In cooperation with the Ohio Emergency Management Agency

Morphological Analyses and Simulated Flood Elevations in a Watershed with Dredged and Leveed Stream Channels, Wheeling Creek, Eastern Ohio

Scientific Investigations Report 2008–5133

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

Cover. Looking downstream at cross-section C-5 on Wheeling Creek in Maynard, Ohio, after dredging was completed in 1985. (Photograph by G.F. Koltun, U.S. Geological Survey)

Above. Looking downstream at cross-section C-5 (photograph taken from same location as cover photograph) on Wheeling Creek in Maynard, Ohio, summer 2006. (Photograph by James M. Sherwood, U.S. Geological Survey)

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By James M. Sherwood, Carrie A. Huitger, Andrew D. Ebner, and G.F. Koltun

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Conversion Factors and Vertical Datum

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	0.004047	square kilometer (km^2)
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)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

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

Morphological Analyses and Simulated Flood Elevations in a Watershed with Dredged and Leveed Stream Channels, Wheeling Creek, Eastern Ohio

By James M. Sherwood, Carrie A. Huitger, Andrew D. Ebner, and G.F. Koltun

Abstract

The USGS, in cooperation with the Ohio Emergency Management Agency, conducted a study in the Wheeling Creek Basin to (1) evaluate and contrast land-cover characteristics from 2001 with characteristics from 1979 and 1992; (2) compare current streambed elevation, slope, and geometry with conditions present in the late 1980s; (3) look for evidence of channel filling and over widening in selected undredged reaches; (4) estimate flood elevations for existing conditions in both undredged and previously dredged reaches; (5) evaluate the height of the levees required to contain floods with selected recurrence intervals in previously dredged reaches; and (6) estimate flood elevations for several hypothetical dredging and streambed aggradation scenarios in undredged reaches.

The amount of barren land in the Wheeling Creek watershed has decreased from 20 to 1 percent of the basin area based on land-cover characteristics from 1979 and 2001. Barren lands appear to have been converted primarily to pasture, presumably as a result of surface-mine reclamation. Croplands also decreased from 13 to 8 percent of the basin area. The combined decrease in barren lands and croplands is approximately offset by the increase in pasture.

Stream-channel surveys conducted in 1987 and again in 2006 at 21 sites in four previously dredged reaches of Wheeling Creek indicate little change in the elevation, slope, and geometry of the channel at most sites. The mean change in width-averaged bed and thalweg elevations for the 21 cross sections was 0.1 feet.

Bankfull widths, mean depths, and cross-sectional areas measured at 12 sites in undredged reaches were compared to estimates determined from regional equations. The mean percentage difference between measured and estimated bankfull widths was -0.2 percent, suggesting that bankfull widths in the Wheeling Creek Basin are generally about the same as regional averages for undisturbed basins of identical drainage area. For bankfull mean depth and cross-sectional area, the mean percentage differences between the measured and estimated values were -16.0 and -11.2, respectively. The predominantly negative bias in differences between the measured and estimated values indicates that bankfull mean depths and cross-sectional areas in studied reaches generally are smaller than the regional trend. This may be an indication of channel filling and over widening or it may reflect insufficient representation in the regional dataset of basins with characteristics like that of Wheeling Creek.

Step-backwater models were constructed for four previously dredged reaches to determine the height of levees required to contain floods with recurrence intervals of 2, 10, 50, and 100 years. Existing levees (all of which are uncertified) were found to contain the 100-year flood at only 20 percent of the surveyed cross sections. At the other 80 percent of the surveyed cross sections, levee heights would have to be raised an average of 2.5 feet and as much as 6.3 feet to contain the 100-year flood.

Step-backwater models also were constructed for three undredged reaches to assess the impacts of selected dredging and streambed aggradation scenarios on water-surface elevations corresponding to the 2-, 10-, 50-, and 100-year floods. Those models demonstrated that changes in water-surface elevations associated with a given depth of dredging were proportionately smaller for larger floods due to the fact that more of the flood waters are outside of the main channel. For example, 2.0 feet of dredging in the three study reaches would lower the water-surface elevation an average of 1.30 feet for the 2-year flood and 0.64 feet for the 100-year flood.

Introduction

Many communities experience occasional damages due to stream flooding. Rural communities in some areas of eastern Ohio may be especially prone to damaging floods due to the fact that narrow valleys with steep walls resulted in preferential development of communities in the flatter floodplain areas adjacent to streams. In addition, historical and (or) current land uses (such as strip mining or logging) have the potential to exacerbate flooding as a result of instream aggradation (fill) and (or) increased runoff.

In response to significant flooding, it is not uncommon for citizens and local officials alike to identify stream dredging, along with construction of ad hoc levees from dredged materials, as an approach to mitigate flooding. However, there exists little scientific data as to how effective such measures are, especially with regard to large, infrequent events such as a 50-year or 100-year flood. Thus, government agencies tasked with evaluating and (or) designing dredging plans have little information about the long-term stability of such mitigation practices or even about the effectiveness of such practices on flood mitigation during periods of moderate to severe flooding.

In 1985, dredging and the construction of uncertified levees[1] were completed in reaches of Wheeling Creek passing through the communities of Lafferty, Crabapple, Maynard, and Crescent in an attempt to help alleviate flooding of the type that had occurred between 1979 and 1981. The U.S. Geological Survey (USGS), in cooperation with the Ohio Department of Natural Resources (ODNR), later completed a study that assessed the short-term channel stability of those reaches following dredging (Koltun, 1988). As part of that study, 21 stream cross sections were monumented and surveyed to evaluate post-dredging changes in geometry.

In 2004, an unusual number of large floods occurred in the Wheeling Creek Basin. As had happened in the 1980s, some residents and local officials suggested that sedimentation was an exacerbating factor and called for dredging as a means to mitigate flooding. Information previously collected in the Wheeling Creek Basin by USGS presented a unique opportunity to evaluate claims regarding sedimentation. In addition, a regional study on geomorphic stream characteristics completed by USGS in 2005 and a concomitance of factors that facilitate the construction of hydraulic models permit other aspects of the sedimentation and flooding questions to be evaluated. Consequently, the Ohio Emergency Management Agency (Ohio EMA) approached the USGS to conduct a study in an attempt to address questions about (a) land-cover changes in the Wheeling Creek Basin, (b) long-term changes in channel morphology, (c) evidence of stream sedimentation, (d) the efficacy of existing dredging and levees to mitigate overbank flooding, and (e) the effects of various depths of dredging and (or) heights of levees on the ability to contain flood water in the main channel and (or) on the resulting elevations of the water surface.

[1] The levees constructed in 1985 are not certified levees (U.S. Army Corps of Engineers, 2006) and were not designed or intended to contain floods of large magnitude, such as the 100-year flood, but rather the piling of dredged materials along the streambanks was an attempt to reduce flood-plain flooding. The levees generally ended at tributaries and road crossings where, during large floods, water might flow around the levee and onto the flood plain.

Purpose and Scope

The purpose of this report is to present the methods and results of a study to —

1. Contrast land-cover characteristics in the Wheeling Creek Basin from 2001 with land-cover characteristics from 1979 and 1992;

2. Resurvey cross sections[2] in Wheeling Creek that had been surveyed in a previous USGS study (Koltun, 1988) and document changes in channel-bed elevation, slope, and geometry;

3. Determine bankfull widths, mean depths, and cross-sectional areas in selected undredged reaches and compare them to characteristics expected for relatively pristine (undisturbed) basins of similar size and character;

4. Use step-backwater techniques to estimate water-surface elevations for existing conditions for floods with recurrence intervals of 2, 10, 50, and 100 years[3] (exceedence probabilities of 0.5, 0.1, 0.02, and 0.01) in both previously dredged and selected undredged reaches;

5. Use step-backwater techniques in previously dredged reaches to estimate the height of the levees required to contain floods with recurrence intervals of 2, 10, 50, and 100 years; and

6. Use step-backwater techniques in selected undredged reaches to estimate the effect of varying amounts of hypothetical instream aggradation and dredging on flood elevations corresponding to floods with recurrence intervals of 2, 10, 50, and 100 years.

While results presented in this report are specific to Wheeling Creek, conclusions drawn from the hypothetical assessments are expected to be applicable to other basins in eastern Ohio with characteristics similar to the Wheeling Creek Basin.

[2] In this report, a "cross section" is defined as "A representation of a vertical section across and through a landscape or landscape feature, as in a cross-valley profile—a section of a valley drawn at right angles to the course of a river at a given point." From A Dictionary of Geography: Oxford University Press, 1992, 1997, 2004., Answers.com, available online at *http://www.answers.com/topic/cross-section. (Accessed on March 14*, 2008.)

[3] The recurrence interval is the inverse of the probability that the given event will be equaled or exceeded in any given year and is an estimate of the average time span between large floods at a particular site. For example, a 50-year flood would have an exceedence probability of 0.02 (2 percent) in any given year and, on average, should be equaled or exceeded once in 50 years.

Background and Previous Studies

Flash flooding is not uncommon on streams in Belmont County. Historical accounts indicate that as many as nine major floods may have occurred in the area since the early 1800s (Shindel, 1991). Most of the small streams in the area have never been gaged as part of a systematic streamflow data-collection network, so there is limited streamflow data in the area. One of the earliest floods of record occurred on August 12, 1866, in which nine people were killed and several bridges were destroyed (McKelvey, 1903). Other years with major floods include 1818, 1881, 1884, 1913, 1919, 1936, 1949, and 2004.

Since 1949, there has been considerable residential development within the Wheeling Creek Basin. A large portion of this development has occurred on the valley flood plains, which in the past had been used for farming (Margaret Kirkland, Belmont County resident and local historian, written commun., 1990).

The Wheeling Creek Basin experienced three damaging floods and four less severe floods during the 29-month period from February 1979 through June 1981. In 1982, the USGS, in cooperation with the ODNR, initiated a study (Kolva and Koltun, 1987) in response to residents' concerns about factors that could have affected the severity and frequency of out-of-bank flooding. The objectives of that initial study were to (1) estimate flood-peak streamflows and recurrence intervals for the seven floods of interest, (2) provide information on current and historical mining-related stream-channel fill or scour, and (3) examine storm-period subbasin contributions to the sediment load in Wheeling Creek. As part of that study, a streamflow-gaging station was established on Wheeling Creek below Blaine, Ohio (USGS station number 03111548, fig. 1).

The major findings of the Kolva and Koltun (1987) study are summarized as follows:

1. Flood-frequency analyses indicated that a statistically unusual number of floods with recurrence intervals of 2 years or more occurred within the time period from February 1979 through June 1981.

2. Stream-channel surveys on Wheeling Creek and four tributaries over a period of approximately 2 years indicated no evidence of appreciable net stream-channel fill or scour, although minor changes were apparent at some locations.

3. Excavation and examination of stream-bottom materials indicated little evidence of appreciable mining-related sediment deposition in the Wheeling Creek main channel.

In 1984, the USGS, in cooperation with the ODNR, undertook a second study (Koltun, 1988) to collect and document evidence of net streambed fill or scour by periodically surveying stream-channel cross sections at a total of 21 sites in four stream reaches scheduled for dredging in an effort to reduce the frequency of out-of-bank flooding. Because of the presence of unreclaimed and actively operating surface mines, State and County officials were concerned that the dredged reaches would rapidly fill with sediments, thus reducing or eliminating the benefits gained by dredging. Dredging and levee construction was done between July and September 1985. Six sets of cross-section surveys were completed at the 21 sites between September 1984 and April 1987—one just before dredging, one soon after dredging, and semiannually after that. The four dredged reaches are located in or near the communities of Lafferty, Crabapple, Maynard, and Crescent, as shown on the map in figure 1. More detailed maps of the communities showing the locations of the 21 sites are in figures 2a–5a (at back of report).

The major findings of the Koltun (1988) study are summarized as follows:

1. A bed-stabilization period of less than 6 months was observed following dredging in each of the four reaches. During that period, the bed materials changed from poorly consolidated to firm.

2. After the bed-stabilization period at the 21 sites, changes in width-averaged bed elevations ranged from -0.1 to 0.4 ft, with 19 sites exhibiting changes in the range of -0.1 to 0.1 ft.

3. Thalweg[4] elevations similarly exhibited little change after the bed-stabilization period. The maximum change in thalweg elevation observed after the bed-stabilization period was 0.3 ft. Changes at 17 of the 21 sites were 0.1 ft or less during the same 6-month period.

Several large floods occurred in 2004 for which gage-height data were recorded at the streamflow-gaging station on Wheeling Creek below Blaine, Ohio (station 03111548). Those data indicate that the largest flood of 2004 occurred on September 17. The flood was a result of heavy rains from the remnants of Hurricane Ivan. As shown in figure 6, the peak streamflow for the September 17, 2004, flood was 8,500 ft^3/s with a corresponding peak gage height of 12.54 ft, which exceeded the previous peak of record of 5,470 ft^3/s (gage height of 8.21 ft) that occurred on June 28, 1998, and was slightly less than the 100-year recurrence-interval peak streamflow of 8,730 ft^3/s published in Koltun and others (2006). Two other large floods occurred in 2004.

[4] A line within the stream channel that joins the lowest points along the entire length of a streambed, thus defining the deepest channel of the stream.

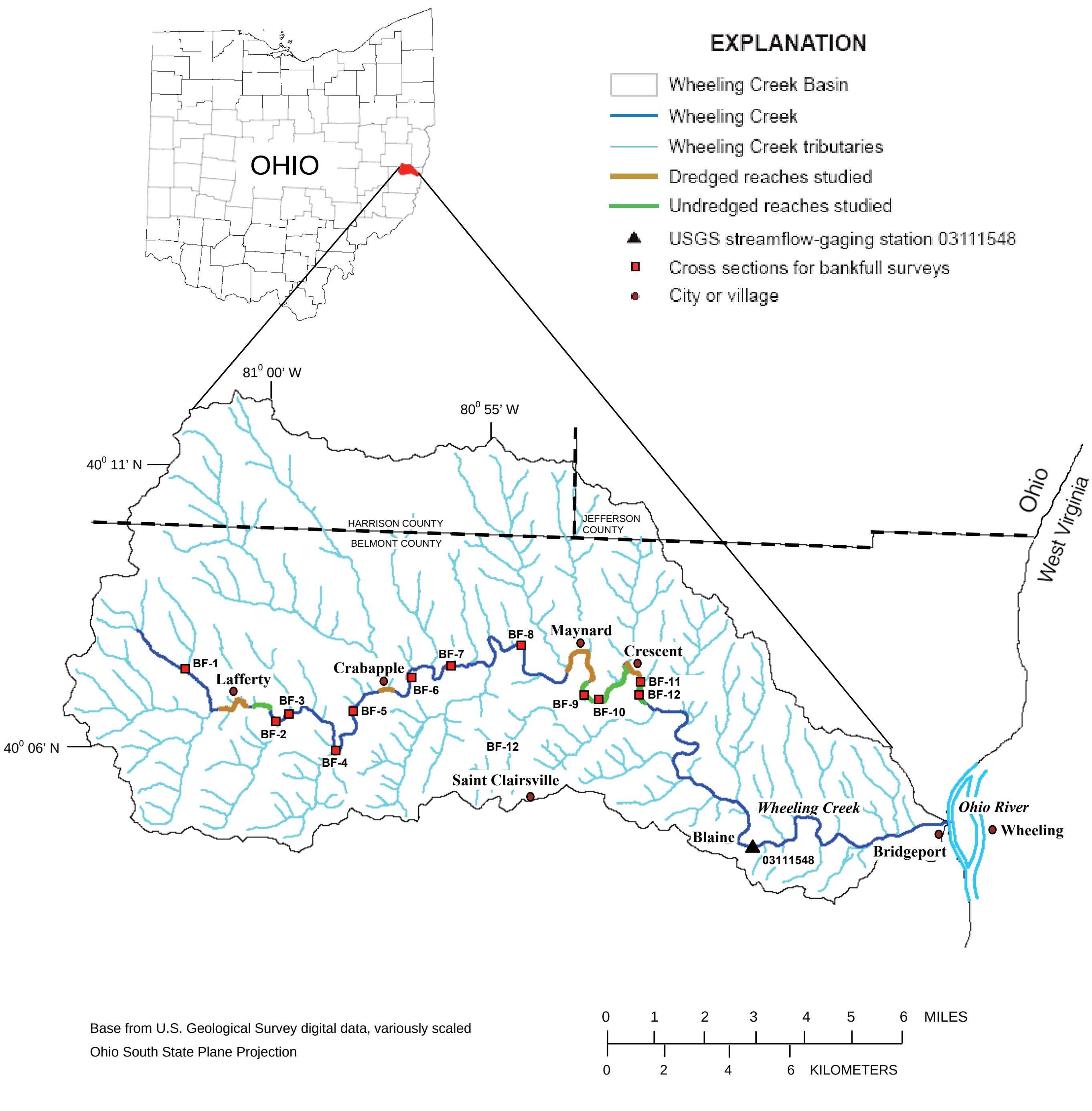


Figure 1. Locations of U.S. Geological Survey streamflow-gaging station 03111548, 12 sites selected for bankfull surveys, and dredged and undredged reaches studied in the Wheeling Creek Basin.

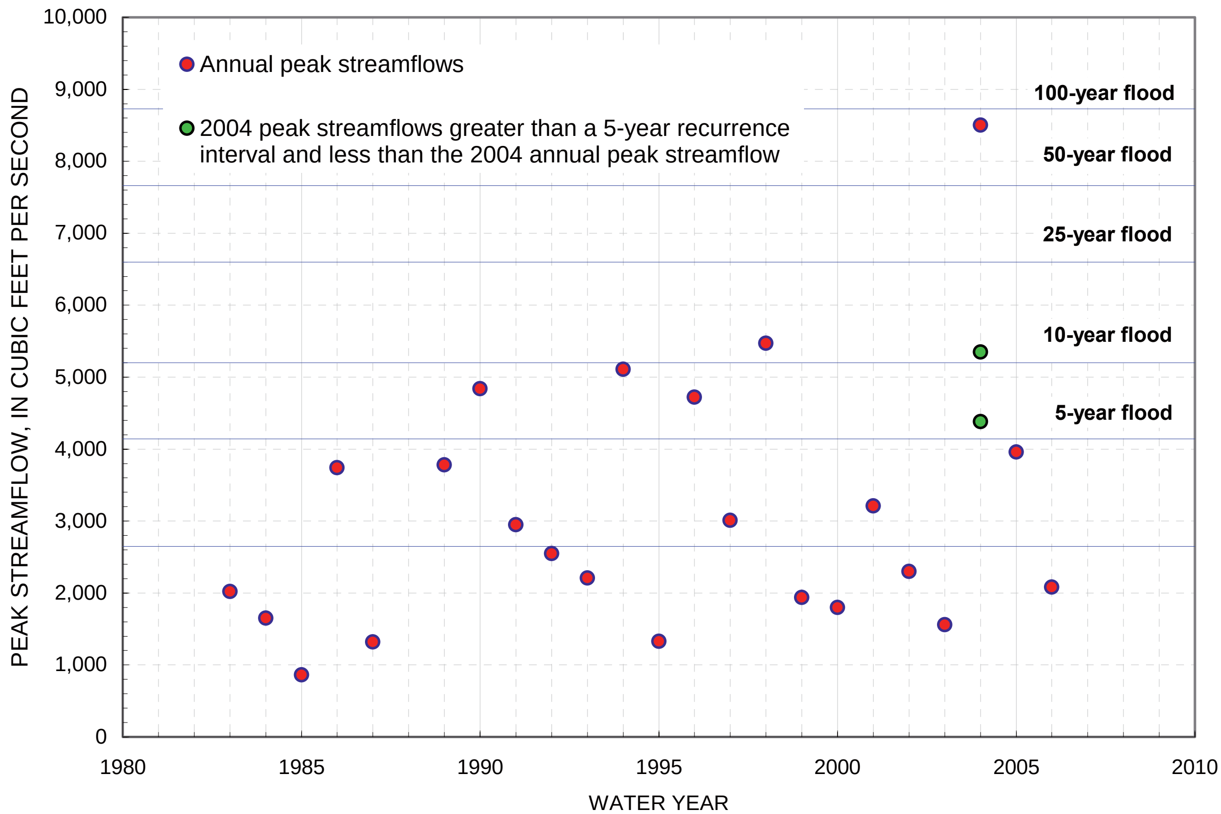


Figure 6. Annual peak streamflows for 1983 through 2006 and peak streamflows for 2004 greater than a 5-year recurrence interval for U.S. Geological Survey streamflow-gaging station Wheeling Creek below Blaine, Ohio (03111548). Recurrence-interval data from Koltun and others (2006). (A water year is the 12-month period from October 1 through September 30 and is designated by the calendar year in which it ends.).

On January 5, 2004, there was a flood with a peak streamflow of 4,380 ft^3/s and corresponding peak gage height of 7.65 ft and on September 9, 2004, there was a flood caused by heavy rains from the remnants of Hurricane Frances with a peak streamflow of 5,350 ft^3/s and corresponding peak gage height of 9.86 ft. From 1983 through 2003 there were four annual peak floods with peak streamflows in excess of the 5-year recurrence-interval peak streamflow of 4,140 ft^3/s published in Koltun and others (2006), and in 2004 alone there were three flood events that had peak streamflows that exceeded the 5-year recurrence interval and one that exceeded all previous floods of record (fig. 6). Thus, an unusual number of large floods were recorded at the streamflow-gaging station on Wheeling Creek below Blaine (station 03111548) in 2004.

Study Approach

Land-cover characteristics of Wheeling Creek from 1979 (Kolva and Koltun, 1987) were compared with land-cover characteristics from the 1992 National Land Cover Dataset (U.S. Geological Survey, 2000) and the 2001 National Land Cover Database (U.S. Geological Survey, 2001) to determine whether land use in the basin has changed appreciably in the last 25 years (item 1, p. 2). Differences in scale and land-cover classification schemes of the various datasets made it impossible to make an exact comparison; however, classification categories were aggregated as necessary to improve comparability.

Following successful recovery of monuments from the previous surveys (Koltun, 1988), 21 cross sections were resurveyed by means of conventional differential surveys and (or) surveys conducted with survey-grade Global Positioning System (GPS) equipment. These data were compared to survey data collected in 1987 after the dredging of the reaches. Width-averaged changes in bed elevations and thalweg elevations that occurred since the 1987 survey were computed to assess changes in bed elevation and channel slope (item 2, p. 2).

Bankfull widths, mean depths, and cross-sectional areas were determined for selected undredged reaches by means of methods described by Harrelson and others (1994). Equations from Sherwood and Huitger (2005) were used to estimate bankfull-width, mean-depth, and cross-sectional-area characteristics that might be expected for a relatively undisturbed basin with characteristics otherwise similar to the Wheeling Creek Basin. Measured characteristics were compared to characteristics estimated for relatively undisturbed basins to provide insight into whether or not Wheeling Creek has over widened and (or) aggraded as might be expected if there were excessive sediment deposition (item 3, p. 2).

Surveyed open-channel cross-sectional data representing present conditions were used along with open-channel cross-sectional data from a digital elevation model (DEM) to help develop HEC-RAS (U.S. Army Corps of Engineers (USACE), Hydrologic Engineering Center, 2002a and 2002b) step-backwater models in four previously dredged and three selected undredged reaches (fig. 1). The open-channel cross-sectional data were supplemented with surveyed cross-sectional data at bridge openings to permit consideration of their influence on the water-surface elevations. Roughness data for the step-backwater models were determined based on field inspections. In both previously dredged and selected undredged reaches, the step-backwater models were used to estimate water-surface elevations corresponding to floods with recurrence intervals of 2, 10, 50, and 100 years for existing conditions (item 4, p. 2). In the four previously dredged reaches, the step-backwater models were used to determine the height of levees required to contain floods with recurrence intervals of 2, 10, 50, and 100 years (item 5, p. 2). This was accomplished by systematically raising the elevations of simulated levees in the models to the height required to contain the flood within the main channel. In the three selected undredged reaches, the step-backwater models were used to estimate the effect of varying amounts of hypothetical instream aggradation and dredging on flood elevations corresponding to floods with recurrence intervals of 2, 10, 50, and 100 years (item 6, p. 2). This was accomplished by systematically raising or lowering bed elevations in the step-backwater model by amounts that might reasonably be associated with aggradation or dredging processes.

Setting and Land Use

The Wheeling Creek Basin is located in parts of Belmont, Harrison, and Jefferson Counties in eastern Ohio (fig. 1). The drainage area of the basin is 108 mi^2. Wheeling Creek empties into the Ohio River at Bridgeport, Ohio, opposite Wheeling, West Virginia. The City of Saint Clairsville, the Belmont county seat, lies partially within the basin and is the largest urban area.

The climate of the basin is temperate; summers are warm to hot, and winters are moderately cold. Average annual precipitation is approximately 43 in/yr. For the period 1961 to 1990, the average precipitation was 3.6 in. per month, with January (2.5 in.) being the driest month, and July (4.8 in.) being the wettest month (Schumacher and others, 1993). Floods can occur during any season. Severe storms in the narrow valleys of the basin can result in flash flooding (Wheeling Creek Watershed Action Committee Agency Task Force, 1983).

The topography of the basin is hilly and characterized by V-shaped valleys and broad, rounded ridges. The basin is unglaciated and the headwater tributaries have generally shallow, broad valleys. The valley of the main stem of Wheeling Creek is generally deep and narrow, but broadens toward the mouth. Relief on Wheeling Creek is approximately 360 ft from source to mouth, a distance of approximately 32 river miles.

The geology of the basin is characterized by horizontally layered sedimentary rock. Exposed strata include shale, sandstone, siltstone, limestone, and coal. These strata are part of the Conemaugh and Monongahela Formations of Pennsylvanian age and the Dunkard Group of Pennsylvanian and Permian age (Berryhill, 1963).

The soils of the upper and middle parts of the basin generally are part of the Lowell-Westmoreland association and their related soils. The lower reaches of the basin contain soils of the Elkinsville-Nolin Variant-Brookside association. All of these soils are moderately erodible. Soils composed primarily of broken bedrock resulting from surface-mining activity also are present, especially in the upper reaches (Wheeling Creek Watershed Action Committee Agency Task Force, 1983).

In general, land use in the Wheeling Creek watershed consists mostly of rural farmland and forest landscapes. In the upper reaches of the watershed, strip mining of coal has played a role in altering the natural landscape. Surface-mine-reclamation laws (Office of Surface Mine Reclamation and Enforcement, 1977) have led to many of these areas being reclaimed into pastures, cropland, or forests.

To evaluate temporal changes in land use, comparisons were made between 1979 land-cover data summarized from the ODNR Ohio Capability Analysis Program (OCAP) dataset (Kolva and Koltun, 1987), the 1992 National Land Cover Dataset (U.S. Geological Survey, 2000), and the 2001 National Land Cover Database (U.S. Geological Survey, 2001). It should be noted that the three land-cover datasets used (1979, 1992, and 2001) do not contain identical classifications, and so they were reclassified in order to document the changes in land cover over time. The 1979 OCAP summary data had 8 land-cover classes, the 1992 dataset had 13 classes, and the 2001 dataset had 15 classes (table 1). Table 1 shows how each class from the 1979, 1992, and 2001 datasets was reclassified.

Changes in land cover in the Wheeling Creek watershed from 1979 to 2001 are marked most notably by a decrease in barren land and an increase in pastures. In 1979, barren land accounted for 20 percent of the land cover in the watershed (table 2). By 1992, barren land only accounted for 1 percent of the land-cover in the watershed due in part to surface-mine reclamation practices in the watershed. Reclamation of barren land into pastures accounted for the increase of over 13,000 acres of pasture from 1979 to 1992. From 1992 to 2001, the percentage of the basin in pasture decreased slightly, being offset by an increase in cropland and other land covers.

Table 1. Land-cover classifications from 1979, 1992, and 2001 land-cover datasets for the Wheeling Creek watershed, and the aggregated classification used to compare datasets.

[OCAP, Ohio Capability Analysis Program; NLCD, National Land Cover Dataset; aggregate land-cover classifications used in this study (in grey) with previous classifications (below aggregate classification) from indicated land-cover datasets]

1979 (OCAP summary)[a]	1992 NLCD[b]	2001 NLCD[c]
Forest		
Forested	Deciduous forest	Deciduous forest
Shrubs and brush	Evergreen forest	Evergreen forest
	Mixed forest	Mixed forest
		Shrub/scrub
Barren land		
Unreclaimed surface mines	Quarries, strip mines, gravel pits	Barren land (rock/sand/clay)
Active surface mines	Transitional	
Cropland		
Cropland	Row crops	Cultivated crops
Pasture		
Pasture	Pasture, hay	Grassland/herbaceous
Totally reclaimed surface mines		Pasture/hay
Other uses		
Other uses (residences, industries, bodies of water, etc.)	Water	Open water
	Low intensity residential	Developed, open space
	High intensity residential	Developed, low intensity
	Commercial, industrial, transportation	Developed, medium intensity
	Woody wetlands	Developed, high intensity
	Emergent herbaceous wetlands	Woody wetlands
		Emergent herbaceous wetlands

[a] The 1979 land-cover data are summarized from the Ohio Department of Natural Resources Ohio Capability Analysis Program (OCAP) dataset (Kolva and Koltun, 1987).

[b] The 1992 National Land Cover Dataset (U.S. Geological Survey, 2000).

[c] The 2001 National Land Cover Dataset (U.S. Geological Survey, 2001).

Table 2. Percentages of land cover from 1979, 1992, and 2001 datasets for the Wheeling Creek watershed.

Land-cover classification	1979 (percent)	1992 (percent)	2001 (percent)
Forest	46	46	48
Barren land	20	1	1
Cropland	13	6	8
Pasture	8	42	33
Other uses (developed, water, etc.)	13	5	10
Total	100	100	100

Collection of Field Data in Study Reaches

Three different surveys were conducted in the field to accomplish the study objectives: (1) resurveys of previously surveyed cross sections in dredged reaches, (2) bankfull profile and cross-section surveys in undredged reaches, and (3) surveys of bridges and open-channel cross sections for step-backwater models. All surveys were conducted by means of conventional differential surveys and (or) survey-grade GPS equipment.

Resurvey of Previously Surveyed Cross Sections in Dredged Reaches

The 21 cross sections in dredged reaches that were surveyed from 1984 to 1987 (Koltun, 1988) are located in or near the communities of Lafferty, Crabapple, Maynard, and Crescent (fig. 1). Cross sections were surveyed at one location upstream and downstream from each of four dredged reaches and at two to five locations within each of four dredged reaches. Of the 21 cross sections, four are located in Lafferty, five in Crabapple, seven in Maynard, and five in Crescent (figs. 2a–5a, at back of report). A cross-section survey consists of a set of ground-point elevations and their associated horizontal distances from some fixed reference point. As part of the Koltun study (1988), the cross sections had been monumented with 0.75-in. rebar to serve as elevation reference marks (ERM) and to facilitate relocation and resurveys of the cross sections. The ERMs had been established using third-order differential-leveling methods and referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). All survey data from Koltun study (1988) were converted from NGVD 29 to the North American Vertical Datum of 1988 (NAVD 88) for use in this study. Cross sections were located as part of this study by either recovering the ERMs at each site or by referring to documents from the 1988 study, such as maps, sketches, and aerial photographs showing the cross-section locations. By convention, horizontal stationing was assumed to increase from left to right when looking in the downstream direction. At a minimum, ground-point elevations and their corresponding horizontal stations were determined at those points that marked significant changes in slope. A photograph was taken looking downstream and upstream at each cross section. Photographs are not presented in this report; however, they are on file in the USGS Ohio Water Science Center.

Bankfull Profile and Cross-Section Surveys in Undredged Reaches

Twelve sites were selected for field surveys in undredged reaches to determine geomorphic characteristics such as bankfull width, mean depth, and cross-sectional area. The measured characteristics were compared to geomorphic characteristics expected for relatively undisturbed basins of similar size and character.

The concept of "bankfull" is important for an understanding of morphology of stream channels. Bankfull stage (fig. 7) is the elevation of the water surface that would fill the main channel to an elevation equal to that of the active flood plain. It is also defined as the elevation at which a stream first begins to overflow its natural banks onto the active flood plain (Wolman and Leopold, 1957). The active flood plain is a relatively flat depositional surface adjacent to a stream. The active flood plain is continually formed by sediment entrained and deposited during flooding. An abandoned flood plain (or terrace) is a flat surface adjacent to and higher than the active flood plain and it floods infrequently, if at all.

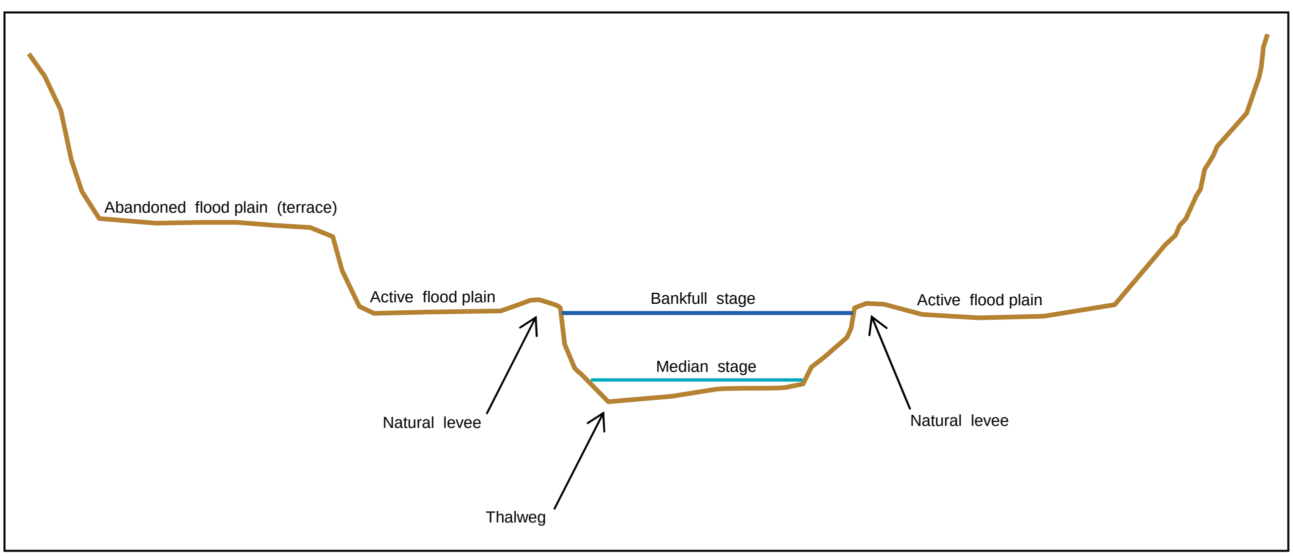


Figure 7. Schematic diagram showing geomorphic features of a stream valley and channel.

Bankfull discharge (streamflow) is the discharge that would fill the main channel to an elevation equal to bankfull stage. Bankfull discharge has often been referred to as the "effective discharge" or "channel-forming discharge." This concept is misleading because there is no single channel-forming discharge but rather a wide range of flows that might be considered effective in the formation of the main channel. More appropriately, the bankfull discharge can be considered a surrogate for this range of flows (Emmett, 2004). Over time, moderate flood flows near bankfull stage do much work in terms of moving sediment and forming the main channel (Leopold and others, 1964). Large floods move great amounts of sediment, but they are rare; small floods occur frequently but move lesser amounts of sediment with each flood (Wolman and Miller, 1960). Under average conditions, bankfull discharge might occur about every 1 to 2 years; for some streams, however, bankfull discharge could be associated with recurrence intervals of less than 1 year or greater than 2 years. As flood flows overtop the streambanks, the abrupt decrease in velocity over the active flood plain often results in deposition of sediments just past the tops of the banks, resulting in the formation of natural levees (fig. 7). The thalweg is a line within the stream channel that joins the lowest points along the entire length of a streambed, thus defining the deepest channel of the stream.

At each of the 12 sites (fig. 1) selected for field surveys in undredged reaches, bankfull indicators and cross-section locations were identified, evaluated, and flagged. Longitudinal profiles of bankfull stage (hereafter referred to as bankfull profiles) and stream cross sections were surveyed. Bankfull widths, mean depths, and cross-sectional areas were determined for the undredged reaches by methods described by Harrelson and others (1994) and Sherwood and Huitger (2005). Bankfull profiles were surveyed along the left and right streambanks. Each bankfull ground point was rated good, fair, or poor, depending on the reliability of the bankfull indicators near the ground point. One cross section that was representative of the general physical characteristics of the stream was surveyed at each site. All bankfull cross sections were surveyed perpendicular to the bankfull flow direction at the crests of riffles. Photographs were taken looking downstream and upstream at each cross section (not shown).

Survey of Bridges and Open-Channel Cross Sections for Step-Backwater Models

As part of this study, step-backwater models were developed for previously dredged reaches of Wheeling Creek to estimate water-surface elevations for simulated levee conditions. Step-backwater models were also developed for undredged reaches to estimate water-surface elevations for simulated dredging and aggradation scenarios. Detailed surveys of the main channel, flood plains, and contracted bridge openings were completed at seven bridges in the modeled reaches. As is common for such surveys, open-channel cross sections were surveyed at the bridge approach section (approximately one bridge width upstream from the bridge), the bridge section (smallest cross-sectional area under the bridge), and tailwater section (just downstream from the bridge). A common practice for step-backwater modeling is to have field-surveyed open-channel cross sections at least every mile to verify the cross sections derived from a triangulated irregular network[5] (TIN). In this study, three open-channel cross sections were surveyed in the modeled reaches to meet this requirement. Photographs were taken at all cross sections, and Manning's n roughness coefficient was estimated for all cross sections by use of a method developed by Cowan (1956). The locations of all cross sections are shown in figures 2a–5a (at back of report).

Morphological Data Analyses

The morphological analyses include an assessment of long-term changes in mean streambed and thalweg elevations in previously dredged reaches and a comparison of bankfull characteristics in undredged reaches to regional estimates.

Long-Term Changes in Mean Streambed Elevations in Previously Dredged Reaches

Cross-sectional data from the August 2006 resurveys of 21 sites (figs. 2–5, at back of report) in the four previously dredged reaches were compared to cross-sectional data from the April 1987 final surveys from Koltun (1988) to document evidence of net streambed aggradation (fill) or degradation (scour) from 1987 to 2006. To accomplish this, both graphical and quantitative methods were used. The graphical comparison made by overlaying plots of cross sections surveyed in 1987 and 2006 provides a qualitative indicator of change within a given cross section. Plots of cross-sectional data for the 1987 and 2006 stream-channel surveys, and locations of the left and right toes of the channel banks in 2006, for Wheeling Creek cross sections at the 21 sites in the dredged reaches, are shown in figures 8–11. Vertical exaggeration in the cross-section plots is 2:1. Plots were visually inspected to evaluate the change in the elevation, shape, and location of the channel cross sections. With a few exceptions, many of the changes that did occur were near the streambanks and not in the channels, with most of the plots indicating only slight changes in the elevation, shape, and horizontal location of the streambed. Three notable exceptions are (1) cross section A-1 in Lafferty, where channel widening and degradation of the streambed is evident (fig. 8); (2) cross sections B-2 and B-3 in Crabapple, where aggradation of the streambed is evident (fig. 9) (possibly due to the cross sections being located immediately downstream of a tributary and spoil pile); and (3) cross section D-2 in Crescent, where some aggradation of the streambed is evident (fig. 11).

[5] A triangulated irregular network (TIN) is a digital data structure used in a geographic information system (GIS) for the representation of a land surface.

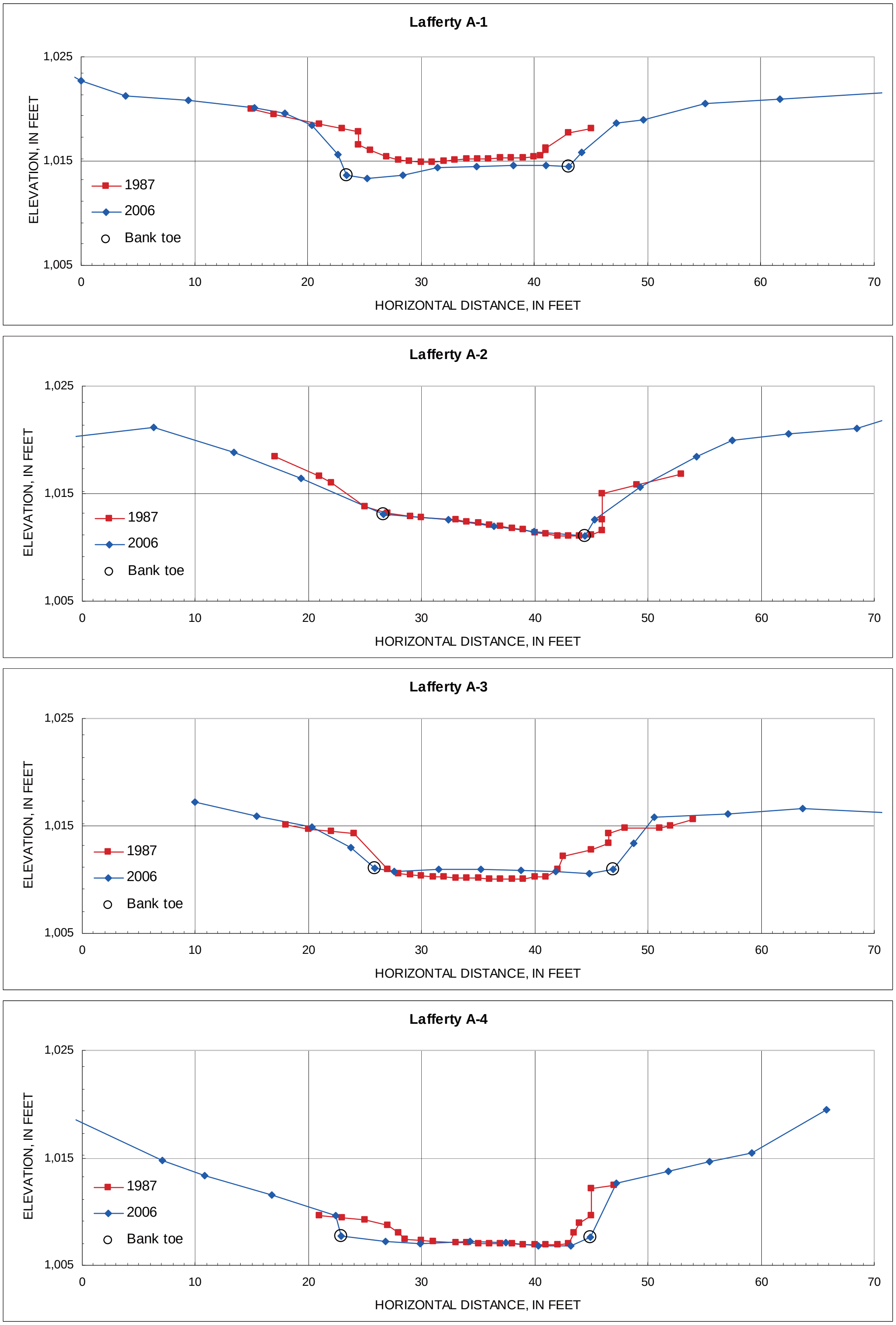


Figure 8. Plots of cross-sectional data for 1987 and 2006 stream-channel surveys for Wheeling Creek cross sections in Lafferty, Ohio. (Data plots that extend beyond edge of plot indicate the existence of additional data.)

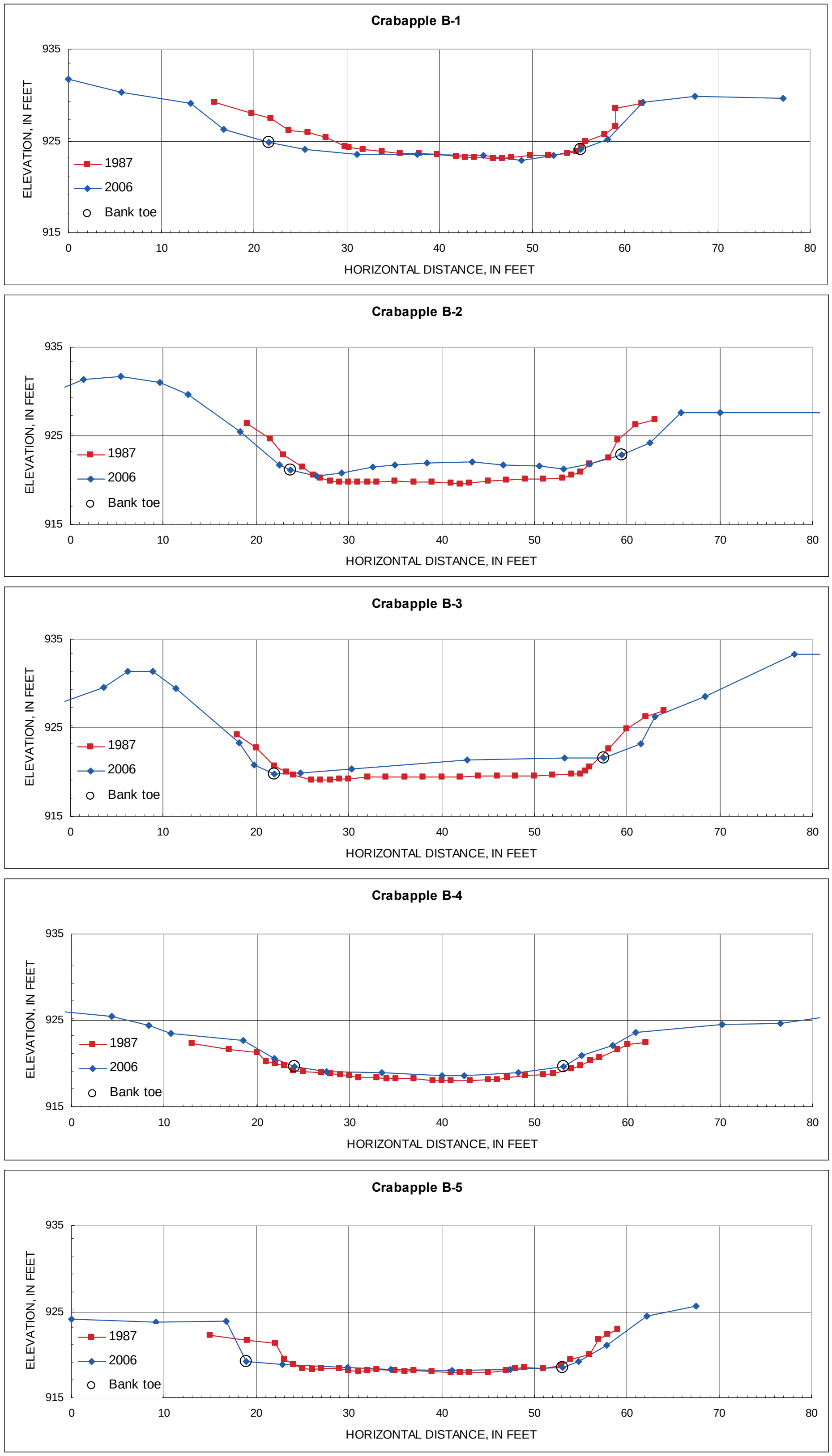


Figure 9. Plots of cross-sectional data for 1987 and 2006 stream-channel surveys for Wheeling Creek cross sections in Crabapple, Ohio. (Data plots that extend beyond edge of plot indicate the existence of additional data.)

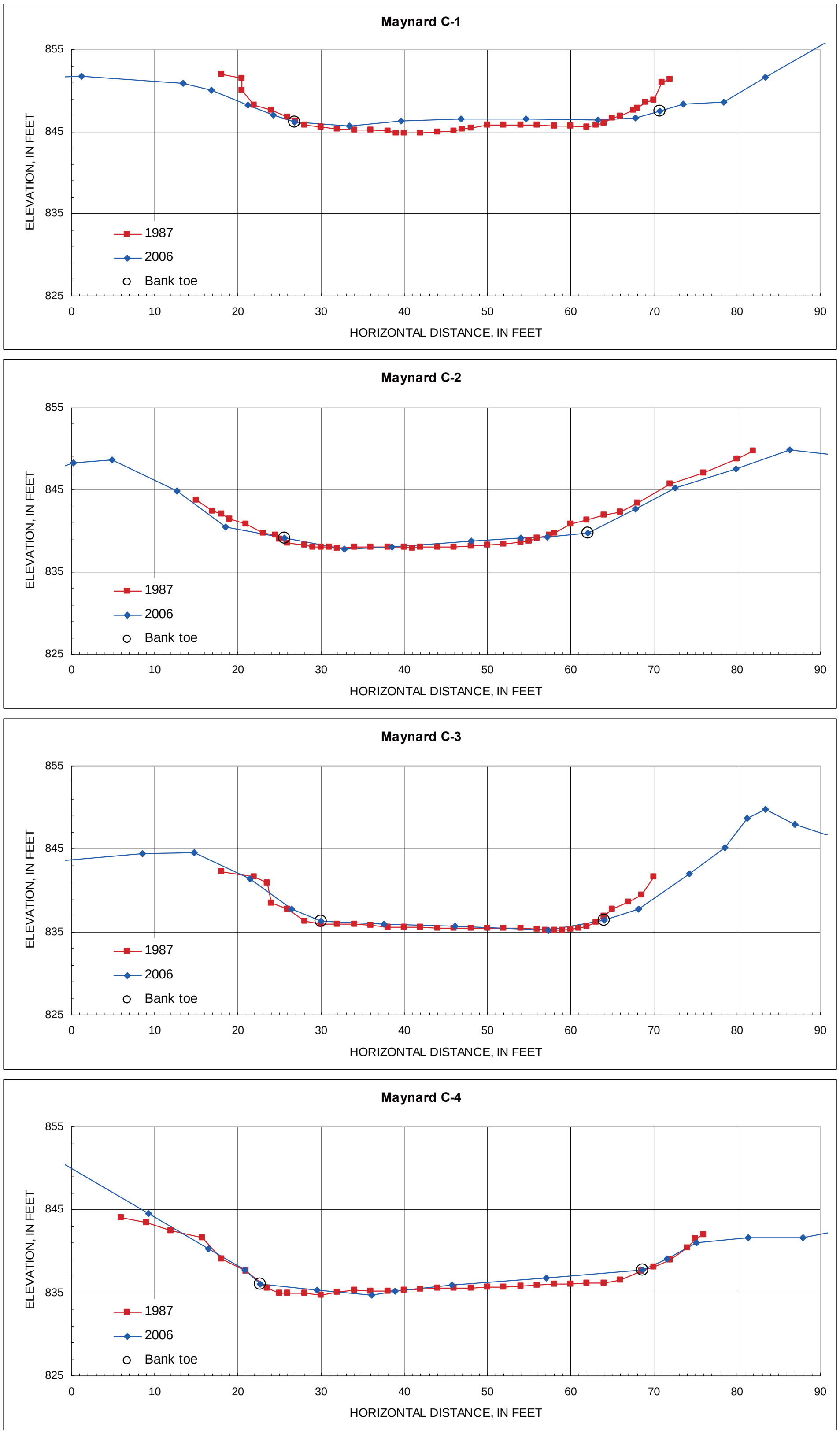


Figure 10. Plots of cross-sectional data for 1987 and 2006 stream-channel surveys for Wheeling Creek cross sections in Maynard, Ohio. (Data plots that extend beyond edge of plot indicate the existence of additional data.)

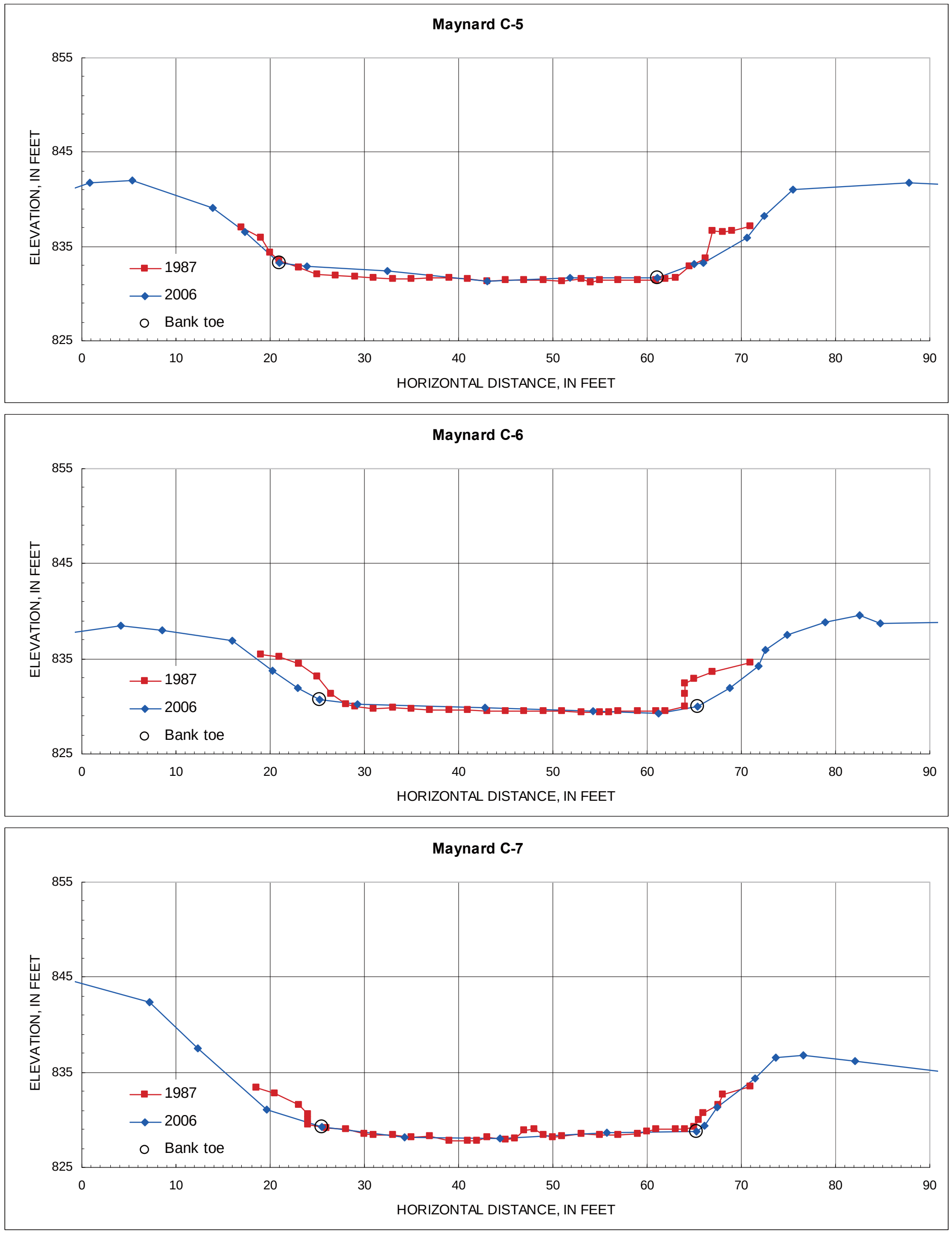


Figure 10. Plots of cross-sectional data for 1987 and 2006 stream-channel surveys for Wheeling Creek cross sections in Maynard, Ohio. (Data plots that extend beyond edge of plot indicate the existence of additional data.)—Continued

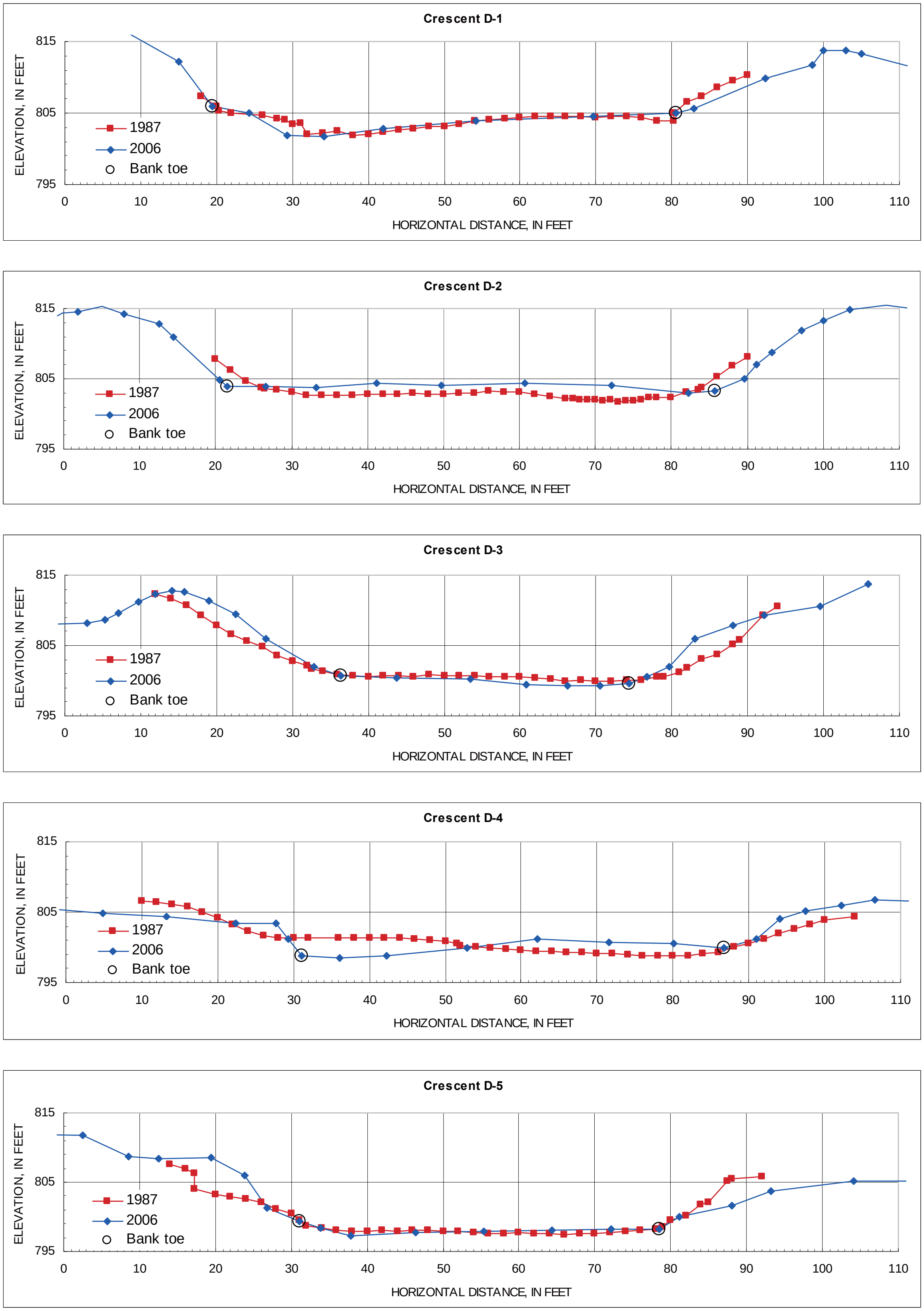


Figure 11. Plots of cross-sectional data for 1987 and 2006 stream-channel surveys for Wheeling Creek cross sections in Crescent, Ohio. (Data plots that beyond edge of plot indicate the existence of additional data.)

Trends in stream-channel aggradation and degradation also were assessed by computing changes in width-averaged bed elevations from April 1987 to August 2006. To accomplish this calculation, the area bounded by an arbitrary fixed upper datum on the top, the streambed on the bottom, and the left and right toes of the streambanks was determined. For the purpose of this study, the toes of the streambank are the cross-section ground points at the point of inflection (point where the greatest change in slope occurs) between the streambed and streambank. That area was divided by the width (as defined by the distance between the toes of the streambanks) to determine the average distance from the upper datum to the streambed. The width-averaged bed elevation was then determined by subtracting the average distance to the streambed from the elevation of the upper datum (fig. 12). Areas within the aforementioned boundaries were computed by means of the trapezoidal rule (Burden and Faires, 2000), a numerical method for approximating the area under a curve. Figure 12 shows a schematic illustrating the concept of a change in the width-averaged bed elevation.

Changes in width-averaged bed elevations and surveyed thalweg elevations from April 1987 to August 2006 are reported for 21 cross sections in the four previously dredged reaches of Wheeling Creek (table 3).

The change in width-averaged bed elevation, if positive, indicates aggradation from April 1987 to August 2006, and, if negative, indicates degradation. Although three cross sections (one in Lafferty and two in Crabapple) exhibited changes of over 1 ft, the 0.1-ft mean change in width-averaged bed elevation indicates that, on average, there has been little net aggradation or degradation of the streambed at the 21 sites. Likewise, on average, there has been little net change in the thalweg elevations.

Bankfull Characteristics from Field Surveys Compared to Regional Estimates in Undredged Reaches

Bankfull widths, mean depths, and cross-sectional areas were measured for 12 sites (fig. 1) in undredged reaches following methods described by Harrelson and others (1994) and Sherwood and Huitger (2005). Equations presented in Sherwood and Huitger (2005) were used to estimate bankfull-width, mean-depth, and cross-sectional-area characteristics that might be expected for relatively undisturbed basins. Comparison of the measured characteristics to estimated characteristics for relatively undisturbed basins is intended to provide insight into whether or not undredged reaches of Wheeling Creek have over widened and (or) aggraded as might be expected if there were excessive sediment deposition (item 3, p. 2).

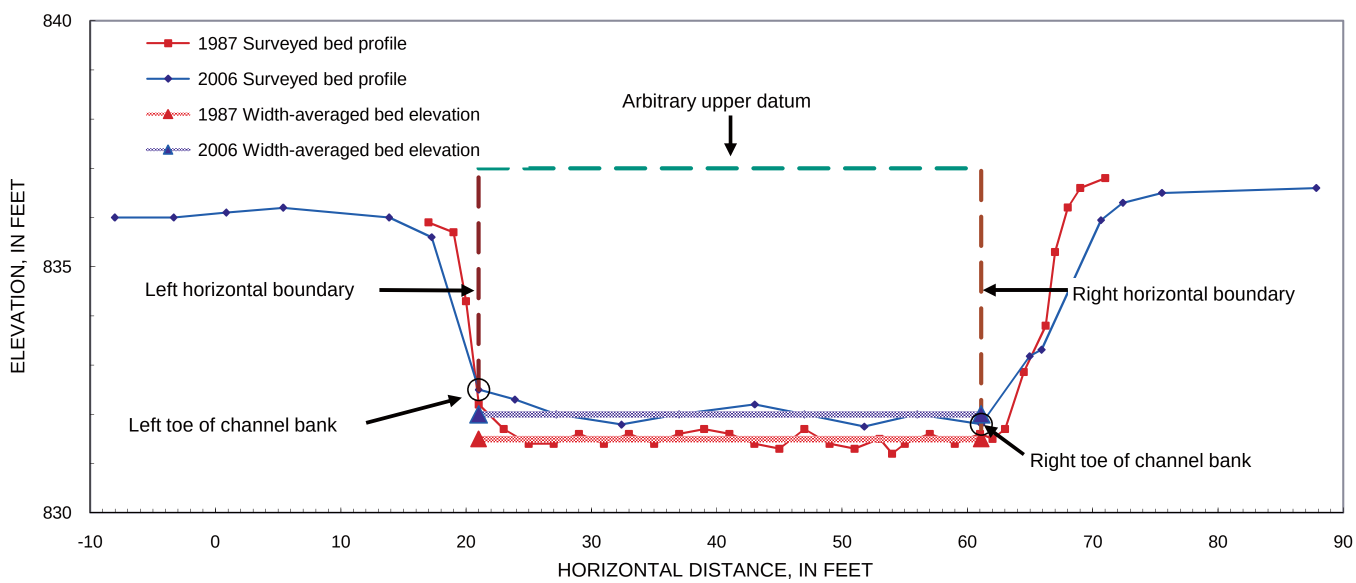


Figure 12. Schematic diagram of method used to compute width-averaged bed elevation.

Table 3. Width-averaged bed elevation data and thalweg elevation data for April 1987 and August 2006 for 21 sites in four reaches of Wheeling Creek.

Community	Site code	Latitude	Longitude	Distance from mouth of Wheeling Creek (river miles)	Channel width (feet)	Width-averaged bed elevation[a] (feet)		Change in width-averaged bed elevation (feet)	Thalweg elevation[a] (feet)		Change in thalweg elevation (feet)
						April 1987	August 2006		April 1987	August 2006	
Lafferty	A-1	40° 06’ 34”	-81° 01’ 24”	28.09	19.7	1015.6	1014.2	-1.4	1014.9	1013.3	-1.6
	A-2	40° 06’ 36”	-81° 01’ 02”	27.72	17.9	1012.1	1012.1	.0	1011.1	1011.1	.0
	A-3	40° 06’ 44”	-81° 00’ 55”	27.50	21.1	1010.9	1010.8	-.1	1010.0	1010.6	.6
	A-4	40° 06’ 36”	-81° 00’ 40”	27.17	22.0	1007.6	1007.1	-.5	1006.9	1006.8	-.1
Crabapple	B-1	40° 06’ 51”	-80° 57’ 36”	22.37	33.6	924.1	923.6	-.5	923.1	922.8	-.3
	B-2	40° 06’ 52”	-80° 57’ 29”	22.27	35.7	920.4	921.6	1.2	919.6	920.5	.9
	B-3	40° 06’ 52”	-80° 57’ 24”	22.19	35.5	919.6	921.0	1.4	919.1	919.8	.7
	B-4	40° 06’ 52”	-80° 57’ 19”	22.12	29.0	918.4	919.0	.6	918.0	918.6	.6
	B-5	40° 06’ 51”	-80° 57’ 16”	22.07	34.2	918.7	918.7	.0	918.0	918.2	.2
Maynard	C-1	40° 07’ 07”	-80° 53’ 13”	15.70	43.9	845.8	846.4	.6	844.9	845.7	.8
	C-2	40° 07’ 26”	-80° 53’ 04”	15.30	36.4	838.5	838.7	.1	837.9	837.8	-.1
	C-3	40° 07’ 30”	-80° 52’ 51”	15.08	34.0	835.6	835.8	.1	835.2	835.2	.0
	C-4	40° 07’ 30”	-80° 52’ 43”	14.97	46.0	835.6	836.1	.5	834.7	834.7	.0
	C-5	40° 07’ 12”	-80° 52’ 41”	14.60	40.1	831.7	832.0	.3	831.2	831.3	.1
	C-6	40° 07’ 04”	-80° 52’ 37”	14.44	40.1	829.9	829.8	-.1	829.4	829.2	-.2
	C-7	40° 06’ 57”	-80° 52’ 42”	14.24	39.7	828.5	828.5	.0	827.8	828.1	.3
Crescent	D-1	40° 07’ 16”	-80° 51’ 50”	12.39	61.0	803.8	803.7	-.1	801.9	801.8	-.1
	D-2	40° 07’ 15”	-80° 51’ 45”	12.29	64.3	802.9	804.0	1.0	801.8	803.0	1.2
	D-3	40° 07’ 08”	-80° 51’ 41”	12.16	38.0	800.4	800.0	-.5	799.9	799.3	-.6
	D-4	40° 07’ 05”	-80° 51’ 34”	12.04	55.7	800.1	800.0	.0	798.8	798.5	-.3
	D-5	40° 06’ 60”	-80° 51’ 27”	11.88	47.5	797.9	798.0	.1	797.4	797.3	-.1
Maximum					64.3			1.4			1.2
Minimum					17.9			-1.4			-1.6
Mean					37.9			.1			.1
Median					36.4			.0			.0

[a] All vertical coordinate information in this report is referenced to the North American Vertical Datum of 1988 (NAVD88). Vertical coordinate information published in Koltun (1988) is referenced to the National Geodetic Vertical Datum of 1929 (NGVD29) and has been converted to NAVD88 in this table for comparison purposes.

Bankfull Characteristics Determined from Field Surveys

Geomorphic field data collected at 12 sites on Wheeling Creek were plotted in plan, profile, and cross-section views. Longitudinal profiles of bankfull stage were used along with qualitative ratings (good, fair, or poor) of bankfull features to determine final bankfull stage at each cross section. Some interpretation of the profile and cross-sectional plots was necessary for this process because field-determined bankfull stage did not always match the active flood-plain elevations. For example, natural levees that were not apparent in the field (because of masking by vegetation) were readily apparent in the cross-section plots at many sites. In those cases, the active flood-plain elevations just beyond the natural levees were used as the final bankfull stage. Frequently, the left and right bankfull stages were averaged to obtain the representative final bankfull stage used in subsequent computations of bankfull width, mean depth, and cross-sectional area. Bankfull width was computed as the horizontal distance between the two points on the cross section where the bankfull stage intersected the land surface. Bankfull cross-sectional area was computed as the area (measured perpendicular to the dominant flow direction at bankfull stage) between the bankfull stage and the land surface below as determined by application of the trapezoidal rule. Bankfull mean depth was computed as the bankfull cross-sectional area divided by the bankfull width. The bankfull characteristics determined from field surveys are listed in table 4 for the 12 sites on Wheeling Creek.

Measured Bankfull Characteristics Compared to Equation Estimates and Regional Curves

Bankfull channel width, bankfull mean depth, and bankfull cross-sectional area are commonly estimated as a function of drainage area.[6] Plots of bankfull characteristics versus drainage area are commonly referred to as "regional curves." Regional curves may also be accompanied by simple-regression equations (one explanatory variable) to estimate bankfull channel width, bankfull mean depth, or bankfull cross-sectional area (response variables) as a function of drainage area (explanatory variable). Simple-regression equations presented in Sherwood and Huitger (2005), in which drainage area is the only explanatory variable, were used to estimate bankfull-channel-width, mean-depth, and cross-sectional-area characteristics that might be expected for relatively undisturbed basins in Ohio. The equations are based on geomorphic and basin characteristic data collected at 50 study sites on unregulated natural alluvial streams in Ohio, of which 40 sites were near streamflow-gaging stations. The average standard error of prediction for the bankfull channel width equation is 24.8 percent; for the bankfull mean depth equation, 20.6 percent; and for the bankfull cross-sectional-area equation, 30.6 percent.

[6] The surface area that contributes surface runoff to a specified location on a stream, measured in a horizontal plane. Computed (by planimeter, digitizer, or grid method) from U.S. Geological Survey 7.5-minute topographic quadrangle maps. A geographic information system (GIS) also may be used to determine drainage area, provided that the GIS data are of sufficiently high resolution.

Table 4. Measured bankfull characteristics from field surveys for 12 sites on Wheeling Creek selected for geomorphic data analyses.

Site code	Latitude	Longitude	Distance from mouth of Wheeling Creek (river miles)	Drainage area (square miles)	Field rating	Bankfull width (feet)	Bankfull mean depth (feet)	Bankfull cross-sectional area (square feet)
BF-1	40° 07’ 17”	-81° 02’ 09”	29.4	2.32	Good	17.4	1.5	26.1
BF-2	40° 06’ 22”	-81° 00’ 00”	26.4	13.8	Good/Fair	39.7	3.2	127.0
BF-3	40° 06’ 27”	-80° 59’ 47”	26.1	17.0	Good	59.7	2.3	137.3
BF-4	40° 05’ 49”	-80° 58’ 36”	24.4	23.6	Good/Fair	56.0	2.6	145.6
BF-5	40° 06’ 34”	-80° 58’ 15”	23.1	24.2	Fair	40.5	4.3	174.2
BF-6	40° 07’ 05”	-80° 56’ 55”	21.3	45.5	Good	65.8	4.4	289.5
BF-7	40° 07’ 16”	-80° 55’ 59”	19.9	51.3	Fair	78.3	3.3	258.4
BF-8	40° 07’ 39”	-80° 54’ 19”	17.4	59.6	Good/Fair	76.1	4.0	304.4
BF-9	40° 06’ 43”	-80° 52’ 46”	13.9	72.4	Fair	72.8	5.2	378.6
BF-10	40° 06’ 37”	-80° 52’ 29”	13.6	76.4	Good/Fair	99.6	4.3	428.3
BF-11	40° 06’ 56”	-80° 51’ 27”	11.8	81.77	Good/Fair	184.2	3.0	552.6
BF-12	40° 06’ 48”	-80° 51’ 30”	11.6	81.82	Good/Fair	119.5	2.6	310.7
Maximum				81.8		184.2	5.2	552.6
Minimum				2.3		17.4	1.5	26.1

Measured and estimated bankfull characteristics for the 12 sites on Wheeling Creek selected for geomorphic data analyses are presented in table 5. Comparison of the measured data to the regression estimates indicates that the median percentage difference between the measured and estimated bankfull widths is -0.2 percent, which suggests that bankfull widths in the Wheeling Creek Basin are generally about the same as regional averages for undisturbed basins of identical drainage area. For bankfull mean depth and cross-sectional area, the median percentage differences between the measured and estimated values are -16.0 and -11.2, respectively. While the differences are smaller than the average standard error of prediction, the predominantly negative bias in percent differences suggests that bankfull mean depths and areas in the Wheeling Creek Basin are generally smaller than regional averages. Another comparison of measured and estimated bankfull characteristics for the 12 sites on Wheeling Creek was made by use of multiple-regression equations presented in Sherwood and Huitger (2005). That comparison (not shown) yielded results that are in agreement with the simple-regression results.

In figure 13, bankfull characteristics for the Wheeling Creek sites are plotted as a function of drainage area, along with data from the 50 Ohio study sites used by Sherwood and Huitger (2005) to develop the regional curves. Two observations may be made from the scatterplots. The first observation is that the two sites with the largest drainage areas (BF-11 and BF-12) have measured bankfull channel width values that are considerably greater (average difference is +75.9 percent) than the estimated values, and measured bankfull-mean-depth values that are considerably less (average difference is -42.7 percent) than the estimated values; however, the measured bankfull cross-sectional area values do not appear to be very different (average difference is +3.4 percent) from the estimated values—thus, it appears that the greater widths compensate for the lesser mean depths. The second observation is that most of the measured data fall within the scatter of data used to prepare the regional curves; however, most of the measured bankfull mean depths and cross-sectional areas lie below the regional curves.

Table 5. Measured and estimated bankfull characteristics for 12 sites on Wheeling Creek selected for geomorphic data analyses.

Site code	Distance from mouth of Wheeling Creek (miles)	Drainage area (square miles)	Bankfull channel width			Bankfull mean depth			Bankfull cross-sectional area		
			Measured (feet)	Estimated[a] (feet)	Percent difference	Measured (feet)	Estimated[a] (feet)	Percent difference	Measured (feet)	Estimated[a] (feet)	Percent difference
BF-1	29.4	2.32	17.4	24.3	-28.3	1.5	1.9	-21.0	26.1	45.7	-42.8
BF-2	26.4	13.8	39.7	45.9	-13.5	3.2	3.0	4.9	127.0	138.6	-8.4
BF-3	26.1	17.0	59.7	49.4	20.9	2.3	3.2	-28.6	137.3	157.6	-12.9
BF-4	24.4	23.6	56.0	55.5	.9	2.6	3.5	-26.0	145.6	193.2	-24.6
BF-5	23.1	24.2	40.5	56.0	-27.6	4.3	3.5	21.6	174.2	196.1	-11.2
BF-6	21.3	45.5	65.8	70.1	-6.1	4.4	4.2	5.3	289.5	290.0	-.2
BF-7	19.9	51.3	78.3	73.1	7.1	3.3	4.3	-23.5	258.4	312.5	-17.3
BF-8	17.4	59.6	76.1	77.1	-1.3	4.0	4.5	-10.9	304.4	343.1	-11.3
BF-9	13.9	72.4	72.8	82.7	-12.0	5.2	4.7	10.0	378.6	387.3	-2.2
BF-10	13.6	76.4	99.6	84.3	18.2	4.3	4.8	-10.3	428.3	400.2	7.0
BF-11	11.8	81.77	184.2	86.3	113.4	3.0	4.9	-38.6	552.6	417.5	32.4
BF-12	11.6	81.82	119.5	86.3	38.4	2.6	4.9	-46.8	310.7	417.7	-25.6
Maximum					113.4			21.6			32.4
Minimum					-28.3			-46.8			-42.8
Mean					9.2			-13.7			-9.8
Median					-.2			-16.0			-11.2

[a] Determined from simple-regression equations presented in Sherwood and Huitger (2005).

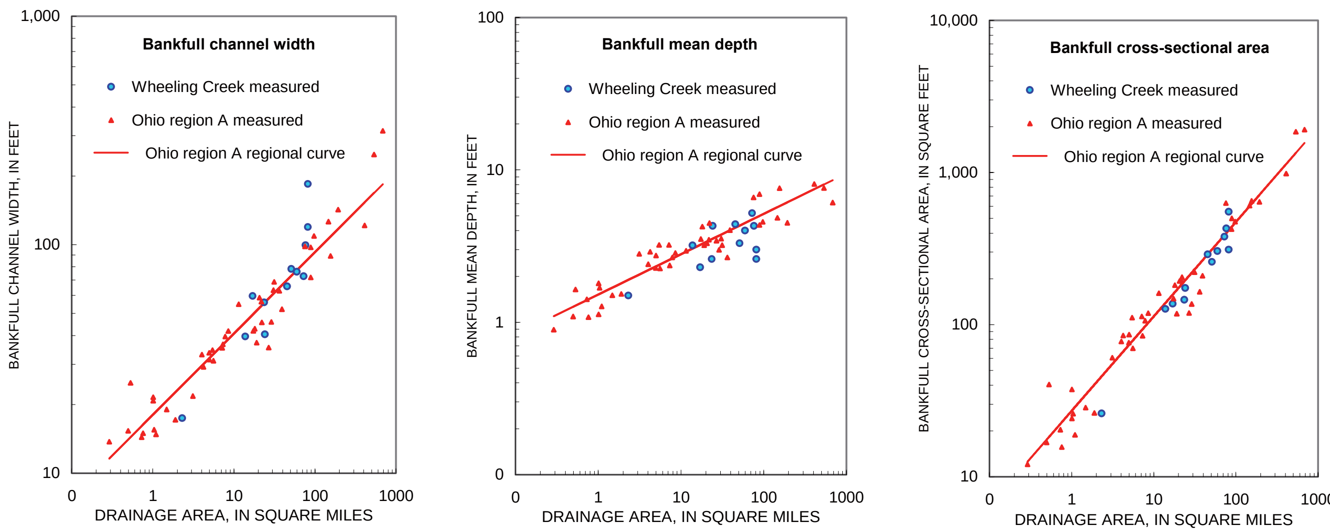


Figure 13. Plots of measured bankfull characteristics for 12 sites on Wheeling Creek compared to 50 sites and regional curves from an Ohio statewide study (Sherwood and Huitger, 2005).

Step-Backwater Analyses and Simulated Flood Elevations

Seven step-backwater models were used to simulate flood elevations for existing conditions corresponding to floods with recurrence intervals of 2, 10, 50, and 100 years (item 4, p. 2) on reaches in or near the Ohio communities of Lafferty, Crabapple, Maynard, and Crescent (fig. 1). Four of the seven models are of previously dredged reaches of Wheeling Creek (item 4, p. 2). These four models were modified to determine the height of levees required to contain floods with recurrence intervals of 2, 10, 50, and 100 years (item 5, p. 2). Three of the seven models are of selected undredged reaches of Wheeling Creek. These three models were modified to simulate the effects of several dredging and aggradation scenarios on flood elevations corresponding to the 2-, 10-, 50-, and 100-year floods (item 6, p. 2).

Development of Step-Backwater Models

Step-backwater modeling is a process whereby water-surface elevations are computed at a series of stream cross sections for a specific value of streamflow. The step-backwater model used in this study was the USACE's Hydrologic Engineering Center River Analysis System (HEC-RAS), Version 3.1.1, released in May 2003 (U.S. Army Corps of Engineers, 2002a and 2002b). The computations are done progressively in an upstream direction (for subcritical flow) by use of the standard step method, for which the input data required are measures of channel geometry, channel slope, and roughness (for open-channel flow). The Federal Emergency Management Agency (2003) explains the step-backwater modeling process in detail on their Web site. Quality-control procedures for the model output include checks for critical and sub-critical water-surface elevations, negative water-surface slopes, and excessive energy loss (headloss), conveyance changes, and distances between successive cross sections. For this study, most cross sections used in the models were derived predominantly from a TIN, which was generated from mass points[7] (grid spacing of 100 ft), contours[8] (10-ft interval), and breaklines[9] based on data collected in 2001 and obtained from the Belmont County Geographic Information System (GIS) coordinator. Because bridges commonly cause contraction of streamflow and backwater conditions, it is necessary to obtain more detailed geometric data for and around the bridges than is available from a TIN. Peak streamflows with recurrence intervals of 2, 10, 50, and 100 years were estimated using StreamStats[10] (Koltun and others, 2006) and incorporated into the step-backwater models to compute corresponding flood profiles at selected locations along Wheeling Creek.

[7] Mass points are the basic elements used to build a TIN. Each point has an X and Y location (horizontal coordinates) and a Z value (elevation).

[8] The 10-ft contours were used, but provided little information toward the generation of the TIN because of the large contour interval. Typically, a smaller contour interval (such as 2 ft or 5 ft) would have been used to generate the TIN, but is not available due to the high relief in Belmont County.

[9] Breaklines represent linear features used to define and control surface smoothness and abrupt changes in slope, such as the top of a streambank.

[10] StreamStats is a Web-based tool that allows users to obtain streamflow statistics, drainage-basin characteristics, and other information for user-selected sites on streams.

Discharge estimates for sites near Maynard and Crescent are gage-weighted using 18 years (1983–1987, 1989–2001) of streamflow data from Wheeling Creek below Blaine (station number 03111548) using methods described by Koltun and others (2006) for ungaged sites on a stream where the drainage area is between 50 and 150 percent of the drainage area of a gaged site on the same stream. The peak streamflow estimates and values of the corresponding basin characteristics at the selected locations are listed in table 6.

The four reaches that were previously dredged are located in and near the communities of Lafferty, Crabapple, Maynard, and Crescent (listed in upstream-to-downstream order). A total of 54 cross sections (including the 21 cross sections discussed previously) and 7 bridges were surveyed and used for model development. Additional GIS-derived cross sections were used to supplement the survey data. The locations of all cross sections are shown in figures 2a–5a (at back of report).

The cross-section labels used for the hydraulic baseline for all reaches are referenced to river miles above the mouth of Wheeling Creek. The most upstream cross section near Lafferty is located 28.09 river miles above the mouth and the most downstream section, near Crescent, is located 11.88 river miles above the mouth. The starting water-surface elevation at the most downstream cross section of each reach was determined by means of a slope-conveyance calculation.

Flood Elevations for Existing Conditions in Previously Dredged Reaches

Water-surface elevations were calculated for floods having recurrence intervals of 2, 10, 50, and 100 years in four previously dredged reaches in the communities of Lafferty, Crabapple, Maynard, and Crescent (fig. 1) and are presented in table 7. All cross sections listed in table 7 were surveyed sections.

Table 6. Basin characteristics and flood-peak streamflow estimates at selected sites along Wheeling Creek in Belmont County, Ohio.

[mi^2, square mile; ft/mi, foot per mile; ft^3/s, cubic foot per second]

Nearest community	Latitude	Longitude	Drainage area (mi^2)	Main-channel slope[a] (ft/mi)	Water or wetland area[b] (percent)	Flood-peak streamflow estimates[c] for selected recurrence intervals (ft^3/s) 2 year	10 year	50 year	100 year
Lafferty	40° 06’ 35”	-81° 01’ 10”	12.0	32.3	1.03	678	1,470	2,230	2,560
	40° 06’ 40”	-81° 00’ 59”	12.2	33.0	1.02	691	1,500	2,270	2,610
	40° 06’ 43”	-81° 00’ 53”	12.4	32.2	1.01	696	1,510	2,290	2,620
	40° 06’ 38”	-81° 00’ 31”	13.4	31.3	1.04	733	1,590	2,400	2,750
Crabapple	40° 06’ 52”	-80° 57’ 22”	25.6	19.0	.79	1,170	2,440	3,640	4,150
	40° 06’ 44”	-80° 57’ 03”	45.3	17.8	1.10	1,750	3,580	5,280	6,010
Maynard	40° 07’ 15”	-80° 53’ 08”	60.6	16.0	1.11	[d]2,090	[d]4,230	[d]6,210	[d]7,070
	40° 07’ 29”	-80° 52’ 42”	68.2	14.9	1.22	[d]2,200	[d]4,400	[d]6,460	[d]7,350
	40° 06’ 40”	-80° 52’ 43”	72.5	14.6	1.17	[d]2,290	[d]4,560	[d]6,690	[d]7,610
Crescent	40° 07’ 17”	-80° 51’ 47”	77.0	14.5	1.18	[d]2,360	[d]4,690	[d]6,890	[d]7,850
	40° 06’ 57”	-80° 51’ 27”	81.0	14.1	1.14	[d]2,430	[d]4,810	[d]7,060	[d]8,050
	40° 06’ 45”	-80° 51’ 31”	81.8	14.0	1.14	[d]2,440	[d]4,840	[d]7,100	[d]8,090

[a] Computed as the difference in elevations (in feet) at points 10 and 85 percent of the distance along the main channel from the site to the topographic divide (following the longest path), divided by the channel distance (in miles) between the two points.

[b] Computed as the percentage of the total drainage area classified as water or wetlands in the 1992 National Land Cover Dataset (U.S. Geological Survey, 2000).

[c] Computed using StreamStats (Koltun and others, 2006). StreamStats is a Web-based tool that allows users to obtain streamflow statistics, drainage-basin characteristics, and other information for user-selected sites on streams.

[d] Discharge estimates for sites near Maynard and Crescent are gage-weighted using 18 years (1983–1987, 1989–2001) of streamflow data from Wheeling Creek below Blaine (station number 03111548) using methods described by Koltun and others (2006) for ungaged sites on a stream where the drainage area is between 50 and 150 percent of the drainage area of a gaged site on the same stream.

Table 7. Flood elevations for selected recurrence intervals with existing conditions in the four previously dredged reaches, Wheeling Creek, Belmont County, Ohio.

[**Bold font** indicates flooding is out of the main channel by submerging the levee or from flowing around the levee; ROF, flow over road]

Distance from mouth of Wheeling Creek (river miles)	Site	Water-surface elevation for indicated recurrence interval			
		2 year (feet)	10 year (feet)	50 year (feet)	100 year (feet)
		Lafferty			
28.09	A-1	1,021.01	**1,023.48**	**1,025.11**	**1,025.68**
27.86	cross section	1,019.98	**1,022.35**	**1,024.07**	**1,024.69**
27.72	A-2	1,019.17	**1,021.64**	**1,023.59**	**1,024.23**
27.70	cross section	1,019.02	1,021.28	**1,023.03**	**1,023.61**
27.70	Brudzenski Road, Bridge			**ROF**	**ROF**
27.69	cross section	1,019.01	1,021.25	1,022.45	1,022.92
27.69	cross section	1,018.98	1,021.24	**1,022.45**	**1,022.92**
27.68	cross section	1,018.92	1,021.05	1,022.07	1,022.46
27.68	Railroad, Bridge				
27.67	cross section	1,018.85	1,020.91	1,021.81	1,022.12
27.66	cross section	1,018.70	**1,020.75**	**1,021.70**	**1,022.03**
27.62	cross section	1,018.41	**1,020.47**	**1,021.41**	**1,021.75**
27.61	cross section	1,018.27	**1,020.27**	**1,021.20**	**1,021.55**
27.61	Park Entrance, Bridge		**ROF**	**ROF**	**ROF**
27.60	cross section	1,018.07	**1,019.87**	**1,020.99**	**1,021.46**
27.60	cross section	1,018.02	1,019.86	**1,020.98**	**1,021.44**
27.50	A-3	1,017.04	**1,019.14**	**1,020.55**	**1,021.08**
27.17	A-4	1,015.18	1,016.22	1,016.98	1,017.18
		Crabapple			
22.37	B-1	928.73	**931.20**	**932.67**	**933.25**
22.27	B-2	927.65	**930.01**	**931.81**	**932.48**
22.19	B-3	926.98	**929.52**	**931.27**	**931.93**
22.12	B-4	**926.22**	**928.39**	**929.79**	**930.32**
22.07	B-5	**925.64**	**927.95**	**929.44**	**930.01**
		Maynard			
15.70	C-1	851.57	**854.29**	**855.82**	**856.28**
15.45	cross section	847.67	**851.02**	**852.78**	**853.37**
15.43	cross section	847.63	**850.96**	**852.68**	**853.26**
15.43	Fairport Road, Bridge		**ROF**	**ROF**	**ROF**
15.42	cross section	847.48	**850.85**	**852.29**	**852.76**
15.42	cross section	847.32	**850.73**	**852.27**	**852.76**
15.30	C-2	845.89	**849.14**	**850.90**	**851.47**
15.08	C-3	844.43	**847.28**	**848.84**	**849.51**
14.97	C-4	843.63	**846.33**	**848.66**	**849.37**
14.95	cross section	843.40	**846.11**	**848.40**	**849.14**

Table 7. Flood elevations for selected recurrence intervals with existing conditions in the four previously dredged reaches, Wheeling Creek, Belmont County, Ohio. —Continued

[**Bold font** indicates flooding is out of the main channel by submerging the levee or from flowing around the levee; ROF, flow over road]

Distance from mouth of Wheeling Creek (river miles)	Site	Water-surface elevation for indicated recurrence interval			
		2 year (feet)	10 year (feet)	50 year (feet)	100 year (feet)
		Maynard—Continued			
14.94	Maynard Road, Bridge			**ROF**	**ROF**
14.93	cross section	843.22	**845.98**	**847.79**	**848.55**
14.92	cross section	843.06	**845.73**	**847.74**	**848.51**
14.60	C-5	**838.90**	**841.25**	**842.22**	**842.55**
14.44	C-6	**837.45**	**840.08**	**841.34**	**841.80**
14.24	C-7	**835.57**	**838.13**	**839.48**	**840.00**
		Crescent			
12.39	D-1	**811.73**	**815.27**	**817.21**	**818.01**
12.33	cross section	811.32	**815.00**	**817.13**	**817.96**
12.32	cross section	810.71	**813.60**	**815.15**	**816.21**
12.31	Crescent Road, Bridge			**ROF**	**ROF**
12.30	cross section	810.44	**813.30**	**814.11**	**814.71**
12.29	D-2	**810.34**	**813.19**	**814.10**	**814.69**
12.16	D-3	**808.19**	**810.34**	**811.32**	**811.78**
12.04	D-4	**806.54**	**808.23**	**809.38**	**809.84**
11.88	D-5	**804.10**	**806.03**	**807.41**	**807.95**

The bolded values in table 7 indicate water is on the flood plain[11] beyond the levee (on one or both banks) at that particular cross section. The source of water on the flood plain may be from overtopping of the bank(s) or levee(s) at that cross section or from overbank flooding at an upstream or downstream cross section. At the bridges, the designation "ROF" (road overflow) indicates that flow overtopped the roadway. With the exception of the Lafferty reach, some flooding of the flood plain occurs in each reach, even at a 2-year recurrence-interval flood. At a 10-year recurrence-interval flood and larger, flood-plain flooding is widespread in all reaches studied. Additional GIS-derived cross sections were used in model development and tables 8–11 (at back of report) list water-surface elevations for the selected recurrence intervals for all cross sections used in the models for the previously dredged reaches. The locations of all cross sections are shown in figures 2a–5a (at back of report). Water-surface profiles estimated from the step-backwater models for existing conditions in dredged reaches of Wheeling Creek are shown in figures 2b–5b (at back of report).

The existing levees were constructed with the dredged channel material in 1985 and are not certified levees (U.S. Army Corps of Engineers, 2006). They were not designed or intended to contain floods of large magnitude, such as the 100-year flood, but rather dredged materials were piled along the streambanks in an attempt to reduce (but not eliminate) flood-plain flooding.

The levees ended at tributaries and road crossings where, during large floods, water can flow out onto the flood plain. At some cross-section locations, the levees are high enough to contain floodwater within the main channel, but because the heights of the levees are not uniform, water may flow around or over the levee at one or more locations upstream or downstream from the cross section. These conditions are illustrated in figure 14 where at cross section A, the levees on both sides of the channel are high enough to contain floodwater but water has spilled onto the flood plain at a location upstream or downstream from the levees. Cross section B shows the condition where floodwater has submerged the levee on the right bank and spilled onto the flood plain beyond.

[11] A flood plain is the flat or nearly flat land that borders a stream and experiences occasional flooding.

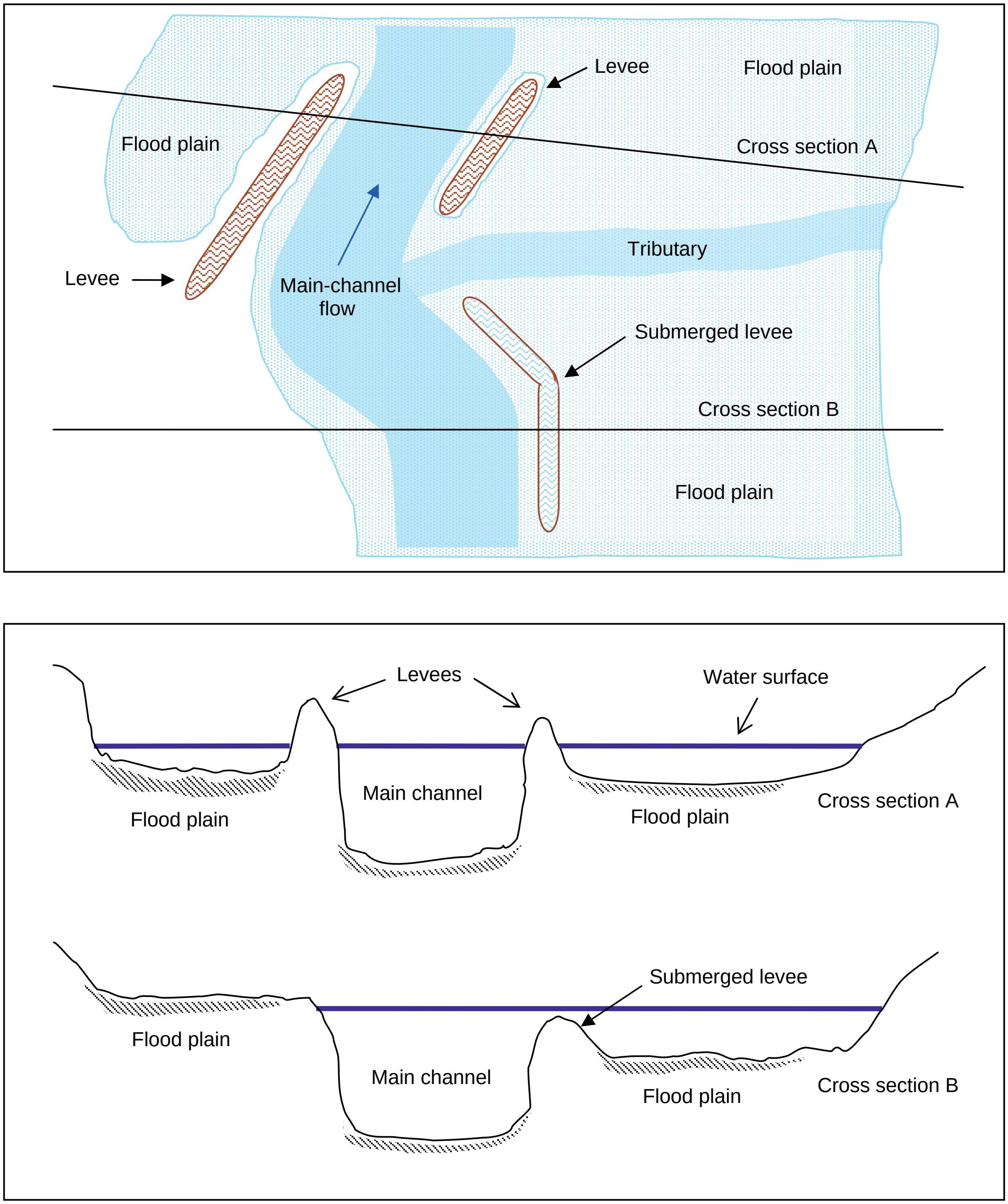


Figure 14. Schematic diagram showing levee heights above the water-surface elevation and flooding on the landward side of the levees by water submerging or flowing around the levees, in plan view and cross-sectional plots.

Flood Elevations for Simulated Levee Conditions in Previously Dredged Reaches

The height of levees required to contain (within the main channel) floods with recurrence intervals of 2, 10, 50, and 100 years was determined for the four previously dredged reaches (item 5, p. 2). The starting water-surface elevations used at the most downstream cross section for all profiles were the estimated water-surface elevations from the current-condition models. As illustrated in figure 15, the levee heights were manually adjusted for each cross section by raising the top of the natural bank or the top of the existing levee using a 2:1 ratio for the side slope of the levee extension. These manually raised levees will hereafter be referred to as “simulated levees.” If actual levees were constructed, it would be necessary to raise the levees further than indicated in this report to allow for freeboard and provide a margin of safety. Generally, levees were raised only at cross sections where man-made levees were already present. There were a few exceptions, discussed later, where levees were added to contain the flow within the main channel and to prevent water from flowing to a flood-plain area beyond the levee of an adjacent cross section. In cases where a valley wall near the bank provided natural containment, no levees were added. Each cross section was evaluated independently to decide if raising a levee was warranted. The openings of bridges were not modified so that current condition water-surface elevations could be compared to the simulated levee models. Additionally, levees were added (across the road) at some road crossings to contain all flow within the main channel and to prevent water from flowing to the flood plain.

The models were constructed so that all flow was contained within the main channel on the streamward side of the levees so that flood-plain areas beyond the levees remain dry. For example, the models do not permit water from the main channel to spill out onto the flood plain at the mouths of tributaries.

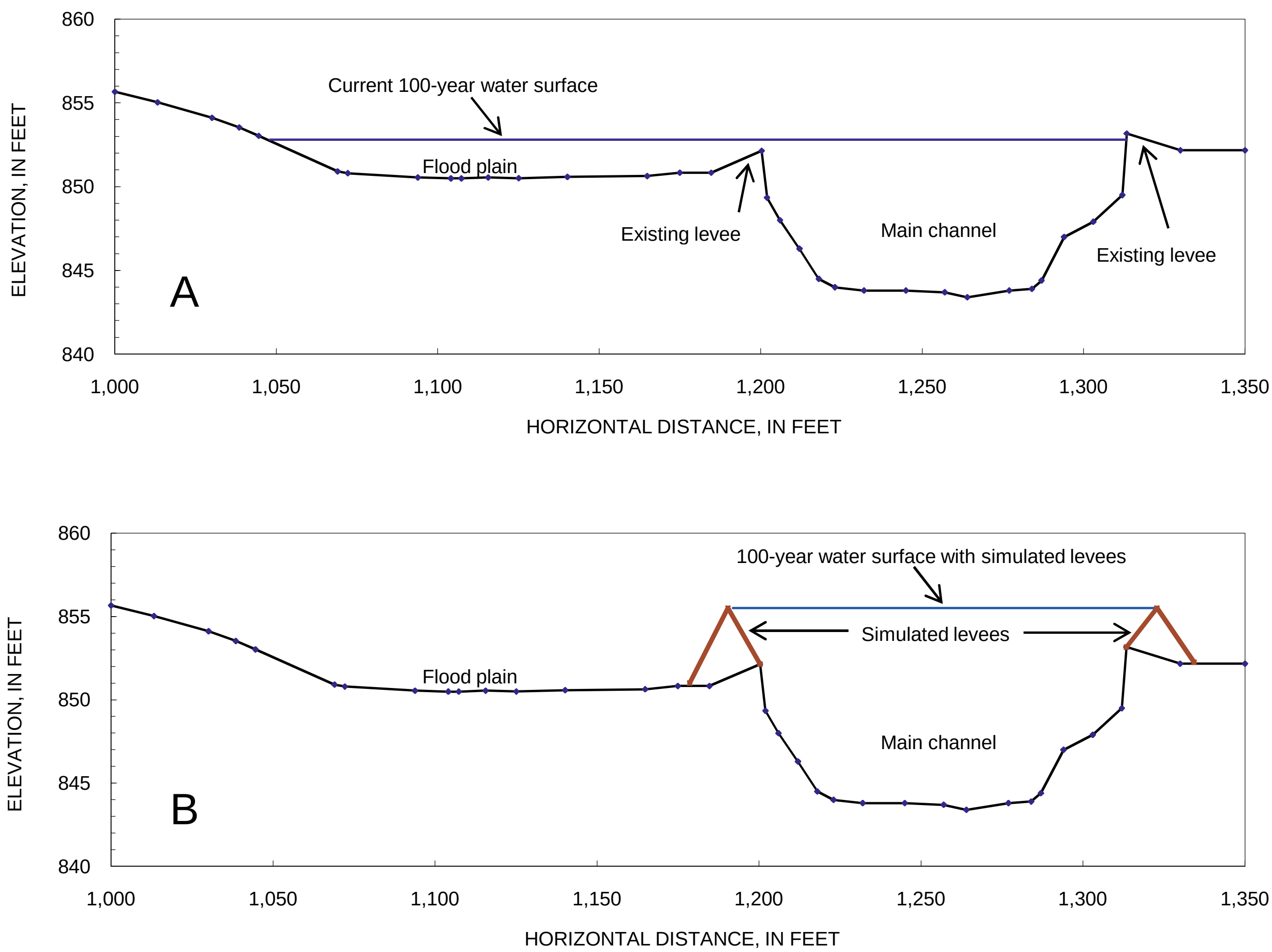


Figure 15. Plot showing cross-sectional data for a previously dredged site with (A) current conditions and (B) simulated levees required to contain a 100-year flood.

The simulated levee models generally show an increase in the water-surface elevations as compared to the current conditions model, but in some cases the water-surface elevations were slightly lower. The lower water-surface elevations may result from having all flow contained within the channel, where composite roughness values tend to be lower and velocities are higher.

Table 12 shows a summary for the four reaches studied and the vertical distances between the existing top-of-levee elevations and the water-surface elevations determined in the simulated levee models. The distance from top of levee to the water surface for the selected recurrence interval was determined by subtracting the minimum of the left- and right-bank levee elevations from the water-surface elevations. Consequently, a positive value indicates the vertical distance the existing levee must be raised to contain the flood and a negative value indicates the vertical distance below the top of the existing levee to the water surface.

There are two areas were levees were added to cross sections where no levee existed before in order to contain the flow within the main channel and prevent water from flowing to a flood plain area beyond the levee of an adjacent cross section. At the lower end of the reach near Crabapple (cross sections B-4 and B-5), levees were added on the left flood plain to prevent water from flowing to upstream flood-plain areas. In Maynard, levees where added on the right flood plain at cross section C-4 and just upstream of cross section C-5 (river mile 14.92) to prevent water from flowing to upstream flood-plain areas.

There are two cross sections without existing levees where no simulated levees were added because the valley wall contained all simulated flood waters near the left bank and the right bank flood plain was undeveloped. One location was near Lafferty cross section A-3 and the other was near Maynard cross section C-7. Since these sites have no existing levees, they were not included in the percentage results for levee height needed to contain the selected recurrence intervals discussed below.

The existing levees contain the 100-year flood at only 20 percent of the surveyed cross sections. At the other 80 percent of the surveyed cross sections, levee heights would have to be raised as much as 6.3 ft to contain the 100-year flood, with an average increase of 2.5 ft. The existing levees contain the 50-year flood at 32 percent of the surveyed cross sections. At the other 68 percent of the surveyed cross sections, levee heights would have to be raised as much as 6.2 ft to contain the 50-year flood, with an average increase of 2.2 ft.

Table 12 shows the summary for only the surveyed cross sections used in the simulated levee models, even though additional GIS-derived sections were also used for model development. All cross sections used to develop models for current conditions and simulated levee conditions are shown in tables 8–11 (at back of report). The locations of all surveyed cross sections are shown in figures 2a–5a (at back of report).

Table 12. Summary of the measured levee elevation and the distance from top of measured levee to the water surface for indicated recurrence intervals in previously dredged reaches of Wheeling Creek, Belmont County, Ohio.

[**Bold font** indicates the increase in levee heights, in feet, required to contain flood peak streamflows for the selected recurrence intervals; the heights shown include no freeboard]

Distance from mouth of Wheeling Creek (river miles)	Site	Minimum measured levee elevation, current conditions (feet)	Distance from top of minimum measured levee elevations to water-surface elevations for indicated recurrence intervals (in feet)			
			2 year	10 year	50 year	100 year
		Lafferty				
28.09	A-1	1,021.3	-0.3	**2.6**	**4.7**	**5.5**
27.86	cross section	1,024.9	-4.9	-2.2	-.2	.6
27.72	A-2	1,021.2	-2.0	**.4**	**2.3**	**3.1**
27.70	cross section	1,022.6	-3.6	-1.2	**.6**	**1.4**
27.70	Brudzenski Road, Bridge					
27.69	cross section	1,023.5	-4.5	-2.2	-.9	-.4
27.69	cross section	1,022.4	-3.4	-1.1	**.2**	**.6**
27.68	cross section	1,026.7	-7.8	-5.6	-4.4	-4.0
27.68	Railroad, Bridge					
27.67	cross section	1,023.3	-4.4	-2.3	-1.3	-.9
27.66	cross section	1,019.5	-.8	**1.4**	**2.3**	**2.7**
27.62	cross section	1,019.1	-.6	**1.5**	**2.4**	**2.8**
27.61	cross section	1,020.0	-1.7	**.4**	**1.4**	**1.8**

Table 12. Summary of the measured levee elevation and the distance from top of measured levee to the water surface for indicated recurrence intervals in previously dredged reaches of Wheeling Creek, Belmont County, Ohio. —Continued

[**Bold font** indicates the increase in levee heights, in feet, required to contain flood peak streamflows for the selected recurrence intervals; the heights shown include no freeboard]

Distance from mouth of Wheeling Creek (river miles)	Site	Minimum measured levee elevation, current conditions (feet)	Distance from top of minimum measured levee elevations to water-surface elevations for indicated recurrence intervals (in feet)			
			2 year	10 year	50 year	100 year
		Lafferty—Continued				
27.61	Park Entrance, Bridge					
27.60	cross section	1,020.0	-1.9	**0.1**	**1.3**	**1.7**
27.60	cross section	1,020.6	-2.5	-.5	**.7**	**1.1**
[a]27.50	[a]A-3	[a]1,018.2	[a]-1.2	[a]**.9**	[a]**2.3**	[a]**2.9**
27.17	A-4	1,019.0	-3.8	-2.8	-2.0	-1.8
		Crabapple				
22.37	B-1	931.8	-3.1	-.4	**1.5**	**2.2**
22.27	B-2	931.7	-4.1	-1.3	**.7**	**1.4**
22.19	B-3	931.3	-4.3	-1.8	-.1	**.5**
22.12	B-4	926.2	**.0**	**2.4**	**3.9**	**4.5**
22.07	B-5	925.2	**.4**	**2.8**	**4.2**	**4.8**
		Maynard				
15.70	C-1	851.8	-.3	**2.5**	**4.5**	**5.4**
15.45	cross section	851.9	-4.4	-1.0	**1.8**	**2.7**
15.43	cross section	852.1	-4.7	-1.3	**1.6**	**2.5**
15.43	Fairport Road, Bridge					
15.42	cross section	851.4	-4.2	-.7	**1.6**	**2.5**
15.42	cross section	852.4	-5.3	-1.9	**.3**	**1.1**
15.30	C-2	848.7	-3.1	**.2**	**2.3**	**3.1**
15.08	C-3	849.8	-5.6	-2.7	-.6	**.1**
14.97	C-4	849.1	-5.7	-2.9	-.9	-.2
14.95	cross section	848.5	-5.4	-2.5	-.5	**.2**
14.94	Maynard Road, Bridge					
14.93	cross section	845.7	-2.8	**.2**	**2.1**	**2.9**
14.92	cross section	845.7	-3.0	**.0**	**1.9**	**2.7**
14.60	C-5	842.0	-3.4	-.6	**.9**	**1.4**
14.44	C-6	838.5	-1.3	**1.3**	**2.5**	**2.9**
[a]14.24	[a]C-7	[a]836.8	[a]-1.2	[a]**1.3**	[a]**2.7**	[a]**3.2**
		Crescent				
12.39	D-1	813.8	-2.3	**.7**	**3.9**	**4.1**
12.33	cross section	811.3	-.3	**2.9**	**6.2**	**6.3**
12.32	cross section	814.3	-3.6	-.7	**2.8**	**2.8**
12.31	Crescent Road, Bridge					
12.30	cross section	813.2	-2.8	**.1**	**2.1**	**2.9**
12.29	D-2	815.3	-5.0	-2.1	-.1	**.6**
12.16	D-3	812.8	-4.6	-2.5	-1.1	-.6
12.04	D-4	810.6	-4.1	-2.4	-1.2	-.8
11.88	D-5	811.8	-7.7	-5.8	-4.4	-3.8

[a] No existing levee at this site. The elevation at the top of the right bank was used as the minimum measured levee elevation and no simulated levees were added to this site.

Flood Elevations for Simulated Dredging and Aggradation Conditions in Undredged Reaches

Step-backwater models corresponding to 2-, 10-, 50-, and 100-year floods were developed for three undredged reaches (fig. 1) to estimate the effect of selected hypothetical instream dredging (without levee construction) and aggradation scenarios (item 6, p. 2). The dredging and aggradation processes were modeled by systematically lowering or raising all current bed elevations between the toes of the existing streambanks. This resulted in a change in the cross-sectional area of the channel (fig. 16). The channel and overbank roughness were not changed from existing conditions.

To simulate dredging, the streambed was lowered in 1.0 ft increments to a minimum elevation 4.0 ft lower than the existing streambed. In this part of the state of Ohio, the streambed typically is dredged 2 to 3 ft, but generally no more than 4 ft (Steven Porter, U.S. Army Corps of Engineers, Huntington, W.V., oral commun., 2006). To simulate the aggradation process, the streambed was raised in 1.0-ft increments up to an elevation 2.0 ft higher than the existing streambed. Each cross section was evaluated individually to identify the toe of the streambank, and all points between the toes of the streambank were lowered or raised by the appropriate 1.0-ft increments to simulate dredging or aggradation.

The flood elevations at each cross section for the current conditions and the dredging and aggradation simulations are shown in tables 13–15 (at back of report). The locations of cross sections in the three undredged reaches are shown in figures 17a–19a (at back of report). Water-surface profiles for existing conditions of dredged reaches of Wheeling Creek estimated from the step-backwater models are shown in figures 17b–19b (at back of report). Summary statistics (maximum, minimum, mean, and median) for the dredging and aggradation simulations are presented in table 16.

As illustrated in table 16, modifications to the channel, such as dredging and aggradation, have the least effect on the 100-year water-surface elevations and the greatest effect on the 2-year water-surface elevations. This is because for the 100-year flood, a larger portion of the total flow is over the flood plains where the change in water-surface elevation results in a relatively large change in flow area and conveyance relative to the main channel. For example, as indicated in table 16, lowering the streambed by 2.0 ft (simulated dredging) in reach 2 between Maynard and Crescent would, on average, lower the mean 2-year water-surface elevation within the reach by 1.41 ft and lower the mean 100-year water-surface elevation within the reach by only 0.77 ft. Similarly, raising the streambed by 1.0 ft (simulated aggradation) in reach 2 would, on average, raise the mean 2-year water-surface elevation within the reach by 0.63 ft and raise the mean 100-year water-surface elevation within the reach by only 0.39 ft.

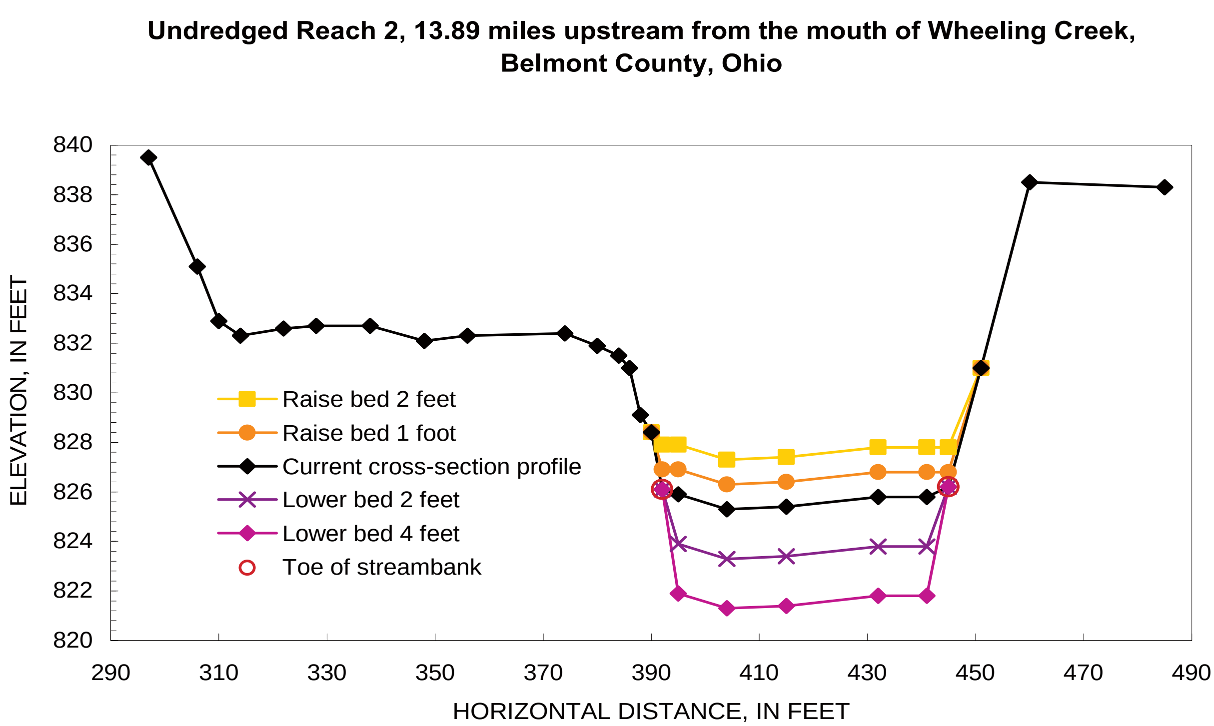


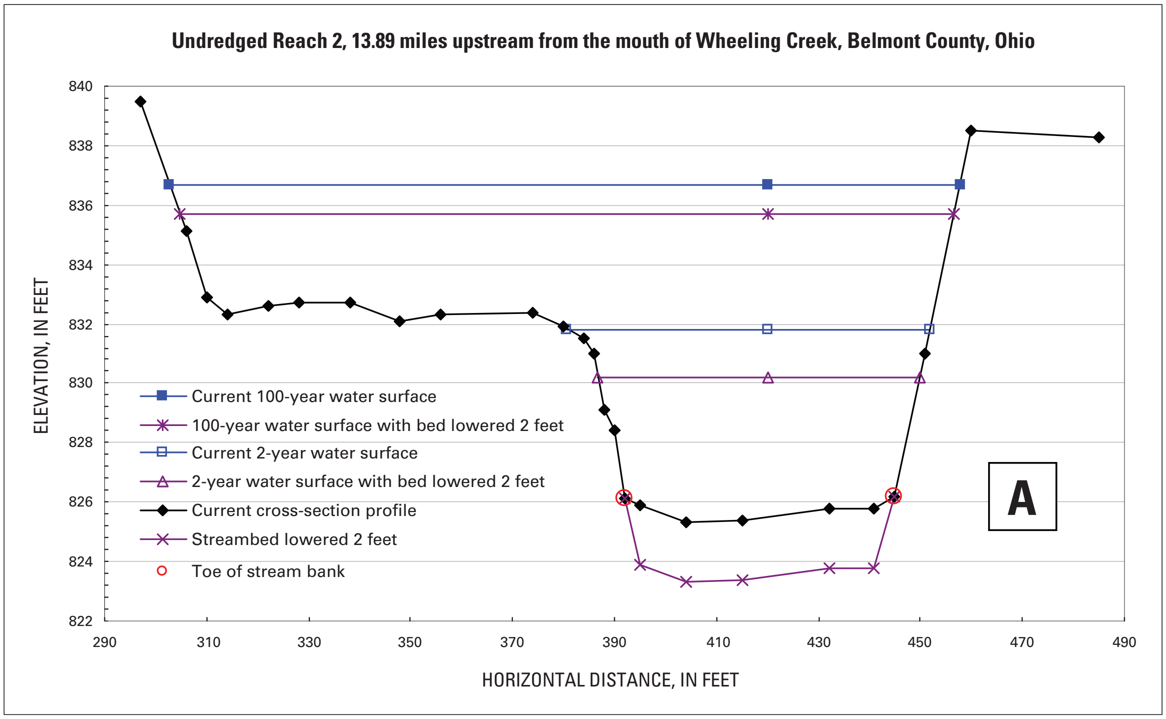
Figure 16. Plot of cross-sectional data for an undredged site showing current conditions and selected conditions where the streambed was lowered or raised to simulate dredging and aggradation.

Table 16. Change in water-surface elevations, in feet, for indicated flood recurrence intervals, in years, and change in bed elevation, in feet, for three undredged reaches, Wheeling Creek, Belmont County, Ohio.

Recurrence interval	Reach 1 near Lafferty				Reach 2 between Maynard and Crescent				Reach 3 below Crescent			
	2	10	50	100	2	10	50	100	2	10	50	100
Statistic												
	Raise bed 2 feet				Raise bed 2 feet				Raise bed 2 feet			
Maximum	1.17	0.59	0.46	0.43	1.59	1.60	1.34	1.45	1.21	0.93	0.84	0.82
Minimum	.60	.49	.38	.34	.88	.36	.28	.25	.93	.77	.73	.72
Mean	.93	.55	.42	.38	1.23	.90	.81	.78	1.12	.86	.79	.78
Median	.94	.55	.41	.38	1.25	.91	.81	.80	1.15	.88	.79	.79
	Raise bed 1 foot				Raise bed 1 foot				Raise bed 1 foot			
Maximum	.52	.31	.24	.22	.78	.82	.69	.66	.65	.47	.42	.41
Minimum	.31	.23	.19	.17	.44	.18	.14	.12	.48	.38	.36	.35
Mean	.41	.28	.21	.19	.63	.45	.40	.39	.59	.43	.39	.39
Median	.41	.28	.20	.19	.63	.45	.40	.39	.63	.43	.38	.39
	Lower bed 1 foot				Lower bed 1 foot				Lower bed 1 foot			
Maximum	-.76	-.34	-.26	-.24	-.82	-.73	-.71	-.68	-.77	-.47	-.40	-.39
Minimum	-.32	-.23	-.20	-.18	-.50	-.14	-.13	-.12	-.49	-.38	-.34	-.33
Mean	-.58	-.30	-.22	-.20	-.68	-.45	-.40	-.38	-.65	-.43	-.38	-.36
Median	-.59	-.31	-.22	-.20	-.69	-.45	-.40	-.39	-.67	-.42	-.38	-.36
	Lower bed 2 feet				Lower bed 2 feet				Lower bed 2 feet			
Maximum	-1.32	-.73	-.54	-.49	-1.68	-1.40	-1.45	-1.38	-1.66	-1.00	-.83	-.80
Minimum	-.68	-.36	-.40	-.36	-1.05	-.32	-.27	-.24	-1.00	-.79	-.69	-.66
Mean	-1.11	-.62	-.46	-.41	-1.41	-.94	-.80	-.77	-1.38	-.91	-.77	-.74
Median	-1.17	-.63	-.45	-.40	-1.43	-.93	-.82	-.77	-1.47	-.89	-.78	-.74
	Lower bed 3 feet				Lower bed 3 feet				Lower bed 3 feet			
Maximum	-2.16	-1.55	-.83	-.76	-2.61	-2.04	-2.22	-2.11	-2.55	-1.61	-1.29	-1.23
Minimum	-1.42	-.72	-.60	-.56	-1.63	-.57	-.42	-.37	-1.52	-1.24	-1.05	-1.01
Mean	-1.88	-1.10	-.71	-.64	-2.18	-1.45	-1.19	-1.15	-2.14	-1.47	-1.19	-1.13
Median	-1.89	-1.08	-.69	-.62	-2.20	-1.44	-1.25	-1.16	-2.31	-1.45	-1.21	-1.15
	Lower bed 4 feet				Lower bed 4 feet				Lower bed 4 feet			
Maximum	-3.05	-2.07	-1.15	-1.05	-3.59	-2.67	-2.85	-2.87	-3.48	-2.40	-1.79	-1.68
Minimum	-2.25	-.98	-.81	-.75	-2.36	-.94	-.52	-.52	-2.27	-1.74	-1.44	-1.38
Mean	-2.71	-1.56	-.97	-.87	-3.02	-2.00	-1.62	-1.53	-3.00	-2.12	-1.65	-1.55
Median	-2.68	-1.58	-.95	-.85	-3.07	-2.03	-1.65	-1.57	-3.19	-2.17	-1.64	-1.59

Figure 20 illustrates the effect of lowering the bed elevation 2.0 ft (fig. 20A) and raising the bed 1.0 ft (fig. 20B) on the water-surface elevations corresponding to the 2-year and 100-year recurrence-interval floods. It is evident from fig. 20 that the change in water-surface elevation due to the change in bed elevation is smaller for the 100-year flood than for the 2-year flood.

In general, as the proportion of flow in the flood plain increased, the change in water-surface elevation decreased for a given increase or decrease in the bed elevation. Consequently, stream channels with wide flood plains will likely experience proportionally smaller changes in water-surface elevation due to dredging or aggradation than reaches where the valley is narrow and the flood plains are small or nonexistent.



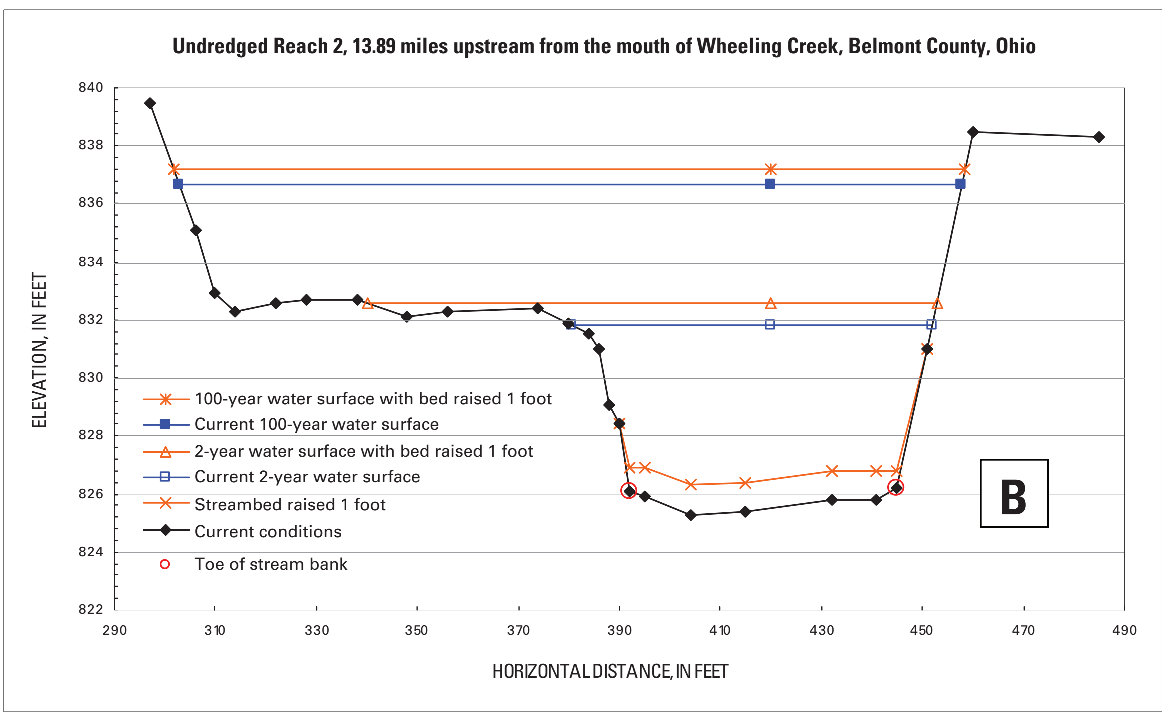


Figure 20. Plots of cross-sectional data for an undredged site with current conditions and changes in bed elevations, and the corresponding water-surface elevations for the 2- and 100-year flood recurrence intervals.

Summary and Conclusions

Wheeling Creek in eastern Ohio has a long history of flooding that has resulted in several deaths and extensive damage to public and private property. In 1985, in response to residents' concerns about flooding that occurred in 1979 through 1981, portions of Wheeling Creek were dredged and the dredged materials were used to construct uncertified levees. The U.S. Geological Survey (USGS) conducted stream-channel cross-sectional surveys before and after the dredging (1987) to assess stream-channel stability.

In 2004, an unusual number of large floods occurred. As a result of these floods, the USGS, in cooperation with the Ohio Emergency Management Agency, conducted a study in the Wheeling Creek Basin to (1) evaluate and contrast land-cover characteristics from 2001 with characteristics from 1979 and 1992; (2) compare current streambed elevation, slope, and geometry with conditions present in the late 1980s; (3) look for evidence of channel filling and over widening in selected undredged reaches; (4) estimate flood elevations for existing conditions in both undredged and previously dredged reaches; (5) evaluate the height of the levees required to contain floods with selected recurrence intervals in previously dredged reaches; and (6) estimate flood elevations for several hypothetical dredging and streambed aggradation scenarios in undredged reaches.

The amount of barren land in the Wheeling Creek watershed has decreased from 20 to 1 percent of the basin area based on land-cover characteristics from 1979 and 2001. Barren lands appear to have been converted primarily to pasture, presumably as a result of surface-mine reclamation. Croplands also decreased from 13 to 8 percent of the basin area. The combined decrease in barren lands and croplands is approximately offset by the increase in pasture.

Stream-channel surveys conducted in 1987 and again in 2006 at 21 sites in four previously dredged reaches of Wheeling Creek indicate little net change in the elevation, slope, and geometry of the channel at most sites. The mean change in width-averaged bed and thalweg elevations for the 21 cross sections was 0.1 ft.

Bankfull widths, mean depths, and cross-sectional areas measured at 12 sites in undredged reaches were compared to estimates determined from regional equations. The mean percentage difference between measured and estimated bankfull widths was -0.2 percent, suggesting that bankfull widths in the Wheeling Creek Basin are generally about the same as regional averages for undisturbed basins of identical drainage area. For bankfull mean depth and cross-sectional area, the mean percentage differences between the measured and estimated values were -16.0 and -11.2, respectively. The predominantly negative bias in differences between the measured and estimated values indicates that bankfull mean depths and cross-sectional areas in studied reaches generally are smaller than the regional trend. This may be an indication of channel filling and over widening or it may reflect insufficient representation in the regional dataset of basins with characteristics similar to Wheeling Creek.

Step-backwater models were constructed for four previously dredged reaches to determine the height of levees required to contain floods with recurrence intervals of 2, 10, 50, and 100 years. Existing levees (all of which are uncertified) were found to contain the 100-year flood at only 20 percent of the surveyed cross sections. At the other 80 percent of the surveyed cross sections, levee heights would have to be raised an average of 2.5 ft and as much as 6.3 ft to contain the 100-year flood.

Step-backwater models also were constructed for three undredged reaches to assess the impacts of selected dredging and streambed aggradation scenarios on water-surface elevations corresponding to the 2-, 10-, 50-, and 100-year floods. Those models demonstrated that changes in water-surface elevations associated with a given depth of dredging were proportionately smaller for larger floods due to the fact that more of the flood waters are outside of the main channel. For example, 2.0 ft of dredging in the three study reaches would lower the water-surface elevation an average of 1.30 ft for the 2-year flood and 0.64 ft for the 100-year flood.

While results presented in this report are specific to Wheeling Creek, conclusions drawn from the hypothetical assessments are expected to be applicable to other basins in eastern Ohio with characteristics similar to the Wheeling Creek Basin.

Acknowledgments

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Maps and Water-Surface Profiles

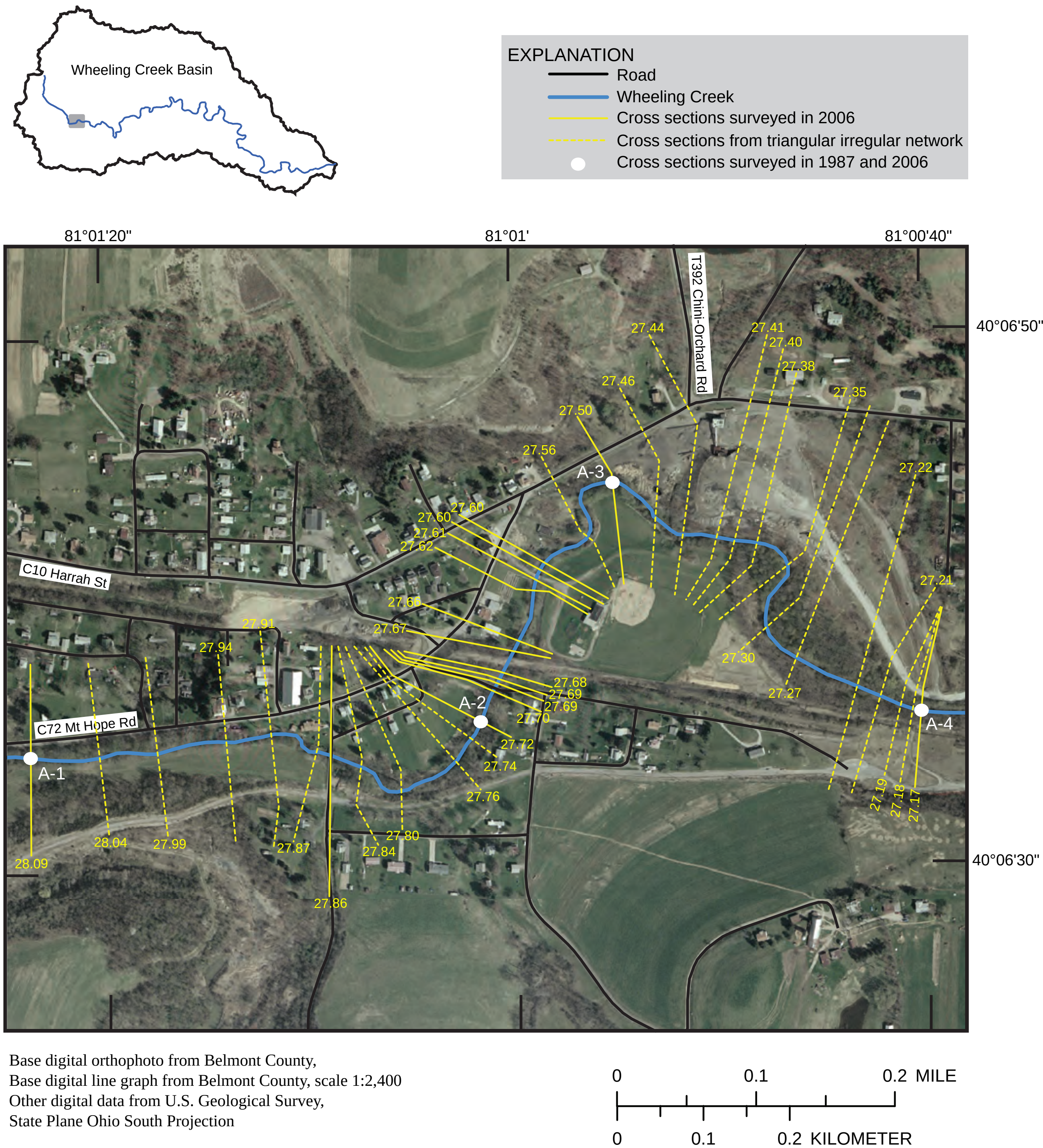


Figure 2a. Locations of cross sections used to create step-backwater model of dredged reaches of Wheeling Creek in the community of Lafferty, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek in yellow. Sites are labeled in white.

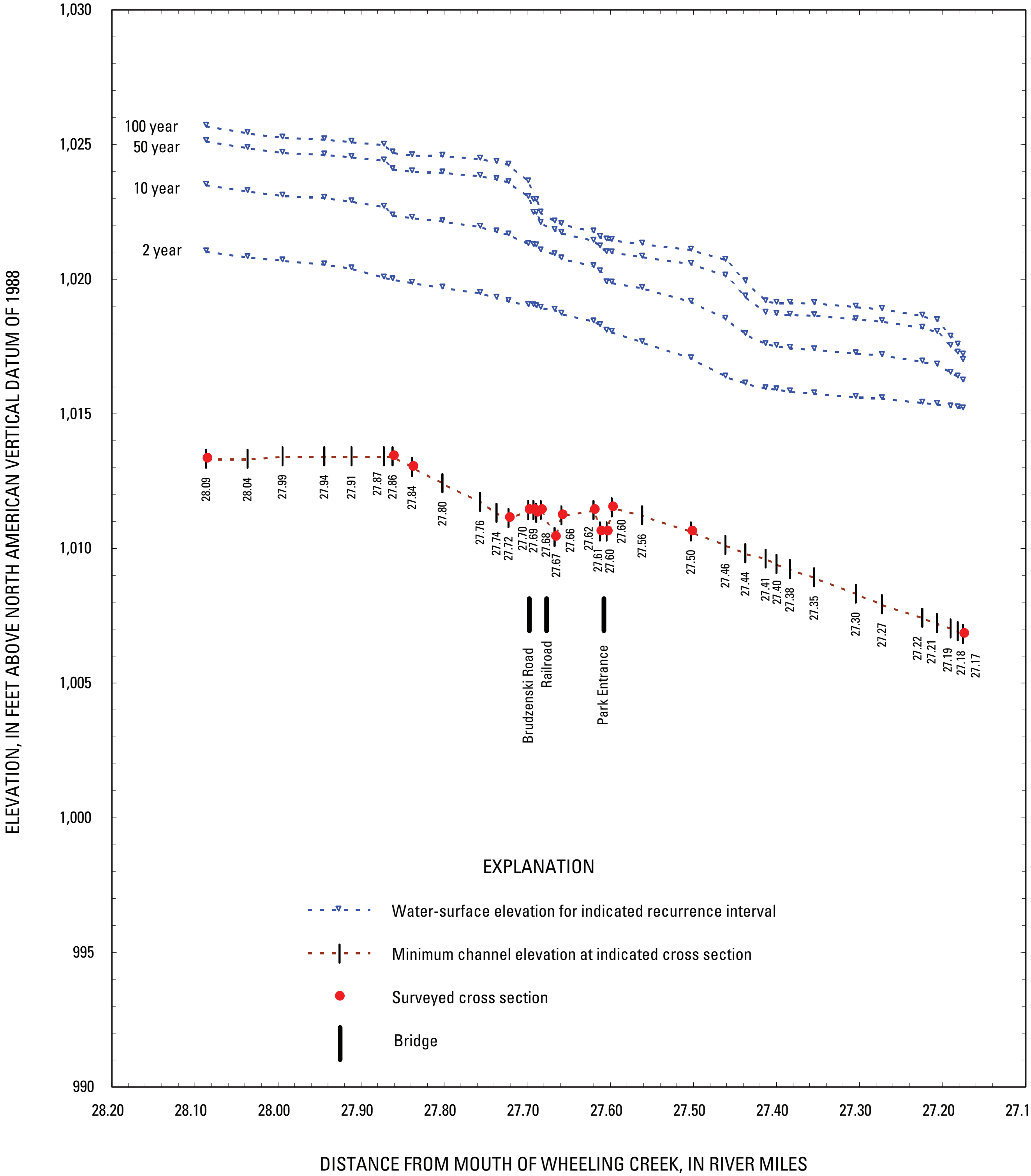
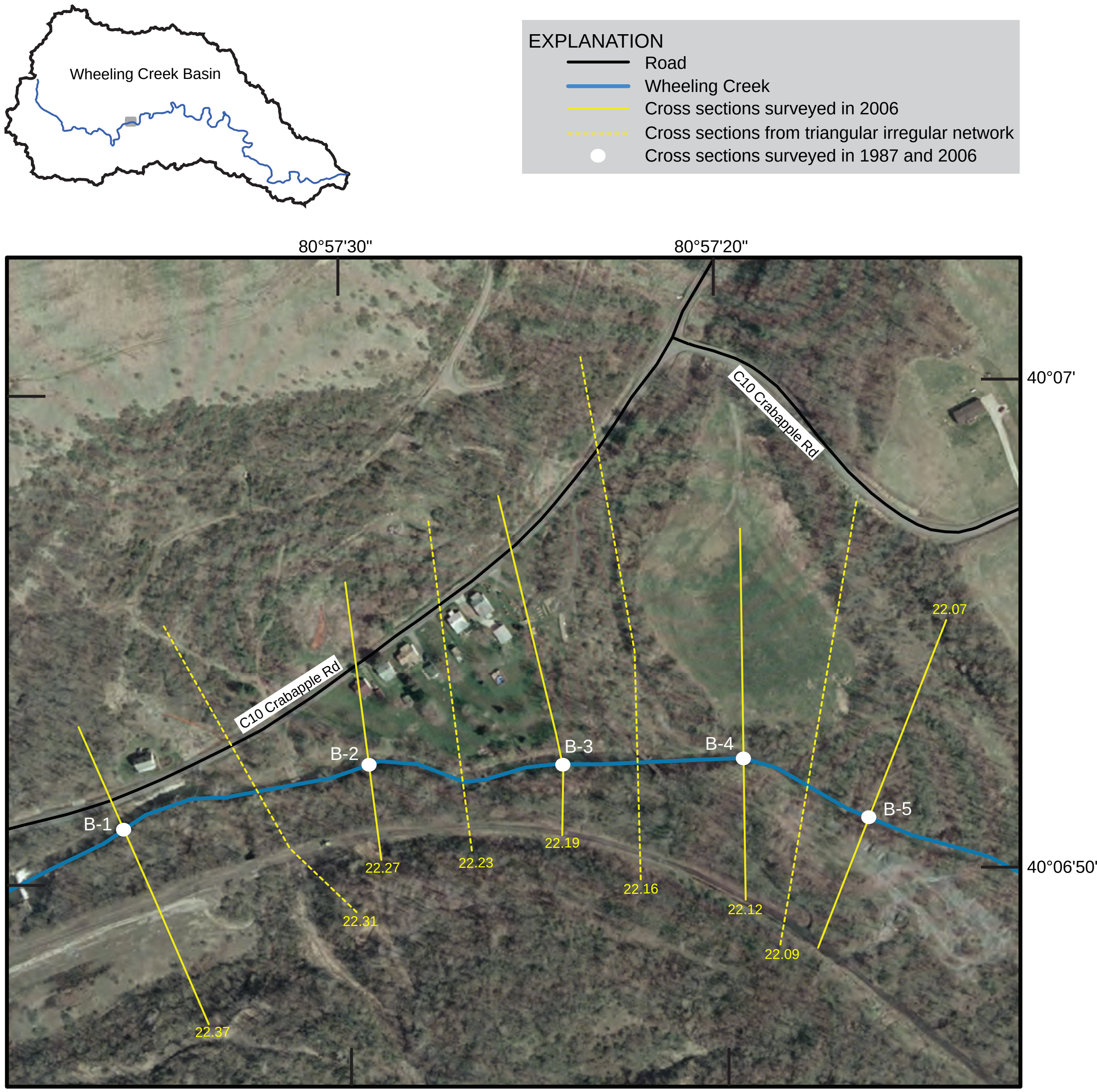


Figure 2b. Water-surface profiles estimated from step-backwater models for existing conditions of dredged reach of Wheeling Creek in the community of Lafferty, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek.



Base digital orthophoto from Belmont County,
Base digital line graph from Belmont County, scale 1:2,400
Other digital data from U.S. Geological Survey,
State Plane Ohio South Projection

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Figure 3a. Locations of cross sections used to create step-backwater model of dredged reach of Wheeling Creek in the community of Crabapple, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek in yellow. Sites are labeled in white.

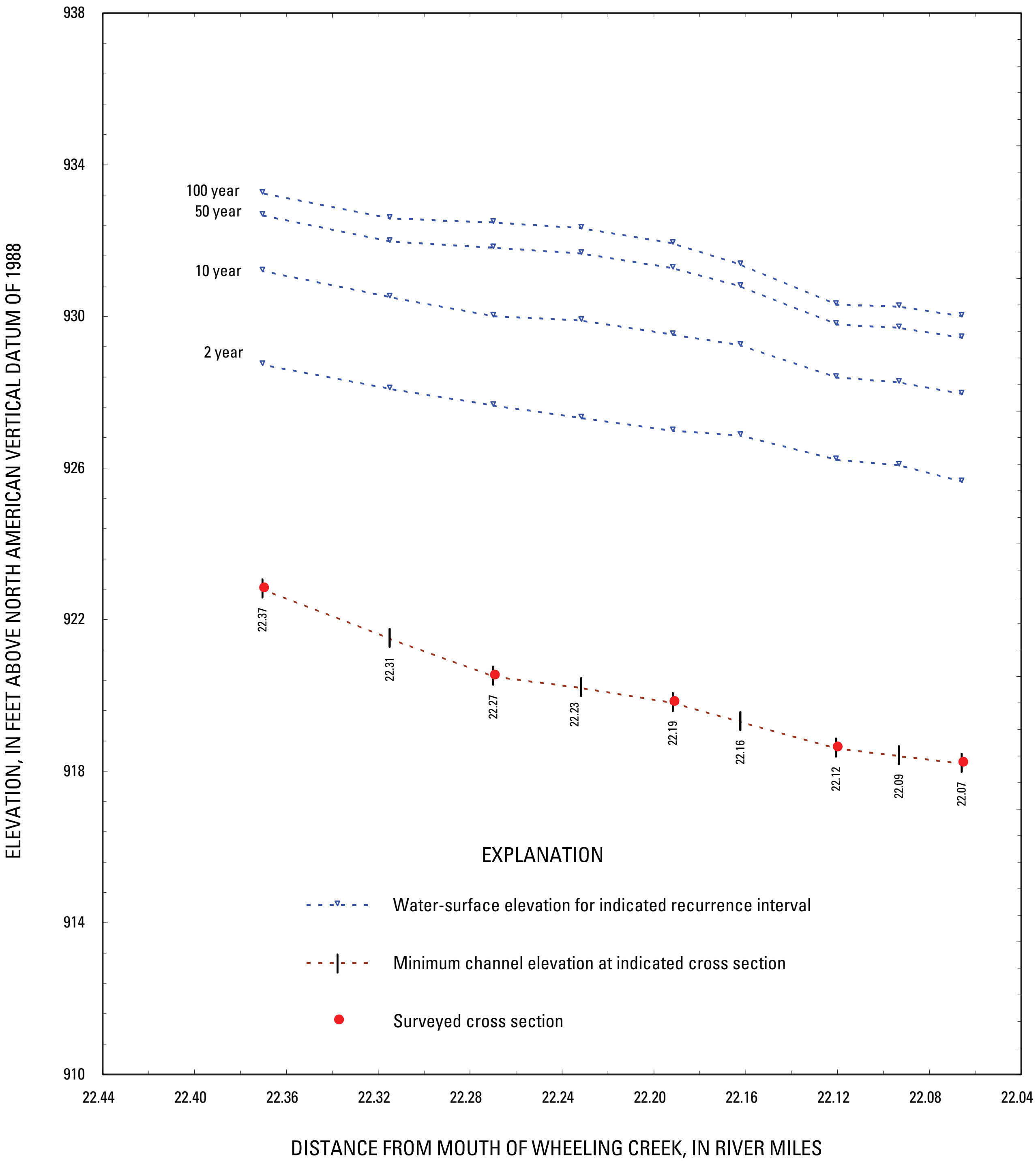
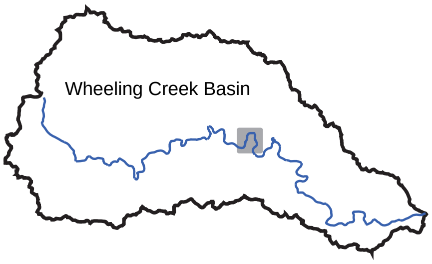
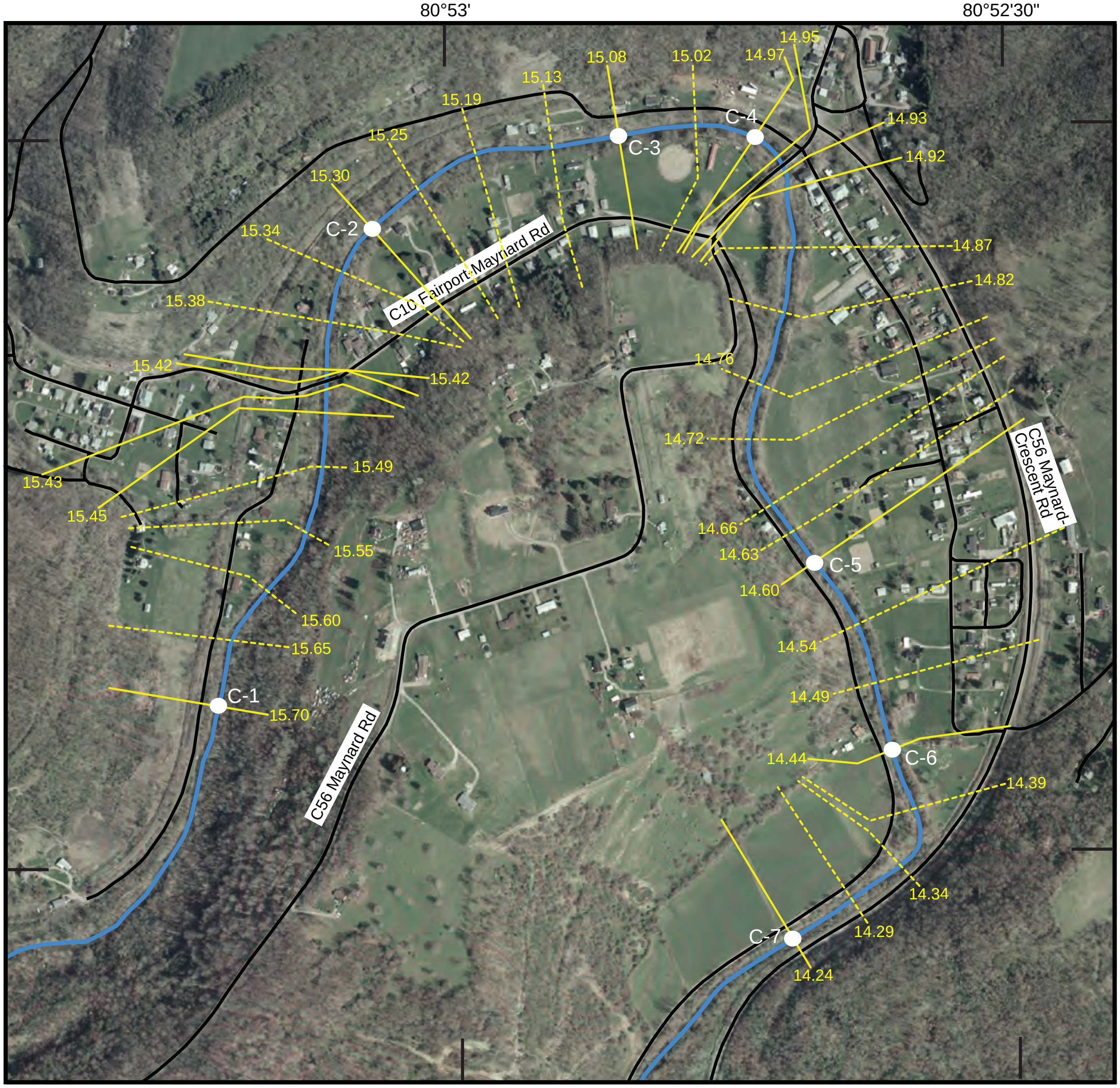


Figure 3b. Water-surface profiles estimated from step-backwater models for existing conditions of dredged reach of Wheeling Creek in the community of Crabapple, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek.



EXPLANATION
- Road
- Wheeling Creek
- Cross sections surveyed in 2006
- Cross sections from triangular irregular network
- Cross sections surveyed in 1987 and 2006



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Other digital data from U.S. Geological Survey,
State Plane Ohio South Projection

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Figure 4a. Locations of cross sections used to create step-backwater model of dredged reach of Wheeling Creek in the community of Maynard, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek in yellow. Sites are labeled in white.

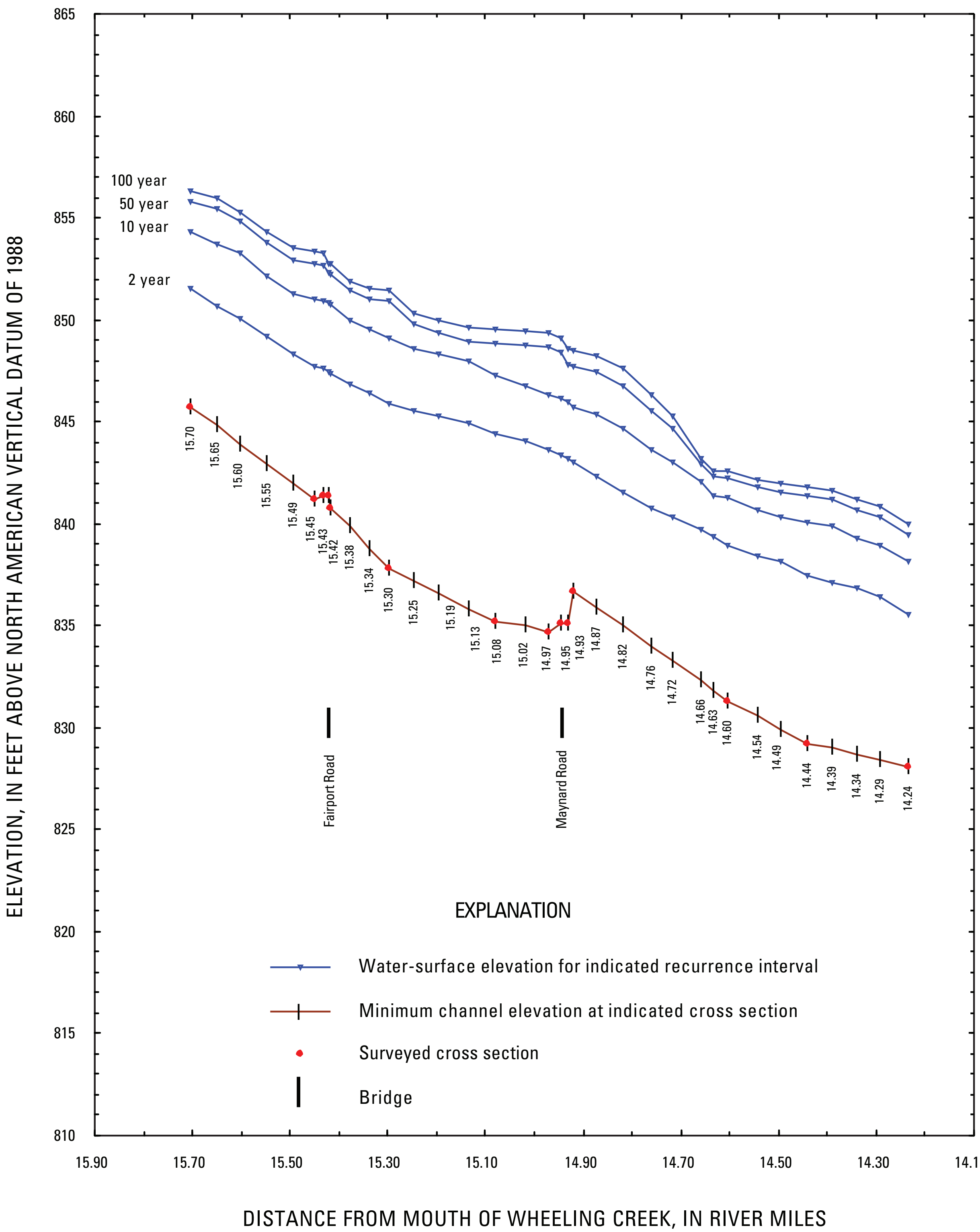
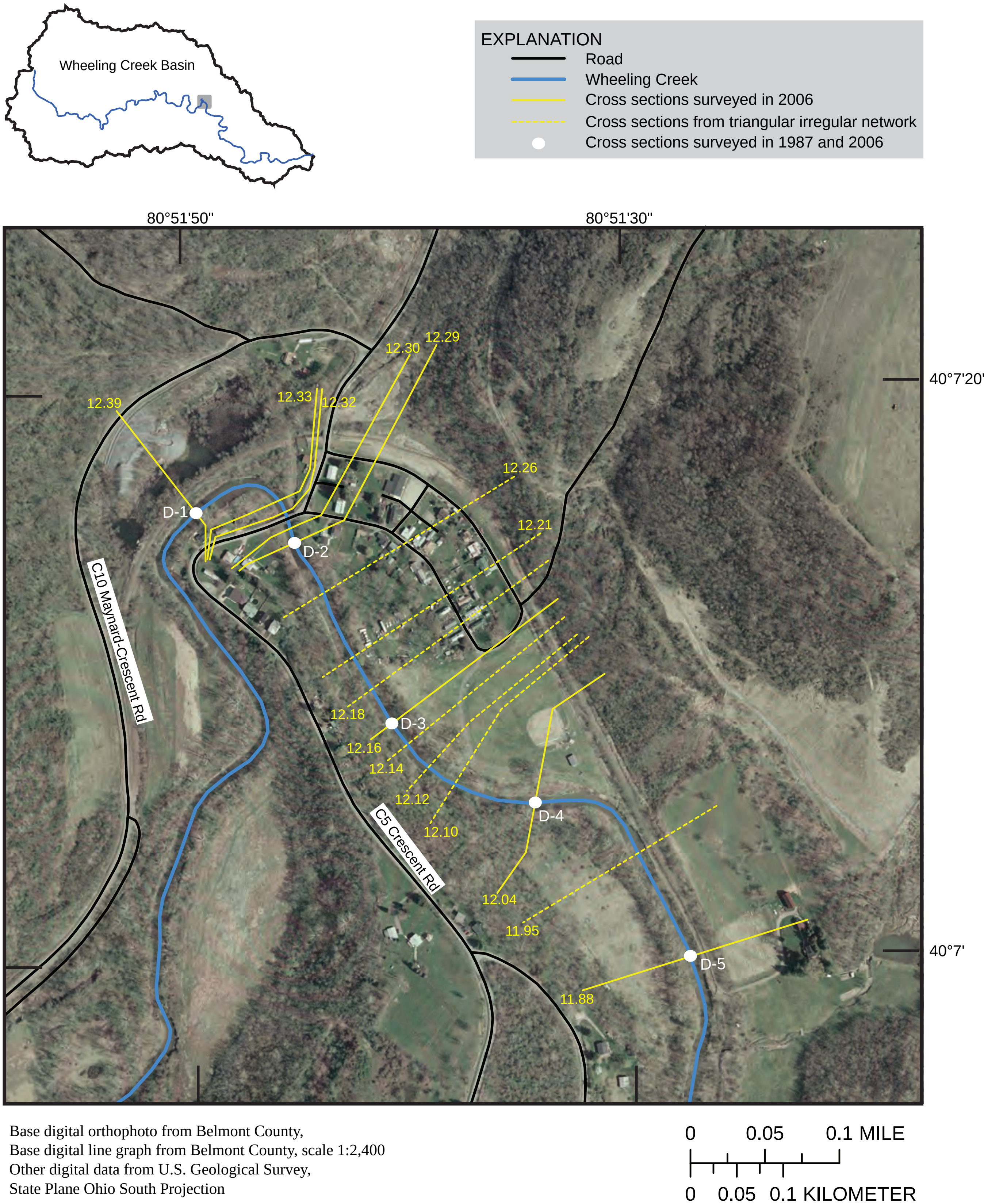


Figure 4b. Water-surface profiles estimated from step-backwater models for existing conditions of dredged reach of Wheeling Creek in the community of Maynard, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek.



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Other digital data from U.S. Geological Survey,
State Plane Ohio South Projection

Figure 5a. Locations of cross sections used to create step-backwater model of dredged reach of Wheeling Creek in the community of Crescent, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek in yellow. Sites are labeled in white.

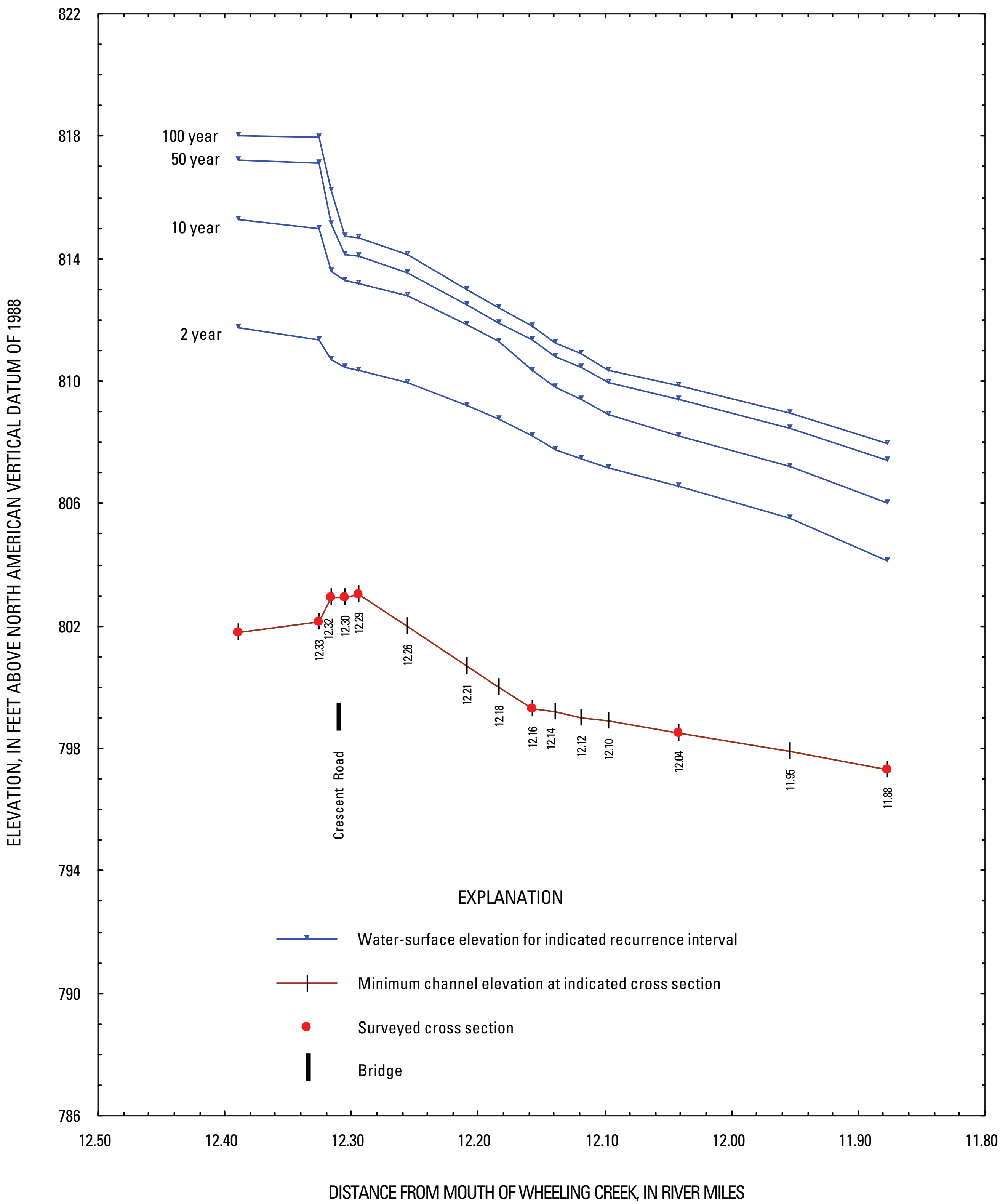


Figure 5b. Water-surface profiles estimated from step-backwater models for existing conditions of dredged reach of Wheeling Creek in the community of Crescent, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek.

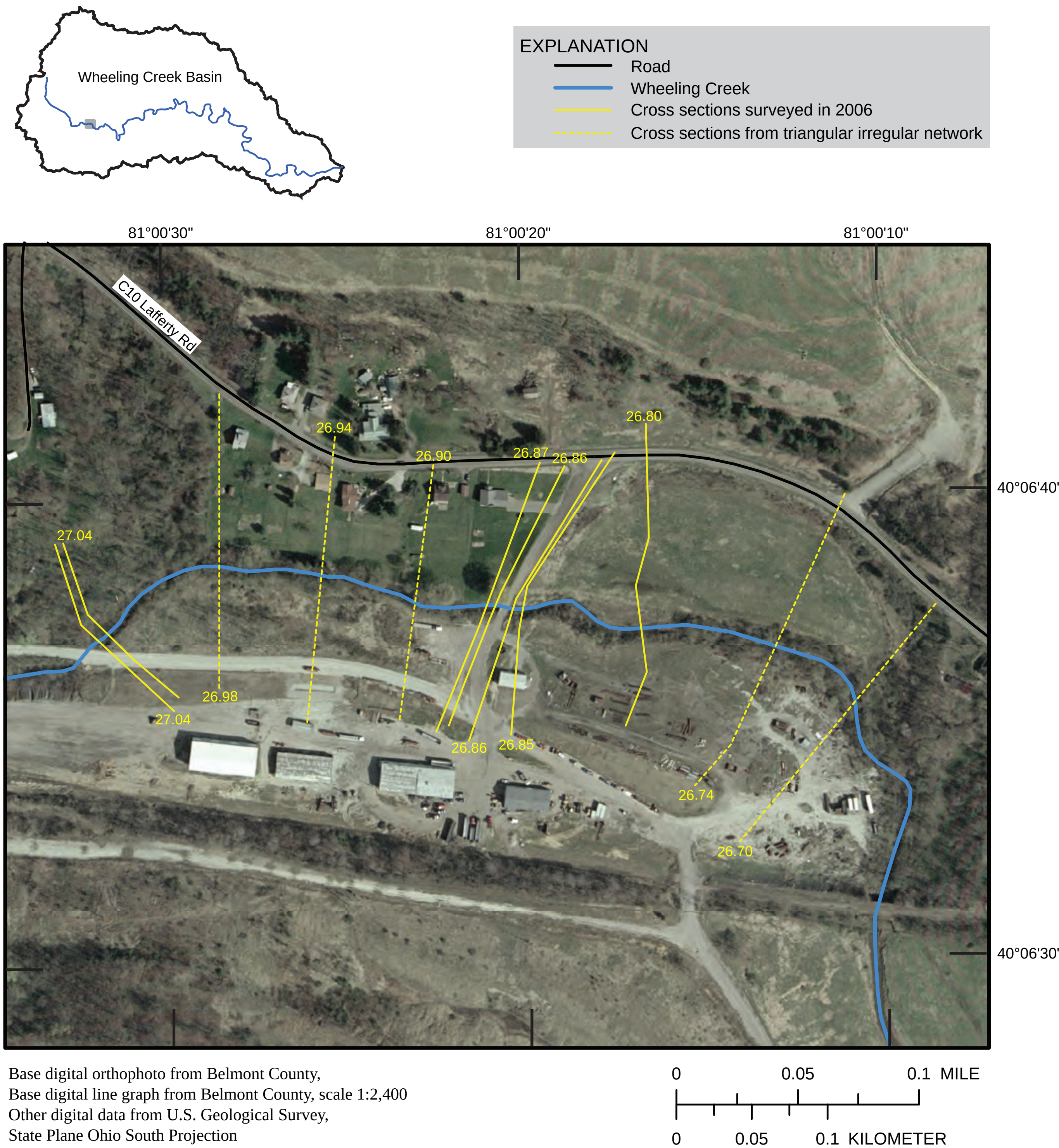


Figure 17a. Locations of cross sections used to create step-backwater model of undredged reach of Wheeling Creek below the community of Lafferty, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek in yellow. Site is labeled in white.

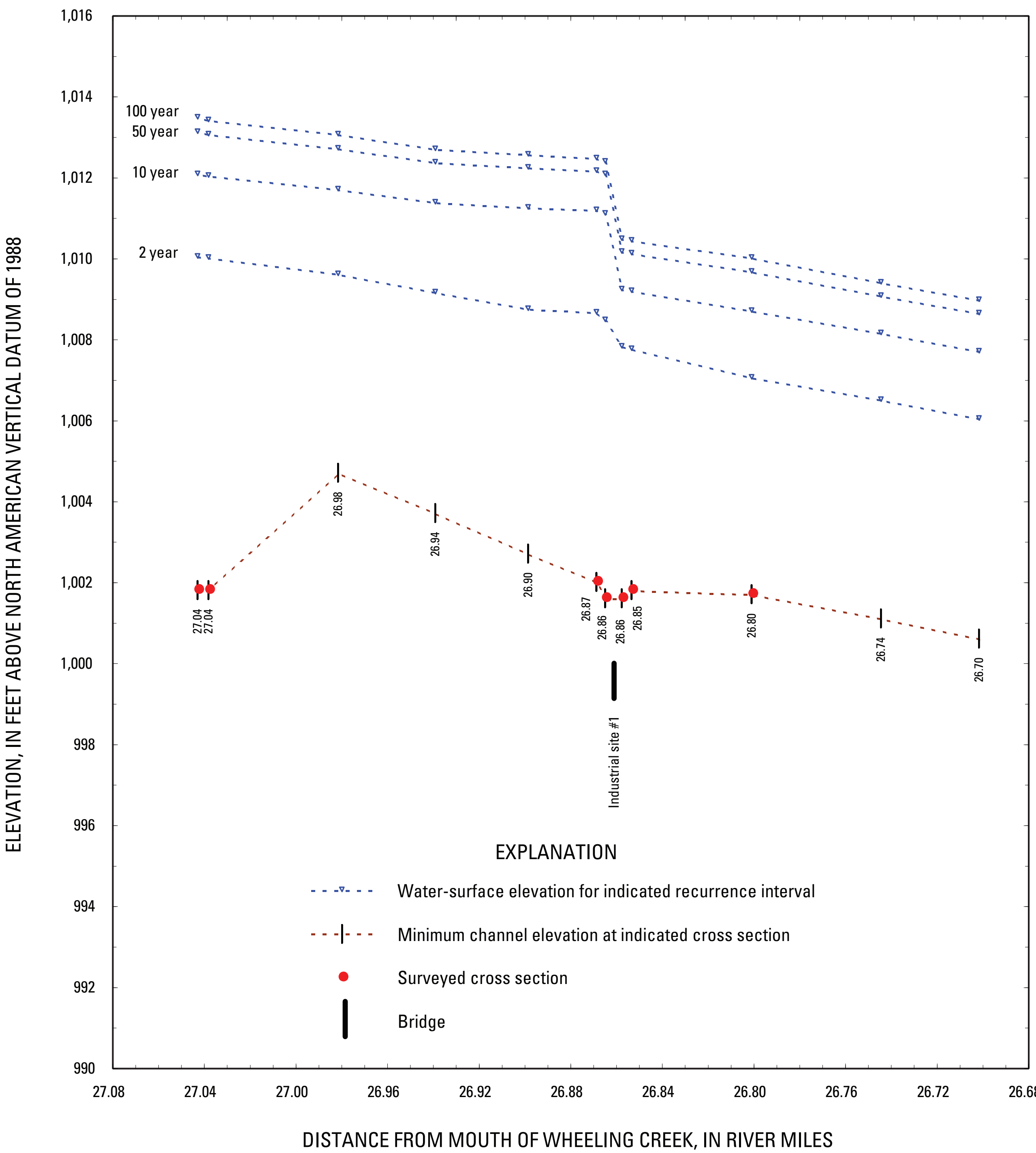


Figure 17b. Water-surface profiles estimated from step-backwater models for existing conditions of undredged reach of Wheeling Creek below the community of Lafferty, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek.

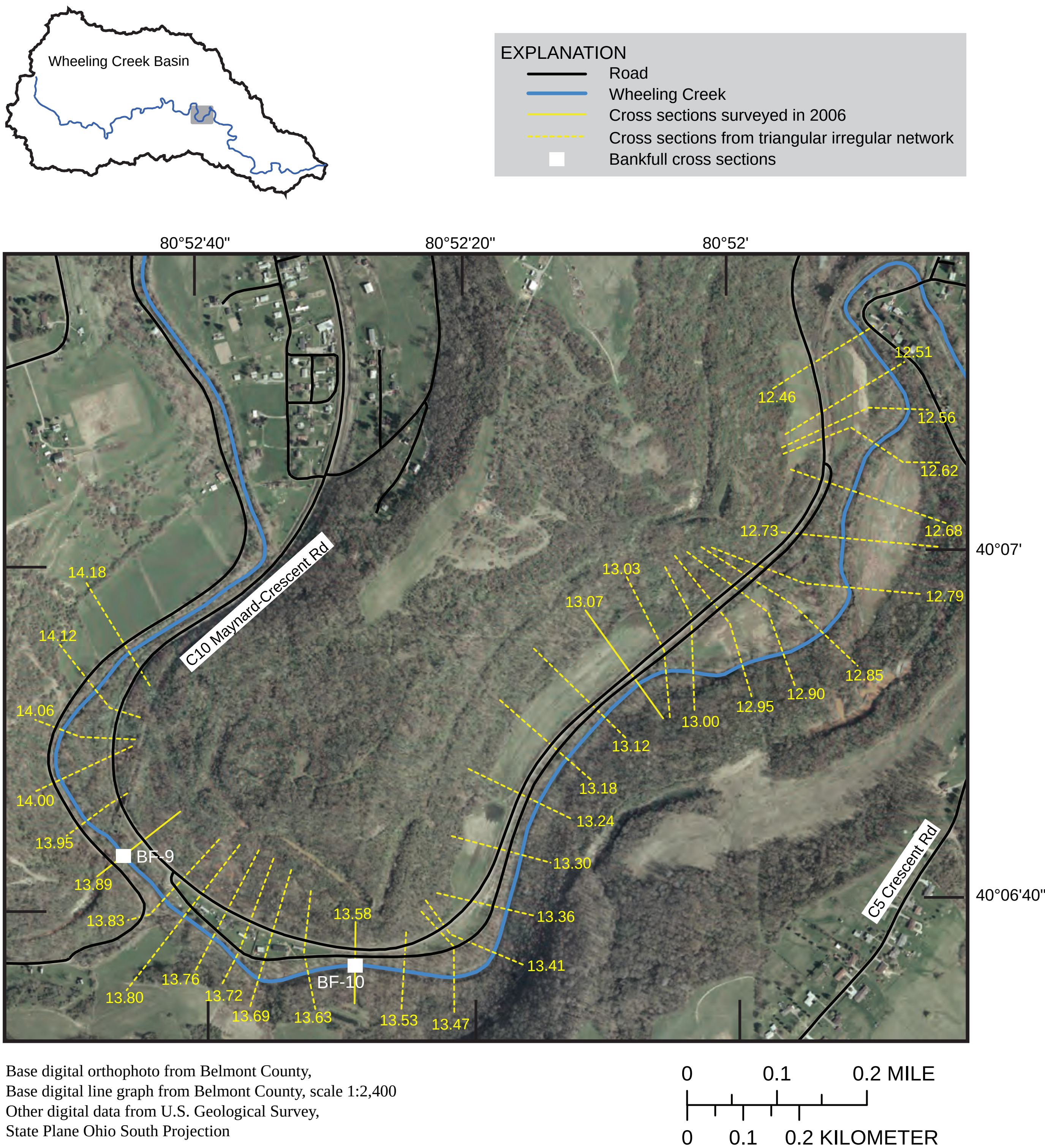


Figure 18a. Locations of cross sections used to create step-backwater model of undredged reach of Wheeling Creek between the communities of Maynard and Crescent, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek in yellow. Sites are labeled in white.

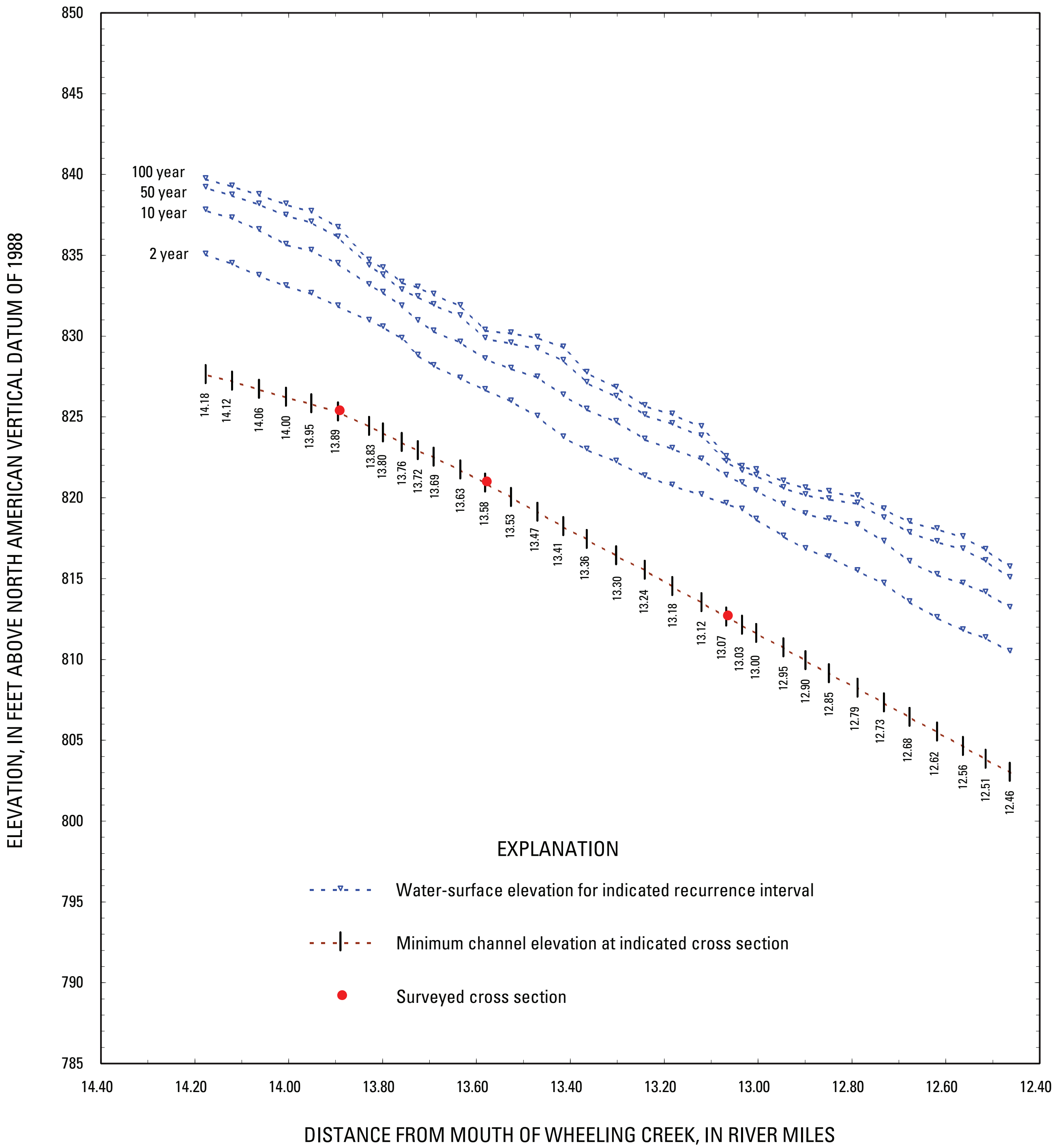
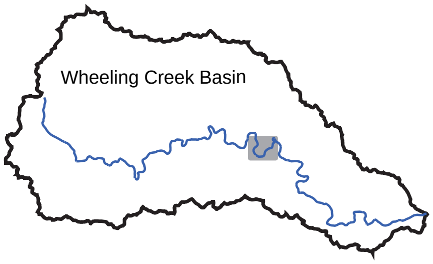
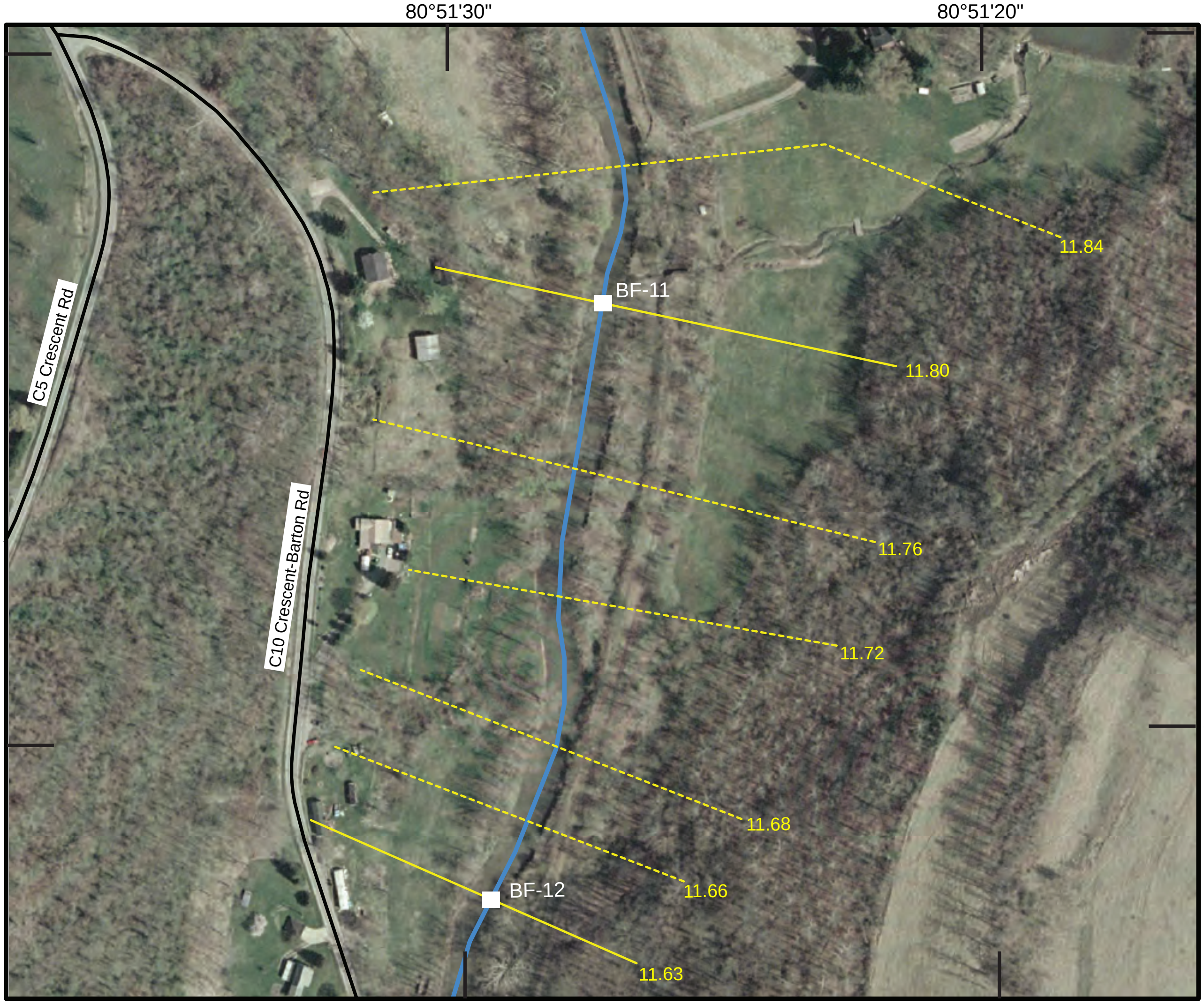


Figure 18b. Water-surface profiles estimated from step-backwater models for existing conditions of undredged reach of Wheeling Creek between the communities of Maynard and Crescent, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek.



EXPLANATION
Road
Wheeling Creek
Cross sections surveyed in 2006
Cross sections from triangular irregular network
Bankfull cross sections



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Base digital line graph from Belmont County, scale 1:2,400
Other digital data from U.S. Geological Survey,
State Plane Ohio South Projection

0 0.05 0.1 MILE
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Figure 19a. Locations of cross sections used to create step-backwater model of undredged reach of Wheeling Creek below the community of Crescent, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek in yellow. Sites are labeled in white.

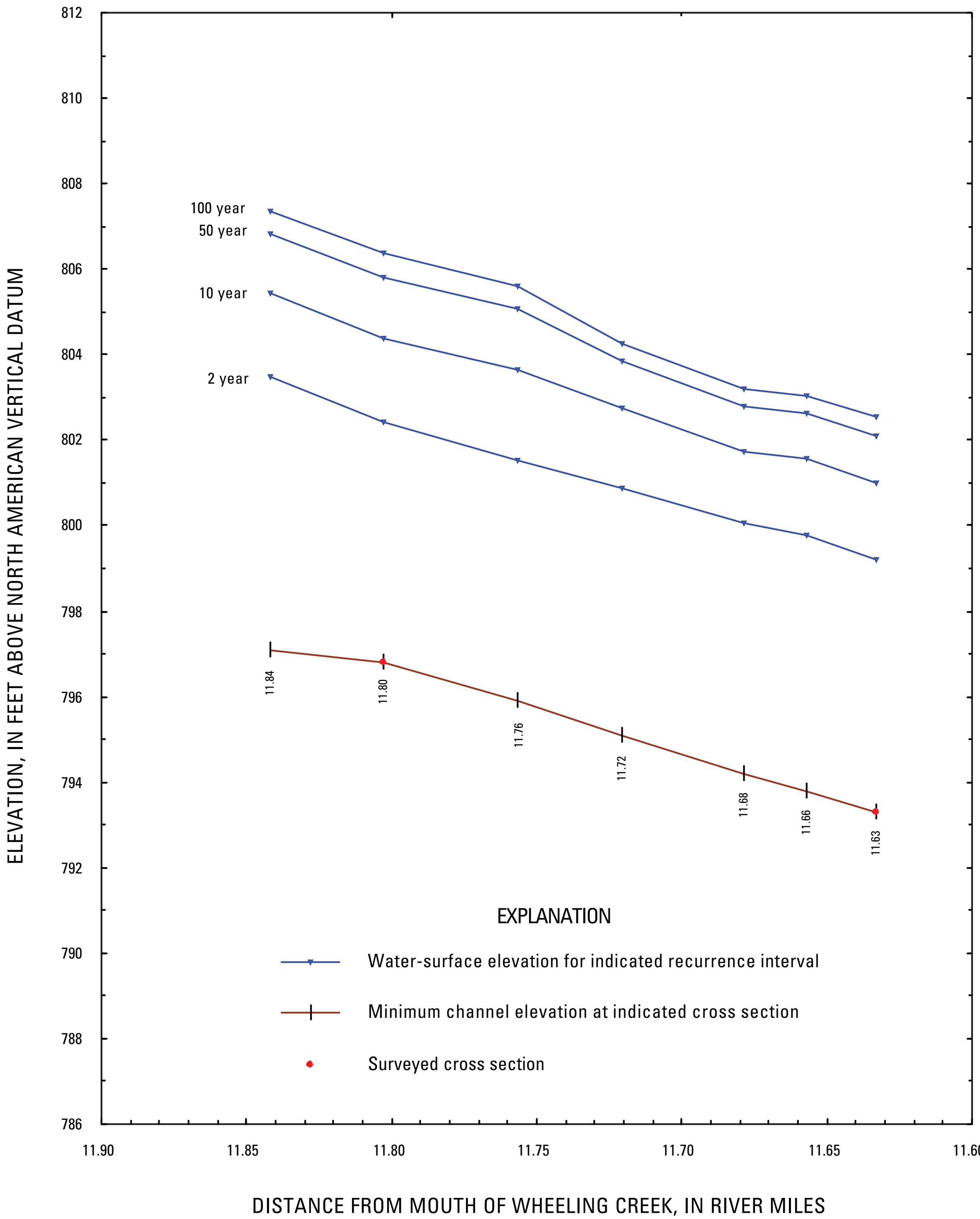

Figure 19b. Water-surface profiles estimated from step-backwater models for existing conditions of undredged reach of Wheeling Creek below the community of Crescent, Ohio. Cross sections are labeled in river miles from the mouth of Wheeling Creek.

Data Tables

Table 8. Flood elevations for simulated levee conditions, current conditions, and the change in water-surface elevations from the current conditions for indicated recurrence intervals in previously dredged reaches near Lafferty, Wheeling Creek, Belmont County, Ohio.

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Site code	Water-surface elevation, in feet, for simulated levee, current conditions, and the difference in water-surface elevations of simulated levee condition from current-condition profiles											
		2 year			10 year			50 year			100 year		
		Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)
28.09	A-1	1021.03	1021.01	0.02	1023.91	1023.48	0.43	1025.97	1025.11	0.86	1026.76	1025.68	1.08
28.04	cross section	1020.83	1020.80	0.03	1023.70	1023.25	0.45	1025.77	1024.85	0.92	1026.56	1025.41	1.15
27.99	cross section	1020.71	1020.68	0.03	1023.59	1023.09	0.50	1025.68	1024.68	1.00	1026.48	1025.24	1.24
27.94	cross section	1020.53	1020.53	0.00	1023.39	1023.00	0.39	1025.45	1024.61	0.84	1026.24	1025.18	1.06
27.91	cross section	1020.39	1020.38	0.01	1023.20	1022.87	0.33	1025.25	1024.52	0.73	1026.04	1025.09	0.95
27.87	cross section	1020.05	1020.04	0.01	1022.86	1022.67	0.19	1024.93	1024.39	0.54	1025.73	1024.97	0.76
27.86	cross section	1019.99	1019.98	0.01	1022.73	1022.35	0.38	1024.71	1024.07	0.64	1025.48	1024.69	0.79
27.84	cross section	1019.86	1019.85	0.01	1022.60	1022.26	0.34	1024.61	1023.98	0.63	1025.39	1024.59	0.80
27.80	cross section	1019.68	1019.67	0.01	1022.34	1022.13	0.21	1024.30	1023.95	0.35	1025.06	1024.57	0.49
27.76	cross section	1019.48	1019.47	0.01	1022.02	1021.93	0.09	1023.98	1023.82	0.16	1024.74	1024.46	0.28
27.74	cross section	1019.30	1019.29	0.01	1021.70	1021.75	-0.05	1023.59	1023.70	-0.11	1024.34	1024.34	0.00
27.72	A-2	1019.19	1019.17	0.02	1021.57	1021.64	-0.07	1023.51	1023.59	-0.08	1024.27	1024.23	0.04
27.70	cross section	1019.04	1019.02	0.02	1021.36	1021.28	0.08	1023.22	1023.03	0.19	1023.95	1023.61	0.34
27.70	Brudzenski Road, Bridge												
27.69	cross section	1019.03	1019.01	0.02	1021.33	1021.25	0.08	1022.57	1022.45	0.12	1023.06	1022.92	0.14
27.69	cross section	1019.00	1018.98	0.02	1021.31	1021.24	0.07	1022.56	1022.45	0.11	1023.05	1022.92	0.13
27.68	cross section	1018.94	1018.92	0.02	1021.15	1021.05	0.10	1022.26	1022.07	0.19	1022.68	1022.46	0.22
27.68	Railroad, Bridge												
27.67	cross section	1018.87	1018.85	0.02	1021.02	1020.91	0.11	1022.01	1021.81	0.20	1022.37	1022.12	0.25
27.66	cross section	1018.73	1018.70	0.03	1020.86	1020.75	0.11	1021.82	1021.70	0.12	1022.17	1022.03	0.14
27.62	cross section	1018.45	1018.41	0.04	1020.59	1020.47	0.12	1021.53	1021.41	0.12	1021.89	1021.75	0.14
27.61	cross section	1018.30	1018.27	0.03	1020.44	1020.27	0.17	1021.41	1021.20	0.21	1021.79	1021.55	0.24

Table 8. Flood elevations for simulated levee conditions, current conditions, and the change in water-surface elevations from the current conditions for indicated recurrence intervals in previously dredged reaches near Lafferty, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Site code	Water-surface elevation, in feet, for simulated levee, current conditions, and the difference in water-surface elevations of simulated levee condition from current-condition profiles											
		2 year			10 year			50 year			100 year		
		Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)
27.61	Park Entrance, Bridge												
27.60	cross section	1018.10	1018.07	0.03	1020.14	1019.87	0.27	1021.28	1020.99	0.29	1021.73	1021.46	0.27
27.60	cross section	1018.06	1018.02	0.04	1020.13	1019.86	0.27	1021.27	1020.98	0.29	1021.72	1021.44	0.28
27.56	cross section	1017.64	1017.64	0.00	1019.61	1019.65	-0.04	1020.73	1020.82	-0.09	1021.20	1021.30	-0.10
27.50	A-3	1017.04	1017.04	0.00	1019.14	1019.14	0.00	1020.55	1020.55	0.00	1021.08	1021.08	0.00
27.46	cross section	1016.37	1016.37	0.00	1018.51	1018.51	0.00	1020.12	1020.12	0.00	1020.70	1020.70	0.00
27.44	cross section	1016.11	1016.11	0.00	1017.94	1017.94	0.00	1019.34	1019.34	0.00	1019.90	1019.90	0.00
27.41	cross section	1015.94	1015.93	0.01	1017.57	1017.57	0.00	1018.74	1018.74	0.00	1019.16	1019.16	0.00
27.40	cross section	1015.90	1015.90	0.00	1017.51	1017.51	0.00	1018.69	1018.69	0.00	1019.11	1019.11	0.00
27.38	cross section	1015.81	1015.81	0.00	1017.43	1017.43	0.00	1018.66	1018.66	0.00	1019.11	1019.11	0.00
27.35	cross section	1015.74	1015.74	0.00	1017.38	1017.38	0.00	1018.64	1018.64	0.00	1019.10	1019.10	0.00
27.30	cross section	1015.62	1015.61	0.01	1017.23	1017.23	0.00	1018.50	1018.50	0.00	1018.96	1018.96	0.00
27.27	cross section	1015.56	1015.56	0.00	1017.16	1017.16	0.00	1018.42	1018.42	0.00	1018.88	1018.88	0.00
27.22	cross section	1015.41	1015.40	0.01	1016.92	1016.92	0.00	1018.17	1018.18	-0.01	1018.63	1018.63	0.00
27.21	cross section	1015.36	1015.35	0.01	1016.81	1016.81	0.00	1018.02	1018.02	0.00	1018.46	1018.46	0.00
27.19	cross section	1015.27	1015.26	0.01	1016.50	1016.51	-0.01	1017.51	1017.51	0.00	1017.85	1017.85	0.00
27.18	cross section	1015.22	1015.22	0.00	1016.36	1016.37	-0.01	1017.26	1017.26	0.00	1017.55	1017.55	0.00
27.17	A-4	1015.18	1015.18	0.00	1016.22	1016.22	0.00	1016.98	1016.98	0.00	1017.18	1017.18	0.00

Table 9. Flood elevations for simulated levee conditions, current conditions, and the change in water-surface elevations from the current conditions for indicated recurrence interval in previously dredged reaches near Crabapple, Wheeling Creek, Belmont County, Ohio.

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Site code	Water-surface elevation, in feet, for simulated levee, current conditions, and the difference in water-surface elevations of simulated levee condition from current-condition profiles											
		2 year			10 year			50 year			100 year		
		Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)
22.37	B-1	928.73	928.73	0.00	931.41	931.20	0.21	933.29	932.67	0.62	934.00	933.25	0.75
22.31	cross section	928.09	928.09	0.00	930.82	930.51	0.31	932.70	931.98	0.72	933.42	932.59	0.83
22.27	B-2	927.65	927.65	0.00	930.42	930.01	0.41	932.37	931.81	0.56	933.11	932.48	0.63
22.23	cross section	927.33	927.32	0.01	929.94	929.89	0.05	931.64	931.66	-0.02	932.27	932.33	-0.06
22.19	B-3	926.99	926.98	0.01	929.53	929.52	0.01	931.18	931.27	-0.09	931.79	931.93	-0.14
22.16	cross section	926.87	926.86	0.01	929.39	929.24	0.15	931.03	930.79	0.24	931.64	931.37	0.27
22.12	B-4	926.23	926.22	0.01	928.58	928.39	0.19	930.10	929.79	0.31	930.68	930.32	0.36
22.09	cross section	926.09	926.08	0.01	928.48	928.26	0.22	930.07	929.70	0.37	930.68	930.26	0.42
22.07	B-5	925.64	925.64	0.00	927.95	927.95	0.00	929.44	929.44	0.00	930.01	930.01	0.00

Table 10. Flood elevations for simulated levee conditions, current conditions, and the change in water-surface elevations from the current conditions for indicated recurrence intervals in previously dredged reaches near Maynard, Wheeling Creek, Belmont County, Ohio.

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Site code	Water-surface elevation, in feet, for simulated levee, current conditions, and the difference in water-surface elevations of simulated levee condition from current-condition profiles											
		2 year			10 year			50 year			100 year		
		Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)
15.70	C-1	851.55	851.57	-0.02	854.25	854.29	-0.04	856.34	855.82	0.52	857.19	856.28	0.91
15.65	cross section	850.59	850.64	-0.05	853.69	853.70	-0.01	856.23	855.46	0.77	857.19	855.98	1.21
15.60	cross section	849.95	850.02	-0.07	853.23	853.25	-0.02	855.79	854.87	0.92	856.74	855.30	1.44
15.55	cross section	849.06	849.18	-0.12	852.15	852.18	-0.03	854.67	853.76	0.91	855.56	854.30	1.26
15.49	cross section	848.17	848.30	-0.13	851.27	851.23	0.04	853.85	852.94	0.91	854.76	853.56	1.20
15.45	cross section	847.52	847.67	-0.15	850.88	851.02	-0.14	853.68	852.78	0.90	854.64	853.37	1.27
15.43	cross section	847.40	847.63	-0.23	850.84	850.96	-0.12	853.67	852.68	0.99	854.64	853.26	1.38
15.43	Fairport Road, Bridge												
15.42	cross section	847.24	847.48	-0.24	850.74	850.85	-0.11	853.02	852.29	0.73	853.88	852.76	1.12
15.42	cross section	847.09	847.32	-0.23	850.47	850.73	-0.26	852.66	852.27	0.39	853.47	852.76	0.71
15.38	cross section	846.56	846.80	-0.24	849.86	849.99	-0.13	851.98	851.41	0.57	852.77	851.87	0.90
15.34	cross section	846.15	846.39	-0.24	849.42	849.52	-0.10	851.56	850.97	0.59	852.38	851.49	0.89
15.30	C-2	845.65	845.89	-0.24	848.91	849.14	-0.23	851.03	850.90	0.13	851.83	851.47	0.36
15.25	cross section	845.34	845.58	-0.24	848.47	848.59	-0.12	850.52	849.81	0.71	851.30	850.34	0.96
15.19	cross section	845.06	845.31	-0.25	848.18	848.29	-0.11	850.25	849.40	0.85	851.04	850.00	1.04
15.13	cross section	844.67	844.91	-0.24	847.66	847.93	-0.27	849.66	848.96	0.70	850.41	849.58	0.83
15.08	C-3	844.19	844.43	-0.24	847.14	847.28	-0.14	849.17	848.84	0.33	849.92	849.51	0.41
15.02	cross section	843.83	844.08	-0.25	846.67	846.79	-0.12	848.62	848.74	-0.12	849.36	849.43	-0.07
14.97	C-4	843.36	843.63	-0.27	846.23	846.33	-0.10	848.19	848.66	-0.47	848.93	849.37	-0.44
14.95	cross section	843.10	843.40	-0.30	846.02	846.11	-0.09	847.98	848.40	-0.42	848.72	849.14	-0.42

Table 10. Flood elevations for simulated levee conditions, current conditions, and the change in water-surface elevations from the current conditions for indicated recurrence intervals in previously dredged reaches near Maynard, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Site code	Water-surface elevation, in feet, for simulated levee, current conditions, and the difference in water-surface elevations of simulated levee condition from current-condition profiles											
		2 year			10 year			50 year			100 year		
		Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)
14.94	Maynard Road, Bridge												
14.93	cross section	842.89	843.22	-0.33	845.88	845.98	-0.10	847.85	847.79	0.06	848.59	848.55	0.04
14.92	cross section	842.71	843.06	-0.35	845.70	845.73	-0.03	847.65	847.74	-0.09	848.39	848.51	-0.12
14.87	cross section	841.95	842.29	-0.34	845.08	845.33	-0.25	847.10	847.41	-0.31	847.84	848.21	-0.37
14.82	cross section	841.22	841.57	-0.35	844.46	844.64	-0.18	846.48	846.77	-0.29	847.21	847.60	-0.39
14.76	cross section	840.44	840.78	-0.34	843.68	843.63	0.05	845.69	845.52	0.17	846.40	846.28	0.12
14.72	cross section	839.96	840.29	-0.33	843.20	843.02	0.18	845.04	844.63	0.41	845.68	845.30	0.38
14.66	cross section	839.39	839.70	-0.31	842.49	842.04	0.45	844.07	842.95	1.12	844.67	843.23	1.44
14.63	cross section	839.06	839.34	-0.28	842.03	841.40	0.63	843.70	842.30	1.40	844.33	842.59	1.74
14.60	C-5	838.58	838.90	-0.32	841.40	841.25	0.15	842.85	842.22	0.63	843.38	842.55	0.83
14.54	cross section	838.14	838.43	-0.29	840.81	840.64	0.17	842.07	841.77	0.30	842.53	842.19	0.34
14.49	cross section	837.85	838.11	-0.26	840.37	840.30	0.07	841.43	841.52	-0.09	841.80	841.98	-0.18
14.44	C-6	837.20	837.45	-0.25	839.76	840.08	-0.32	840.95	841.34	-0.39	841.39	841.80	-0.41
14.39	cross section	836.89	837.11	-0.22	839.55	839.90	-0.35	840.84	841.19	-0.35	841.30	841.65	-0.35
14.34	cross section	836.66	836.85	-0.19	839.15	839.31	-0.16	840.50	840.66	-0.16	840.99	841.15	-0.16
14.29	cross section	836.30	836.45	-0.15	838.82	838.95	-0.13	840.22	840.36	-0.14	840.74	840.88	-0.14
14.24	C-7	835.57	835.57	0.00	838.13	838.13	0.00	839.48	839.48	0.00	840.00	840.00	0.00

Table 11. Flood elevations for simulated levee conditions, current conditions, and the change in water-surface elevations from the current conditions for indicated recurrence intervals in previously dredged reaches near Crescent, Wheeling Creek, Belmont County, Ohio.

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Site code	Water-surface elevation, in feet, for simulated levee, current conditions, and the difference in water-surface elevations of simulated levee condition from current-condition profiles											
		2 year			10 year			50 year			100 year		
		Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)	Levee (feet)	Current (feet)	Difference (feet)
12.39	D-1	811.53	811.73	-0.20	814.54	815.27	-0.73	817.70	817.21	0.49	817.89	818.01	-0.12
12.33	cross section	811.05	811.32	-0.27	814.15	815.00	-0.85	817.48	817.13	0.35	817.63	817.96	-0.33
12.32	cross section	810.71	810.71	0.00	813.60	813.60	0.00	817.10	815.15	1.95	817.11	816.21	0.90
12.31	Crescent Road, Bridge												
12.30	cross section	810.44	810.44	0.00	813.30	813.30	0.00	815.33	814.11	1.22	816.14	814.71	1.43
12.29	D-2	810.34	810.34	0.00	813.19	813.19	0.00	815.18	814.10	1.08	815.94	814.69	1.25
12.26	cross section	809.93	809.93	0.00	812.78	812.78	0.00	814.76	813.56	1.20	815.52	814.13	1.39
12.21	cross section	809.21	809.21	0.00	811.82	811.82	0.00	813.63	812.47	1.16	814.34	812.97	1.37
12.18	cross section	808.75	808.75	0.00	811.30	811.30	0.00	813.07	811.91	1.16	813.76	812.39	1.37
12.16	D-3	808.19	808.19	0.00	810.34	810.34	0.00	811.67	811.32	0.35	812.17	811.78	0.39
12.14	cross section	807.77	807.77	0.00	809.80	809.80	0.00	811.08	810.80	0.28	811.55	811.24	0.31
12.12	cross section	807.46	807.46	0.00	809.39	809.39	0.00	810.57	810.44	0.13	811.01	810.88	0.13
12.10	cross section	807.14	807.14	0.00	808.91	808.91	0.00	809.96	809.93	0.03	810.35	810.35	0.00
12.04	D-4	806.54	806.54	0.00	808.23	808.23	0.00	809.36	809.38	-0.02	809.81	809.84	-0.03
11.95	cross section	805.53	805.53	0.00	807.21	807.21	0.00	808.45	808.45	0.00	808.95	808.95	0.00
11.88	D-5	804.10	804.10	0.00	806.03	806.03	0.00	807.41	807.41	0.00	807.95	807.95	0.00

Table 13. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach below Lafferty, Wheeling Creek, Belmont County, Ohio.

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
27.04	+ 2.0	1010.97	0.93	1012.65	0.57	1013.58	0.46	1013.91	0.43
	+ 1.0	1010.49	0.45	1012.37	0.29	1013.35	0.23	1013.69	0.21
	Current conditions	1010.04	0.00	1012.08	0.00	1013.12	0.00	1013.48	0.00
	- 1.0	1009.45	-0.59	1011.77	-0.31	1012.89	-0.23	1013.26	-0.22
	- 2.0	1008.87	-1.17	1011.46	-0.62	1012.65	-0.47	1013.05	-0.43
	- 3.0	1008.15	-1.89	1011.01	-1.07	1012.40	-0.72	1012.82	-0.66
	- 4.0	1007.37	-2.67	1010.57	-1.51	1012.15	-0.97	1012.59	-0.89
27.04	+ 2.0	1010.95	0.94	1012.61	0.57	1013.51	0.45	1013.83	0.42
	+ 1.0	1010.47	0.46	1012.33	0.29	1013.29	0.23	1013.62	0.21
	Current conditions	1010.01	0.00	1012.04	0.00	1013.06	0.00	1013.41	0.00
	- 1.0	1009.42	-0.59	1011.73	-0.31	1012.83	-0.23	1013.19	-0.22
	- 2.0	1008.84	-1.17	1011.42	-0.62	1012.59	-0.47	1012.98	-0.43
	- 3.0	1008.11	-1.90	1010.97	-1.07	1012.35	-0.71	1012.75	-0.66
	- 4.0	1007.33	-2.68	1010.52	-1.52	1012.09	-0.97	1012.52	-0.89
26.94	+ 2.0	1010.10	0.94	1011.92	0.54	1012.76	0.39	1013.05	0.35
	+ 1.0	1009.51	0.35	1011.66	0.28	1012.57	0.20	1012.88	0.18
	Current conditions	1009.16	0.00	1011.38	0.00	1012.37	0.00	1012.70	0.00
	- 1.0	1008.58	-0.58	1011.07	-0.31	1012.16	-0.21	1012.51	-0.19
	- 2.0	1008.11	-1.05	1010.76	-0.62	1011.94	-0.43	1012.32	-0.38
	- 3.0	1007.42	-1.74	1010.26	-1.12	1011.71	-0.66	1012.12	-0.58
	- 4.0	1006.67	-2.49	1009.81	-1.57	1011.47	-0.90	1011.90	-0.80
26.90	+ 2.0	1009.92	1.17	1011.81	0.56	1012.62	0.38	1012.90	0.34
	+ 1.0	1009.14	0.39	1011.54	0.29	1012.43	0.19	1012.73	0.17
	Current conditions	1008.75	0.00	1011.25	0.00	1012.24	0.00	1012.56	0.00
	- 1.0	1008.03	-0.72	1010.93	-0.32	1012.03	-0.21	1012.37	-0.19
	- 2.0	1007.60	-1.15	1010.60	-0.65	1011.81	-0.43	1012.18	-0.38
	- 3.0	1006.90	-1.85	1010.02	-1.23	1011.57	-0.67	1011.97	-0.59
	- 4.0	1006.18	-2.57	1009.48	-1.77	1011.31	-0.93	1011.75	-0.81
26.87	+ 2.0	1009.83	1.17	1011.75	0.56	1012.55	0.39	1012.82	0.35
	+ 1.0	1009.05	0.39	1011.48	0.29	1012.36	0.20	1012.65	0.18
	Current conditions	1008.66	0.00	1011.19	0.00	1012.16	0.00	1012.47	0.00
	- 1.0	1007.90	-0.76	1010.86	-0.33	1011.95	-0.21	1012.29	-0.18
	- 2.0	1007.43	-1.23	1010.52	-0.67	1011.73	-0.43	1012.10	-0.37
	- 3.0	1006.58	-2.08	1009.87	-1.32	1011.48	-0.68	1011.88	-0.59
	- 4.0	1005.65	-3.01	1009.31	-1.88	1011.22	-0.94	1011.65	-0.82

Table 13. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach below Lafferty, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
26.86	+ 2.0	1009.63	1.16	1011.69	0.59	1012.48	0.40	1012.76	0.37
	+ 1.0	1008.83	0.36	1011.41	0.31	1012.28	0.20	1012.58	0.19
	Current conditions	1008.47	0.00	1011.10	0.00	1012.08	0.00	1012.39	0.00
	- 1.0	1007.72	-0.75	1010.76	-0.34	1011.86	-0.22	1012.19	-0.20
	- 2.0	1007.28	-1.19	1010.37	-0.73	1011.62	-0.46	1011.99	-0.40
	- 3.0	1006.49	-1.98	1009.55	-1.55	1011.36	-0.72	1011.76	-0.63
	- 4.0	1005.65	-2.82	1009.03	-2.07	1011.08	-1.00	1011.52	-0.87
26.86	Industrial site # 1, Bridge								
26.86	+ 2.0	1008.44	0.62	1009.72	0.49	1010.54	0.38	1010.83	0.35
	+ 1.0	1008.14	0.32	1009.46	0.23	1010.35	0.19	1010.65	0.17
	Current conditions	1007.82	0.00	1009.23	0.00	1010.16	0.00	1010.48	0.00
	- 1.0	1007.50	-0.32	1009.00	-0.23	1009.96	-0.20	1010.30	-0.18
	- 2.0	1007.14	-0.68	1008.87	-0.36	1009.76	-0.40	1010.12	-0.36
	- 3.0	1006.40	-1.42	1008.51	-0.72	1009.56	-0.60	1009.92	-0.56
	- 4.0	1005.57	-2.25	1008.25	-0.98	1009.35	-0.81	1009.73	-0.75
26.85	+ 2.0	1008.36	0.60	1009.68	0.49	1010.50	0.38	1010.79	0.35
	+ 1.0	1008.07	0.31	1009.44	0.25	1010.32	0.20	1010.62	0.18
	Current conditions	1007.76	0.00	1009.19	0.00	1010.12	0.00	1010.44	0.00
	- 1.0	1007.43	-0.33	1008.95	-0.24	1009.92	-0.20	1010.26	-0.18
	- 2.0	1007.06	-0.70	1008.68	-0.51	1009.71	-0.41	1010.07	-0.37
	- 3.0	1006.30	-1.46	1008.43	-0.76	1009.50	-0.62	1009.87	-0.57
	- 4.0	1005.46	-2.30	1008.16	-1.03	1009.28	-0.84	1009.67	-0.77
26.80	+ 2.0	1007.88	0.83	1009.24	0.54	1010.10	0.43	1010.40	0.39
	+ 1.0	1007.51	0.46	1008.98	0.28	1009.90	0.23	1010.21	0.20
	Current conditions	1007.05	0.00	1008.70	0.00	1009.67	0.00	1010.01	0.00
	- 1.0	1006.49	-0.56	1008.40	-0.30	1009.43	-0.24	1009.79	-0.22
	- 2.0	1005.76	-1.29	1008.05	-0.65	1009.17	-0.50	1009.55	-0.46
	- 3.0	1004.94	-2.11	1007.63	-1.07	1008.88	-0.79	1009.29	-0.72
	- 4.0	1004.06	-2.99	1007.11	-1.59	1008.57	-1.10	1009.01	-1.00

Table 13. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach below Lafferty, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
26.74	+ 2.0	1007.39	0.89	1008.69	0.54	1009.53	0.46	1009.82	0.42
	+ 1.0	1006.99	0.49	1008.43	0.28	1009.31	0.24	1009.62	0.22
	Current conditions	1006.50	0.00	1008.15	0.00	1009.07	0.00	1009.40	0.00
	- 1.0	1005.90	-0.60	1007.84	-0.31	1008.82	-0.25	1009.17	-0.23
	- 2.0	1005.19	-1.31	1007.48	-0.67	1008.56	-0.51	1008.92	-0.48
	- 3.0	1004.36	-2.14	1007.06	-1.09	1008.27	-0.80	1008.66	-0.74
	- 4.0	1003.48	-3.02	1006.54	-1.61	1007.97	-1.10	1008.39	-1.01
26.70	+ 2.0	1006.97	0.93	1008.26	0.56	1009.10	0.46	1009.39	0.42
	+ 1.0	1006.56	0.52	1008.00	0.30	1008.87	0.23	1009.19	0.22
	Current conditions	1006.04	0.00	1007.70	0.00	1008.64	0.00	1008.97	0.00
	- 1.0	1005.44	-0.60	1007.38	-0.32	1008.38	-0.26	1008.73	-0.24
	- 2.0	1004.72	-1.32	1007.01	-0.69	1008.10	-0.54	1008.48	-0.49
	- 3.0	1003.88	-2.16	1006.58	-1.12	1007.81	-0.83	1008.21	-0.76
	- 4.0	1003.00	-3.04	1006.06	-1.64	1007.49	-1.15	1007.92	-1.05

Table 14. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach between Maynard and Crescent, Wheeling Creek, Belmont County, Ohio.

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
14.18	+ 2.0	836.44	1.41	838.50	0.73	839.85	0.68	840.40	0.69
	+ 1.0	835.78	0.75	838.15	0.38	839.50	0.33	840.05	0.34
	Current conditions	835.03	0.00	837.77	0.00	839.17	0.00	839.71	0.00
	- 1.0	834.21	-0.82	837.30	-0.47	838.84	-0.33	839.38	-0.33
	- 2.0	833.36	-1.67	836.73	-1.04	838.49	-0.68	839.05	-0.66
	- 3.0	832.46	-2.57	836.08	-1.69	838.12	-1.05	838.71	-1.00
	- 4.0	831.53	-3.50	835.35	-2.42	837.67	-1.50	838.34	-1.37
14.12	+ 2.0	835.94	1.48	838.05	0.78	839.43	0.73	840.00	0.75
	+ 1.0	835.24	0.78	837.67	0.40	839.05	0.35	839.62	0.37
	Current conditions	834.46	0.00	837.27	0.00	838.70	0.00	839.25	0.00
	- 1.0	833.64	-0.82	836.75	-0.52	838.34	-0.36	838.90	-0.35
	- 2.0	832.78	-1.68	836.13	-1.14	837.98	-0.72	838.55	-0.70
	- 3.0	831.88	-2.58	835.46	-1.81	837.58	-1.12	838.18	-1.07
	- 4.0	830.94	-3.52	834.71	-2.56	837.08	-1.62	837.79	-1.46
14.06	+ 2.0	835.21	1.49	837.49	0.94	838.99	0.86	839.60	0.87
	+ 1.0	834.47	0.75	837.04	0.49	838.55	0.42	839.16	0.43
	Current conditions	833.72	0.00	836.55	0.00	838.13	0.00	838.73	0.00
	- 1.0	832.95	-0.77	835.96	-0.59	837.72	-0.41	838.32	-0.41
	- 2.0	832.13	-1.59	835.31	-1.24	837.28	-0.85	837.91	-0.82
	- 3.0	831.27	-2.45	834.63	-1.92	836.81	-1.32	837.48	-1.25
	- 4.0	830.35	-3.37	833.93	-2.62	836.25	-1.88	837.03	-1.70
14.00	+ 2.0	834.49	1.41	836.80	1.16	838.49	1.04	839.15	1.02
	+ 1.0	833.81	0.73	836.22	0.58	837.96	0.51	838.64	0.51
	Current conditions	833.08	0.00	835.64	0.00	837.45	0.00	838.13	0.00
	- 1.0	832.33	-0.75	835.10	-0.54	836.93	-0.52	837.63	-0.50
	- 2.0	831.53	-1.55	834.53	-1.11	836.40	-1.05	837.13	-1.00
	- 3.0	830.67	-2.41	833.92	-1.72	835.88	-1.57	836.61	-1.52
	- 4.0	829.76	-3.32	833.26	-2.38	835.34	-2.11	836.10	-2.03
13.95	+ 2.0	834.08	1.48	836.41	1.14	838.05	1.02	838.69	1.01
	+ 1.0	833.36	0.76	835.85	0.58	837.54	0.51	838.19	0.51
	Current conditions	832.60	0.00	835.27	0.00	837.03	0.00	837.68	0.00
	- 1.0	831.84	-0.76	834.70	-0.57	836.52	-0.51	837.19	-0.49
	- 2.0	831.02	-1.58	834.10	-1.17	836.00	-1.03	836.70	-0.98
	- 3.0	830.15	-2.45	833.44	-1.83	835.49	-1.54	836.20	-1.48
	- 4.0	829.23	-3.37	832.75	-2.52	834.94	-2.09	835.71	-1.97

Table 14. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach between Maynard and Crescent, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
13.89	+ 2.0	833.31	1.48	835.60	1.13	837.10	1.00	837.68	1.00
	+ 1.0	832.57	0.74	835.05	0.58	836.60	0.50	837.17	0.49
	Current conditions	831.83	0.00	834.47	0.00	836.10	0.00	836.68	0.00
	- 1.0	831.06	-0.77	833.88	-0.59	835.58	-0.52	836.19	-0.49
	- 2.0	830.22	-1.61	833.24	-1.23	835.07	-1.03	835.70	-0.98
	- 3.0	829.33	-2.50	832.55	-1.92	834.58	-1.52	835.22	-1.46
	- 4.0	828.39	-3.44	831.87	-2.60	834.02	-2.08	834.76	-1.92
13.83	+ 2.0	832.20	1.26	833.97	0.82	834.83	0.51	835.08	0.41
	+ 1.0	831.60	0.66	833.57	0.42	834.59	0.27	834.89	0.22
	Current conditions	830.94	0.00	833.15	0.00	834.32	0.00	834.67	0.00
	- 1.0	830.24	-0.70	832.75	-0.40	834.01	-0.31	834.41	-0.26
	- 2.0	829.43	-1.51	832.23	-0.92	833.68	-0.64	834.15	-0.52
	- 3.0	828.56	-2.38	831.65	-1.50	833.38	-0.94	833.86	-0.81
	- 4.0	827.64	-3.30	831.02	-2.13	832.94	-1.38	833.58	-1.09
13.80	+ 2.0	831.84	1.30	833.45	0.78	834.51	0.76	834.99	0.79
	+ 1.0	831.23	0.69	833.07	0.40	834.13	0.38	834.59	0.39
	Current conditions	830.54	0.00	832.67	0.00	833.75	0.00	834.20	0.00
	- 1.0	829.77	-0.77	832.31	-0.36	833.38	-0.37	833.81	-0.39
	- 2.0	828.88	-1.66	831.77	-0.90	833.05	-0.70	833.45	-0.75
	- 3.0	827.93	-2.61	831.14	-1.53	832.81	-0.94	833.17	-1.03
	- 4.0	826.95	-3.59	830.43	-2.24	832.38	-1.37	832.95	-1.25
13.76	+ 2.0	831.04	1.21	832.45	0.62	833.65	0.82	834.18	0.88
	+ 1.0	830.46	0.63	832.10	0.27	833.21	0.38	833.72	0.42
	Current conditions	829.83	0.00	831.83	0.00	832.83	0.00	833.30	0.00
	- 1.0	829.12	-0.71	831.59	-0.24	832.49	-0.34	832.93	-0.37
	- 2.0	828.28	-1.55	831.00	-0.83	832.27	-0.56	832.60	-0.70
	- 3.0	827.39	-2.44	830.40	-1.43	832.18	-0.65	832.45	-0.85
	- 4.0	826.48	-3.35	829.75	-2.08	831.73	-1.10	832.36	-0.94
13.72	+ 2.0	830.14	1.35	832.04	1.11	833.42	1.01	833.98	0.99
	+ 1.0	829.48	0.69	831.53	0.60	832.91	0.50	833.49	0.50
	Current conditions	828.79	0.00	830.93	0.00	832.41	0.00	832.99	0.00
	- 1.0	828.06	-0.73	830.24	-0.69	831.89	-0.52	832.48	-0.51
	- 2.0	827.24	-1.55	829.63	-1.30	831.30	-1.11	831.94	-1.05
	- 3.0	826.41	-2.38	829.01	-1.92	830.62	-1.79	831.34	-1.65
	- 4.0	825.52	-3.27	828.36	-2.57	830.00	-2.41	830.66	-2.33

Table 14. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach between Maynard and Crescent, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
13.69	+ 2.0	829.52	1.38	831.52	1.24	833.06	1.14	833.66	1.10
	+ 1.0	828.82	0.68	830.90	0.62	832.48	0.56	833.12	0.56
	Current conditions	828.14	0.00	830.28	0.00	831.92	0.00	832.56	0.00
	- 1.0	827.42	-0.72	829.70	-0.58	831.34	-0.58	832.01	-0.55
	- 2.0	826.65	-1.49	829.10	-1.18	830.74	-1.18	831.43	-1.13
	- 3.0	825.87	-2.27	828.51	-1.77	830.17	-1.75	830.84	-1.72
	- 4.0	824.96	-3.18	827.89	-2.39	829.63	-2.29	830.27	-2.29
13.63	+ 2.0	828.76	1.39	830.83	1.24	832.34	1.12	832.92	1.07
	+ 1.0	828.05	0.68	830.19	0.60	831.78	0.56	832.38	0.53
	Current conditions	827.37	0.00	829.59	0.00	831.22	0.00	831.85	0.00
	- 1.0	826.66	-0.71	829.02	-0.57	830.68	-0.54	831.33	-0.52
	- 2.0	825.92	-1.45	828.46	-1.13	830.14	-1.08	830.80	-1.05
	- 3.0	825.16	-2.21	827.90	-1.69	829.61	-1.61	830.27	-1.58
	- 4.0	824.28	-3.09	827.30	-2.29	829.10	-2.12	829.76	-2.09
13.58	+ 2.0	827.78	1.12	829.40	0.84	830.64	0.81	831.14	0.81
	+ 1.0	827.22	0.56	828.97	0.41	830.22	0.39	830.72	0.39
	Current conditions	826.66	0.00	828.56	0.00	829.83	0.00	830.33	0.00
	- 1.0	825.99	-0.67	828.15	-0.41	829.45	-0.38	829.96	-0.37
	- 2.0	825.25	-1.41	827.70	-0.86	829.08	-0.75	829.59	-0.74
	- 3.0	824.48	-2.18	827.22	-1.34	828.70	-1.13	829.23	-1.10
	- 4.0	823.59	-3.07	826.67	-1.89	828.31	-1.52	828.86	-1.47
13.53	+ 2.0	827.03	1.08	828.95	0.97	830.49	0.95	831.09	0.93
	+ 1.0	826.49	0.54	828.45	0.47	830.01	0.47	830.61	0.45
	Current conditions	825.95	0.00	827.98	0.00	829.54	0.00	830.16	0.00
	- 1.0	825.27	-0.68	827.53	-0.45	829.07	-0.47	829.71	-0.45
	- 2.0	824.52	-1.43	827.04	-0.94	828.62	-0.92	829.26	-0.90
	- 3.0	823.72	-2.23	826.54	-1.44	828.17	-1.37	828.80	-1.36
	- 4.0	822.82	-3.13	825.96	-2.02	827.71	-1.83	828.35	-1.81
13.47	+ 2.0	826.37	1.37	828.56	1.13	830.25	1.04	830.89	0.99
	+ 1.0	825.72	0.72	827.97	0.54	829.73	0.52	830.38	0.48
	Current conditions	825.00	0.00	827.43	0.00	829.21	0.00	829.90	0.00
	- 1.0	824.25	-0.75	826.90	-0.53	828.67	-0.54	829.40	-0.50
	- 2.0	823.44	-1.56	826.25	-1.18	828.13	-1.08	828.87	-1.03
	- 3.0	822.57	-2.43	825.53	-1.90	827.58	-1.63	828.32	-1.58
	- 4.0	821.64	-3.36	824.79	-2.64	827.02	-2.19	827.76	-2.14

Table 14. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach between Maynard and Crescent, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
13.41	+ 2.0	825.31	1.59	827.92	1.60	829.81	1.34	830.49	1.21
	+ 1.0	824.49	0.77	827.14	0.82	829.16	0.69	829.88	0.60
	Current conditions	823.72	0.00	826.32	0.00	828.47	0.00	829.28	0.00
	- 1.0	822.99	-0.73	825.59	-0.73	827.76	-0.71	828.60	-0.68
	- 2.0	822.24	-1.48	824.92	-1.40	827.02	-1.45	827.90	-1.38
	- 3.0	821.46	-2.26	824.28	-2.04	826.25	-2.22	827.17	-2.11
	- 4.0	820.59	-3.13	823.65	-2.67	825.62	-2.85	826.41	-2.87
13.36	+ 2.0	824.49	1.52	826.75	1.31	828.43	1.33	829.17	1.45
	+ 1.0	823.71	0.74	826.08	0.64	827.69	0.59	828.38	0.66
	Current conditions	822.97	0.00	825.44	0.00	827.10	0.00	827.72	0.00
	- 1.0	822.24	-0.73	824.83	-0.61	826.54	-0.56	827.18	-0.54
	- 2.0	821.50	-1.47	824.24	-1.20	826.00	-1.10	826.64	-1.08
	- 3.0	820.72	-2.25	823.66	-1.78	825.46	-1.64	826.12	-1.60
	- 4.0	819.86	-3.11	823.07	-2.37	824.94	-2.16	825.61	-2.11
13.30	+ 2.0	823.67	1.45	825.82	1.14	827.24	1.01	827.78	0.99
	+ 1.0	822.94	0.72	825.24	0.56	826.72	0.49	827.26	0.47
	Current conditions	822.22	0.00	824.68	0.00	826.23	0.00	826.79	0.00
	- 1.0	821.52	-0.70	824.14	-0.54	825.77	-0.46	826.35	-0.44
	- 2.0	820.79	-1.43	823.61	-1.07	825.30	-0.93	825.91	-0.88
	- 3.0	820.04	-2.18	823.08	-1.60	824.83	-1.40	825.46	-1.33
	- 4.0	819.21	-3.01	822.54	-2.14	824.37	-1.86	825.01	-1.78
13.24	+ 2.0	822.64	1.33	824.72	1.12	826.18	1.08	826.75	1.09
	+ 1.0	821.97	0.66	824.14	0.54	825.62	0.52	826.19	0.53
	Current conditions	821.31	0.00	823.60	0.00	825.10	0.00	825.66	0.00
	- 1.0	820.64	-0.67	823.11	-0.49	824.60	-0.50	825.17	-0.49
	- 2.0	819.93	-1.38	822.64	-0.96	824.14	-0.96	824.70	-0.96
	- 3.0	819.20	-2.11	822.18	-1.42	823.70	-1.40	824.27	-1.39
	- 4.0	818.38	-2.93	821.70	-1.90	823.30	-1.80	823.85	-1.81
13.18	+ 2.0	822.00	1.26	824.13	1.11	825.67	1.12	826.28	1.13
	+ 1.0	821.37	0.63	823.55	0.53	825.09	0.54	825.70	0.55
	Current conditions	820.74	0.00	823.02	0.00	824.55	0.00	825.15	0.00
	- 1.0	820.08	-0.66	822.55	-0.47	824.04	-0.51	824.63	-0.52
	- 2.0	819.34	-1.40	822.11	-0.91	823.57	-0.98	824.15	-1.00
	- 3.0	818.58	-2.16	821.68	-1.34	823.14	-1.41	823.70	-1.45
	- 4.0	817.75	-2.99	821.22	-1.80	822.76	-1.79	823.29	-1.86

Table 14. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach between Maynard and Crescent, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
13.12	+ 2.0	821.40	1.24	823.44	1.08	824.94	1.14	825.54	1.17
	+ 1.0	820.80	0.64	822.87	0.51	824.35	0.55	824.94	0.57
	Current conditions	820.16	0.00	822.36	0.00	823.80	0.00	824.37	0.00
	- 1.0	819.49	-0.67	821.92	-0.44	823.30	-0.50	823.85	-0.52
	- 2.0	818.73	-1.43	821.52	-0.84	822.84	-0.96	823.37	-1.00
	- 3.0	817.94	-2.22	821.14	-1.22	822.45	-1.35	822.95	-1.42
	- 4.0	817.09	-3.07	820.70	-1.66	822.12	-1.68	822.58	-1.79
13.07	+ 2.0	820.56	0.95	821.88	0.53	822.69	0.48	822.98	0.47
	+ 1.0	820.13	0.52	821.61	0.26	822.43	0.22	822.72	0.21
	Current conditions	819.61	0.00	821.35	0.00	822.21	0.00	822.51	0.00
	- 1.0	819.01	-0.60	821.14	-0.21	822.01	-0.20	822.32	-0.19
	- 2.0	818.29	-1.32	820.92	-0.43	821.82	-0.39	822.14	-0.37
	- 3.0	817.53	-2.08	820.66	-0.69	821.64	-0.57	821.97	-0.54
	- 4.0	816.71	-2.90	820.30	-1.05	821.49	-0.72	821.80	-0.71
13.03	+ 2.0	820.14	0.88	821.26	0.36	821.92	0.28	822.15	0.25
	+ 1.0	819.76	0.50	821.08	0.18	821.78	0.14	822.02	0.12
	Current conditions	819.26	0.00	820.90	0.00	821.64	0.00	821.90	0.00
	- 1.0	818.66	-0.60	820.76	-0.14	821.51	-0.13	821.78	-0.12
	- 2.0	817.95	-1.31	820.58	-0.32	821.37	-0.27	821.66	-0.24
	- 3.0	817.22	-2.04	820.33	-0.57	821.22	-0.42	821.53	-0.37
	- 4.0	816.41	-2.85	819.96	-0.94	821.12	-0.52	821.38	-0.52
13.00	+ 2.0	819.64	1.01	820.87	0.46	821.75	0.40	822.10	0.39
	+ 1.0	819.23	0.60	820.64	0.23	821.54	0.19	821.90	0.19
	Current conditions	818.63	0.00	820.41	0.00	821.35	0.00	821.71	0.00
	- 1.0	818.00	-0.63	820.18	-0.23	821.14	-0.21	821.52	-0.19
	- 2.0	817.31	-1.32	819.92	-0.49	820.94	-0.41	821.32	-0.39
	- 3.0	816.60	-2.03	819.63	-0.78	820.72	-0.63	821.12	-0.59
	- 4.0	815.80	-2.83	819.24	-1.17	820.50	-0.85	820.91	-0.80
12.95	+ 2.0	818.64	1.04	820.04	0.48	820.99	0.39	821.37	0.37
	+ 1.0	818.13	0.53	819.81	0.25	820.79	0.19	821.18	0.18
	Current conditions	817.60	0.00	819.56	0.00	820.60	0.00	821.00	0.00
	- 1.0	817.02	-0.58	819.30	-0.26	820.41	-0.19	820.81	-0.19
	- 2.0	816.38	-1.22	818.99	-0.57	820.20	-0.40	820.62	-0.38
	- 3.0	815.73	-1.87	818.63	-0.93	819.98	-0.62	820.42	-0.58
	- 4.0	814.97	-2.63	818.20	-1.36	819.73	-0.87	820.21	-0.79

Table 14. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach between Maynard and Crescent, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
12.90	+ 2.0	817.80	0.99	819.48	0.50	820.52	0.37	820.94	0.36
	+ 1.0	817.30	0.49	819.24	0.26	820.34	0.19	820.76	0.18
	Current conditions	816.81	0.00	818.98	0.00	820.15	0.00	820.58	0.00
	- 1.0	816.26	-0.55	818.67	-0.31	819.96	-0.19	820.39	-0.19
	- 2.0	815.68	-1.13	818.34	-0.64	819.75	-0.40	820.20	-0.38
	- 3.0	815.07	-1.74	817.98	-1.00	819.52	-0.63	820.01	-0.57
	- 4.0	814.35	-2.46	817.57	-1.41	819.25	-0.90	819.79	-0.79
12.85	+ 2.0	817.20	0.88	819.16	0.51	820.26	0.36	820.70	0.35
	+ 1.0	816.76	0.44	818.92	0.27	820.08	0.18	820.52	0.17
	Current conditions	816.32	0.00	818.65	0.00	819.90	0.00	820.35	0.00
	- 1.0	815.82	-0.50	818.32	-0.33	819.71	-0.19	820.16	-0.19
	- 2.0	815.27	-1.05	817.96	-0.69	819.51	-0.39	819.98	-0.37
	- 3.0	814.69	-1.63	817.59	-1.06	819.28	-0.62	819.79	-0.56
	- 4.0	813.96	-2.36	817.19	-1.46	819.01	-0.89	819.58	-0.77
12.79	+ 2.0	816.55	1.09	818.88	0.58	820.01	0.38	820.45	0.36
	+ 1.0	816.01	0.55	818.61	0.31	819.82	0.19	820.27	0.18
	Current conditions	815.46	0.00	818.30	0.00	819.63	0.00	820.09	0.00
	- 1.0	814.87	-0.59	817.89	-0.41	819.43	-0.20	819.89	-0.20
	- 2.0	814.24	-1.22	817.36	-0.94	819.21	-0.42	819.69	-0.40
	- 3.0	813.60	-1.86	816.79	-1.51	818.94	-0.69	819.49	-0.60
	- 4.0	812.81	-2.65	816.25	-2.05	818.62	-1.01	819.25	-0.84
12.73	+ 2.0	815.77	1.10	817.97	0.70	819.26	0.54	819.77	0.50
	+ 1.0	815.24	0.57	817.64	0.37	818.99	0.27	819.53	0.26
	Current conditions	814.67	0.00	817.27	0.00	818.72	0.00	819.27	0.00
	- 1.0	814.05	-0.62	816.84	-0.43	818.44	-0.28	819.00	-0.27
	- 2.0	813.39	-1.28	816.39	-0.88	818.15	-0.57	818.72	-0.55
	- 3.0	812.69	-1.98	815.91	-1.36	817.82	-0.90	818.43	-0.84
	- 4.0	811.89	-2.78	815.42	-1.85	817.44	-1.28	818.13	-1.14
12.68	+ 2.0	814.54	1.01	816.84	0.82	818.51	0.70	819.08	0.59
	+ 1.0	814.04	0.51	816.44	0.42	818.17	0.36	818.80	0.31
	Current conditions	813.53	0.00	816.02	0.00	817.81	0.00	818.49	0.00
	- 1.0	812.97	-0.56	815.59	-0.43	817.43	-0.38	818.15	-0.34
	- 2.0	812.40	-1.13	815.16	-0.86	817.05	-0.76	817.79	-0.70
	- 3.0	811.79	-1.74	814.73	-1.29	816.66	-1.15	817.42	-1.07
	- 4.0	811.04	-2.49	814.28	-1.74	816.27	-1.54	817.04	-1.45

Table 14. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence intervals for the previously undredged reach between Maynard and Crescent, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
12.62	+ 2.0	813.56	1.00	816.13	0.91	818.06	0.80	818.69	0.65
	+ 1.0	813.07	0.51	815.67	0.45	817.67	0.41	818.39	0.35
	Current conditions	812.56	0.00	815.22	0.00	817.26	0.00	818.04	0.00
	- 1.0	811.99	-0.57	814.77	-0.45	816.83	-0.43	817.64	-0.40
	- 2.0	811.42	-1.14	814.33	-0.89	816.40	-0.86	817.23	-0.81
	- 3.0	810.81	-1.75	813.89	-1.33	815.97	-1.29	816.81	-1.23
	- 4.0	810.07	-2.49	813.44	-1.78	815.53	-1.73	816.38	-1.66
12.56	+ 2.0	812.88	1.08	815.66	0.99	817.60	0.80	818.24	0.68
	+ 1.0	812.36	0.56	815.17	0.50	817.22	0.42	817.91	0.35
	Current conditions	811.80	0.00	814.67	0.00	816.80	0.00	817.56	0.00
	- 1.0	811.15	-0.65	814.18	-0.49	816.37	-0.43	817.18	-0.38
	- 2.0	810.52	-1.28	813.70	-0.97	815.92	-0.88	816.76	-0.80
	- 3.0	809.85	-1.95	813.24	-1.43	815.45	-1.35	816.33	-1.23
	- 4.0	809.12	-2.68	812.77	-1.90	814.98	-1.82	815.89	-1.67
12.51	+ 2.0	812.37	1.07	815.03	0.91	816.81	0.73	817.34	0.57
	+ 1.0	811.87	0.57	814.57	0.45	816.47	0.39	817.07	0.30
	Current conditions	811.30	0.00	814.12	0.00	816.08	0.00	816.77	0.00
	- 1.0	810.61	-0.69	813.67	-0.45	815.69	-0.39	816.43	-0.34
	- 2.0	809.96	-1.34	813.22	-0.90	815.29	-0.79	816.06	-0.71
	- 3.0	809.28	-2.02	812.78	-1.34	814.88	-1.20	815.67	-1.10
	- 4.0	808.56	-2.74	812.33	-1.79	814.47	-1.61	815.29	-1.48
12.46	+ 2.0	811.55	1.09	814.07	0.89	815.79	0.76	816.34	0.65
	+ 1.0	811.05	0.59	813.62	0.44	815.42	0.39	816.02	0.33
	Current conditions	810.46	0.00	813.18	0.00	815.03	0.00	815.69	0.00
	- 1.0	809.74	-0.72	812.74	-0.44	814.64	-0.39	815.34	-0.35
	- 2.0	809.08	-1.38	812.29	-0.89	814.25	-0.78	814.98	-0.71
	- 3.0	808.40	-2.06	811.86	-1.32	813.85	-1.18	814.60	-1.09
	- 4.0	807.68	-2.78	811.43	-1.75	813.45	-1.58	814.22	-1.47

Table 15. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence interval for the previously undredged reach below the community of Crescent, Wheeling Creek, Belmont County, Ohio.

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
11.84	+ 2.0	804.43	0.93	806.20	0.77	807.54	0.73	808.07	0.72
	+ 1.0	803.98	0.48	805.81	0.38	807.17	0.36	807.70	0.35
	Current conditions	803.50	0.00	805.43	0.00	806.81	0.00	807.35	0.00
	- 1.0	802.99	-0.51	805.05	-0.38	806.47	-0.34	807.02	-0.33
	- 2.0	802.44	-1.06	804.64	-0.79	806.12	-0.69	806.69	-0.66
	- 3.0	801.83	-1.67	804.19	-1.24	805.76	-1.05	806.34	-1.01
	- 4.0	801.06	-2.44	803.69	-1.74	805.37	-1.44	805.97	-1.38
11.80	+ 2.0	803.47	1.04	805.31	0.92	806.65	0.84	807.18	0.82
	+ 1.0	802.95	0.52	804.84	0.45	806.23	0.42	806.76	0.40
	Current conditions	802.43	0.00	804.39	0.00	805.81	0.00	806.36	0.00
	- 1.0	801.94	-0.49	803.97	-0.42	805.42	-0.39	805.98	-0.38
	- 2.0	801.43	-1.00	803.53	-0.86	805.01	-0.80	805.59	-0.77
	- 3.0	800.91	-1.52	803.06	-1.33	804.60	-1.21	805.19	-1.17
	- 4.0	800.16	-2.27	802.56	-1.83	804.17	-1.64	804.77	-1.59
11.76	+ 2.0	802.75	1.21	804.59	0.93	805.90	0.84	806.41	0.82
	+ 1.0	802.18	0.64	804.13	0.47	805.48	0.42	806.00	0.41
	Current conditions	801.54	0.00	803.66	0.00	805.06	0.00	805.59	0.00
	- 1.0	800.87	-0.67	803.20	-0.46	804.66	-0.40	805.20	-0.39
	- 2.0	800.18	-1.36	802.69	-0.97	804.23	-0.83	804.80	-0.79
	- 3.0	799.45	-2.09	802.09	-1.57	803.78	-1.28	804.37	-1.22
	- 4.0	798.54	-3.00	801.38	-2.28	803.27	-1.79	803.91	-1.68
11.72	+ 2.0	802.10	1.21	803.64	0.88	804.66	0.80	805.06	0.81
	+ 1.0	801.53	0.64	803.19	0.43	804.24	0.38	804.64	0.39
	Current conditions	800.89	0.00	802.76	0.00	803.86	0.00	804.25	0.00
	- 1.0	800.15	-0.74	802.34	-0.42	803.51	-0.35	803.92	-0.33
	- 2.0	799.35	-1.54	801.87	-0.89	803.14	-0.72	803.58	-0.67
	- 3.0	798.52	-2.37	801.31	-1.45	802.75	-1.11	803.22	-1.03
	- 4.0	797.65	-3.24	800.59	-2.17	802.32	-1.54	802.83	-1.42
11.68	+ 2.0	801.11	1.07	802.57	0.84	803.59	0.79	803.98	0.79
	+ 1.0	800.60	0.56	802.14	0.41	803.18	0.38	803.58	0.39
	Current conditions	800.04	0.00	801.73	0.00	802.80	0.00	803.19	0.00
	- 1.0	799.38	-0.66	801.31	-0.42	802.42	-0.38	802.83	-0.36
	- 2.0	798.57	-1.47	800.84	-0.89	802.04	-0.76	802.46	-0.73
	- 3.0	797.73	-2.31	800.28	-1.45	801.64	-1.16	802.08	-1.11
	- 4.0	796.85	-3.19	799.65	-2.08	801.19	-1.61	801.68	-1.51

Table 15. Flood elevations for simulated dredging and aggradation, current conditions, and the change in water-surface elevations from current conditions for indicated recurrence interval for the previously undredged reach below the community of Crescent, Wheeling Creek, Belmont County, Ohio. —Continued

[Shaded river miles indicate surveyed cross sections and non-shaded river miles indicate TIN-derived cross sections]

Distance from mouth of Wheeling Creek (river miles)	Elevation difference from current conditions (feet)	Water-surface elevation, in feet, for indicated recurrence interval and the difference in water-surface elevations of simulated profiles from current-condition profiles							
		2 year (feet)	Difference (feet)	10 year (feet)	Difference (feet)	50 year (feet)	Difference (feet))	100 year (feet)	Difference (feet)
11.66	+ 2.0	800.94	1.15	802.39	0.83	803.41	0.77	803.80	0.76
	+ 1.0	800.42	0.63	801.97	0.41	803.02	0.38	803.42	0.38
	Current conditions	799.79	0.00	801.56	0.00	802.64	0.00	803.04	0.00
	- 1.0	799.02	-0.77	801.12	-0.44	802.26	-0.38	802.68	-0.36
	- 2.0	798.13	-1.66	800.60	-0.96	801.86	-0.78	802.30	-0.74
	- 3.0	797.24	-2.55	799.95	-1.61	801.42	-1.22	801.89	-1.15
	- 4.0	796.31	-3.48	799.16	-2.40	800.91	-1.73	801.44	-1.60
11.63	+ 2.0	800.42	1.21	801.86	0.88	802.89	0.79	803.29	0.76
	+ 1.0	799.86	0.65	801.42	0.44	802.50	0.40	802.91	0.38
	Current conditions	799.21	0.00	800.98	0.00	802.10	0.00	802.53	0.00
	- 1.0	798.47	-0.74	800.51	-0.47	801.70	-0.40	802.14	-0.39
	- 2.0	797.62	-1.59	799.98	-1.00	801.27	-0.83	801.73	-0.80
	- 3.0	796.74	-2.47	799.37	-1.61	800.81	-1.29	801.30	-1.23
	- 4.0	795.82	-3.39	798.66	-2.32	800.32	-1.78	800.85	-1.68

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