1); (2) acquisition of a hydraulic model that is being used for an ongoing update of the FIS for De Soto, Missouri (Alicia Williams, Wood Environmental and Infrastructure Solutions, written commun., 2018); (3) calibration of energy-loss factors (roughness coefficients) in the stream channel and flood plain and determination of steady-flow data; (4) computation of water-surface profiles using the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) computer program (USACE, 2016); (5) production of estimated flood-inundation maps for selected stream stages using the USACE Hydrologic Engineering Center's Geospatial River Analysis System (HEC-GeoRAS) computer program (Ackerman, 2009) and a GIS; and (6) preparation of the maps as shapefile polygons that depict the areal extent of flood inundation at various stages and as depth grids that provide the depth of floodwaters for display on a USGS flood-inundation mapping application.

## Computation of Water-Surface Profiles

The hydraulic model used in this study was developed in 2015 for an ongoing update of the FIS for De Soto, Missouri (Alecia Williams, Wood Environment and Infrastructure Solutions, written commun., 2018). This model, which was developed using HEC-RAS, version 4.1 (USACE, 2010), was calibrated by the USGS and used to produce the 10 flood-inundation maps in this study using HEC-RAS version 5.0.3 (USACE, 2016). HEC-RAS is a one-dimensional model for simulation of water-surface profiles with steady-state (gradually varied) or unsteady-state flow computation options.

## Hydrologic Data

The study reach includes one USGS streamgage (station number 07019500; fig. 1; table 1) established for this project. Stage is measured every 15 minutes, transmitted hourly by a satellite radio in the streamgage, and made available on the internet through the USGS National Water Information System (NWIS; USGS, 2018b). Stage data from this streamgage are referenced to a local datum but can be converted to water-surface elevations referenced to the North American Vertical Datum of 1988 (NAVD 88) by adding 491.90 ft. Continuous records of discharge are computed from a stage-discharge relation (Turnipseed and Sauer, 2010), which has been developed for the streamgage, and are available through the USGS NWIS website.

The estimated discharges used for specific stages in the model simulations (table 3) were obtained from a theoretical stage-discharge rating (Turnipseed and Sauer, 2010) at the streamgage location generated from discrete streamflow measurements and simulated peak discharges derived from the calibrated hydraulic model corresponding to the AEPs provided in table 2 (see "Hydraulic Model" section). No major tributaries join Joachim Creek within the 6.7-mile study reach; therefore, the streamgage-derived discharges were not adjusted for tributary inflows but were held constant throughout the study reach for a given profile.

**Table 2.** Peak discharges for selected annual exceedance probabilities for Joachim Creek at De Soto, Missouri.

[Data from U.S. Geological Survey StreamStats application (USGS, 2018c). mi<sup>2</sup>, square mile; ft<sup>3</sup>/s, cubic foot per second; USGS, U.S. Geological Survey]

Location on Joachim Creek	Drainage area (mi <sup>2</sup> )	Estimated discharge (ft <sup>3</sup> /s) for indicated annual exceedance probabilities (percent)			
		10	2	1	0.2
At upstream end of study reach at Bade Road	31.4	6,780	11,500	13,500	18,300
At USGS streamgage number 07019500	42.4	8,030	13,500	15,900	21,500
At downstream end of study reach	60.8	9,610	16,000	18,800	25,400

**Table 3.** Estimated discharges for corresponding stages and water-surface elevations at the streamgage Joachim Creek at De Soto, Missouri, used in the hydraulic model for the study reach.

[ft, foot; NAVD 88, North American Vertical Datum of 1988; ft<sup>3</sup>/s, cubic foot per second]

Stage of water-surface profile <sup>1</sup> (ft)	Water-surface elevation (ft, NAVD 88)	Estimated discharge at streamgage location for indicated stage <sup>2</sup> (ft <sup>3</sup> /s)
8.0	499.90	4,550
9.0	500.90	5,850
10.0	501.90	7,300
11.0	502.90	8,900
12.0	503.90	10,500
13.0	504.90	12,600
14.0	505.90	14,400
15.0	506.90	16,900
16.0	507.90	19,200
17.0	508.90	22,500

<sup>1</sup>Water-surface profiles are 1-foot increments of stage, referenced to the gage datum of the U.S. Geological Survey streamgage Joachim Creek at De Soto, Missouri (station number 07019500).

<sup>2</sup>Discharges corresponding to stages greater than 8 feet were derived from the calibrated model using simulated peak discharges indicated in table 2.

## Topographic and Bathymetric Data

All topographic data used in this study are referenced vertically to NAVD 88 and horizontally to the North American Datum of 1983. Cross-section elevation data were obtained from a digital elevation model (DEM) that was derived from light detection and ranging (lidar) data that were collected during December 2010 by Surdex Corporation, Chesterfield, Missouri, through a contract with the USACE, St. Louis Division. Postprocessing of these data was completed by Surdex Corporation on April 6, 2011 (Missouri Spatial Data Information Service, 2018). The bare-earth lidar data were processed using USGS Base Lidar Specifications version 1.3 (Heidemann, 2018) that met or exceeded the National Map Accuracy standards for vertical and horizontal accuracy guidelines for 2-ft contours (American Society for Photogrammetry and Remote Sensing [ASPRS], 1990, 2004). The lidar data have a horizontal accuracy of 1.97 ft (60 centimeters) root mean squared error (RMSE) and vertical accuracy of 0.607 ft (18.5 centimeters) RMSE. The final DEM, which was resampled to a 3.28-ft grid-cell size to decrease the GIS processing time, has a vertical accuracy of plus or minus 1 ft.

Any development or landscape modifications within the Joachim Creek flood plain that took place after the lidar was flown (December 2010) and that could result in substantial topographic and hydraulic changes to the flood plain, were considered for inclusion in the DEM. Modifications within the Union Pacific rail yard in De Soto (fig. 1) were considered but were based on the February 19, 2016, site development package (TranSystems, 2016). The modifications within the De Soto rail yard generally were within the stated contour

accuracy of the original lidar-based DEM and, therefore, were not included in the final DEM.

By using HEC-GeoRAS (Ackerman, 2009), a set of procedures, tools, and utilities for processing geospatial data in ArcGIS, elevation data were extracted from the DEM for 97 cross sections (fig. 1) and subsequently input to the HEC-RAS model. Because lidar data cannot provide ground elevations below a stream's water surface, channel cross sections in the HEC-RAS model were surveyed by Wood Environment and Infrastructure Solutions during 2015 (Alicia Williams, Wood Environment and Infrastructure Solutions, written commun., 2018) and spot verified by USGS field crews during 2018. Cross-sectional depths were measured by wading at all cross-section locations. A differential global positioning system with real-time kinematic technology was used to derive horizontal locations and the elevation of the water surface at each surveyed cross section.

## Hydraulic Structures

Seven structures, consisting of six road crossings (three county road bridges and three state highway bridges) and one railroad bridge have the potential to affect water-surface elevations during floods along the stream. Bridge-geometry data were obtained from a HEC-RAS model developed by Wood Environment and Infrastructure Solutions (Alicia Williams, Wood Environment and Infrastructure Solutions, written commun., 2018), and the data were verified by field surveys and from as-built bridge plans by personnel from the USGS Central Midwest Water Science Center.

## Energy-Loss Factors

Hydraulic analyses require the estimation of energy losses that result from frictional resistance exerted by a channel on flow. These energy losses are quantified by the Manning's roughness coefficient ("n" value). Initial (precalibration) *n* values were selected on the basis of field observations, high-resolution aerial photographs (Farm Service Agency, 2012), and tabulated estimates of *n* values (Chow, 1959).

As part of the calibration process, the initial *n* values were varied by flow and adjusted until the differences between simulated and observed water-surface elevations at the streamgage and elsewhere along the study reach were minimized. The final *n* values ranged from 0.022 to 0.045 for the main channel and from 0.03 to 0.12 for the overbank areas modeled in this analysis. The lowest channel coefficients were placed in straight bedrock-lined reaches and the highest were placed in low-gradient, fine-material substrate reaches with vegetated banks. The lowest flood plain coefficients were placed in open fields and the highest in densely forested areas.

## Hydraulic Model

The HEC-RAS analysis for this study was done by using the steady-state flow computation option. Steady-state flow

data consisted of flow regime, boundary conditions, and peak flows that produced water-surface elevations at the streamgage cross section that matched target water-surface elevations.

These target elevations coincided with 1ft increments of stage, referenced to the local gage datum. Subcritical (tranquil) flow regime was assumed for the simulations. Normal depth, based on an estimated average water-surface slope of 0.003, was used as the reach's downstream boundary condition. The peak flows that were used in the model were discussed in the section, "Hydrologic Data."

The HEC-RAS model was calibrated to a theoretical developed stage-discharge relation at the Joachim Creek at De Soto, Missouri, streamgage and to documented high-water marks from the flood of April 18, 2013. Model calibration was accomplished by adjusting Manning's *n* values until the results of the hydraulic computations closely agreed with the observed water-surface elevations for given flows. Differences between target and modeled water-surface elevations for two simulated flows at the USGS streamgage were equal to or less than 0.49 ft (table 4). Differences between surveyed and modeled elevations of seven high-water marks in the study reach for the flood of April 18, 2013, were less than or equal to 0.52 ft (table 5). The results demonstrate that the model is capable of simulating accurate water levels over a range of stages and flows in the reach.

**Table 4.** Calibration of model to target in-channel water-surface elevations at U.S. Geological Survey streamgage Joachim Creek at De Soto, Missouri (station number 07019500).

[ft, foot; NAVD 88, North American Vertical Datum of 1988]

Stage of water-surface profile (ft)	Target water-surface elevation (ft, NAVD 88)	Modeled water-surface elevation (ft, NAVD 88)	Difference in elevation (ft)
7	498.90	499.29	-0.39
8	499.90	500.39	-0.49

**Table 5.** Calibration of model to water-surface elevations at selected locations along Joachim Creek for the flood of April 18, 2013 (streamgage stage of 14.3 ft).

[ft, foot; NAVD 88, North American Vertical Datum of 1988]

Cross-section identifier <sup>1</sup> (ft)	Surveyed water-surface elevation (ft, NAVD 88)	Modeled water-surface elevation (ft, NAVD 88)	Difference in elevation (ft)
118539.8	481.76	481.28	0.48
125649.2	496.85	496.36	0.49
126963.9	501.03	501.55	-0.52
127475.3	501.96	502.07	-0.11
129891.6	507.77	507.65	0.12
137451	527.56	527.43	0.13
142510	543.10	543.21	-0.11

<sup>1</sup>Cross-section identification numbers are referenced to the longitudinal baseline used in the hydraulic model.

## Development of Water-Surface Profiles

The calibrated hydraulic model was used to generate water-surface profiles for 10 stages at 1-ft intervals between 8.0 and 17.0 ft as referenced to the local datum of the Joachim Creek at De Soto, Missouri, streamgage. These stages correspond to elevations of 499.9 and 508.9 ft, NAVD 88, respectively. Discharges corresponding to the various stages were obtained from a theoretical stage-discharge rating generated from discrete streamflow measurements and simulated peak discharges corresponding to the AEPs provided in table 2.

## Development of Flood-Inundation Maps

Flood-inundation maps were created for the Joachim Creek study reach and referenced to the USGS streamgage Joachim Creek at De Soto, Missouri (station number 07019500), which has been designated as a NWS flood-forecast point (site DESM7) as of 2018 (NWS, 2018a). The DEM data were derived from the same lidar data described previously in the section “Topographic and Bathymetric Data” and, therefore, have an estimated vertical accuracy of 2 ft (that is, plus or minus 1 ft). Estimated flood-inundation boundaries for each simulated profile were developed with HEC–GeoRAS software (Ackerman, 2009), which allows the preparation of geometric data for import into HEC–RAS and processes simulation results exported from HEC–RAS (USACE, 2010). Shapefile polygons and depth grids of the inundated areas for each profile were modified, as required, in the ArcMap application of ArcGIS (Esri, 2018) to ensure a hydraulically reasonable transition of the flood boundaries between modeled cross sections.

Any inundated areas that were detached from the main channel were examined to identify subsurface connections with the main river, such as through culverts under roadways. Where such connections existed, the mapped inundated areas were retained in their respective flood maps; otherwise, the erroneously delineated parts of the flood extent were deleted. The flood-inundation areas are overlaid on high-resolution, georeferenced, aerial photographs of the study area. Bridge surfaces are shown as not inundated until the lowest flood stage that either exceeds the bridge deck or completely inundates both approaches to the bridge. In these latter circumstances, the bridge surface is depicted as being inundated. Estimates of water depth can be obtained from the depth-grid data (Heimann and others, 2019) that are included with the presentation of the flood maps on an interactive USGS mapping application described in the following section, “Flood-Inundation Map Delivery.” The flood map corresponding to the highest simulated water-surface profile, a stage of 17.0 ft, is presented in figure 2.

## Flood-Inundation Map Delivery

The current study documentation is available online at the USGS Publications Warehouse (<https://doi.org/10.5066/P9MD7KUL>). Also, a Flood Inundation Mapping Program website (USGS, 2018d) has been established to make USGS flood-inundation study information available to the public. The website links to a mapping application that presents map libraries and provides detailed information on flood extents and depths for modeled sites. The mapping application enables the production of customized flood-inundation maps from the map library for Joachim Creek, De Soto, Missouri (Heimann and others, 2019). A link on the mapping application website connects to the USGS NWIS (USGS, 2018a), which presents the current stage and streamflow at the USGS streamgage Joachim Creek at De Soto, Missouri (station number 07019500), to which the inundation maps are referenced. A second link connects to the NWS AHPS site (NWS, 2018a) so that the user can obtain applicable information on forecasted peak stage. The estimated flood-inundation maps are displayed in sufficient detail so that preparations for flooding and decisions for emergency response can be performed efficiently. Depending on the flood magnitude, roadways are shown as shaded (inundated and likely impassable) or not shaded (dry and passable) to facilitate emergency planning and use. Bridges are shaded—that is, shown as inundated—when the flood stage exceeds the elevation of the bridge deck or that of both approaches to the bridge. A shaded building should not be interpreted to mean that the structure is completely submerged but, rather, that bare-earth surfaces in the vicinity of the building are inundated. In these instances, the water depth (as indicated in the mapping application by holding the cursor over an inundated area) near the building would be an estimate of the water level inside the structure, unless flood-proofing measures had been implemented.

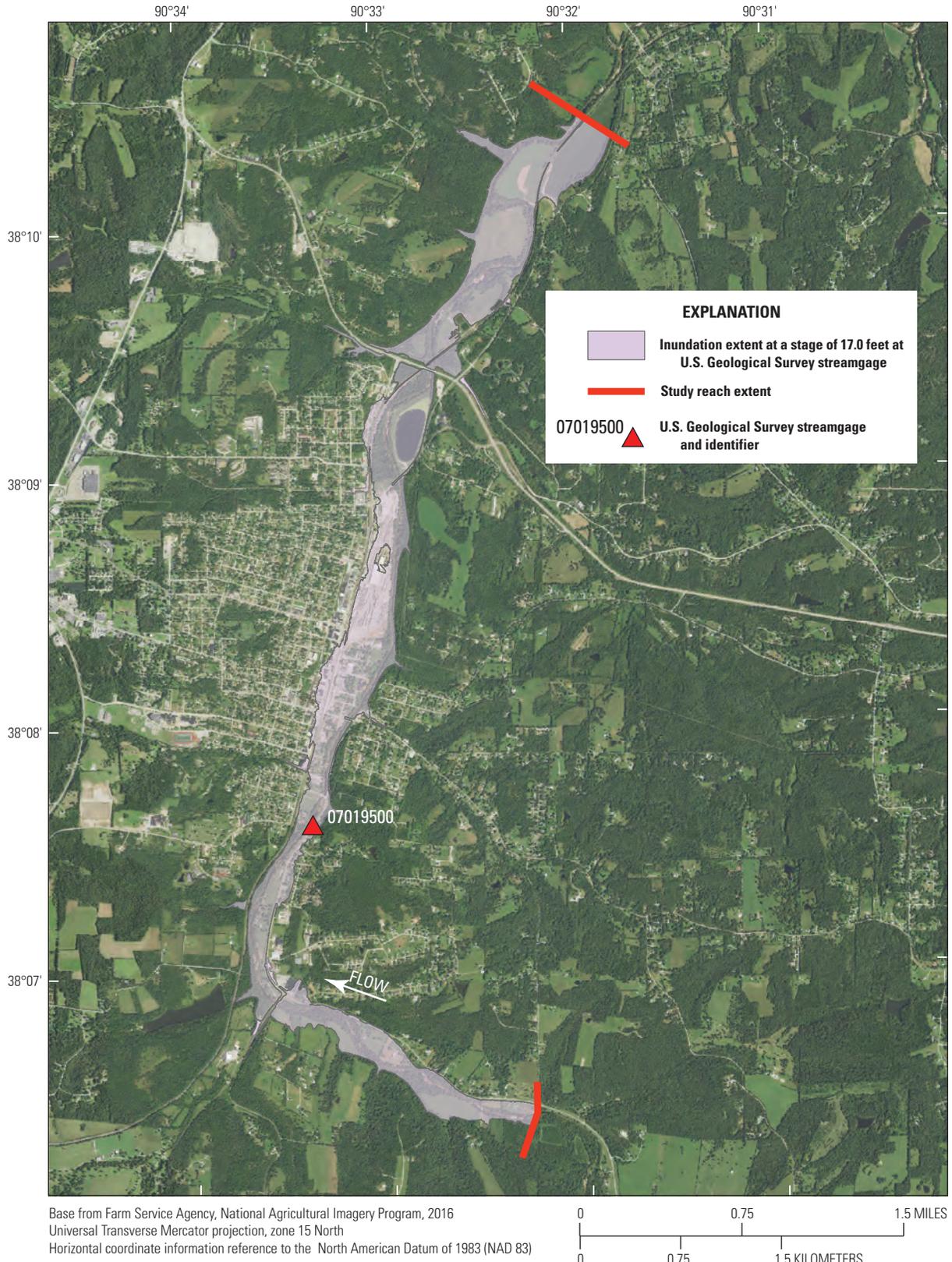
## Disclaimer for Flood-Inundation Maps

The flood-inundation maps should not be used for navigation, regulatory, permitting, or other legal purposes. The USGS provides these maps “as is” for a quick reference, emergency planning tool but assumes no legal liability or responsibility resulting from the use of this information.

## Uncertainties and Limitations Regarding Use of Flood-Inundation Maps

Although the flood-inundation maps represent the boundaries of inundated areas with a distinct line, some uncertainty is associated with these maps. The flood boundaries shown were estimated on the basis of water stages and streamflows at selected USGS streamgages. Water-surface elevations along the stream reaches were estimated by steady-state hydraulic modeling, assuming unobstructed flow, and used discharges and hydrologic conditions anticipated at the USGS

8 Flood-Inundation Maps for Joachim Creek, De Soto, Missouri, 2018



**Figure 2.** Flood-inundation map for Joachim Creek, De Soto, Missouri, corresponding to a stage of 17.0 feet at the U.S. Geological Survey streamgage 07019500.

streamgauge. The hydraulic model reflects the land-cover characteristics and any bridge, dam, levee, or other hydraulic structures existing as of July 2015. Unique meteorological factors (timing and distribution of precipitation) may cause actual streamflows along the modeled reach to vary from those assumed during a flood, which may lead to deviations in the water-surface elevations and inundation boundaries shown. Additional areas may be flooded because of unanticipated conditions such as changes in the streambed elevation or roughness, backwater into major tributaries along a main stem river, or backwater from localized debris or ice jams. The accuracy of the floodwater extent portrayed on these maps will vary with the accuracy of the digital elevation model used to simulate the land surface.

If this series of flood-inundation maps will be used in conjunction with NWS river forecasts, the user should be aware of additional uncertainties that may be inherent or factored into NWS forecast procedures. The NWS uses forecast models to estimate the quantity and timing of water flowing through selected stream reaches in the United States. These forecast models (1) estimate the amount of runoff generated by precipitation and snowmelt, (2) simulate the movement of floodwater as it proceeds downstream, and (3) predict the flow and stage (and water-surface elevation) for the stream at a given location (AHPS forecast point) throughout the forecast period (every 6 hours and in many cases, 3 to 5 days into the future). For more information on AHPS forecasts, please see: [http://water.weather.gov/ahps/pcpn\\_and\\_river\\_forecasting.pdf](http://water.weather.gov/ahps/pcpn_and_river_forecasting.pdf).

## Summary

A series of digital flood-inundation maps were developed in cooperation with the city of De Soto, Missouri, and Jefferson County, Missouri, for Joachim Creek, De Soto, Missouri. The maps cover a reach about 6.7 miles long corresponding to the reach limits of Joachim Creek within the De Soto city limits. The maps were developed by using the U.S. Army Corps of Engineers' Hydrologic Engineering Center's River Analysis System (HEC-RAS) and Hydrologic Engineering Center's Geospatial River Analysis System (HEC-GeoRAS) programs to compute water-surface profiles and to delineate estimated flood-inundation areas and depths of flooding for selected stream stages. The HEC-RAS hydraulic model was calibrated to discrete streamflow measurements at the Joachim Creek streamgauge and to observed high-water marks from the April 2013 flood. The model was used to compute 10 water-surface profiles for flood stages at 1-foot (ft) intervals referenced to the streamgauge datum and ranging from 8.0 ft, or near bankfull, to 17.0 ft, which exceeds the stage corresponding to the estimated 0.2 percent annual exceedance probability flood (500-year recurrence interval).

The simulated water-surface profiles were then combined with a geographic information system digital elevation model derived from light detection and ranging data to delineate

estimated flood-inundation areas as shapefile polygons and depth grids for each profile. These flood-inundation polygons were overlaid on high-resolution, georeferenced aerial photographs of the study area. The flood maps are available through a mapping application that can be accessed on the USGS Flood Inundation Mapping Science website (<https://www.usgs.gov/mission-areas/water-resources/science/flood-inundation-mapping-fim-program>).

Interactive use of the maps on this mapping application can give users a general indication of depth of water at any point by using the mouse cursor to click within the shaded areas. These maps, in conjunction with the real-time stage data from the U.S. Geological Survey streamgauge Joachim Creek at De Soto, Missouri (station number 07019500), and forecasted flood stage data from the National Weather Service Advanced Hydrologic Prediction Service will help guide the general public in taking individual safety precautions and will provide emergency management personnel with a tool to efficiently manage emergency flood operations and postflood recovery efforts.

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