Hydrologic and Hydraulic Analyses of Selected Streams in Lorain County, Ohio, 2003

By K. Scott Jackson, Chad J. Ostheimer, and Mattew T. Whitehead

In Cooperation with the
Lorain County Engineer

Water-Resources Investigation Report 03-4215

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

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
Charles G. Groat, Director

U.S. Geological Survey, Reston, Virginia: 2004
For sale by U.S. Geological Survey, Information Services
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Denver, CO 80225

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Suggested citation:

Library of Congress Cataloging-in-Publication Data

ISBN

Conversion Factors and Datum

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
acre-foot (acre-ft)	1,233	cubic meter (m^3)

Vertical coordinate information is referenced to the *in, "North American Vertical Datum of 19988 (NAVD 88)."*

Horizontal coordinate information is referenced to the *"North American Datum of 19988 (NAVD 88)."*

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

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
foot (ft)	0.3048	meter
inch (in)	0.3937	centimeter
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
acre-foot (ac-ft)	1233.62	cubic meter

In this report, all elevations are referenced to the North American Vertical Datum of 1988 (NAVD88).

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Abstract

Hydrologic and hydraulic analyses were done for selected reaches of nine streams in Lorain County, Ohio. To assess the alternatives for flood-damage mitigation, the Lorain County Engineer and the U.S. Geological Survey (USGS) initiated a cooperative study to investigate aspects of the hydrology and hydraulics of the nine streams. Historical streamflow data and regional regression equations were used to estimate instantaneous peak discharges for floods having recurrence intervals of 2, 5, 10, 25, 50, and 100 years. Explanatory variables used in the regression equations were drainage area, main-channel slope, and storage area. Drainage areas of the nine stream reaches studied ranged from 1.80 to 19.3 square miles.

The step-backwater model HEC-RAS was used to determine water-surface-elevation profiles for the 10-year-recurrence-interval (10-year) flood along a selected reach of each stream. The water-surface profile information was used then to generate digital mapping of flood-plain boundaries. The analyses indicate that at the 10-year flood elevation, road overflow results at numerous hydraulic structures along the nine streams.

Introduction

Parts of Lorain County recently have undergone residential and commercial development, and more development is expected in the future. Development in the upper basins of some streams may result in increased flood-peak discharges, potentially causing increased flood damage along the downstream reaches of these streams. The Lorain County Engineer and Commissioners are considering various options to mitigate downstream flood damage along particular streams: Battenhouse Ditch, Beaver Creek, Brighton-Camden Ditch, Engle Ditch, Gable Ditch, Heider Ditch, Plum Creek, Ridgeway Ditch and Schroeder Ditch. To assess the alternatives for flood-damage mitigation, Lorain County and the U.S. Geological Survey (USGS) initiated a cooperative study in 2001 to investigate aspects of the hydrology and hydraulics of the nine streams.

Description of the study area

Lorain County is in north-central Ohio; its northern border is the shore of Lake Erie (fig. 1), and it lies to the west of Cleveland (Cuyahoga County). The estimated population of Lorain County is about 287,000 (U.S. Bureau of Census, 2000), making Lorain County the ninth most populated county in Ohio. The cities of Lorain and Elyria form the largest metropolitan area in the county. Generally, the terrain is relatively flat in the northern half of the county and more relief in the south.

The nine streams included in this study effort generally flow northward and eventually drain into Lake Erie. Some segments of the stream reaches studied have been straightened. Periodically, areas along the banks of some of the streams are cleared of brush and debris. No structural flood-protection measures (levees or dikes) currently are in place along any of the studied stream reaches. With the exception of parts of the Gable and Heider Ditch Basins, the study areas primarily are rural. The hydraulic model limits for the nine streams are shown in table 1.

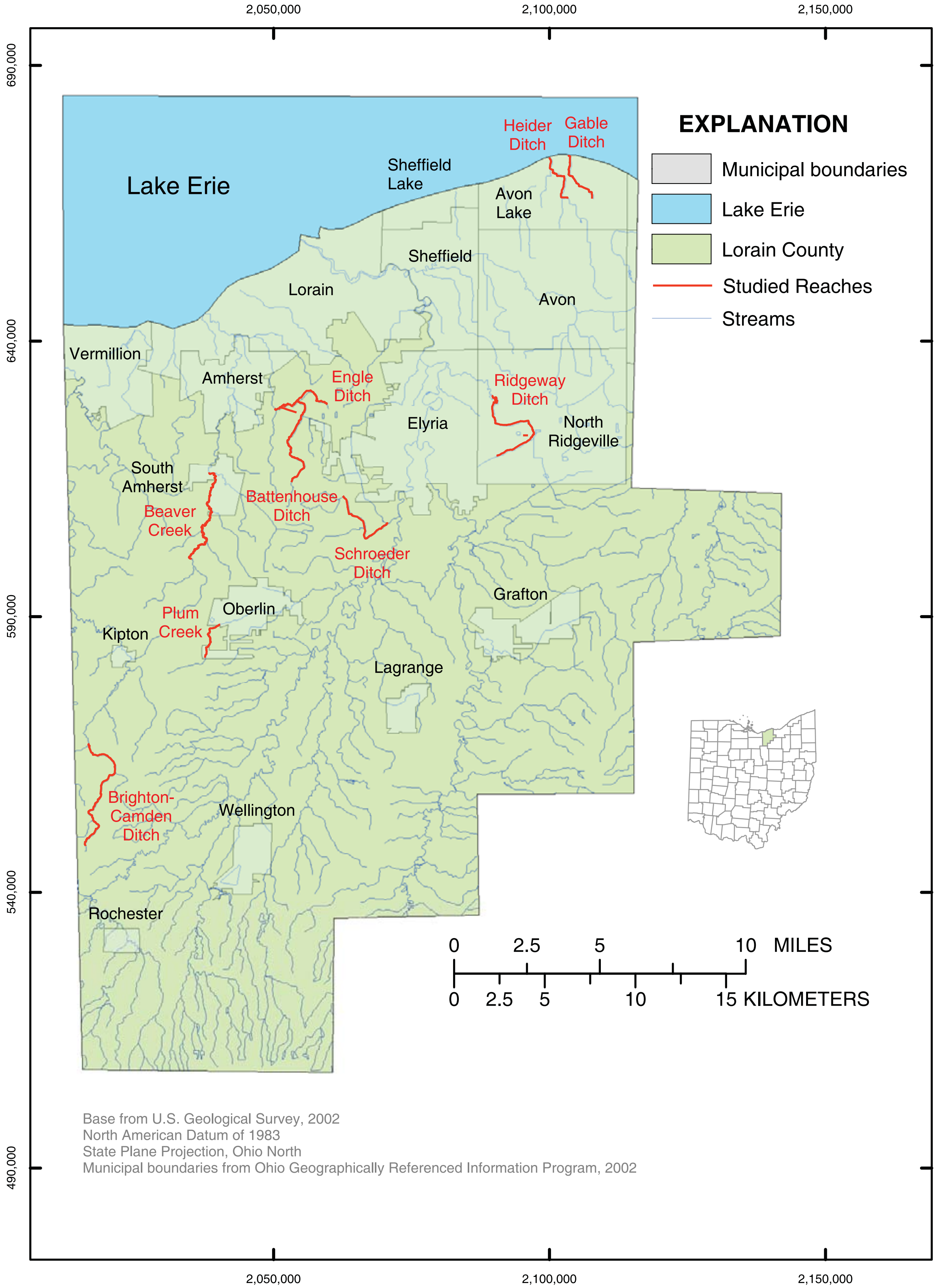

Figure 1. Location of streams studied in Lorain County, Ohio.

Table 1. Hydraulic model limits for selected streams in Lorain County, Ohio

Stream name (Fig. 1)	Downstream limit	Upstream limit	Approximate channel length (miles)
Battenhouse Ditch	Middle Ridge Road	Albrecht Road	5.0
Beaver Creek	State Route 113	Quarry Road (upstream bridge)	5.2
Brighton-Camden Ditch	Mouth	State Route 18	5.2
Engle Ditch	Mouth	Stang Road	1.5
Gable Ditch	Mouth	Walker Road	2.0
Heider Ditch	Mouth	Walker Road	2.0
Plum Creek	Pyle South Amherst Road	State Route 20	1.7
Ridgeway Ditch	Case Road	Bender Road	4.8
Schroeder Ditch	State Route 20	Approximately, 2,400 feet upstream from former Conrail railroad (currently a bike path)	2.9

Purpose and scope

This report describes methods and results of hydrologic and hydraulic analyses of Battenhouse Ditch, Beaver Creek, Brighton-Camden Ditch, Engle Ditch, Gable Ditch, Heider Ditch, Plum Creek, Ridgeway Ditch, and Schroeder Ditch. The analyses include (1) estimates of flood-peak discharges corresponding to floods with recurrence intervals of 2, 5, 10, 25, 50, and 100 years, and (2) determination of water-surface-elevation profiles and flood-plain boundaries corresponding to the 10-year-recurrence-interval (10-year) flood. As requested by the Lorain County Engineer, 10-year flood profiles were developed along the nine streams to assist local officials in assessing various alternatives to mitigate flood damages. The downstream and upstream limits of the nine stream reaches studied are presented in table 1. These reaches range from 1.5 to 5.2 mi in length and flood profiles were developed along a total of 30.3 stream miles.

Acknowledgments

The authors would like to acknowledge Betty Blair, Lorain County Commissioner and Kenneth Carney, Sr., Lorain County Engineer, for their cooperation and support during this study. The authors thank Lorain County Auditor, Mark Stewart and his staff for furnishing the digital mapping data of Lorain County. Additionally, the authors thank the personnel of the Lorain County Engineer's Office— in particular, John Hamilton and Douglas Hasel— for providing valuable assistance throughout the study.

Study Methods

Data collection

Field visits were made to Lorain County to determine stream-channel-roughness coefficients (Manning's *n*), cross-section elevations, and hydraulic-structure geometries. Drainage-basin divides for the streams, initially defined on topographic maps, were field checked for accuracy. More than half of the channel and overbank cross-section elevation data used in the hydraulic models were obtained from field surveys. Using a geographic information system (GIS), the USGS generated a triangular irregular network (TIN) from digital 2-ft contour-interval mapping data provided by Lorain County to obtain supplemental synthetic cross-sectional data. In-channel data for all synthetic cross sections were estimated by interpolation from cross-sectional data surveyed in the field. For this investigation, 472 cross sections were surveyed in the field, and 405 synthetic sections were developed. Geometries of 90 culverts and bridges also were obtained from field surveys.

The USGS used Global Positioning System (GPS) static surveys to establish a local control network at pertinent locations near the streams studied. Control for the USGS surveys was established by means of seven horizontal monuments, five vertical monuments, and four 3-dimensional monuments. Recommended GPS survey guidelines for establishing local networks (National Oceanic and

Atmospheric Administration, 1997) at accuracies of +/-5 cm were followed by the USGS except that no facsimiles/reproductions of monuments (rubbings) were obtained. Real-Time Kinematic (RTK) GPS survey techniques were used to establish local spatial and elevation data at hydraulic structures and at pertinent locations. Stream and hydraulic structure geometries were obtained using conventional survey equipment. Third-order accuracy (horizontal and vertical) was maintained for all conventional survey data collected. All surveyed data are referenced (horizontally) to the North American Datum (NAD83) of 1983 Ohio State Plane (Ohio North) coordinates and (vertically) to the North American Vertical Datum of 1988 (NAVD 88).

Selected data collected during the GPS field surveys were used by the USGS to perform quality- control checks of the mapping data provided by Lorain County. These checks indicated the digital mapping data for this study meet both horizontal and vertical criteria (applicable for digital mapping produced at 1 in equal to 500 ft with 2-ft contour-interval data) established by the National Standard for Spatial Data Accuracy (Federal Geographic Data Committee, 1998). The radial Root Mean Square Error was found to be 1.42 ft, and the vertical Root Mean Square Error was 0.48 ft.

Estimation of flood-peak discharges

For the streams studied in this investigation, flood-peak discharges for the selected recurrence intervals were estimated using the current USGS flood-frequency report for Ohio (Koltun and Roberts, 1990). Techniques described in Koltun and Roberts, 1990 for developing gage-weighted flood-peak discharge estimates were used to incorporate the available historical peak-flow data for Plum Creek. Determinations from a previous study (Jones and Henry, 1982) were incorporated by the USGS in the estimation flood-peak discharges for the Heider Ditch Basin.

Development of water-surface profiles

The step-backwater hydraulic analysis model, Hydrologic Engineering Center's River Analysis System (HEC-RAS) 3.0.1 (U.S. Army Corps of Engineers, 2001a-c) was used to determine water-surface profiles based on the 10-year peak discharges determined in the hydrologic analyses for the nine streams studied. Input data for the hydraulic models included stream cross-section and hydraulic-structure geometries, 10-year peak discharges, and roughness coefficients (Manning's *n*).

Delineation of flood-plain boundaries

Using the digital mapping data provided by Lorain County and the results from the 10-year flood water-surface profiles obtained form the hydraulic models, the USGS established flood plain boundaries for all streams studied. The flood-boundary delineations were developed from the computed edge-of-water stations at each cross section. Between cross sections, flood boundaries were interpolated, following the contours of the land.

Hydrologic Analyses

Historical streamflow data were available for Plum Creek. 31 years of record (1947-1978) of streamflow data were available at an inactive USGS crest-stage gage, Plum Creek at Oberlin, Ohio (04200100). This gage was downstream from the study reach on Plum Creek. No historical streamflow data were available for any of the other streams included in this study.

Hydrologic analyses for rural basins

Flood-peak discharges having recurrence intervals of 2, 5, 10, 25, 50, and 100 years were estimated for Battenhouse Ditch, Beaver Creek, Brighton-Camden Ditch, Engle Ditch, Ridgeway Ditch, and Schroeder Ditch by use of the rural-unregulated-stream equations in Koltun and Roberts (1990). Techniques described in Koltun and Roberts (1990) for developing gage-weighted flood-peak discharge estimates were used to incorporate the available peak-flow data for Plum Creek. Input variables for all the rural regression equations are drainage area, channel slope, and percent storage. Results for these streams are listed in table 2.

Hydrologic analyses for urban basins

In order to reflect the urbanization in parts of the Heider and Gable Ditch Basins, the rural flood-peak discharge estimates were modified using methods presented in Sauer and others (1983). Explanatory variables for the three-parameter regression equations presented in Sauer and others (1983) are drainage area, rural flood-peak discharge estimate, and a basin development factor (a measure of urban development in a basin).

Flood-peak discharges having recurrence intervals of 2, 5, 10, 25, 50, and 100 years were estimated for selected locations along each stream. These estimates and the respective explanatory variables are listed in table 3.

Flow apportionment analyses for Engle Ditch

Analysis of flooding along Engle Ditch indicated that a portion of the estimated 10-year flood-peak discharge will leave the main channel and flow to the north, passing beneath an abandoned railroad grade through three

Table 2. Basin characteristics and flood-peak discharge estimates at various locations for selected streams in Lorain County, Ohio

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

Location	Drainage area (mi^2)	Main-channel slope (ft/mi)	Percent storage	Flood-peak discharge estimates for selected recurrence intervals (ft^3/s)					
				2-year	5-year	10-year[a]	25-year	50-year	100-year
Battenhouse Ditch									
Above State Route 113	1.85	11.74	2.71	94	153	196	250	292	333
Above Engle Ditch	4.63	13.89	3.67	185	299	380	485	565	644
Above unamed tributary	6.91	12.89	5.07	231	368	464	589	683	775
Above Middle Ridge Road	9.14	13.04	4.81	292	464	585	742	859	976
Beaver Creek									
Above Herrick Ditch	9.02	10.10	0.55	409	664	847	1,090	1,270	1450
Above Squires Schramm Ditch	13.2	10.92	.38	580	942	1,200	1,550	1,810	2070
Above State Route 113	19.3	11.19	.67	738	1,190	1,510	1,940	2,260	2580
Brighton-Camden Ditch									
Above Peck-Wadsworth Rd	0.40	14.46	4.97	26	42	55	70	82	94
Above unamed tributary	1.56	16.55	1.28	101	170	220	285	336	386
At mouth	3.82	12.28	1.31	192	315	403	518	606	694
Engle Ditch									
At mouth	1.80	12.72	0.56	121	202	261	338	398	457
Plum Creek									
Above unamed tributary	2.24	12.52	2.23	115	188	241	309	361	413
Above Pyle S. Amherst Rd	3.88	12.40	1.29	219	361	465	603	709	819
Ridgeway Ditch									
Above unamed tributary	4.21	9.54	0.47	227	371	475	610	714	819
Above Case Road	7.66	9.82	0.78	344	556	709	907	1060	1210
Schroeder Ditch									
Above unamed tributary	2.22	9.42	0.45	138	227	292	376	441	505
Above State Route 20	3.68	11.23	0.81	198	324	416	535	627	718

[a] The discharge estimates in the shaded column are the discharges used in this report.

cattle-crossing openings which function effectively as culverts. The area of interest is approximately 0.75 mi northeast ofthe intersection of Oberlin and Middle Ridge Roads (fig. 2). For this reach of Engle Ditch, the total estimated 10-year flood-peak discharge of 261 ft^3/s flows generally westward and parallels an abandoned railroad grade. A portion of the total discharge, after passing under the railroad through the three cattle crossings, will continue to flow northward under Middle Ridge Road and subsequently into an adjacent drainage basin.

To estimate the amount of flood-peak discharge escaping the main channel of Engle Ditch, a separate step-backwater model was created for the drainage ditches that convey discharge toward and beneath Middle Ridge Road. A portion of the 261 ft^3/s flood-peak discharge was routed through the drainage ditches, with the remaining flood-peak discharge being routed along Engle Ditch. It was assumed that a valid flow apportionment would occur when cross section 1,661 of the drainage-ditches model and cross section 2,853 of the Engle Ditch model shared a common water-surface elevation.

Table 3. Basin characteristics and flood-peak discharge estimates at various locations for Gable Ditch and Heider Ditch in Lorain County, Ohio

[mi², square miles; ft/mi, feet per mile; ft³/s, cubic feet per second]

Location	Drainage area (mi²)	Main-channel slope (ft/mi)	Percent storage	Basin development factor	Flood-peak discharge estimates for selected recurrence intervals (ft³/s)					
					2-year	5-year	10-year[a]	25-year	50-year	100-year
Gable Ditch										
At mouth	1.94	14.47	1.06	6	216	348	424	519	604	689
Heider Ditch										
Above turnpike	1.29	23.11	4.84	3	115	185	228[b]	279	325	367
Above railroad	3.26	21.09	6.46	3	221	348	424[a]	517	603	682
Above unnamed tributary	4.01	16.62	5.54	4	271	423	511[a]	618	718	814
Above Carriage Lane	5.17	15.70	4.59	5	358	555	666[a]	805	936	1,060
Above unnamed tributary	5.43	15.50	4.37	5	375	580	698[a]	843	980	1,110
At mouth	6.19	15.22	3.93	6	447	689	825[a]	993	1,150	1,310

[a] The discharge estimates in the shaded column are the dischrges used in this report.

[b] These peak-discharge estimates represent regression-equation output and do not represent the final peak-discharge estimates used in the hydraulic model. These estimates were modified as described in the section, "Hydrologic Analysis for Heider Ditch."

Step-backwater calculations were done for Engle Ditch and the drainage ditches using a series of inversely related discharges (that summed to 261 ft³/s) until the water-surface elevations at cross sections 1,661 and 2,853 were equal. A flow apportionment of 161 ft³/s for the drainage ditches and 100 ft³/s for the main channel of Engle Ditch resulted in a common water surface elevation of 729.46 ft at both cross sections. This represents a loss of approximately 62 percent of the Engle Ditch main channel estimated 10-year flood-peak discharge to the drainage ditches and the adjacent drainage basin.

Several factors were taken into consideration to assess the validity of the flow apportionment analysis: (1) The water-surface profile slope along Engle Ditch along the abandoned railroad grade is relatively flat due to backwater caused by a culvert under a private driveway located downstream at river station 875. (2) The backwater[1] from the driveway culvert results in inundation of the Engle Ditch overbank areas. (3) The upstream invert elevations of the three cattle crossings are approximately equal to the minimum channel elevations for the main channel of Engle Ditch. (4) The land-surface elevations along the right overbank of Engle Ditch are low enough that the water is not impeded from flowing northward through the cattle crossings.

From inspection of the 2-ft contour mapping and site visits, it was determined that any discharge flowing north and passing under Middle Ridge Road will leave the Engle Ditch Basin. Therefore, the flood-peak discharge estimate for Engle Ditch downstream from river station 2,853 was reduced from 261 ft³/s to 100 ft³/s in the Engle Ditch step-backwater model to reflect the loss of discharge.

Storage area analyses for Heider Ditch

Initial storage-area values (as a percentage of drainage area) for each of the six discharge-estimation points along Heider Ditch were estimated from storage areas visible on USGS 7.5-minute topographic quadrangle maps (as detailed in Koltun and Roberts, 1990). The topographic maps used were Avon (photorevised 1979) and North Olmsted (photorevised 1970). City of Avon Lake officials were concerned that these versions of the USGS topographic maps did not reflect current storage areas. In addition, recently passed City of Avon Lake legislation requires that all future

[1]Water backed up or retarded in its course as compared with its normal or natural condition of flow.

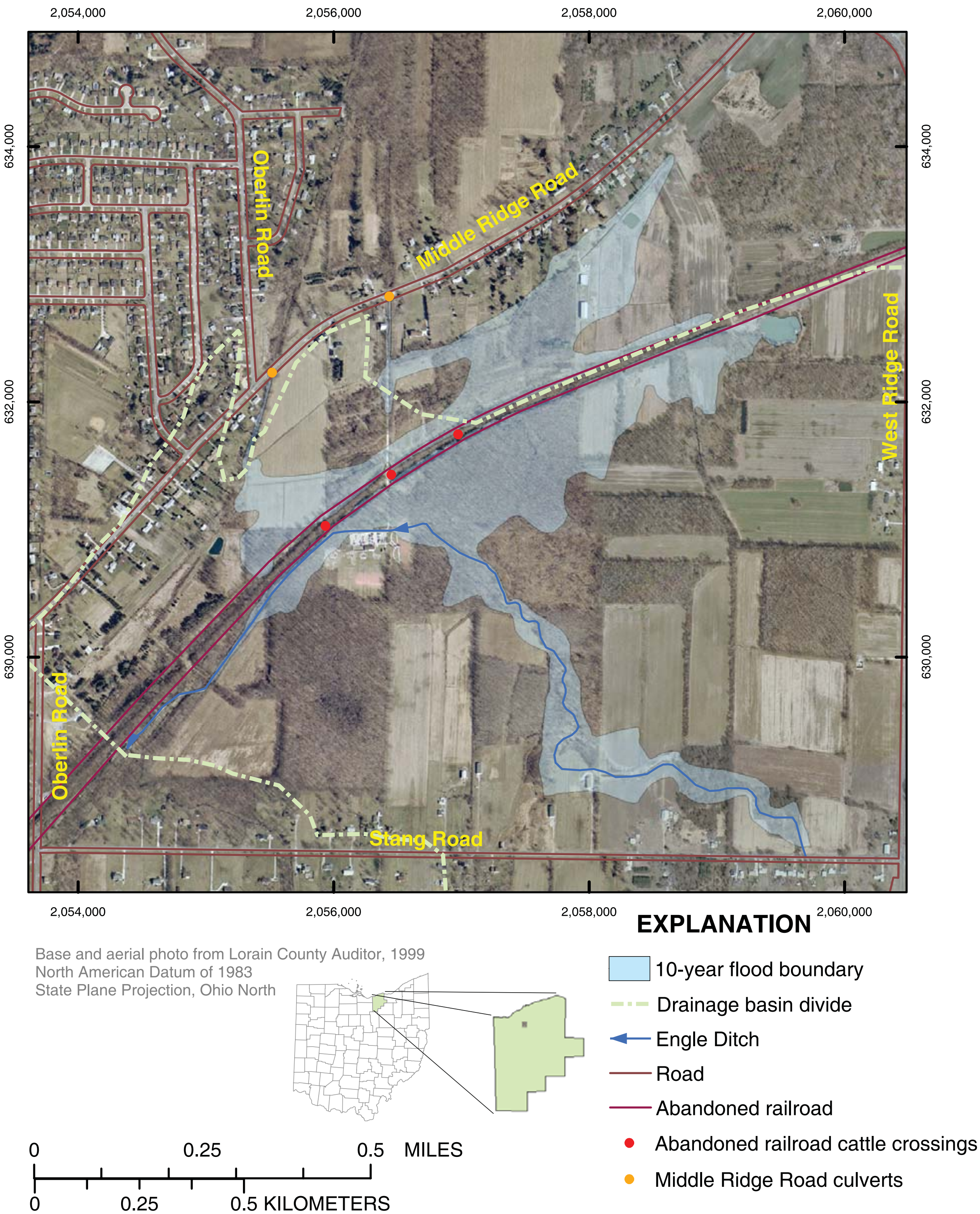

Figure 2. The 10-year flood boundary for Engle Ditch, Lorain County, Ohio, and the abandoned railroad cattle crossing that allows Engle Ditch flood discharge to flow to the north and then pass beneath Middle Ridge Road.

development within the Heider Ditch Basin south of the Norfolk and Western Railroad[2] set aside 0.17 acre-feet of storage per acre of land developed.

The USGS met with city officials to determine the extent and locations of present and required future storage areas within the Heider Ditch Basin. During the meeting with city officials, storage areas created since the last topographic map revision, as well as, areas within the Heider Ditch Basin anticipated to be developed, were delineated. Because of the input requirement of the storage term in the rural-regression equations and uncertainty about how the storage areas would be constructed, a relation between required storage volume and percent storage area had to be estimated.

To obtain a storage surface area, the required storage volume (0.17 acre-feet per acre) was divided by an assumed average depth. For the Heider Ditch Basin, the USGS assumed an average depth of 3.6 ft for each required future storage area. The total percent storage value at each of the six discharge estimation points along Heider Ditch was tabulated by summing the storage areas visible on the quadrangle maps, the provided current storage areas, and the estimated future storage areas based upon an assumed depth. Results are listed in table 3.

It should be noted that the estimated percent storage values for one of the six discharge estimation points (Heider Ditch above the Norfolk and Western Railroad) was outside of the range of storage-area values from which the regression equations were developed. The maximum storage area value for the regression equations (Koltun and Roberts, 1990) is 5.6 percent, whereas the Heider Ditch storage area above the railroad is 6.46 percent. The exceedance of the storage- area upper limit was judged to be acceptable for this analysis, and was not unexpected, because the regression equations were not developed in areas with appreciable required storage.

Hydrologic analyses for Heider Ditch

Original estimates of the 10-year flood-peak discharges along each of the studied streams were provided to Lorain County and the City of Avon Lake for review and comment. Based on their local, long-term knowledge of flooding in the Heider Ditch Basin, concerns were raised about the preliminary flood-peak estimates for Heider Ditch. City of Avon Lake officials expressed concerns that the flood-peak discharges may be overestimated. The officials presented USGS representatives with the “Avon Lake Storm Drainage Master Plan” (Jones and Henry, 1982), which had been done for the city and which provides some insight into the hydrologic characteristics in the upper part of the Heider Ditch Basin (upstream from the study reach for this investigation). The upstream conditions may attenuate the flood-peak discharges for Heider Ditch and potentially reduce the flood-peak discharges observed in the downstream study reach. The USGS reviewed pertinent aspects of the report related to Heider Ditch and found the analyses presented to be based upon reasonable and sound engineering judgement. All further hydrologic explanation for Heider Ditch is based on the assumption that the analyses presented in the Jones and Henry report (1982) are valid.

The Heider Ditch Basin is bisected by the Norfolk & Western Railroad running east-west near the middle of the drainage basin (fig. 3). According to Jones and Henry (1982), the railroad restricts flow from the upper to the lower part of the basin. The report also lists the design maximum flow capacities of the culverts through the railroad embankment (table 4). Five culverts within the railroad embankment convey flow from the southern half of the Heider Ditch Basin (fig. 3) to the northern half. Because flows will be unable to overtop the railroad embankment, the culverts will restrict the flow passing through the embankment and cause some of the 10-year flood-peak discharge to be placed into temporary storage. This temporary storage caused by the railroad embankment will result in a reduction of the 10-year flood-peak discharge estimates obtained from the Koltun and Roberts (1990) for six discharge estimation points along Heider Ditch downstream from the railroad (table 3).

To establish the attenuated 10-year flood-peak discharge estimates, the Heider Ditch drainage area was divided into seven sub-basins based on the six discharge-estimation points and the location of the Norfolk & Western Railroad (fig. 3). Intervening flood-peak discharges for each subbasin were calculated as the difference between the regression estimate at the downstream end of the subbasin and the discharge passed into the subbasin from upstream subbasins(s) (table 5). The drainage area between Carriage Lane and Unnamed Tributary B was split into subbasins C and D. The flood-peak discharges for subbasins C and D were apportioned on the basis of drainage area size. Final attenuated discharge estimates for the six discharge estimation points along Heider Ditch were determined by accounting for (1) flood-peak discharges passed on from upstream areas, (2) flood-peak discharge generated by the intervening area (subbasin), and where applicable, (3) the maximum intrabasin discharge conveyed by the railroad culverts.

The three culverts under the railroad near the main channel of Heider Ditch collectively will convey a maximum of 341 ft^3/s (54 ft^3/s + 67 ft^3/s + 220 ft^3/s); table 4 and fig. 3. Two additional culverts under the railroad, west of the Heider Ditch main channel, will convey a maximum total of 91 ft^3/s (50 ft^3/s + 41 ft^3/s). Tabulating the

[2]The Norfolk and Western Railroad name was obtained from USGS quadrangle maps. Since the publication of the maps, the name has been changed to the Norfolk Southern Railroad. To maintain consistency with the published USGS quadrangle maps, the railroad will be referred to as the Norfolk and Western Railroad in this report.

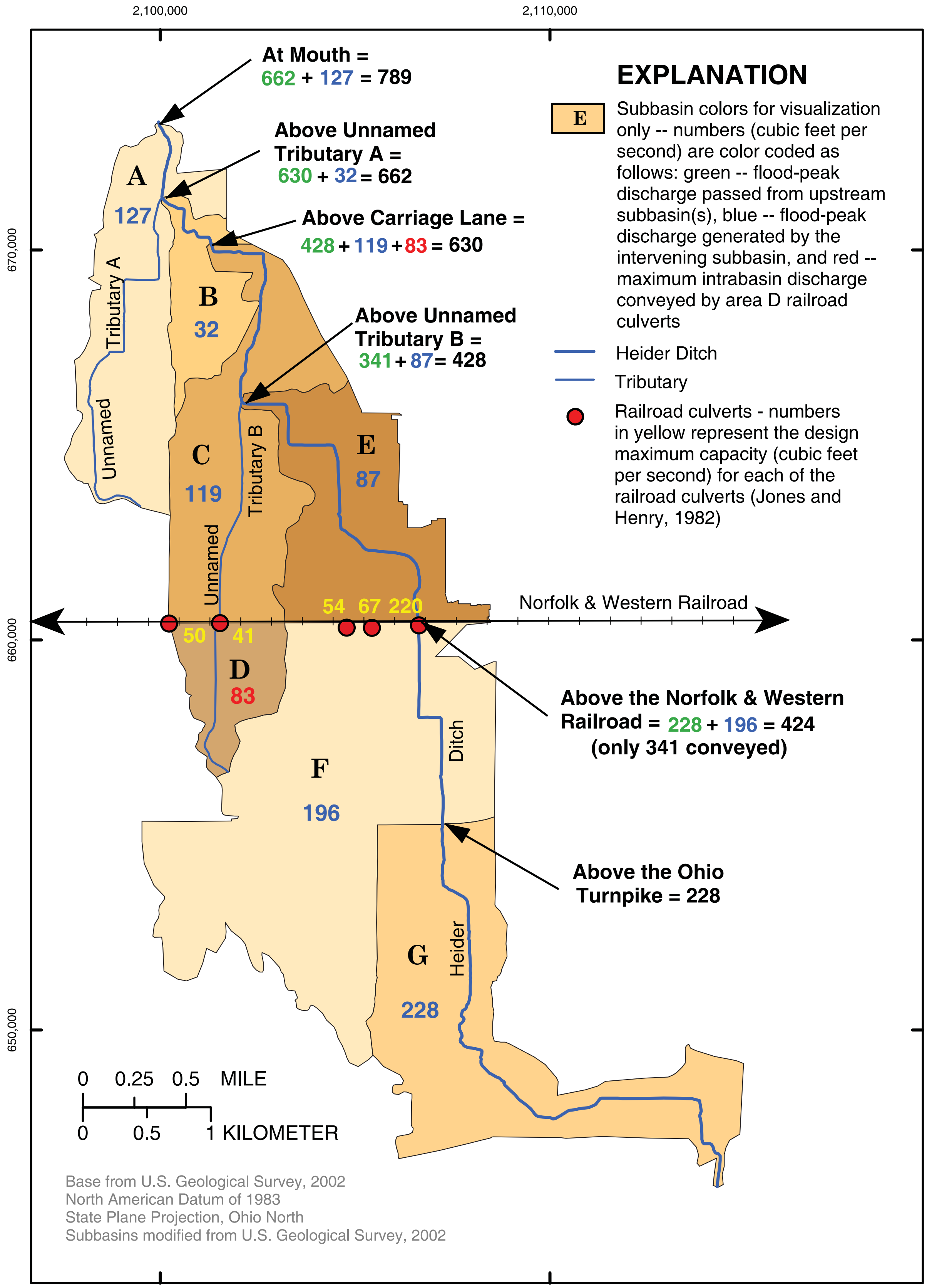

Figure 3. Heider Ditch subbasins, Lorain County, Ohio.

Table 4. Railroad culverts design maximum discharge capacities, Lorain County, Ohio

[Source: Jones and Henry, 1982. Abbreviations: inch, in.; ft, feet; ft^3/s, cubic feet per second]

Culvert location along the Norfolk & Western Railroad tracks	Culvert shape	Existing culvert dimensions	Design maximum capacity (ft^3/s)
At Avon-Belden Road	Box	8 feet by 3.5 ft	50
1,400 ft east of Avon-Belden Road	Circular	33-in. diameter	41
200 ft west of Jaycox Road	Circular	36-in. diameter	54
At Jaycox Road	Circular	48-in. diameter	67
800 ft east of Jaycox Road	Box	8 feet by 6.6 ft	220

intervening regression peak-flow discharge estimates up to the railroad (subbasins G and F) results in 424 ft^3/s (196 ft^3/s + 228 ft^3/s). This would indicate that 341 ft^3/s will pass through the main-stem culverts and 83 ft^3/s will be put into potential storage upstream of the railroad. Because of the relatively flat terrain, it was assumed that all of the flow (83 ft^3/s) put into potential storage by the railroad culverts on the main stem of Heider Ditch would be able to pass over the intrabasin divide and into subbasin D to the west. The intrabasin flow likely would result because of the small elevation difference (approximately 2 ft) between the basin confines and the main-channel top of bank.

Because of the large difference in drainage area between the sum of subbasins F and G (3.26 mi^2) and subbasin D (0.271 mi^2), it was assumed that the flood-peak discharge generated by subbasin D (36 ft^3/s, table 5) already would have passed before the intrabasin flow from subbasins F and G would flow into subbasin D. Then it was assumed that the culverts downstream from subbasin D would pass the 83 ft^3/s from the intrabasin flow (less than the combined culvert design maximum of 91 ft^3/s). The flood-peak discharge from area D eventually returns to the main channel of Heider Ditch at a downstream location (fig. 3).

The flood-peak discharges for Heider Ditch main-channel locations downstream from the Norfolk & Western railroad were calculated by adding the total flood-peak discharge passed from upstream subbasins to the discharge generated by the intervening drainage area (fig. 3). The final attenuated flood-peak estimates (used in the HEC-RAS model) are listed in table 6.

Table 5. Peak-flow estimates for the intervening subbasins for Heider Ditch and Unnamed Tributaries A and B, Lorain County, Ohio

[ft^3/s, cubic feet per second; mi^2, square miles]

Subbasin designation (Figure 3)	Intervening subbasin area (mi^2)	Subbasin peak-flow estimate (ft^3/s)
A	0.760	127
B	.263	32
C	.893	119
D	.271	36
E	.743	87
F	1.97	196
G	1.29	228

Table 6. Final attenuated flood-peak estimates for Heider Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second]

Hydraulic model stream reach (Figure 1)		Final attenuated flood-peak estimate (ft^3/s)
From	To	
Mouth	Unnamed Tributary A	789
Unnamed Tributary A	Carriage Lane	662
Carriage Lane	Unnamed Tributary B	630
Unnamed Tributary B	Norfolk & Western Railroad	428
Norfolk & Western Railroad	Ohio Turnpike	424
Ohio Turnpike	Upper basin limit	228

Hydraulic Analyses

The step-backwater model HEC-RAS, 3.0.1 (U.S. Army Corps of Engineers 2001a-c), was used to determine water-surface profiles for all nine streams studied. All hydraulic analyses in this investigation were based on computations of one-dimensional, steady, gradually varied flow. The analyses also are based on the assumption that flow is unobstructed in all stream channels and through all simulated hydraulic structures. Flooding on each stream was evaluated independently of the other streams.

Analyses of open channels

In general, the streams studied in Lorain County have narrow channels, commonly less than 80 ft wide. Typically, flows in small streams are affected by rapid transitions in channel geometry, leading to abrupt changes in cross-sectional area and conveyance[3] between sections; these abrupt changes can result in inaccurate estimation of water-surface profiles. To help diminish abrupt transitions of area and conveyance in the hydraulic analyses, the maximum distance between open-channel cross sections was limited to no more than 500 ft. Nearly all distances between sections in the hydraulic models developed for the nine streams studied are much less than 500 ft (approximately 250 ft).

Flow in open channels typically encounters resistance. This resistance to flow can result in energy losses because of friction, contractions and expansions, and abrupt flow transitions at hydraulic structures. Stream channel and overbank roughness coefficients (Manning's n) were estimated for all cross sections developed for the hydraulic models. HEC-RAS default values for contraction- and expansion-loss coefficients were used for most of the cross sections in the models. At select locations, typically upstream and downstream from hydraulic structures and at abrupt changes in the stream channel cross-sectional area, default values for the coefficients were modified on the basis of engineering judgement. At structures with abrupt flow transitions, contraction- and expansion-loss coefficient typically were increased from the HEC-RAS default values to account for the additional energy losses.

Starting water-surface elevations for all streams were established using the normal depth[4] (slope conveyance) option in HEC-RAS. A main-channel slope was computed from the average of main-channel streambed elevations from surveyed cross sections near the downstream limit of each stream reach. These main-channel slopes were assumed to approximate the respective energy-grade-line slopes for the purposes of normal-depth calculations. Values of selected hydraulic parameters used in the hydraulic models are listed in table 7. Selected results of the final hydraulic analyses done for this study are presented in tabular and graphical formats in the appendixes at the back of this report.

[3] The capacity of a channel cross section to carry flow without regard to channel slope.

[4] Normal depth is the depth of uniform flow. Flow is considered uniform if the energy line, water surface, and channel bottom all are parallel (Chow, 1959).

Table 7. Selected hydraulic parameters used for the step-backwater models in Lorain County, Ohio

[ft/ft, feet per foot]

Stream name (Fig. 1)	Baseline reference location[a]	Number of surveyed cross sections	Number of synthetic cross sections derived from triangular irregular network'	Number of hydraulic structures	Slope used for normal depth calculation (ft/ft)	Manning's roughness coefficient (*n*)			
						Lowest value for main channel	Highest value for main channel	Lowest value for overbanks	Highest value for overbanks
Battenhouse Ditch	Middle Ridge Road	108	53	20	0.00246	0.038	0.048	0.038	0.080
Beaver Creek	State Route 113	22	81	4	.00194	.034	.048	.040	.074
Brighton-Camden Ditch	Mouth	38	78	7	.00105	.036	.054	.030	.070
Engle Ditch	Mouth	13	24	2	.00237	.036	.048	.030	.068
Gable Ditch	Mouth	36	44	7	.00914	.028	.048	.028	.048
Heider Ditch	Mouth	71	24	14	.00846	.032	.050	.034	.066
Plum Creek	Pyle South Amherst Road	17	24	3	.00242	.036	.052	.038	.084
Ridgeway Ditch	Case Road	107	35	21	.00181	.038	0.05	.040	.078
Schroeder Ditch	State Route 20	60	42	11	.00316	.036	.060	.030	.090

[a] Downstream limit of the study reach.

Analyses of hydraulic structures

Four methods for computing losses through bridges are available in HEC-RAS. The energy equation (standard-step method) is applicable to the widest range of hydraulic problems (U.S. Army Corps of Engineers, 2001b). The standard-step method performs computations at bridges basically as open-channel flow, except that adjustments are made to account for the cross-sectional area and wetted perimeter[5] within the bridge opening. For most bridges in the HEC-RAS hydraulic models developed for this study, the energy equation was used to account for energy losses (table 8).

By definition, pressure flow occurs when the water surface on the upstream side of a bridge equals or exceeds the low-chord elevation, a condition that can cause the bridge to function as a pressurized orifice. In these cases, pressure-flow computations are warranted for use in HEC-RAS simulation. The use of this type of solution was checked at all bridges in the hydraulic models where the water-surface elevation derived from the energy equation was found to be within 1.0 ft of the low-chord elevation of a bridge. Review of the HEC-RAS model output yielded three valid pressure-flow computation situations at the following locations: Ridgeway Ditch, river stations 4,816 and 13,080; and Schroeder Ditch, river station 458 (table 8).

When road overflow occurs at a culvert, a weir-flow computation to determine the amount of flow passing over the road is used in HEC-RAS simulation (U.S. Army Corps of Engineers, 2001c). The validity of the use of this computation type must be checked by means of a submergence[6] calculation. In order for a weir-flow computation to be considered valid, the road embankment must be high enough to cause the flow to pass through critical depth[7]. If a wier flow computation is not valid, computations are based upon contracted open-channel flow. For situations where road grades are submerged, Shearman and others (1986) recommend

[5]Wetter perimeter is defined as the length of the line of intersection of the channel wetted surface with a cross-section plane normal to the direction flow (Chow, 1959).

[6] Submergence is defined as the ratio of the depth of water above the minimum weir elevation on the downstream side of a structure divided by the height of the energy grade line above the minimum weir elevation on the upstream side of a structure (U.S. Army Corps of Engineers, 2001c). The model default maximum submergence is set to 0.95 (95 percent).

[7] Critical depth is the depth of flow at which the specific energy is a minimum for a given discharge (Chow, 1959).

Table 8. Selected bridge and culvert modeling approaches for Lorain County, Ohio

River station	Location description	Hydraulic structure	Modeling approach	Road overflow
		Battenhouse Ditch		
0	Middle Ridge Road	Culvert	Energy	No
1,359	Railroad 1	Culvert	energy	No
2,062	Private Driveway 1	Culvert	Energy	Yes
3,425	Abandoned Railroad 1	Culvert	Energy	No
4,146	Abandoned Railroad 2	Culvert	Energy	No
4,678	Oberlin Road 1	Culvert	Energy	Yes
7,568	Stang Road	Culvert	Energy	No
9,563	Railroad 2	Culvert	Energy	No
10,267	Ohio Turnpike	Culvert	Energy	No
11,505	Farm Path 1	Culvert	Energy	Yes
12,498	Farm Path 2	Culvert	Energy	Yes
14,562	Oberlin Road 2	Culvert	Energy	Yes
15,012	Private driveway 2	Culvert	Energy	Yes
15,315	Private Driveway 3	Bridge	Energy	Yes
15,701	Private Driveway 4	Culvert	Energy	Yes
15,832	Private Driveway 5	Culvert	Energy	Yes
16,122	Oberlin Road 3	Culvert	Energy	Yes
16,301	Private Driveway 6	Bridge	Energy	Yes
18,000	State Route 113	Culvert	Energy	Yes
21,379	Farm Path 3	Culvert	Energy	Yes
24,463	Farm Path 4	Culvert	Energy	Yes
		Beaver Creek		
0	State Route 113	Culvert	Energy	No
10,860	Russia Road	Bridge	Energy	No
26,293	Quarry Road	Culvert	Energy	No
26,459	Garfield Road	Culvert	Energy	No
		Brighton-Camden Ditch		
2,950	Baird Road 1	Culvert	Energy	No
6,113	Betts Road	Culvert	Energy	Yes
14,747	Farm Path	Culvert	Energy	Yes
17,267	Baird Road 2	Culvert	Energy	No
17,854	Private Driveway	Bridge	Energy	No
20,622	Peck-wadsworth Rd	Culvert	Energy	No
23,332	Railroad	Culvert	Energy	No
		Engle Ditch		
875	Private Driveway 1	Culvert	Energy	Yes
2,830	Private Driveway 2	Culvert	Composite[a]	Yes
		Gable Ditch		
249	Private Driveway 1	Culvert	Energy	No
334	Private Driveway 2	Bridge	Energy	No

Table 8. Selected bridge and culvert modeling approaches for Lorain County, Ohio —Continued

River station	Location description	Hydraulic structure	Modeling approach	Road overflow
376	Private Driveway 3	Culvert	Energy	No
637	State Route 6	Culvert	Energy	No
1,740	Electric Boulevard	Culvert	Energy	No
5,603	Redwood Boulevard	Culvert	Energy	No
7,956	Jaycox Road	Culvert	Energy	No
	Heider Ditch			
333	State Route 6	Culvert	Energy	No
1,497	Electric Boulevard	Culvert	Energy	No
2,472	State Route 83	Culvert	Energy	No
2,634	High School Footbridge 1	Bridge	Energy	No
2,854	High School Footbridge 2	Bridge	Energy	No
3,009	High School Driveway	Culvert	Energy	No
4,232	Carriage Lane	Culvert	Energy	No
5,924	Surrey Lane	Culvert	Energy	No
7,037	Belle Road	Culvert	Energy	Yes
7,787	Proposed Road 1[b]	Culvert	Energy	Yes
8,146	Proposed Road 2[b]	Culvert	Energy	Yes
8,492	Proposed Road 3[b]	Culvert	Energy	Yes
9,564	Spinnaker Road	Culvert	Energy	No
10,678	Amour Road	Culvert	Energy	No
	Plum Creek			
0	Pyle-south Amherst Road	Bridge	Energy	No
2,158	Hamilton Road	Bridge	Energy	No
2,285	Bike Path	Bridge	Energy	No
	Ridgeway Ditch			
0	Case Road	Culvert	Energy	No
343	Private Driveway 1	Bridge	Energy	No
4,816	Private Driveway #2	Bridge	Pressure	No
7,298	State Route 113	Culvert	Energy	No
8,207	Private Driveway #3	Bridge	Energy	No
11,435	Race Road	Culvert	Energy	No
12,174	Private Driveway 4	Bridge	Energy	Yes
12,745	School Driveway 1	Culvert	Energy	Yes
13,080	School Driveway 2	Bridge	Pressure	Yes
15,609	Ohio Turnpike	Culvert	Energy	No
16,142	Maddock Road 1	Culvert	Energy	No
16,331	Private Driveway 5	Bridge	Energy	No
16,859	Private Driveway 6	Bridge	Energy	No
17,286	Railroad	Culvert	Energy	No
17,358	Maddock Road 2	Culvert	Energy	No
17,718	Private Driveway 7	Bridge	Na[c]	Yes
17,946	Sugar Ridge Road	Culvert	Energy	No

Table 8. Selected bridge and culvert modeling approaches for Lorain County, Ohio —Continued

River station	Location description	Hydraulic structure	Modeling approach	Road overflow
18,540	Line Drive	Culvert	Energy	No
19,284	Shady Drive	Culvert	Energy	Yes
20,225	Private Driveway 8	Culvert	Energy	Yes
21,290	Lexington Way	Culvert	Energy	Yes
		Schroeder Ditch		
0	State Route 20	Bridge	Energy	No
458	Cemetery Footbridge	Bridge	Pressure	Yes
889	Blanche Avenue	Culvert	Energy	Yes
2,022	Libby Road	Culvert	Energy	No
10,870	West Ridge Road	Culvert	Energy	No
11,044	Russia Road	Culvert	Energy	No
12,692	Bike Path	Culvert	Energy	No
13,420	Private Driveway 1	Culvert	Energy	Yes
13,593	Private Driveway 2	Bridge	Energy	Yes
14,197	Private Driveway 3	Culvert	Energy	Yes
15,108	Farm Path	Culvert	Composite[a]	Yes

[a] Modeled using composite sections because of the structure submergence.
[b]At these locations, culverts spanning Heider Ditch have been constructed; however, the associated roadways have not been cleared on constructed.
[c] Modeled using open-channel hydraulics because of the structure being completely submerged.

abandoning culvert and weir hydraulics in favor of composite sections (the combination of the road and culvert cross-section geometries) to reflect pseudo-open-channel conditions.

Preliminary HEC-RAS simulation indicated that road overflow would occur at numerous culverts on most of the studied streams (table 8). A check for submergence was done at each situation of road overflow at a culvert to assess the validity of the model default weir-flow calculation. In two locations (Schroeder Ditch, river station 15,108; and Engle Ditch, river station 2,830), the model default weir-flow solution was found to be invalid because of submergence. The culverts at these two locations then were simulated using composite sections.

Model simulation also indicated that one bridge (Ridgeway Ditch - river station 17,718) would be completely inundated (submerged). Water would move around the bridge opening and over the top of the bridge deck. In such a situation, standard hydraulic computations for bridges are not considered valid, and hydraulic computations for open channels are applied. The bridge water-surface elevation was based on open-channel hydraulics, where the bridge was removed from the model and the channel was simulated as open-channel cross sections.

Results of Hydraulic Analyses

Water-surface profiles corresponding to the 10-year-flood-peak discharges are presented in tabular format (appendix A) and in graphical formats (appendix B) in the back of this report. These profiles show computed water-surface elevations as a function of distance from a reference location. Also depicted on the profile plots are the minimum channel elevations at each cross section and the hydraulic structures. All elevations presented in the profile plots are referenced to the NAVD 88.

Base Maps and Flood-boundary Delineation

All base maps used for this study effort were compiled by Surdex Corporation of St. Louis, Missouri, under contract with the Lorain County Auditor. The data included a 2-ft topographic map layer (2-ft contour-interval) and digital orthophotos rectified to the digital terrain. All data were provided by the Lorain County Auditor.

The aerial photography for the mapping effort was shot March 27, 1999, at a scale of 1 in. = 660 ft. The horizontal datum for the mapping is the NAD83, Ohio State

Plane (Ohio North) coordinates. The vertical datum for the mapping is the NAVD 88.

CD-ROMs were obtained from Lorain County containing copies of digital exchange format (DXF) files of all the mapping information and orthophotos. The DXF files were imported into the geographic information system (GIS) ARC/INFO and the different mapping features were separated into coverages. Coverages included, but were not limited to, roads, topographic contours (2-ft interval), hydrographic features, buildings, and railroads. These coverages served as the base-map features for this study.

Using the digital mapping data and the results from the 10-year flood water-surface profiles obtained from the hydraulic models, flood plain boundaries were established for the nine streams studied. Flood-boundary delineations were developed from the computed edge-of-water stations at each cross section in the HEC-RAS models. Between cross sections, flood boundaries were interpolated and were based on the contours of the land as indicated on the mapping data.

The locations of cross sections used in the models and the flood-boundary delineations for the stream reaches studied are presented as overlays on digital orthophoto images and are available for viewing in plates 1-9 on the CD-ROM in the back pocket of this report.

Summary

Hydrologic and hydraulic analyses were done for selected reaches of nine streams in Lorain County, Ohio: Battenhouse Ditch, Beaver Creek, Brighton-Camden Ditch, Engle Ditch, Gable Ditch, Heider Ditch, Plum Creek, Ridgeway Ditch, and Schroeder Ditch. This study was done by the USGS in cooperation with the Lorain County Engineer and will assist local officials in assessing various alternatives to mitigate flood hazards in Lorain County, Ohio.

Historical streamflow data and regional regression equations from the current flood-frequency report for Ohio were used to estimate instantaneous peak discharges, for primarily rural basins, for floods having recurrence intervals of 2, 5, 10, 25, 50, and 100 years. Explanatory variables used in the regression equations were drainage area, main-channel slope, and storage area. Techniques for developing gage-weighted flood-peak discharge estimates were used to incorporate the available historical peak-flow data for Plum Creek. To reflect urban development in the Heider and Gable Ditch Basins, rural flood-peak discharge estimates were modified using methods to reflect the effects of urbanization on flood characteristics. Flow- apportionment analyses for Engle Ditch indicated that about 62 percent of the main-channel estimated 10-year flood-peak discharge will flow into the adjacent drainage basin. Determinations from a previous study were incorporated in the estimated 10-year flood-peak discharges for the Heider Ditch Basin.

Hydraulic models were developed to determine water-surface profiles along the nine stream reaches studied for the 10-year flood-peak discharges established in the hydrologic analyses. The step-backwater hydraulic analysis model HEC-RAS was used to determine water-surface profiles for the nine streams. Starting water-surface elevations for all streams were established using normal depth computations in HEC-RAS. Cross-sectional elevation data, hydraulic-structure geometries, and roughness coefficients were collected in the field and (along with peak-discharge estimates) used as input for the models. Data for 877 open-channel cross sections and 90 hydraulic structures were collected and developed. Model simulation indicated that road overflow results at numerous hydraulic structures along the nine streams for the 10-year flood.

Water-surface profiles plots corresponding to the 10-year floods are presented for the nine stream studied. Flood-plain boundaries were delineated for the nine streams using the digital mapping data and the results from the 10-year flood water-surface profiles. The flood-boundary delineations and cross-section locations for the stream reaches studied are presented as digital overlays on orthophoto images in electronic format on a CD-ROM that accompanies this report.

References

Chow, V.T., 1959, Open-channel hydraulics: New York, McGraw-Hill, 680 p.

Federal Geographic Data Committee, 1998, Geospatial Accuracy Standards, National; Standard for Spatial Data Accuracy (FGDC-STD-007.3-1998), 28p.

Jones and Henry Engineers Limited, 1982, City of Avon Lake, storm drainage master plan: Toledo, Ohio, 148 p.

Koltun, G.F., and Roberts, J. W., 1990, Techniques for estimating flood-peak discharges of rural, unregulated streams in Ohio: U.S. Geological Survey Water-Resources Investigations Report 89-4126, 68 p.

National Oceanic and Atmospheric Administration, 1997, Guidelines for establishing GPS-derived ellipsoid heights (Standards: 2 cm and 5 cm), version 4.3: Technical Memorandum NOS NGS-58, 21 p.

Sauer, V.B., Thomas, W.O., Jr., Stricker, V.A., and Wilson, K.V., 1983, Flood characteristics of urban watersheds in the United States: U.S. Geological Survey Water-Supply Paper 2207, 63 p.

Shearman, J.O., Kirby, W.H., Schneider, V.R., and Flippo, H.N., 1986, Bridge waterways analysis model—Research report: Federal Highway Administration Publication FHWA-RD-86-108, 112 p.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, January 2001a: HEC-RAS River Analysis System, Users Manual, Version 3.0, 243 p.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, January 2001b: HEC-RAS River Analysis System, Hydraulic Reference Manual, Version 3.0, 251 p.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, January 2001c: HEC-RAS River Analysis System, Applications Guide, Version 3.0, 283 p.

U. S Bureau of the Census, 1999, County Population Estimates (accessed at www.census.gov, March 2000)

Table A-1. Selected HEC-RAS output for Battenhouse Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
-192	585	707.60	712.79	713.03	0.002461	3.87	151.18	40.94	0.35
-148	585	707.40	712.89	713.12	.002037	3.84	152.24	41.19	.33
0					Culvert				
10	585	708.00	714.41	714.53	.000928	2.79	209.71	118.38	.23
42	585	708.50	714.48	714.57	.000958	2.49	254.68	128.10	.23
381	464	710.20	714.86	715.18	.004289	4.53	102.41	32.51	.45
628	464	711.40	715.76	715.92	.002168	3.30	140.89	45.53	.33
827	464	712.50	716.24	716.48	.003401	3.97	116.85	40.43	.40
989	464	713.10	716.92	717.37	.008438	5.38	86.22	36.35	.62
1098	464	713.80	717.73	718.27	.007647	5.88	78.97	25.69	.59
1281	464	712.49	718.77	719.15	.003025	4.95	93.81	31.52	.38
1359					Culvert				
1369	464	712.65	720.95	721.04	.000469	2.48	187.21	54.15	.17
1404	464	714.70	720.99	721.07	.000553	2.35	209.62	52.04	.18
1643	464	715.10	721.14	721.28	.001252	3.04	156.06	43.14	.25
2022	464	715.60	721.68	721.85	.001821	3.32	139.68	37.19	.30
2030	464	715.60	721.70	721.87	.001795	3.30	140.43	37.28	.30
2062					Culvert				
2072	464	716.30	722.93	723.04	.000682	2.65	185.82	200.70	.20
2089	464	716.30	722.99	723.05	.000456	2.07	250.87	202.16	.16
2451	464	716.90	723.11	723.12	.000122	1.18	592.64	248.22	.08
2687	464	717.30	723.14	723.15	.000136	1.19	575.42	238.75	.09
2822	464	717.50	723.15	723.19	.000309	1.72	349.73	125.65	.13
3043	464	717.90	723.21	723.32	.001058	2.78	203.51	114.70	.24
3325	464	718.30	723.55	723.69	.001567	3.08	151.96	138.17	.29
3347	464	718.70	723.49	723.85	.002958	4.81	96.55	132.51	.40
3425					Culvert				
3435	464	718.30	725.14	725.24	.000585	2.53	183.17	228.08	.19
3458	464	718.30	725.22	725.26	.000264	1.58	323.77	229.07	.13
3740	464	718.80	725.29	725.31	.000120	1.20	519.93	179.67	.08
4030	464	719.40	725.31	725.41	.000879	2.64	198.69	186.34	.22
4066	464	719.40	725.27	725.53	.001653	4.05	114.71	184.90	.31
4146					Culvert				
4156	464	719.50	726.29	726.39	.000600	2.56	181.16	223.81	.19
4169	464	720.10	726.35	726.41	.000426	2.05	250.86	226.61	.16
4635	464	721.40	726.63	726.88	.003095	4.04	114.93	34.44	.39
4640	464	719.90	726.86	726.94	.000619	2.33	199.26	122.39	.16
4678					Culvert				
4683	464	720.90	726.94	727.04	.000964	2.55	183.12	158.64	.21

Table A-1. Selected HEC-RAS output for Battenhouse Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
4689	464	721.10	726.93	727.05	.000982	2.70	173.14	158.45	.23
5100	464	721.90	727.24	727.27	.000324	1.69	395.30	169.51	.13
5551	464	722.70	727.43	727.51	.001013	2.40	250.24	129.57	.22
5825	380	723.30	727.58	727.59	.000158	1.05	646.39	350.03	.09
6185	380	724.00	727.67	727.71	.000787	2.02	269.76	159.16	.19
6554	380	724.70	728.12	728.46	.007146	4.74	93.75	179.43	.54
6872	380	725.30	729.26	729.37	.001482	2.74	167.58	109.16	.26
7001	380	725.60	729.42	729.55	.001217	2.91	139.81	56.30	.28
7294	380	726.20	729.89	730.13	.003237	3.98	101.66	57.28	.42
7393	380	726.30	730.16	730.59	.005253	5.27	72.60	31.36	.54
7520	380	726.60	730.87	731.33	.006237	5.47	69.50	25.53	.58
7536	380	727.20	730.98	731.44	.006816	5.44	69.88	25.24	.58
7568					Culvert				
7578	380	727.20	731.73	732.04	.003632	4.44	85.57	23.50	.41
7611	380	726.90	731.83	732.19	.004515	4.82	78.84	23.36	.46
7930	380	727.50	732.69	732.79	.000939	2.50	184.16	148.71	.22
8309	380	728.20	733.05	733.15	.000961	2.55	172.25	88.43	.22
8758	380	729.00	733.45	733.52	.000729	2.16	176.93	51.99	.19
9100	380	729.60	733.85	734.19	.008020	4.71	80.62	34.03	.54
9472	380	730.30	735.20	735.32	.001534	2.69	141.19	42.07	.25
9489	380	730.30	735.21	735.36	.001656	3.03	125.21	42.18	.27
9563					Culvert				
9568	380	731.00	735.60	735.72	.001325	2.83	134.14	61.00	.24
9573	380	730.40	735.62	735.73	.001343	2.60	147.97	61.16	.24
9993	380	731.60	736.20	736.29	.001340	2.43	177.34	93.45	.24
10024	380	731.80	736.26	736.32	.000671	2.05	184.92	78.17	.18
10267					Culvert				
10277	380	732.00	736.39	736.46	.000712	2.02	191.98	58.89	.18
10306	380	731.70	736.44	736.49	.001125	2.09	220.16	122.62	.21
10488	380	732.40	736.60	736.68	.000949	2.30	195.69	200.57	.21
10603	380	733.00	736.37	737.18	.017588	7.22	52.94	136.94	.80
10751	380	733.90	738.17	738.40	.004420	3.95	110.84	147.91	.42
10899	380	734.60	738.69	738.84	.002085	3.28	145.21	132.95	.31
11036	380	735.30	739.00	739.13	.002015	3.10	171.87	195.87	.30
11306	380	736.60	739.70	739.98	.004917	4.25	89.50	32.40	.45
11458	380	736.60	740.76	741.24	.014225	5.86	82.52	105.84	.72
11471	380	736.60	741.25	741.43	.004349	3.88	146.08	169.82	.42
11505					Culvert				
11515	380	736.40	742.05	742.10	.001404	2.42	257.55	280.80	.23
11546	380	737.10	742.11	742.15	.001093	2.09	291.56	305.93	.21

Table A-1. Selected HEC-RAS output for Battenhouse Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
11798	380	737.30	742.34	742.50	.001481	3.26	130.02	115.96	.28
12082	380	737.60	742.76	742.91	.001398	3.20	139.86	106.15	.27
12456	380	738.00	743.44	743.69	.003123	4.00	95.24	31.74	.40
12472	380	738.00	743.51	743.75	.003210	3.91	97.42	32.14	.39
12498					Culvert				
12508	380	738.90	745.10	745.20	.001336	2.79	216.00	204.04	.28
12525	380	740.10	745.15	745.23	.001088	2.60	222.03	211.17	.25
13021	380	741.30	745.62	745.69	.000797	2.44	247.89	186.08	.22
13385	380	742.10	746.03	746.42	.006458	5.02	75.72	37.46	.58
13515	380	742.50	746.67	746.85	.001875	3.50	135.97	129.41	.33
13807	380	743.10	747.23	747.39	.001791	3.45	158.16	137.94	.33
13979	380	743.40	747.53	747.89	.003881	4.81	79.05	22.28	.45
14105	380	743.80	748.06	748.46	.005046	5.08	74.87	25.13	.51
14330	380	744.00	748.91	749.10	.001748	3.68	145.81	140.64	.31
14478	380	744.70	749.11	749.66	.006434	5.97	63.68	18.55	.57
14513	380	744.80	749.72	749.87	.001271	3.11	122.36	27.82	.26
14562					Culvert				
14572	380	744.80	749.95	750.08	.001136	3.01	133.74	142.72	.23
14580	380	744.90	749.86	750.14	.002609	4.22	89.97	22.75	.37
14971	380	746.90	751.07	751.23	.002931	3.79	144.09	133.38	.42
14987	380	746.70	751.13	751.27	.002622	3.65	149.45	144.29	.38
15012					Culvert				
15022	380	746.40	751.74	751.81	.001103	2.60	236.31	207.61	.26
15053	380	747.30	751.79	751.85	.001100	2.50	236.71	198.81	.25
15298	380	747.80	752.08	752.29	.003258	4.22	121.54	107.61	.43
15303	380	748.20	752.16	752.33	.002967	3.97	131.81	109.02	.40
15315					Bridge				
15325	380	747.80	752.85	752.90	.000818	2.34	273.02	222.02	.21
15360	380	747.80	752.89	752.94	.000691	2.17	281.36	225.26	.20
15496	380	748.50	752.94	753.11	.002174	3.52	152.26	164.53	.33
15653	380	748.50	753.34	753.57	.003701	4.21	117.43	82.98	.40
15684	380	748.50	753.46	753.69	.003227	4.19	121.00	83.93	.39
15701					Culvert				
15711	380	748.50	754.26	754.39	.001748	3.20	157.61	109.94	.28
15721	380	749.30	754.30	754.41	.001444	2.98	175.28	116.81	.27
15788	380	749.80	754.41	754.53	.002160	3.30	169.64	153.75	.32
15807	380	749.80	754.50	754.59	.001865	2.86	195.47	166.00	.28
15832					Culvert				
15842	380	750.40	755.58	755.64	.000940	2.50	275.13	266.35	.23
15856	380	750.40	755.63	755.65	.000568	1.80	350.12	281.75	.17

Table A-1. Selected HEC-RAS output for Battenhouse Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
16054	380	748.20	755.71	755.79	.000655	2.38	170.65	138.41	.18
16070	380	748.10	755.74	755.81	.000412	2.02	192.05	141.03	.14
16122				Culvert					
16132	380	748.10	756.05	756.10	.000209	1.80	210.79	49.25	.12
16155	380	748.40	756.05	756.11	.000305	2.07	194.08	36.07	.14
16266	380	748.80	756.04	756.21	.001353	3.27	116.21	23.78	.26
16278	380	748.60	756.13	756.24	.000709	2.73	155.27	45.32	.21
16301				Bridge					
16311	380	748.60	756.66	756.72	.000308	2.16	206.05	57.57	.15
16330	380	749.40	756.64	756.74	.000684	2.57	150.24	31.34	.18
16491	380	750.50	756.74	756.94	.001746	3.66	104.26	21.83	.29
16624	380	751.50	756.98	757.20	.002081	3.79	100.36	20.64	.30
16724	380	752.30	756.89	757.87	.014145	7.96	47.76	12.83	.73
16887	380	754.10	758.61	758.92	.003287	4.40	86.30	21.23	.38
17053	380	755.50	759.22	759.64	.005515	5.20	73.10	21.26	.49
17137	380	757.10	759.73	760.43	.014184	6.70	56.71	22.07	.74
17307	380	758.40	761.43	761.79	.004907	4.81	79.00	27.16	.50
17443	380	760.00	762.27	762.99	.015291	6.84	55.59	26.02	.82
17530	380	760.80	763.50	763.95	.007940	5.42	70.14	29.00	.61
17680	380	761.60	764.68	765.11	.007477	5.27	72.15	27.84	.58
17820	380	762.60	765.71	766.11	.006769	5.08	74.86	28.22	.55
17929	380	764.60	766.60	767.36	.018658	7.04	54.01	29.11	.91
17950	380	764.30	767.10	767.68	.008635	6.12	62.05	35.69	.67
18000				Culvert					
18010	380	764.60	769.72	769.86	.001435	3.06	124.34	195.93	.28
18032	380	764.60	769.81	769.90	.001106	2.49	164.91	169.64	.25
18327	196	765.30	770.06	770.08	.000267	1.33	160.22	75.41	.12
18689	196	766.10	770.19	770.27	.001057	2.35	83.44	25.84	.23
19117	196	767.10	770.67	770.73	.001097	2.03	96.70	43.42	.23
19578	196	768.10	771.32	771.45	.002188	2.88	68.15	28.34	.33
19877	196	768.80	771.83	771.91	.001130	2.21	88.67	32.45	.24
20029	196	769.20	772.02	772.14	.001899	2.73	71.75	27.80	.30
20269	196	770.10	772.64	772.91	.005366	4.15	47.20	21.20	.49
20508	196	770.50	773.51	773.63	.001841	2.73	71.84	27.74	.30
20886	196	771.00	774.16	774.27	.001578	2.61	75.16	28.18	.28
21157	196	771.60	774.68	774.83	.002679	3.15	66.65	41.47	.35
21339	196	772.50	775.36	775.83	.011982	5.51	35.57	16.38	.66
21344	196	772.40	775.55	775.90	.005753	4.78	41.03	17.49	.49
21379				Culvert					
21389	196	772.40	776.67	776.72	.000598	1.84	156.44	200.85	.20

Table A-1. Selected HEC-RAS output for Battenhouse Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
21412	196	772.90	776.69	776.74	.000618	1.94	175.42	223.21	.20
21700	196	772.60	776.86	776.93	.000664	2.03	114.28	78.16	.19
21935	196	773.20	777.02	777.07	.000505	1.70	115.38	33.37	.16
22151	196	773.70	777.16	777.23	.000911	2.08	94.18	32.46	.22
22284	196	774.00	777.30	777.38	.001253	2.35	83.55	30.71	.25
22490	196	774.40	777.62	777.80	.003265	3.40	57.72	24.61	.39
22770	196	774.90	778.32	778.43	.001638	2.71	76.64	56.63	.29
23046	196	775.60	778.76	778.86	.001465	2.55	89.81	77.60	.27
23316	196	776.20	779.19	779.30	.001798	2.69	82.40	81.41	.30
23678	196	776.90	779.77	779.83	.001154	2.23	130.77	161.21	.24
24110	196	777.80	780.42	780.57	.002626	3.03	64.88	30.22	.36
24392	196	778.00	780.79	780.80	.000382	1.22	268.69	246.97	.14
24432	196	777.00	780.80	780.83	.000515	1.63	213.82	221.85	.17
24463					Culvert				
24468	196	776.80	781.09	781.17	.002892	2.65	104.69	167.66	.35
24475	196	778.50	781.10	781.21	.003858	3.00	92.70	146.33	.42
24767	196	778.60	781.78	781.87	.001484	2.47	87.33	54.21	.26
25064	196	778.80	782.08	782.11	.000483	1.48	245.78	302.40	.15
25555	196	779.00	782.22	782.22	.000139	0.80	424.37	601.99	.08
25768	196	779.10	782.25	782.25	.000149	0.84	419.91	401.70	.09
26011	196	779.20	782.29	782.30	.000254	1.06	353.75	401.04	.11
26246	196	779.30	782.33	782.62	.009439	4.46	54.07	99.20	.58

[a] Referenced to feet above Middle Ridge Road

Table A-2. Selected HEC-RAS output for Beaver Creek, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
-92	1510	742.90	750.17	750.61	0.001942	5.51	296.2	72.7	.39
-78	1510	742.50	750.18	750.65	.001845	5.48	275.6	72.8	.37
0					Culvert				
10	1510	742.80	751.47	751.76	.000976	4.40	357.5	69.5	.27
20	1510	742.40	751.48	751.78	.001216	4.61	364.8	65.0	.30
123	1510	743.00	751.75	751.88	.000544	3.31	601.2	133.7	.20
385	1510	743.50	751.96	752.01	.000285	2.20	1101.7	378.3	.14
612	1510	743.90	752.03	752.10	.000500	2.77	904.2	382.2	.19
953	1510	744.50	752.17	752.27	.000658	3.07	881.9	345.7	.20
1439	1510	745.40	752.42	752.45	.000316	2.04	1169.0	320.7	.14
1605	1510	745.80	752.47	752.51	.000383	2.18	1134.7	301.9	.15
1948	1200	746.40	752.60	752.75	.001041	3.44	498.9	198.0	.25
2186	1200	746.80	752.88	753.01	.001184	3.50	552.9	220.3	.26
2546	1200	747.50	753.26	753.51	.001621	4.21	354.0	121.1	.32
2804	1200	748.00	753.75	753.88	.001229	3.44	501.8	162.2	.27
3073	1200	748.50	754.13	754.23	.001291	3.12	654.9	322.6	.26
3329	1200	749.00	754.41	754.88	.004026	5.67	274.4	194.9	.46
3618	1200	749.50	755.58	755.93	.003310	5.12	348.1	225.9	.43
4000	1200	750.20	756.56	756.65	.001137	3.07	642.9	308.2	.25
4370	1200	750.90	756.96	757.13	.001891	3.91	548.8	359.2	.32
4662	1200	751.50	757.48	757.61	.002004	3.73	586.0	324.9	.32
5054	1200	752.20	758.27	758.75	.003624	5.65	266.2	247.8	.47
5378	1200	752.80	759.35	759.60	.001930	4.31	374.5	160.0	.33
5676	1200	753.40	759.92	760.20	.001989	4.39	329.1	139.8	.34
5942	1200	753.90	760.47	760.80	.002319	4.66	291.8	125.0	.37
6080	1200	754.10	760.78	761.12	.002341	4.65	265.8	71.4	.37
6452	1200	754.90	761.61	761.72	.001098	3.31	579.4	208.9	.25
6848	1200	755.40	762.05	762.15	.001570	3.26	606.4	328.4	.28
7046	1200	755.70	762.25	762.32	.000537	2.53	759.5	279.2	.18
7371	1200	756.10	762.45	762.51	.000580	2.43	836.9	354.6	.19
7718	1200	756.60	762.66	762.82	.001311	3.52	511.9	255.8	.28
7892	1200	756.90	762.87	763.06	.001407	3.71	452.3	229.9	.29
8342	1200	757.50	763.49	763.65	.001503	3.64	528.6	311.7	.29
8748	1200	758.10	764.09	764.23	.001328	3.38	503.6	225.0	.28
9239	1200	758.80	764.90	765.17	.002738	4.49	388.9	242.7	.39
9428	1200	759.10	765.35	765.51	.001175	3.46	512.7	241.7	.27
9812	1200	759.70	765.90	766.09	.002075	3.90	432.2	188.7	.33
10199	1200	760.20	766.45	766.53	.000792	2.69	692.1	286.7	.21
10516	1200	760.70	766.70	766.83	.001026	3.18	569.1	300.8	.25
10793	1200	761.10	767.03	767.38	.003577	5.12	278.0	358.9	.43

Table A-2. Selected HEC-RAS output for Beaver Creek, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
10808	1200	761.00	767.03	767.51	.005648	5.78	225.5	356.9	.51
10860					Bridge				
10870	1200	761.00	767.48	768.15	.007239	6.57	187.4	167.6	.59
10897	1200	761.30	768.09	768.30	.002250	4.03	367.1	293.3	.34
11090	847	761.70	768.46	768.54	.000637	2.47	441.4	160.5	.19
11459	847	762.30	768.68	768.73	.000422	2.09	549.2	185.3	.15
11722	847	762.80	768.79	768.91	.000896	2.86	364.5	148.5	.22
12062	847	763.50	769.18	769.26	.001192	2.78	467.5	219.8	.24
12445	847	764.20	769.70	769.91	.002227	3.95	275.8	134.5	.33
12924	847	765.10	770.62	770.82	.001744	3.69	279.2	124.8	.30
13267	847	765.70	771.17	771.33	.001431	3.39	319.5	141.9	.27
13484	847	766.10	771.56	771.75	.002555	3.95	321.9	195.0	.35
13880	847	766.90	772.47	772.69	.002181	3.94	264.8	155.6	.33
14290	847	767.70	773.18	773.31	.001134	3.06	388.6	205.7	.24
14461	847	768.00	773.37	773.61	.002320	3.98	229.6	90.5	.34
14929	847	768.80	774.34	774.55	.001811	3.75	263.8	138.9	.30
15163	847	769.30	774.76	774.99	.001935	3.89	248.3	115.2	.31
15622	847	770.10	775.59	775.71	.001275	3.18	402.6	209.6	.26
15940	847	770.70	776.02	776.23	.001940	3.90	267.8	112.6	.32
16164	847	771.10	776.53	776.91	.004407	5.09	206.7	149.9	.46
16470	847	771.50	777.52	777.73	.001813	3.83	306.5	191.5	.31
16640	847	772.00	777.83	778.12	.002762	4.29	208.2	75.1	.36
16985	847	772.70	778.58	778.73	.001203	3.18	337.7	200.5	.25
17411	847	773.50	779.18	779.40	.001975	3.86	250.0	107.4	.31
17879	847	774.30	780.02	780.20	.001613	3.65	290.4	130.4	.29
18020	847	774.60	780.27	780.53	.003142	4.40	226.8	99.3	.39
18118	847	774.70	780.53	780.81	.002417	4.31	221.2	118.6	.35
18530	847	775.40	781.23	781.28	.000836	2.46	597.9	291.5	.20
18812	847	775.80	781.47	781.70	.002199	4.07	290.3	179.3	.33
19178	847	776.30	782.15	782.25	.001048	2.96	507.2	496.1	.23
19472	847	776.80	782.45	782.59	.001190	3.27	391.3	292.9	.25
19899	847	777.40	783.00	783.11	.001713	3.26	464.0	334.1	.29
20312	847	778.00	783.60	783.67	.001155	2.70	548.8	335.4	.24
20767	847	778.70	784.10	784.15	.000943	2.40	601.4	318.5	.21
20976	847	779.00	784.25	784.28	.000440	1.90	804.0	418.0	.15
21371	847	779.60	784.41	784.48	.000880	2.55	560.9	317.3	.21
21786	847	780.30	784.88	785.31	.006406	5.61	214.9	205.2	.54
22127	847	780.80	786.11	786.25	.001530	3.37	361.4	196.8	.28
22572	847	781.40	786.71	786.80	.001079	2.93	454.2	222.8	.24
22881	847	781.90	787.10	787.20	.001583	3.20	450.8	272.4	.28

Table A-2. Selected HEC-RAS output for Beaver Creek, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
23136	847	782.30	787.54	787.95	.005307	5.39	200.6	118.0	.50
23595	847	783.00	788.91	789.01	.001440	3.17	445.1	319.5	.26
24044	847	783.70	789.38	789.47	.000864	2.81	484.0	258.9	.22
24293	847	784.00	789.58	789.67	.000919	2.88	457.6	245.6	.22
24697	847	784.60	790.03	790.35	.003931	4.78	218.7	310.6	.43
25136	847	785.30	790.91	790.99	.000856	2.70	530.7	375.9	.22
25411	847	785.70	791.12	791.30	.001359	3.58	293.5	114.4	.29
25772	847	786.20	791.62	791.81	.001632	3.76	292.2	141.1	.32
26069	847	786.70	792.18	792.67	.004843	5.63	154.7	70.5	.51
26205	847	786.90	792.86	793.05	.001633	3.68	263.5	124.7	.32
26264	847	786.60	792.88	793.28	.002448	5.08	166.9	125.0	.38
26293					Culvert				
26303	847	786.10	794.31	794.51	.000846	3.58	238.6	73.2	.25
26319	847	786.10	794.36	794.52	.000762	3.30	276.8	73.9	.25
26399	847	787.50	794.41	794.61	.001140	3.67	241.2	87.5	.28
26426	847	787.10	794.41	794.68	.001369	4.23	200.1	87.5	.29
26459					Culvert				
26469	847	787.30	795.49	795.65	.000646	3.17	267.4	138.3	.22
26476	847	788.10	795.52	795.65	.000427	3.00	300.4	125.4	.21
26602	847	788.30	795.65	795.69	.000182	1.96	631.9	204.2	.14
26898	847	788.90	795.71	795.76	.000227	2.11	569.0	201.2	.15
27205	847	789.50	795.76	795.83	.000344	2.47	476.4	182.5	.19
27436	847	789.90	795.83	795.93	.000607	2.89	404.4	188.0	.24

[a] Referenced to feet above State Route 113

Table A-3. Selected HEC-RAS output for Brighton-Camden Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
617	403	865.20	869.77	869.80	0.001051	2.10	329.6	230.6	0.21
996	403	865.80	870.13	870.17	.000888	2.31	302.8	226.6	.20
1488	403	866.50	870.54	870.58	.000778	2.14	308.9	206.2	.19

Table A-3. Selected HEC-RAS output for Brighton-Camden Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
1934	403	867.20	871.06	871.29	.003703	4.26	146.8	137.7	.40
2250	403	867.60	871.90	871.98	.001412	2.87	245.1	179.0	.25
2541	403	868.10	872.38	872.62	.003050	4.28	123.1	125.2	.38
2903	403	868.60	873.30	873.47	.001967	3.41	122.5	89.2	.32
2915	403	868.10	873.30	873.51	.001397	3.63	112.2	146.0	.30
2950					Culvert				
2960	403	867.70	873.81	873.90	.000467	2.44	170.0	179.1	.19
2969	403	867.70	873.84	873.91	.000430	2.26	200.4	180.4	.18
3393	403	868.10	874.01	874.04	.000239	1.73	368.2	200.1	.13
3827	403	868.50	874.13	874.15	.000234	1.54	537.3	398.9	.12
4240	403	868.90	874.24	874.25	.000265	1.55	511.9	375.0	.12
4644	403	869.30	874.35	874.37	.000318	1.57	473.5	325.6	.13
4976	403	869.60	874.47	874.50	.000496	1.94	371.4	268.8	.16
5359	403	870.00	874.64	874.66	.000382	1.70	592.9	612.2	.14
5662	403	870.30	874.78	874.84	.000806	2.44	320.3	385.9	.21
6017	403	870.60	875.20	875.40	.003318	3.90	135.8	138.1	.40
6064	403	870.70	875.42	875.50	.000959	2.40	174.4	173.1	.19
6113					Culvert				
6123	403	870.70	875.70	875.78	.000481	2.23	194.7	537.1	.18
6170	403	870.80	875.77	875.80	.000312	1.71	335.4	601.1	.14
6395	403	871.10	875.84	875.90	.000557	2.22	295.8	382.4	.19
6841	403	871.70	876.10	876.14	.000532	2.08	375.6	377.7	.18
7213	403	872.20	876.32	876.37	.000664	2.20	331.5	299.3	.20
7634	403	872.80	876.68	876.86	.002049	3.50	134.0	78.6	.33
7961	403	873.30	877.35	877.46	.001605	3.00	194.2	154.4	.27
8436	403	874.00	878.26	878.43	.002615	3.59	180.3	365.2	.33
8808	403	874.50	878.89	878.94	.000793	2.04	317.9	304.2	.19
9148	403	875.00	879.41	879.51	.004957	3.29	201.9	538.5	.41
9433	403	875.20	880.20	880.34	.001871	3.02	135.7	63.5	.28
9618	403	875.40	880.53	880.66	.001542	2.93	150.8	93.9	.26
10107	403	875.90	880.85	880.87	.000189	1.14	525.1	278.0	.09
10370	403	876.10	880.98	881.02	.000739	2.10	408.6	646.0	.18
10672	403	876.40	881.23	881.37	.001606	3.16	172.2	629.3	.27
10798	403	876.50	881.42	881.60	.001913	3.49	126.7	46.7	.29
11139	403	876.80	882.01	882.13	.001262	3.06	172.3	94.9	.25
11449	403	877.10	882.34	882.38	.000517	2.01	341.2	218.3	.17
11817	403	877.40	882.45	882.46	.000107	0.92	724.3	649.0	.08
12266	403	877.80	882.52	882.54	.000356	1.64	411.8	227.3	.14
12662	403	878.20	882.70	882.83	.001576	3.07	151.3	79.6	.26
13118	403	878.60	883.03	883.04	.000190	1.07	734.7	553.3	.09

Table A-3. Selected HEC-RAS output for Brighton-Camden Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
13567	220	879.00	883.11	883.11	.000116	0.66	577.4	934.7	.06
13915	220	879.30	883.17	883.25	.001628	2.34	128.9	741.1	.22
14317	220	879.70	883.95	884.09	.002531	2.97	74.2	18.9	.26
14455	220	879.80	884.49	884.95	.020135	5.48	43.1	45.4	.72
14697	220	880.00	885.48	885.54	.000807	1.95	115.4	35.6	.18
14712	220	880.00	885.51	885.56	.000752	1.80	122.0	35.7	.17
14747					Culvert				
14757	220	881.70	888.27	888.37	.001625	2.49	112.6	397.0	.24
14783	220	882.40	888.38	888.40	.000676	1.52	266.2	426.3	.15
15159	220	883.90	888.65	888.72	.001019	2.26	115.7	95.2	.20
15335	220	884.60	888.84	888.94	.001348	2.54	100.3	72.0	.24
15655	220	885.90	889.41	889.60	.003202	3.42	64.3	22.6	.36
15751	220	886.30	889.73	889.90	.003079	3.34	65.8	23.4	.35
15975	220	887.20	890.47	890.67	.003736	3.59	61.2	22.5	.38
16167	220	888.00	891.20	891.45	.004225	3.96	55.6	19.7	.42
16270	220	888.40	891.69	892.21	.011477	5.79	38.0	16.1	.66
16450	220	889.20	892.85	892.99	.002116	3.00	73.4	26.6	.31
16606	220	889.80	893.23	893.47	.004150	3.93	55.9	20.6	.42
16799	220	890.60	893.98	894.16	.003054	3.42	64.4	24.8	.37
17018	220	891.50	894.81	895.08	.005689	4.20	52.4	20.8	.47
17221	220	892.30	896.06	896.37	.007038	4.51	48.8	23.0	.55
17233	220	891.10	896.30	896.47	.003079	3.37	65.3	37.9	.35
17267					Culvert				
17277	220	891.10	896.56	896.72	.001342	3.15	69.8	16.6	.27
17337	220	892.50	896.61	896.94	.004272	4.60	49.5	26.1	.49
17552	220	893.00	897.15	897.21	.000546	2.15	121.5	64.6	.20
17810	220	893.50	897.27	897.62	.004921	4.78	46.0	20.0	.56
17828	220	893.60	897.39	897.71	.004228	4.54	48.5	22.1	.52
17854					Bridge				
17864	220	893.60	897.94	898.11	.001938	3.23	68.4	34.0	.36
17895	220	893.40	897.95	898.22	.003703	4.16	52.9	22.8	.48
18199	220	894.50	898.64	898.75	.000962	2.65	83.0	25.3	.26
18573	220	895.90	899.14	899.48	.004270	4.66	47.2	18.1	.51
18908	220	897.10	900.24	900.38	.001802	3.04	79.4	48.2	.32
19118	220	897.80	900.77	901.26	.011248	5.65	38.9	19.7	.71
19356	220	898.70	902.13	902.28	.002142	3.21	68.7	25.3	.34
19500	220	899.20	902.53	902.81	.006221	4.28	52.9	36.6	.53
19697	220	900.00	903.53	903.78	.003945	4.03	54.8	23.7	.45
19935	220	900.90	904.49	904.68	.003563	3.55	69.9	70.0	.43
20141	220	901.60	905.02	905.14	.001524	2.86	87.7	56.9	.30

Table A-3. Selected HEC-RAS output for Brighton-Camden Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
20417	220	902.60	905.57	905.74	.003095	3.34	71.1	47.2	.41
20558	220	903.10	906.09	906.34	.005653	4.01	54.9	31.8	.53
20572	220	902.20	906.27	906.43	.002766	3.17	69.5	49.1	.37
20622					Culvert				
20632	220	902.50	907.97	908.07	.001153	2.50	90.3	42.3	.24
20648	220	902.80	907.99	908.09	.001117	2.51	95.5	219.5	.24
21018	55	903.80	908.22	908.22	.000043	0.52	143.3	165.1	.05
21399	55	904.90	908.24	908.25	.000176	0.80	74.1	75.1	.09
21767	55	906.00	908.34	908.36	.000571	1.15	49.0	37.7	.15
22102	55	906.90	908.58	908.60	.000872	1.22	64.2	104.3	.18
22310	55	907.50	908.77	908.79	.000992	1.18	77.7	150.2	.19
22389	55	907.70	908.87	908.94	.004007	2.11	30.1	36.3	.35
22490	55	908.00	909.34	909.44	.006369	2.55	21.6	23.3	.47
22601	55	908.30	909.76	909.80	.001969	1.75	31.4	24.1	.27
22861	55	909.10	910.38	910.44	.003013	1.94	34.3	76.5	.33
22985	55	909.40	910.73	910.77	.002368	1.79	52.4	148.4	.28
23268	55	910.20	911.82	912.02	.010911	3.60	15.3	173.3	.59
23273	55	909.80	911.87	912.07	.009088	3.62	15.2	173.7	.56
23273	55	909.80	911.87	912.07	.009088	3.62	15.2	173.7	.56
23332					Culvert				
23342	55	909.80	913.25	913.26	.000184	0.81	73.2	633.2	.09
23360	55	909.80	913.26	913.27	.000112	0.63	106.3	636.7	.07
23755	55	910.80	913.33	913.35	.000499	1.13	48.7	23.4	.14
24143	55	911.70	913.61	913.65	.001262	1.52	36.2	22.8	.21
24453	55	912.50	914.11	914.16	.002088	1.73	31.8	24.5	.27
24913	55	913.70	915.22	915.28	.002864	2.01	27.3	21.0	.31
25210	55	914.40	916.03	916.09	.002593	1.94	28.3	19.7	.29
25396	55	914.80	916.69	916.82	.005997	2.91	18.9	13.0	.43
25632	55	915.40	917.57	917.63	.002167	2.02	27.2	14.1	.26
25978	55	916.30	918.44	918.53	.003128	2.41	22.8	13.3	.32
26342	55	917.20	919.67	919.77	.003678	2.62	21.0	12.0	.35
26639	55	917.90	920.20	920.23	.000802	1.31	42.0	21.5	.17
26819	55	918.40	920.44	920.50	.003403	2.12	30.6	49.6	.32
27091	55	919.10	921.05	921.09	.001466	1.54	35.8	21.7	.21
27284	55	919.60	921.43	921.49	.003173	2.00	27.5	19.0	.29
27344	55	919.70	921.66	921.89	.013299	3.78	14.6	10.8	.57

[a] Referenced to feet above mouth

Table A-4. Selected HEC-RAS output for Engle Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
0	261	722.40	725.38	725.49	0.002373	2.98	115.7	70.2	.32
231	261	722.90	726.06	726.35	.005584	4.30	60.6	23.3	.47
403	261	723.40	726.93	727.17	.004083	3.92	66.6	22.7	.40
531	261	723.70	727.44	727.64	.003262	3.61	72.4	23.7	.36
843	261	724.40	728.43	728.59	.002805	3.23	80.9	27.9	.33
852	261	724.40	728.45	728.62	.002551	3.38	83.2	45.4	.33
875					Culvert				
885	261	724.40	731.21	731.24	.000102	1.33	369.2	525.9	.09
896	261	724.40	731.23	731.24	.000069	0.96	727.9	808.8	.07
1156	261	724.70	731.25	731.27	.000136	1.31	387.9	345.6	.09
1598	261	725.10	731.29	731.30	.000051	0.80	724.8	552.5	.06
1977	261	725.50	731.32	731.33	.000053	0.82	730.7	387.5	.06
2403	261	726.00	731.35	731.35	.000068	0.89	674.0	412.8	.07
2777	261	726.40	731.37	731.38	.000040	0.53	1012.6	601.8	.05
2802	261	726.40	731.38	731.38	.000029	0.45	1017.7	603.4	.04
2812	261	726.50	731.39	731.39	.000054	0.31	942.6	623.8	.02
2830	261	726.50	731.40	731.40	.000056	0.31	921.2	508.3	.02
2840	261	726.20	731.41	731.41	.000037	0.54	1013.4	508.7	.05
2853	261	726.20	731.42	731.42	.000034	0.52	1017.8	509.1	.05
3371	261	727.50	731.44	731.44	.000047	0.54	1070.8	3406.2	.05
3536	261	727.90	731.45	731.47	.000468	1.59	489.7	619.7	.16
3646	261	728.20	731.51	731.52	.000459	1.57	451.8	515.6	.16
3923	261	728.90	731.70	731.76	.001901	2.81	198.0	203.2	.31
4142	261	729.40	732.19	732.41	.004201	4.37	102.1	169.9	.47
4481	261	730.30	733.26	733.32	.001816	2.81	214.0	280.1	.30
4687	261	730.80	733.63	733.70	.001850	2.75	185.3	184.1	.31
4989	261	731.50	734.06	734.09	.000888	1.92	281.9	305.2	.22
5211	261	732.10	734.24	734.25	.000664	1.49	354.8	375.2	.18
5330	261	732.40	734.37	734.44	.004647	3.33	205.8	436.2	.45
5738	261	733.50	735.30	735.34	.003275	2.73	241.0	525.1	.38
5946	261	733.90	736.06	736.10	.004103	2.88	251.3	880.2	.40
6140	261	734.40	736.62	736.65	.002049	2.33	277.0	550.8	.30
6432	261	735.10	737.08	737.10	.001173	1.78	295.3	368.4	.23
6630	261	735.60	737.39	737.42	.002347	2.23	232.1	299.7	.30
6798	261	736.00	738.02	738.20	.010958	4.83	114.4	194.3	.61
7009	261	736.60	738.94	738.98	.001734	2.37	229.8	353.7	.29
7282	261	737.20	739.40	739.45	.001687	2.70	172.6	213.0	.33
7580	261	738.00	740.26	740.48	.007022	4.77	90.9	185.9	.62
7839	261	738.60	741.06	741.10	.001139	2.11	187.0	239.8	.26
8077	261	739.10	741.46	741.76	.008630	5.19	65.2	83.4	.69

[a] Referenced to feet above mouth

Table A-5. Selected HEC-RAS output for Engle Ditch Drainage Ditches, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
0	161	720.00	721.03	721.24	0.016204	3.73	43.2	53.1	0.73
45	161	718.50	721.36	721.41	.001029	1.76	92.9	44.4	.21
146				Culvert					
168	161	719.70	725.97	725.99	.000175	0.98	172.0	58.7	.09
191	161	721.60	725.97	726.00	.000726	1.38	116.4	61.8	.18
510	161	724.00	726.29	726.36	.001907	2.14	75.5	43.9	.28
789	161	724.50	726.59	726.60	.000450	0.94	351.7	736.3	.14
1056	161	726.00	726.80	726.81	.001690	0.68	214.1	416.2	.18
1237	161	726.80	727.21	727.22	.003186	0.68	254.2	1777.8	.23
1426	161	727.00	728.35	728.51	.020707	3.37	51.6	1684.5	.72
1469	161	725.80	728.88	728.97	.006120	2.41	67.4	1211.6	.35
1549				Culvert					
1586	161	726.00	729.33	729.37	.001885	1.63	102.0	1614.4	.21
1661	161	727.90	729.46	729.48	.001166	1.23	132.2	1795.7	.18

[a] Referenced in relation to the upstream side of Middle Ridge Road (river station 146), in feet.

Table A-6. Selected HEC-RAS output for Gable Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
196	424	573.90	578.17	578.98	0.009141	7.23	58.7	16.0	0.67
207	424	573.90	578.66	579.15	.004177	5.61	75.6	16.0	.45
249				Culvert					
259	424	574.50	579.65	579.94	.001913	4.31	98.4	25.1	.38
265	424	574.40	579.65	579.96	.003181	4.47	94.9	25.1	.40
291	424	574.20	579.83	580.02	.001144	3.47	122.1	30.3	.30
297	424	574.20	579.84	580.03	.001138	3.46	122.4	30.3	.30
298	424	577.00	579.85	580.22	.007158	4.88	86.9	32.1	.52
299	424	577.00	579.86	580.22	.007111	4.87	87.1	32.2	.52
300	424	576.80	579.90	580.23	.005922	4.64	91.4	33.4	.47
311	424	576.80	579.92	580.51	.005956	6.13	69.2	30.5	.65
334				Bridge					
344	424	576.60	580.64	581.12	.005049	5.56	76.2	24.0	.55
346	424	576.60	580.66	581.13	.004977	5.54	76.6	24.0	.55
357	424	577.00	580.68	581.34	.006956	6.51	65.1	22.3	.64
376				Culvert					
386	424	576.70	582.46	582.73	.001938	4.21	100.8	23.8	.36
388	424	577.00	582.46	582.76	.002186	4.38	96.8	23.8	.38
549	424	580.50	582.74	583.61	.011608	7.48	56.7	29.4	.95
569	424	581.20	583.20	584.18	.017343	7.96	53.2	28.8	1.00
637				Culvert					
647	424	581.50	585.65	586.15	.004184	5.67	74.8	18.0	.49
661	424	581.50	585.74	586.22	.003952	5.56	76.2	18.0	.48
738	424	582.40	586.11	587.33	.021084	8.85	47.9	13.9	.84
772	424	583.40	586.80	588.16	.025614	9.37	45.2	13.7	.91
809	424	583.90	587.72	589.14	.025264	9.54	44.4	12.3	.88
824	424	584.10	588.04	589.52	.023341	9.77	43.4	13.0	.94
868	424	584.50	589.31	590.48	.018818	8.68	48.9	15.6	.86
963	424	585.30	590.83	591.65	.008293	7.25	58.4	17.5	.70
1023	424	585.80	591.65	592.11	.006036	5.47	77.6	16.5	.44
1057	424	586.10	591.83	592.64	.012185	7.20	58.9	12.8	.59
1106	424	586.60	592.33	593.35	.014207	8.09	52.4	12.0	.68
1204	424	587.50	593.69	594.54	.010278	7.39	57.4	18.0	.73
1267	424	588.10	594.49	595.16	.008985	6.57	64.5	17.9	.61
1337	424	588.70	595.14	595.93	.012369	7.11	59.7	21.1	.73
1431	424	589.50	596.10	596.76	.006393	6.49	65.3	16.6	.58
1647	424	591.50	597.16	597.49	.001926	4.59	92.3	20.7	.38
1669	424	592.20	597.18	597.55	.002012	4.88	86.9	20.7	.40
1740				Culvert					
1750	424	592.70	598.76	598.91	.000636	3.13	137.2	31.4	.25

Table A-6. Selected HEC-RAS output for Gable Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
1766	424	592.70	598.77	598.93	.000736	3.18	133.6	31.3	.27
1886	424	593.10	598.79	599.14	.002469	4.76	89.0	19.5	.39
2083	424	594.00	599.24	599.69	.002829	5.36	79.2	18.2	.45
2280	424	594.90	599.84	600.57	.006242	6.89	61.6	16.8	.63
2467	424	595.60	601.02	601.50	.003799	5.53	76.7	19.3	.49
2620	424	596.20	601.63	602.40	.008128	7.03	60.3	15.3	.62
2750	424	596.80	602.58	603.19	.004451	6.23	68.1	14.6	.51
2931	424	597.60	603.43	603.70	.001759	4.14	102.3	26.3	.37
3205	424	598.70	603.80	604.90	.009848	8.40	50.5	12.8	.74
3407	424	599.60	605.41	605.72	.001922	4.43	95.6	21.9	.37
3606	424	600.40	605.77	606.33	.004052	5.98	70.9	16.4	.51
3783	424	601.20	606.52	606.96	.003011	5.30	79.9	18.1	.44
4051	424	602.30	607.36	607.87	.003678	5.71	74.2	17.3	.49
4221	424	603.00	608.07	608.82	.007823	6.93	61.2	14.9	.60
4356	424	603.60	609.19	609.59	.003950	5.06	83.7	24.9	.49
4481	424	604.10	609.70	610.28	.006869	6.11	69.4	23.9	.63
4639	424	604.80	610.78	611.11	.003941	4.64	91.3	25.3	.43
4759	424	605.30	611.24	611.52	.002944	4.27	99.2	30.8	.42
4955	424	606.10	611.83	612.18	.003617	4.73	89.7	26.3	.45
5175	424	607.00	612.64	612.94	.003290	4.39	96.5	27.7	.41
5464	424	608.20	613.48	613.70	.002132	3.74	113.4	32.9	.35
5513	424	608.40	613.65	613.79	.000959	3.01	140.8	34.9	.24
5603					Culvert				
5613	424	608.30	614.14	614.24	.000828	2.51	168.6	39.4	.21
5649	424	608.20	614.16	614.28	.001147	2.82	150.2	39.5	.25
5969	424	609.10	614.70	614.95	.003946	4.12	116.5	94.7	.43
6288	424	609.90	615.65	615.87	.002172	3.83	111.7	41.0	.39
6521	424	610.60	616.22	616.63	.004500	5.14	83.2	33.3	.52
6647	424	610.90	616.82	617.30	.005958	5.56	77.1	30.4	.57
6951	424	611.70	618.09	618.32	.002075	3.84	110.3	29.5	.35
7223	424	612.40	618.65	618.92	.002259	4.17	101.7	25.3	.37
7430	424	613.00	619.19	619.38	.002034	3.51	121.0	41.4	.35
7625	424	613.80	619.68	619.93	.003811	4.00	106.0	38.1	.42
7827	424	614.10	620.27	620.46	.001937	3.55	119.7	34.1	.32
7867	424	613.50	620.38	620.52	.000730	3.06	138.7	32.1	.21
7956					Culvert				
7966	424	613.80	620.85	620.95	.000390	2.58	164.6	36.7	.20
7987	424	614.10	620.85	620.97	.000994	2.79	156.4	59.0	.24
8200	424	614.30	621.10	621.22	.001480	2.89	157.1	72.9	.27
8418	424	614.40	621.45	621.55	.001493	2.60	163.3	54.5	.26
8601	424	614.60	621.68	621.77	.001008	2.44	173.5	45.7	.22

Table A-6. Selected HEC-RAS output for Gable Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
8756	424	614.70	621.84	621.92	.000908	2.40	198.1	89.6	.21
8943	424	614.80	622.02	622.15	.001485	2.85	148.9	48.7	.27
9170	424	615.00	622.37	622.55	.001926	3.40	132.1	79.0	.31
9479	424	615.20	622.87	622.97	.000999	2.54	178.0	79.9	.23
9651	424	615.30	623.04	623.13	.000872	2.52	191.7	84.7	.21
9939	424	615.60	623.25	623.31	.000476	2.16	235.1	110.4	.17
10148	424	615.70	623.35	623.51	.001588	3.13	135.6	35.7	.28
10425	424	615.90	623.68	623.79	.000704	2.66	164.0	34.4	.19
10610	424	616.10	623.82	623.99	.001393	3.25	131.0	30.2	.27
10943	424	616.30	624.17	624.24	.000459	2.18	194.4	30.8	.15

[a] Referenced to feet above mouth

Table A-7. Selected HEC-RAS output for Heider Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
229	789	571.90	577.32	578.43	0.008461	8.47	93.9	21.6	0.70
268	789	571.90	578.21	578.80	.004044	6.19	127.5	22.0	.45
333					Culvert				
343	789	572.70	579.21	579.66	.002695	5.39	146.4	27.0	.41
363	789	573.00	579.25	579.73	.003271	5.56	141.9	26.4	.42
472	789	574.20	579.61	580.09	.003282	5.51	144.2	32.2	.45
576	789	575.10	579.84	580.70	.007604	7.42	106.4	24.8	.63
628	789	575.70	580.41	581.07	.005868	6.52	120.9	31.4	.59
690	789	576.30	580.74	581.58	.009462	7.37	107.0	27.2	.66
738	789	576.90	581.35	581.99	.006975	6.46	122.2	31.0	.57
822	789	578.00	581.83	582.99	.015485	8.66	91.1	27.7	.84
887	789	578.60	582.90	583.87	.011462	7.92	99.6	26.4	.72
933	789	579.20	583.33	584.56	.015588	8.92	88.5	24.9	.83
994	789	580.00	584.49	585.29	.008530	7.19	110.1	29.7	.64
1063	789	580.90	585.01	586.08	.012543	8.29	95.6	27.2	.77
1120	789	581.50	585.74	586.82	.013133	8.36	94.4	25.6	.77
1204	789	582.50	586.83	587.96	.013550	8.54	92.4	23.7	.76
1302	789	584.00	588.05	589.26	.012637	8.84	89.3	25.1	.82
1408	789	585.20	589.33	590.60	.012247	9.08	89.0	29.0	.86
1421	789	585.40	590.20	590.88	.005683	6.58	119.9	27.9	.56
1497					Culvert				
1507	789	585.90	591.97	592.31	.002782	4.71	167.4	33.9	.37
1530	789	585.70	592.02	592.39	.003977	4.88	161.8	34.3	.39
1688	789	586.60	592.66	593.16	.005350	5.66	139.6	27.8	.44
1772	789	586.90	593.14	593.56	.004194	5.23	152.8	31.5	.39
1896	789	587.70	593.70	594.05	.003548	4.73	166.9	31.6	.36
2051	789	588.50	594.26	594.71	.004747	5.37	148.2	34.7	.43
2204	662	589.40	595.03	595.35	.003497	4.56	145.5	30.7	.37
2291	662	590.30	595.34	595.72	.004712	4.95	133.6	30.1	.41
2385	662	591.80	595.81	596.35	.008699	5.91	112.1	32.3	.56
2402	662	591.60	595.89	596.52	.006913	6.36	104.0	34.3	.55
2472					Culvert				
2482	662	592.30	599.06	599.29	.001293	3.80	175.3	38.5	.29
2517	662	593.00	599.06	599.36	.001580	4.37	152.1	34.0	.35
2618	662	593.00	599.24	599.52	.001515	4.27	156.6	36.4	.35
2634					Bridge				
2644	662	593.50	599.13	599.84	.004882	6.77	97.8	27.3	.63
2662	662	593.50	599.28	599.93	.004407	6.50	101.8	28.2	.60
2838	662	594.30	599.98	600.83	.004725	7.39	89.6	20.2	.62
2854					Bridge				

Table A-7. Selected HEC-RAS output for Heider Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
2864	662	594.30	600.21	600.98	.004118	7.03	94.1	20.5	0.58
2919	662	595.50	600.21	601.41	.008012	8.78	75.4	21.5	.82
2969	662	595.80	601.59	601.80	.000795	3.73	186.3	39.7	.27
3009					Culvert				
3019	662	596.00	601.86	602.06	.000760	3.66	184.0	34.6	.27
3075	662	595.50	601.86	602.14	.001197	4.26	155.6	25.9	.31
3130	662	595.80	601.86	602.26	.001865	5.09	130.0	23.9	.38
3256	662	596.40	602.07	602.54	.002303	5.50	120.4	24.4	.44
3335	662	596.80	602.34	602.71	.001780	4.91	134.9	31.1	.41
3437	662	597.30	602.39	603.05	.003717	6.53	101.3	21.8	.53
3547	662	597.70	602.95	603.39	.002147	5.33	124.6	28.4	.44
3793	662	598.70	603.34	604.56	.008686	8.87	74.7	16.6	.74
3897	662	599.10	604.54	605.13	.003091	6.15	107.6	22.5	.50
4012	662	599.60	604.86	605.57	.003958	6.75	98.0	21.3	.55
4133	630	600.30	605.40	606.05	.004015	6.47	97.4	26.7	.60
4146	630	601.00	605.77	606.16	.001779	5.08	126.6	35.1	.42
4232					Culvert				
4242	630	601.00	606.96	607.18	.000839	3.84	175.6	39.4	.28
4296	630	601.00	606.97	607.25	.001124	4.30	151.0	32.0	.33
4581	630	601.20	607.32	607.60	.001341	4.22	149.4	28.3	.32
4902	630	601.50	607.74	608.05	.001418	4.47	142.6	28.5	.34
5120	630	601.80	608.05	608.33	.001125	4.24	154.2	34.2	.32
5306	630	602.10	608.22	608.66	.002065	5.36	120.9	28.0	.41
5676	630	602.70	608.99	609.44	.002154	5.36	118.7	25.0	.41
5837	630	603.20	609.43	609.78	.001944	4.73	133.1	26.3	.37
5852	630	603.20	609.47	609.81	.001906	4.70	134.1	26.4	.37
5924					Culvert				
5934	630	603.70	610.21	610.49	.001192	4.31	149.8	29.3	.31
5978	630	603.70	610.26	610.54	.001158	4.27	151.3	29.7	.30
6166	630	603.80	610.52	610.73	.000897	3.70	170.7	31.1	.27
6350	630	604.00	610.69	610.88	.000695	3.51	186.4	38.6	.25
6543	630	604.30	610.77	611.11	.001424	4.86	142.1	36.2	.36
6766	630	604.80	611.14	611.41	.001179	4.18	153.2	32.5	.31
6976	630	605.50	611.36	611.77	.002001	5.18	124.5	30.4	.42
6997	630	605.70	611.39	611.81	.002088	5.25	122.9	30.6	.42
7037					Culvert				
7047	630	605.90	613.47	613.69	.000910	3.79	169.8	35.9	.28
7067	630	606.20	613.51	613.70	.000633	3.62	184.5	36.0	.25
7442	630	606.40	613.76	613.97	.000770	3.69	175.9	33.9	.26
7734	630	606.90	614.00	614.18	.000670	3.49	188.3	38.0	.24

Table A-7. Selected HEC-RAS output for Heider Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
7747	630	606.60	614.03	614.20	.000588	3.33	196.7	38.9	.23
7787					Culvert				
7797	630	607.10	615.03	615.17	.000452	3.07	225.6	73.6	.20
7806	630	607.40	615.03	615.18	.000501	3.18	217.8	73.5	.22
7909	630	607.90	615.04	615.24	.000691	3.62	182.6	46.9	.25
8101	630	608.70	615.19	615.38	.000657	3.50	192.3	45.3	.27
8111	630	608.60	615.21	615.38	.000605	3.41	197.8	45.4	.25
8146					Culvert				
8156	630	608.60	616.53	616.62	.000257	2.43	273.9	71.0	.17
8177	630	608.70	616.54	616.64	.000300	2.56	261.5	71.2	.19
8309	630	609.30	616.56	616.69	.000390	2.95	229.3	45.6	.20
8442	630	610.20	616.56	616.80	.000899	4.00	172.4	56.4	.31
8457	630	609.50	616.62	616.82	.000714	3.69	187.2	58.1	.27
8492					Culvert				
8502	630	609.50	617.68	617.86	.000597	3.37	195.5	43.6	.24
8522	630	609.60	617.69	617.87	.000645	3.48	189.5	43.6	.26
8718	630	610.30	617.85	617.96	.000319	2.80	238.0	41.6	.19
9007	630	611.00	617.92	618.11	.000609	3.56	188.4	37.7	.25
9249	630	611.70	618.08	618.26	.000644	3.48	187.7	41.7	.26
9425	428	612.20	618.25	618.36	.000457	2.68	161.8	35.9	.21
9486	428	611.60	618.32	618.39	.000208	2.14	211.8	43.4	.15
9564					Culvert				
9574	428	611.60	618.68	618.74	.000171	2.02	221.9	44.9	.14
9605	428	612.00	618.68	618.75	.000268	2.18	196.7	38.4	.16
9946	428	613.10	618.72	618.98	.001252	4.06	106.4	25.3	.33
10199	428	613.60	619.06	619.35	.001678	4.34	99.6	25.0	.37
10415	428	613.80	619.39	619.75	.001743	4.82	91.4	22.9	.38
10594	428	614.30	619.74	620.18	.003210	5.35	80.1	24.1	.52
10602	428	614.30	620.09	620.27	.000729	3.34	131.6	27.7	.25
10678					Culvert				
10688	428	614.60	620.31	620.46	.000658	3.09	139.0	28.4	.24
10698	428	614.60	620.31	620.47	.000739	3.23	132.8	28.1	.26
10995	428	615.40	620.50	620.97	.003225	5.48	78.1	22.5	.52

[a] Referenced to feet above mouth

Table A-8. Selected HEC-RAS output for Plum Creek, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
-82	465	805.30	809.47	809.67	0.002421	4.04	145.9	133.2	0.42
-29	465	804.30	809.57	809.79	.001713	3.84	124.4	140.6	.33
0					Bridge				
10	465	804.30	809.76	809.97	.001573	3.73	124.8	33.7	.34
19	465	804.70	809.76	810.00	.002446	3.88	119.7	30.5	.35
323	465	805.30	810.35	810.55	.001385	3.57	135.5	68.9	.32
520	465	806.00	810.62	811.12	.005256	5.73	91.2	69.8	.59
796	465	806.70	811.81	812.25	.003301	5.34	87.1	21.4	.46
1100	465	807.50	812.71	812.90	.001414	3.90	155.5	97.7	.33
1474.	465	808.40	813.29	813.59	.002227	4.67	121.8	73.0	.40
1831	465	809.30	814.18	814.62	.003521	5.38	92.1	50.4	.46
2105	465	810.00	815.17	815.46	.002635	4.48	115.5	39.0	.39
2122	465	809.50	815.40	815.54	.001167	3.10	159.0	40.9	.23
2158					Bridge				
2168	465	809.50	815.56	815.66	.000716	2.48	193.7	132.1	.19
2206	465	810.00	815.61	815.69	.000708	2.37	220.9	106.8	.19
2258	465	809.20	815.64	815.76	.001038	2.80	170.0	134.4	.22
2285					Bridge				
2295	465	809.20	815.91	816.01	.000966	2.61	182.4	241.9	.21
2307	465	810.50	815.91	816.03	.001354	2.91	184.2	241.9	.26
2619	241	811.40	816.25	816.28	.000355	1.54	222.8	128.3	.13
2886	241	812.30	816.37	816.50	.001971	3.01	87.4	54.6	.29
3077	241	813.00	816.80	816.99	.003166	3.55	67.9	21.7	.35
3293	241	813.50	817.47	817.66	.003048	3.56	67.8	20.2	.34
3530	241	814.20	818.26	818.50	.003964	3.95	61.8	23.7	.40
3864	241	815.20	819.37	819.55	.002557	3.41	72.4	30.1	.32
4155	241	816.10	820.11	820.25	.002225	3.05	83.3	74.2	.30
4581	241	817.40	821.08	821.21	.002300	3.17	114.8	114.4	.31
4917	241	818.40	821.77	821.85	.001681	2.73	154.9	136.8	.27
5318	241	819.70	822.67	822.93	.005386	4.28	71.4	72.5	.47
5581	241	820.50	823.69	823.78	.002066	2.76	150.0	170.8	.29
5890	241	821.40	824.34	824.41	.002180	2.73	160.9	164.9	.29
6107	241	822.10	824.98	825.28	.007395	4.75	74.2	80.5	.53
6347	241	822.80	826.25	826.37	.002999	3.40	117.5	140.1	.35
6671	241	823.20	826.85	826.89	.001086	2.12	212.9	170.6	.21

Table A-8. Selected HEC-RAS output for Plum Creek, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
6947	241	823.50	827.23	827.36	.002391	3.10	117.1	108.9	.31
7078	241	823.70	827.49	827.52	.000698	1.78	239.0	151.7	.17
7453	241	824.10	827.84	827.99	.002362	3.13	78.5	28.7	.30
7915	241	824.60	828.84	828.93	.001742	2.71	124.5	108.7	.25
8240	241	825.00	829.26	829.31	.000855	2.00	191.8	195.4	.18
8666	241	825.50	829.81	829.95	.002941	3.21	94.7	76.9	.31

[a] Referenced to feet above Pyle-South Amherst Road

Table A-9. Selected HEC-RAS output for Ridgeway Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
-58	709	688.60	695.18	695.36	0.001810	3.45	205.6	56.0	0.30
-38	709	689.30	695.22	695.40	.001393	3.40	208.6	58.0	.27
0					Culvert				
10	709	688.40	695.64	695.83	.001678	3.52	201.6	49.6	.27
26	709	688.10	695.66	695.88	.001834	3.75	194.9	49.8	.30
307	709	689.80	696.15	696.36	.001617	3.66	194.5	58.1	.30
322	709	689.50	696.16	696.38	.001868	3.78	187.5	57.2	.30
343					Bridge				
350	709	689.50	696.38	696.68	.002718	4.42	160.4	61.1	.37
360	709	689.70	696.45	696.71	.002142	4.11	172.4	58.9	.34
699	709	690.50	697.19	697.42	.002069	3.87	193.4	73.7	.34
1148	709	691.60	698.07	698.28	.001781	3.69	203.1	206.8	.32
1583	709	692.70	698.87	699.10	.001936	3.84	187.9	55.1	.33
1765	709	693.10	699.26	699.56	.003113	4.39	161.9	50.0	.41
2188	709	694.20	700.27	700.46	.001520	3.50	209.4	72.0	.30
2681	709	695.40	701.02	701.15	.001293	3.18	333.1	200.1	.28
3017	709	696.20	701.53	701.85	.003145	4.50	157.5	44.1	.42
3357	709	697.00	702.39	702.57	.001494	3.45	235.6	133.0	.30
3571	709	697.50	702.71	702.91	.001698	3.56	203.5	58.4	.32
3844	709	698.20	703.22	703.46	.002332	4.07	203.8	104.2	.36
4126	709	698.90	703.82	704.01	.001610	3.54	211.6	72.6	.31
4389	709	699.50	704.24	704.40	.001382	3.39	253.4	105.8	.29
4781	709	700.50	705.00	705.49	.005970	5.62	126.1	40.6	.56
4794	709	700.20	705.06	705.60	.005828	5.88	120.5	40.8	.56
4816					Bridge				
4821	709	700.20	706.17	706.49	.002485	4.49	157.8	83.3	.38
4830	709	700.20	706.26	706.51	.002398	4.08	173.6	85.7	.37
5222	709	700.10	706.91	707.03	.000790	2.92	312.2	135.0	.22
5664	709	701.50	707.35	707.57	.001859	3.73	212.3	89.8	.33
6149	709	702.30	708.17	708.38	.001538	3.67	196.0	49.8	.30
6501	709	702.90	708.83	709.14	.002919	4.51	157.2	35.4	.38
6884	709	703.60	709.83	710.06	.001995	3.93	182.1	43.6	.32
7154	709	704.10	710.32	710.50	.001307	3.45	205.4	42.9	.28
7245	709	704.70	710.42	710.62	.001228	3.63	195.4	43.4	.28
7298					Culvert				
7308	709	704.00	711.10	711.25	.001075	3.12	227.0	43.0	.24
7337	709	704.00	711.10	711.30	.001652	3.61	196.6	43.0	.30
7728	709	705.50	711.88	712.34	.003954	5.47	129.7	23.7	.41

Table A-9. Selected HEC-RAS output for Ridgeway Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
7938	709	706.30	712.63	712.80	.001195	3.31	214.3	36.8	.24
8178	709	707.30	712.84	713.57	.008097	6.88	103.1	27.2	.62
8185	709	707.10	712.99	713.65	.007189	6.50	109.1	24.6	.54
8207					Bridge				
8217	709	707.10	713.36	714.28	.010651	7.73	91.8	22.9	.68
8252	709	707.30	714.12	714.54	.003754	5.21	136.2	30.3	.43
8510	709	707.80	715.06	715.38	.002777	4.58	154.7	32.2	.37
8726	709	708.20	715.62	715.85	.001669	3.81	186.3	34.3	.29
9176	709	709.00	716.41	716.69	.002015	4.29	165.8	28.7	.30
9657	709	709.90	717.41	717.68	.002097	4.15	171.4	34.9	.32
10108	709	710.80	718.24	718.49	.001550	4.11	190.8	49.5	.29
10606	709	711.70	719.04	719.24	.001402	3.60	196.9	35.7	.27
11099	709	712.70	719.66	719.84	.001060	3.40	212.6	40.1	.25
11381	709	713.20	720.05	720.41	.003158	4.83	147.2	38.3	.40
11388	709	713.00	720.14	720.45	.002543	4.47	158.6	39.3	.34
11435					Culvert				
11445	709	713.20	720.74	720.92	.000929	3.35	217.6	49.8	.23
11470	709	713.20	720.77	720.94	.000926	3.34	221.0	50.2	.23
11857	709	713.80	721.16	721.30	.000921	3.21	321.4	201.6	.23
12150	709	714.20	721.43	721.66	.001408	3.85	184.0	195.1	.27
12154	709	714.20	721.44	721.67	.001403	3.85	184.2	196.0	.27
12174					Bridge				
12184	709	714.10	721.81	722.00	.000912	3.62	238.7	243.4	.24
12199	709	714.10	721.91	722.02	.000644	2.94	414.4	255.9	.19
12696	709	714.40	722.32	722.56	.001610	4.02	204.1	272.1	.29
12701	709	714.00	722.35	722.57	.001452	3.87	215.0	284.4	.26
12745					Culvert				
12755	709	714.40	723.65	723.71	.000511	2.30	491.4	476.9	.15
12772	709	714.40	723.67	723.72	.000398	2.18	505.4	480.7	.14
12888	709	714.60	723.71	723.76	.000457	2.13	537.3	398.2	.15
13038	709	714.00	723.77	723.81	.000311	1.92	615.3	462.0	.13
13050	709	714.00	723.77	723.81	.000327	1.96	631.2	462.3	.13
13080					Bridge				
13090	709	714.90	723.83	723.89	.000573	2.25	603.8	494.3	.17
13102	709	714.00	723.85	723.90	.000340	2.03	656.8	474.8	.14
13495	709	714.70	723.99	724.03	.000359	1.97	725.0	632.9	.14
13985	709	715.60	724.21	724.31	.000796	2.63	371.4	498.5	.20
14266	709	716.10	724.44	724.53	.000746	2.58	351.4	379.7	.20

Table A-9. Selected HEC-RAS output for Ridgeway Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
14606	709	716.70	724.68	724.80	.000831	2.81	315.3	196.2	.21
15081	709	717.60	725.09	725.21	.000894	2.80	253.7	48.4	.21
15425	709	718.20	725.32	725.37	.000276	1.92	378.9	167.9	.13
15432	709	718.80	725.32	725.38	.000300	2.00	355.4	167.8	.14
15609				Culvert					
15619	709	719.40	725.41	725.50	.000584	2.44	307.2	66.2	.18
15649	709	719.10	725.41	725.51	.000684	2.58	298.5	71.3	.19
16059	709	717.60	725.67	725.75	.000494	2.35	309.4	58.5	.16
16068	709	717.60	725.68	725.76	.000337	2.20	330.5	77.9	.14
16142				Culvert					
16152	709	718.80	725.85	725.98	.000982	2.89	250.7	57.1	.21
16183	709	718.80	725.88	726.01	.001224	2.88	247.6	57.5	.23
16289	709	718.90	725.96	726.26	.003145	4.41	160.9	35.7	.37
16308	709	718.30	726.03	726.32	.002858	4.37	162.2	35.3	.34
16331				Bridge					
16341	709	718.30	726.29	726.54	.002562	4.08	173.9	36.3	.32
16377	709	718.90	726.32	726.69	.003731	4.83	146.7	31.8	.39
16814	709	719.80	727.44	727.61	.001317	3.33	213.2	35.7	.24
16831	709	720.10	727.43	727.66	.001986	3.85	184.0	35.4	.30
16859				Bridge					
16869	709	720.10	727.65	727.87	.001746	3.76	188.4	35.6	.29
16880	709	719.80	727.74	727.89	.001080	3.19	222.3	35.9	.23
17186	709	720.90	728.06	728.18	.000781	2.80	263.3	51.1	.20
17220	709	720.90	728.08	728.21	.000824	2.88	246.0	51.1	.20
17286				Culvert					
17296	709	721.10	730.85	730.95	.000671	2.61	271.7	49.3	.18
17302	709	721.10	730.86	730.96	.000659	2.58	281.5	51.1	.17
17308	709	721.10	730.76	731.08	.001307	4.54	156.1	49.9	.27
17358				Culvert					
17368	709	723.20	732.29	732.43	.000682	3.05	232.6	105.5	.20
17411	709	723.20	732.36	732.46	.000596	2.65	292.7	106.3	.18
17528	709	723.30	732.47	732.54	.000602	2.54	450.7	230.8	.17
17852	475	723.40	732.63	732.66	.000190	1.44	472.1	224.1	.10
17895	475	723.40	732.65	732.66	.000147	1.18	516.9	222.5	.08
17946				Culvert					
17956	475	723.60	732.74	732.76	.000178	1.32	425.5	537.0	.09
17988	475	723.80	732.75	732.77	.000124	1.16	555.2	535.0	.08
18168	475	723.70	732.78	732.80	.000269	1.55	568.6	431.0	.11

Table A-9. Selected HEC-RAS output for Ridgeway Ditch, Lorain County, Ohio —Continued

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
18470	475	723.50	732.84	732.96	.000932	2.82	186.2	82.4	.21
18480	475	724.00	732.87	732.98	.001030	2.64	204.8	105.2	.19
18540					Culvert				
18550	475	723.90	733.80	733.84	.000197	1.78	447.2	351.7	.11
18567	475	724.10	733.81	733.85	.000231	1.77	453.7	372.1	.12
18817	475	724.50	733.87	733.90	.000177	1.53	525.6	331.2	.10
19218	475	725.10	733.95	733.98	.000223	1.70	447.4	278.2	.12
19233	475	725.10	733.95	733.98	.000240	1.62	450.6	278.9	.11
19284					Culvert				
19294	475	725.60	734.30	734.32	.000153	1.39	663.7	622.8	.10
19308	475	725.70	734.31	734.32	.000100	1.13	811.0	613.6	.08
19707	475	725.60	734.34	734.39	.000384	2.07	348.2	384.1	.15
20182	475	725.40	734.52	734.57	.000333	2.07	384.4	231.4	.14
20195	475	724.50	734.53	734.57	.000271	1.92	405.9	232.0	.12
20225					Culvert				
20235	475	725.00	734.54	734.59	.000329	2.07	358.2	193.5	.14
20240	475	725.40	734.55	734.60	.000353	2.14	351.1	193.8	.14
20712	475	725.90	734.72	734.78	.000414	2.13	335.4	305.4	.15
21205	475	726.50	734.91	734.96	.000340	2.01	359.5	251.1	.15
21223	475	726.40	734.93	734.97	.000362	1.81	372.3	243.2	.13
21290					Culvert				
21300	475	726.60	735.29	735.33	.000286	2.00	444.5	290.4	.14
21353	475	726.70	735.31	735.34	.000217	1.78	506.0	275.4	.13
21831	475	727.30	735.42	735.53	.000599	2.73	182.0	43.4	.20
22256	475	727.80	735.67	735.77	.000520	2.53	208.7	67.6	.19
22739	475	728.40	735.97	736.11	.000925	3.07	159.6	36.5	.24
23215	475	729.00	736.38	736.50	.000702	2.81	202.0	165.0	.21
23594	475	729.50	736.63	736.75	.000630	2.74	184.7	72.6	.20
23902	475	729.90	736.86	736.98	.000835	2.90	206.4	133.2	.23
24144	475	730.20	737.08	737.31	.001857	3.88	122.7	73.9	.33
24623	475	730.80	737.69	737.80	.000617	2.72	204.4	93.3	.21
24899	475	731.70	737.86	738.01	.000859	3.06	156.0	34.5	.24
25173	475	731.50	738.16	738.36	.001913	3.83	164.2	284.8	.35

[a] Referenced to feet above Case Road

Table A-10. Selected HEC-RAS output for Schroeder Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
-110	416	732.00	736.99	737.40	0.003161	5.25	88.9	36.3	0.49
-60	416	733.30	737.25	737.58	.002853	4.82	100.8	42.2	.47
0				Bridge					
10	416	733.30	737.66	737.87	.001765	3.69	117.3	44.9	.36
80	416	733.30	737.80	737.97	.001163	3.29	129.5	41.5	.30
224	416	733.70	737.88	738.35	.004247	5.49	76.5	41.9	.53
338	416	734.10	738.46	738.88	.005084	5.24	79.6	23.3	.49
450	416	734.30	739.03	739.23	.001375	3.54	119.9	78.7	.30
451	416	734.30	739.03	739.23	.001561	3.62	116.7	78.6	.30
458				Bridge					
468	416	734.30	739.52	739.65	.000967	2.93	151.9	87.9	.24
476	416	734.30	739.55	739.66	.000808	2.82	163.0	88.6	.23
587	416	735.40	739.64	739.84	.002864	3.65	114.1	30.6	.33
701	416	736.50	740.00	740.35	.006144	4.77	87.2	28.9	.48
778	416	737.20	740.58	741.19	.018441	6.27	68.1	31.5	.68
834	416	736.80	741.48	741.71	.003909	3.98	112.8	40.4	.34
889				Culvert					
899	416	737.00	743.34	743.41	.000368	2.34	311.2	156.2	.17
914	416	737.20	743.40	743.42	.000156	1.26	456.7	158.0	.09
1066	416	737.70	743.42	743.47	.000534	2.03	299.0	175.5	.17
1352	416	738.70	743.55	743.60	.000415	1.85	274.9	120.4	.15
1678	416	739.80	743.72	743.88	.001774	3.30	163.6	88.0	.30
1967	416	740.80	744.46	744.94	.008315	5.82	85.6	59.1	.60
1985	416	740.80	744.81	745.10	.004001	4.51	107.4	75.4	.41
2022				Culvert					
2032	416	741.10	745.72	745.91	.001702	3.63	133.0	67.2	.32
2047	416	741.10	745.79	745.94	.002028	3.42	157.3	83.2	.31
2254	416	741.50	746.17	746.30	.001490	2.94	164.6	162.1	.27
2560	416	742.10	746.60	746.70	.001164	2.62	163.9	56.6	.23
2944	416	742.80	747.27	747.58	.005000	4.45	93.5	31.4	.45
3228	416	743.30	748.39	748.58	.002572	3.60	131.3	87.7	.33
3437	416	743.70	749.01	749.33	.004300	4.64	101.1	63.7	.40
3445	416	743.40	749.02	749.43	.007695	5.39	97.0	72.5	.44
3460	416	743.40	749.24	749.56	.005658	4.73	104.9	44.0	.38
3468	416	743.40	749.28	749.61	.005638	4.75	104.9	43.5	.40
3698	416	744.20	750.02	750.16	.001255	2.97	162.0	68.3	.24
4013	416	744.90	750.51	750.65	.002058	3.08	159.9	106.6	.29

Table A-10. Selected HEC-RAS output for Schroeder Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
4315	416	745.60	751.22	751.40	.002920	3.68	165.6	138.5	.34
4618	416	746.30	751.80	751.89	.000992	2.57	206.7	112.3	.21
4964	416	747.10	752.29	752.51	.003365	3.76	113.5	55.4	.36
5224	416	747.70	752.79	752.86	.000694	2.10	217.3	99.5	.18
5546	416	748.40	752.97	753.68	.016865	6.75	61.6	23.0	.73
5671	416	748.70	754.43	754.67	.004231	3.88	108.7	53.5	.41
5889	416	749.20	755.01	755.11	.001149	2.68	181.2	99.4	.23
6253	416	750.00	755.47	755.58	.001421	2.60	169.0	77.2	.25
6616	416	750.80	756.15	756.32	.002961	3.29	141.0	155.4	.35
7015	416	751.70	756.88	757.00	.001122	2.81	158.6	67.9	.24
7508	292	752.80	757.59	757.73	.002249	3.28	120.9	102.4	.34
7914	292	754.20	758.38	758.54	.001785	3.23	97.5	67.5	.30
8154	292	755.00	758.89	759.10	.003028	3.95	102.9	107.4	.39
8382	292	755.70	759.55	759.75	.002628	3.57	81.9	27.5	.36
8806	292	757.10	760.39	760.43	.000956	1.93	266.9	474.5	.22
9003	292	757.80	760.59	760.68	.001541	2.53	125.9	298.1	.28
9211	292	758.50	760.99	761.15	.003284	3.21	91.1	45.0	.40
9344	292	758.90	761.64	762.04	.014778	5.10	57.3	43.1	.78
9520	292	759.50	762.58	762.68	.001497	2.63	137.3	150.7	.28
9890	292	760.70	763.35	763.56	.003900	3.74	78.1	34.1	.43
10160	292	761.60	764.33	764.51	.003145	3.46	91.7	90.5	.40
10334	292	762.10	765.00	765.24	.005631	4.37	108.3	207.5	.52
10560	292	762.90	766.07	766.34	.004199	4.15	72.3	84.1	.45
10687	292	763.30	766.62	767.01	.005979	5.06	63.0	42.7	.54
10786	292	763.70	767.21	767.52	.004351	4.46	65.5	21.3	.45
10828	292	763.70	767.56	767.67	.001337	2.70	108.0	28.0	.24
10870					Culvert				
10880	292	763.60	767.65	767.75	.001255	2.56	115.1	208.2	.22
10940	292	764.40	767.64	767.98	.008529	4.76	62.0	197.2	.54
10996	292	764.30	768.01	768.32	.004314	4.53	66.4	206.9	.44
11044					Culvert				
11054	292	764.50	768.77	769.07	.005507	4.37	66.8	23.1	.42
11074	292	764.50	768.84	769.25	.010159	5.15	57.6	25.9	.54
11212	292	764.90	769.48	769.57	.000869	2.40	133.5	59.2	.21
11468	292	765.70	769.70	769.75	.000599	1.92	199.2	129.9	.18
11773	292	766.60	769.94	770.07	.001883	2.94	104.5	50.9	.30
11940	292	767.10	770.26	770.38	.001898	2.88	126.5	150.2	.30
12316	292	768.00	771.08	771.18	.002330	3.05	159.7	190.7	.33

Table A-10. Selected HEC-RAS output for Schroeder Ditch, Lorain County, Ohio

[ft^3/s, cubic feet per second; ft, feet; ft/ft, foot per foot; ft/s, feet per second; ft^2, square feet. All elevations referenced to the North American Vertcial Datum of 1988]

River station[a]	Streamflow (ft^3/s)	Minimum elevation in channel (ft)	Water-surface elevation (ft)	Energy grade elevation (ft)	Energy grade slope (ft/ft)	Mean velocity in channel (ft/s)	Flow area (ft^2)	Top width (ft)	Froude number in channel
12629	292	769.10	771.97	772.14	.003944	3.75	94.9	443.1	.43
12665	292	769.10	772.09	772.31	.003975	3.87	77.5	636.0	.40
12692					Culvert				
12702	292	769.30	773.11	773.18	.001102	2.29	139.4	563.2	.22
12725	292	769.30	773.16	773.20	.000646	1.82	196.0	577.0	.18
13085	292	769.50	773.41	773.46	.000652	1.85	193.8	142.7	.17
13244	292	769.60	773.52	773.66	.002091	2.95	99.0	32.2	.30
13374	292	769.60	773.79	773.93	.002104	3.03	96.4	32.7	.30
13392	292	769.60	773.81	774.00	.002450	3.52	82.8	32.9	.32
13420					Culvert				
13430	292	769.60	775.05	775.08	.000291	1.64	279.5	190.4	.14
13448	292	769.60	775.07	775.09	.000270	1.38	315.6	224.0	.12
13557	292	770.80	775.10	775.12	.000442	1.47	288.7	214.0	.14
13571	292	770.50	775.11	775.14	.000759	1.67	256.1	215.1	.17
13593					Bridge				
13603	292	770.50	775.18	775.20	.000497	1.63	289.0	218.5	.15
13623	292	771.30	775.19	775.21	.000489	1.52	296.1	221.1	.15
13863	292	771.20	775.33	775.44	.001743	2.95	153.9	145.7	.28
14157	292	771.10	775.91	776.13	.002932	3.80	79.2	28.3	.37
14166	292	771.10	775.99	776.17	.002414	3.51	92.2	38.5	.32
14197					Culvert				
14207	292	771.10	778.41	778.47	.000232	2.04	192.7	133.6	.14
14219	292	771.70	778.47	778.48	.000117	1.09	454.4	218.7	.09
14578	292	772.80	778.52	778.55	.000201	1.42	385.3	302.5	.11
15067	292	774.20	778.62	778.63	.000135	1.02	586.8	530.1	.09
15087	292	774.00	778.62	778.63	.000134	1.08	589.6	530.7	.10
15097	292	774.30	778.62	778.63	.000545	0.78	446.0	532.0	.07
15108	292	774.30	778.63	778.64	.000819	0.96	366.3	471.3	.08
15118	292	774.30	778.63	778.64	.000217	1.05	482.6	473.1	.10
15126	292	774.30	778.64	778.65	.000191	1.13	483.9	474.4	.11

[a] Referenced to feet above State Route 20

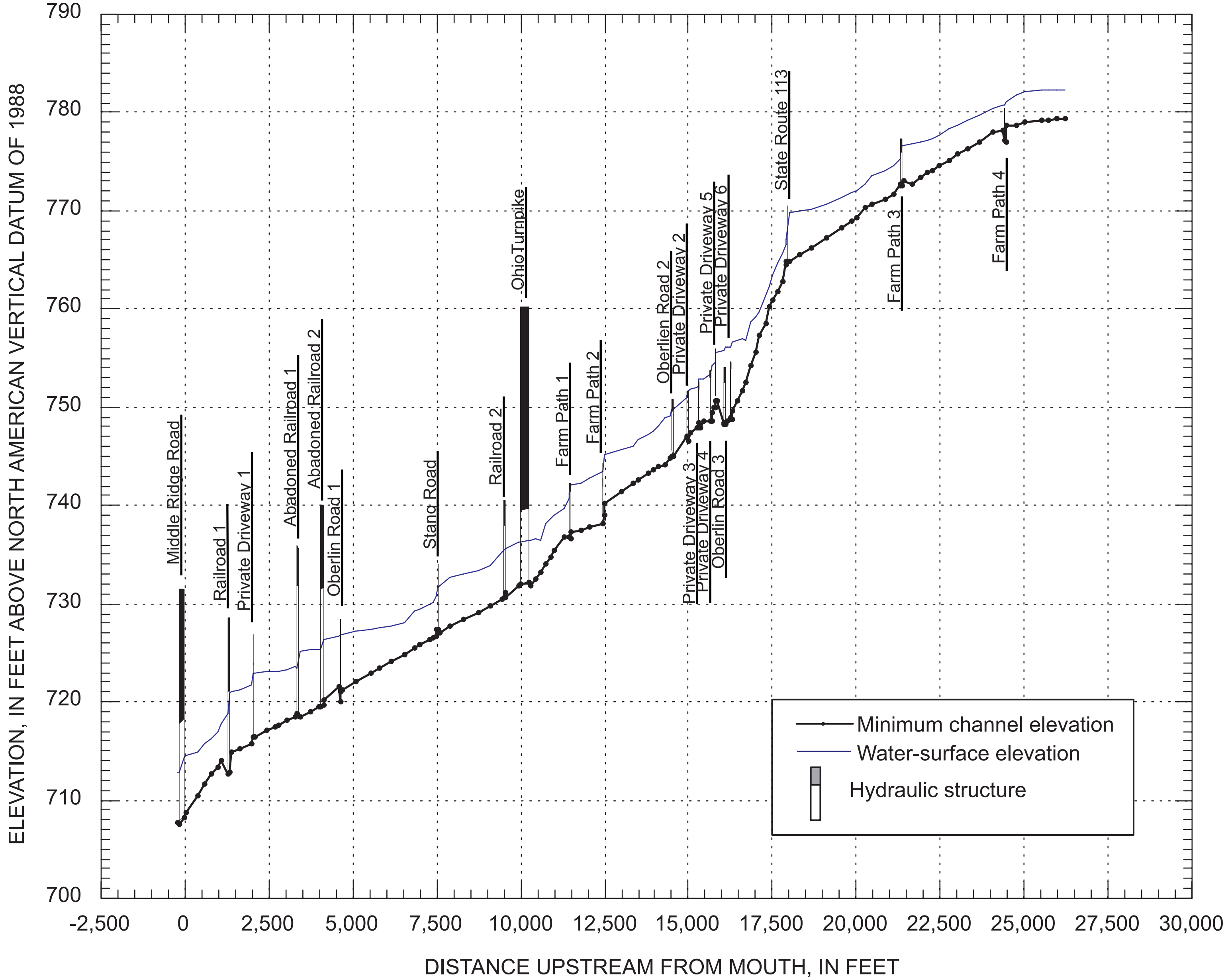

Figure B-1. Computed water-surface profile for 10-year-recurrence-interval peak flood discharge, Battenhouse Ditch, Ohio.

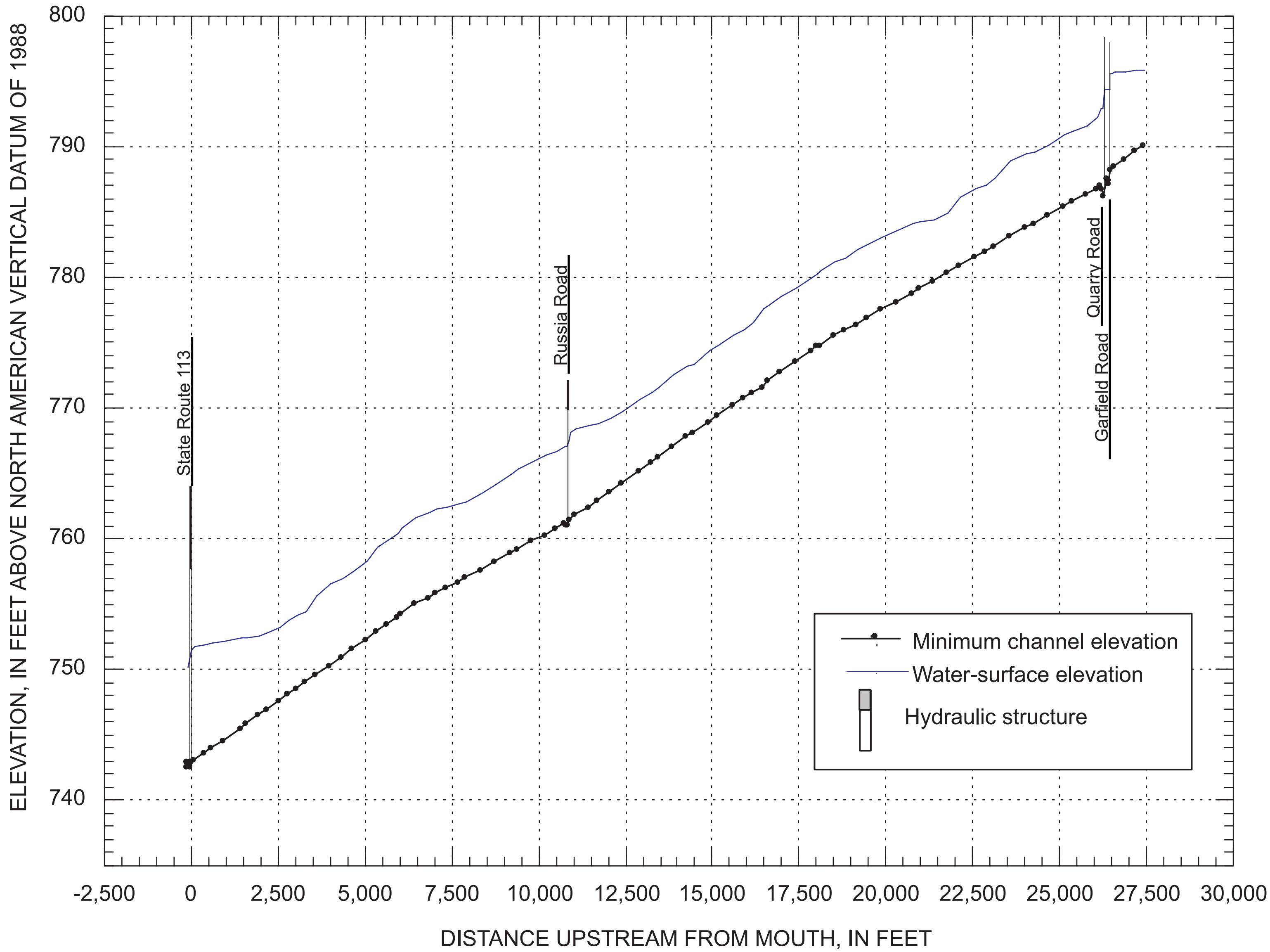

Figure B-2. Computed water-surface profile for 10-year-recurrence-interval peak flood discharge, Beaver Creek, Ohio.

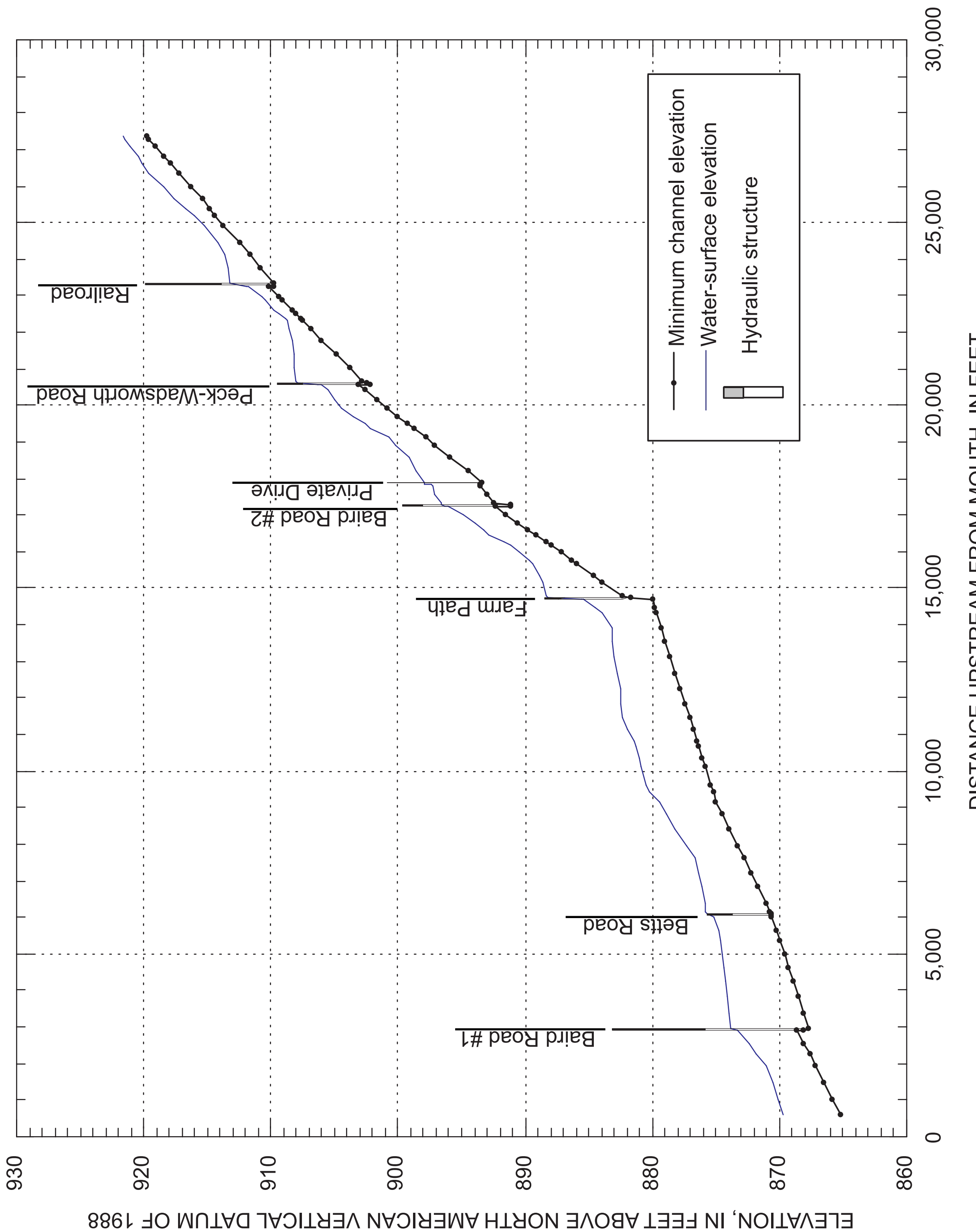

Figure B-3. Computed water-surface profile for 10-year-recurrence-interval peak flood discharge, Brighton-Camden Ditch, Ohio.

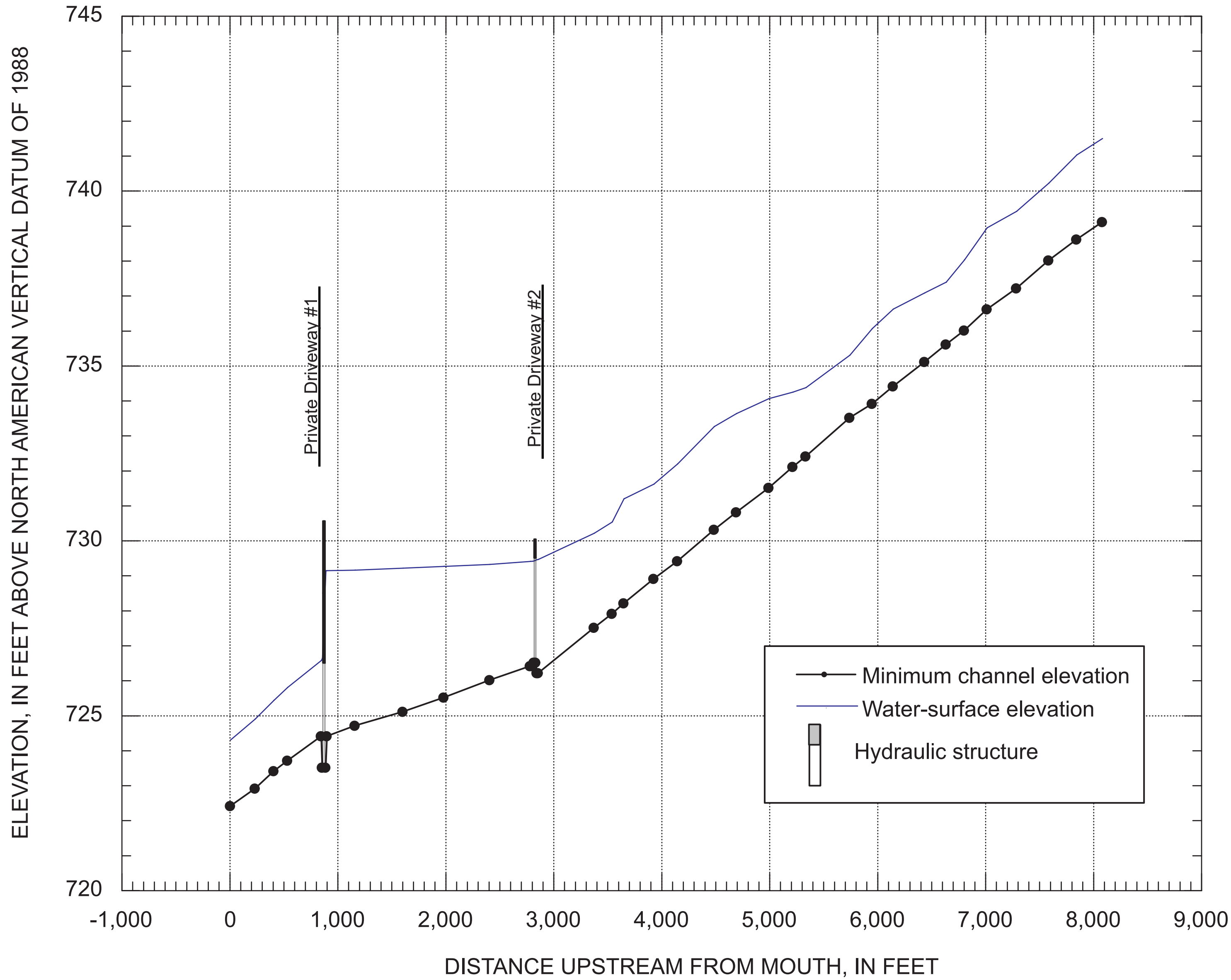

Figure B-4. Computed water-surface profile for 10-year-recurrence-interval peak flood discharge, Engle Ditch, Ohio.

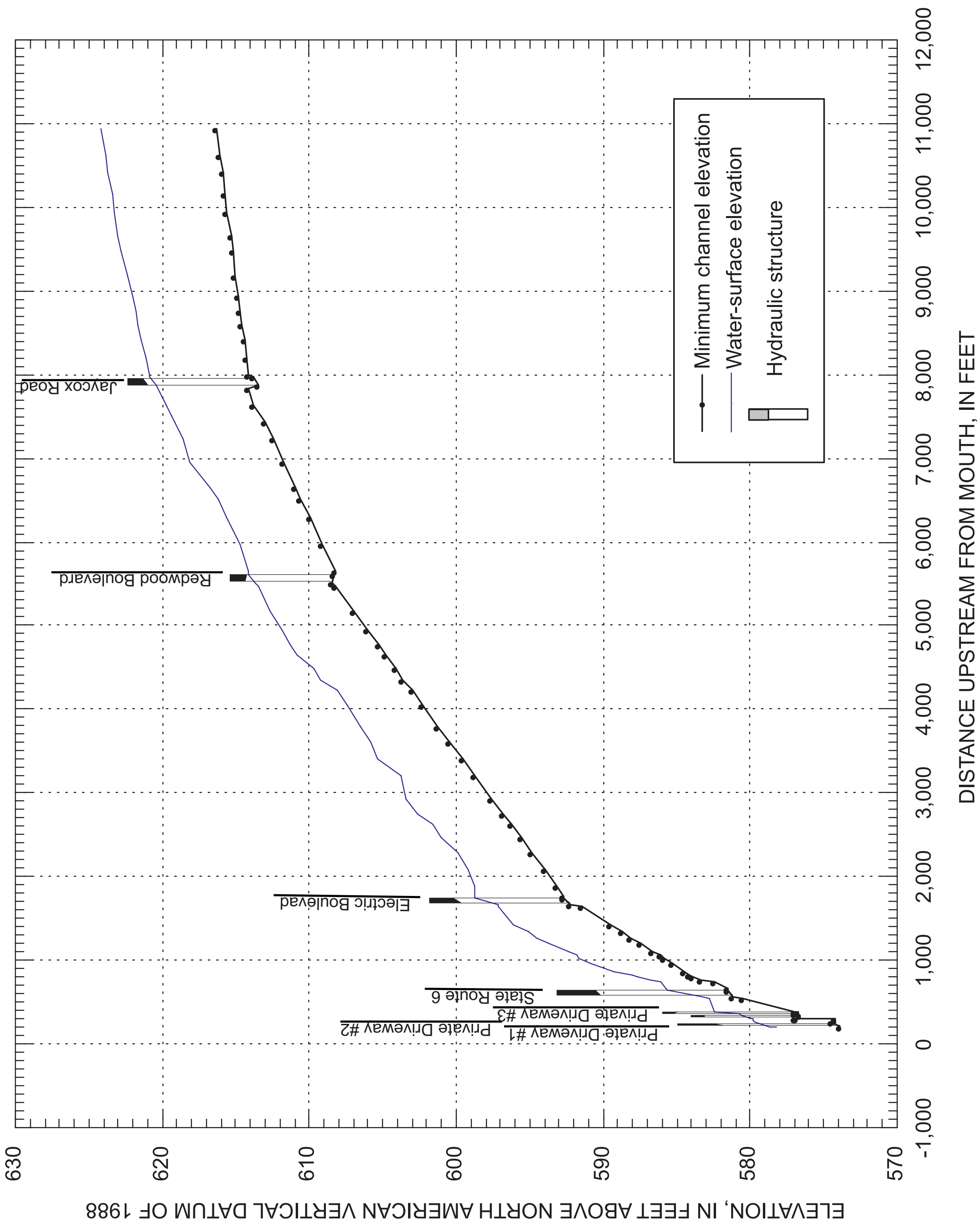

Figure B-5. Computed water-surface profile for 10-year-recurrence-interval peak flood discharge, Gable Ditch, Ohio.

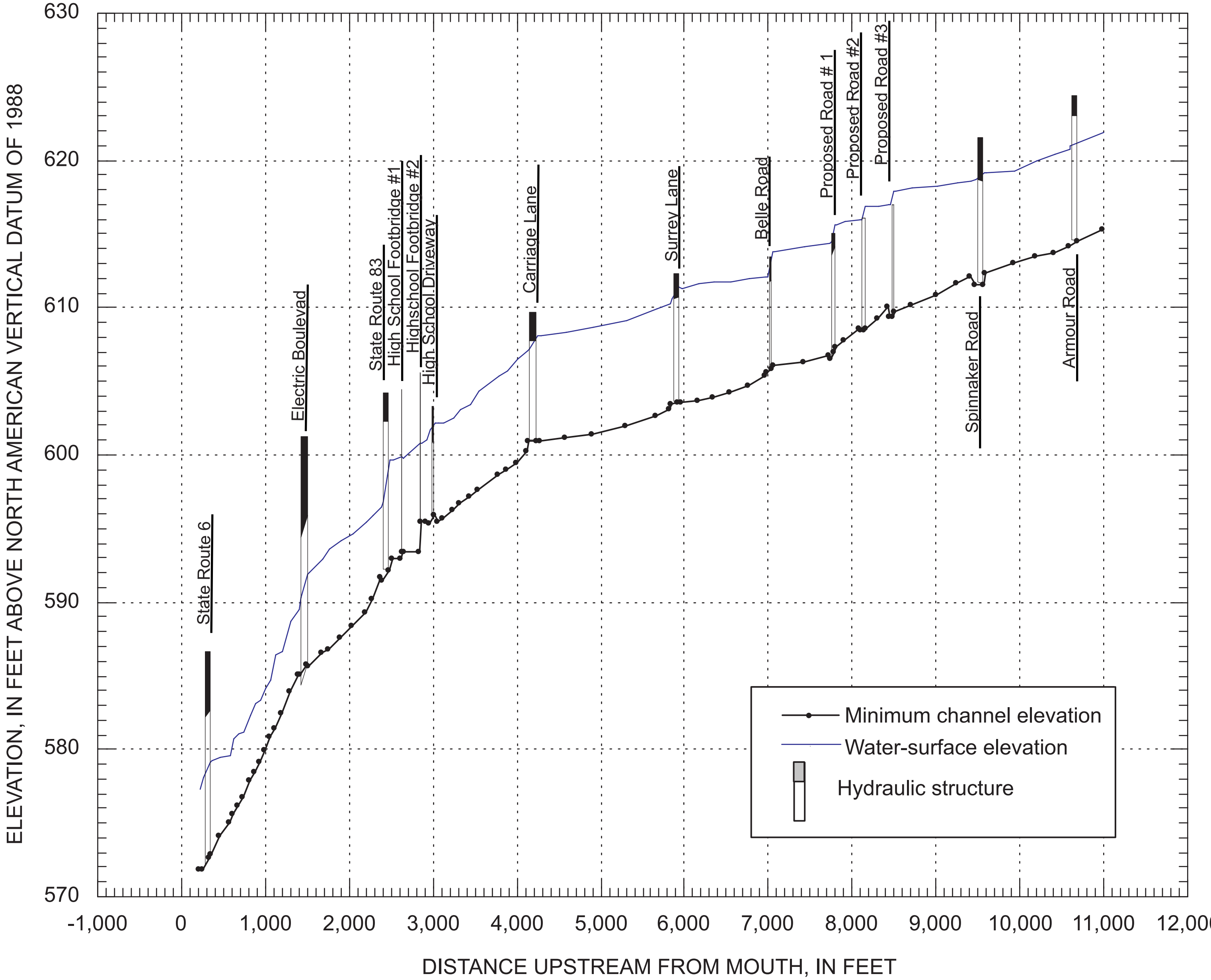

Figure B-6. Computed water-surface profile for 10-year-recurrence-interval peak flood discharge, Heider Ditch, Ohio.

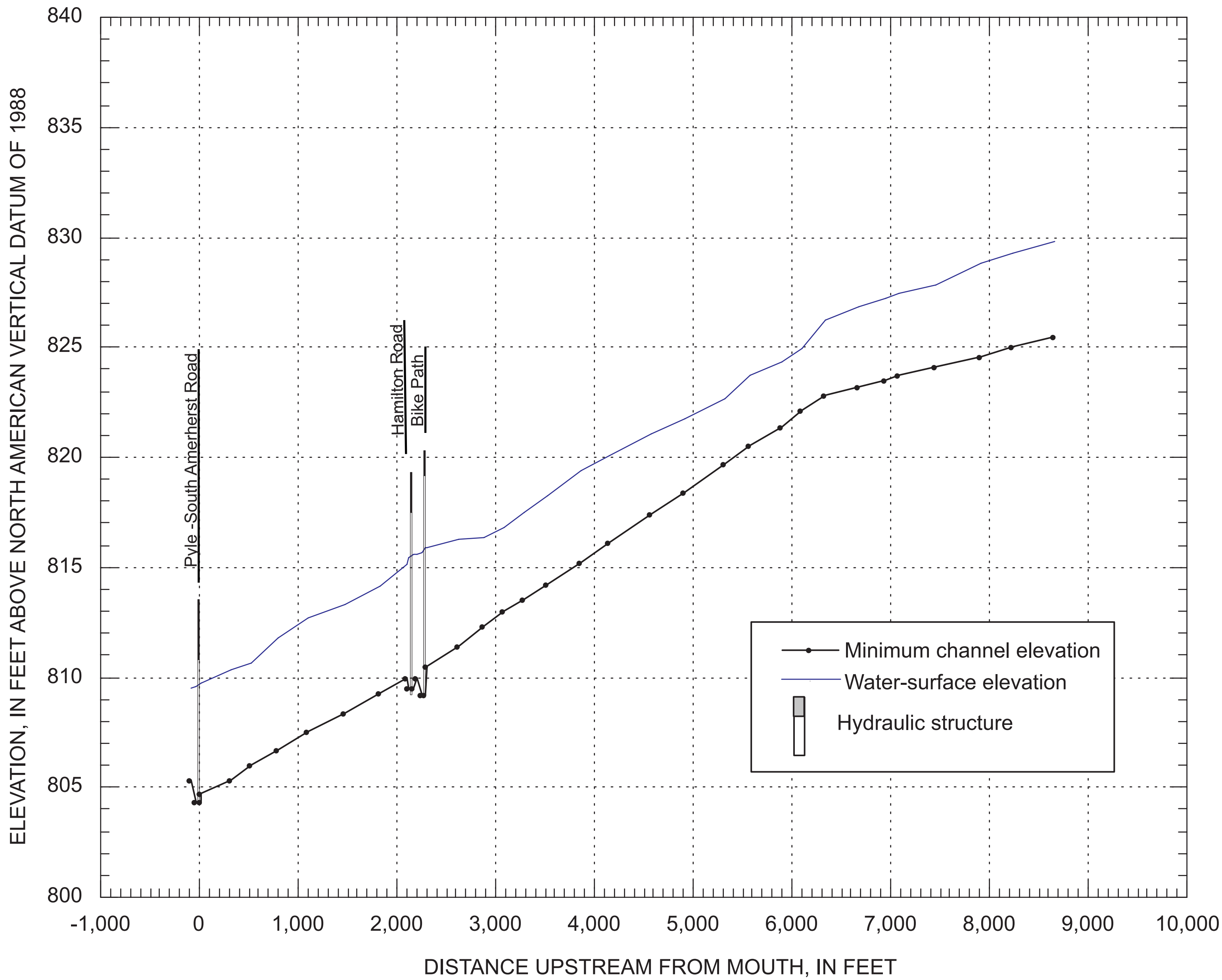

Figure B-7. Computed water-surface profile for 10-year-recurrence-interval peak flood discharge, Plum Creek, Ohio.

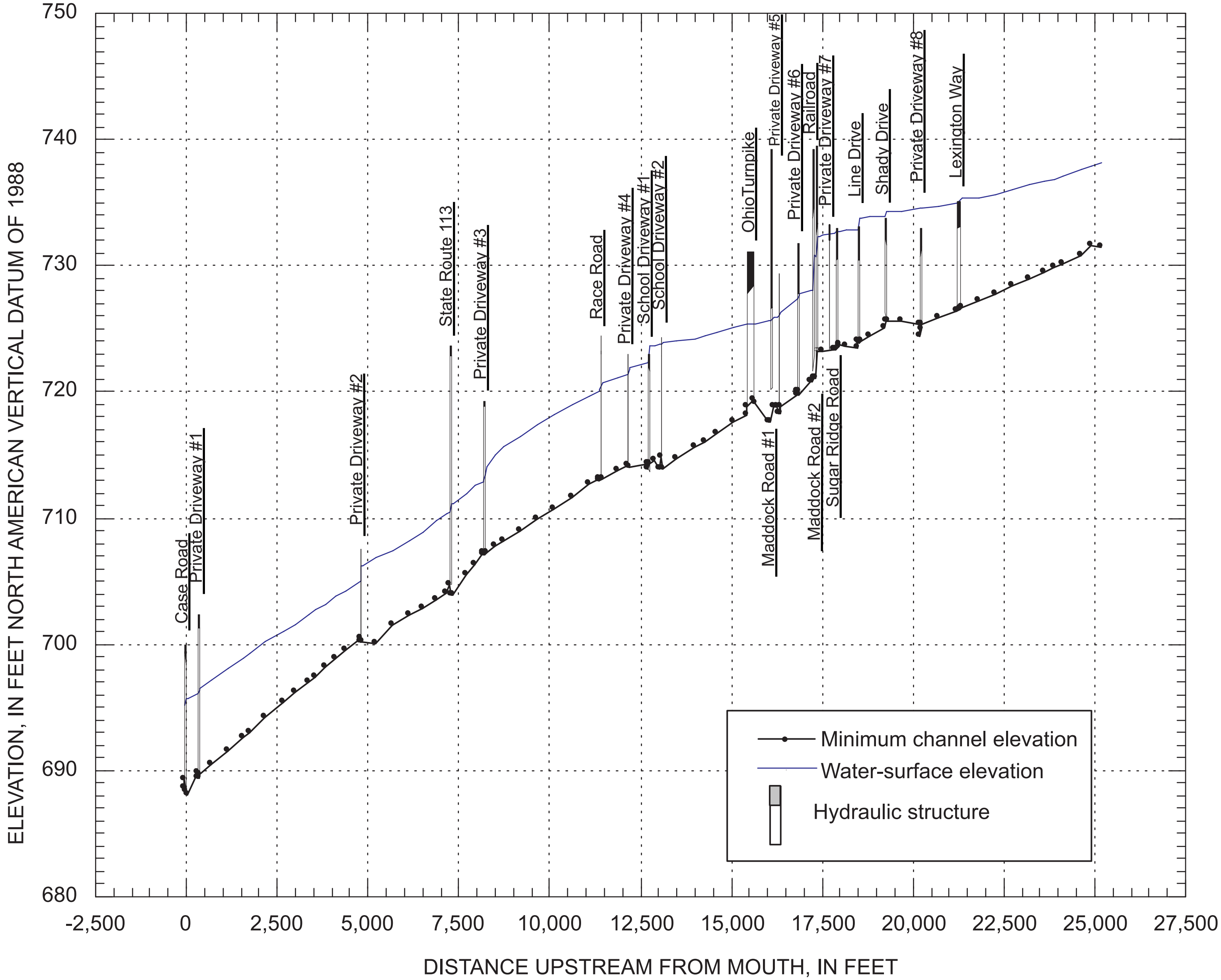

Figure B-8. Computed water-surface profile for 10-year-recurrence-interval peak flood discharge, Ridgeway Creek, Ohio.

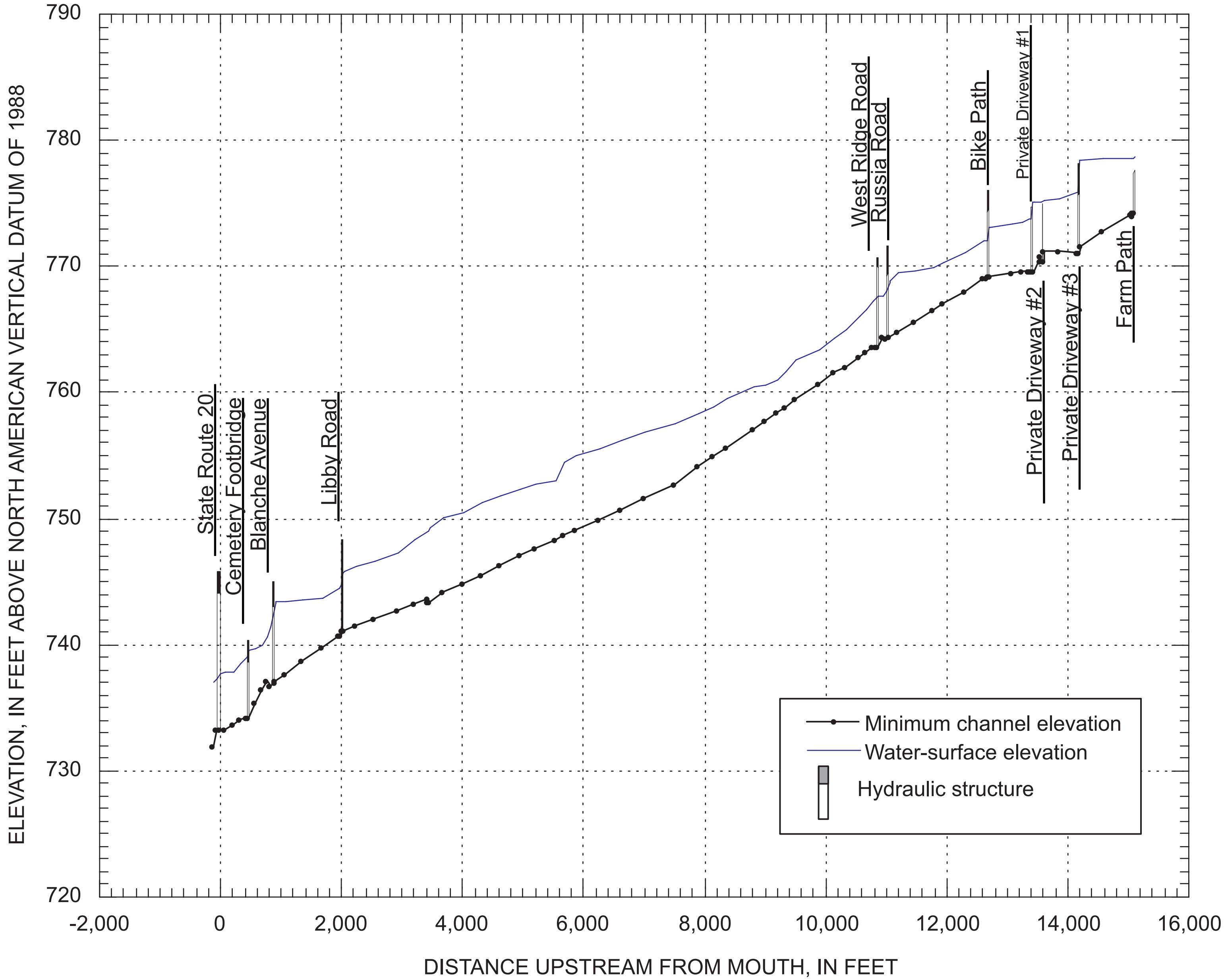

Figure B-9. Computed water-surface profile for 10-year-recurrence-interval peak flood discharge, Schroeder Ditch, Ohio.