Erosion and Deposition at the Riffle-Pool Scale in Gravel-Bed Streams, Ozark Plateaus, Missouri and Arkansas, 1990–95

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ABSTRACT

A channel geometry network of 101 cross sections in 7 reaches of 3 streams in the Ozark Plateaus was monitored from March 1990 to March 1995 to evaluate rates of channel change at the riffle-pool scale. Drainage areas of monitored reaches range from 87 to 2,150 square kilometers. Cross sections were installed to monitor channel changes in a pool-riffle-pool-riffle-pool sequence and were spaced less than five low-flow channel widths apart; sections were resurveyed annually. The area eroded, area deposited, and net change were calculated for each consecutive survey of each cross section, as well as for the entire monitoring period. In addition, cross section data were interpolated to calculate total erosion and deposition and net channel change for each monitoring reach.

The data document the style of erosion and deposition occurring in the monitoring reaches, spatial variations in the magnitude of geomorphic change, spatial variations in vertical and lateral channel changes, and temporal responses to floods of varying magnitude. The data quantify substantial variations in erosion and deposition rates between and within rivers in the Ozark Plateaus. When normalized for contributing drainage area, reaches in the Buffalo River had substantially less total annual change than reaches in Little Piney Creek and Jacks Fork. Total change includes volume eroded and volume deposited and is a measure of the magnitude of channel disturbance. When normalized for contributing drainage area, there was no apparent difference or trend in net annual change among the study reaches. Net annual change is calculated as deposition minus erosion and, therefore, is a measure of change in sediment (or channel) volume in the reach; net change can be indicative of changes in habitat type and quantity.

INTRODUCTION

A widespread perception among residents of the Ozark Plateaus Physiographic Province (hereafter referred to as the Ozarks in this report) is that local streams have been rapidly aggrading with gravel (Jacobson and Primm, 1994). Conventionally, aggradation has been ascribed to post-settlement land-use changes, including deforestation of the uplands during 1880 to 1920, open-range grazing, upland row-crop agriculture, riparian land-use changes, and seasonal burning (Baumann, 1944; Saucier, 1983).

The U.S. Geological Survey, in cooperation with the Missouri Department of Conservation and the National Biological Service [as of October 1, 1996, known as the Biological Resources Division (BRD), U.S. Geological Survey], has conducted a series of studies designed to increase understanding of the linkages among land use, channel changes, and aquatic habitat availability. Another part of the study considers the relative sensitivity of physical habitat in Ozarks streams to past and future climate change. The aggregate study includes evaluations at spatial scales ranging from the Ozarks to individual channel cross sections and at temporal scales from millennia to single seasons. This report documents data collected to evaluate channel dynamics over several years at the riffle-pool scale, a spatial scale directly applicable to aquatic habitat.

Previous studies have corroborated the conventional belief that Ozarks streams are disturbed from their natural state, but these studies also have indicated that disturbance and recovery of Ozarks streams have been a complex process with many interacting variables. Stratigraphic data collected from terraces and floodplains in several Ozarks stream basins indicate material deposited recently contains more gravel than material deposited before settlement (Jacobson and Pugh, 1992; Pugh, 1992; Albertson and others, 1995). Sediment deposited before settlement contains a substantial amount of silt and clay material (Jacobson and Pugh, 1992; Pugh, 1992). Coarsening of deposited sediment probably is caused by lowered flow resistance from riparian land clearing (Jacobson and Pugh, 1992; Jacobson and Primm, 1994).

Data from 23 continuous streamflow-gaging stations throughout the Missouri Ozarks indicate that within the last 70 years some basins experienced degradation, some experienced waves of aggradation and degradation, and some were stable (Jacobson, 1995). Degraded bed-elevation patterns occur at smaller basin areas, wavy patterns occur at intermediate basin areas, and stable patterns occur at large basin areas (Jacobson, 1995). These bed-elevation data indicate an aggradation-related wave of sediment is moving downstream through basins in the Ozarks. The sediment wave(s) may be the result of an increase in the gravel supply caused by headward extension of small streams (Jacobson and Primm, 1994).

Documented changes in stream sedimentation and the existence of waves of channel aggradation indicate the potential for channel disturbance at a scale applicable to aquatic habitat. Aggradational episodes may cause water to be shallow throughout a reach or cause elevation differences between riffle crest and pool bottoms to decrease (Lisle, 1982), resulting in higher water temperatures, altered substrate characteristics, and decreased cover. Coarse bank material does not support high, steep slopes as well as cohesive, fine sediment does (Schumm, 1960), so marginal, shallow pools tend to develop in areas where banks are composed of gravel. Hence, net export of fine sediment is expected to result in shallower, wider channels. In addition, as the stream responds to the influx of sediment, rates of channel and habitat disturbance may increase. Increased habitat disturbance may have the greatest effect on benthic invertebrates that need habitats with stable substrate.

Monitoring of channel cross section changes at the riffle-pool scale provides information about processes and rates of channel change and spatial variations of channel stability. These data can be used by resource managers to evaluate if aquatic habitat is being degraded, to determine if habitat rehabilitation is needed, and to aid in design of habitat stabilization or mitigation projects. A temporal record of channel changes also adds an understanding of channel dynamics to static habitat and channel classification systems (for example, Rabeni and Jacobson, 1993b; Rosgen, 1994). To facilitate comparison with data from other streams and for future resurveys of the Ozarks study reaches, the cross section data developed in this study are archived digitally at the U.S. Geological Survey, Rolla, Missouri, and with the Vigil Network, an international collection of geomorphic data sets (Leopold, 1962; Emmett, 1965; Hadley, 1965).

Study Area

This study was conducted on the Little Piney Creek and Jacks Fork in Missouri, and on the Buffalo River in Arkansas, within the Ozarks (fig. 1). Streams of the Ozarks are incised into uplifted Paleozoic sedimentary rocks, which form gently rolling uplands. Lithologies are predominantly cherty carbonate rocks that supply the low-gradient streams with chert-rich gravel bedload.

Planform morphologies[1] of Ozarks streams are strongly controlled by interactions of the channel with the valley walls (Miller and Jacobson, 1995; Jacobson and Pugh, in press). In river segments[2] with channels that are wide relative to the valley width, the channel flows for long distances along the valley wall, and most planform channel morphology is directly con-

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[1]*Planform morphology* is the shape of a stream when viewed from above (straight or meandering, for example).

[2]The term *segment* is used in this report to indicate longitudinal parts of a stream system between substantial tributaries and with relatively uniform properties of bedrock and valley physiography (Frissell and others, 1986). In Ozarks streams, segments are typically on the order of several to tens of kilometers long.

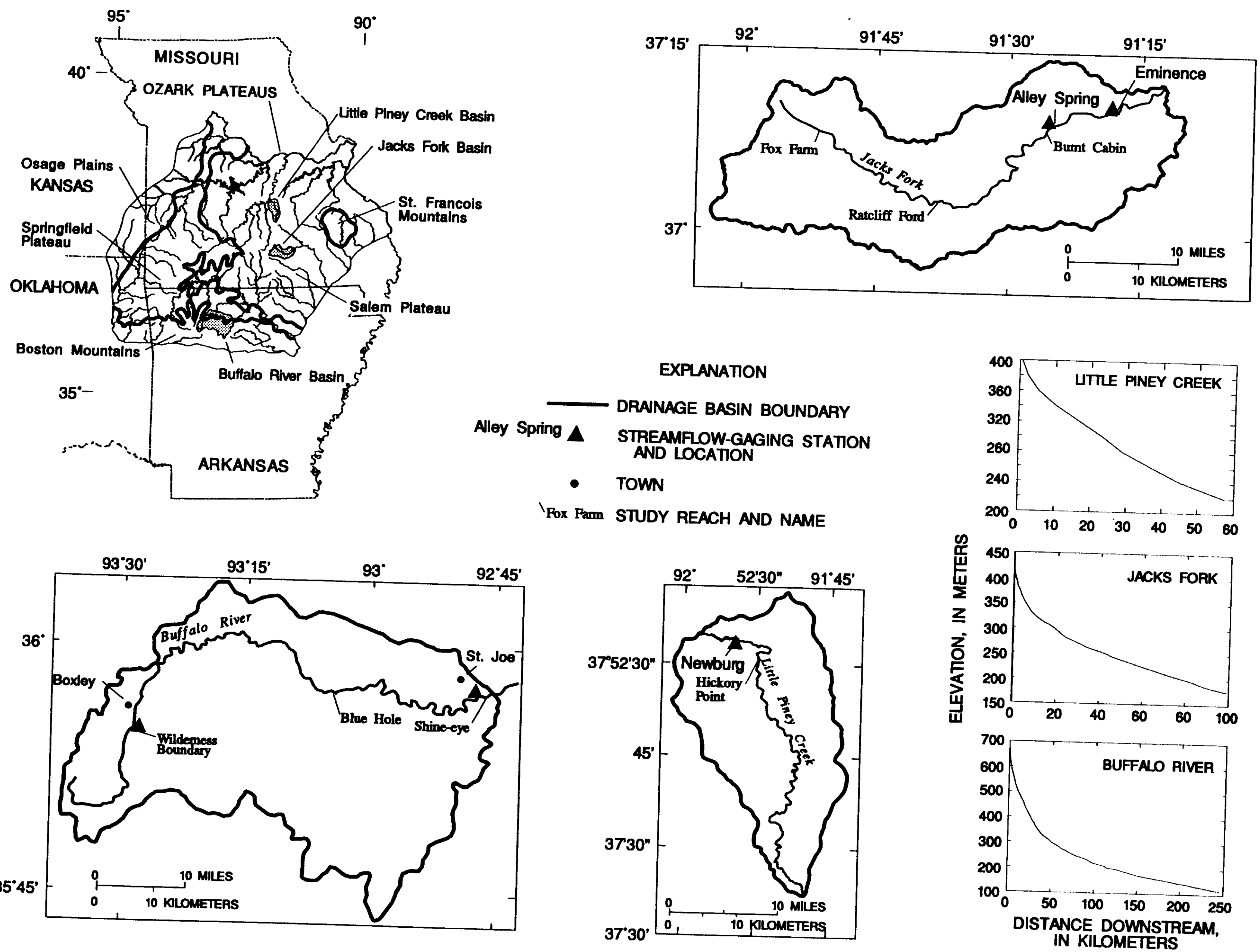

Figure 1. Location maps and longitudinal profiles of Little Piney Creek, Jacks Fork, and the Buffalo River Basins and location of seven monitoring reaches.

trolled by the valley wall. River segments with channels that are narrow relative to the valley width tend to meander through alluvium as they cross the valley and create disturbance reaches[3,4] as a result of collisions with the valley wall or because of sudden constrictions or expansions of valley width.

The Little Piney Creek drains a part of the Salem Plateau (Fenneman, 1938) in south-central Missouri (fig. 1) and flows in a wide valley bounded by bedrock walls that have an average height of 60 m (meters). The Little Piney Creek Basin is underlain by flat lying to gently folded cherty sandstone and cherty dolomite of Ordovician age. Elevations in the study area range from 204 to 400 m.a.s.l. (meters above sea level). Summer low flow of the Little Piney Creek at Newburg, Missouri, is approximately 2 m^3/s (cubic meters per second). A large number of springs drain into Little Piney Creek, maintaining base flow. In addition to spring-fed base flow, Little Piney Creek has rapidly rising floods that result from intense rainfall (table 1).

The Jacks Fork drains a part of the Salem Plateau (Fenneman, 1938) in south-central Missouri (fig. 1) and is underlain by flat lying to gently folded cherty sandstone and cherty dolomite of Ordovician age. Elevations in the study area range from 220 to 470 m.a.s.l. The river flows in a valley of variable width bounded by bedrock walls that have an average height of 60 m. The upper reaches of the Jacks Fork (typified by the Fox Farm study reach) have a narrow channel flowing in a relatively wide valley. From the Fox Farm reach to the Ratcliff Ford reach (fig. 1), the valley narrows into a canyon-like segment bounded by steep dolomite bluffs. The Jacks Fork valley remains narrow downstream until immediately upstream of the Burnt Cabin study reach, and then widens into a substantial alluvial bottomland. Summer base flow of the Jacks Fork at Eminence, Missouri, is approximately 3 m^3/s and is maintained by discharge from multiple springs within the cavernous dolomite. During intense rainfall, the cavern system is by-passed and water flows overland, resulting in fast-rising floods (table 1).

The Buffalo River drains a part of the Springfield Plateau and is flanked to the south by the Boston Mountains (Fenneman, 1938; fig. 1). The basin is underlain by gently folded sandstone, shale, cherty dolomite, and limestone of Mississippian and Ordovician age. Elevations in the study area range from 180 to 785 m.a.s.l. Although some valley segments on the Buffalo River are relatively wide (for example, near Boxley, Arkansas; fig. 1), most of the river from the upper reaches to St. Joe, Arkansas, flows in a relatively narrow valley; all three of the Buffalo River study reaches are in narrow valley segments. Bedrock walls average 70 m high. Summer base flow of the Buffalo River near St. Joe, Arkansas, is approximately 4 m^3/s. The Buffalo River Basin contains fewer springs than the Jacks Fork Basin, thus during dry periods surface flow is discontinuous between the Wilderness Boundary and Blue Hole reaches (fig. 1). Steeper slopes, larger drainage basin, and shale bedrock result in larger, faster-rising floods on the Buffalo River than those on the Little Piney Creek and Jacks Fork (table 1).

Purpose and Scope

The purpose of this report is to present the data that characterizes and quantifies channel morphological changes in three representative Ozarks rivers. The channel morphology has been measured and monitored at spatial and temporal scales that are applicable to aquatic habitat evaluations. This report documents the stream channel monitoring network and measurement and analysis methods. The monitoring data are presented in tabular and graphical form, and channel-change processes are described. Erosion and deposition rate data are calculated from consecutive resurveys and for the entire monitoring period; calculations are presented for each cross section and aggregated by study reach.

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[3]The term *reach* is used in this report to indicate longitudinal subdivisions of stream segments between breaks in channel slope and characterized by channel patterns that contrast with those upstream and downstream. This definition differs somewhat from Frissell and others (1986) because it does not use riparian vegetation or valley floor width. Reaches in Ozarks streams typically include multiple riffle-pool sequences and are tens to thousands of meters long.

[4]*Disturbance reaches* are defined as longitudinal zones characterized by rapid channel migration, as much as 25 channel widths in 50 years (Jacobson, 1995). In valley segments where the channel width is narrow relative to the valley width, disturbance reaches alternate with stable reaches (reaches with less than a channel width of migration in 50 years). Disturbance reaches were originally termed sedimentation zones by Saucier (1983).

Table 1. Hydrologic characteristics for continuous streamflow-gaging stations

[km^2, square kilometers; m^3/s, cubic meters per second]

Gaging station (fig. 1)	Period of record	Years of record	Drainage area (km^2)	Date of recorded peak discharge	Peak discharge of record (m^3/s)	Unit peak discharge of record [$(m^3/s)/km^2$]	95 percent discharge[a] (m^3/s)	5 percent discharge[b] (m^3/s)	Annual mean discharge (m^3/s)
				Little Piney Creek, Missouri					
At Newburg (06932000)	[c]October 1928 to present	66	[c]518	[c]August 14, 1946	[c]920	1.78	1.1	12.8	[c]4.6
				Jacks Fork, Missouri					
At Alley Spring (07065495)	[c]March 1993 to present	2	[c]790	[c]November 14, 1993	[c]1,380	1.79	2.3	30.1	[c]10.8
At Eminence (07066000)	[c]October 1921 to present	73	[c]1,030	[c]November 15, 1993	[c]1,660	1.61	3.1	39.3	[c]13.1
				Buffalo River, Arkansas					
Near Boxley (07055646)	April 1993 to October 1995	2	[d]151	[d]November 14, 1993	[d]70	.47	0.02	11.7	[d]2.2
Near St. Joe (07056000)	[d]October 1939 to present	55	[d]2,147	[d]December 3, 1982	[d]4,470	2.08	.9	369	[d]29.6

[a]Discharge is exceeded 95 percent of the time. Value is calculated from daily mean discharges of the period of record.
[b]Discharge is exceeded 5 percent of the time. Value is calculated from daily mean discharges of the period of record.
[c]Hauck and others, 1996.
[d]Evans and others, 1995.

Acknowledgments

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EROSION AND DEPOSITION DATA COLLECTION

Channel cross section survey data were collected for 3 to 5 years at seven monitoring reaches: three monitoring reaches are on the Jacks Fork, three are on the Buffalo River, and one is on the Little Piney Creek (fig. 1). A total of 101 cross sections are in the network, with 12 to 19 cross sections per reach.

Monitoring Reach Selection

The monitoring reaches were chosen to evaluate channel change at multiple drainage areas in streams that are representative of the morphology, hydrology, and geology of most streams in the Ozarks. The reaches represent different valley and stream morphologies to quantify differences in channel change processes and rates for a range of valley and stream interactions. To minimize effects of short-term land-use changes, monitoring reaches were located in areas that currently (1996) contain a forested riparian zone. Monitoring reaches were located in basins with U.S. Geological Survey continuous streamflow-gaging stations (fig. 1) to compare hydrologic variation to channel change during the monitoring period and to link the amount and type of channel change with individual floods or groups of floods (fig. 2; table 1). In addition, monitoring reaches were selected in areas where road access was available, but in areas where recreational use was not intense.

Reach drainage areas, valley-stream morphology, and channel morphology represent a range of values common in Ozarks streams. Drainage area of the monitoring reaches range from 87 to 789 km^2 (square kilometers) on the Jacks Fork and from 150 to 2,150 km^2 on the Buffalo River (table 2). Drainage area of the Hickory Point reach on the Little Piney Creek is 380 km^2. Channel gradients range from 0.067 to 0.31 percent, average bankfull[5] channel width ranges from 31 to 100 m, and average bankfull depth ranges from 0.9 to 3.0 m (table 2). Valley width ranges from 96 to 530 m in the study reaches. The monitoring reaches range from 350 to 910 m long and encompass a pool-riffle-pool-riffle-pool sequence in the stream (figs. 3–9). Channel sinuosity[6] ranges from 1.26 to 1.76.

Channel Monitoring Methods

Erosion and deposition were monitored using a network of channel cross sections at the seven monitoring reaches. Benchmarks were installed to mark the cross section endpoints. Cross sections were resurveyed annually using a total station and a digital data logger. Net erosion and net deposition were calculated for consecutive survey pairs and for the entire survey period using a geographic information system to compute changes in the vertical channel cross sections.

Cross Section Installation

Within each monitoring reach, cross sections were spaced less than five low-flow channel widths apart and were oriented perpendicular to bankfull flow directions. Spacing was adjusted to make individual cross sections representative of hydraulic habitat units (fig. 10) common in streams of the Ozarks (Rabeni and Jacobson, 1993a, 1993b).

Hydraulic habitat units (HHUs) are repeated, recognizable units that occur at the sub-riffle-pool scale in Ozarks streams. The HHUs are classified and identified at low flow by using a hierarchical system based on position relative to main flow, gradient, channel morphology, and inferred formation mechanisms.

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[5] The *bankfull* channel is defined here as the channel bounded by the active flood plain (Wolman and Leopold, 1957). Depositional bar tops were used to determine the margins of the active floodplain.

[6] *Channel sinuosity* is calculated every 200 m by dividing a 3-km stream length by the straight line distance between the endpoints. The values presented here are averages for 15-km stream lengths. Small sinuosity values represent straight streams, whereas larger sinuosity values indicate the stream meanders. The minimum sinuosity value is 1.

The HHUs are classified as main flow units (riffles, races, pools, and glides[7]) and marginal units (forewaters, backwaters, and edgewaters). Main flow units are subdivided by gradient: 0.075 to 4 percent are high-gradient units (riffles and races) and 0 to 0.075 percent are low-gradient units (pools and glides). High- and low-gradient units are further subdivided by morphology. Riffles are generally characterized by shallow depths and high velocities, trapezoidal to u-shaped cross sections, well-sorted gravel to cobble bed material, and a wetted width to maximum depth ratio greater than 30. Tributary riffles form at tributary junctions and alluvial riffles form at bar crests. Races have u-shaped cross sections with moderate to high velocities, well-sorted cobble-gravel bed material, and a wetted width to maximum depth ratio less than 30. Pools have slight to no surface gradient, low velocities, and wetted width to maximum depth ratios less

[7]*Hydraulic habitat unit* terminology and definition has been slightly altered in this paper as compared to that used in Rabeni and Jacobson (1993a,b); "run" has been divided into glide and race, and alluvial and tributary riffles have replaced "low-gradient," "medium-gradient," and "high-gradient" categories.

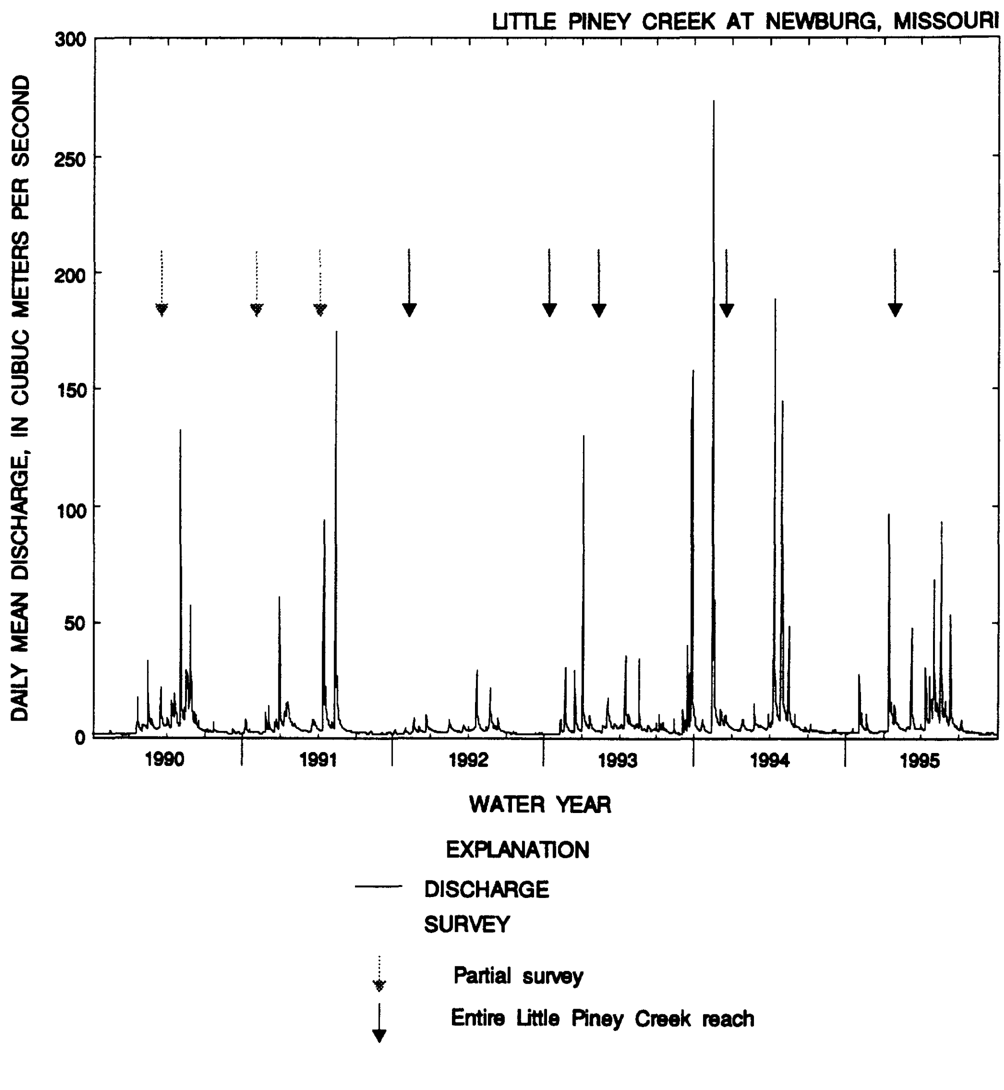

Figure 2. Hydrographs from streamflow-gaging stations on Little Piney Creek, Jacks Fork, and the Buffalo River showing dates of floods and surveys.

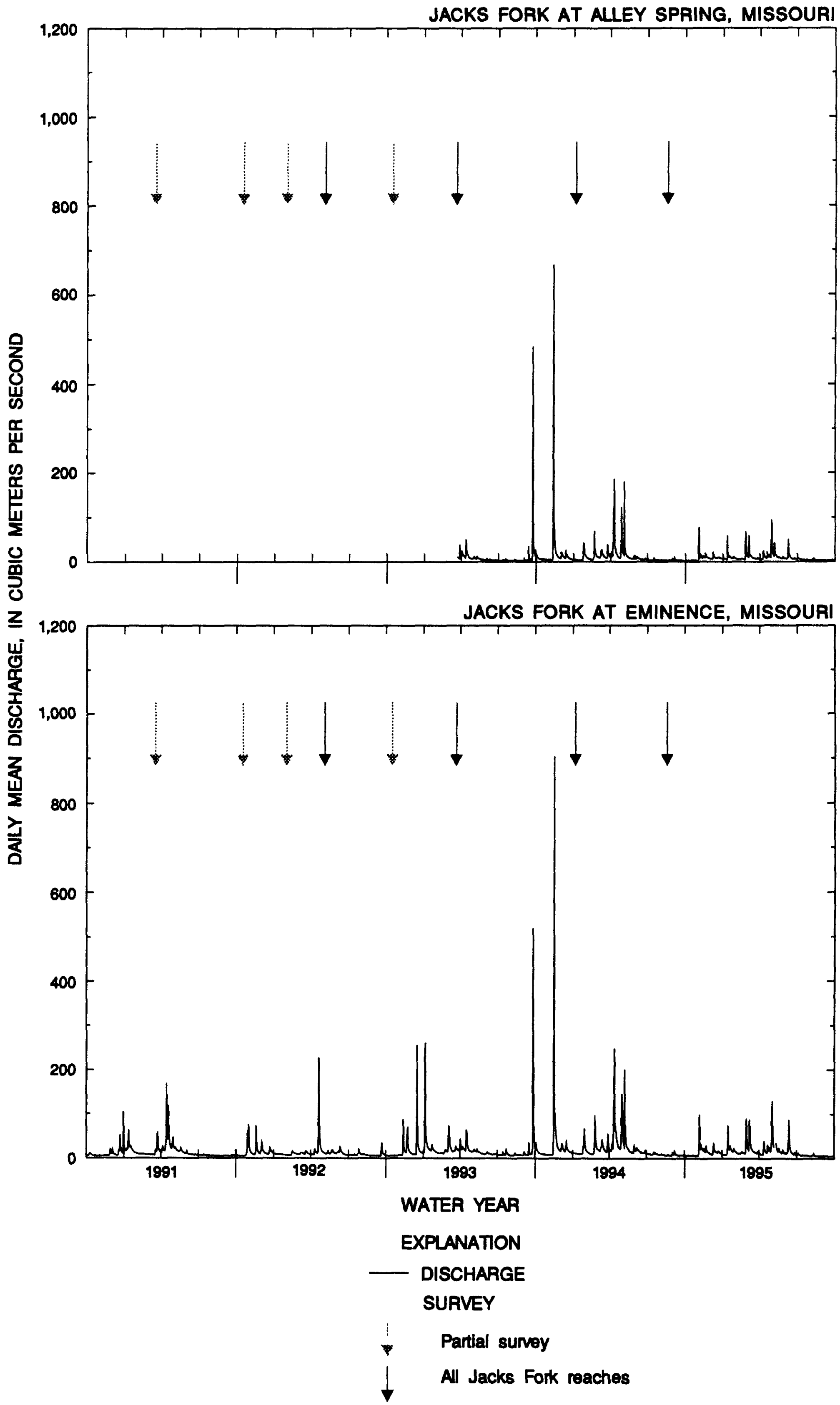

Figure 2. Hydrographs from streamflow-gaging stations on Little Piney Creek, Jacks Fork, and the Buffalo River showing dates of floods and surveys—Continued.

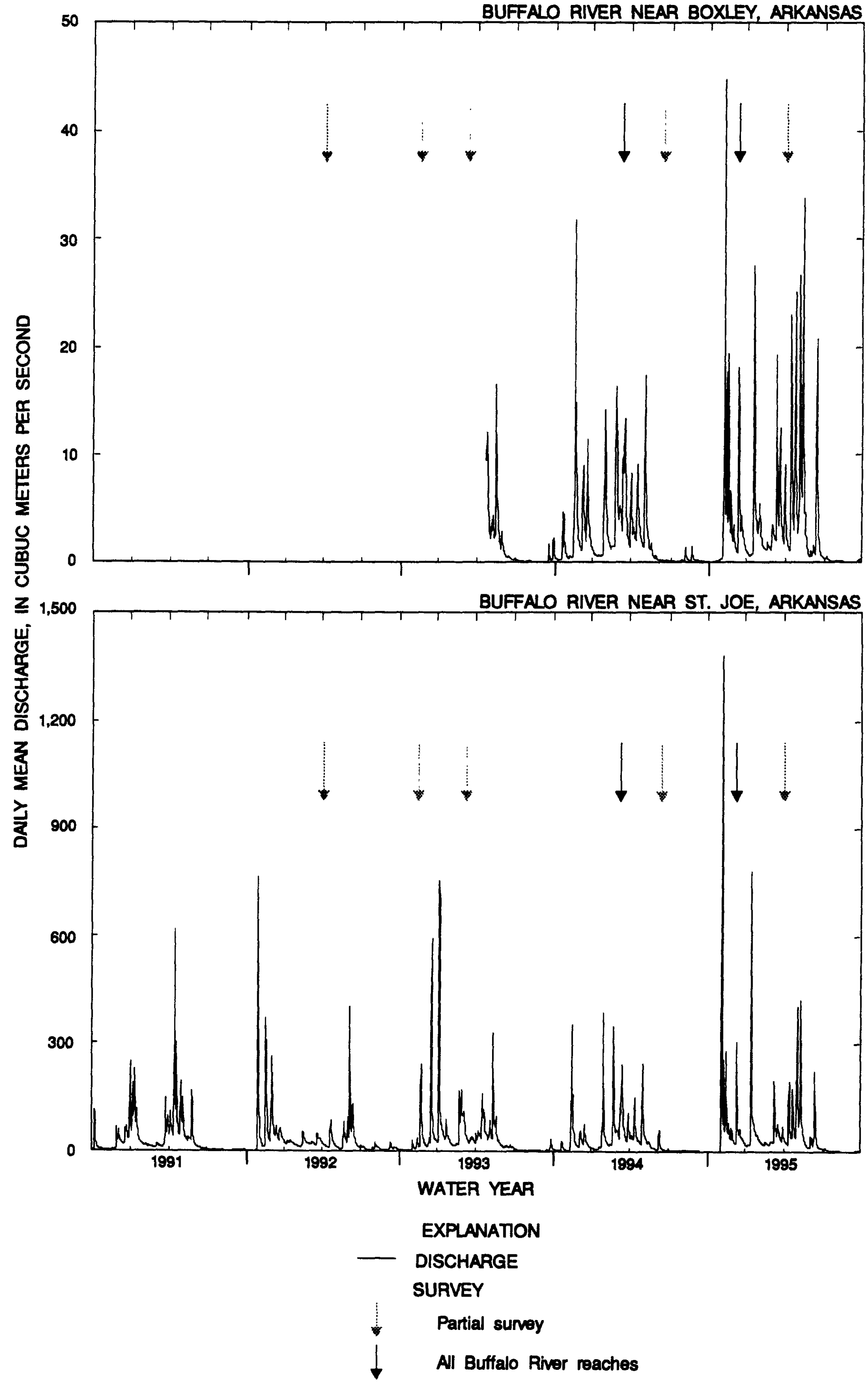

Figure 2. Hydrographs from streamflow-gaging stations on the Little Piney Creek, Jacks Fork, and the Buffalo River showing dates of floods and surveys—Continued.

Table 2. Geomorphic characteristics of the monitoring reaches

[km^2, square kilometer; m, meter; m/m, meter per meter; mm, millimeter; ±, plus or minus; --, no data]

Reach (fig. 1)	Drainage area (km^2)	Valley gradient[1] (percent)	Channel gradient[2] (percent)	Valley width (m)	Reach length (m)	Bankfull channel width[3] (m)	Bankfull channel depth[3] (m)	Channel sinuosity[4] (m/m)	Geometric mean grain size of bed material[5] [phi (mm)]
Little Piney Creek, Missouri									
Hickory Point	380	0.18	0.16	280	760	43 ± 7.1	0.9 ± 0.16	1.29	--
Jacks Fork, Missouri									
Fox Farm	87	.30	.31	150	350	31 ± 10.2	1.0 ± .19	1.26	-4.48 ± 1.61(22.2)
Ratcliff Ford	422	.17	.20	96	560	57 ± 11.2	1.8 ± .69	1.76	-4.92 ± 1.46 (30.4)
Burnt Cabin	789	.15	.067	530	910	75 ± 20.6	1.7 ± .37	1.59	-4.39 ± 1.48(21.0)
Buffalo River, Arkansas									
Wilderness Boundary	150	.60	.24	123	470	58 ± 19.9	2.1 ± .48	1.27	-4.69 ± 2.31(25.7)
Blue Hole	1,020	.10	.089	150	840	83 ± 25.9	2.3 ± .68	1.39	-4.51 ± 1.78(22.9)
Shine-eye	2,150	.06	.097	140	800	100 ± 18.1	3.0 ± 1.09	1.74	-4.62 ± 1.92(24.6)

[1]Calculated from U.S. Geological Survey 7.5 minute topographic maps.
[2]Calculated from water-surface profile survey data.
[3]Average bankfull values plus or minus one standard deviation.
[4]Average of channel sinuosities calculated every 200 meters for 3-kilometer lengths of the stream. The average was calculated for 15-kilometer stream lengths centered on the monitoring reaches.
[5]Calculated from pebble count data plus or minus one standard deviation.

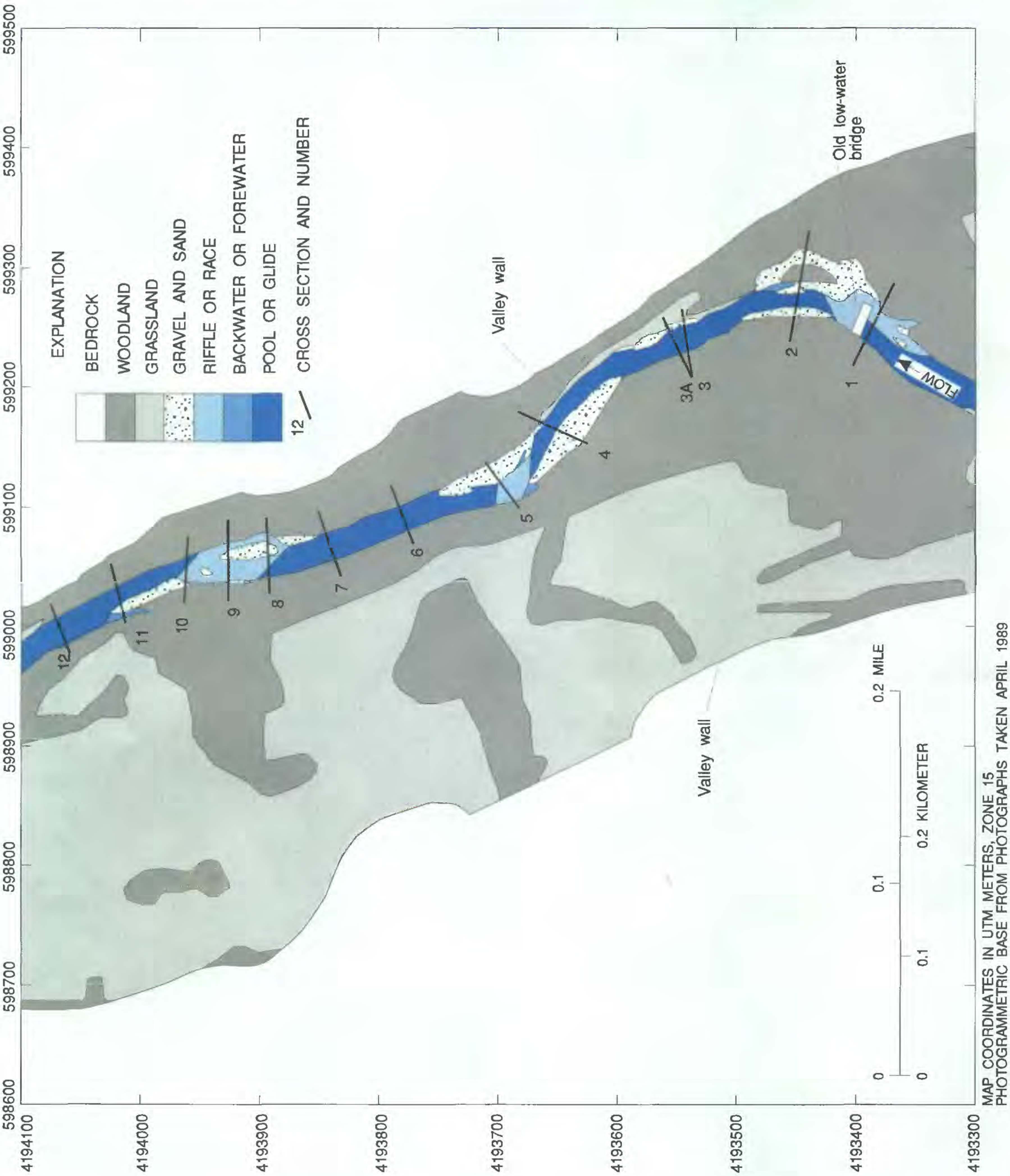

Figure 3. Hickory Point reach, Little Piney Creek, Missouri.

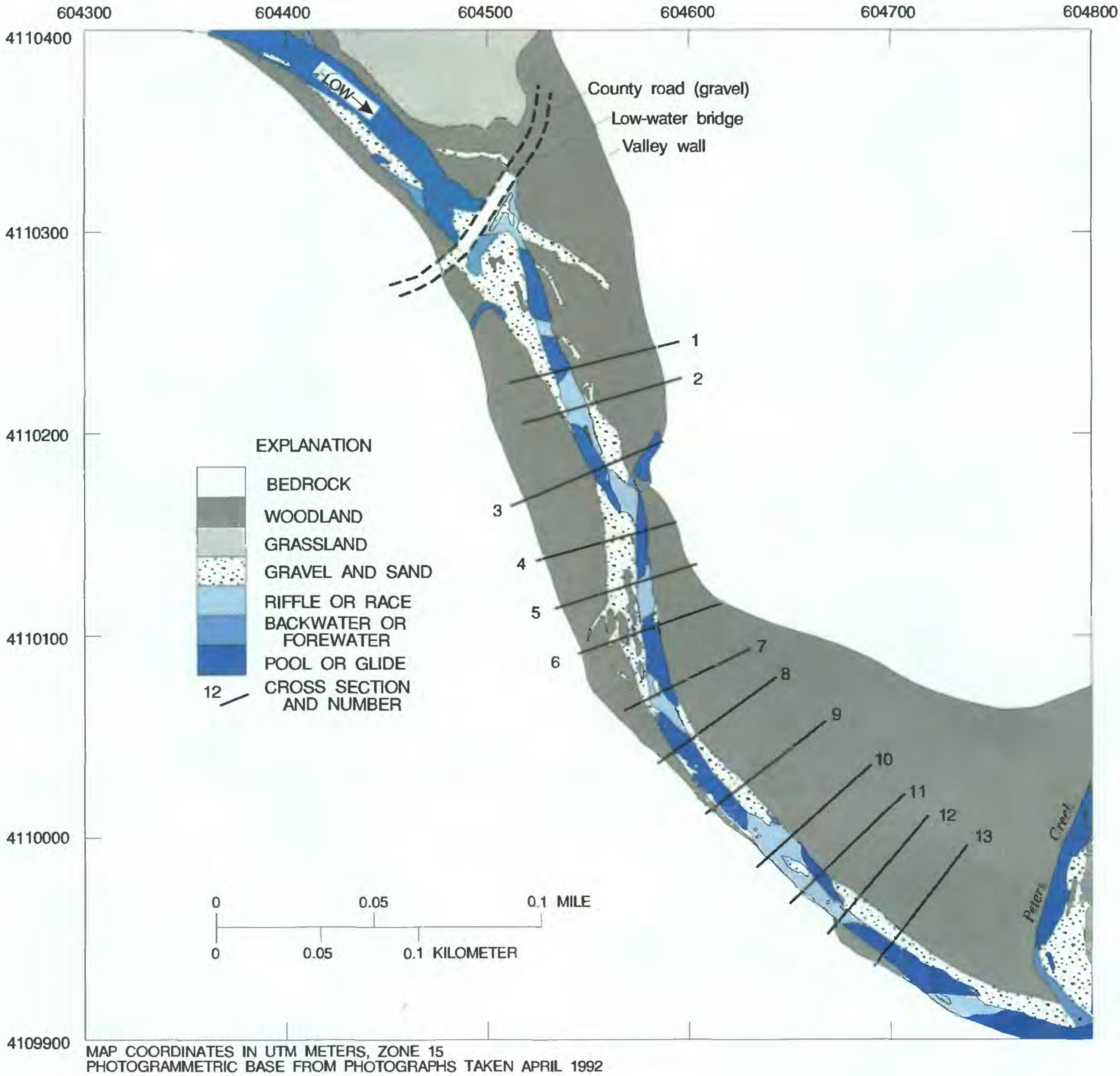

Figure 4. Fox Farm reach, Jacks Fork, Missouri.

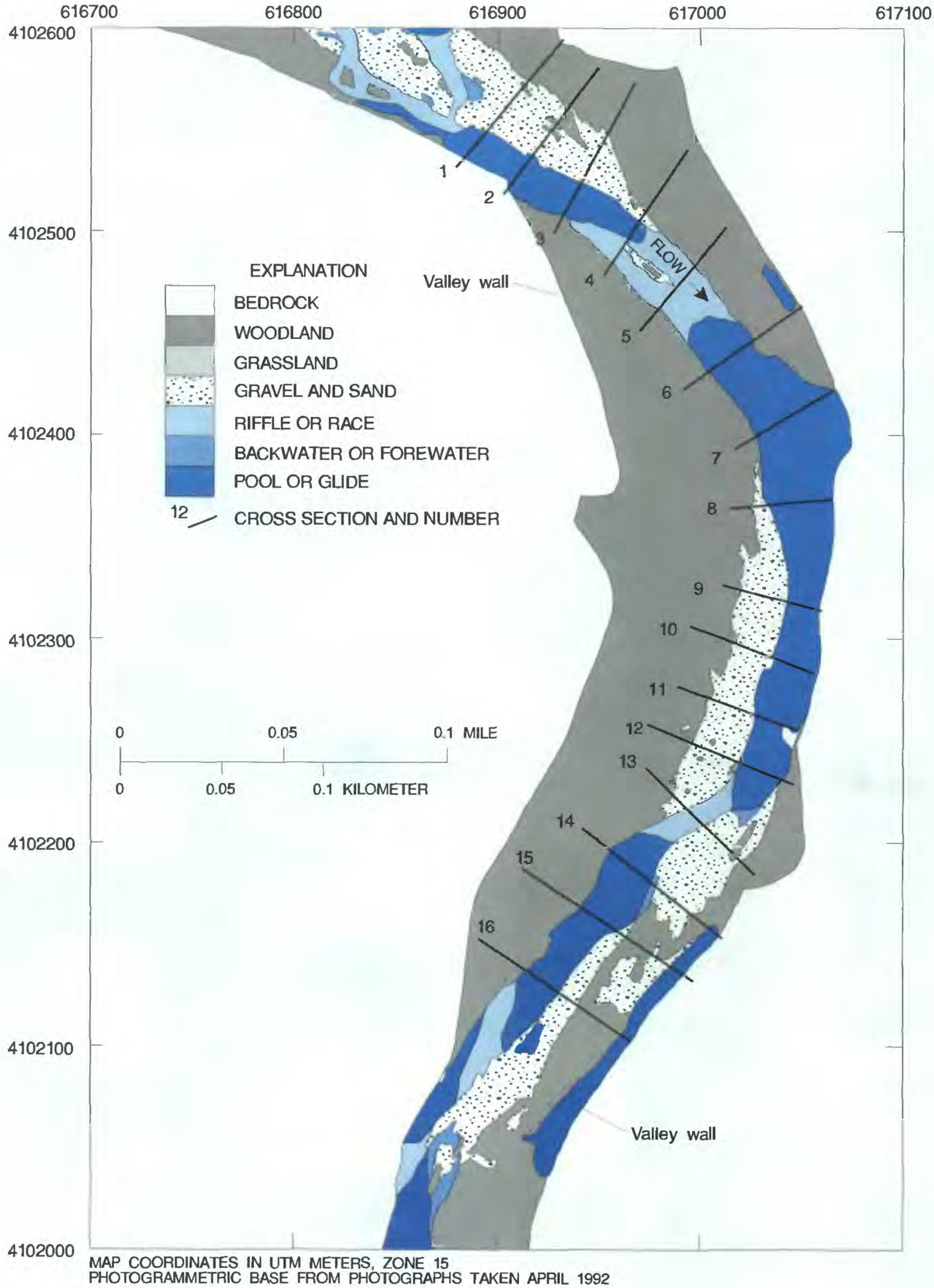

Figure 5. Ratcliff Ford reach, Jacks Fork, Missouri.

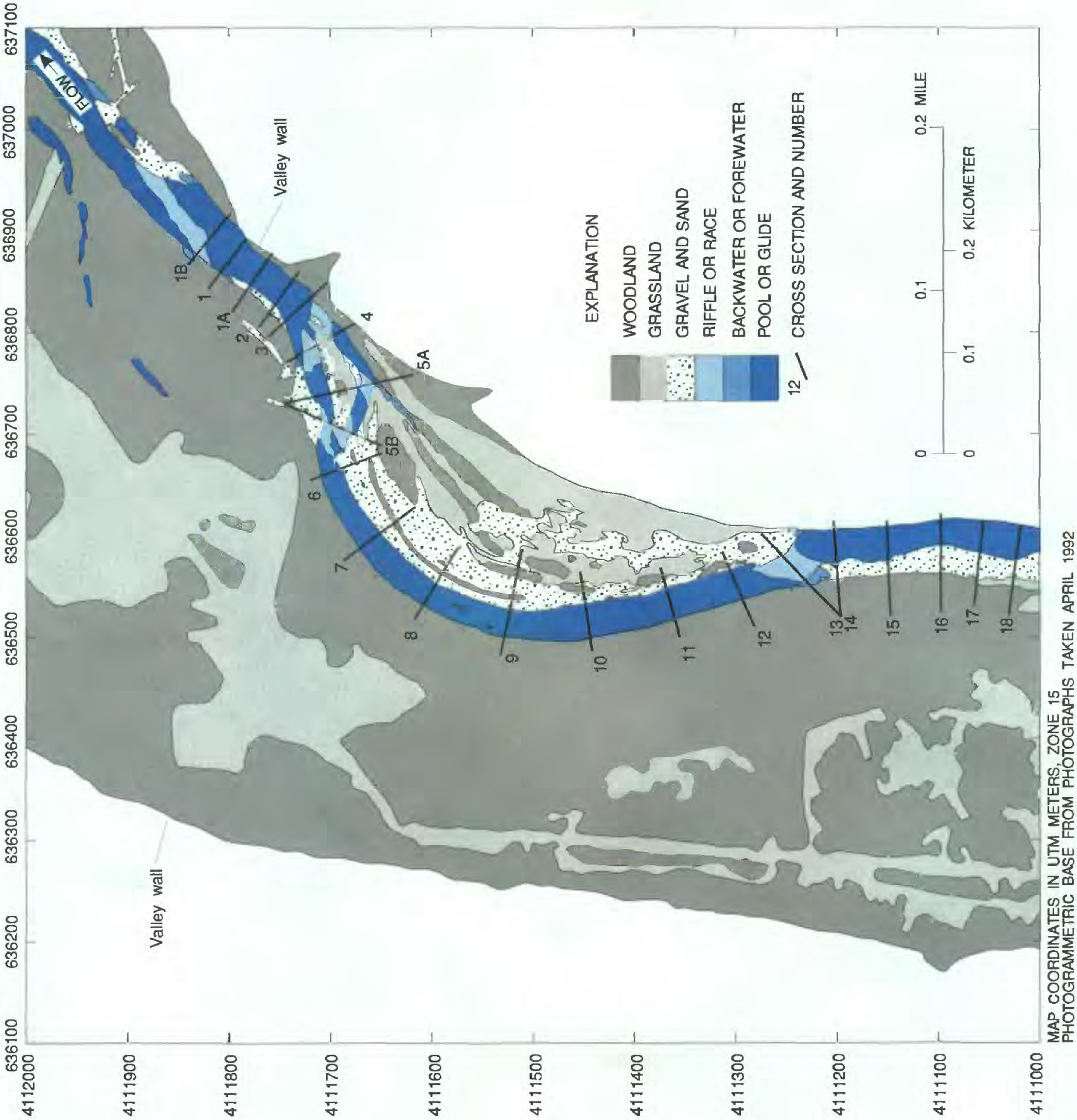

Figure 6. Burnt Cabin reach, Jacks Fork, Missouri.

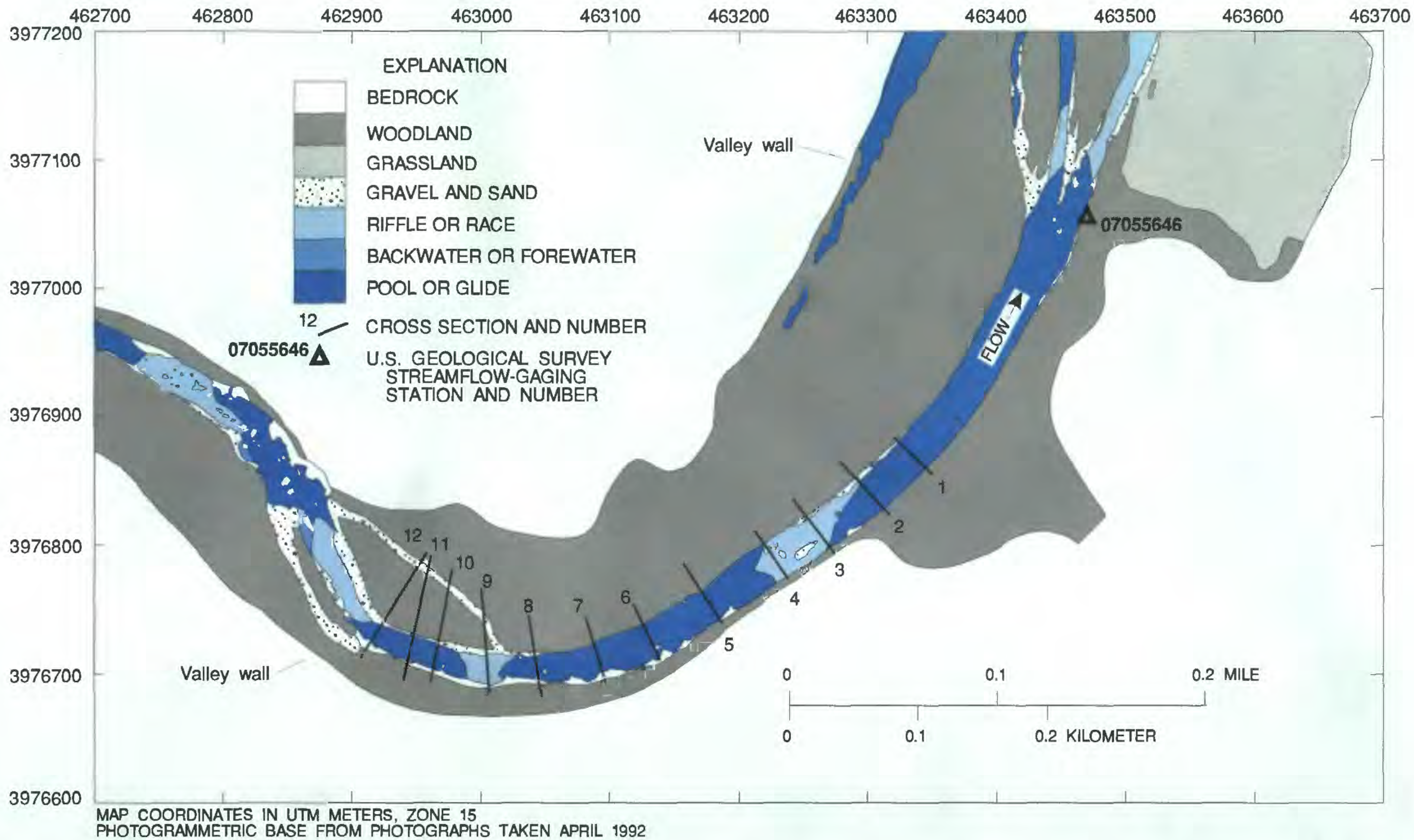

Figure 7. Wilderness Boundary reach, Buffalo River, Arkansas.

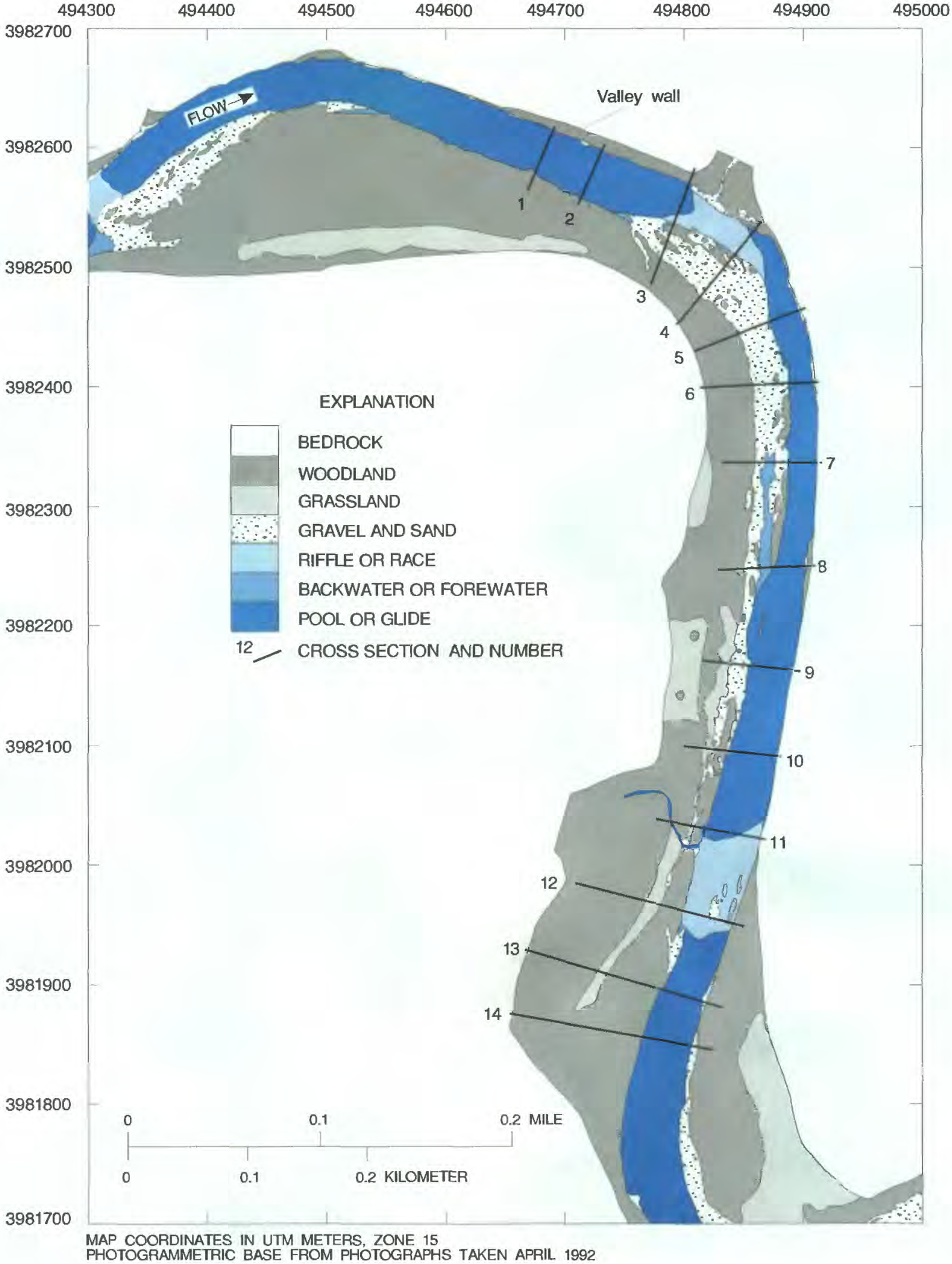

Figure 8. Blue Hole reach, Buffalo River, Arkansas.

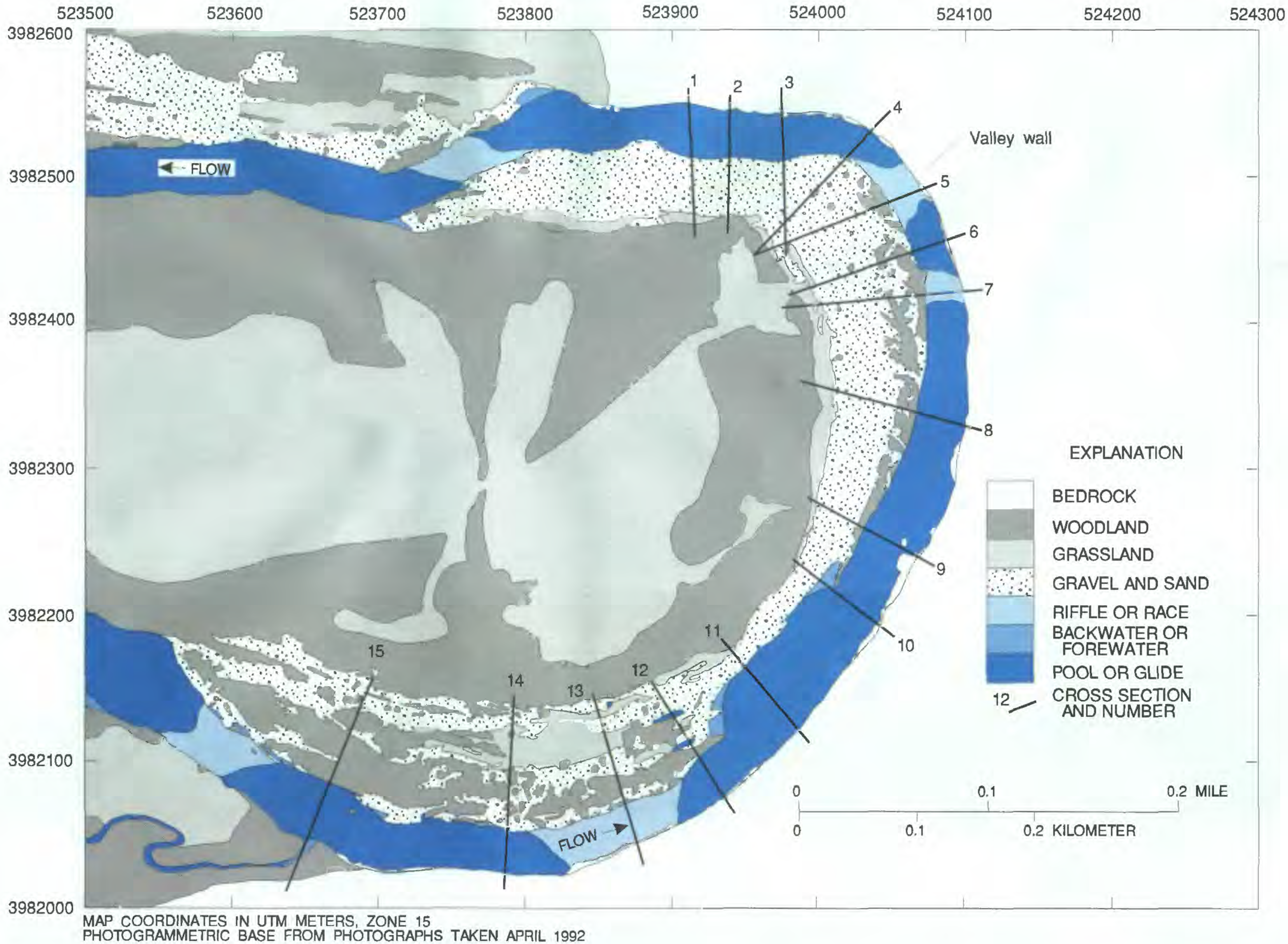

Figure 9. Shine-eye reach, Buffalo River, Arkansas.

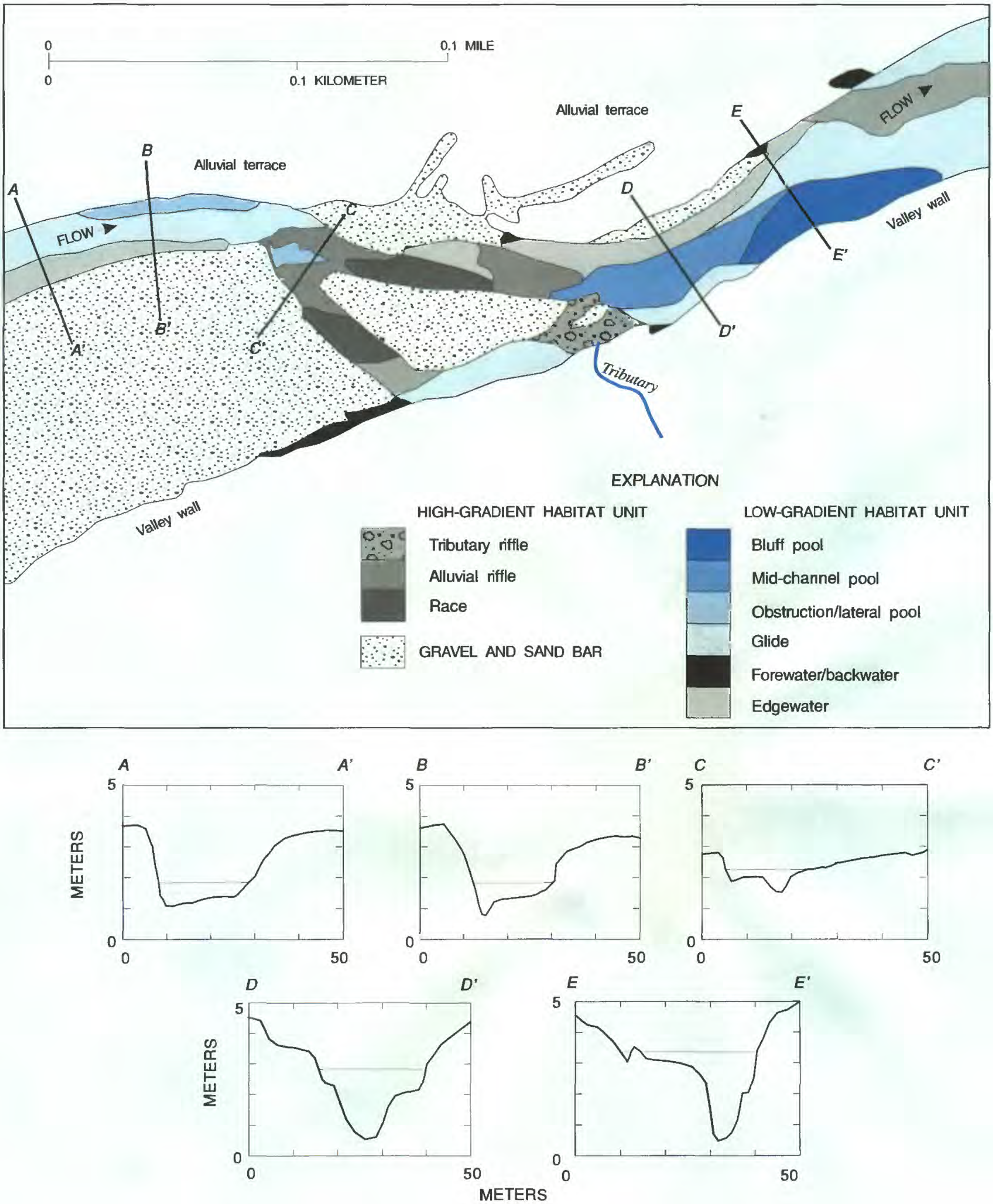

Figure 10. Hydraulic habitat units.

than 25. Bluff pools form at the base of a bedrock bluff or talus slope, lateral pools form at the base of an alluvial cutbank, and obstruction pools form around wood debris and boulder obstructions. Glides have trapezoidal cross sections, depths intermediate between those of riffles and pools, moderate velocities, and wetted width to maximum depth ratios greater than 25. Marginal units have little to no velocity. At low flow, forewaters open upstream to the main flow, backwaters open downstream to the main flow, and edgewaters are shallow margins adjacent to the main flow.

Most of the cross sections were benchmarked and initially surveyed from March 1990 to March 1992. Two additional cross sections were installed in March 1995 to extend a modeling network at the Burnt Cabin reach. The endpoints of transects were permanently fixed with iron rebar benchmarks and marked with flagging and copper identification tags. Right and left bank benchmarks were described, cross section azimuth was noted, and general habitat type was noted (table 3, at the back of this report). Cross sections 1–3, 5, 7, and 12 were benchmarked and initially surveyed at the Hickory Point reach, Little Piney Creek in November 1990 (fig. 3). Cross section 3A replaced cross section 3, and cross sections 4, 6, 9, and 11 were added at the Hickory Point reach in February-March 1991. Cross sections 8 and 10 at the Hickory Point reach were added in November 1991. Cross sections 1 and 2 through 16 were benchmarked and initially surveyed at the Burnt Cabin reach, Jacks Fork in March 1991 (fig. 6). Cross sections 1A and 17 at the Burnt Cabin reach were added in November 1991. Cross sections 1B and 18 were added at the Burnt Cabin reach in March 1995. All cross sections at the Ratcliff Ford and Fox Farm reaches, Jacks Fork were benchmarked and initially surveyed in February 1992 (figs. 4, 5). All cross sections at the Wilderness Boundary and Blue Hole reaches, Buffalo River were benchmarked and initially surveyed in March 1992 (figs. 7, 8). Cross sections 1 through 11 at the Shine-eye reach, Buffalo River also were benchmarked and initially surveyed in March 1992 (fig. 9). Cross sections 12 through 15 at the Shine-eye reach were added in December 1992.

Cross Section Surveying

Surveying was conducted along a tag line stretched between the benchmarks using an electronic total station and digital data logger. A metal detector was required frequently to locate benchmarks for resurveys. Where water depth and velocity permitted, surveying was conducted by wading the stream at the cross section locations. The surveying rod was placed at breaks in the slope to record the form of the channel and banks. Where breaks in slope were widely separated, intermediate points were surveyed. Distance north, distance east, and elevation of each point relative to an arbitrary origin were collected. From these data, distance from the original left bank stake and elevation pairs were calculated.

Where water depth or velocity prevented wading, a boat was used as a stable surveying platform. A safety rope was secured across the channel upstream of the tag line, so the boat would be centered under the tag line. A bracket, bolted to both sides of the boat in front of the oar locks, was attached to the safety line, holding the boat stationary in the current.

When water depths were greater than the extended rod height of 3.65 m or water velocity was too high to hold the rod on the channel bottom, channel depth was detected with a recording sonic depth detector (hereafter referred to as sonic detector). Depths were read from the sonic detector, and the water surface elevation of the point was surveyed using the total station. The sonic detector depth was subtracted from the water surface elevation to calculate the channel-bed elevation. To calibrate sonic detector depths, data were collected from areas that could be surveyed using both the rod and the sonic detector. A regression equation and 95 percent confidence intervals were calculated from the sonic detector and survey data.

High-water marks were identified and surveyed during cross section resurveys. Data from crest-stage gages installed at each site were used to check high-water-mark data. Cross sections were resurveyed annually for 3 to 5 years and after selected floods (table 4).

Surveying Error Analysis

Survey data contain both vertical and horizontal error. Instrument error, operator error, datum shifts, and ground conditions can be sources of vertical and horizontal surveying error. Most of the vertical surveying error results from the uneven or loose ground under the rod. This error is approximately 4 cm (centimeters). Additional vertical error results from surveying over coarse streambed material. Minor fluctuations in streambed elevation may reflect differences in rod placement around coarse particle sizes rather than erosion and deposition. Error from coarse bed material

Table 4. Cross section survey dates
[--, no survey conducted]

Reach	May through June 1991		Nov. 1991 through Mar. 1992		May through June 1992		Nov. 1992 through Mar. 1993		Nov. 1993 through Mar. 1994		Nov. 1994 through Mar. 1995	
	Month	Section surveyed	Month	Sections surveyed	Month	Sections surveyed	Month	Sections surveyed	Month	Sections surveyed	Month	Sections surveyed
Little Piney Creek, Missouri												
Hickory Point	May	1–4, 7, 9	Nov.	All	--	--	Nov.	All	Dec.–Jan.	All	Feb.	All
	--	--	--	--	--	--	Jan.	1, 2, 10, 12	--	--	--	--
	--	--	--	--	--	--	Feb.	3–9, 11	--	--	--	--
Jacks Fork, Missouri												
Fox Farm	--	--	Mar.	All	May	All	Feb.	All	Jan.	All	Jan.	All
Ratcliff Ford	--	--	Feb.	All	May	1–6, 8–16	Mar.	All	Jan.	All	Mar.	All
Burnt Cabin	--	--	Nov.	1–17	May	1–17	Dec.	1–3, 5A, 6, 8	Jan.	1–17	Mar.	All
	--	--	--	--	--	--	Mar.	1–17	--	--	--	--
Buffalo River, Arkansas												
Wilderness Boundary	--	--	Mar.	All	--	--	Dec.	3, 4	Mar.	All	Dec.	All
	--	--	--	--	--	--	Mar.	1, 2, 5–12	--	--	--	--
Blue Hole	--	--	Mar.	All	--	--	Dec.	All	Mar.	All	Dec.	All
Shine-eye	--	--	Mar.	1–11	--	--	Dec.	All	Mar.	All[1]	Dec.	All[2]

[1]Main channel of cross sections 2–7 and 12–14 surveyed in August 1994 because of high water in March.

[2]Main channel of cross sections 4–7, 13, and 14 surveyed in July 1995 because of high water in December.

generally is concentrated in tributary riffles and in bluff pools near the bedrock walls. Most horizontal error results from surveying around vegetation, from boat movement in current, and from slightly different placement of the tag line around vegetation during resurveys. Slightly different rod placement on topographically complex bedrock walls can result in different representations of a stable channel margin. In these cases, all resurveys of the bluff wall were corrected to the original survey prior to erosion and deposition calculations. Horizontal error, assessed from the mean standard deviation of 15 cross section endpoint resurveys, is 0.20 m.

Erosion and Deposition Calculation

Erosional and depositional areas were calculated for consecutive survey pairs and for the entire survey period using a geographic information system to calculate vertical changes in the channel cross sections. Distance elevation data for each survey of each cross section were converted to lines and nodes in the geographic information system and polygons of "channel" and "sediment" were created (fig. 11). The areas that changed from "channel" in the first survey to "sediment" in the second survey were tabulated as area deposited. The areas that changed from "sediment" in the first survey to "channel" in the second survey were tabulated as area eroded. Net change is the area deposited minus the area eroded for individual survey pairs.

This method was applied to the entire length of each resurveyed cross section. Therefore, much of the area outside of the low-flow channel is included in the erosion and deposition calculations. In many cross sections, bank erosion may be balanced by deposition on the bar well above the low-flow channel; the basic channel shape is unchanged. Hence, large amounts of erosion and deposition do not always indicate that large changes in habitats occurred, but may reflect changes in the lateral position of the channel in the floodplain.

Erosion and deposition caused by small and moderate, frequent floods [recurrence interval (RI) less than 5 years] occur within the bankfull channel. All the cross sections extend across the bankfull channel for all of the study reaches. As a result, erosion and deposition values are generally for the bankfull channel. Channel change calculations for large, infrequent floods (RI greater than 20 years) are an exception, because erosion and deposition occur outside of the bankfull channel for these floods.

Volumetric channel changes were calculated using the difference between the initial and final survey for each cross section. Net volumetric change for the monitoring period was calculated by multiplying the net areal change of each cross section times the sum of one-half the distance to the nearest cross section upstream and one-half the distance to the nearest cross section downstream (fig. 12). The net volumetric change for all the cross sections in a reach was summed to yield the reach net volumetric change. Total volumetric change for the monitoring period was calculated by multiplying the sum of erosion and deposition of each cross section times the sum of one-half the distance to the nearest cross section upstream and one-half the distance to the nearest cross section downstream. Total volumetric change for the reach is the sum of total volumetric change of the cross sections.Total and net volumetric changes were normalized for basin drainage area above the reach, length of monitoring period, and reach length.

Volumetric calculations use the cross section to represent conditions halfway to the adjacent cross sections because (1) generally HHU boundaries are gradual, (2) most HHUs contain multiple cross sections, and (3) HHU boundary locations varied through the monitoring period. In addition, the close spacing of the cross sections (less than one bankfull channel width in most cases) minimizes interpolation error.

EROSION, DEPOSITION, AND CHANNEL CHANGE IN OZARK STREAMS

Data from cross section resurveys indicate these Ozark streams generally had more erosion than deposition during the monitoring period (table 5). The amount of annual total change (combined erosion and deposition) that occurred in the Jacks Fork monitoring reaches was similar to annual total change that occurred at larger drainage areas in the Buffalo River monitoring reaches. The Ratcliff Ford and Blue Hole reaches, for example, had approximately the same amount of total volumetric change (table 5), although the Buffalo River at the Blue Hole reach has a drainage area more than two times the drainage area of the Jacks Fork at the Ratcliff Ford reach. Annual total volumetric change normalized for drainage area shows the largest amount of change occurred in the Jacks Fork monitoring reaches and the least amount of

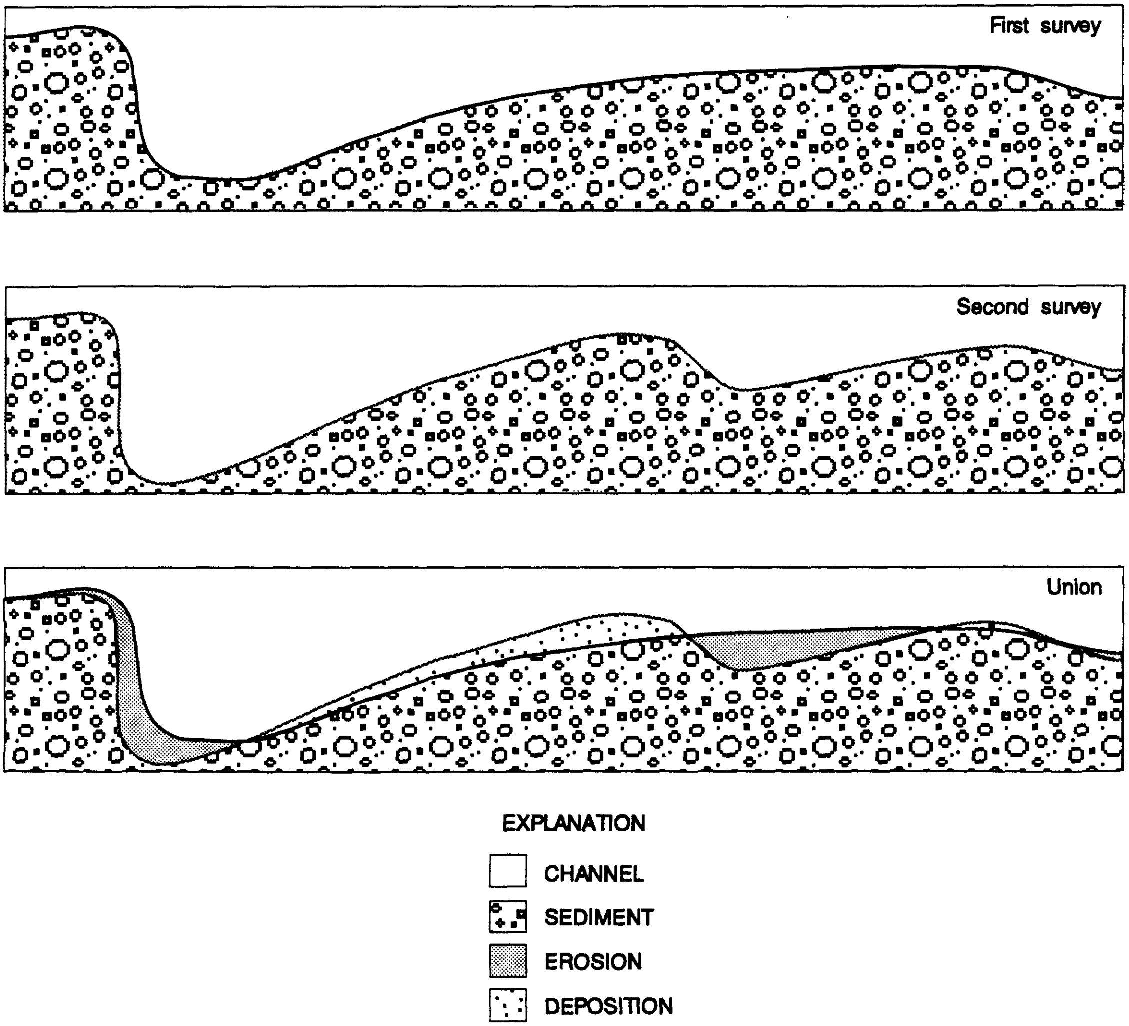

Figure 11. Erosion and depostion calculations performed in a geographic information system.

change occurred in the Buffalo River monitoring reaches (table 5). However, no trend in net change was apparent between drainage basins (table 5). The differences in total and net volumetric change arise because less deposition occurred in the Buffalo River than in the Jacks Fork and Little Piney Creek during the monitoring period (figs. 13–19, at the back of this report). These patterns are consistent when normalized for differences in drainage area, reach length, and length of monitoring period (table 5).

A range of floods occurred in the study basins during the monitoring period (fig. 2). A large overbank flood occurred in the Little Piney Creek Basin in November 1993 (approximate RI 10 years). Two large overbank floods occurring the Jacks Fork Basin in September and November 1993 (approximate RI 20 and 50 years, respectively). Hereafter, these large overbank floods are called large floods. Approximately bankfull events (RI 2 to 5 years) are called moderate floods. Less than bankfull floods (RI less than 2 years) are called small floods.

The location of erosion and deposition within the monitoring reaches varied greatly between basins (figs. 20–26, at the back of this report). Most channel change in the Buffalo River Basin occurred as either bar modification, which did not affect the low-flow channel (fig. 26, cross section 8), or as widening of the low-flow channel (fig. 26, cross sections 1 and 14). In the Jacks Fork and Little Piney Creek Basins, however, both bar surfaces and the low-flow channel were extensively

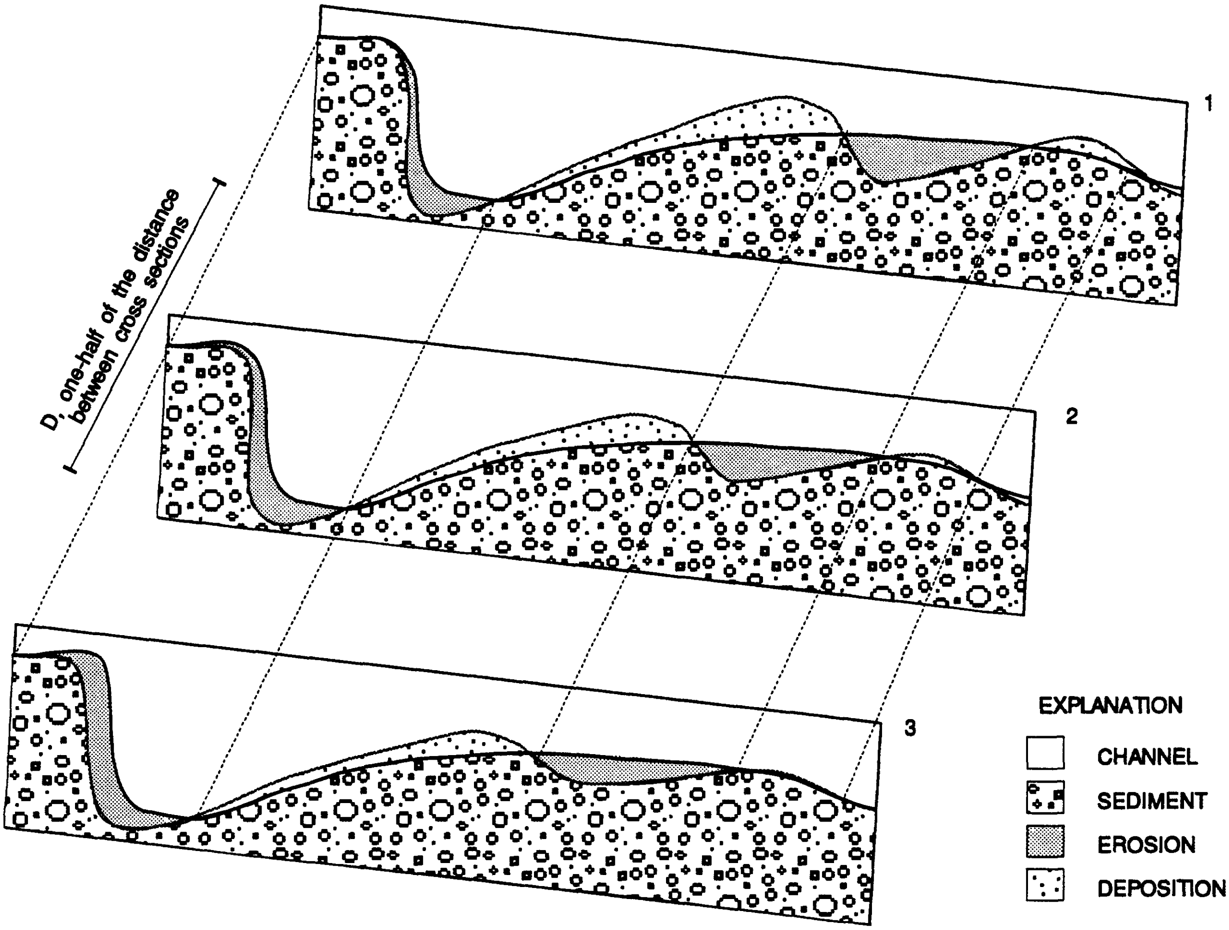

Figure 12. Total and net volume change calculations. (Total volume change is area eroded plus area deposited times D, one-half of the distance between cross sections. Net volume change is the area deposited minus area eroded times D.)

modified in many cross sections (fig. 20, cross section 3; fig. 23, cross section 5B). Many mid-channel bars and small alternate bars eroded during large floods and were reformed during subsequent moderate and small floods (fig. 20, cross section 5; fig. 23, cross sections 1, 13, and 15). Lateral migration of as much as 20 m occurred during the monitoring period in the Little Piney Creek and Jacks Fork reaches (fig. 20, cross sections 3 and 11; fig. 23, cross sections 6–9).

The quantity and style of channel change also varied from upstream to downstream (tables 5, 6, at the back of this report; figs. 13–19). Monitoring data on the Jacks Fork from November 1991 to the present (1996) indicate channel changes from individual floods are less extensive at the Fox Farm reach than at the Ratcliff Ford and Burnt Cabin reaches (figs. 14–16). For example, at the Fox Farm reach, the area eroded, area deposited, and net change between the February 1992 and May 1992 surveys were substantially smaller than at the Ratcliff Ford and Burnt Cabin reaches (table 6). Moderate (fig. 2, November 1992–March 1993 surveys) and large floods (fig. 2, November 1993–March 1994 surveys) caused more combined erosion and deposition at the Burnt Cabin reach than at the Ratcliff Ford reach (table 6), but approximately the same amount of net change (figs. 15, 16). Although the amount of net change is approximately equal at the Burnt Cabin and Ratcliff Ford reaches, the type of channel change that occurred is different. Removal and redeposition of bars, lateral bank erosion, and bed-elevation changes occurred at the Burnt Cabin reach (fig. 23, cross sections 1–7), whereas at the Ratcliff Ford reach

Table 5. Volume of channel change for each monitoring reach

[m^3, cubic meters; m^3/m, cubic meters per meter; m^3/y, cubic meters per year; km^2, square kilometers]

Reach	Total change (m^3)	Total change per unit channel length (m^3/m)	Annual total change (m^3/y)	Annual total change per unit drainage area[1] [$(m^3/y)/km^2$]	Annual total change per unit channel length [$(m^3/m)/y$]	Net change (m^3)	Net change per unit channel length (m^3/m)	Annual net change (m^3/y)	Annual net change per unit drainage area[2] [$(m^3/y)/km^2$]	Annual net change per unit channel length [$(m^3/m)/y$]
Little Piney Creek, Missouri										
Hickory Point	3,679	4.8	818	2.15	1.1	-1,562	-2.0	-347	-0.91	-0.5
Jacks Fork, Missouri										
Fox Farm	858	2.5	286	3.30	.8	-103	-.3	-34	- .39	-.1
Ratcliff Ford	4,371	7.9	1,457	3.40	2.6	461	.8	154	.36	.3
Burnt Cabin	14,081	15.4	3,520	4.50	3.9	-5,434	-6.0	-1,359	-1.72	-1.5
Buffalo River, Arkansas										
Wilderness Boundary	722	1.5	241	1.60	.5	-520	-1.1	-173	-1.15	-.4
Blue Hole	3,129	3.7	1,043	1.02	1.2	-1,263	-1.5	-421	- .41	-.5
Shine-eye	10,047	12.4	3,349	1.55	4.1	-7,302	-9.0	-2,434	-1.13	-3.0

[1]Annual total change normalized by reach drainage area in square kilometers.

[2]Annual net change normalized by reach drainage area in square kilometers.

vertical bed-elevation changes were dominant (fig. 22, cross sections 1–3 and 8–10).

Similarly, within the Buffalo River, only minor erosion and deposition occurred at the Wilderness Boundary reach (fig. 17). Channel changes were mostly small amounts of deposition and erosion of the bed and slight (less than 0.5 m) channel widening (fig. 24, cross section 8). The Blue Hole reach had slightly more erosion and deposition than the Wilderness Boundary reach (figs. 17, 18). Most changes at the Blue Hole reach resulted from erosion and deposition of the channel bed. Erosion and deposition at the Shine-eye reach were highly variable. A large amount of channel change occurred on the unvegetated bar at the downstream end of bend (fig. 26, cross sections 1 and 2), whereas relatively small amounts of erosion and deposition occurred in the rest of the reach (fig. 26). The largest amount of change was caused by a series of floods between December 1992 and March 1994 (figs. 2, 17–19). Slightly less erosion was caused by the moderate flood in December 1994 (figs. 17–19). Seasonal changes in bar form near the low-flow channel at the Shine-eye reach were recorded because high-flow conditions prevented full survey of some cross sections (table 4) during the March 1994 and December 1994 surveys. Partial surveys indicate some areas on the bar at Shine-eye experienced repeated erosion or deposition while others experienced substantial fluctuations between erosion and deposition (table 7).

Within actively changing reaches, some groups of cross sections experienced mostly lateral bank erosion and bar deposition (fig. 20, cross section 3; fig. 23, cross sections 2–9, for example), whereas other groups of cross sections had mostly vertical erosion and deposition within the main channel (fig. 22, cross sections 1, 2, and 5–9; fig. 23, cross sections 1, 1A, and 15–17, for example). Within a given reach, the balance between vertical and lateral changes depends on valley and stream morphology. For example, at the Ratcliff Ford reach, a high sinuosity reach in a narrow valley (table 2), ero-sion and deposition was dominantly vertical (fig. 22, cross sections 7–12), whereas many cross sections at the Hickory Point and Burnt Cabin reaches, both moderately sinuous reaches in wide valleys (table 2), had lateral erosion and deposition (fig. 20, cross sections 2, 3A, 4, 6, 7, 9, and 11; fig. 23, cross sections 2–11). Bank erosion at the Ratcliff Ford reach led to channel widening of 1 to 5 m (fig. 22, cross sections 13–15), and deepening of 1 to 2 m was common (fig. 22, cross sections 7–12). Bank erosion at the Hickory Point and Burnt Cabin reaches resulted in lateral migration of as much as 20 m (fig. 20, cross sections 2, 3A, 4, 9, and 11; fig. 23, cross sections 2–11), while deepening was generally less than 1 m. Slightly less erosion occurred at the Hickory Point reach than at the Ratcliff Ford reach (figs. 13, 15), despite the narrow valley at the Ratcliff Ford reach and the wide valley at the Hickory Point reach (table 2).

Monitoring reach topography changed through time in response to floods of different sizes. In general, the area of erosion and deposition was larger for a given reach from floods with higher peak stages than from floods with lower peak stages (figs. 2, 13–26). For example, the Burnt Cabin reach had a minor decrease in bed relief caused by deposition in lateral pools during the small floods prior to the May 1992 survey (fig. 23, cross section 9). A moderate flood in April 1992 caused some deepening in pools (fig. 23, cross section 1, May 1992 survey) and some cutbank migration (fig. 23, cross section 6, May 1992 survey). The moderate floods between the May 1992 and March 1993 surveys and the large floods between the March 1993 and January 1994 surveys (fig. 2) continued the bed and bank erosion, deepening pools (fig. 23, cross sections 1 and 9), extending the low bar opposite the cut bank, and modifying the high bar (fig. 23, cross sections 8 and 9). In addition, the floods between the May 1992 and March 1993 surveys (fig. 2) deposited material at cross section 7, forming a new riffle. Small alternate bars were removed by large floods between the March 1993 and January 1994 surveys (fig. 2). Small floods following the January 1994 survey (fig. 2) resulted in redeposition of one of the bars (fig. 23, cross sections 1, 1A, and 15).

In addition, small waves of sediment moved through reaches causing temporary changes in pool and riffle morphology. A sediment wave moved into the Ratcliff Ford reach between the May 1992 and March 1993 survey, causing the pool at cross sections 1 and 2 to shallow to a glide and a small hump to appear in the riffle at cross section 5 (fig. 22). During the large flood in November 1993 (fig. 2), the sediment was moved out of the glide and onto the bar at cross sections 1 and 2, while more material accumulated in the riffle and downstream of the riffle in cross sections 4 through 7 (fig. 22). Between February 1994 and March 1995, the riffle and the cross section downstream were scoured (fig. 22, cross sections 4–6),

Table 7. Erosion and deposition data from partial surveys
[m^2, square meters; --, no data]

Cross section	August 1994		December 1994		July 1995	
	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)
			Shine-eve reach, Buffalo River, Arkansas			
2	13.83	0.00	--	--	--	--
3	6.11	1.09	--	--	--	--
4	.69	1.79	3.32	0.19	1.00	1.04
5	.11	.14	.11	.30	.41	.10
6	.18	.53	2.25	.33	1.00	1.14
7	.00	.60	.00	.74	.04	.27
13	.03	3.93	.92	2.21	.00	2.94
14	.27	.52	1.17	2.15	.03	3.61

probably causing the sediment wave to move into the pool downstream (fig. 22, cross section 7). Substantial morphologic change occurred in the pool and on the adjacent bar during previous floods; therefore, it is difficult to attribute changes which were detected in the pool during the March 1995 survey to the sediment wave (fig. 22, cross section 8).

Changes in Pool Habitats

Generally, large and moderate floods caused pools to increase in depth, width, and length, whereas small floods caused pools to shorten, narrow, and shallow (fig. 23, cross sections 1, 1A, and 15; fig. 26, cross sections 1–3). Glides are included in this analysis because they are low-gradient units and are often formed when pools are shallow. The degree of change in the pool size was affected by pool type and local planform geometry. Some lateral pools shallowed and shortened during small floods until only a few meters of the cross section next to the bank remained a pool, whereas the rest of the cross section was a glide (fig. 23, cross sections 8, 10, and 11). Bluff pools, however, generally retained pool characteristics, though the width, length, and depth changed (fig. 22, cross sections 9 and 10; fig. 23, cross sections 1 and 1A).

Obstruction pool development varied with deposition and scour around individual root wads, coarse wood debris, and large boulders. Wood debris is generally delivered to the stream during lateral bank migration, and boulders are transported to the channel by block fall from bluffs. Both the obstruction-delivery mechanisms and sediment transport around the obstructions are variable processes that result from changes in local conditions. These factors make formation and persistence of obstruction pools difficult to quantify.

Changes in Riffle Habitats

Changes in riffles depended on riffle type: tributary or alluvial. In this analysis, changes in races are grouped with changes in the nearest riffle. Tributary riffles generally had minor or no deposition during the monitoring period (fig. 22, cross sections 4 and 5; fig. 25, cross section 3) probably because of large bed material. When material was deposited in a tributary riffle during a flood, it was removed during a subsequent flood (fig. 22, cross sections 4 and 5). Alluvial riffles, however, had large amounts of change, including avulsion (fig. 23, cross section 5A), formation and destruction of mid-channel bars (fig. 20, cross section

5; fig. 23, cross section 13), lateral movement (fig. 22, cross section 13; fig. 23, cross sections 4–5B), and downstream movement (fig. 22, cross sections 2–4). Larger amounts of change occurred in many alluvial riffles than in pools for the same flood within a reach (fig. 20, cross sections 5 and 6; fig. 23, cross sections 1–5B). Complex changes in alluvial riffles result in a spatially and temporally diverse habitat structure.

Changes in Habitats Marginal to the Main Flow

Marginal habitat modification was associated with bar deposition and erosion patterns. Changes in forewaters and backwaters varied according to the lateral stability of the channel that affected bar deposition and erosion. Edgewater extent varied with changes in the angle of bar deposition (fig. 20, cross section 3A; fig. 23, cross sections 1–2, and 16).

Forewaters formed from scour at the heads of high-water channels and were modified according to their relation to the main channel. Forewaters at the upstream, inner side of a channel bend changed size and shape, but were otherwise stable (fig. 22, cross section 13; fig. 23, cross section 14). Forewaters at the downstream, outer side of a channel bend formed before avulsion or channel migration and were subsequently replaced by the main channel (fig. 23, cross section 5B).

Backwater formation, modification, and stability were affected by lateral channel stability. In laterally migrating areas, channel migration and channel cutoff formed large, often deep backwaters (fig. 22, cross sections 14–16; fig. 23, cross sections 4 and 5A). Lateral migration preserved the backwaters throughout the monitoring period, although deposition changed the length and depth of the backwaters (fig. 22, cross sections 14–16; fig. 23, cross sections 4–5B). In laterally stable areas, backwaters form on bars with ridge and swale topography and from separation of the bar crest from the bank (fig. 22, cross section 9; fig. 23, cross sections 1A and 15). Substantial bar erosion during large floods caused bar crests to be submerged at low flow, destroying the backwaters associated with the bar (fig. 23, cross sections 1 and 15).

SUMMARY

Data from 101 channel cross sections record short-term channel changes caused by a wide range of flood stages in 7 stream reaches in the Ozark Plateaus. The data document rates of channel change, dominant geomorphic processes, and areas of relative stability and instability. These channel change processes can then be evaluated in terms of habitat stability and distribution. Resource management, facility siting, habitat restoration, and design of instream engineering structures benefit from detailed knowledge of rates and processes of channel change.

Channel cross section data document differences in channel change processes in Ozark streams. The data demonstrate variations in net and total deposition occurred among and within the streams studied. In addition, these data demonstrate that hydraulic habitat unit type and location affect hydraulic habitat unit sensitivity to channel change. This data set may become the foundation of a long-term record of channel change at the riffle-pool scale in streams of the Ozarks. Continued monitoring could record changes in habitat in response to long term aggradation and degradation patterns in the Ozarks.

REFERENCES CITED

Albertson, P.E., Meinert, D., and Butler, G., 1995, Geomorphic evaluation of Fort Leonard Wood: Vicksburg, Miss., U.S. Army Corps of Engineers, Waterways Experiment Station, Technical Report GL–95–19, 241 p.

Bauman, A., 1944, Prescription for a sick stream: Missouri Conservationist, p. 2–3, 14–15.

Emmett, W.W., 1965, The Vigil Network—Methods of measurement and a sampling of data collected: International Association of Scientific Hydrology Publication 66, p. 89–106.

Evans, D.A., Porter, J.E., and Westerfield, P.W., 1995, Water resources data, Arkansas, water year 1994: U.S. Geological Survey Water-Data Report AR–94–1, 466 p.

Fenneman, N.M., 1938, Physiography of eastern United States: McGraw-Hill Book Co., New York, 714 p.

Frissell, C.A., Liss, W.J., Warren, C.E., and Hurley, M.D., 1986, A hierarchical framework for stream habitat classification—Viewing streams in a watershed context: Environmental Management, v. 10, p. 199–214.

Hadley, R.F., 1965, Selecting sites for observation of geomorphic and hydrologic processes through time: International Association of Scientific Hydrology Publication 66, p. 217–233.

Hauck, H.S., Huber, L.G., and Nagel, C.D., 1996, Water resources data, Missouri, water year 1995: U.S. Geological Survey Water-Data Report MO–95–1, 320 p.

Jacobson, R.B., 1995, Spatial controls on patterns of land-use induced stream disturbance at the drainage-basin scale—An example from gravel-bed streams of the Ozark Plateaus, Missouri, *in* Costa, J.E., Miller, A.J., Potter, K.W., and Wilcock, P.R., eds., American Geophysical Union Geophysical Monograph 89, The Wolman Volume, p. 219–239.

Jacobson, R.B., and Primm, A.T., 1994, Historical land-use changes and potential effects on stream disturbance in the Ozark Plateaus, Missouri: U.S. Geological Survey Open-File Report 94–333, 95 p.

Jacobson, R.B., and Pugh, A.L., 1992, Effects of land use and climate shifts on channel instability, Ozark Plateaus, Missouri, U.S.A.: Proceedings of the workshop on the effects of global climate change on hydrology and water resources at the catchment scale, February 3–6, 1992, Tsukuba, Japan, Japan-U.S. Committee on Hydrology, Water Resources and Global Climate Change, p. 423–444.

_____in press, Riparian vegetation and the spatial pattern of stream-channel instability, Little Piney Creek, Missouri: U.S. Geological Survey Water-Supply Paper 2494.

Leopold, L.B., 1962, The Vigil Network: Bulletin of International Association of Scientific Hydrology, v. 7, no. 2, p. 5–9.

Lisle, T.E., 1982, Effects of aggradation and degradation on riffle-pool morphology in natural gravel channels, northwestern California: Water Resources Research, v. 18, no. 6, p. 1,643–1,651.

Miller, A.J., and Jacobson, R.B., 1995, Channel planform in confining valleys [abs]: International Association of Geomorphologists, Southeast Asia Conference, Singapore, June 18–23, 1995, Programme with Abstracts, p. 57.

Pugh, A.L., 1992, Recent geomorphic evolution of the Little Piney Creek, Phelps County, Missouri: University of Missouri-Rolla, unpublished M.S. thesis, 84 p.

Rabeni, C.F., and Jacobson, R.B., 1993a, Geomorphic and hydraulic influences on the abundance and distribution of stream centrarchids in Ozark U.S.A. streams: Polskie Archiwum Hydrolobiologii, v. 40, p. 87–99.

_____1993b, The importance of fluvial hydraulics to fish-habitat restoration in low-gradient alluvial streams: Freshwater Biology, v. 29, p. 211–220.

Rosgen, D.L., 1994, A classification of natural rivers: Catena, v. 22, p. 169–199.

Saucier, R.T., 1983, Historic changes in Current River meander regime: Proceedings of Conference, Rivers '83, American Society of Civil Engineers, p. 180–190.

Schumm, S.A., 1960, The shape of alluvial channels in relation to sediment type: U.S. Geological Survey Professional Paper 352–B, 30 p.

Wolman, M.G., and Leopold, L.B., 1957, River flood plains—Some observations on their formation: U.S. Geological Survey Professional Paper 282-C, p. 87–107.

TABLES AND ILLUSTRATIONS

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Table 3. End-point descriptions for cross sections

Cross section	Type	Azimuth	Bank	Description
Hickory Point reach, Little Piney Creek, Missouri—cross sections are numbered from upstream to downstream (fig. 3)				
1	Riffle	125	Right	10 meters back from cutbank by double trunked Hawthorn (*Cretaegus* sp.), both 8-centimeter diameter. Stake on downstream side. Field label LP2.
			Left	Upstream side of large tree, immediately upstream from access road.
2	Race	096	Right	1.5 meters from old cutbank on valley side of vegetated bar, 0.25 meter upstream from 1.2-centimeter diameter box elder (*Acer negundo*). Field label LP6.
			Left	0.5 meter toward stream from 5-centimeter diameter, flagged sycamore (*Platanus occidentalis*).
3A	Glide/pool	075	Right	3 meters east of tributary at base of wild cherry shrub (*Prunus serotina*). Field label LP1A.
			Left	1 meter downstream from 3 box elders (*Acer negundo*), 46-centimeter, 31-centimeter, and 15-centimeter diameter. 0.5 meter from many saplings.
4	Glide	075	Right	0.5 meter back from a 3-centimeter diameter flagged sapling, 10 meters back from three maples (*Acer* sp.) on the bank, all 0.3- to 0.6-meter diameter. Field label LP7.
			Left	Base of large dying tree on old cutbank above vegetated gravel/sand bar.
5	Riffle	070	Right	2 meters from tributary bank behind backwater, 10 centimeters downstream from a 20-centimeter diameter tree. Flag on 3-centimeter diameter paw paw (*Asimina triloba*). Stake 10 meters from backwater. Tributary has a 1- to 2-meter fan of clean gravel 0.25 to 0.5 meter high. Field label LP3.
			Left	In new fence line 3 meters upstream from and toward valley from 20-centimeter diameter elm (*Ulmus* sp.). Fence is flagged.
6	Glide/pool	070	Right	At base of 20-centimeter diameter box elder (*Acer negundo*), 5 meters back from cutbank behind backwater in middle of flat bench. Field label LP8.
			Left	In new fence line immediately opposite a 5-centimeter diameter tree next to double trunked tree; one-half is dead, the other is 0.9-meter diameter. The dead part is 0.6-centimeter diameter. A 20-centimeter diameter box elder (*Acer negundo*) is flagged. Stake on stream side of fence.
7	Glide	064	Right	On slope above the bench behind the backwater at base of small tree. Large downed tree in front of stake. Field label LP4.
			Left	In new fence line 2 meters from flagged double trunked tree, 15-centimeter and 10-centimeter diameter.

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
Hickory Point reach, Little Piney Creek, Missouri—cross sections are numbered from upstream to downstream (fig. 3)—Continued				
8	Riffle	085	Right	North side of old leaning maple, 10 meters above tributary inlet. Field label LP12.
8			Left	Base of stump with beaver teeth marks next to large sycamore (*Platanus occidentalis*).
9	Race/Riffle	066	Right	Locust tree 10-centimeter diameter covered in poison ivy (*Rhus radicans*) and virginia creeper (*Parthenocissus quinquefolia*). Stake 25 centimeters from valley toward tree, 1.5 centimeters above ground. Field label LP10.
			Left	At base of 25-centimeter diameter elm (*Ulmus* sp.) and approximately 10 meters toward valley from bank.
10	Race	069	Right	10 centimeters in front of 5-centimeter diameter paw paw (*Asimina triloba*). Wooden and metal stake 3 meters back from cutbank. Field label LP11.
			Left	At base of 15-centimeter diameter elm (*Ulmus* sp.), 8 meters back from bank.
11	Glide/race/ riffle	070	Right	3 meters back from bank in 4-centimeter diameter tree on bank under downed log, 1.5 meters upstream from dogwood shrub (*Cornus* sp.). Field label LP9.
			Left	Under 5-centimeter diameter elm (*Ulmus* sp.). Stake at base of flagged dogwood shrub (*Cornus* sp.), immediately downstream from tributary bank.
12	Glide	071	Right	1.5 meters upstream from 0.4-meter diameter flagged cedar (*Juniperus virginiana*), 3 meters from edge of bank. Field label LP5.
			Left	5 centimeters into pasture from new fence line, halfway between fence posts, near small flagged 8-centimeter diameter oak (*Quercus* spp.), and 15-centimeter diameter flagged oak.
Fox Farm reach, Jacks Fork, Missouri—cross section numbered from upstream to downstream (fig. 4)				
1	Glide	250	Right	15 meters on valley side of fence, 1 meter upstream from 3-centimeter diameter tree.
			Left	1 meter downstream from 30-centimeter diameter oak (*Quercus* spp.) on bedrock slope.
2	Glide/pool	245	Right	On upper fan surface next to twinned 2.5-cementer diameter sapling.
			Left	60 centimeters upslope and upstream from 22-centimeter diameter oak (*Quercus* spp.) on bedrock slope.
3	Riffle	242	Right	On upper fan surface next to 15-centimeter diameter tree.
			Left	4 meters up bedrock wall at base of 35-centimeter diameter oak (*Quercus* spp.).
4	Race	249	Right	Base of 7-centimeter diameter curving tree above brush pile on valley wall.
			Left	30 centimeters from base of 35-centimeter diameter oak (*Quercus* spp.), 17 meters upstream from post 2.

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
Fox Farm reach, Jacks Fork, Missouri—cross section numbered from upstream to downstream (fig. 4)—Continued				
5	Glide	246	Right	Base of 60-centimeter diameter oak (*Quercus* spp.), 10 meters above 2-meter boulder.
			Left	15 meters downstream from post 2 at base of 60-centimeter diameter oak (*Quercus* spp.) on scarp.
6	Glide	245	Right	0.5 meter upstream from 1-centimeter diameter sapling on slope.
			Left	Base of 7-centimeter diameter dogwood (*Cornus* sp.) on upper edge of gravel alluvial terrace.
7	Riffle/race	245	Right	Next to 2.5-centimeter diameter sapling on talus from bedrock wall.
			Left	Base of 5-centimeter diameter tree on edge of gravel alluvial terrace, in old fence line.
8	Race	228	Right	Next to clump of 1- to 2-centimeter diameter saplings, 1 meter downstream from 10-centimeter diameter tree.
			Left	Base of clump of musclewood (*Carpinus caroliniana*) 20 meters upstream from tree stand on edge of alluvial terrace.
9	Glide/pool	226	Right	Base of 1-meter tall rock outcrop, 0.5 meter toward valley from 15-centimeter diameter leaning tree.
			Left	Base of 2.5-centimeter diameter dogwood (*Cornus* sp.) tree on upper edge of gravel alluvial terrace, 10 meters downstream from tree stand.
10	Riffle	223	Right	0.5 meter upstream from branching 5-centimeter diameter dead tree at base of root wad.
			Left	Base of 60-centimeter diameter oak (*Quercus* spp.) at edge of alluvial terrace.
11	Glide/race	219	Right	0.5 meter upslope from 7-centimeter diameter sycamore (*Platanus occidentalis*), downslope 1-meter high outcrop.
			Left	In musclewood (*Carpinus caroliniana*) with grape vines (*Vitis* spp.) on edge of terrace.
12	Glide/pool	215	Right	At base of slope 3 meters back from stream, 2 meters downstream from 45-centimeter diameter sycamore (*Platanus occidentalis*).
			Left	Edge of terrace 5 meters downstream from large double-trunked oak (*Quercus* spp.).
13	Glide/pool	219	Right	At base of 2 meter bedrock outcrop.
			Left	Base of fallen log on middle terrace.
Ratcliff Ford reach, Jacks Fork, Missouri—cross section numbered from upstream to downstream (fig. 5)				
1	Glide	224	Right	3 meters back from small point in bedrock wall, 0.75 meter in front of small rock bench, 1 meter downstream from 10-centimeter diameter flagged oak (*Quercus* spp.).
			Left	On ledge overhanging bedrock wall between two oaks (*Quercus* spp.), flagging on downstream oak.

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
				Ratcliff Ford reach, Jacks Fork, Missouri—cross section numbered from upstream to downstream (fig. 5)—Continued
2	Pool	218	Right	On small U-shaped bench downstream from first bedrock wall, 1 meter toward stream from large leaning oak (*Quercus* spp.).
			Left	In crevice below and toward stream from small tree in bedrock wall.
3	Glide	210	Right	On bank 1 meter above small bench, 4 meters upstream from 45-centimeter diameter oak (*Quercus* spp.), downstream from large slumping boulder.
			Left	Base of 20-centimeter diameter tree in front of small cave at base of bedrock wall.
4	Riffle	223	Right	At base of a leaning musclewood (*Carpinus caroliniana*).
			Left	On debris fan on downstream side of gully, at base of 7-centimeter diameter oak (*Quercus* spp.).
5	Riffle	223	Right	At base of double trunked musclewood (*Carpinus caroliniana*), downstream trunk 15-centimeter diameter, upstream trunk 28-centimeter diameter.
			Left	On overhang in extremely rocky ground at base of 2.5-centimeter diameter oak (*Quercus* spp.), immediately above notch over dry area in overhang.
6	Glide	232	Right	Base of 20-centimeter diameter oak (*Quercus* spp.) with scar on upstream base of tree.
			Left	3 to 4 meters toward valley wall from 25-centimeter leaning sycamore (*Platanus occidentalis*), base of small branched tree.
7	Pool	250	Right	Base of 17-centimeter diameter horizontal tree on terrace.
			Left	On debris fan at base of 50-centimeter diameter oak (*Quercus* spp.).
8	Pool	268	Right	Post 2, 3 meters toward stream from 35-centimeter diameter oak (*Quercus* spp.), 1.5 meters back from steep bank.
			Left	At oak (*Quercus* spp.) growing in joint on bedrock wall.
9	Pool	268	Right	At base of the larger of two double-trunked trees 1 to 2 meters apart.
			Left	Horizontal rebar in bedrock wall by sycamore (*Platanus occidentalis*). Tree and rebar flagged.
10	Pool	280	Right	Base of 38-centimeter diameter oak (*Quercus* spp.) upstream from small grassy clearing.
			Left	No stake. End point is root of old sycamore (*Platanus occidentalis*) growing in bedrock wall.

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
Ratcliff Ford reach, Jacks Fork, Missouri—cross section numbered from upstream to downstream (fig. 5)—Continued				
11	Pool/glide	283	Right	1.5 meters upstream and toward valley wall from crest-stage gage at base of 10-centimeter diameter oak (*Quercus* spp.).
			Left	At base of bedrock wall behind 2- to 3-meter diameter boulders.
12	Pool/glide	302	Right	4 meters back from steep bank above high-water channel, base of 40-centimeter diameter leaning oak (*Quercus* spp.).
			Left	At base of 60-centimeter diameter tree.
13	Riffle	312	Right	Base of 30-centimeter diameter oak (*Quercus* spp.) with hollow opening on upstream side, 1 meter from steep bank.
			Left	Base of 17-centimeter diameter oak (*Quercus* spp.) on valley wall behind vegetated gravel bar.
14	Race/pool	318	Right	4 meters back from steep bank at base of 25-centimeter diameter oak (*Quercus* spp.), downstream from large fallen oak.
			Left	Base of bedrock wall behind backwater, base of oak (*Quercus* spp.).
15	Glide	310	Right	On post 3, 1.5 to 2 meters upstream and toward stream from marker tree.
			Left	Against bedrock wall behind backwater, base of spice bush (*lindera benzoin*), tag on vine on bedrock wall.
16	Glide	304	Right	At edge of steep bank, base of 25-centimeter diameter oak (*Quercus* spp.) with large scar on valley wall side and old wire wrapped around base.
			Left	Base of 10-centimeter diameter oak (*Quercus* spp.) by bedrock wall on valley side of backwater.
Burnt Cabin reach, Jacks Fork, Missouri—cross sections are numbered from downstream to upstream (fig. 6)				
1B	Pool	137	Right	At base of 0.5-meter diameter oak (*Quercus* spp.), 6 meters from valley wall, and 6 meters downstream from flagged sapling.
			Left	Next to 8-centimeter diameter flagged elm (*Ulmus* sp.), 30 meters in woods from edge of channel.
1	Pool	133	Right	3 meters from valley wall. At base of 3-centimeter diameter oak (*Quercus* spp.). Tree is flagged.
			Left	10 centimeters from 20-centimeter diameter sycamore (*Platanus occidentalis*). Stake buried by organic debris, 5 meters toward stream from post 2.
1A	Pool	305	Right	At base of 8-centimeter diameter tree with flagging. Approximately 3 meters upstream from crest-stage gage, 5 meters toward stream from bank.
			Left	Next to 10-centimeter diameter box elder (*Acer negundo*), 10 meters from edge of bank toward valley wall.

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
Burnt Cabin reach, Jacks Fork, Missouri—cross sections are numbered from downstream to upstream (fig. 6)—Continued				
2	Pool	327	Right	1.5 meters upstream from a small tributary at base of 0.3-meter diameter flagged tree, 0.5 meter downstream from double trunked flagged sapling with vines.
			Left	Extension. 1 meter upstream from flagged dead 5-centimeter diameter tree. 1 meter downstream from flagged walnut, and 2 meters toward valley wall from high-water channel. Only 1 centimeter above ground.
3	Pool/glide	333	Right	At base of 15-centimeter diameter stump with new sprouts coming off of it, 20 meters toward valley wall from gravel bar.
			Left	Extension put in 1–20–94. On a hump in bar behind high-water channel, 2.5 meters downstream and toward valley wall of 8-centimeter diameter flagged box elder (*Acer negundo*), 1.5 meters in front of downed box elder.
4	Riffle	348	Right	Original stake at base of 20-centimeter diameter tree, at base of valley wall. The tree is flagged. Second stake added 5–92 at base of 20-centimeter diameter flagged sycamore (*Platanus occidentalis*) near valley wall, but toward stream from muddy backwater area.
			Left	25 centimeters upstream from small sycamore (*Platanus occidentalis*) that has three to four trunks less than 3-centimeters diameter, 1.5 meters back from bank.
5A	Race	358	Right	At base of 20-centimeter diameter, flagged sycamore (*Platanus occidentalis*), 10-centimeter diameter flagged elm (*Ulmus* sp.) 0.3 meter upstream. On terrace on valley wall side of backwater.
			Left	In middle of gravel patch 3 meters from bottom of flagged hickory (*Carga* sp.), 3 meters toward valley wall from bottom of flagged Ohio buckeye (*Aesculus glabra*). Tree top leans toward stake. 1 meter downstream from downed flagged box elder (*Acer negundo*). 5A is upstream from 5B.
5B	Riffle	23	Right	0.3 meter from 5-centimeter diameter flagged box elder (*Acer negundo*), 50 meters from stream toward valley wall.
			Left	Extension. Stake is buried by approximately 0.5 meter of gravel, 2 meters upstream from downed flagged box elder (*Acer negundo*) and 2 meters back from bank in a gravel ramp. In hole over buried stake is a flagged cobble. 10 meters back up gravel ramp there is a flagged 5-centimeter diameter box elder. This is next extension point, but there is no stake.
6	Pool/glide	334	Right	2 meters upstream from 5B. At base of downed flagged tree, with three flagged 3- to 8-centimeter diameter saplings within 1-meter radius of stake.
			Left	10 centimeters upstream next to 0.3-meter diameter box elder (*Acer negundo*), 2 meters back from edge of bank.

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
Burnt Cabin reach, Jacks Fork, Missouri—cross sections are numbered from downstream to upstream (fig. 6)—Continued				
7	Glide	321	Right	30 meters from stream toward valley wall near base of dead willow (*Salix* spp.). Three willows around it flagged.
			Left	Extension. 15 meters toward valley from two honey locusts (*Gletitoia triacanthos*) 15-centimeter diameter. 1.5 meters downstream from flagged elm (*Ulmus* sp.) 8-centimeter diameter.
8	Glide/pool	308	Right	On upper bar surface on edge of poison ivy (*Rhus radicans*) toward stream and witchhazel (*Hamamelis virginiana*). Witchhazel behind poison ivy, 3 meters downstream and toward valley wall from flagged willow (*Salix* spp.), and 5 meters back from 5-centimeter diameter flagged box elder (*Acer negundo*), which is in a line of vegetation.
			Left	Extension. 25 centimeters upstream from 20-centimeter diameter Ohio buckeye (*Aesculus glabra*), 4 meters back from edge of bank.
9	Pool	292	Right	At base of 10-centimeter diameter flagged sycamore (*Platanus occidentalis*), 100 meters from stream toward valley wall.
			Left	Extension. In high-water channel, 2 meters toward stream from 0.6-meter diameter box elder (*Acer negundo*), 1 meter from downstream bank of high-water channel.
10	Glide/pool	270	Right	At base of 25-centimeter diameter flagged sycamore (*Platanus occidentalis*), 15 meters from stream toward valley wall.
			Left	10 centimeters toward stream side of 20-centimeter diameter flagged cedar (*Juniperus virginiana*). Stake 5 centimeters from bank edge. Extended endpoint back 2 meters from cedar is 46-centimeter diameter flagged elm (*Ulmus* sp.), no stake.
11	Glide/pool	262	Right	At base of 0.5-meter diameter flagged sycamore (*Platanus occidentalis*), 15 meters from stream toward valley wall.
			Left	Extension put in 1-24-94. 25 centimeters in front of 1-meter diameter sycamore (*Platanus occidentalis*) next to a 0.3-meter diameter flagged sycamore. Original stake is near 10-centimeter diameter flagged dead tree with yellow, orange, and pink flagging. Tree has aluminum tag.
12	Glide	066	Right	At base of flagged willow (*Salix* spp.) 10 meters from stream toward valley wall, near downed tree.
			Left	By 10-centimeter diameter Ohio buckeye (*Aesculus glabra*), 1 meter from bank. Extension on downstream side of two, 5-centimeter diameter Ohio buckeyes.
13	Riffle	253	Right	At base of 20-centimeter diameter flagged sycamore (*Platanus occidentalis*), 30 meters from stream toward valley wall.
			Left	10 centimeters downstream from 45-centimeter diameter maple (*Acer* sp.), 1 meter back from bank. Tree has two washers nailed to it and top of stake is painted orange.

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
Burnt Cabin reach, Jacks Fork, Missouri—cross sections are numbered from downstream to upstream (fig. 6)—Continued				
14	Riffle	226	Right	At base of 13-centimeter diameter flagged tree, 10 meters from stream toward valley wall. Intermediate stake.
			Left	1 meter upstream from 10-centimeter diameter dead cedar (*Juniperus virnigiana*) and 1 meter downstream from 20-centimeter diameter maple (*Acer* sp.) on bench.
15	Pool/glide	266	Right	1.5 meters from edge of stream at base of 15-centimeter diameter flagged Sycamore (*Platanus occidentalis*); 3-centimeter sapling 0.3 meter upstream is also flagged.
			Left	Halfway between 13-centimeter diameter mostly dead cedar (*Juniperus virnigiana*) downstream and 20-centimeter diameter maple (*Acer* sp.) upstream, 1 meter from each tree.
16	Pool	263	Right	On top of small bench 1 meter toward stream from bedrock wall. At base of 8-centimeter diameter dogwood (*Cornus* sp.). Many other saplings around.
			Left	On downstream side of 25-centimeter diameter maple (*Acer* sp.), 20-centimeter diameter cedar (*Juniperus virnigiana*), 10-centimeter diameter maple (*Acer* sp.) on bench. Smaller maple flagged. Downstream from 3 trees.
17	Pool	090	Right	3 meters back from 1-meter diameter boulder on edge of stream on stream side of 1-meter wide shelf, between two shrubs. At base of 9-centimeter diameter tree with yellow flagging.
			Left	25 centimeters downstream from 5-centimeter diameter walnut (*Juglans nigra*) on bench.
18	Pool	271	Right	Stake at base of 30-centimeter diameter oak(?), 2 meters downstream and toward channel.
			Left	Stake 1 meter toward valley wall from flagged 5-centimeter diameter tree on bench.
Wilderness Boundary reach, Buffalo River, Arkansas—cross sections are numbered from downstream to upstream (fig. 7)				
1	Glide/pool	310	Right	Next to 5- to 6-centimeter diameter beech (*Fagus grandifolia*), 2 meters from bank.
			Left	On road embankment, 2 meters upstream and toward valley wall from 30-centimeter diameter tree with tag.
2	Glide	313	Right	Stake is fence post 1, 1.5 meters from bank, 20 centimeters from 5-centimeter diameter beech (*Fagus grandifolia*).
			Left	1 meter downstream from 60-centimeter diameter tree.
3	Riffle	318	Right	Extremely steep slope, 60-centimeter diameter oak (*Quercus* spp.).
			Left	Next to 60-centimeter diameter rotting stump, 15 centimeters tall, 10 centimeters in front of 3-centimeter diameter sapling.
4	Riffle	323	Right	Base of 12-centimeter diameter tree.
			Left	Just upstream from 12-centimeter diameter tree, 10 meters from tributary stream.

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
Wilderness Boundary reach, Buffalo River, Arkansas—cross sections are numbered from downstream to upstream (fig. 7)—Continued				
5	Pool	325	Right	Steep, base of 7 centimeter musclewood (*Carpunus caroliniana*).
			Left	Stake in fence line, 2 meters toward valley wall of beaver-girdled 20-centimeter diameter tree.
6	Glide/pool	334	Right	Stake in clump of small trees.
			Left	1 meter upstream from 5-centimeter diameter tree with tag, about 30 meters from bank.
7	Glide	337	Right	Top of mossy boulder behind very large boulder, 30 meters downslope and 3 meters upstream from huge old sycamore (*Platanus occidentalis*).
			Left	0.5 meter downstream from 15 centimeter beech (*Fagus grandifolia*). Transect passes about 10 meters downstream from post 3.
8	Glide	345	Right	Top of boulder berm, base of 7-centimeter diameter ash (*Fraxinus* sp.).
			Left	Top of road berm, base of 7-centimeter diameter tree.
9	Riffle	353	Right	1 meter from 10-centimeter beech (*Fagus grandifolia*), top of boulder berm.
			Left	Beside 7-centimeter beech (*Fagus grandifolia*), 4 meters from high-water channel.
10	Glide/pool	005	Right	Severely flood-damaged musclewood (*Carpinus caroliniana*), top of boulders.
			Left	Fence line, 0.5 meter upstream from a 15-centimeter diameter gnarled tree.
11	Glide/pool	008	Right	3 meters up slope from 17-centimeter diameter musclewood (*Carpinus caroliniana*), in boulders.
			Left	On fence line, base of sapling, tag on 10-centimeter diameter beech (*Fagus grandifolia*), 3 meters downstream from transect.
12	Pool	025	Right	Base of 50-centimeter diameter ash (*Fraxinul* sp.), top of boulder berm.
			Left	In fence line, 2 meters downstream from 15-centimeter diameter tree, 2 meters valley side of 15-centimeter diameter beech (*Fagus grandifolia*).
Blue Hole reach, Buffalo River, Arkansas—cross sections numbered from upstream to downstream (fig. 8)				
1	Glide/pool	195	Right	1 meter back from edge of second terrace, 10 centimeters from 2.5-centimeter diameter musclewood (*Carpinus caroliniana*).
			Left	Base of tall bush downstream from downed cedar (*Juniperus virginiana*) and 4 meters toward valley wall from flood damaged sycamore (*Platanus occidentalis*).

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
Blue Hole reach, Buffalo River, Arkansas—cross sections numbered from upstream to downstream (fig. 8)—Continued				
2	Glide	197	Right	1.5 meters back from bank, 17.5 centimeters of rebar showing, in group of four ashes (*Fraxinus* sp.) on bank edge.
			Left	In middle of cane, upstream and between sycamore (*Platanus occidentalis*) and other tree.
3	Riffle	187	Right	On intermediate terrace 2.5 meters on valley wall side of flood damaged 18-centimeter diameter ash (*Fraxinus* sp.).
			Left	Base of rock outcrop on upstream edge of alluvial fan, in cane.
4	Riffle/race	211	Right	1 meter toward valley wall from large terrace edge, in cane behind row of ashes (*Fraxinus* sp.).
			Left	Base of 5-centimeter diameter tree on second bedrock shelf downstream from alluvial fan.
5	Pool	248	Right	1.5 meters from intermediate terrace edge, 0.5 meter toward stream from 7-centimeter diameter musclewood (*Carpinus caroliniana*).
			Left	Base of beaver damaged bush.
6	Glide/pool	257	Right	3 meters downstream from 30-centimeter diameter sycamore (*Platanus occidentalis*), immediately downstream from small gully on embankment.
			Left	Base of flood-damaged sycamore (*Platanus occidentalis*).
7	Glide	269	Right	1 meter back from field surface, 1 meter downstream from 38-centimeter diameter ash (*Fraxinus* sp.).
			Left	Base of 2.5-centimeter diameter musclewood (*Carpinus caroliniana*) on depositional bench.
8	Glide/pool	275	Right	Base of 50-centimeter diameter ash (*Fraxinus* sp.), immediately downstream from gully.
			Left	Second bedrock shelf up, downstream side of base of falling rock slab.
9	Glide/pool	275	Right	Base of 23-centimeter diameter tree near edge of field surface downstream from parking area.
			Left	First bench up, base of 2.5-centimeter diameter redbud (*Cercis canadensis*).
10	Glide/pool	275	Right	Base of dead standing 35-centimeter diameter tree on small ridge behind cane.
			Left	Base of 4-centimeter diameter redbud (*Cercis canadensis*) on first bench up.
11	Riffle	281	Right	3 meters valley side of 1.5-meter diameter sycamore (*Platanus occidentalis*).
			Left	Base of 5.5-centimeter diameter cedar (*Juniperus virginiana*) in cane.
12	Race/riffle	283	Right	1.5 meters back from field surface, 2 meters downstream from J-shaped ash (*Fraxinus* sp.) above dump.
			Left	Base of 7-centimeter diameter sapling.

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
		Blue Hole reach, Buffalo River, Arkansas—cross sections numbered from upstream to downstream (fig. 8)—Continued		
13	Pool/glide	286	Right	2 meters back from field surface edge, 3 meters upstream from large double-trunked ash (*Fraxinus* sp.).
			Left	Base of 20-centimeter diameter elm (*Ulmus* sp.).
14	Pool/glide	278	Right	Middle of glade surrounded by 1- to 7-centimeter diameter saplings, 20 meters back from clump of six 10-centimeter diameter curved trees.
			Left	Base of 12-centimeter diameter tree.
		Shine-eye reach, Buffalo River, Arkansas—cross sections numbered from downstream to upstream (fig. 9)		
1	Pool	182	Right	In bedrock wall near rock shelter at base of a cedar (*Juniperus virginiana*).
			Left	Immediately upstream from a 45-centimeter diameter snag in the cane 40 meters downstream from parking area.
2	Pool	180	Right	A bolt and washer pounded horizontally into a crack in the bedrock wall below the overhanging shelf.
			Left	At the base of a 0.75-meter diameter tree in the cane.
3	Pool/glide	185	Right	In small rock overhang at the base of a shrub.
			Left	On sand bench in flood-damaged trees approximaely 50 meters from parking area.
4	Riffle	222	Right	At base of 2.5-centimeter diameter sapling.
			Left	Immediately upstream from the upstream trail from parking area to gravel bar, next to 3-centimeter diameter sapling.
5	Riffle	242	Right	On slope 15 meters downstream from the bluff that overlooks the riffle.
			Left	Same as SH4 left bank.
6	Pool/glide	255	Right	Bolt just above UTAH 88 graffiti, 15 meters upstream from small cave; small tree 2 meters toward stream from bolt is flagged.
			Left	Base of 2.5-centimeter diameter J-shaped sapling, 25 meters toward stream from last curve in road before parking area.
7	Riffle	265	Right	Base of vertical bedrock wall 40 centimeters upstream from a 5-centimeter diameter flagged dogwood (*Cornus* sp.).
			Left	Base of sapling 3 meters downstream and toward stream from 2.5 meter tall cedar (*Juniperus virginiana*).

Table 3. End-point descriptions for cross sections—Continued

Cross section	Type	Azimuth	Bank	Description
Shine-eye reach, Buffalo River, Arkansas—cross sections numbered from downstream to upstream (fig. 9)—Continued				
8	Glide	285	Right	Base of 7-centimeter diameter sapling.
			Left	3 meters downstream from 10-centimeter diameter flagged tree, 4 meters upstream from three 30- to 38-centimeter diameter trees.
9	Pool/glide	285	Right	Top of second bench up at base of 2.5-centimeter diameter sapling, behind two large boulders 5 meters upstream from staff gage.
			Left	4 meters into cane from post 4, in middle of three 5-centimeter diameter ashes (*Fraxinus* sp.).
10	Pool	308	Right	Top of second bench up, next to vertical bedrock wall.
			Left	3 meters toward stream from redbud (*Cercis canadensis*) in the cane on second bench.
11	Pool	320	Right	Horizontal stake on second bedrock shelf under overhang, 4 meters upstream from small cedar (*Juniperus virginiana*).
			Left	Near 30-centimeter diameter leaning tree, on the stream side of 20-centimeter diameter downed tree with adventitious sprouts.
12	Race	333	Right	Base of 2.5-centimeter diameter moss covered tree on first bedrock bench. Transect is upstream from 20-centimeter diameter elm (*Ulmus* sp.).
			Left	Base of 7-centimeter diameter tree on bench, 4 meters downstream from large clump of 5- to 10-centimeter diameter trees.
13	Riffle	346	Right	20 centimeters downstream from 5-centimeter diameter tree. Transect is 2 meters downstream from 35-centimeter diameter elm (*Ulmus* sp.) on a colluvial bench.
			Left	2 meters downstream from a 30-centimeter diameter tree.
14	Glide	009	Right	On colluvial slope at base of mossy boulder 1 meter downstream from 2.5-centimeter diameter tree, 5 meters downstream from a leaning sycamore (*Platanus occidentalis*).
			Left	Next to 50-centimeter diameter flood-damaged sycamore (*Platanus occidentalis*).
15	Glide/pool	019	Right	Next to bedrock wall on top of bench 3 meters upstream from tributary junction.
			Left	2 meters downstream from a 10-centimeter diameter tree in cane halfway up bank. Flagged tree supports a grape vine (*Vitis* spp.).

Table 6. Channel erosion and deposition data for March 1990 through March 1995

[m^2, square meter; km^2, square kilometer; --, no data]

Cross section	May through June 1991[1]		Nov. 1991 through Mar. 1992[1]		May through June 1992[1]		Nov. 1992 through Mar. 1993[1]		Nov. 1993 through Mar. 1994[1]		Nov. 1994 through Mar. 1995[1]		Net	
	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)
Hickory Point reach, Little Piney Creek, Missouri (drainage area 380 km^2)														
1	11.89	3.26	0.48	5.16	1.62	6.03	5.30	6.97	8.37	6.95	5.71	8.75	5.20	8.79
2	6.18	11.35	6.20	2.62	2.71	1.31	.87	13.65	12.20	4.46	2.96	6.99	7.34	16.59
3A	--	--	5.50	7.11	1.05	1.74	6.88	6.43	10.70	7.00	11.01	8.79	28.25	24.18
4	3.46	10.46	2.23	1.89	3.19	.39	3.01	1.43	9.87	4.93	6.21	5.31	17.36	13.82
5	--	--	7.67	14.42	2.26	4.21	17.71	9.96	13.78	16.63	6.58	6.04	20.90	24.15
6	--	--	3.63	4.19	3.39	2.26	3.33	5.93	8.62	4.67	2.32	5.54	7.54	8.84
7	5.90	8.07	7.77	2.06	3.34	4.42	3.59	7.42	6.18	6.30	4.53	3.76	6.94	10.56
8	--	--	--	--	2.15	1.59	1.45	3.67	3.69	3.97	6.34	10.26	2.66	8.53
9	7.45	13.49	6.02	1.45	.91	2.67	2.17	2.86	5.57	7.92	3.95	8.71	6.77	17.80
10	--	--	--	--	.95	3.65	3.66	1.68	5.43	4.17	.78	7.70	5.06	11.44
11	--	--	.77	4.83	1.98	2.20	1.53	4.01	9.60	9.62	2.97	4.03	2.82	10.65
12	3.55	.48	2.43	3.30	1.71	.91	3.92	2.30	1.66	4.96	4.93	1.31	6.48	1.55

Table 6. Channel erosion and deposition data for March 1990 through March 1995—Continued

Cross section	May through June 1991[1]		Nov. 1991 through Mar. 1992[1]		May through June 1992[1]		Nov. 1992 through Mar. 1993[1]		Nov. 1993 through Mar. 1994[1]		Nov. 1994 through Mar. 1995[1]		Net	
	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)
Fox Farm reach, Jacks Fork, Missouri (drainage area 87 km^2)														
1	--	--	--	--	1.45	2.15	3.94	2.88	7.73	4.44	4.00	6.72	5.06	4.14
2	--	--	--	--	2.53	1.11	.98	3.57	3.18	5.31	4.13	2.90	2.61	4.70
3	--	--	--	--	2.10	1.22	4.81	1.08	2.25	3.78	2.48	2.27	6.50	3.20
4	--	--	--	--	1.72	1.11	1.03	2.84	2.26	2.49	2.98	3.54	2.58	4.56
5	--	--	--	--	3.62	.86	1.89	2.40	3.46	2.05	2.06	2.87	4.89	2.04
6	--	--	--	--	2.55	.70	2.46	3.02	1.87	6.75	3.60	3.21	3.63	6.83
7	--	--	--	--	3.54	.30	.49	1.94	1.28	1.28	.50	1.56	1.88	1.17
8	--	--	--	--	4.28	.10	1.12	2.83	.75	1.22	1.41	2.58	1.71	.89
9	--	--	--	--	.50	1.13	3.71	.16	2.15	2.04	3.19	2.59	4.03	.41
10	--	--	--	--	.73	1.22	1.41	.27	1.61	.40	.45	1.98	2.12	1.79
11	--	--	--	--	.37	2.43	2.13	.37	.47	.82	.02	4.49	.03	5.15
12	--	--	--	--	.29	2.97	3.93	.05	.17	1.47	.86	3.83	1.55	4.61
13	--	--	--	--	.15	3.77	2.96	.49	.10	1.97	.54	2.48	.56	5.51

Table 6. Channel erosion and deposition data for March 1990 through March 1995—Continued

Cross section	May through June 1991[1]		Nov. 1991 through Mar. 1992[1]		May through June 1992[1]		Nov. 1992 through Mar. 1993[1]		Nov. 1993 through Mar. 1994[1]		Nov. 1994 through Mar. 1995[1]		Net	
	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)
							Ratcliff Ford reach, Jacks Fork, Missouri (drainage area 422 km^2)							
1	--	--	--	--	0.96	4.44	6.52	3.83	19.38	8.96	1.54	13.06	7.64	9.54
2	--	--	--	--	1.24	2.45	5.39	1.27	12.34	7.79	1.84	11.61	4.28	6.58
3	--	--	--	--	1.60	1.45	1.15	12.30	5.14	3.47	2.86	5.20	2.73	14.39
4	--	--	--	--	1.73	1.22	2.51	.95	3.77	4.25	2.80	4.80	2.63	3.04
5	--	--	--	--	.35	2.26	4.10	.40	4.35	.83	.40	8.43	.36	3.09
6	--	--	--	--	1.90	1.10	2.85	1.03	12.53	1.68	.87	15.49	1.70	2.85
7	--	--	--	--	--	--	1.89	19.12	26.78	4.28	27.94	10.81	28.02	5.62
8	--	--	--	--	15.45	.71	.30	19.19	10.97	1.86	24.33	3.49	31.50	5.70
9	--	--	--	--	2.14	17.51	9.67	10.95	4.01	17.65	18.55	2.74	5.64	20.12
10	--	--	--	--	1.11	8.07	.99	11.58	8.19	7.15	7.74	5.19	3.77	17.71
11	--	--	--	--	1.70	5.38	11.52	3.23	11.26	12.57	5.32	9.09	6.61	7.08
12	--	--	--	--	2.55	4.76	9.39	2.17	17.38	3.21	.34	17.20	8.80	6.48
13	--	--	--	--	3.58	2.63	3.40	9.76	13.43	1.57	2.51	11.70	8.40	11.13
14	--	--	--	--	12.17	2.32	2.40	8.03	5.31	3.73	8.11	3.90	17.55	7.54
15	--	--	--	--	9.34	3.13	1.24	7.17	4.43	5.67	1.60	5.89	2.84	8.09
16	--	--	--	--	2.88	.87	1.13	3.39	12.90	1.40	2.22	5.03	10.98	2.54

Table 6. Channel erosion and deposition data for March 1990 through March 1995—Continued

Cross section	May through June 1991[1]		Nov. 1991 through Mar. 1992[1]		May through June 1992[1]		Nov. 1992 through Mar. 1993[1]		Nov. 1993 through Mar. 1994[1]		Nov. 1994 through Mar. 1995[1]		Net	
	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)
Burnt Cabin reach, Jacks Fork, Missouri (drainage area 789 km^2)														
1	--	--	2.55	2.98	2.06	5.09	0.99	15.35	4.21	6.43	24.75	1.76	6.03	3.11
1A	--	--	--	--	1.24	2.47	2.71	4.82	1.82	15.34	17.69	4.35	1.36	4.88
2	--	--	4.83	10.49	3.07	4.37	.23	7.88	5.14	14.38	5.83	3.79	2.90	24.70
3	--	--	2.21	13.26	3.76	5.58	5.21	7.90	11.90	17.15	3.70	15.76	2.74	35.62
4	--	--	9.14	6.80	2.25	8.01	7.42	10.12	14.29	31.45	12.87	20.34	14.88	45.59
5A	--	--	4.29	9.51	13.12	4.42	7.20	16.24	27.50	24.74	12.08	18.58	39.61	54.98
5B	--	--	4.25	12.58	14.48	11.39	22.84	18.84	23.69	24.08	8.71	13.82	52.87	59.57
6	--	--	2.97	3.12	5.86	6.11	13.75	20.48	10.20	17.11	4.10	11.47	19.89	41.30
7	--	--	2.33	5.55	8.67	2.49	12.51	25.64	21.33	21.76	5.73	17.05	32.71	54.61
8	--	--	1.95	5.38	6.88	6.60	4.71	13.33	62.25	24.55	3.13	8.21	67.70	46.85
9	--	--	10.56	7.66	5.99	5.41	10.64	15.37	30.77	18.99	14.96	9.07	44.83	27.97
10	--	--	5.88	5.35	7.05	2.48	1.04	15.96	32.16	3.69	1.81	10.85	21.16	11.55
11	--	--	1.66	2.63	.52	3.74	16.75	1.29	16.82	6.09	1.22	16.99	13.73	7.49
12	--	--	.62	3.08	3.34	2.18	13.31	3.53	7.42	4.68	.10	9.82	7.23	5.74
13	--	--	1.92	2.02	3.75	2.64	11.22	1.12	4.96	13.84	2.08	11.81	2.50	10.01
14	--	--	2.68	4.71	5.57	1.76	2.81	5.93	.84	24.12	3.36	4.96	2.82	29.04
15	--	--	4.23	1.90	6.77	2.50	1.60	10.92	.43	50.95	34.12	.29	1.57	20.98
16	--	--	2.66	2.87	1.89	6.16	2.26	6.79	.44	18.14	5.46	7.84	.32	29.42
17	--	--	--	--	3.89	2.73	.33	6.20	1.21	10.47	4.72	5.65	1.26	16.15

Table 6. Channel erosion and deposition data for March 1990 through March 1995—Continued

Cross section	May through June 1991[1]		Nov. 1991 through Mar. 1992[1]		May through June 1992[1]		Nov. 1992 through Mar. 1993[1]		Nov. 1993 through Mar. 1994[1]		Nov. 1994 through Mar. 1995[1]		Net	
	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)
Wilderness Boundary reach, Buffalo River, Arkansas (drainage area 150 km^2)														
1	--	--	--	--	--	--	1.35	1.40	2.13	0.77	0.72	2.89	1.77	2.62
2	--	--	--	--	--	--	.66	3.30	2.42	.63	1.94	3.34	1.16	3.40
3	--	--	--	--	--	--	3.57	.15	.67	4.79	1.32	1.95	1.27	2.59
4	--	--	--	--	--	--	3.42	.32	.42	2.89	.98	.66	1.66	.73
5	--	--	--	--	--	--	3.33	1.61	1.68	2.79	1.45	1.81	2.65	2.41
6	--	--	--	--	--	--	.89	3.19	1.82	2.19	1.88	1.39	.83	3.01
7	--	--	--	--	--	--	.72	1.30	1.43	1.85	1.56	2.38	.40	2.22
8	--	--	--	--	--	--	2.10	2.21	.30	4.15	1.68	1.99	.78	5.06
9	--	--	--	--	--	--	2.12	1.37	1.20	1.64	.82	2.06	1.63	2.55
10	--	--	--	--	--	--	1.33	1.13	1.31	2.71	2.11	.96	1.29	1.36
11	--	--	--	--	--	--	2.17	2.08	1.82	4.58	5.14	3.51	2.06	3.11
12	--	--	--	--	--	--	8.20	.65	1.23	5.33	2.18	2.90	4.01	1.28

Table 6. Channel erosion and deposition data for March 1990 through March 1995—Continued

Cross section	May through June 1991[1]		Nov. 1991 through Mar. 1992[1]		May through June 1992[1]		Nov. 1992 through Mar. 1993[1]		Nov. 1993 through Mar. 1994[1]		Nov. 1994 through Mar. 1995[1]		Net	
	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)
Blue Hole reach, Buffalo River, Arkansas (drainage area 1,020 km^2)														
1	--	--	--	--	--	--	2.67	0.48	2.35	4.60	1.82	4.56	3.15	5.96
2	--	--	--	--	--	--	.66	1.74	8.91	.89	1.14	2.17	7.16	1.26
3	--	--	--	--	--	--	2.41	2.39	2.33	5.40	1.86	3.96	2.24	7.41
4	--	--	--	--	--	--	2.65	6.03	2.71	7.21	6.77	1.86	3.36	6.20
5	--	--	--	--	--	--	3.91	2.19	.86	13.80	9.92	.71	5.78	7.81
6	--	--	--	--	--	--	2.63	1.01	3.14	3.53	2.18	2.51	3.47	2.59
7	--	--	--	--	--	--	3.69	2.83	5.00	1.90	.12	9.59	1.51	7.03
8	--	--	--	--	--	--	2.79	3.79	7.10	3.26	4.60	4.31	5.44	2.32
9	--	--	--	--	--	--	1.46	1.41	3.12	6.62	2.83	2.50	3.78	6.90
10	--	--	--	--	--	--	3.41	7.32	3.99	6.18	3.95	4.73	2.00	8.88
11	--	--	--	--	--	--	1.98	4.71	5.61	2.89	5.27	2.56	8.41	5.23
12	--	--	--	--	--	--	1.84	4.57	5.20	4.01	5.29	4.46	6.38	7.09
13	--	--	--	--	--	--	.56	10.22	5.37	3.65	3.61	1.14	1.55	7.03
14	--	--	--	--	--	--	6.36	2.38	2.62	6.22	1.67	5.15	2.32	5.43

Table 6. Channel erosion and deposition data for March 1990 through March 1995—Continued

Cross section	May through June 1991[1]		Nov. 1991 through Mar. 1992[1]		May through June 1992[1]		Nov. 1992 through Mar. 1993[1]		Nov. 1993 through Mar. 1994[1]		Nov. 1994 through Mar. 1995[1]		Net	
	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)	Deposition (m^2)	Erosion (m^2)
Shine-eye reach, Buffalo River, Arkansas (drainage area 2,150 km^2)														
1	--	--	--	--	--	--	11.96	6.40	17.10	17.53	14.99	19.15	20.97	20.02
2	--	--	--	--	--	--	7.38	8.16	7.88	22.77	5.86	32.33	8.17	50.31
3	--	--	--	--	--	--	9.72	21.63	2.58	35.04	10.08	21.30	2.66	58.20
4	--	--	--	--	--	--	3.30	9.42	9.11	9.46	14.80	5.06	15.96	12.68
5	--	--	--	--	--	--	3.81	5.98	10.95	9.06	10.35	6.90	17.26	14.19
6	--	--	--	--	--	--	7.03	3.70	7.91	7.57	5.38	9.91	13.84	14.70
7	--	--	--	--	--	--	13.79	6.51	3.29	19.95	5.42	10.83	12.98	27.79
8	--	--	--	--	--	--	8.93	5.81	1.12	24.20	5.52	8.65	4.21	27.15
9	--	--	--	--	--	--	1.65	5.73	7.20	8.08	2.15	10.92	1.78	15.51
10	--	--	--	--	--	--	2.55	1.83	6.20	4.69	2.56	14.96	3.64	13.81
11	--	--	--	--	--	--	4.95	3.72	15.52	2.28	5.62	9.13	13.83	2.87
12	--	--	--	--	--	--	--	--	12.75	5.67	5.49	7.26	12.56	7.21
13	--	--	--	--	--	--	--	--	12.23	9.48	7.10	9.96	15.85	16.08
14	--	--	--	--	--	--	--	--	6.26	16.82	13.72	4.81	15.16	16.82
15	--	--	--	--	--	--	--	--	10.30	14.38	8.13	14.20	6.08	16.40

[1]Erosion and deposition are calculated using the previous cross section survey and the survey that occurred between the dates listed.

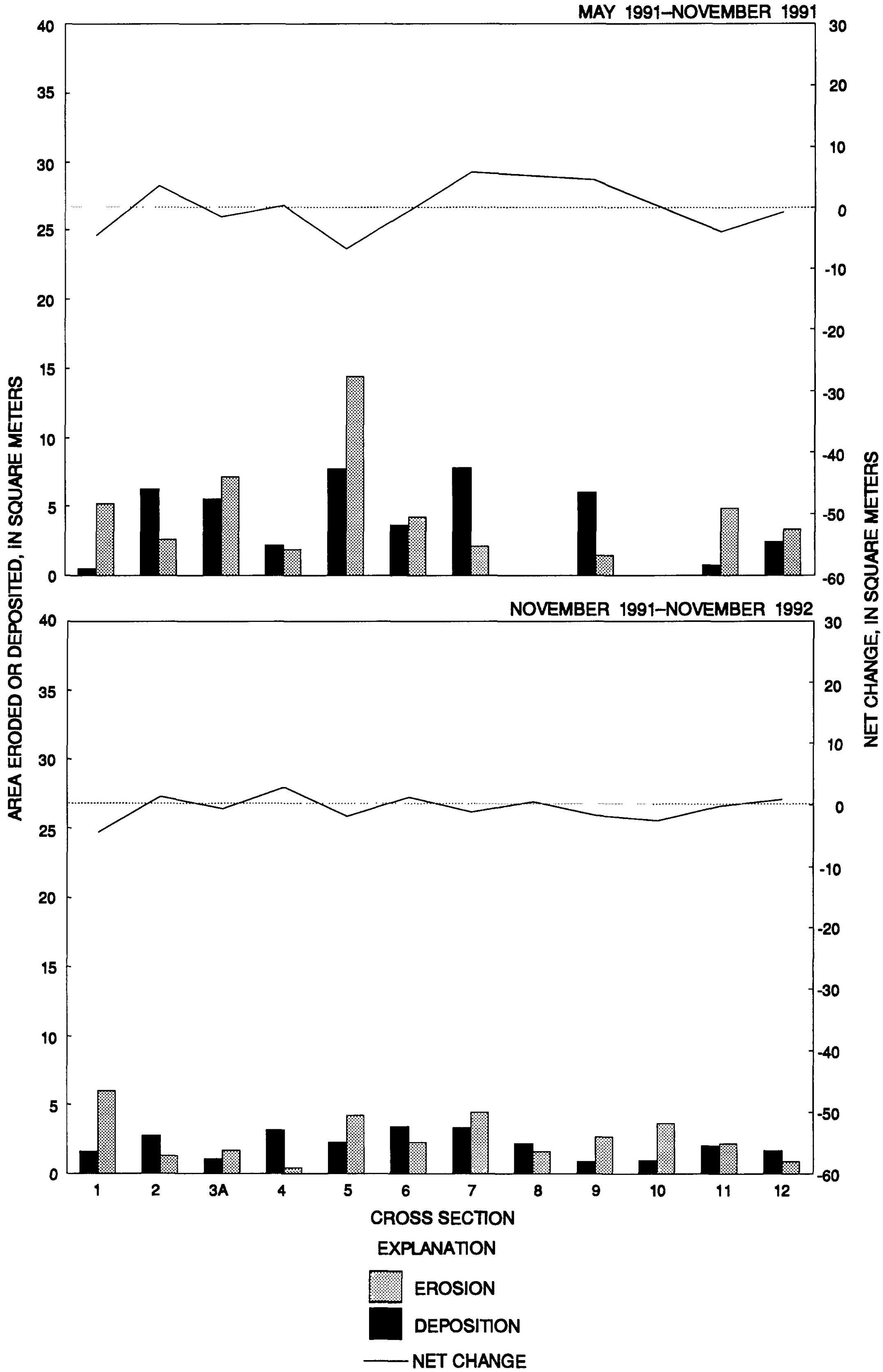


Figure 13. Area eroded, area deposited, and net channel change for each cross section at the Hickory Point reach, Little Piney Creek, Missouri. Dominant hydraulic habitat units of cross sections—1, 5, and 8 alluvial riffle; 2 and 10 race; 3A and 6 glide/lateral pool; 4, 7, and 12 glide; 9 race/alluvial riffle; and 11 glide/race/alluvial riffle.

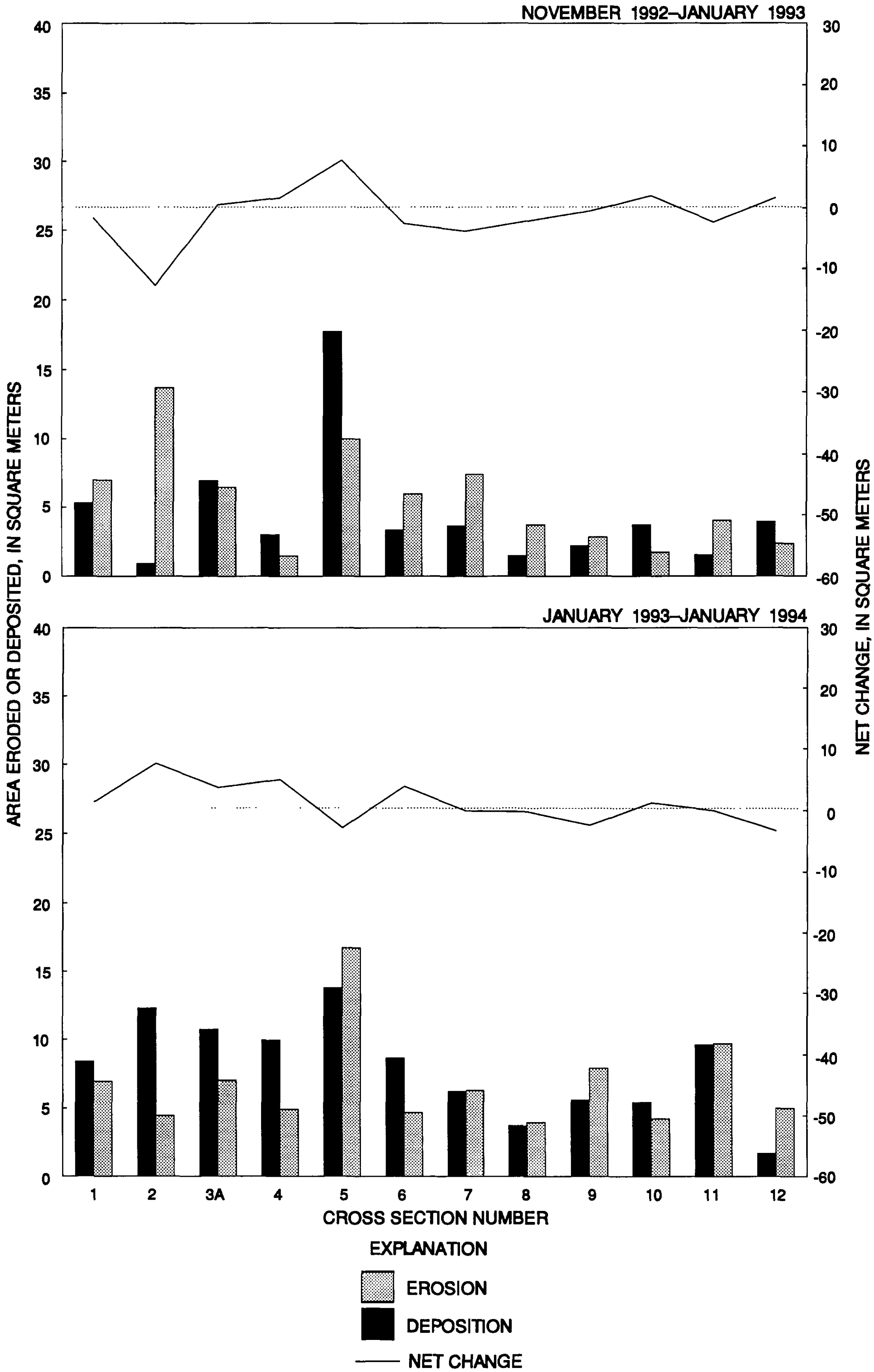


Figure 13. Area eroded, area deposited, and net channel change for each cross section at the Hickory Point reach, Little Piney Creek, Missouri. Dominant hydraulic habitat units of cross sections—1, 5, and 8 alluvial riffle; 2 and 10 race; 3A and 6 glide/lateral pool; 4, 7, and 12 glide; 9 race/alluvial riffle; and 11 glide/race/alluvial riffle—Continued.

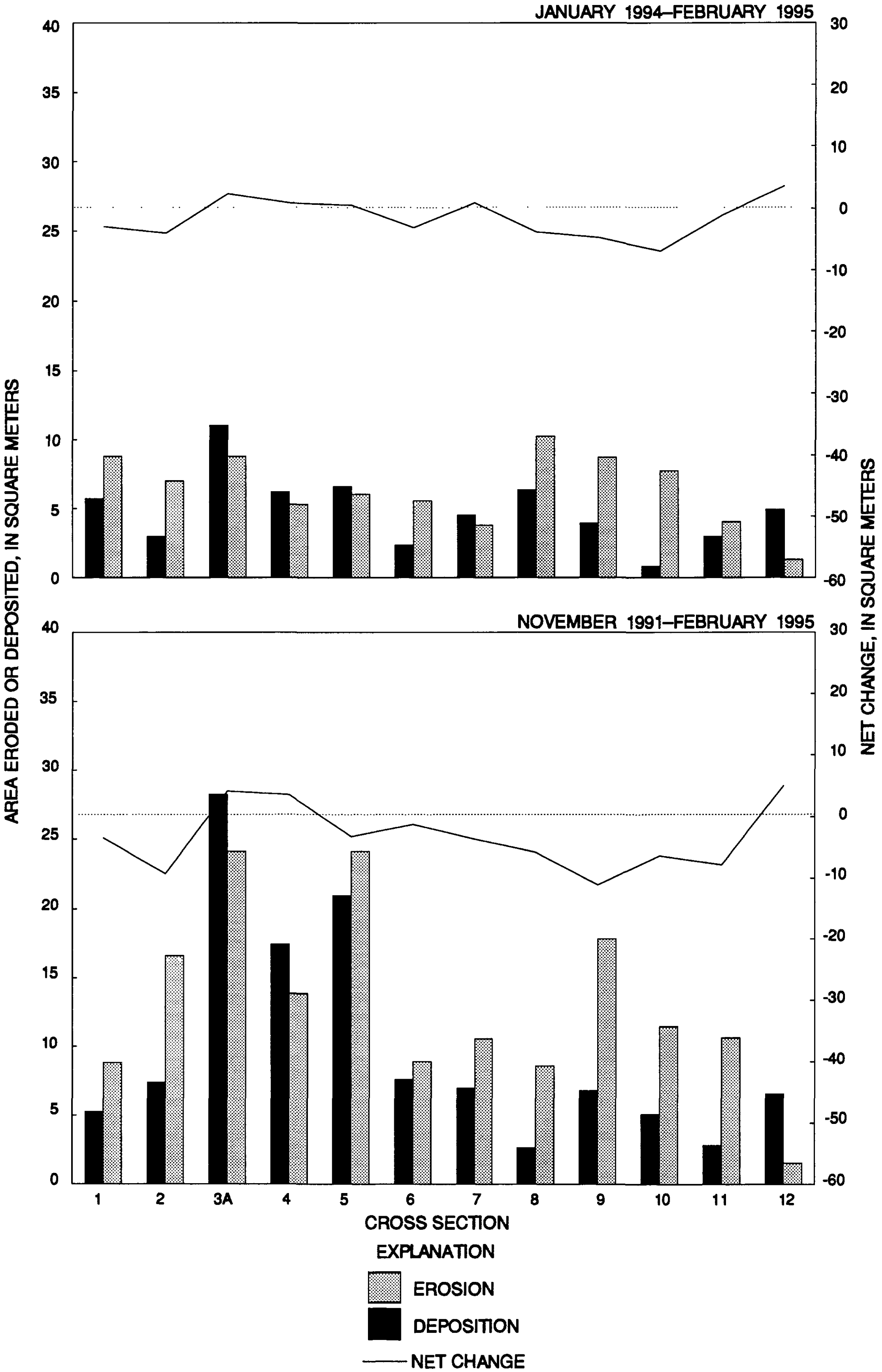


Figure 13. Area eroded, area deposited, and net channel change for each cross section at the Hickory Point reach, Little Piney Creek, Missouri. Dominant hydraulic habitat units of cross sections—1, 5, and 8 alluvial riffle; 2 and 10 race; 3A and 6 glide/lateral pool; 4, 7, and 12 glide; 9 race/alluvial riffle; and 11 glide/race/alluvial riffle—Continued.

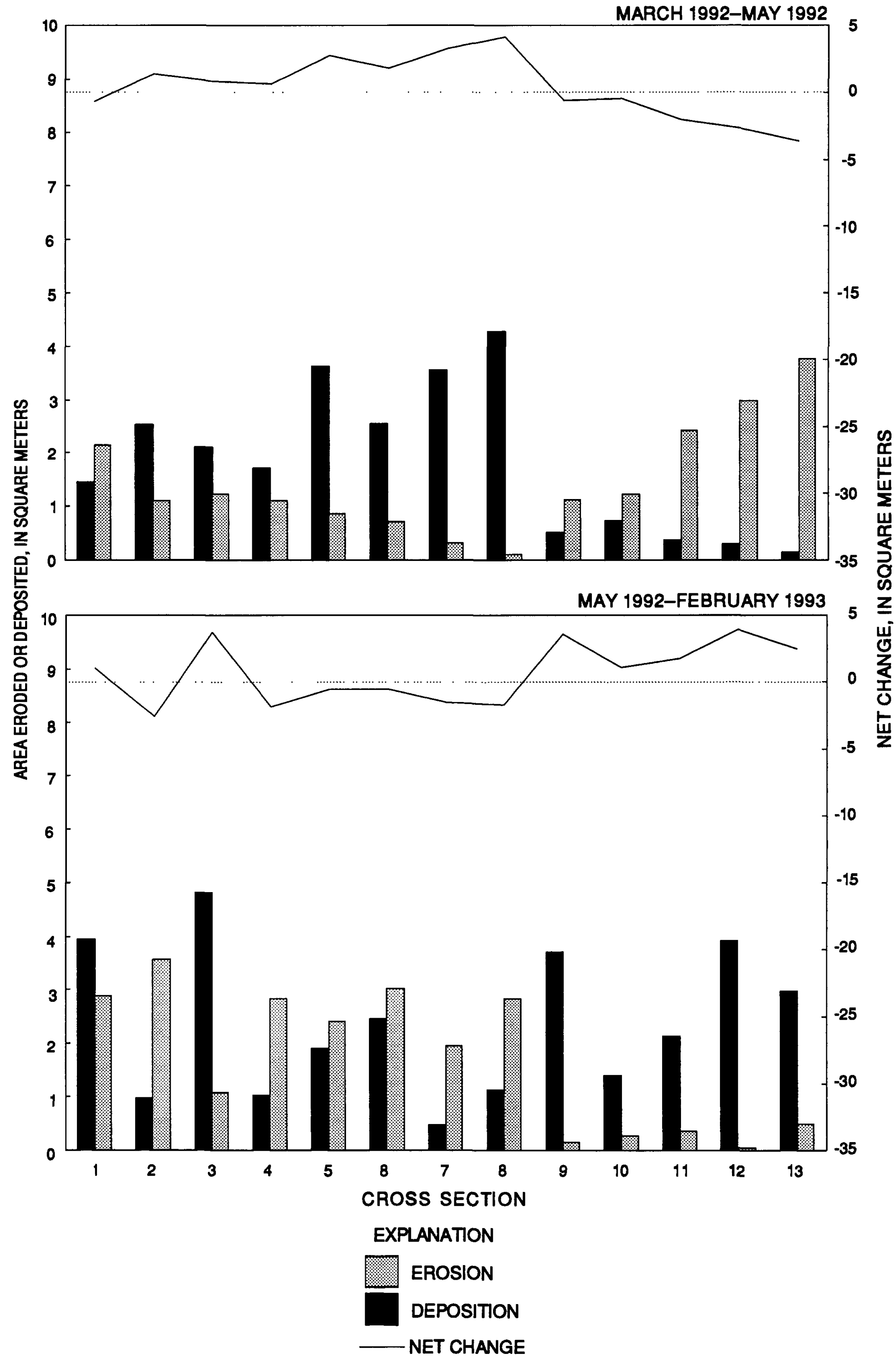


Figure 14. Area eroded, area deposited, and net channel change for each cross section at the Fox Farm reach, Jacks Fork, Missouri. Dominant hydraulic habitat units of cross sections—1, 5, and 6 glide; 2 and 9 glide/lateral pool; 3 and 10 alluvial riffle; 4 and 8 race; 7 alluvial riffle/race; 11 glide/race; 12 and 13 glide/bluff pool.

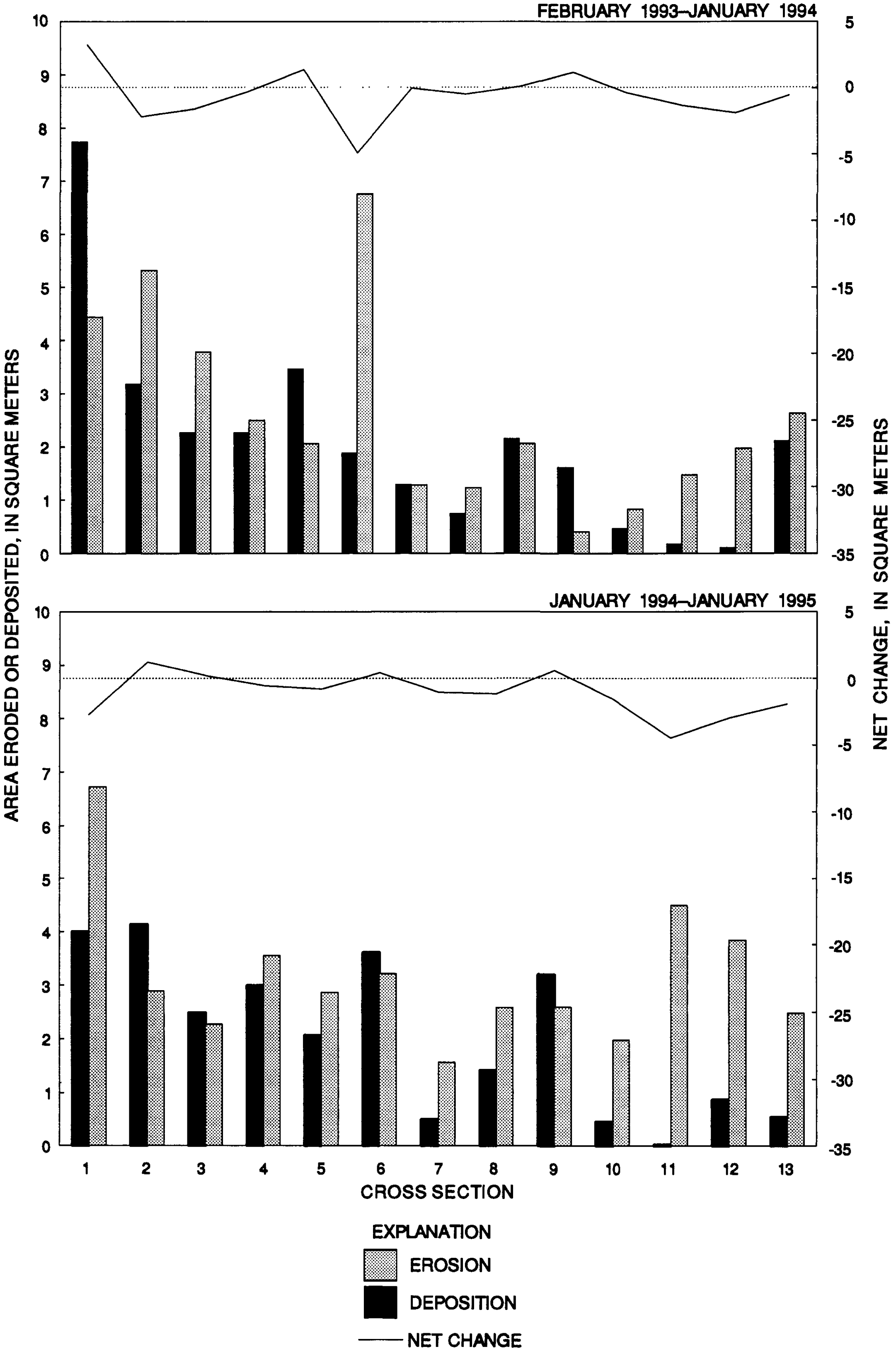


Figure 14. Area eroded, area deposited, and net channel change for each cross section at the Fox Farm reach, Jacks Fork, Missouri. Dominant hydraulic habitat units of cross sections—1, 5, and 6 glide; 2 and 9 glide/lateral pool; 3 and 10 alluvial riffle; 4 and 8 race; 7 alluvial riffle/race; 11 glide/race; 12 and 13 glide/bluff pool—Continued.

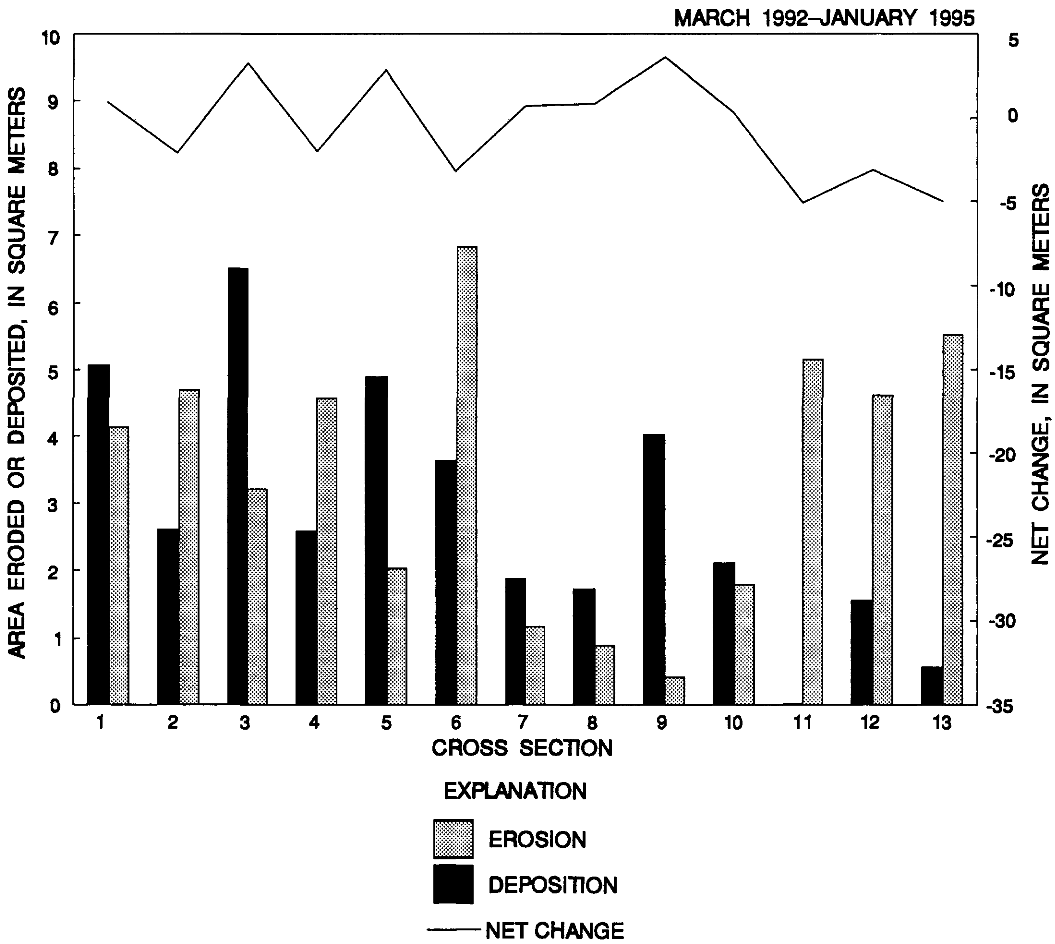


Figure 14. Area eroded, area deposited, and net channel change for each cross section at the Fox Farm reach, Jacks Fork, Missouri. Dominant hydraulic habitat units of cross sections—1, 5, and 6 glide; 2 and 9 glide/lateral pool; 3 and 10 alluvial riffle; 4 and 8 race; 7 alluvial riffle/race; 11 glide/race; 12 and 13 glide/bluff pool—Continued.

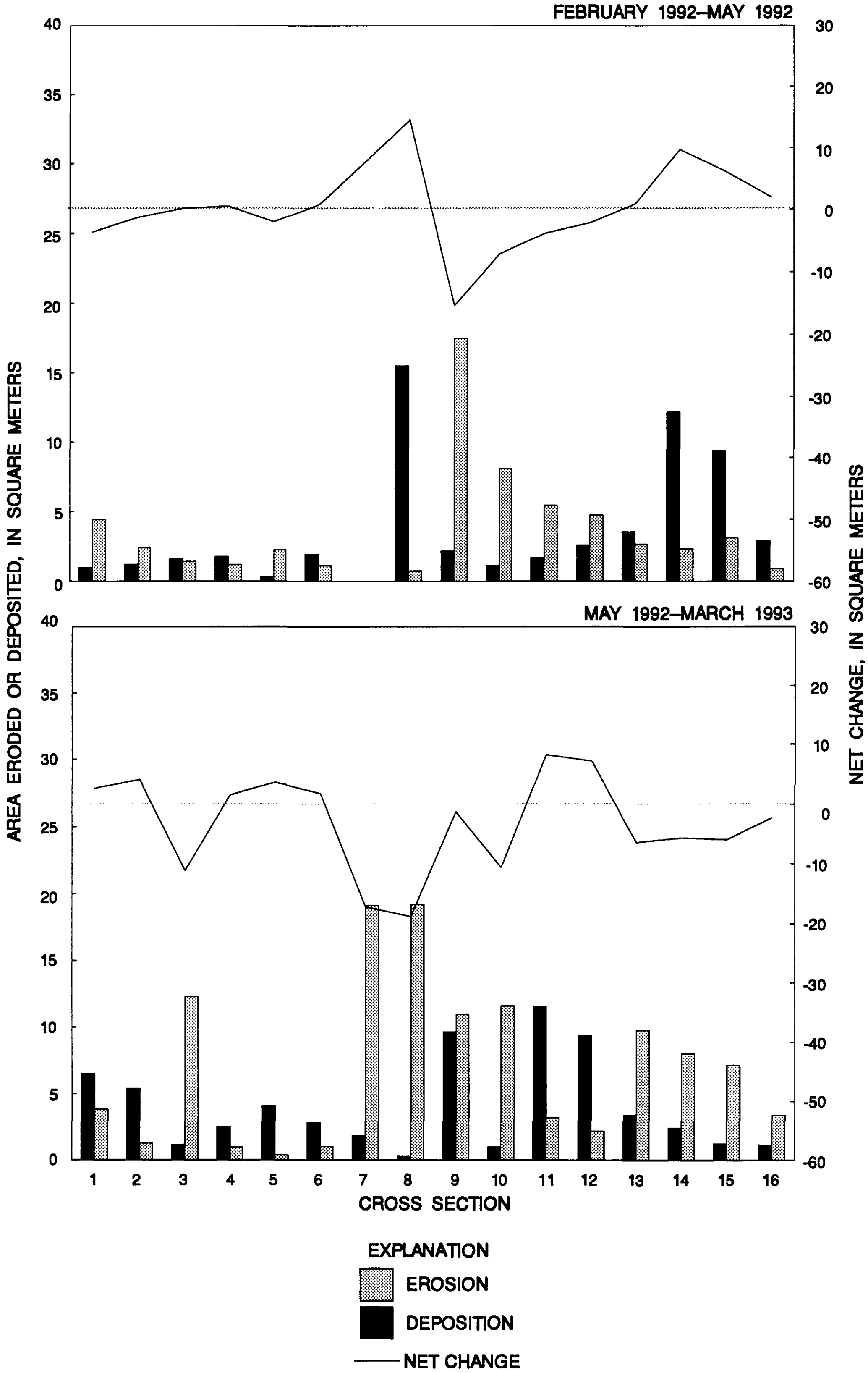


Figure 15. Area eroded, area deposited, and net channel change for each cross section at the Ratcliff Ford reach, Jacks Fork, Missouri. Dominant hydraulic habitat units of cross sections—1, 3, 6, 15, and 16 glide; 2, 7, 8, 9, and 10 bluff pool; 4 and 5 tributary riffle; 11 and 12 bluff pool/glide; 13 alluvial riffle; and 14 race/lateral pool.

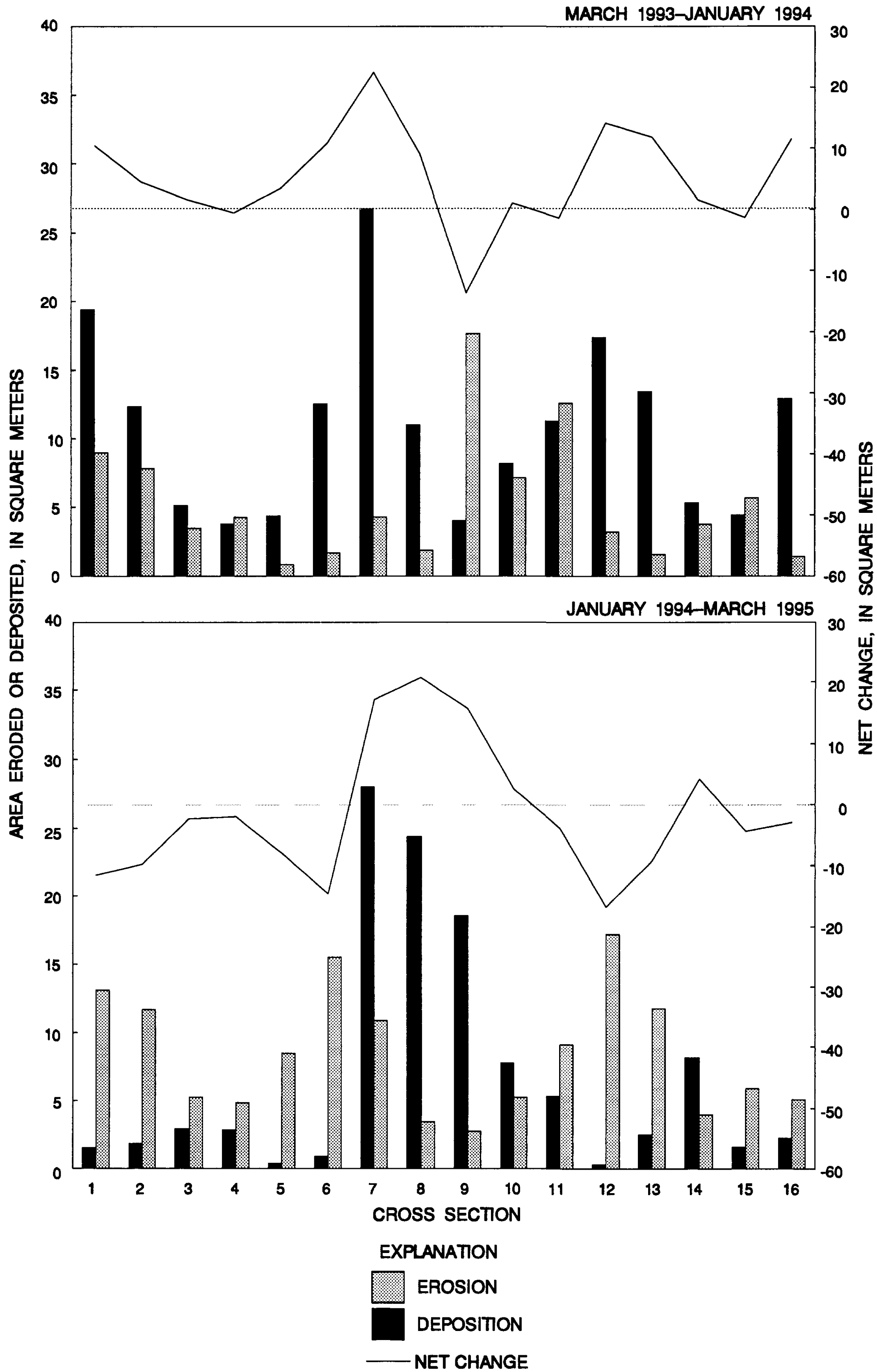


Figure 15. Area eroded, area deposited, and net channel change for each cross section at the Ratcliff Ford reach, Jacks Fork, Missouri. Dominant hydraulic habitat units of cross sections—1, 3, 6, 15, and 16 glide; 2, 7, 8, 9, and 10 bluff pool; 4 and 5 tributary riffle; 11 and 12 bluff pool/glide; 13 alluvial riffle; and 14 race/lateral pool—Continued.

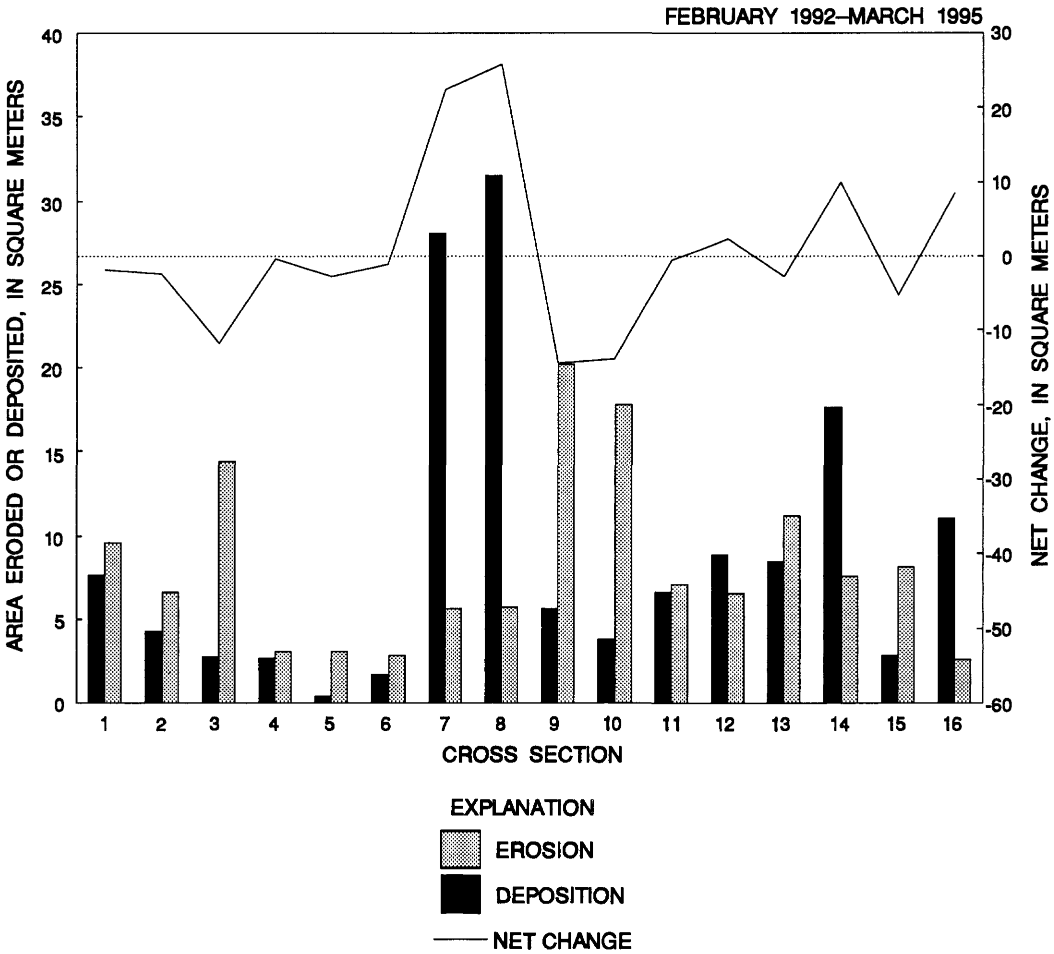


Figure 15. Area eroded, area deposited, and net channel change for each cross section at the Ratcliff Ford reach, Jacks Fork, Missouri. Dominant hydraulic habitat units of cross sections—1, 3, 6, 15, and 16 glide; 2, 7, 8, 9, and 10 bluff pool; 4 and 5 tributary riffle; 11 and 12 bluff pool/glide; 13 alluvial riffle; and 14 race/lateral pool—Continued.

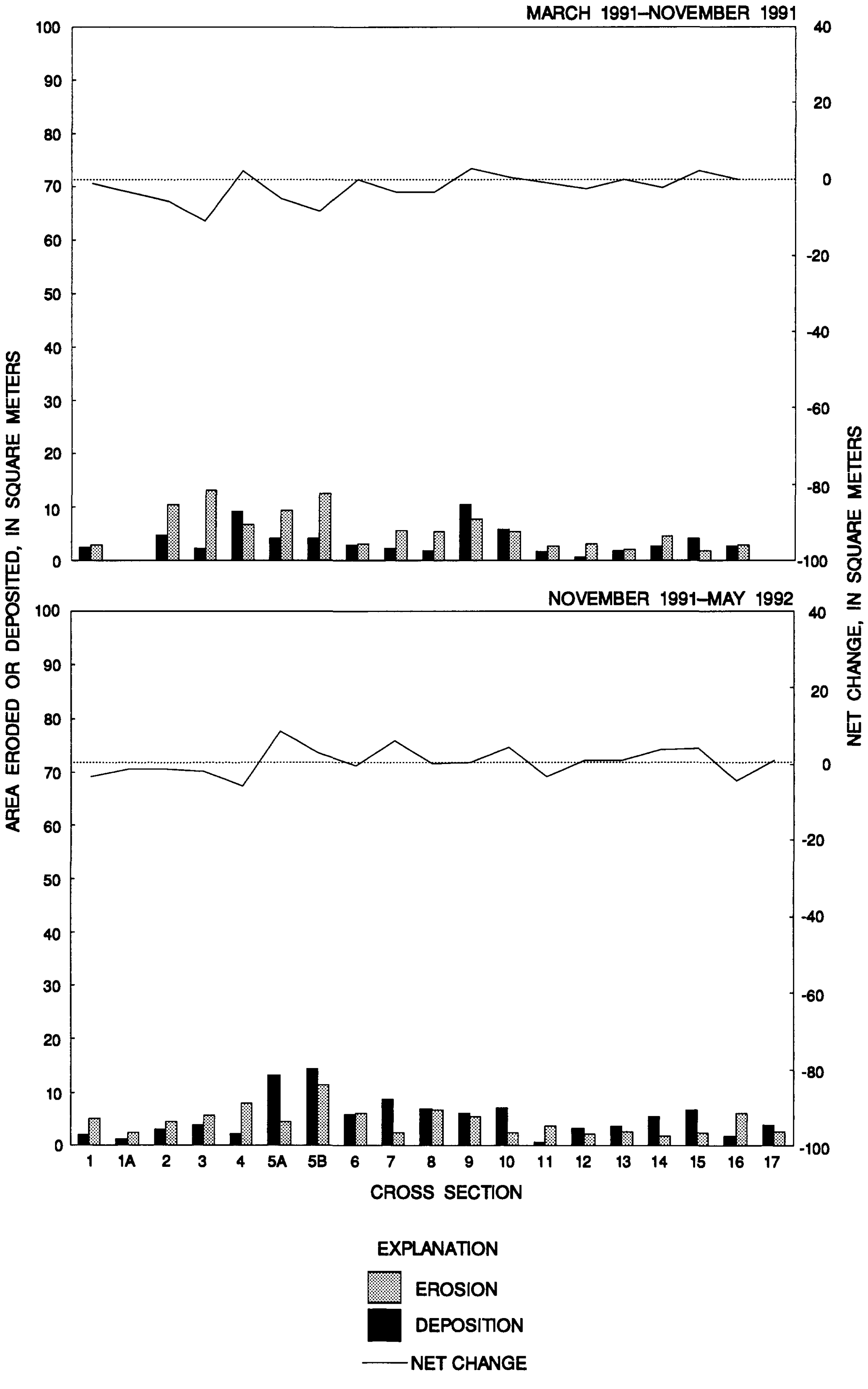


Figure 16. Area eroded, area deposited, and net channel change for each cross section at the Burnt Cabin reach, Jacks Fork, Missouri. Dominant hydraulic habitat units of cross sections—1, 1A, 2, 16 and 17 bluff pool; 3 and 15 bluff pool/glide; 4, 5B, 13, and 14 alluvial riffle; 5A race; 6, 8, 10, and 11 glide/lateral pool; 7 and 12 glide; and 9 lateral pool.

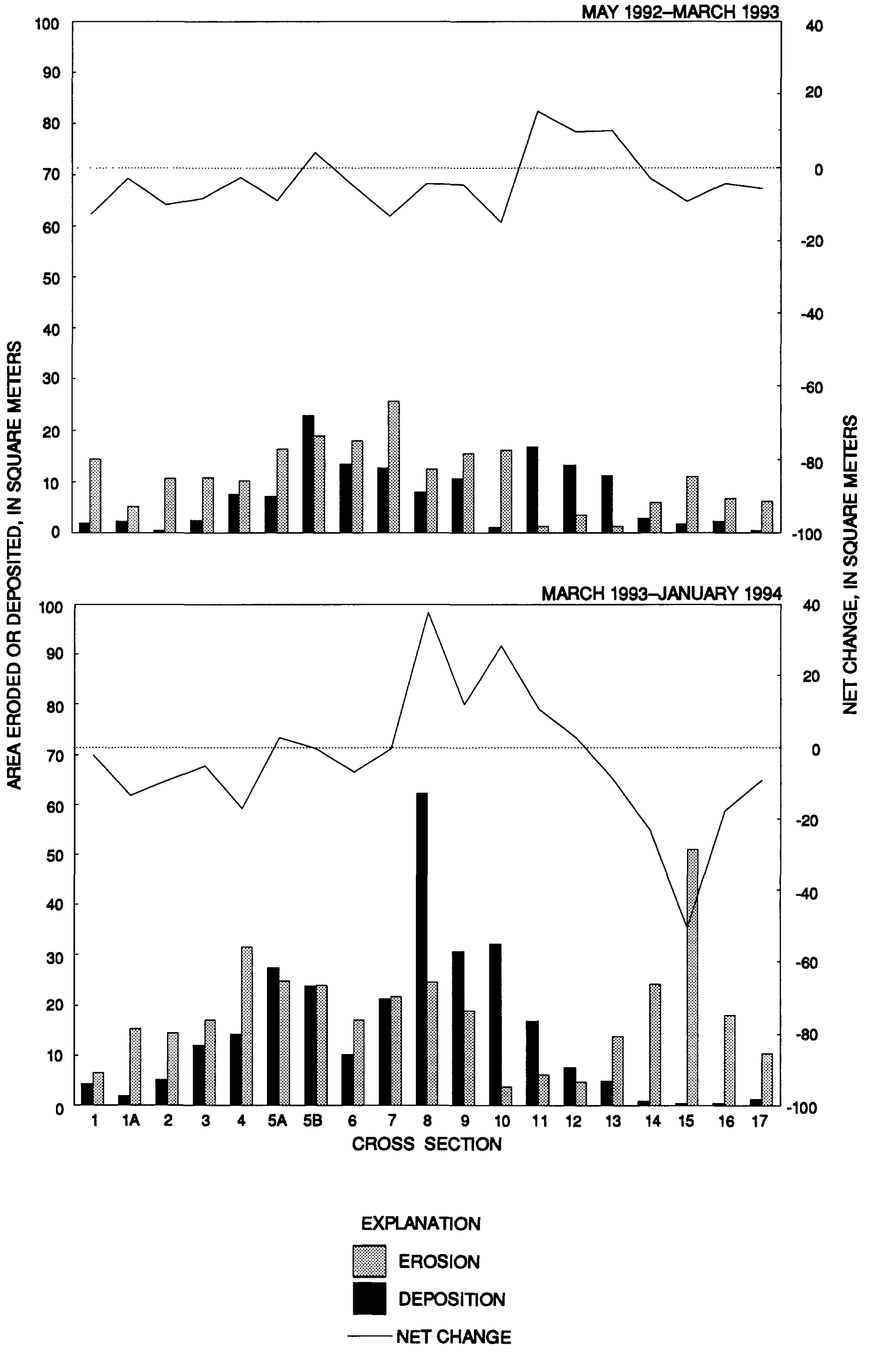


Figure 16. Area eroded, area deposited, and net channel change for each cross section at the Burnt Cabin reach, Jacks Fork, Missouri. Dominant hydraulic habitat units of cross sections—1, 1A, 2, 16, and 17 bluff pool; 3 and 15 bluff pool/glide; 4, 5B, 13, and 14 alluvial riffle; 5A race; 6, 8, 10, and 11 glide/lateral pool; 7 and 12 glide; and 9 lateral pool—Continued.

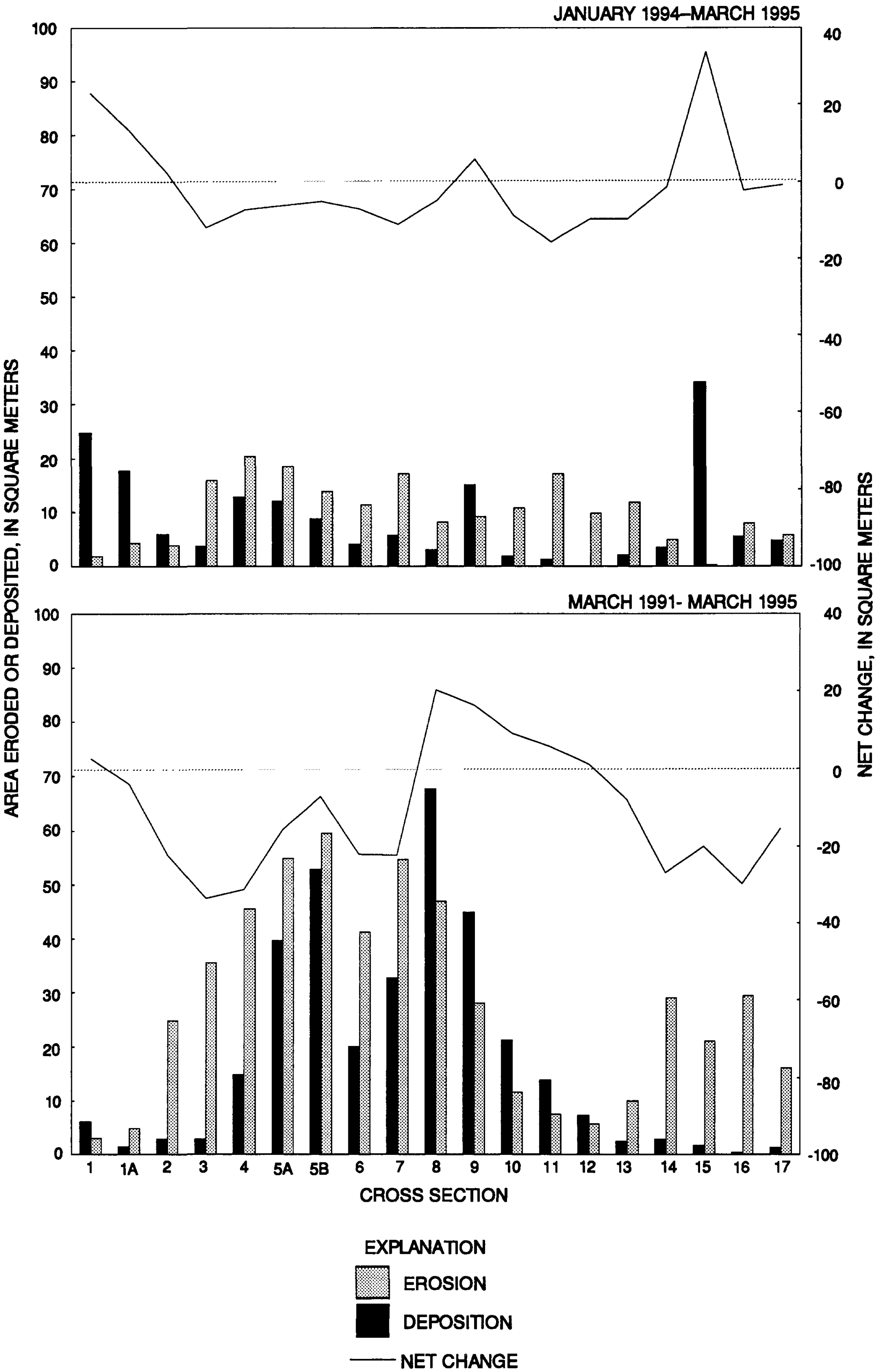


Figure 16. Area eroded, area deposited, and net channel change for each cross section at the Burnt Cabin reach, Jacks Fork, Missouri. Dominant hydraulic habitat units of cross sections—1, 1A, 2, 16, and 17 bluff pool; 3 and 15 bluff pool/glide; 4, 5B, 13, and 14 alluvial riffle; 5A race; 6, 8, 10, and 11 glide/lateral pool; 7 and 12 glide; and 9 lateral pool—Continued.

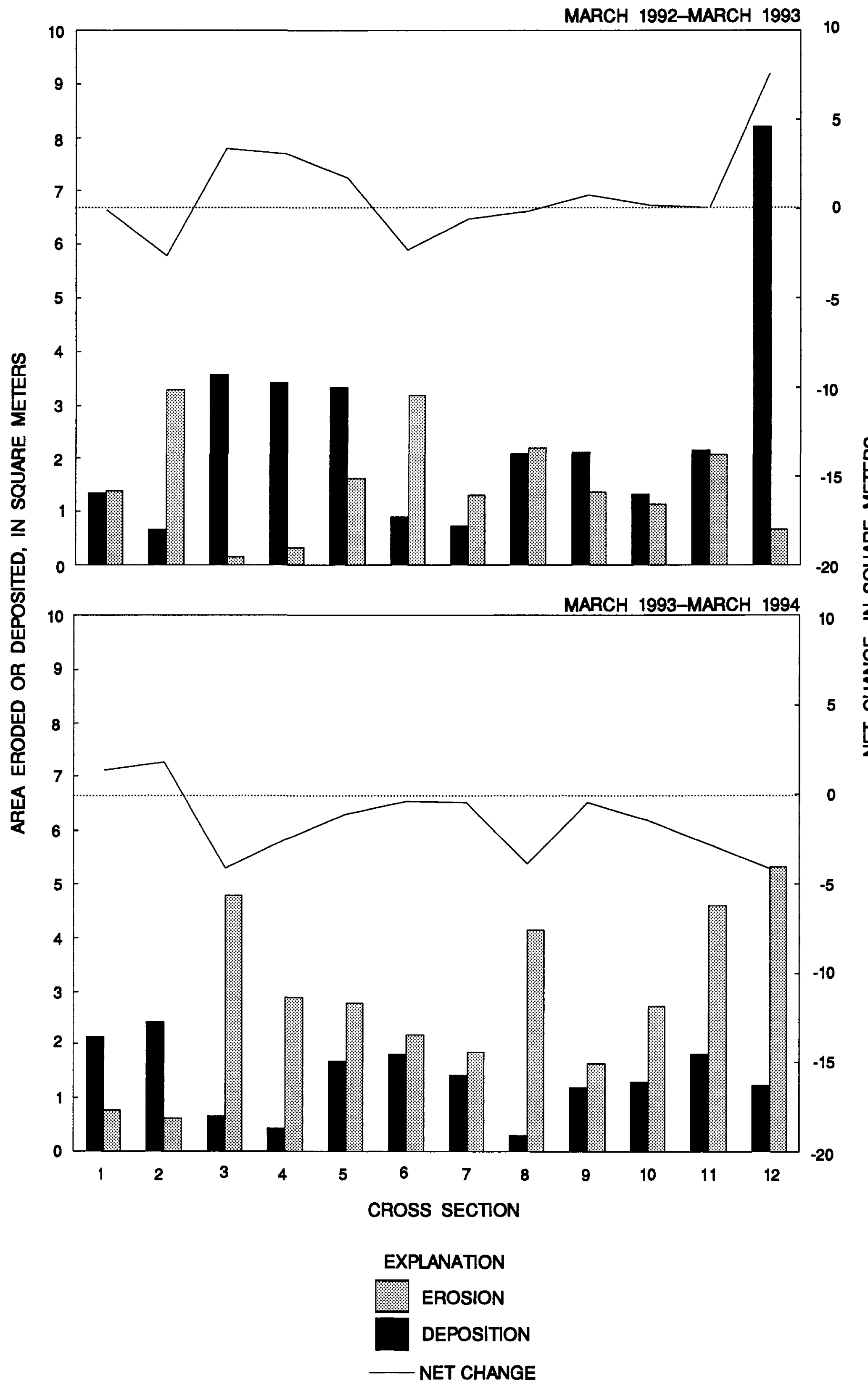


Figure 17. Area eroded, area deposited, and net channel change for each cross section at the Wilderness Boundary reach, Buffalo River, Arkansas. Dominant hydraulic habitat units of cross sections—1 glide/lateral pool; 2, 7, and 8 glide; 3 and 4 alluvial riffle; 5 and 12 bluff pool; 9 bedrock riffle; and 6, 10, and 11 glide/bluff pool.

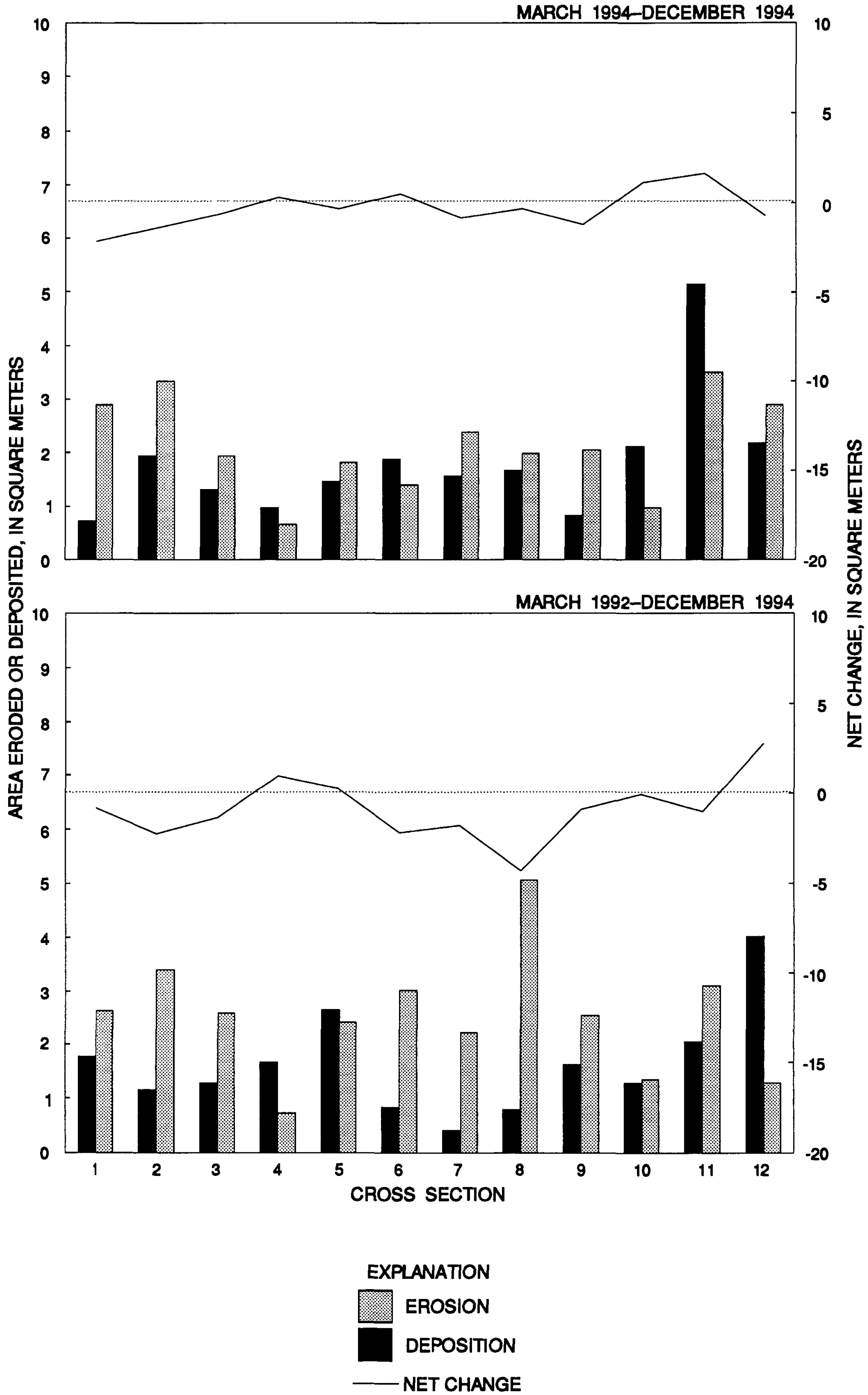


Figure 17. Area eroded, area deposited, and net channel change for each cross section at the Wilderness Boundary reach, Buffalo River, Arkansas. Dominant hydraulic habitat units of cross sections—1 glide/lateral pool; 2, 7, and 8 glide; 3 and 4 alluvial riffle; 5 and 12 bluff pool; 9 bedrock riffle; and 6, 10, and 11 glide/bluff pool—Continued.

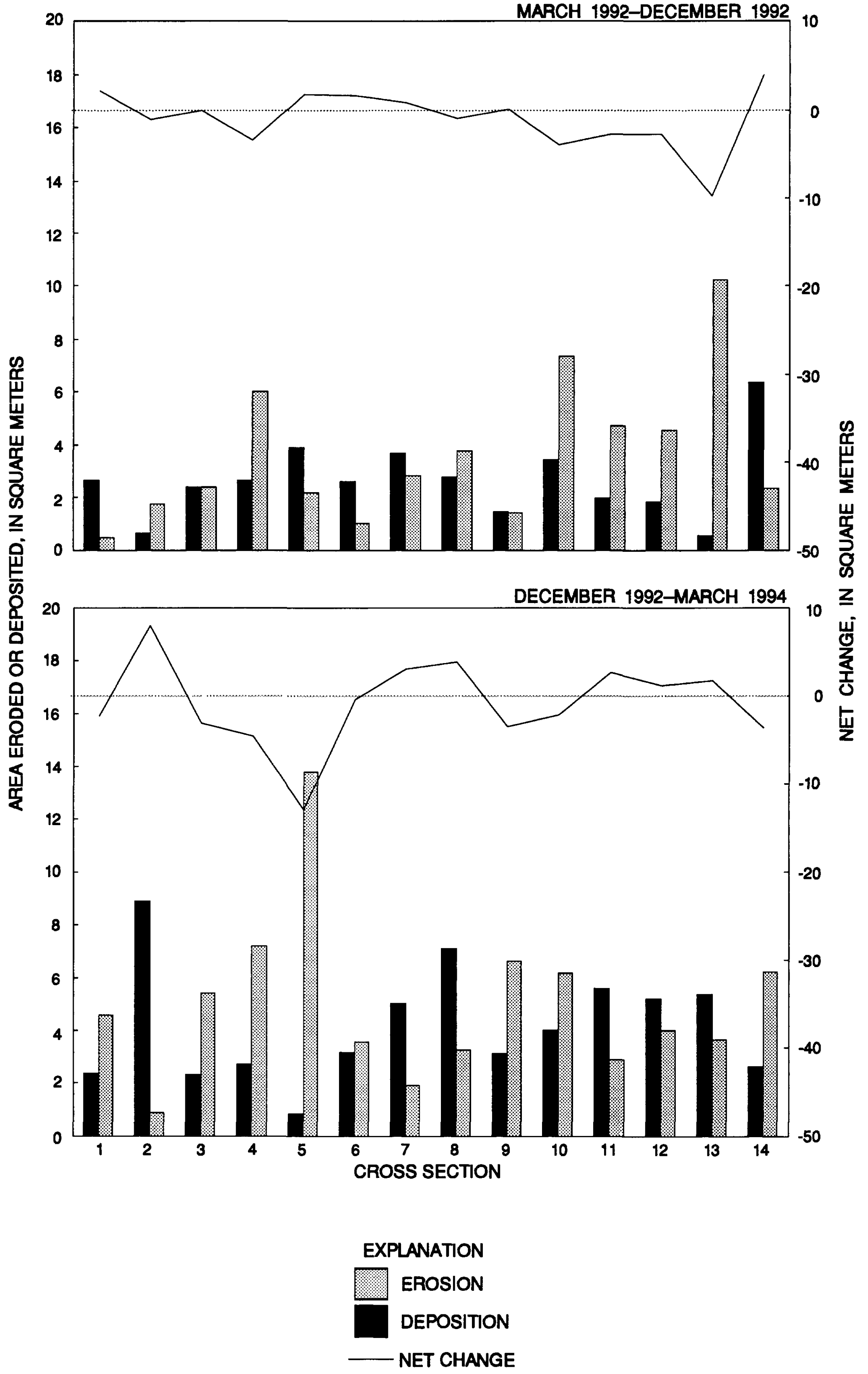


Figure 18. Area eroded, area deposited, and net channel change for each cross section at the Blue Hole reach, Buffalo River, Arkansas. Dominant hydraulic habitat units of cross sections—1 and 8, 9, and 10 glide/bluff pool; 2, 6, and 7 glide; 3 tributary riffle; 4 tributary riffle/race; 5 bluff pool; 11 alluvial riffle; 12 race/alluvial riffle; and 13 and 14 mid-channel pool/glide.

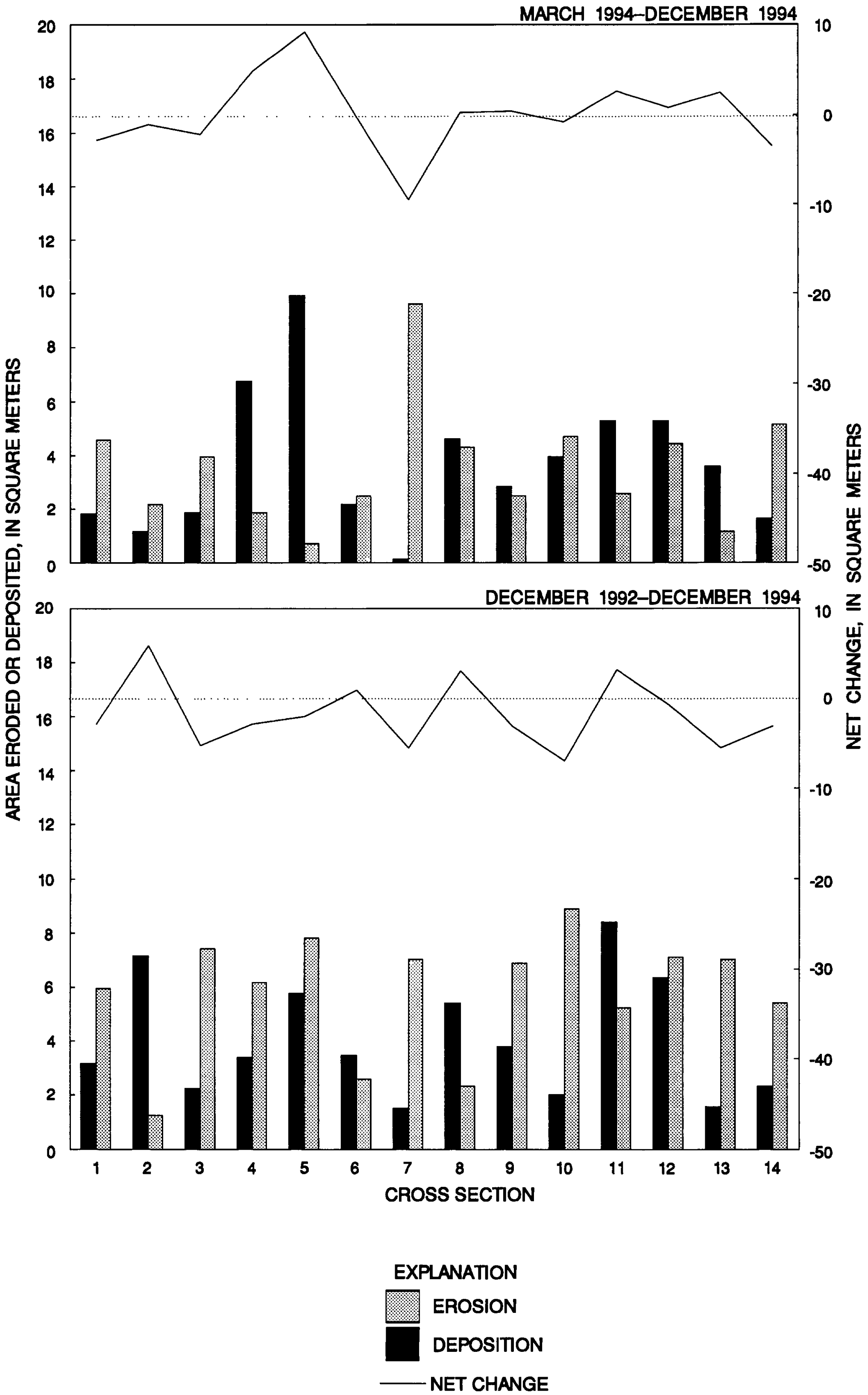


Figure 18. Area eroded, area deposited, and net channel change for each cross section at the Blue Hole reach, Buffalo River, Arkansas. Dominant hydraulic habitat units of cross sections—1 and 8, 9, and 10 glide/bluff pool; 2, 6, and 7 glide; 3 tributary riffle; 4 tributary riffle/race; 5 bluff pool; 11 alluvial riffle; 12 race/alluvial riffle; and 13 and 14 mid-channel pool/glide—Continued.

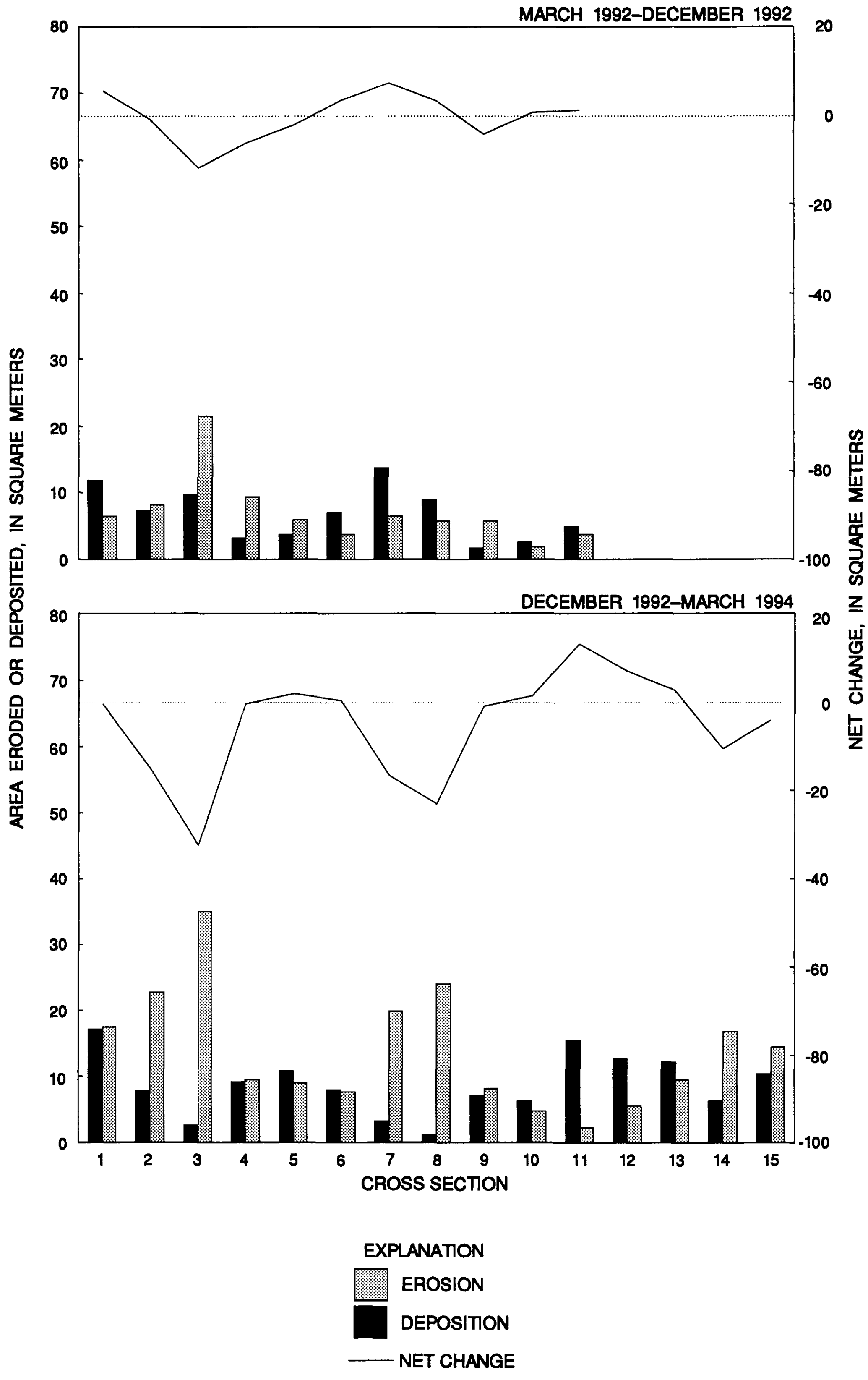


Figure 19. Area eroded, area deposited, and net channel change for each cross section at the Shine-eye reach, Buffalo River, Arkansas. Dominant hydraulic habitat units of cross sections—1, 2, 10, and 11 bluff pool; 3, 6, and 9 bluff pool/glide; 4, 5, 7, and 13 alluvial riffle; 8 and 14 glide; 12 race; and 15 lateral pool/glide.

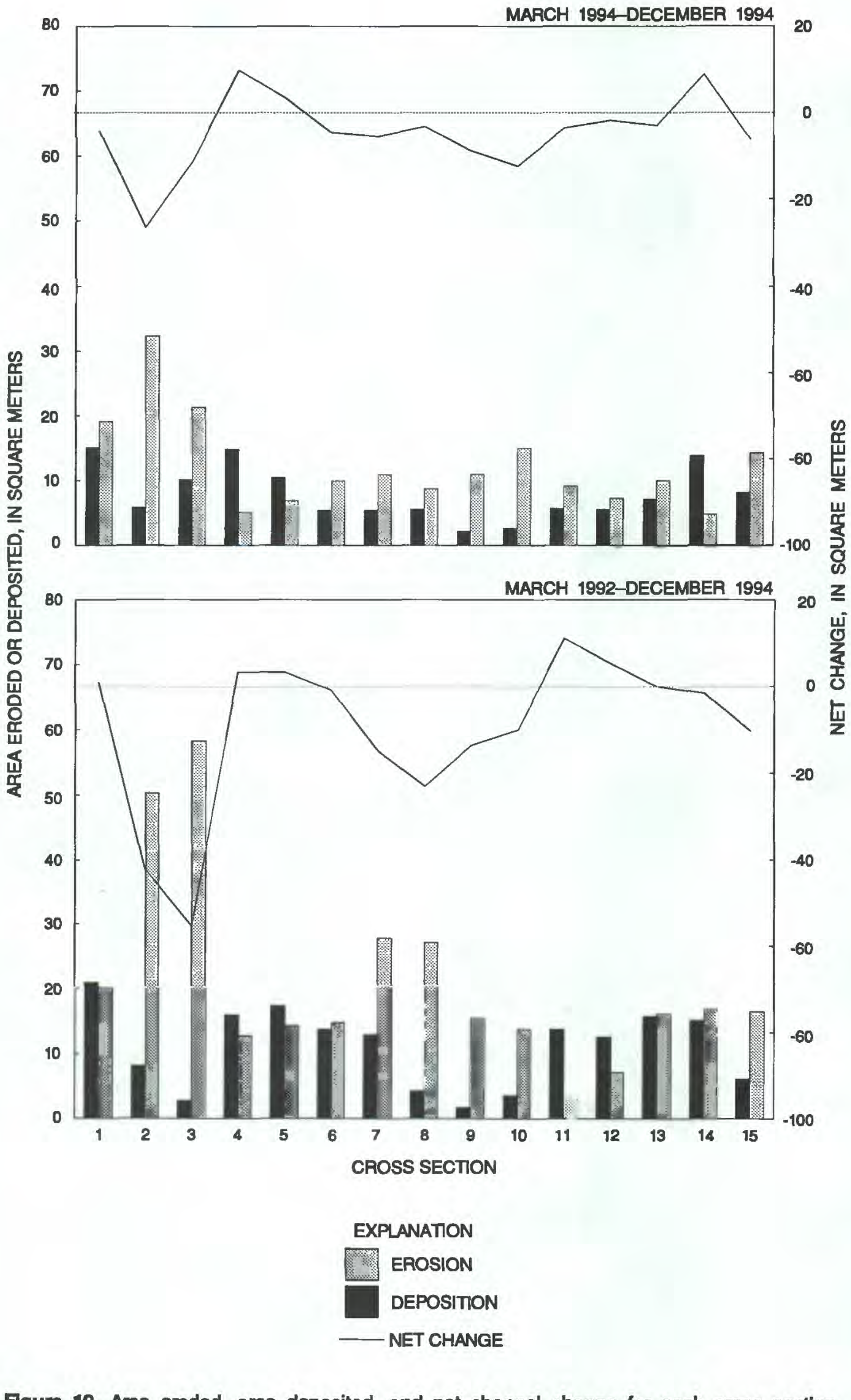


Figure 19. Area eroded, area deposited, and net channel change for each cross section at the Shine-eye reach, Buffalo River, Arkansas. Dominant hydraulic habitat units of cross sections—1, 2, 10, and 11 bluff pool; 3, 6, and 9 bluff pool/glide; 4, 5, 7, and 13 alluvial riffle; 8 and 14 glide; 12 race; and 15 lateral pool/glide—Continued.

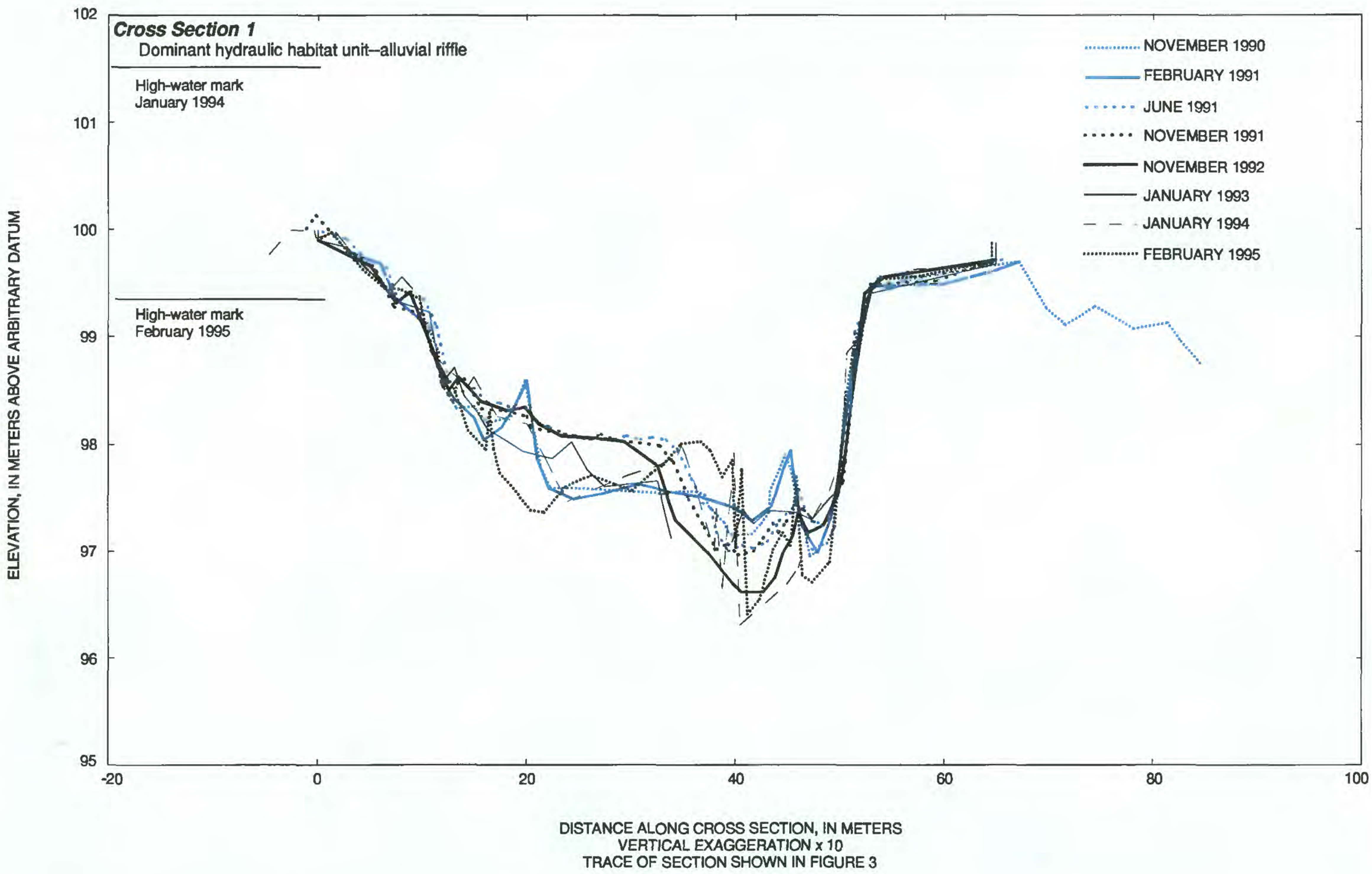


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri.

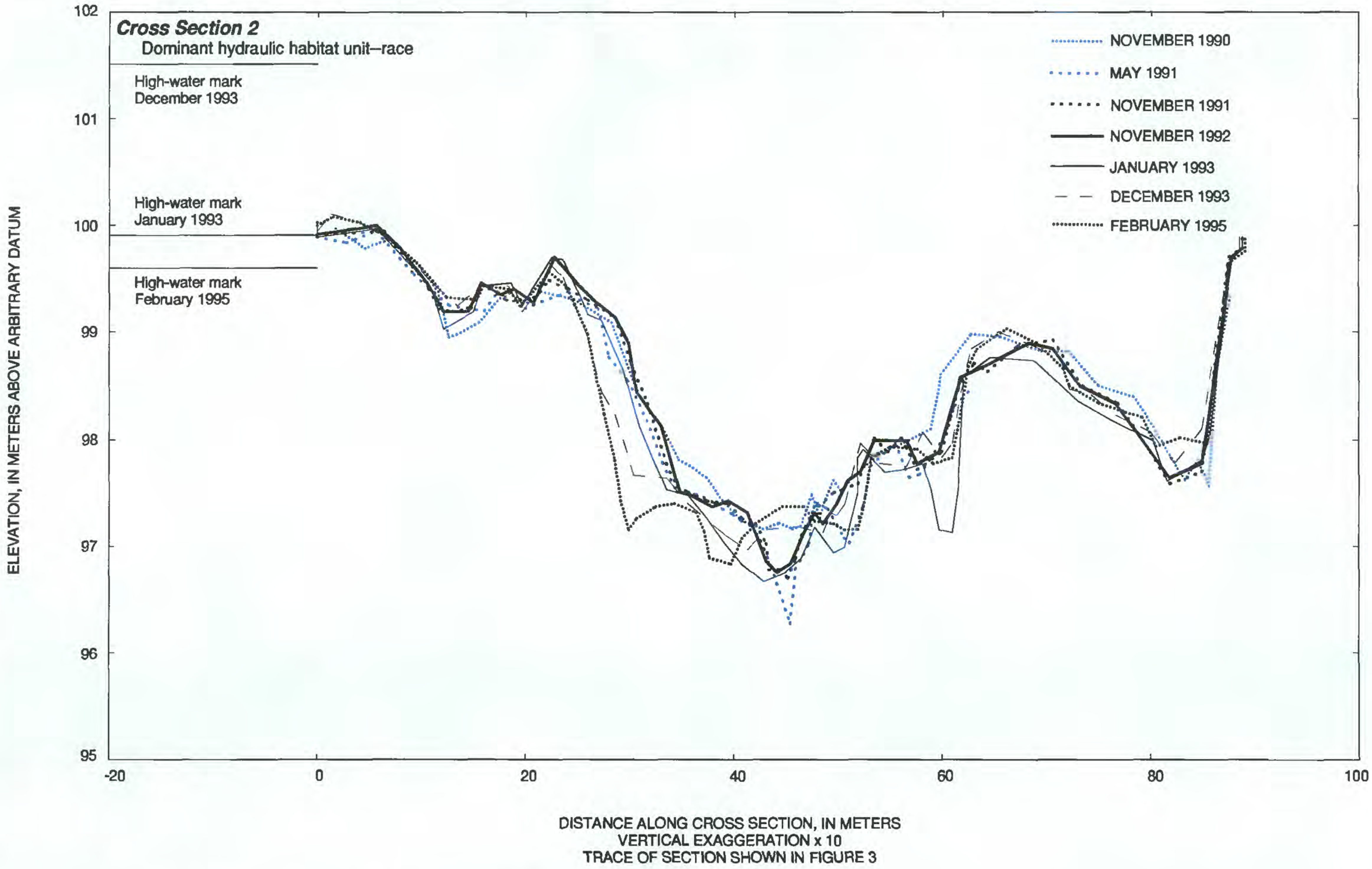


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri–Continued.

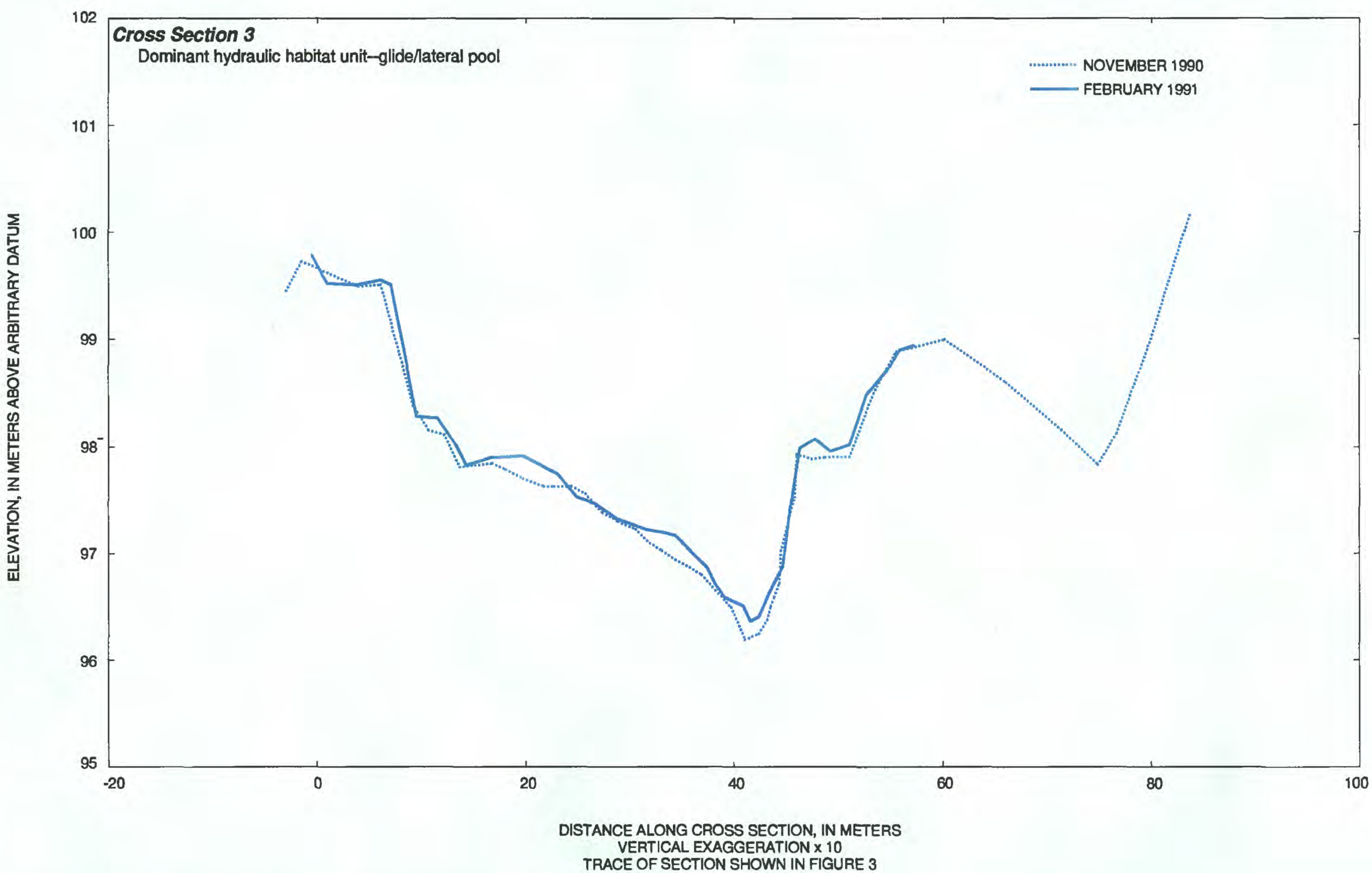


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri–Continued.

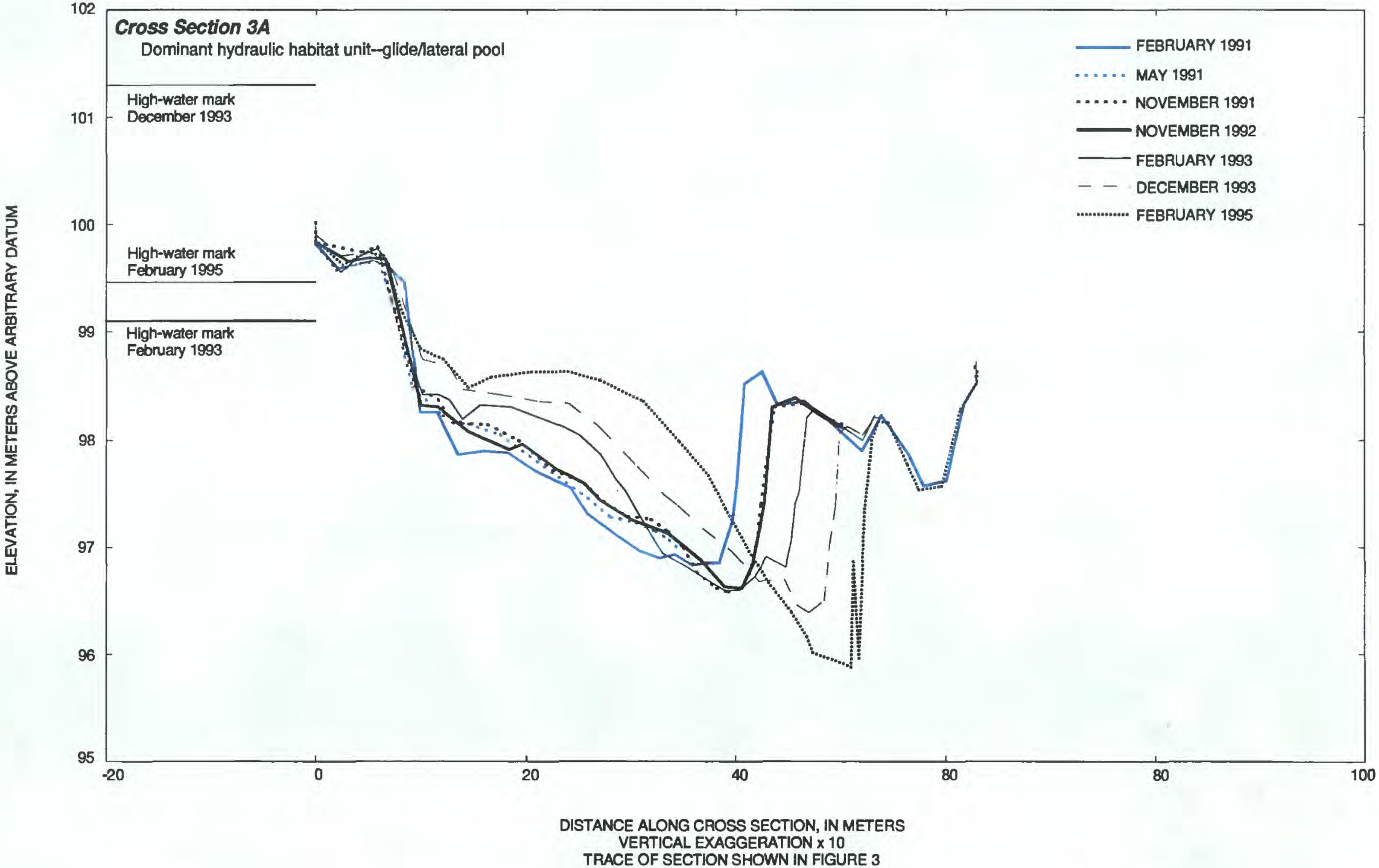


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri—Continued.

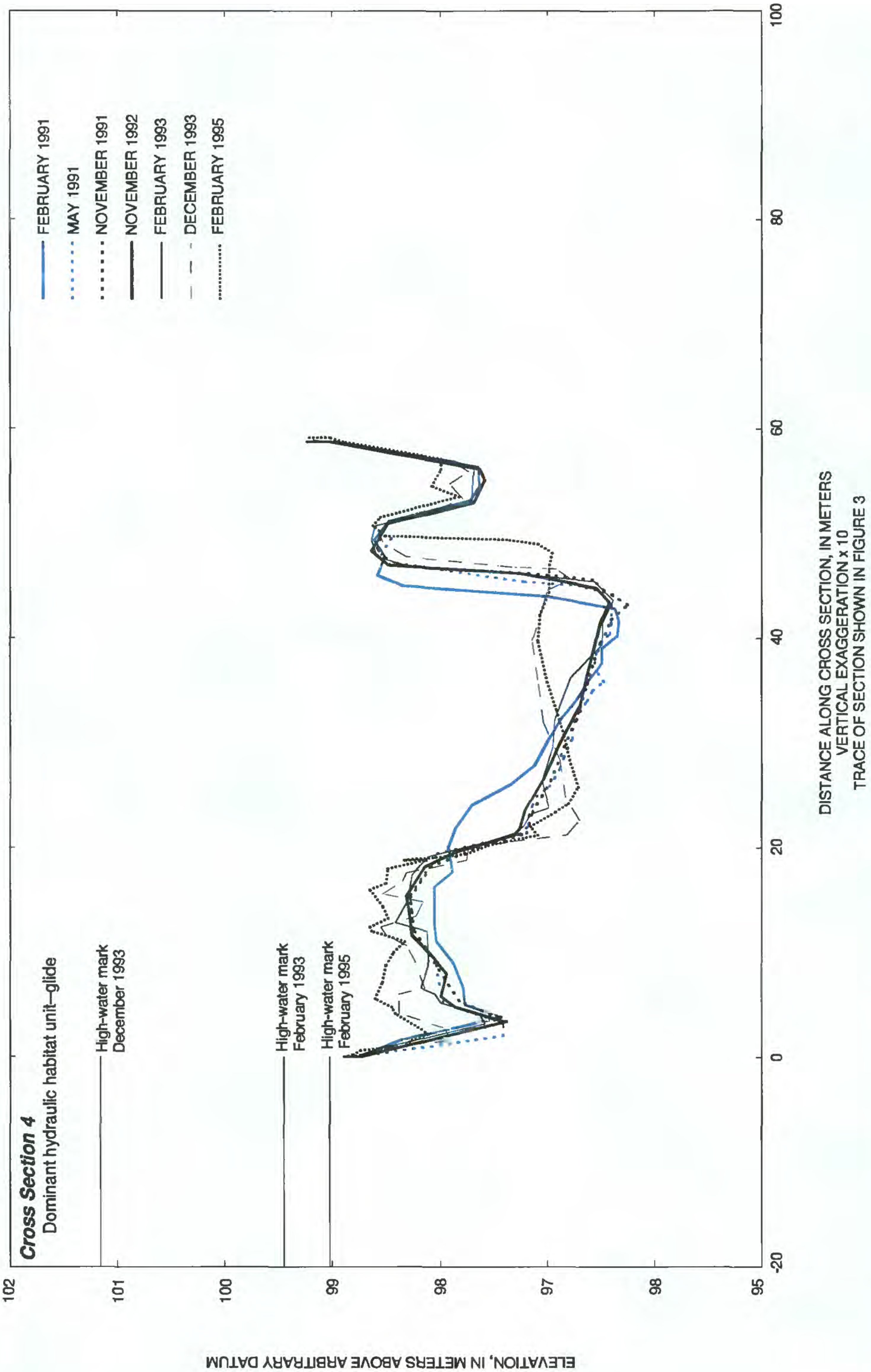


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri–Continued.

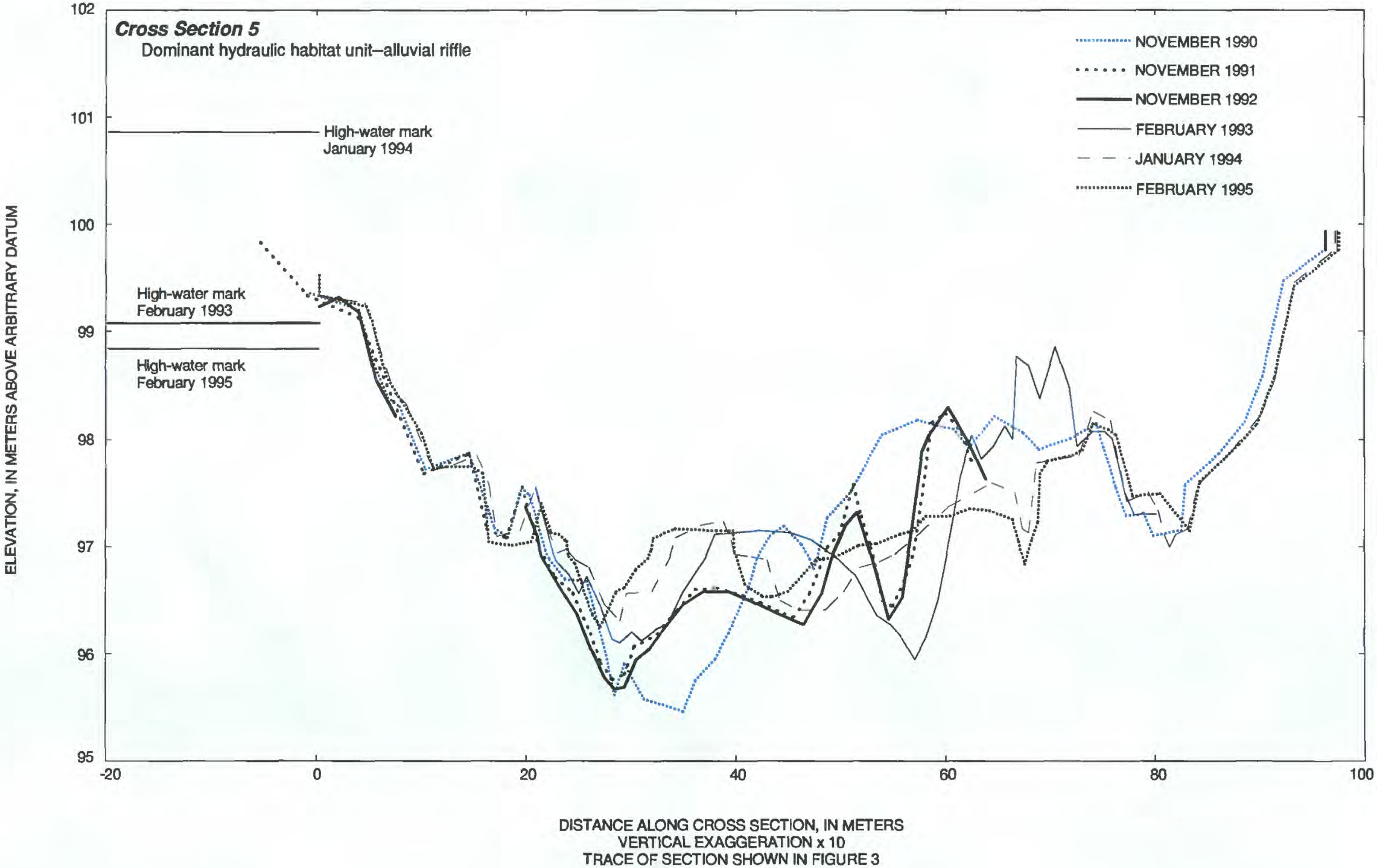


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri–Continued.

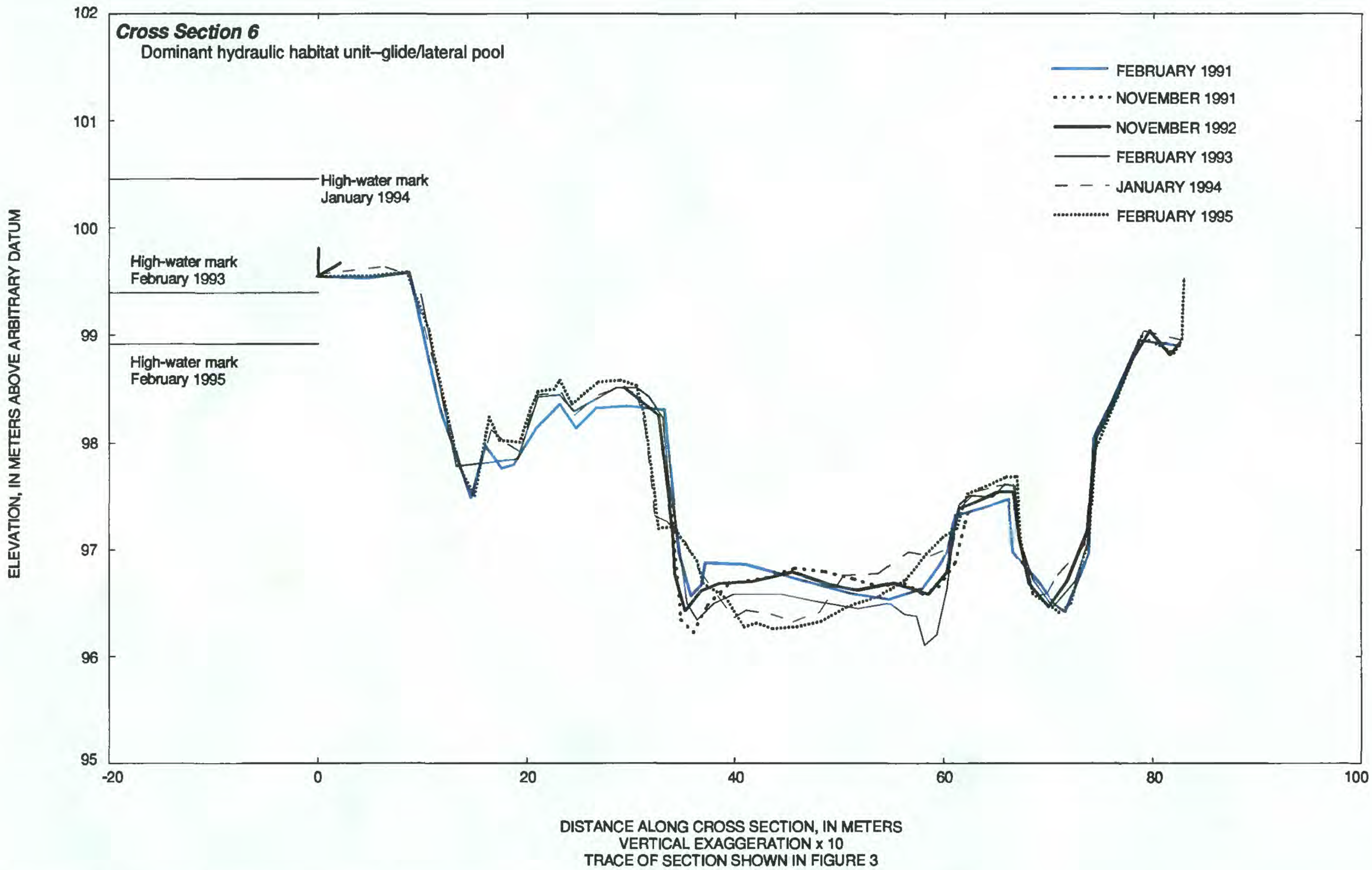


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri—Continued.

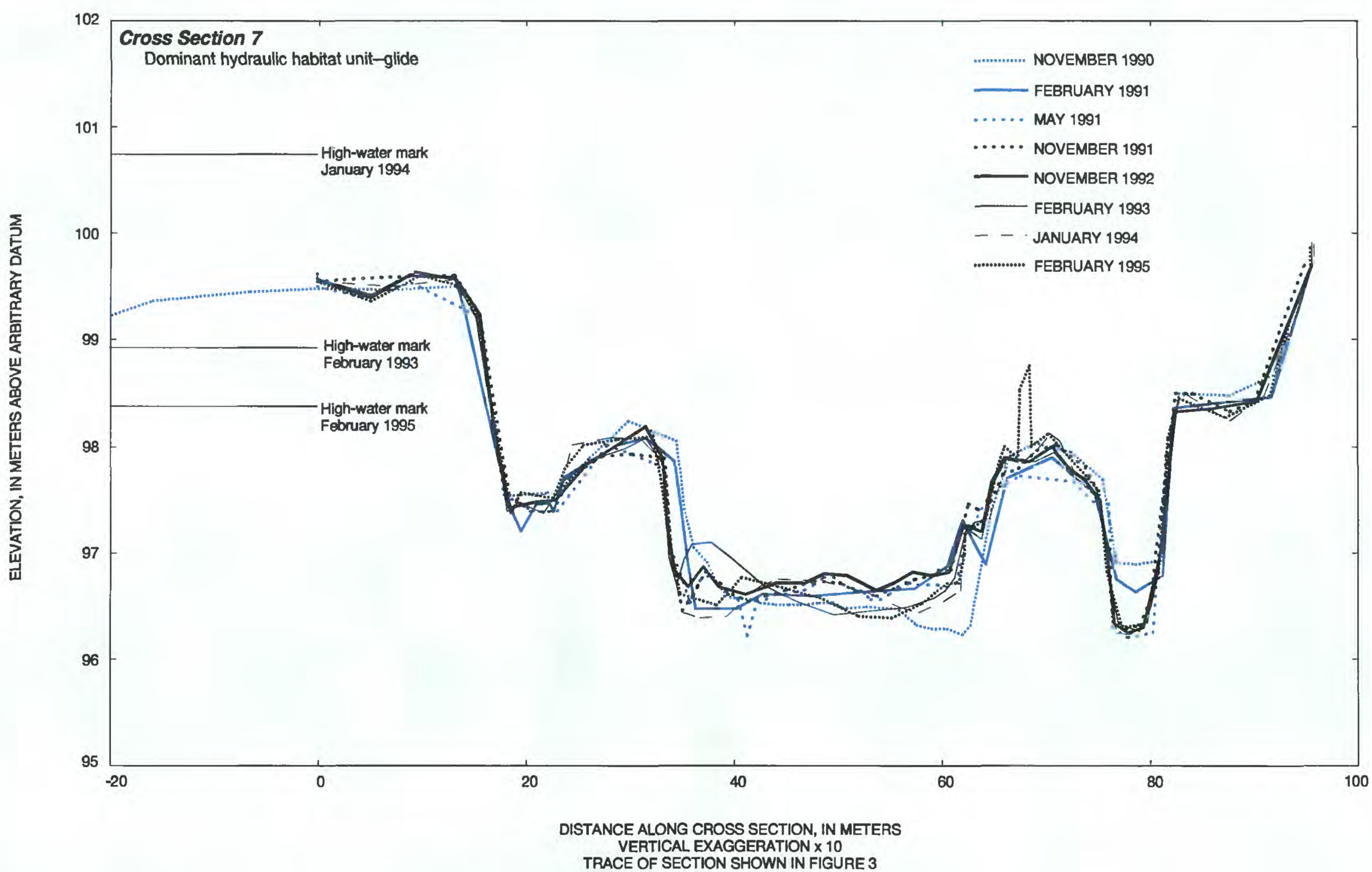


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri–Continued.

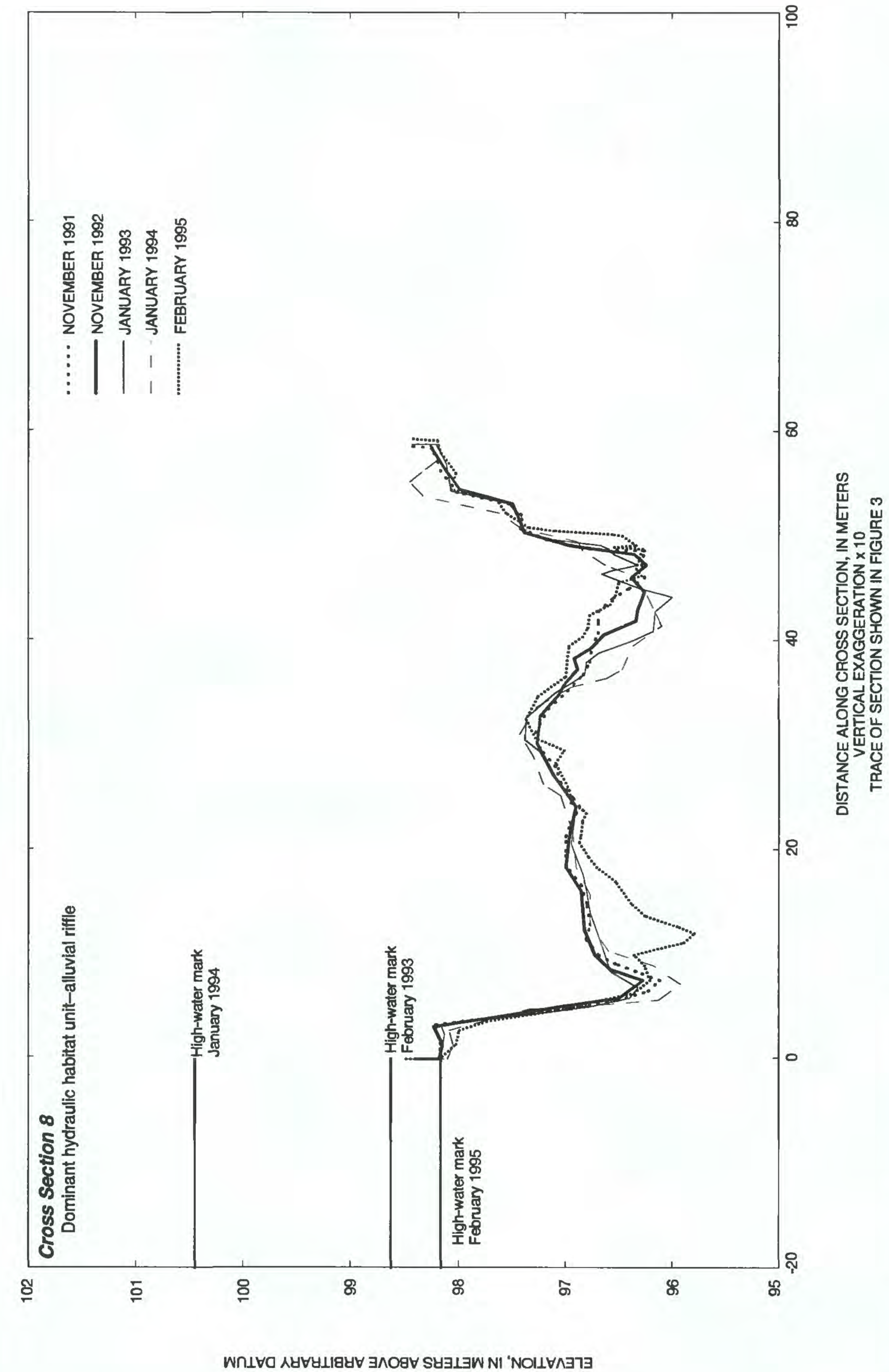


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri—Continued.

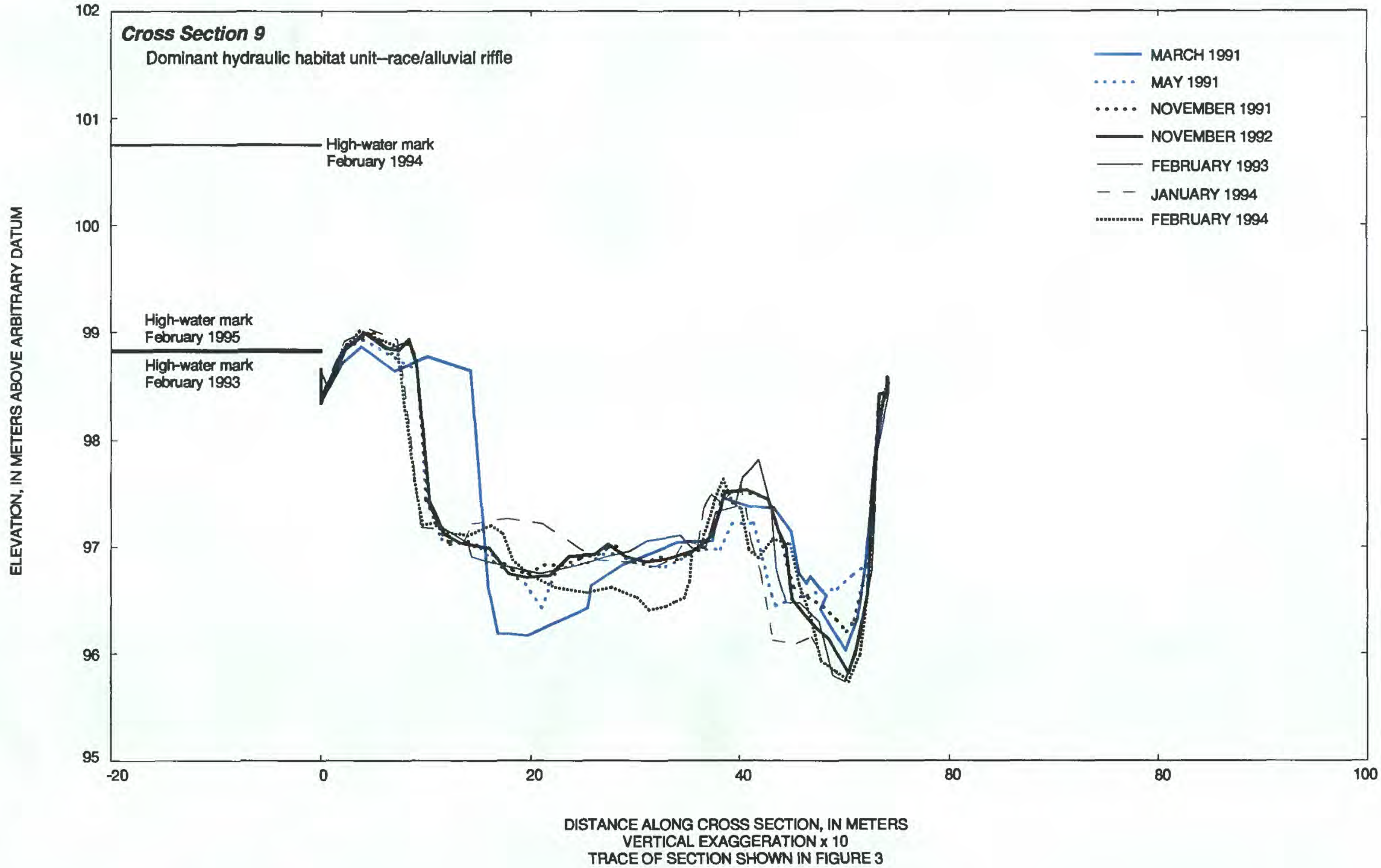


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri–Continued.

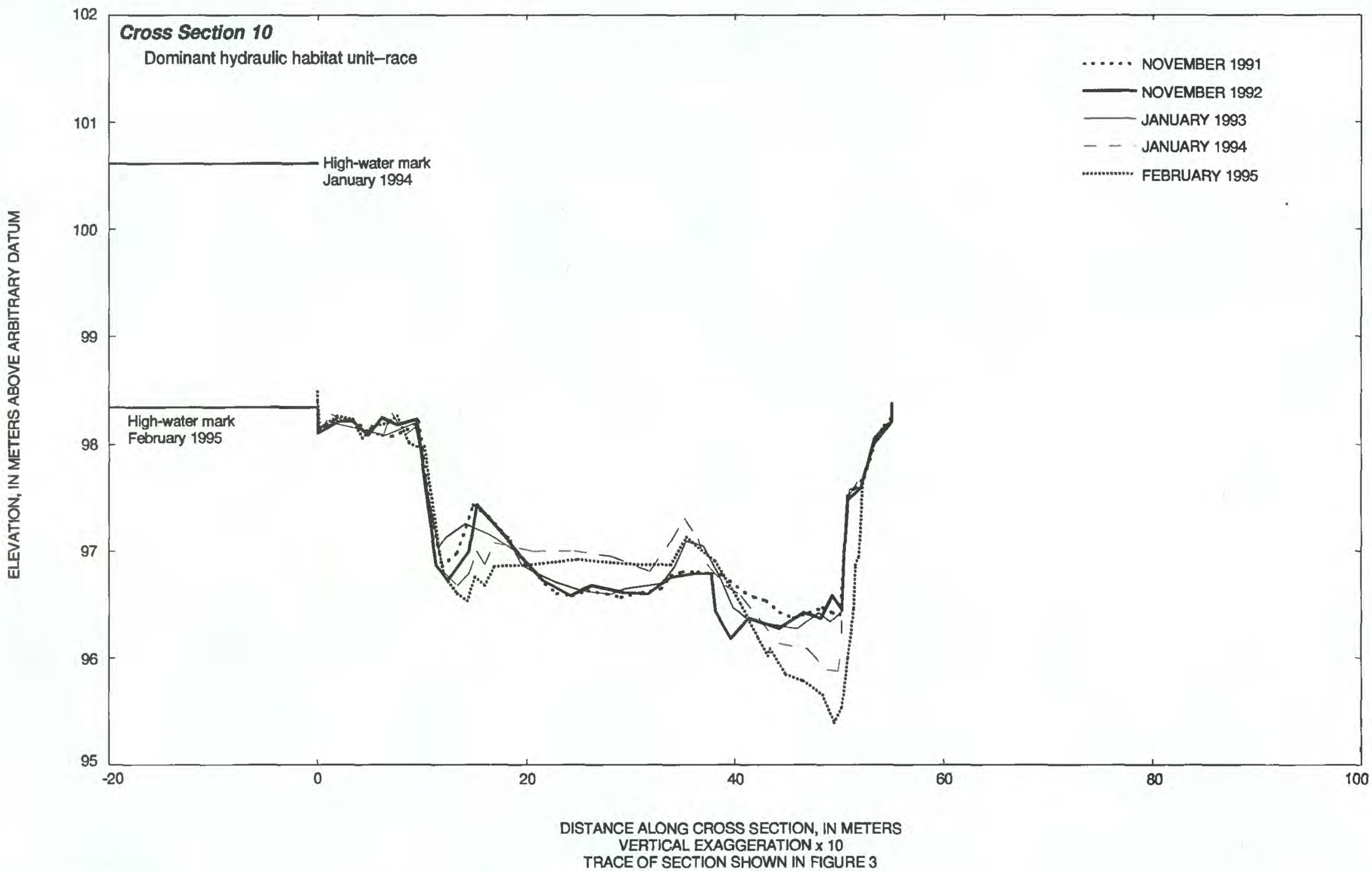


Figure 20. *Cross sections located at Hickory Point reach, Little Piney Creek, Missouri–Continued.*

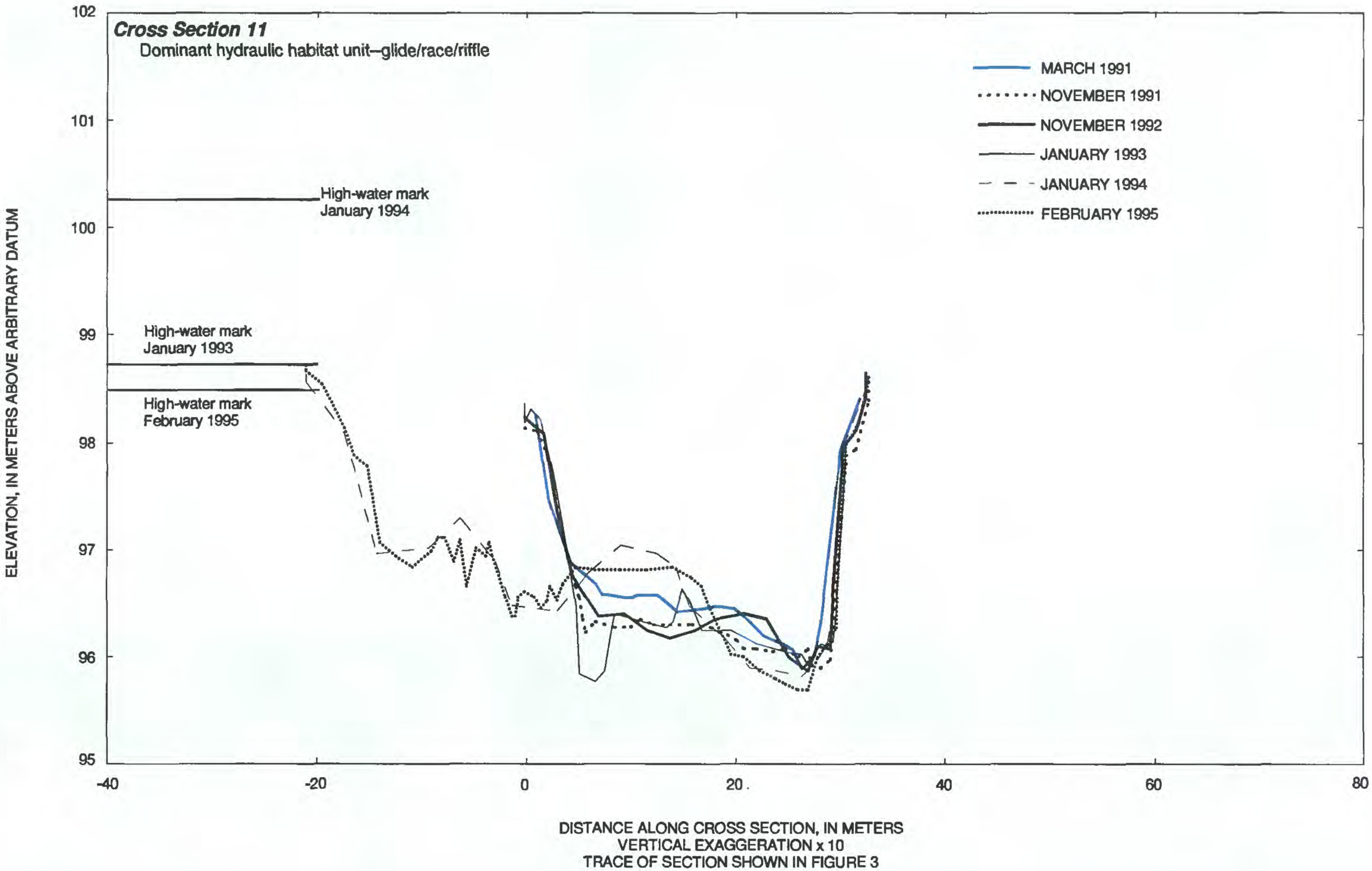


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri–Continued.

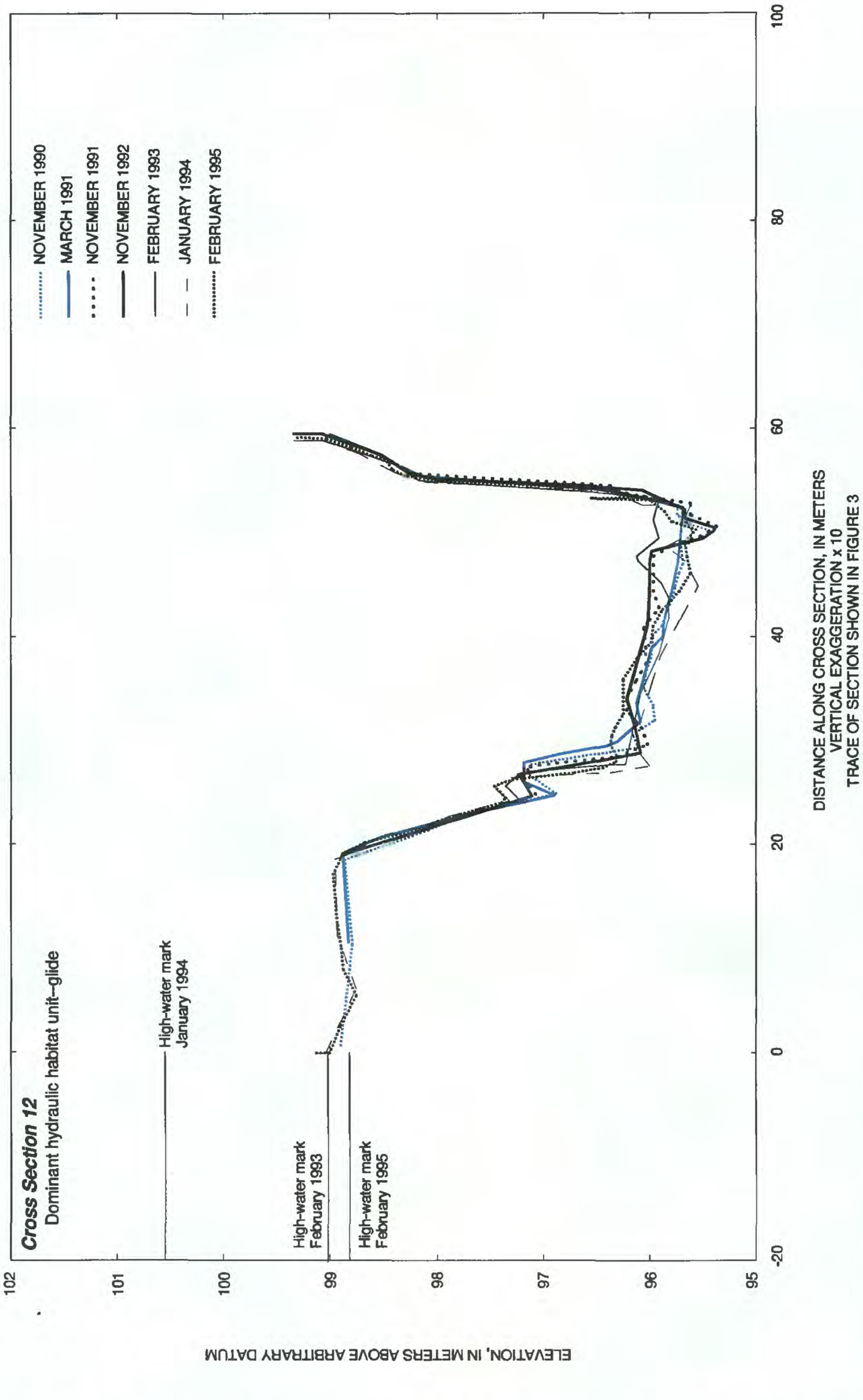


Figure 20. Cross sections located at Hickory Point reach, Little Piney Creek, Missouri—Continued.

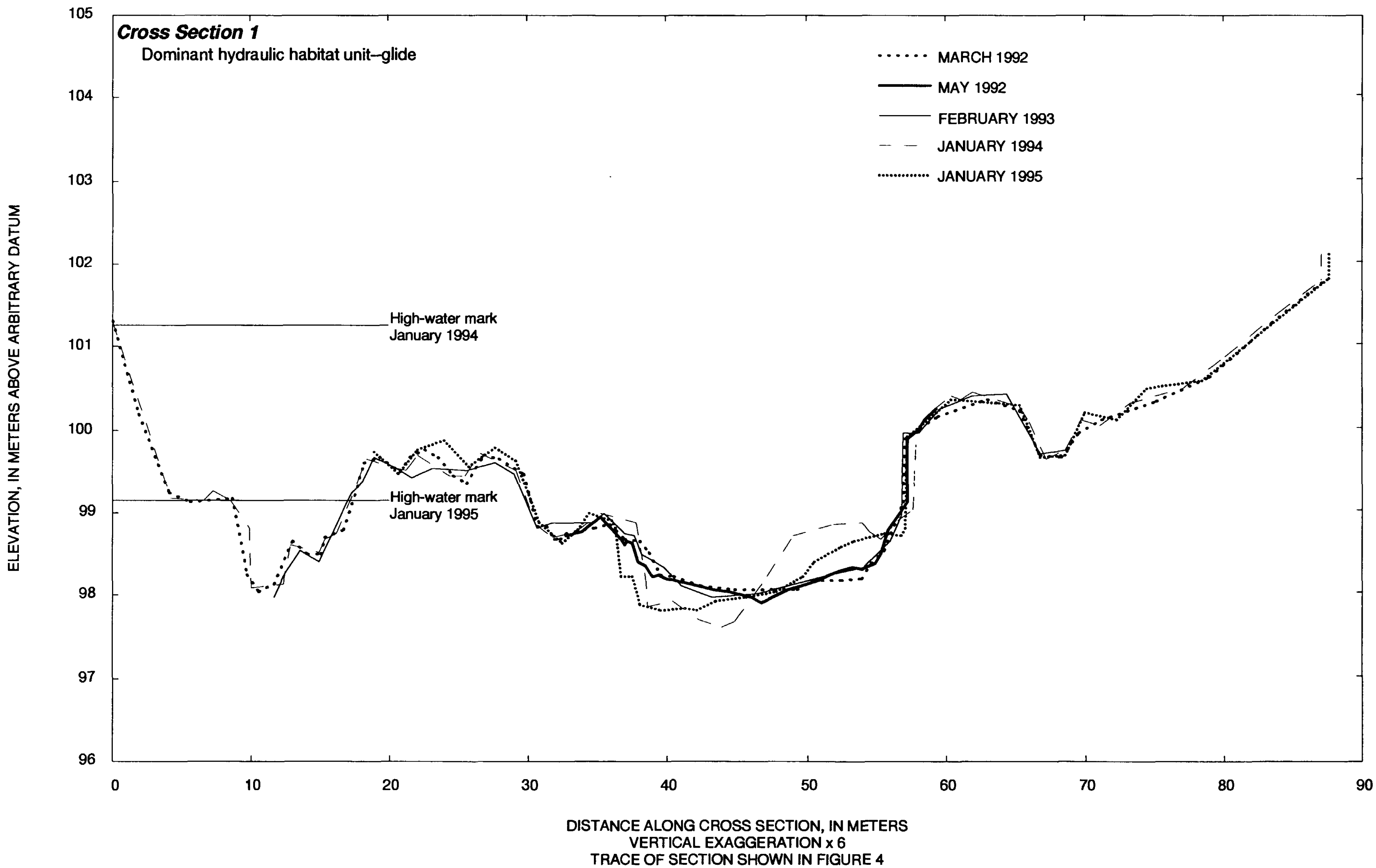


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri .

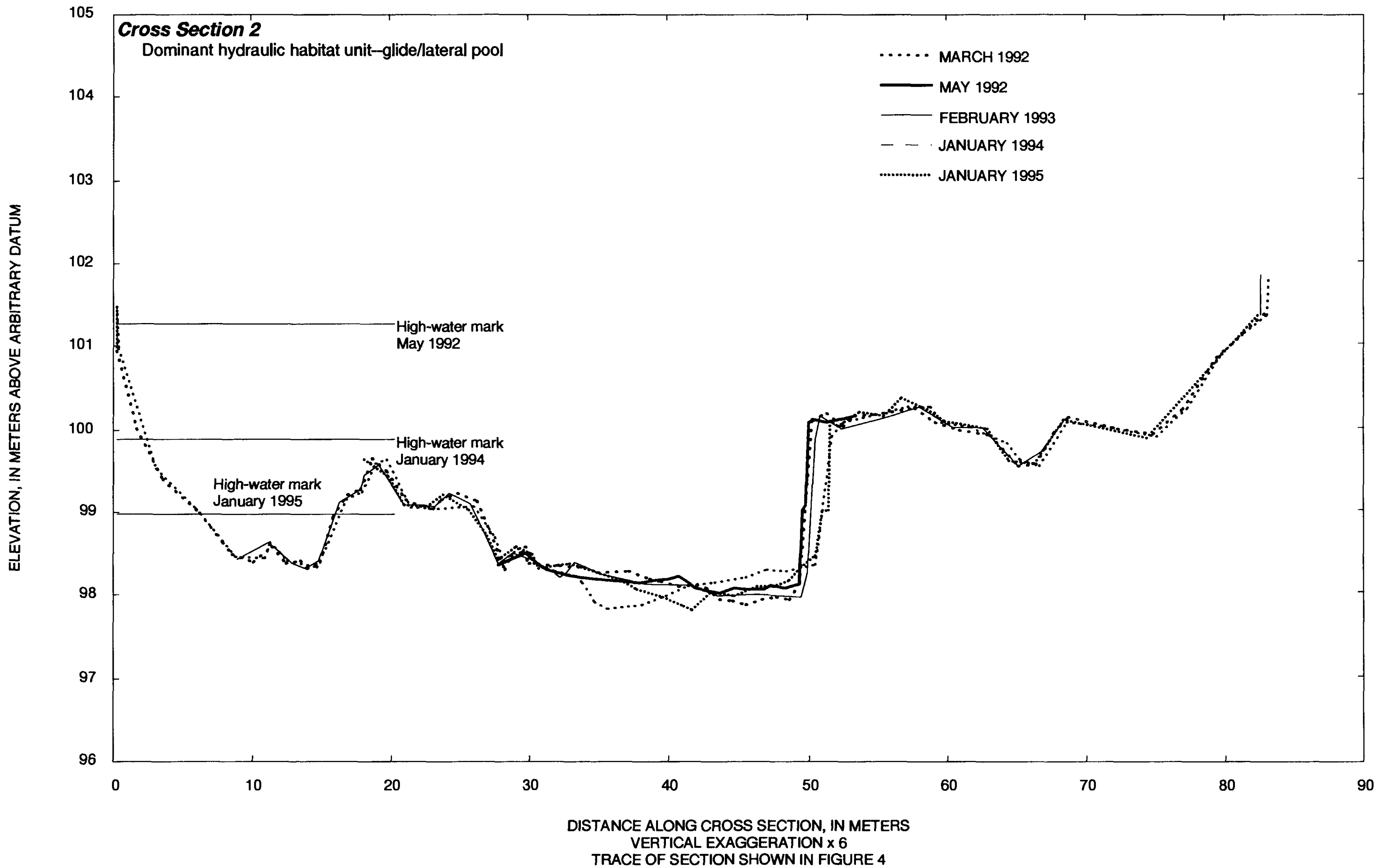


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri—Continued.

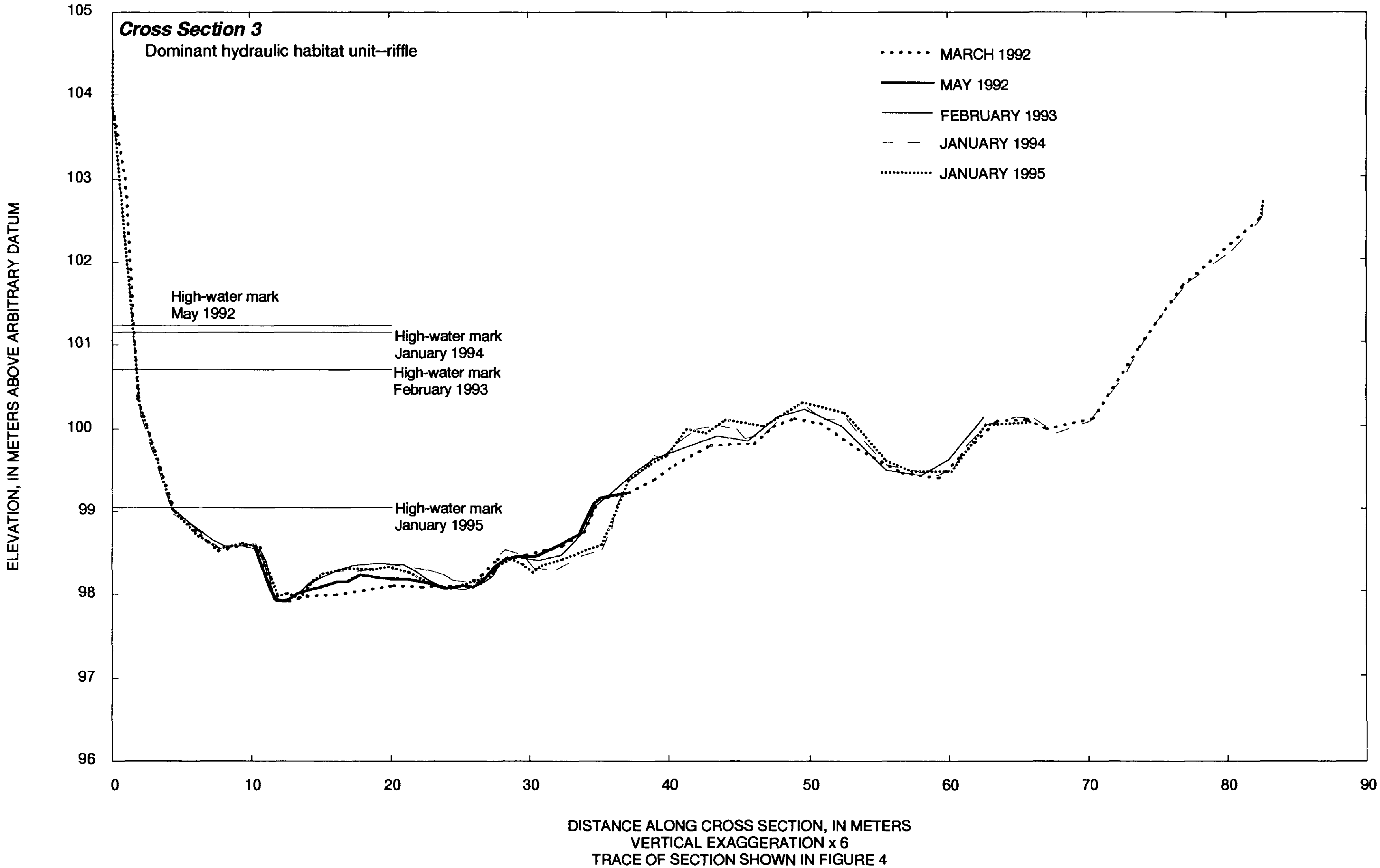


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri–Continued.

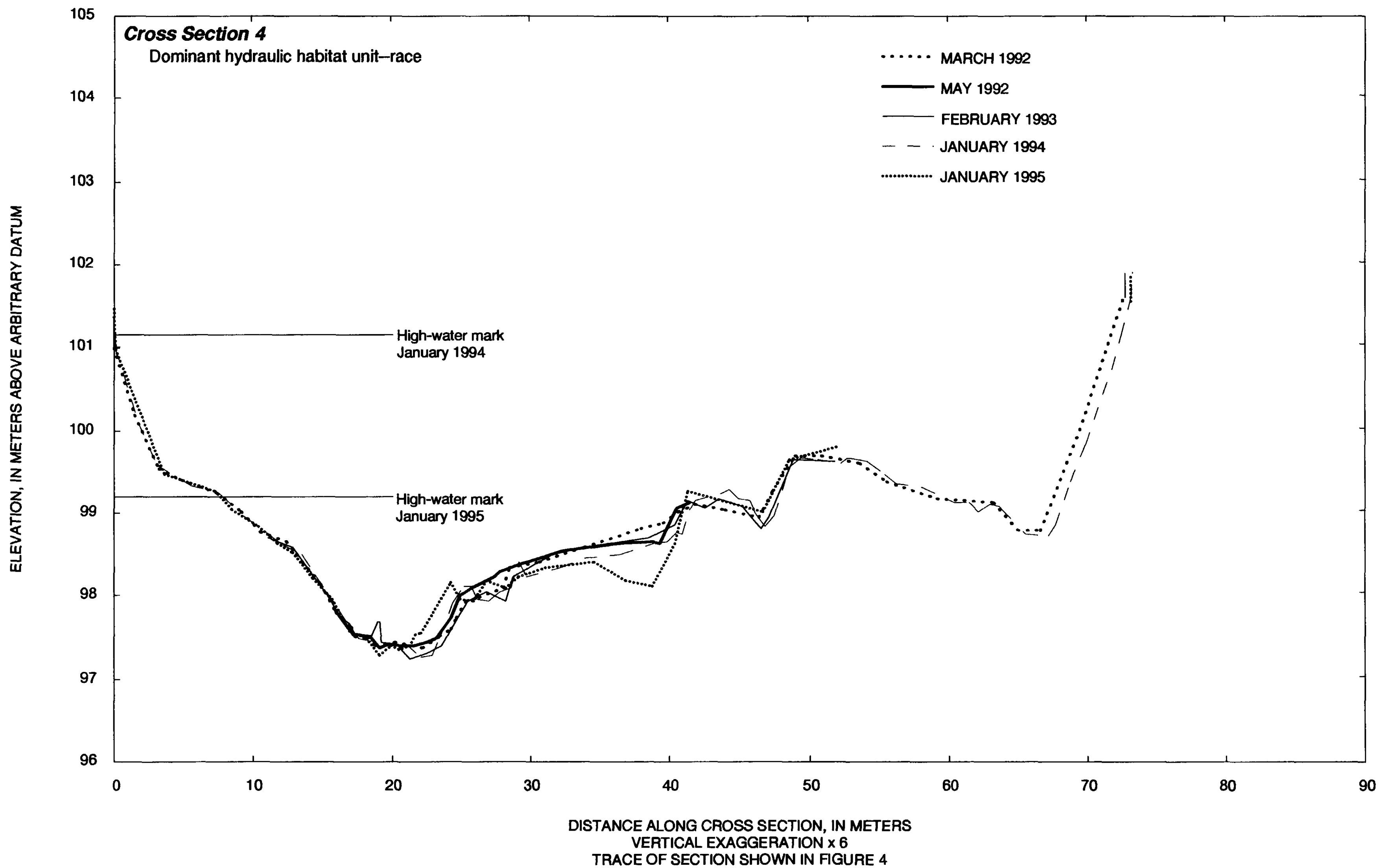


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri–Continued.

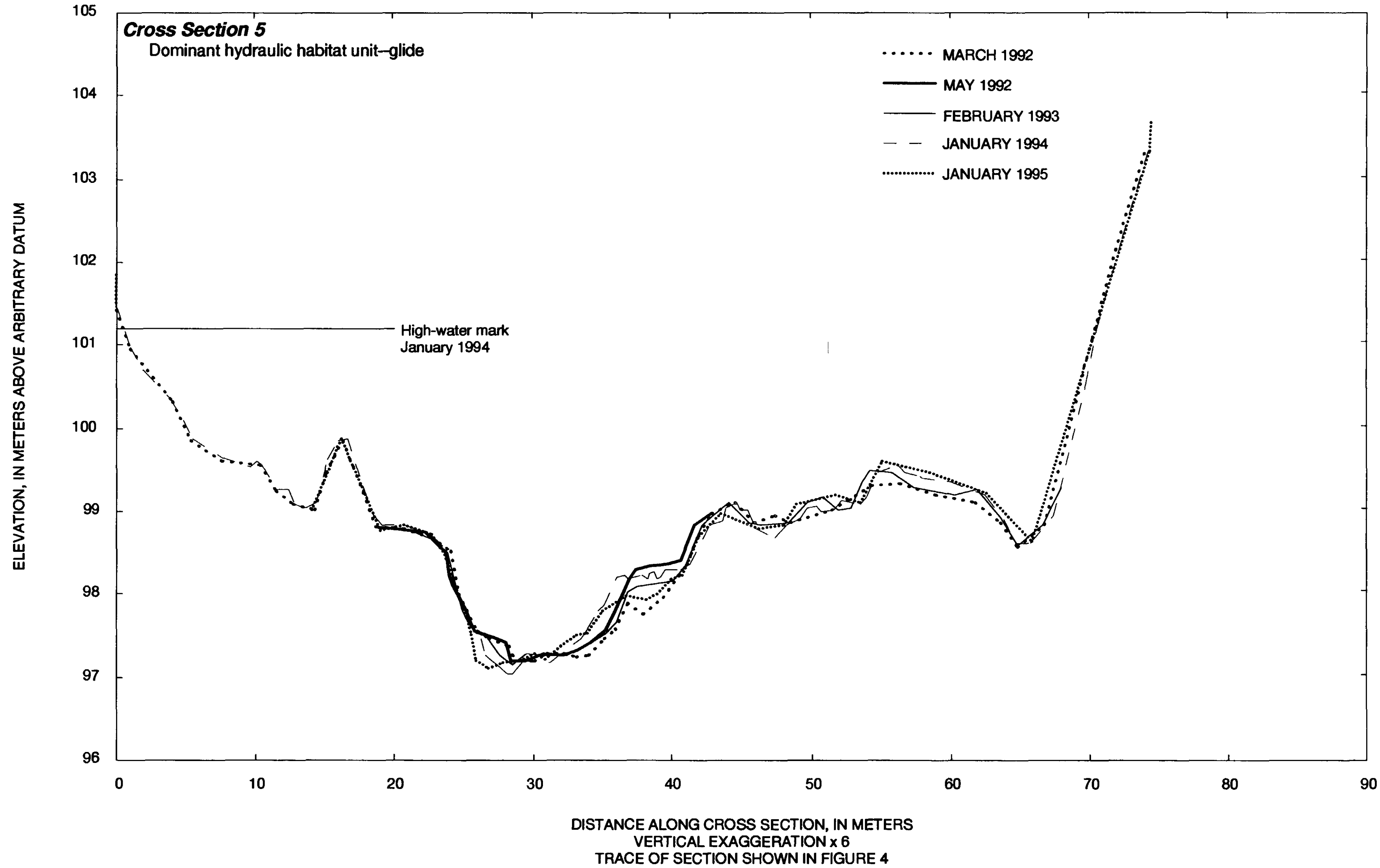


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri—Continued.

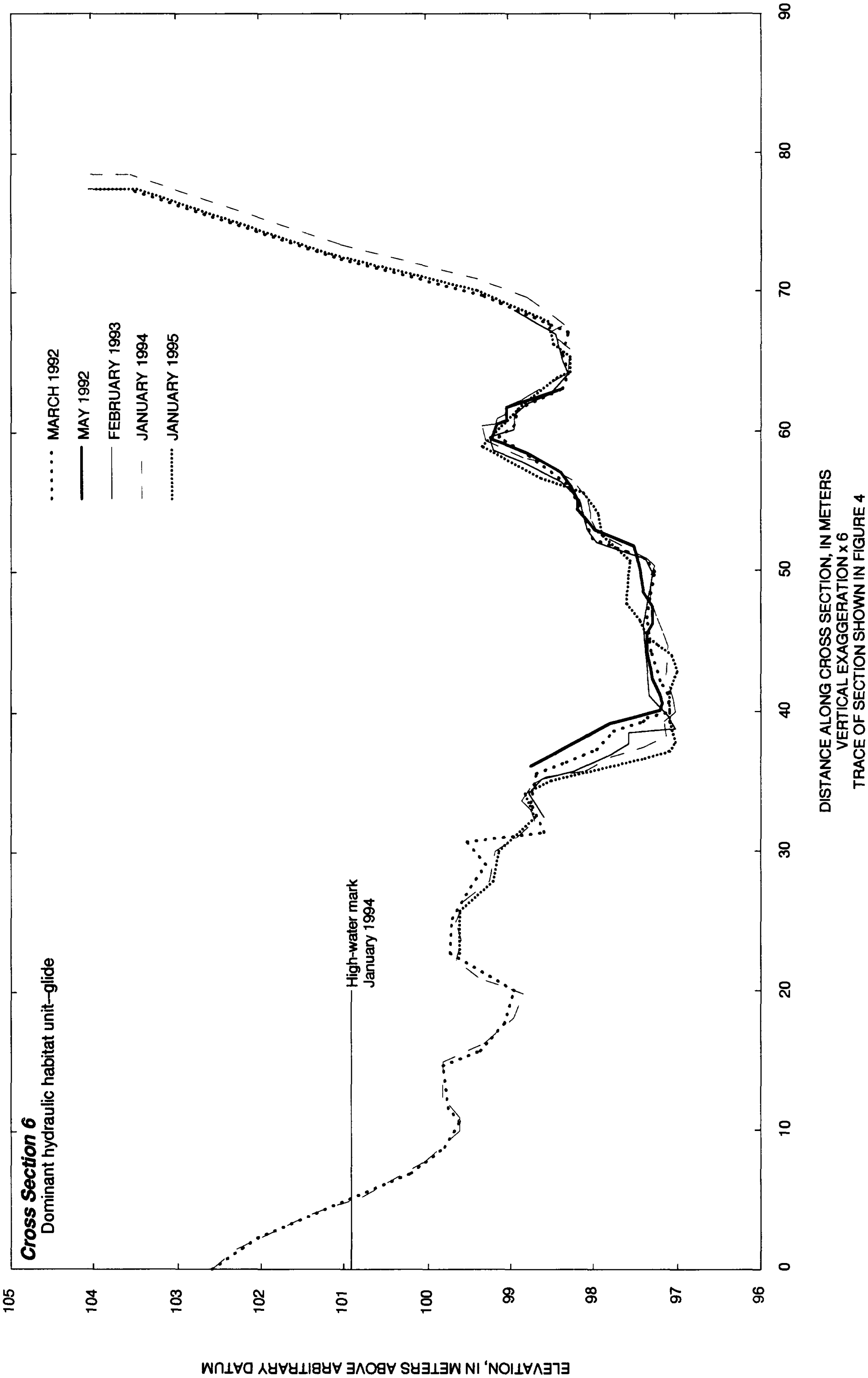


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri—Continued.

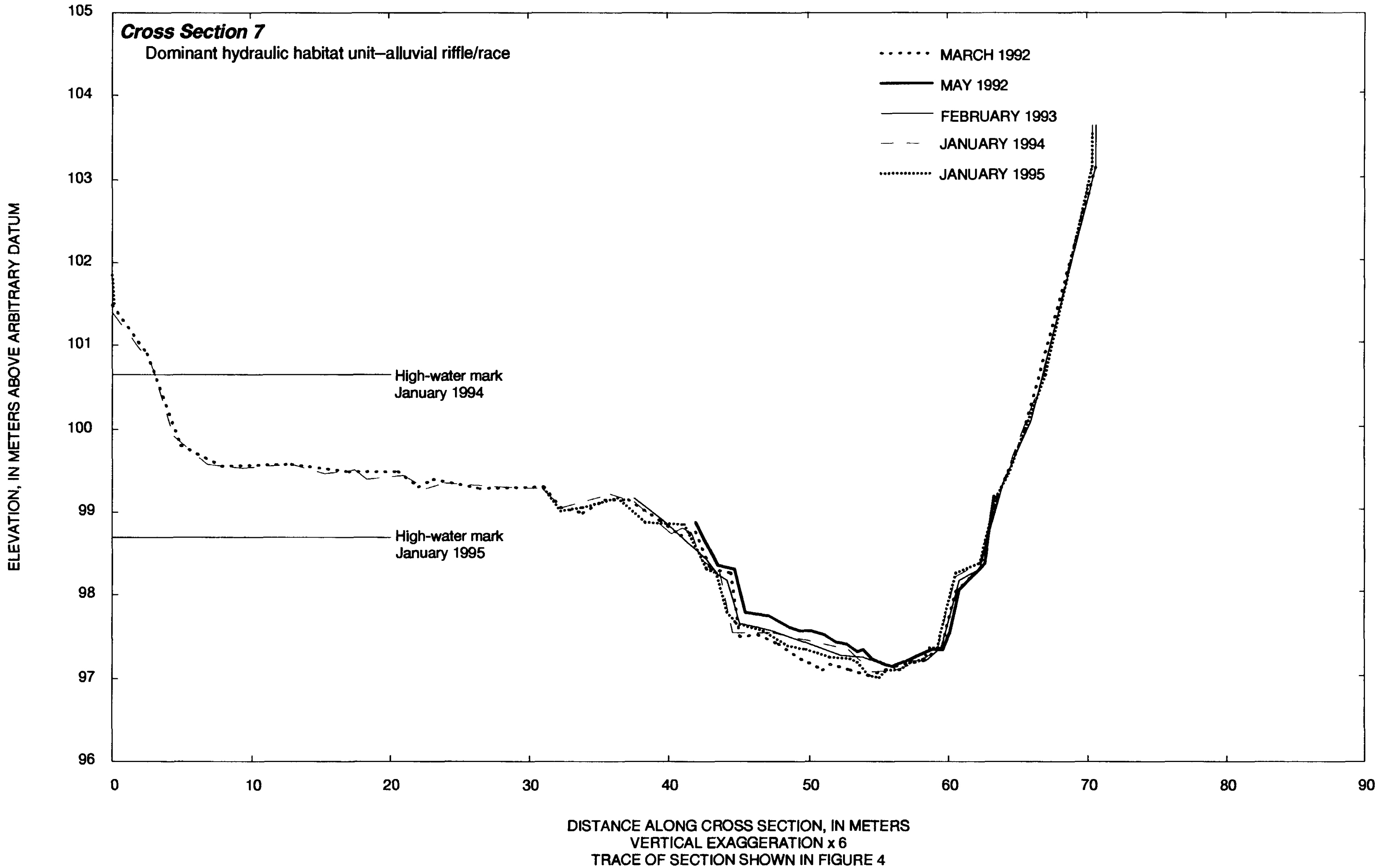


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri–Continued.

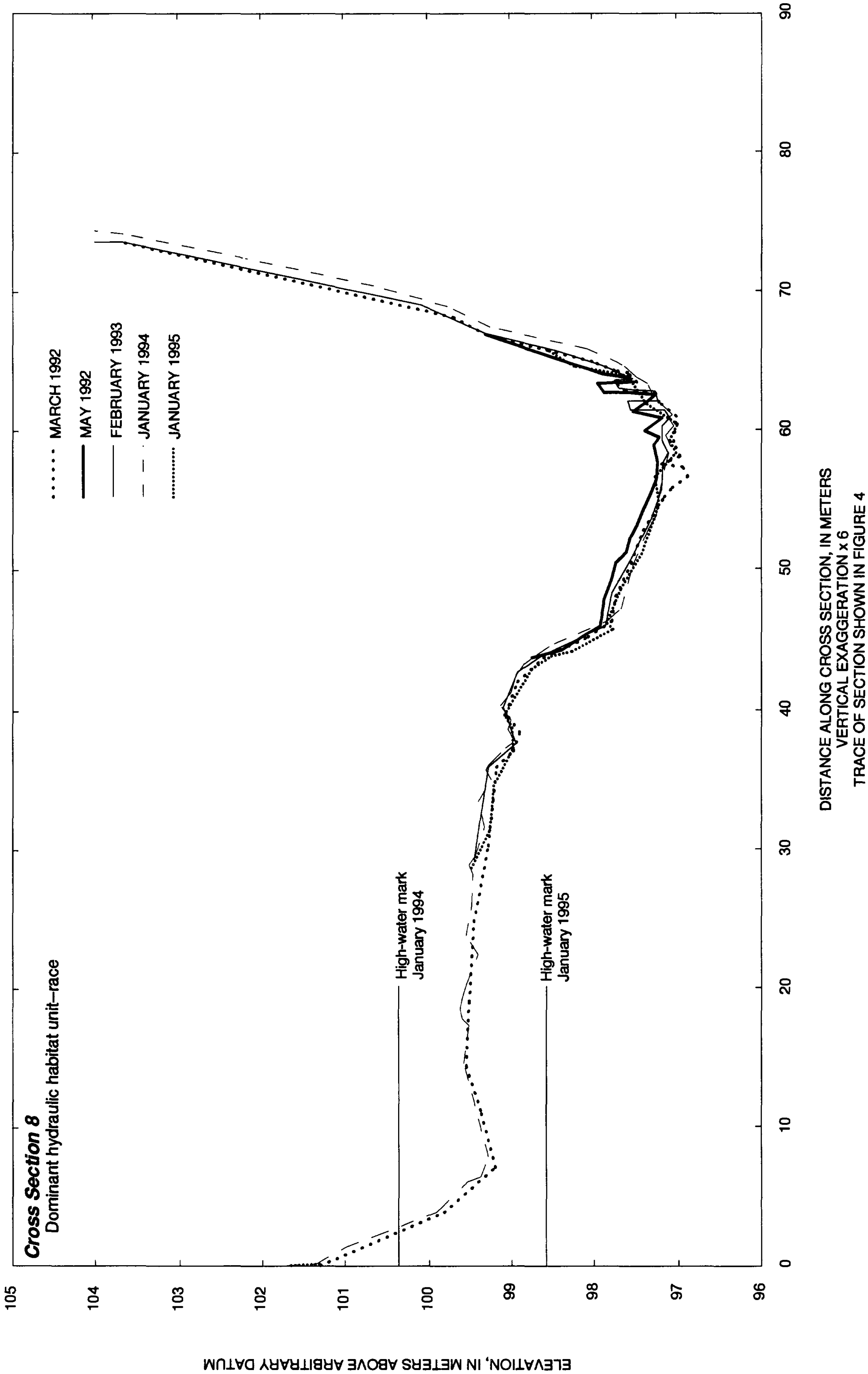


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri—Continued.

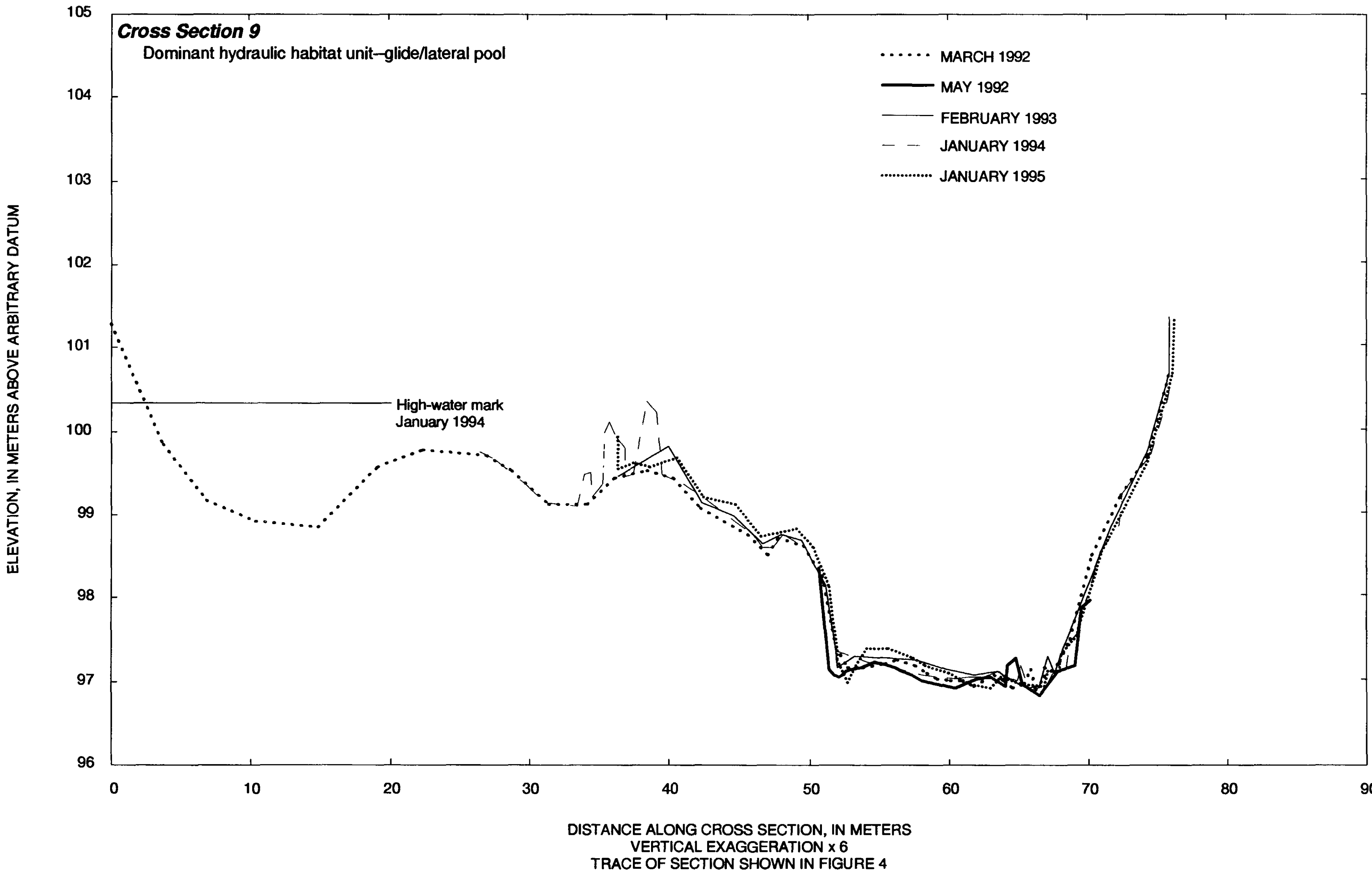


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri—Continued.

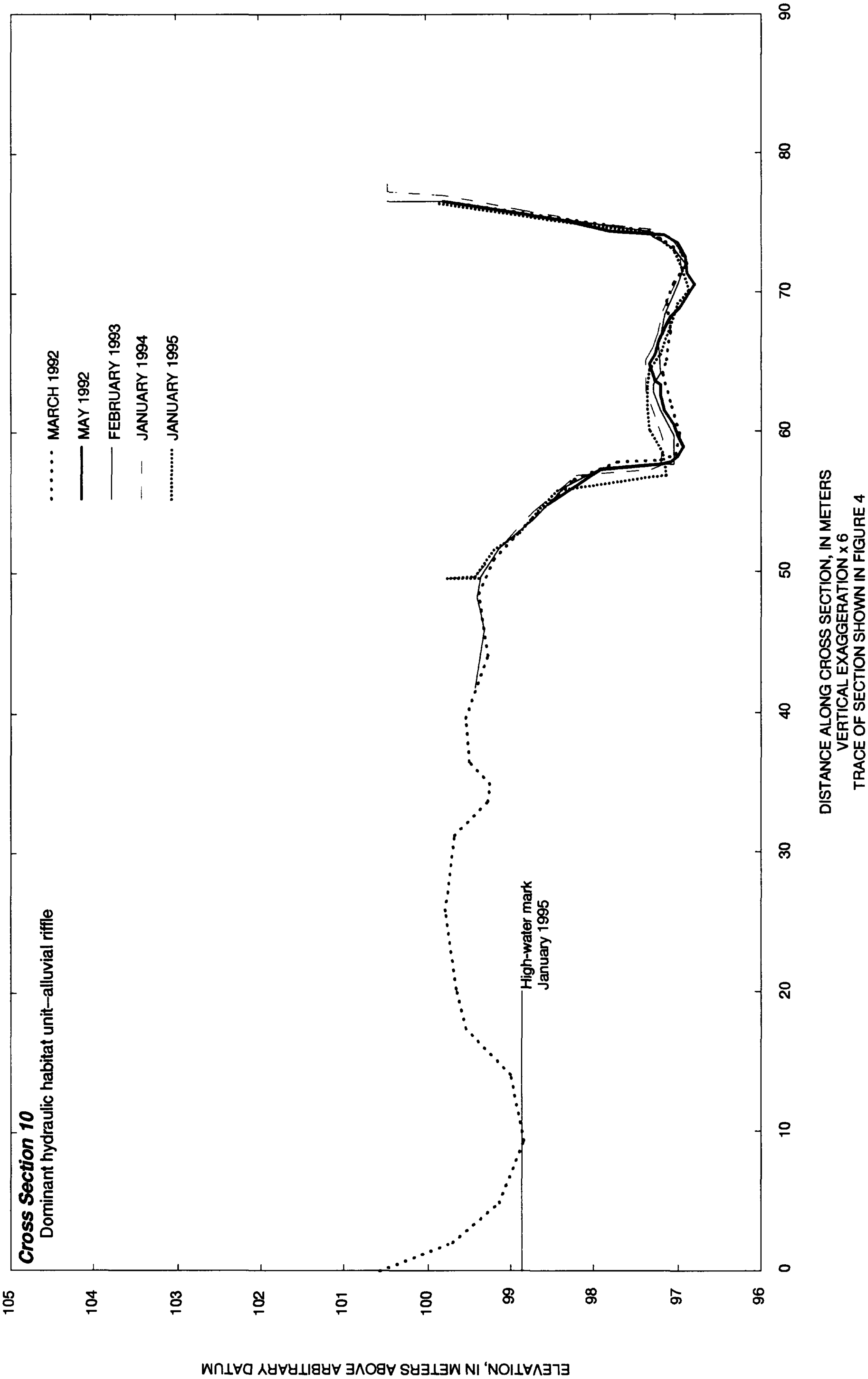


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri—Continued.

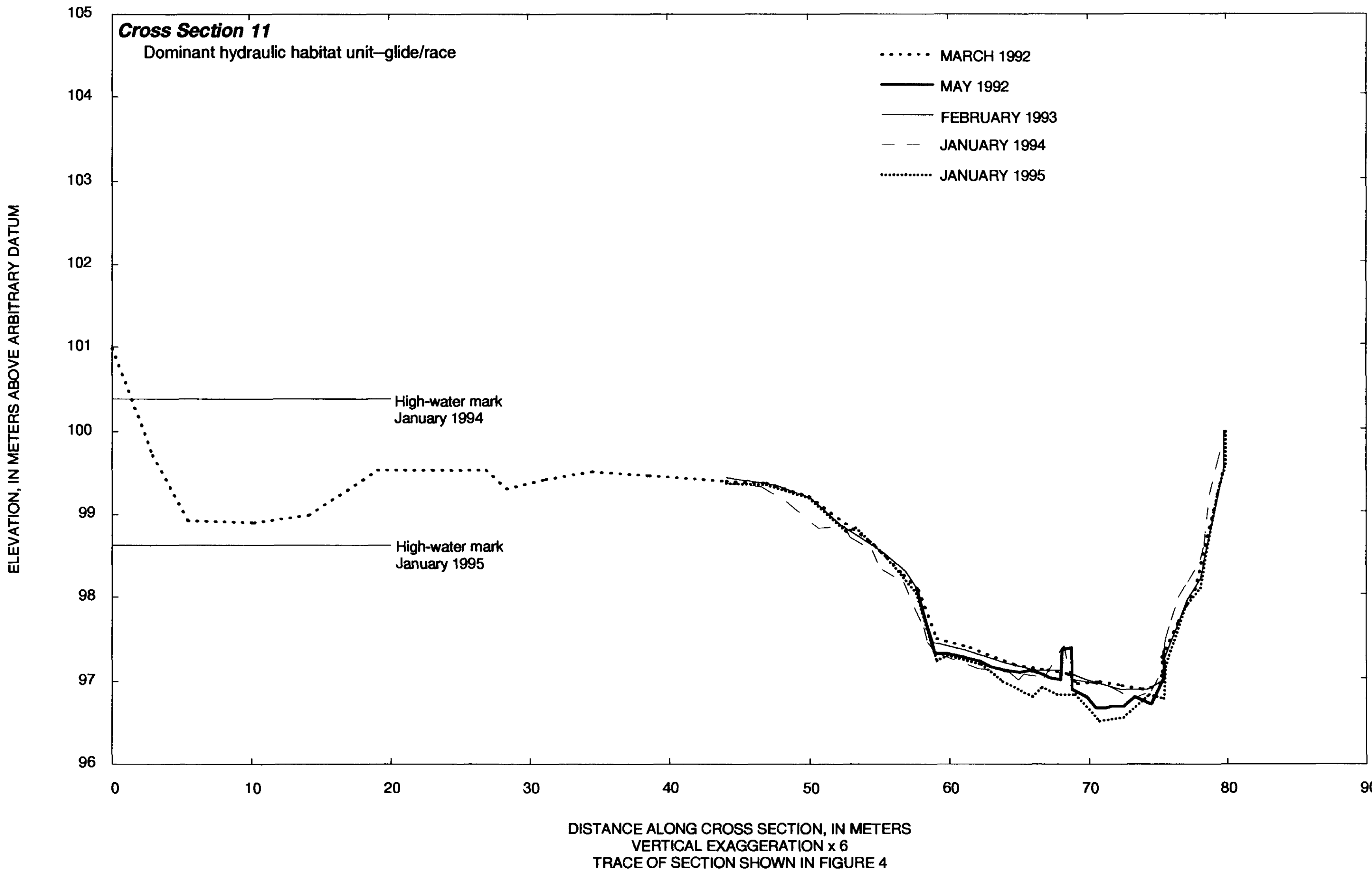


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri—Continued.

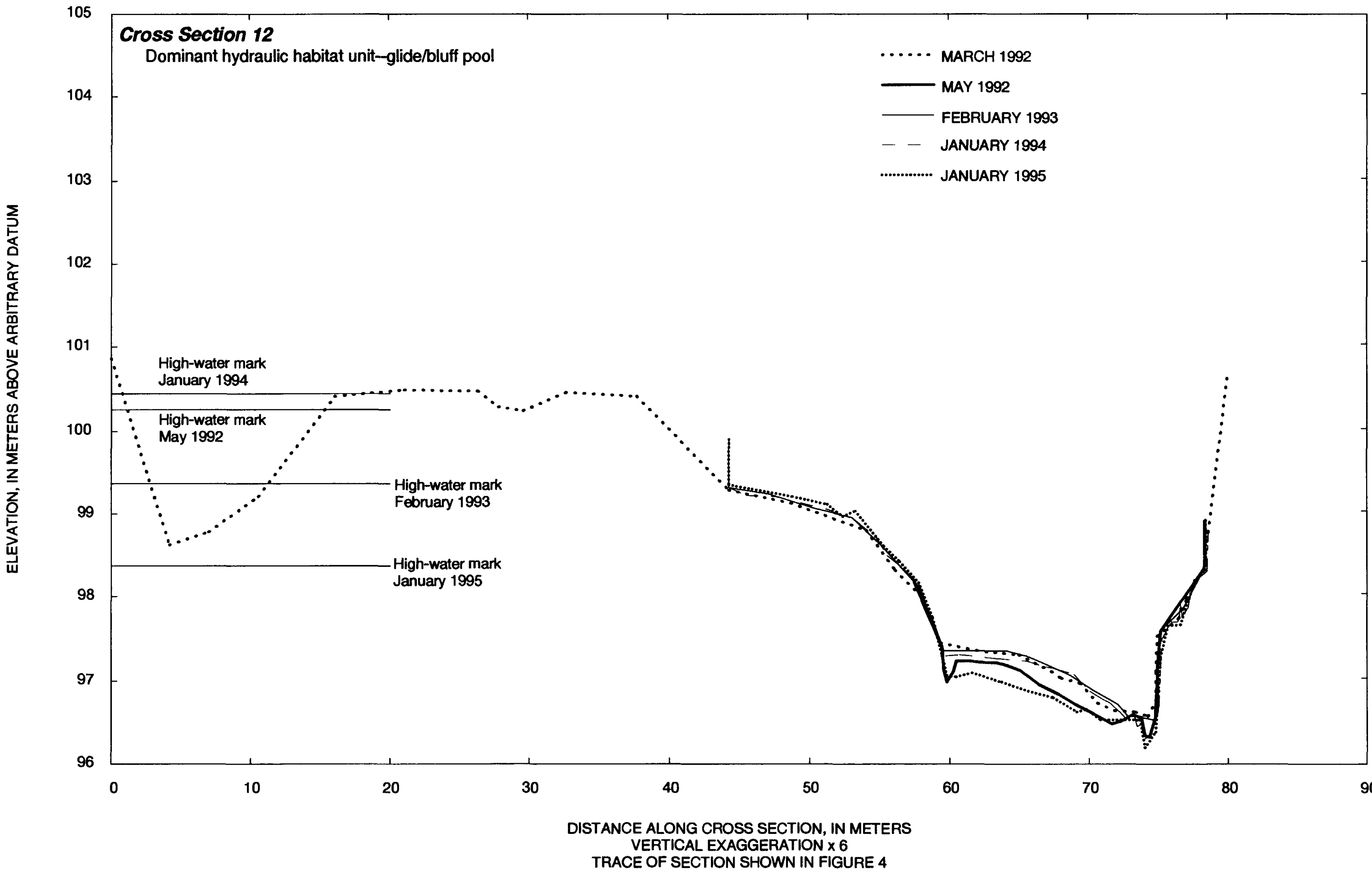


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri—Continued.

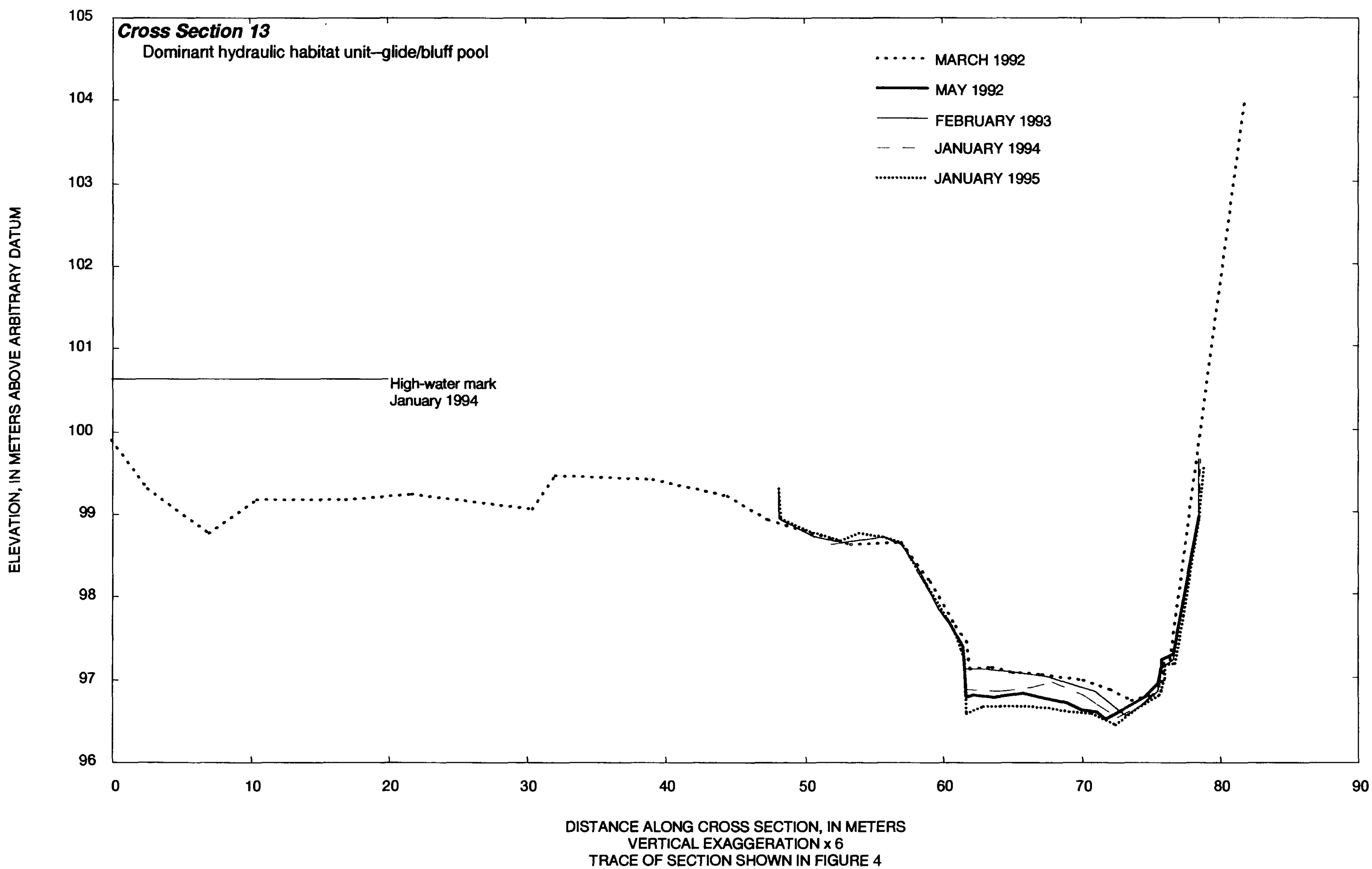


Figure 21. Cross sections located at Fox Farm reach, Jacks Fork, Missouri --Continued.

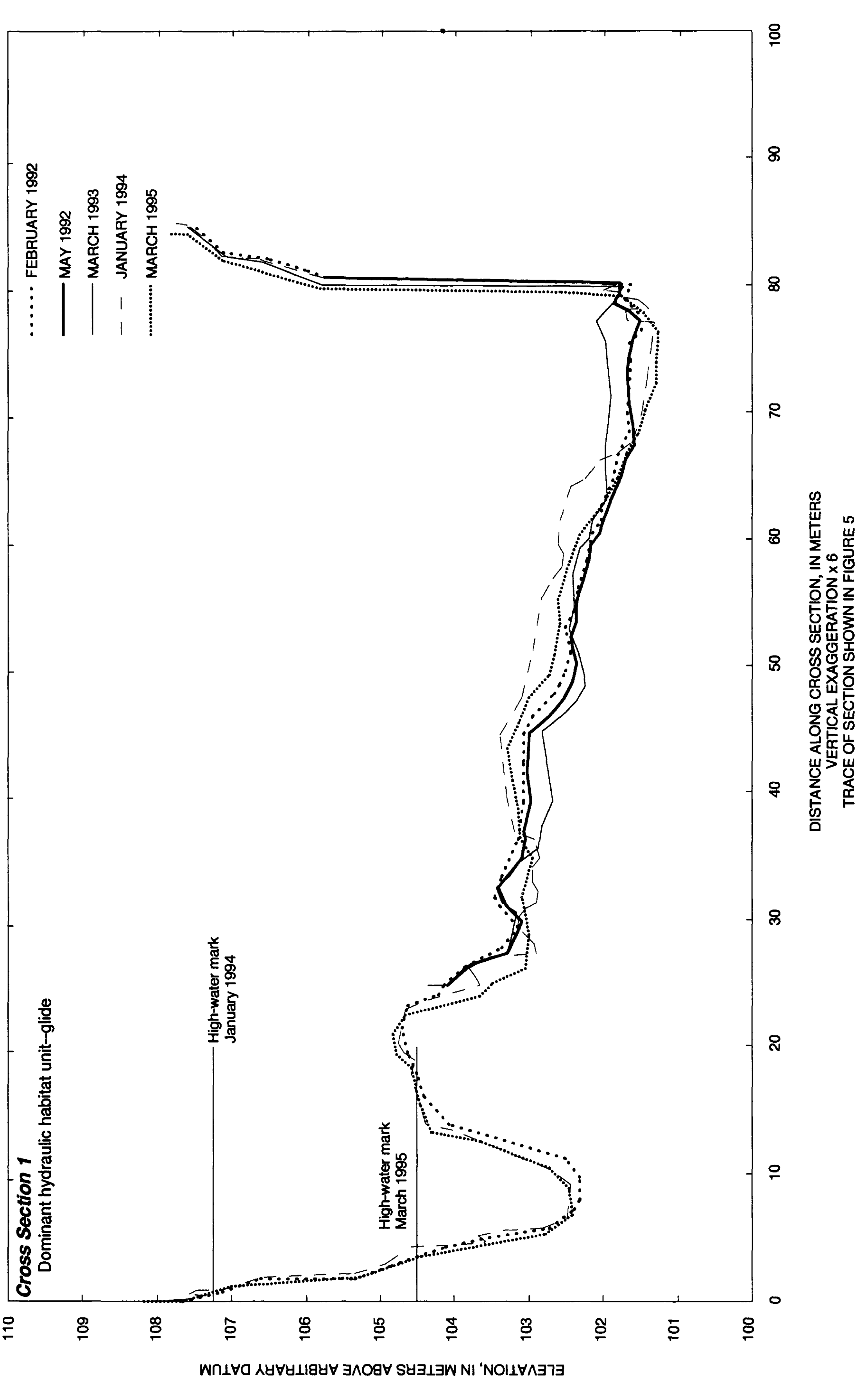


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri.

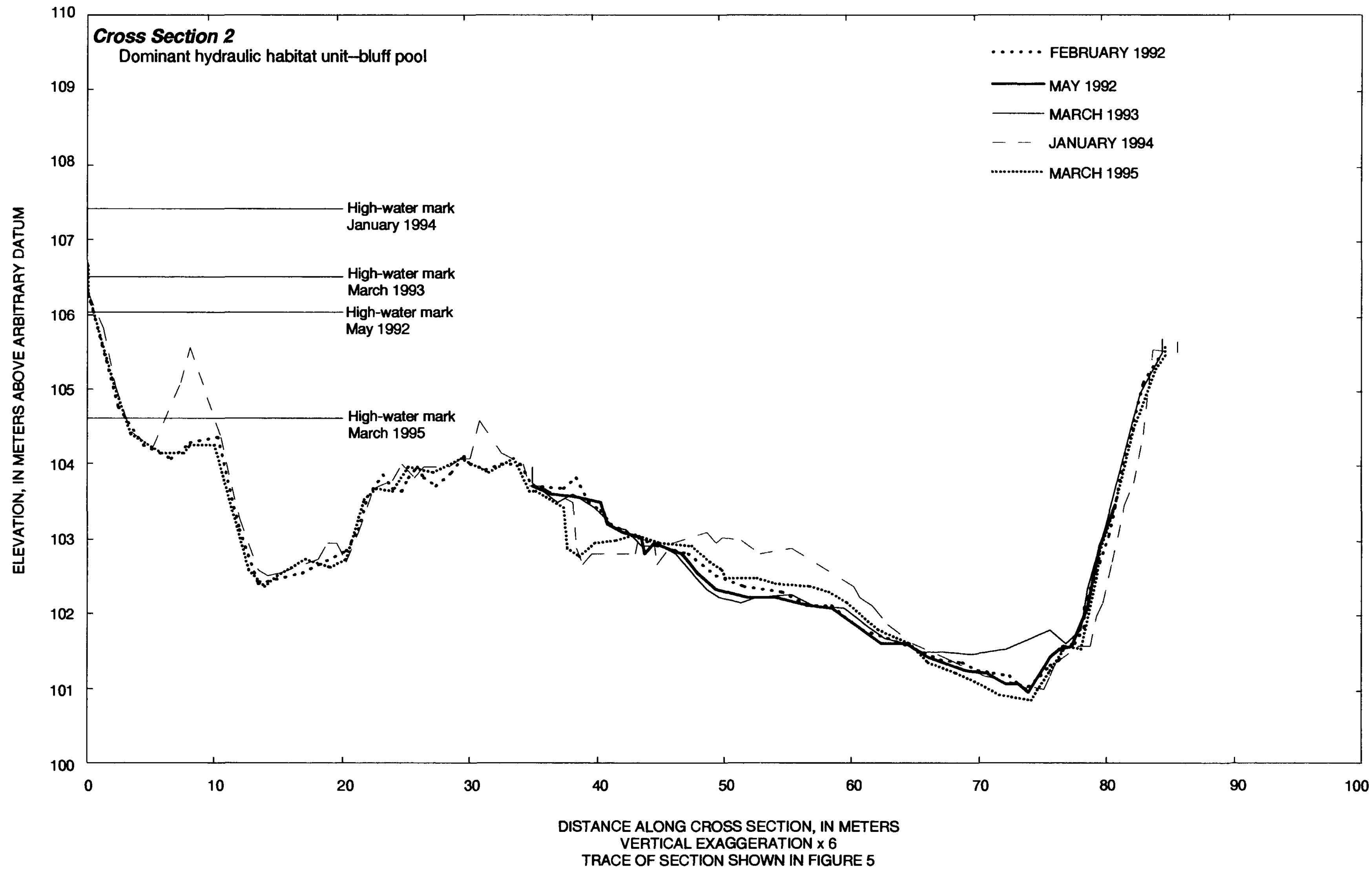


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri–Continued.

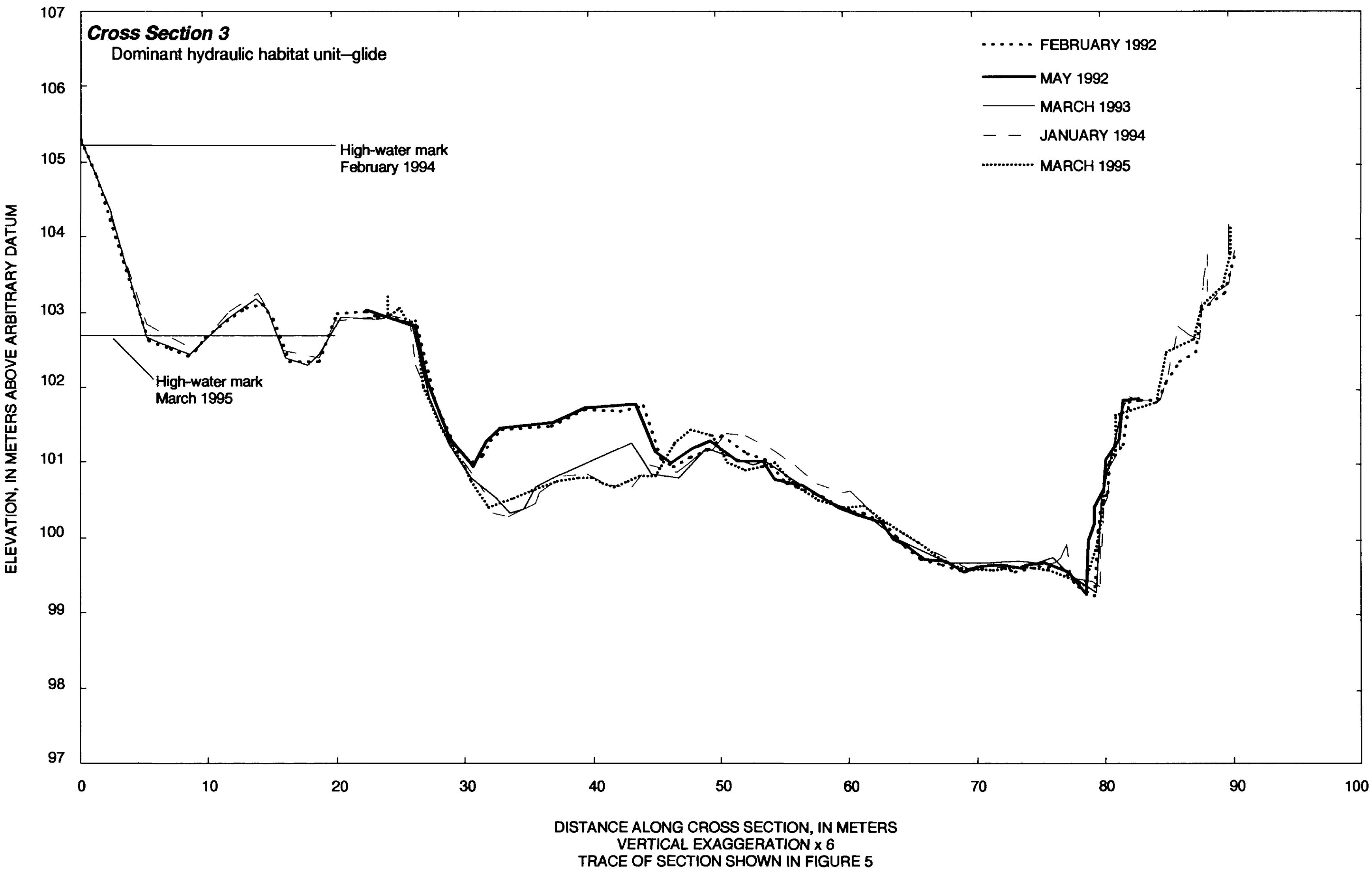


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri—Continued.

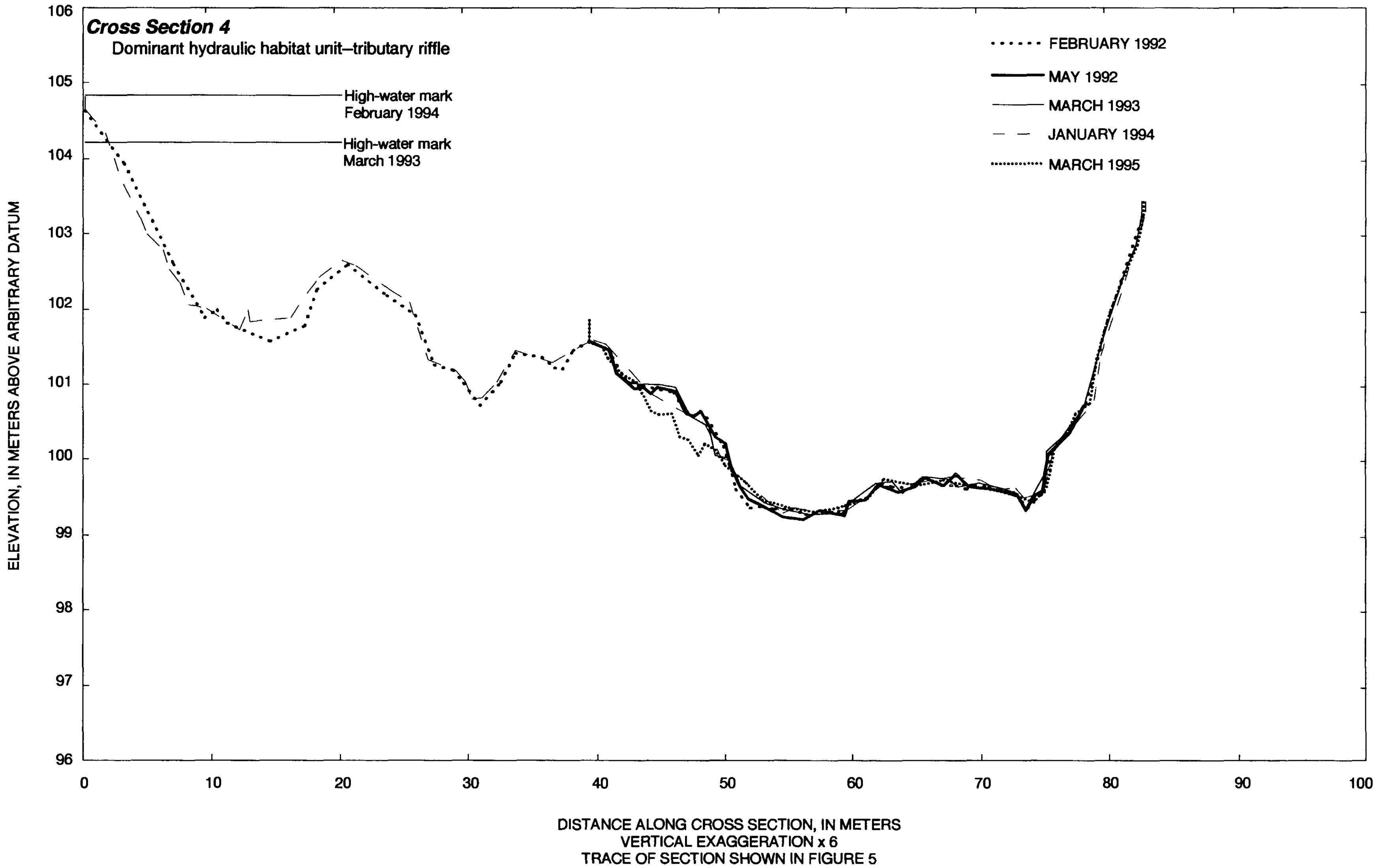


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri–Continued.

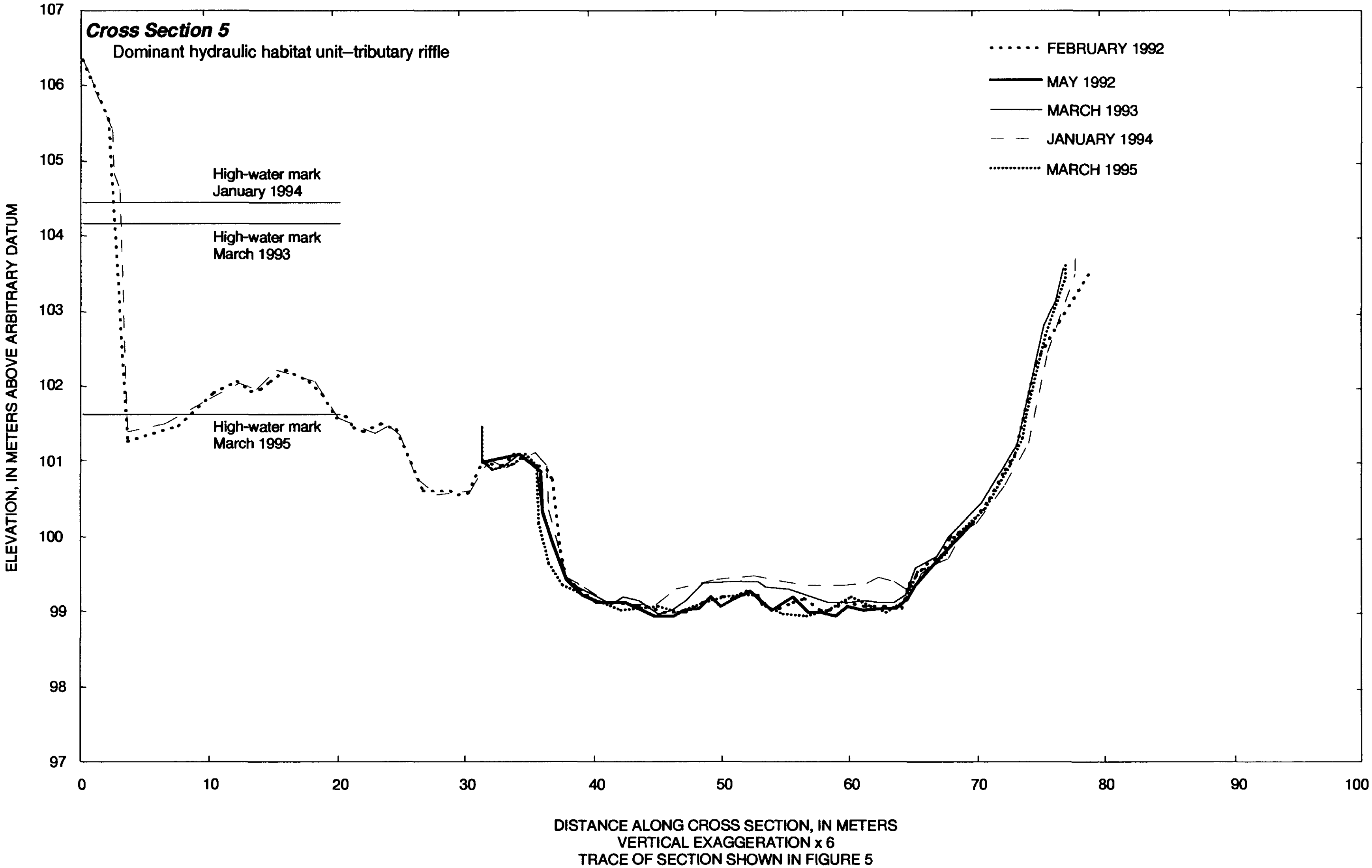


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri–Continued.

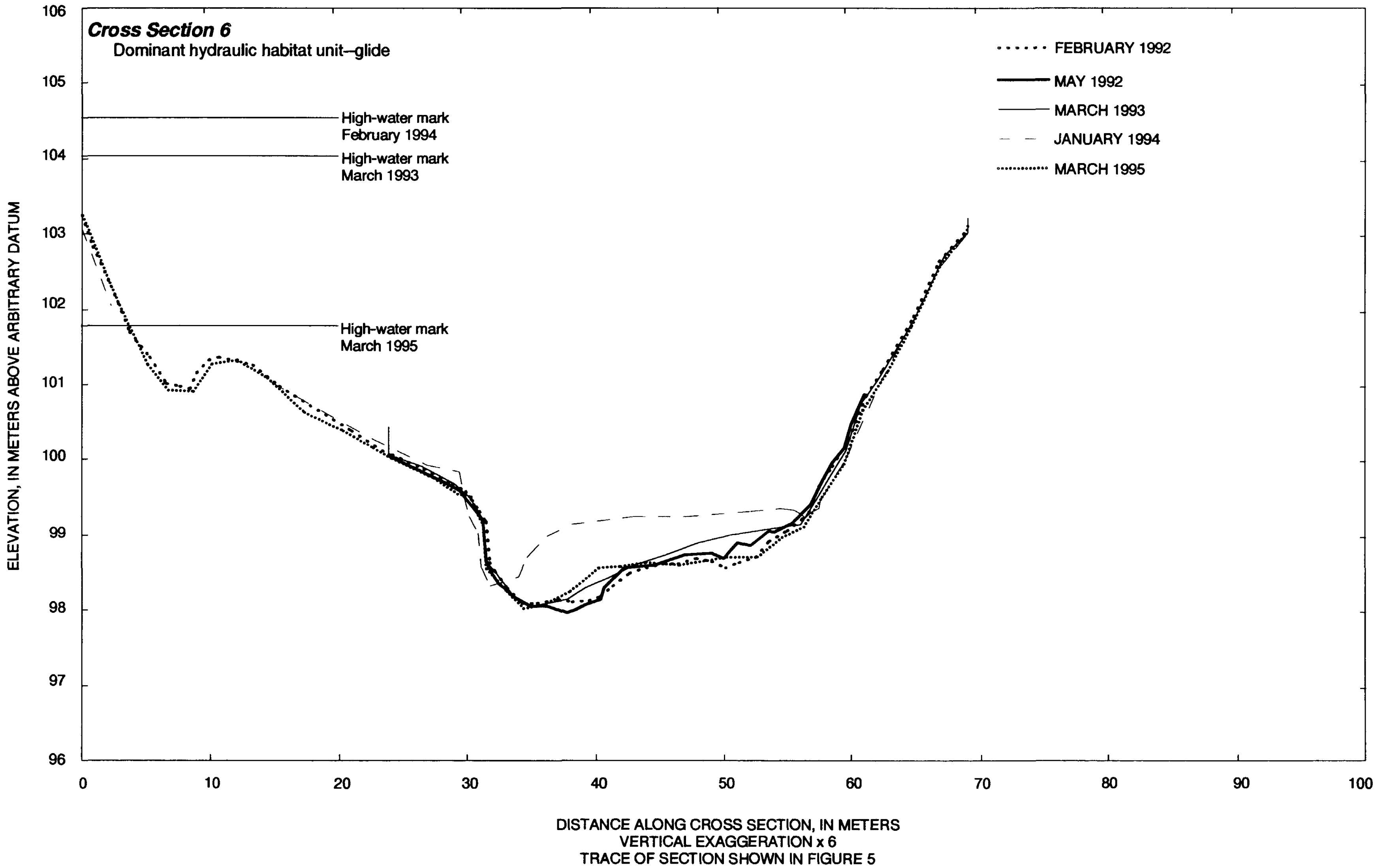


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri–Continued.

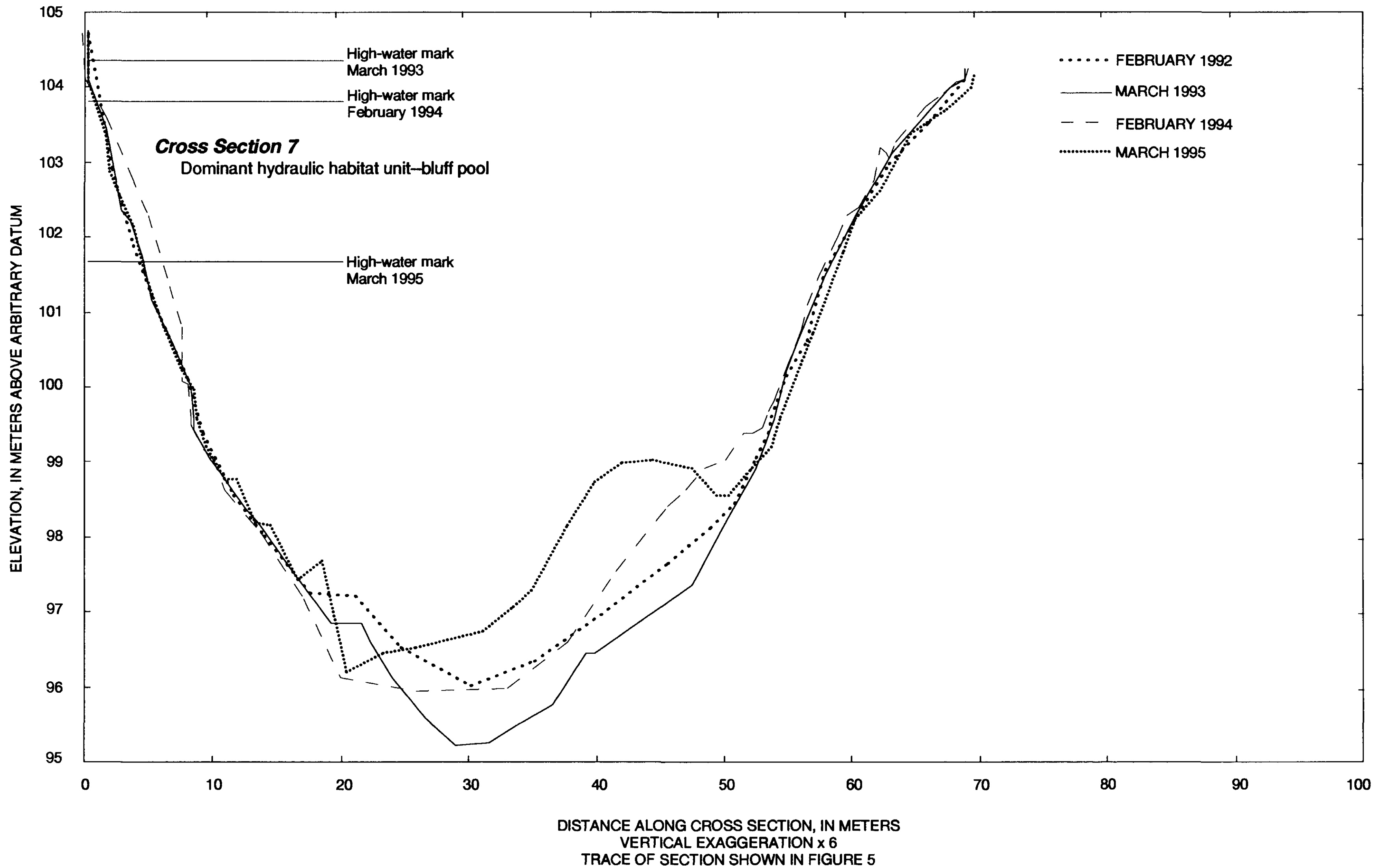


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri--Continued.

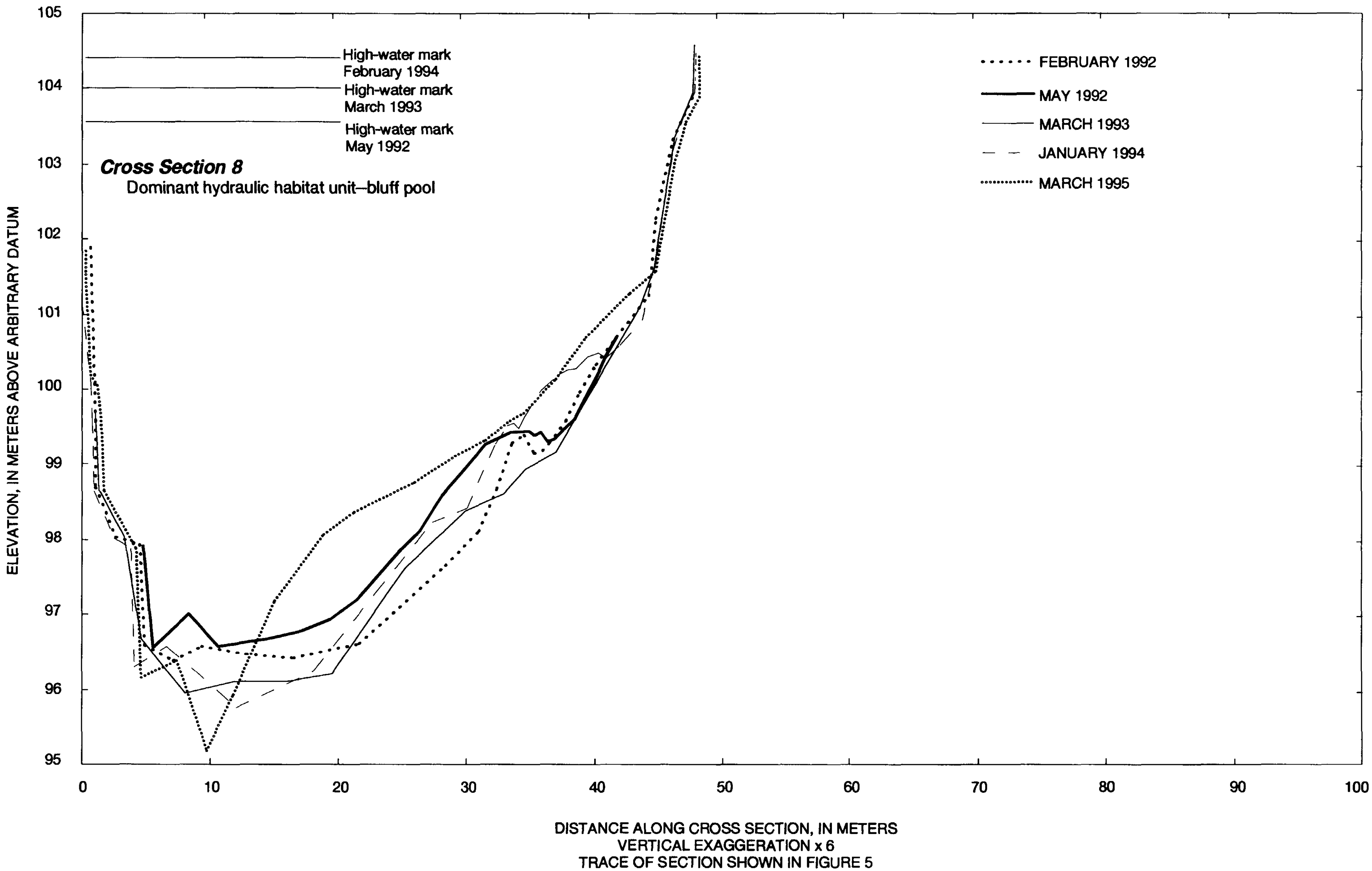


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri–Continued.

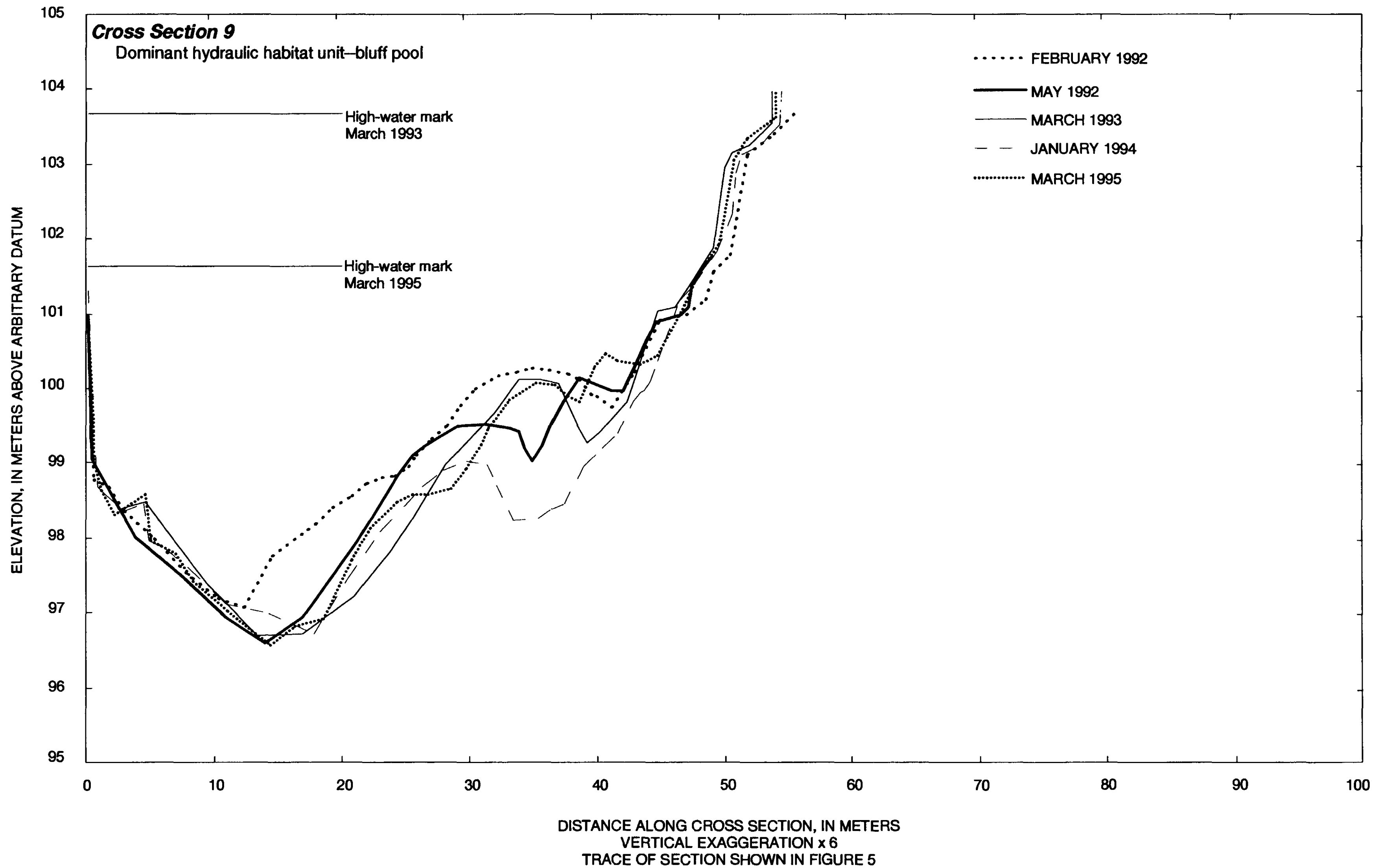


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri–Continued.

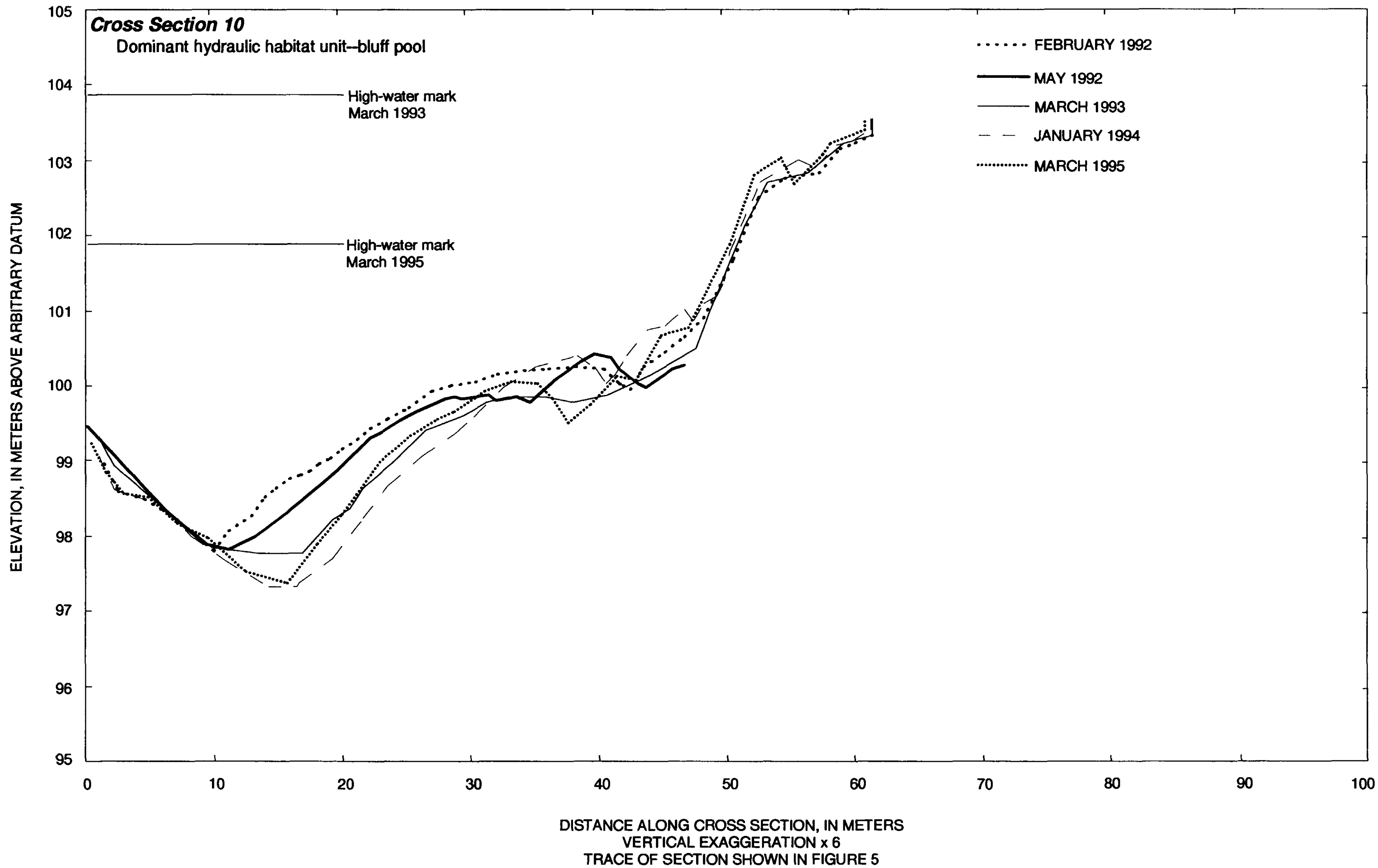


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri--Continued.

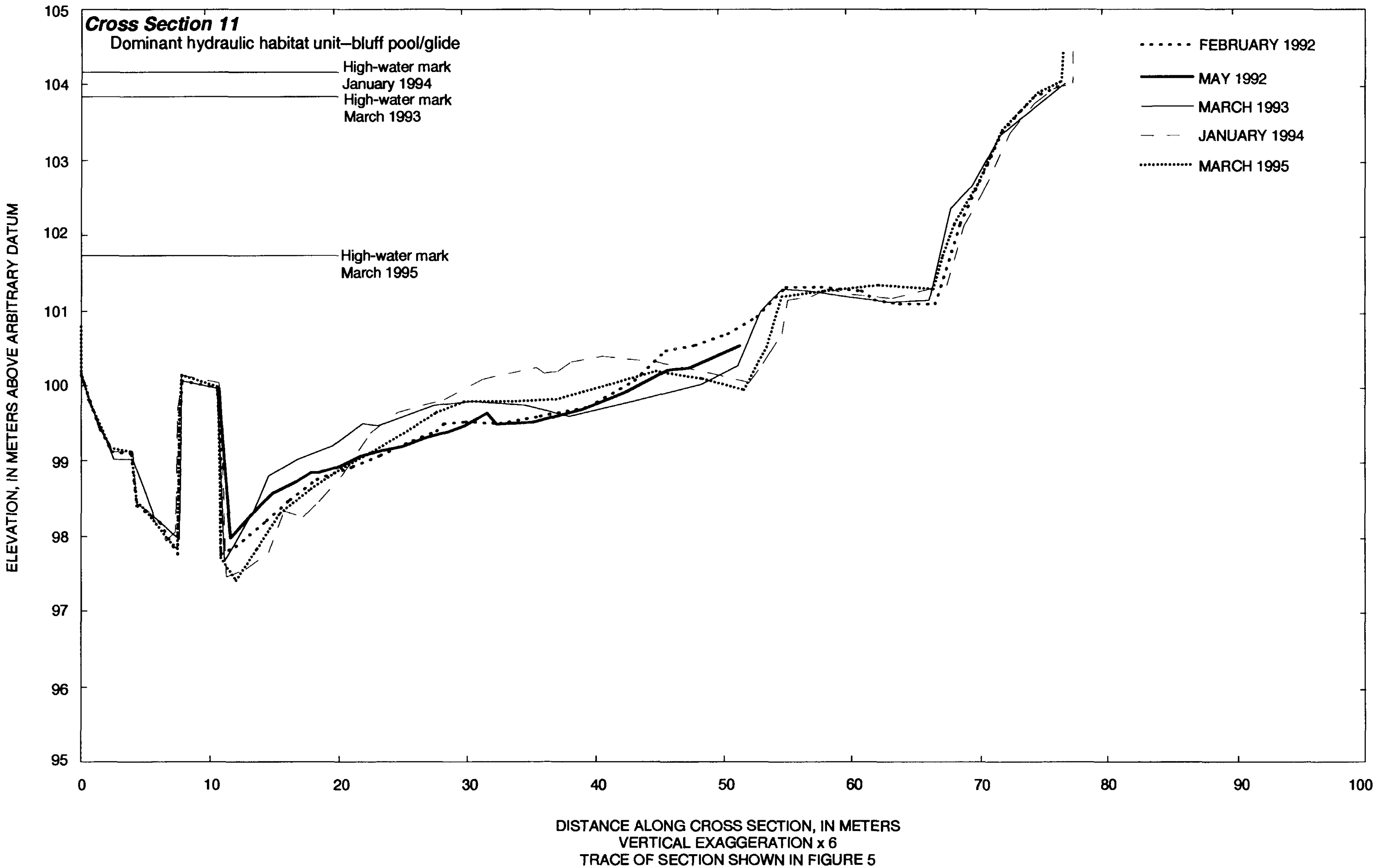


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri—Continued.

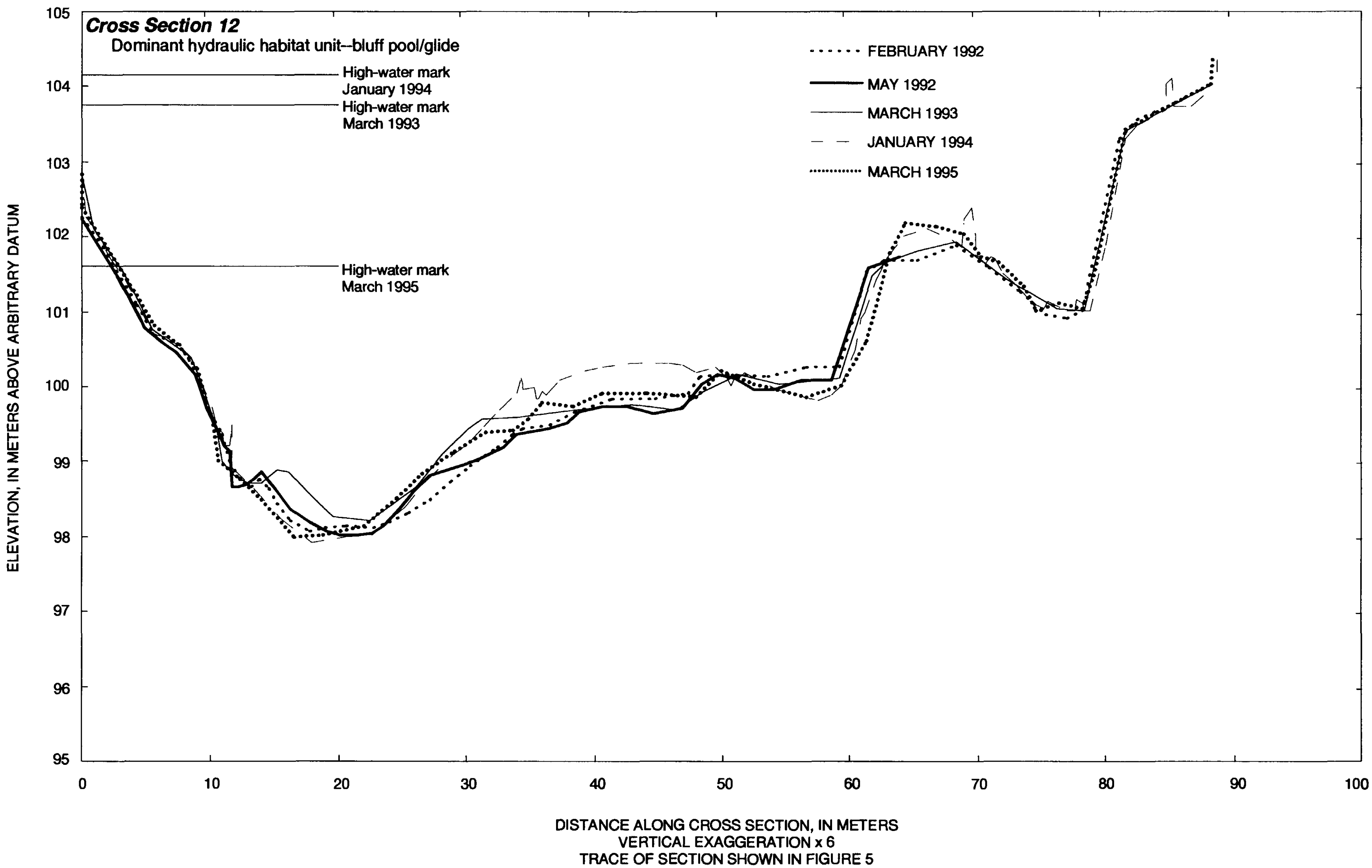


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri—Continued.

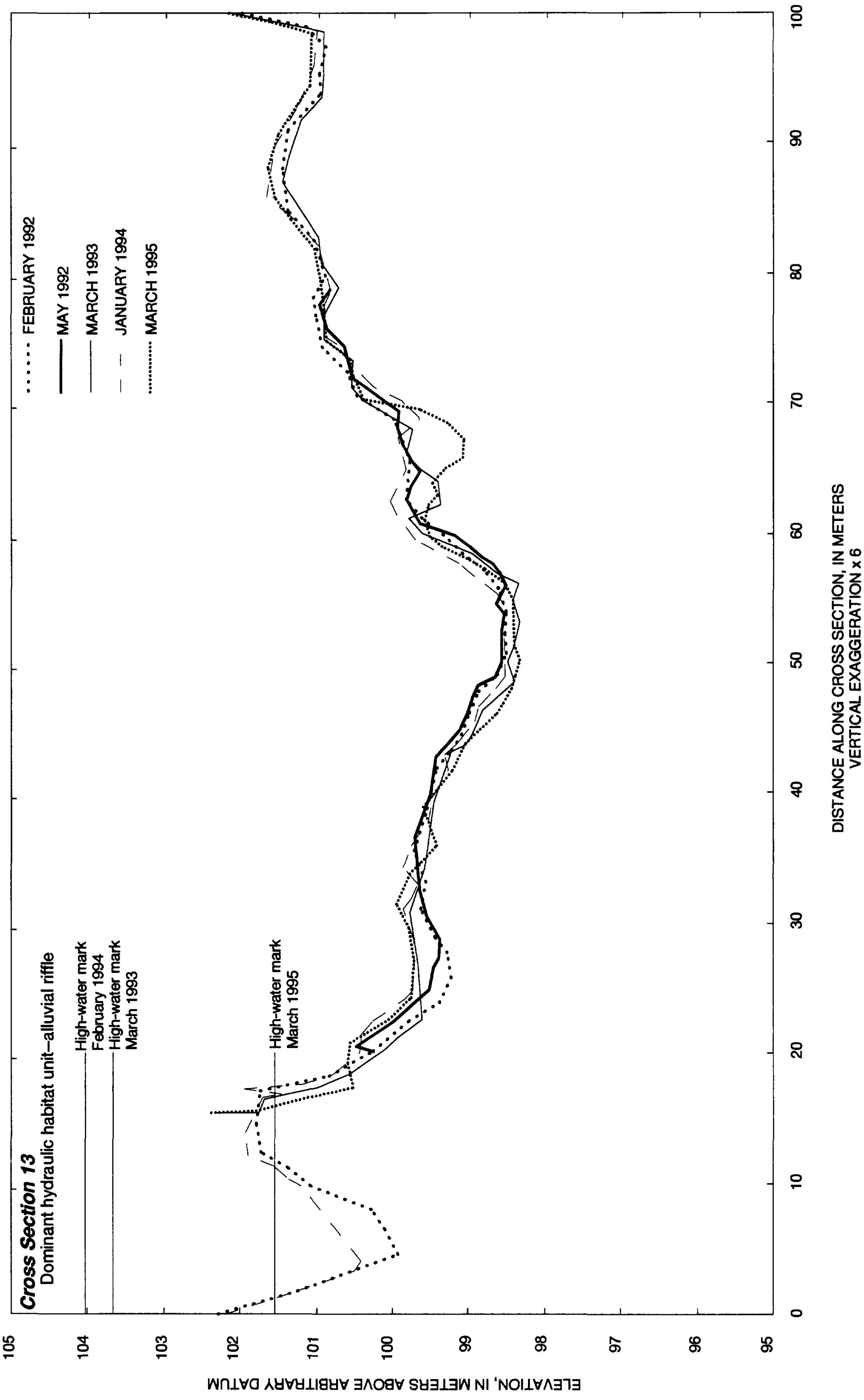


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri—Continued.

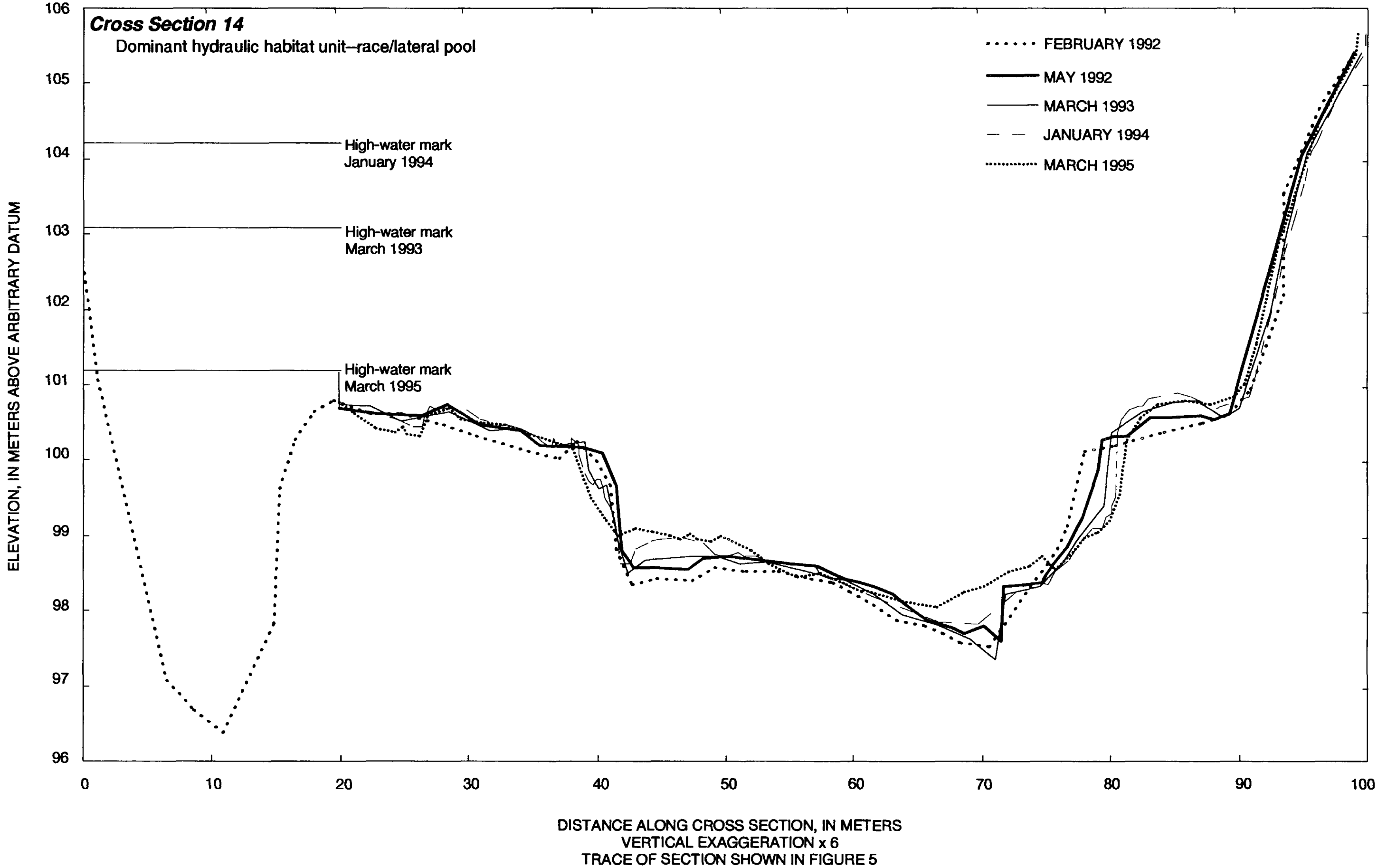
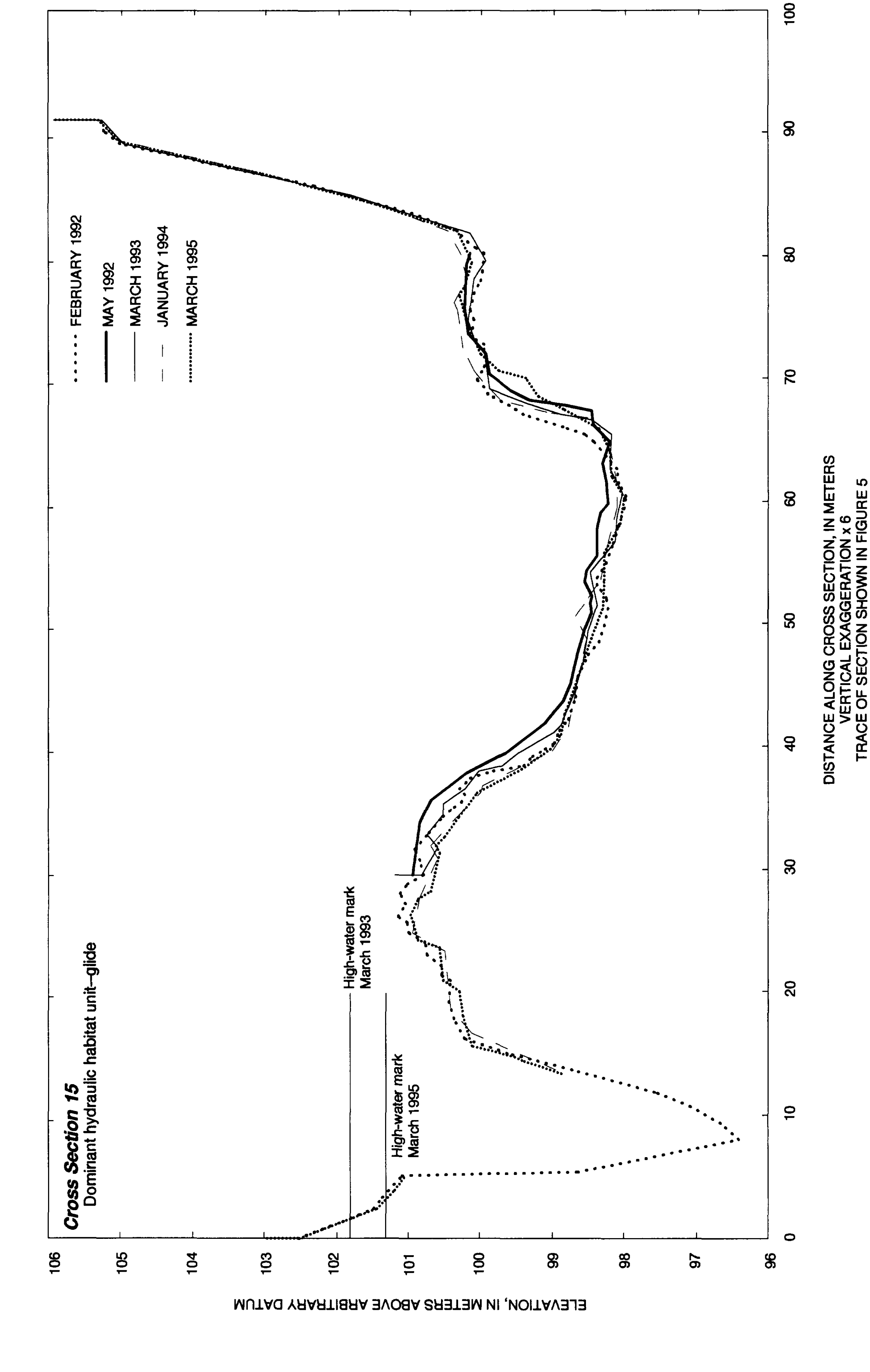


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri—Continued.



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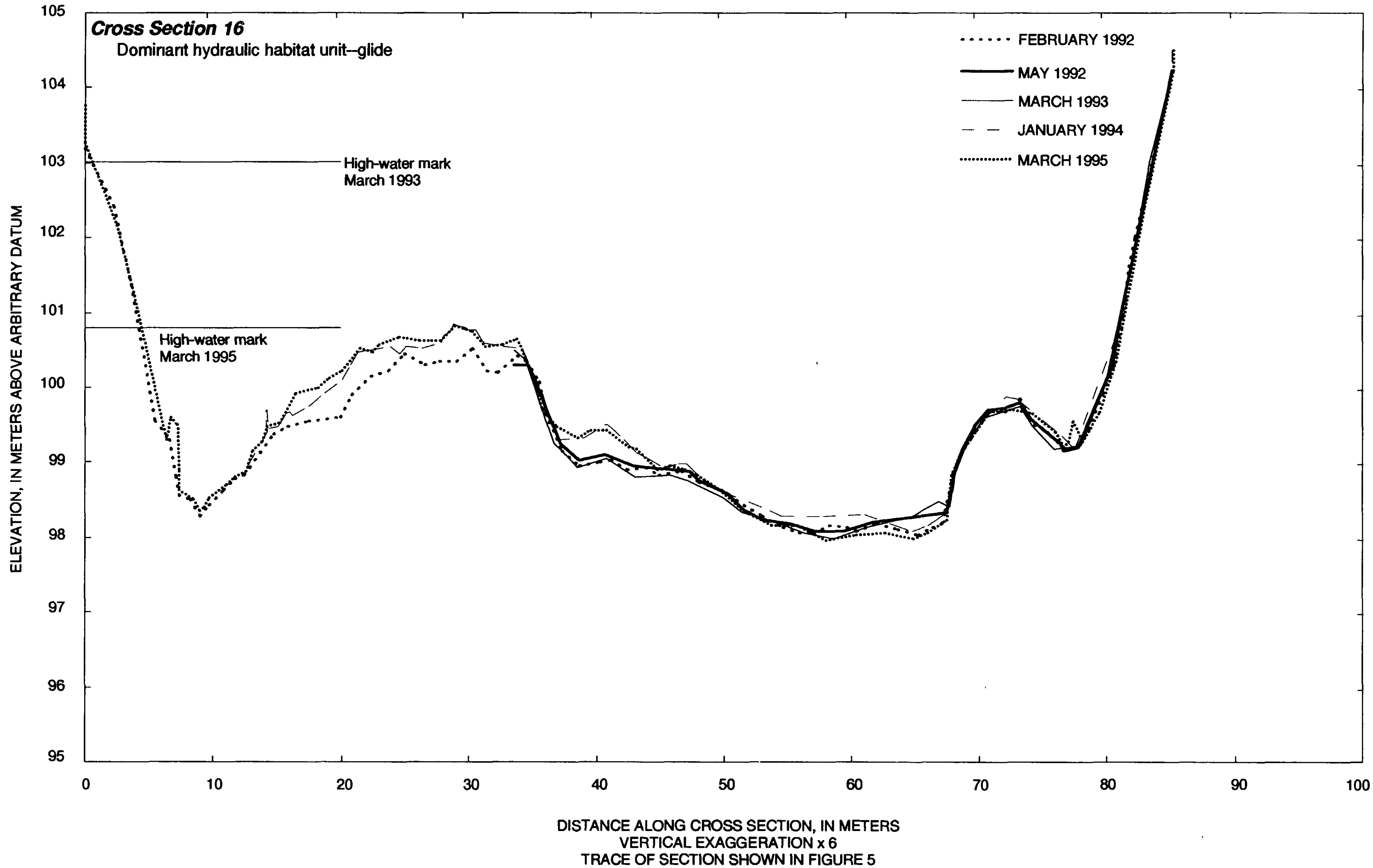


Figure 22. Cross sections located at Ratcliff Ford reach, Jacks Fork, Missouri–Continued.

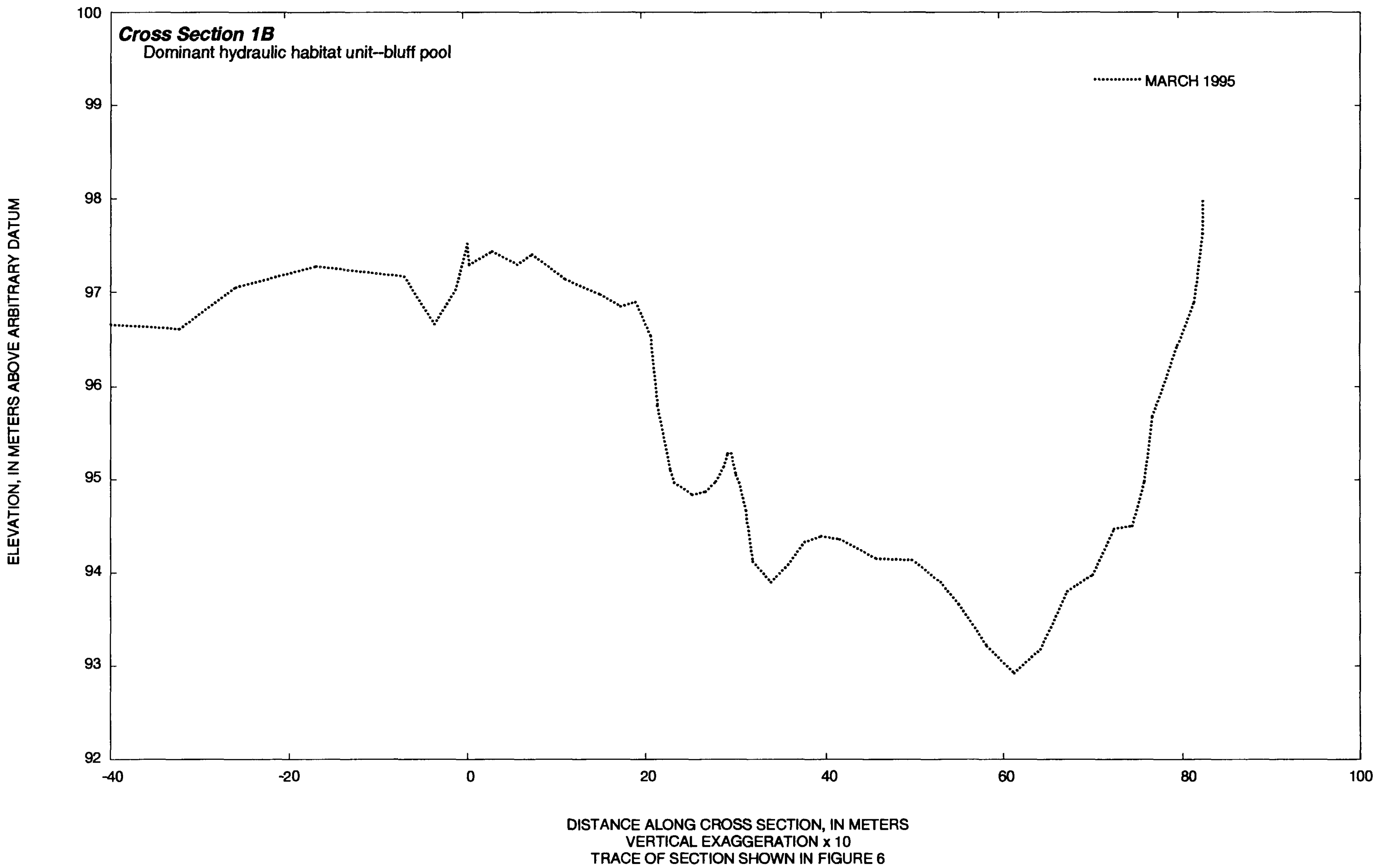


Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri.

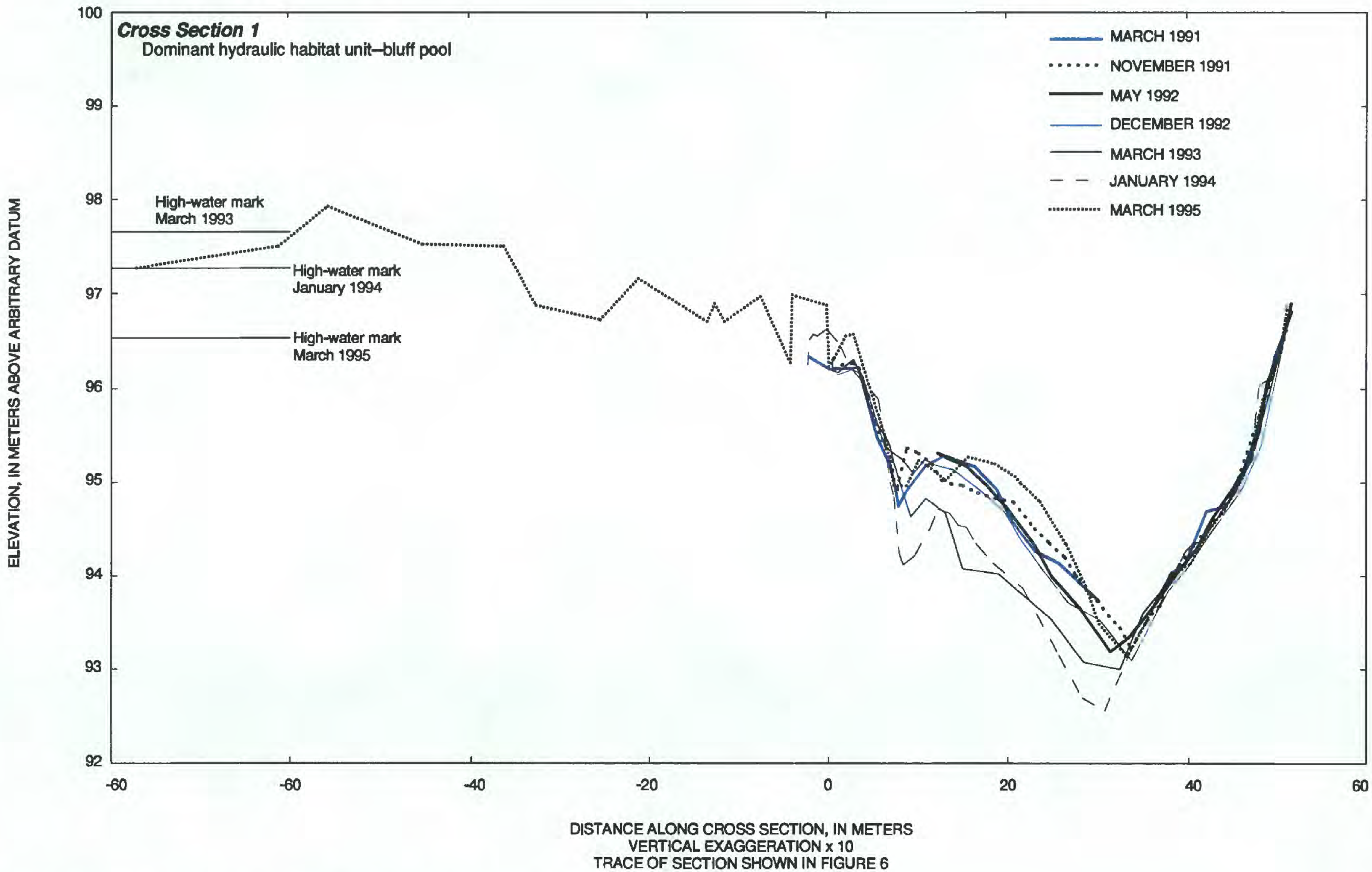


Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri–Continued.

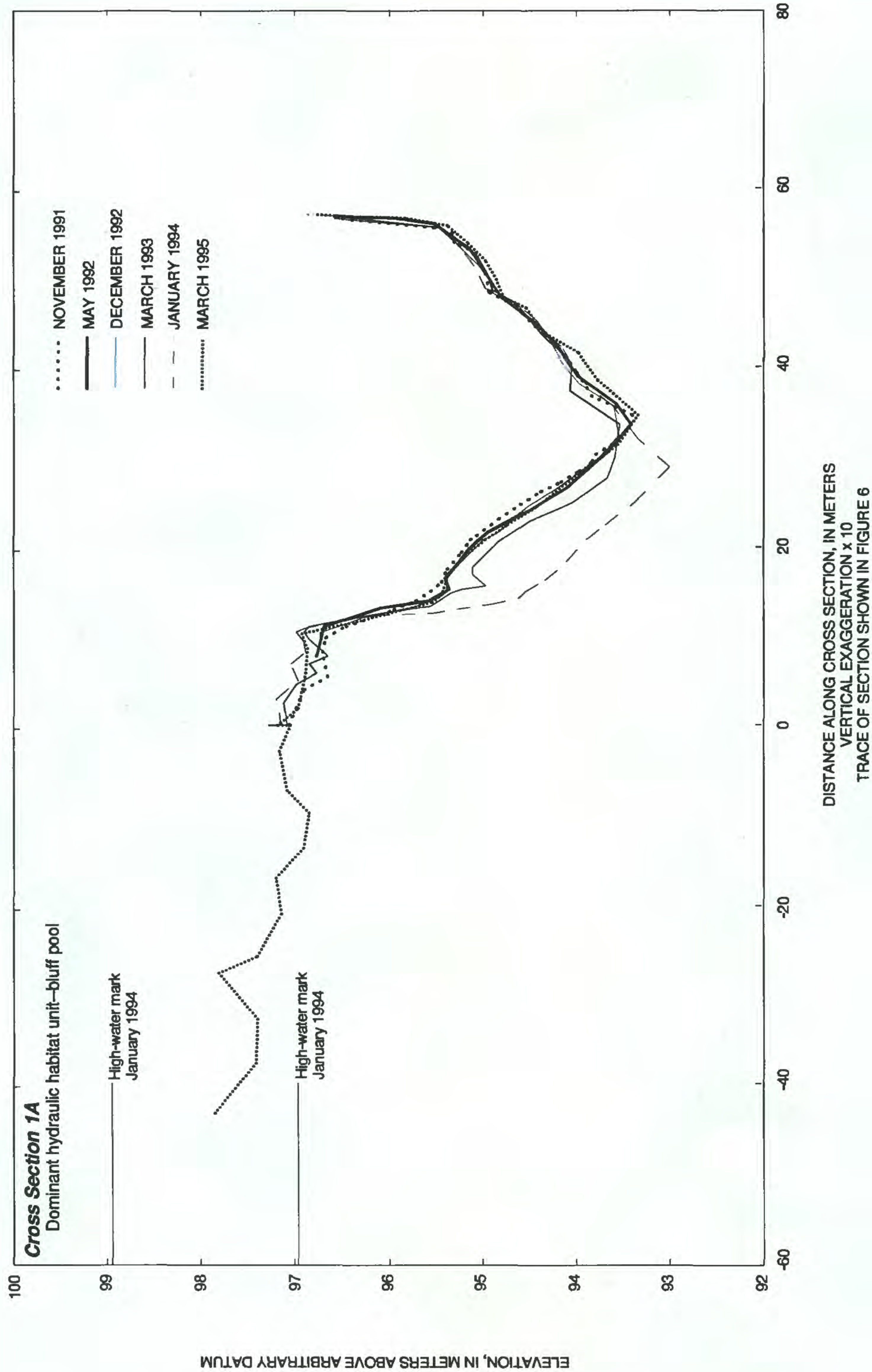
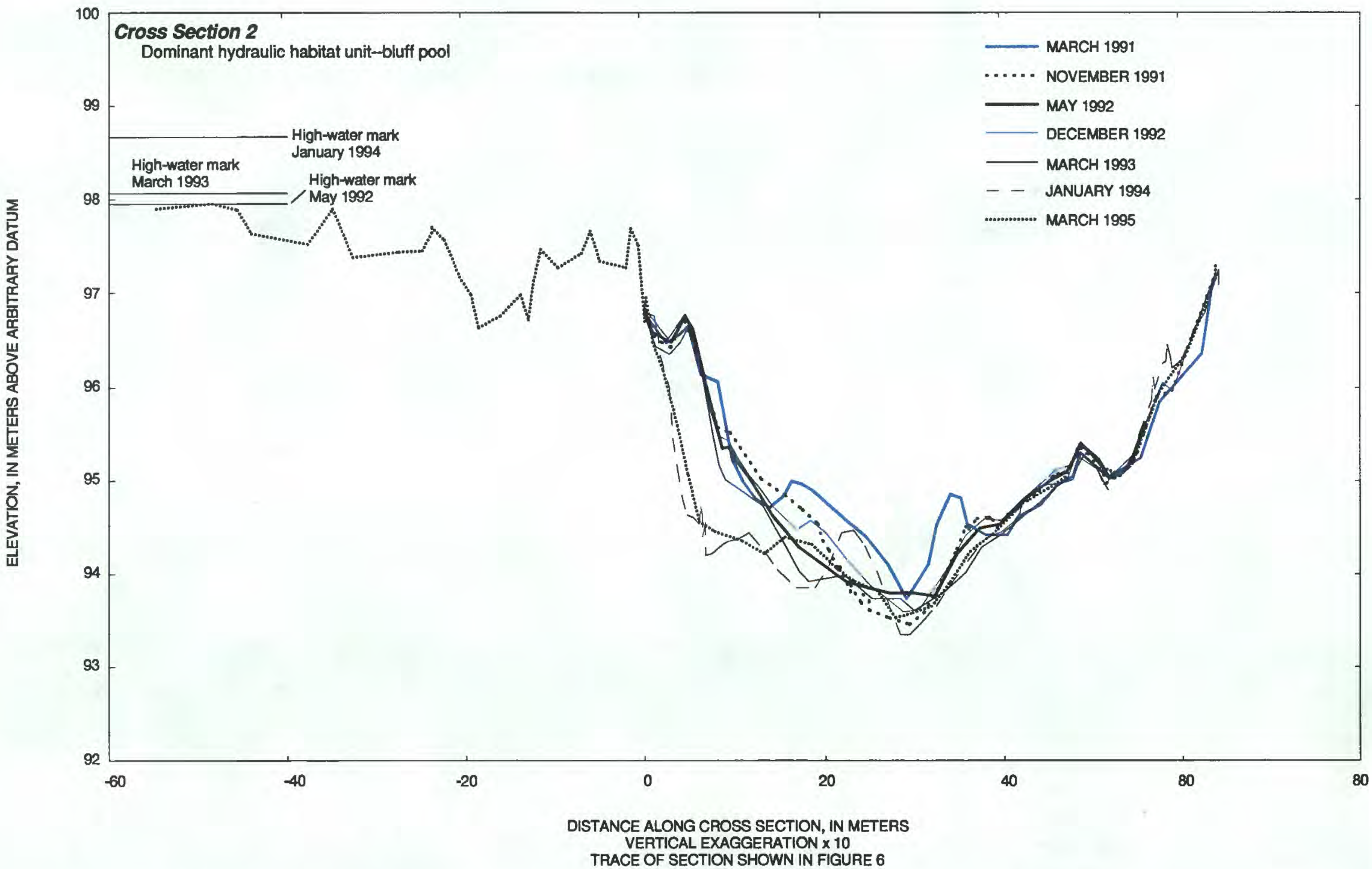


Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri --Continued.



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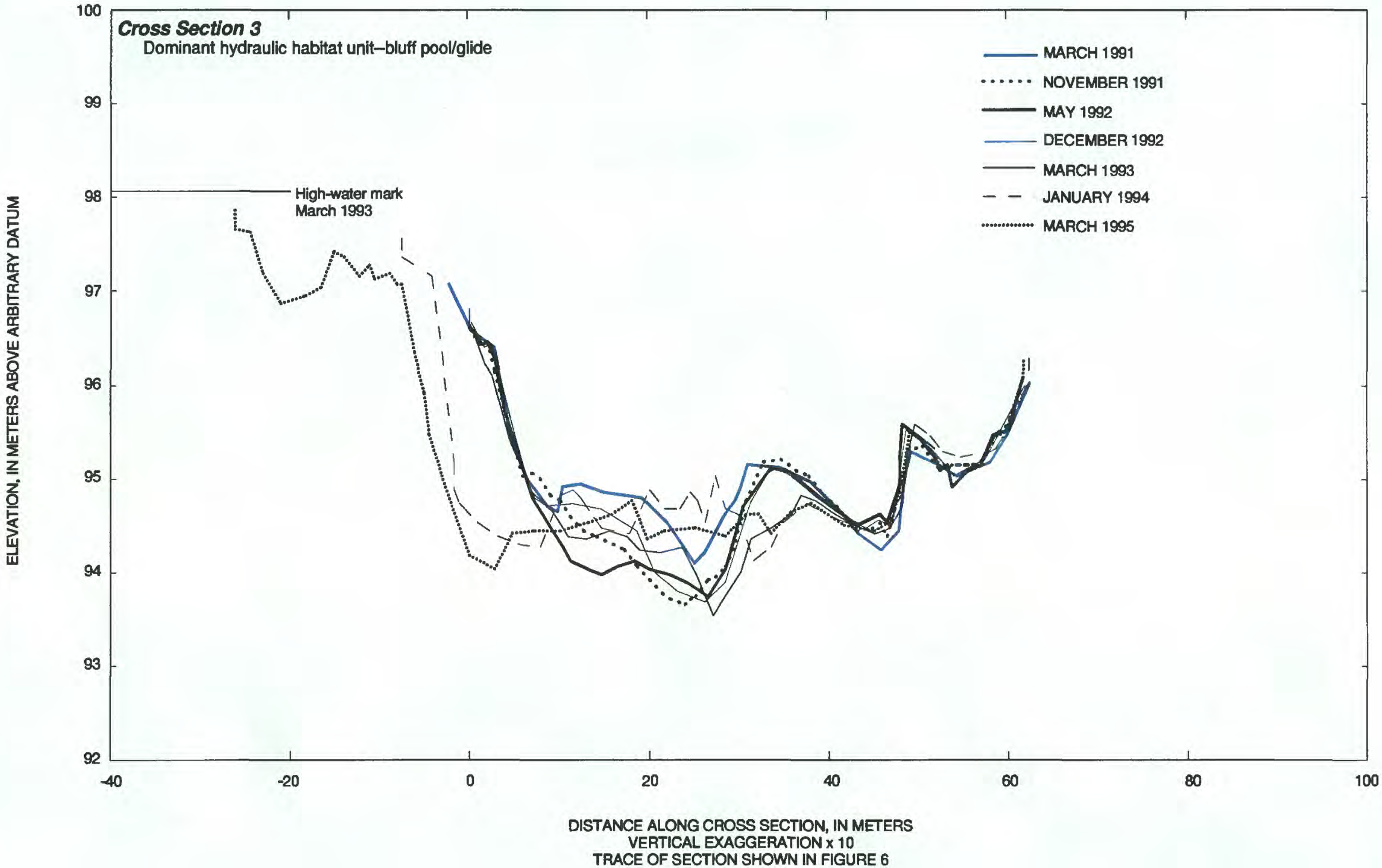

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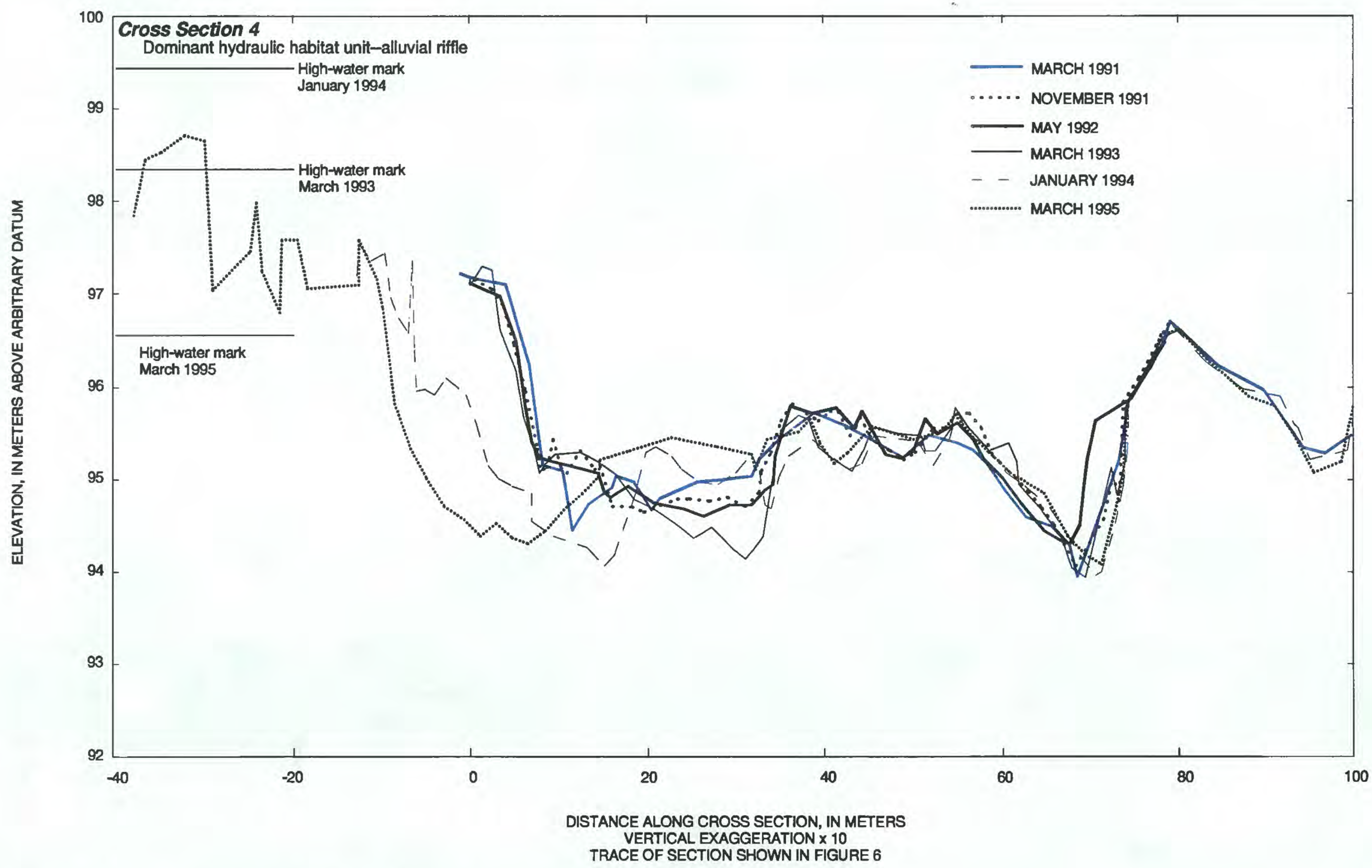

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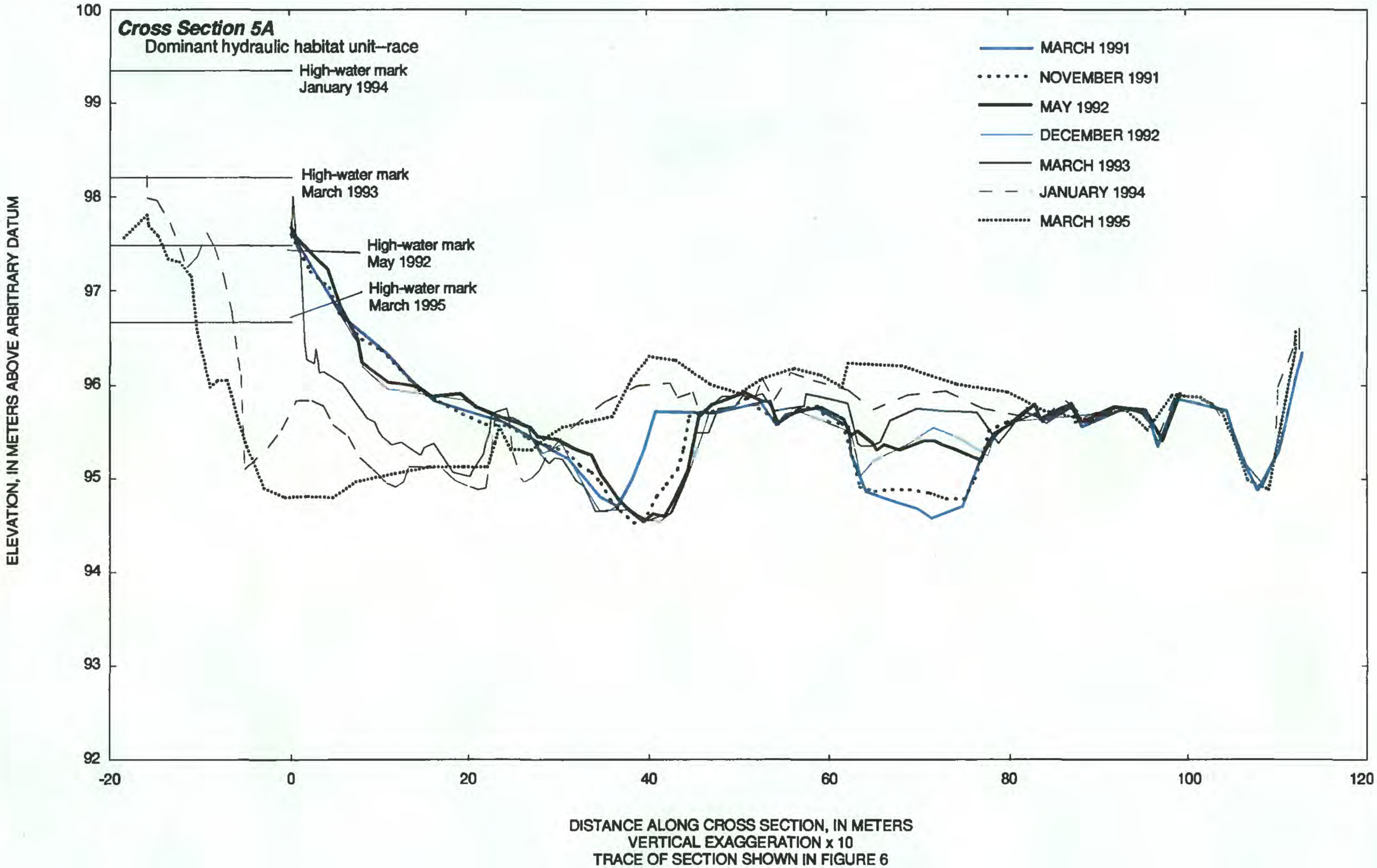

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri--Continued.

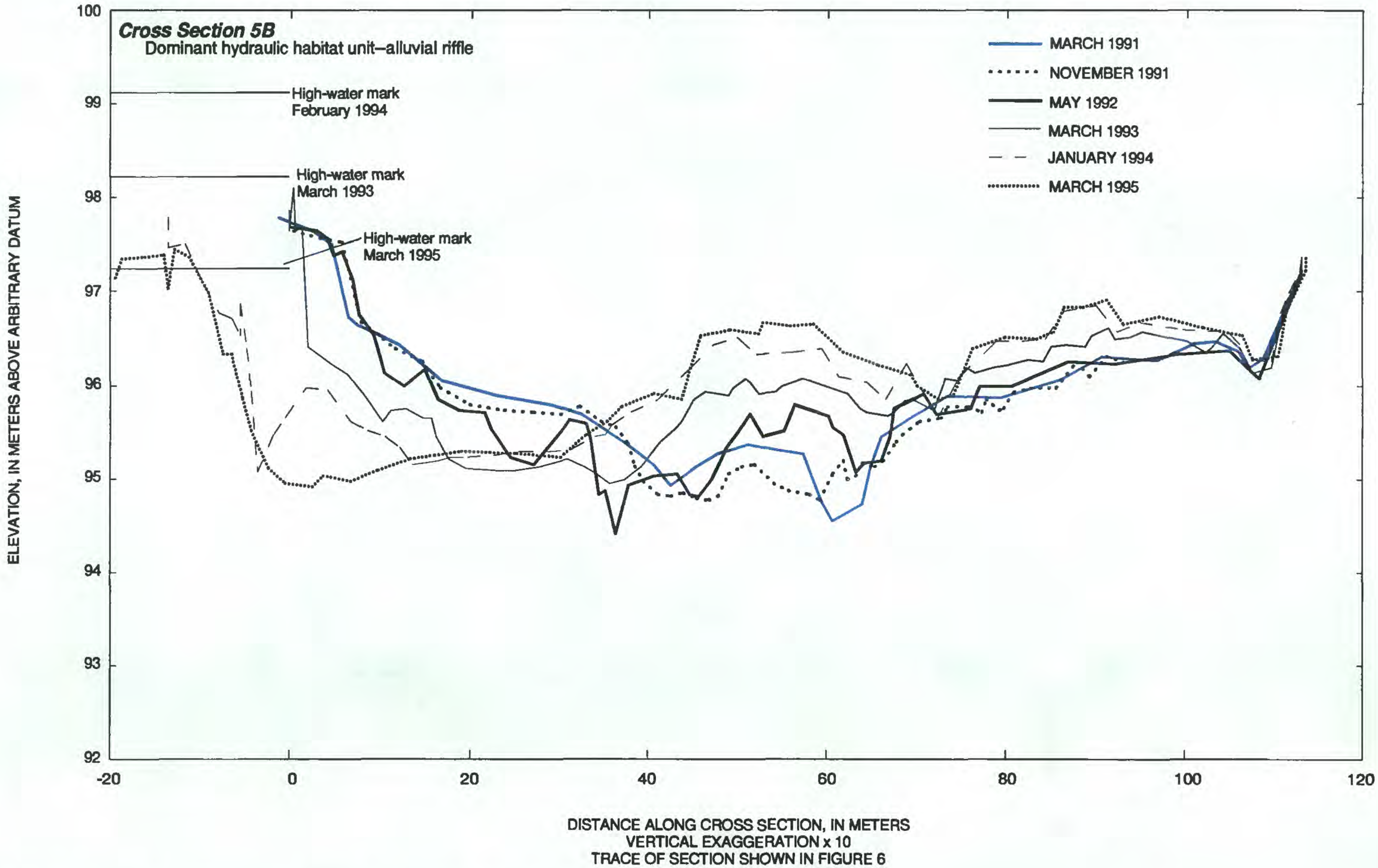

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri—Continued.

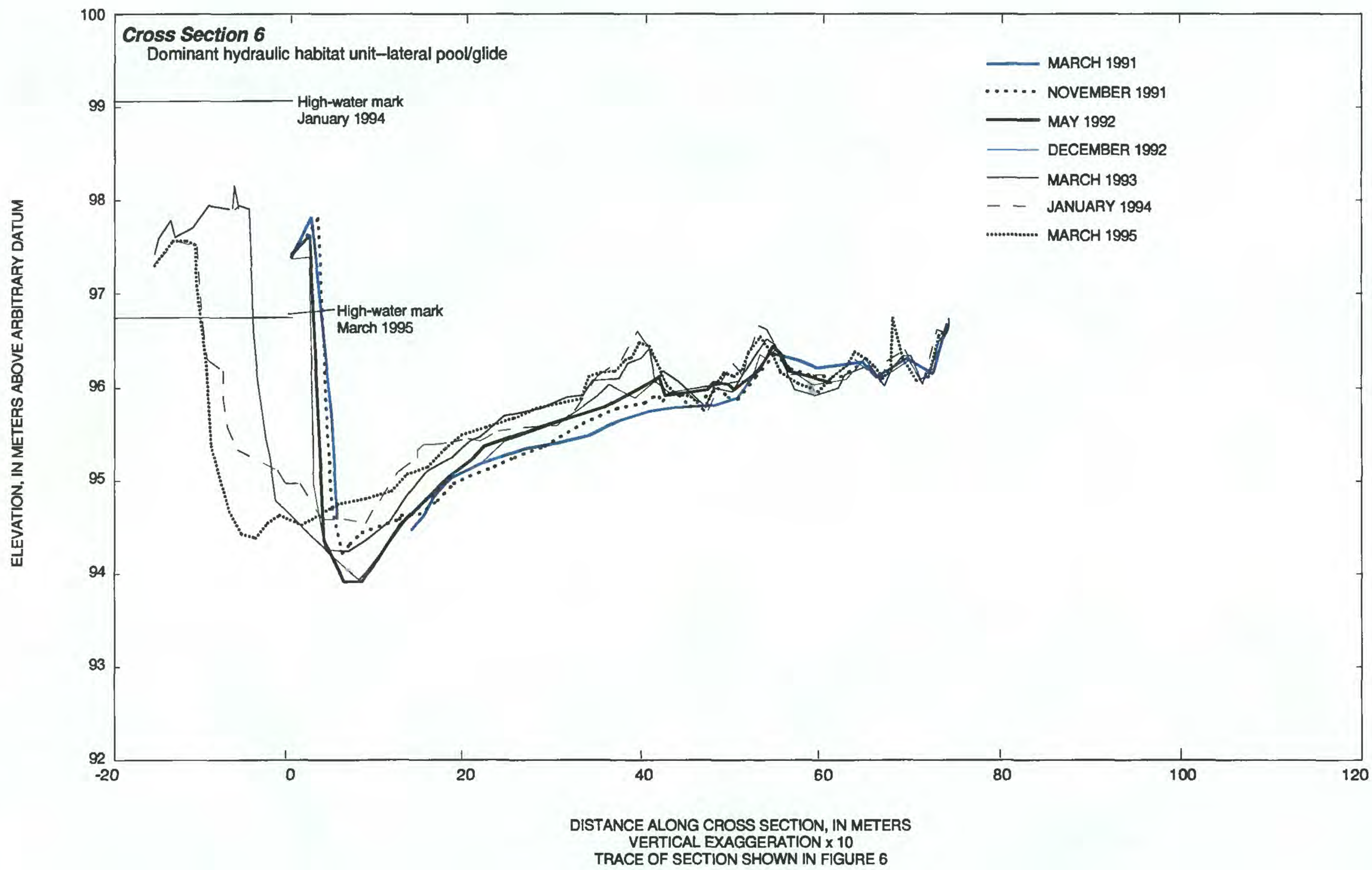

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri—Continued.

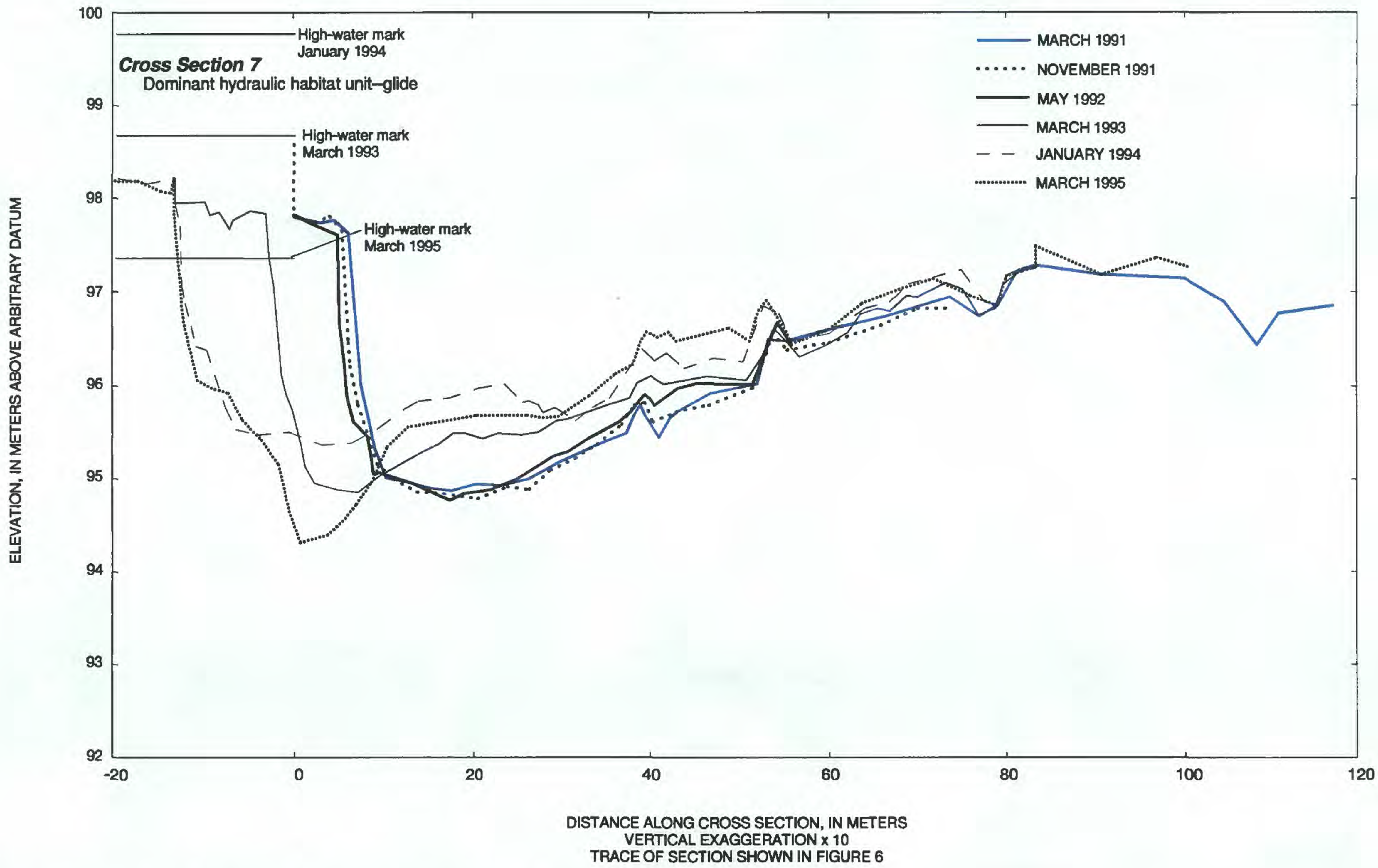

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri–Continued.

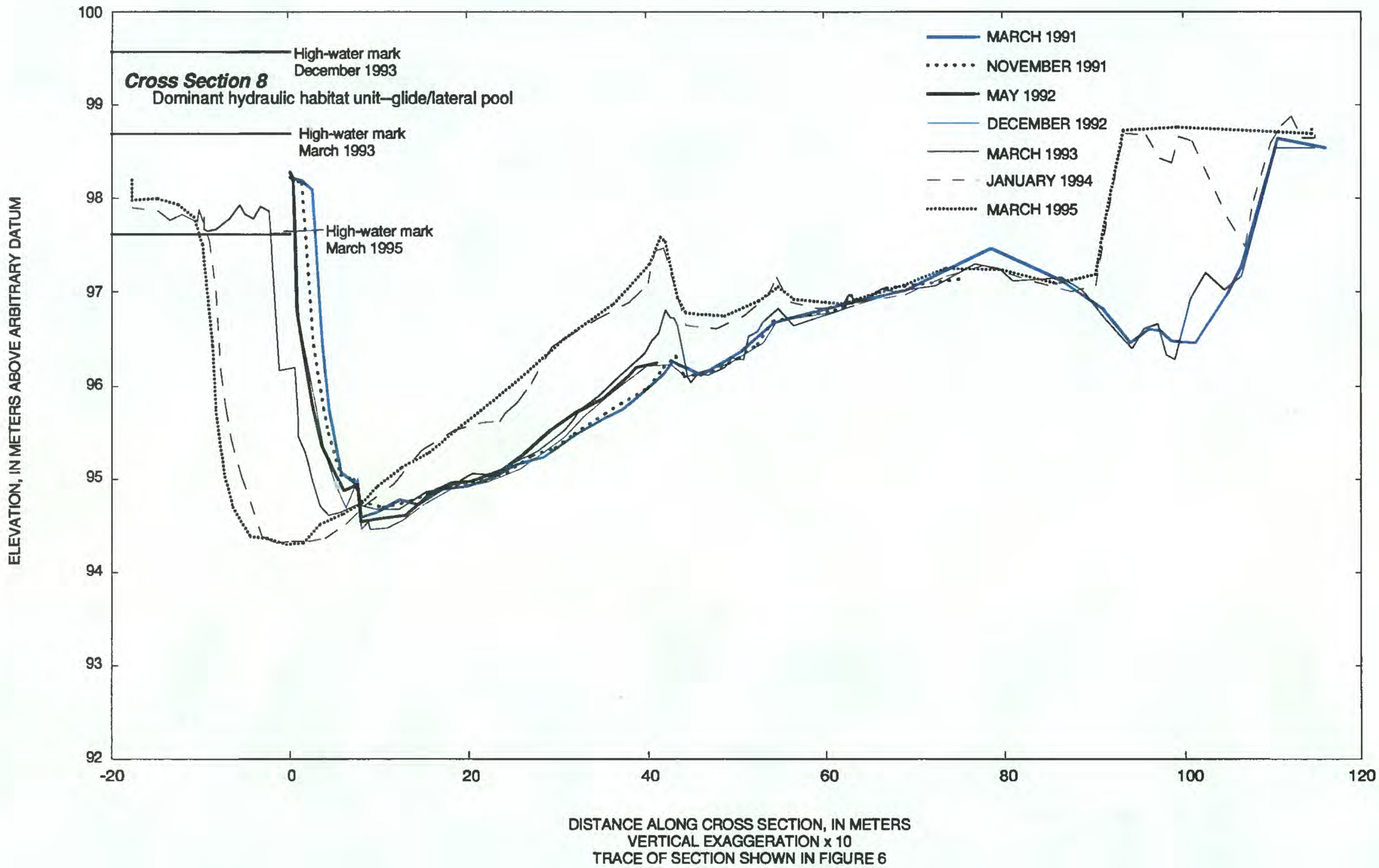

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri –Continued.

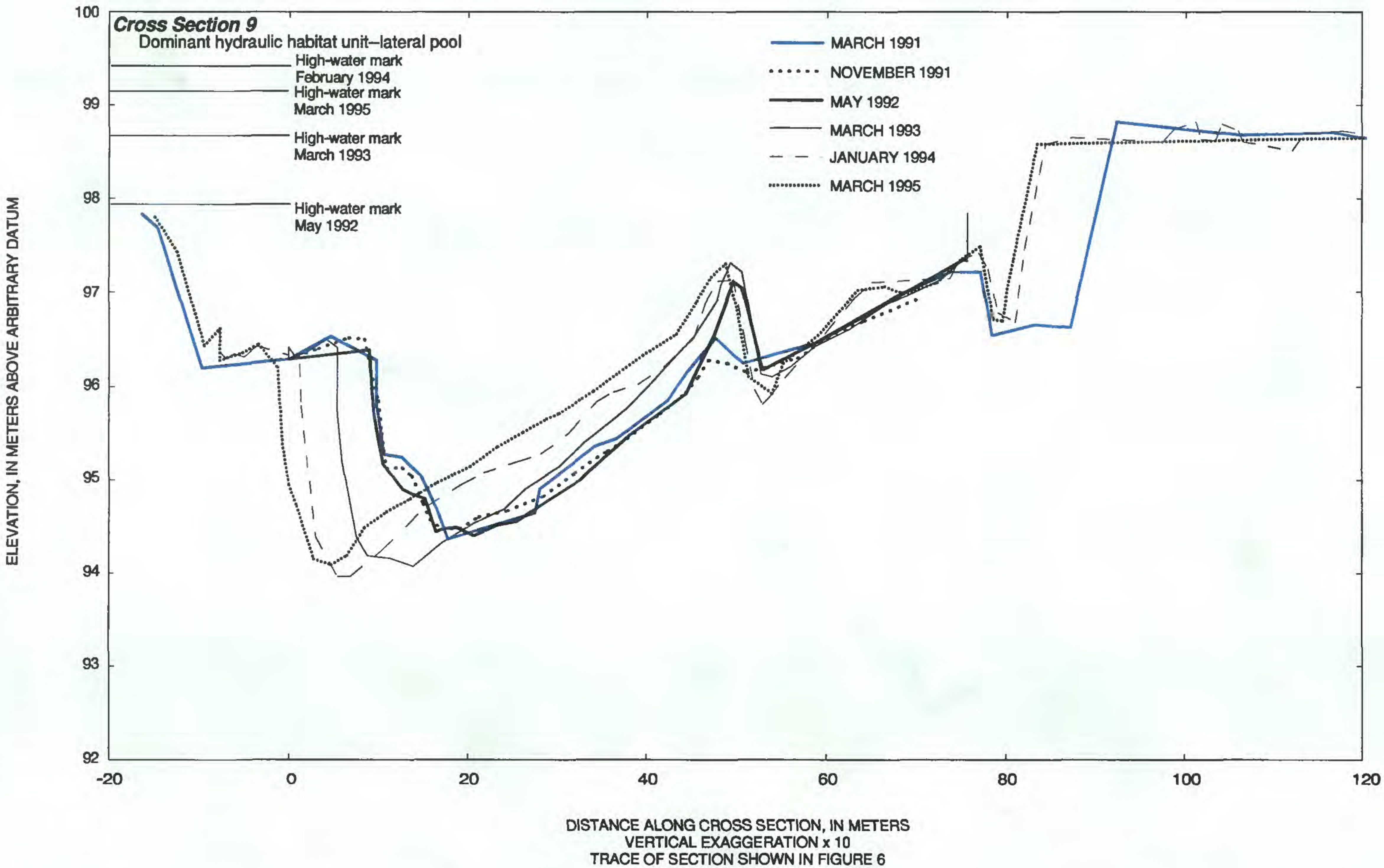

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri–Continued.

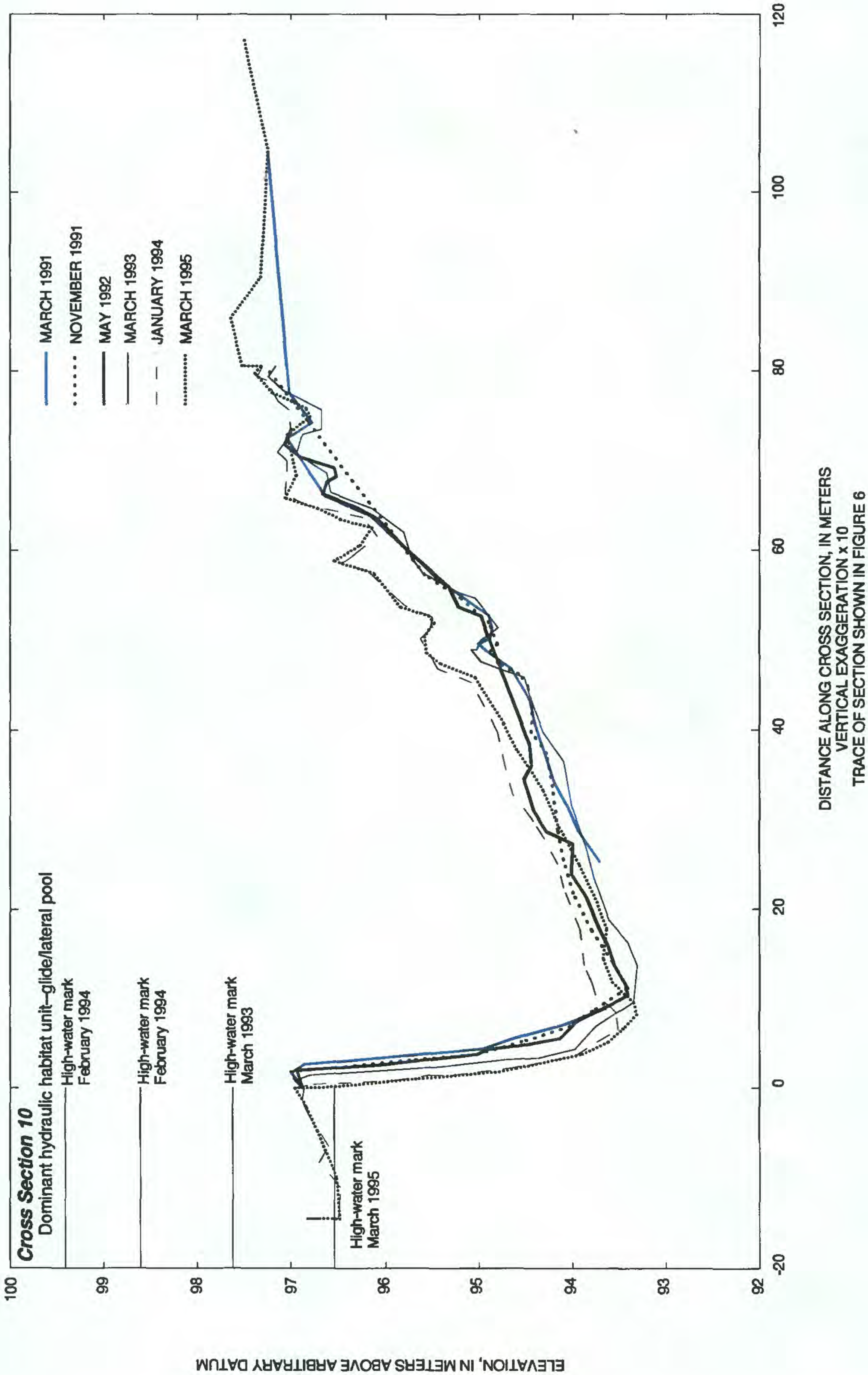

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri—Continued.

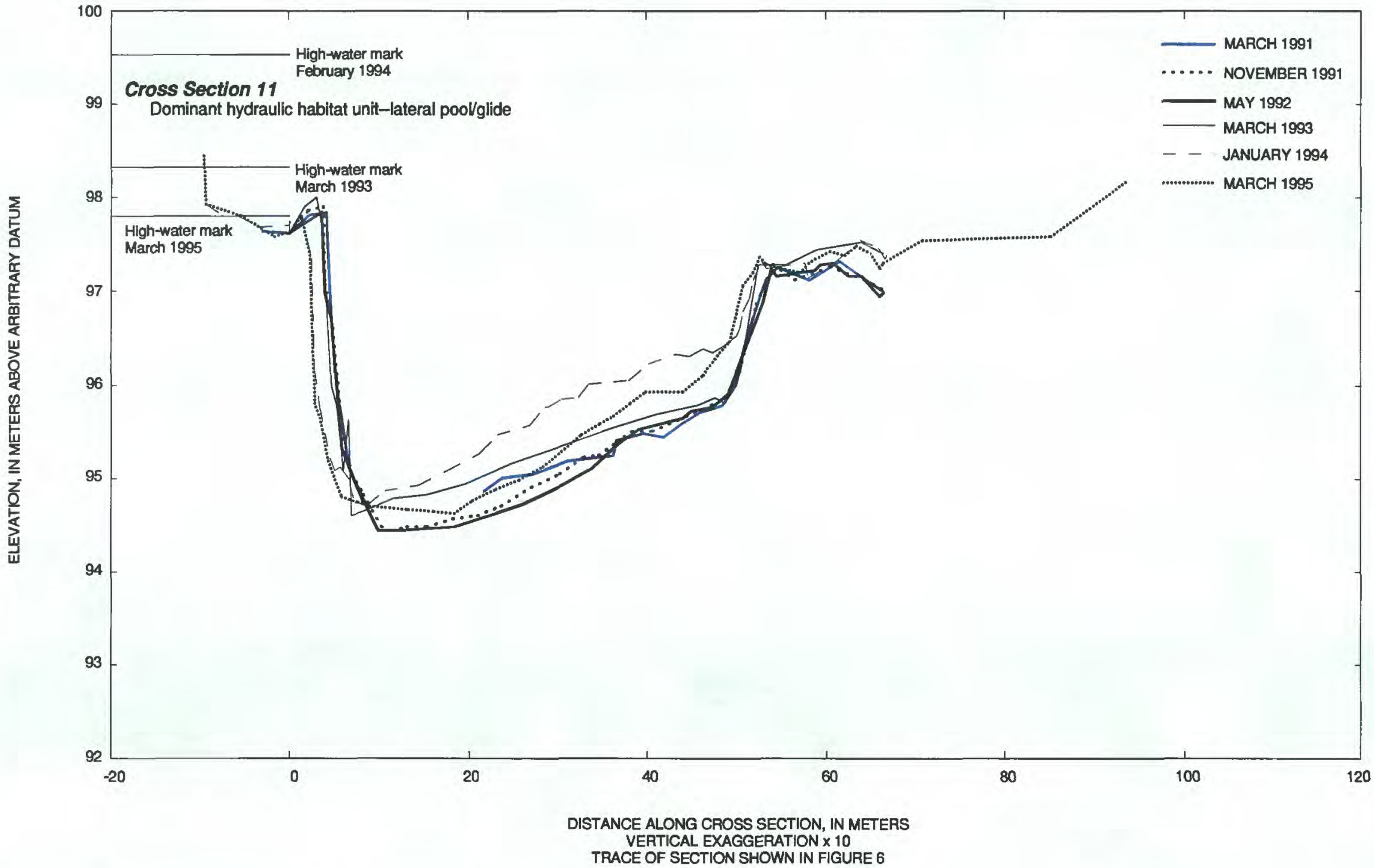

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri--Continued.

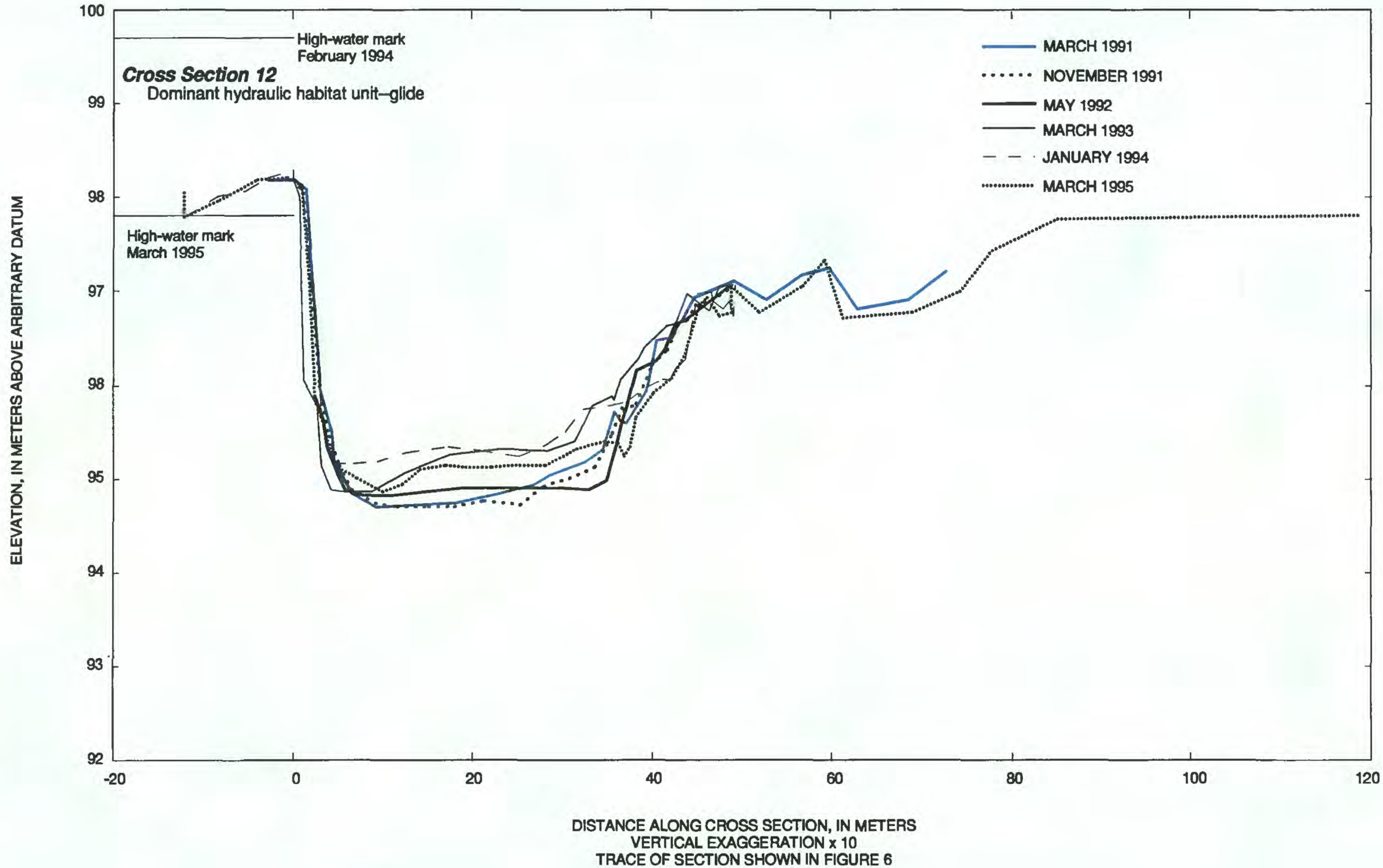

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri—Continued.

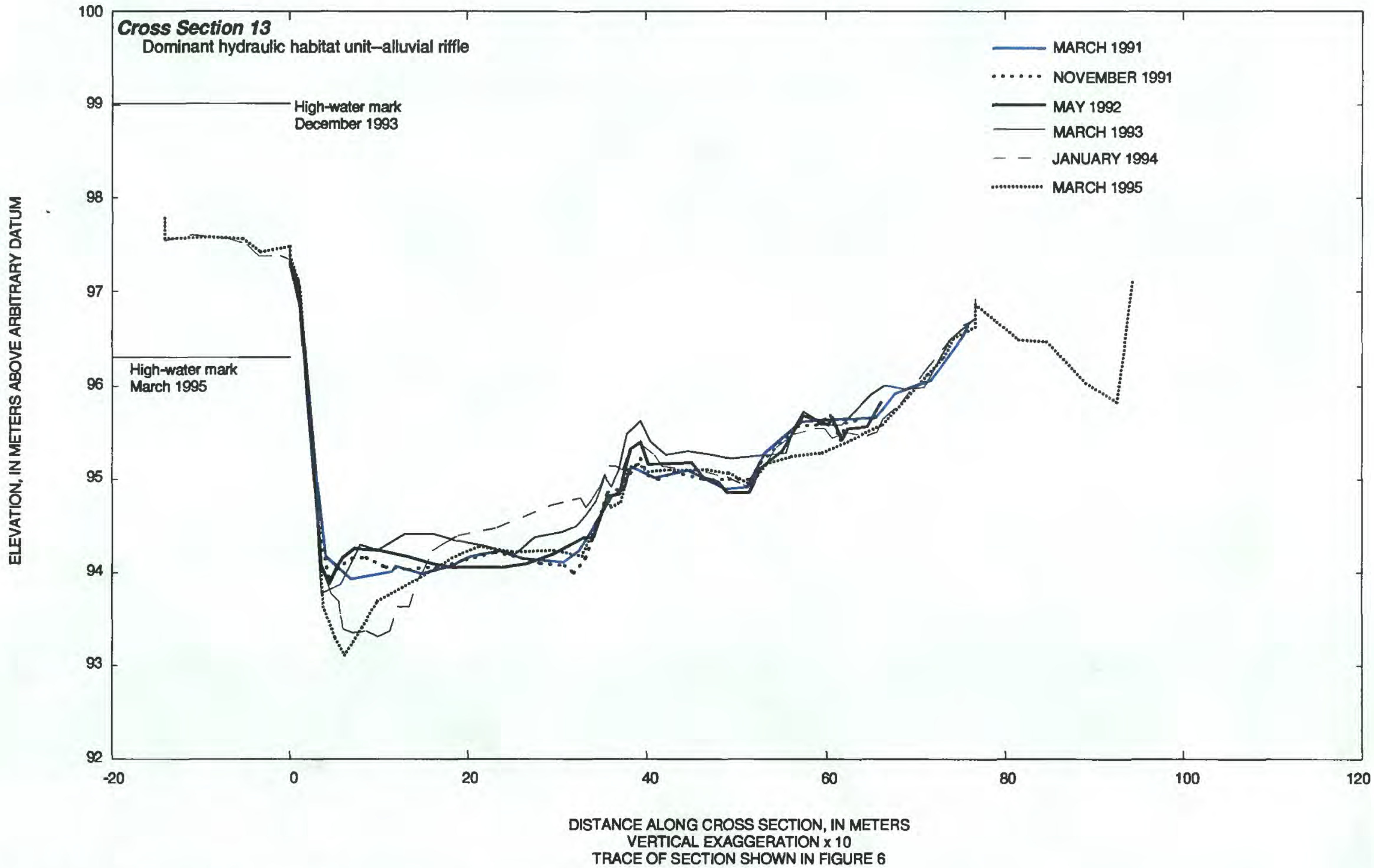

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri—Continued.

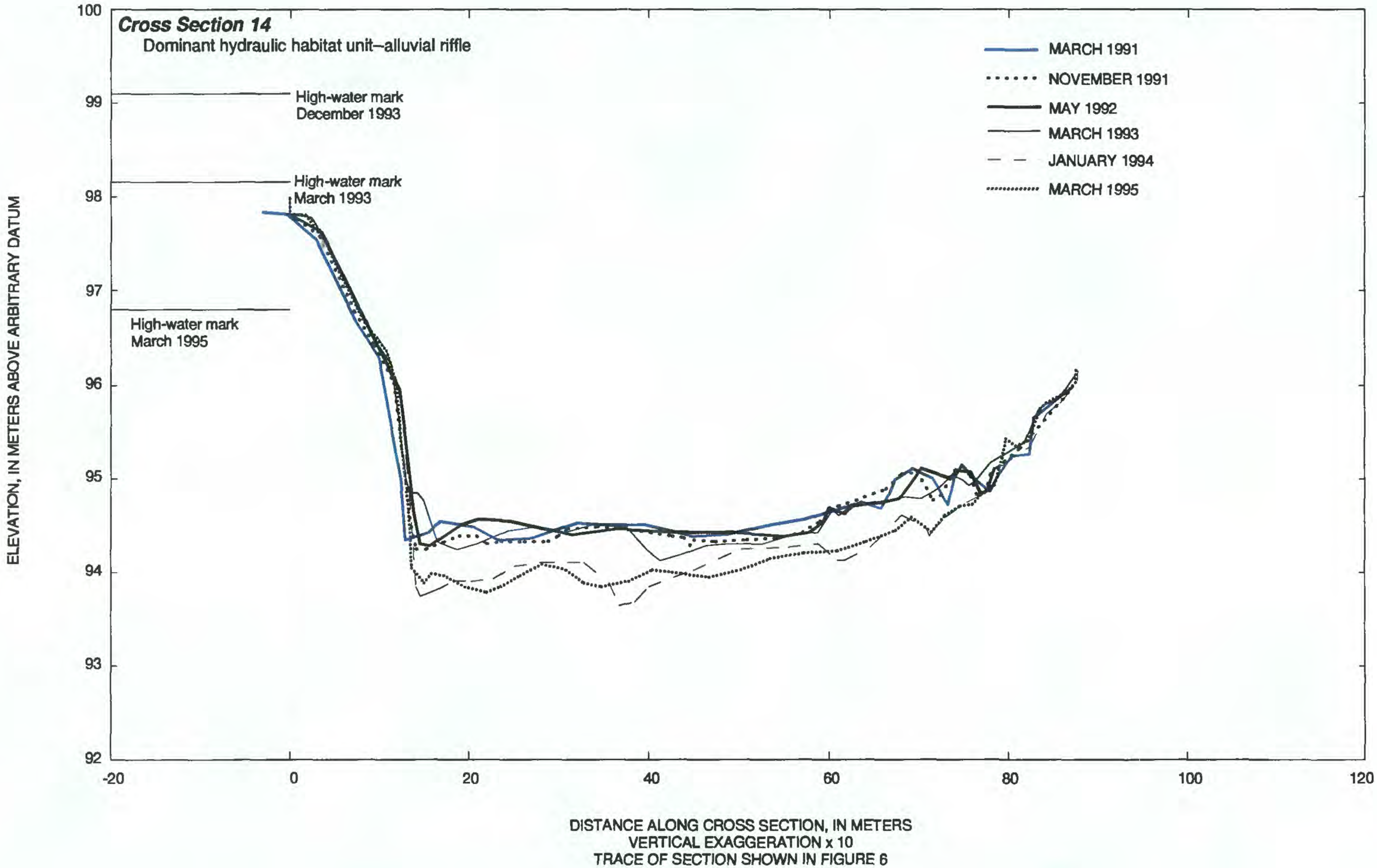

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri—Continued.

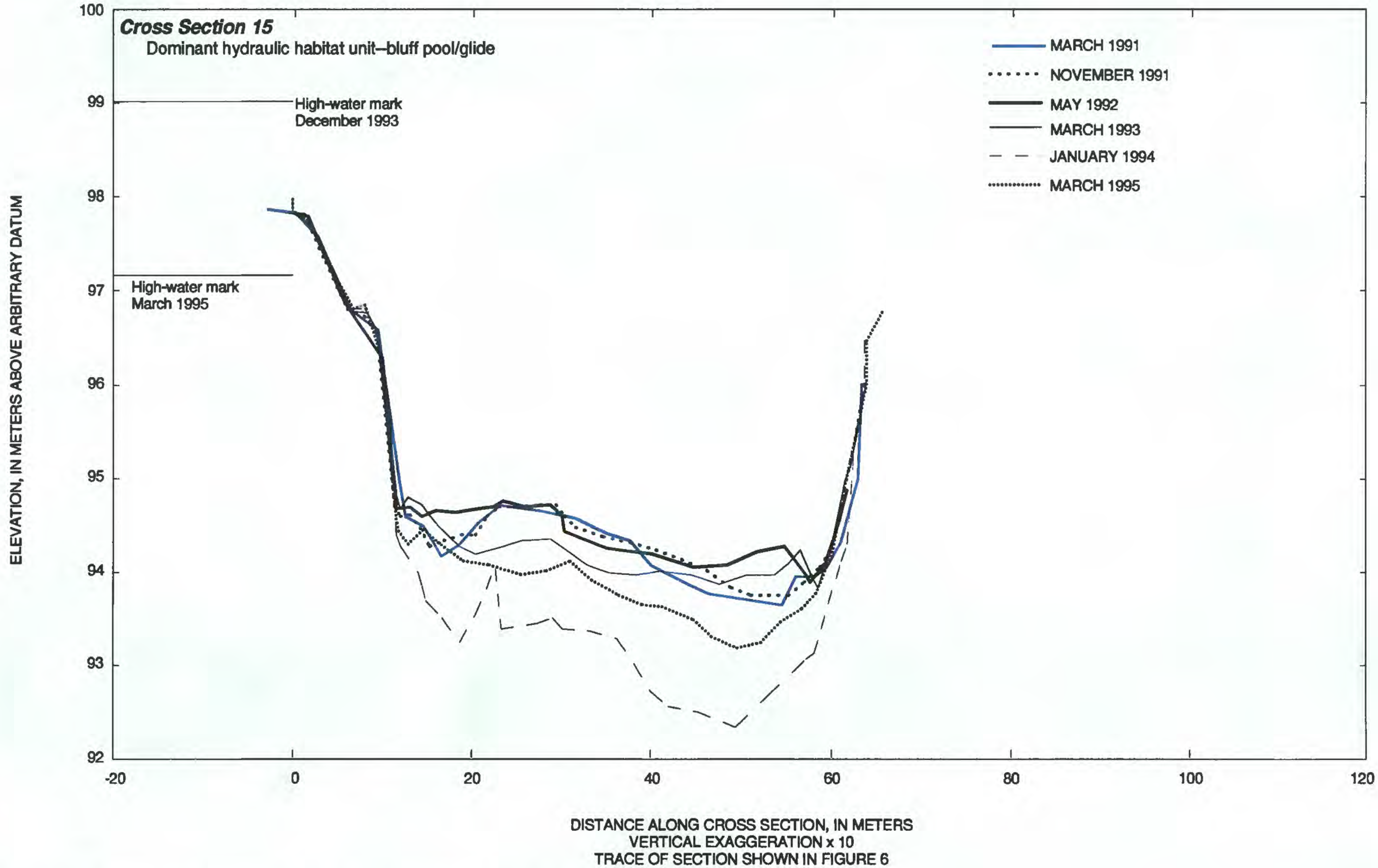

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri—Continued.

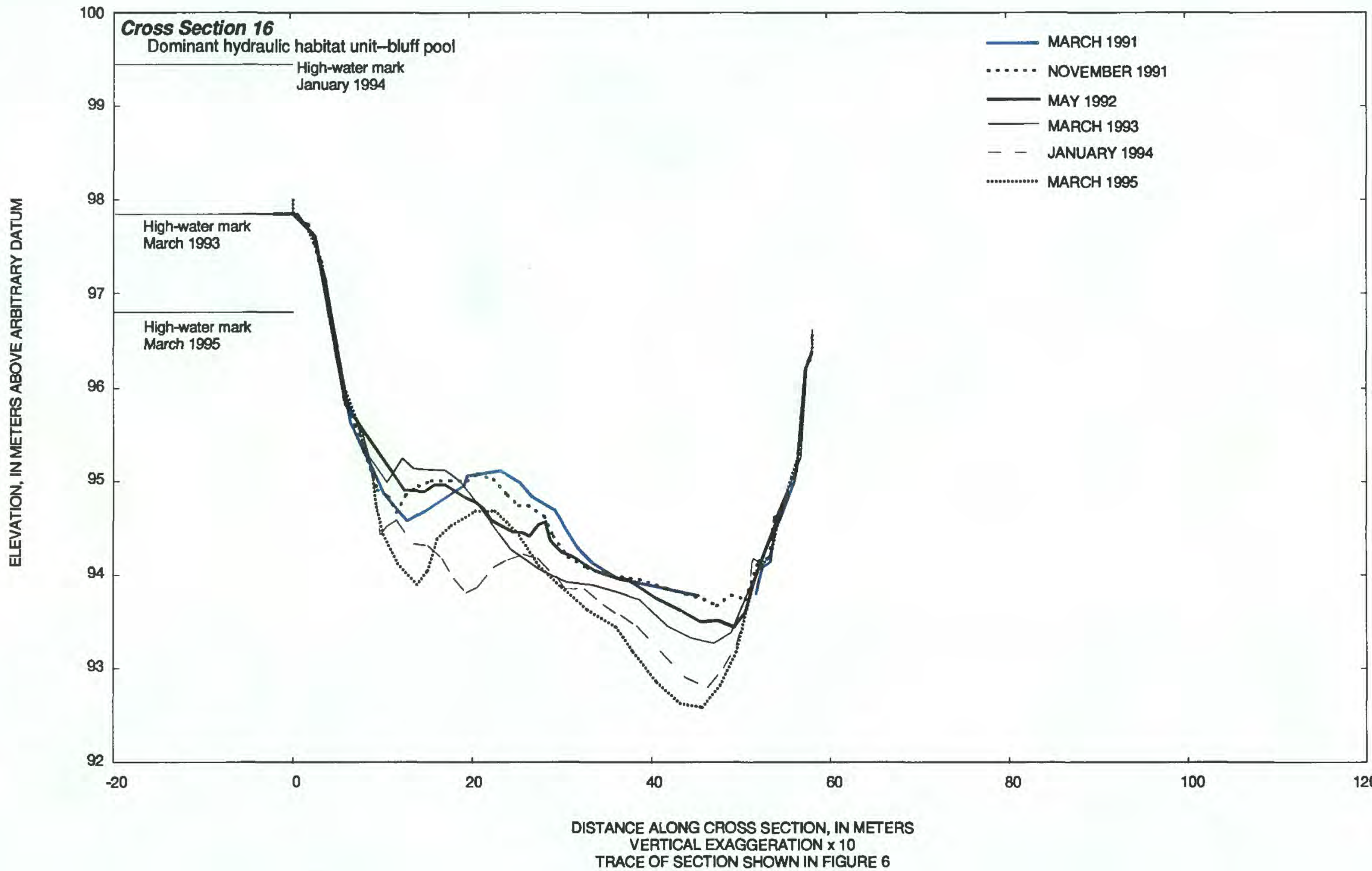

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri--Continued.

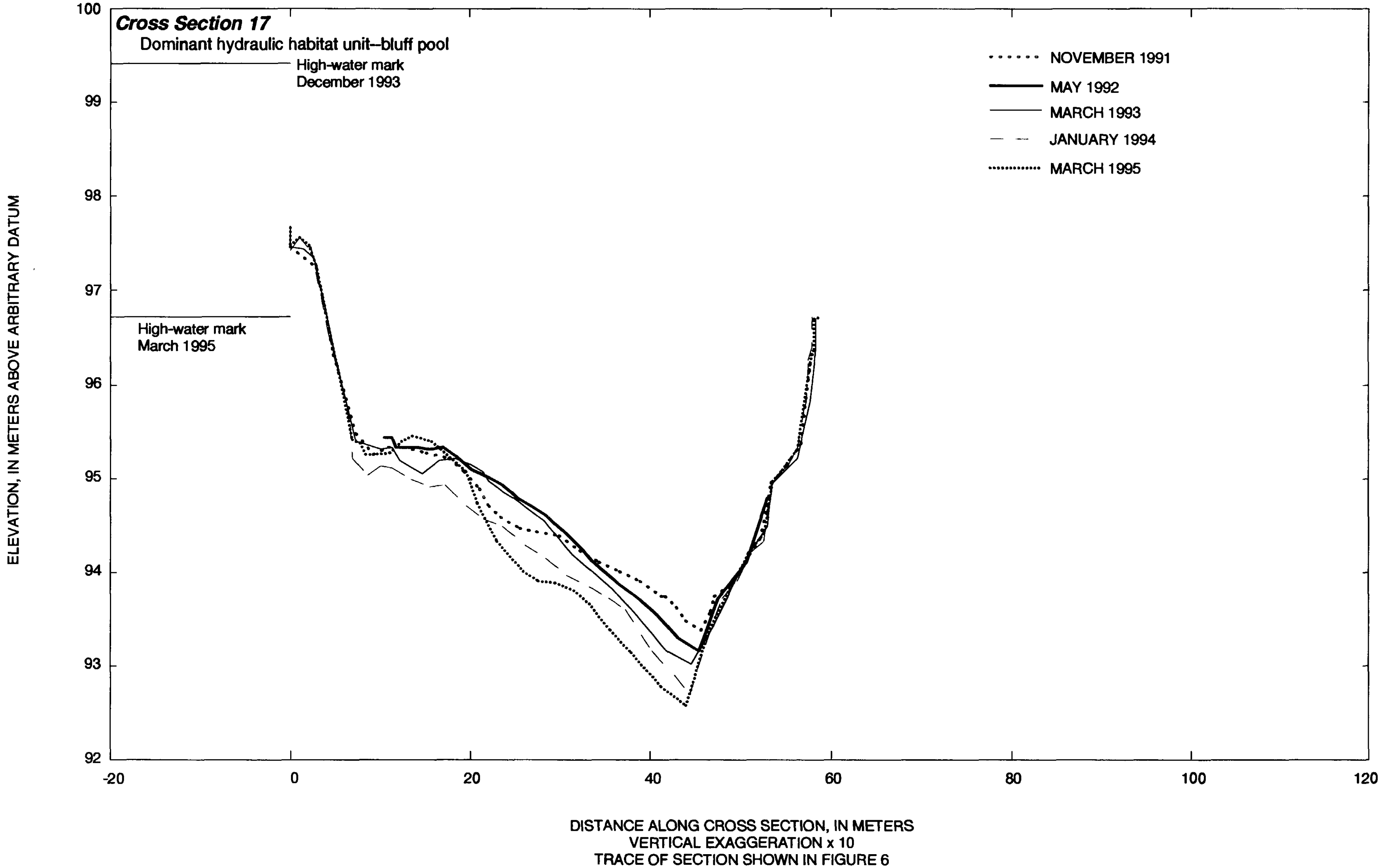

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri--Continued.

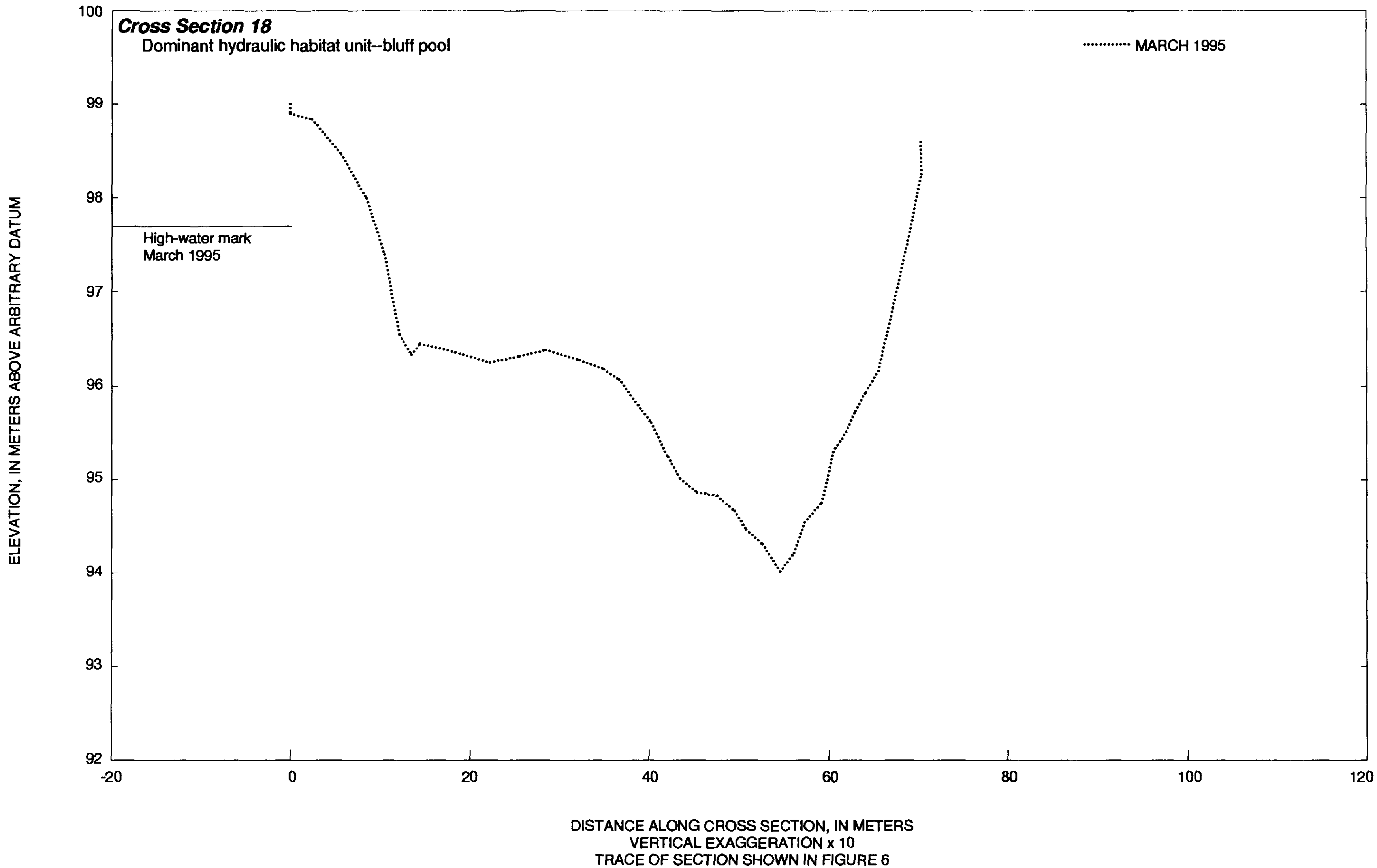

Figure 23. Cross sections located at Burnt Cabin reach, Jacks Fork, Missouri—Continued.

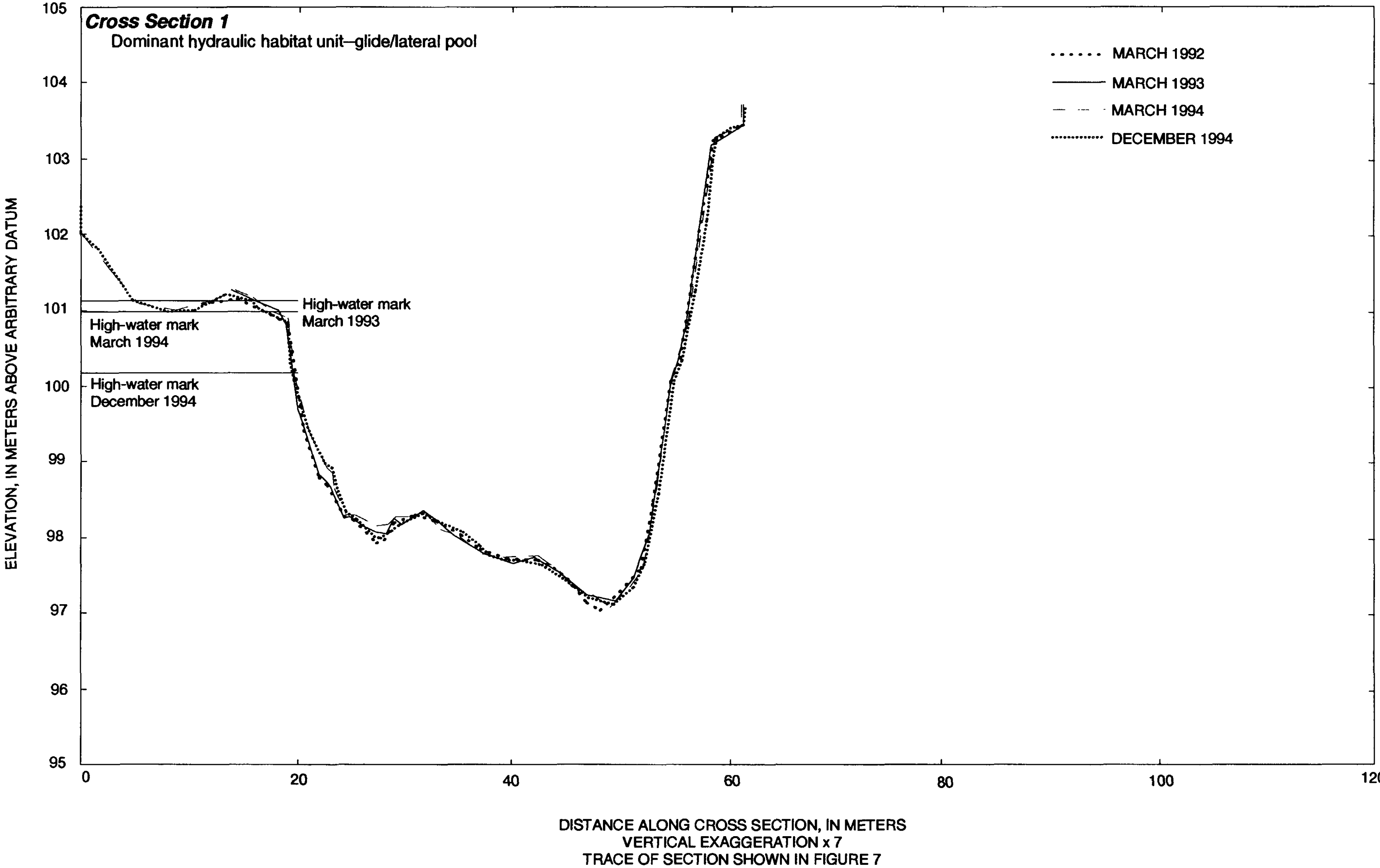

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas.

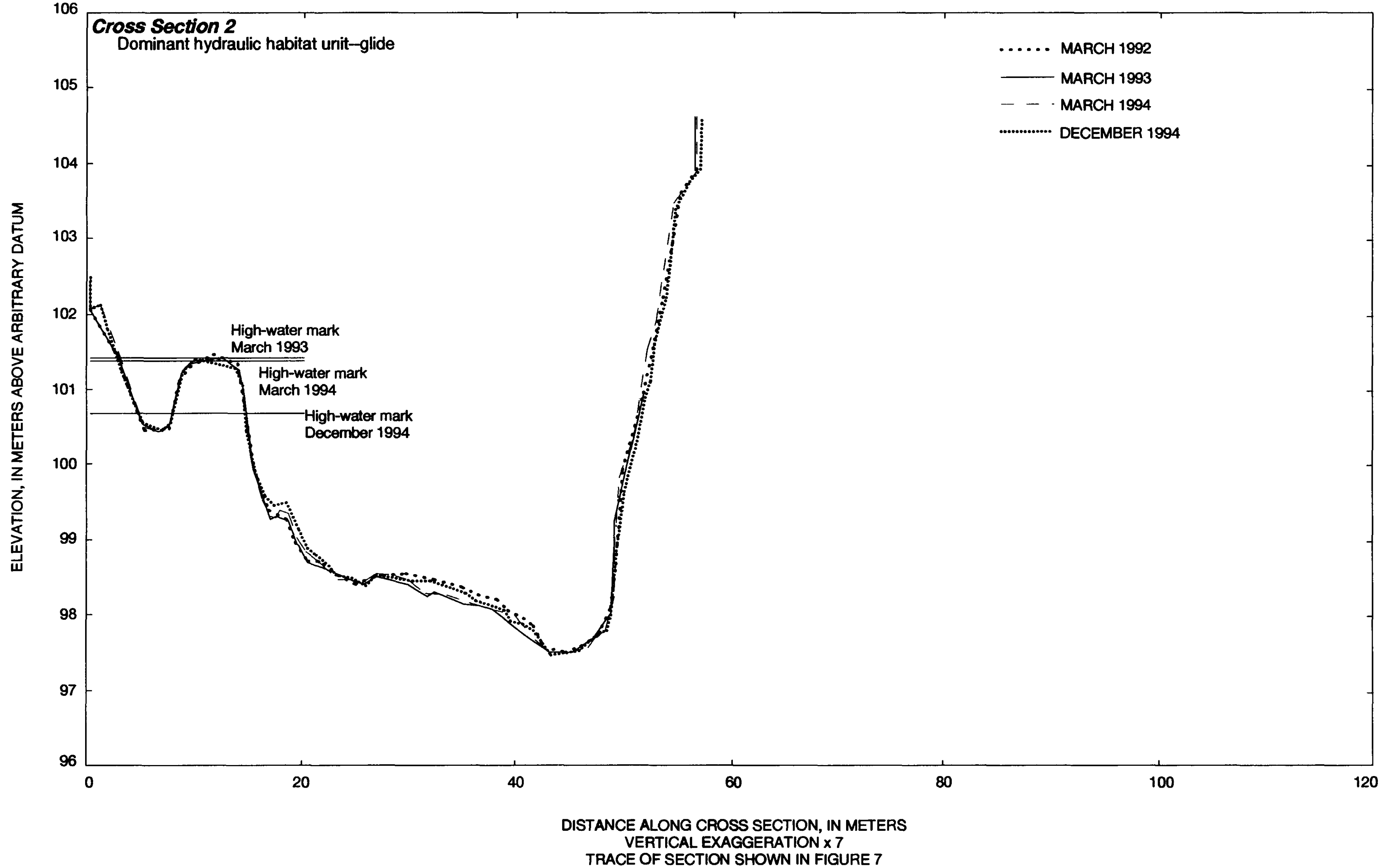

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas—Continued.

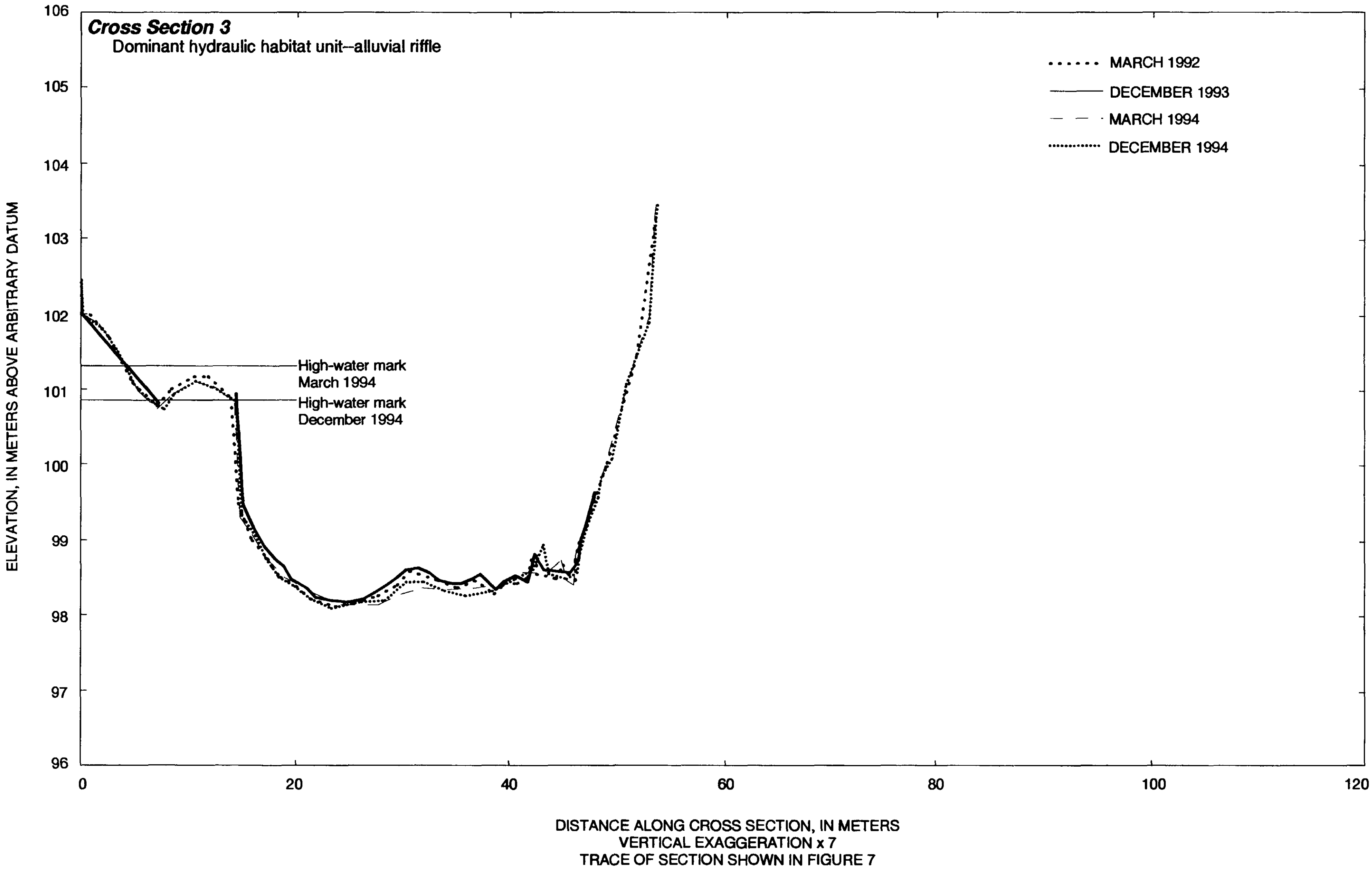

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas--Continued.

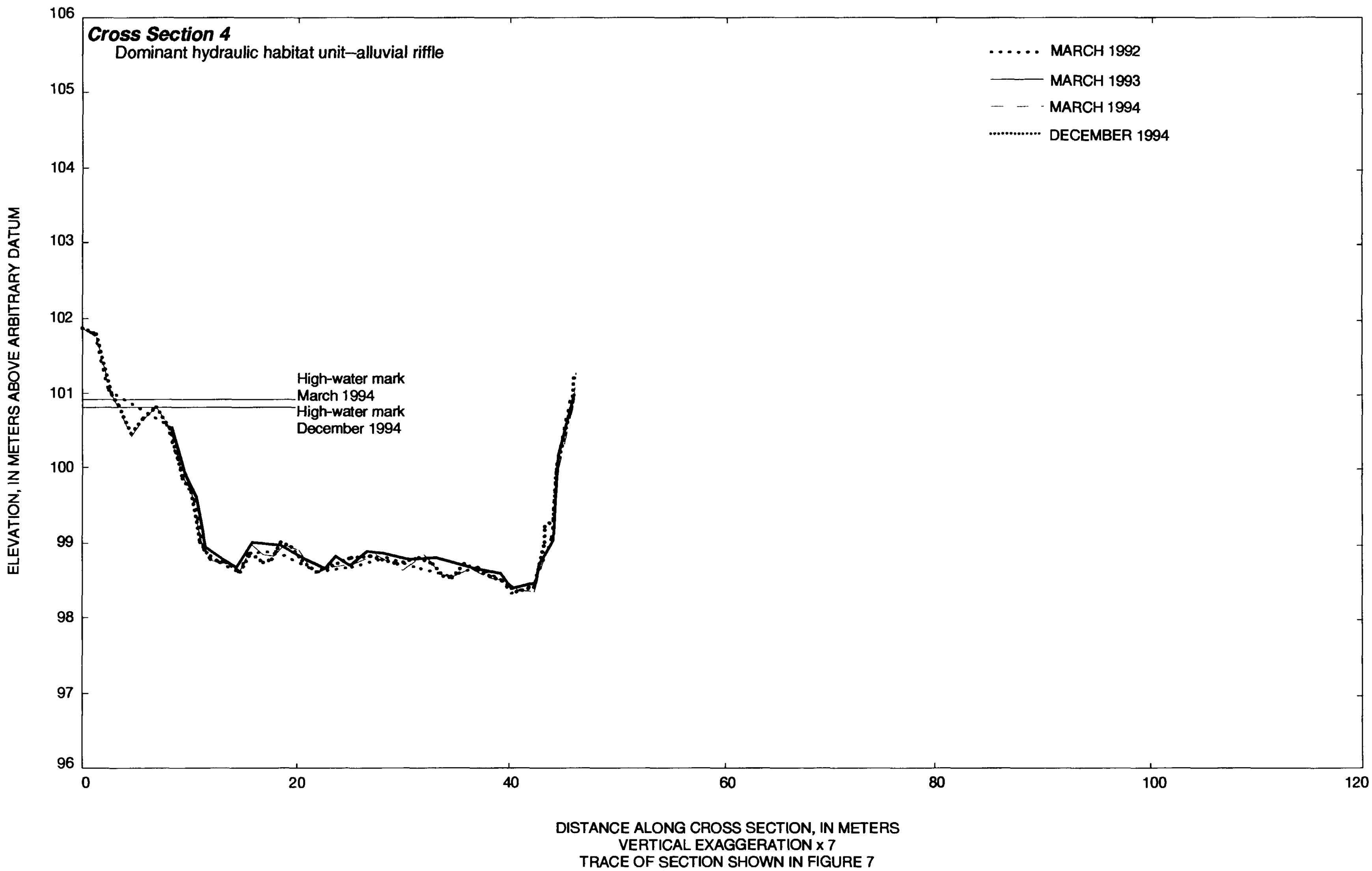

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas--Continued.

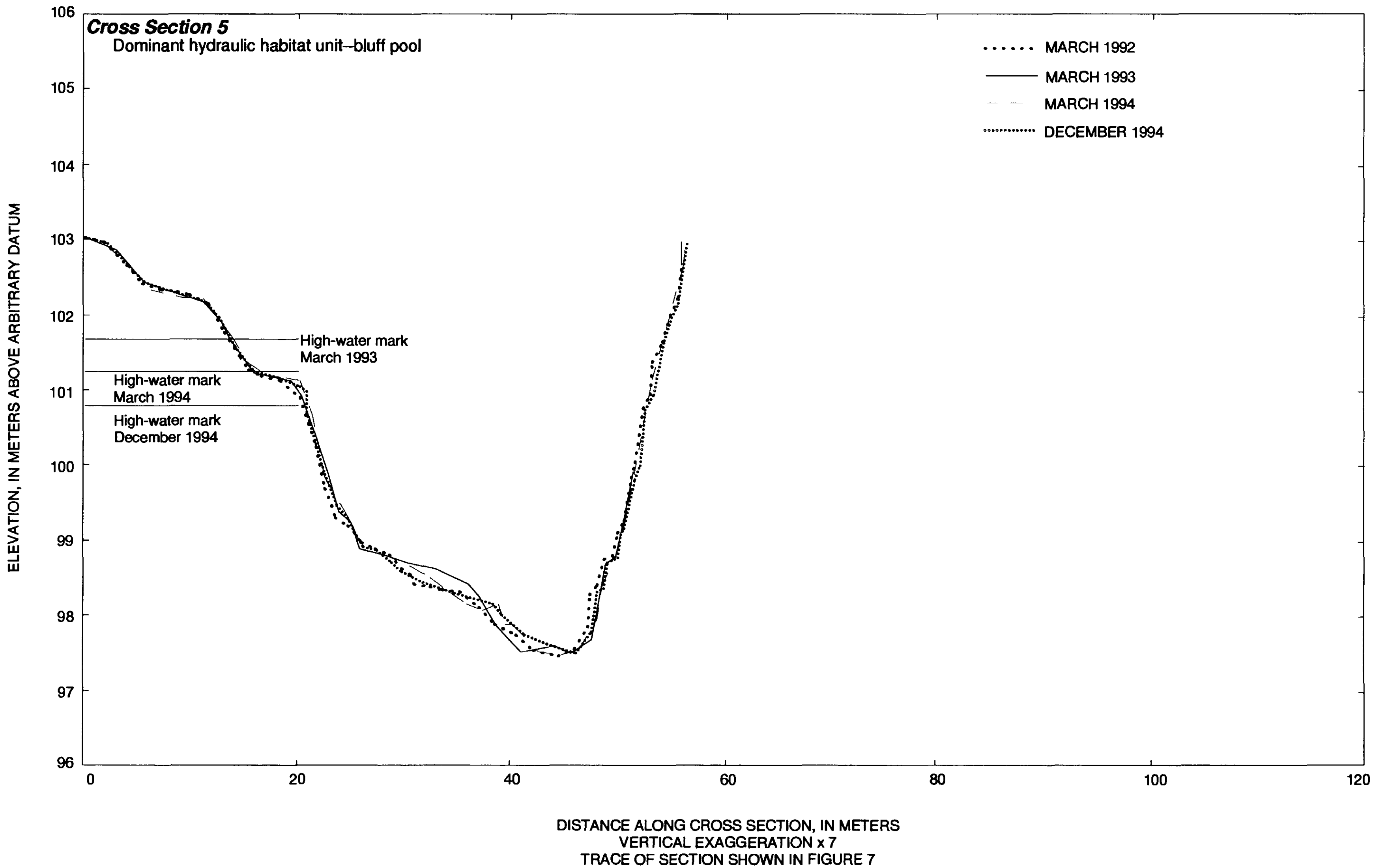

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas –Continued.

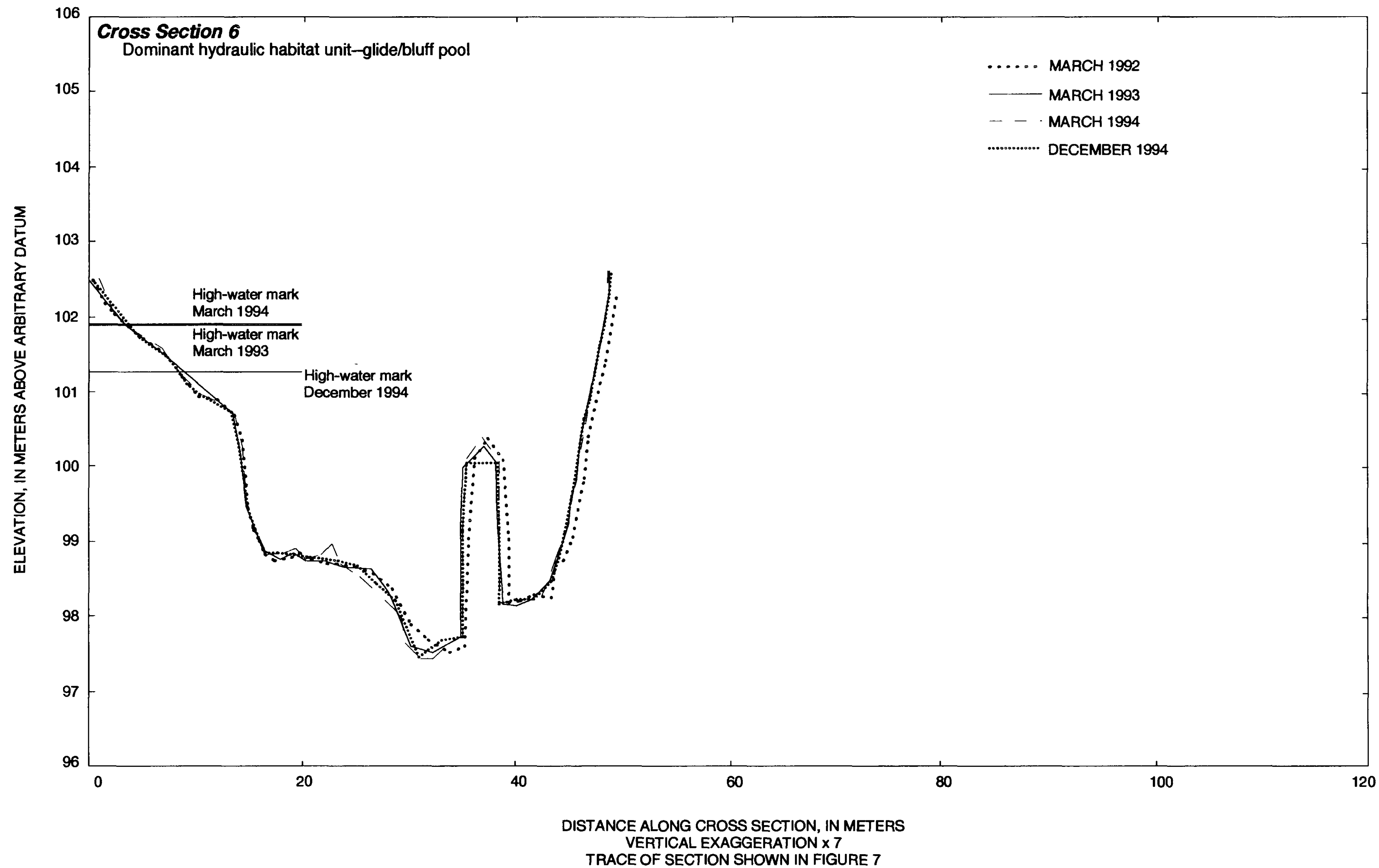

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas–Continued.

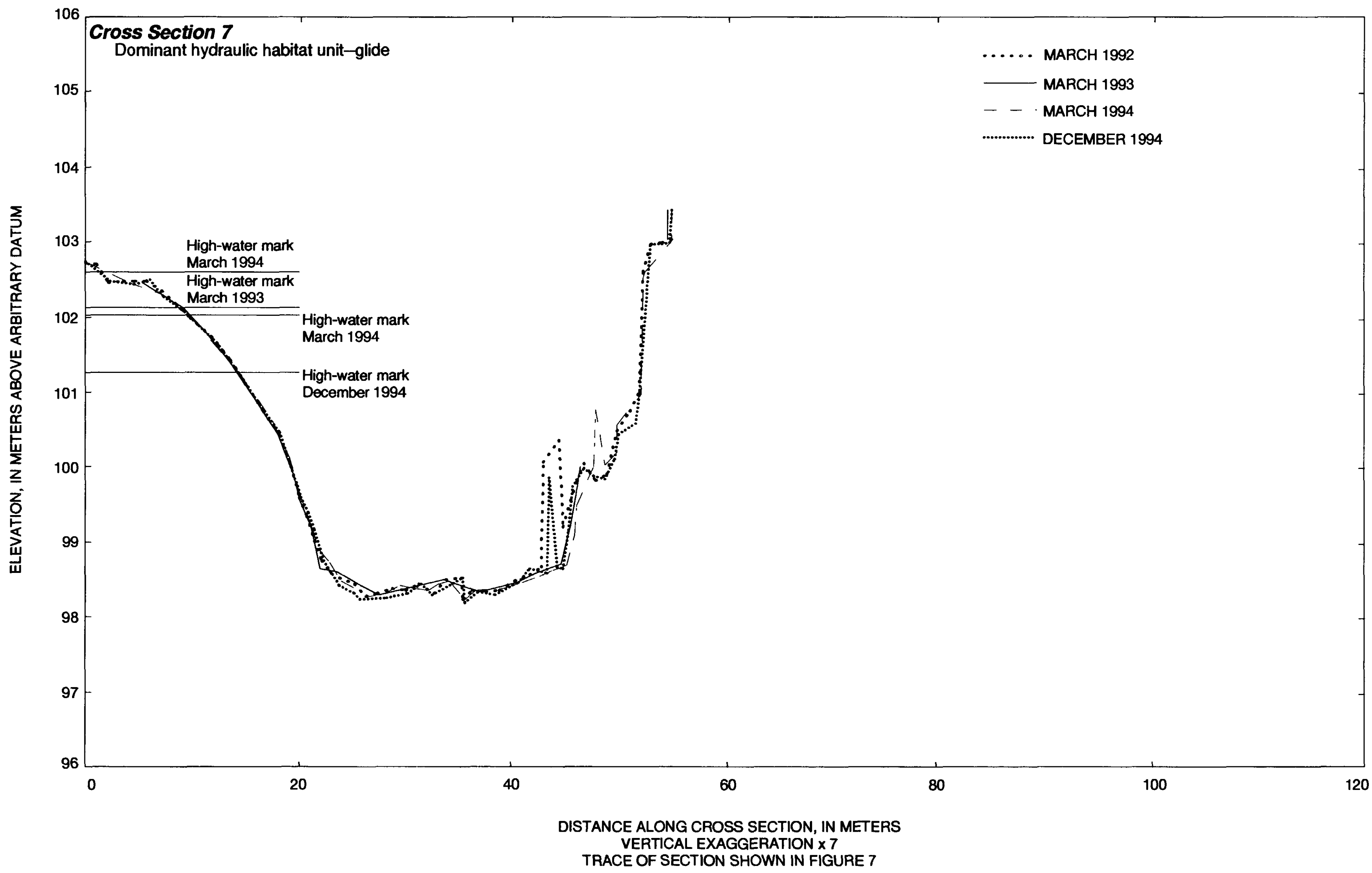

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas–Continued.

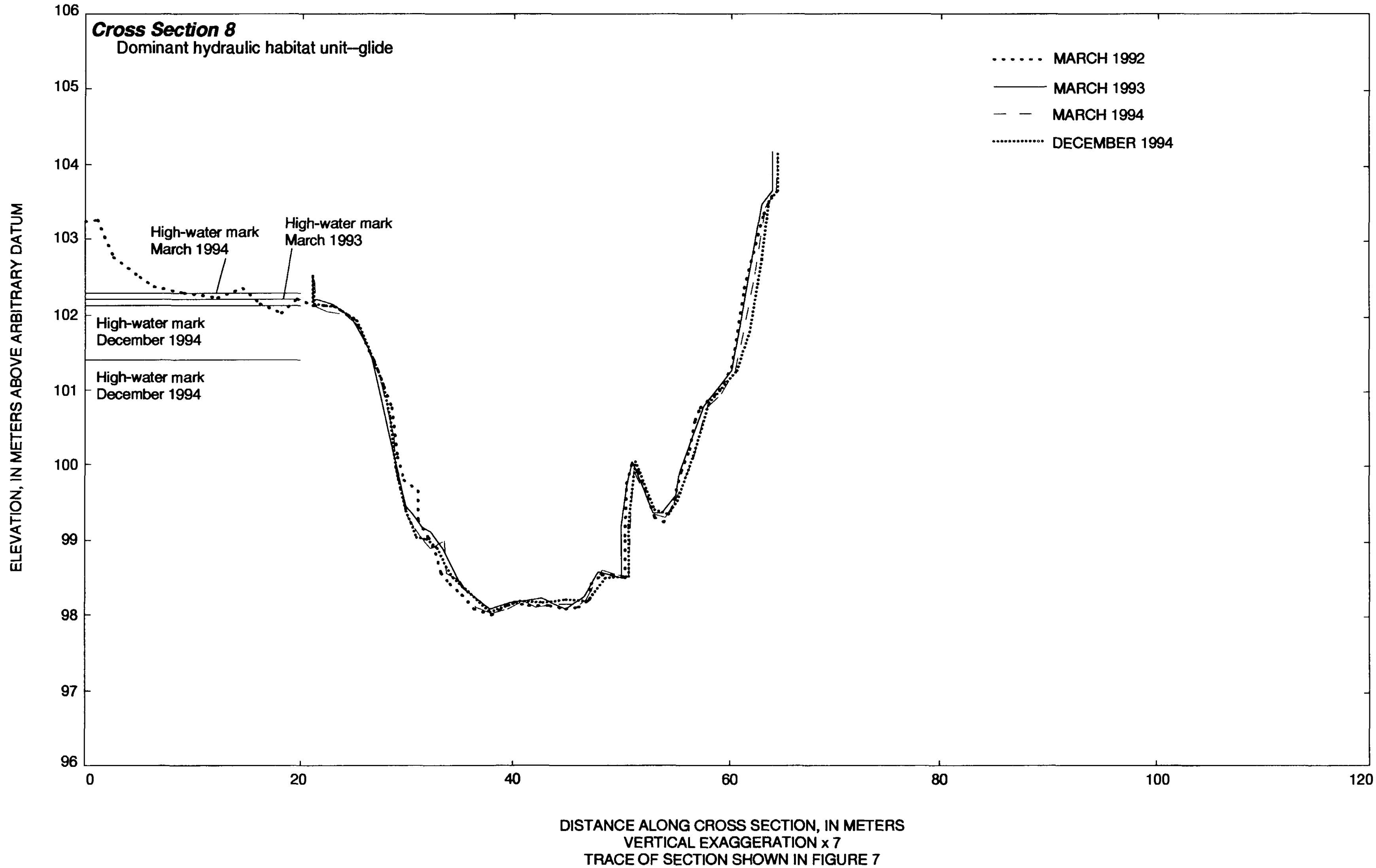

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas—Continued.

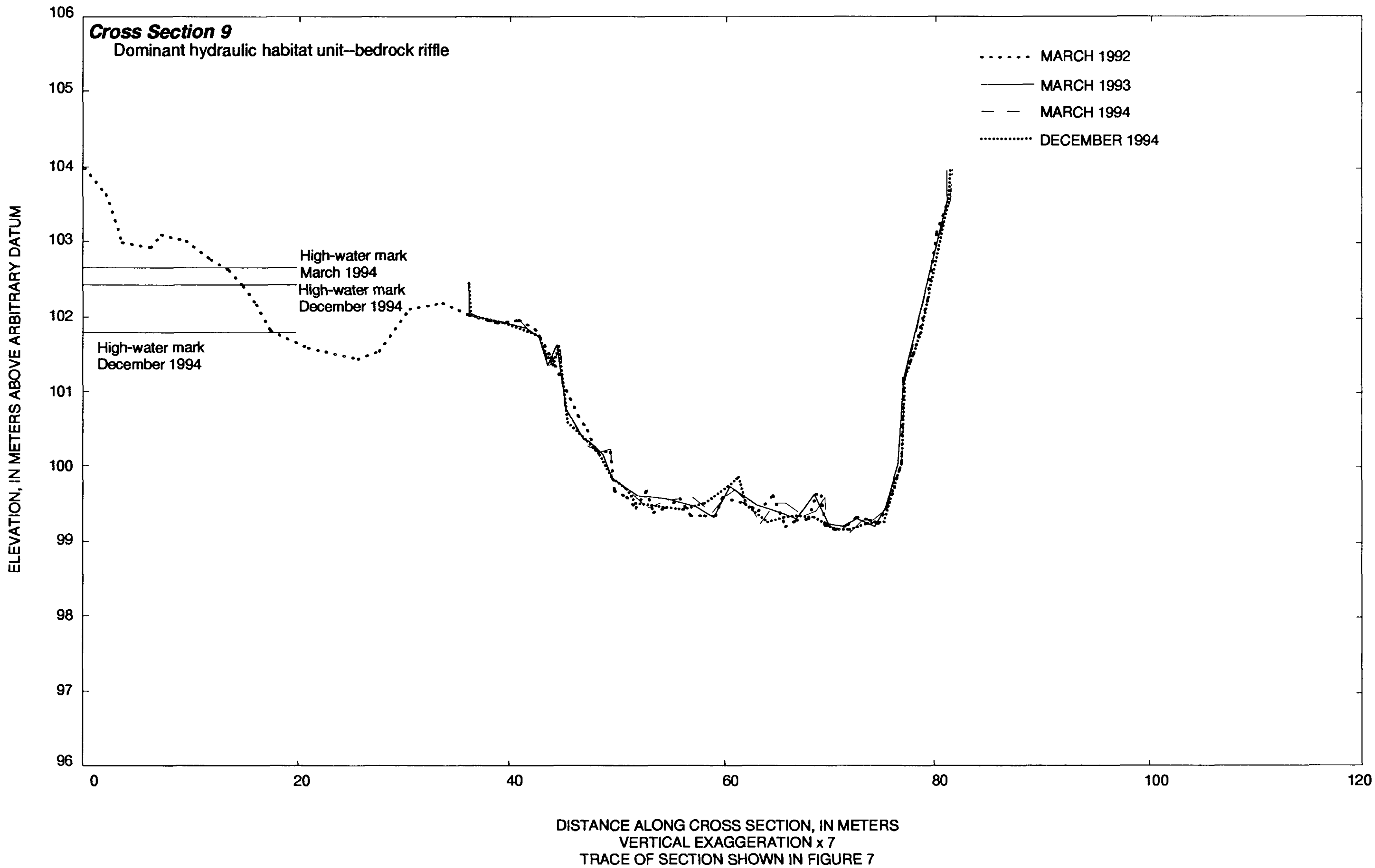

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas --Continued.

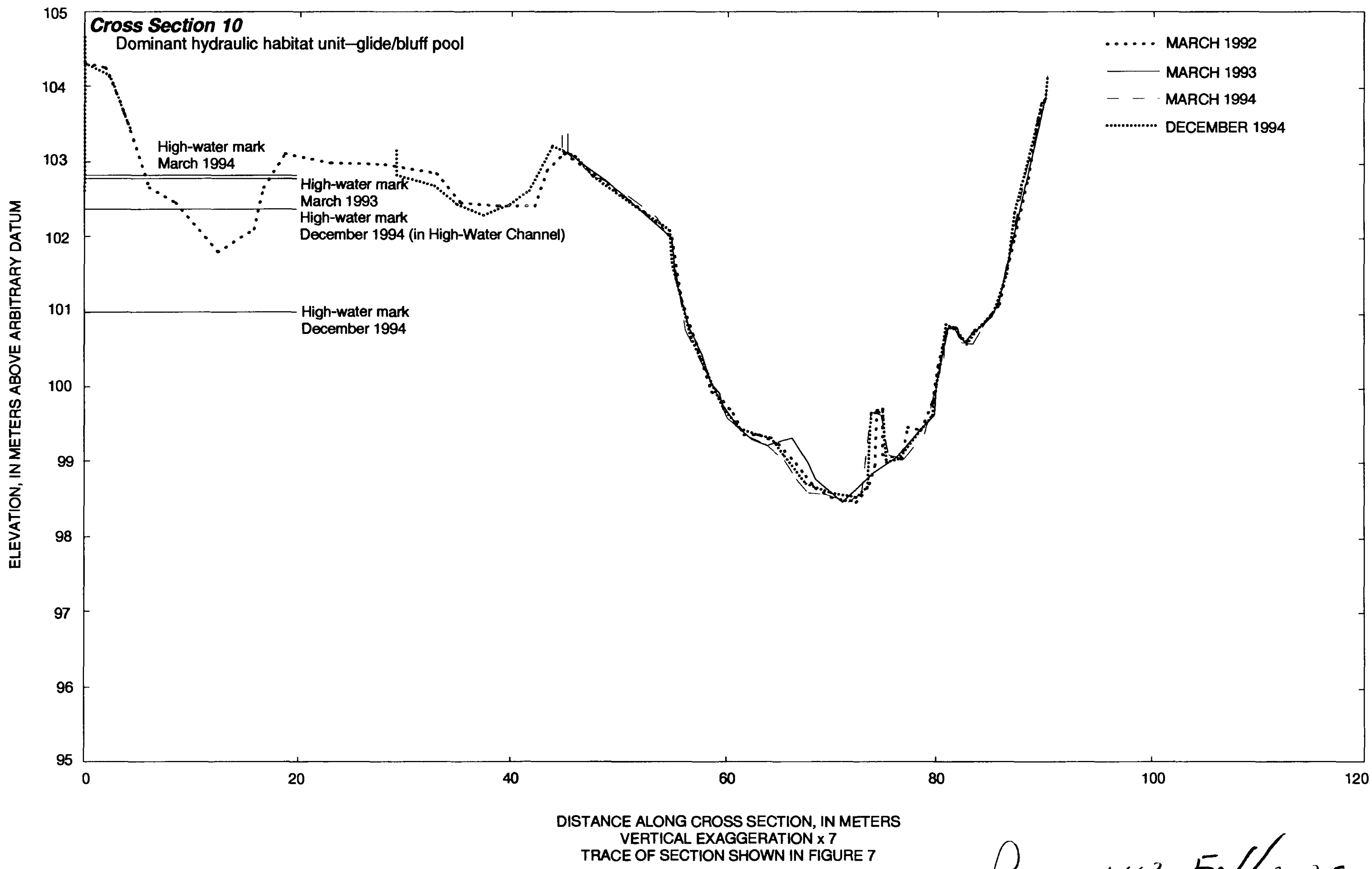

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas –Continued.

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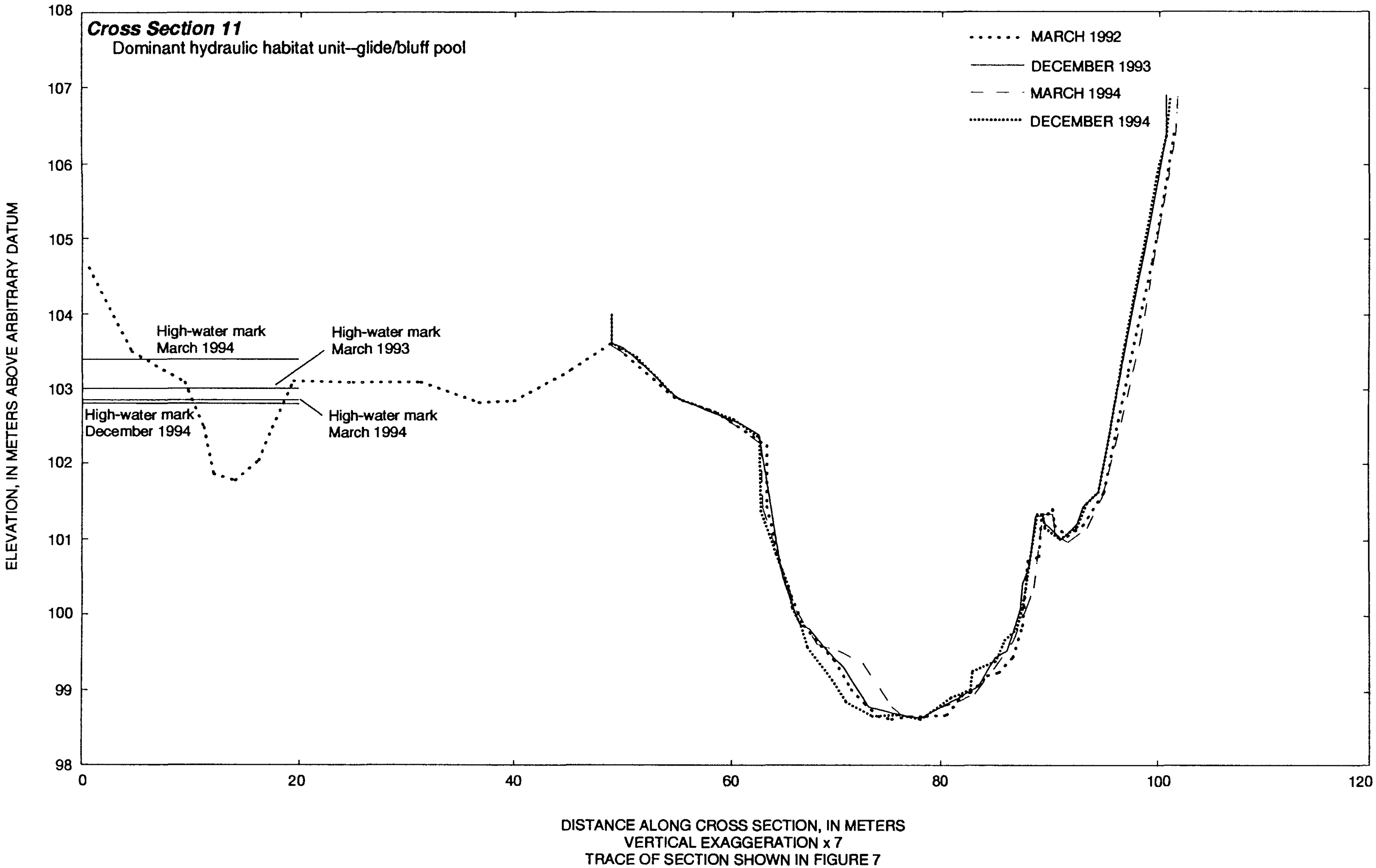

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas—Continued.

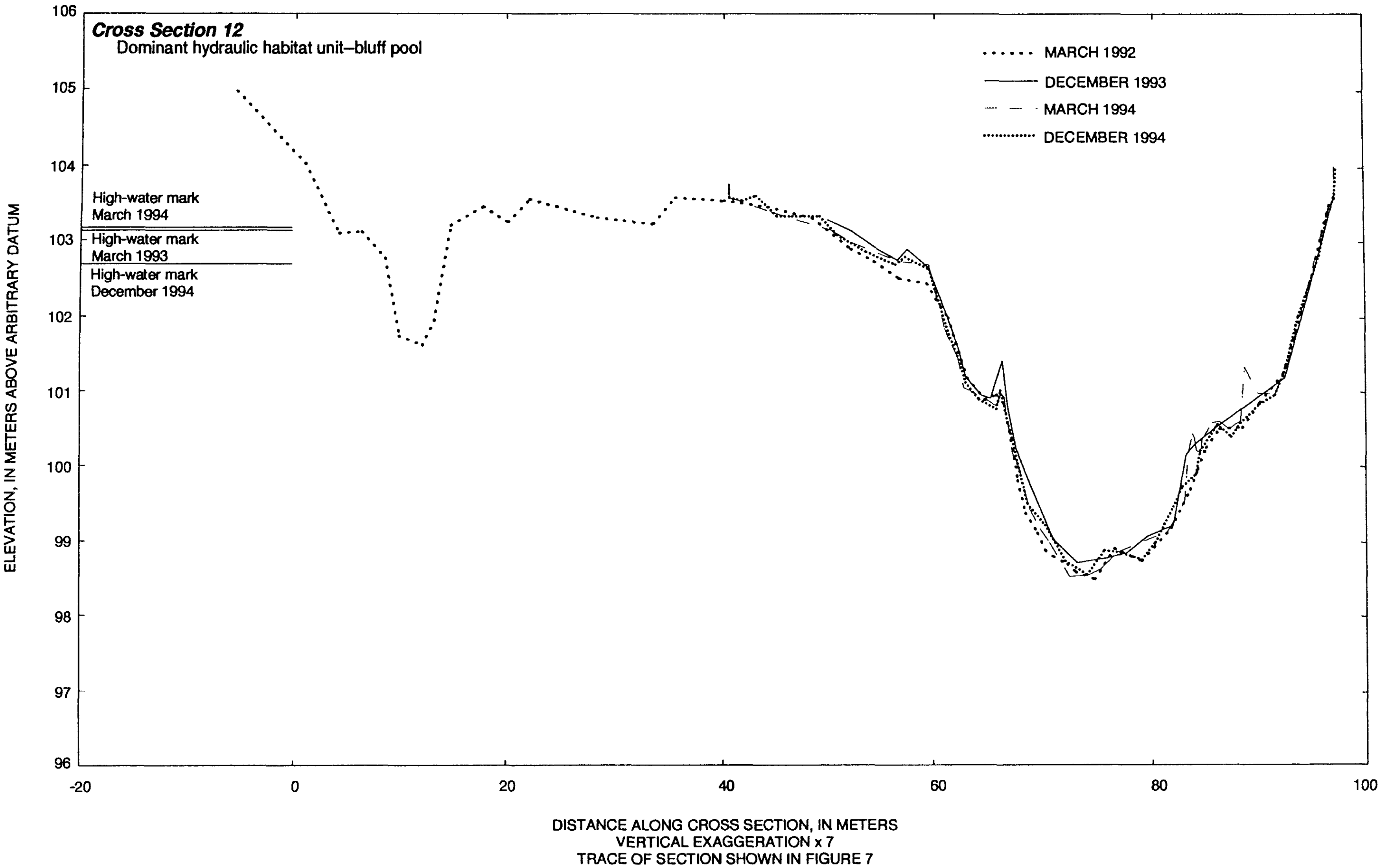

Figure 24. Cross sections located at Wilderness Boundary reach, Buffalo River, Arkansas–Continued.

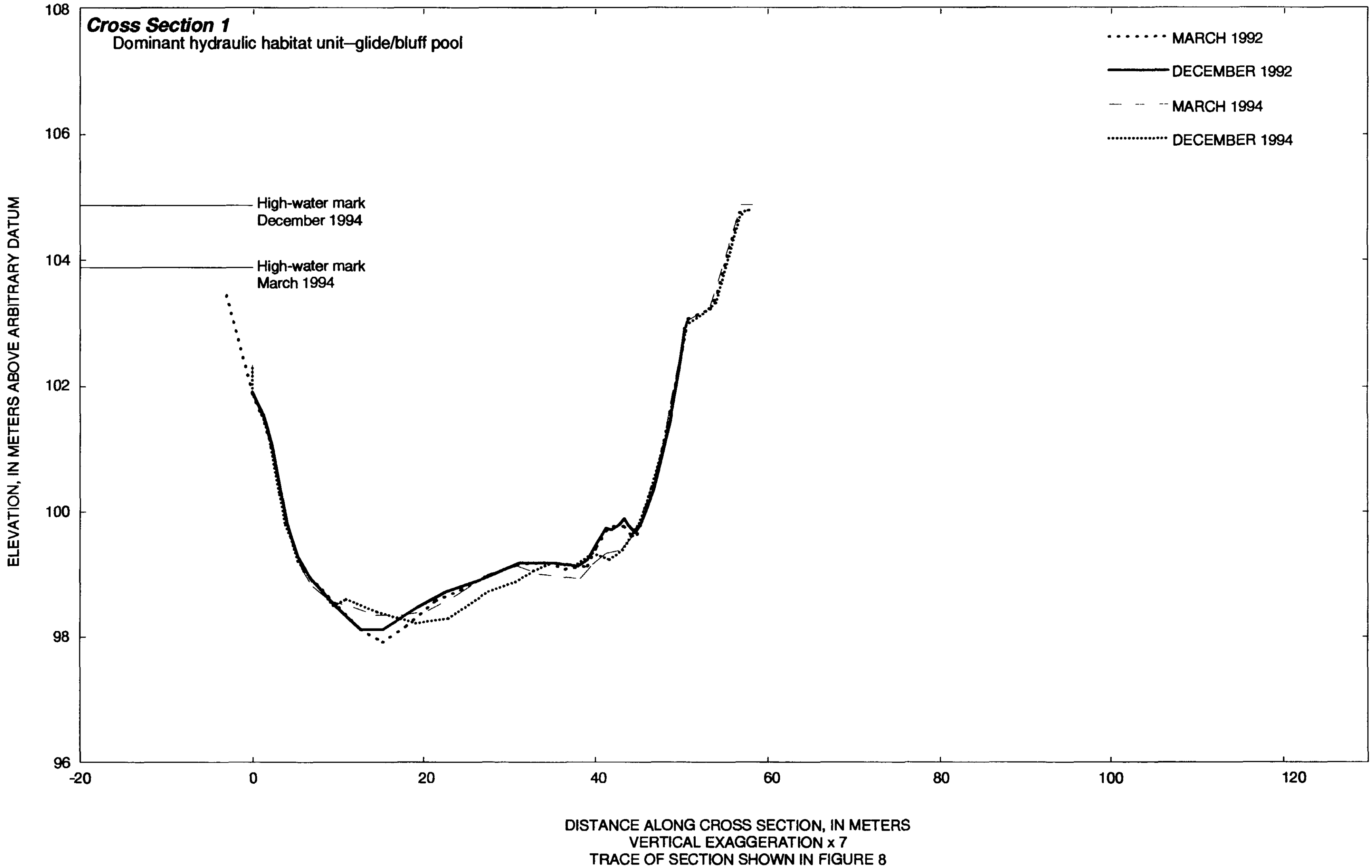

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas.

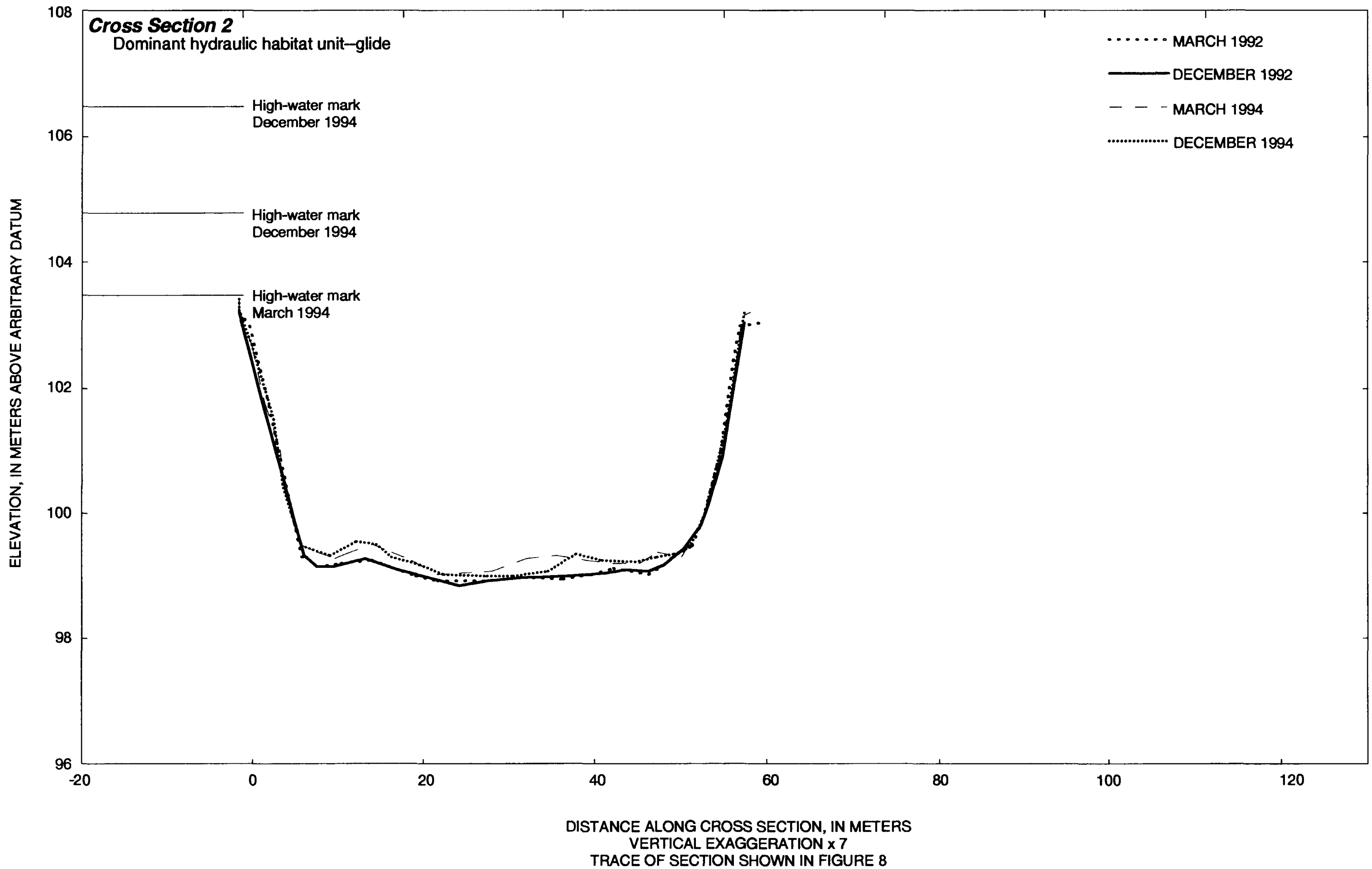

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas–Continued.

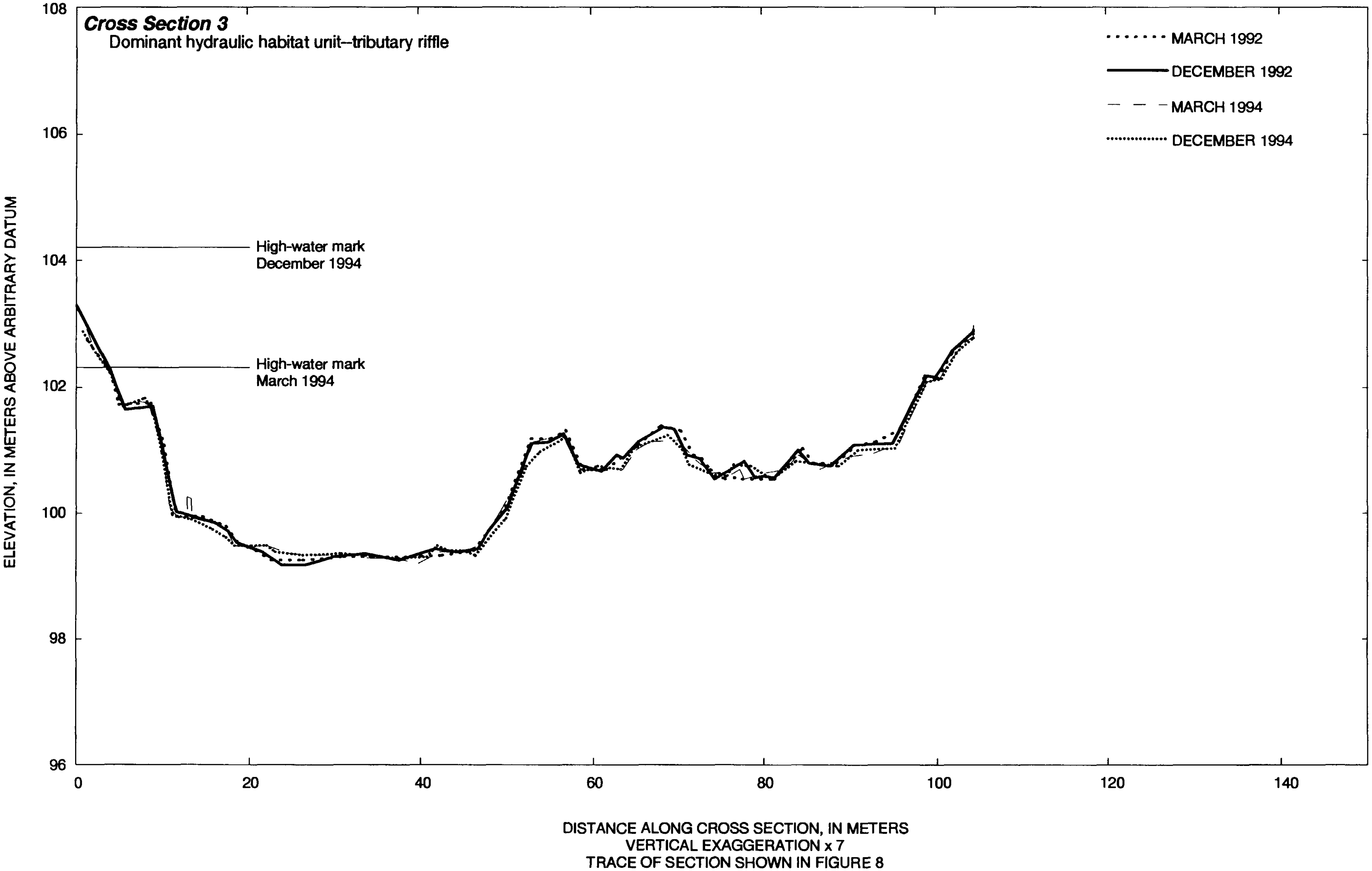

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas—Continued.

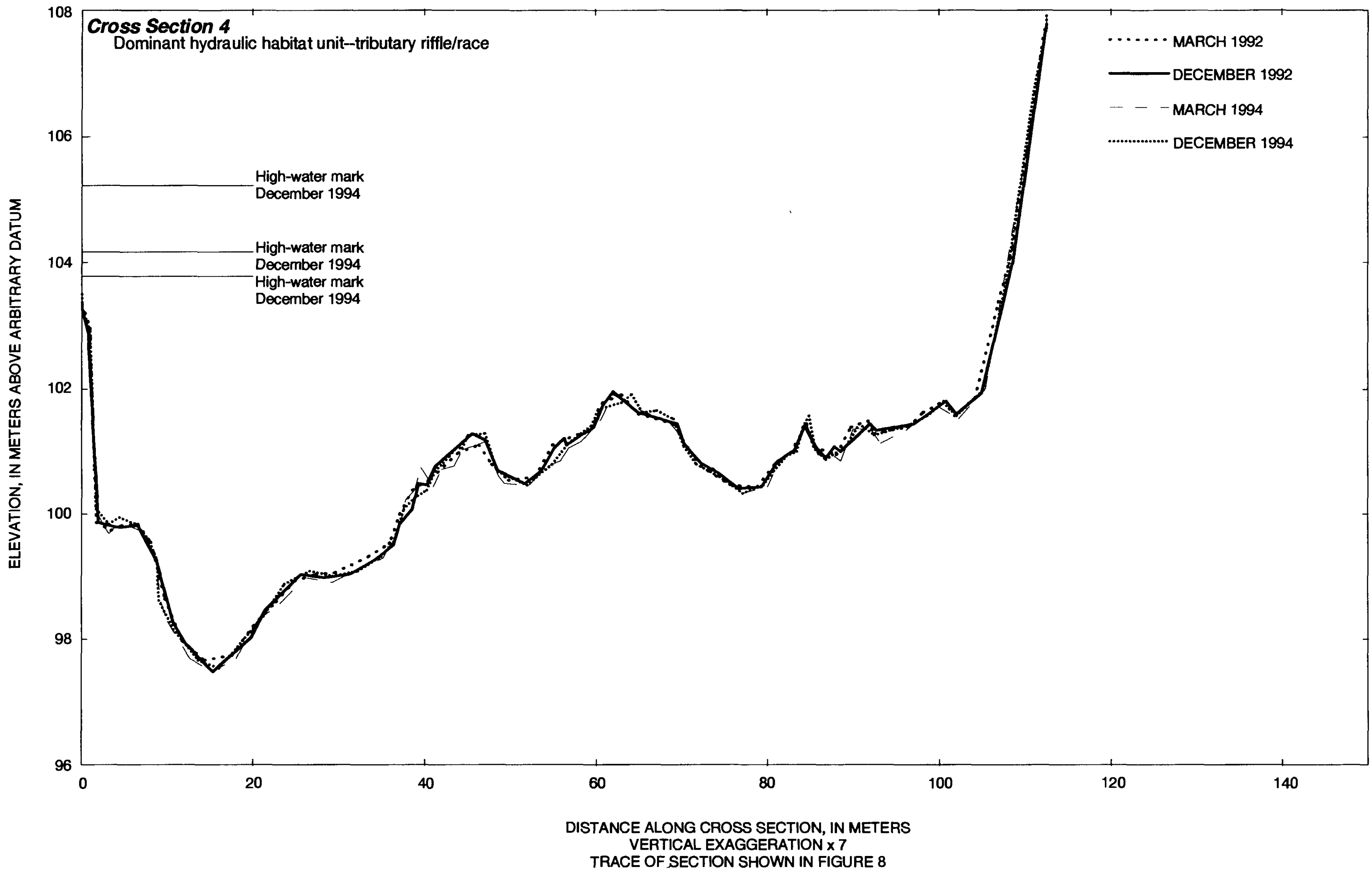

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas–Continued.

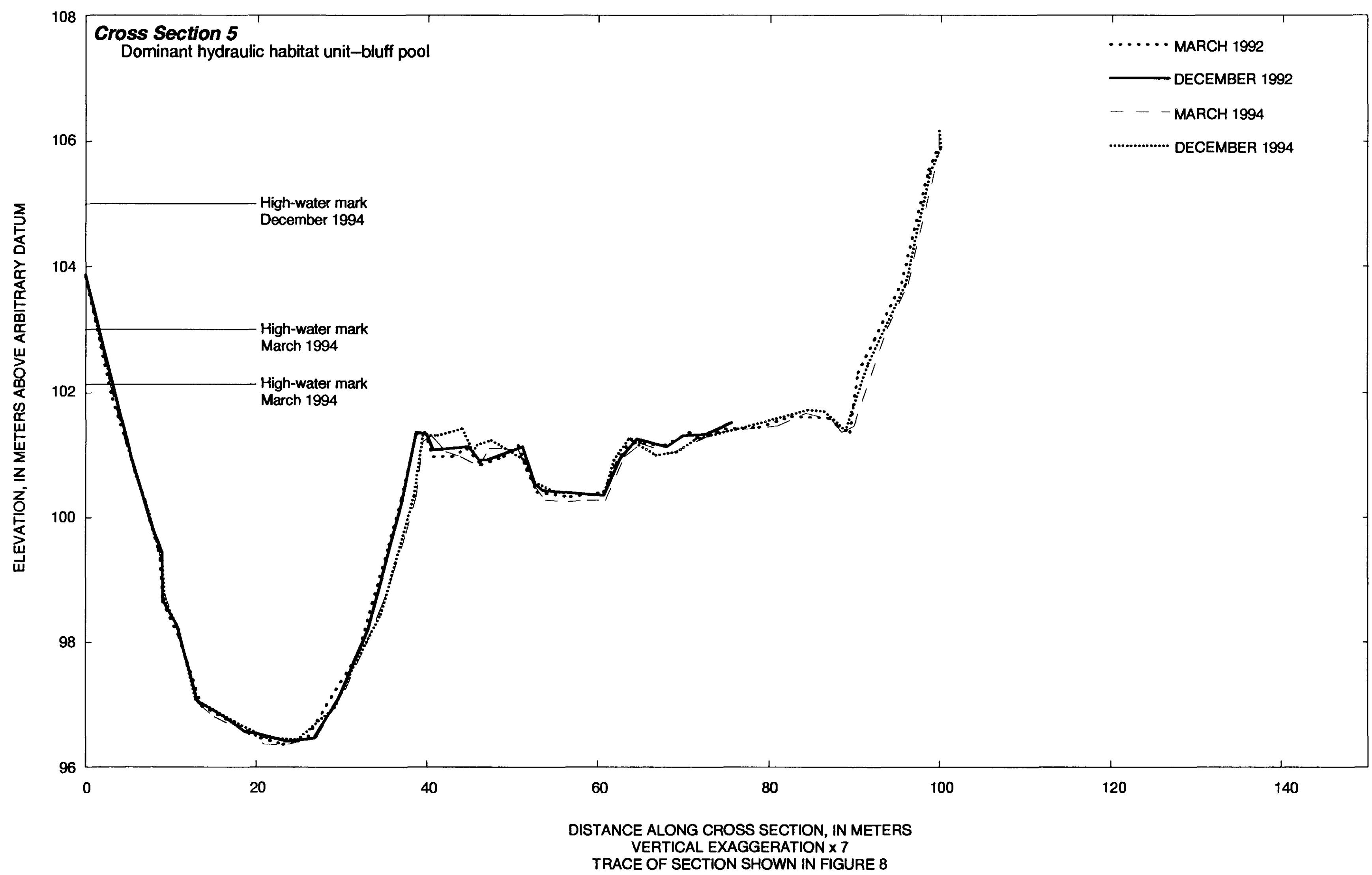

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas–Continued.

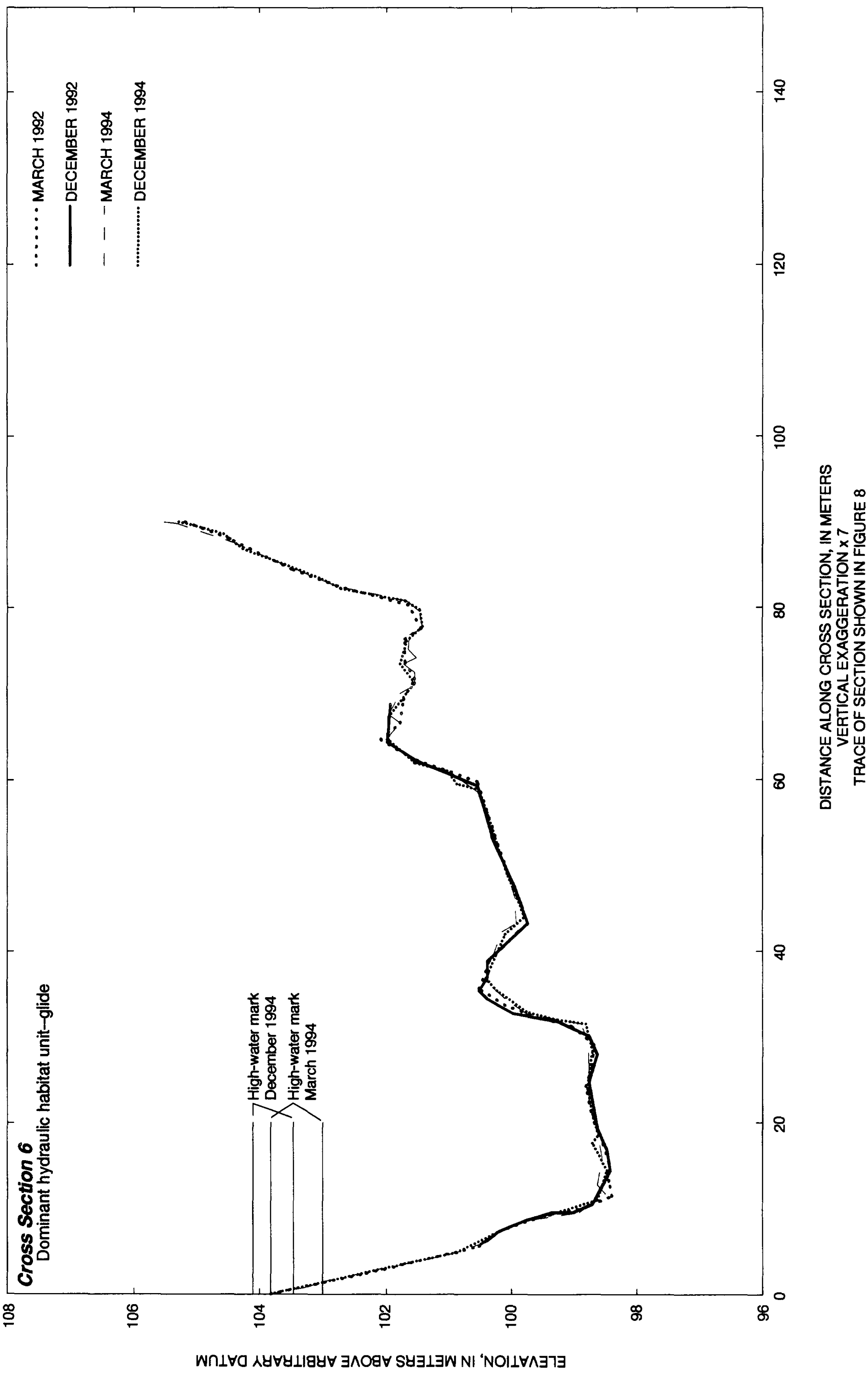

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas —Continued.

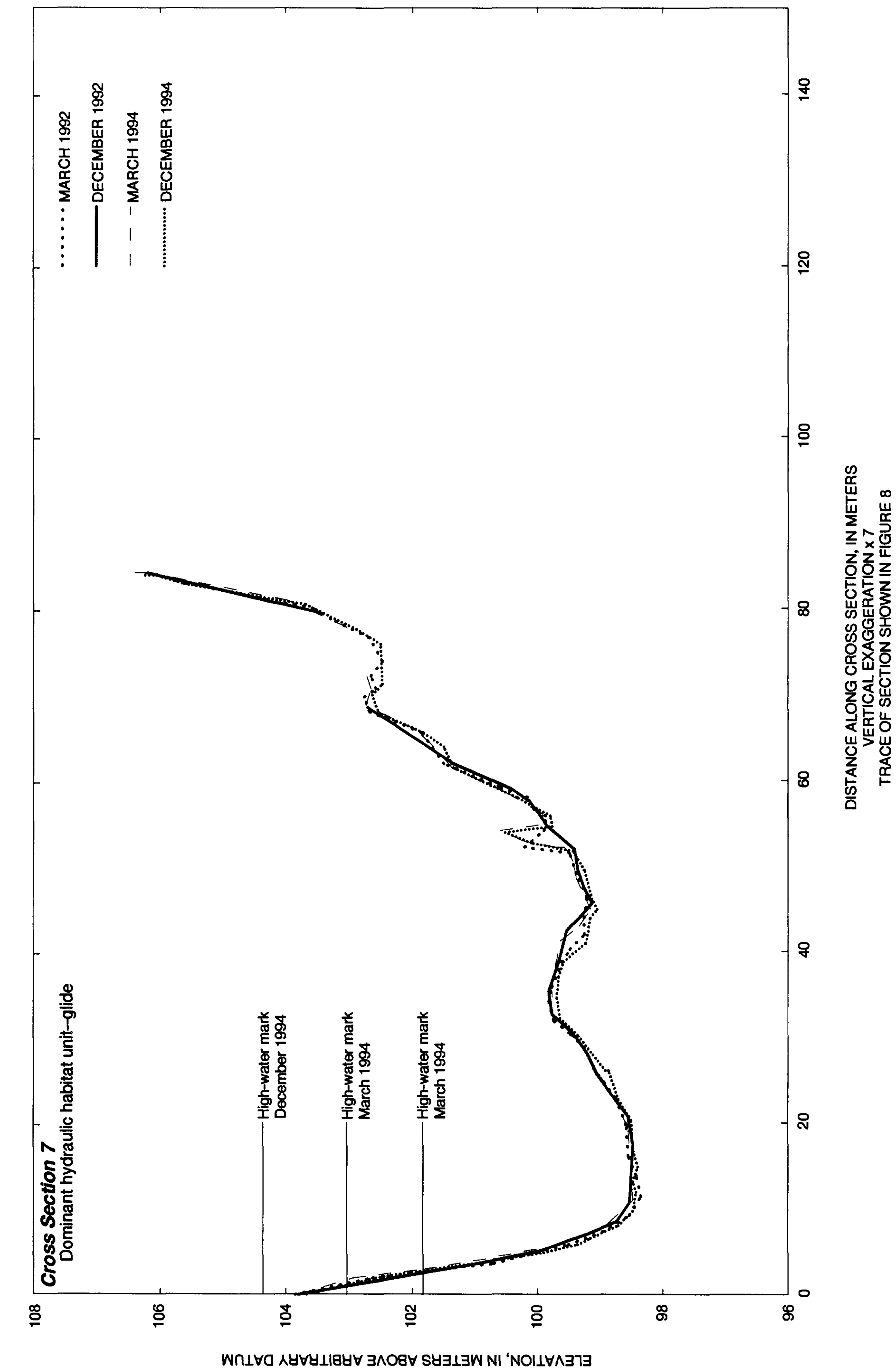

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas—Continued.

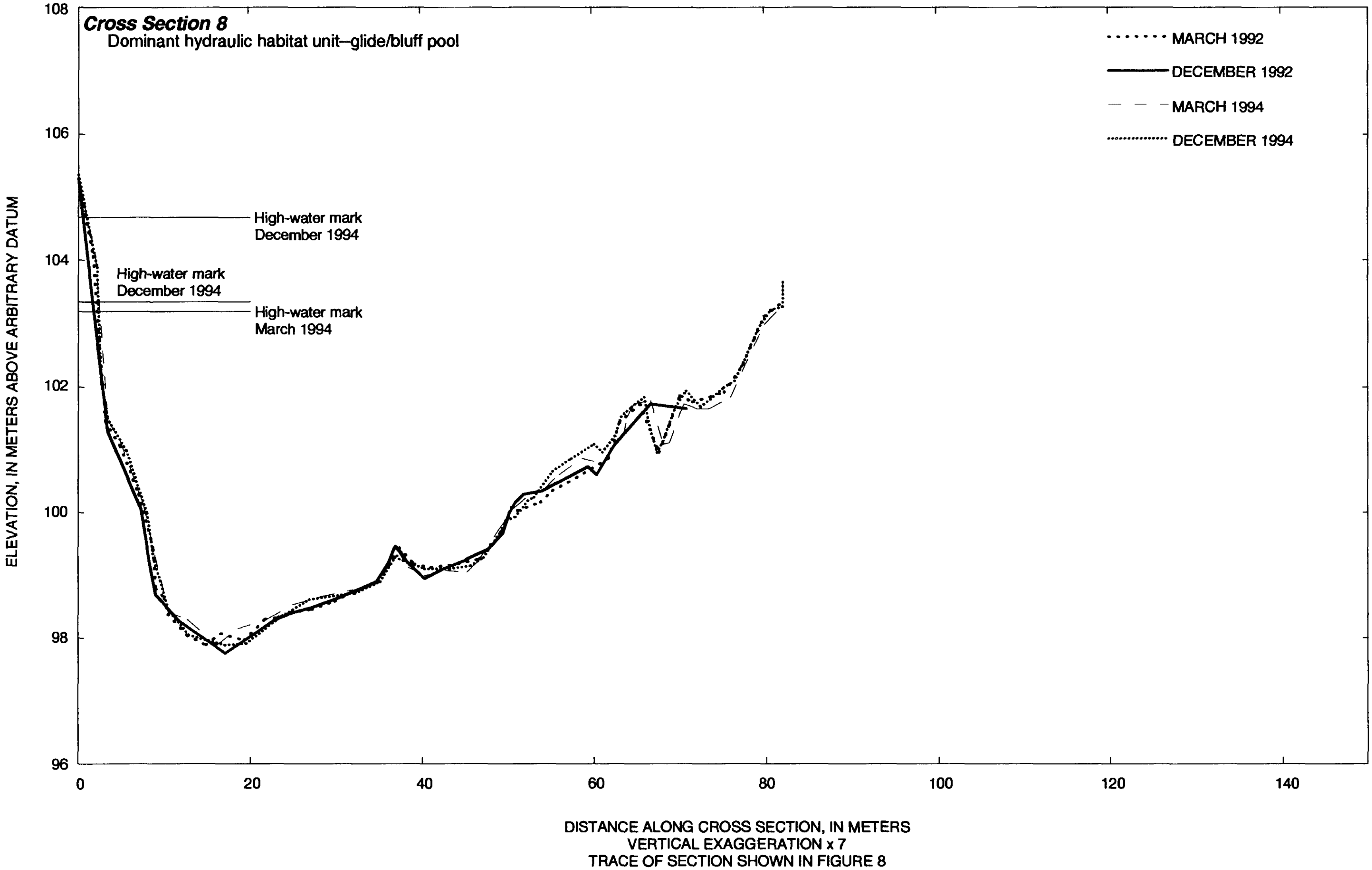

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas—Continued.

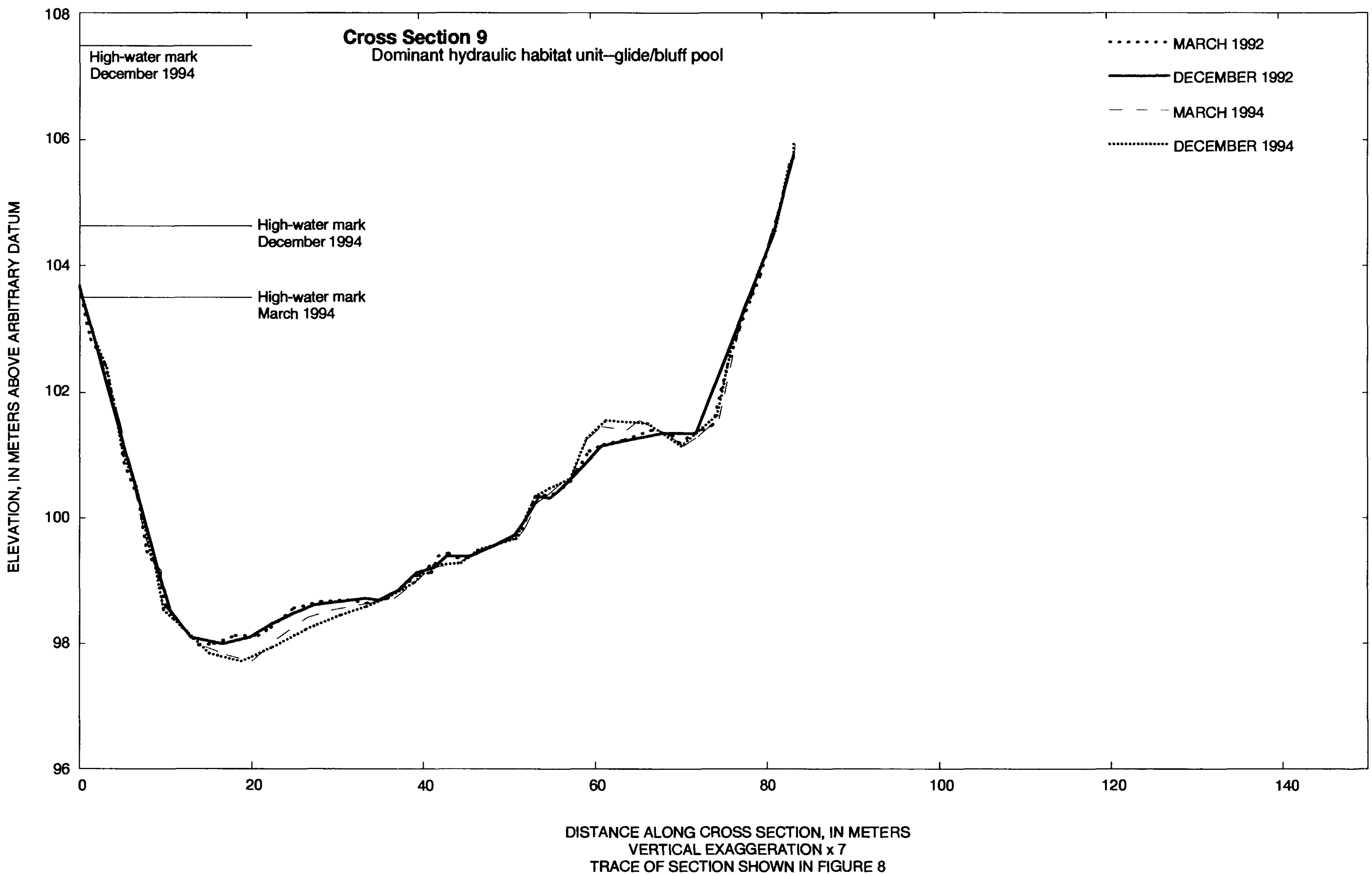

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas—Continued.

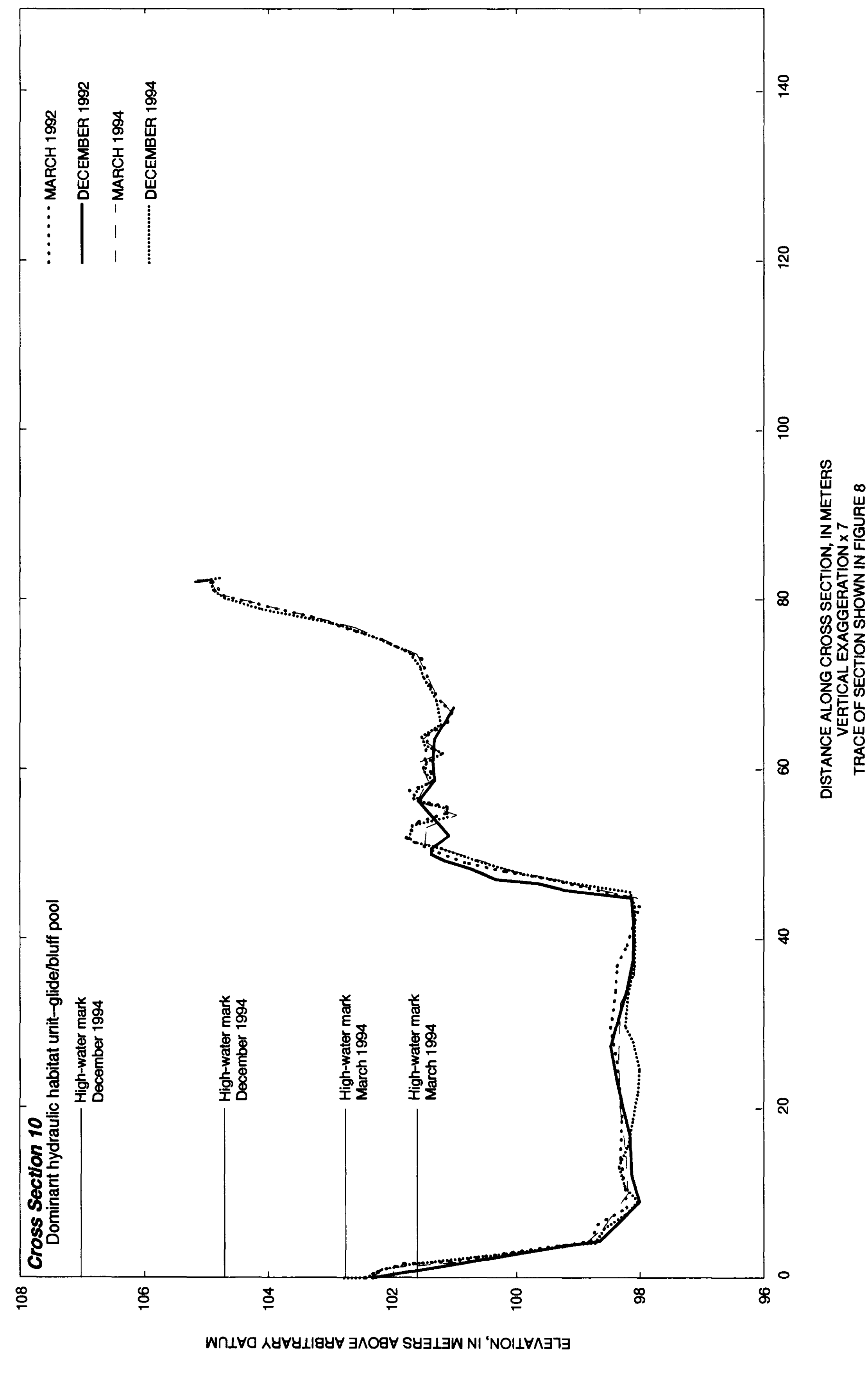

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas—Continued.

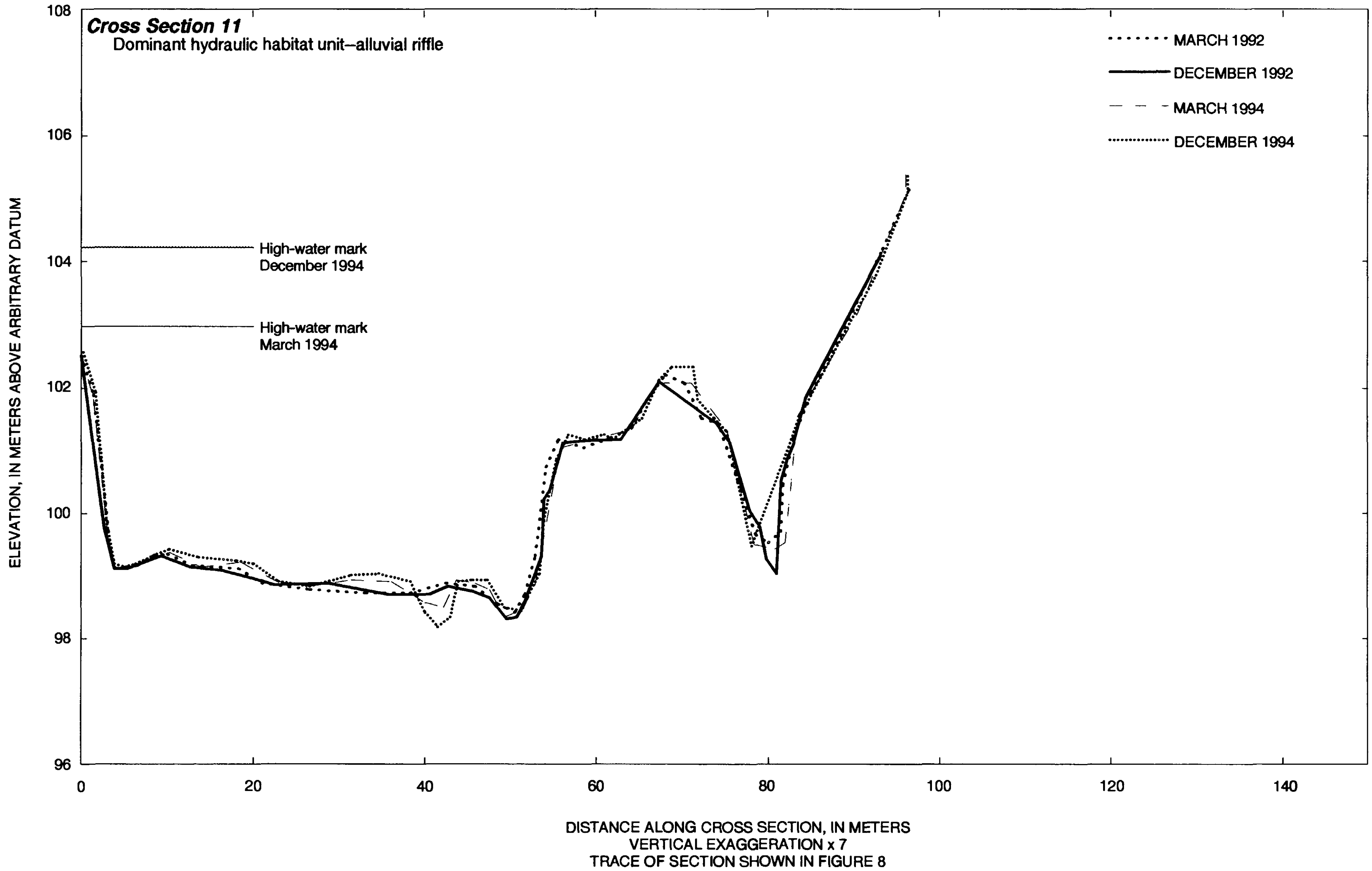

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas—Continued.

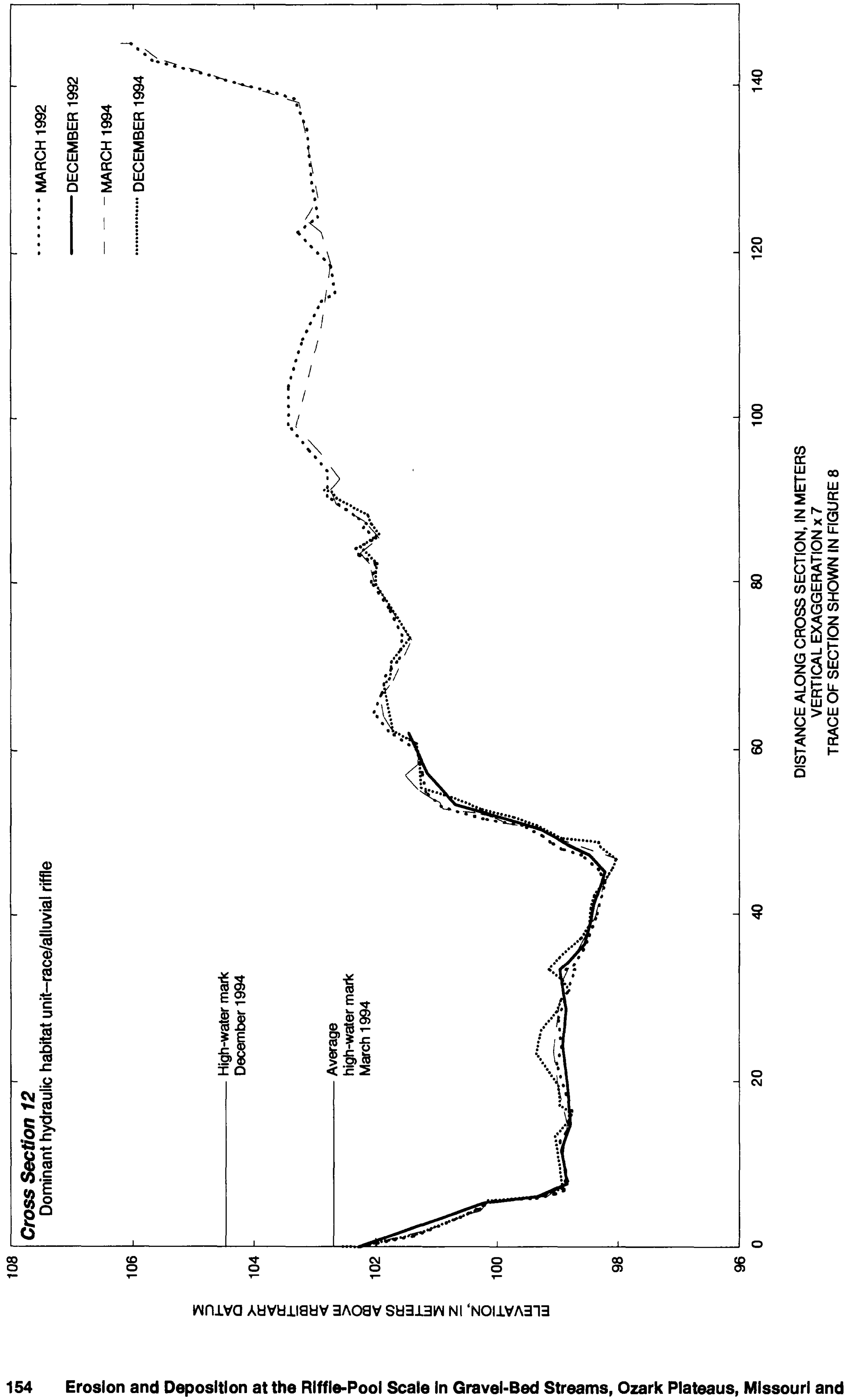

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas—Continued.

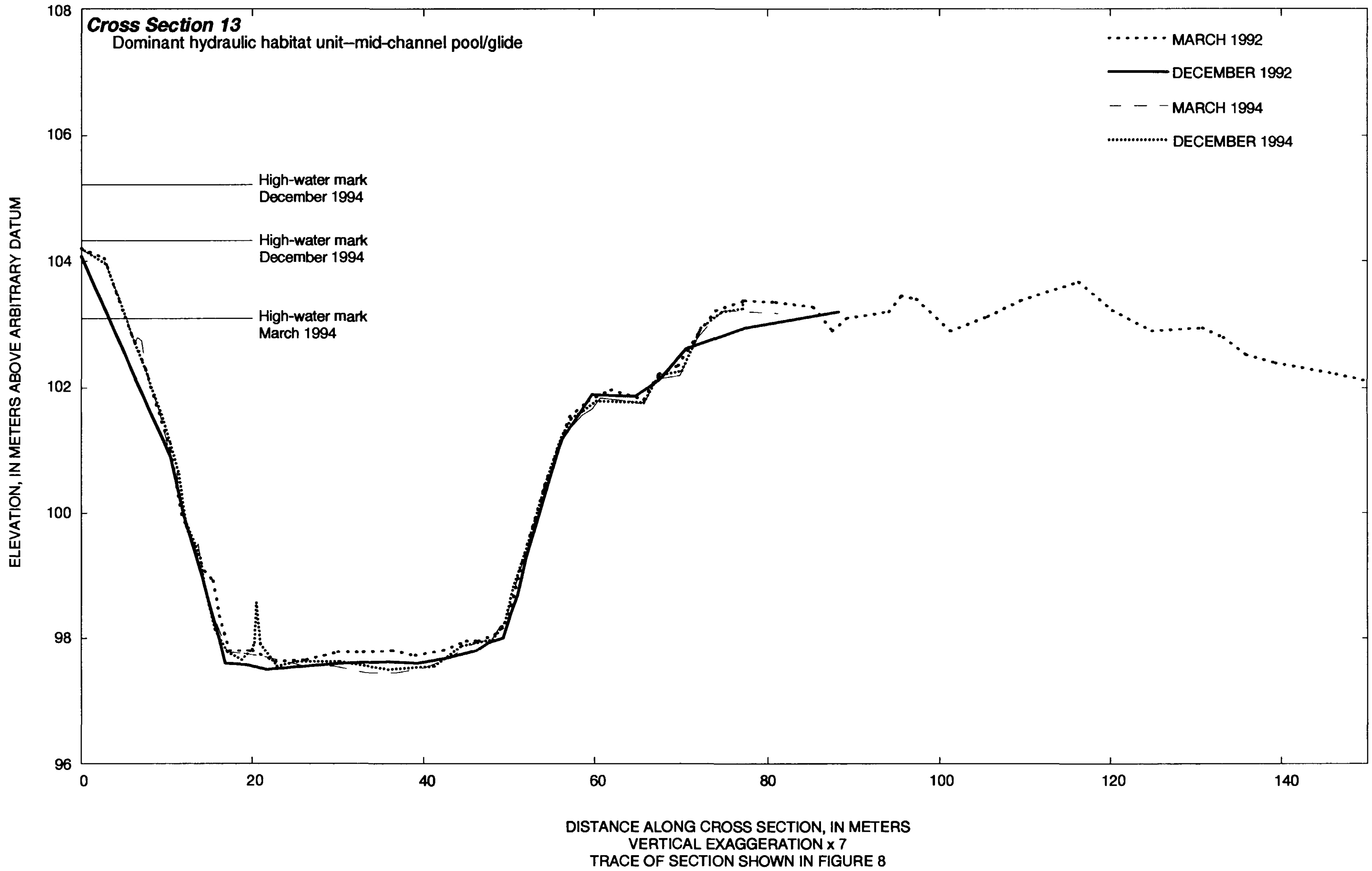

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas—Continued.

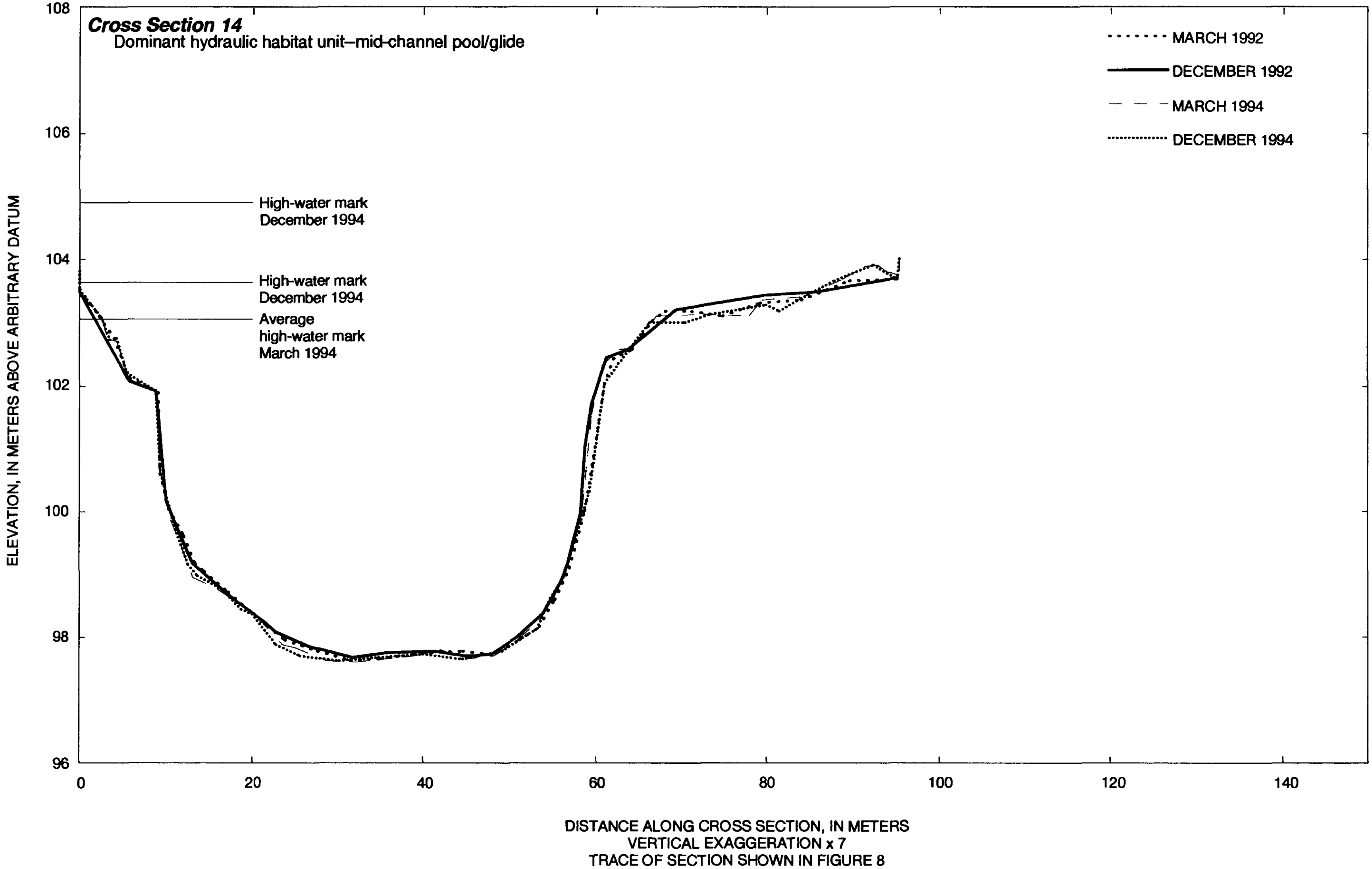

Figure 25. Cross sections located at Blue Hole reach, Buffalo River, Arkansas—Continued.

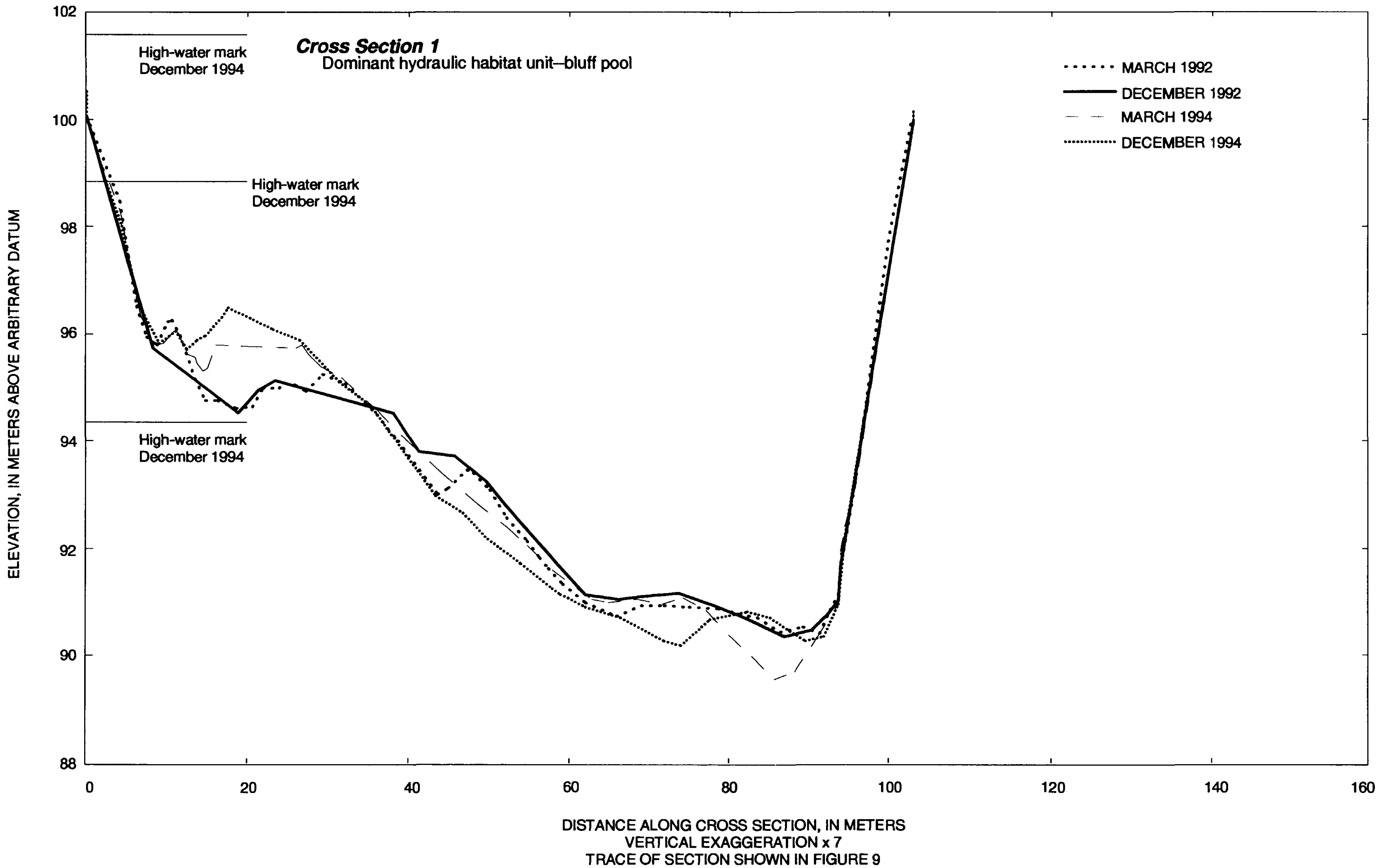

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas.

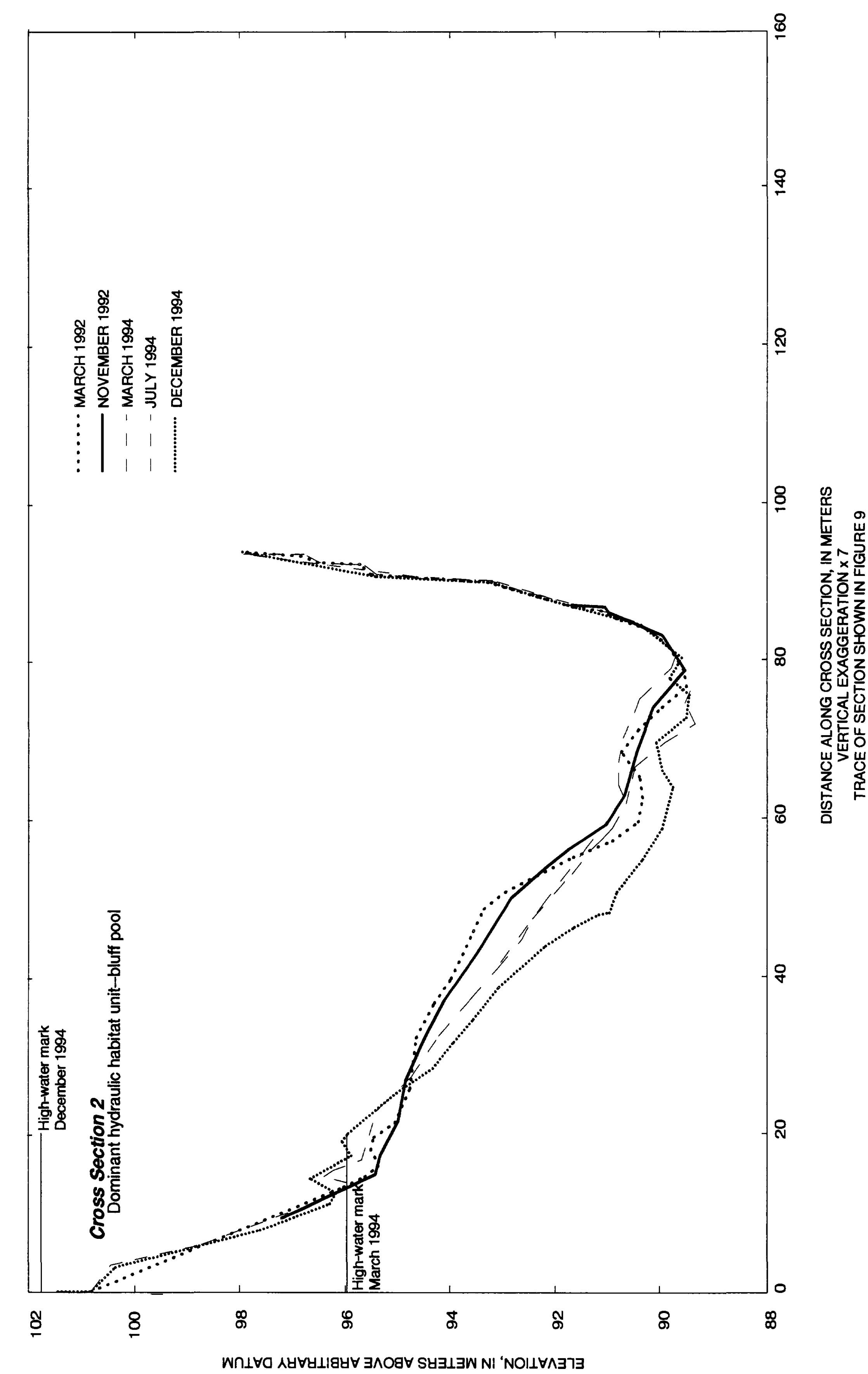

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas—Continued.

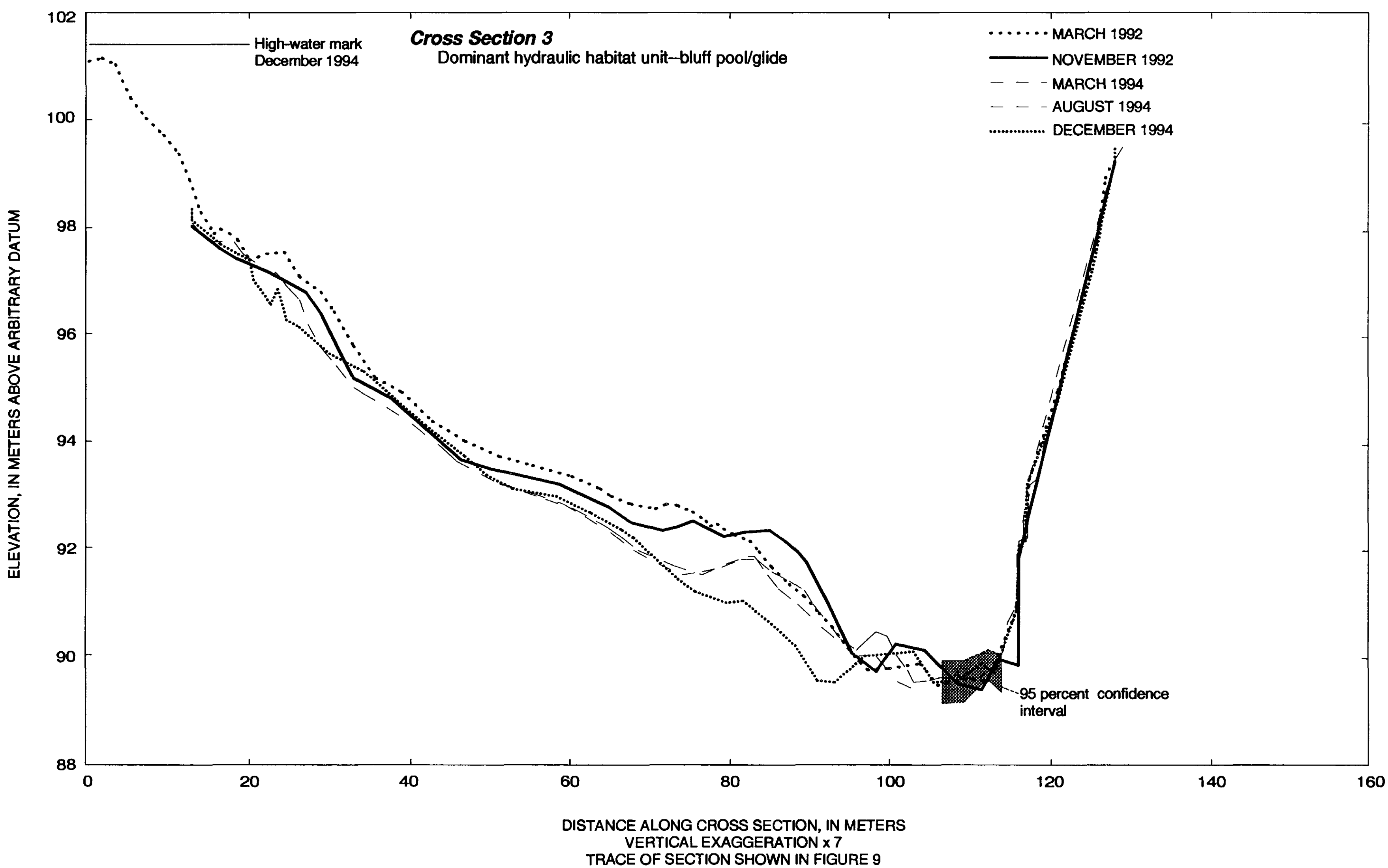

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas--Continued.

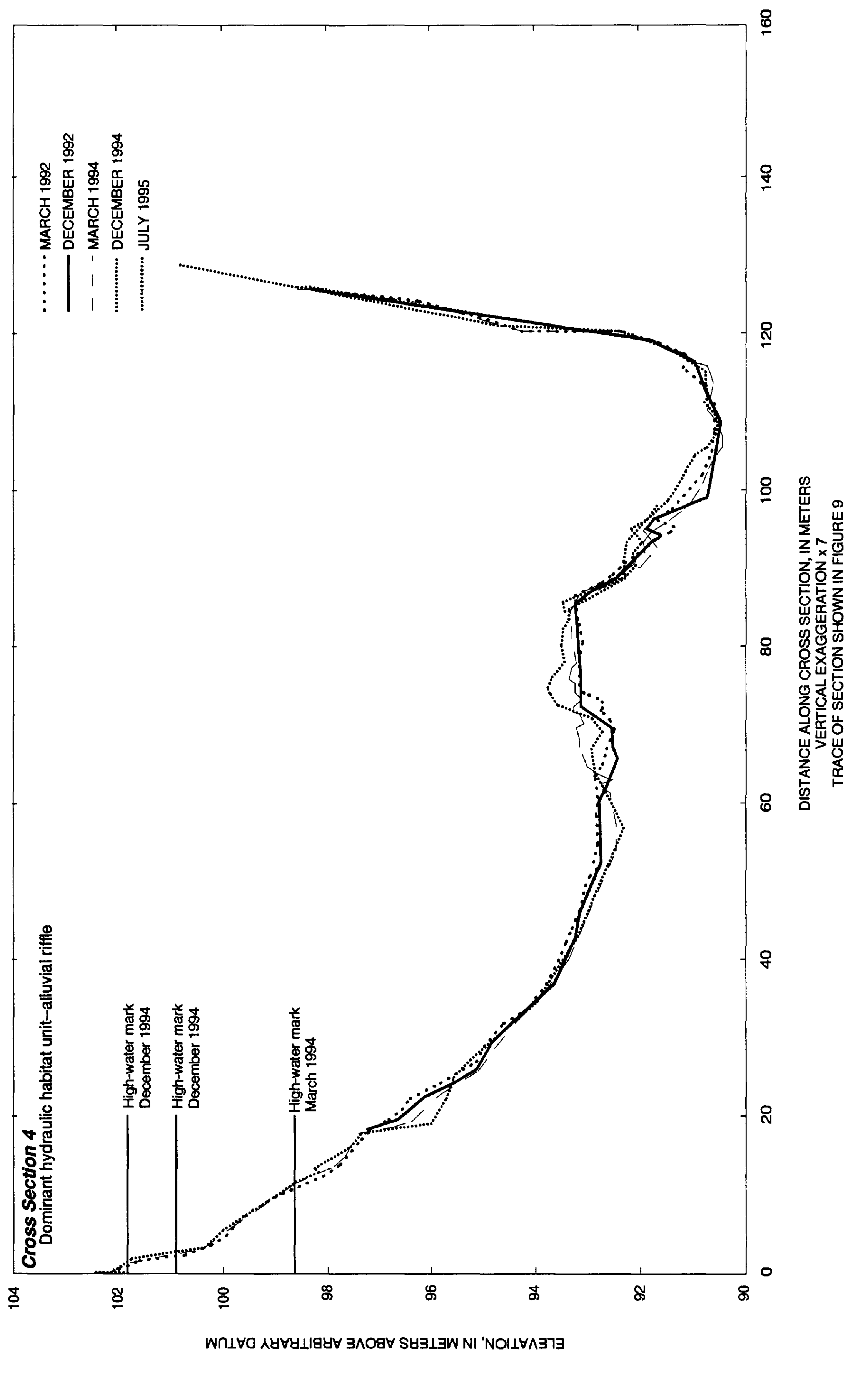

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas--Continued.

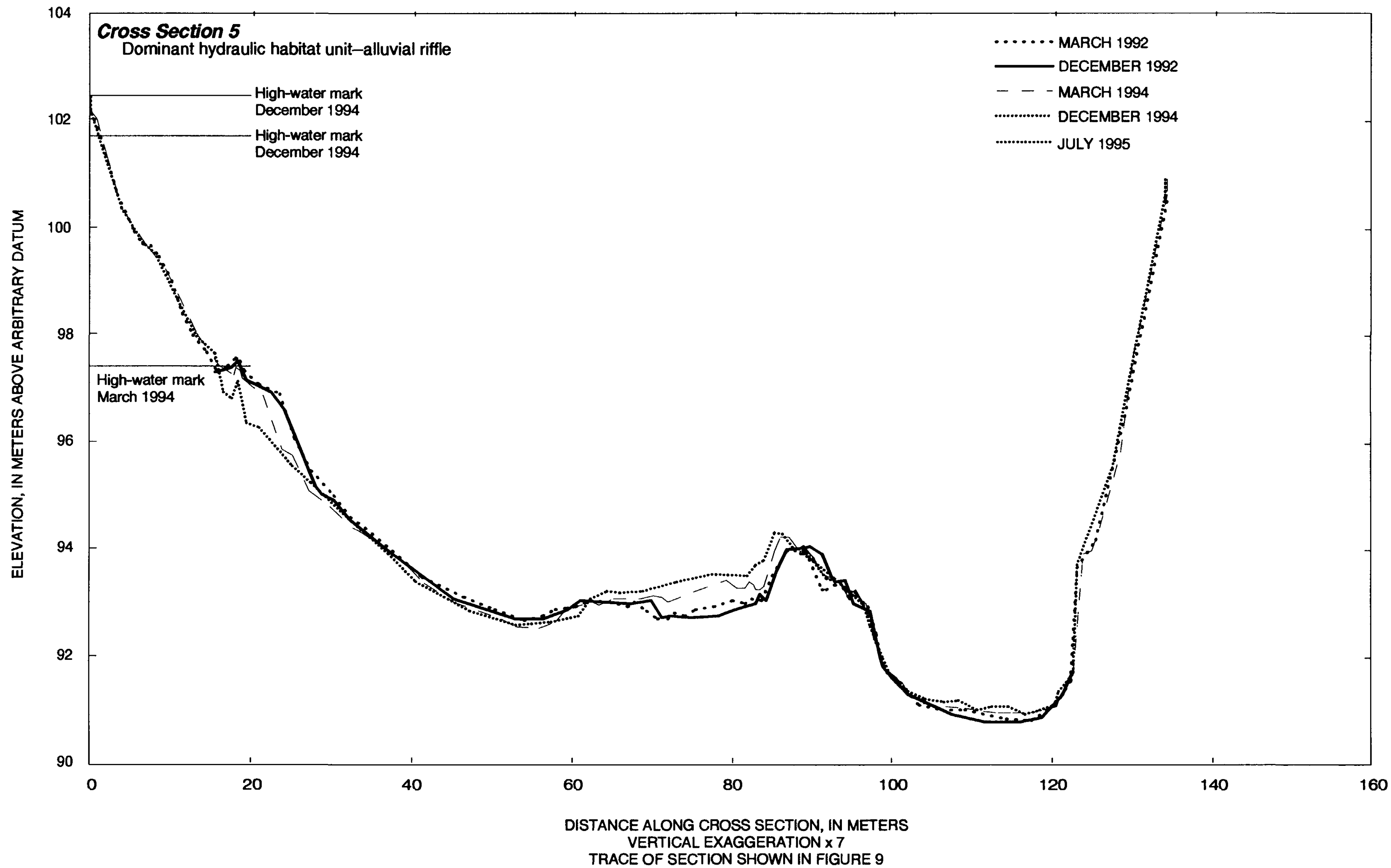

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas–Continued.

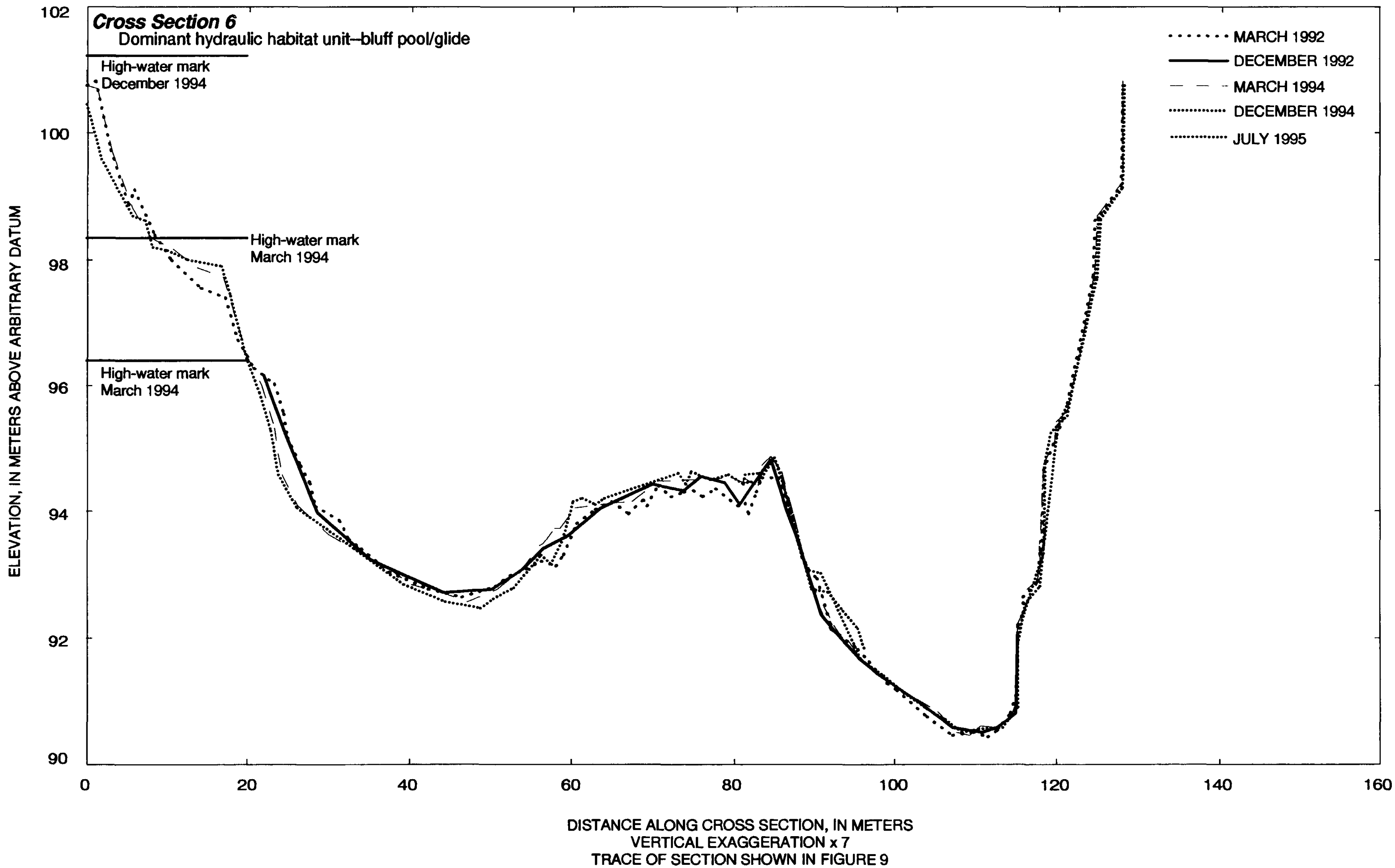

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas--Continued.

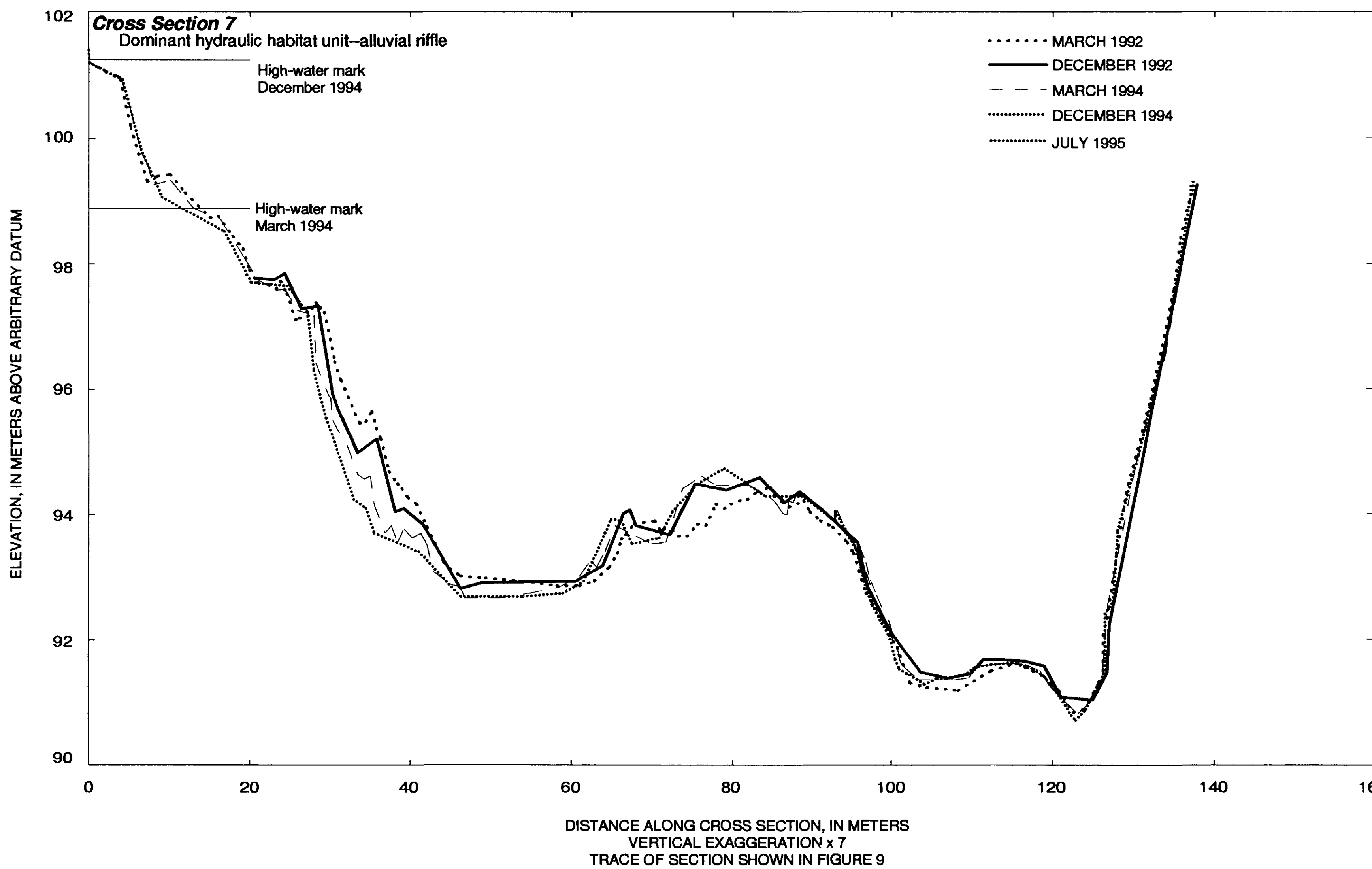

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas --Continued.

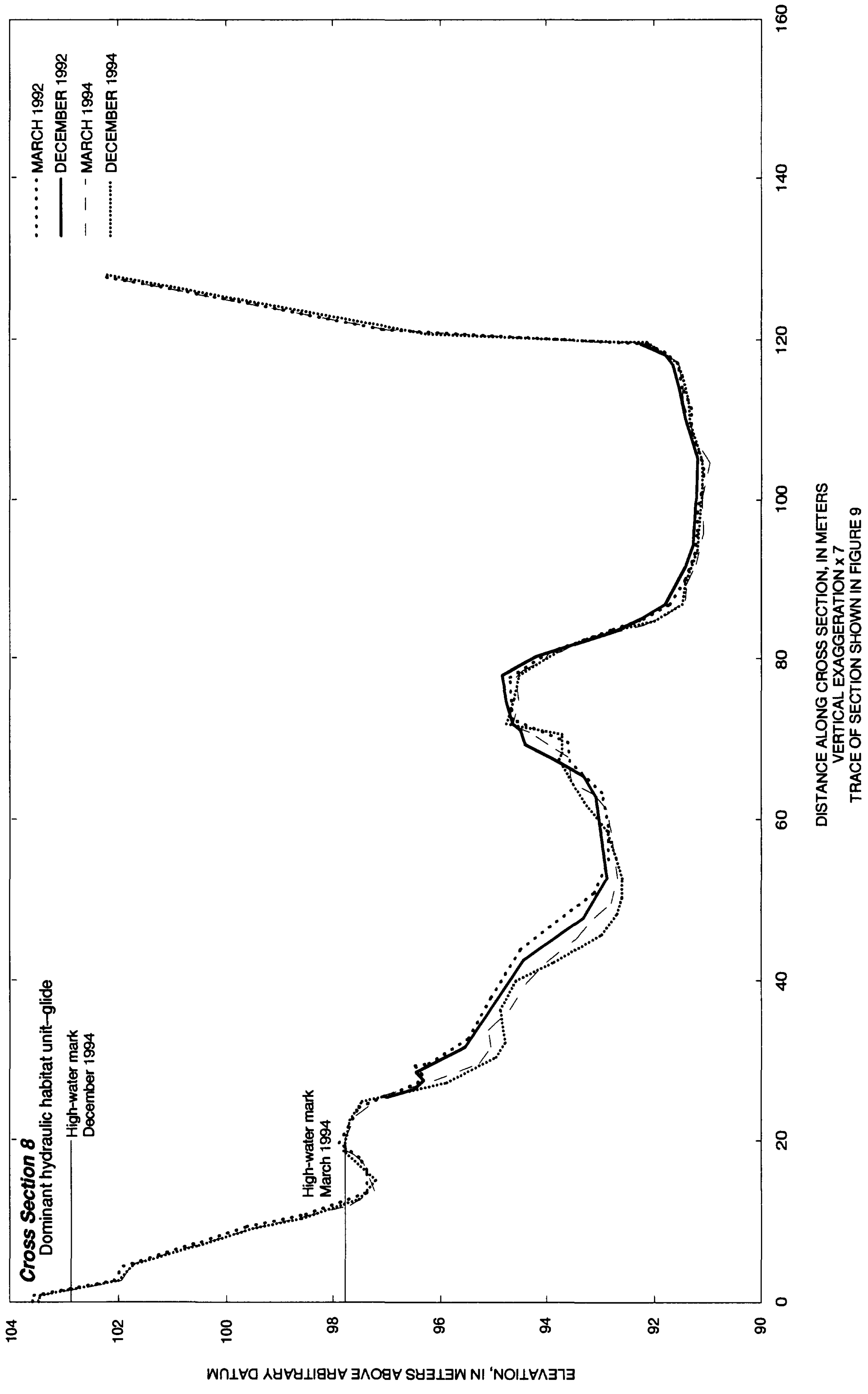

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas –Continued.

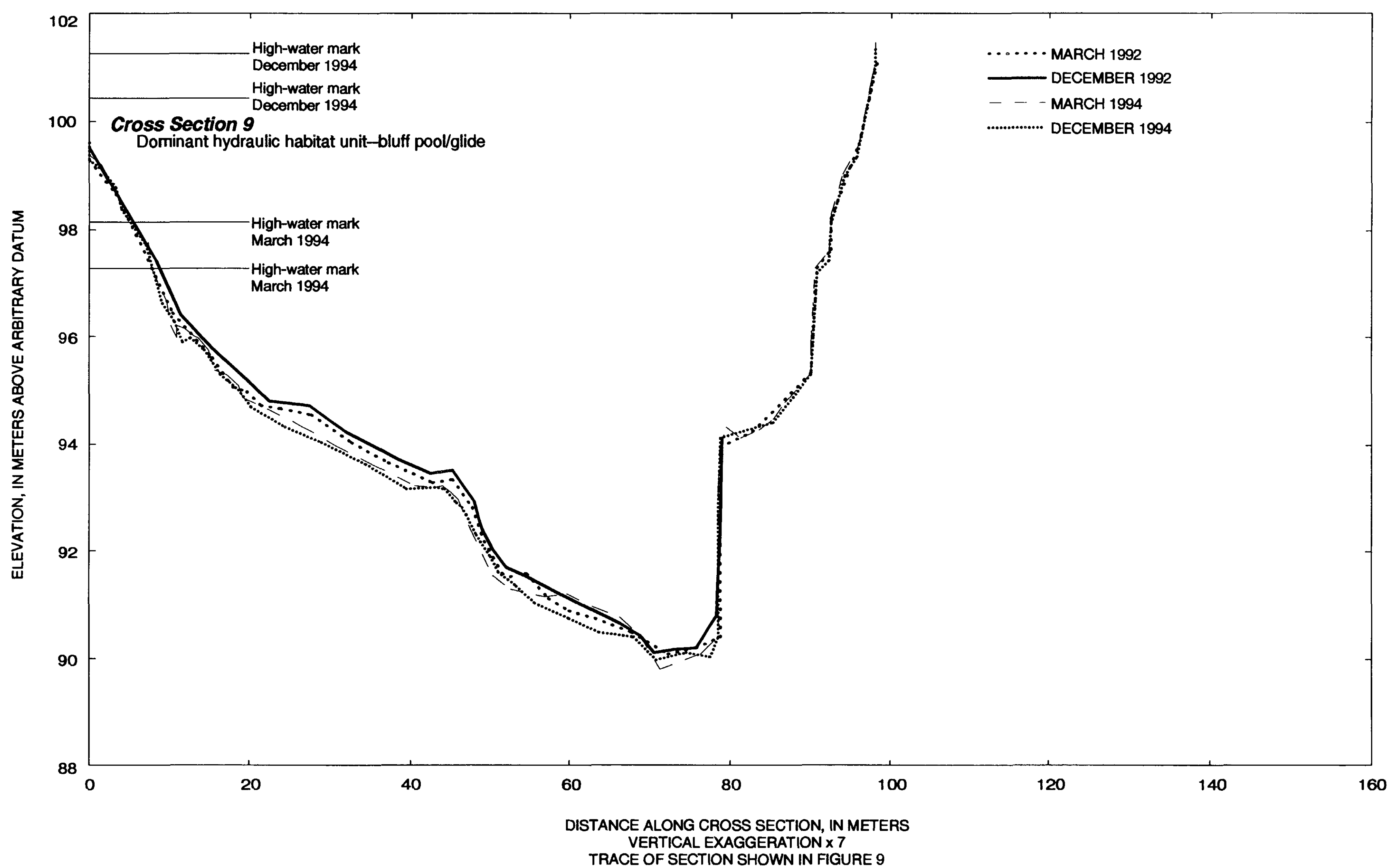

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas--Continued.

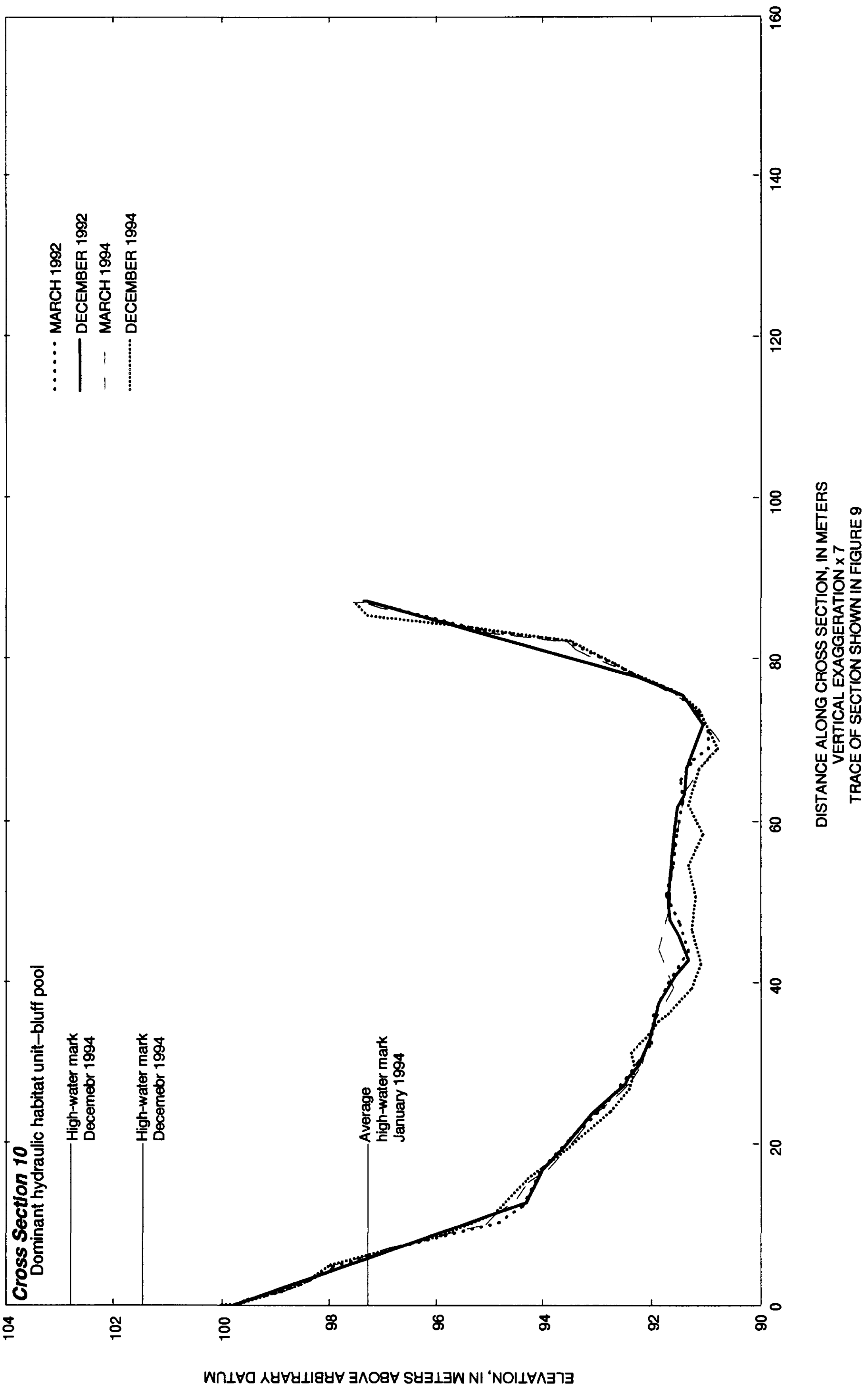

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas—Continued.

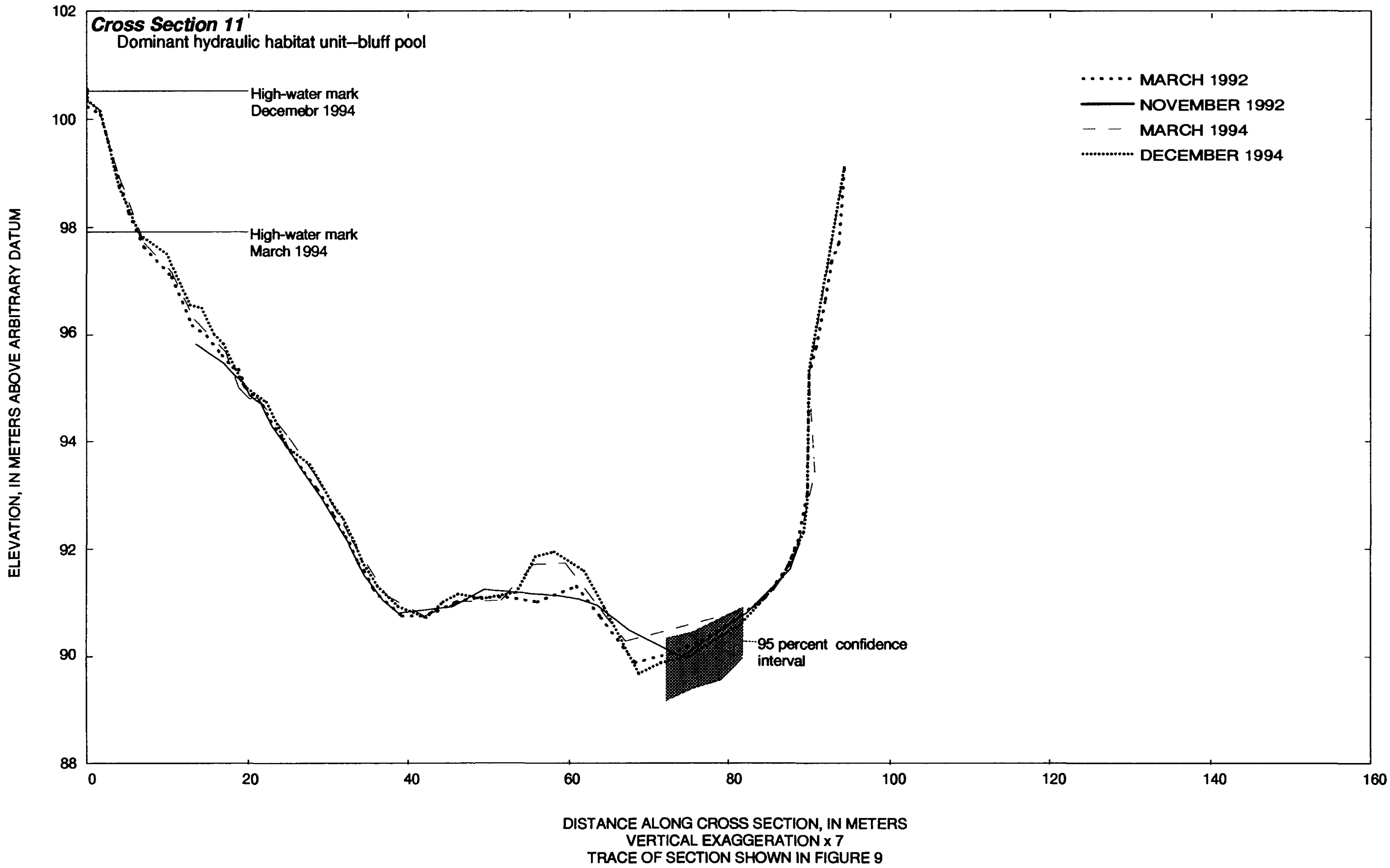

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas--Continued.

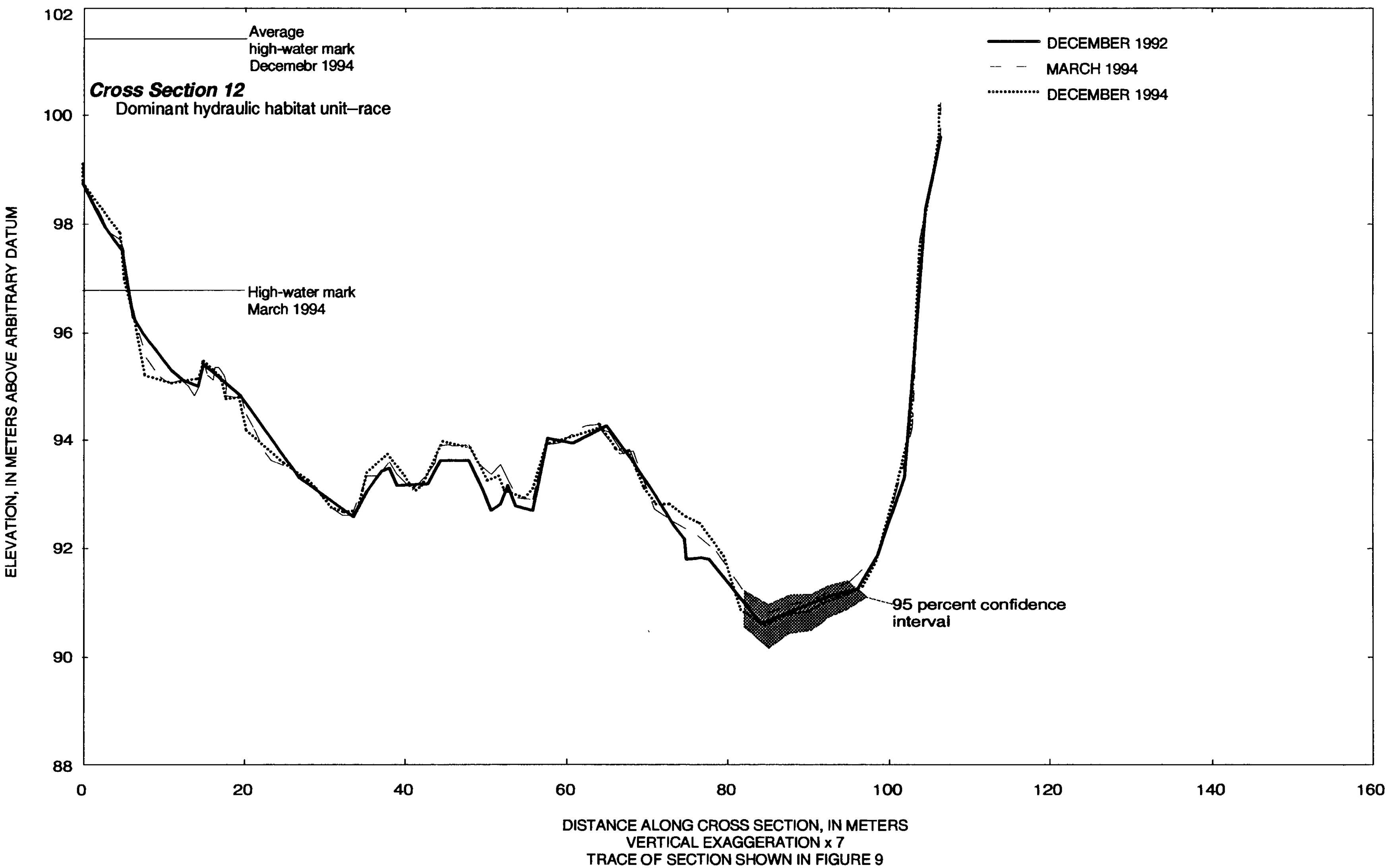

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas--Continued.

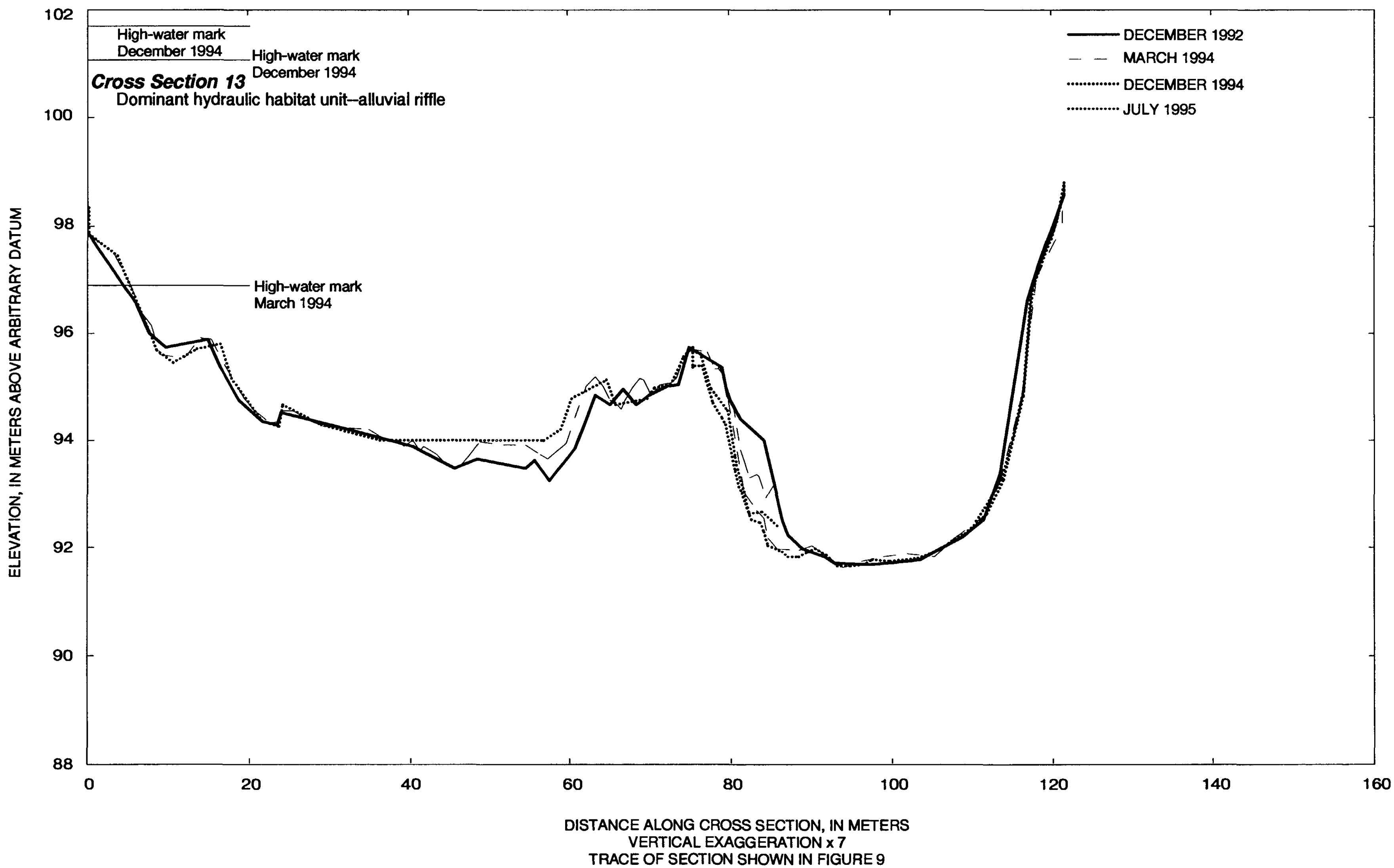

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas—Continued.

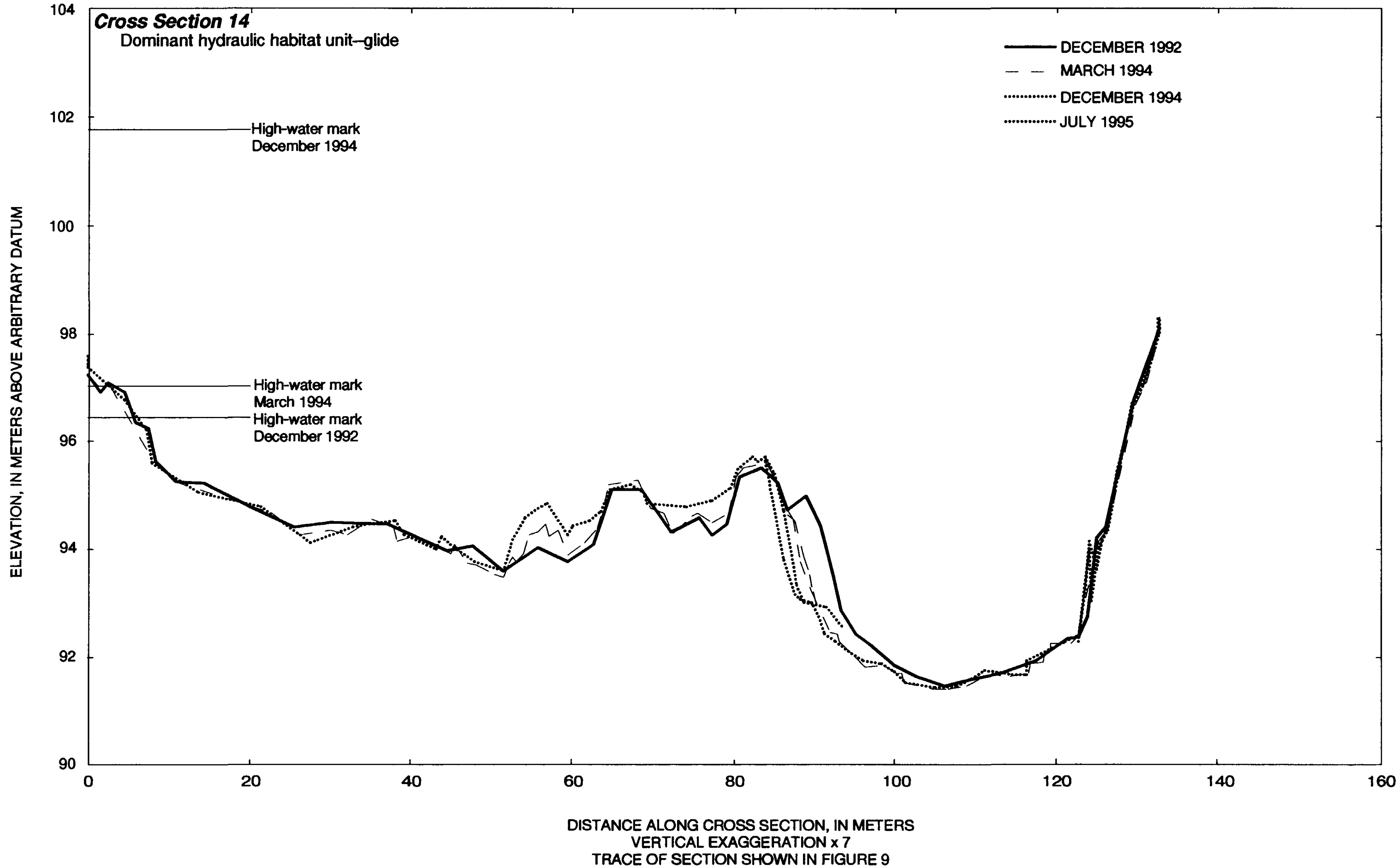

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas--Continued.

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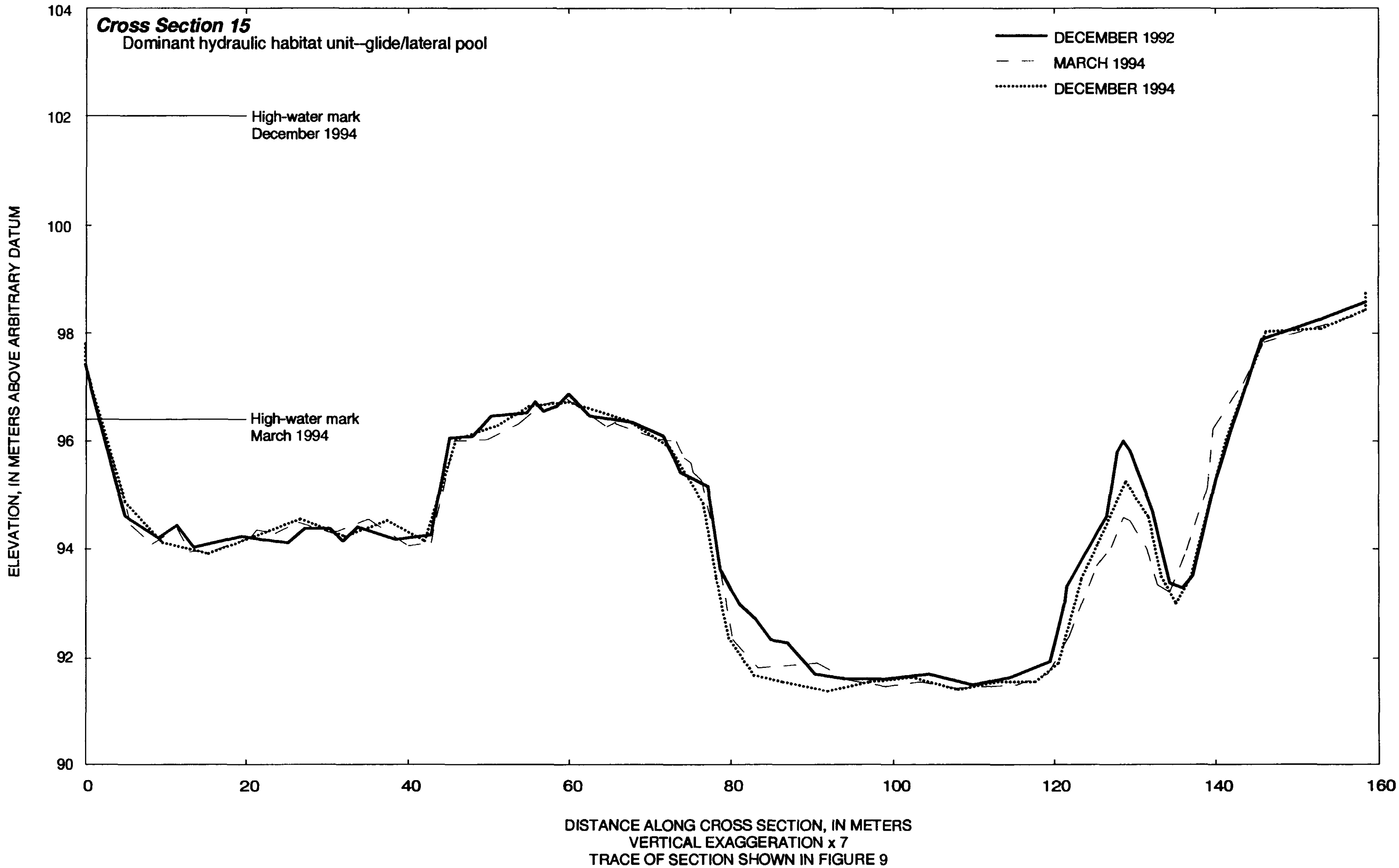

Figure 26. Cross sections located at Shine-eye reach, Buffalo River, Arkansas—Continued.