Prepared in cooperation with the city of Rittman and the
Muskingum Watershed Conservancy District

Hydrologic and Hydraulic Analyses of Selected Streams near the City of Rittman in Wayne and Medina Counties, Ohio

Scientific Investigations Report 2021–5040

Front, back covers. View looking upstream at the CSX transportation railroad bridge over Chippewa Creek just upstream from the confluence with the Tuscarawas River near Clinton, Ohio (Photograph by U.S. Geological Survey, September 2009).

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

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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)
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi ²)	2.590	square kilometer (km ²)
Flow rate		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)

Datum

Vertical coordinate information for stage is referenced to the height above an arbitrary datum established at a streamgage, and vertical coordinate information for elevation is referenced to the height above the North American Vertical Datum of 1988 (NAVD 88) and [or] the National Geodetic Vertical Datum of 1929 (NGVD 29).

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

Abbreviations

AEP	annual exceedance probability
DEM	digital elevation model
DGPS	differential global positioning system
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
HEC–GeoRAS	Hydrologic Engineering Center Geospatial River Analysis System
HEC–RAS	Hydrologic Engineering Center River Analysis System
lidar	light detection and ranging
USGS	U.S. Geological Survey

Hydrologic and Hydraulic Analyses of Selected Streams near the City of Rittman in Wayne and Medina Counties, Ohio

By Chad J. Ostheimer

Abstract

The U.S. Geological Survey, in cooperation with the Muskingum Watershed Conservancy District and the city of Rittman, Ohio, did a study to provide data to update and expand parts of two Federal Emergency Management Agency Flood Insurance Studies. The study consisted of hydrologic and hydraulic analyses for selected reaches of four streams (Chippewa Creek, Little Chippewa Creek, Styx River, and the unnamed tributary to Styx River) near the city of Rittman in Wayne and Medina Counties, Ohio. The study covered 36.2 miles of stream reaches.

Instantaneous peak streamflows for floods with 10-, 4-, 2-, 1-, and 0.2-percent and 1-percent plus annual exceedance probabilities were estimated using historical streamflow data from three U.S. Geological Survey streamgages and regional flood-frequency regression equations. The flood-frequency estimates were then used in a Hydrologic Engineering Center River Analysis System step-backwater model to determine water-surface profiles; flood-inundation boundaries for the 10-, 4-, 2-, 1-, and 0.2-percent and 1-percent plus annual exceedance probabilities; and a regulatory floodway for the study reaches. Model inputs included cross sections derived from a digital elevation model supplemented with field surveys of open-channel cross sections and hydraulic structures, field estimates of Manning's roughness values, and flood estimates determined from regional regression equations and historical streamflow data. Flood-inundation boundaries were mapped for each stream reach for the 1- and 0.2-percent annual exceedance probability floods and a regulatory floodway. All data used in the creation of the flood-inundation boundaries are available through a U.S. Geological Survey data release (Ostheimer, 2021) and will be submitted to the Federal Emergency Management Agency for inclusion in updated Flood Insurance Studies for Wayne and Medina Counties.

Introduction

Several streams within the Chippewa Creek Basin in Wayne and Medina Counties, Ohio, were damaged by flooding in 1913, 1935, 1950, 1959, 1969, 2003, and 2019. The July 1969 flood on Chippewa Creek in Rittman, Ohio, had an estimated annual exceedance probability (AEP) of 1-percent (a recurrence interval of 100 years) (Federal Emergency Management Agency, 2009).

Before this study, officials and emergency responders relied on several information sources to make decisions on how to best alert the public to potential flood hazards and mitigate flood damages. These sources include:

1. the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Wayne County, Ohio, dated August 18, 2009 (Federal Emergency Management Agency, 2009);
2. the FEMA FIS for Medina County, Ohio, dated August 19, 2013 (Federal Emergency Management Agency, 2013); and
3. the U.S. Geological Survey (USGS) National Water Information System database from which current (U.S. Geological Survey, 2020a, b, c) and historical (U.S. Geological Survey, 2020d) stages and streamflows, including annual peak streamflows, can be obtained for streams in the study area.

After the 2019 flooding in Rittman, Ohio, the USGS began a study in cooperation with the city of Rittman, Ohio, and the Muskingum Watershed Conservancy District to update and expand the FEMA FIS for Wayne and Medina Counties, Ohio.

Purpose and Scope

The purpose of this report is to describe the methods used to carry out hydrologic and hydraulic analyses for four stream reaches in Wayne and Medina Counties, Ohio, totaling 36.2 miles in length (fig. 1) and the results of those analyses. The analyses include (1) estimates of flood-peak streamflows corresponding to floods with AEPs of 10-, 4-, 2-, 1-, and 0.2-percent and 1-percent plus and (2) determination of water-surface profiles and flood-plain boundaries associated with the AEPs and a regulatory floodway. Streamflows with AEPs of 10, 4, 2, 1, and 0.2 percent correspond to recurrence intervals of 10, 25, 50, 100, and 500 years, respectively.

Study Area Description

The northeast Ohio counties of Wayne and Medina had 2019 estimated populations of approximately 115,700 (U.S. Census Bureau, 2010a) and 179,700 (U.S. Census Bureau, 2010b), respectively. This study's focus is near the city of Rittman, which is a small town of approximately 6,500 residents (U.S. Census Bureau, 2010c) in north-east Wayne County and encompasses the confluences of the unnamed tributary to Styx River with the Styx River, Styx River with Chippewa Creek, and Little Chippewa Creek with Chippewa Creek. The streams evaluated in this study lie within the Chippewa Creek Basin and (except for Little Chippewa Creek which drains northeast) drain mainly to the south and east. The 1981 to 2010 mean annual precipitation in the Chippewa Creek Basin was 38.3 inches as determined from Parameter-Elevation Regressions on Independent Slopes Model datasets (PRISM Climate Group, 2012). Land cover in the Chippewa Creek Basin is predominately planted or cultivated land (61 percent), with the rest of the basin having mostly developed or forested land covers (19 and 17 percent, respectively) (U.S. Geological Survey, 2014). Development within the Chippewa Creek Basin is concentrated in several pockets that are surrounded by large rural expanses.

Previous Studies

The effective FEMA FIS for Wayne County (Federal Emergency Management Agency, 2009) was published on August 18, 2009, while the effective FEMA FIS for Medina County (Federal Emergency Management Agency, 2013) was published on August 19, 2013. The detailed hydrologic and hydraulic analyses in the 2009 FIS and 2013 FIS

(for all four stream reaches) were completed in the 1980s. Little Chippewa Creek has not been studied using detailed hydraulic methods.

Study Approach

The study included the following elements:

1. collection of topographic and bathymetric data for selected cross sections and geometric data for structures and bridges along the study reaches;
2. estimation of 10-, 4-, 2-, 1-, and 0.2-percent AEP peak streamflows using regional regression equations and streamgage data (where available);
3. estimation of energy-loss factors (Manning's roughness coefficients) for the stream channel and flood plain;
4. computation of flood profiles (including a regulatory floodway) using the U.S. Army Corps of Engineers Hydrologic Engineering Center's (HEC) River Analysis System (HEC-RAS) computer program (U.S. Army Corps of Engineers, 2016);
5. production of flood-inundation maps, initially using the HEC Geospatial River Analysis System (HEC-GeoRAS) computer program (U.S. Army Corps of Engineers, 2009) and then refined with a geographic information system; and
6. submission of flood profile and regulatory floodway data to FEMA for inclusion in revised flood-insurance studies.

Hydrologic Analyses

Regional regression equations were used to estimate the 10-, 4-, 2-, 1-, and 0.2-percent and 1-percent plus AEP flood-peak streamflows for selected locations (generally at stream confluences or at easily identifiable points [such as a road crossing] along stream reaches with gradually increasing drainage area) on all stream reaches. The 1-percent plus flood elevation is defined as a flood elevation derived using streamflows that are at the upper 84-percent confidence limit as calculated in the streamgage analysis for the 1-percent AEP flood (Federal Emergency Management Agency, 2019).

Figure 1. Locations of study reaches and U.S. Geological Survey streamgages in Wayne and Medina Counties, Ohio.

The Ohio StreamStats application (Koltun, 2019) was used to solve regional regression equations that use (1) drainage area, (2) main channel slope ([SL10–85] determined by the 10–85 method), and (3) storage (percentage of drainage classified as water and wetlands area) as explanatory variables. The explanatory variables are computed within StreamStats for user-defined locations from geospatial datasets. StreamStats estimates assume that the basin is not appreciably regulated and is without substantial urbanization (Koltun, 2019). The resulting initial flood-peak estimates are listed in [table 1](#).

Of the five USGS streamgages in the study area ([table 2](#)), three streamgages (Chippewa Creek at Miller Road at Sterling, Ohio [U.S. Geological Survey station number 03116077], Little Chippewa Creek near Smithville, Ohio [U.S. Geological Survey station number 03116100], and Chippewa Creek at Easton, Ohio [U.S. Geological Survey station number 03116200]), have sufficient peak-flow record (greater than or equal to 10 years) to estimate flood-frequency statistics (Interagency Advisory Committee on Water Data, 1982). Flood-frequency statistics were not computed for the unnamed tributary to Styx River at Rittman, Ohio (03116192), or Chippewa Creek above Easton, Ohio (03116196), due to lack of streamflow data and insufficient streamflow record, respectively. Hereafter, the USGS streamgages Chippewa Creek at Miller Road at Sterling, Ohio (03116077), and Chippewa Creek at Easton, Ohio (03116200), will be referred to as the Sterling and Easton streamgages, respectively.

Flood-frequency estimates determined with StreamStats for ungaged locations on Chippewa Creek were subsequently adjusted using the gage-weighting technique described by Koltun (2019). For the 1-percent plus flood, the R factor from equation 15 in Koltun (2019) was assumed to be the same as for the 1-percent AEP flood. The data used to determine the R factors are shown in [table 3](#).

For Chippewa Creek, the gage-weighting process resulted in logically increasing flood-peak streamflows with increasing drainage area for locations between the Sterling and Easton streamgages. However, for locations upstream from the Sterling streamgage, the gage-weighting process resulted in flood-peak streamflows increasing with decreasing drainage area. Likewise, downstream from the Easton streamgage, the gage-weighting process resulted in flood-peak streamflows decreasing with increasing drainage area. Consequently, a different method was used to estimate flood-frequency statistics at ungaged locations in those reaches. Koltun (2019) provides equations for estimating flood-frequency statistics, using drainage area as the only explanatory variable. These are referred to as “drainage-area only” equations. To produce a logical progression of flood-frequency estimates for locations upstream from the Sterling streamgage and downstream from the Easton streamgage, the gage-weighted estimate at the nearest streamgage was multiplied by the ratio of the drainage-area

only estimate at the ungaged locations to the drainage-area only estimate at the streamgage location. This ratio adjustment technique resulted in flood-frequency estimates that monotonically decreased upstream from the Sterling streamgage and increased downstream from the Easton streamgage at rates approximately equal to those indicated by the drainage-area only equations. The final adjusted flood-frequency estimates are given in [table 4](#).

Hydraulic Analyses

The water-surface profiles used to develop the flood-inundation maps for this study were computed using HEC–RAS, version 5.0.3 (U.S. Army Corps of Engineers, 2016). HEC–RAS can perform one- and two-dimensional hydraulic calculations for a network of channels under steady- or unsteady-state streamflow conditions. All profiles in this study were computed using one-dimensional steady-state streamflow calculations. Inputs for steady-state streamflow calculations include streamflow regime, boundary conditions, selected hydraulic characteristics, and streamflow estimates. A subcritical streamflow regime was indicated and used for all calculations.

Roughness Estimates

Hydraulic analyses require the estimation of energy losses exerted by a channel on flow. These energy losses are quantified by Manning’s roughness coefficient (“ n ” value). The n values were selected on the basis of field observations and high-resolution aerial photographs. For the study reaches, the n values ranged from 0.010 to 0.049 (open lake to riprap/debris piles) for the main channel and from 0.028 to 0.090 (short grass to heavily wooded) for the overbank areas ([table 5](#)).

Field Surveys

The USGS used a differential global positioning system (DGPS) and differential-leveling surveys (hereafter referred to as conventional surveys) for this study. The DGPS surveys were used to establish an elevation control network at pertinent locations along each of the streams studied. Conventional surveys were done to obtain stream and hydraulic-structure geometry. All conventional survey data met third-order accuracy (horizontal and vertical) criteria (Federal Geodetic Control Committee, 1984). DGPS surveys were completed using real-time network surveying techniques (Rydland and Densmore, 2012). Elevations determined using the DGPS

Table 1. Summary of the explanatory variable values used in the regression equations, the initial 10-, 4-, 2-, 1-, and 0.2-percent and 1-percent plus¹ annual exceedance probability flood-peak streamflow estimates, and locations for the selected streams in Wayne and Medina Counties, Ohio.

[mi², square mile; ft/mi, foot per mile; ft³/s, cubic foot per second; %, percent; US, upstream; °, degree; ', minute; ", second; approx, approximately; ft, foot; Rd, Road; USGS, U.S. Geological Survey; DS, downstream; S, South; St, Street]

Location description	Latitude	Longitude	Drainage area (mi ²)	Main channel slope ² (ft/mi)	Storage (water or wetlands area) (percent)	Annual exceedance probability flood-peak streamflows ³ (ft ³ /s)					
						10%	4%	2%	1%	0.20%	1% plus ¹
Chippewa Creek											
US from Buck Creek	41°02'54"	81°53'58"	22.4	23.8	4.76	1,320	1,650	1,900	2,160	2,760	3,020
US from Westfield Ditch	41°02'10"	81°53'26"	26.3	20.7	4.31	1,470	1,830	2,110	2,390	3,050	3,340
US from unnamed tributary (approx 1,600 ft US from Greenwich Rd)	41°01'22"	81°52'50"	33.9	17.7	4.25	1,720	2,140	2,460	2,780	3,540	3,880
US from Hubbard Creek	41°00'38"	81°51'52"	35.8	14.4	4.11	1,720	2,140	2,450	2,760	3,510	3,870
US from McCoy Ditch	40°59'08"	81°51'36"	46.1	11.4	3.5	2,030	2,510	2,880	3,240	4,100	4,540
At USGS streamgage (03116077) ⁴	40°57'59"	81°51'02"	50.4	9.75	3.59	2,090	2,580	2,940	3,310	4,180	4,620
US from Fall Creek	40°57'25"	81°49'21"	65.8	8.27	2.84	2,560	3,150	3,600	4,040	5,100	5,640
US from Tommy Run	40°57'22"	81°48'16"	71.4	7.37	2.72	2,670	3,280	3,740	4,200	5,300	5,880
US from Little Chippewa Creek	40°57'48"	81°46'43"	80.2	6.43	2.59	2,850	3,490	3,980	4,460	5,610	6,240
US from Styx River	40°57'32"	81°45'56"	113	6.37	2.05	3,820	4,680	5,330	5,990	7,530	8,360
At USGS streamgage (03116200) ⁴	40°56'47"	81°44'36"	146	6.07	2.41	4,490	5,470	6,210	6,950	8,700	9,700
US from Mill Creek	40°56'24"	81°43'44"	147	5.31	2.42	4,380	5,320	6,030	6,750	8,420	9,420
US from Red Run	40°56'13"	81°43'06"	155	4.98	2.39	4,500	5,460	6,190	6,920	8,630	9,660
US from Silver Creek	40°55'53"	81°40'28"	176	4.02	2.31	4,750	5,740	6,490	7,240	8,990	10,100
At mouth	40°54'51"	81°38'16"	188	3.16	2.48	4,690	5,630	6,340	7,050	8,720	9,840
Little Chippewa Creek											
US from unnamed tributary (approx 1,300 ft DS from Steiner Rd)	40°55'55"	81°49'33"	23.4	6.54	0.63	1,310	1,650	1,920	2,190	2,840	3,060
US from unnamed tributary (approx 3,800 feet US from S Main St)	40°56'54"	81°48'34"	26.7	6	0.57	1,430	1,800	2,090	2,380	3,090	3,320
US from Whitman Ditch	40°57'19"	81°47'28"	28.2	5.5	0.59	1,460	1,840	2,120	2,420	3,130	3,380
At mouth	40°57'47"	81°46'42"	32.2	6.38	0.57	1,680	2,110	2,440	2,780	3,600	3,880

Table 1. Summary of the explanatory variable values used in the regression equations, the initial 10-, 4-, 2-, 1-, and 0.2-percent and 1-percent plus¹ annual exceedance probability flood-peak streamflow estimates, and locations for the selected streams in Wayne and Medina Counties, Ohio.—Continued

[mi², square mile; ft/mi, foot per mile; ft³/s, cubic foot per second; %, percent; US, upstream; °, degree; ', minute; ", second; approx, approximately; ft, foot; Rd, Road; USGS, U.S. Geological Survey; DS, downstream; S, South; St, Street]

Location description	Latitude	Longitude	Drainage area (mi ²)	Main channel slope ² (ft/mi)	Storage (water or wetlands area) (percent)	Annual exceedance probability flood-peak streamflows ³ (ft ³ /s)					
						10%	4%	2%	1%	0.20%	1% plus ¹
Styx River											
US from unnamed tributary (approx 1,000 ft DS from Blake Rd)	41°02'38"	81°47'13"	6.84	67.8	3.3	715	927	1,090	1,260	1,660	1,760
US from unnamed tributary (approx 900 ft US from Interstate-76)	41°02'01"	81°46'43"	9.35	54	2.57	895	1,160	1,360	1,570	2,070	2,190
US from unnamed tributary (approx 1,400 ft DS from Greenwich Rd)	41°01'17"	81°46'37"	11.3	44.4	2.73	981	1,260	1,480	1,700	2,230	2,370
US from unnamed tributary (approx 300 ft US from Seville Rd)	41°00'39"	81°46'13"	12.3	37.3	2.51	1,020	1,310	1,530	1,760	2,300	2,460
US from Holmes Brook	41°00'22"	81°45'59"	14.6	35.5	2.64	1,140	1,460	1,700	1,950	2,550	2,720
US from unnamed tributary to Styx River	40°58'38"	81°46'19"	24.9	25.5	1.95	1,660	2,110	2,460	2,810	3,650	3,920
At mouth	40°57'33"	81°45'55"	29.6	23.6	2.63	1,780	2,250	2,610	2,970	3,840	4,150
Unnamed tributary to Styx River											
At North Main Street	40°58'50"	81°46'53"	2.91	70.9	0.42	470	630	758	892	1,220	1,250
At mouth	40°58'37"	81°46'20"	3.27	63.9	0.51	495	662	795	932	1,270	1,300

¹The 1-percent-plus flood elevation is defined as a flood elevation derived using streamflows that are at the upper 84-percent confidence limit as calculated in the gage analysis for the 1-percent annual exceedance probability flood.

²The main channel slope (SL10–85) was determined with the 10–85 method described by Koltun (2019).

³Annual exceedance probability flood-peak streamflows were determined using the Ohio StreamStats web application that solves regional regression equations (Koltun, 2019).

⁴Locations of U.S. Geological Survey streamgages.

Table 2. Selected characteristics of U.S. Geological Survey gages within the Chippewa Creek drainage area in Wayne and Medina Counties, Ohio.

[Site locations are shown in figure 1. USGS, U.S. Geological Survey; ft, foot; NAVD 88, North American Vertical Datum of 1988; NGVD 29, National Geodetic Vertical Datum of 1929; Rd, Road; OH, Ohio; °, degree; ', minute; ", second]

Site name	USGS station number	Drainage area (square miles)	Latitude	Longitude	Period of record	Maximum stage (ft) (elevation in NAVD 88 or NGVD 29 [ft])	Date of occurrence
Chippewa Creek at Miller Rd at Sterling OH ¹	03116077	50.4	40°57'59"	81°51'02"	2001–21	10.34 ft (965.28 ft NAVD 88)	June 17, 2019
Little Chippewa Creek near Smithville OH ¹	03116100	16.4	40°53'39"	81°48'46"	1947–72	17.17 ft (992.17 ft NGVD 29)	July 5, 1969
Unnamed tributary to Styx River at Rittman OH	03116192	2.84	40°58'44"	81°46'48"	2019–21	4.06 ft (958.19 ft NAVD 88)	January 24, 2020
Chippewa Creek above Easton OH	03116196	143	40°57'29"	81°45'47"	2020–21	16.22 ft (949.90 ft NAVD 88)	March 19, 2020
Chippewa Creek at Easton OH ¹	03116200	146	40°56'47"	81°44'35"	1960–81	18.54 ft (958.14 ft NGVD 29)	September 15, 1979

¹U.S. Geological Survey streamgages used in the hydrologic analyses.

Table 3. Peak-flood streamflow estimates for the 10-, 4-, 2-, 1-, and 0.2-percent annual exceedance probability floods as reported in Koltun (2019), where *R* is equal to the weighted estimate divided by the regression estimate.

[ft³/s, cubic foot per second; %, percent; Rd, Road; OH, Ohio]

Site name and U.S. Geological Survey station number	Annual exceedance probability flood-peak streamflows (ft ³ /s)					Estimate type
	10%	4%	2%	1%	0.20%	
Chippewa Creek at Miller Rd at Sterling OH (03116077)	1,440	1,580	1,670	1,750	1,940	Log Pearson Type III
	2,090	2,580	2,940	3,310	4,170	Regression
	1,460	1,610	1,730	1,840	2,110	Weighted
	0.699	0.624	0.588	0.556	0.506	<i>R</i>
Little Chippewa Creek near Smithville OH (03116100)	1,630	2,190	2,650	3,160	4,550	Log Pearson Type III
	1,090	1,380	1,610	1,850	2,410	Regression
	1,540	2,000	2,360	2,730	3,560	Weighted
	1.413	1.449	1.466	1.476	1.477	<i>R</i>
Chippewa Creek at Easton OH (03116200)	4,720	6,620	8,270	10,200	15,500	Log Pearson Type III
	4,490	5,470	6,210	6,960	8,700	Regression
	4,680	6,320	7,620	8,950	12,000	Weighted
	1.042	1.155	1.227	1.286	1.379	<i>R</i>

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Table 4. Summary of the final 10-, 4-, 2-, 1-, and 0.2-percent and 1-percent plus annual exceedance probability flood-peak streamflow estimates and locations for the selected streams in Wayne and Medina Counties, Ohio.

[ft³/s, cubic foot per second; %, percent; US, upstream; approx, approximately; ft, foot; Rd, Road; USGS, U.S. Geological Survey; DS, downstream; S, South; St, Street]

Location description	Annual exceedance probability flood-peak streamflows ¹ (ft ³ /s)					
	10%	4%	2%	1%	0.20%	1% plus ²
Chippewa Creek						
US from Buck Creek	854	957	1,040	1,110	1,300	1,560
US from Westfield Ditch	950	1,060	1,150	1,230	1,430	1,720
US from unnamed tributary (approx 1,600 ft US from Greenwich Rd)	1,120	1,250	1,350	1,440	1,670	2,010
US from Hubbard Creek	1,170	1,290	1,390	1,490	1,730	2,080
US from McCoy Ditch	1,380	1,520	1,640	1,740	2,010	2,430
At USGS streamgage (03116077) ³	³ 1,460	³ 1,610	³ 1,730	³ 1,840	³ 2,120	³ 2,570
US from Fall Creek	2,260	2,690	3,020	3,340	4,120	4,660
US from Tommy Run	2,540	3,070	3,480	3,890	4,860	5,430
US from Little Chippewa Creek	2,860	3,540	4,070	4,590	5,820	6,410
US from Styx River	3,910	5,080	5,990	6,930	9,100	9,670
At USGS streamgage (03116200) ³	³ 4,680	³ 6,320	³ 7,620	³ 8,940	³ 12,000	³ 12,500
US from Mill Creek	4,700	6,350	7,660	8,980	12,100	12,600
US from Red Run	4,860	6,570	7,920	9,270	12,400	13,000
US from Silver Creek	5,290	7,130	8,580	10,000	13,400	14,000
At mouth	5,530	7,430	8,930	10,500	13,900	14,600
Little Chippewa Creek						
US from unnamed tributary (approx 1,300 ft DS from Steiner Rd)	1,380	1,750	2,040	2,320	3,010	3,240
US from unnamed tributary (approx 3,800 ft US from S Main St)	1,430	1,800	2,090	2,380	3,090	3,320
US from Whitman Ditch	1,460	1,840	2,120	2,420	3,130	3,380
At mouth	1,680	2,110	2,440	2,780	3,600	3,880
Styx River						
US from unnamed tributary (approx 1,000 ft DS from Blake Rd)	715	927	1,090	1,260	1,660	1,760
US from unnamed tributary (approx 900 ft US from Interstate-76)	895	1,160	1,360	1,570	2,070	2,190
US from unnamed tributary (approx 1,400 ft DS from Greenwich Rd)	981	1,260	1,480	1,700	2,230	2,370
US from unnamed tributary (approx 300 ft US from Seville Rd)	1,020	1,310	1,530	1,760	2,300	2,460
US from Holmes Brook	1,140	1,460	1,700	1,950	2,550	2,720
US from unnamed tributary to Styx River	1,660	2,110	2,460	2,810	3,650	3,920
At mouth	1,780	2,250	2,610	2,970	3,840	4,150
Unnamed tributary to Styx River						
At North Main Street	470	630	758	892	1,220	1,250
At mouth	495	662	795	932	1,270	1,300

¹Annual exceedance probability flood-peak streamflows were initially estimated using the Ohio StreamStats web application (Koltun, 2019). Where applicable, the estimates were gage-weighted using techniques in Koltun (2019) or adjusted by multiplying by a ratio equal to the regression estimate for the ungaged location divided by the regression estimate for the nearest gage location, both computed using drainage-area only equations in Koltun (2019).

²The 1-percent-plus flood elevation is defined as a flood elevation derived using streamflows that are at the upper 84-percent confidence limit as calculated in the gage analysis for the 1-percent annual exceedance probability flood.

³Locations of U.S. Geological Survey streamgages.

Table 5. Survey characteristics and hydraulic parameters used in the hydraulic models.

[DEM, digital elevation model; ft/ft, foot per foot]

Stream name	Base line reference location ¹	Study reach length (miles)	Number of surveyed cross sections	Number of cross sections derived from DEM	Number of hydraulic structures	Slope used for normal depth ² calculation (ft/ft)	Manning's roughness coefficient (<i>n</i>)			
							Main channel		Overbanks	
							Lowest value	Highest value	Lowest value	Highest value
Chippewa Creek	Mouth	23.5	132	434	32	0.00034	0.024	0.049	0.049	0.085
Little Chippewa Creek	Mouth	3.4	15	70	3	0.00220	0.036	0.038	0.036	0.065
Styx River	Mouth	8.1	79	202	19	0.00130	0.03	0.04	0.028	0.075
Unnamed tributary to Styx River	Mouth	1.2	18	63	4	0.00150	0.038	0.046	0.028	0.052

¹Location from which the river stationing is measured upstream, in feet.

²Normal depth is the depth when the streamflow is uniform, steady, one-dimensional, and is not affected by downstream obstructions. Flow is considered uniform if the energy line, water surface, and channel bottom all are parallel (Chow, 1959).

system at 15 benchmark locations had a root-mean-square error of 0.06 foot (ft) when compared with National Geodetic Survey published elevations.

The USGS field crews surveyed a total of 244 channel cross sections and 58 hydraulic structures (table 5). The cross sections were surveyed to provide ground elevations below stream water surfaces that are not provided by conventional light detection and ranging (lidar). The structures were surveyed for geometrical data that have the potential to affect water-surface elevations during floods along the streams.

Topographic and Bathymetric Data

Cross-section elevation data were obtained from a digital elevation model (DEM) that was derived from lidar data collected during March 2006 for the Ohio Geographically Referenced Information Program (Ohio Geographically Referenced Information Program, 2007). The lidar data have a horizontal resolution that meets National Map Accuracy Standards with a vertical accuracy of plus or minus 1.0 ft at a 95-percent confidence level for the “open terrain” land-cover category (root-mean-square error of 0.5 ft) (Federal Geographic Data Committee, 1998). By this criterion, the lidar data support production of 2-ft contours (Dewberry, 2012) and a DEM that has a vertical accuracy of plus or minus 1.0 ft. The DEM data from the Ohio Geographically Referenced Information Program (2007) were used to develop 2-ft contours by USGS personnel.

HEC-GeoRAS was used to extract elevation data from the DEM for a total of 769 cross sections (table 5) for use in the HEC-RAS models. For all modeled stream reaches, the

maximum distance between cross sections (conventionally surveyed and DEM derived) was less than or equal to 500 ft. Spacing between cross sections averaged 780 ft for conventionally surveyed cross sections and 250 ft for DEM-derived cross sections. DEM-derived cross sections were collocated with the locations of the in-channel field-surveyed cross sections where available. In those cases, DEM-based elevations within the channel were substituted with in-channel survey elevations to form composite cross sections. In-channel elevations for DEM-derived cross sections that did not have surveyed channels were estimated by interpolating between the closest field-surveyed cross sections as a function of distance along the hydraulic baseline.

Hydraulic Modeling

The hydraulic base lines for all modeled stream reaches were referenced to feet upstream from their respective mouths (table 5). Normal depth boundary conditions (table 5) were used for all streams. Normal depth is defined as the depth when the streamflow is uniform, steady, one-dimensional, and is not affected by downstream obstructions. Streamflow is considered uniform if the energy line, water surface, and channel bottom all are parallel (Chow, 1959). The friction slopes (equal to the channel slopes) for the normal depth calculations were determined from field surveys done near the downstream limits. The HEC-RAS models were used to generate seven water-surface profiles corresponding to the 10-, 4-, 2-, 1-, and 0.2-percent and 1-percent plus AEP floods and a regulatory floodway. A “regulatory floodway” is defined as the channel of a river or other watercourse and the adjacent land areas that

must be reserved to discharge the 1-percent AEP flood without increasing the water-surface elevation more than a designated height (Federal Emergency Management Agency, 2020).

Overflow Reaches

During the modeling process, it was noted that the main channels of Chippewa Creek and the unnamed tributary to Styx River did not contain all the modeled streamflows. As a result, the hydraulic models for Chippewa Creek and the unnamed tributary to Styx River include overflow channels. The overflow channels were used to model streamflow that spills out of the main channel, travels for a distance, and then rejoins the main channel at a downstream location. The overflow channels were connected to the main channels using junctions within HEC–RAS. Junctions are defined as locations where two or more streams join together or split apart (U.S. Army Corps of Engineers, 2016).

For Chippewa Creek, streamflows were contained within the main channel for 10- and 4- percent AEP flood-peak streamflows. However, for the higher streamflows, water spills out of the main channel from the right overbank near Gloria Glens Park (fig. 2) and flowed through a swampy wooded area before entering a small tributary (Westfield Ditch) and returning to the main channel of Chippewa Creek just upstream from Interstate 71. In the hydraulic model, Chippewa Creek was split into an upper, middle, and lower reach at the split and join junctions. Streamflows routed along the overflow reach were subtracted from the streamflows routed down the Chippewa Creek middle reach. The model was run iteratively until the water-surface elevations for the overflow reach and the upstream end of the Chippewa Creek middle reach at the split junction were equal. For the floodway run, the streamflow was contained within the main channel. The final balanced streamflows are listed in table 6.

The unnamed tributary to Styx River also has split flow. Upstream from North Main Street (fig. 3), there are two points or junctions (split A and split B) where the streamflow spills out of the main channel before rejoining just upstream from North Main Street. Overflow at the split B junction leaves the main channel of the unnamed tributary to Styx River and moves parallel before joining with additional overflow near the split A junction (fig. 3). The combined overflow then continues downgradient, eventually rejoining the main stem just upstream from where the unnamed tributary to Styx River crosses under North Main Street. Streamflows routed along the

overflow reaches were subtracted from the streamflows routed down the unnamed tributary to Styx River reaches B and C. The unnamed tributary to Styx River model was run iteratively until (1) the water-surface elevations for overflow 2 reach and the unnamed tributary to Styx River reach C at the split B junction were balanced and (2) streamflow no longer escaped from the unnamed tributary to Styx River reach B to the overflow reach A downstream from the split A junction.

The maximum capacity of the unnamed tributary to Styx River reach B is 446 cubic feet per second. Any increase in streamflow greater than 446 cubic feet per second results in streamflow overflowing the main channel at multiple locations along the east overbank and moving into the overflow reach A. There was no overflow into the overflow 2 reach for the 10- and 4- percent AEP flood-peak streamflows. For the floodway run, all streamflow was contained within the main channel until split A junction, after which 413 cubic feet per second of streamflow escaped as overflow. The final balanced streamflows are listed in table 7.

Development of Flood-Inundation Boundaries

Flood-inundation boundaries were mapped with a geographic information system for three water-surface profiles (1- and 0.2-percent AEP floods and a regulatory floodway) using flood-profile data, the DEM, and contours developed from the DEM. Initial flood-inundation boundaries were developed for each profile using the HEC–GeoRAS software (U.S. Army Corps of Engineers, 2009). HEC–GeoRAS provides a set of procedures, tools, and utilities for processing HEC–RAS outputs and geospatial data in ArcGIS. Flood-inundation boundaries for the inundated areas were refined in ArcMap (Environmental Systems Research Institute, 2020) using the DEM-derived 2-ft contours to ensure hydraulically reasonable boundary transitions between model cross sections.

Any inundated areas that were disconnected from the main channel were examined to determine whether there were artificial 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-inundation boundaries; otherwise, the disconnected inundated areas were deleted.

Figure 2. Locations of flow path and junctions at which flow leaves and returns to the main channel of Chippewa Creek.

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Table 6. Streamflows resulting in balanced water-surface elevations between the main stem of Chippewa Creek and the overflow reach or Westfield Ditch.

[ft³/s, cubic foot per second; %, percent; US, upstream; DS, downstream; N/A, not applicable]

Stream	Reach	Location	Annual exceedance probability flood-peak streamflows (ft ³ /s)						
			10%	4%	2%	1%	0.20%	1% plus	Floodway
Chippewa Creek	Upper	US from split	854	957	1,040	1,110	1,300	1,560	1,110
	Middle	US from Buck Creek	854	957	988	1,008	1,062	1,107	1,110
	Middle	DS from Buck Creek	950	1,060	1,098	1,128	1,192	1,267	1,230
	Lower	DS from Westfield Ditch	1,120	1,250	1,350	1,440	1,670	2,010	1,440
Overflow channel or Westfield Ditch	N/A	DS from split	0	0	52	102	238	453	0

Table 7. Streamflows resulting in balanced water-surface elevations between the main stem of the unnamed tributary to Styx River and the overflow reaches.

[ft³/s, cubic foot per second; %, percent; US, upstream; DS, downstream; N/A, not applicable]

Stream	Reach	Location	Annual exceedance probability flood-peak streamflows (ft ³ /s)						
			10%	4%	2%	1%	0.20%	1% plus	Floodway
Unnamed tributary to Styx River	Reach D	US from split B	470	630	758	892	1,220	1,250	892
	Reach C	US from split A	470	630	743	859	1,089	1,108	892
	Reach B	DS from split A	446	446	446	446	446	446	479
	Reach A	DS from join A	495	662	662	932	1,270	1,300	932
Overflow	Reach B	US from join B	24	184	297	413	643	662	413
	Reach A	DS from join A	24	184	312	446	774	804	413
Overflow 2	N/A	DS from split B	0	0	15	33	131	142	0

EXPLANATION

	Corporate areas		Flow arrow, indicates direction of water flow
	Corporate boundaries		U.S. Geological Survey streamgage and number
	Study reaches		Streamflow junctions

Figure 3. Locations of flow paths and points at which flow leaves and returns to the main channel of the unnamed tributary to Styx River.

Data Dissemination

All data used in the creation of the flood-inundation boundaries are available through a USGS data release at <https://doi.org/10.5066/P9W6ROMC> (Ostheimer, 2021) and will be submitted to FEMA for inclusion in updated FISs for Wayne and Medina Counties. FEMA has the sole statutory responsibility for publishing an FIS and regulatory flood-plain boundaries. As a result, the information in the data release should not be used for regulatory purposes until they have been published by FEMA in an FIS. Floodway data tables, listing floodway characteristics and 1-percent AEP flood and floodway water-surface elevations at model cross sections on each stream, are presented in appendix 1.

Summary

The U.S. Geological Survey, in cooperation with the city of Rittman, Ohio, and the Muskingum Watershed Conservancy District, did a study to provide data with which to update and expand parts of two Federal Emergency Management Agency Flood Insurance Studies. The study covered a total of 36.2 miles on four streams (Chippewa Creek, Little Chippewa Creek, Styx River, and the unnamed tributary to Styx River) in the Chippewa Creek Basin. Water-surface profiles were developed for the 10-, 4-, 2-, 1-, and 0.2-percent and 1-percent plus annual exceedance probability floods and a regulatory floodway. Flood boundaries for each stream were mapped for the 1- and 0.2-percent annual exceedance probability floods and a regulatory floodway. The water-surface profiles and flood-inundation boundaries can help emergency planners and the public make more informed decisions about flood risk.

The U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis and Geo River Analysis Systems were used to compute water-surface profiles and help delineate estimated flood-inundation-area boundaries. Model input included cross sections derived from a digital elevation model supplemented with field surveys of open-channel cross sections and hydraulic structures, estimates of roughness values, downstream boundary conditions, and annual exceedance probability flood estimates from regional regression equations and historical streamflow data. All data used in the creation of the flood-inundation boundaries are available through a U.S. Geological Survey data release (Ostheimer, 2021) and will be submitted to the Federal Emergency Management Agency for inclusion in updated Flood Insurance studies for Wayne and Medina Counties.

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Appendix 1

Table 1.1. Floodway data table for Chippewa Creek, Wayne and Medina Counties, Ohio.

Table 1.2. Floodway data table for Little Chippewa Creek, Wayne County, Ohio.

Table 1.3. Floodway data table for Styx River, Wayne and Medina Counties, Ohio.

Table 1.4. Floodway data table for unnamed tributary to Styx River, Wayne County, Ohio.

Table 1.5. Floodway data table for unnamed tributary to Styx River overflow, Wayne County, Ohio.

Table 1.1. Floodway data table for Chippewa Creek, Wayne and Medina Counties, Ohio.

[%, percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
A	369	635	4,398	2.4	946.7	946.7	947.6	0.9
B	751	167	1,839	5.7	946.8	946.8	947.6	0.8
C	777	172	2,036	5.2	947.7	947.7	948.7	1.0
D	1,288	180	2,258	4.6	948.2	948.2	949.1	0.9
E	1,768	120	1,546	6.8	948.3	948.3	949.2	0.9
F	1,797	135	1,773	5.9	948.7	948.7	949.6	0.9
G	1,848	135	1,846	5.7	949.8	949.8	950.2	0.4
H	1,893	185	2,231	4.7	950.1	950.1	950.4	0.3
I	2,372	350	3,534	3.0	950.5	950.5	950.7	0.2
J	3,970	700	7,038	1.5	950.7	950.7	951.1	0.4
K	4,896	146	1,731	6.1	950.6	950.6	951.0	0.4
L	5,019	148	1,760	6.0	950.8	950.8	951.2	0.4
M	5,402	300	3,693	2.8	951.7	951.7	952.0	0.3
N	5,582	400	4,927	2.2	951.8	951.8	952.1	0.3
O	7,812	950	5,934	1.8	951.9	951.9	952.3	0.4
P	7,851	918	6,401	1.6	952.4	952.4	952.8	0.4
Q	9,763	1,450	15,059	0.7	952.5	952.5	953.1	0.6
R	17,055	1,600	10,648	0.9	952.7	952.7	953.3	0.6
S	17,096	1,600	10,828	0.9	952.7	952.7	953.3	0.6
T	22,936	1,504	11,182	0.9	952.9	952.9	953.5	0.6
U	22,976	1,504	10,968	0.9	952.9	952.9	953.5	0.6
V	25,238	2,250	12,288	0.8	953.0	953.0	953.6	0.6
W	28,346	2,719	17,406	0.5	953.0	953.0	953.7	0.7
X	28,391	2,719	17,049	0.5	953.0	953.0	953.7	0.7
Y	28,862	2,800	17,209	0.5	953.0	953.0	953.7	0.7
Z	31,506	1,200	7,312	1.2	953.1	953.1	953.8	0.7
AA	33,360	590	3,469	2.6	953.3	953.3	954.1	0.8
AB	34,277	153	1,911	4.7	953.5	953.5	954.3	0.8

Table 1.1. Floodway data table for Chippewa Creek, Wayne and Medina Counties, Ohio.—Continued

[%; percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
AC	34,348	154	1,947	4.6	953.6	953.6	954.4	0.8
AD	34,776	450	3,238	2.8	954.1	954.1	954.8	0.7
AE	35,181	700	5,134	1.7	954.2	954.2	955.0	0.8
AF	39,294	1,600	8,940	1.0	954.4	954.4	955.3	0.9
AG	41,321	151	1,905	4.7	954.7	954.7	955.6	0.9
AH	41,377	151	1,916	4.7	954.8	954.8	955.7	0.9
AI	41,438	230	2,429	3.7	954.9	954.9	955.8	0.9
AJ	42,226	400	3,126	2.2	955.4	955.4	956.2	0.8
AK	46,739	662	2,684	2.1	955.8	955.8	956.7	0.9
AL	46,788	506	2,283	2.1	955.8	955.8	956.7	0.9
AM	47,369	1,200	6,193	0.7	955.9	955.9	956.9	1.0
AN	53,306	1,700	6,779	0.7	956.2	956.2	957.1	0.9
AO	53,329	1,700	6,722	0.7	956.2	956.2	957.1	0.9
AP	54,107	1,409	3,996	1.0	956.3	956.3	957.2	0.9
AQ	55,991	1,451	3,428	1.1	956.9	956.9	957.5	0.6
AR	56,023	1,500	3,973	1.0	957.2	957.2	958.1	0.9
AS	58,759	1,730	3,275	1.0	957.7	957.7	958.4	0.7
AT	58,790	1,733	3,429	1.0	957.8	957.8	958.7	0.9
AU	61,585	980	1,950	1.8	958.5	958.5	959.4	0.9
AV	61,621	1,058	1,919	2.0	958.9	958.9	959.5	0.6
AW	62,957	305	709	4.7	960.0	960.0	960.6	0.6
AX	63,398	300	764	4.4	960.7	960.7	961.1	0.4
AY	63,869	169	496	6.7	961.2	961.2	961.7	0.5
AZ	64,302	175	585	5.7	962.2	962.2	962.5	0.3
BA	64,644	125	573	5.8	962.5	962.5	963.0	0.5
BB	64,690	101	653	5.1	962.9	962.9	963.3	0.4
BC	64,721	103	665	5.0	962.9	962.9	963.4	0.5
BD	64,937	190	792	4.2	963.5	963.5	963.7	0.2

Table 1.1. Floodway data table for Chippewa Creek, Wayne and Medina Counties, Ohio.—Continued

[%, percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
BE	66,365	690	1,680	2.0	964.1	964.1	964.7	0.6
BF	66,404	690	1,887	1.8	964.1	964.1	965.0	0.9
BG	66,782	550	1,402	2.4	964.1	964.1	965.1	1.0
BH	67,142	500	1,260	2.7	964.4	964.4	965.2	0.8
BI	69,018	410	1,015	1.8	965.1	965.1	965.9	0.8
BJ	69,045	410	1,038	1.8	965.1	965.1	966.0	0.9
BK	69,879	250	764	2.4	965.3	965.3	966.2	0.9
BL	70,700	110	521	3.5	965.7	965.7	966.6	0.9
BM	71,195	81	564	3.3	966.2	966.2	967.1	0.9
BN	71,253	93	600	3.1	966.4	966.4	967.2	0.8
BO	72,487	150	539	3.4	967.2	967.2	967.8	0.6
BP	73,271	125	631	2.9	967.6	967.6	968.6	1.0
BQ	73,953	100	565	3.3	968.0	968.0	968.9	0.9
BR	74,557	70	411	4.5	968.6	968.6	969.3	0.7
BS	74,747	70	498	3.7	969.0	969.0	969.5	0.5
BT	75,501	56	364	5.1	969.3	969.3	969.8	0.5
BU	75,547	56	368	5.0	969.4	969.4	969.9	0.5
BV	75,599	60	364	5.0	969.6	969.6	970.0	0.4
BW	76,468	75	426	4.3	970.8	970.8	971.1	0.3
BX	78,529	85	456	3.8	972.1	972.1	972.8	0.7
BY	78,890	80	430	4.0	972.6	972.6	973.0	0.4
BZ	80,625	80	363	4.8	974.2	974.2	974.6	0.4
CA	82,428	80	375	4.6	977.2	977.2	977.3	0.1
CB	82,776	80	349	5.0	977.6	977.6	977.8	0.2
CC	83,564	47	343	5.1	979.2	979.2	979.3	0.1
CD	83,594	47	351	5.0	979.3	979.3	979.5	0.2
CE	83,937	67	393	4.4	979.9	979.9	980.0	0.1
CF	84,627	65	407	4.3	980.7	980.7	980.8	0.1

Table 1.1. Floodway data table for Chippewa Creek, Wayne and Medina Counties, Ohio.—Continued

[%; percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
CG	85,236	57	371	4.7	981.2	981.2	981.5	0.3
CH	85,614	57	392	4.4	981.8	981.8	982.0	0.2
CI	85,628	57	395	4.4	982.0	982.0	982.1	0.1
CJ	85,993	50	263	6.6	982.3	982.3	982.4	0.1
CK	86,051	51	248	7.0	982.4	982.4	982.5	0.1
CL	86,116	45	319	5.4	982.9	982.9	983.0	0.1
CM	86,475	55	367	4.1	983.6	983.6	983.7	0.1
CN	86,852	80	578	2.6	983.9	983.9	984.1	0.2
CO	88,898	100	684	2.2	984.3	984.3	984.5	0.2
CP	88,914	100	685	2.2	984.3	984.3	984.5	0.2
CQ	91,024	70	563	2.6	984.5	984.5	984.9	0.4
CR	91,063	70	572	2.6	984.5	984.5	984.9	0.4
CS	91,461	120	859	1.7	984.7	984.7	985.1	0.4
CT	92,060	150	924	1.6	984.8	984.8	985.2	0.4
CU	95,932	62	358	4.0	984.9	984.9	985.7	0.8
CV	96,088	50	308	4.7	985.2	985.2	985.9	0.7
CW	96,297	75	439	3.3	985.7	985.7	986.2	0.5
CX	96,450	76	412	3.5	985.7	985.7	986.3	0.6
CY	96,611	76	420	3.4	985.9	985.9	986.4	0.5
CZ	96,891	135	557	2.6	986.3	986.3	986.6	0.3
DA	99,695	130	463	2.7	986.7	986.7	987.7	1.0
DB	100,505	42	258	4.8	987.8	987.8	988.5	0.7
DC	101,334	39	248	5.0	988.7	988.7	989.3	0.6
DD	101,821	26	189	6.5	989.1	989.1	989.6	0.5
DE	101,850	33	219	5.6	989.3	989.3	989.8	0.5
DF	101,868	45	257	4.8	989.5	989.5	990.0	0.5
DG	102,400	48	288	4.3	990.4	990.4	990.9	0.5
DH	103,298	63	379	3.2	991.5	991.5	991.9	0.4

Table 1.1. Floodway data table for Chippewa Creek, Wayne and Medina Counties, Ohio.—Continued

[%, percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
DI	104,495	71	468	2.4	992.0	992.0	992.7	0.7
DJ	104,538	71	474	2.3	992.1	992.1	992.7	0.6
DK	104,550	71	606	1.8	992.1	992.1	992.8	0.7
DL	114,578	800	3,831	0.3	992.3	992.3	993.0	0.7
DM	114,610	800	3,608	0.3	992.3	992.3	993.0	0.7
DN	120,793	75	384	2.9	992.4	992.4	993.2	0.8
DO	121,461	42	230	4.8	992.7	992.7	993.4	0.7
DP	121,832	39	200	5.5	993.1	993.1	993.7	0.6
DQ	122,490	45	220	5.0	994.4	994.4	994.6	0.2
DR	122,987	43	199	5.6	995.1	995.1	995.3	0.2
DS	123,049	47	203	5.5	995.3	995.3	995.4	0.1
DT	123,099	50	222	5.0	995.7	995.7	995.8	0.1
DU	123,373	39	234	4.7	996.3	996.3	996.3	0.0
DV	124,337	35	203	5.5	997.7	997.7	998.3	0.6

¹A floodway is defined as the channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the 1-percent annual exceedance probability flood without increasing the water-surface elevation more than a designated height (Federal Emergency Management Agency, 2020).

²Station is the distance in feet upstream from stream mouth.

Table 1.2. Floodway data table for Little Chippewa Creek, Wayne County, Ohio.

[%, percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
A	88	57	434	6.4	³ 956.8	951.1	951.4	0.3
B	824	70	374	7.4	³ 956.8	952.7	952.9	0.2
C	886	105	524	5.3	³ 956.8	953.4	953.6	0.2
D	963	105	550	5.1	³ 956.8	953.7	953.8	0.1
E	1,018	325	969	2.9	³ 956.8	954.1	954.1	0.0
F	1,515	375	1,075	2.6	³ 956.8	954.5	954.5	0.0
G	2,799	486	2,064	1.3	³ 956.8	954.8	955.3	0.5
H	3,597	600	2,057	1.4	³ 956.8	954.8	955.5	0.7
I	3,631	600	1,932	1.4	³ 956.8	954.8	955.5	0.7
J	5,588	750	3,153	0.8	³ 956.8	954.9	955.8	0.9
K	5,990	750	2,967	0.8	³ 956.8	955.0	955.9	0.9
L	7,357	750	2,784	0.9	³ 956.8	955.0	956.0	1.0
M	7,637	800	3,264	0.7	³ 956.8	955.1	956.1	1.0
N	8,386	850	2,260	1.1	³ 956.8	955.1	956.1	1.0

Table 1.2. Floodway data table for Little Chippewa Creek, Wayne County, Ohio.—Continued

[% , percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
O	9,304	1,050	2,560	1.5	³ 956.8	955.4	956.3	0.9
P	9,579	1,190	2,805	1.6	³ 956.8	955.4	956.4	1.0
Q	10,511	1,493	3,756	1.9	³ 956.8	955.9	956.8	0.9
R	11,540	1,682	3,959	3.0	³ 956.8	956.7	957.6	0.9
S	11,634	1,987	5,761	2.8	957.3	957.3	957.8	0.5
T	12,065	859	1,026	4.6	957.6	957.6	958.3	0.7
U	12,705	400	1,006	2.8	958.7	958.7	959.4	0.7
V	13,024	250	784	3.0	959.0	959.0	959.7	0.7
W	13,573	175	713	3.3	959.8	959.8	960.2	0.4
X	15,507	196	752	3.2	961.0	961.0	961.7	0.7
Y	15,805	222	688	3.5	961.1	961.1	961.9	0.8
Z	17,040	270	812	2.9	961.8	961.8	962.7	0.9
AA	17,552	250	651	3.7	962.1	962.1	963.0	0.9
AB	18,186	250	717	3.2	962.8	962.8	963.6	0.8

¹A floodway is defined as the channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the 1-percent annual exceedance probability flood without increasing the water-surface elevation more than a designated height (Federal Emergency Management Agency, 2020).

²Station is the distance in feet upstream from stream mouth.

³Backwater elevation from river station 55,585 of the Chippewa Creek model.

Table 1.3. Floodway data table for Styx River, Wayne and Medina Counties, Ohio.

[%; percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width, (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
A	189	70	523	5.7	955.6 ³	947.9	947.9	0.0
B	1,172	85	615	4.8	955.6 ³	949.3	949.3	0.0
C	2,469	88	666	4.5	955.6 ³	950.8	950.8	0.0
D	3,818	52	484	6.1	955.6 ³	951.9	952.0	0.1
E	3,866	52	488	6.1	955.6 ³	952.0	952.1	0.1
F	3,924	55	407	7.3	955.6 ³	952.0	952.1	0.1
G	3,957	55	413	7.2	955.6 ³	952.1	952.2	0.1
H	3,990	61	515	5.8	955.6 ³	952.5	952.6	0.1
I	4,016	60	517	5.7	955.6 ³	952.6	952.7	0.1
J	4,078	59	524	5.7	955.6 ³	952.7	952.8	0.1
K	4,109	59	527	5.6	955.6 ³	952.7	952.8	0.1
L	4,291	63	537	5.5	955.6 ³	953.0	953.1	0.1
M	4,344	66	553	5.4	955.6 ³	953.2	953.2	0.0
N	4,710	73	642	4.6	955.6 ³	953.7	953.7	0.0
O	5,433	69	559	5.3	955.6 ³	954.3	954.3	0.0
P	5,471	70	569	5.2	955.6 ³	954.4	954.5	0.1
Q	6,358	91	618	4.8	955.6 ³	955.2	955.2	0.0
R	6,387	86	599	5.0	955.6 ³	955.2	955.3	0.1
S	6,466	94	713	4.2	955.6 ³	955.5	955.5	0.0
T	6,514	94	722	4.1	955.6 ³	955.6	955.6	0.0
U	6,911	250	1,264	2.3	955.9	955.9	955.9	0.0
V	8,893	250	949	3.0	956.3	956.3	956.6	0.3
W	8,959	250	1,140	2.5	956.9	956.9	957.3	0.4
X	9,609	400	1,641	1.7	957.2	957.2	957.6	0.4
Y	10,586	450	1,680	1.7	957.3	957.3	957.9	0.6
Z	11,943	450	1,255	2.2	957.8	957.8	958.6	0.8
AA	12,016	450	1,548	1.8	958.8	958.8	959.6	0.8
AB	14,828	650	1,532	1.8	959.3	959.3	960.2	0.9

Table 1.3. Floodway data table for Styx River, Wayne and Medina Counties, Ohio.—Continued

[%, percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width, (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
AC	14,874	592	1,804	1.6	959.8	959.8	960.8	1.0
AD	15,805	400	1,309	2.1	960.1	960.1	961.1	1.0
AE	16,358	250	688	4.1	960.4	960.4	961.3	0.9
AF	16,682	165	584	4.8	961.0	961.0	961.7	0.7
AG	17,358	100	489	5.7	961.7	961.7	962.4	0.7
AH	17,529	150	583	4.8	962.2	962.2	962.8	0.6
AI	17,624	150	619	4.5	962.7	962.7	962.9	0.2
AJ	17,786	250	1,439	2.0	963.1	963.1	963.5	0.4
AK	17,801	250	1,312	2.1	963.2	963.2	963.5	0.3
AL	19,052	400	1,723	1.1	963.4	963.4	964.1	0.7
AM	20,521	600	1,767	1.1	963.6	963.6	964.2	0.6
AN	20,573	600	2,472	0.8	963.6	963.6	964.3	0.7
AO	21,779	600	1,636	1.1	963.7	963.7	964.5	0.8
AP	21,805	600	1,617	1.1	963.7	963.7	964.5	0.8
AQ	22,235	550	1,534	1.1	963.8	963.8	964.5	0.7
AR	22,805	450	1,340	1.3	963.9	963.9	964.7	0.8
AS	23,466	400	818	2.2	964.1	964.1	965.0	0.9
AT	24,408	254	507	3.5	965.0	965.0	965.6	0.6
AU	25,507	300	546	3.2	966.0	966.0	966.8	0.8
AV	26,148	300	771	2.2	966.8	966.8	967.7	0.9
AW	27,085	120	437	3.9	967.7	967.7	968.5	0.8
AX	27,268	53	214	8.0	968.1	968.1	968.6	0.5
AY	27,341	52	257	6.6	968.7	968.7	969.6	0.9
AZ	27,585	65	298	5.7	969.9	969.9	970.5	0.6
BA	27,996	200	533	3.2	970.7	970.7	971.5	0.8
BB	29,243	200	463	3.7	971.8	971.8	972.6	0.8
BC	29,710	100	383	4.4	972.4	972.4	973.2	0.8
BD	29,839	61	321	5.3	972.7	972.7	973.4	0.7
BE	29,960	65	354	4.8	973.5	973.5	973.9	0.4

Table 1.3. Floodway data table for Styx River, Wayne and Medina Counties, Ohio.—Continued

[% , percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width, (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
BF	30,076	100	464	3.7	973.9	973.9	974.2	0.3
BG	31,166	200	798	2.0	974.9	974.9	975.4	0.5
BH	32,671	400	1,170	1.3	975.7	975.7	976.6	0.9
BI	32,693	400	1,043	1.5	975.7	975.7	976.6	0.9
BJ	33,199	275	565	2.8	976.2	976.2	977.2	1.0
BK	33,442	200	521	3.0	976.8	976.8	977.5	0.7
BL	34,071	200	394	4.0	977.9	977.9	978.4	0.5
BM	34,515	200	516	3.0	979.1	979.1	979.4	0.3
BN	35,185	162	408	3.8	980.2	980.2	980.3	0.1
BO	35,778	73	308	5.1	980.8	980.8	981.8	1.0
BP	36,015	100	352	4.5	981.7	981.7	982.4	0.7
BQ	36,301	125	378	3.3	982.5	982.5	983.1	0.6
BR	36,935	150	527	2.4	983.3	983.3	983.9	0.6
BS	36,991	150	629	2.0	984.1	984.1	984.9	0.8
BT	37,784	125	417	3.0	984.5	984.5	985.4	0.9
BU	37,813	125	549	2.3	985.4	985.4	986.3	0.9
BV	38,378	100	532	2.4	985.9	985.9	986.6	0.7
BW	40,484	150	608	2.1	986.7	986.7	987.6	0.9
BX	40,611	150	579	2.2	986.7	986.7	987.7	1.0
BY	41,373	175	523	2.4	987.6	987.6	988.4	0.8
BZ	41,820	125	405	3.1	987.9	987.9	988.8	0.9
CA	42,001	40	181	7.0	988.2	988.2	989.0	0.8
CB	42,065	44	197	6.4	989.0	989.0	989.4	0.4
CC	42,168	75	380	3.3	990.0	990.0	990.1	0.1
CD	43,167	75	356	3.5	990.6	990.6	991.4	0.8

¹A floodway is defined as the channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the 1-percent annual exceedance probability flood without increasing the water-surface elevation more than a designated height (Federal Emergency Management Agency, 2020).

²Station is the distance in feet upstream from stream mouth.

³Backwater elevation from river station 44,302 of the Chippewa Creek model.

Table 1.4. Floodway data table for the unnamed tributary to Styx River, Wayne County, Ohio.

[%, percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width, (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
A	64	35	222	4.2	³ 956.0	953.7	954.5	0.8
B	254	40	249	3.7	³ 956.0	953.9	954.8	0.9
C	423	40	186	5.0	³ 956.0	954.3	955.1	0.8
D	440	40	187	5.0	³ 956.0	954.4	955.2	0.8
E	642	45	230	4.0	³ 956.0	955.4	955.9	0.5
F	814	40	167	5.6	³ 956.0	955.7	956.2	0.5
G	842	45	188	5.0	956.1	956.1	956.4	0.3
H	906	50	254	3.7	957.4	957.4	957.6	0.2
I	1,609	35	156	6.0	958.9	958.9	959.0	0.1
J	2,007	40	179	5.2	960.6	960.6	960.6	0.0
K	2,212	40	133	7.0	961.2	961.2	961.3	0.1
L	2,404	30	128	7.3	962.6	962.6	962.6	0.0
M	2,425	28	138	6.7	962.9	962.9	962.9	0.0
N	2,492	28	166	5.6	963.7	963.7	964.1	0.4
O	2,546	35	164	5.7	964.0	964.0	964.3	0.3
P	2,642	40	178	5.2	964.2	964.2	964.6	0.4
Q	2,782	45	156	6.0	964.9	964.9	964.9	0.0
R	3,134	240	289	3.2	965.5	965.5	966.3	0.8
S	3,286	398	436	2.2	965.8	965.8	966.7	0.9
T	3,340	335	732	3.1	966.6	966.6	967.0	0.4
U	3,577	40	143	3.4	967.7	967.7	967.7	0.0
V	3,774	32	95	5.0	967.9	967.9	968.1	0.2
W	4,078	33	80	6.0	969.4	969.4	969.8	0.4
X	4,111	32	90	5.3	969.9	969.9	970.2	0.3
Y	4,368	30	80	6.0	971.4	971.4	971.7	0.3
Z	4,766	34	93	5.2	974.2	974.2	974.5	0.3

Table 1.4. Floodway data table for the unnamed tributary to Styx River, Wayne County, Ohio.—Continued

[%, percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width, (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
AA	4,966	35	139	6.4	976.3	976.3	976.6	0.3
AB	5,166	37	123	7.2	977.3	977.3	977.6	0.3
AC	5,365	40	137	6.5	979.0	979.0	979.1	0.1
AD	5,567	34	116	7.7	980.3	980.3	980.4	0.1
AE	5,963	35	120	7.4	983.7	983.7	983.8	0.1
AF	6,152	40	164	5.4	985.0	985.0	985.2	0.2
AG	6,416	40	127	7.0	985.8	985.8	986.3	0.5

¹A floodway is defined as the channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the 1-percent annual exceedance probability flood without increasing the water-surface elevation more than a designated height (Federal Emergency Management Agency, 2020).

²Station is the distance in feet upstream from stream mouth.

³Backwater elevation from river station 7,295 of the Styx River model.

Table 1.5. Floodway data table for the unnamed tributary to Styx River overflow, Wayne County, Ohio.

[%, percent; AEP, annual exceedance probability; BW, backwater; NAVD 88, North American Vertical Datum of 1988]

Location		Floodway ¹			1% AEP water-surface elevation			
Cross section letter	Station ² (feet)	Width (feet)	Cross sectional area (square feet)	Mean velocity (feet per second)	Modeled stream with BW (if any) from receiving stream (feet, NAVD 88)	Modeled stream without BW from receiving stream (feet, NAVD 88)	Modeled stream with floodway without BW from receiving stream, (feet, NAVD 88)	Increase in water surface (without BW) due to floodway (feet)
A	374	140	507	0.8	967.5	967.5	967.6	0.1
B	559	100	335	1.2	967.5	967.5	967.6	0.1
C	846	100	221	1.9	967.6	967.6	967.8	0.2
D	1,121	100	174	2.4	967.9	967.9	968.3	0.4
E	1,377	100	138	3.0	968.9	968.9	968.9	0.0
F	1,673	100	117	3.5	970.5	970.5	970.9	0.4
G	1,807	100	175	2.4	970.9	970.9	971.7	0.8
H	2,154	100	113	3.7	972.8	972.8	973.3	0.5
I	2,392	100	139	3.0	975.2	975.2	975.4	0.2
J	2,487	100	199	2.1	976.0	976.0	976.3	0.3

¹A floodway is defined as the channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the 1-percent annual exceedance probability flood without increasing the water-surface elevation more than a designated height (Federal Emergency Management Agency, 2020).

²Station is the distance in feet upstream from stream mouth.

For additional information contact:

Director, [Ohio-Kentucky-Indiana Water Science Center](#)
U.S. Geological Survey
6460 Busch Blvd., Suite 100
Columbus, OH 43229
614-430-7700

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