Floods of May and June 2004 in Central and Eastern Ohio: FEMA Disaster Declaration 1519

By Andrew D. Ebner, David E. Straub, and Jonathan D. Lageman

In cooperation with the Ohio Emergency Management Agency

Open-File Report 2008–1290

U.S. Department of the Interior
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U.S. Department of the Interior
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Suggested citation:
Ebner, A.D., Straub, D.E., and Lageman, J.D., 2008, Floods of May and June 2004 in central and eastern Ohio—FEMA Disaster Declaration 1519: U.S. Geological Survey Open-File Report 2008–1290, 85 p.

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Conversion Factors and Abbreviations

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Vertical coordinate information is referenced to North American Vertical Datum of 1988 (NAVD 88), the National Geodetic Vertical Datum of 1929 (NGVD 29), and the U.S. Army Corps of Engineers 1912 Datum (COE 1912), as noted.

Elevation, as used in this report, refers to distance above the vertical datum.

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

Abbreviations

FEMA – Federal Emergency Management Agency

FIS – Flood Insurance Study

GPS – Global Positioning System

GIS – Geographical Information System

NEORSD – Northeast Ohio Regional Sewer District

NGS – National Geodetic Survey

NOAA – National Oceanic and Atmospheric Administration

NWS – National Weather Service

Ohio EMA – Ohio Emergency Management Agency

RTK – Real-Time Kinematic

TIN – Triangulated Irregular Network

USACE – United States Army Corps of Engineers

USGS – U.S. Geological Survey

USC&GS – United States Coast & Geodetic Survey

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Abstract

Several severe thunderstorms that passed through Ohio between May 17 and June 17, 2004, produced large amounts of rain in an already wet central and eastern Ohio, resulting in flooding in this region from May 18 to June 21, 2004. Record peak streamflow occurred at three U.S. Geological Survey (USGS) streamgages. Damages caused by the flooding resulting from these storms were severe enough that 25 counties in central and eastern Ohio were declared Federal disaster areas. In all, there were two storm- or flood-related deaths, 3,529 private structures damaged or destroyed, and an estimated $43 million in damages.

This report describes the meteorological factors that resulted in severe flooding in central and eastern Ohio between May 18 and June 21, 2004, and addresses the damages caused by the storms and flooding. Peak-stage, peak-streamflow, and recurrence-interval data are reported for selected USGS streamgages. Flood profiles determined by the USGS are presented for selected streams.

Introduction

Several severe thunderstorms[1] crossed Ohio between May 17 and June 17, 2004, causing flooding in central and eastern Ohio. The Federal Emergency Management Agency (FEMA) declared 25 counties affected by these storms as disaster areas (FEMA–1519–DR, Ohio, declared on June 3, 2004, with an incident period from May 18 through June 21, 2004). Figure 1 shows the 25 counties that were declared Federal disaster areas and whether they were declared to be eligible for Individual Assistance[2], Public Assistance[3], or both (Federal Emergency Management Agency, 2007). In many of these counties, several floods occurred during this month-long period.

Because of the magnitude of these floods, the U.S. Geological Survey (USGS), in cooperation with the Ohio Emergency Management Agency (Ohio EMA), completed a study to document this historic event. Documentation of floods can assist Federal, State, and local agencies in making informed decisions on flood-plain management and flood-emergency practices. Flood profiles were developed for West Fork Duck Creek near the Village of Belle Valley (appendix 1–A), Plum Creek near the City of Brunswick (appendix 1–B), West Branch Sunday Creek near the Village of Hemlock (appendix 1–C), a tributary of West Branch Sunday Creek near the Village of Hemlock (appendix 1–C), a tributary of East Branch Rocky River near the City of North Royalton (appendix 1–D), and a tributary of Mud Brook near the City of Stow (appendix 1–E), and a tributary of the Cuyahoga River near the City of Stow (appendix 1–E) as requested by Ohio EMA.

The disaster declaration is divided into three separate flood events in this report: May 18–25, 2004; June 9, 2004; and June 11–18, 2004. This report describes the weather conditions leading to each flood. A general description of each flood is also presented, along with damage estimates.

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[1] Severe thunderstorms are defined as those that produce wind gusts equal to or greater than 50 knots and (or) hail at least three-quarters of an inch in diameter and (or) produces a tornado (National Weather Service, 2007a).

[2] Individual Assistance is defined as assistance to individuals and households.

[3] Public Assistance is defined as assistance to State and local governments for the repair or replacement of disaster-damaged public facilities.

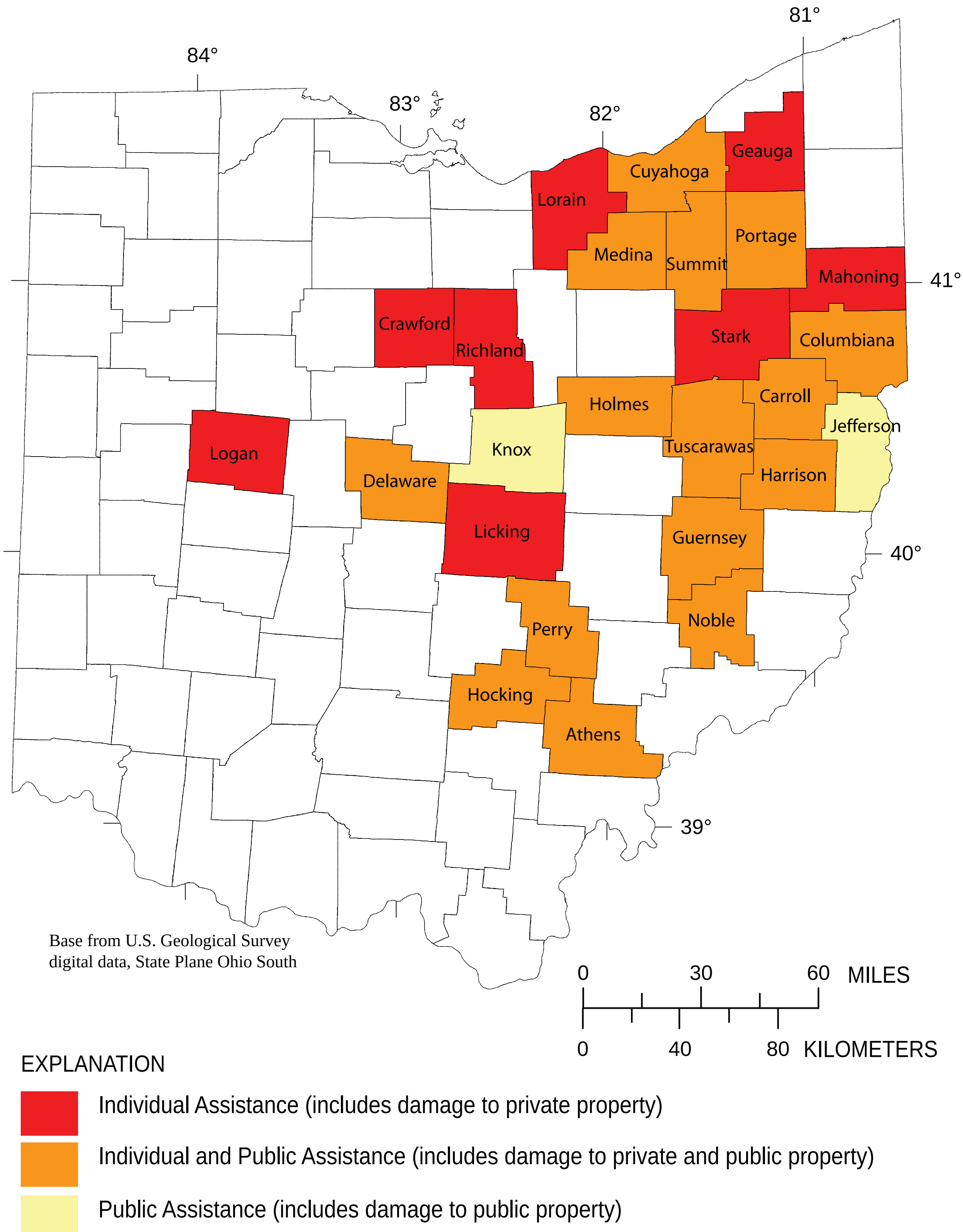

Figure 1. Ohio counties declared disaster areas under FEMA declaration 1519 (modified from Federal Emergency Management Agency, 2007).

Antecedent Climatic Conditions

Unusually wet conditions that preceded the floods in Ohio during May and June of 2004 contributed to the severity of flooding. Climatic conditions prior to the flooding are presented in this section.

March 2004. The National Oceanic and Atmospheric Administration (NOAA) divides Ohio into 10 regions based on similar climatological characteristics. Much of the eastern two-thirds of the State received above-normal[4] precipitation, whereas the western third received below-normal precipitation (fig. 2A). The State as a whole was 0.15 in. above normal for the month, with an average precipitation of 3.32 in. The North Central, Central Hills, and Northeast Regions (Ohio's snowbelt is contained within these regions) were all well above normal precipitation for March (fig. 2A)(Cashell and Kirk, 2004a).

April 2004. Precipitation totals in the eastern and south-central parts of the State were above normal for the month, whereas the western part of the State was below normal (fig. 2B). As a whole, the State was 0.28 in. below normal for the month, with an average precipitation of 3.30 in. The Northeast Hills Region received the most precipitation with 4.48 in., and the Northwest Region received the least precipitation with only 0.82 in. (fig. 2B) (Cashell and Kirk, 2004b).

May 18–25, 2004, Flood

Storms between May 17 and 23, 2004, led to flooding in central and eastern Ohio from May 18 to 25, 2004. These storms crossed central and eastern Ohio following a wetter than normal March and April (fig. 2A, B).

Storms of May 17–23, 2004

From May 17 to 23, 2004, winds from the southwest brought moisture-laden air from the Gulf of Mexico into Ohio. This led to high levels of moisture convergence[5], which increases the potential for high rainfall totals during storms.

During the afternoon and evening of May 17, a warm front associated with a mid-latitude cyclone[6] centered over Lake Superior moved northeast across Ohio and brought scattered thunderstorms to the region. In Richland County nearly 1.5 in. of rain fell during the passage of this storm, while areas of Hocking County recorded 0.6 in. (National Oceanic and Atmospheric Administration, 2004a). These storms were isolated; much of the State did not receive any precipitation.

On the morning of May 18, the mid-latitude cyclone that was centered over Lake Superior moved northeast into northeastern Canada. By late evening on May 18, the cold front associated with the mid-latitude cyclone began to move southeast across Ohio before stalling out over central Ohio during the early morning of May 19. This stationary front remained over Ohio until the late evening of May 19. Precipitation formed along the stationary front, with 0.1–0.5 in. of rain falling on most of northwestern Ohio during the 48-hour period of May 18–19. During the same period, much of central and southeastern Ohio received 1.5–2.5 in., with parts of Hocking County receiving more than 3.5 in. of rain (National Oceanic and Atmospheric Administration, 2004a).

In the early morning of May 20, the warm air that was south of the stationary front over Ohio on May 19 began to move north. In the wake of this passing warm front, Ohio received little precipitation. This warm front was associated with another mid-latitude cyclone that had formed over northern Minnesota. As this mid-latitude cyclone advanced eastward into Canada, its associated cold front stretched across Lake Erie, just north of Ohio.

Three different rounds of severe thunderstorms swept across Ohio during a 24-hour period from May 21 to May 22. The first round of thunderstorms occurred in the early morning of May 21 as the cold front moved southward and stalled out over northern Ohio. A line of severe thunderstorms spawned by this stalled cold front moved across central and northern Ohio between 2:00 a.m. and 5:00 a.m. The second round of thunderstorms occurred in the afternoon of May 21 between 4:00 p.m. and 8:00 p.m. This line of severe thunderstorms formed along the stalled front and moved southeast from Michigan across Ohio. The third round of thunderstorms occurred on May 22 between 2:00 a.m. and 5:00 a.m. This line of severe thunderstorms again formed along the stalled front and moved eastward from Michigan, across Lake Erie, and into northeastern Ohio. The southwestern half of the State received 0–0.5 in. of rain, and much of the northeastern half of the State received 1.0–3.0 in. during the 48-hour period of May 21–22. Parts of Summit, Cuyahoga, and Portage Counties received more than 3.5 in. in this 48-hour period (National Oceanic and Atmospheric Administration, 2004a).

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[4] "Normal" refers to the average value for the period 1951–2000 (Cashell and Kirk, 2004 a,b).

[5] Moisture convergence is defined as a measure of the degree to which moist air is converging into a given area.

[6] A mid-latitude cyclone is defined as a low pressure system characterized by the presence of frontal boundaries. Also called an extratropical cyclone.

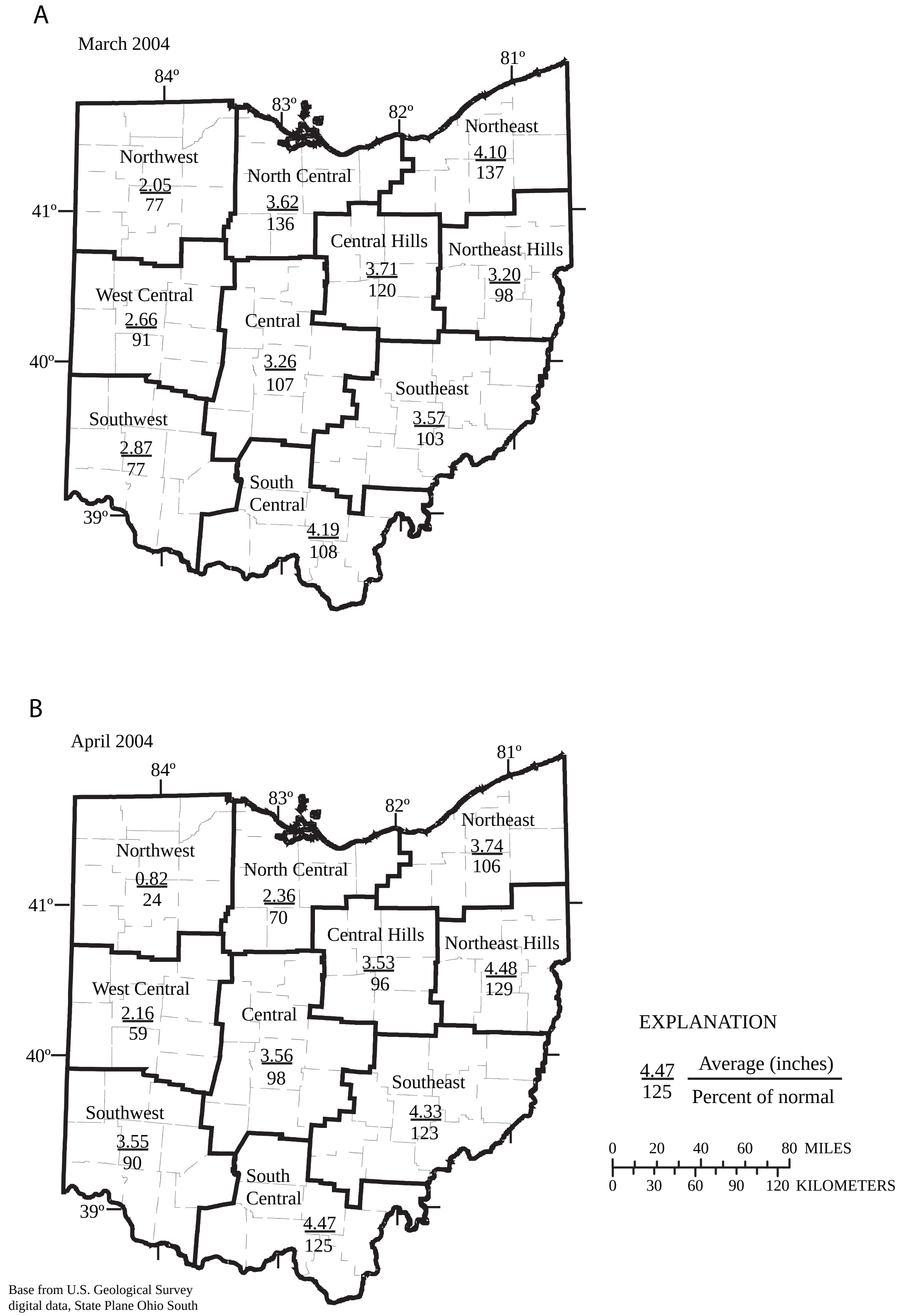


Figure 2. Regionally averaged monthly total precipitation and percentage of normal precipitation for the 10 climatic regions of Ohio for *A*, March and *B*, April 2004 (modified from Cashell and Kirk, 2004 a,b; "normal" refers to the average value for the period 1951–2000).

Scattered thunderstorms in the late evening of May 23 brought less than 1.0 in. of rain to parts of northern and eastern Ohio (National Oceanic and Atmospheric Administration, 2004a). In the morning of May 24, the frontal system that had stalled out over northern Ohio moved northward, and the unstable air that had been over Ohio for 3 days was replaced by warm, stable air.

During the 7-day period from May 17–23, 2004, rainfall was spread across the State with more than 5 in. of rain falling in parts of central, eastern, northeastern, and northwestern Ohio (fig. 3). Woodsfield, in Monroe County, received the most rainfall for the State during this 7-day period with 5.70 in. of rain. Rainfall intensities and recurrence intervals for selected National Weather Service (NWS) sites from this storm are listed in table 1. The time period used in table 1 is variable in order to show the most intense period of rainfall at the selected rain-gage sites.

General Description of the May 18–25, 2004, Flood

The following sections present information about the flooding that resulted from the May 17–23, 2004, storms. This section focuses on streamflow and stage at selected USGS streamgages in the affected counties (fig. 4). The omission from this report of any rivers or communities that experienced flooding is not a reflection of the severity of the flooding or the impact on those communities but rather is due to a lack of available streamflow data.

Areal Distribution

The counties listed in table 2 were declared Federal disaster areas (FEMA–1519–DR) as a result of the flooding of May 18–25, 2004. Table 2 also lists the areas affected by flooding and the streams that caused the flooding. Locations of USGS streamgages and streams in the areas that were flooded are shown in figures 5–8.

Flood Stages, Streamflows, and Recurrence Intervals

USGS streamgage records were examined to determine the gages where notable flooding occurred. The peak streamflows determined for those gages were compared to the recurrence intervals for streamflows that are reported in Koltun and others (2006). For streamgages that did not have sufficient record to compute a reliable recurrence-interval estimate and so are not reported in Koltun and others (2006), recurrence intervals were estimated by use of Ohio StreamStats (U.S. Geological Survey, 2007). Table 3 lists the peak stage, peak streamflow, and recurrence-interval range for selected USGS streamgages for May 18–25, 2004. For those stations on regulated rivers, a recurrence interval is not given. Record peak streamflow occurred at the streamgage on Leatherwood Creek (station 03141870). However, the period of record for this station is relatively short. The 100–500 year recurrence interval estimated for Schocalog Run at Copley Junction (station 03115973) and the 50–100 year recurrence interval estimated for Yellow Creek at Botzum (station 04206220) were the two largest recurrence intervals estimated for USGS streamgages for May 18–June 21, 2004. Of the 29 gages for which an estimated recurrence-interval range was computed, 8 of the gages had estimated recurrence-interval ranges of less than 2 years and 13 of the gages had estimated recurrence-interval ranges of 2–5 years. Whereas this indicates that these were small events, more widespread damage assessments indicate that a majority of the flooding occurred on ungaged streams.

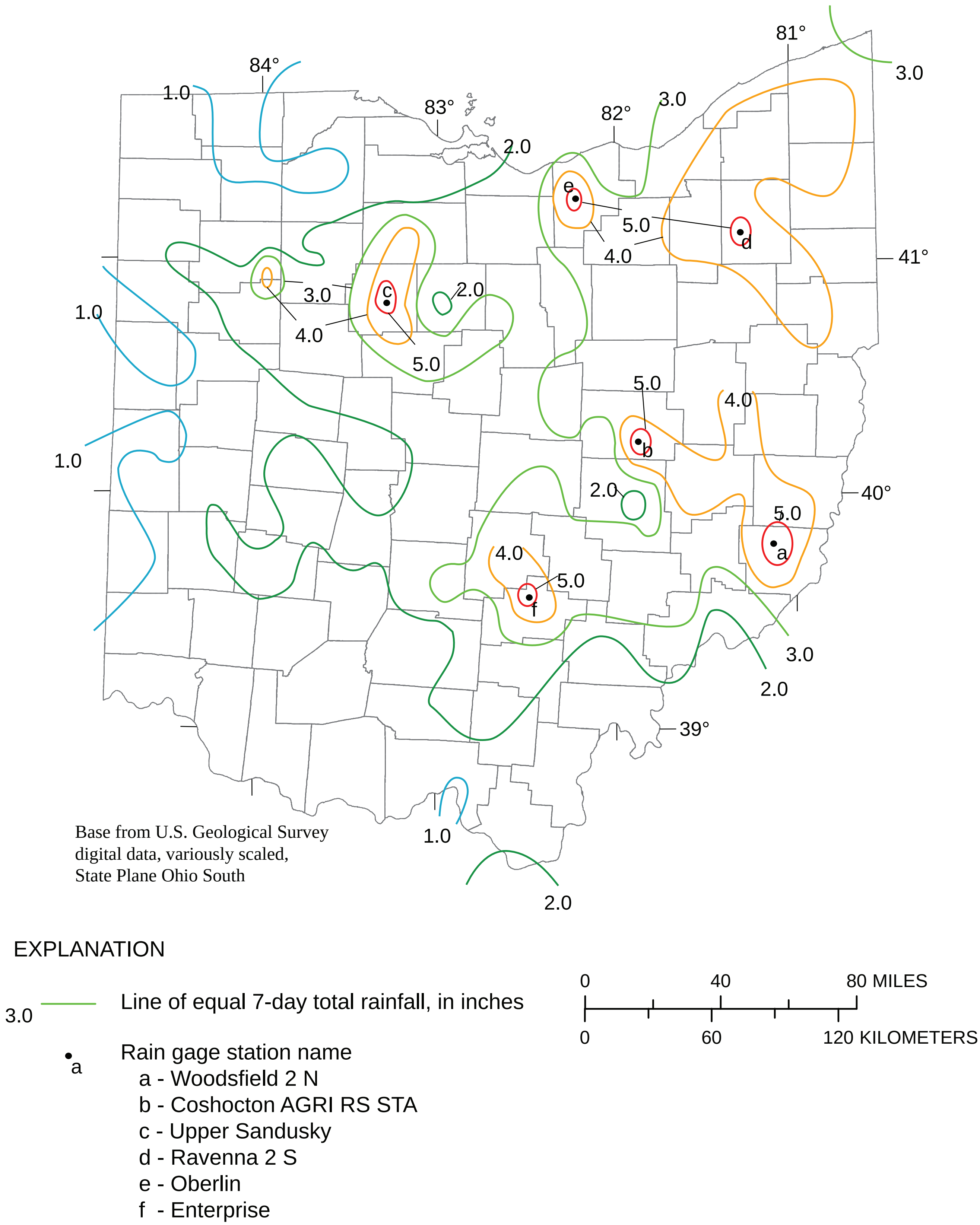


Figure 3. Isohyetal map of 7-day rainfall totals in Ohio for May 17–23, 2004. Based on data collected at 138 rain gages throughout Ohio (National Oceanic and Atmospheric Administration, 2004a).

Table 1. Precipitation totals and recurrence intervals for selected National Weather Service rain gages in Ohio for May 17–23, 2004. Station locations are shown on figure 3.

[Data from National Oceanic and Atmospheric Administration, 2004a]

Station name	County	Dates (2004)	Period (days)	Precipitation (inches)	Recurrence interval[1] (years)
Woodsfield 2 N	Monroe	May 19–22	4	5.70	25–50
Coshocton AGRI RS STA	Coshocton	May 18–21	4	5.20	10–25
Upper Sandusky	Wyandot	May 19–22	4	5.10	10–25
Ravenna 2 S	Portage	May 19–22	4	5.08	10–25
Oberlin	Lorain	May 19–22	4	4.59	10–25
Enterprise	Hocking	May 17–20	4	4.24	5–10

[1]From National Weather Service (2007b).

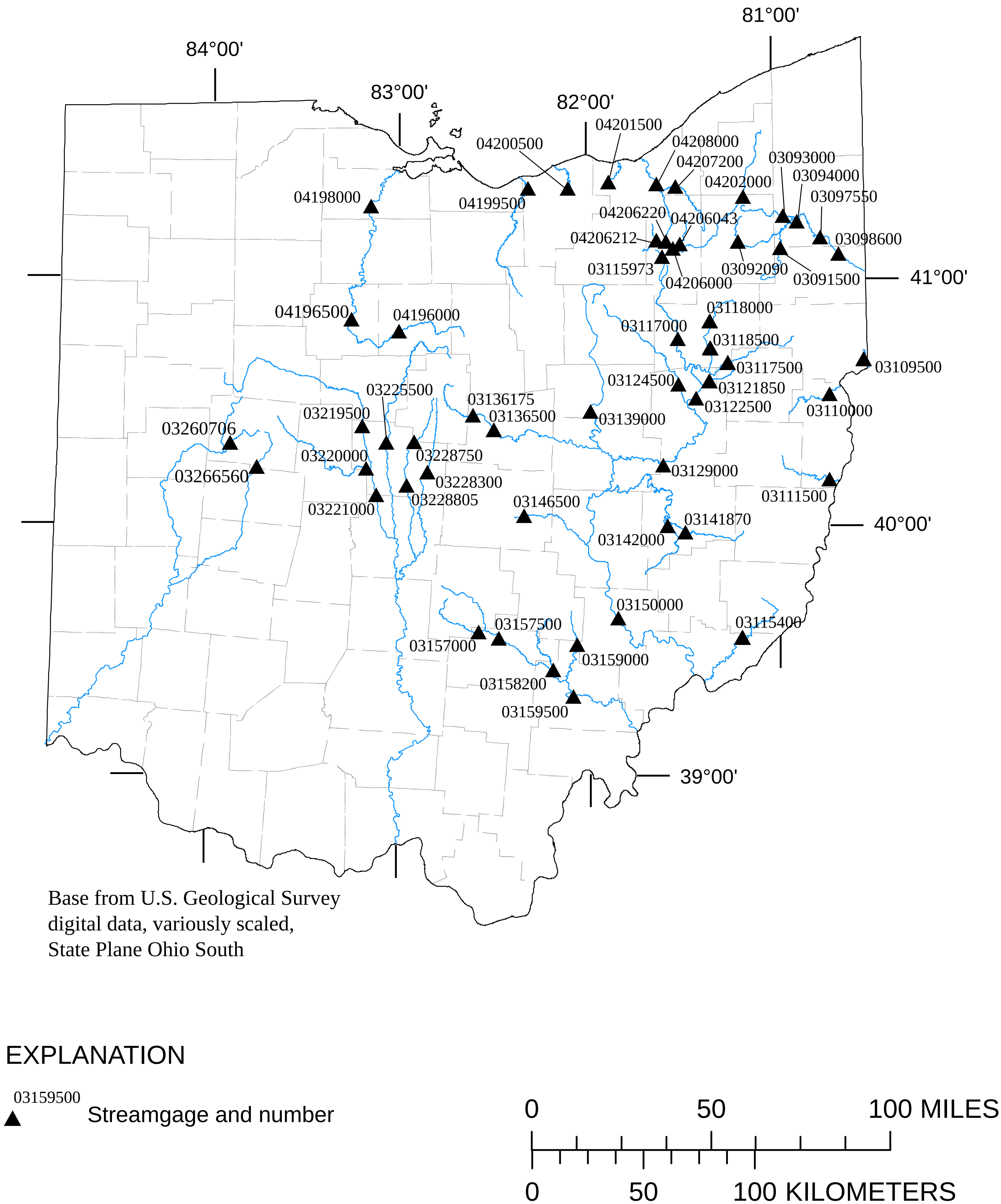


Figure 4. Locations of selected U.S. Geological Survey streamgages that are referred to in this report.

Table 2. Areas and streams affected by flooding during May 18–25, 2004.

[Data from Angel and others, 2004a]

County	Stream(s)	Areas	Figure
Athens	West Branch Sunday Creek	Glouster	5
	Sunday Creek	Glouster, Trimble, and Jacksonville	5
Carroll	*Data not available*	Dellroy to Carrollton	6
Columbiana	Middle Fork Little Beaver Creek	Lisbon	7
	North Fork Little Beaver Creek	Negley	7
	Leslie Run	Negley, East Palestine	7
	Brush Run	Negley	7
	East Fork Little Beaver Creek	Leetonia and Washingtonville	7
Cuyahoga	Cuyahoga River	Valley View	8
	Big Creek	Parma	8
	Rocky River	widespread	8
	East Branch Rocky River	North Royalton	8
	Baldwin Creek	North Royalton	8
Guernsey	Miller Creek	Cumberland	6
Hocking	Monday Creek	Carbon Hill	5
	Hocking River	Logan	5
Lorain	West Branch Black River	Wellington, Lagrange, and Oberlin	8
	East Branch Black River	Grafton	8
Mahoning	Yellow Creek	Poland	7
	Mahoning River	Youngstown and Mill Creek Park	7
Medina	Chippewa Creek	Gloria Glens Park	6
	East Branch Rocky River	Widespread	8
	West Branch Rocky River	Widespread	8
	Plum Creek	Brunswick	8
Noble	West Fork Duck Creek	Caldwell and Belle Valley	6
Perry	West Branch Sunday Creek	Hemlock	5
	Sunday Creek	Corning	5
Portage	West Branch Mahoning River	Ravenna	7
	Cuyahoga River	Kent	8
Summit	Wolf Creek	Barberton, Copley, and Norton	6
	Pigeon Creek	Copley	6
	Schocalog Run	Copley	6
	Cuyahoga River	Cuyahoga Falls and Stow	8
	Mud Brook	Stow	8
Tuscarawas	Huff Run	Mineral City	6
	Tuscarawas River	Northeast of New Philadelphia	6

Figure 5. Selected areas of southeastern Ohio affected by flooding during May 18–25, 2004.

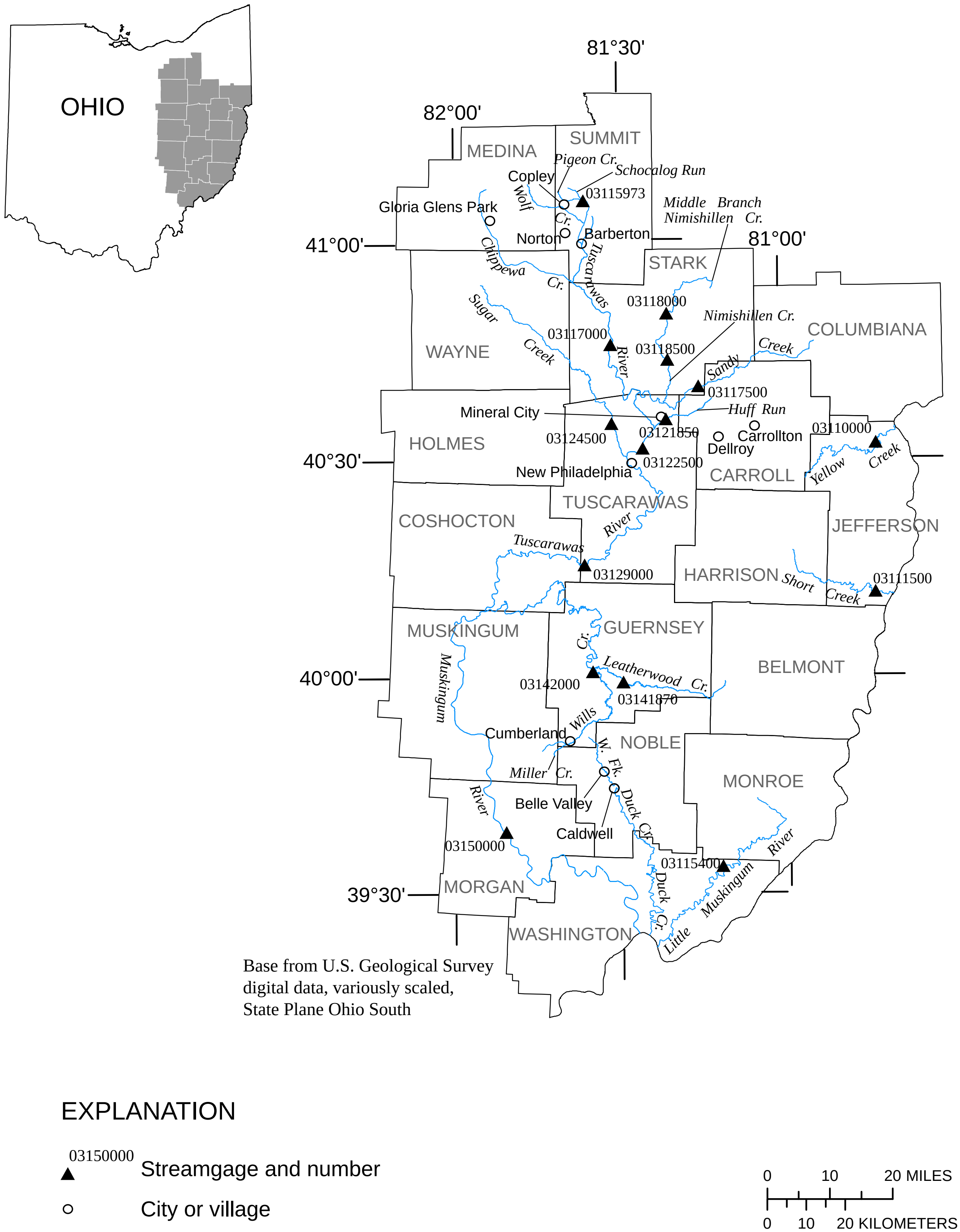


Figure 6. Selected areas of eastern Ohio affected by flooding during May 18–25, 2004.

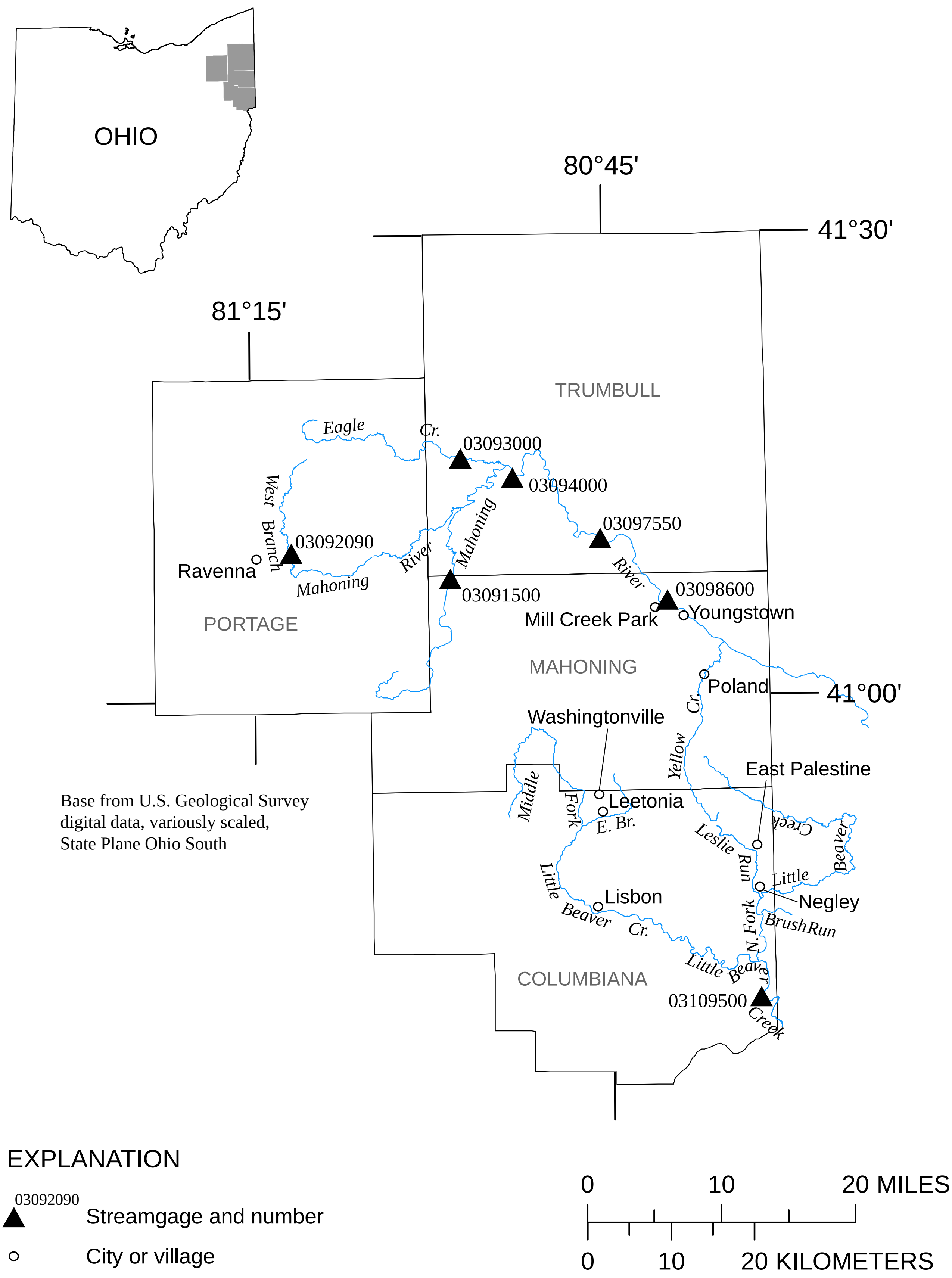


Figure 7. Selected areas of northeastern Ohio affected by flooding during May 18–25, 2004.

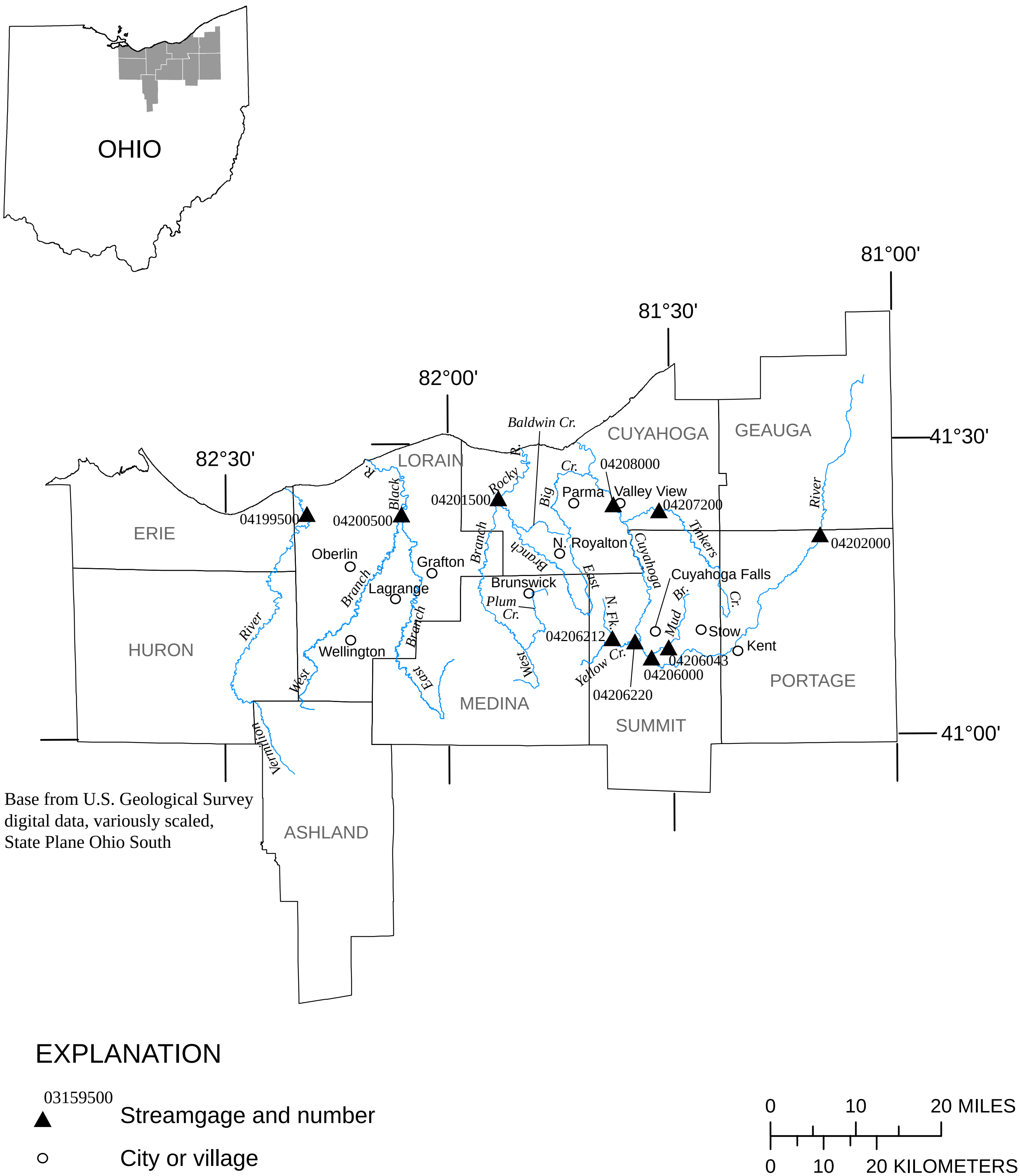


Figure 8. Selected areas of northern Ohio affected by flooding during May 18–25, 2004.

Table 3. Peak stages, peak streamflows, and estimated recurrence-interval ranges at selected USGS streamgages in Ohio, May 18–25, 2004.

[mi^2, square miles; ft, feet (above gage datum); ft^3/s, cubic feet per second; <, less than; N/A, not available; thick lines separate dates of maximum peak]

Permanent station number	Stream and place of determination	Drainage area (mi^2)	Gage datum (ft)	Period of systematic record (water years)[a]	Maximum prior to May 18			Maximum during May 18–25			Estimated recurrence-interval range (years)
					Water year[a]	Stage (ft)	Streamflow (ft^3/s)	Date	Stage (ft)	Streamflow (ft^3/s)	
03121850	Huff Run at Mineral City	12.3	886.98[b]	9	2000	5.16	1,090	May 18	4.25	602	2–5[c]
03122500	Tuscarawas River below Dover Dam near Dover	1,405	861.51[b]	84	1913	23.5	62,000	May 19	7.21	4,810	< 2[d]
03141870	Leatherwood Creek near Kipling	69.5	795.78[b]	6	2002	12.06	1,240	May 19	12.07	1,440	< 2[c]
03157000	Clear Creek near Rockbridge	89	760.13[e]	67	1948	17.68	16,000	May 19	9.17	3,140	2–5[d]
03157500	Hocking River at Enterprise	459	723.58[b]	76	1964	21.31	26,000	May 19	13.35	7,140	2–5[d]
03158200	Monday Creek at Doanville	114	650[f]	9	1998	19.42	5,130	May 19	18.55	3,200	2–5[c]
03159500	Hocking River at Athens	943	611.26[b]	94	1907	27.00	50,000	May 20	20.70	14,300	2–5[d]
03110000	Yellow Creek near Hammondsville	147	692.10[b]	66	1952	12.17	9,580	May 21	6.74	2,600	< 2[d]
03111500	Short Creek near Dillonvale	123	676.10[b]	65	1990	12.27	8,200	May 21	6.53	1,980	< 2[d]
03092090	West Branch Mahoning River near Ravenna	21.8	1,011.80[b]	41	2003	10.76	4,810	May 22	7.98	1,800	10–25[d]
03093000	Eagle Creek at Phalanx Station	97.6	887.14[b]	77	1959	13.12	6,700	May 22	12.68	3,050	2–5[d]
03097550	Mahoning River at Ohio Edison Power Plant at Niles	854	843.08[b]	19	2003	15.42	13,000	May 22	13.02	9,920	N/A

Table 3. Peak stages, peak streamflows, and estimated recurrence-interval ranges at selected USGS streamgages in Ohio, May 18–25, 2004.—Continued

[mi^2, square miles; ft, feet (above gage datum); ft^3/s, cubic feet per second; <, less than; N/A, not available; thick lines separate dates of maximum peak]

Permanent station number	Stream and place of determination	Drainage area (mi^2)	Gage datum (ft)	Period of systematic record (water years)[a]	Maximum prior to May 18			Maximum during May 18–25			Estimated recurrence-interval range (years)
					Water year[a]	Stage (ft)	Streamflow (ft^3/s)	Date	Stage (ft)	Streamflow (ft^3/s)	
03098600	Mahoning River below West Ave at Youngstown	978	824.10[b]	19	2003	17.49	15,800	May 22	15.91	14,300	N/A
03115400	Little Muskingum River at Bloomfield	210	645.99[b]	32	1998	30.78	32,300	May 22	20.2	6,360	< 2[d]
03115973	Schocalog Run at Copley Junction	3.65	994[b]	15	2003	13.64	275	May 22	13.59	267	100–500[d]
03117500	Sandy Creek at Waynesburg	253	955.00[e]	68	1959	10.05	15,000	May 22	7.27	3,560	2–5[d]
03118000	Middle Branch Nimishillen Creek at Canton	43.1	1,046.60[e]	66	1959	6.50[g]	2,470	May 22	6.42	1,080	5–10[d]
03118500	Nimishillen Creek at North Industry	175	976.72[e]	85	2003	14.18	9,310	May 22	7.85	3,390	2–5[d]
03121850	Huff Run at Mineral City	12.3	886.98[b]	9	2000	5.16	1,090	May 22	4.43	706	2–5[c]
03124500	Sugar Creek at Strasburg	311	896.24[e]	53	1935	12.70	19,700	May 22	5.66	2,070	N/A
03129000	Tuscarawas River at Newcomerstown	2,443	780.00[e]	84	1913	21.50	83,000	May 22	8.26	11,300	< 2[d]
03150000	Muskingum River at McConnelsville	7,422	650.31[e]	79	1913	33.50	270,000	May 22	10.27	36,700	< 2[d]
04199500	Vermilion River near Vermilion	262	595.14[b]	38	1969	17.14	40,800	May 22	7.58	6,970	2–5[d]
04200500	Black River at Elyria	396	620.83[b]	62	1959	22.90	24,000	May 22	17.29	13,300	5–10[d]

Table 3. Peak stages, peak streamflows, and estimated recurrence-interval ranges at selected USGS streamgages in Ohio, May 18–25, 2004.—Continued

[mi^2, square miles; ft, feet (above gage datum); ft^3/s, cubic feet per second; <, less than; N/A, not available; thick lines separate dates of maximum peak]

Permanent station number	Stream and place of determination	Drainage area (mi^2)	Gage datum (ft)	Period of systematic record (water years)[a]	Maximum prior to May 18			Maximum during May 18–25			Estimated recurrence-interval range (years)
					Water year[a]	Stage (ft)	Streamflow (ft^3/s)	Date	Stage (ft)	Streamflow (ft^3/s)	
04201500	Rocky River near Berea	267	649.90[b]	75	1959	14.10	21,400	May 22	9.12	14,700	10–25[d]
04206000	Cuyahoga River at Old Portage	404	740.11[b]	83	1959	11.54[h]	6,500	May 22	13.74	5,570	N/A
04206043	Mud Brook at Cuyahoga Falls	25.6	953.78[b]	5	2003	12.93	1,120	May 22	12.6	863	N/A
04206212	North Fork at Bath Center	5.58	950[b]	15	1992	12.93	885	May 22	13.41	720	5–10[d]
04206220	Yellow Creek at Botzum	30.7	760[b]	15	2003	19.53	2,960	May 22	17.34	2,150	50–100[d]
04207200	Tinkers Creek at Bedford	83.9	876.18[b]	44	1969	10.10	7,220	May 22	7.16	2,810	2–5[d]
04208000	Cuyahoga River at Independence	707	583.57[b]	77	1959	22.41	24,800	May 22	21.66	15,000	10–25[d]
03094000	Mahoning River at Leavittsburg	575	871.25[e]	67	1959	19.37	20,300	May 23	14.16	7,470	N/A
03109500	Little Beaver Creek near East Liverpool	496	702.77[e]	92	1941	17.40	25,000	May 23	12.52	12,000	2–5[d]
03142000	Wills Creek at Cambridge	406	772.34[b]	72	1998	26.91	11,400	May 23	15.26	3,940	N/A
03117000	Tuscarawas River at Massillon	518	916.00[e]	68	1969	16.43	10,700	May 24	11.78	5,240	2–5[d]
04202000	Cuyahoga River at Hiram Rapids	151	1,087.46[b]	70	1959	8.11	3,670	May 24	4.29	1,020	< 2[d]

Table 3. Peak stages, peak streamflows, and estimated recurrence-interval ranges at selected USGS streamgages in Ohio, May 18–25, 2004.—Continued

[mi^2, square miles; ft, feet (above gage datum); ft^3/s, cubic feet per second; <, less than; N/A, not available; thick lines separate dates of maximum peak]

Permanent station number	Stream and place of determination	Drainage area (mi^2)	Gage datum (ft)	Period of systematic record (water years)[a]	Maximum prior to May 18			Maximum during May 18–25			Estimated recurrence-interval range (years)
					Water year[a]	Stage (ft)	Streamflow (ft^3/s)	Date	Stage (ft)	Streamflow (ft^3/s)	
03091500	Mahoning River at Pricetown	273	905.00[e]	77	1937	15.01	6,770	May 25	7.21	2,170	N/A

[a] A water year is a 12-month period from October 1 through September 30 and is designated by the calendar year in which it ends.

[b] NGVD 29.

[c] Based on frequency estimates from Ohio StreamStats (U.S. Geological Survey, 2007).

[d] Based on weighted estimates from Koltun and others (2006).

[e] COE 1912.

[f] From topographic map.

[g] A peak stage of 6.63 ft occurred in water year 2003 but is associated with a peak discharge of only 1,630 ft^3/s.

[h] A peak stage of 13.29 ft occurred in water year 1979 but is associated with a peak discharge of only 6,230 ft^3/s.

June 9, 2004, Flood

Storms on June 9, 2004, led to localized flooding on that date in northeastern Ohio. These storms affected northeastern Ohio following a wet April and the second wettest May (fig. 2B) on record for the State (Cashell and Kirk, 2004c) for 122 years preceding this event. These wet conditions likely contributed to the severity of the flooding that resulted from the June 9 storms.

Storms of June 9, 2004

On June 9, 2004, a cold front associated with an occluded mid-latitude cyclone[7] centered over northeastern Canada moved slowly southward over the southern Great Lakes. With southwest winds bringing moisture-laden air into the region, moisture convergence over Ohio was high. In the late afternoon and early evening of June 9, a line of severe thunderstorms formed along the cold front and swept across northeastern Ohio. Isolated thunderstorms brought intense rainfall to central and southern Cuyahoga County, northern Medina County, and southwestern Geauga County. Figure 9 shows the 6-hour precipitation totals for June 9 from 3:00 p.m. to 9:00 p.m. based on data from the Northeast Ohio Regional Sewer District (NEORSD) and NWS rain-gage sites. Southeastern Cuyahoga County received the most rain, with 2.23 in. falling in Oakwood for this 6-hour period. Rainfall intensities and recurrence intervals for selected NEORSD sites from this storm are listed in table 4. The time period used in table 4 is variable in order to show the most intense period of rainfall at the selected rain-gage sites.

General Description of the June 9, 2004, Flood

The following sections present information about the flooding that resulted from the June 9, 2004, storms. This section will focus on streamflow and stage at selected USGS streamgages in the affected counties (fig. 4). The omission from this report of any rivers or communities that experienced flooding is not a reflection of the severity of the flooding or the impact on those communities but rather is due to a lack of available streamflow data.

Areal Distribution

Cuyahoga, Geauga, and Medina Counties were declared Federal disaster areas (FEMA–1519–DR) as a result of the flooding on June 9, 2004. Table 5 lists the areas affected by flooding and the streams that caused the flooding. Locations of USGS streamgages and streams in the flooded areas are shown in figure 10.

Flood Stages, Streamflows, and Recurrence Intervals

USGS streamgage records were examined to determine which streams were most affected by these storms. The peak streamflows for these streams were compared to the recurrence intervals for streamflows reported in Koltun and others (2006). Table 6 lists the peak stage, peak streamflow, and recurrence interval for selected USGS streamgages for June 9, 2004. Because of the localized nature of this storm, flooding occurred mostly on small streams and creeks and had less impact on the larger streams in the region that are gaged by the USGS.

June 11–18, 2004, Flood

Storms between June 11 and 17, 2004, led to flooding in central and eastern Ohio from June 11 to 18, 2004. These storms crossed east-central, central, and west-central Ohio following a wet April and the second-wettest May (fig. 2B) on record for the State (Cashell and Kirk, 2004c). These wet conditions likely contributed to the severity of the flooding that resulted from the June 9 storms.

[7] Occluded means that the mid-latitude cyclone is in the final phase of its life cycle. An occluded front marks the boundary between two polar air masses.

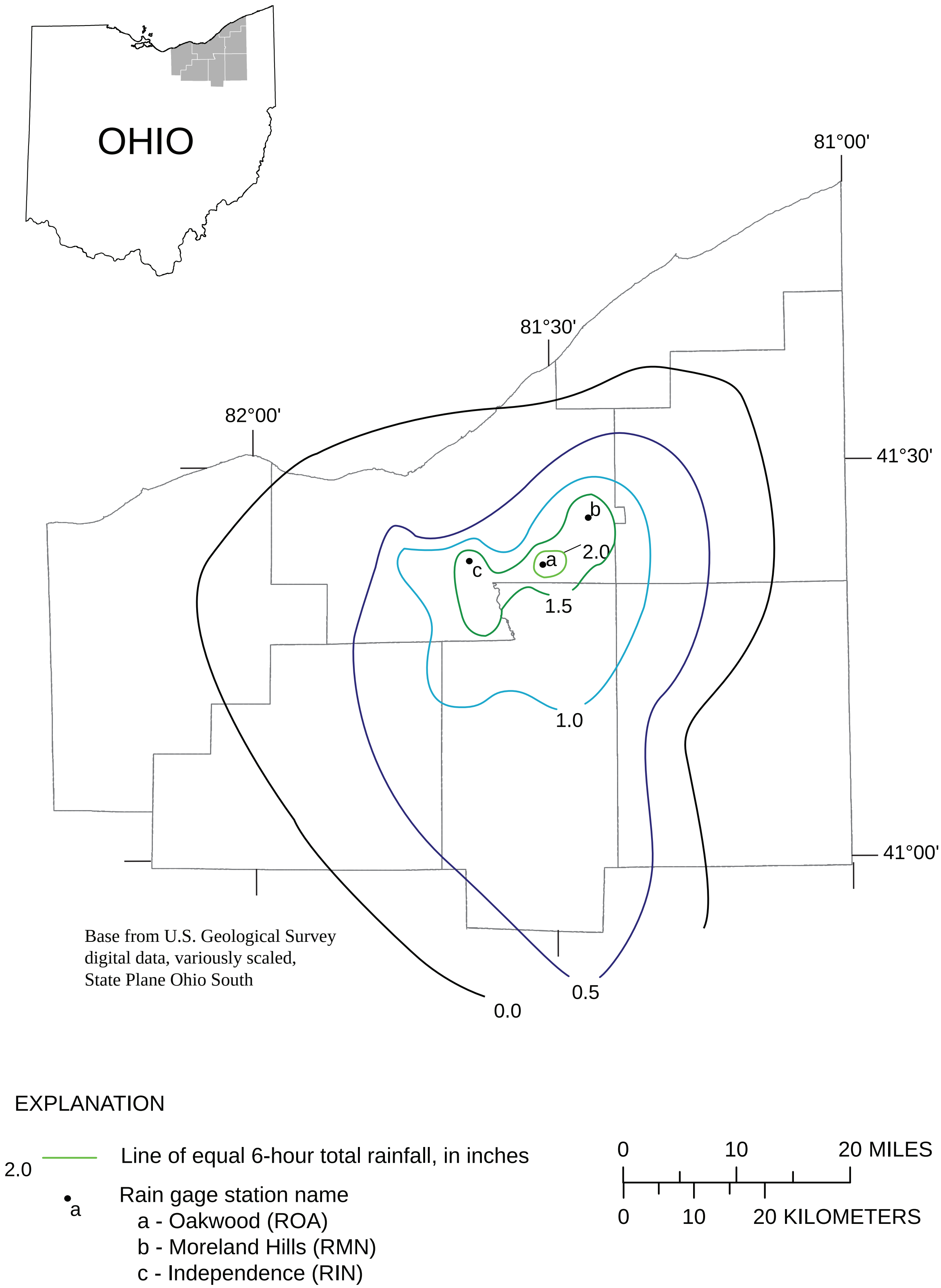


Figure 9. Isohyetal map of 6-hour rainfall totals from 3:00 p.m. to 9:00 p.m. on June 9, 2004. Based on data collected at 31 rain gages throughout northeast Ohio (Thomas Knight, Northeast Ohio Regional Sewer District, written commun., 2007; National Oceanic and Atmospheric Administration, 2004b).

Table 4. Precipitation totals and recurrence intervals for selected Northeast Ohio Regional Sewer District rain gages in Cuyahoga County, Ohio, on June 9, 2004. Station locations are shown on figure 9.

[Data from the Northeast Ohio Regional Sewer District (Thomas Knight, written commun., 2007)]

Station name and location	Time	Period (minutes)	Precipitation (inches)	Recurrence interval[1] (years)
ROA – Oakwood	17:40–18:40	60	1.83	10–25
RMN – Moreland Hills	17:25–18:25	60	1.93	10–25
RIN - Independence	17:35–18:05	30	1.29	5–10

[1]From National Weather Service (2007b).

Table 5. Areas and streams affected by flooding on June 9, 2004.

[Data from Angel and others, 2004b]

County	Stream(s)	Areas	Figure
Cuyahoga	East Branch Rocky River and its tributaries	North Royalton	10
	Baldwin Creek	North Royalton	10
	Chippewa Creek	Brecksville, Broadview Heights	10
	Data no available	Moreland Hills, Solon, Strongsville	10
Geauga	*Data no available*	Southwestern part of county	10
Medina	West Branch Rocky River, East Branch Rocky River	Northern part of county	10

Table 6. Peak stages, peak streamflows, and estimated recurrence-interval ranges at selected USGS streamgages in Cuyahoga County, Ohio, June 9, 2004.

[mi^2, square miles; ft, feet (above gage datum); ft^3/s, cubic feet per second; <, less than]

Permanent station number	Stream and place of determination	Drainage area (mi^2)	Gage datum (ft) (NGVD 29)	Period of systematic record (water years)[a]	Maximum prior to June 9			Maximum during June 9		Estimated recurrence-interval range (years)
					Water year[a]	Stage (ft)	Streamflow (ft^3/s)	Stage (ft)	Streamflow (ft^3/s)	
04207200	Tinkers Creek at Bedford	83.9	876.18	44	1969	10.10	7,220	7.22	2,890	2-5[b]
04208000	Cuyahoga River at Independence	707	583.57	77	1959	22.41	24,800	13.67	7,380	< 2[b]

[a] A water year is a 12-month period from October 1 through September 30 and is designated by the calendar year in which it ends.

[b] Based on weighted estimates from Koltun and others (2006).

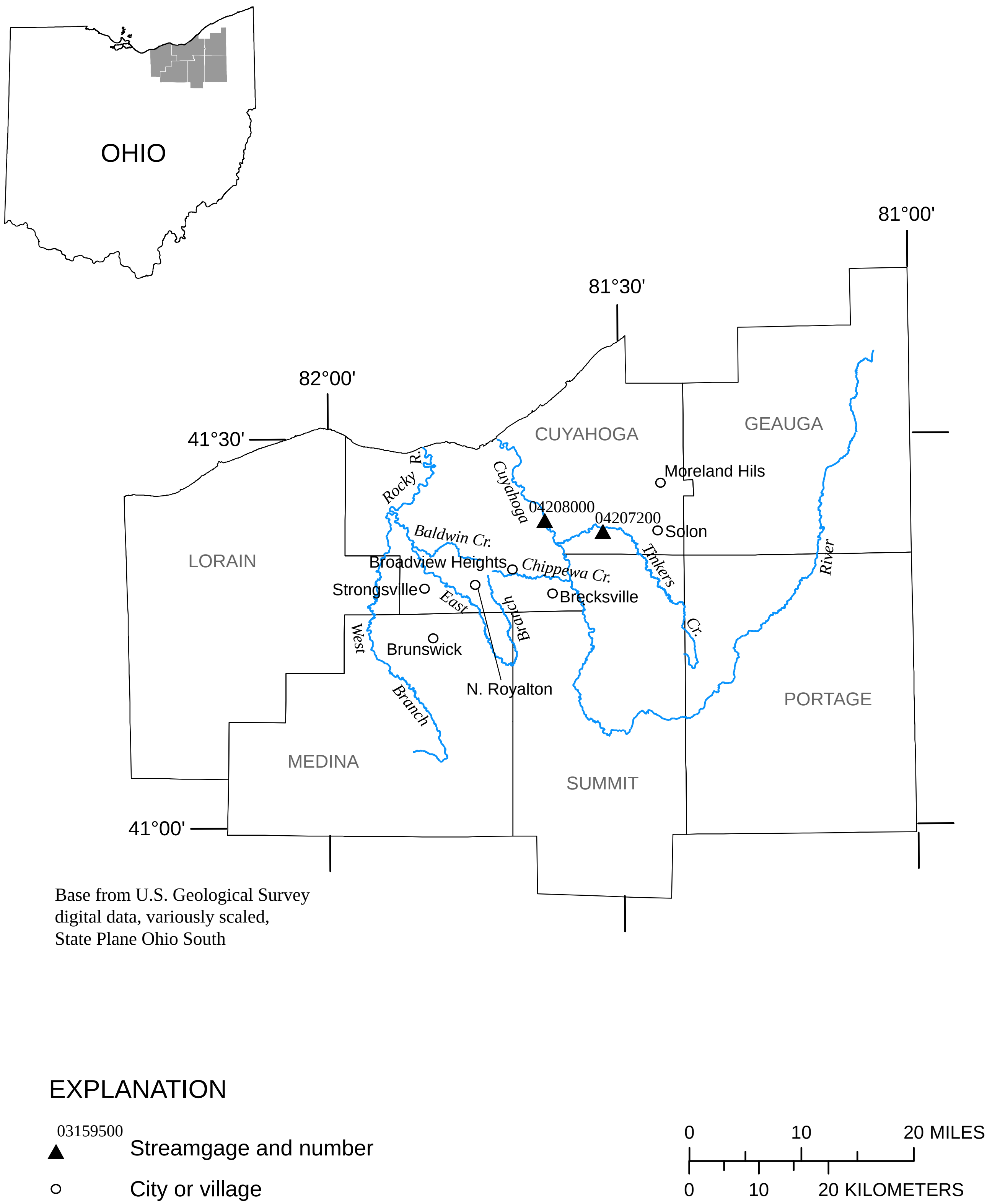


Figure 10. Selected areas of northern Ohio affected by flooding on June 9, 2004.

Storms of June 11–17, 2004

For the period from June 11 to 17, 2004, an upper-level trough[8] was positioned west of Ohio, allowing the air over the region to rise, which resulted in increased thunderstorm development. Moisture convergence during this time period was also high over the Midwest, providing the moisture needed for large thunderstorms to develop. As this trough moved over and past Ohio on June 18, 2004, thunderstorm development in the region was inhibited by the descending air behind the trough.

On June 11, 2004, a stationary front was located over central Ohio. Thunderstorms formed along this stationary front and moved across central Ohio, resulting in 2–3 in. of rain in parts of Darke, Preble, Miami, Greene, Montgomery, Franklin, Coshocton, Muskingum, Perry, and Athens Counties. Columbus, in Franklin County, received 2.89 in. of rain from this storm (National Oceanic and Atmospheric Administration, 2004b).

On the morning of June 12, 2004, with a stationary front still spread across Illinois, Indiana, and southern Ohio, a cluster of thunderstorms moved over Ohio from the northwest to the southeast, dumping 1–2.5 in. of rain on much of northwestern, central, and southeastern Ohio. Parts of Monroe County received 2.5 in. from this storm (National Oceanic and Atmospheric Administration, 2004b).

On the evening of June 13 and the early morning of June 14, 2004, a mid-latitude cyclone was located over northern Michigan. Ahead of a slow-moving cold front associated with this mid-latitude cyclone, a squall line[9] formed over northeastern Indiana and moved southwest across Ohio. This line of severe storms brought 1–2 in. of rain to central and northwestern Ohio, and more than 2 in. of rain fell in parts of Delaware and Richland Counties (National Oceanic and Atmospheric Administration, 2004b).

As the mid-latitude cyclone moved northeastward into Canada, its associated cold front stalled northwest of Ohio. On the evening of June 14 and early morning of June 15, 2004, another squall line formed over northern Indiana ahead of the stalled cold front and moved eastward across northern Ohio. On the afternoon of June 15, 2004, a cluster of thunderstorms formed along this cold front as it began to move southward over Ohio. These thunderstorms crossed Ohio between June 14 and 15, 2004, and dropped 1–3 in. of rain on much of northern Ohio, with more than 4 in. of rain falling in parts of Carroll and Stark Counties (National Oceanic and Atmospheric Administration, 2004b).

On the morning of June 16, 2004, the mid-latitude cyclone over northern Canada dissipated, and the frontal boundary over Ohio lifted. On the evening of June 16, a warm front associated with a mid-latitude cyclone over Iowa moved northward across Ohio. Thunderstorms formed along this warm front, bringing 0.5–2 in. of rain to parts of western and eastern Ohio. A total of 2.13 in. of rain fell on Cambridge in Guernsey County during this storm (National Oceanic and Atmospheric Administration, 2004b).

Storms that moved across Ohio during this week-long period from June 11 to 17, 2004, brought more than 7 in. of rain to parts of Logan, Delaware, Tuscarawas, and Carroll Counties (fig. 11). Figure 11 was created from NWS data (National Oceanic and Atmospheric Administration, 2004b) collected at 141 rain gages throughout Ohio. Rainfall intensities and recurrence intervals for selected NWS sites from this storm are listed in table 7.

General Description of the June 11–18, 2004, Flood

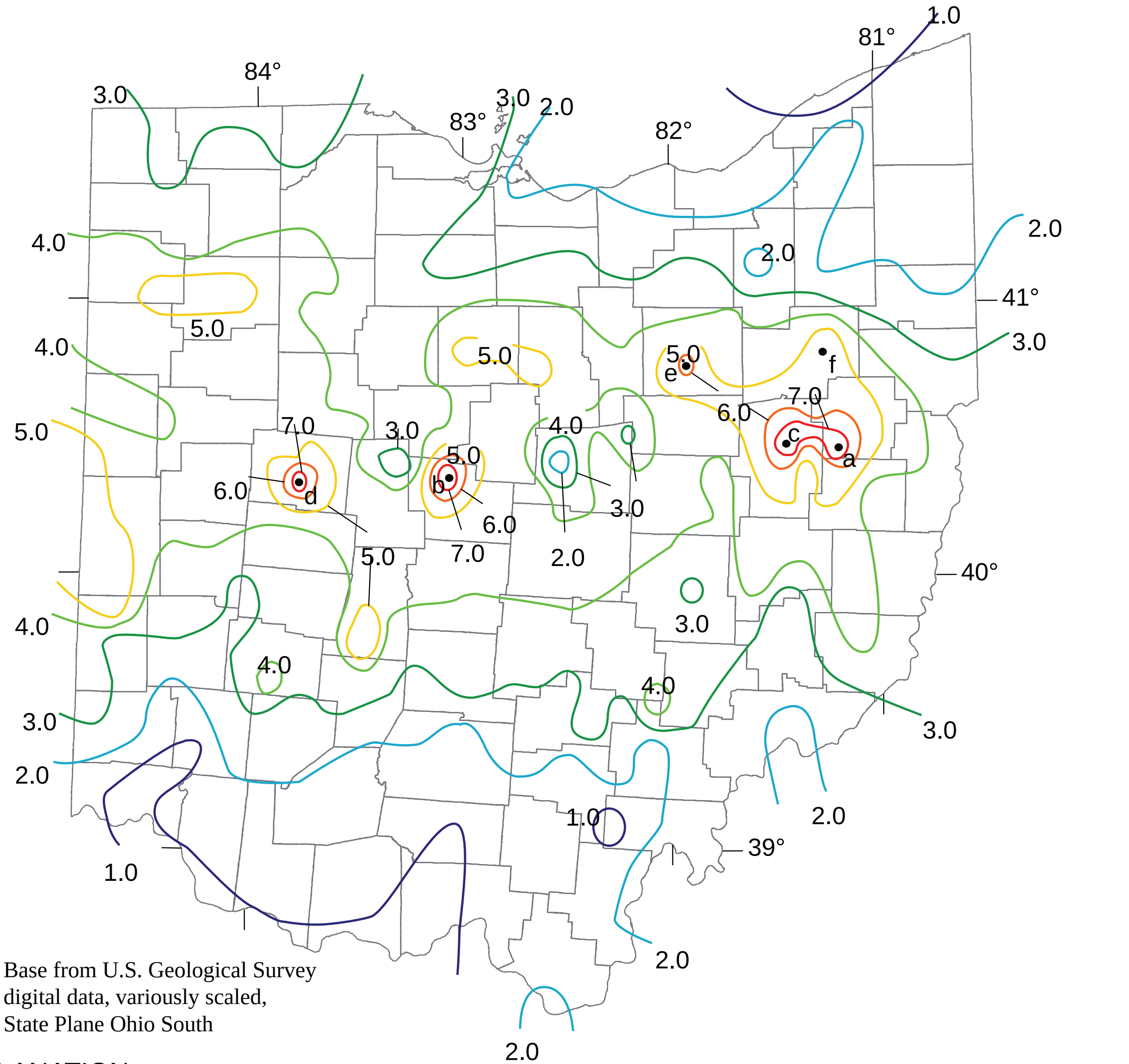
The following sections present information about the flooding from June 11 to 18, 2004, that resulted from storms during that period. This section focuses on streamflow and stage at selected USGS streamgages in the affected counties (fig. 4). The omission from this report of any rivers or communities that experienced flooding is not a reflection of the severity of the flooding or the impact on those communities but rather is due to a lack of available streamflow data.

Areal Distribution

The counties listed in table 8 were declared Federal disaster areas (FEMA–1519–DR) as a result of flooding from June 11 to 18, 2004. Table 8 also lists the areas affected by flooding and the streams that caused the flooding. Locations of USGS streamgages and streams in the areas flooded are shown in figures 12–15.

[8] An upper-level trough is defined as an elongated region of low pressure at high levels in the atmosphere.

[9] A squall line is defined as a linear band of severe thunderstorms that often forms ahead of or along a cold front.



EXPLANATION

4.0 —— Line of equal 7-day total rainfall, in inches

•a Rain gage station name
- a - Leesville Lake
- b - Delaware Lake
- c - New Philadelphia
- d - Bellefontaine
- e - Wooster Exp Stn
- f - Louisville

0 40 80 MILES
0 50 100 KILOMETERS

Figure 11. Isohyetal map of 7-day rainfall totals in Ohio for June 11–17, 2004. Based on data collected at 141 rain gages throughout Ohio (National Oceanic and Atmospheric Administration, 2004b).

Table 7. Precipitation totals and recurrence intervals for selected National Weather Service rain gages in Ohio for June 11–17, 2004. Station locations shown on figure 11.

[Data from National Oceanic and Atmospheric Administration, 2004b]

Station name	County	Period (days)	Precipitation (inches)	Recurrence interval[1] (years)
Leesville Lake	Carroll	7	7.80	50–100
Delaware Lake	Delaware	7	7.70	50–100
New Philadelphia	Tuscarawas	7	7.59	50–100
Bellefontaine	Logan	7	7.18	25–50
Wooster Exp Stn	Wayne	7	6.18	10–25
Louisville	Stark	7	5.84	10–25

[1]From National Weather Service (2007b).

Table 8. Areas and streams affected by flooding during June 11–18, 2004.

[Data from Angel and others, 2004b]

County	Stream(s)	Areas	Figure
Carroll	Sandy Creek	Malvern	12
	Data not available	Carrollton and Dellroy	12
Columbiana	Sandy Creek	East Rochester	12
	Data not available	East Palestine, Lisbon, and New Waterford	12
Crawford	Sandusky River and its tributaries	Bucyrus, Crestline, and Galion	13
Delaware	Olentangy River	Delaware and Powell	14
Guernsey	Wills Creek	Byesville and Guernsey	12
Harrison	*Data not available*	Bowerston and Deersville	12
Holmes	Salt Creek	Northern part of county	15
	Killbuck Creek	Killbuck	15
	Walnut Creek	Widespread	12
Knox	*Data not available*	Countywide	15
Licking	*Data not available*	Johnstown	15
Logan	Bokengehalas Creek	Bellefontaine	14
Noble	*Data not available*	Sarahsville	12
Richland	Black Fork Mohican River and it tributaries	Charles Mill Lake Park and Shelby	15
	Data not available	Plymouth	15
Stark	Sugar Creek	Beach City	12
	Data not available	Wilmot	12
	Nimishillen Creek	Louisville and North Industry	12
Tuscarawas	Tuscarawas River	New Philadelphia and Port Washington	12
	Walnut Creek	Dundee	12
	Stone Creek	Widespread	12

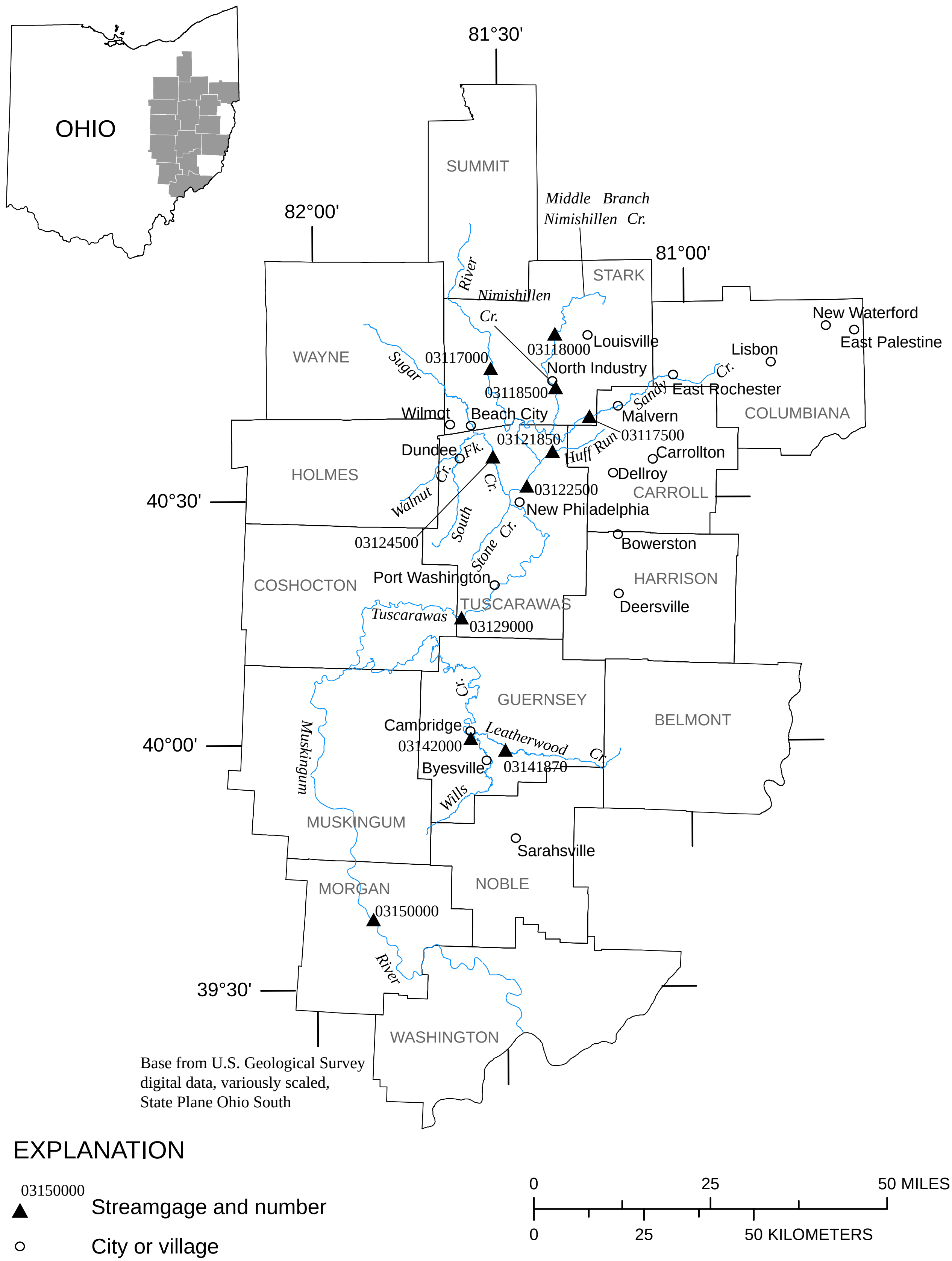


Figure 12. Selected areas of eastern Ohio affected by flooding during June 11–17, 2004.

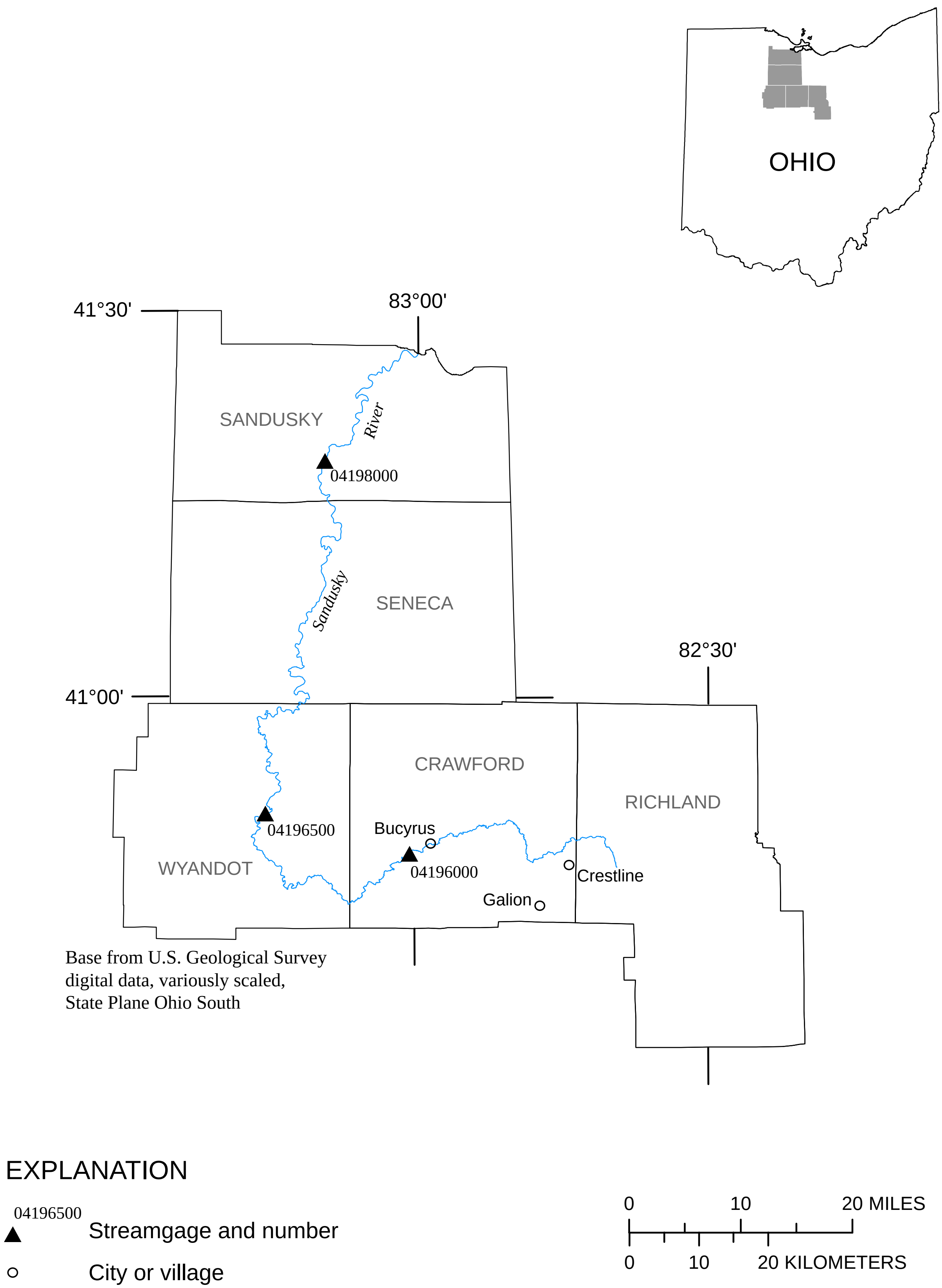


Figure 13. Selected areas of north-central Ohio affected by flooding during June 11–17, 2004.

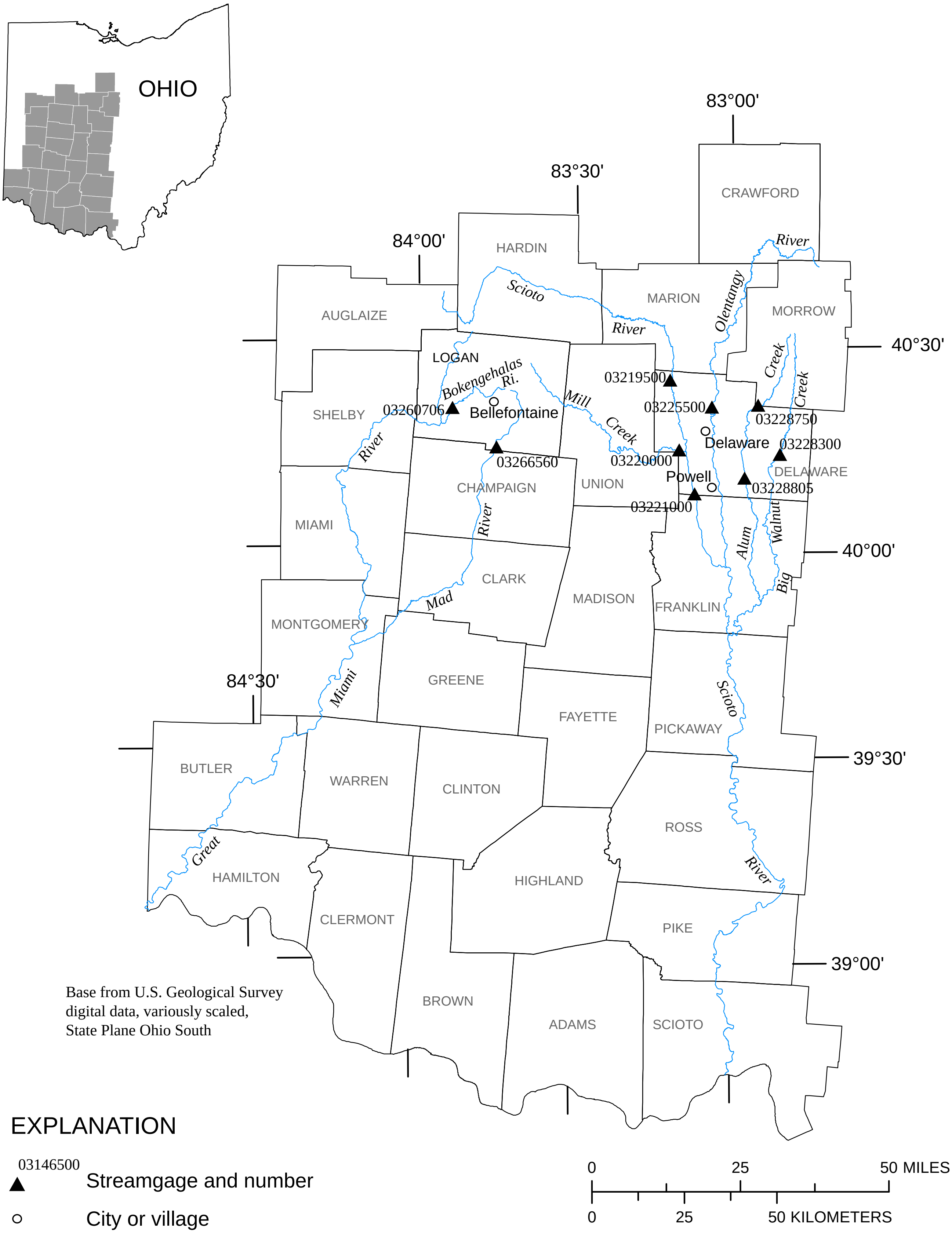


Figure 14. Selected areas of southwestern, western, and central Ohio affected by flooding during June 11–17, 2004.

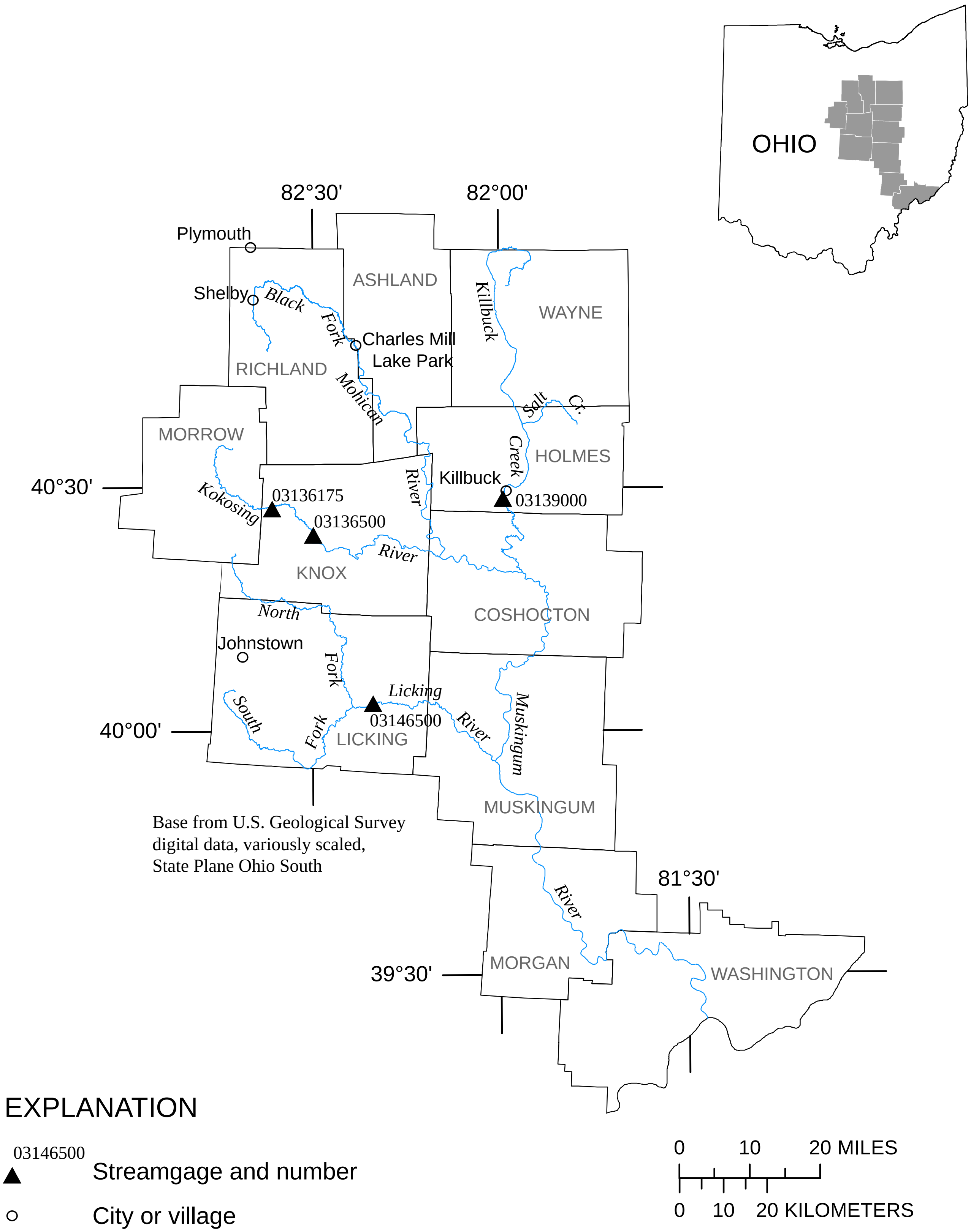


Figure 15. Selected areas of east-central Ohio affected by flooding during June 11–17, 2004.

Flood Stages, Streamflows, and Recurrence Intervals

USGS streamgage records were examined to determine which streams were most affected by these storms. The peak streamflows for these streams were compared to the recurrence intervals for streamflows that are reported in Koltun and others (2006). For streamgages that did not have sufficient record to compute a reliable recurrence-interval estimate and so are not reported in Koltun and others (2006), recurrence intervals were estimated by use of Ohio StreamStats (U.S. Geological Survey, 2007). Table 9 lists the peak stage, peak streamflow, and recurrence-interval range for selected USGS streamgages for June 11–18, 2004. For those stations on regulated rivers, a recurrence interval is not given. Record peak streamflow occurred on the Kokosing River near Lucerne (station 03136175) and Mad River at West Liberty (station 03266560). However, these two stations have a relatively short period of record. Of the 25 streamgages for which an estimated recurrence-interval range was computed, 13 had estimated recurrence-interval ranges of less than 2 years and 8 had estimated recurrence-interval ranges of 2–5 years. Although these estimated recurrence-interval ranges indicate that these were small floods, more widespread damage assessments indicate that a majority of the flooding occurred on ungaged streams.

Flood and Storm Damages Associated with FEMA-1519-DR

Although it was not possible to determine an exact value of the damages caused by the flooding, Ohio EMA was able to obtain some estimates of the extent of the damage. According to the Ohio EMA (Kay Phillips, written commun., 2007) flooding for the period May 18–June 21, 2004, resulted in two deaths and damage to or destruction of 3,529 private properties. Damages to public property were estimated to be $16.7 million. FEMA approved nearly $32.5 million of assistance to aid in the repair of both public and private properties. The Small Business Administration approved an additional $11 million in loans to aid with repair of local businesses affected by the flooding.

Tables 10 and 11 list the extent of the damages to private and public property. Table 10 lists the estimated damages incurred to private property (Individual Assistance). Table 11 indicates estimated damages to public properties such as city and county buildings, roadways, vehicles, certain utilities, and other publicly owned property.

Table 9. Peak stages, peak streamflows, and estimated recurrence-interval ranges at selected USGS streamgages in Ohio, June 11–18, 2004.

[mi^2, square miles; ft, feet (above gage datum); ft^3/s, cubic feet per second; <, less than; N/A, not available; thick lines separate dates of maximum peak]

Permanent station number	Stream and place of determination	Drainage area (mi^2)	Gage datum (ft)	Period of systematic record (water years)[a]	Maximum prior to June 11			Maximum during June 11–18			Estimated recurrence-interval range (years)
					Water year[a]	Stage (ft)	Streamflow (ft^3/s)	Date	Stage (ft)	Streamflow (ft^3/s)	
03121850	Huff Run at Mineral City	12.3	886.98[b]	9	2000	5.16	1,090	June 11	3.06	153	< 2[c]
03115400	Little Muskingum River at Bloomfield	210	645.99[b]	32	1998	30.78	32,300	June 12	17.15	4,420	< 2[d]
03110000	Yellow Creek near Hammondsville	147	692.10[b]	66	1952	12.17	9,580	June 14	6.71	2,580	< 2[d]
03111500	Short Creek near Dillonvale	123	676.10[b]	65	1990	12.27	8,200	June 14	5.89	1,590	< 2[d]
03121850	Huff Run at Mineral City	12.3	886.98[b]	9	2000	5.16	1,090	June 14	3.27	204	< 2[c]
03136175	Kokosing River near Lucerne	59.5	1,065[e]	5	2002	8.26	1,430	June 14	8.35	1,550	< 2[c]
03136500	Kokosing River at Mount Vernon	202	984.16[b]	53	1959	18.19	38,000	June 14	8.23	2,670	< 2[d]
03146500	Licking River near Newark	537	779.02[b]	66	1959	20.30	45,000	June 14	12.38	12,500	2–5[d]
03220000	Mill Creek near Bellepoint	178	865.14[f]	64	1997	14.45	21,800	June 14	7.74	3,820	< 2[d]
03228300	Big Walnut Creek at Sunbury	101	945[b]	17	1997	11.20[g]	6,700	June 14	11.23	6,300	10–25[d]
03228750	Alum Creek near Kilbourne	64.9	900.99[b]	13	1975	12.05	4,850	June 14	8.98	3,060	2–5[c]
03260706	Bokengehalas Creek at De Graff	40.4	977.38[b]	14	2003	6.80	925	June 14	5.99	749	< 2[c]
03266560	Mad River at West Liberty	36.6	1,078.00[b]	10	1997	8.43	1,200	June 14	8.73	1,640	2–5[c]
04196000	Sandusky River near Bucyrus	88.8	955.04[b]	52	1959	11.90	13,500	June 14	9.5	4,230	5–10[d]
03109500	Little Beaver Creek near East Liverpool	496	702.77[f]	92	1941	17.40	25,000	June 15	9.73	6,550	< 2[d]
03117500	Sandy Creek at Waynesburg	253	955.00[f]	68	1959	10.05	15,000	June 15	8.24	5,110	5–10[d]
03118000	Middle Branch Nimishillen Creek at Canton	43.1	1,046.60[f]	66	1959	6.50[h]	2,470	June 15	5.21	529	< 2[d]
03118500	Nimishillen Creek at North Industry	175	976.72[f]	85	2003	14.18	9,310	June 15	11.46	6,480	25–50[d]
03221000	Scioto River below O'Shaughnessy Dam near Dublin	980	775.00[f]	86	1913	24.60	74,500	June 15	11.86	14,000	2–5[d]

Table 9. Peak stages, peak streamflows, and estimated recurrence-interval ranges at selected USGS streamgages in Ohio, June 11–18, 2004.—Continued

[mi^2, square miles; ft, feet (above gage datum); ft^3/s, cubic feet per second; <, less than; N/A, not available; thick lines separate dates of maximum peak]

Permanent station number	Stream and place of determination	Drainage area (mi^2)	Gage datum (ft)	Period of systematic record (water years)[a]	Maximum prior to June 11			Maximum during June 11–18			Estimated recurrence-interval range (years)
					Water year[a]	Stage (ft)	Streamflow (ft^3/s)	Date	Stage (ft)	Streamflow (ft^3/s)	
03228750	Alum Creek near Kilbourne	64.9	900.99[b]	13	1975	12.05	4,850	June 15	6.27	1,110	< 2[c]
03219500	Scioto River near Prospect	567	886.90[b]	93	1913	21.10	27,000	June 16	12.69	6,820	2–5[d]
04196500	Sandusky River near Upper Sandusky	298	792.25[b]	65	1959	15.00	10,000	June 16	9.27	5,760	2–5[d]
03121850	Huff Run at Mineral City	12.3	886.98[b]	9	2000	5.16	1,090	June 17	4.11	528	2–5[c]
03124500	Sugar Creek at Strasburg	311	896.24[f]	53	1935	12.70	19,700	June 17	6.37	2,680	N/A
03139000	Killbuck Creek at Killbuck	464	788.05[b]	76	1969	26.40	47,500	June 18	17.01	3,530	2–5[d]
03228805	Alum Creek at Africa	221	822.00[b]	44	1963	14.20i	6,460	June 18	5.19	1,750	< 2[d]

[a] A water year is a 12-month period from October 1 through September 30 and is designated by the calendar year in which it ends.

[b] NGVD 29.

[c] Based on frequency estimates from Ohio StreamStats (U.S. Geological Survey, 2007).

[d] Based on weighted estimates from Koltun and others (2006).

[e] From topographic map.

[f] COE 1912.

[g] A peak stage of 11.86 ft occurred in water year 1991 but is associated with a peak discharge of 5,690 ft^3/s.

[h] A peak stage of 6.63 ft occurred in water year 2003 but is associated with a peak discharge of 1,630 ft^3/s.

[i] A peak stage of 27.74 ft occurred in water year 1979 but is associated with a peak discharge of 2,150 ft^3/s.

Table 10. Damage estimates for Individual Assistance associated with Federal Emergency Management Agency disaster declaration FEMA–1519–DR.

[Source: Kay Phillips, Ohio Emergency Management Agency, written commun., 2007]

County	Structures damaged[1]	Structures destroyed[2]	Deaths
Athens	132	3	0
Carroll	19	0	0
Columbiana	80	0	1
Crawford	144	0	0
Cuyahoga	1,079	16	0
Delaware	154	0	0
Geauga	13	0	0
Guernsey	28	0	0
Harrison	139	1	0
Hocking	21	0	0
Holmes	445	1	0
Licking	43	0	0
Logan	88	0	0
Lorain	406	1	0
Mahoning	6	0	0
Medina	345	2	1
Noble	15	0	0
Perry	57	3	0
Portage	46	0	0
Richland	44	0	0
Stark	12	0	0
Summit	130	0	0
Tuscarawas	56	0	0

[1]Properties that received damage considered to be repairable.

[2]Properties that were considered to be a total loss.

Table 11. Damage estimates for Public Assistance associated with Federal Emergency Management Agency disaster declaration FEMA–1519–DR.

[Source: Kay Phillips, Ohio Emergency Management Agency, written commun., 2007]

County	Estimated damages
Athens	$72,000
Carroll	$126,800
Columbiana	$2,531,668
Cuyahoga	$3,572,100
Delaware	$301,989
Guernsey	$951,109
Harrison	$2,061,426
Hocking	$156,581
Holmes	$643,000
Jefferson	$319,425
Knox	$772,841
Lorain	$236,700
Medina	$394,500
Noble	$237,700
Perry	$776,700
Portage	$699,136
Summit	$2,194,427
Tuscarawas	$682,500

Summary

The passage of several severe thunderstorms over Ohio between May 17 and May 23, on June 9, and between June 11 and June 17, 2004, resulted in flooding and widespread damage throughout much of central and eastern Ohio between May 18 and June 21. From May 17 through May 23, rain was widespread across eastern and central Ohio, with parts of Monroe County receiving more than 5.5 in. of rain from May 19 to May 22. Storms on June 9 were localized to parts of Cuyahoga County, with nearly 2 in. of rain falling in Moreland Hills during a 1-hour period. From June 11 through June 17, rain was widespread across eastern and central Ohio, with nearly 8 in. of rain falling in parts of Carroll County during this 7-day period.

The largest estimated flood-recurrence intervals at USGS streamgages for May 18–June 21, 2004, occurred in Summit County, where a 100–500 year flood occurred on Schocalog Run at Copley Junction (station 03115973) and a 50–100 year flood occurred on Yellow Creek at Botzum (station 04206220). Record peak streamflow occurred at three streamgages. Estimated recurrence intervals associated with peak flows during this month-long period were variable, and in many areas flooding is assumed to have occurred on ungaged streams.

In all, 25 counties in central and eastern Ohio were declared Federal disaster areas (FEMA–1519–DR) as a result of the storms and flooding between May 18 and June 21, 2004. Two storm- or flood-related fatalities were reported, and an economic impact of more than $43 million is estimated by the Ohio EMA.

Acknowledgments

Special thanks are extended to Kay Phillips of Ohio EMA for her help in providing damage estimates for the counties affected by this flood. Thanks also to Jeff Smith of the Ohio Geographically Referenced Information Program (OGRIP) for providing Ohio Statewide Imagery Program (OSIP) data used to make certain figures in this report.

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