SPATIAL DISTRIBUTION OF STREAM VELOCITIES FOR THE KOOTENAI RIVER NEAR BONNERS FERRY, IDAHO, JUNE 1997

By Stephen W. Lipscomb, Charles Berenbrock, *and* Jack D. Doyle

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CONVERSION FACTORS

Multiply	By	To obtain
Length		
kilometer (km)	0.6214	mile
meter (m)	3.281	foot
Area		
square kilometer (km^2)	0.3861	square mile
Flow rate		
cubic meter per second (m^3/s)	35.31	cubic foot per second
meter per second (m/s)	3.281	foot per second

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Abstract

Over the past few decades, populations of Kootenai River white sturgeon (*Acipenser transmontanus*) have been declining. It is postulated that changes in the natural streamflow regime of the Kootenai River, resulting from the operation of Libby Dam in Montana, have had an adverse effect on sturgeon spawning habitat. Decreased streamflows and, hence, decreased stream velocities and discharges during the spring spawning period are viewed as being partly responsible for these declines.

The Idaho Department of Fish and Game requested that the U.S. Geological Survey aid in the investigation of the declining sturgeon populations by collecting and summarizing velocity data for three reaches of the Kootenai River in the vicinity of Bonners Ferry, Idaho. These data were collected during June 10–12, 1997, at a river discharge ranging from 1,240 to 1,260 cubic meters per second. These dates coincide with the typical peak of the sturgeon's spawning activities. The data were collected using a broadband Acoustic Doppler Current Profiler in conjunction with a Global Positioning System and total station for georeferencing. Velocity data subsequently were post-processed and contoured using a surface-modeling software package. Horizontally and vertically distributed velocity-contour plots were generated using a triangulation-with-linear-interpolation method employed by the software.

INTRODUCTION

The Kootenai River in northern Idaho (fig. 1) is home to a population of white sturgeon (*Acipenser transmontanus*) that were listed as an endangered species in September 1994. The listing was a result of declining populations of the fish over the past 30 to 40 years. The reason for these declines has, in part, been attributed to changes in the natural streamflow regime as a result of the construction, in 1972, and operation of Libby Dam on the Kootenai River in Montana. Reduced streamflow velocities and discharges in the spring during the sturgeon's spawning period may have had an adverse effect on the ability of the fish to spawn successfully.

To aid in the investigation of the declining sturgeon populations, the Idaho Department of Fish and Game (IDFG) requested that the U.S. Geological Survey (USGS) collect velocity data in three reaches of the Kootenai River in the vicinity of Bonners Ferry. These data were collected during June 10–12, 1997, to coincide with the sturgeon's optimum spawning period. Data were collected using a combination of equipment including an Acoustic Doppler Current Profiler (ADCP) for the velocity measurements and a Global Positioning System (GPS) coupled with electronic surveying equipment for georeferencing. Once obtained, the velocity and georeference data were used to construct horizontal and vertical velocity-contour plots to provide a means for efficient analysis of the data. This report provides a summary of the velocity data in two formats. Horizontally distributed, or plan view, velocity-contour plots at various depths are provided for each reach (figs. 4–10, 58–64, and 117–121, back of report). Vertically distributed, or cross-section velocity-contour plots, are provided for each of the cross sec-

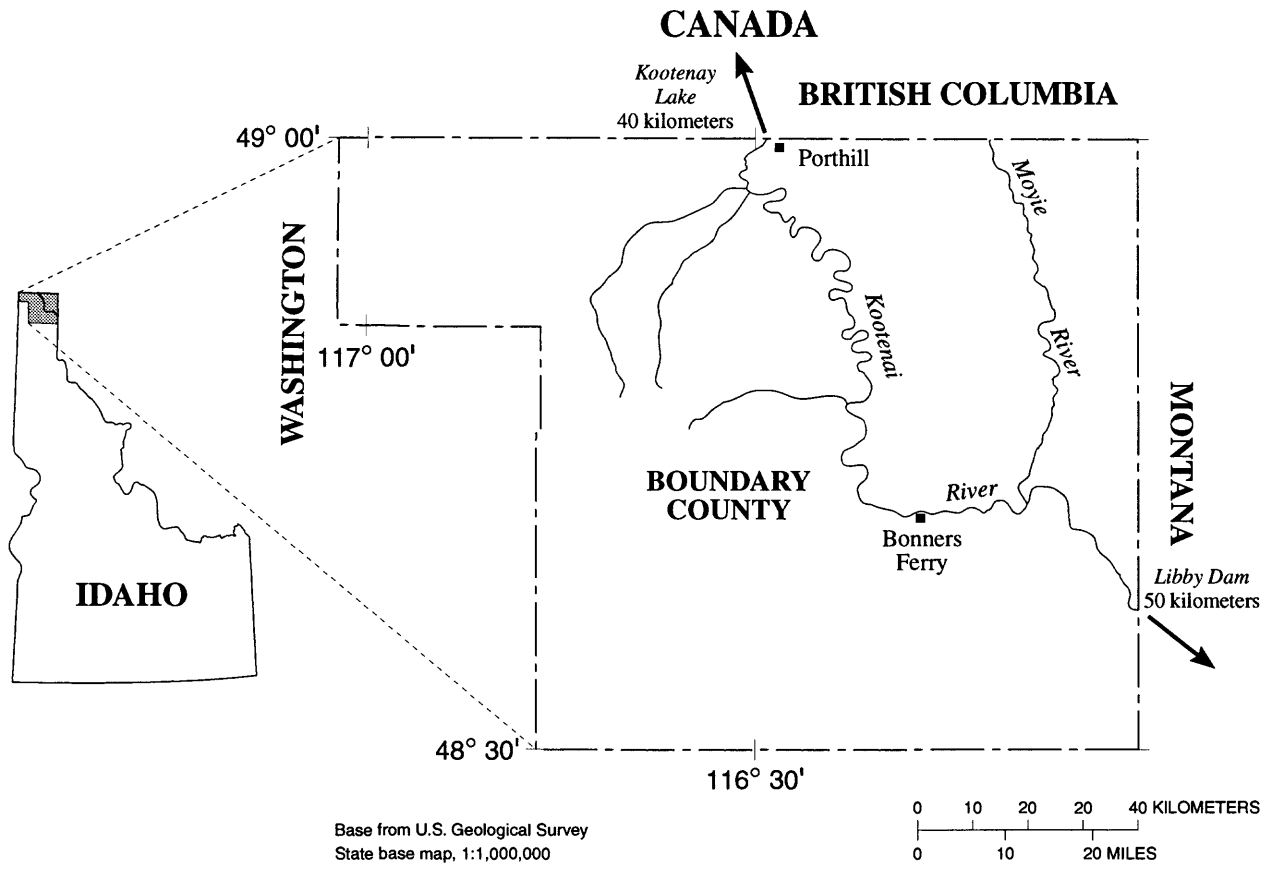

Figure 1. Location of the Kootenai River, Idaho.

sections that were surveyed (figs. 11–56, 65–115, and 122–163, back of report).

DESCRIPTION OF STUDY AREA

The Kootenai River originates in British Columbia, Canada. It flows south into Montana for approximately 80 km, then turns abruptly in a northwesterly direction. The river continues in this direction across northern Idaho and reenters British Columbia where it eventually joins the Columbia River. The Kootenai River is 721 km long and drains an area of 50,375 km^2. Of its total length and drainage area, 261 km and 12,700 km^2, respectively, are within the United States. From Bonners Ferry through the international boundary at Porthill, Idaho, and thence downstream to where it enters Kootenay Lake in British Columbia, the Kootenai River is characterized as a low-velocity, meandering stream. Variable backwater conditions are prevalent as a result of the changing water-surface elevations of Kootenay Lake.

Velocity data were collected within three 500-m reaches of the Kootenai River (fig. 2). Reach 1 is located at approximately river kilometer (rkm) 236, reach 2 at rkm 240, and reach 3 at rkm 245. Reach 3 is located within the Bonners Ferry city limits. Also located within reach 3 is the USGS streamflow-gaging station, Kootenai River at Bonners Ferry (12309500).

COLLECTION OF VELOCITY DATA

Velocity data were collected along cross sections spaced approximately 10 m apart over the length of each reach (figs. 3, 57, and 116, back of report). The left-bank end of each cross section was located and marked with flagging by personnel from IDFG prior to the field surveys. The field surveys were conducted during June 10–12, 1997. Reach 1 was surveyed on June 10, reach 2 on June 11, and reach 3 on June 12. Mean daily discharge was 13,300 m^3/s on June 10 and 13,600 m^3/s on June 11 and 12.

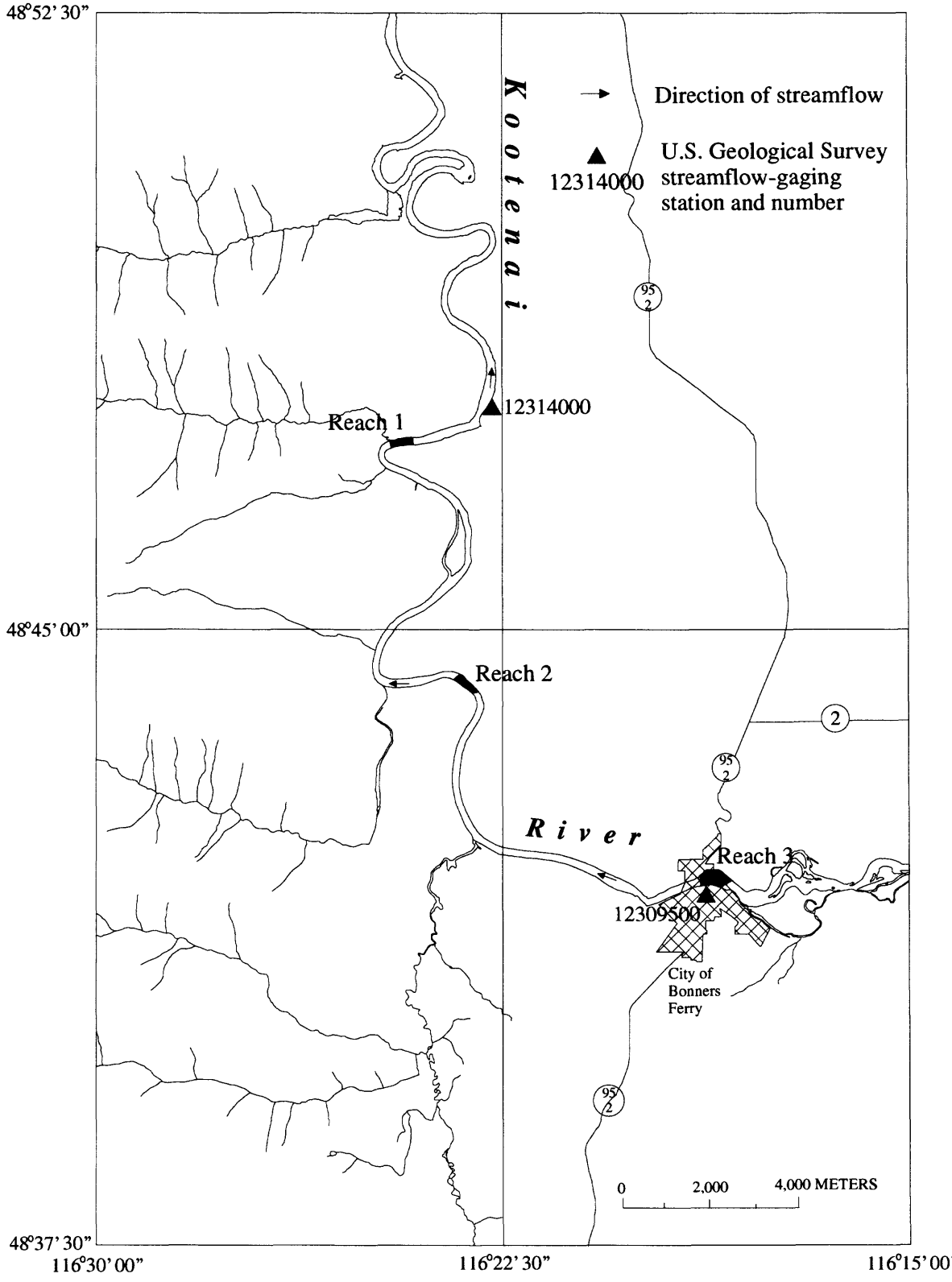

Figure 2. Locations of Kootenai River study reaches 1-3 near Bonners Ferry, Idaho.

Velocity data were obtained using a broadband ADCP developed and manufactured by RD Instruments of San Diego, California. Typically, the instrument is mounted on a boat and transmits acoustic signals into the water column by means of four orthogonally oriented transducers. ADCP's with various transducer frequencies can be obtained from the manufacturer. Typical frequencies range from 300 to 1,200 kilohertz (kHz). Each frequency is suitable for application over a particular range of physical conditions including water depth and type of bed material.

The initial frequency of the transmitted signals is compared with the frequency of backscatter signals reflected off particles in the water. The difference in frequency is defined as the *doppler shift* (RD Instruments, 1989). Once this shift is calculated, the velocity of the water-borne particle is determined and, from that, the water velocity is inferred. Concurrent with the measurement of velocity, the instrument also interprets backscatter signals from the riverbed and uses the information to calculate depth and boat velocity. Finally, the ADCP contains an electronic compass that maintains a spatial reference of the instrument's orientation around its vertical axis, and tilt and roll sensors that provide data on movement of the ADCP around its two horizontal axes. The data from these sensors provide a means to compensate for any movement in the boat when the water velocity is computed. In addition, the combination of boat velocity and compass data allows for the calculation of distance and direction traveled over the bed, which is referred to as *bottom tracking*. The data from all the sensors are processed and downloaded to an onboard computer for further real-time processing, storage, and postprocessing.

A significant advantage of the ADCP over mechanical current meters is its ability to collect three-dimensional velocity data simultaneously for several discrete segments, or *depth cells*, in the water column. Further, the ADCP is capable of continuously collecting these data while attached to a moving vessel. As a result, water-velocity surveys can be completed much quicker and with much better coverage than could be accomplished by traditional methods.

A 600-kHz ADCP attached to a 22-ft (6.7-m) aluminum boat was used for this project. The aluminum construction of the boat was critical to prevent interference with the ADCP's electronic compass. Velocity data were obtained along the predetermined cross sections and then previewed and stored using a laptop computer. The ADCP was configured to collect velocities at 0.5-m depth-cell intervals; the center of the first cell was 1.82 m below the water surface. The depth of the first cell is a function of the depth of the transducers below the water surface plus the *blanking distance*. The blanking distance is an unmeasured zone in the water column near the surface. This zone results from turning the transducers off briefly, immediately following the transmission of acoustic energy, to avoid ringing of the transducers and, hence, interference with backscatter signal reception.

SPATIAL REFERENCING

The velocity data obtained from this survey were contoured, vertically at each cross section and horizontally at various depths through each reach. Horizontal contouring required that the data also be spatially referenced. Spatial referencing, sometimes referred to as georeferencing, was accomplished using a GPS and an electronic surveying instrument commonly referred to as a total station.

The GPS was used to determine the position of the total station and to orient it to a known coordinate system. The GPS receiver determines its location by calculating distance to at least three satellites. The distance from each satellite to the GPS receiver can be used to describe a unique sphere. The point at which these spheres intersect is the position of the GPS receiver. The more satellites that are acquired, and hence used in the calculation, the more accurate the position will be.

GPS satellites provide two levels of positioning services, Standard Positioning Service (SPS) and Precise Positioning Service (PPS). The GPS satellites transmit SPS data, which contain built-in errors that limit the accuracy of an SPS receiver. PPS receivers have the ability to decode the SPS signal and to eliminate the built-in errors when computing position. The GPS receiver used for this project was a Precise Lightweight GPS Receiver (PLGR), which is a PPS receiver (Rockwell International Corp., 1996). During collection of data on the Kootenai River, the PLGR indicated that horizontal positioning errors were about 5 to 10 m. The GPS was used only to determine the position of the total station and to orient it to true north. Once the positioning and orientation were completed, the total station was used to determine the location of the boat and ADCP at the start and finish of each cross section. Using the ADCP's bottom-tracking capability, which

maintains distance and direction traveled, coupled with the absolute location of the boat's start and endpoints obtained from the total station, the location of each velocity measurement could be determined.

VELOCITY CONTOURING

The ADCP is capable of collecting considerable amounts of velocity data over large areas and in very short periods of time. This can be used to great advantage in obtaining a clear picture of the vertically distributed velocity structure at a single cross section or the horizontally distributed velocity structure over a river reach. To efficiently evaluate such large quantities of data, it is necessary to summarize them in some way. For this project, the data were contoured horizontally and vertically to provide a means for fishery biologists to evaluate correlations that might exist between stream velocities and sturgeon spawning habits.

Velocities were contoured using Surfer, a PC-based surface-modeling software package. Horizontally distributed velocity-contour plots were constructed for each of the three reaches and at various depths coinciding with the depth cells measured by the ADCP (figs. 4–10, 58–64, and 117–121, back of report). Though velocities were not actually measured at the surface, contour plots at the water surface for the three reaches were constructed using a surface-velocity value calculated as 85 percent of the mean water-column velocity (Rantz, 1982, p. 137). Means and standard deviations for horizontally distributed velocities were calculated for selected depths below the water surface by reach (table 1). These values provide a simple reference for evaluating general changes in velocity from reach to reach at various depths.

Vertically distributed velocity-contour plots were constructed for each cross section (figs. 11–56, 65–115, and 122–163, back of report). The contouring was constrained at the channel bed with a zero velocity. Surface velocities were estimated as previously described. Contouring was performed using the triangulation-with-linear-interpolation method (Golden Software Inc., 1995). This method was selected over several available contouring algorithms because of 1) its exact interpolation that honors all data points, 2) its effectiveness in contouring evenly distributed data, and 3) its overall speed of computation.

Table 1. Mean and standard deviations of velocities at selected depths below the water surface, by reach, Kootenai River

[m, meters; vel, velocity; m/s, meters per second; std dev, standard deviation]

	Reach 1		Reach 2		Reach 3	
Depth (m)	vel (m/s)	std dev (m/s)	vel (m/s)	std dev (m/s)	vel (m/s)	std dev (m/s)
2.82	0.83	0.20	0.82	0.25	0.79	0.37
3.82	.85	.19	.82	.23	.75	.34
4.82	.88	.17	.85	.22	.67	.32
5.82	.89	.16	.85	.22	.59	.35
6.82	.89	.16	.86	.22	.53	.35

The combined use of the ADCP, GPS, and total station for collecting velocity data, coupled with readily available surface-modeling software, made it possible to acquire and analyze large amounts of velocity data in a short period of time. This equipment and the approach used are sure to have many potential applications in hydrologic and habitat surveys of large rivers such as the Kootenai.

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Rantz, S.E., 1982, Measurement and computation of streamflow—Volume 1, Measurement of stage and discharge: U.S. Geological Survey Water-Supply Paper 2175, 284 p.

Rockwell International Corp., 1996, Precision Lightweight GPS Receiver PLGR+96 & PLGR+96FEDERAL Precise Positioning Service (PPS): Cedar Rapids, Iowa, Rockwell International Corp., 232 p.

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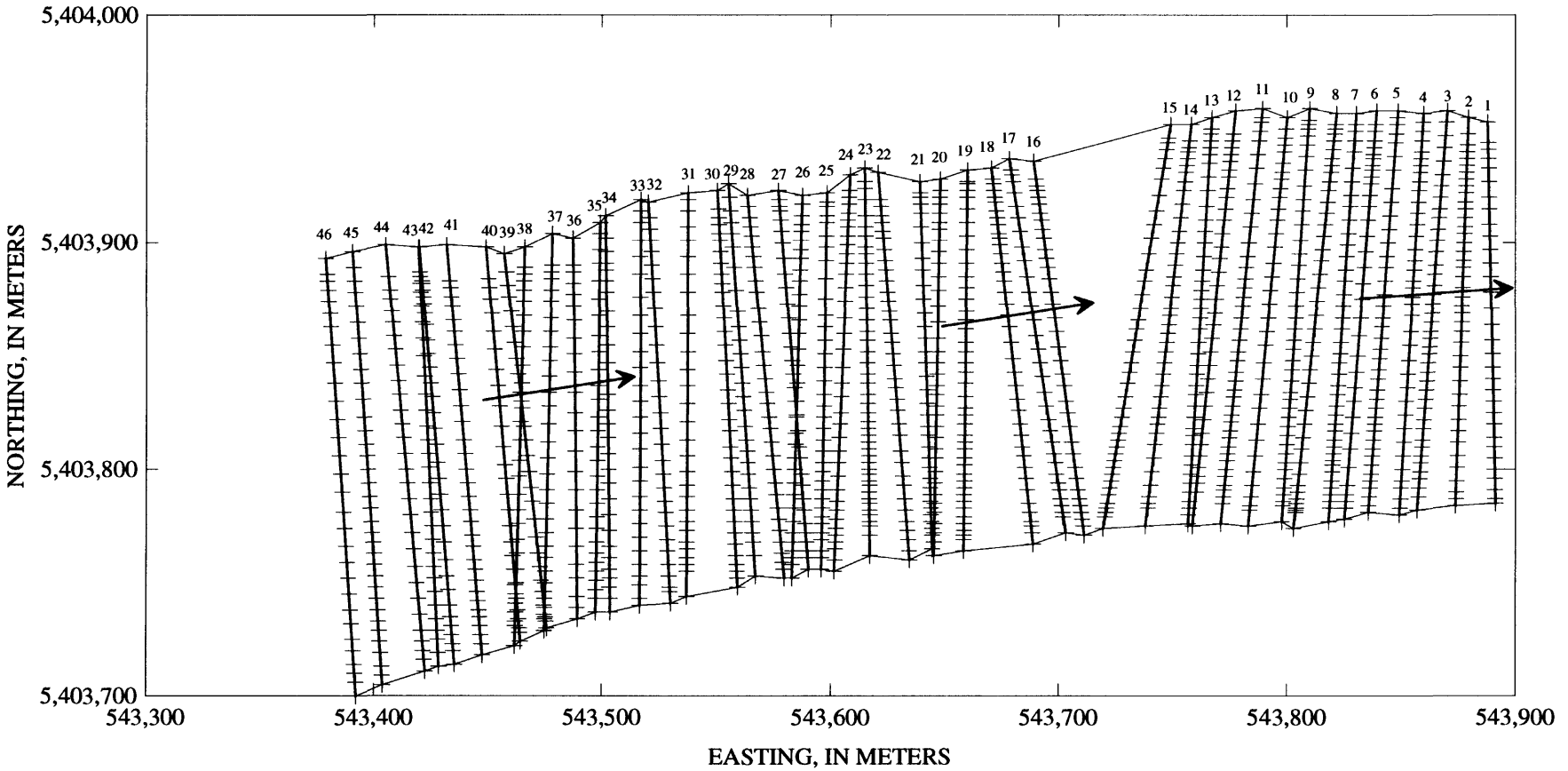


Figure 3. Locations of cross sections and data points in reach 1.
(Arrows indicate direction of streamflow)

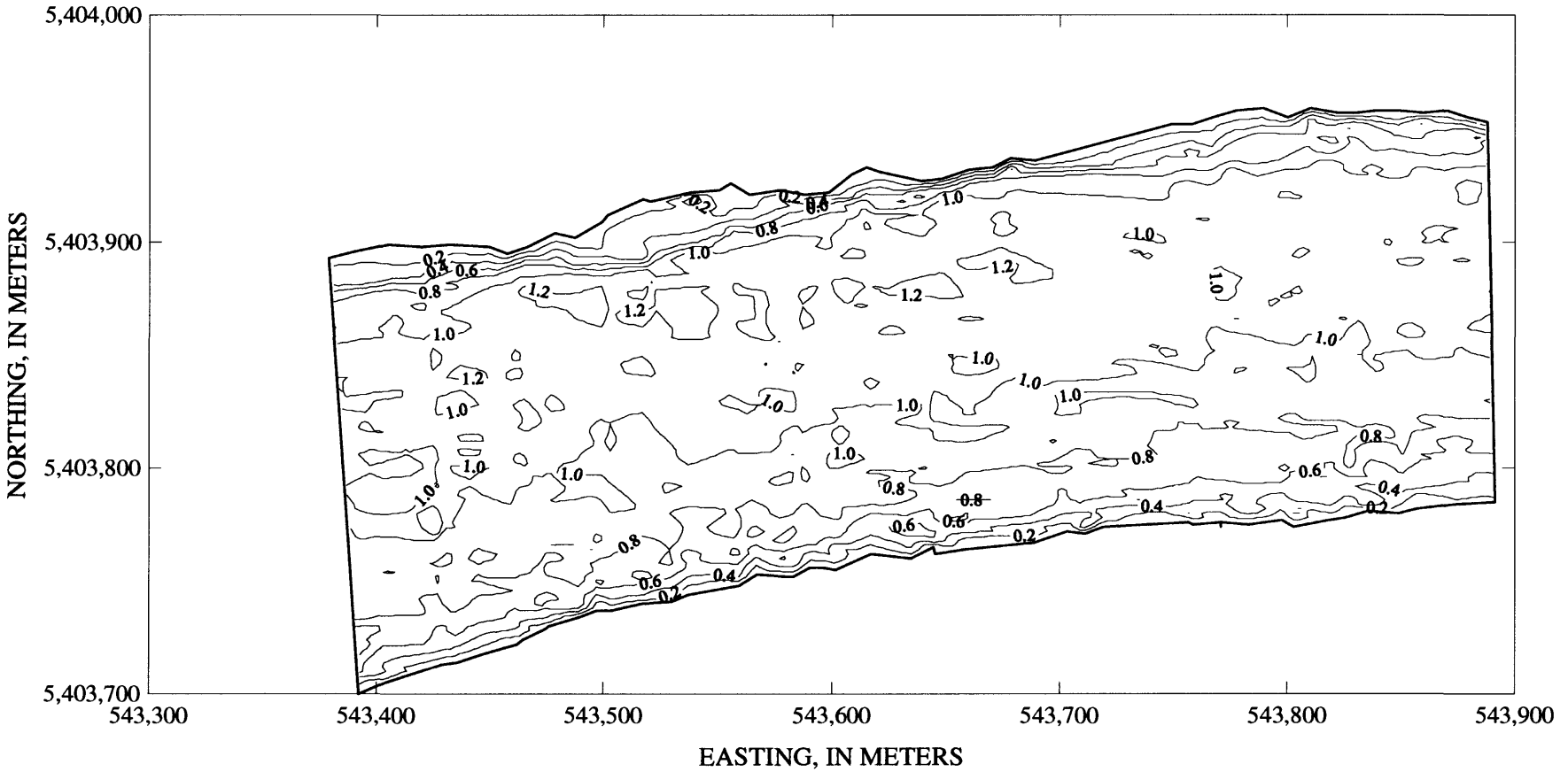


Figure 4. Plan view of velocity contours for Kootenai River reach 1 at a 0-meter depth, June 10, 1997. (Contours in meters per second)

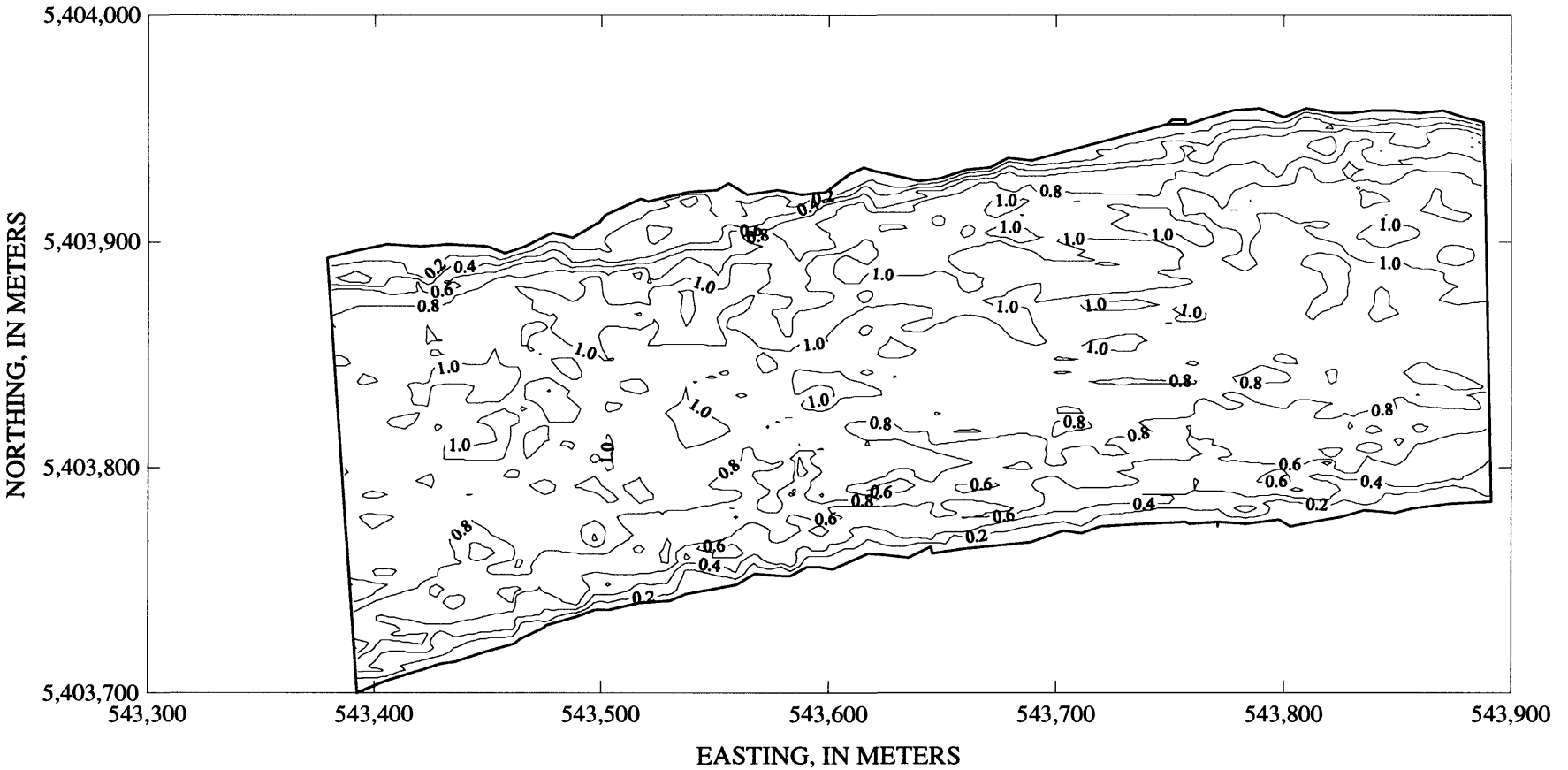


Figure 5. Plan view of velocity contours for Kootenai River reach 1 at a 1.82-meter depth, June 10, 1997. (Contours in meters per second)

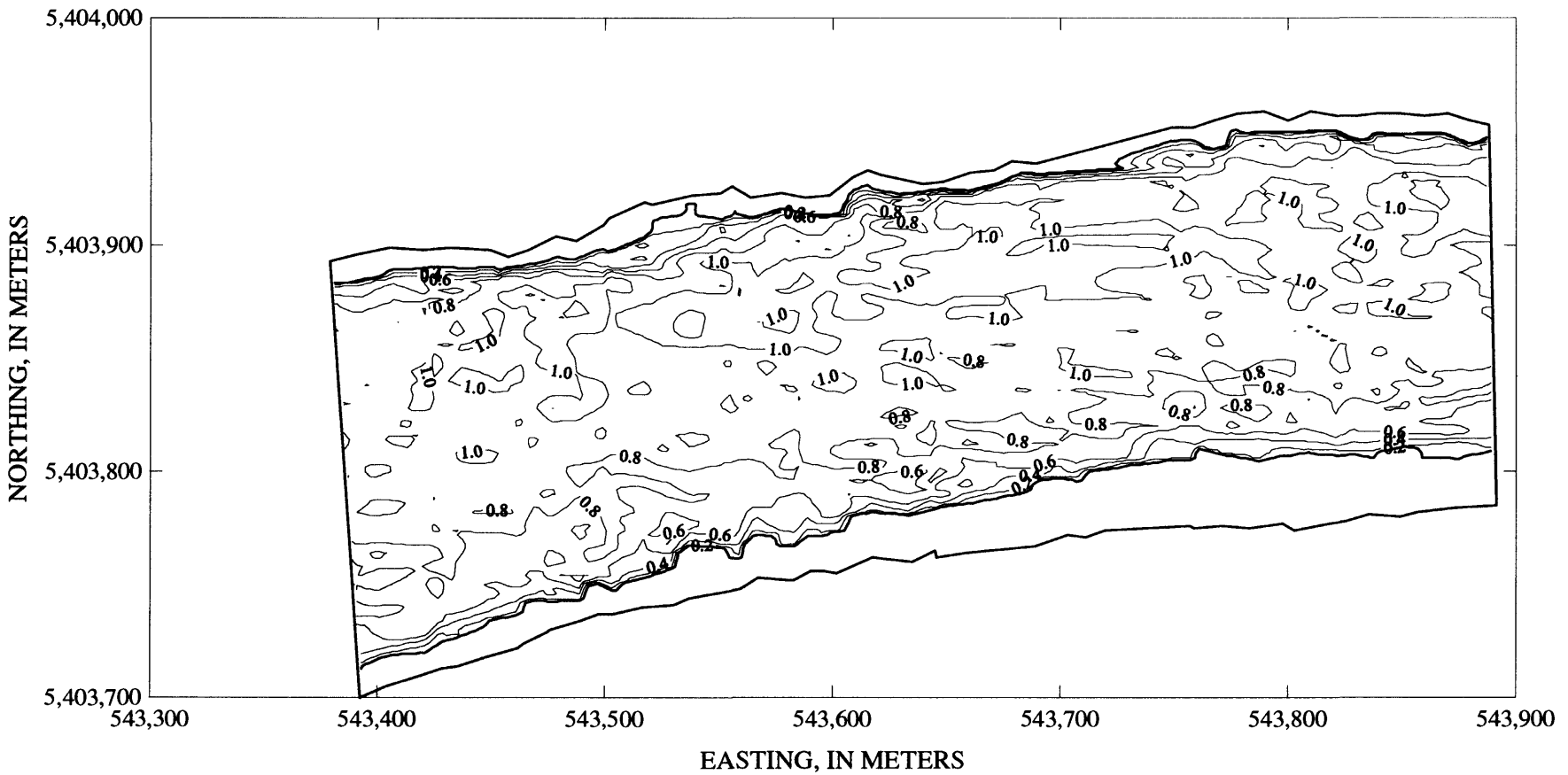


Figure 6. Plan view of velocity contours for Kootenai River reach 1 at a 3.82-meter depth, June 10, 1997. (Contours in meters per second)

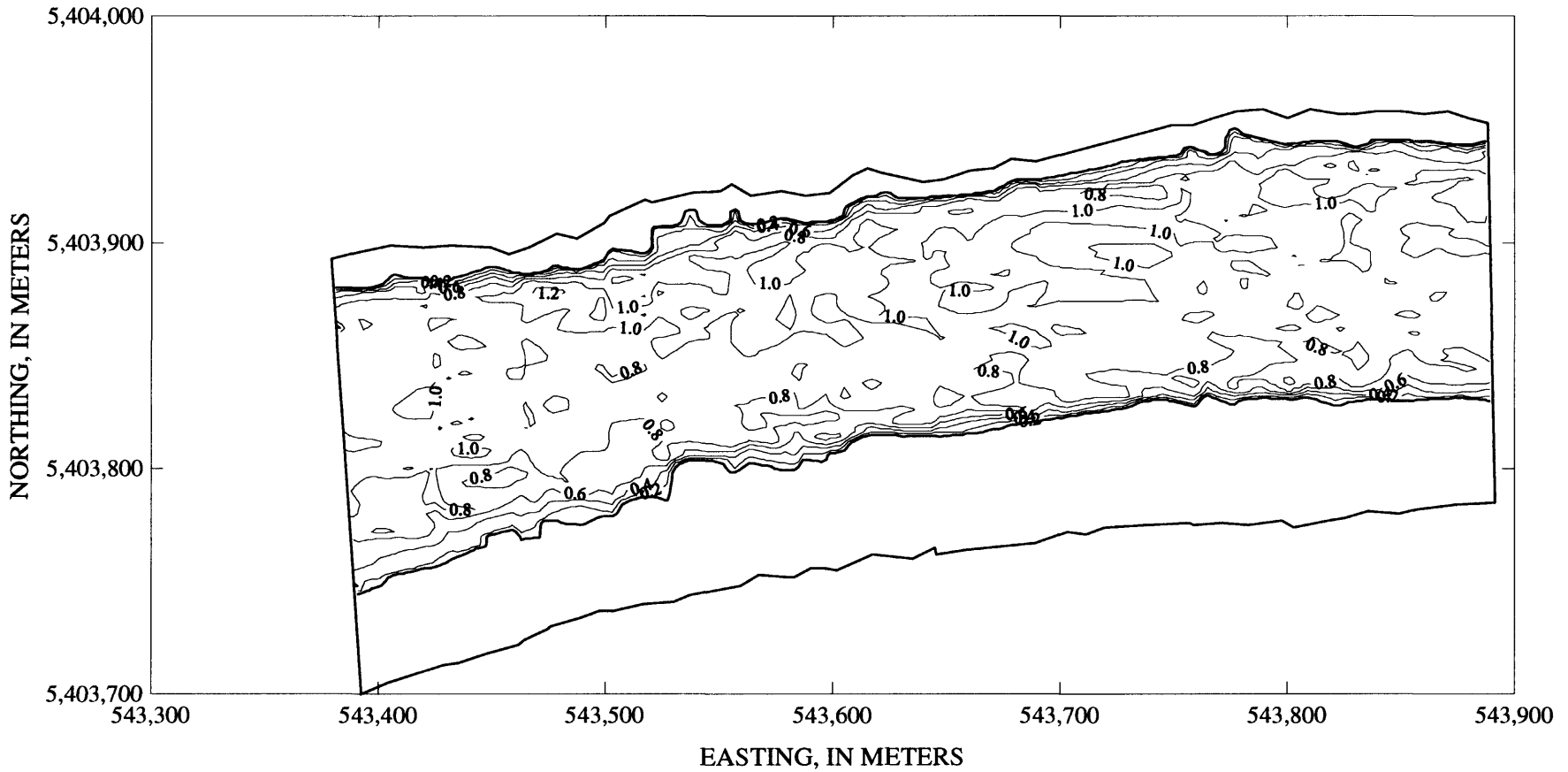


Figure 7. Plan view of velocity contours for Kootenai River reach 1 at a 5.82-meter depth, June 10, 1997. (Contours in meters per second)

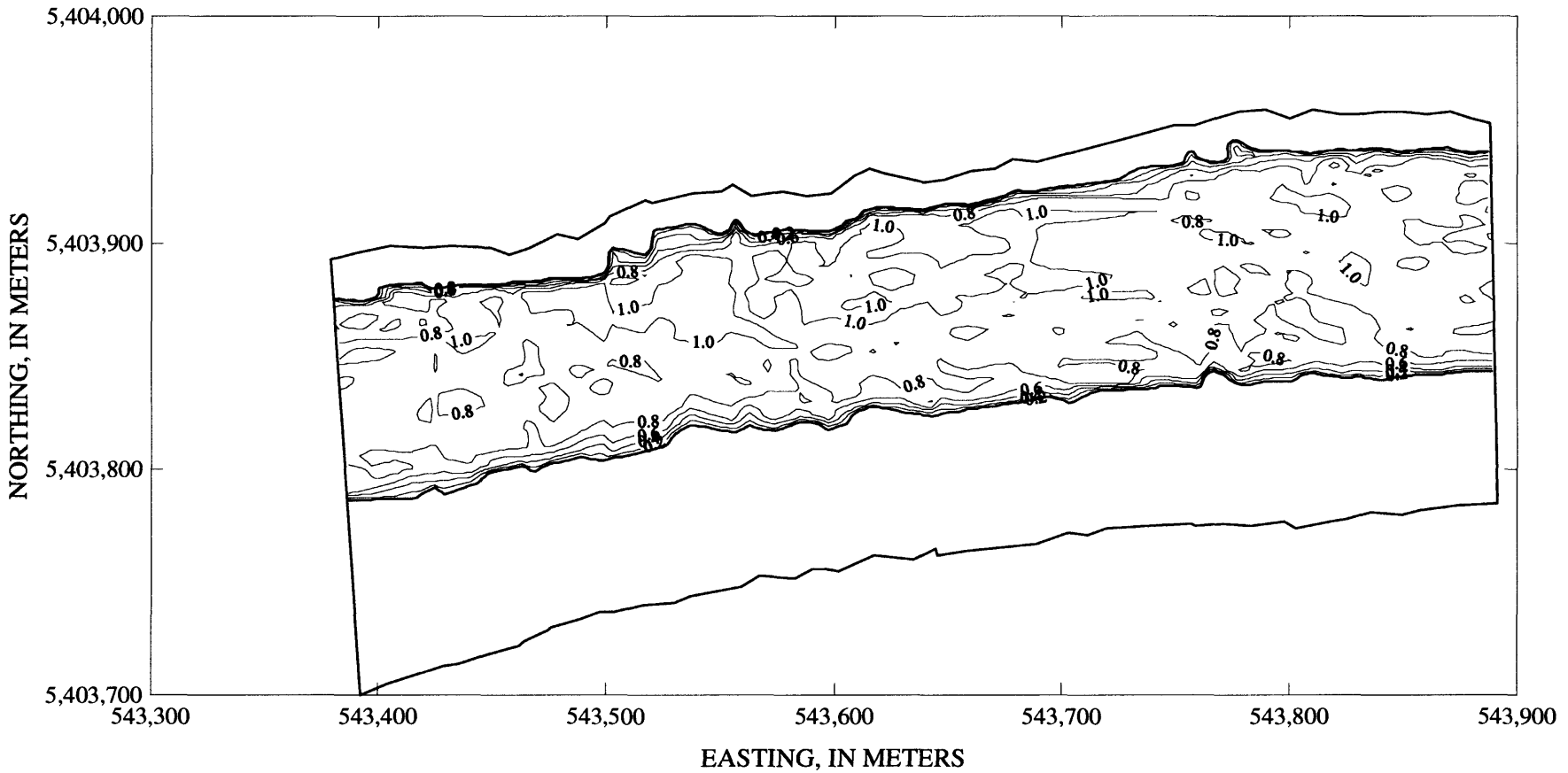


Figure 8. Plan view of velocity contours for Kootenai River reach 1 at a 7.82-meter depth, June 10, 1997. (Contours in meters per second)

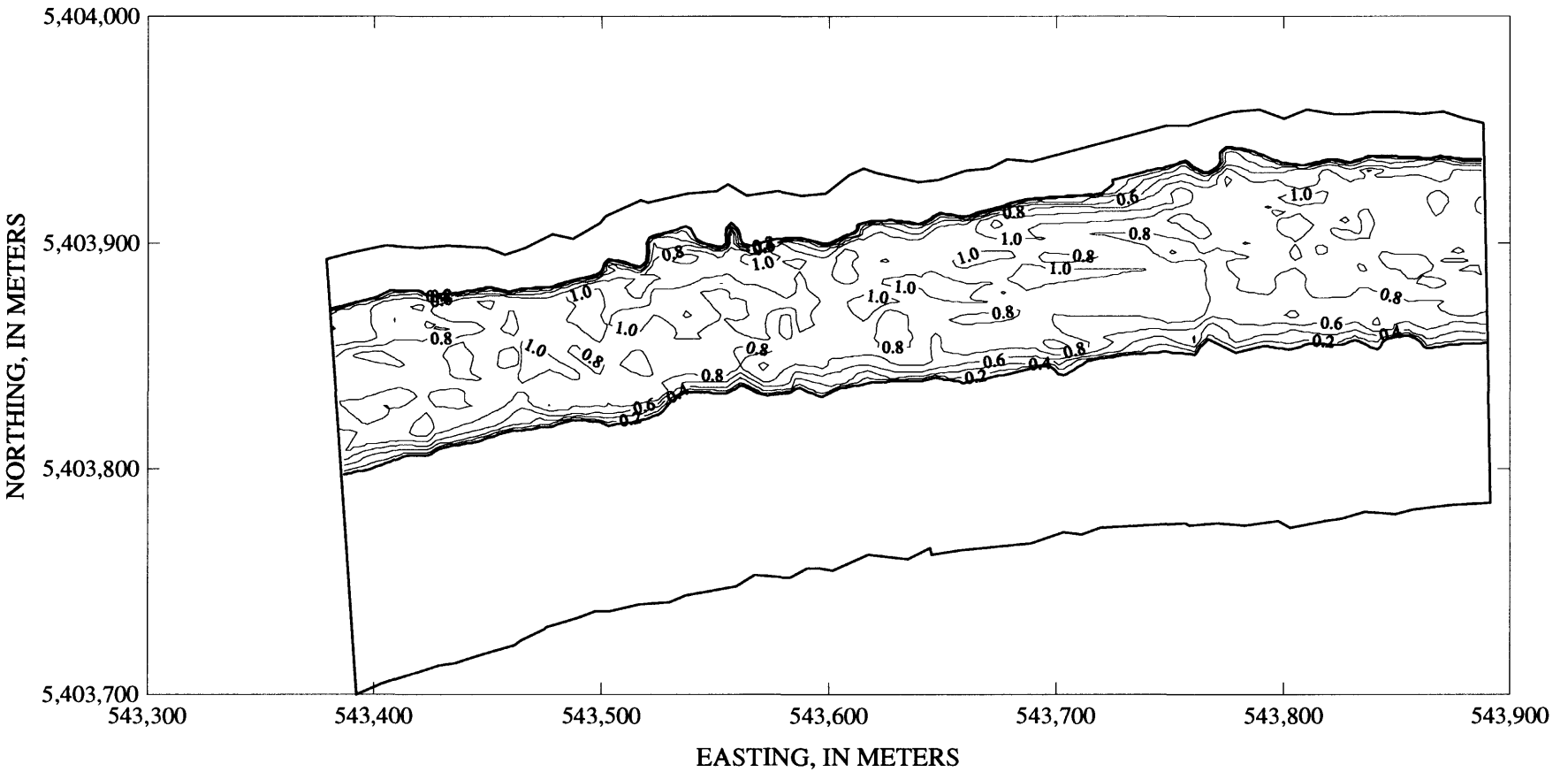


Figure 9. Plan view of velocity contours for Kootenai River reach 1 at a 9.82-meter depth, June 10, 1997. (Contours in meters per second)

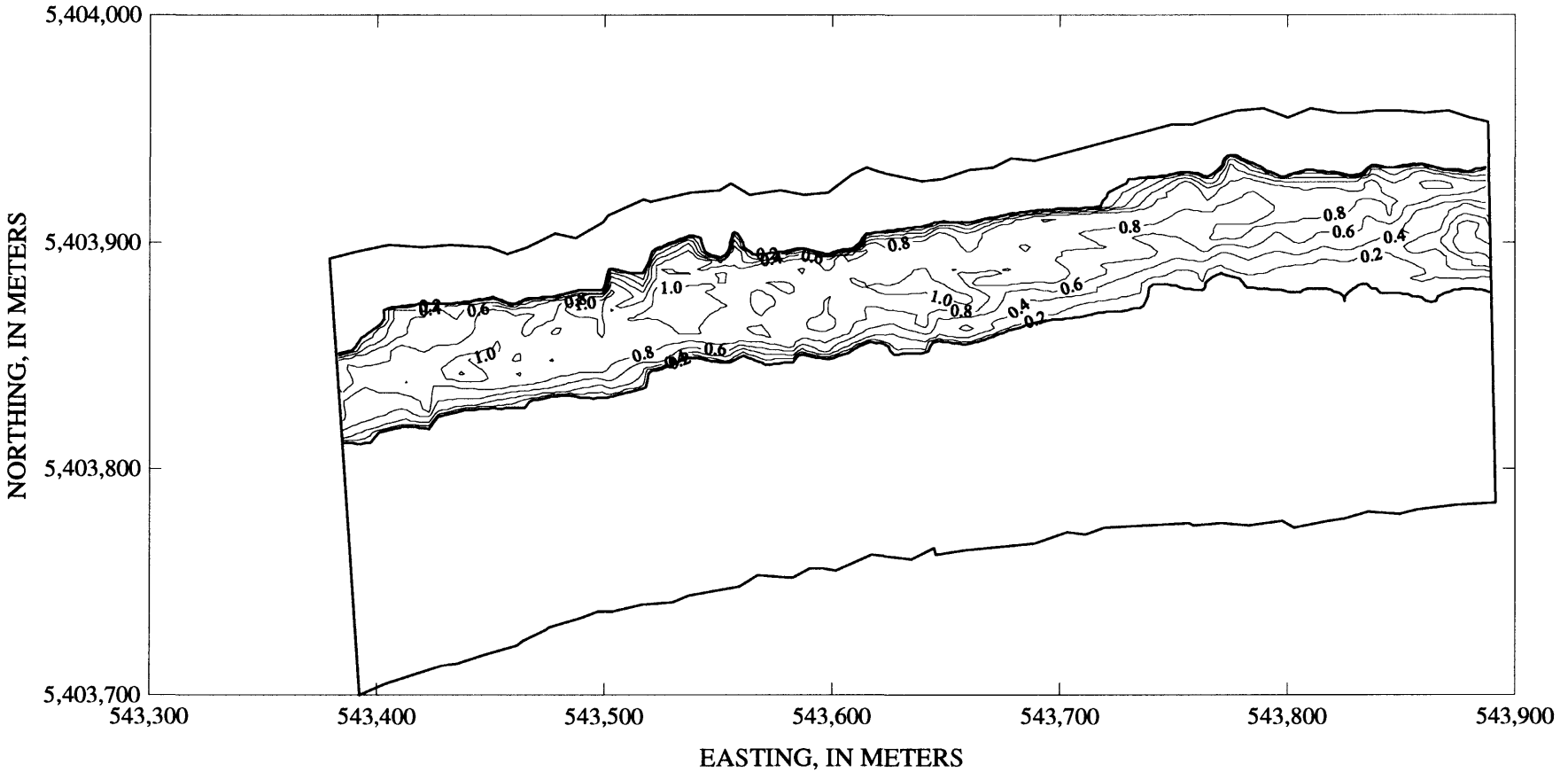


Figure 10. Plan view of velocity contours for Kootenai River reach 1 at an 11.82-meter depth, June 10, 1997. (Contours in meters per second)

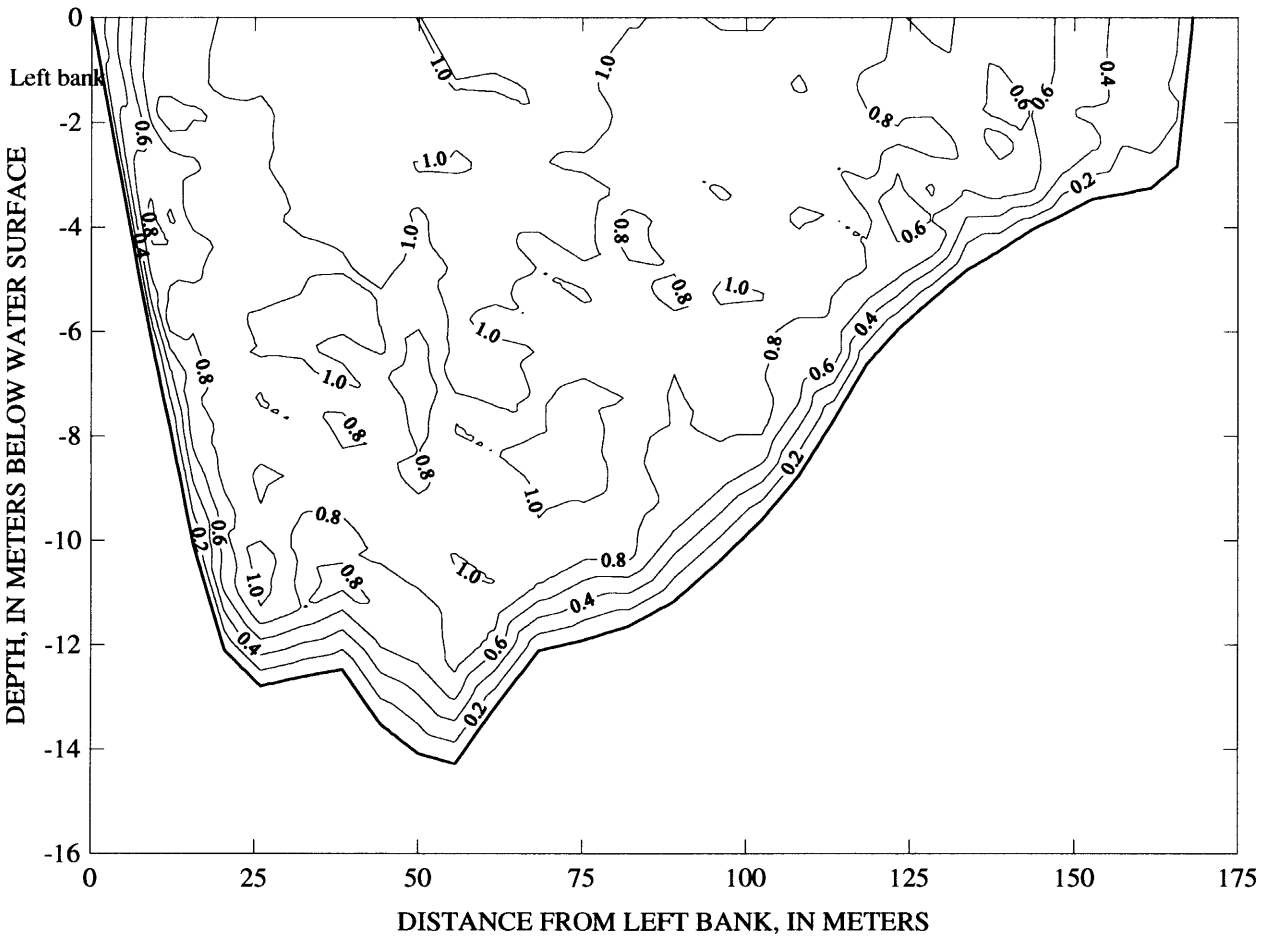


Figure 11. Velocity contours for Kootenai River reach 1, cross-section 1, June 10, 1997. (Contours in meters per second)

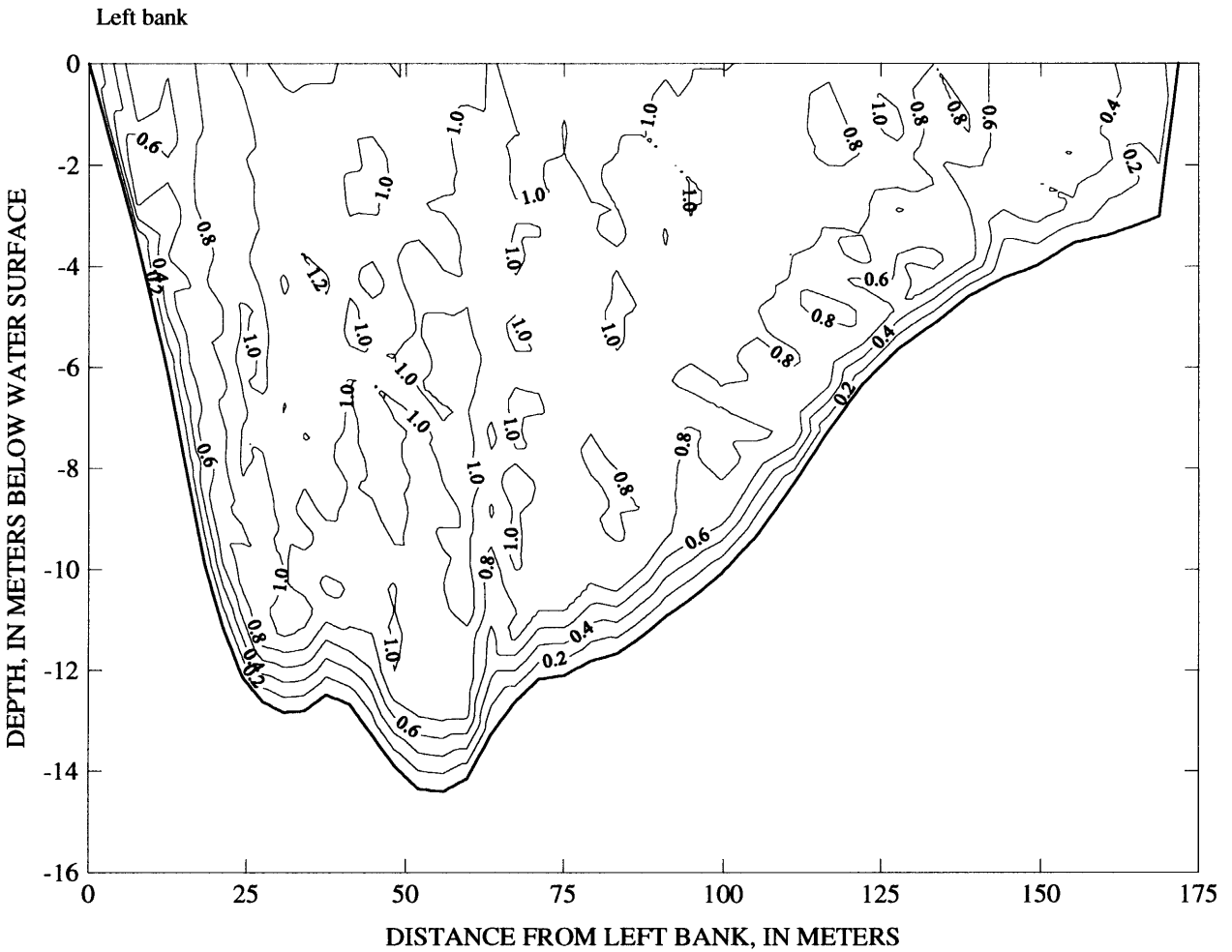


Figure 12. Velocity contours for Kootenai River reach 1, cross-section 2, June 10, 1997. (Contours in meters per second)

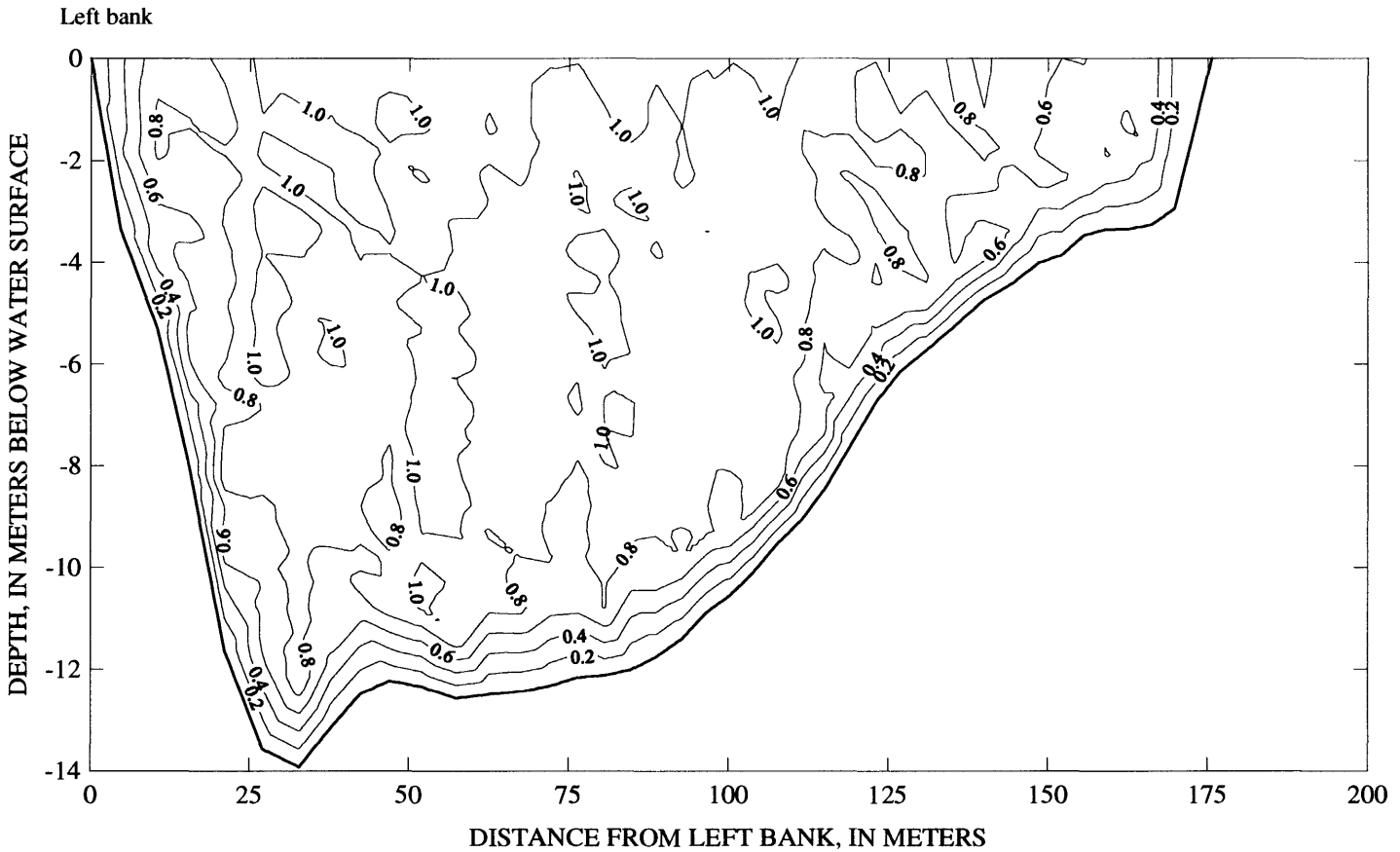


Figure 13. Velocity Contours for Kootenai River reach 1, cross-section 3, June 10, 1997. (Contours in meters per second)

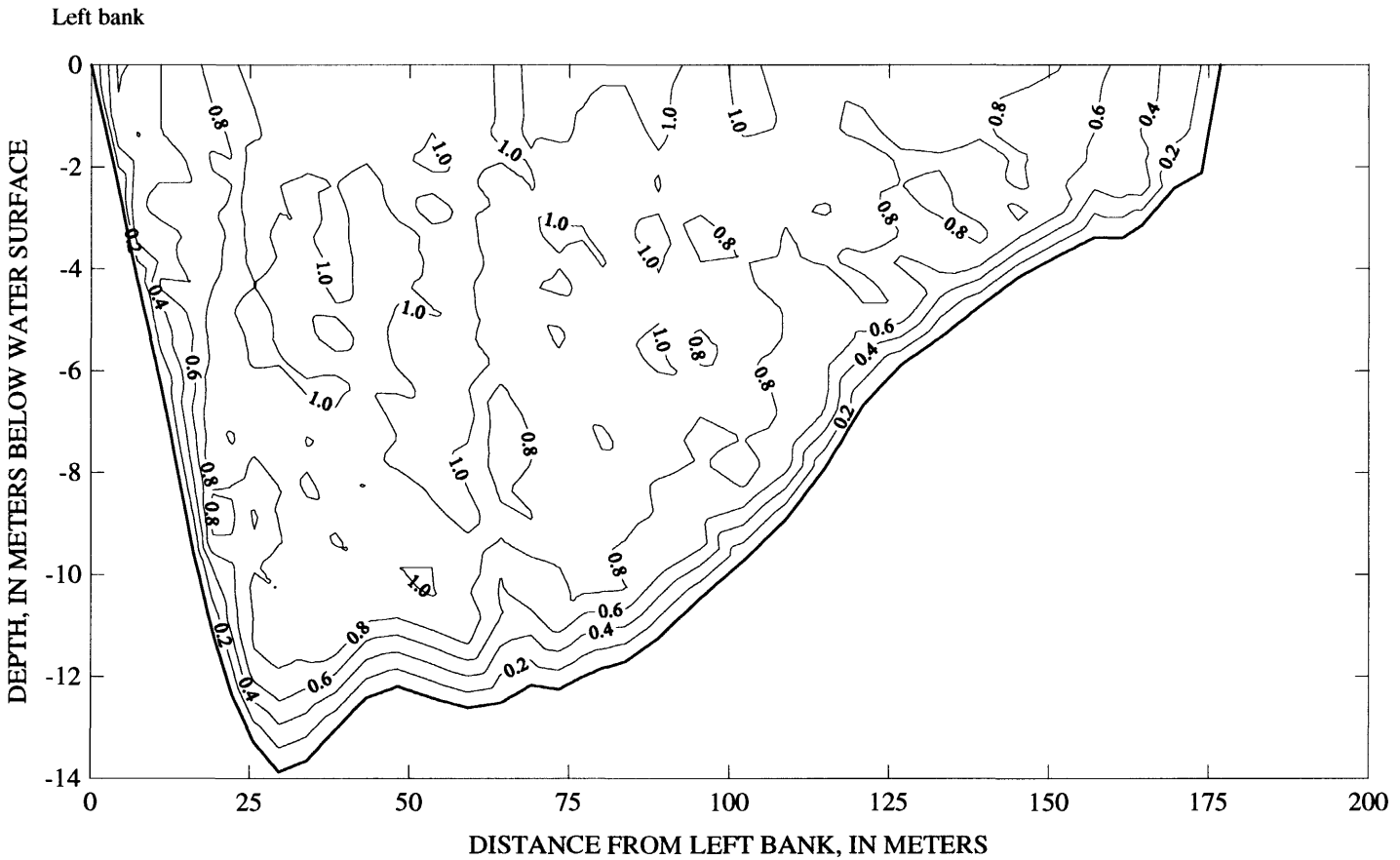


Figure 14. Velocity contours for Kootenai River reach 1, cross-section 4, June 10, 1977. (Contours in meters per second)

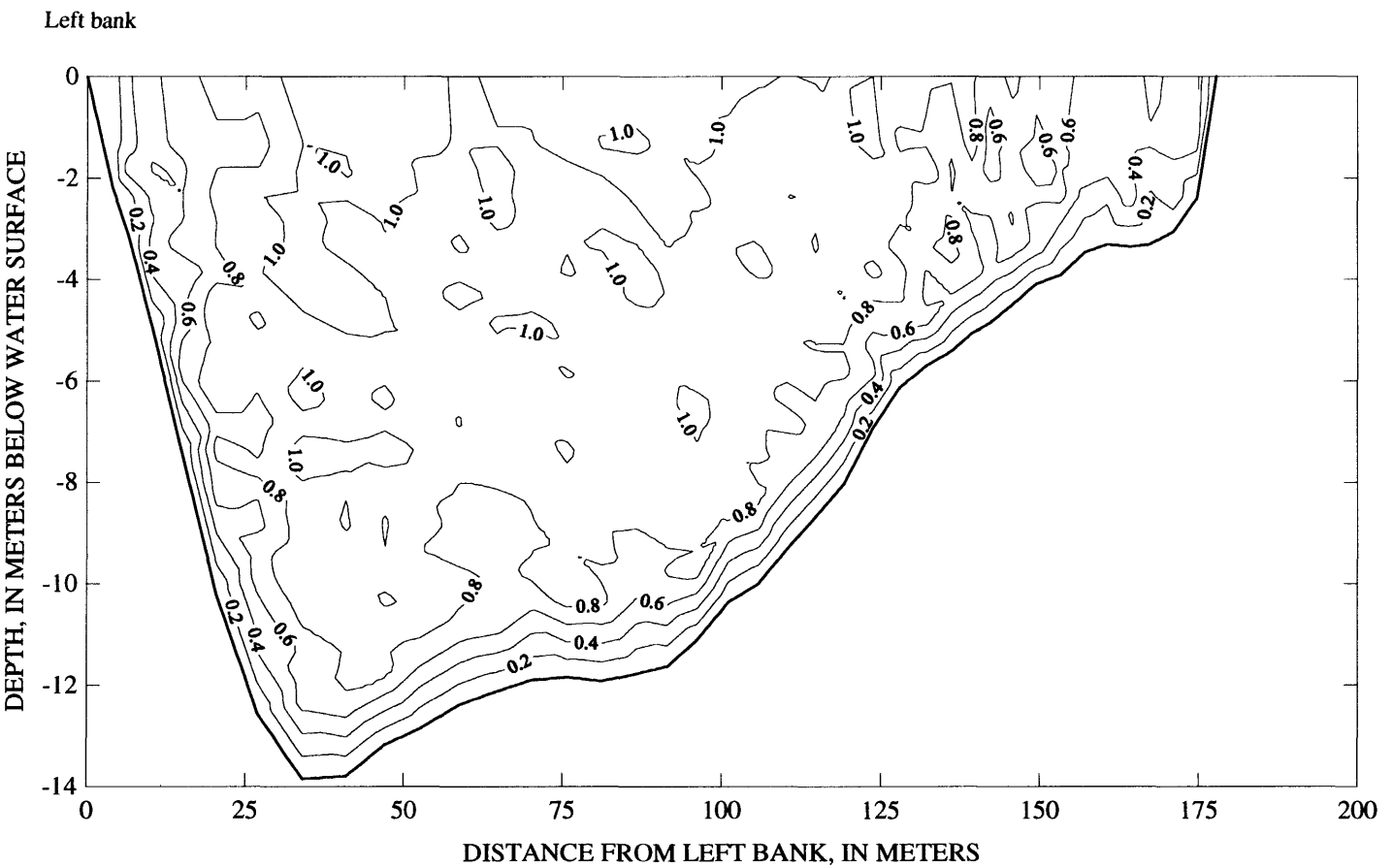


Figure 15. Velocity contours for Kootenai River reach 1, cross-section 5, June 10, 1997. (Contours in meters per second)

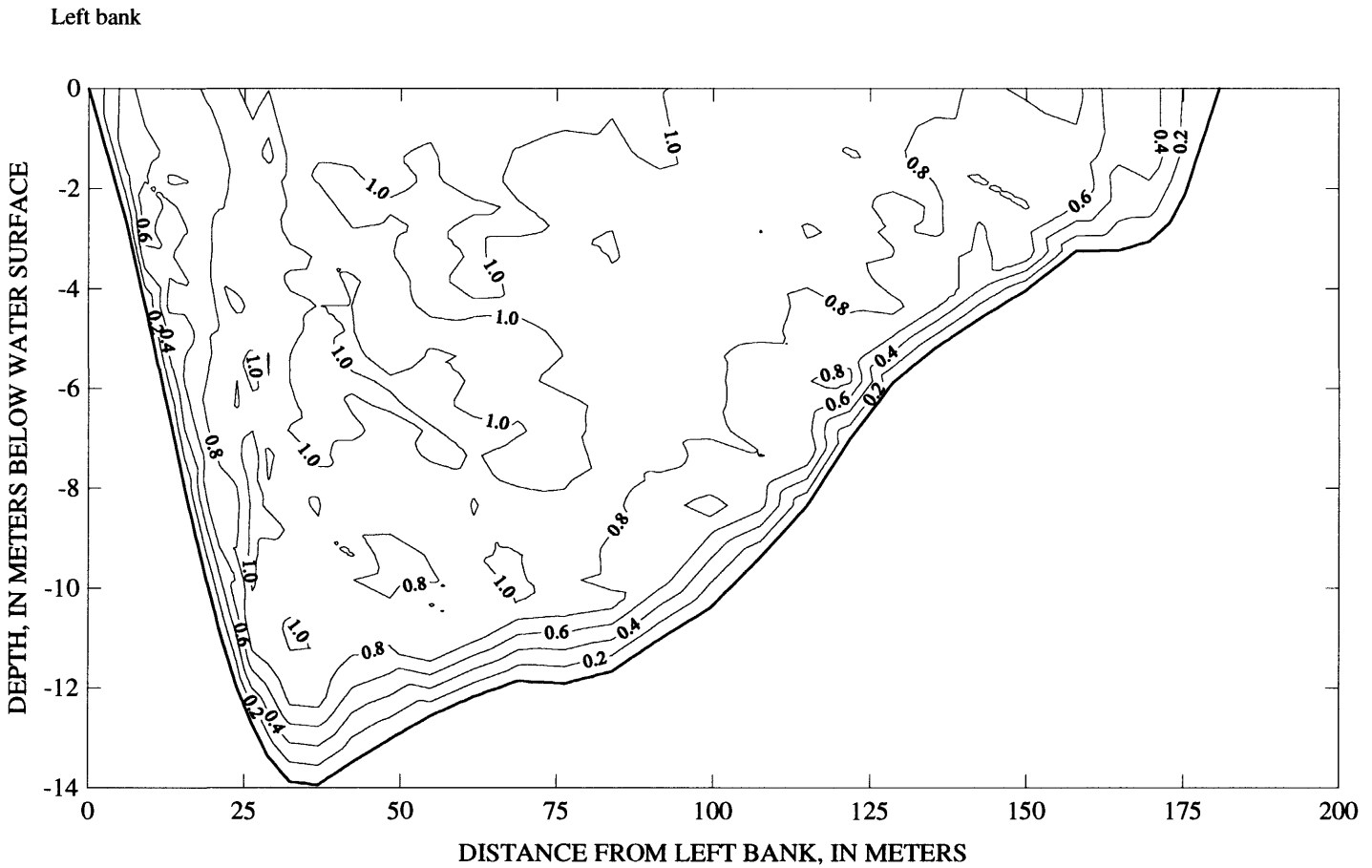


Figure 16. Velocity contours for Kootenai River reach 1, cross-section 6, June 10, 1997. (Contours in meter per second)

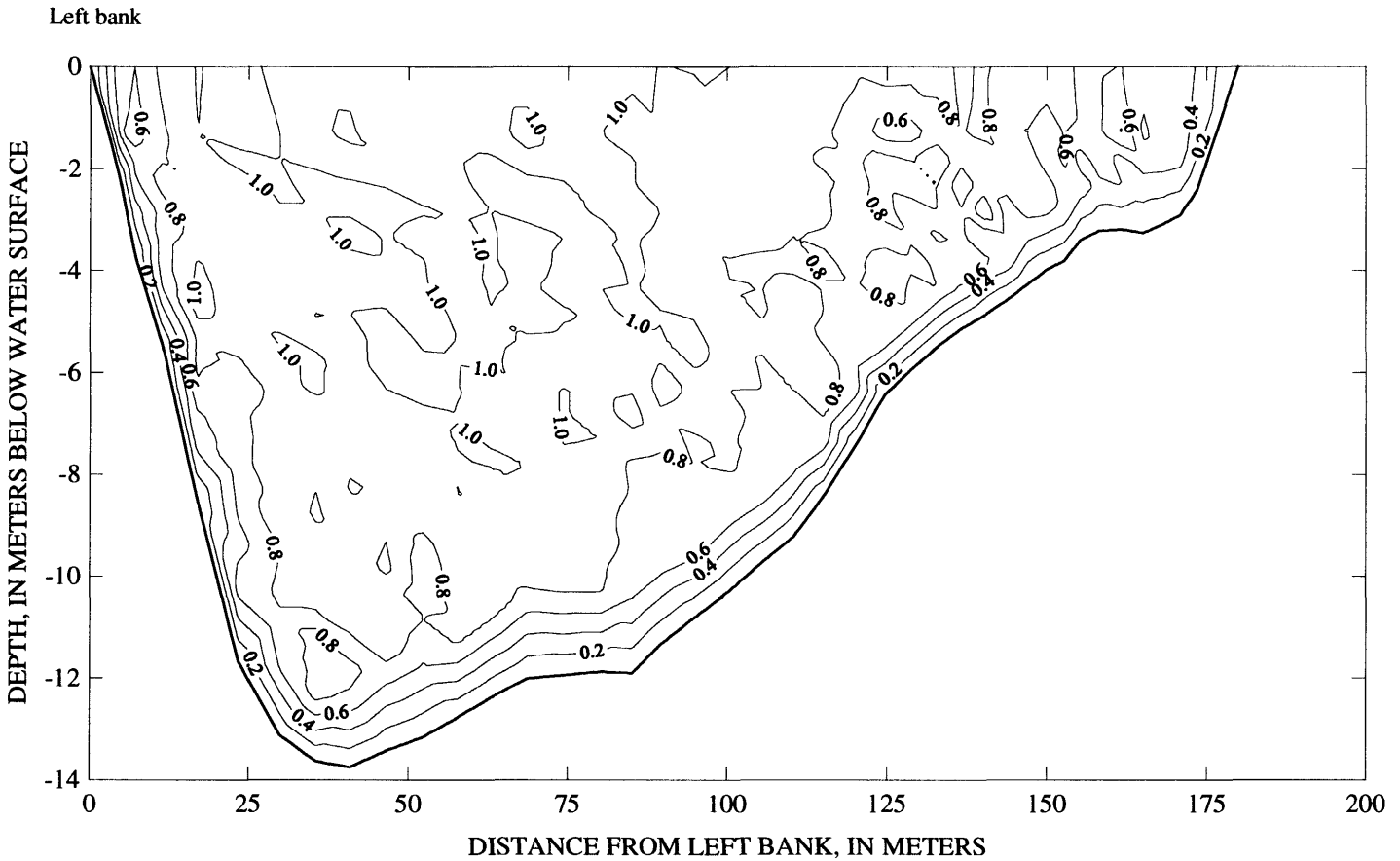
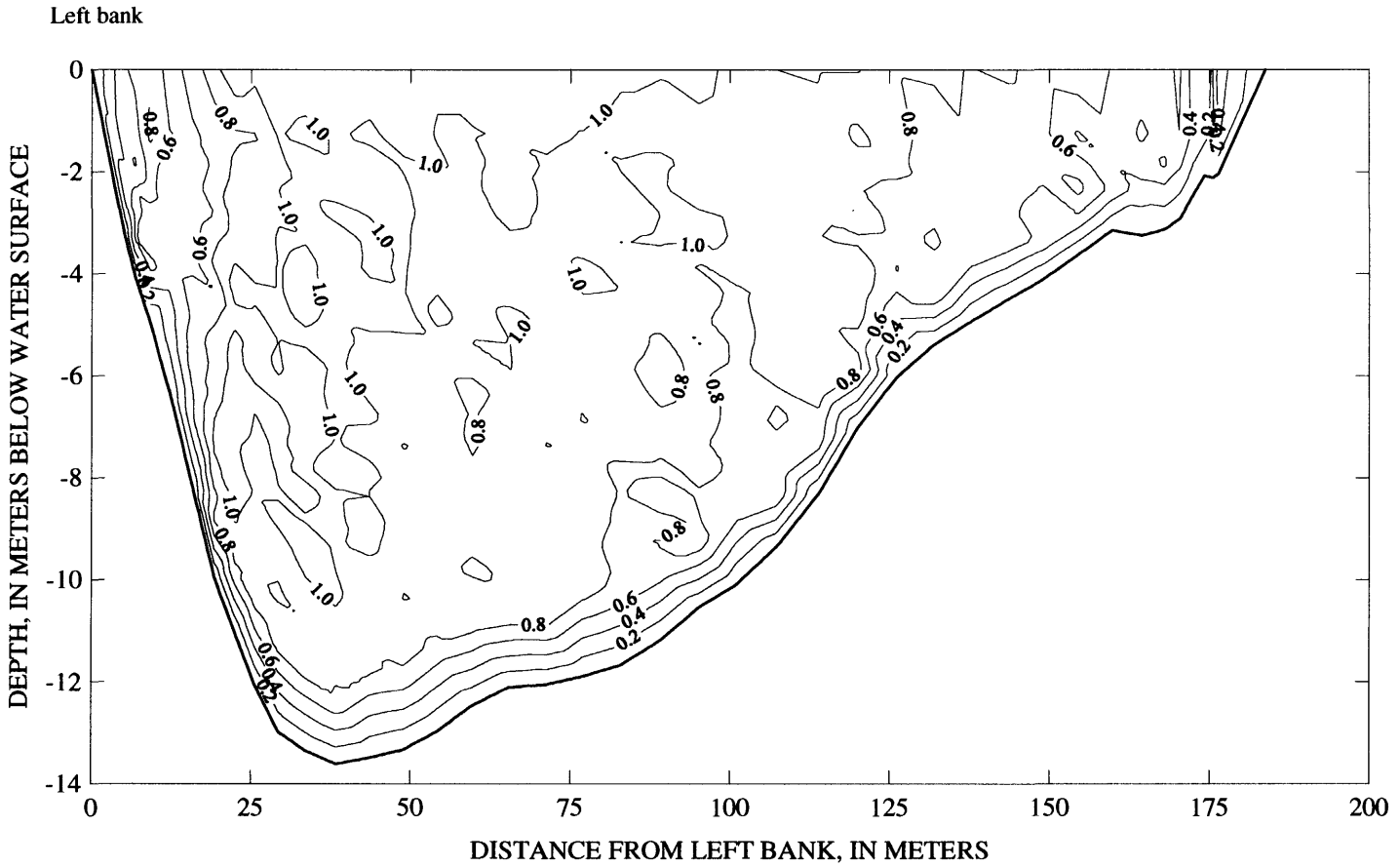


Figure 17. Velocity contours for Kootenai River reach 1, cross-section 7, June 10, 1997. (Contours in meters per second)



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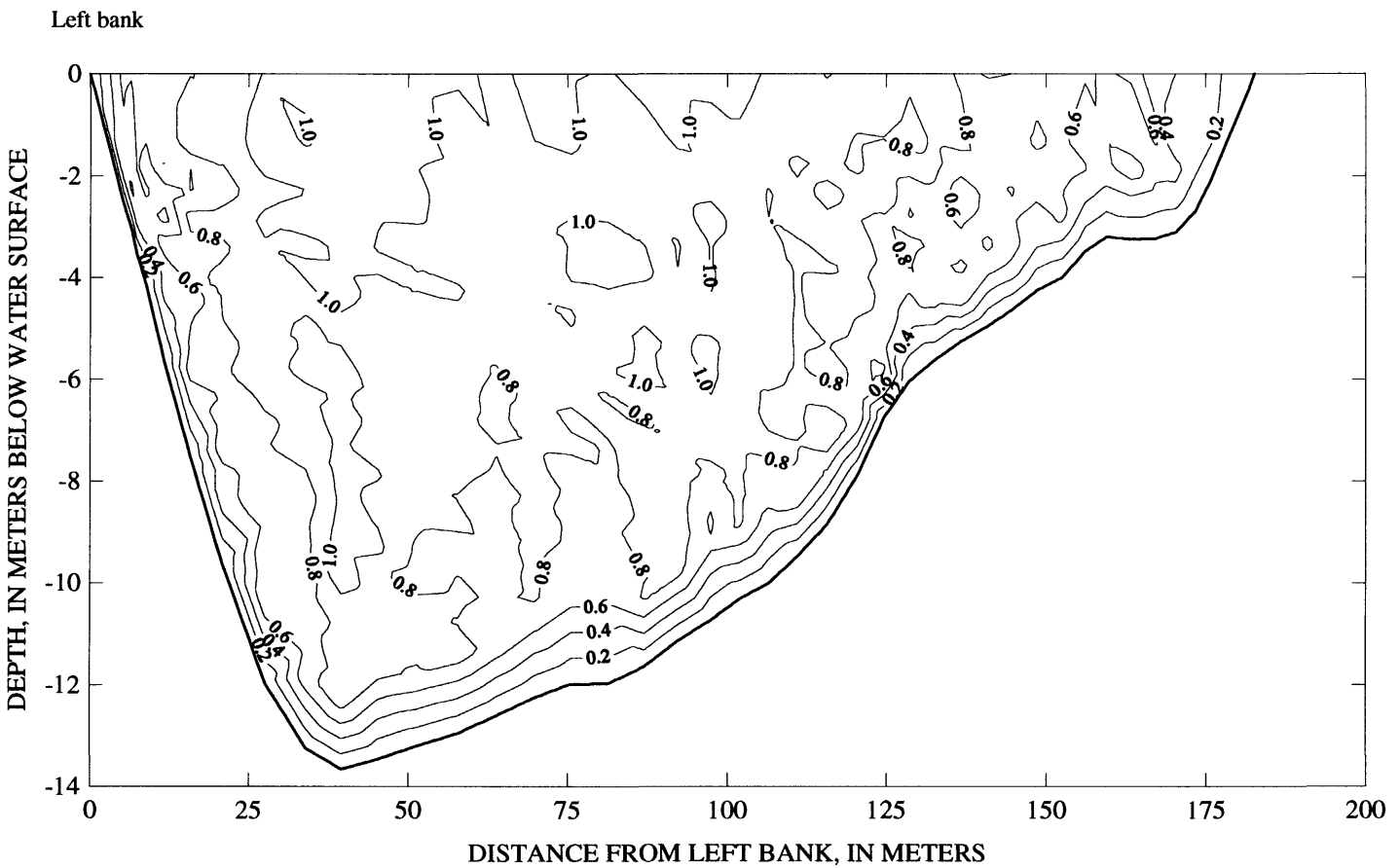


Figure 19. Velocity contours for Kootenai River reach 1, cross-section 9, June 10, 1997. (Contours in meters per second)

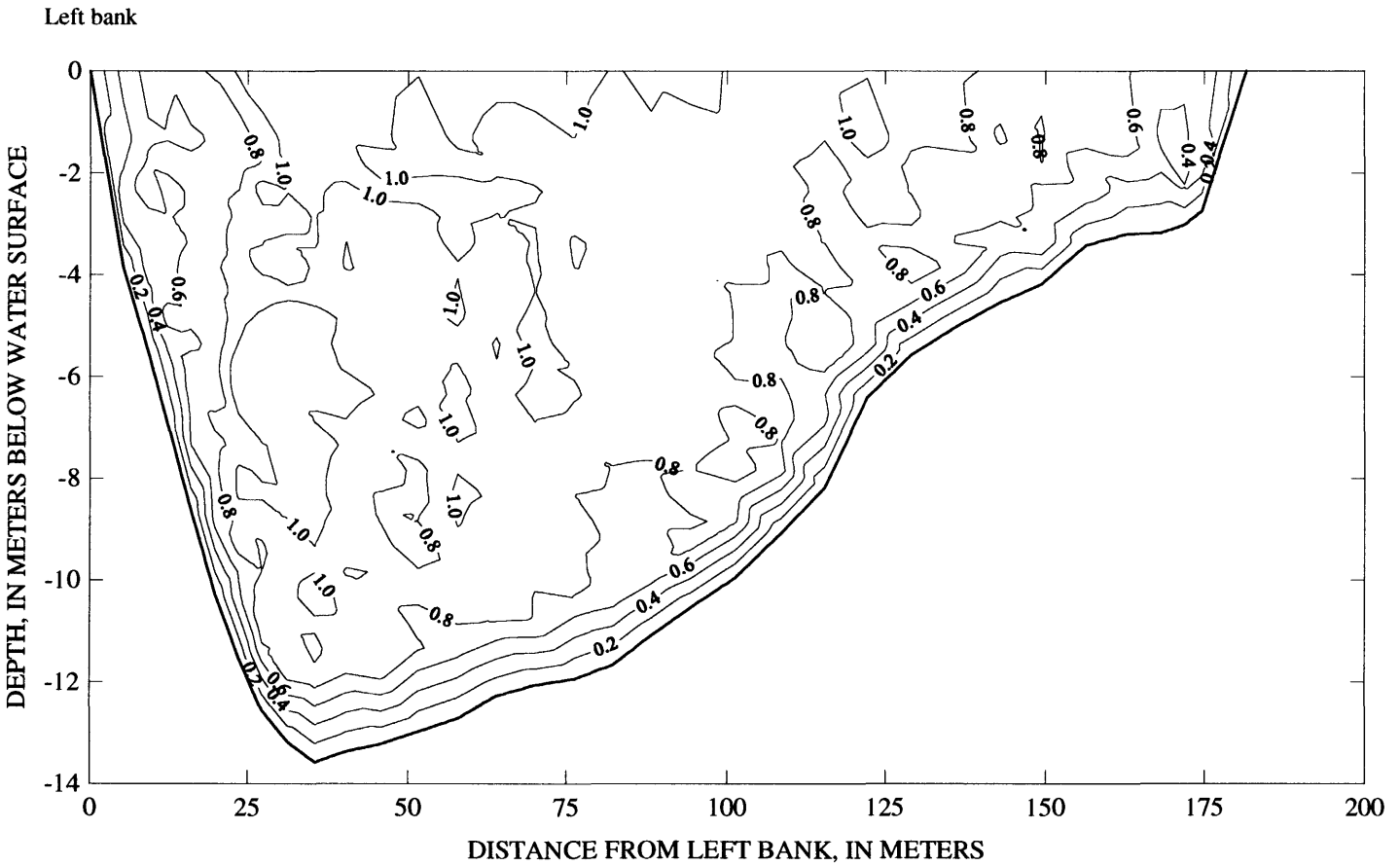


Figure 20. Velocity contours for Kootenai River reach 1, cross-section 10, June 10, 1997. (Contours in meters per second)

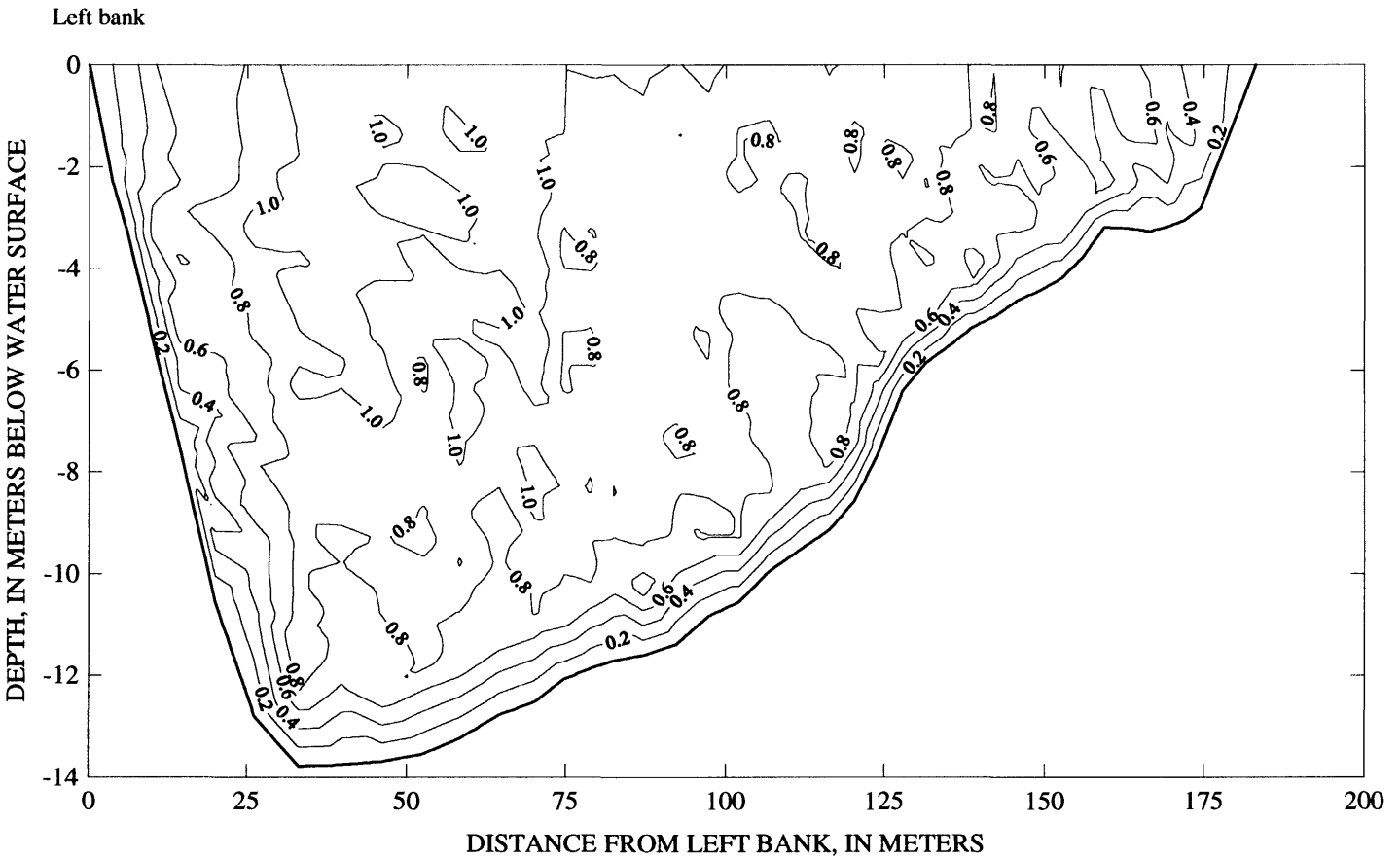


Figure 21. Velocity contours for Kootenai River reach 1, cross-section 10, June 10, 1997. (Contours in meters per second)

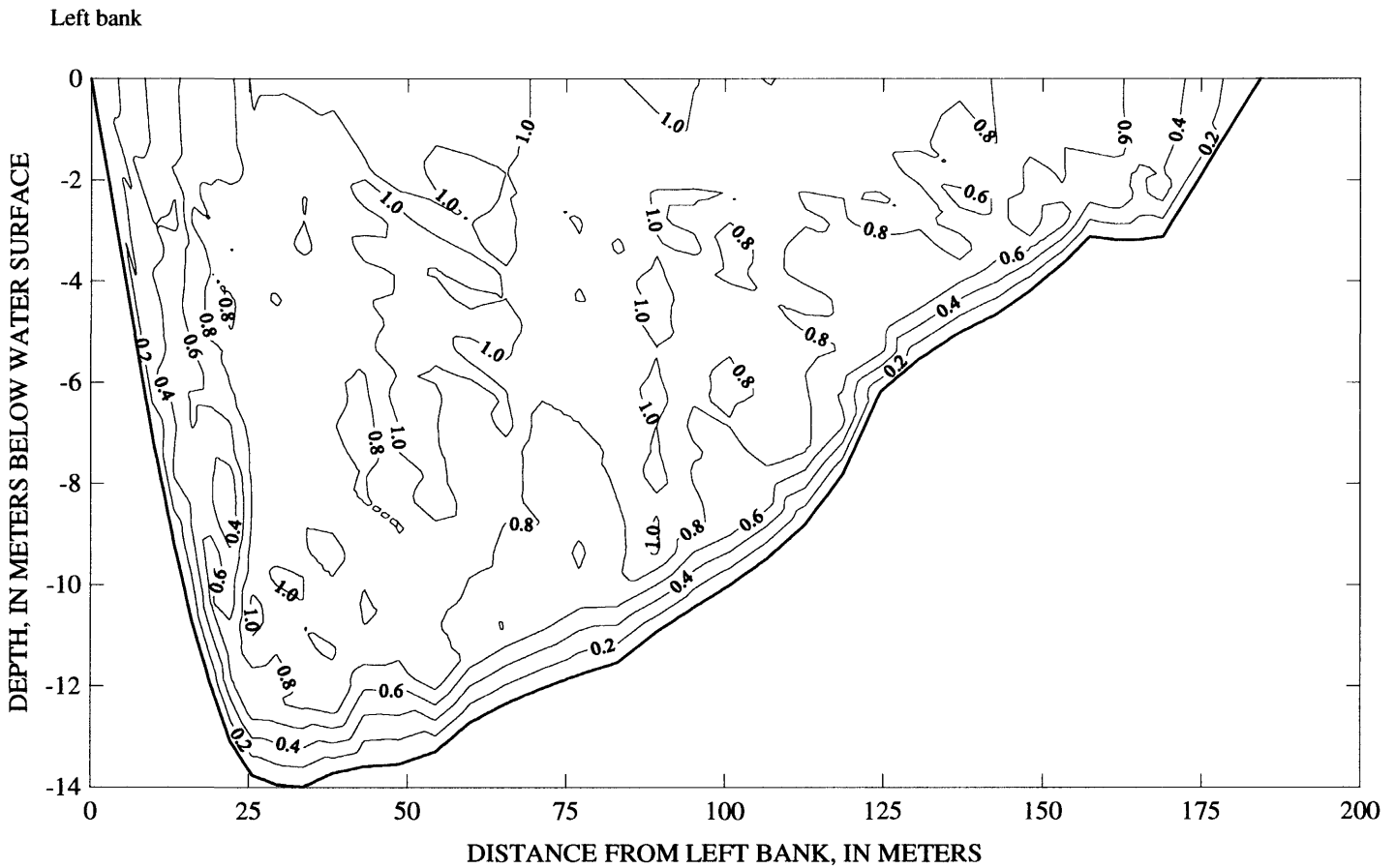


Figure 22. Velocity contours for Kootenai River reach 1, cross-section 12, June 10, 1997. (Contours in meters per second)

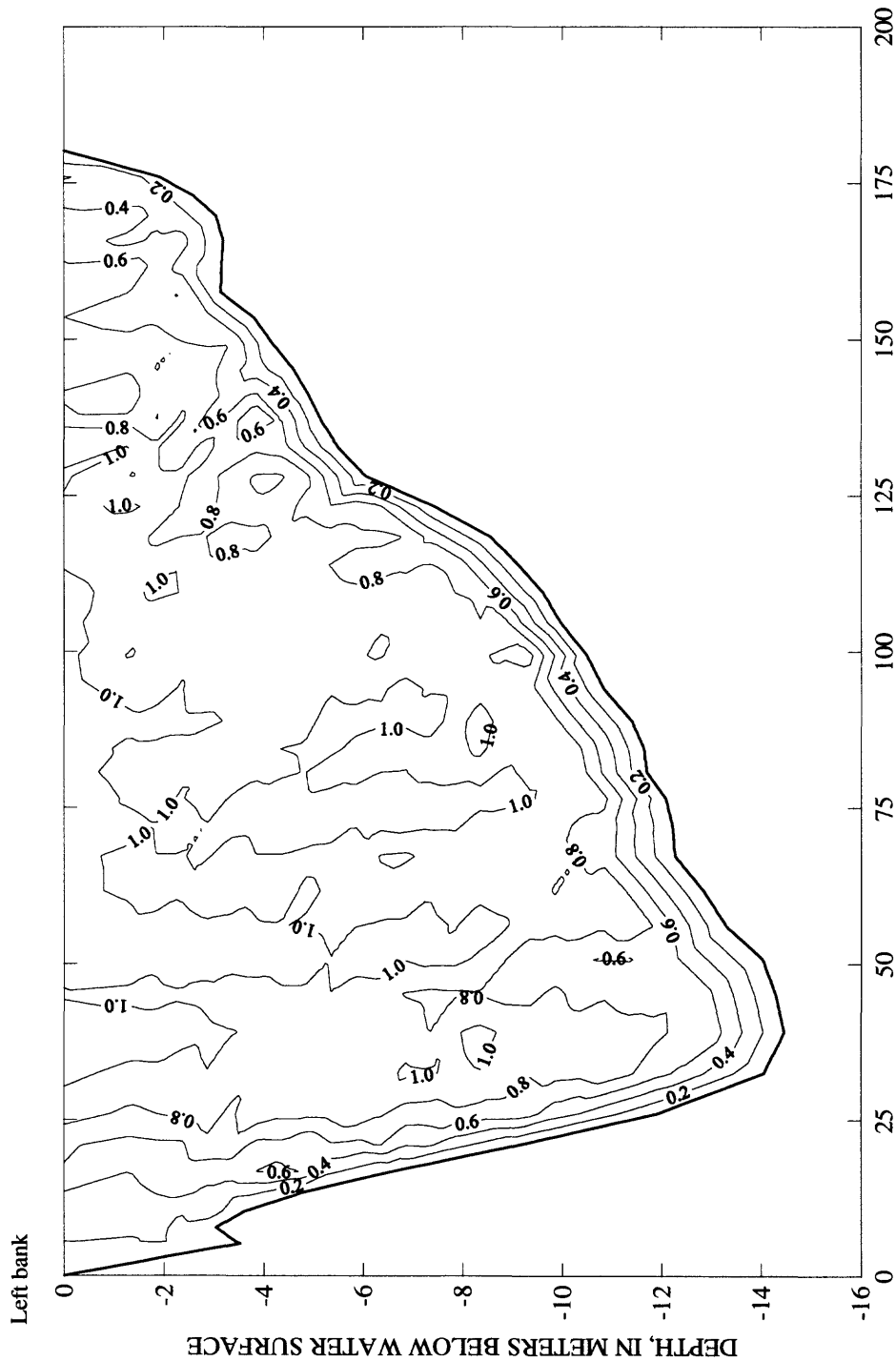


Figure 23. Velocity contours for Kootenai River reach 1, cross-section 13, June 10, 1997. (Contours in meters per second)

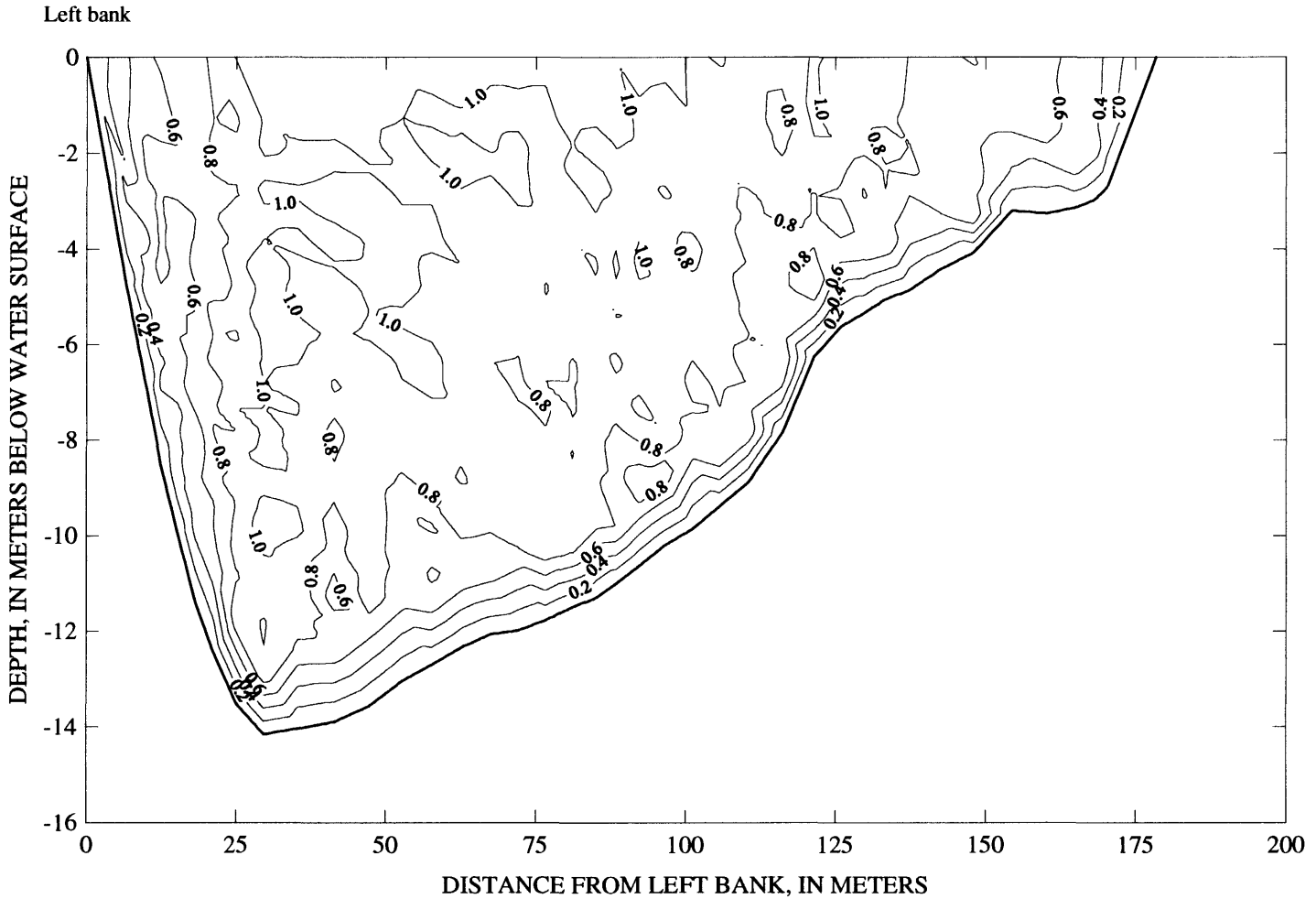
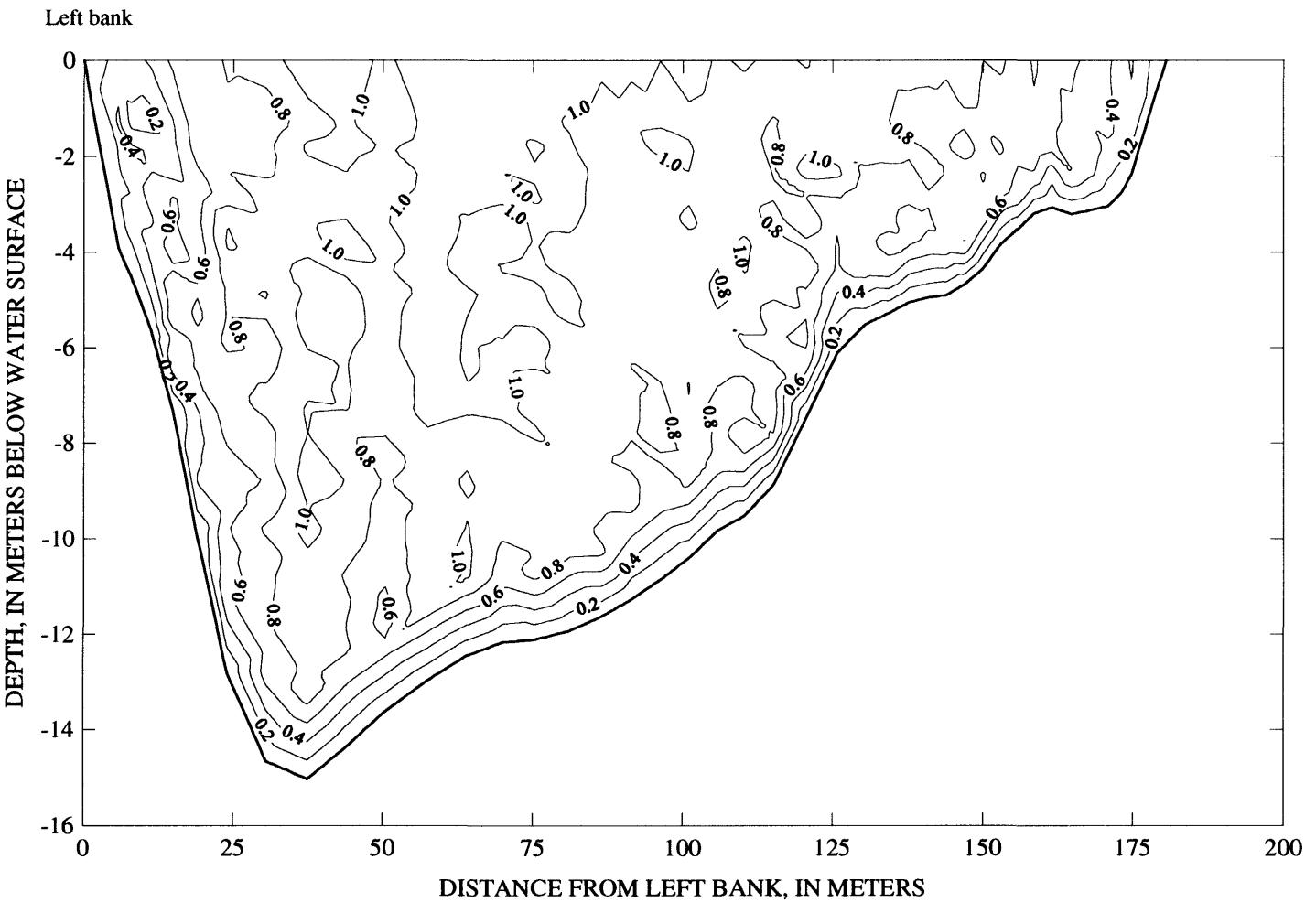


Figure 24. Velocity contours for Kootenai River reach 1, cross-section 14, June 10, 1997. (Contours in meters per second)



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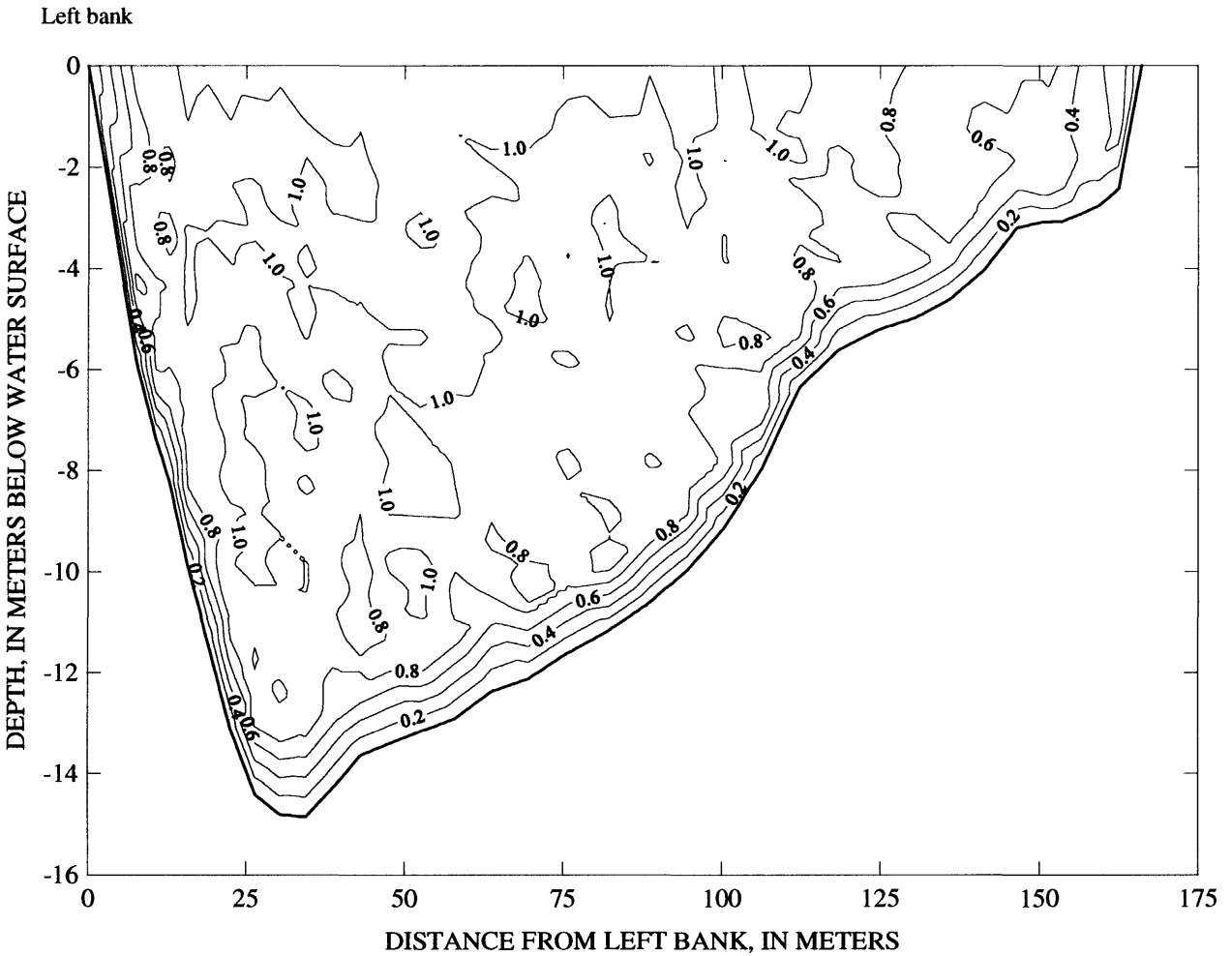

Figure 26. Velocity contours for Kootenai River reach 1, cross-section 16, June 10, 1997. (Contours in meters per second)

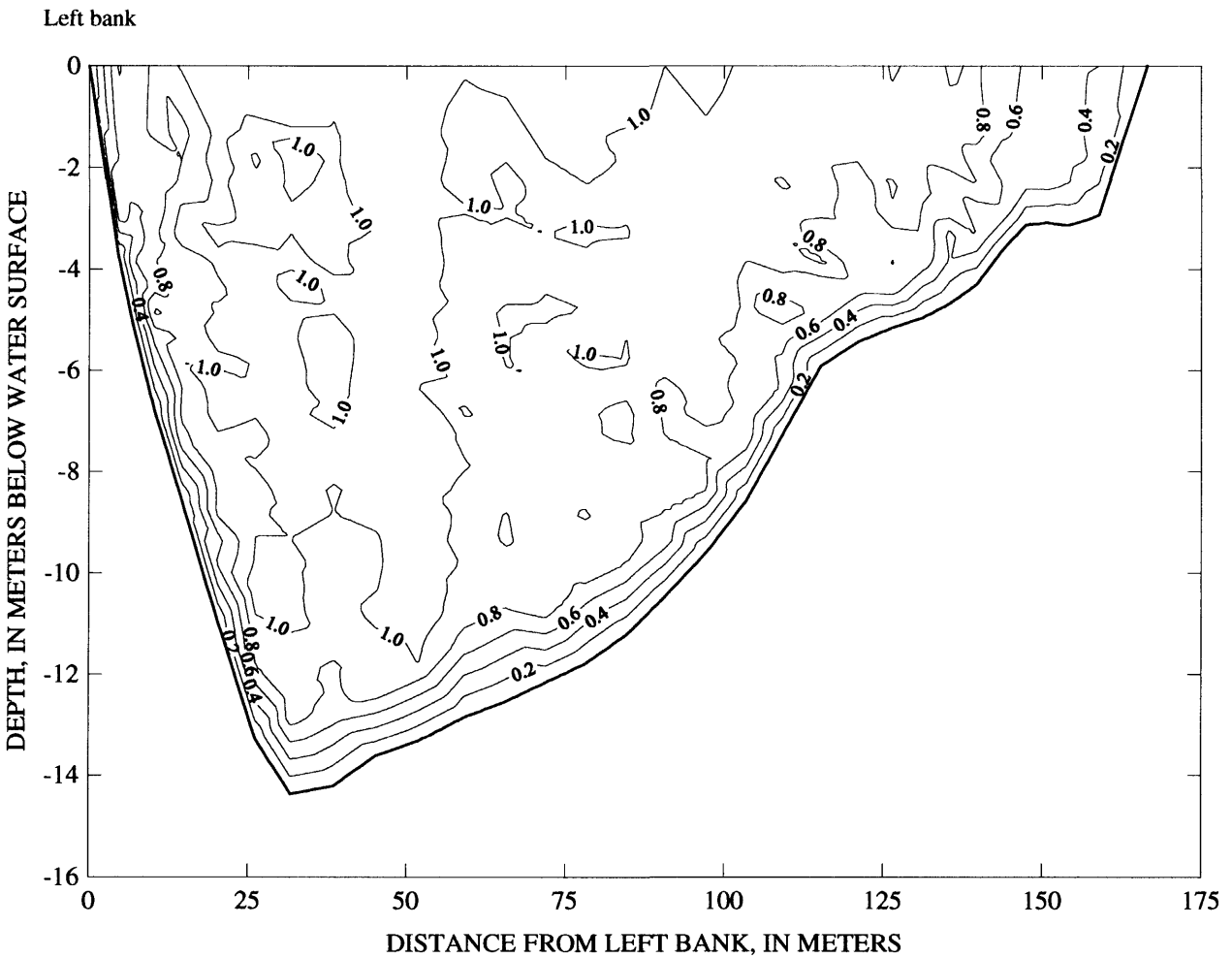

Figure 27. Velocity contours for Kootenai River reach 1, cross-section 17, June 10, 1997. (Contours in meters per second)

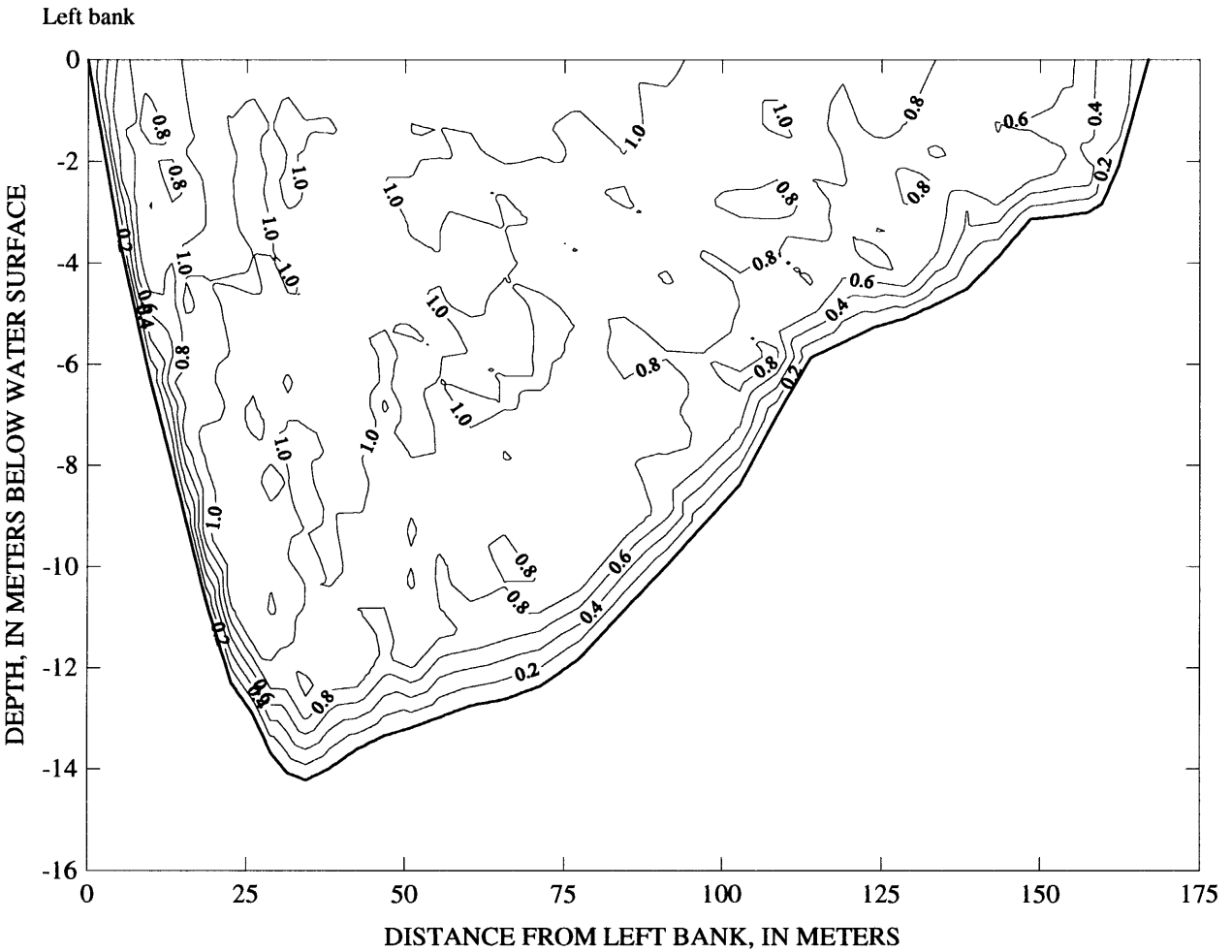

Figure 28. Velocity contours for Kootenai River reach 1, cross-section 18, June 10, 1997. (Contours in meters per second)

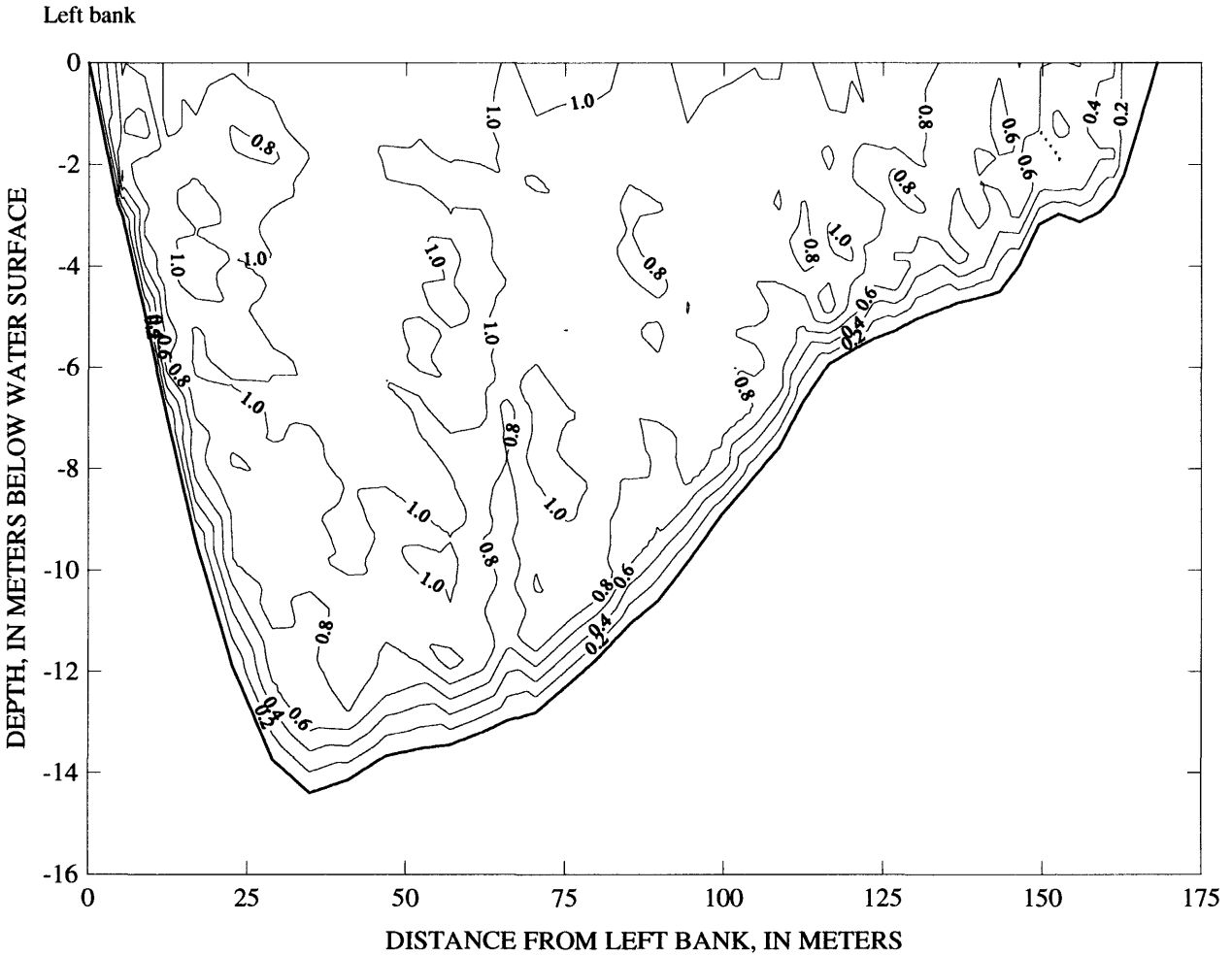

Figure 29. Velocity contours for Kootenai River reach 1, cross-section 19, June 10, 1997. (Contours in meters per second)

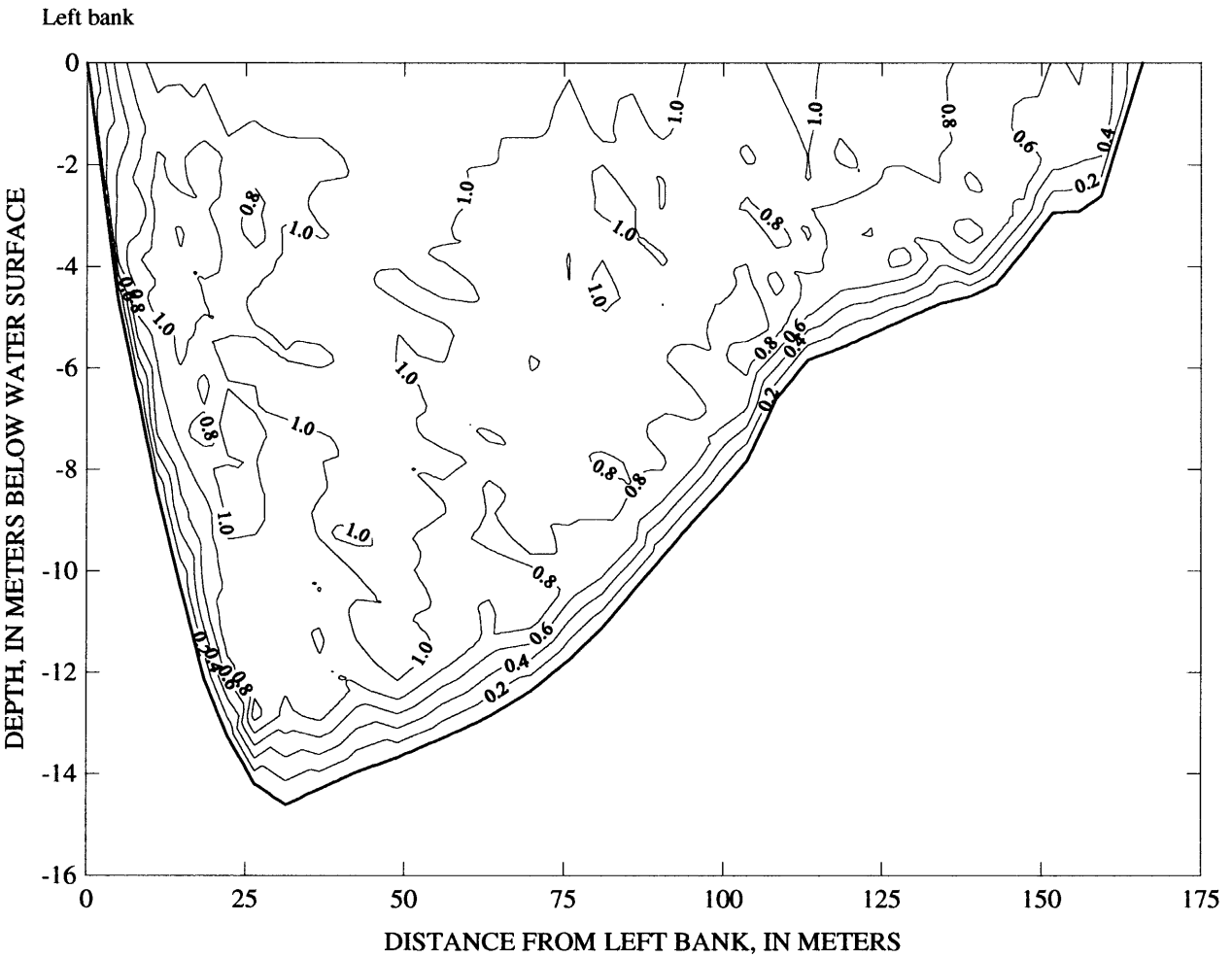

Figure 30. Velocity contours for Kootenai River reach 1, cross-section 20, June 10, 1997. (Contours in meters per second)

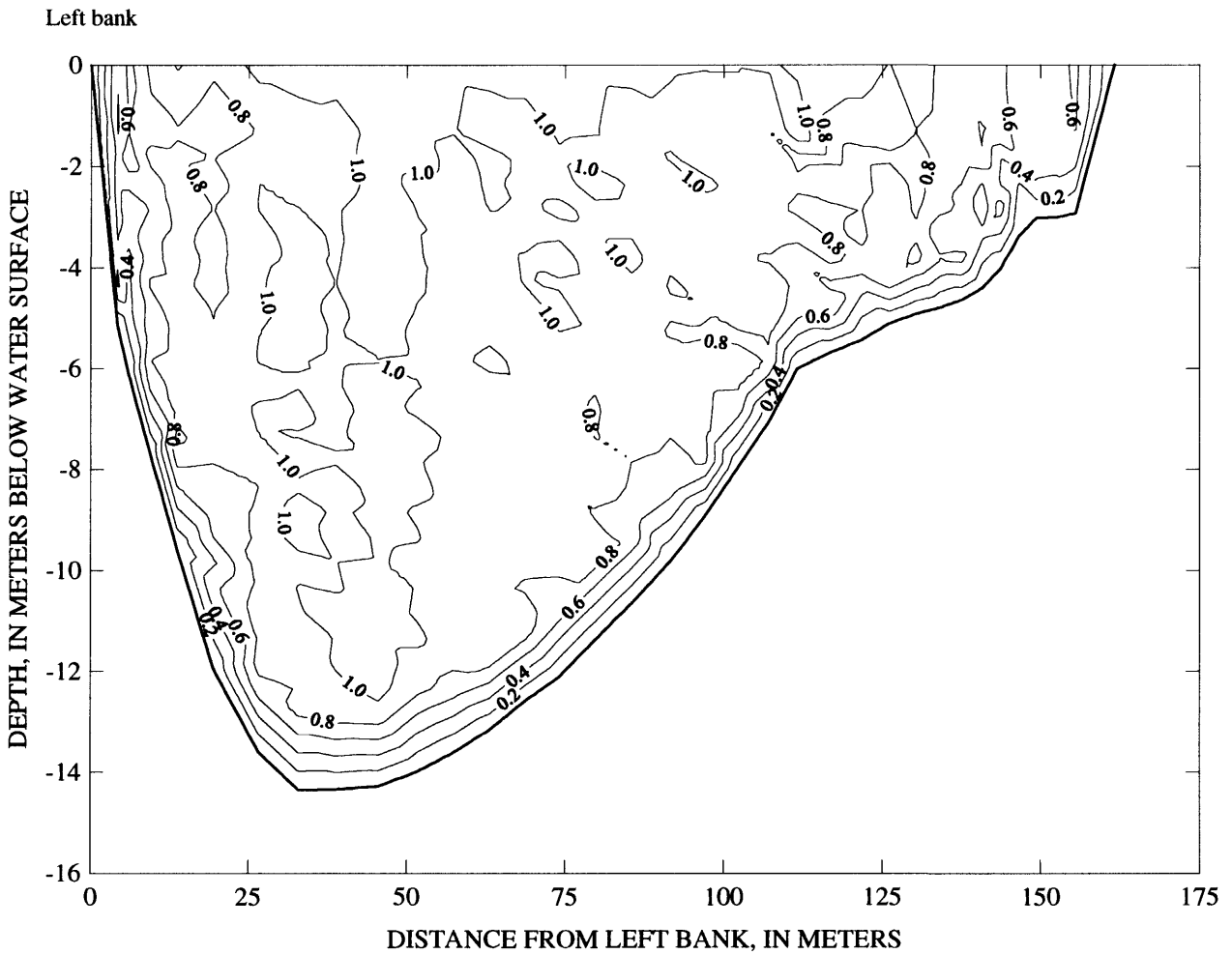

Figure 31. Velocity contours for Kootenai River reach 1, cross-section 21, June 10, 1997. (Contours in meters per second)

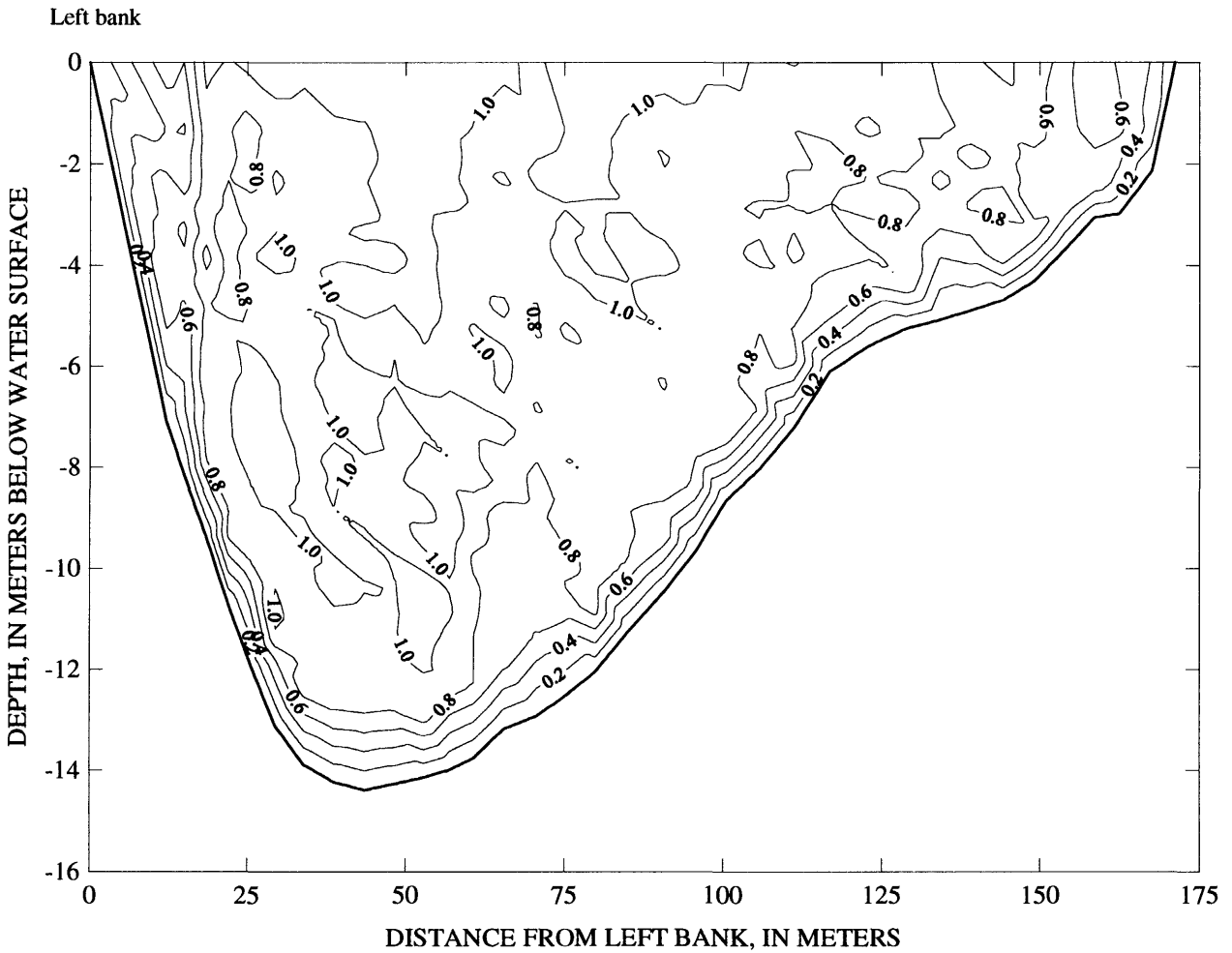

Figure 32. Velocity contours for Kootenai River reach 1, cross-section 22, June 10, 1997. (Contours in meters per second)

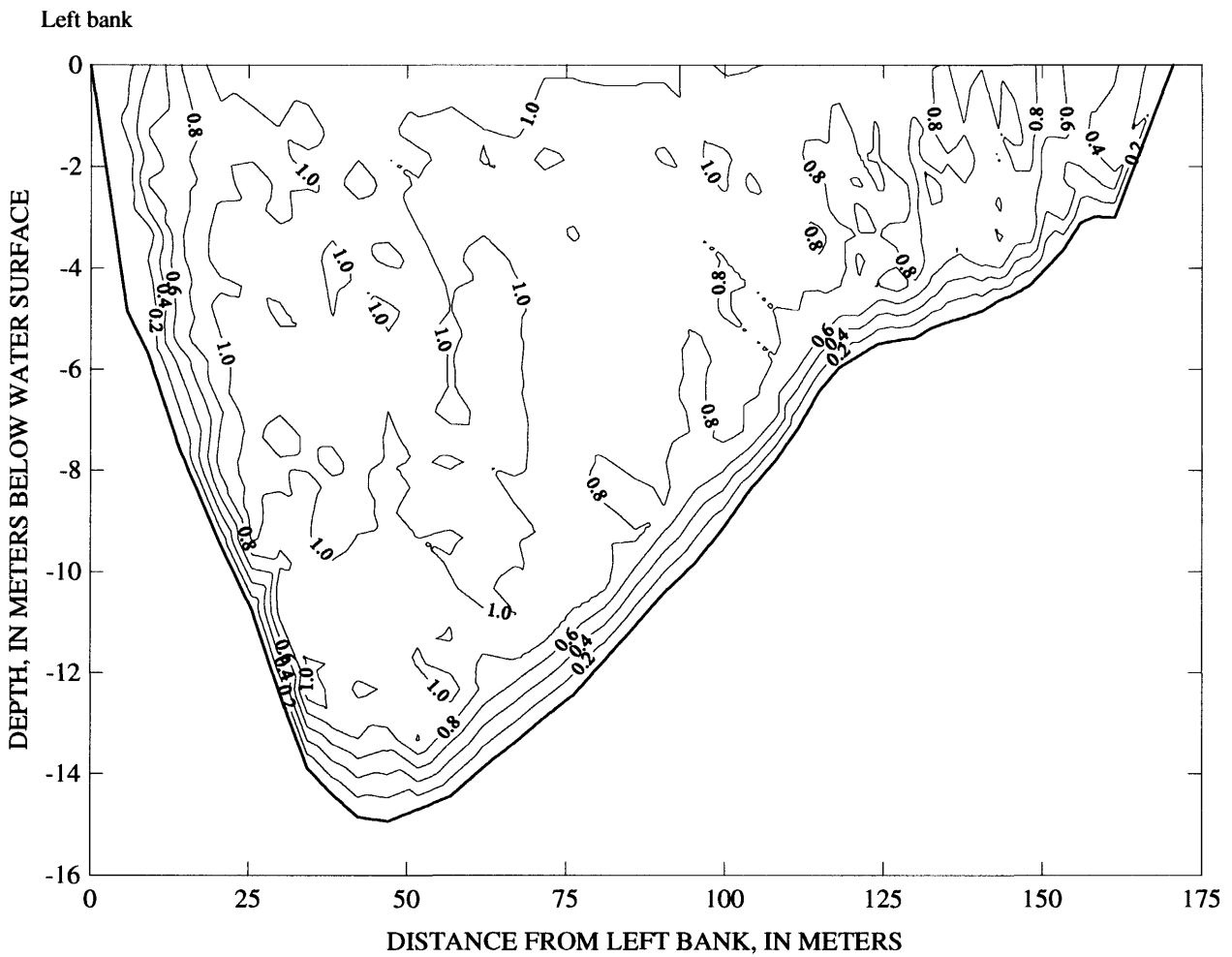

Figure 33. Velocity contours for Kootenai River reach 1, cross-section 23, June 10, 1997. (Contours in meters per second)

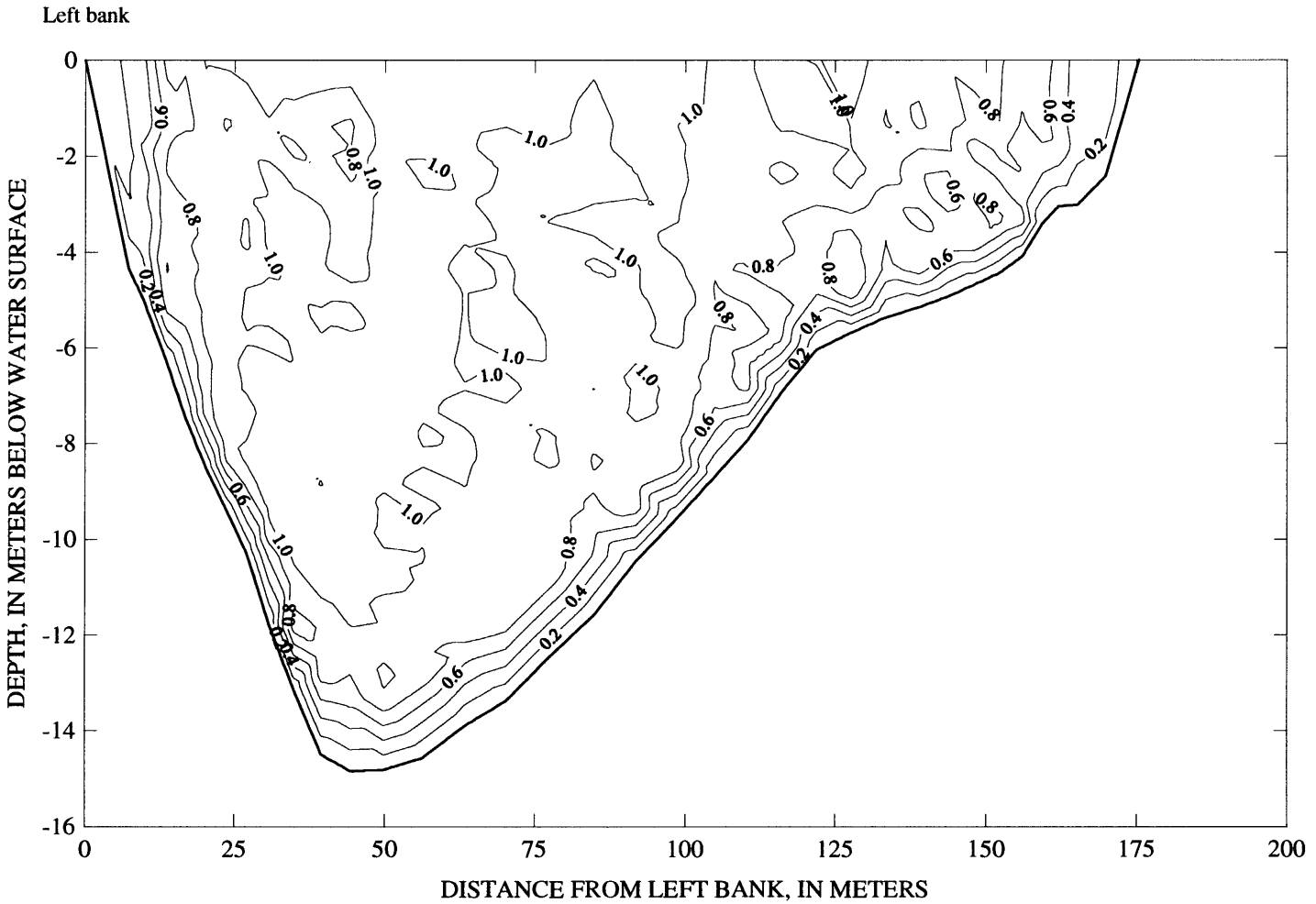

Figure 34. Velocity contours for Kootenai River reach 1, cross-section 24, June 10, 1997. (Contours in meters per second)

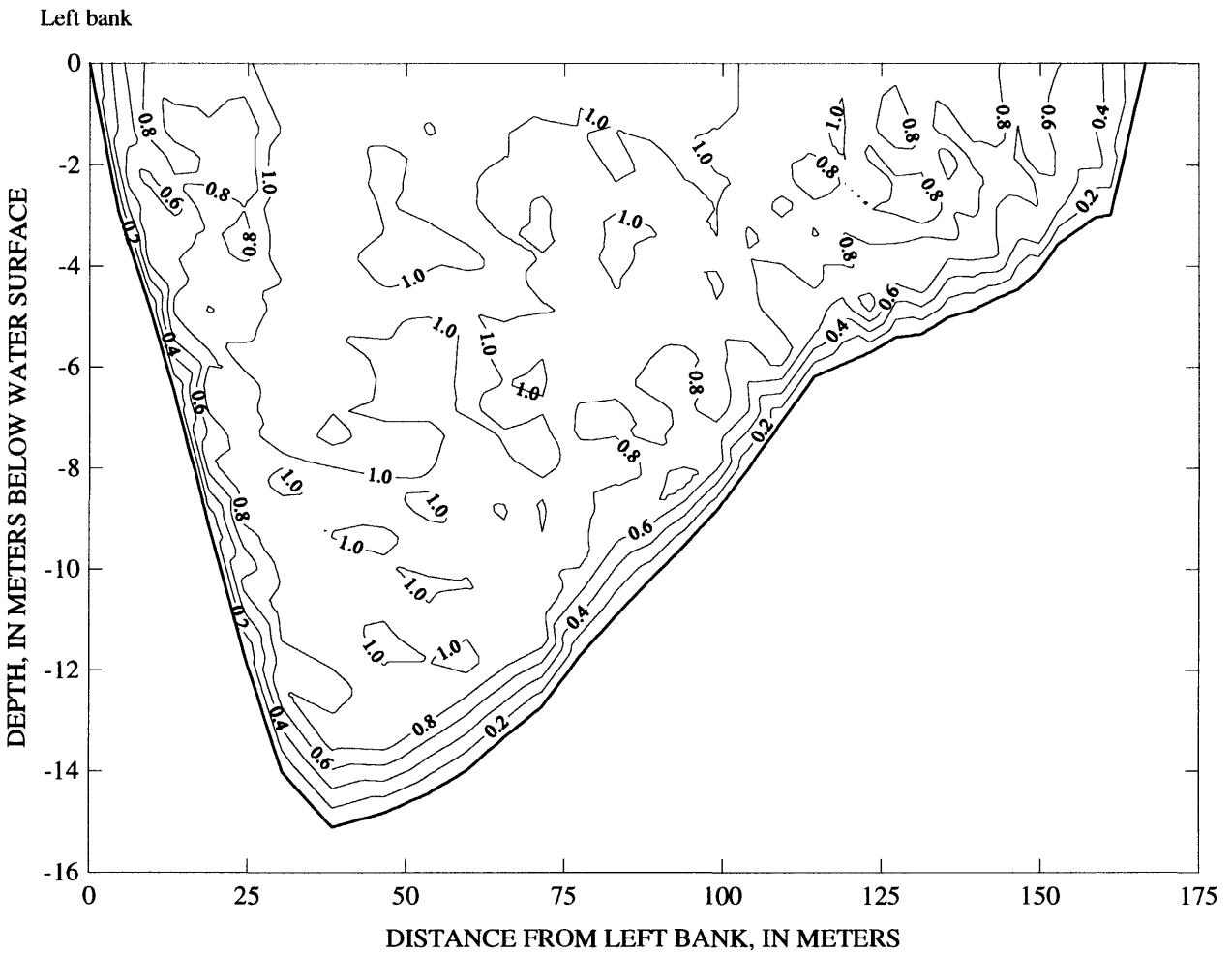

Figure 35. Velocity contours for Kootenai River reach 1, cross-section 25, June 10, 1997. (Contours in meters per second)

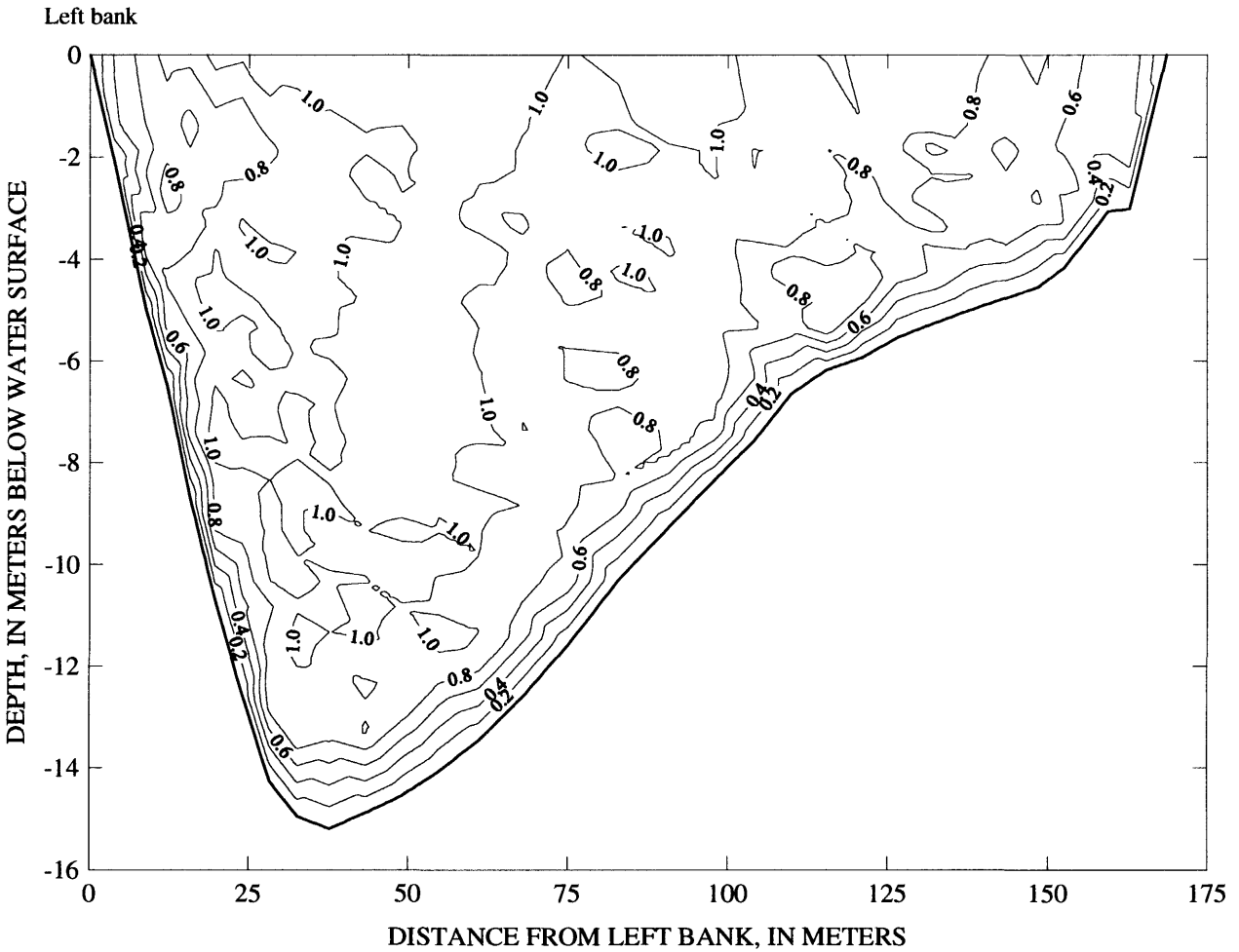

Figure 36. Velocity contours for Kootenai River reach 1, cross-section 26, June 10, 1997. (Contours in meters per second)

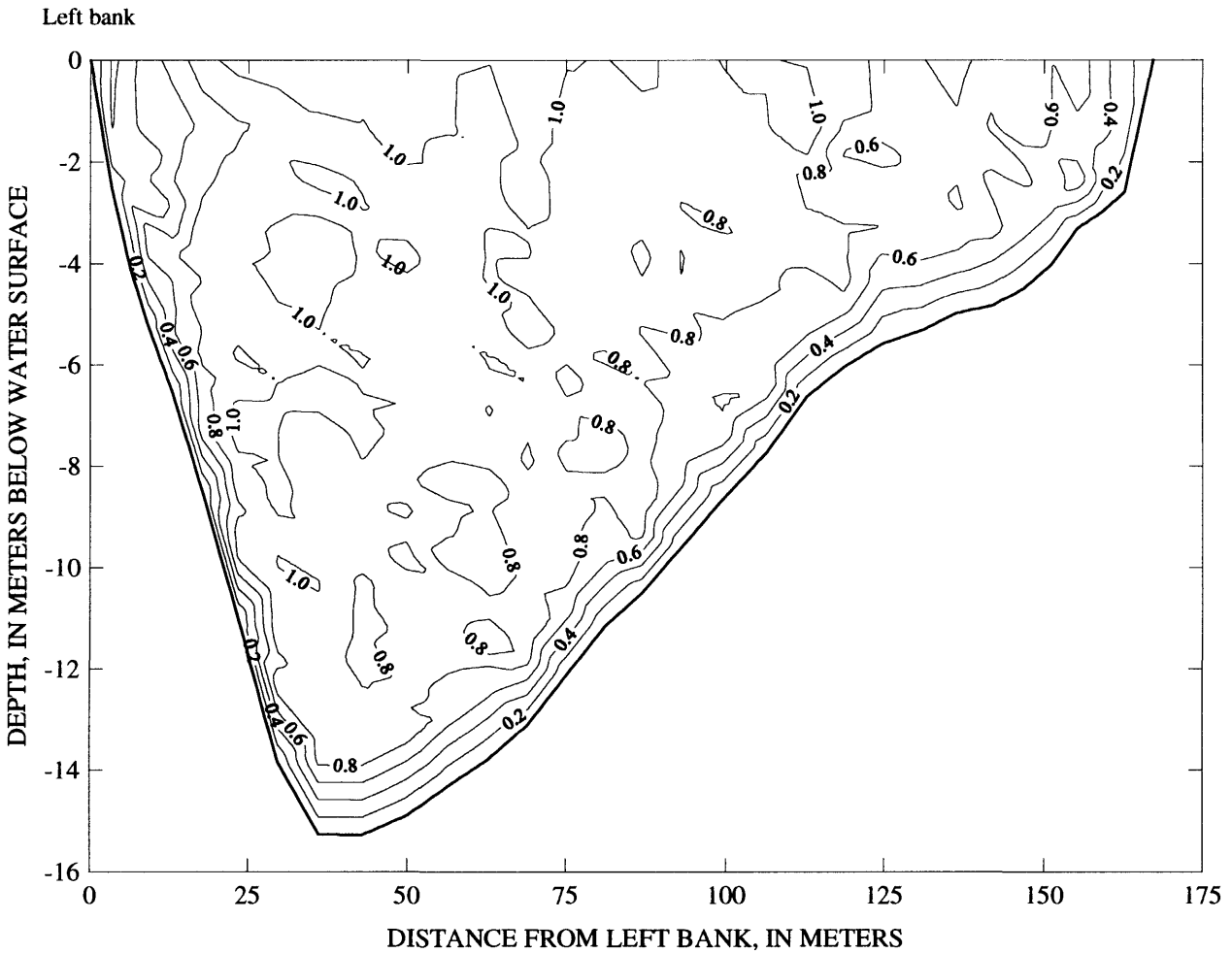

Figure 37. Velocity contours for Kootenai River reach 1, cross-section 27, June 10, 1997. (Contours in meters per second)

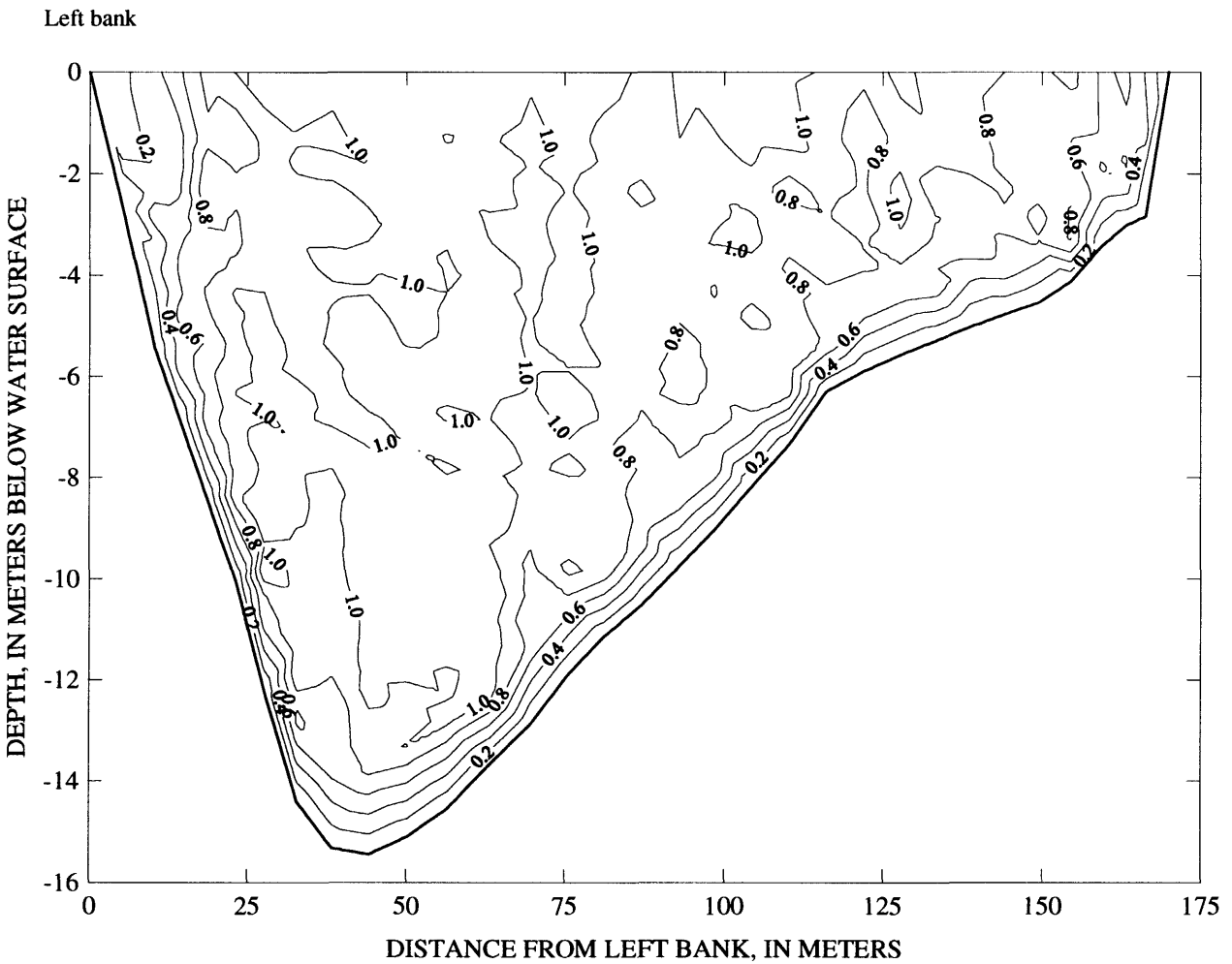

Figure 38. Velocity contours for Kootenai River reach 1, cross-section 28, June 10, 1997. (Contours in meters per second)

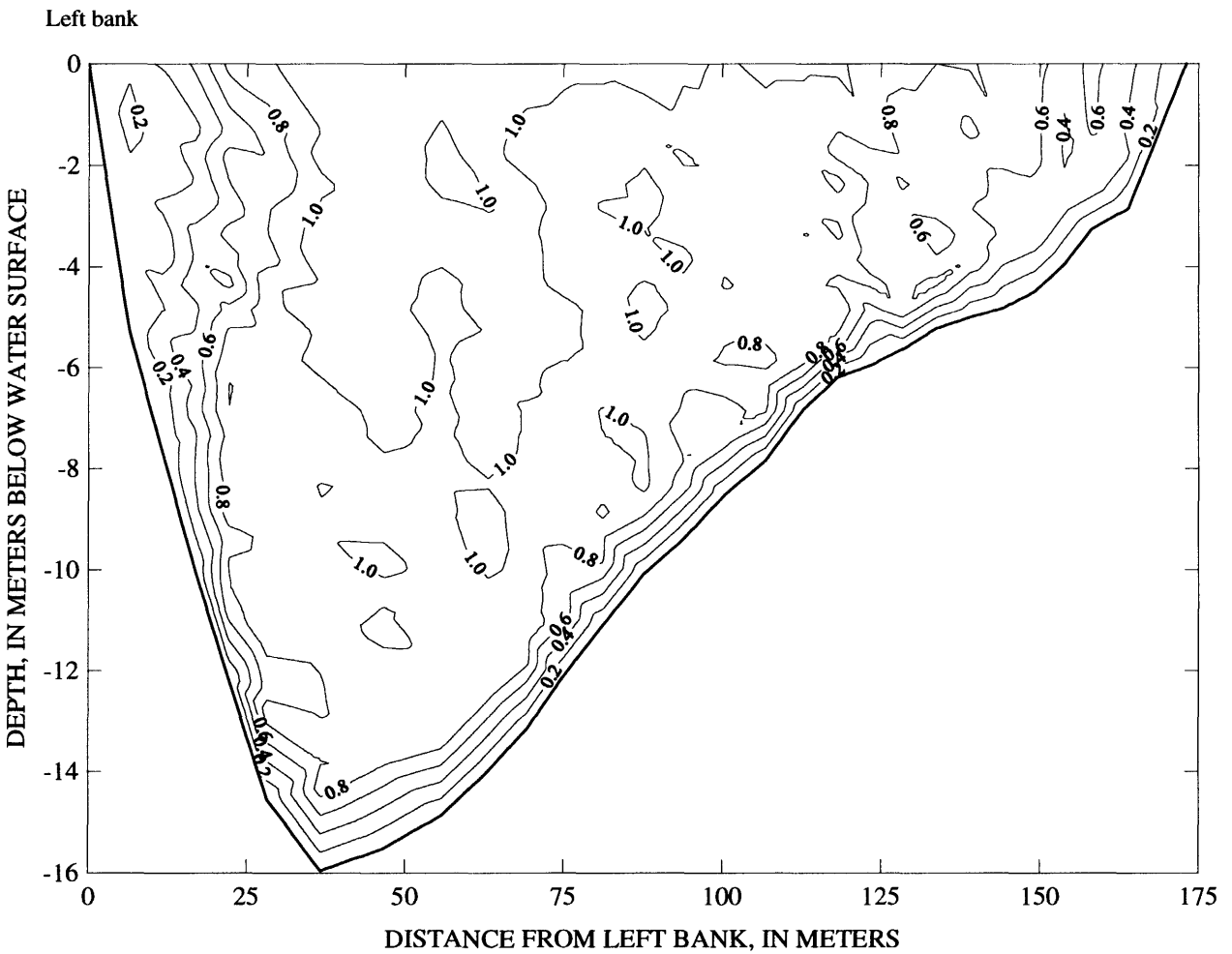

Figure 39. Velocity contours for Kootenai River reach 1, cross-section 29, June 10, 1997. (Contours in meters per second)

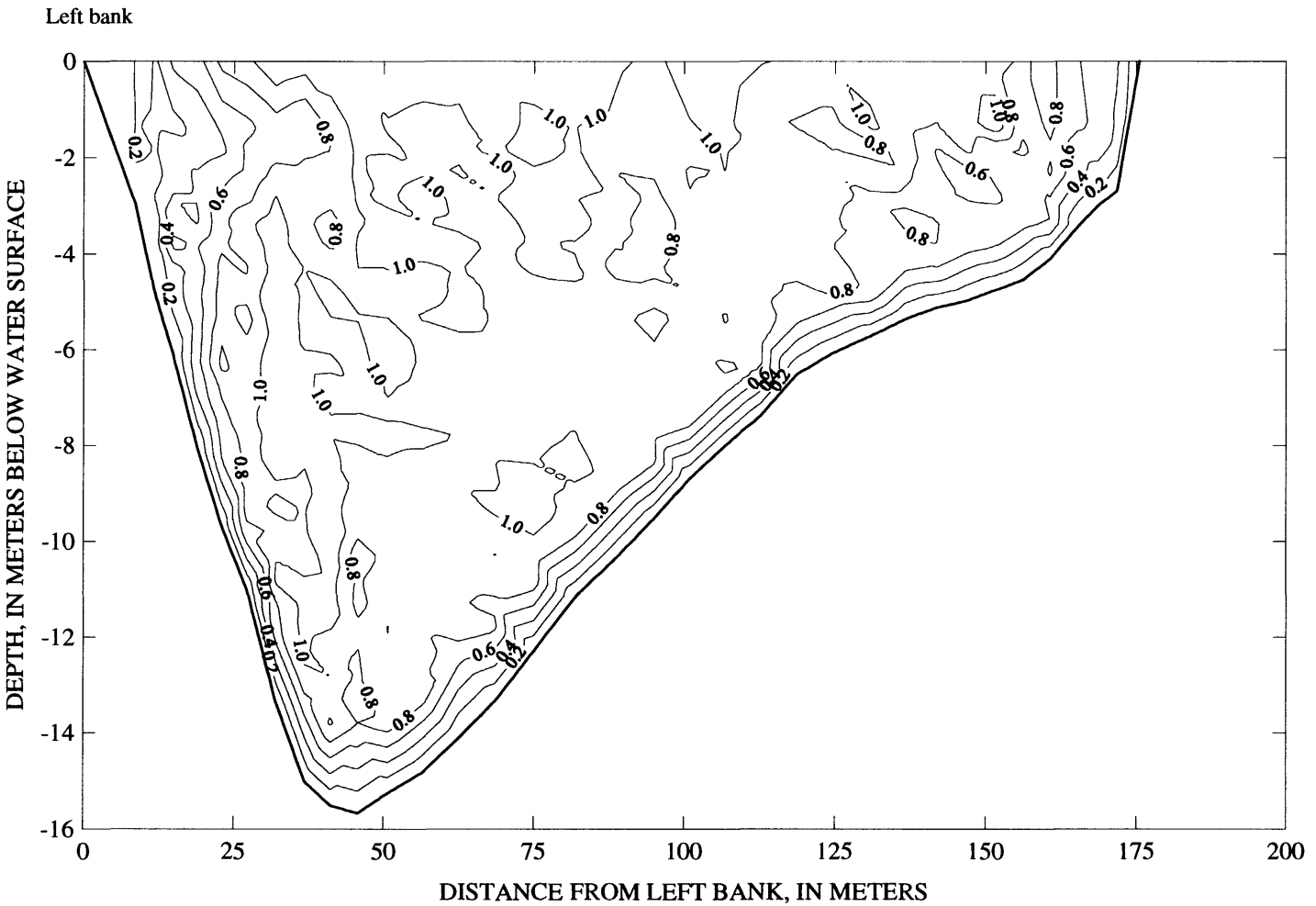

Figure 40. Velocity contours for Kootenai River reach 1, cross-section 30, June 10, 1997. (Contours in meters per second)

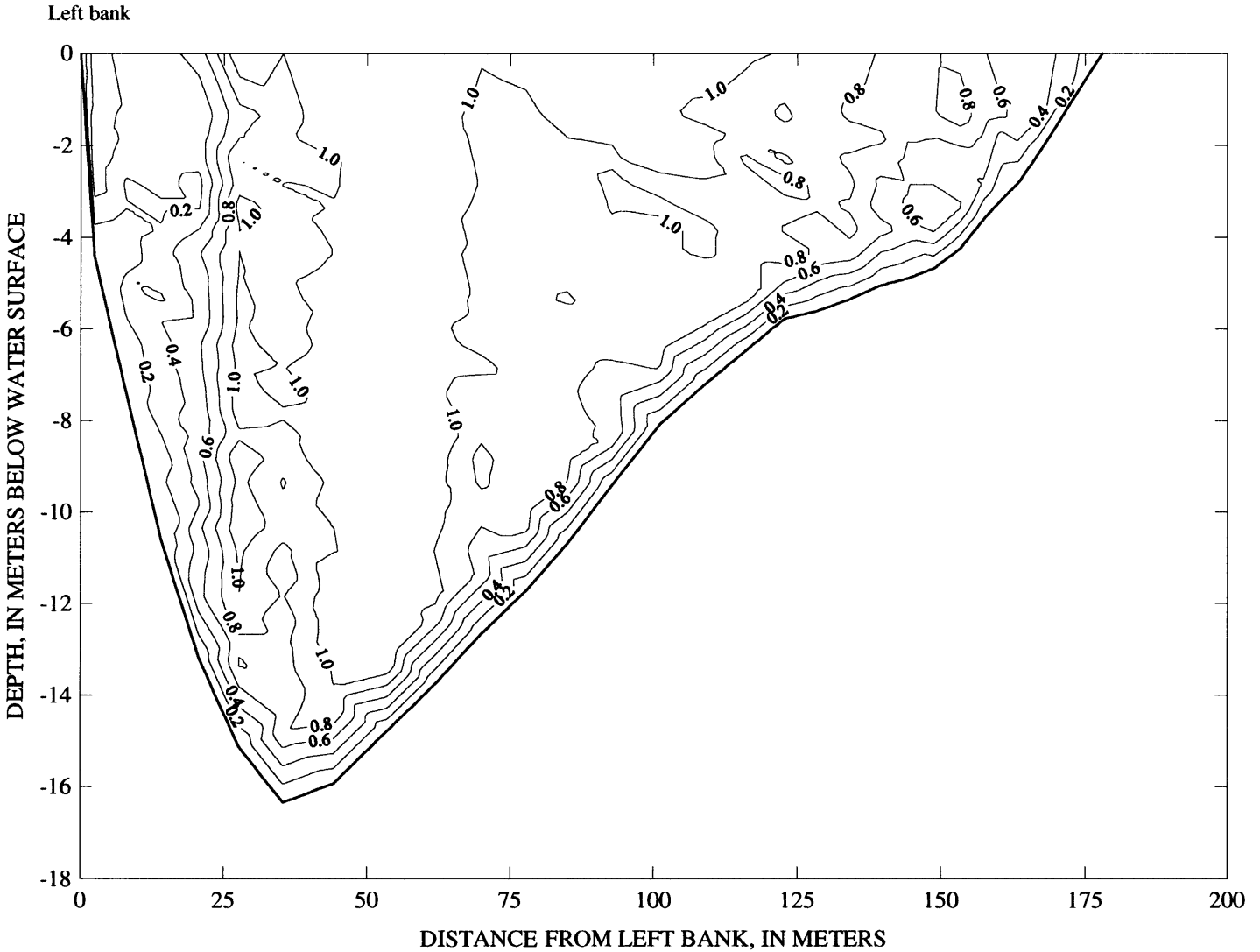

Figure 41. Velocity contours for Kootenai River reach 1, cross-section 31, June 10, 1997. (Contours in meters per second)

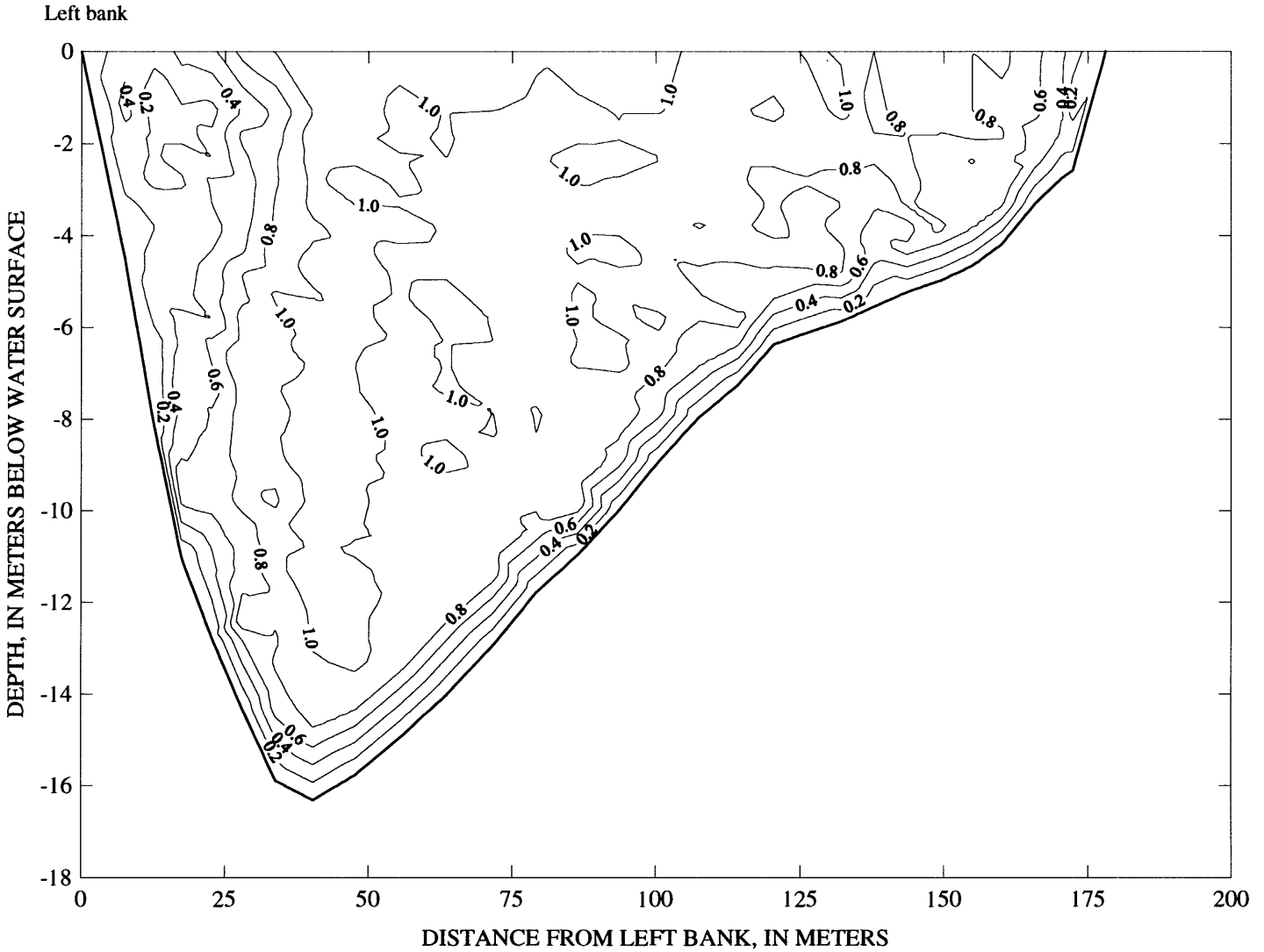

Figure 42. Velocity contours for Kootenai River reach 1, cross-section 32, June 10, 1997. (Contours in meters per second)

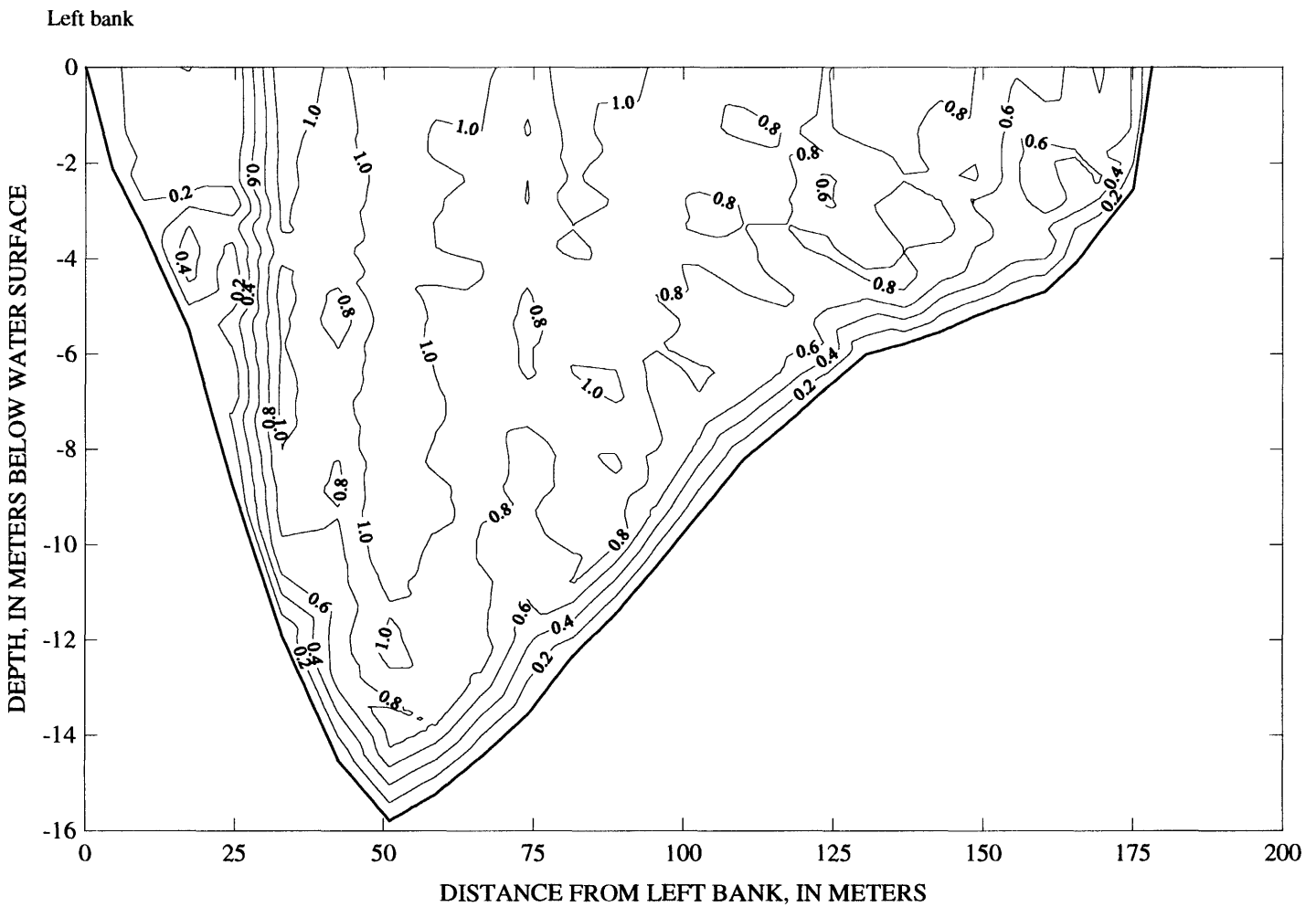

Figure 43. Velocity contours for Kootenai River reach 1, cross-section 33, June 10, 1997. (Contours in meters per second)

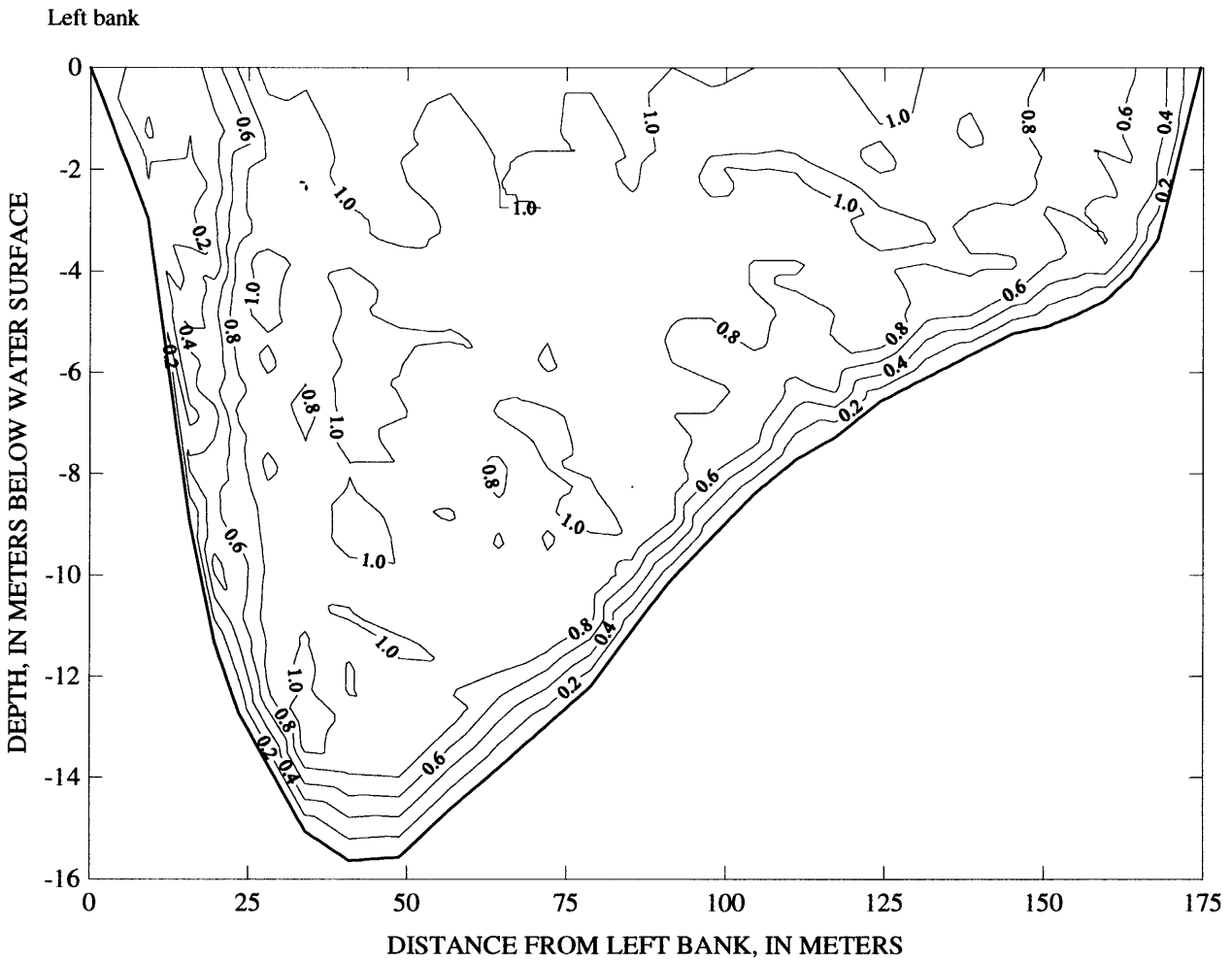

Figure 44. Velocity contours for Kootenai River reach 1, cross-section 34, June 10, 1997. (Contours in meters per second)

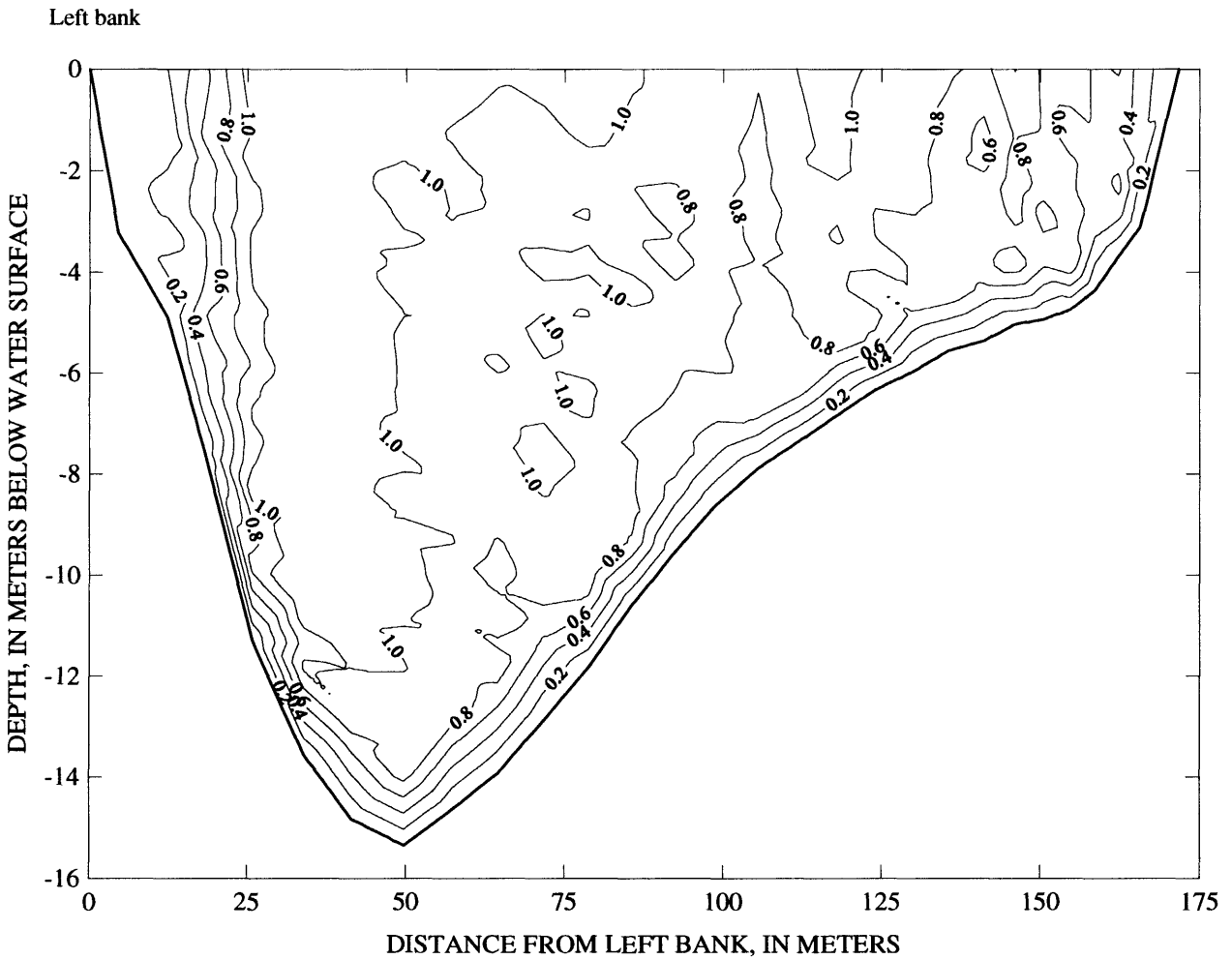

Figure 45. Velocity contours for Kootenai River reach 1, cross-section 35, June 10, 1997. (Contours in meters per second)

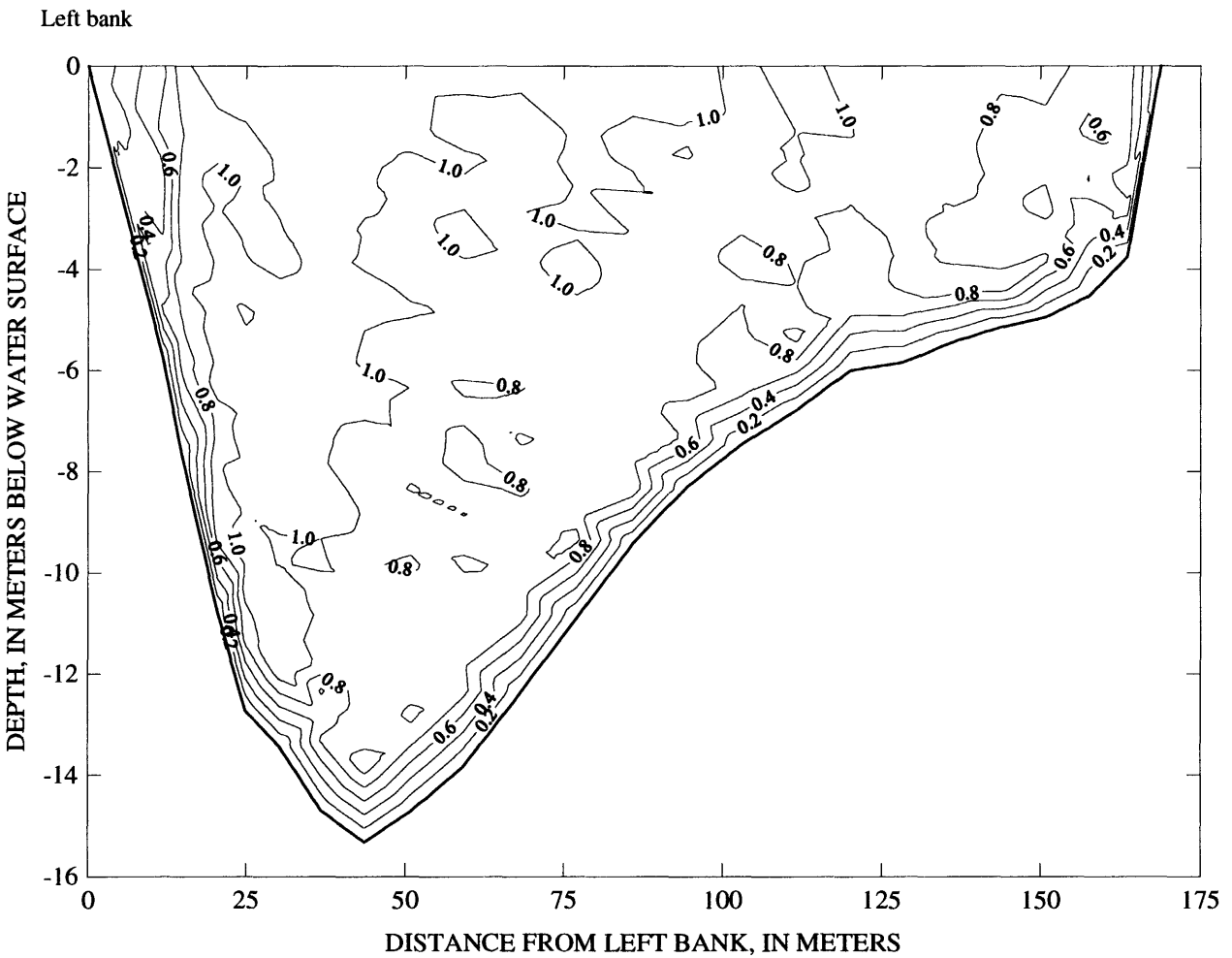

Figure 46. Velocity contours for Kootenai River reach 1, cross-section 36, June 10, 1997. (Contours in meters per second)

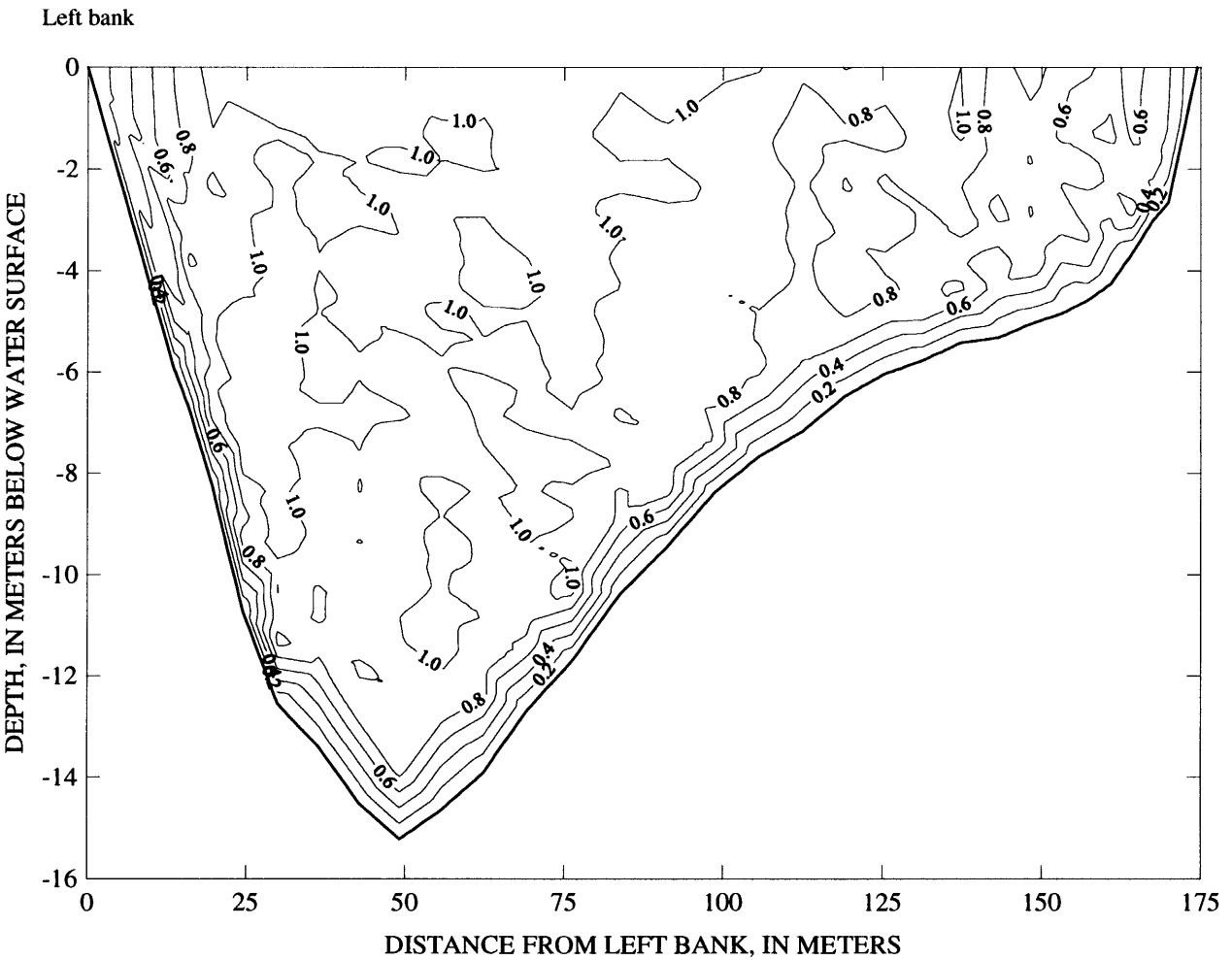

Figure 47. Velocity contours for Kootenai River reach 1, cross-section 37, June 10, 1997. (Contours in meters per second)

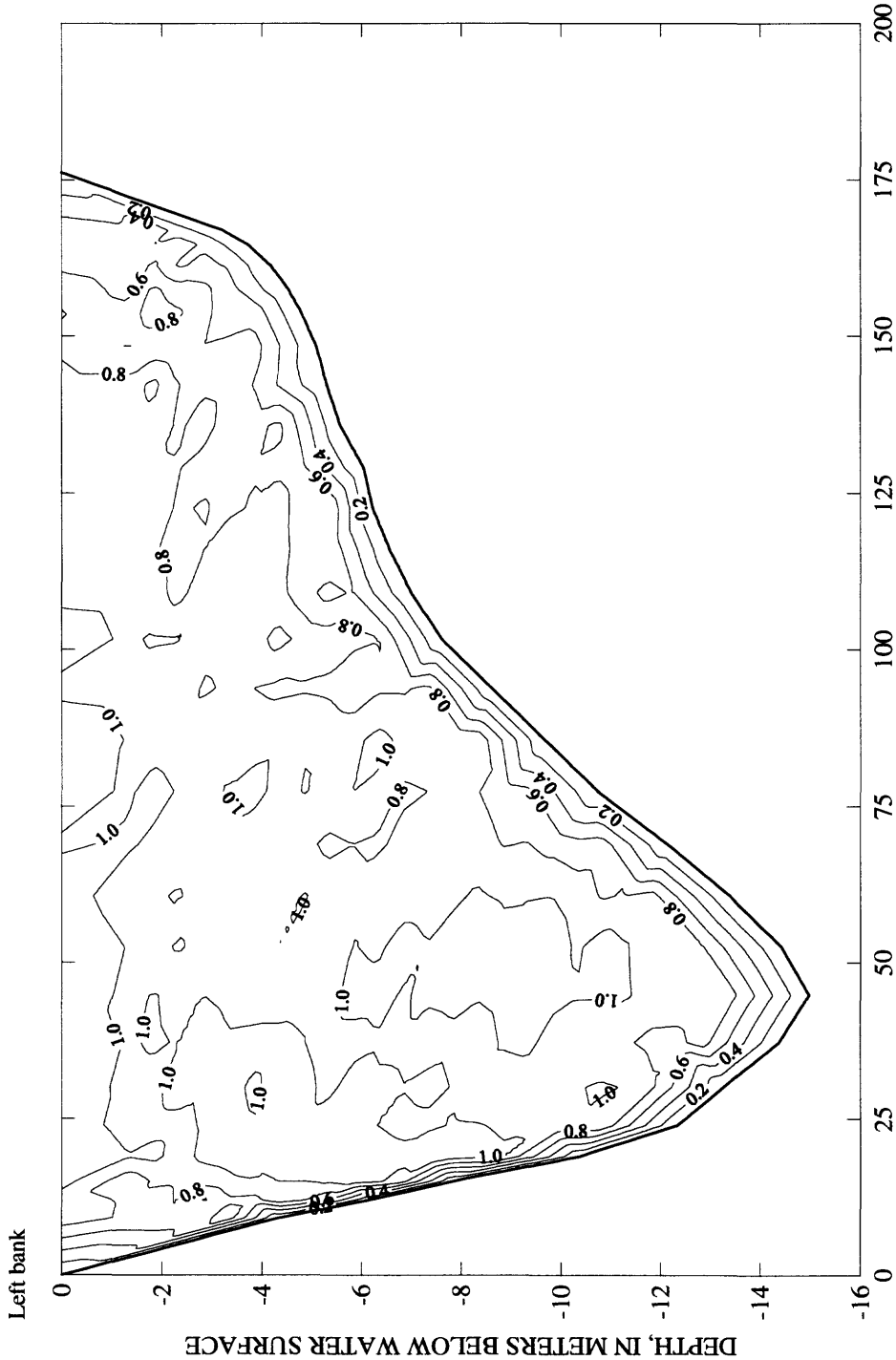

Figure 48. Velocity contours for Kootenai River reach 1, cross-section 38, June 10, 1997.
(Contours in meters per second)

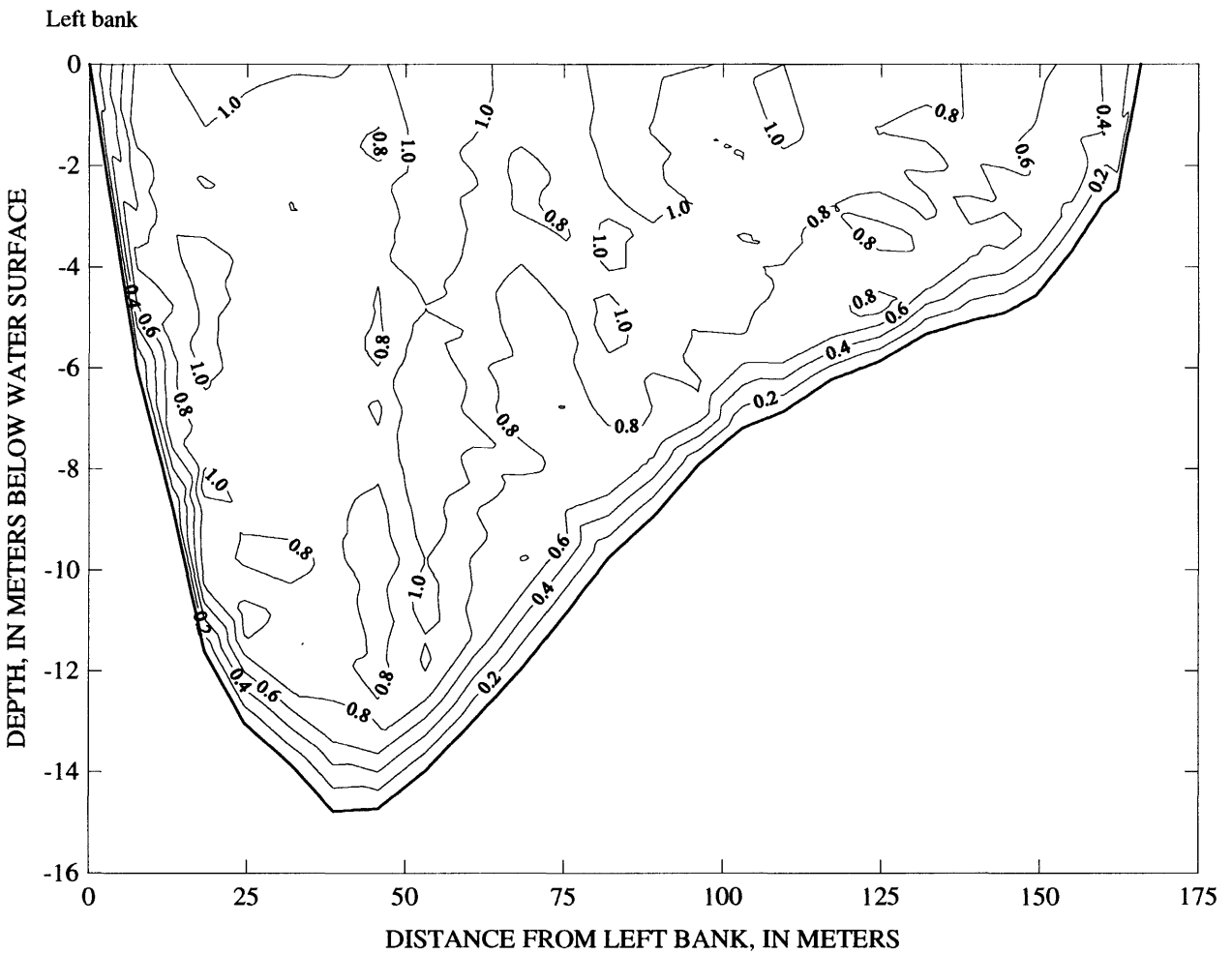

Figure 49. Velocity contours for Kootenai River reach 1, cross-section 39, June 10, 1997. (Contours in meters per second)

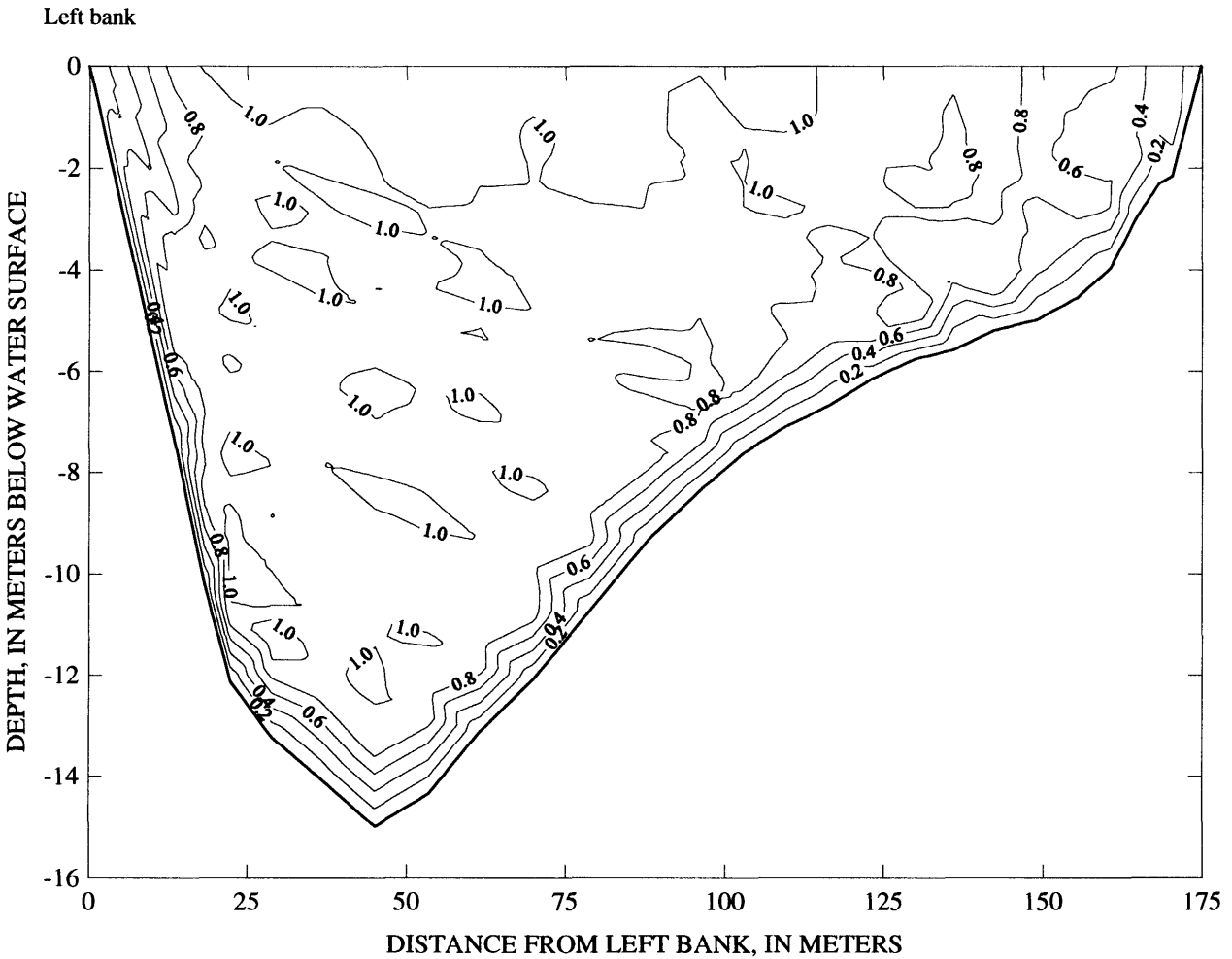

Figure 50. Velocity contours for Kootenai River reach 1, cross-section 40, June 10, 1997. (Contours in meters per second)

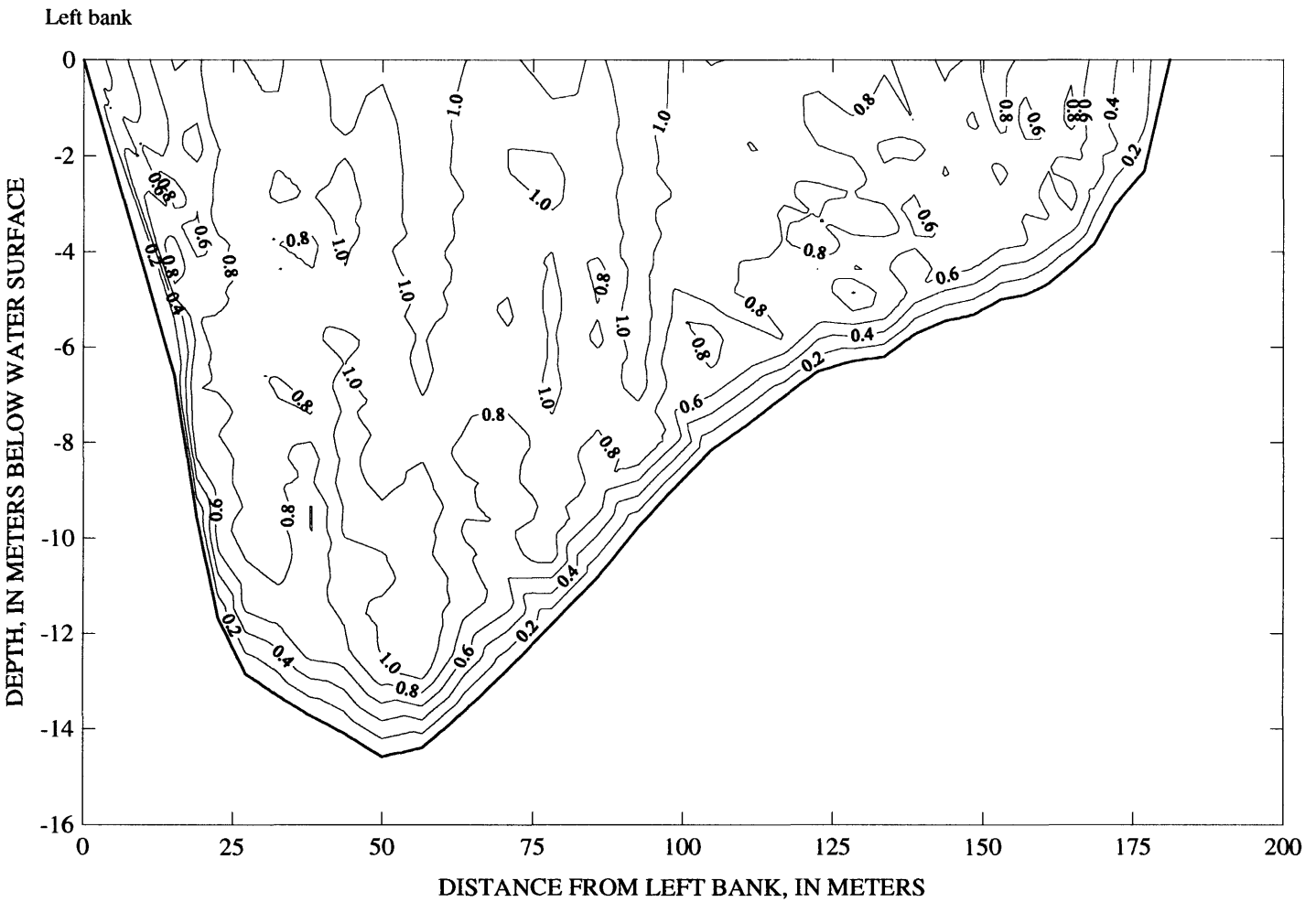

Figure 51. Velocity contours for Kootenai River reach 1, cross-section 41, June 10, 1997. (Contours in meters per second)

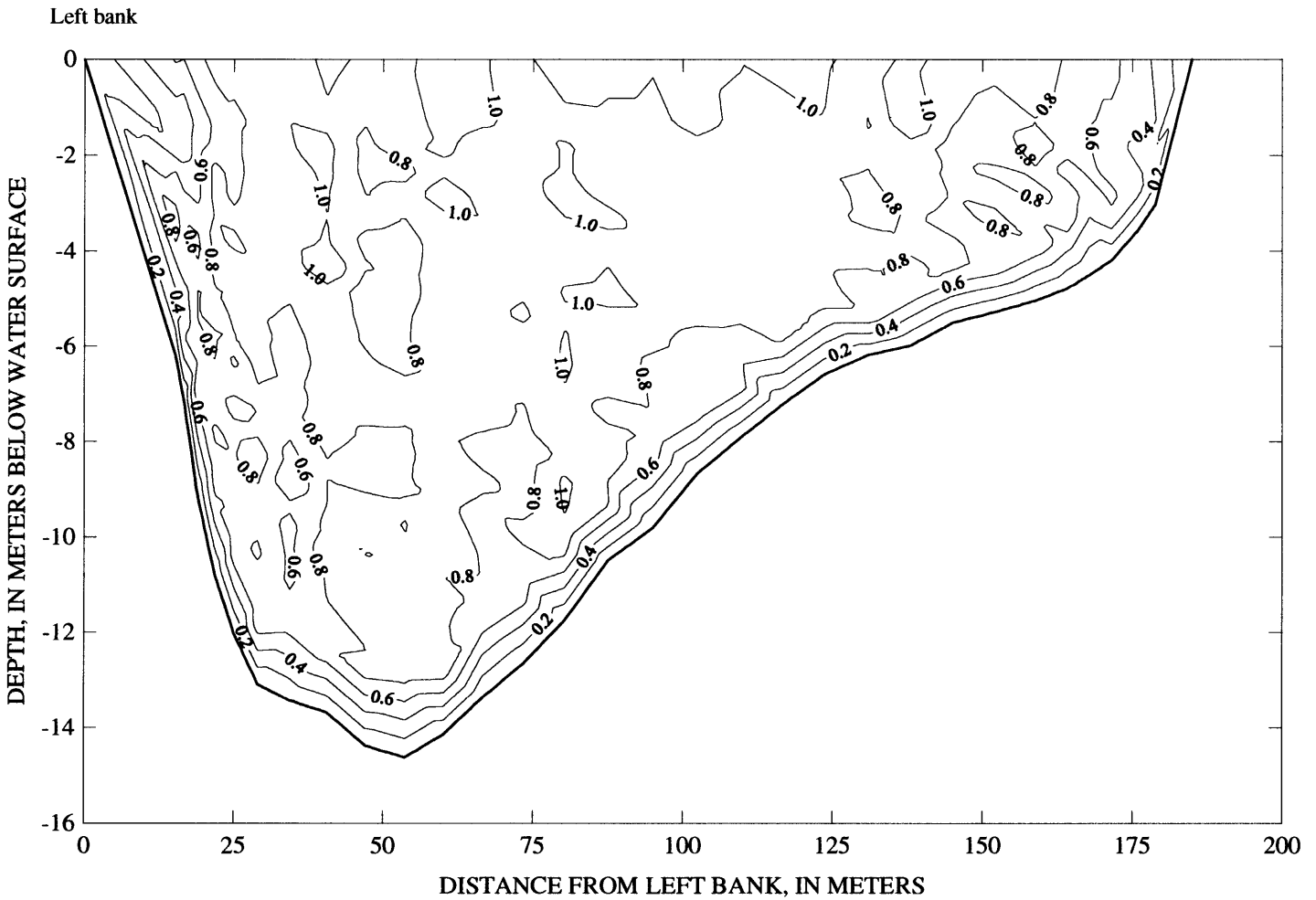

Figure 52. Velocity contours for Kootenai River reach 1, cross-section 42, June 10, 1997. (Contours in meters per second)

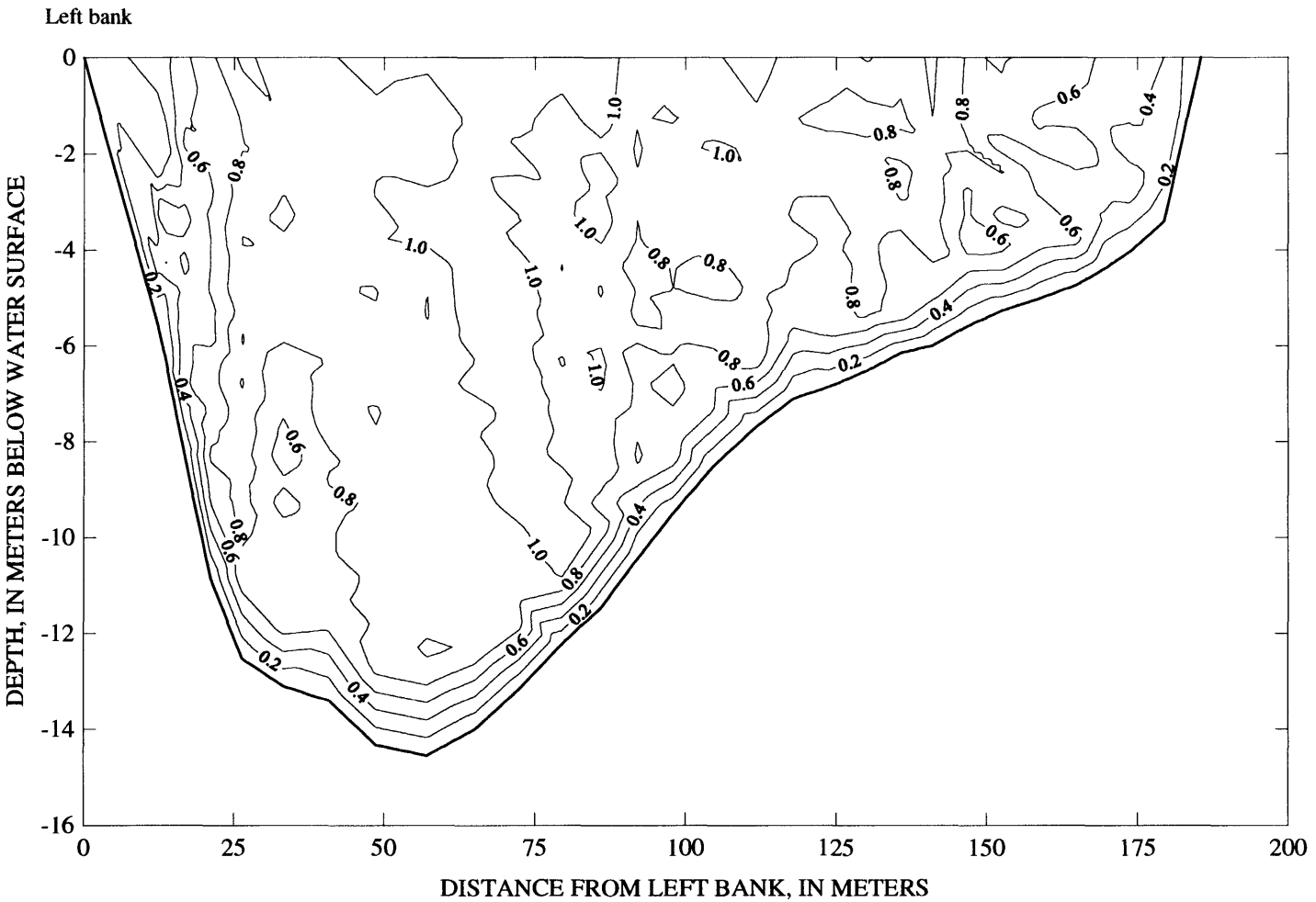

Figure 53. Velocity contours for Kootenai River reach 1, cross-section 43, June 10, 1997. (Contours in meters per second)

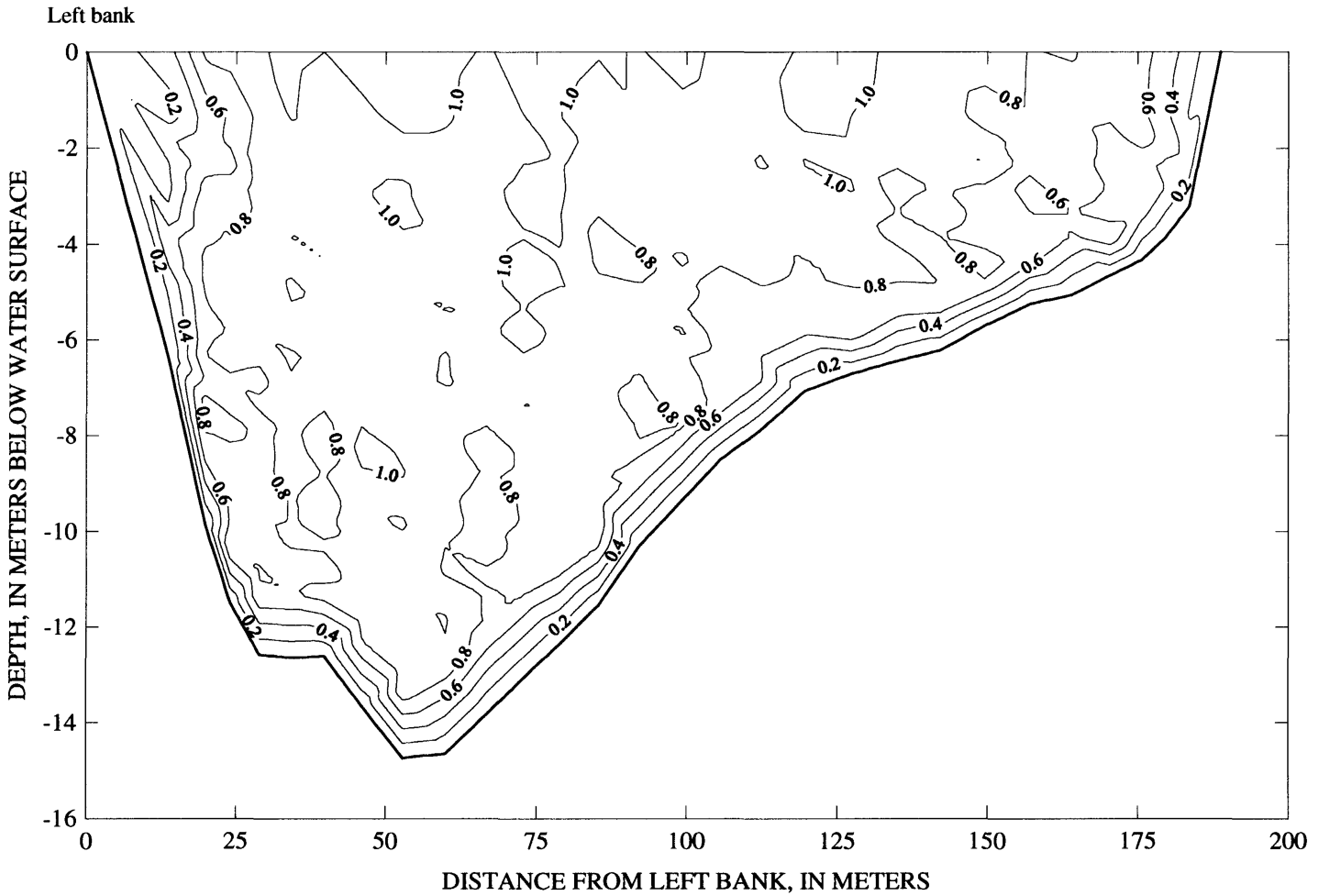

Figure 54. Velocity contours for Kootenai River reach 1, cross-section 44, June 10, 1997. (Contours in meters per second)

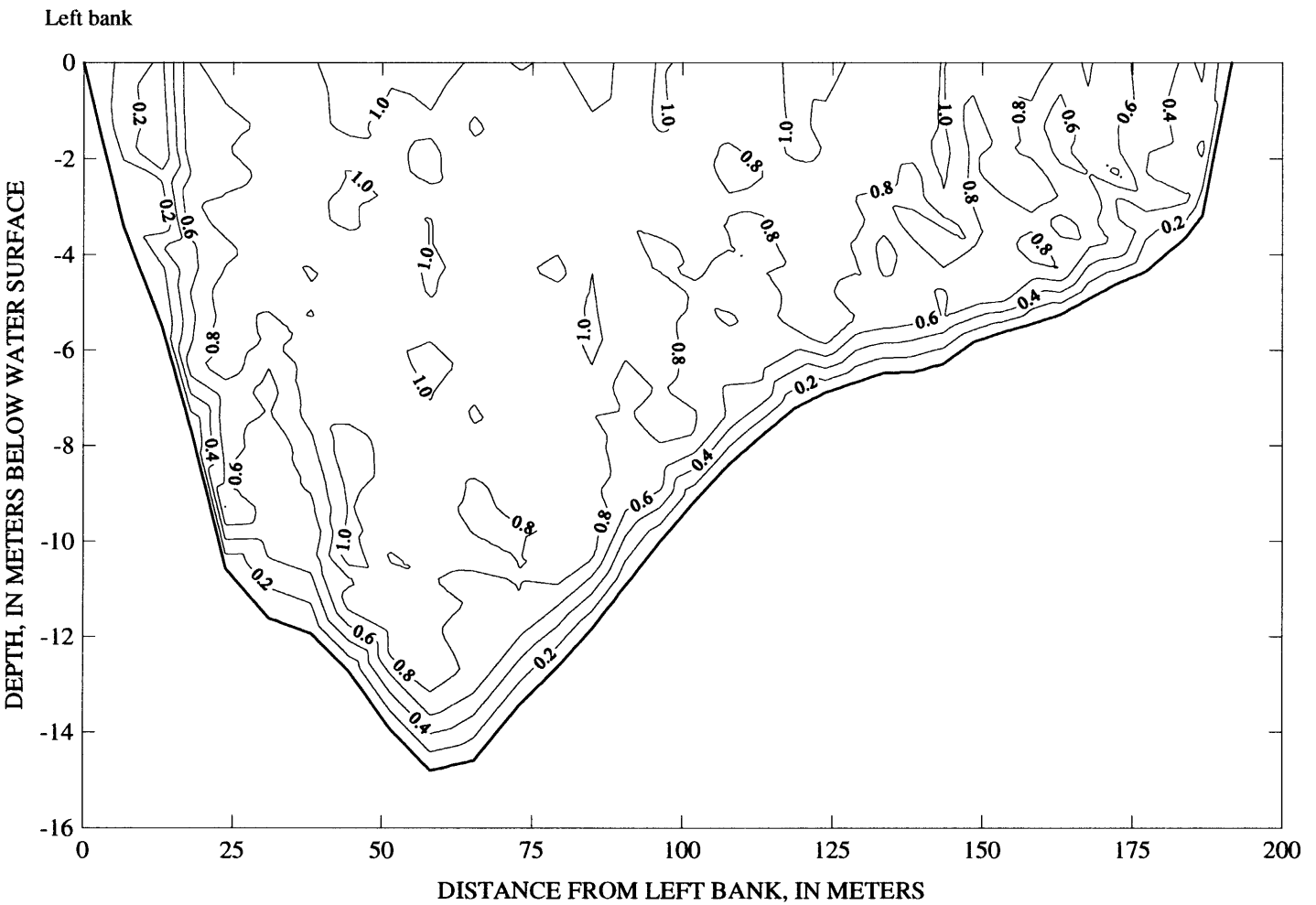

Figure 55. Velocity contours for Kootenai River reach 1, cross-section 45, June 10, 1997. (Contours in meters per second)

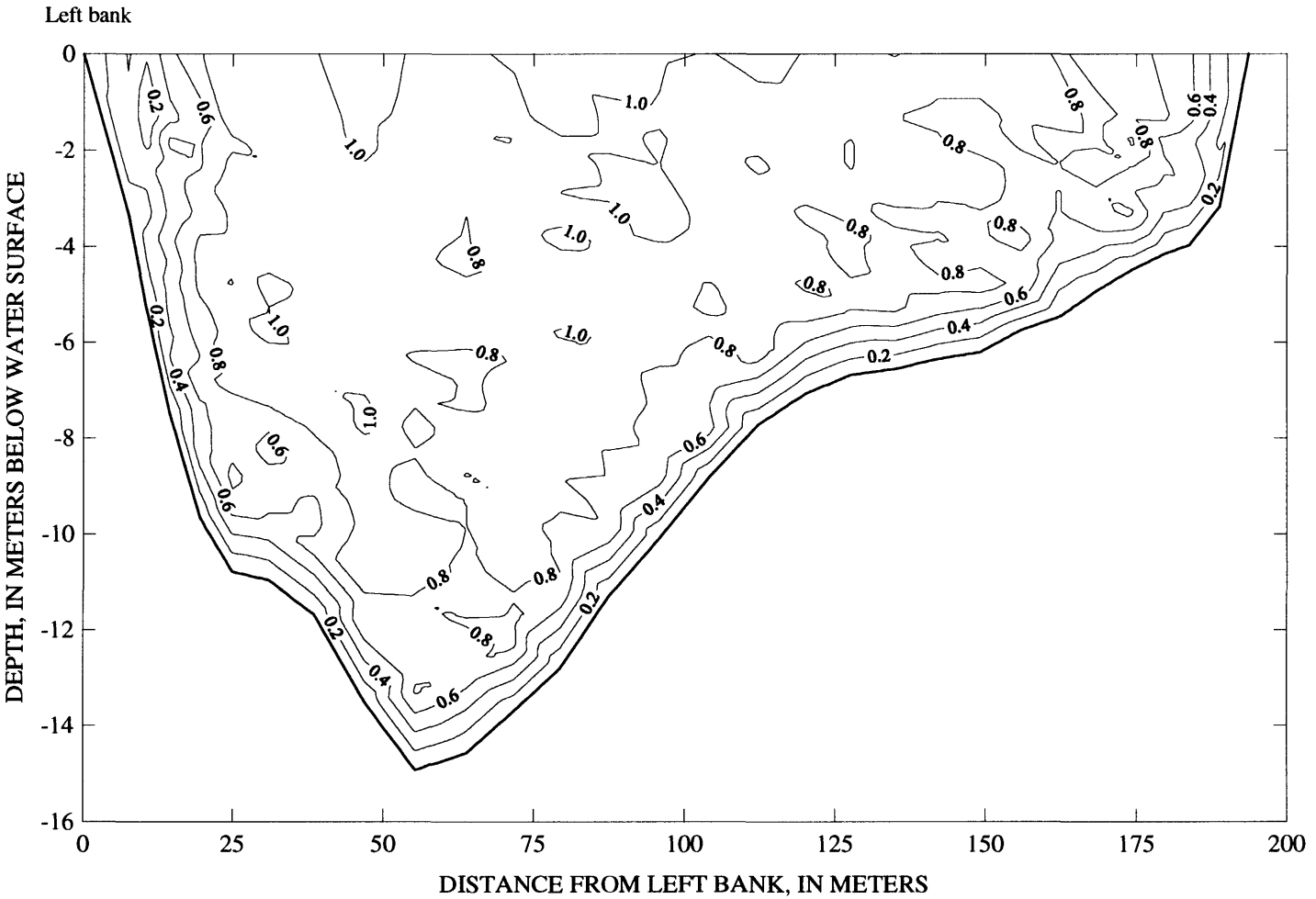

Figure 56. Velocity contours for Kootenai River reach 1, cross-section 46, June 10, 1997. (Contours in meters per second)

Figures 57–115

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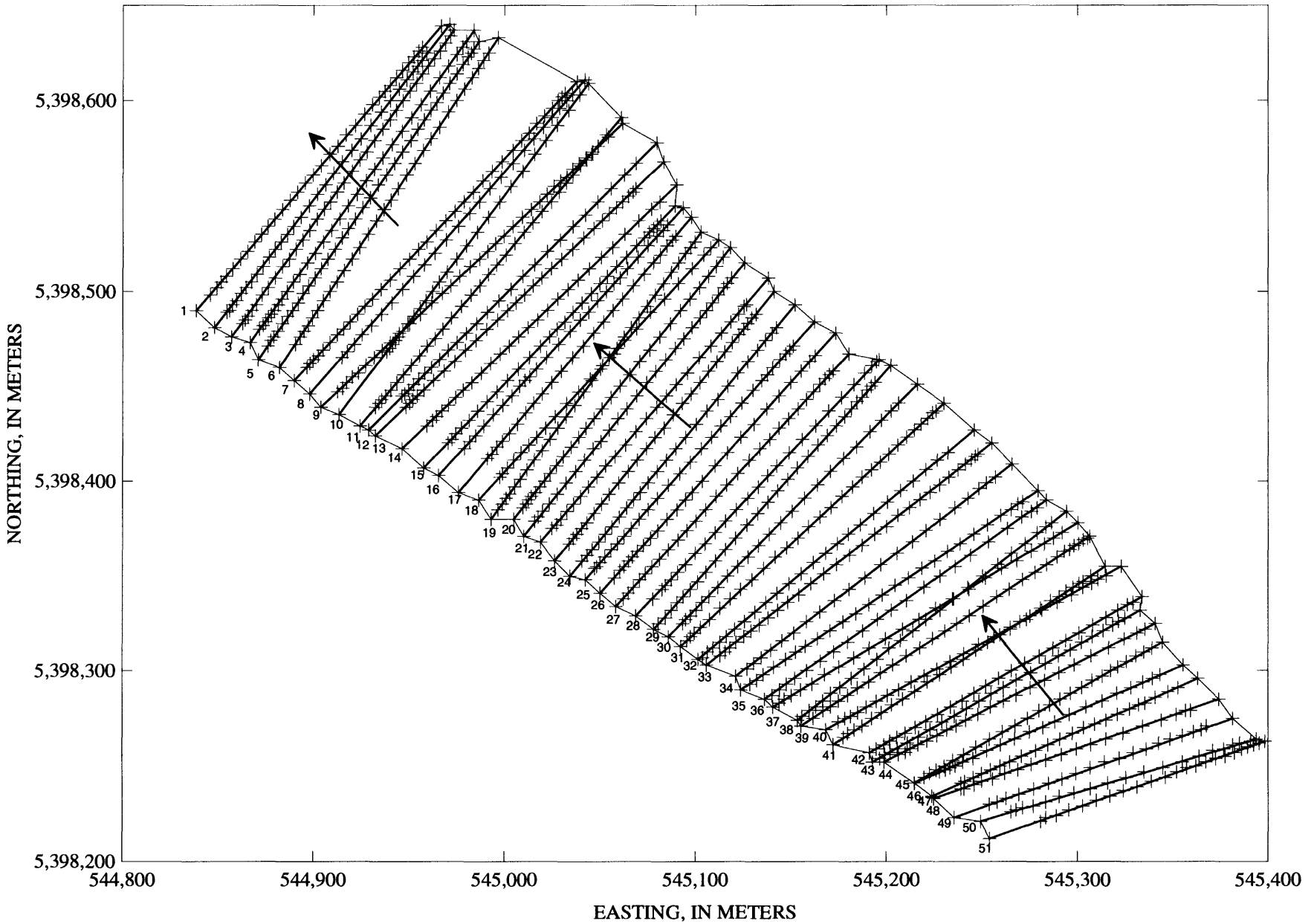

Figure 57. Locations of cross sections and data points in reach 2.
(Arrows indicate direction of streamflow)

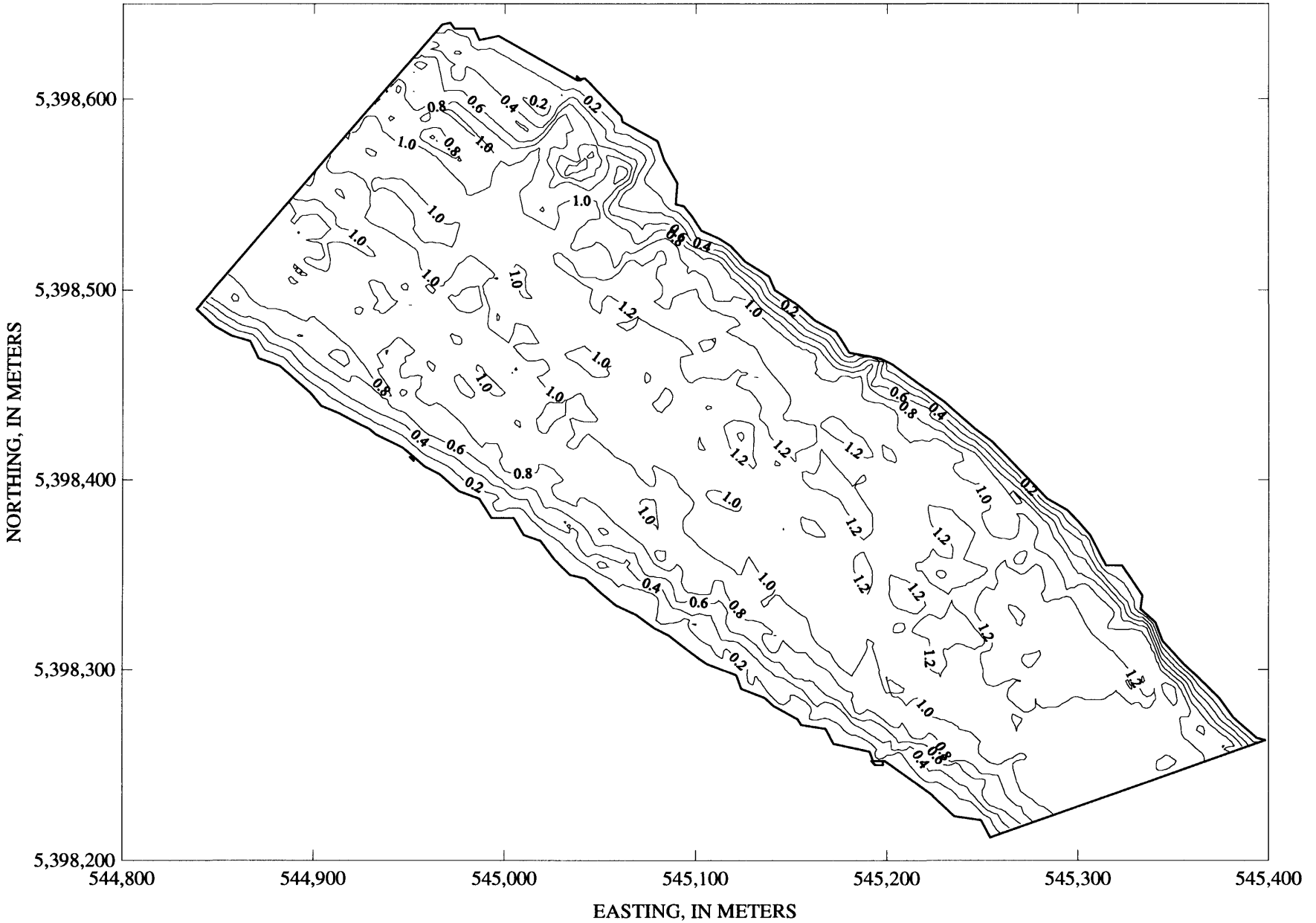

Figure 58. Plan view of velocity contours for Kootenai River reach 2 at a 0-meter depth, June 11, 1997. (Contours in meters per second)

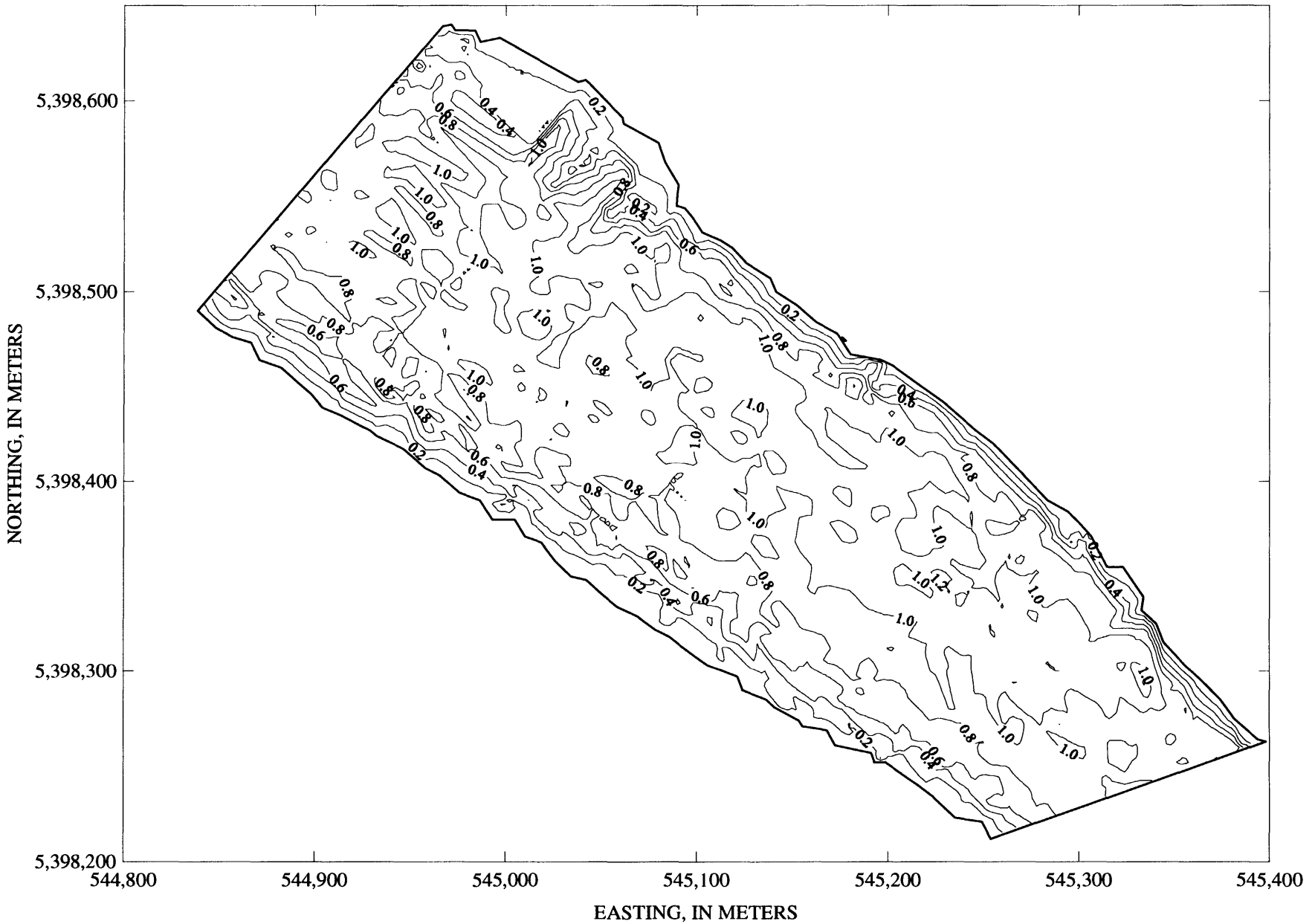

Figure 59. Plan view of velocity contours for Kootenai River reach 2 at a 1.82-meter depth, June 11, 1997. (Contours in meters per second)

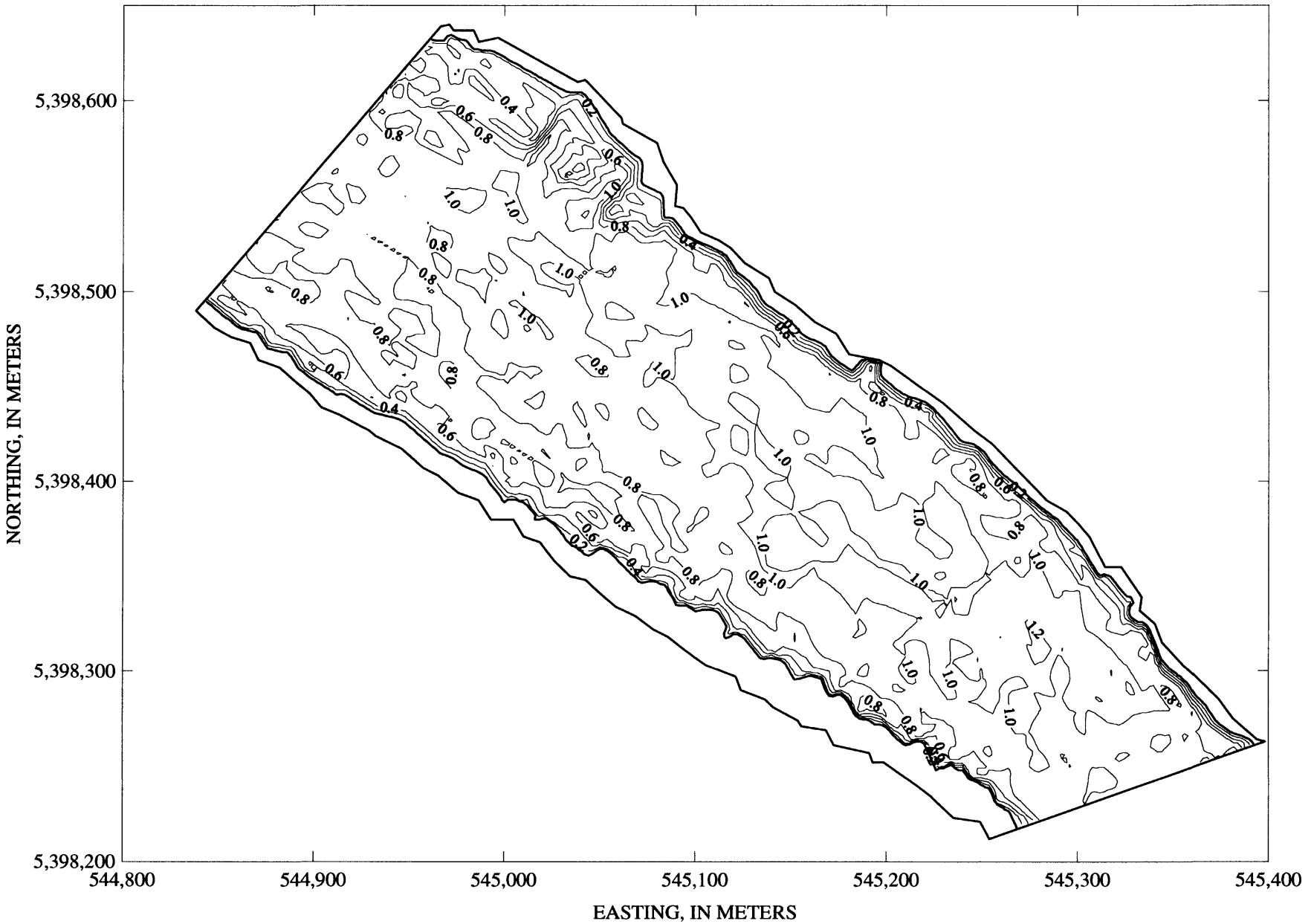

Figure 60. Plan view of velocity contours for Kootenai River reach 2 at a 3.82-meter depth, June 11, 1997. (Contours in meters per second)

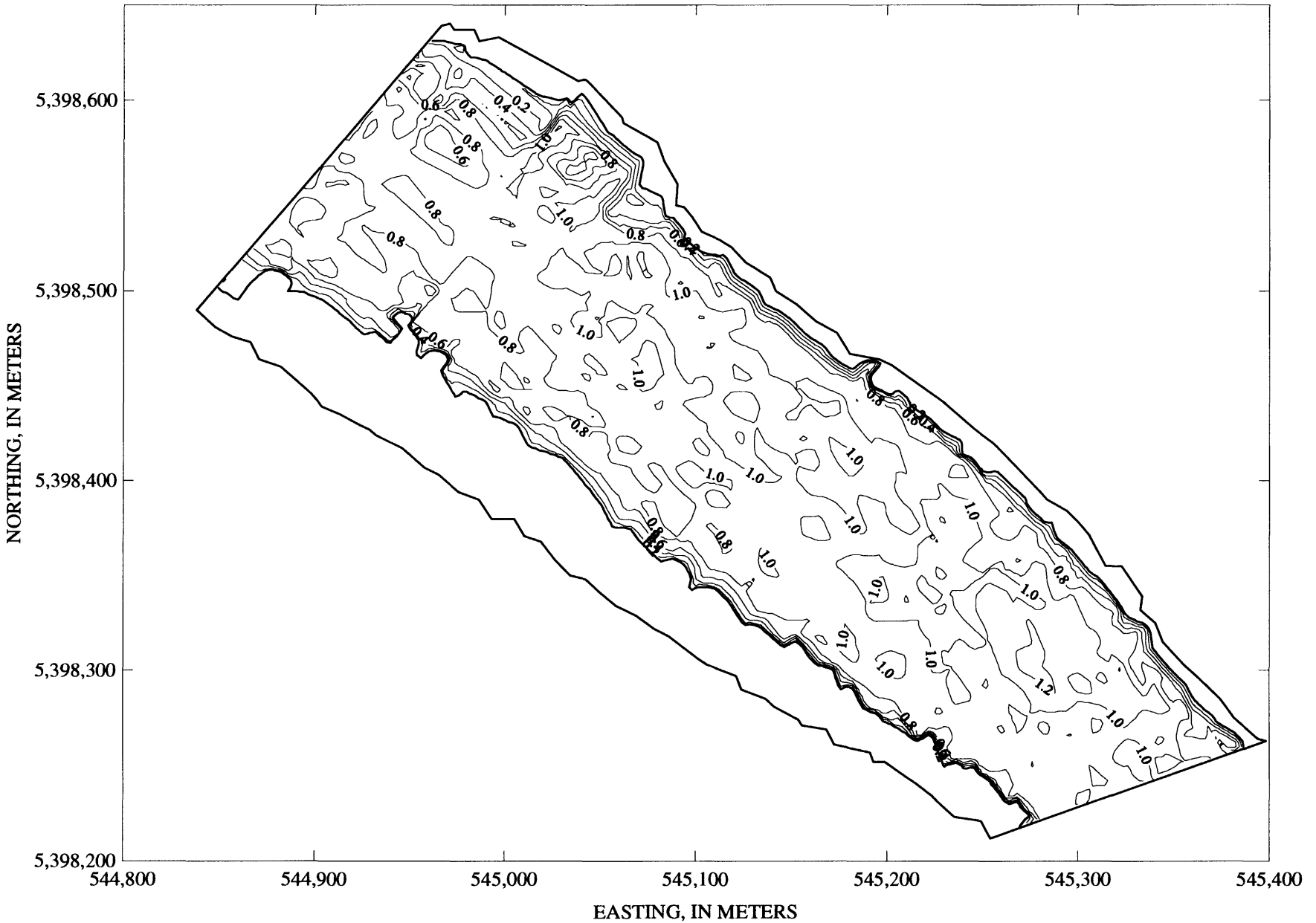

Figure 61. Plan view of velocity contours for Kootenai River reach 2 at a 5.82-meter depth, June 11, 1997. (Contours in meters per second)

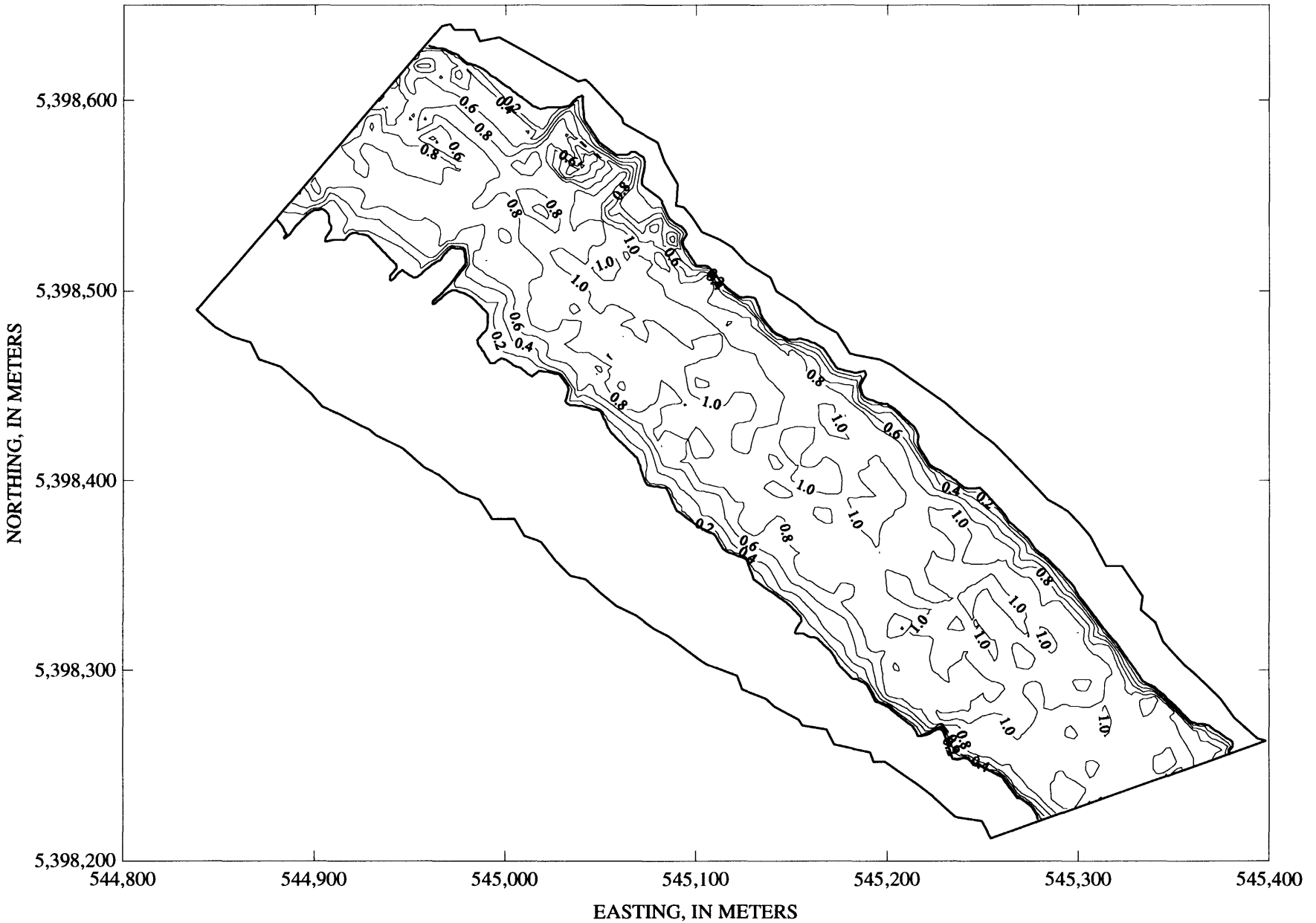

Figure 62. Plan view of velocity contours for Kootenai River reach 2 at a 7.82-meter depth, June 11, 1997. (Contours in meters per second)

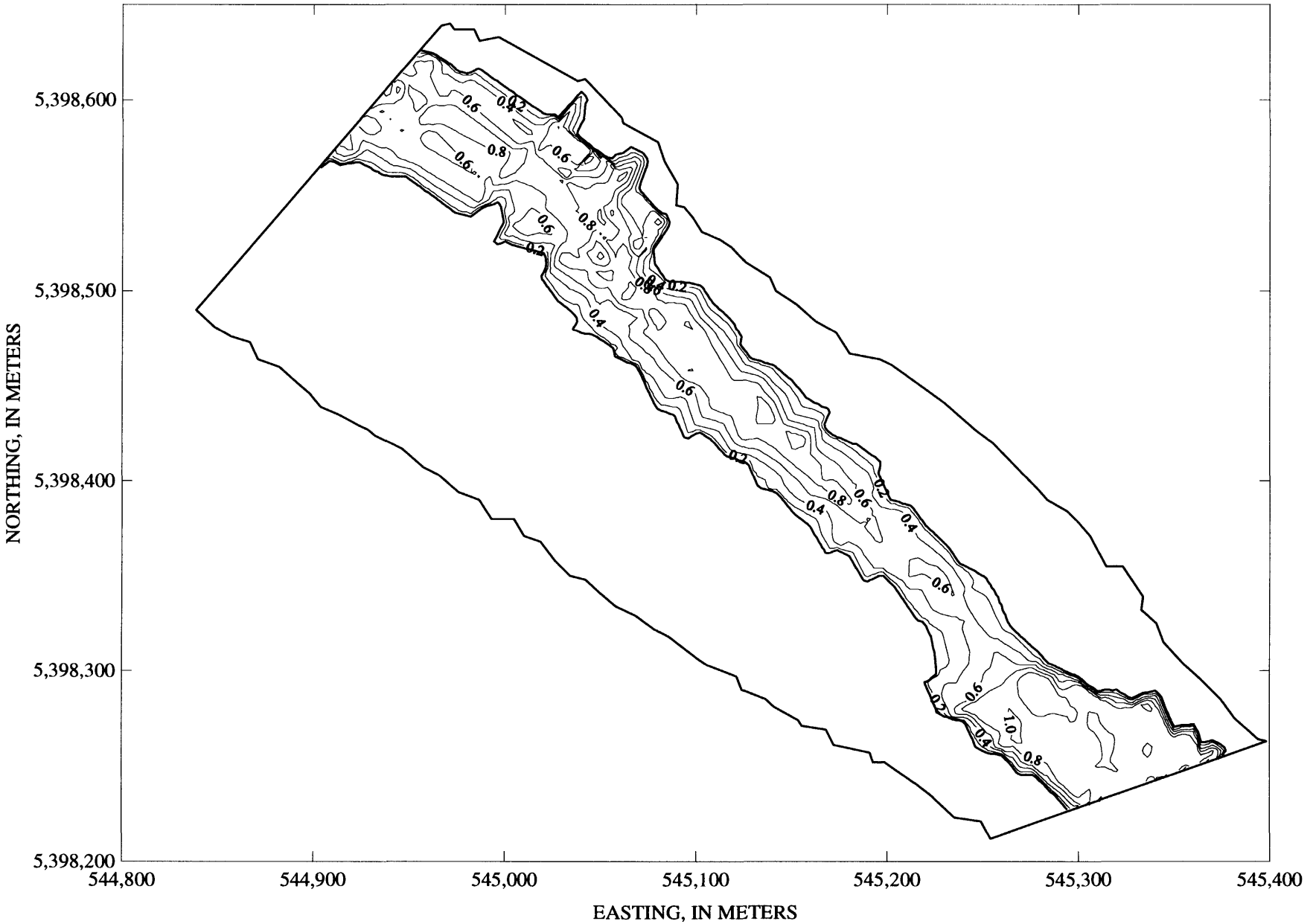

Figure 63. Plan view of velocity contours for Kootenai River reach 2 at a 9.82-meter depth, June 11, 1997. (Contours in meters per second)

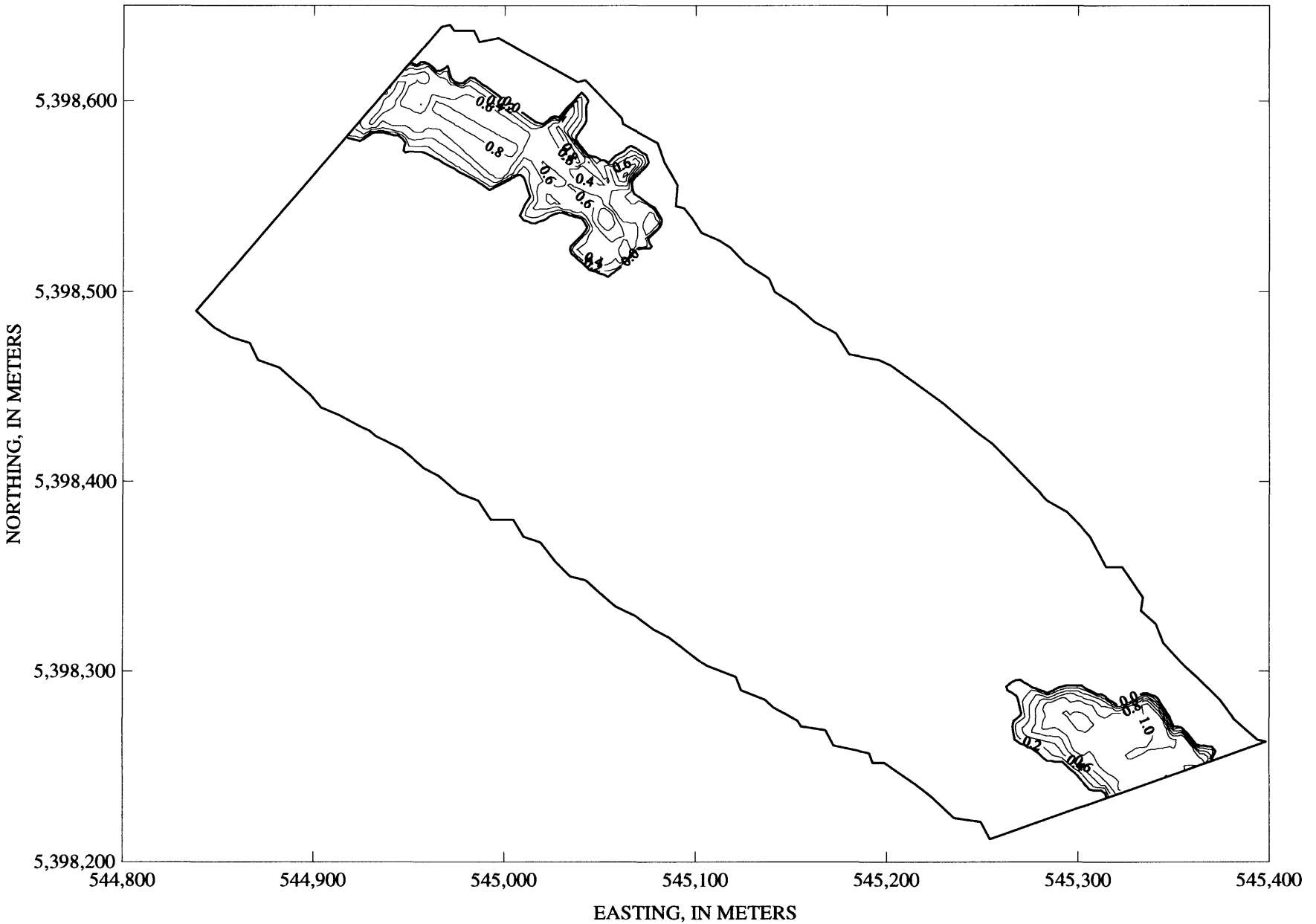

Figure 64. Plan view of velocity contours for Kootenai River reach 2 at an 11.82-meter depth, June 11, 1997. (Contours in meters per second)

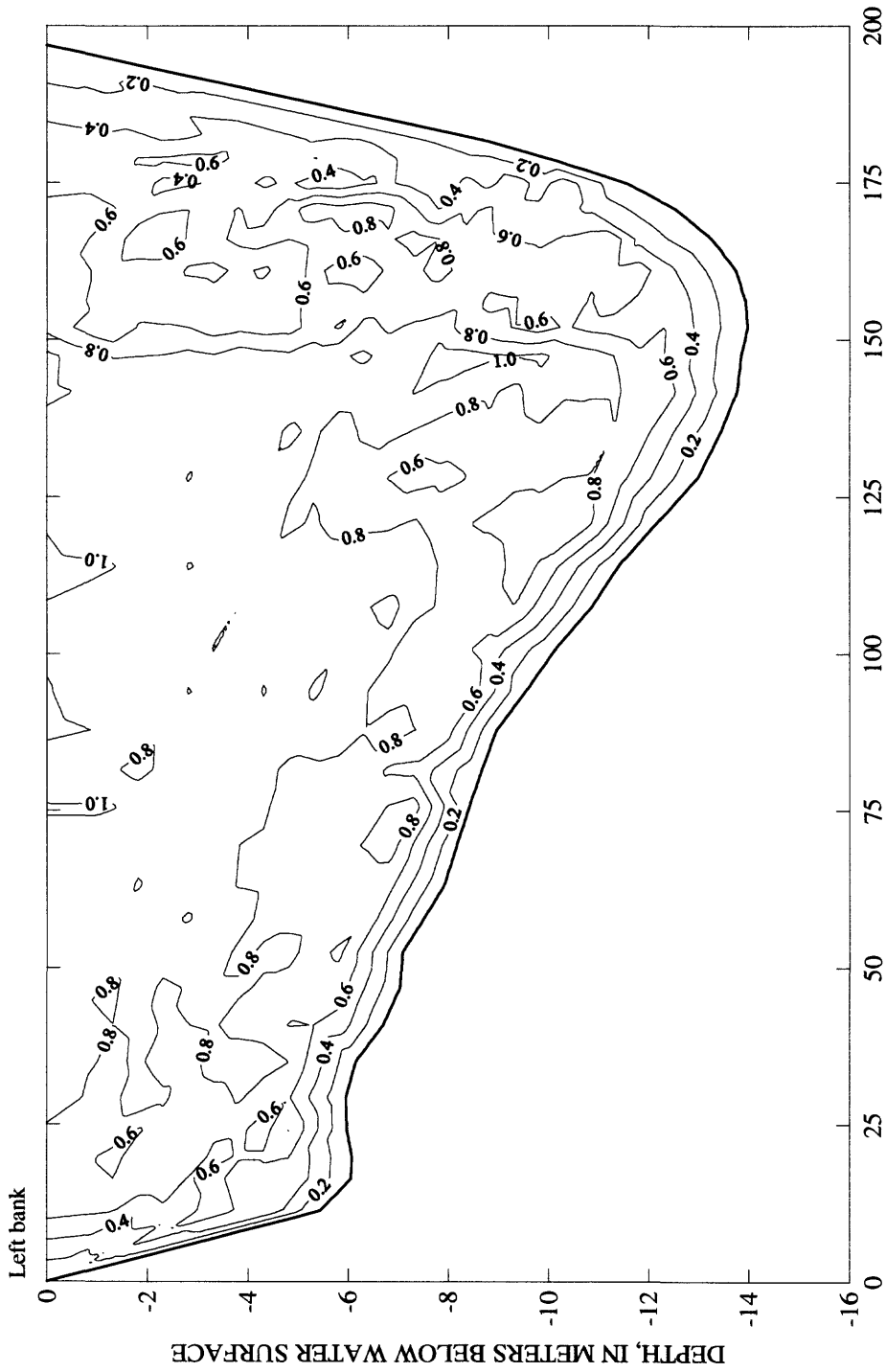

Figure 65. Velocity contours for Kootenai River reach 2, cross-section 1, June 11, 1997.
(Contours in meters per second)

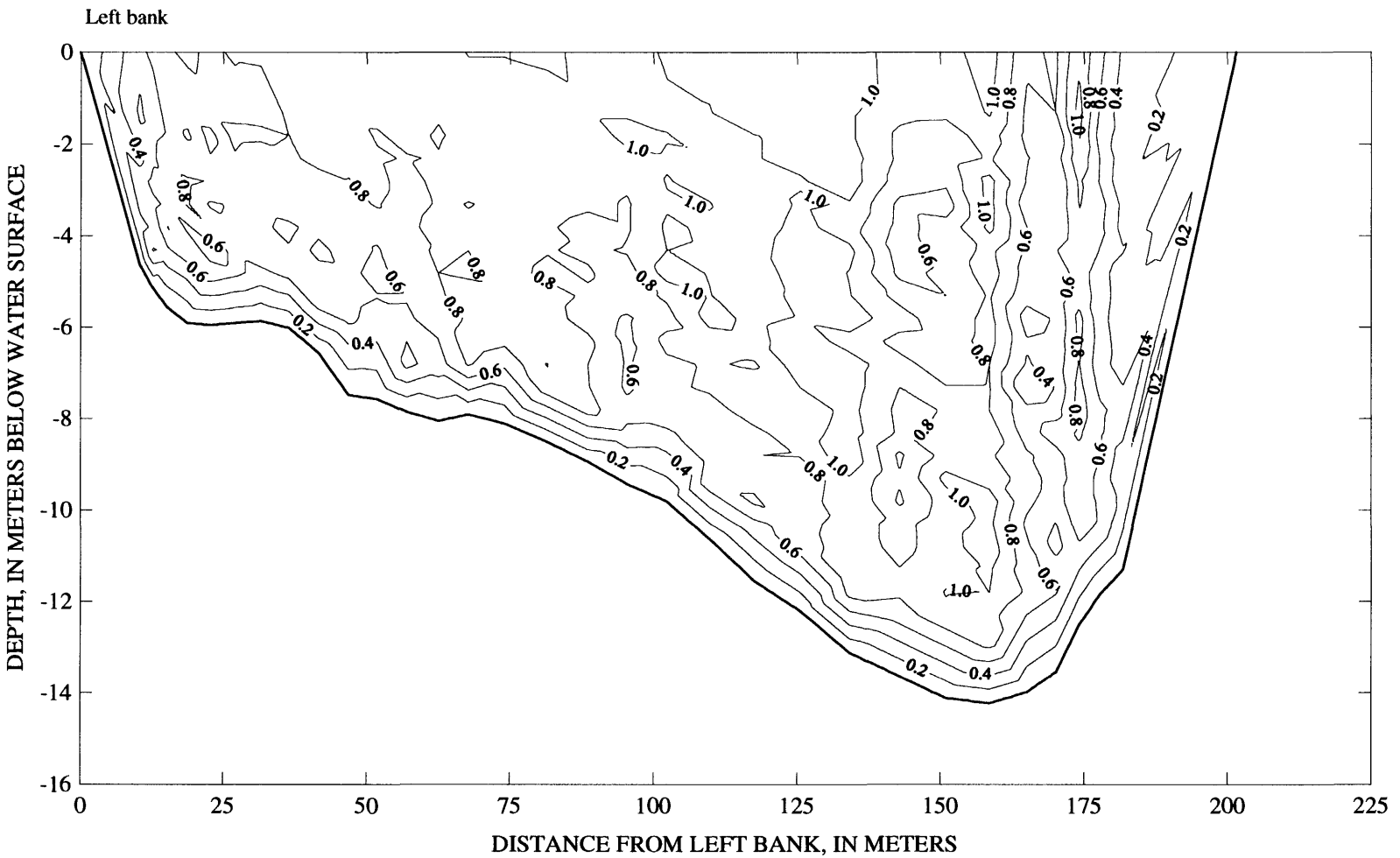

Figure 66. Velocity contours for Kootenai River reach 2, cross-section 2, June 11, 1997. (Contours in meter per second)

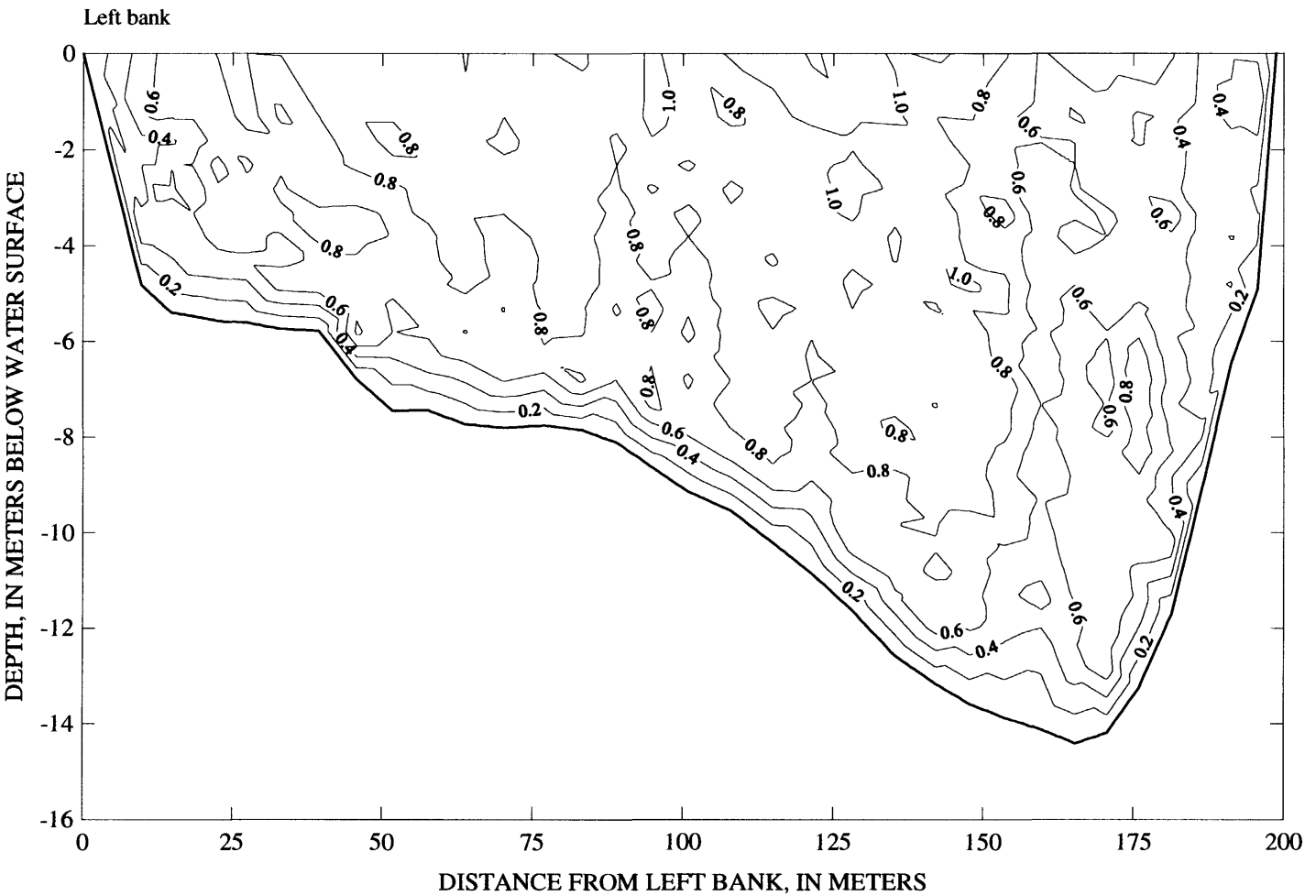

Figure 67. Velocity contours for Kootenai River reach 2, cross-section 3, June 11, 1997. (Contours in meters per second)

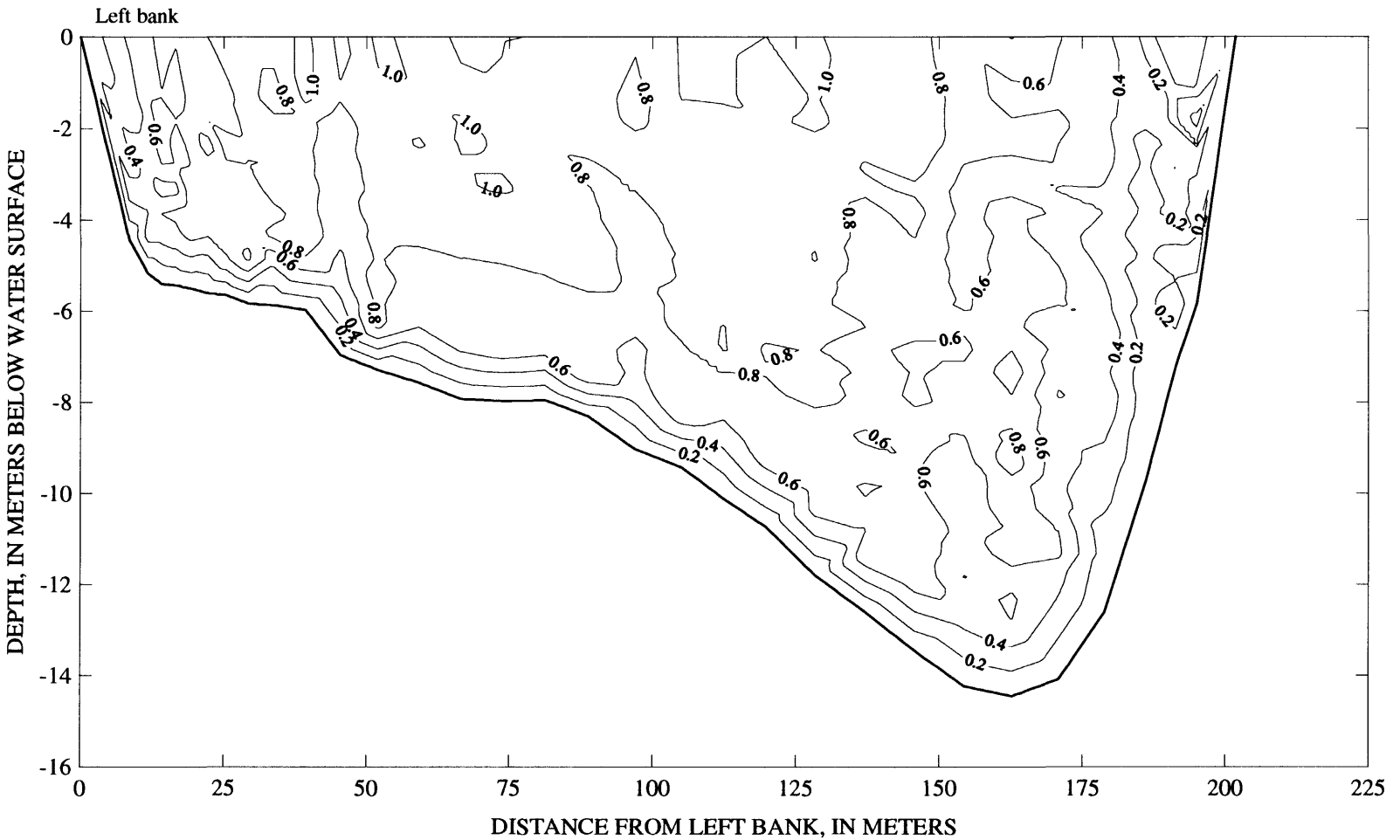

Figure 68. Velocity contours for Kootenai River reach 2, cross-section 4, June 11, 1997. (Contours in meters per second)

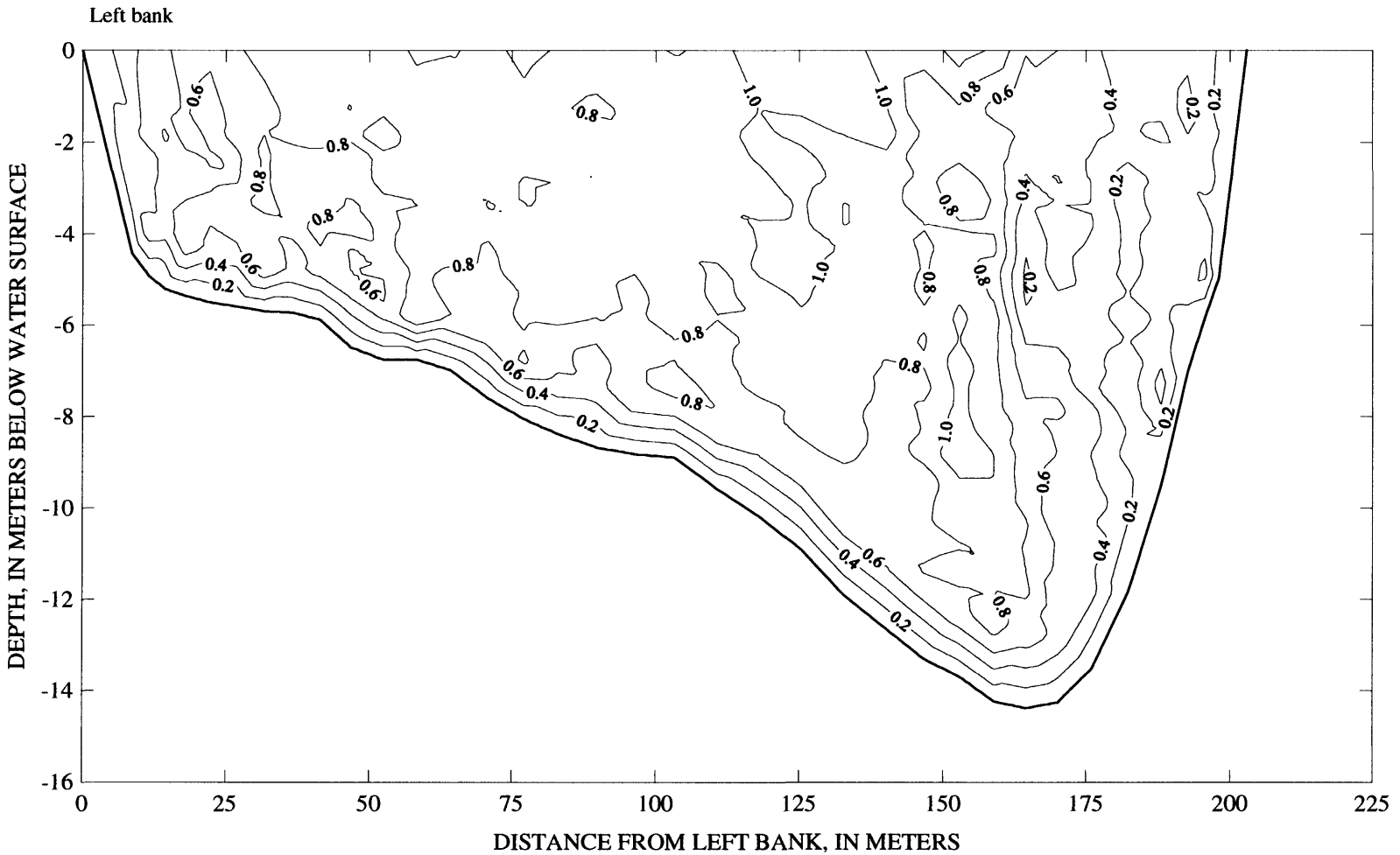

Figure 69. Velocity contours for Kootenai River reach 2, cross-section 5, June 11, 1997. (Contours in meters per second)

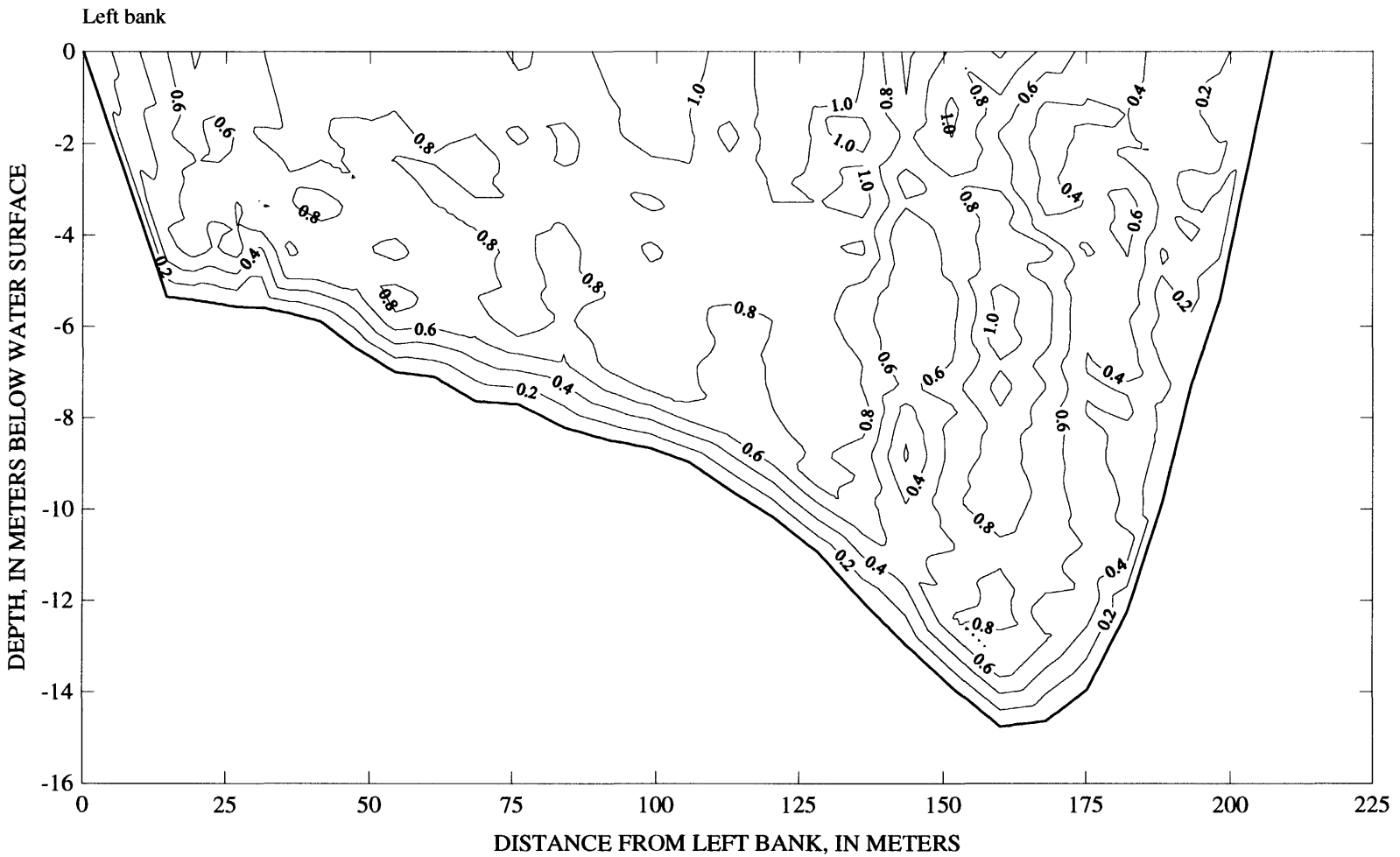

Figure 70. Velocity contours for Kootenai River reach 2, cross-section 6, June 11, 1997. (Contours in meters per second)

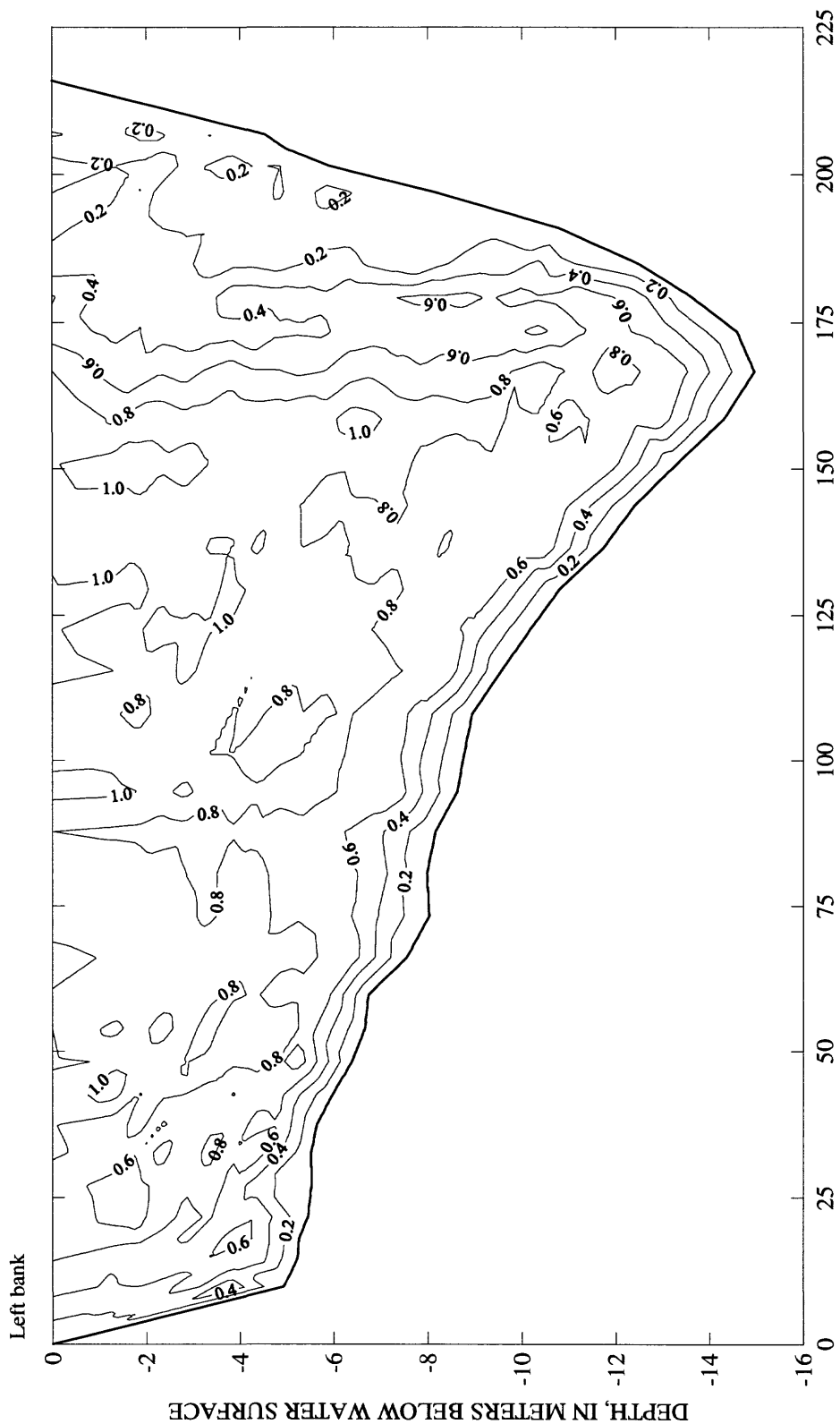

Figure 71. Velocity contours for Kootenai River reach 2, cross-section 7, June 11, 1997.
(Contours in meters per second)

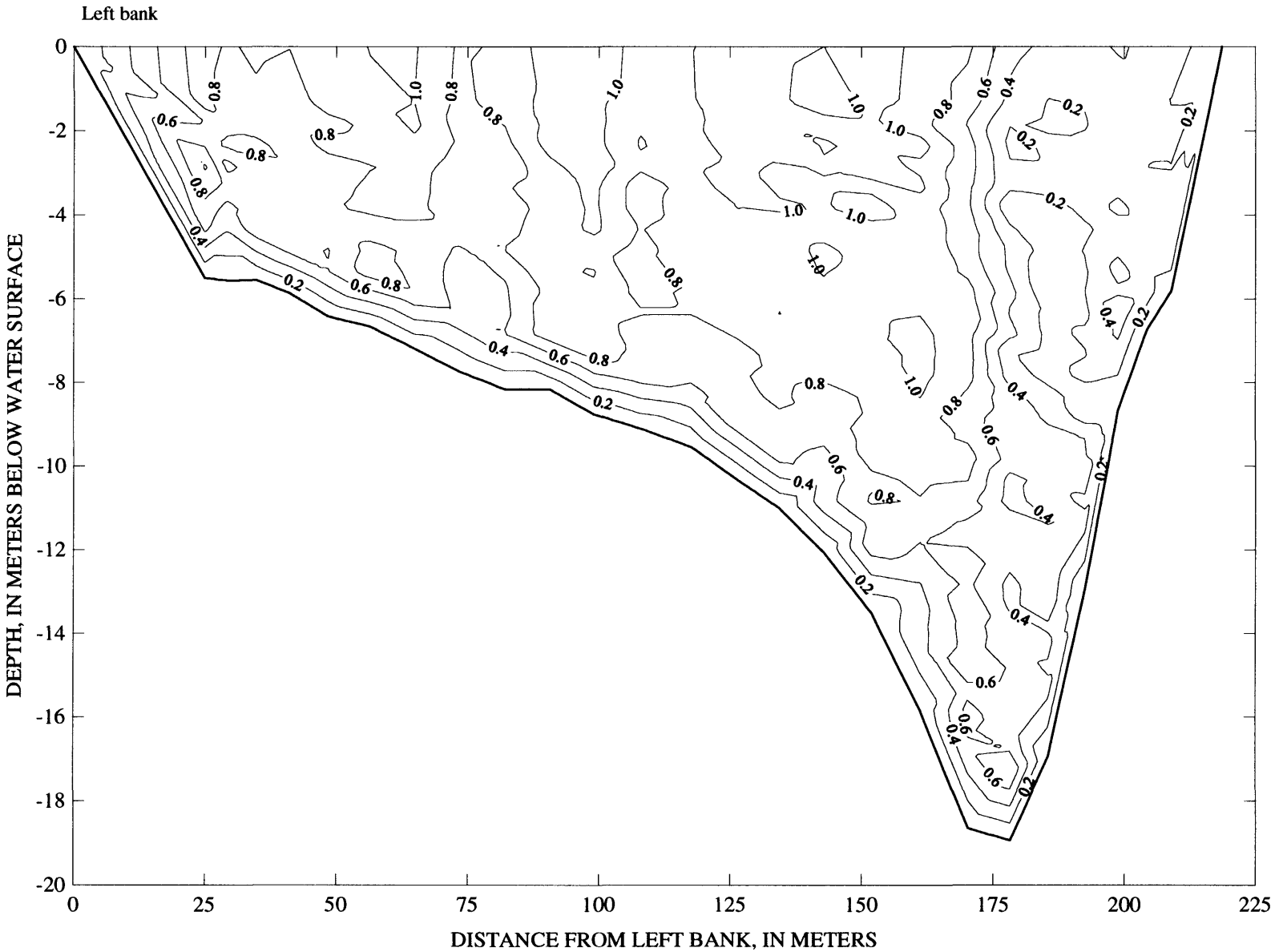

Figure 72. Velocity contours for Kootenai River reach 2, cross-section 8, June 11, 1997. (Contours in meters per second)

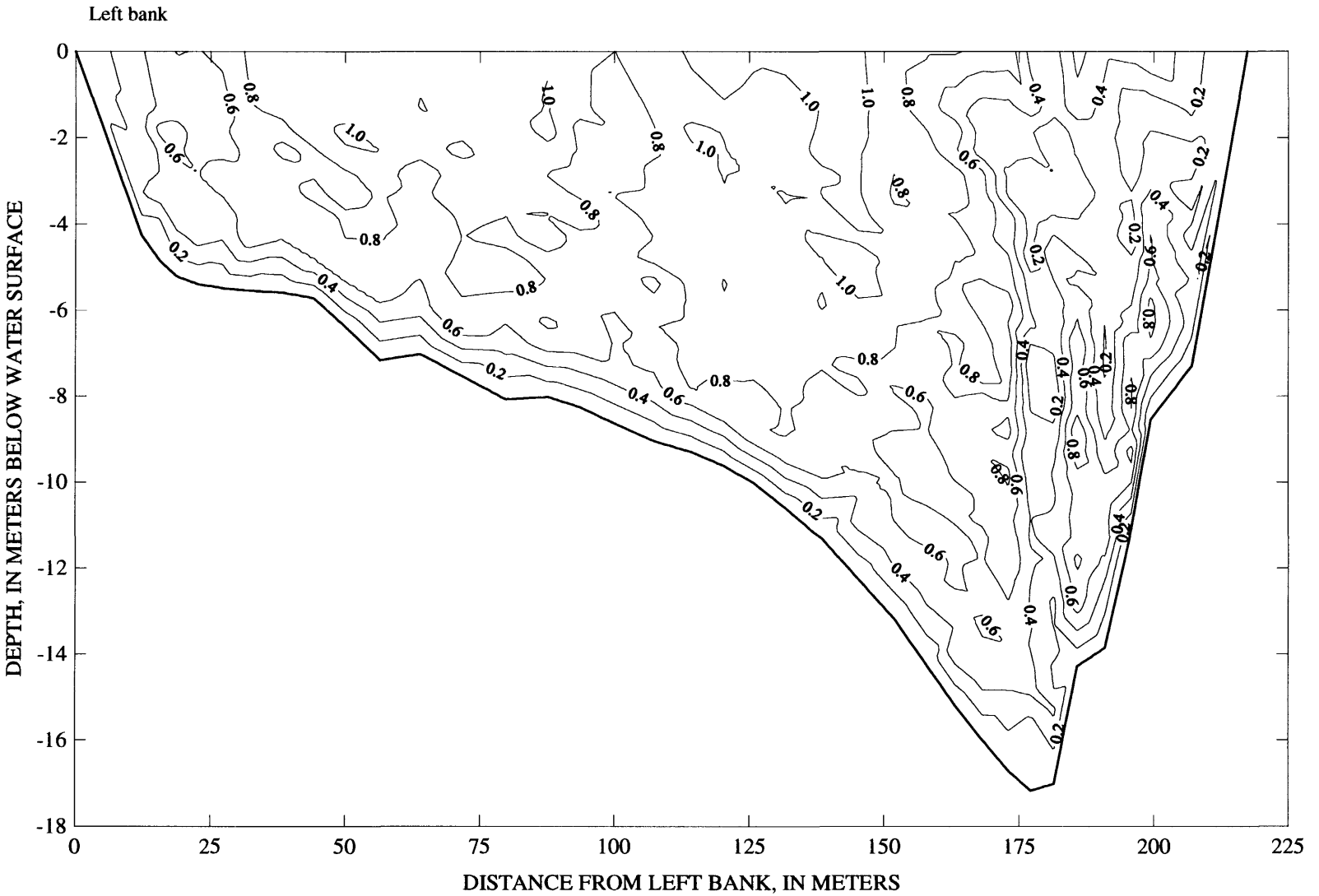

Figure 73. Velocity contours for Kootenai River reach 2, cross-section 9, June 11, 1997. (Contours in meters per second)

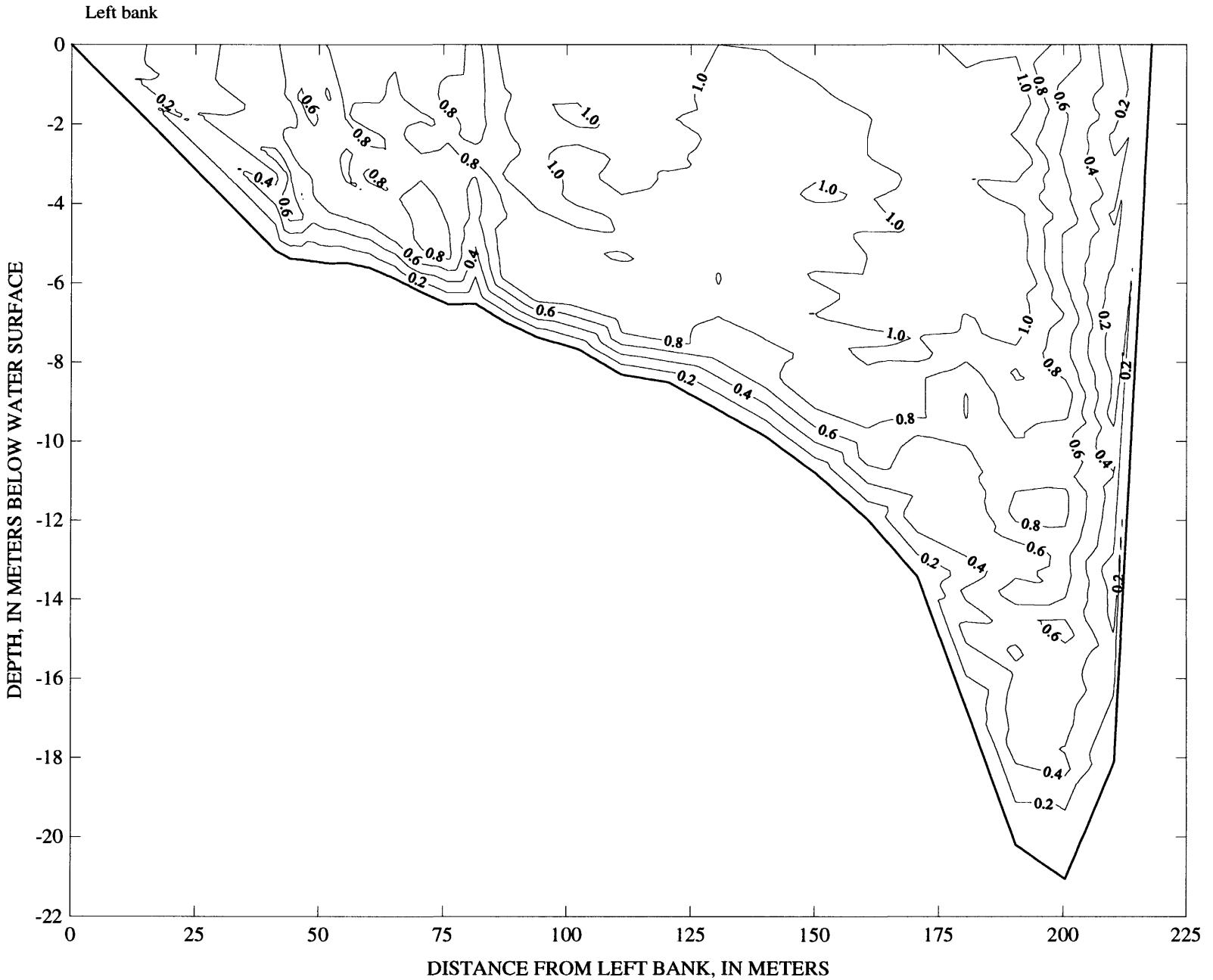

Figure 74. Velocity contours for Kootenai River reach 2, cross-section 10, June 11, 1997. (Contours in meters per second)

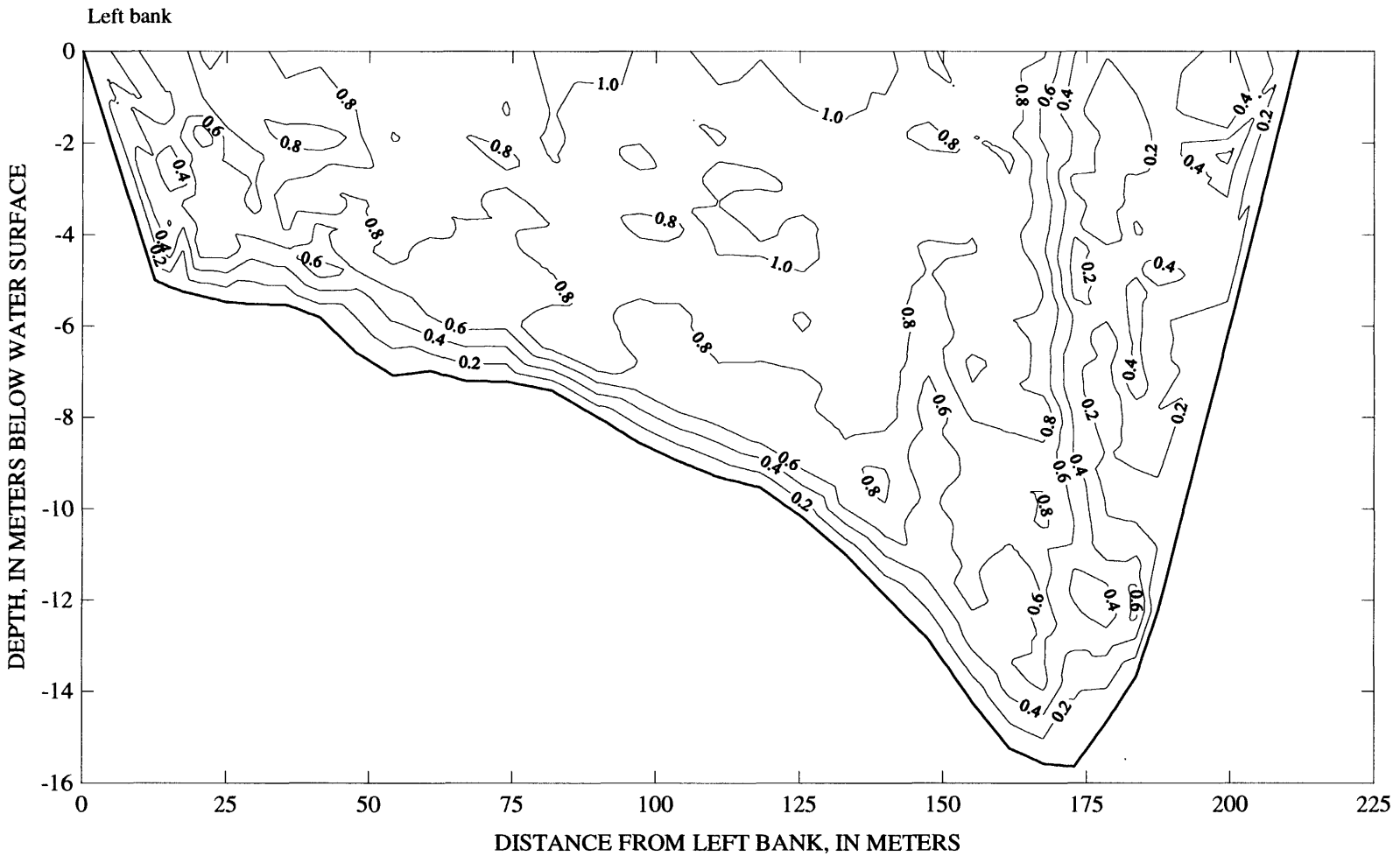

Figure 75. Velocity contours for Kootenai River reach 2, cross-section 11, June 11, 1997. (Contours in meters per second)

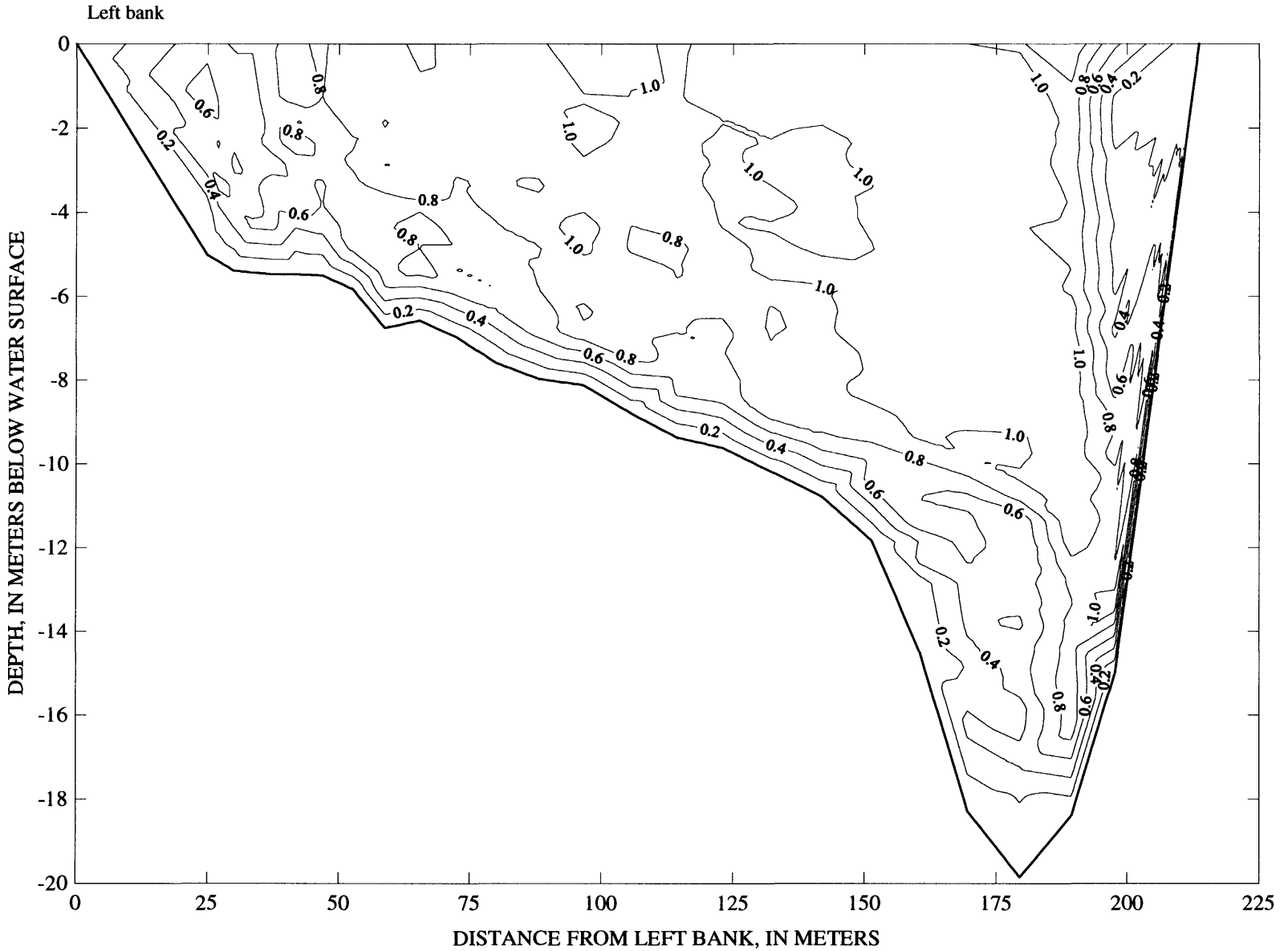

Figure 76. Velocity contours for Kootenai River reach 2, cross-section 12, June 11, 1997. (Contours in meters per second)

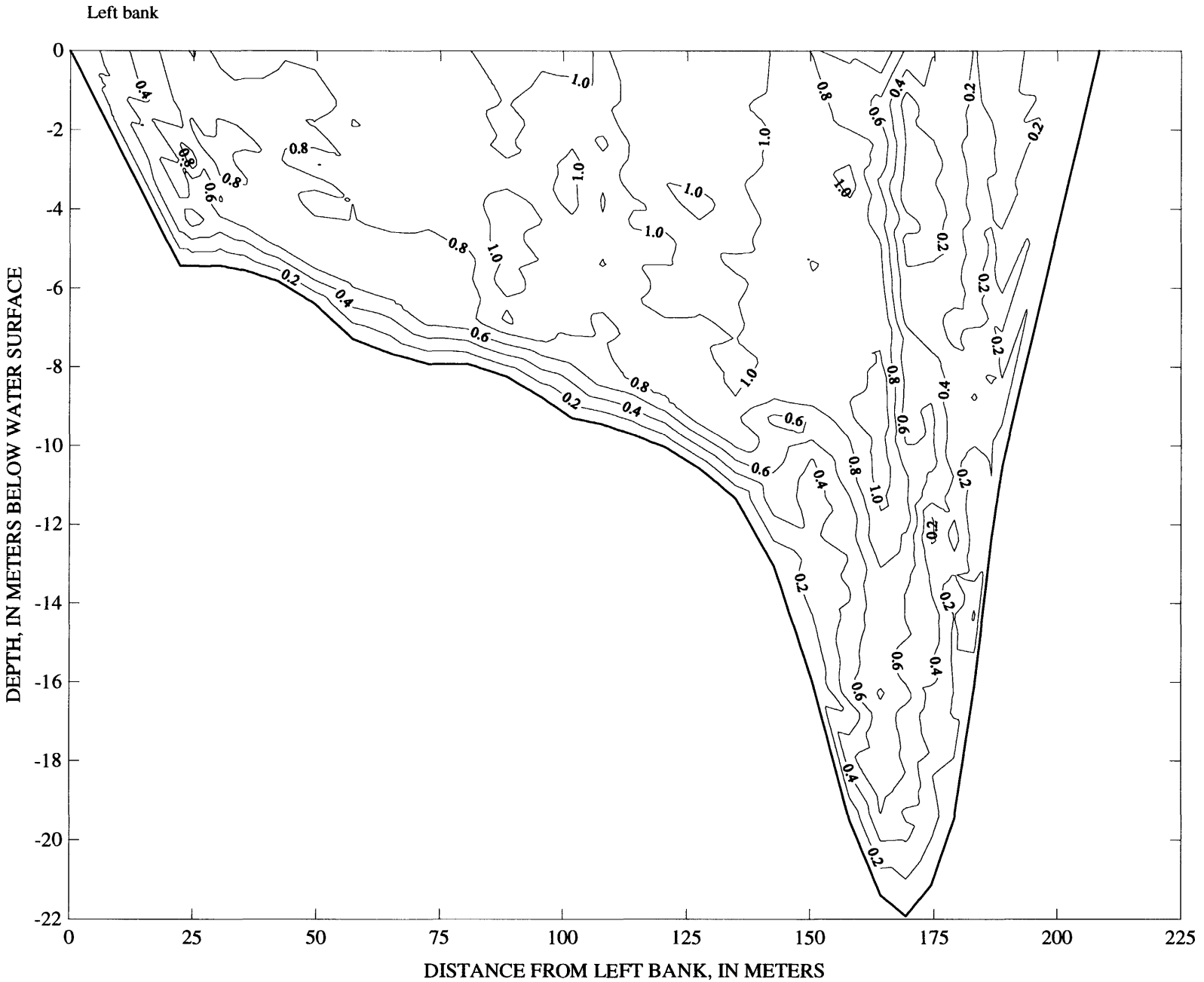

Figure 77. Velocity contours for Kootenai River reach 2, cross-section 13, June 11, 1997. (Contours in meters per second)

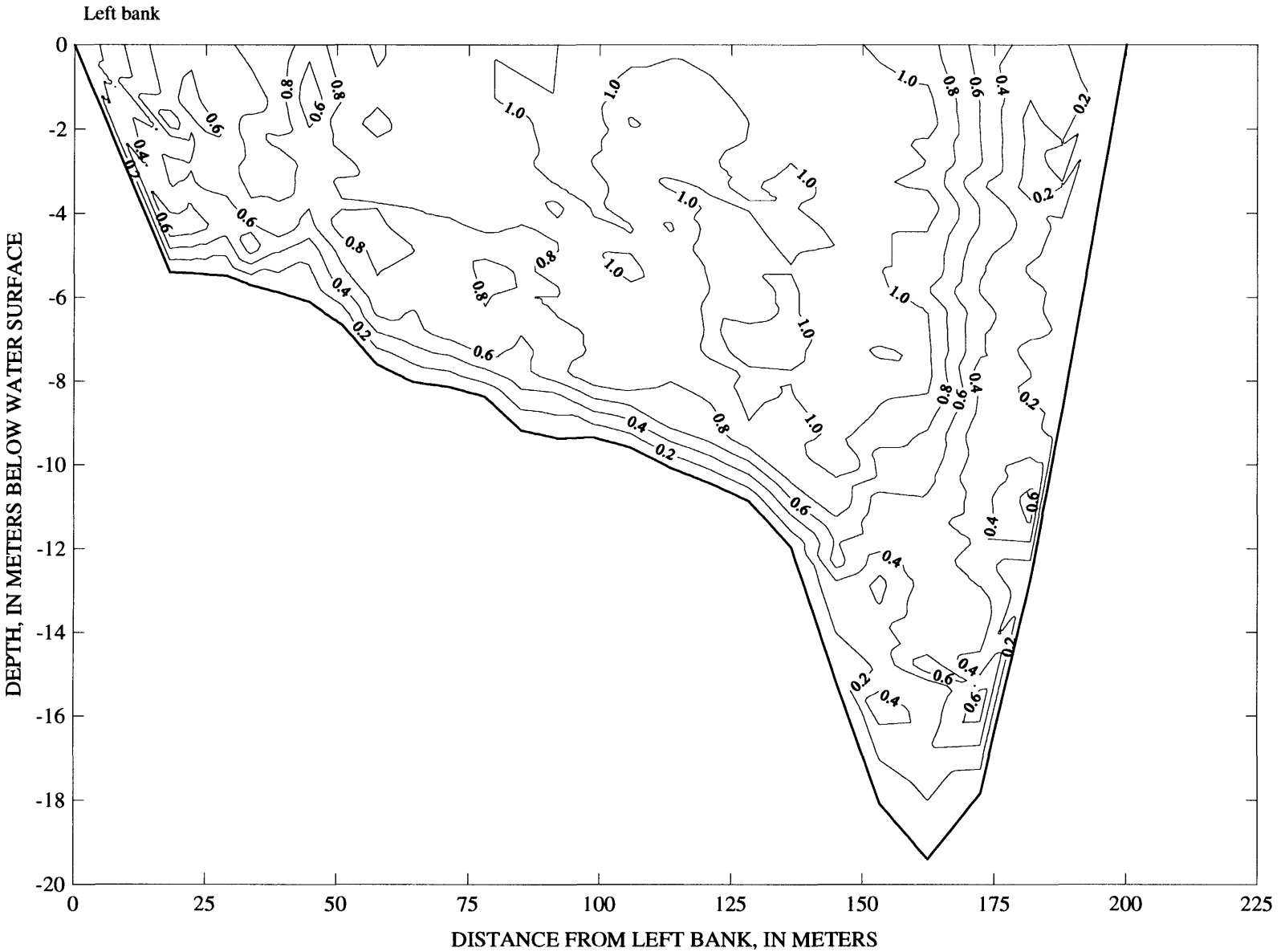

Figure 78. Velocity contours for Kootenai River reach 2, cross-section 14, June 11, 1997. (Contours in meters per second)

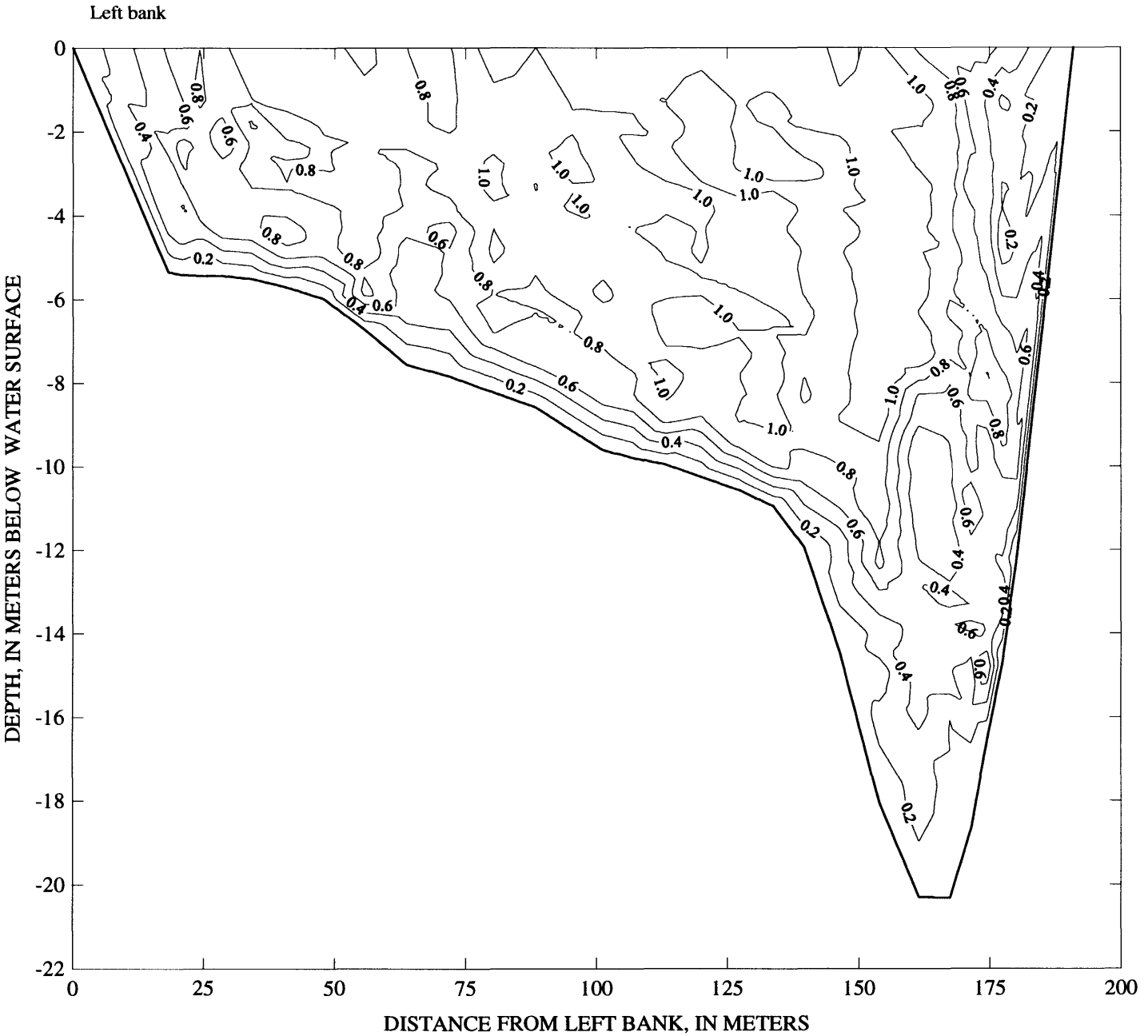

Figure 79. Velocity contours for Kootenai River reach 2, cross-section 15, June 11, 1997. (Contours in meters per second)

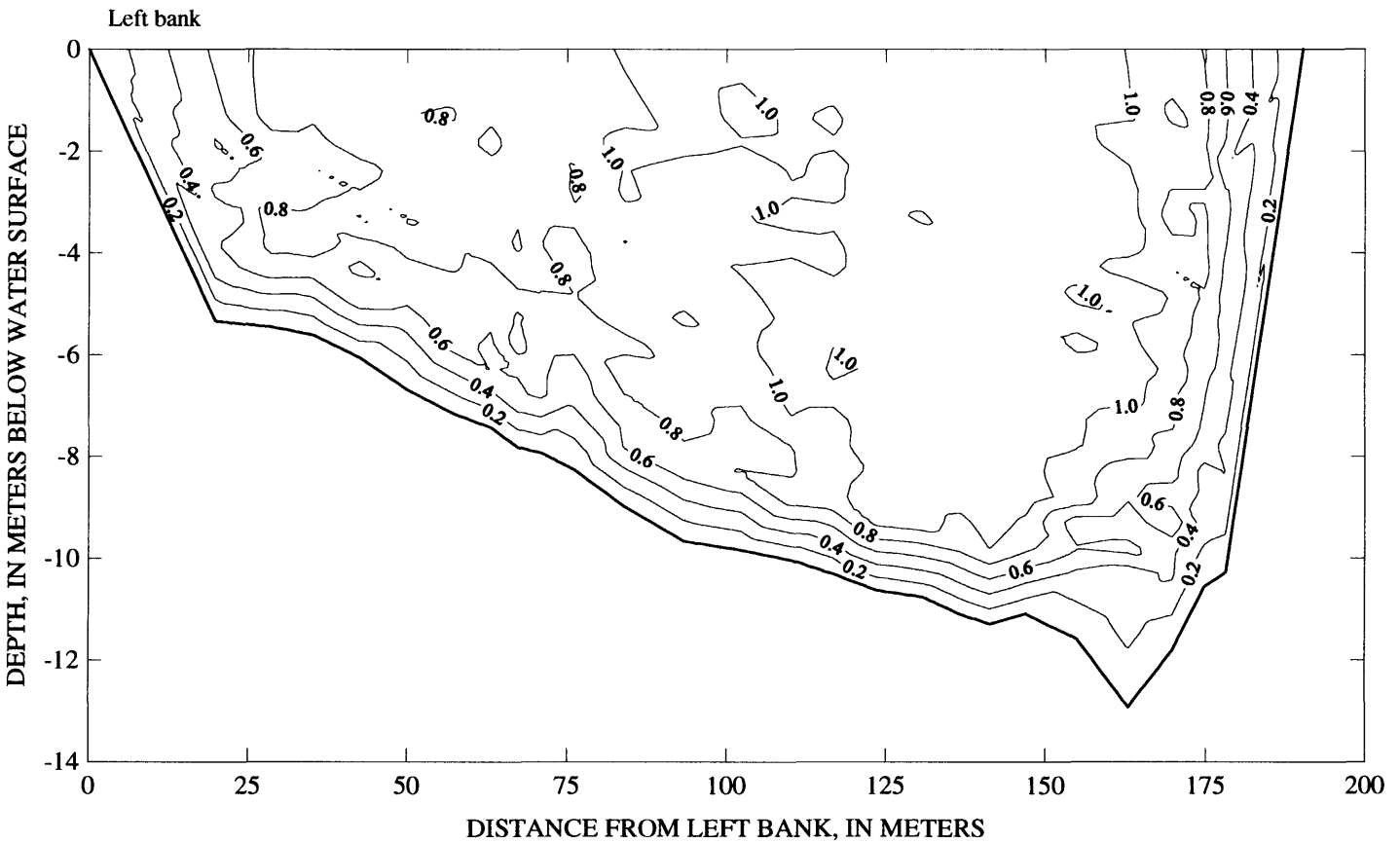

Figure 80. Velocity contours for Kootenai River reach 2, cross-section 16, June 11, 1997. (Contours in meters per second)

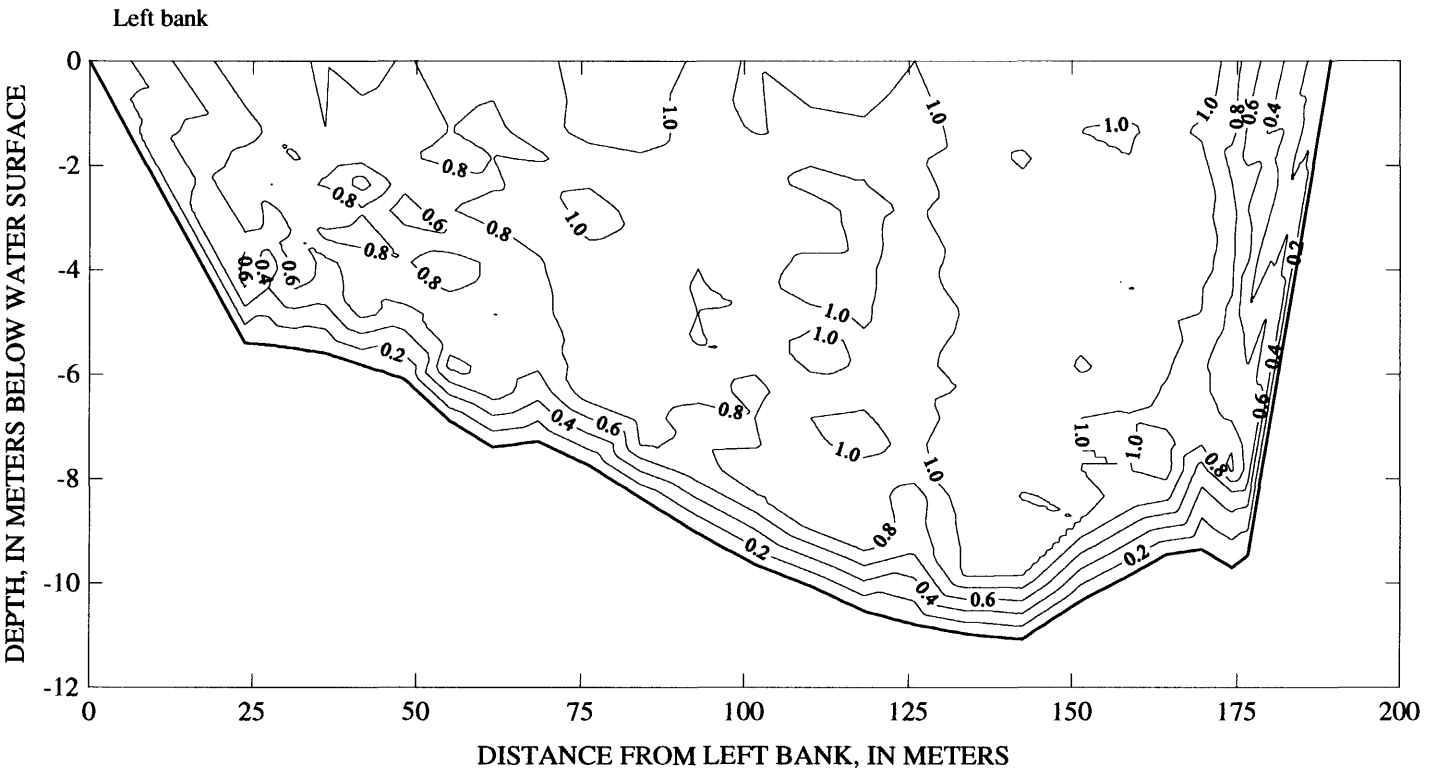

Figure 81. Velocity contours for Kootenai River reach 2, cross-section 17, June 11, 1997. (Contours in meters per second)

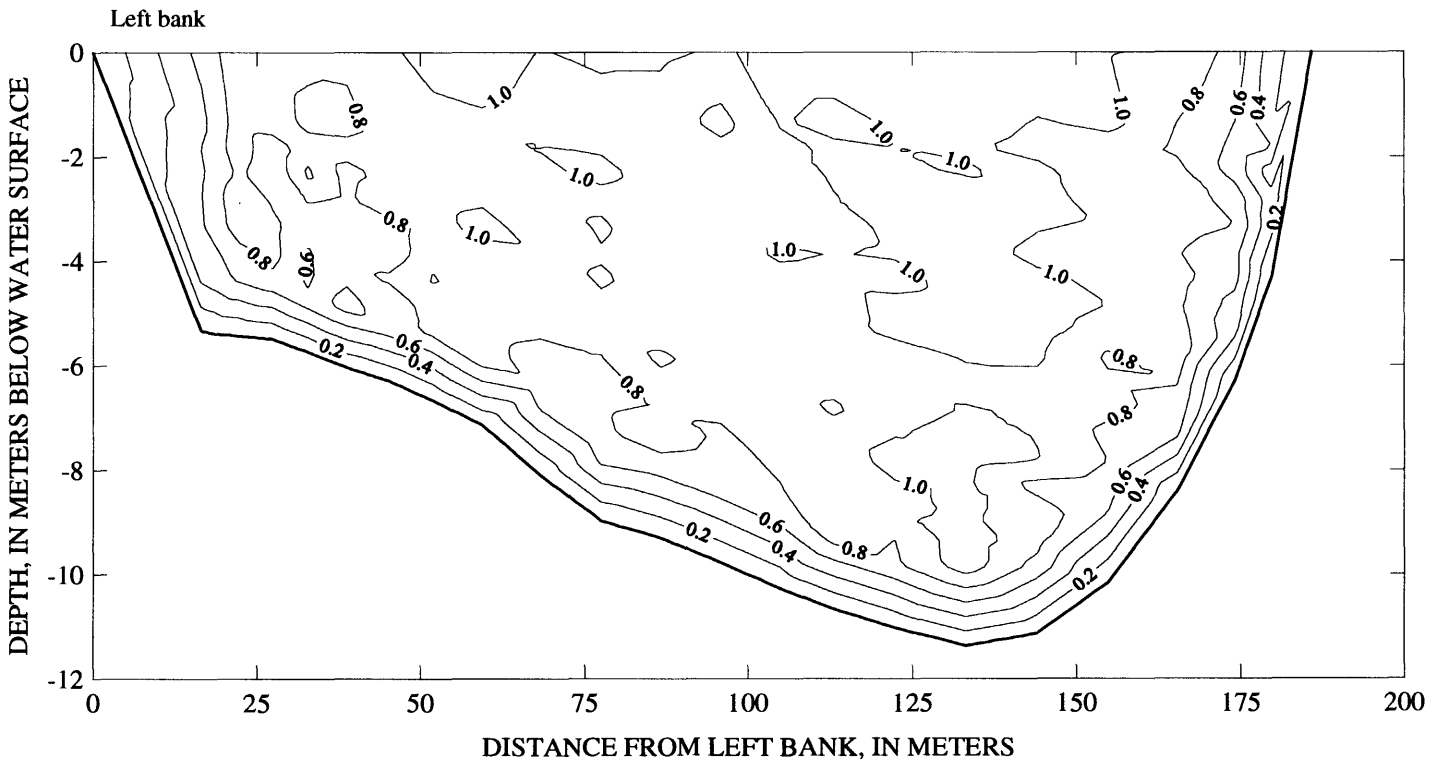

Figure 82. Velocity contours for Kootenai River reach 2, cross-section 18, June 11, 1997. (Contours in meters per second)

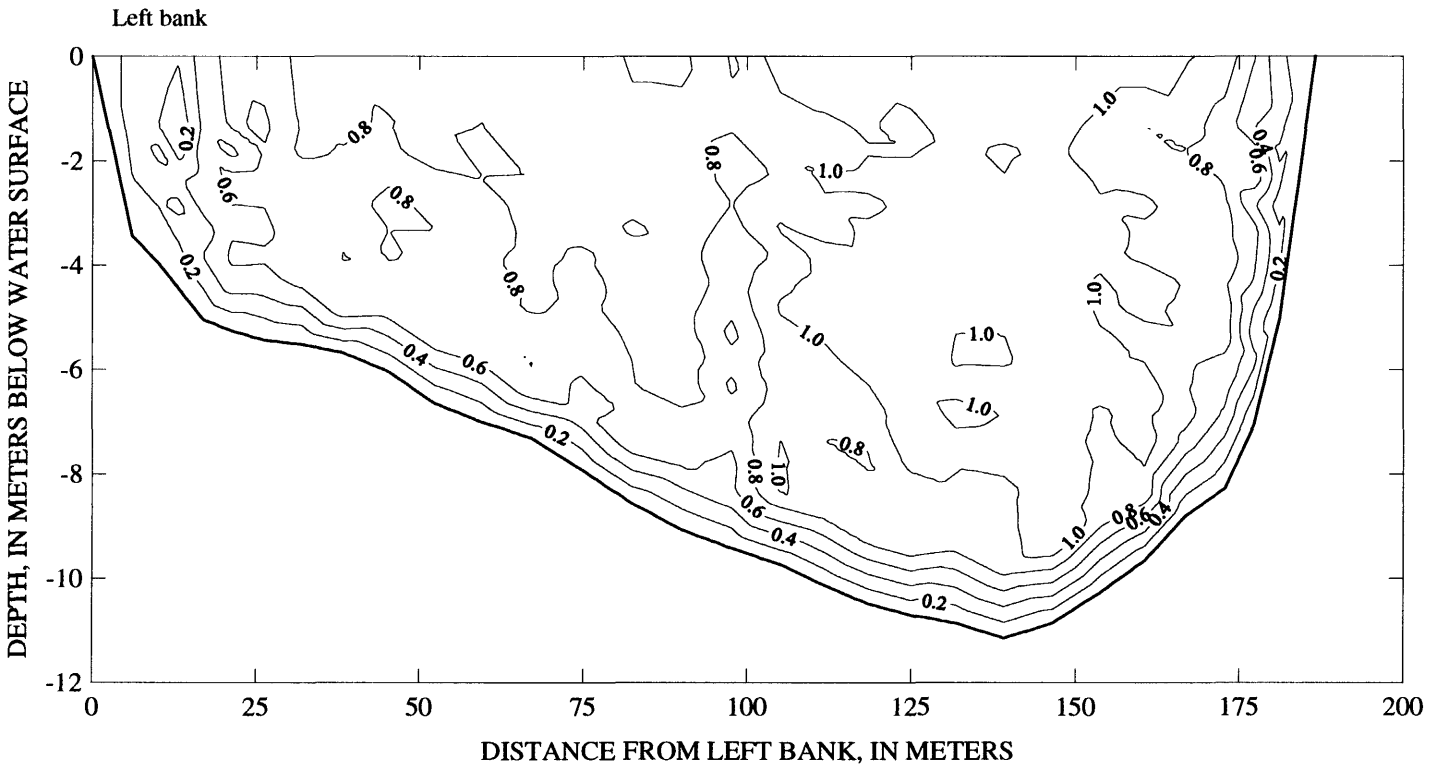

Figure 83. Velocity contours for Kootenai River reach 2, cross-section 19, June 11, 1997. (Contours in meters per second)

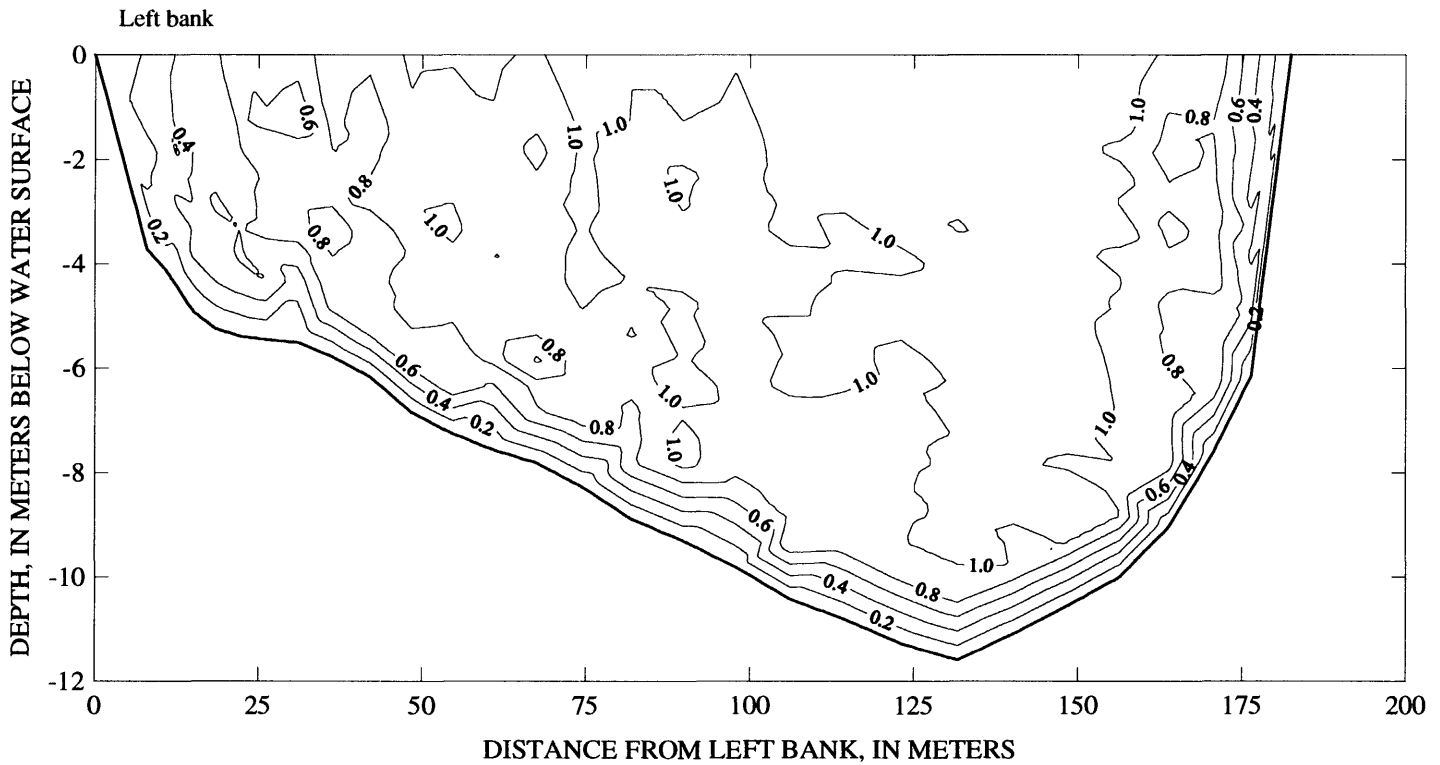

Figure 84. Velocity contours for Kootenai River reach 2, cross-section 20, June 11, 1997. (Contours in meters per second)

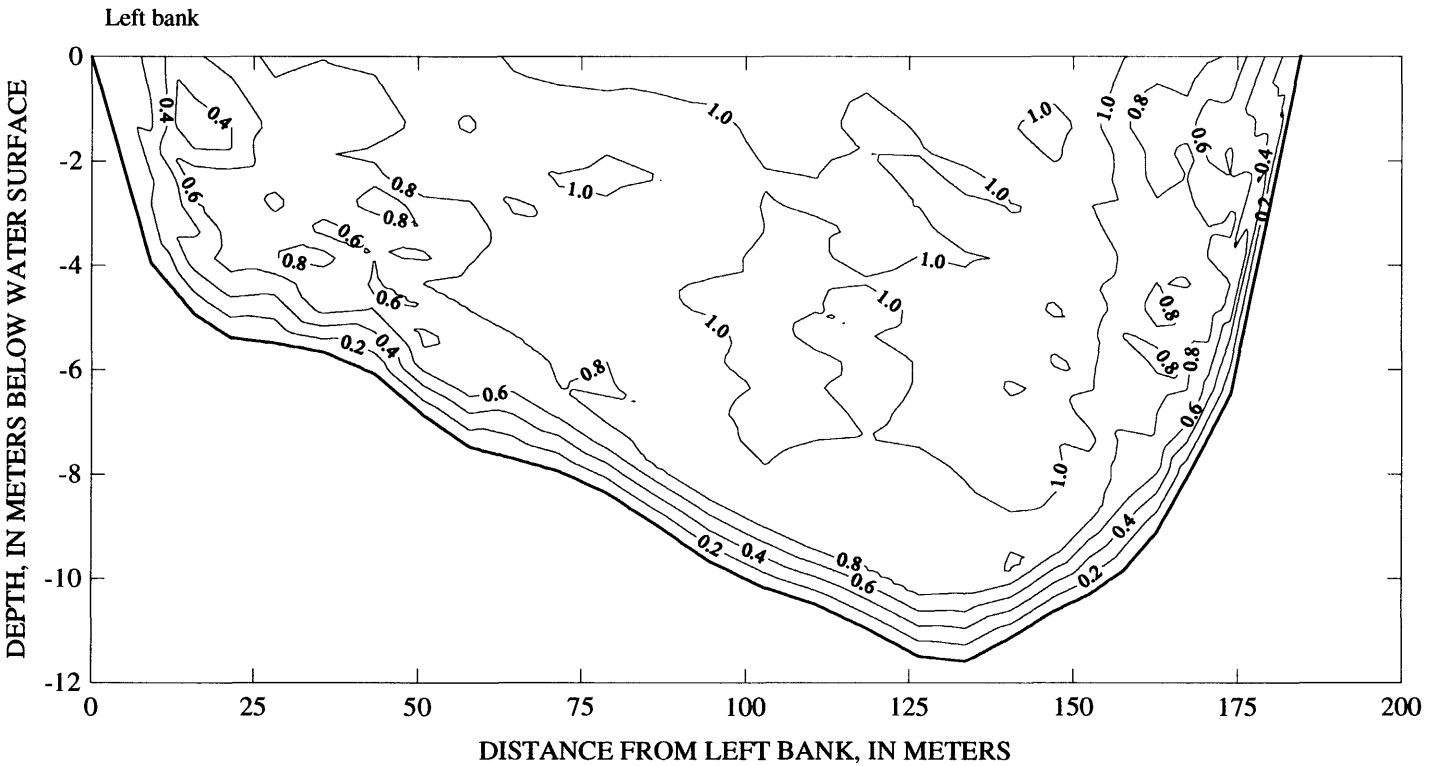

Figure 85. Velocity contours for Kootenai River reach 2, cross-section 21, June 11, 1997. (Contours in meters per second)

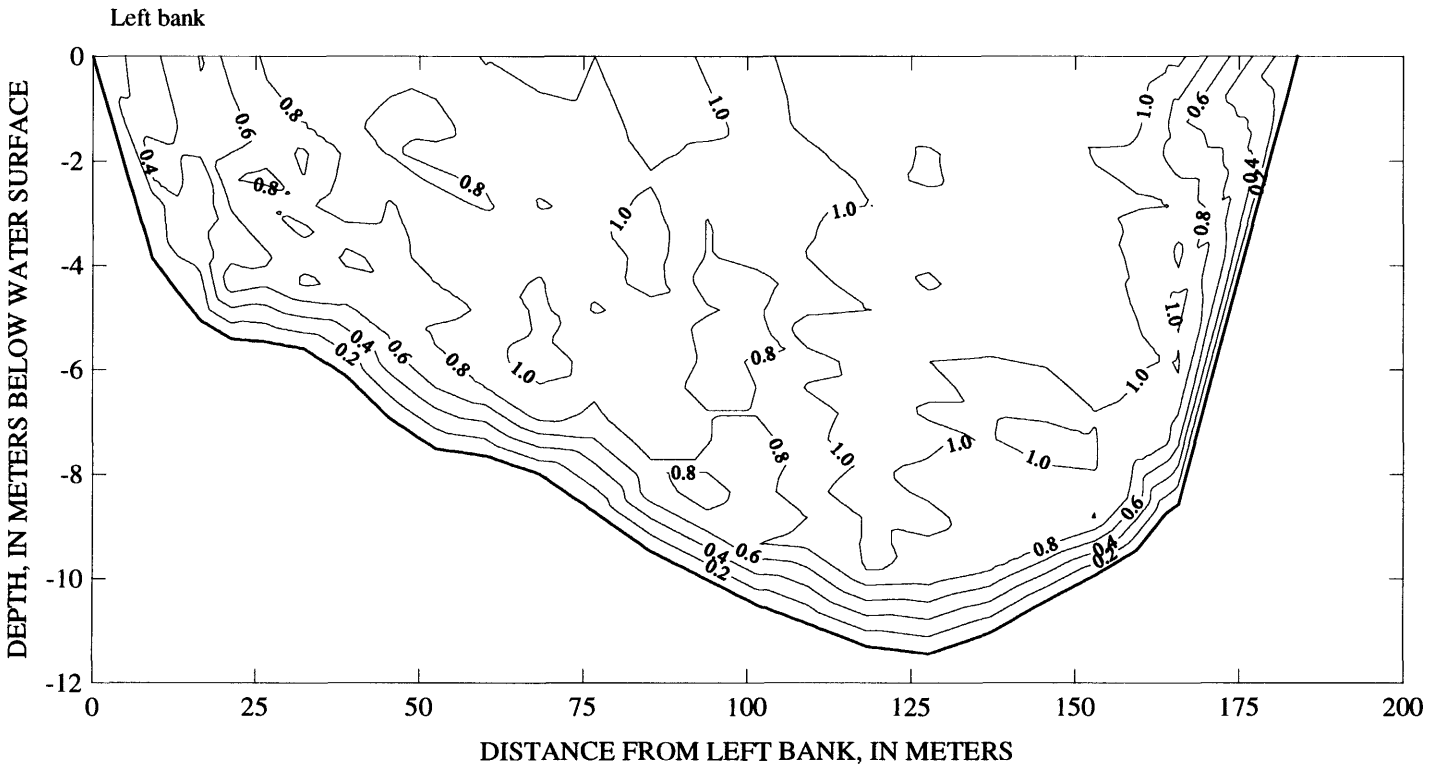

Figure 86. Velocity contours for Kootenai River reach 2, cross-section 22, June 11, 1997. (Contours in meters per second)

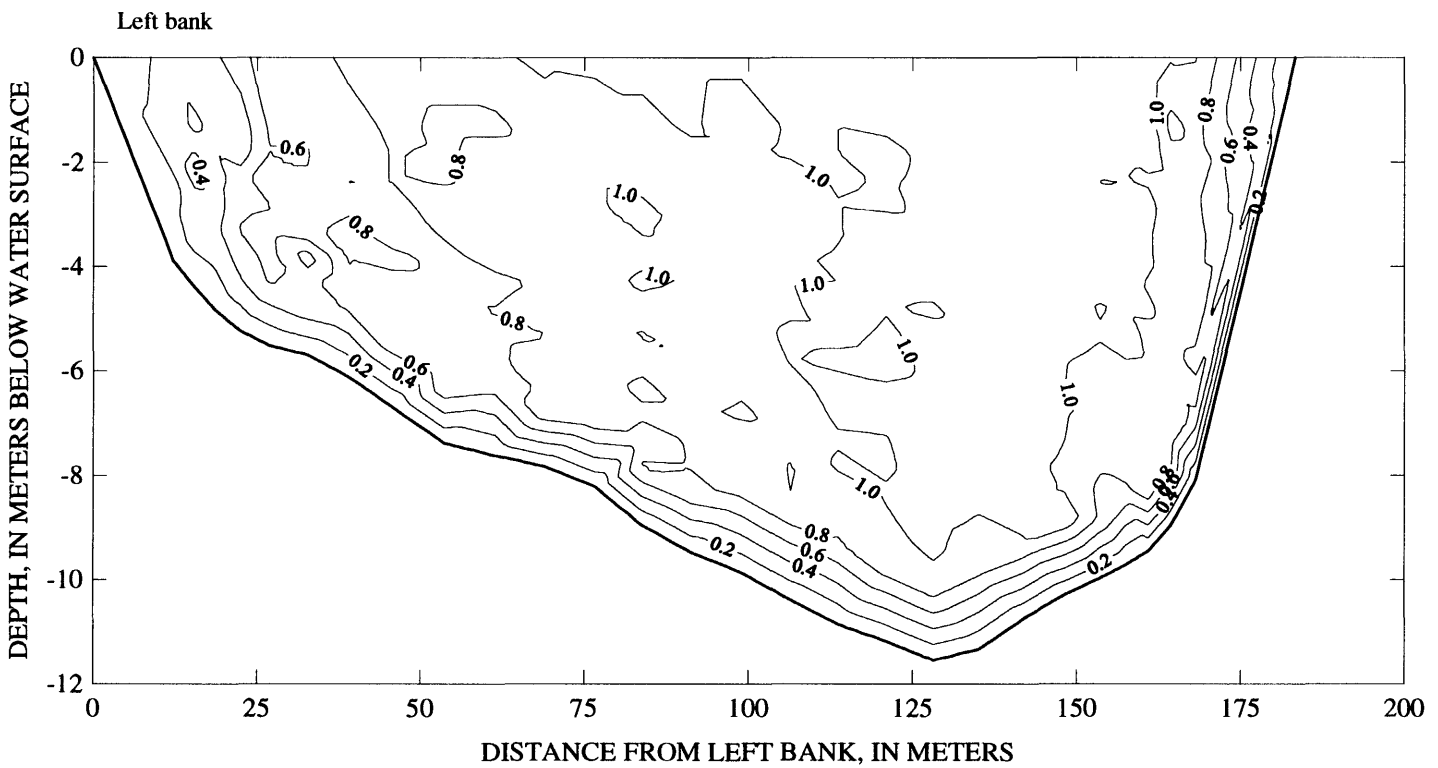

Figure 87. Velocity contours for Kootenai River reach 2, cross-section 23, June 11, 1997. (Contours in meters per second)

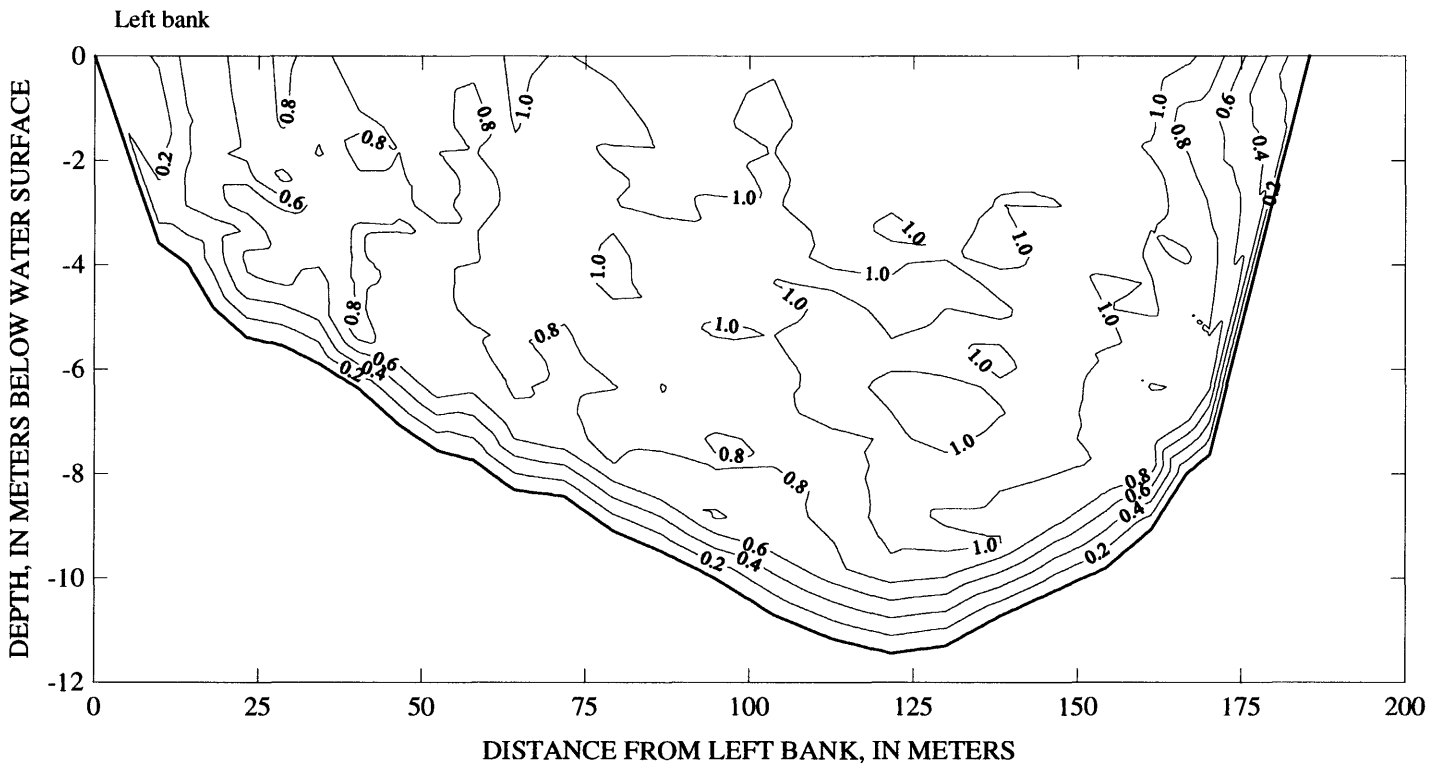

Figure 88. Velocity contours for Kootenai River reach 2, cross-section 24, June 11, 1997. (Contours in meters per second)

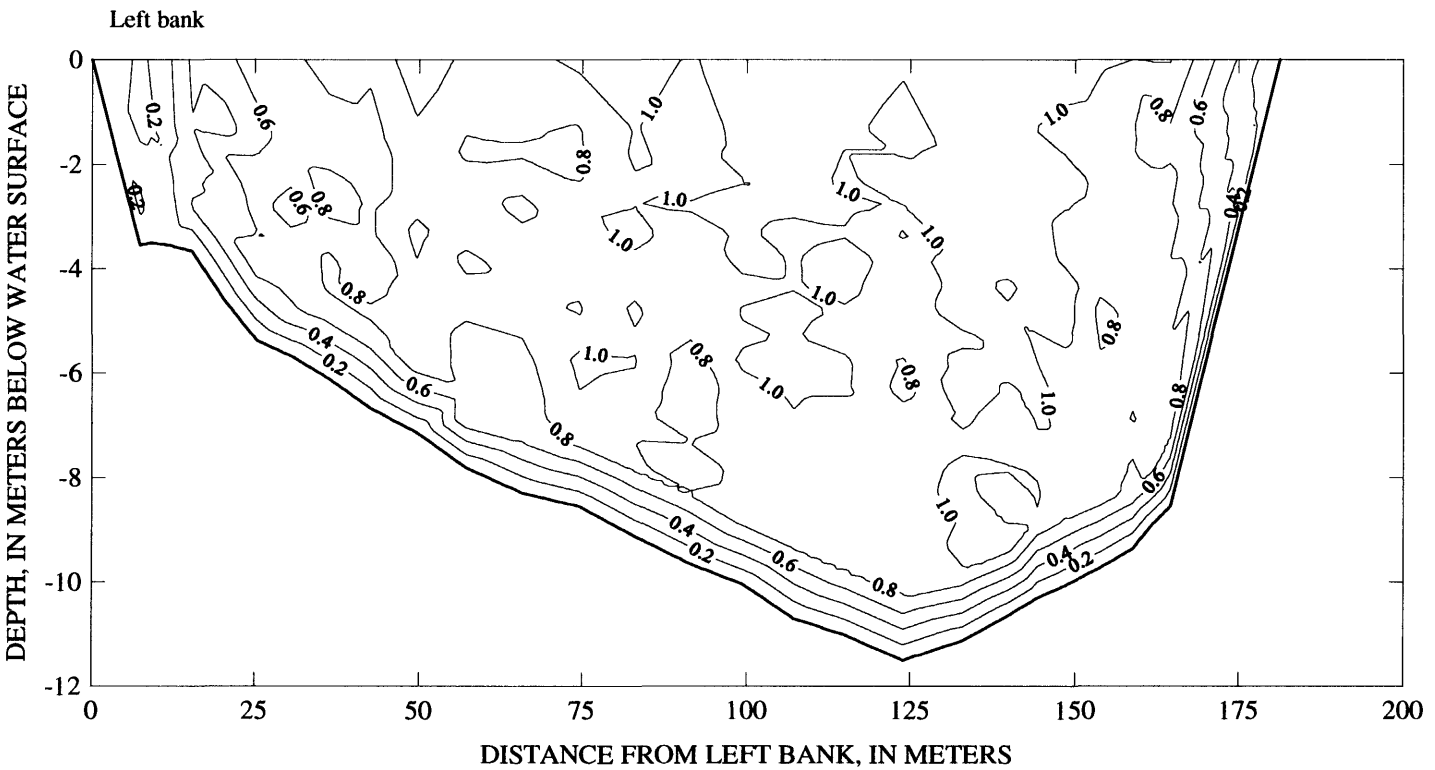

Figure 89. Velocity contours for Kootenai River reach 2, cross-section 25, June 11, 1997. (Contours in meters per second)

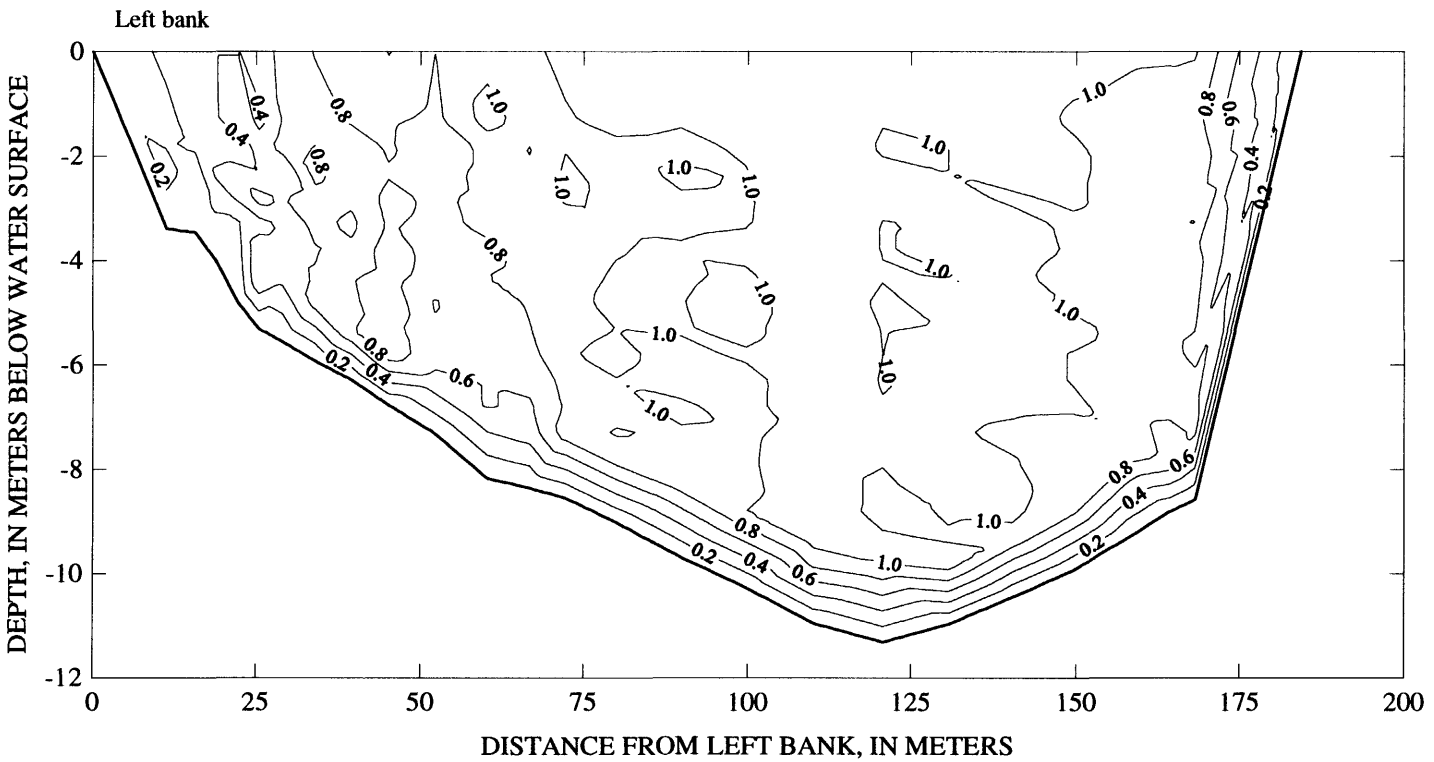

Figure 90. Velocity contours for Kootenai River reach 2, cross-section 26, June 11, 1997. (Contours in meters per second)

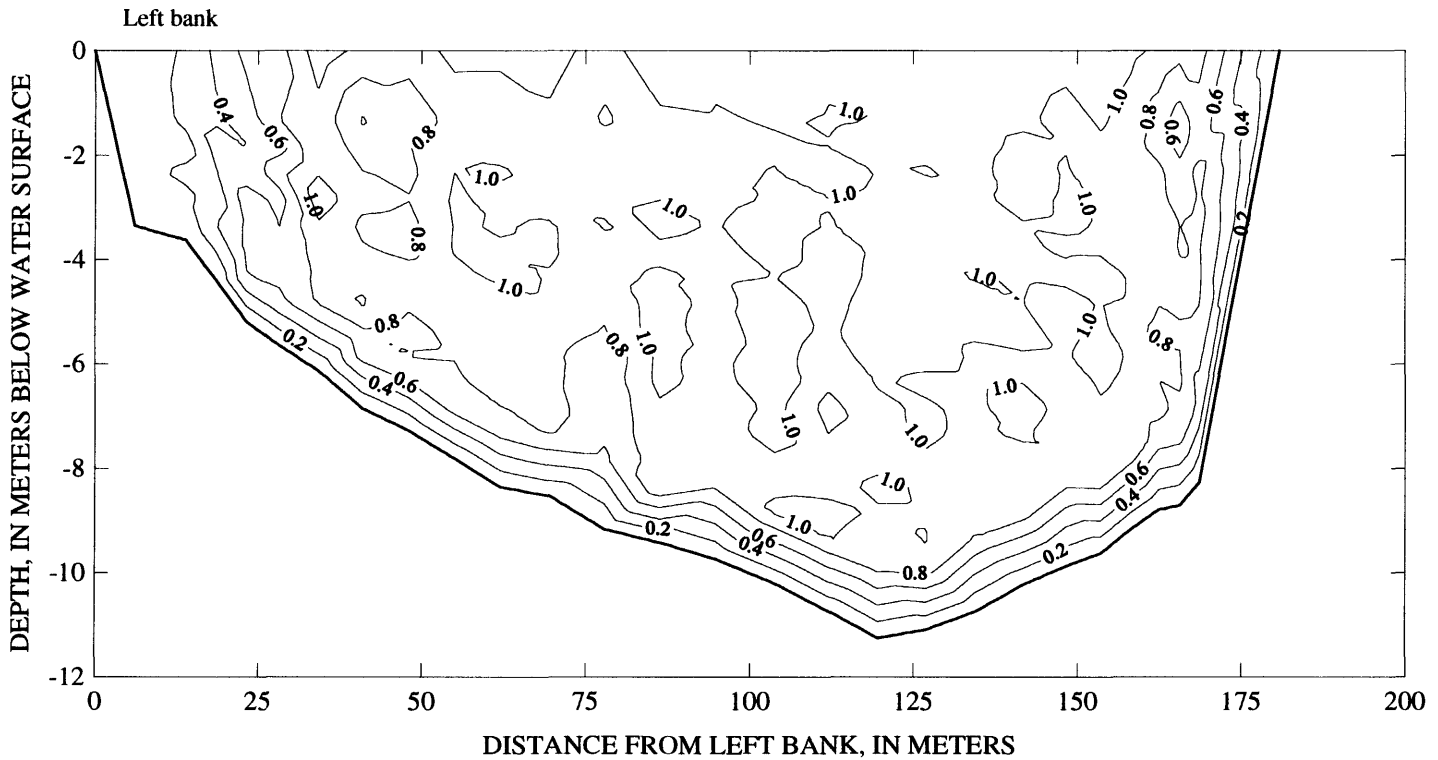

Figure 91. Velocity contours for Kootenai River reach 2, cross-section 27, June 11, 1997. (Contours in meters per second)

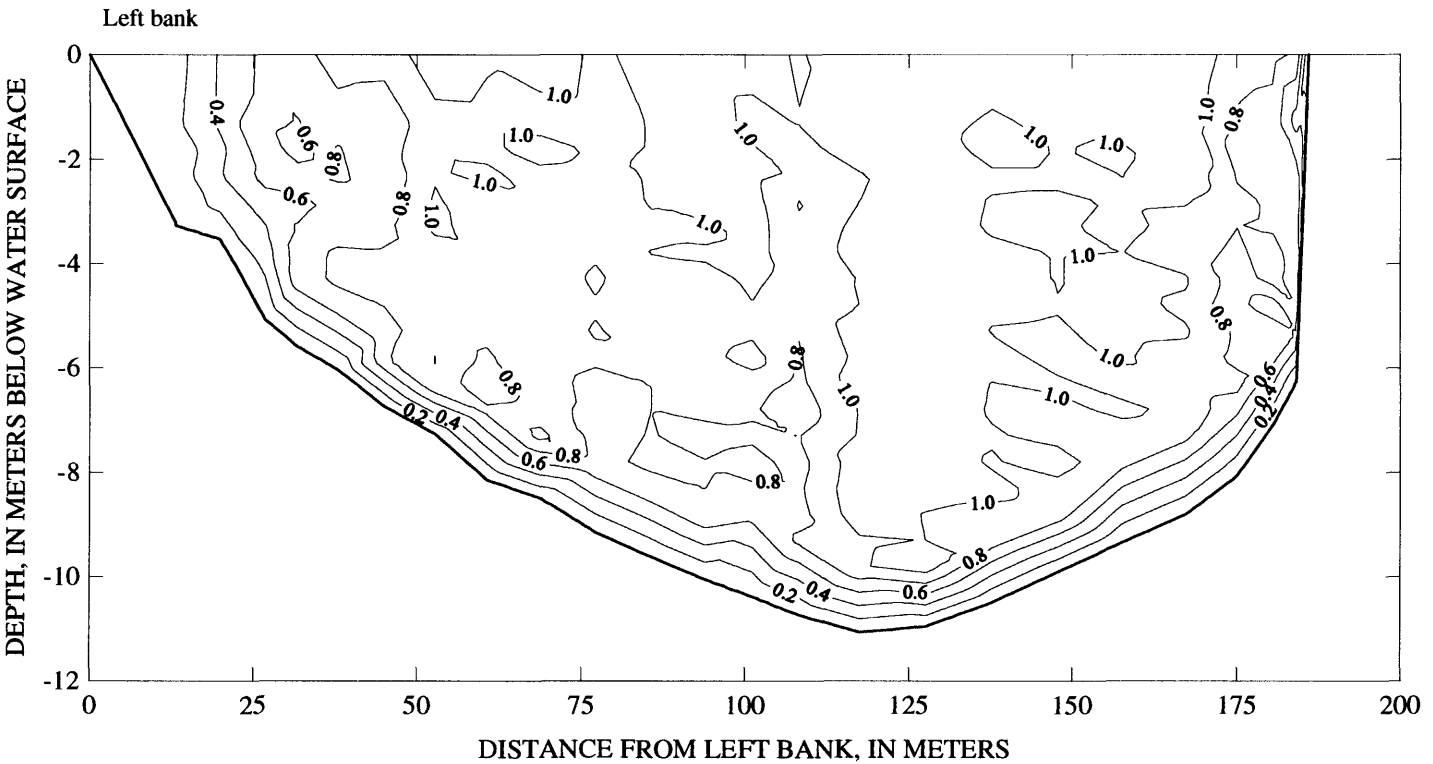

Figure 92. Velocity contours for Kootenai River reach 2, cross-section 28, June 11, 1997. (Contours in meters per second)

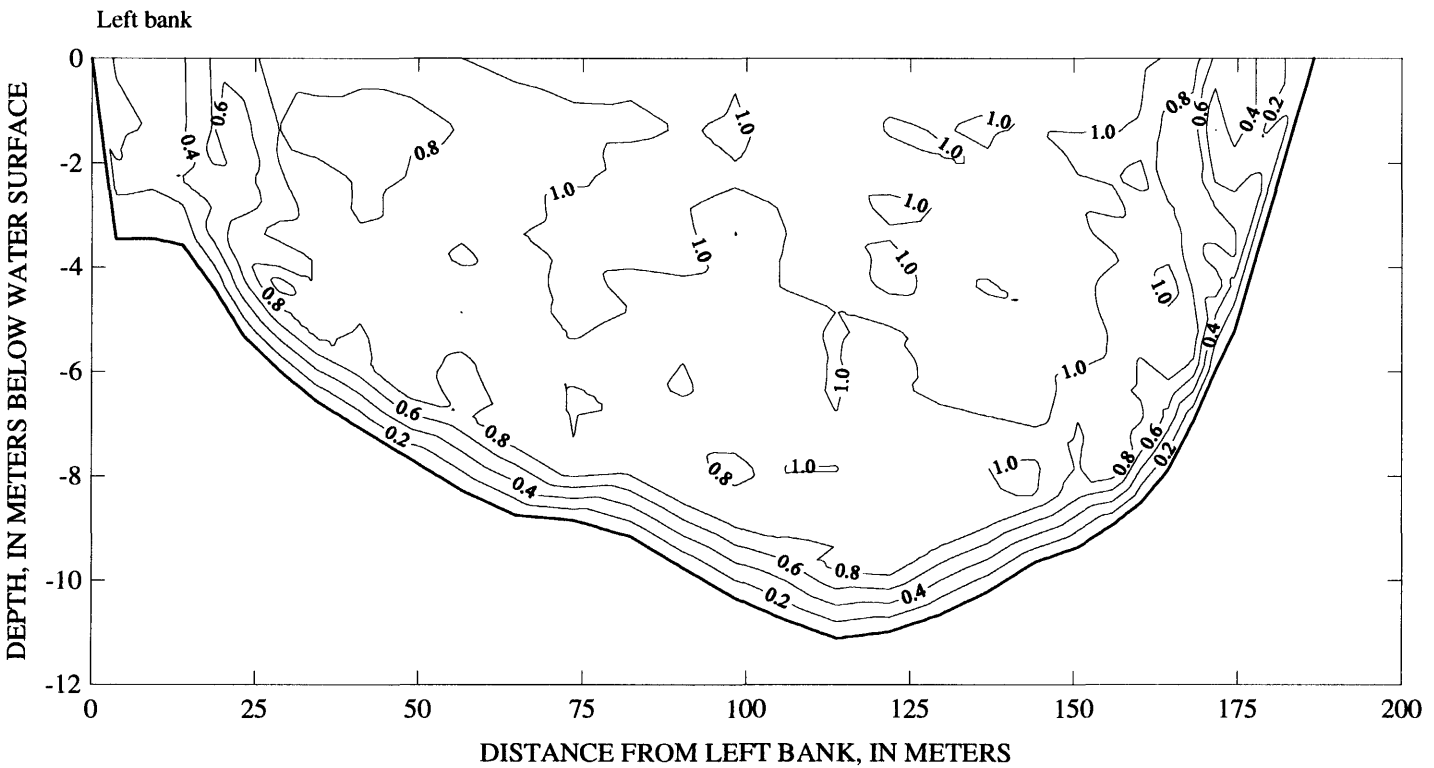

Figure 93. Velocity contours for Kootenai River reach 2, cross-section 29, June 11, 1997. (Contours in meters per second)

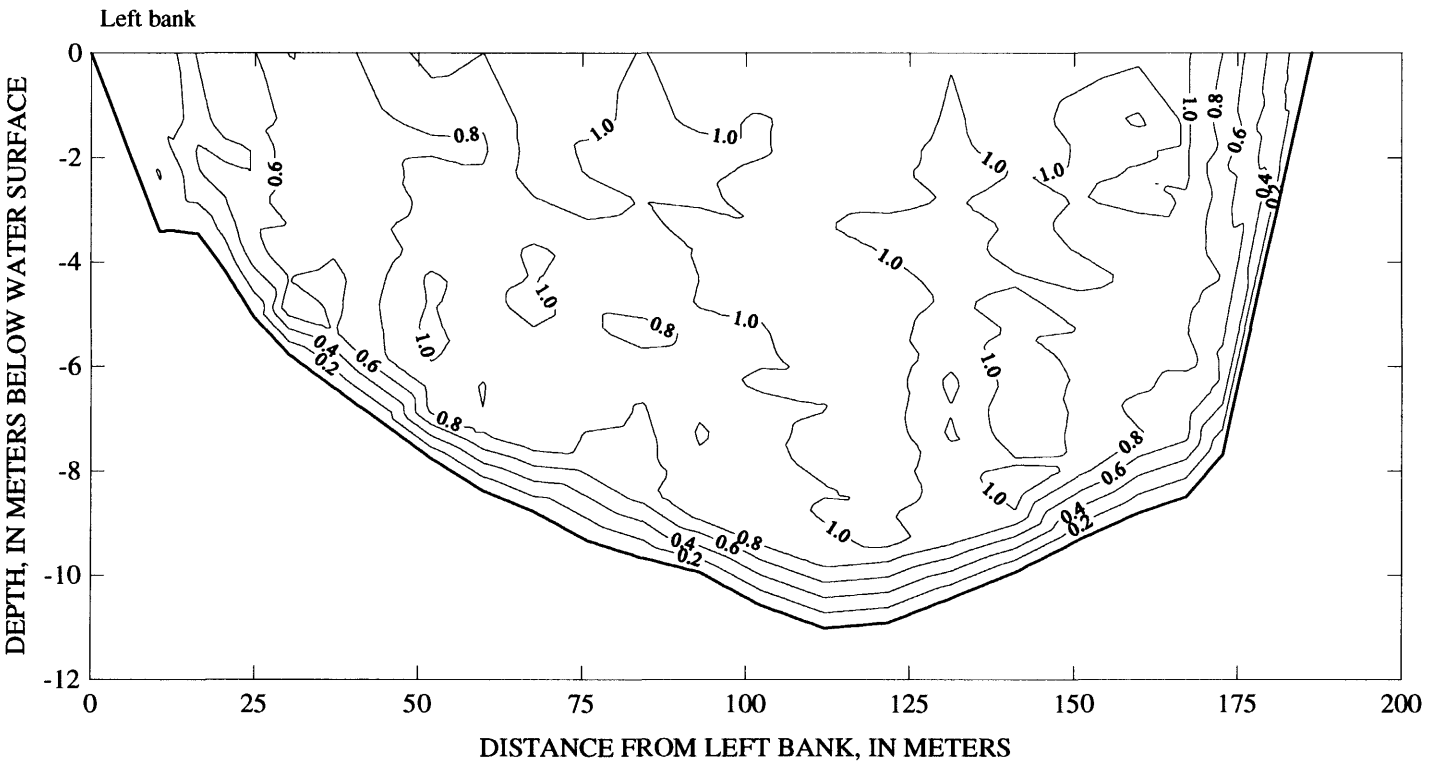

Figure 94. Velocity contours for Kootenai River reach 2, cross-section 30, June 11, 1997. (Contours in meters per second)

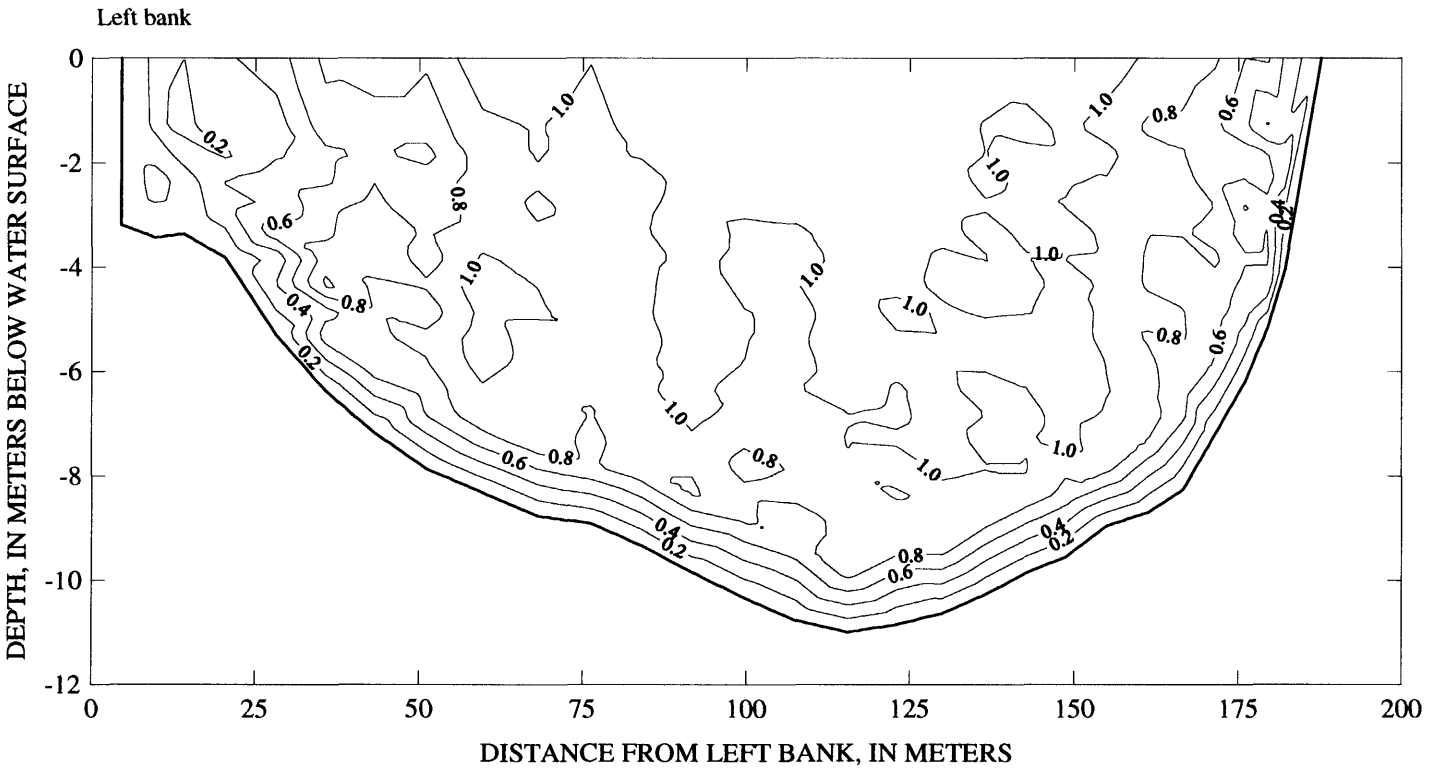

Figure 95. Velocity contours for Kootenai River reach 2, cross-section 31, June 11, 1997. (Contours in meters per second)

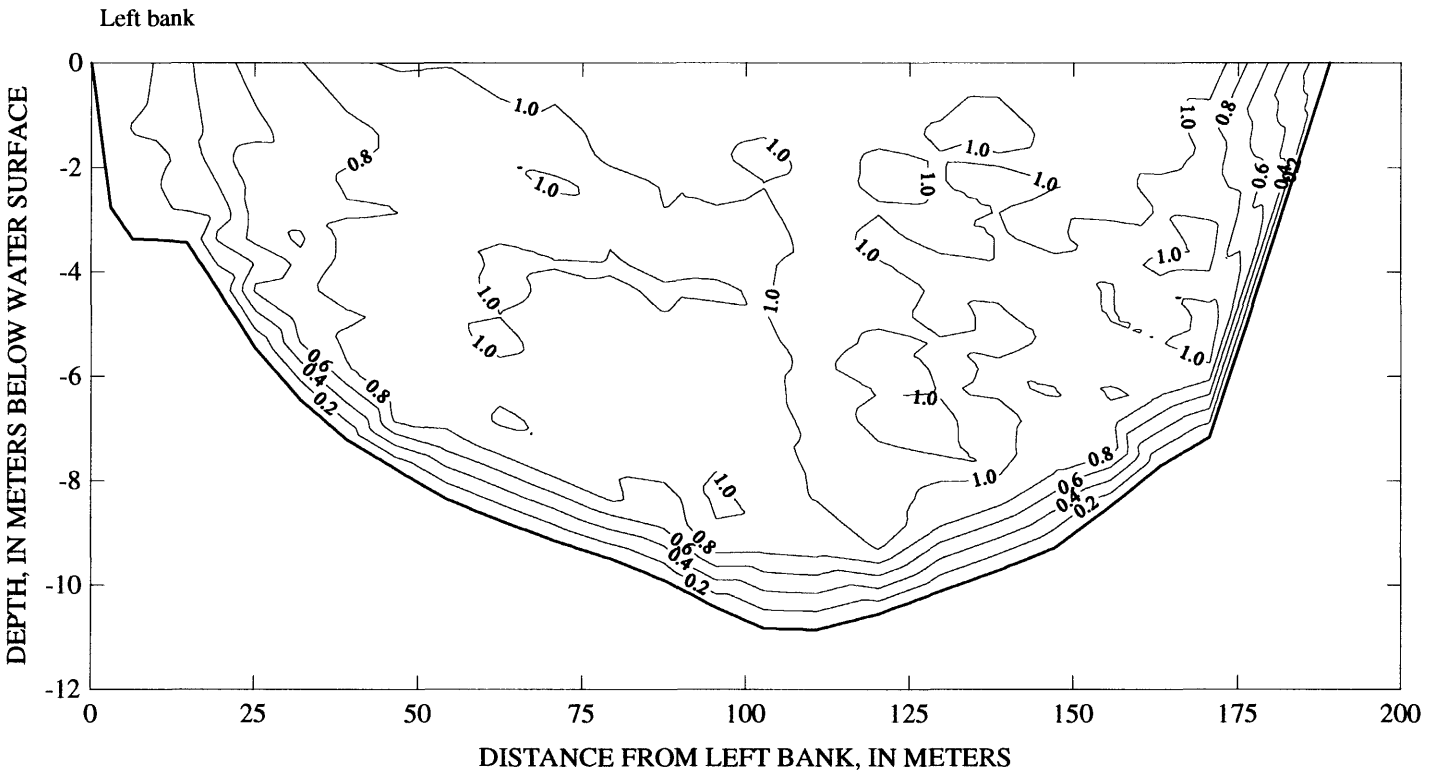

Figure 96. Velocity contours for Kootenai River reach 2, cross-section 32, June 11, 1997. (Contours in meters per second)

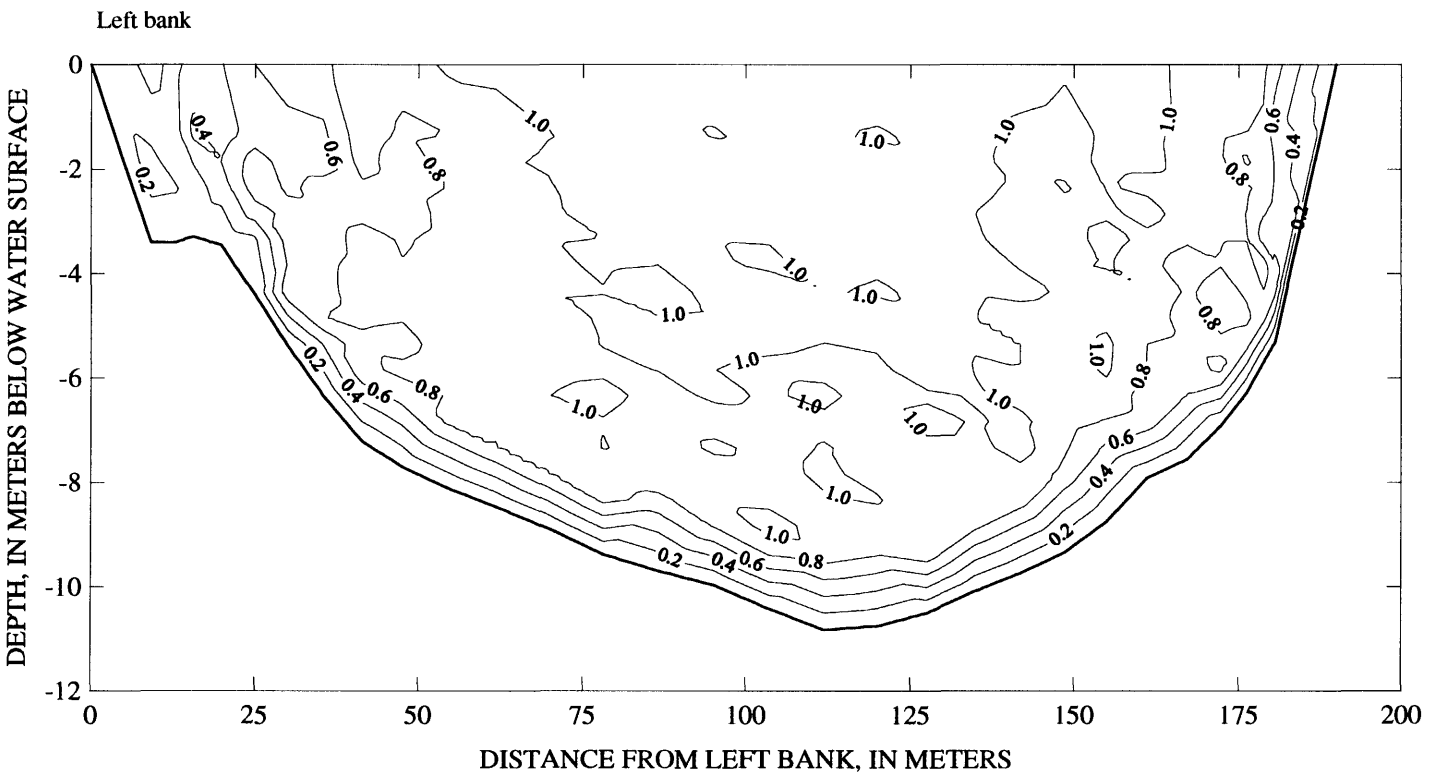

Figure 97. Velocity contours for Kootenai River reach 2, cross-section 33, June 11, 1997. (Contours in meters per second)

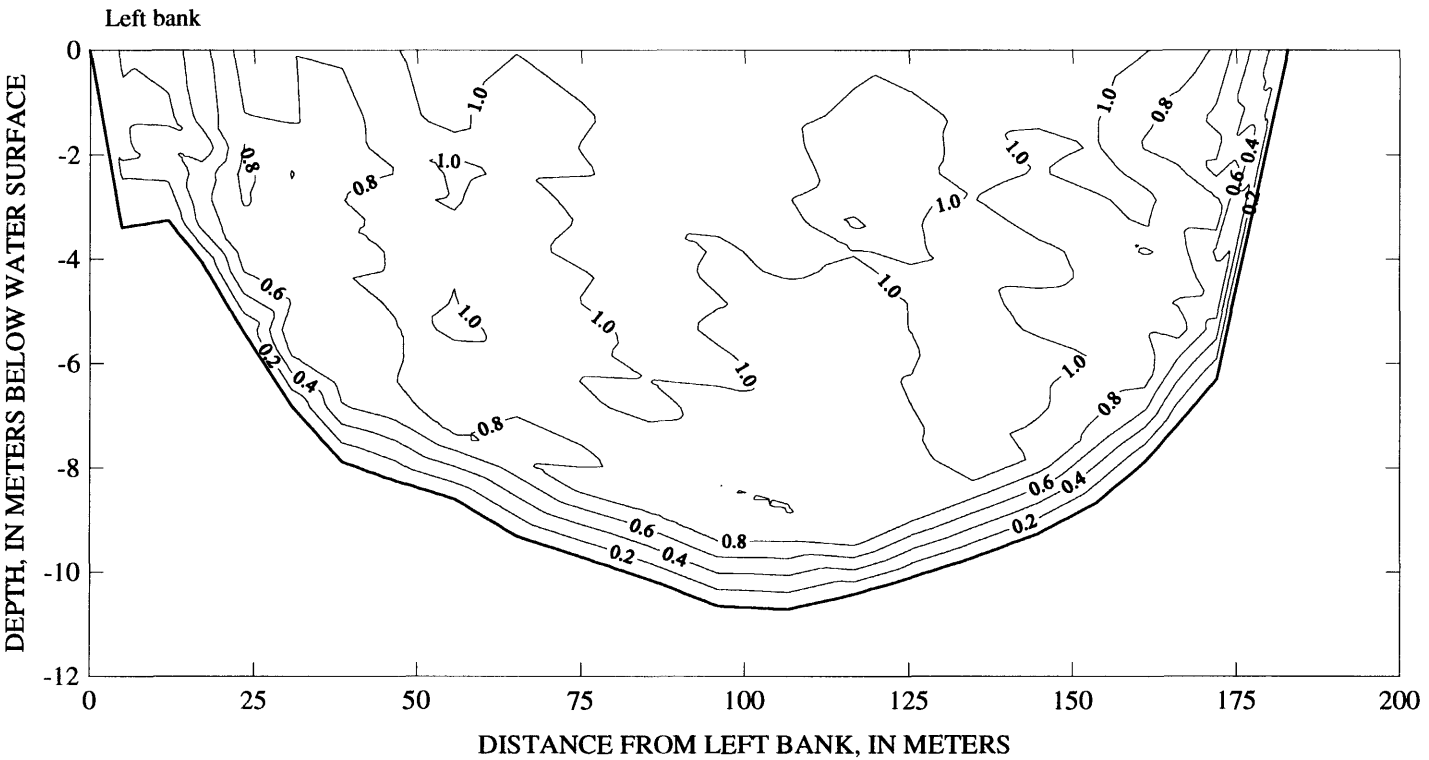

Figure 98. Velocity contours for Kootenai River reach 2, cross-section 34, June 11, 1997. (Contours in meters per second)

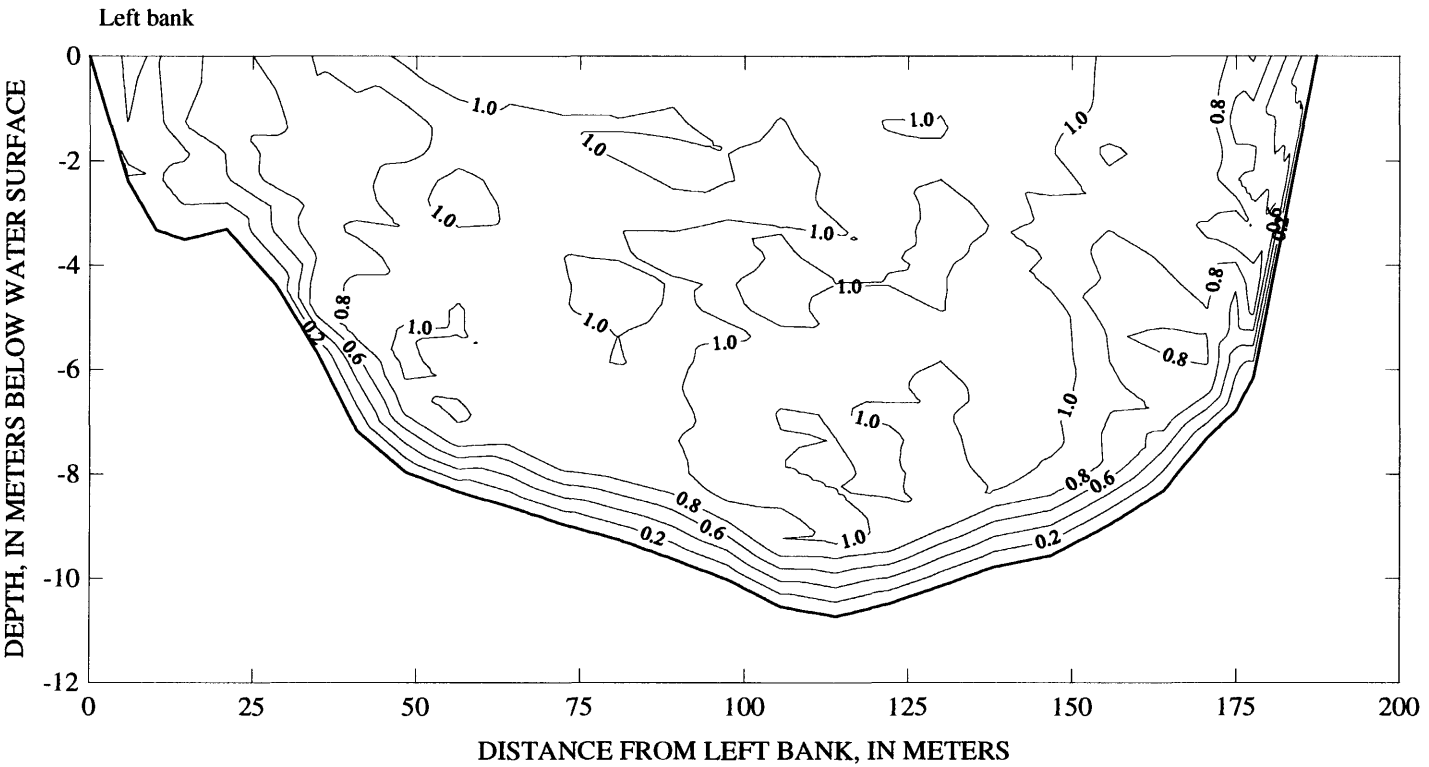

Figure 99. Velocity contours for Kootenai River reach 2, cross-section 35, June 11, 1997. (Contours in meters per second)

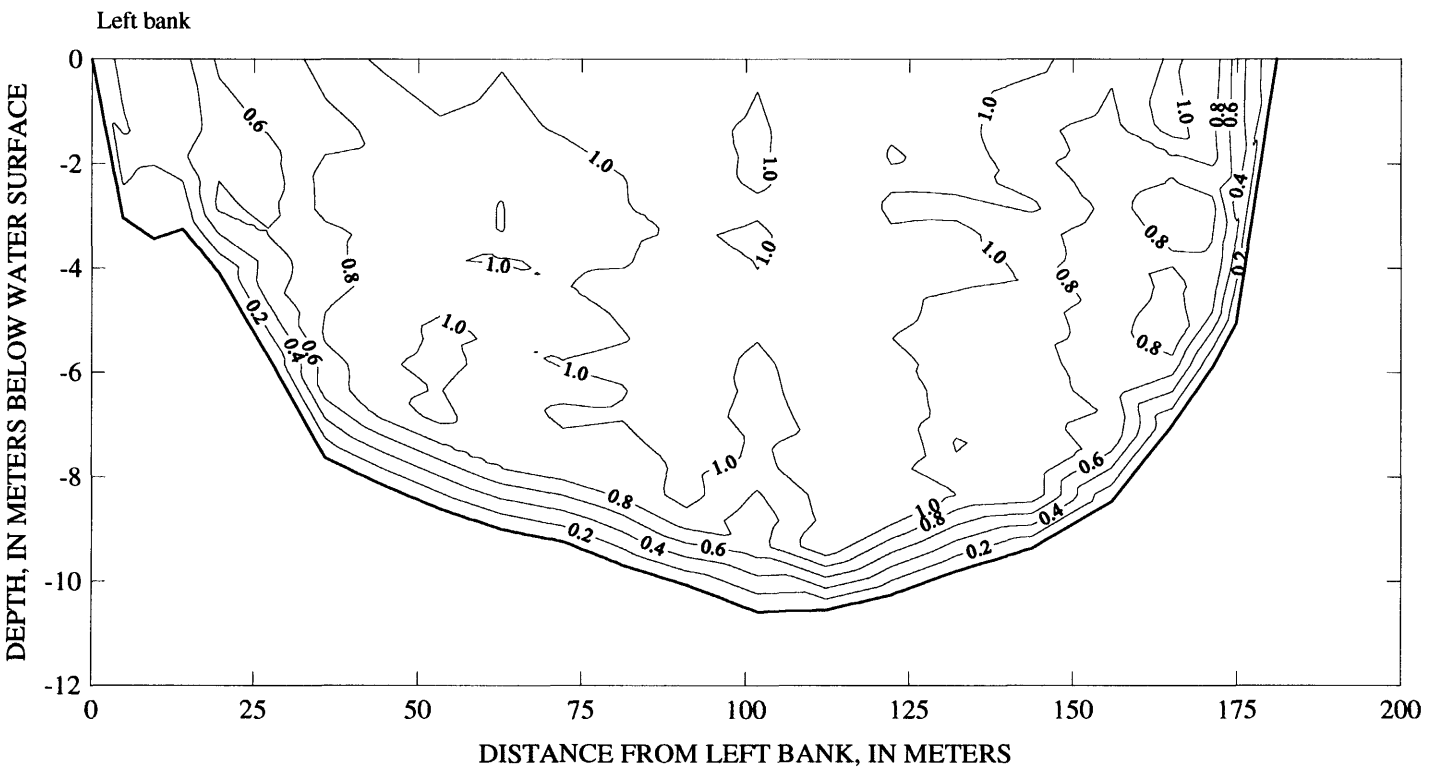

Figure 100. Velocity contours for Kootenai River reach 2, cross-section 36, June 11, 1997. (Contours in meters per second)

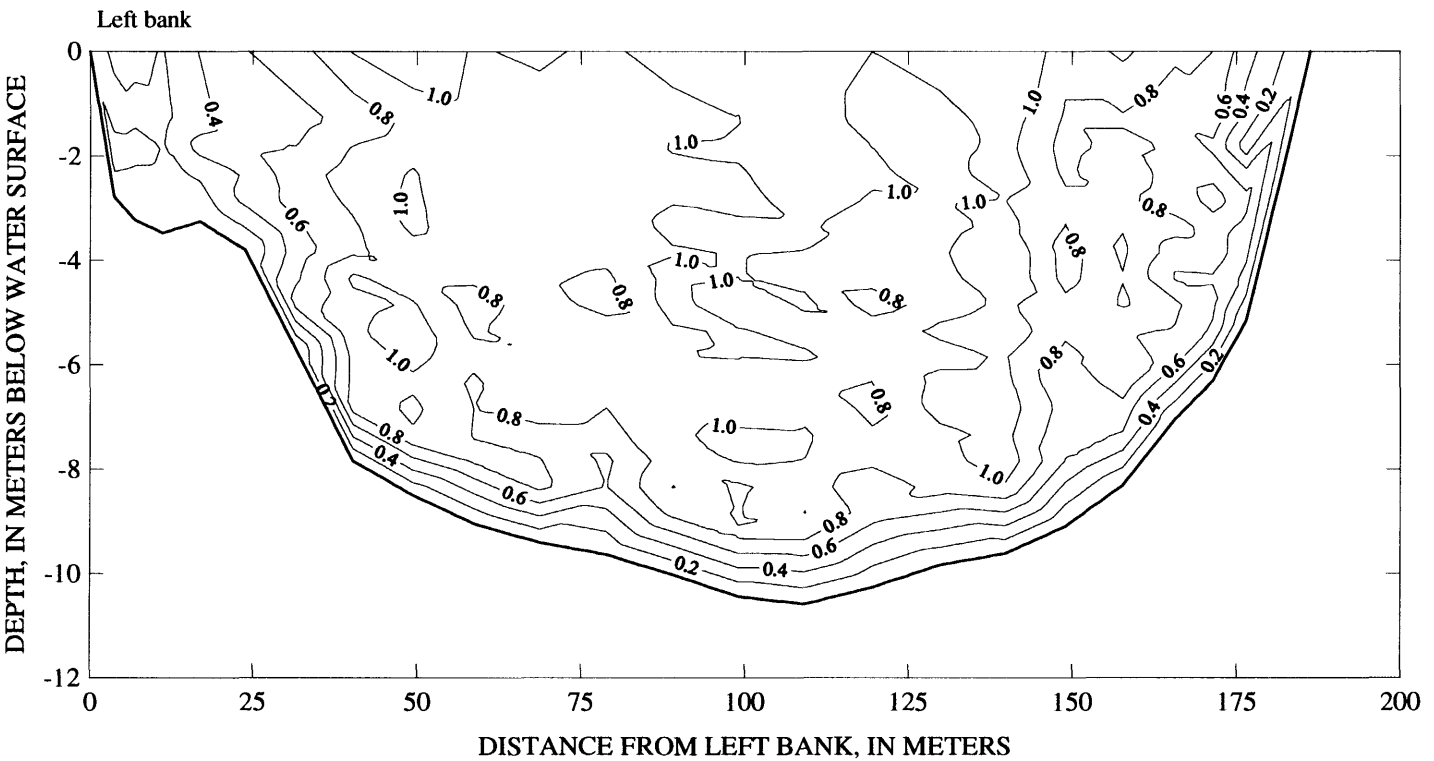

Figure 101. Velocity contours for Kootenai River reach 2, cross-section 37, June 11, 1997. (Contours in meters per second)

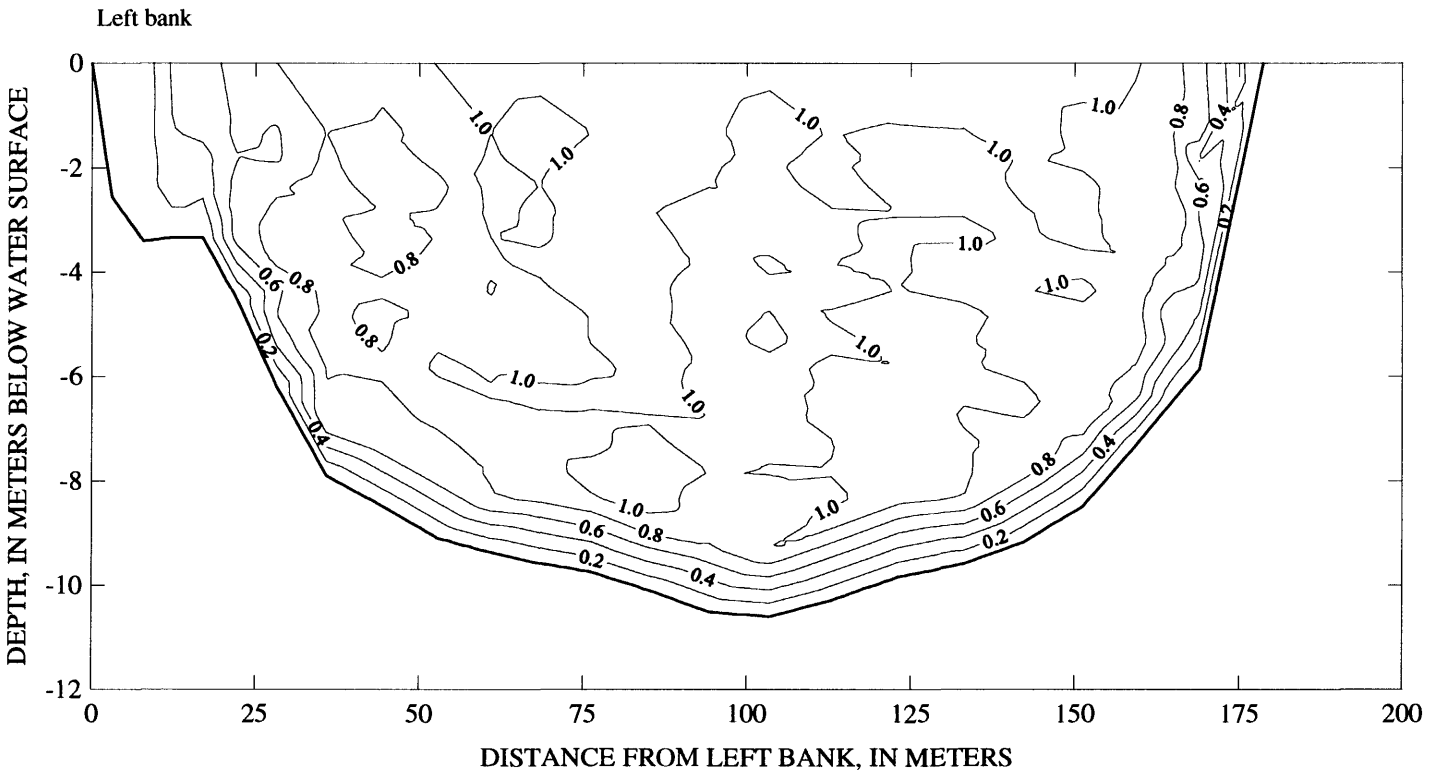

Figure 102. Velocity contours for Kootenai River reach 2, cross-section 38, June 11, 1997. (Contours in meters per second)

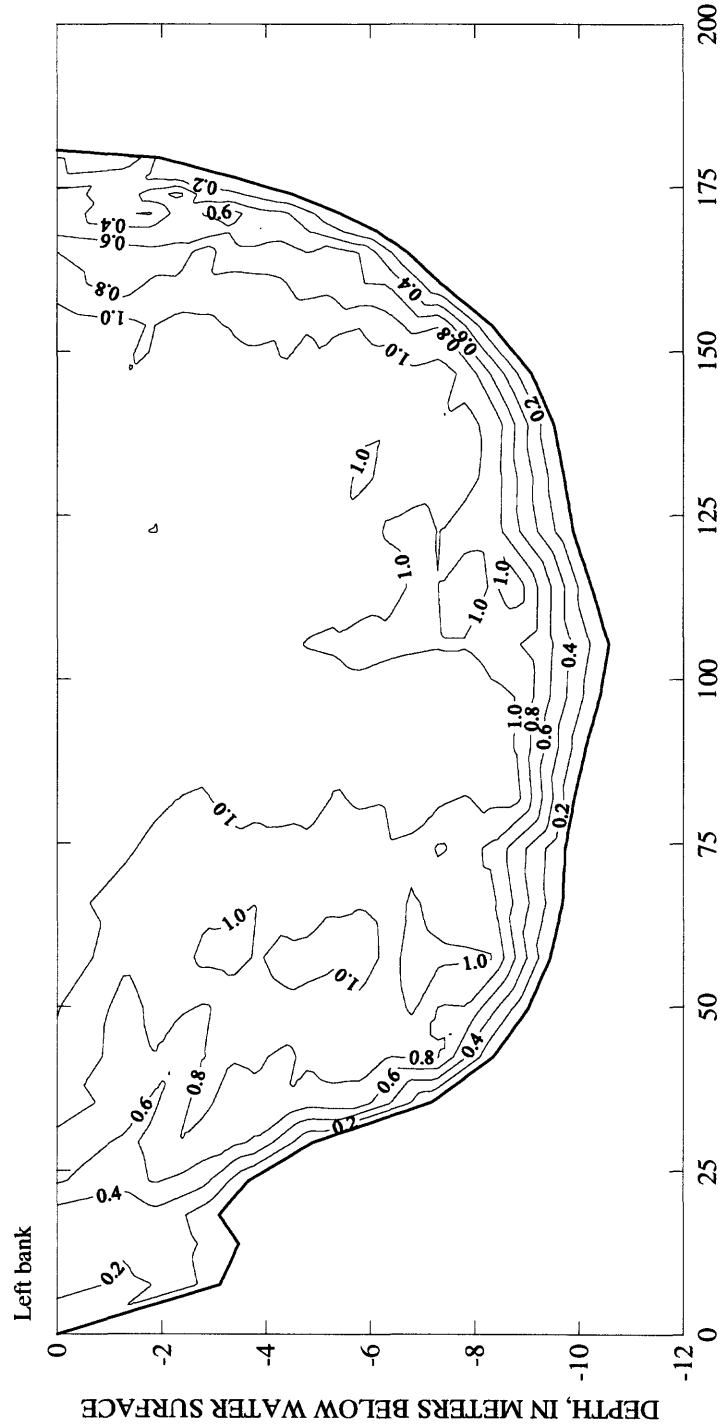

Figure 103. Velocity contours for Kootenai River reach 2, cross-section 39, June 11, 1997.
(Contours in meters per second)

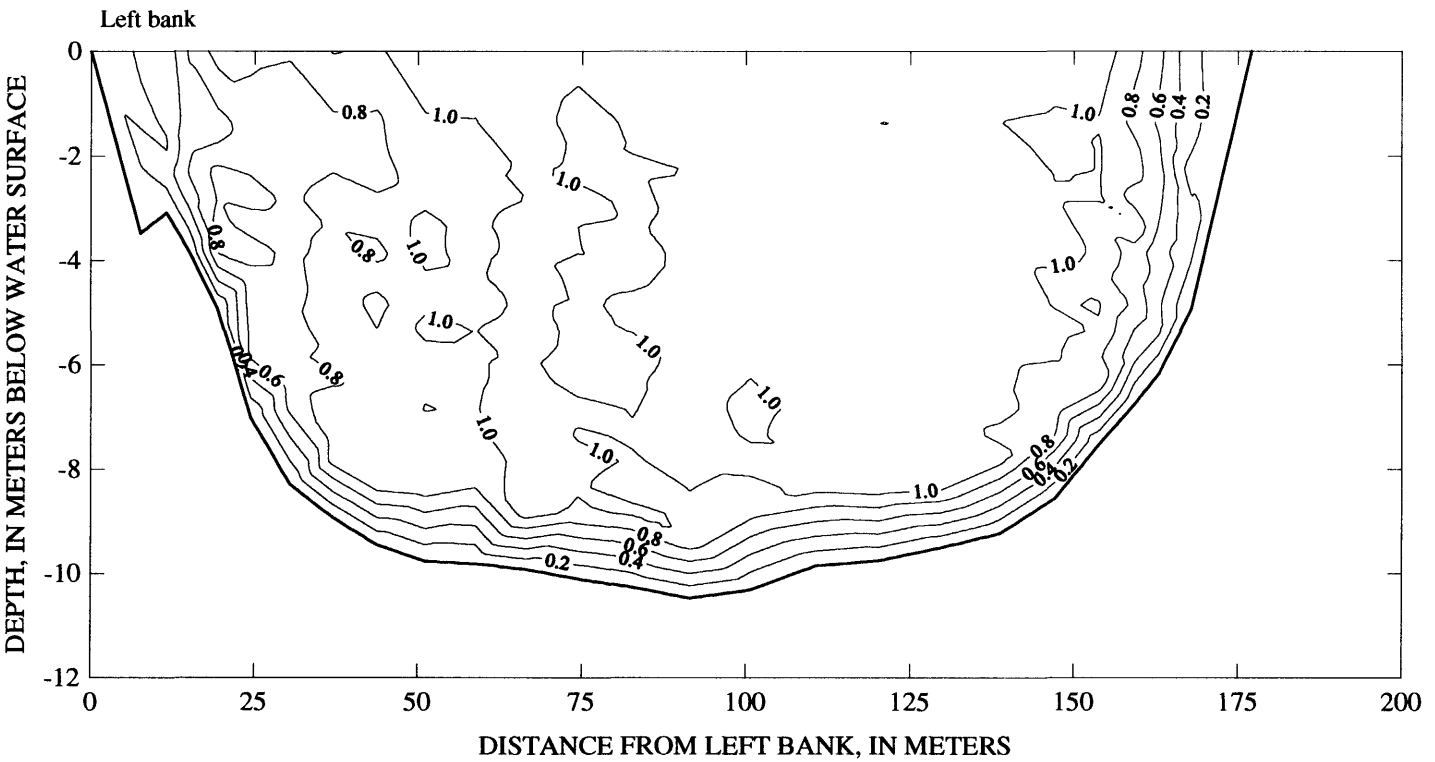

Figure 104. Velocity contours for Kootenai River reach 2, cross-section 40, June 11, 1997. (Contours in meters per second)

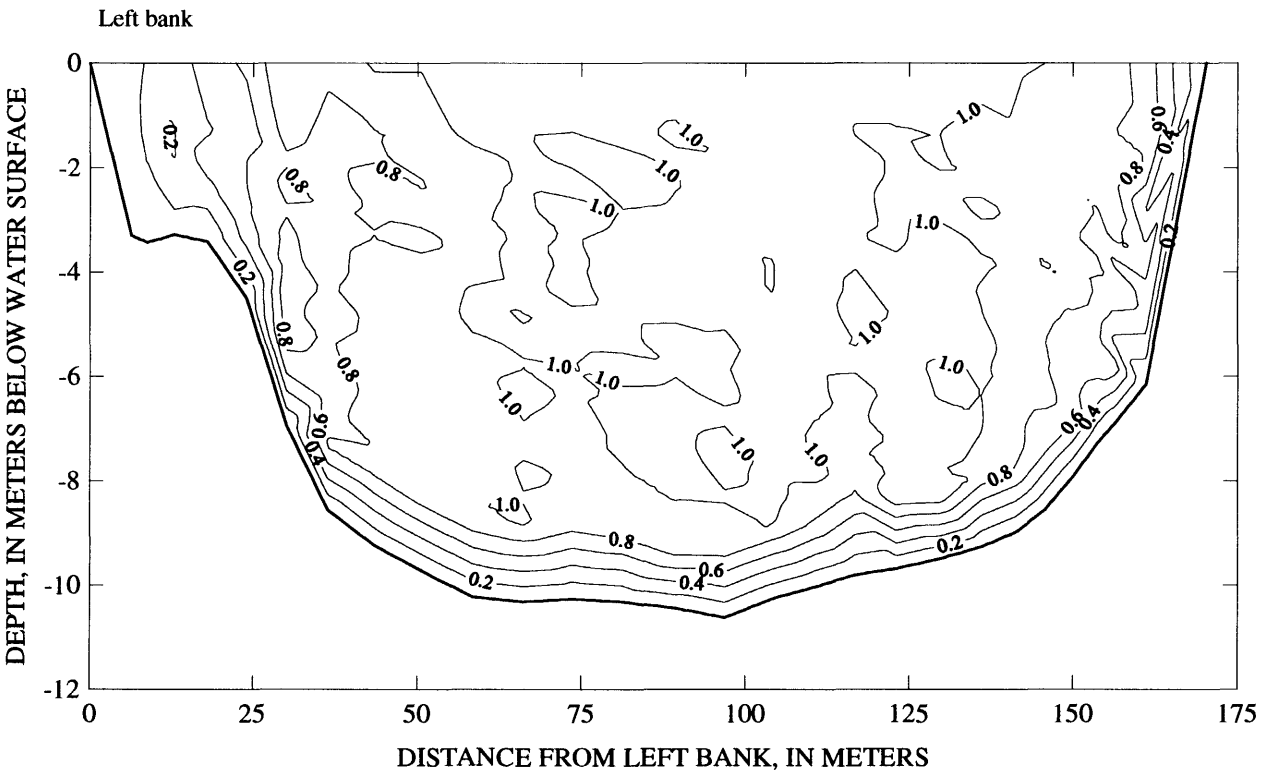

Figure 105. Velocity contours for Kootenai River reach 2, cross-section 41, June 11, 1997. (Contours in meters per second)

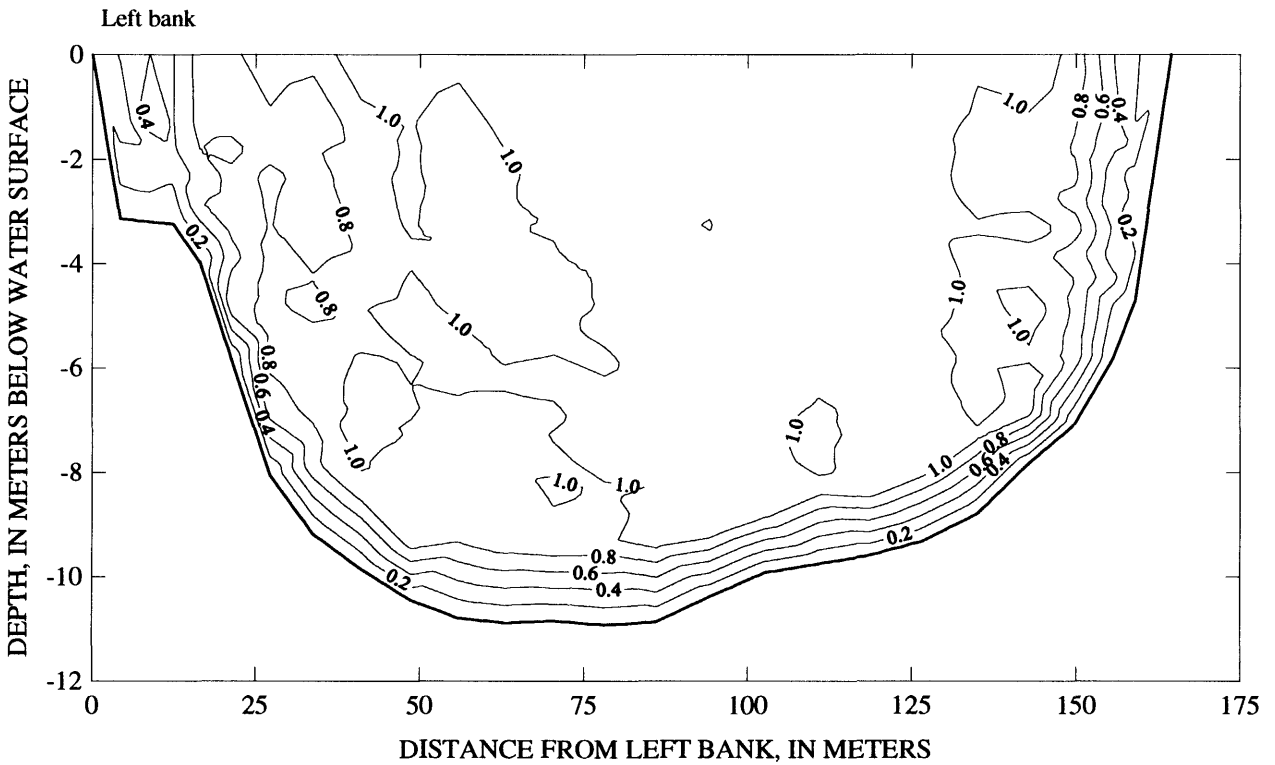

Figure 106. Velocity contours for Kootenai River reach 2, cross-section 42, June 11, 1997. (Contours in meters per second)

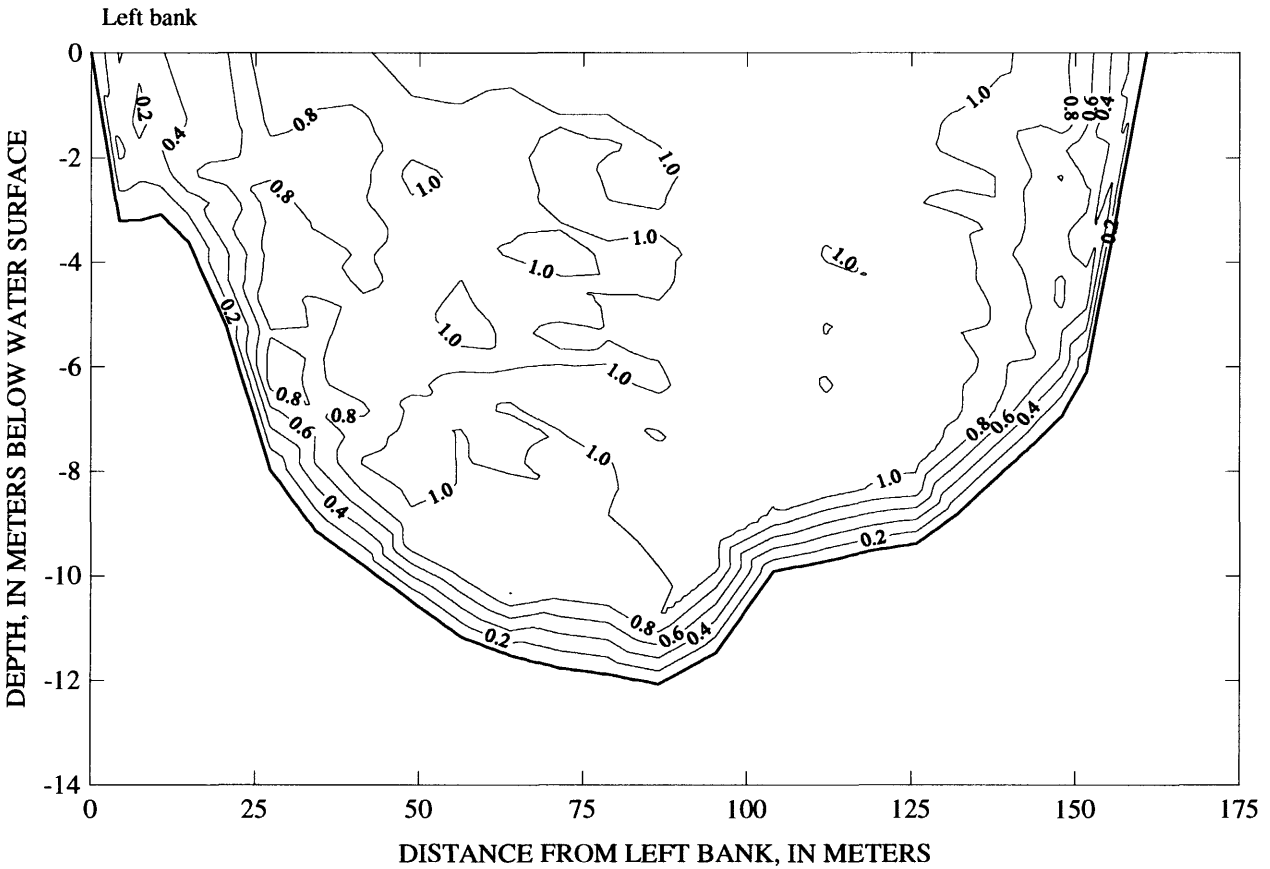

Figure 107. Velocity contours for Kootenai River reach 2, cross-section 43, June 11, 1997. (Contours in meters per second)

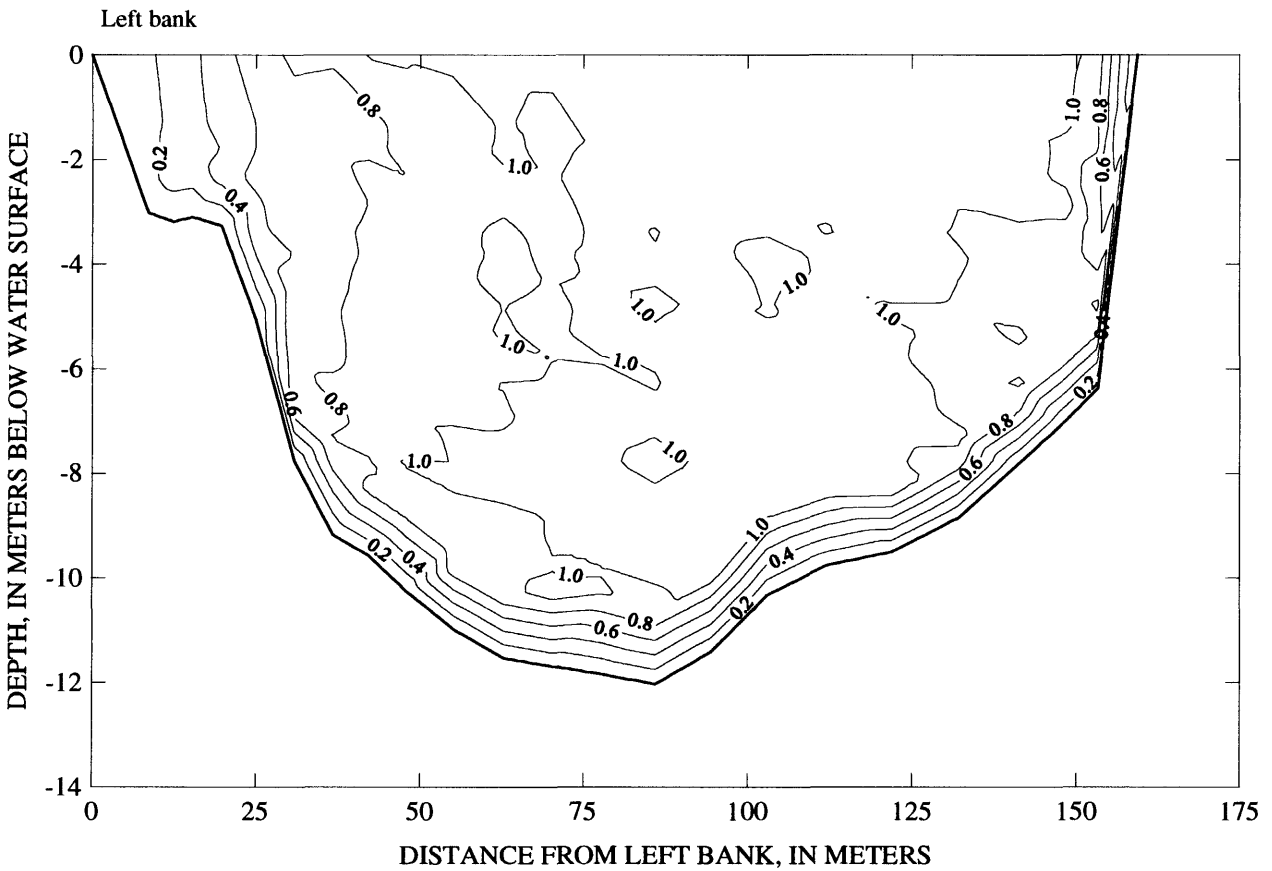

Figure 108. Velocity contours for Kootenai River reach 2, cross-section 44, June 11, 1997. (Contours in meters per second)

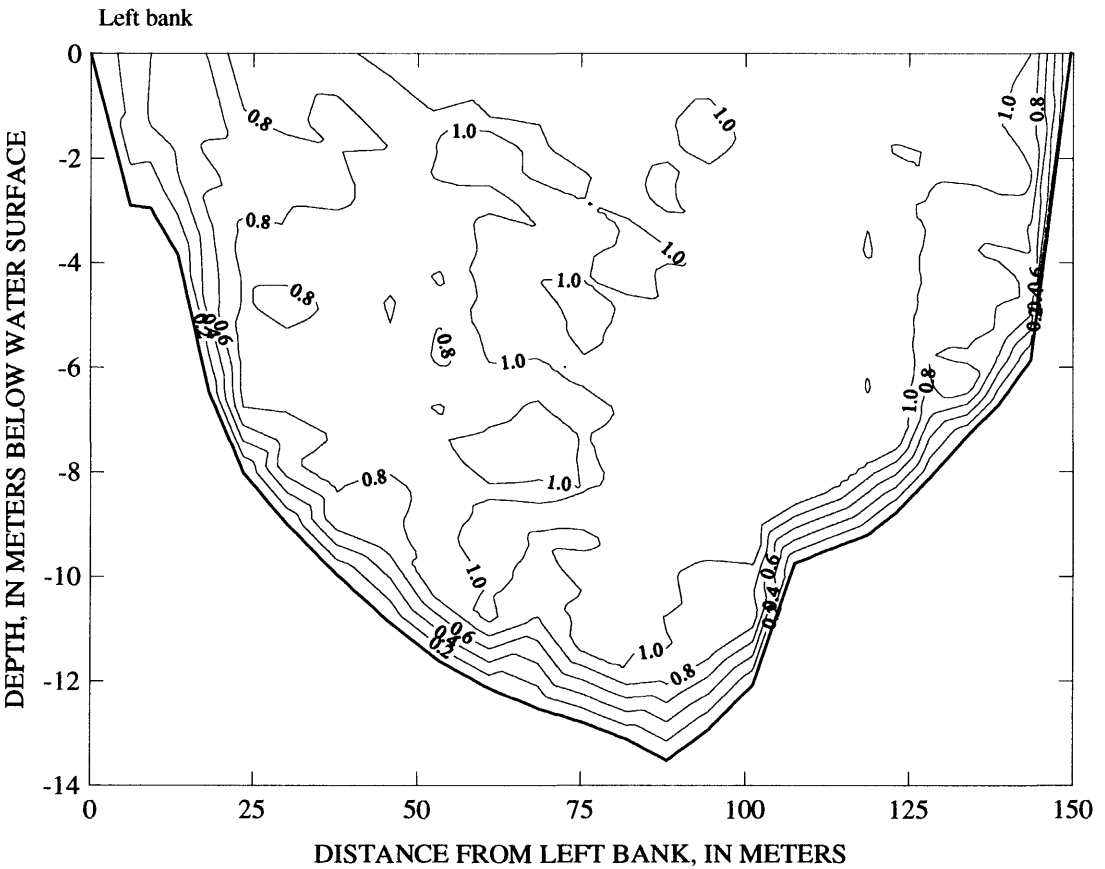

Figure 109. Velocity contours for Kootenai River reach 2, cross-section 45, June 11, 1997. (Contours in meters per second)

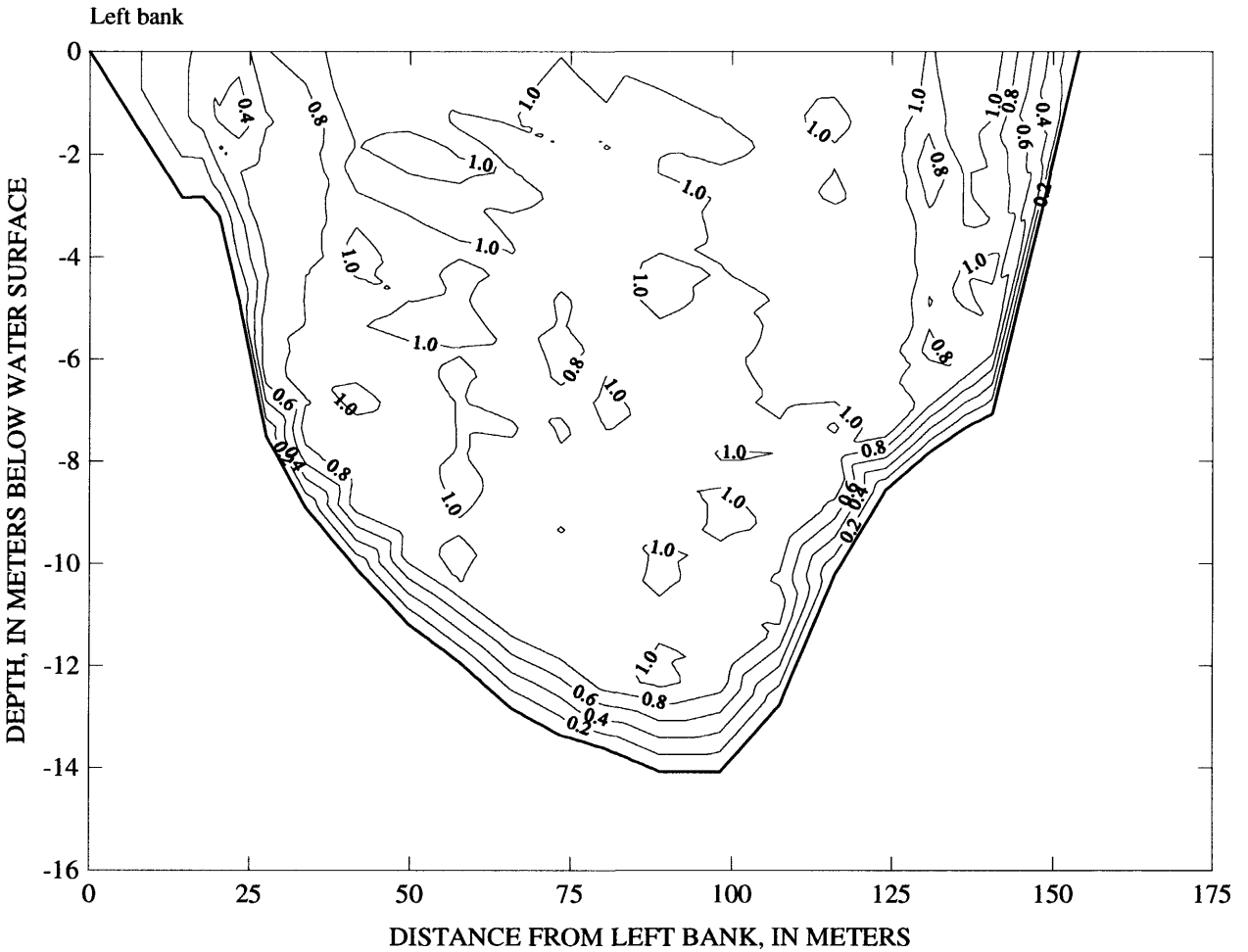

Figure 110. Velocity contours for Kootenai River reach 2, cross-section 46, June 11, 1997. (Contours in meters per second)

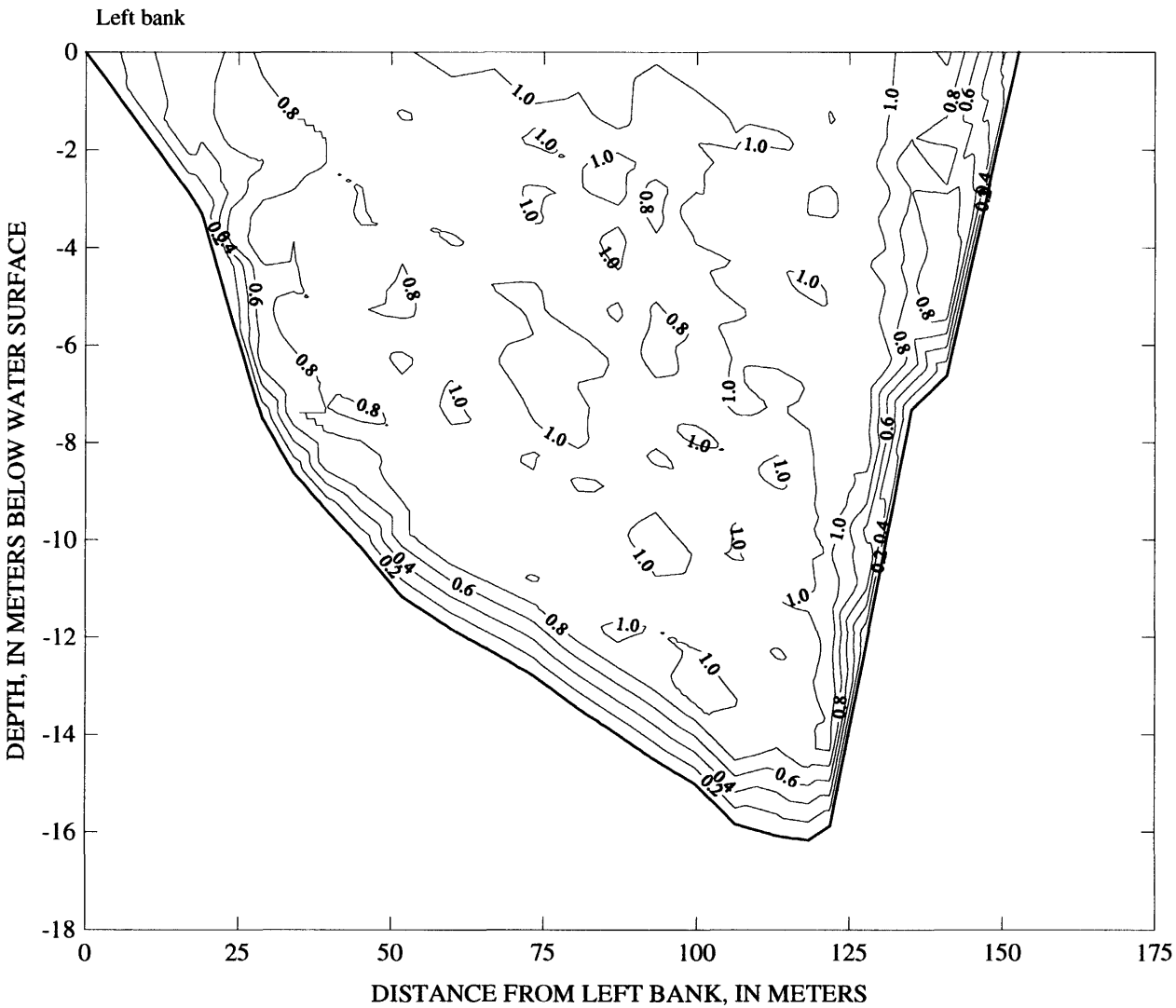

Figure 111. Velocity contours for Kootenai River reach 2, cross-section 47, June 11, 1997. (Contours in meters per second)

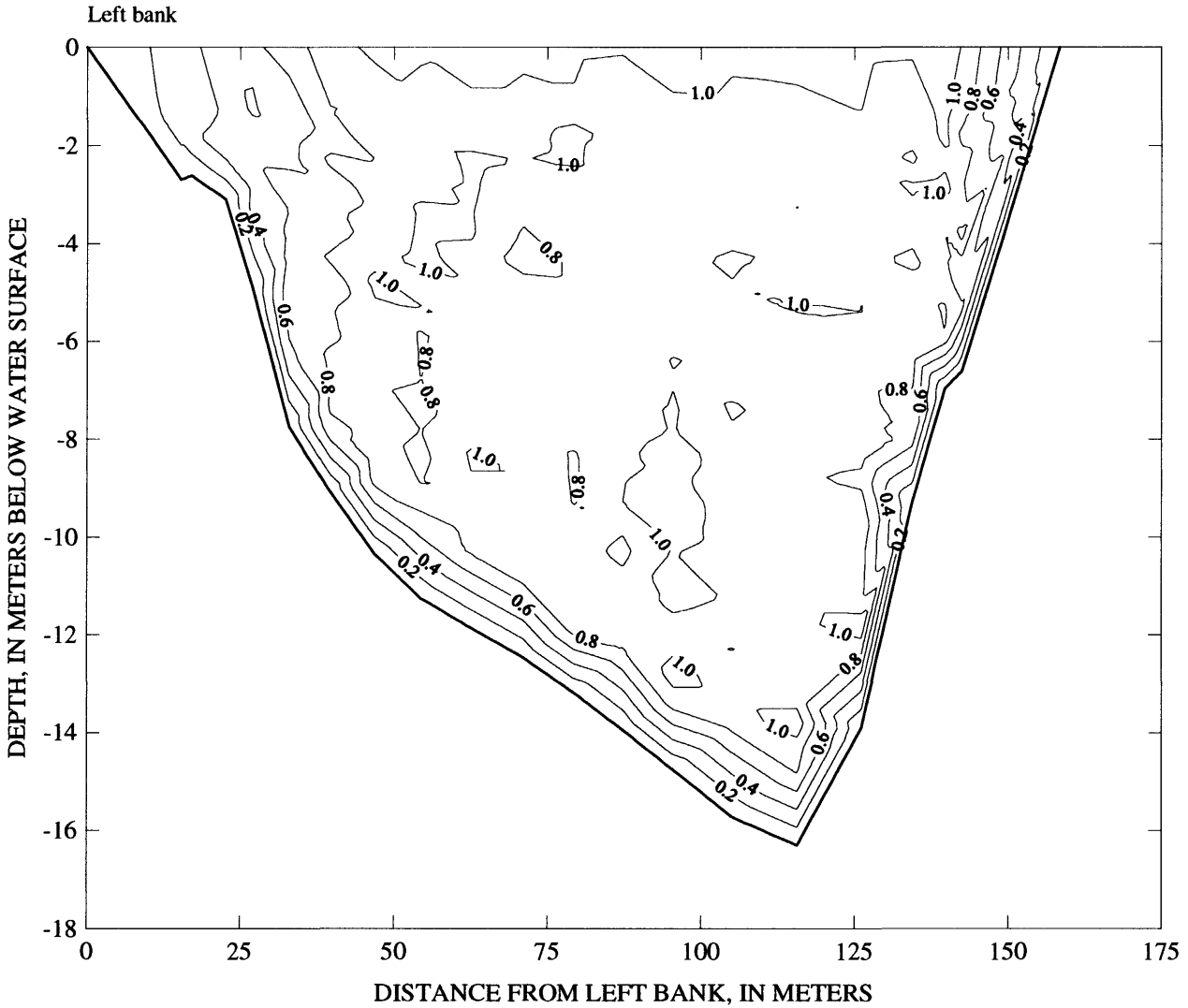

Figure 112. Velocity contours for Kootenai River reach 2, cross-section 48, June 11, 1997. (Contours in meters per second)

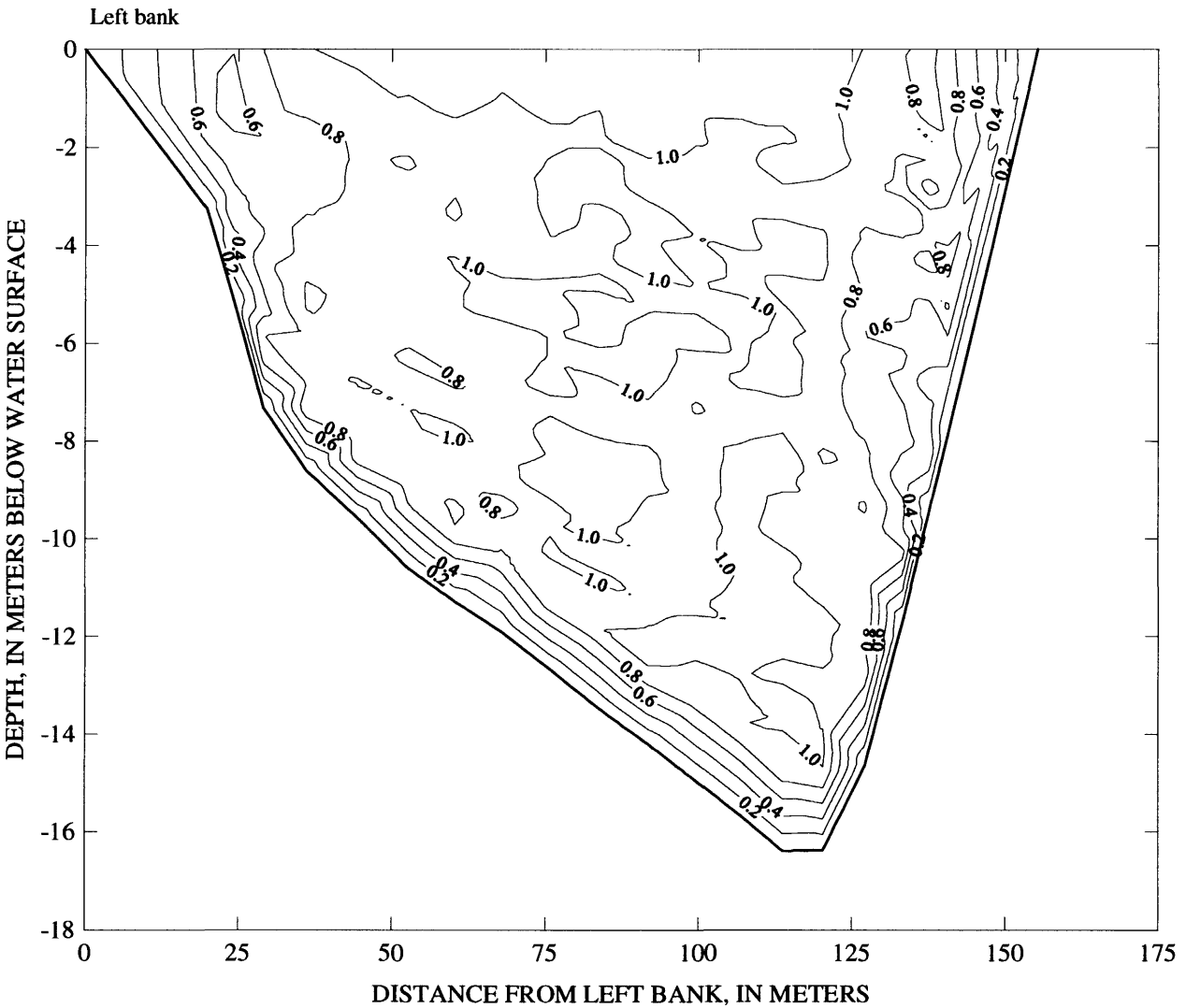

Figure 113. Velocity contours for Kootenai River reach 2, cross-section 49, June 11, 1997. (Contours in meters per second)

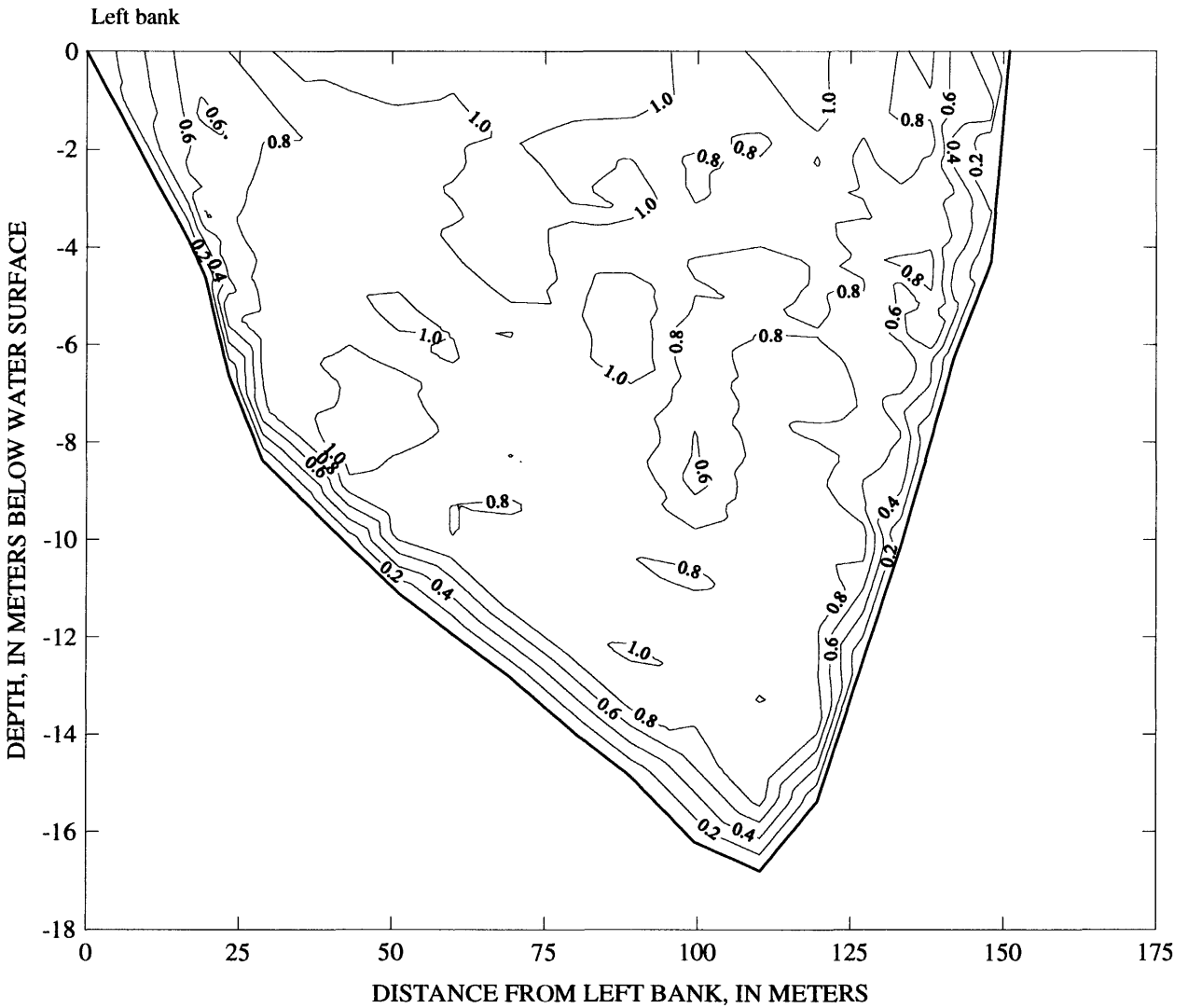

Figure 114. Velocity contours for Kootenai River reach 2, cross-section 50, June 11, 1997. (Contours in meters per second)

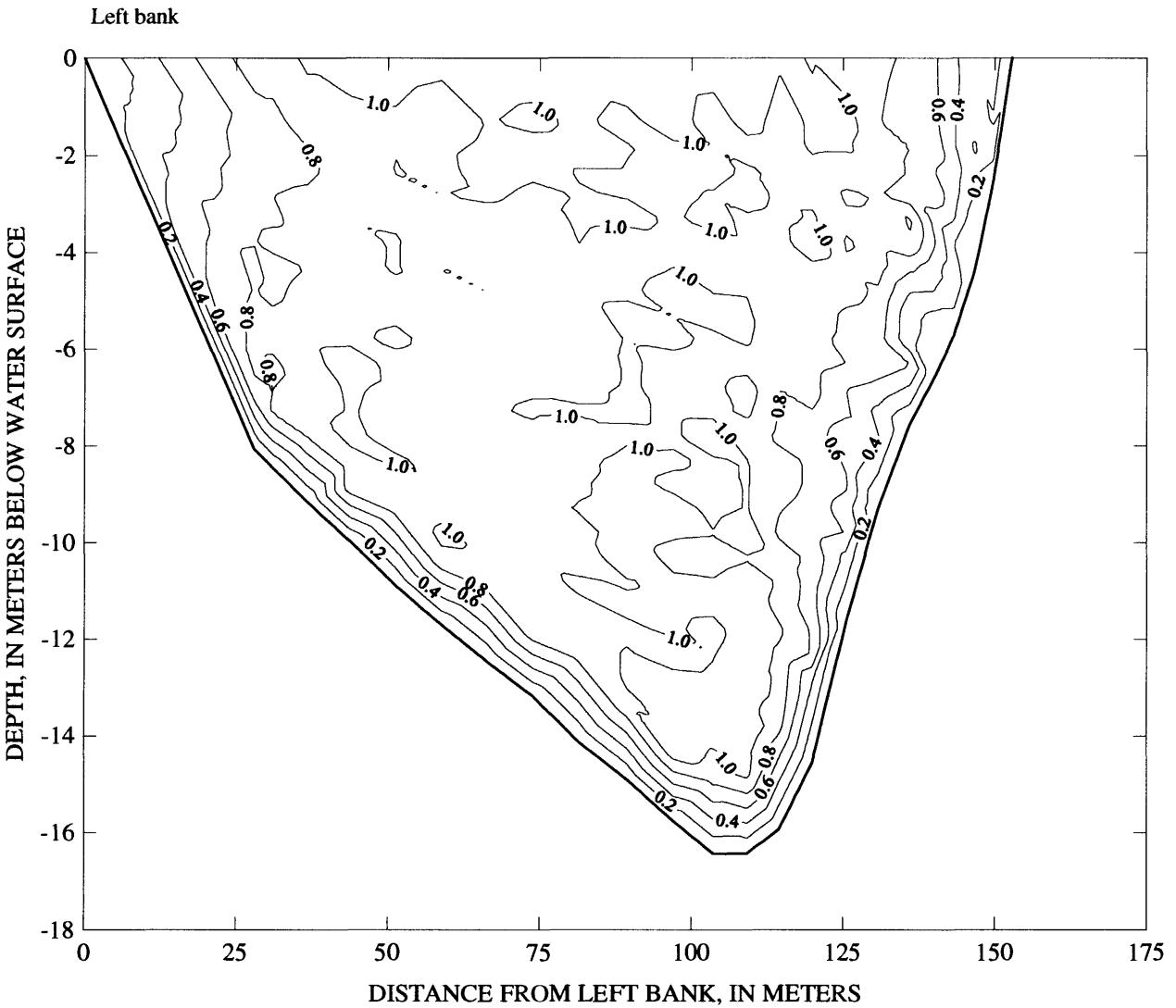

Figure 115. Velocity contours for Kootenai River reach 2, cross-section 51, June 11, 1997. (Contours in meters per second)

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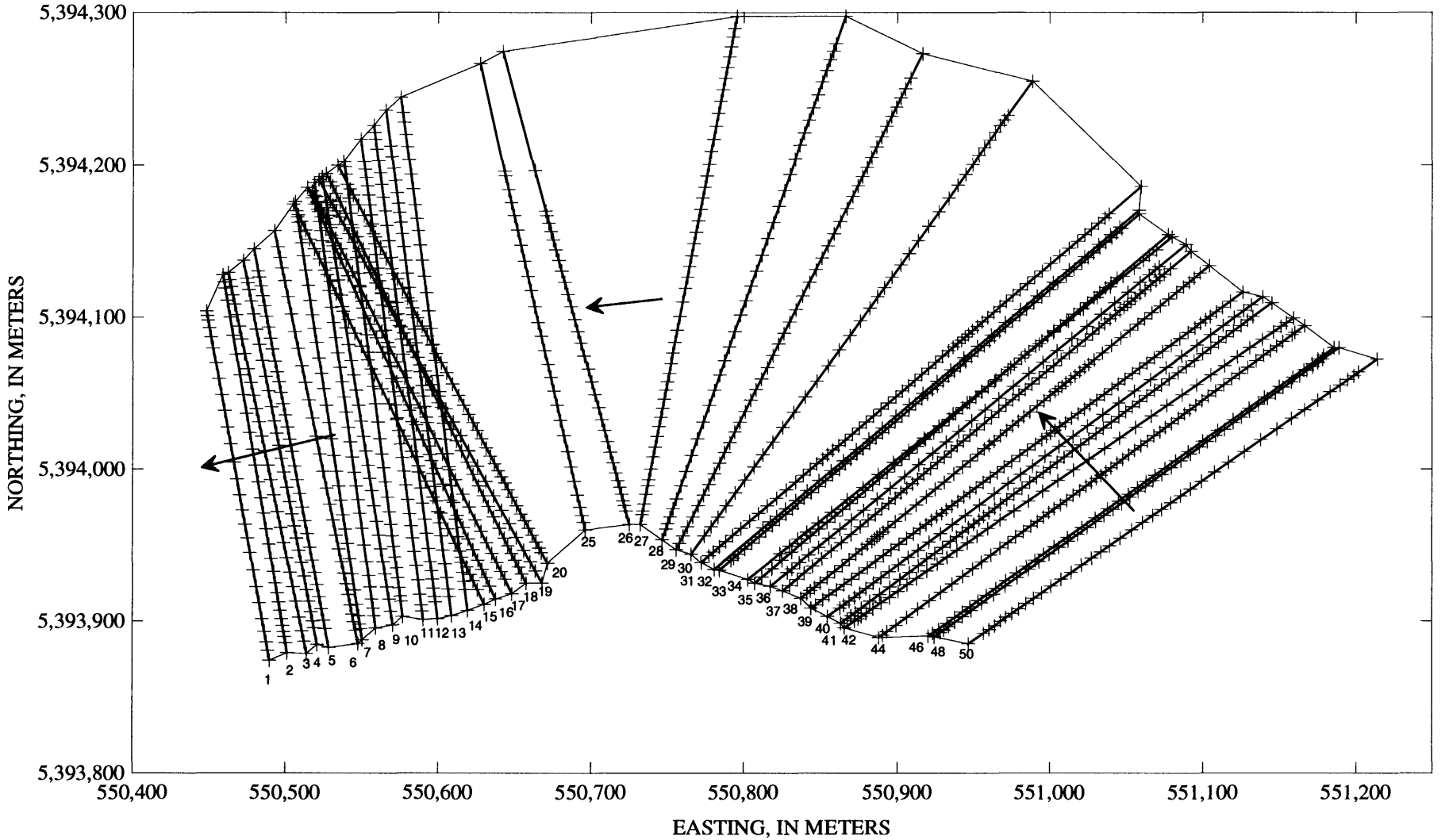

Figure 116. Locations of cross sections and data points in reach 3.
(Arrows indicate direction of streamflow)

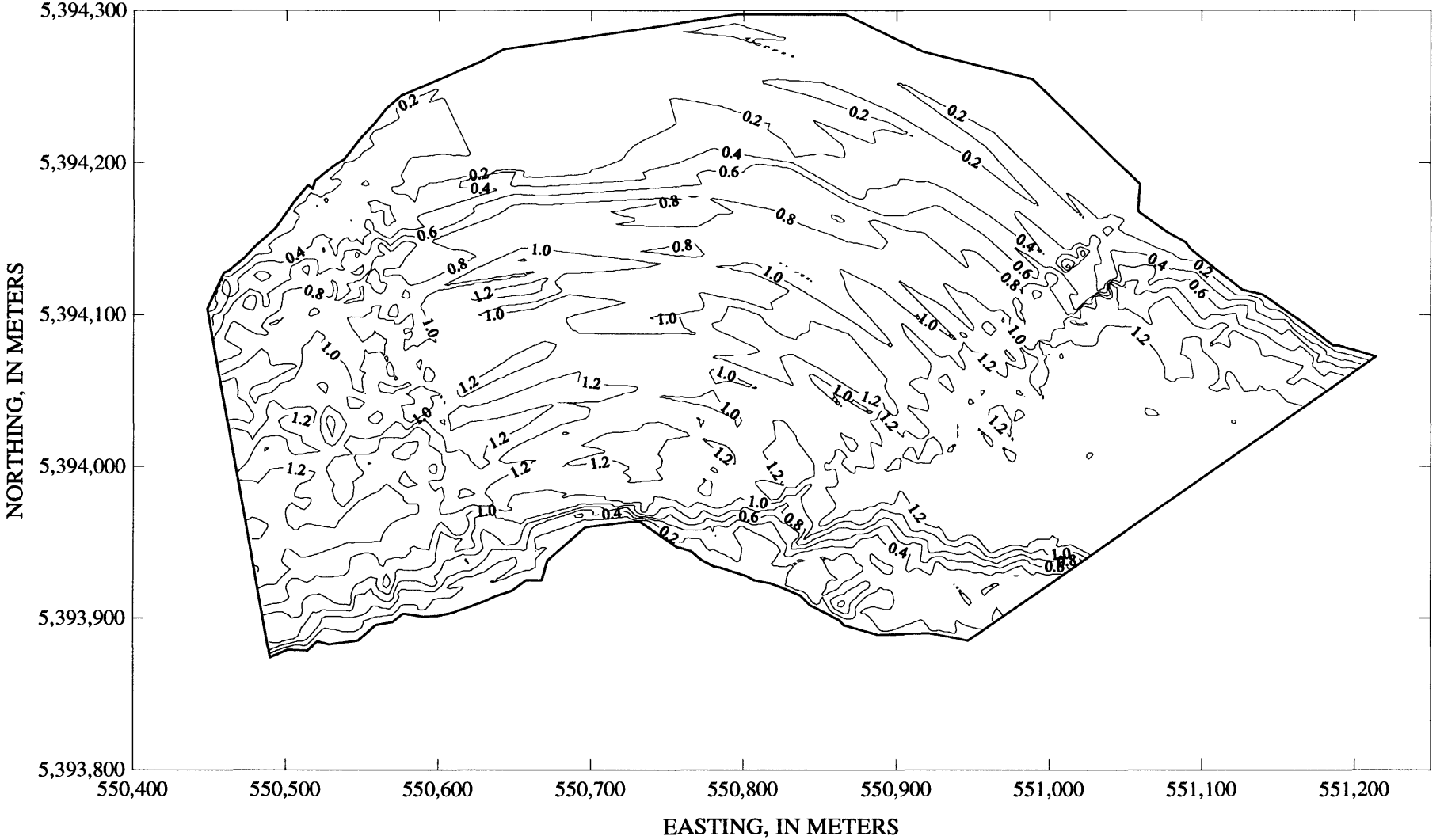

Figure 117. Plan view of velocity contours for Kootenai River reach 3 at a 0-meter depth, June 12, 1997. (Contours in meters per second)

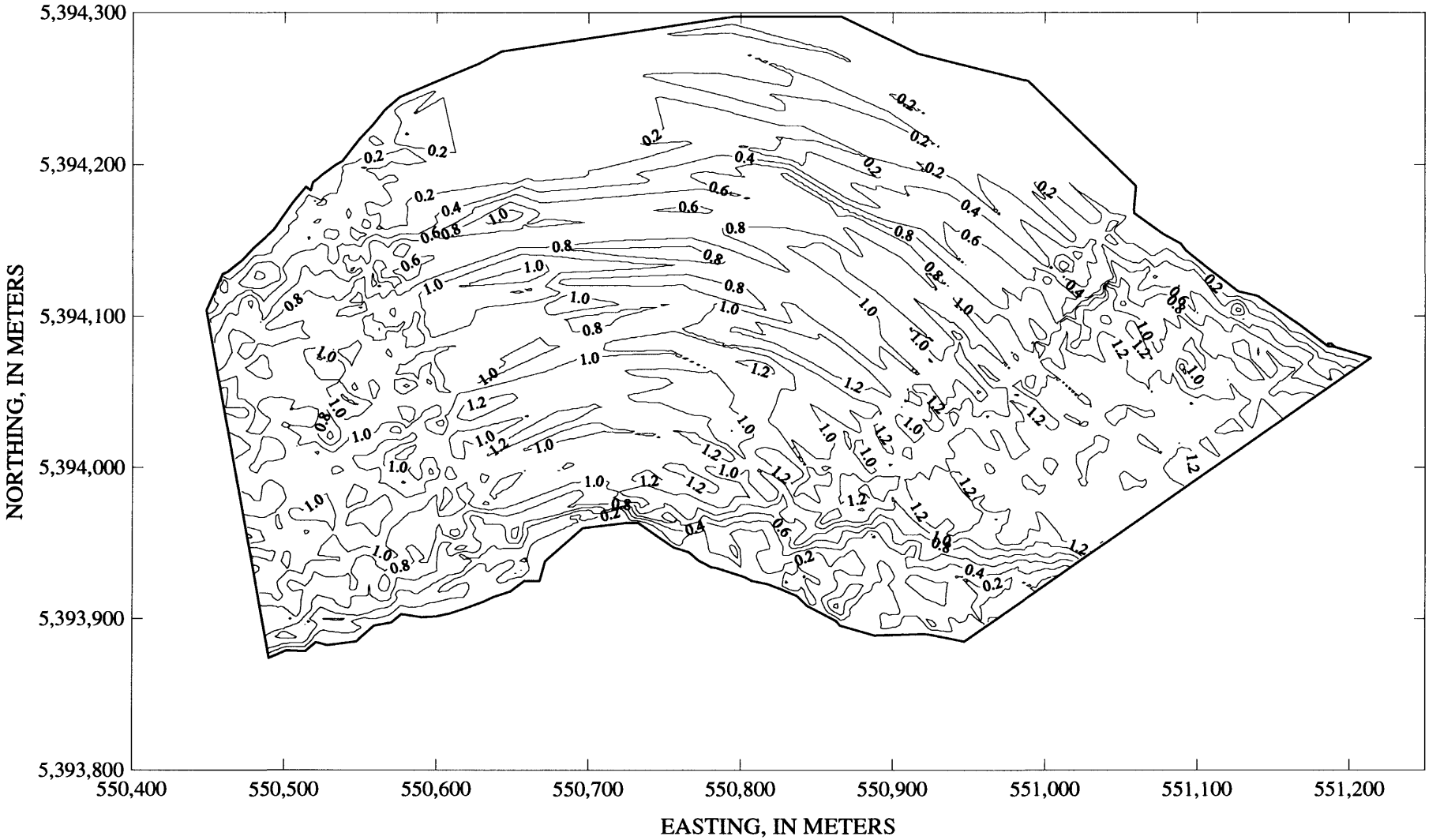

Figure 118. Plan view of velocity contours for Kootenai River reach 3 at a 1.82-meter depth, June 12, 1997. (Contours in meters per second)

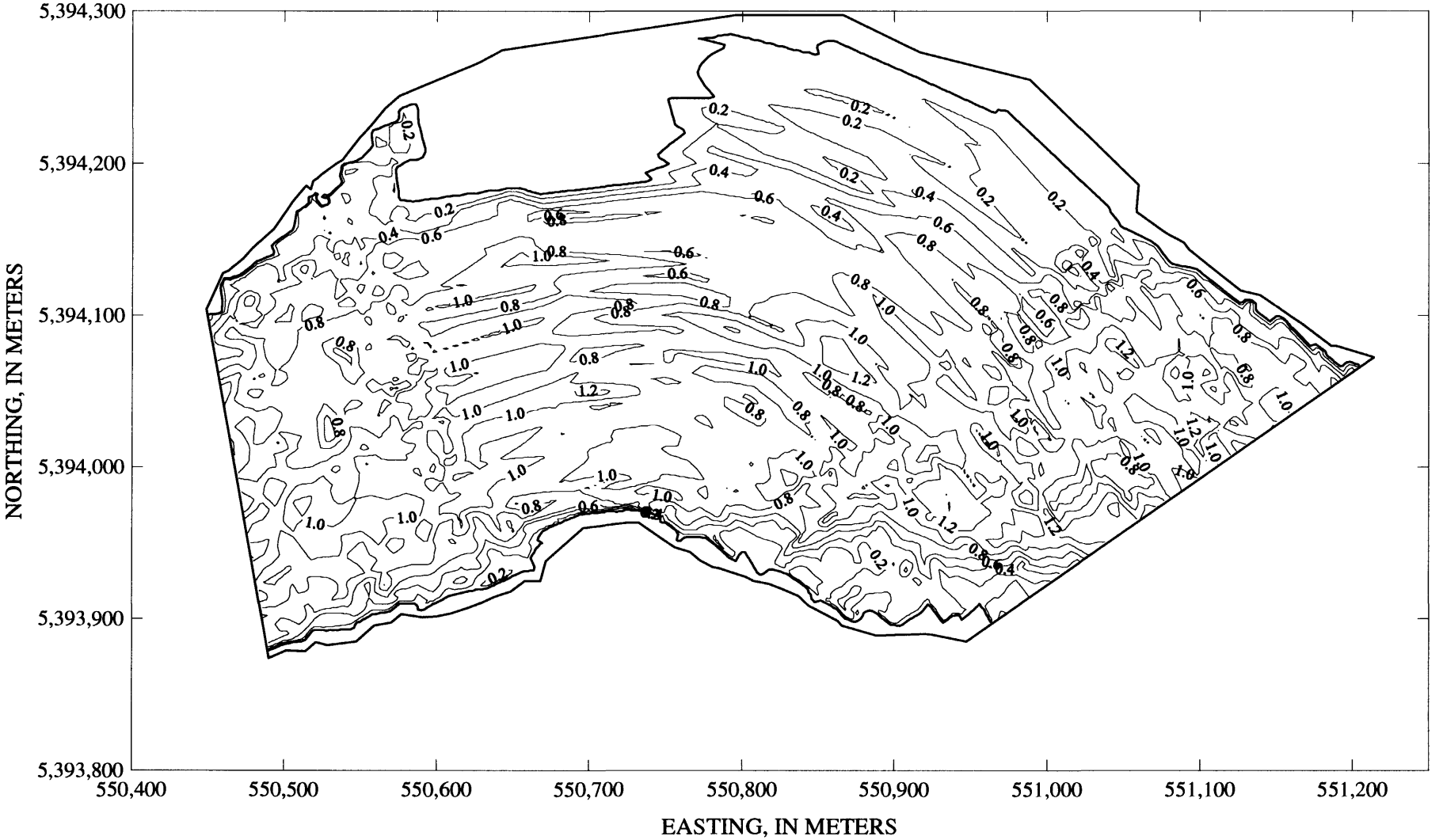

Figure 119. Plan view of velocity contours for Kootenai River reach 3 at a 3.82-meter depth, June 12, 1997. (Contours in meters per second)

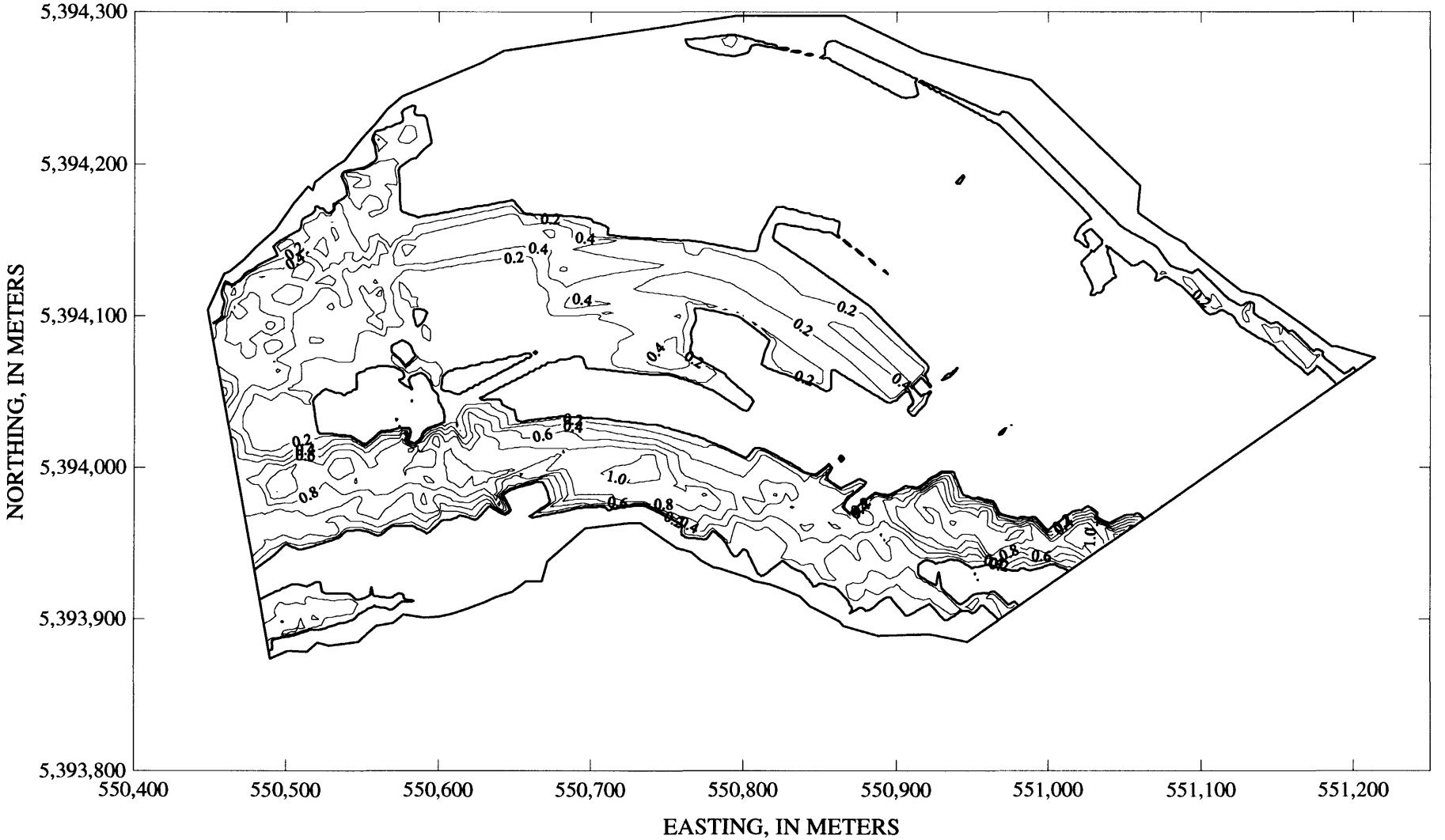

Figure 120. Plan view of velocity contours for Kootenai River reach 3 at a 5.82-meter depth, June 12, 1997. (Contours in meters per second)

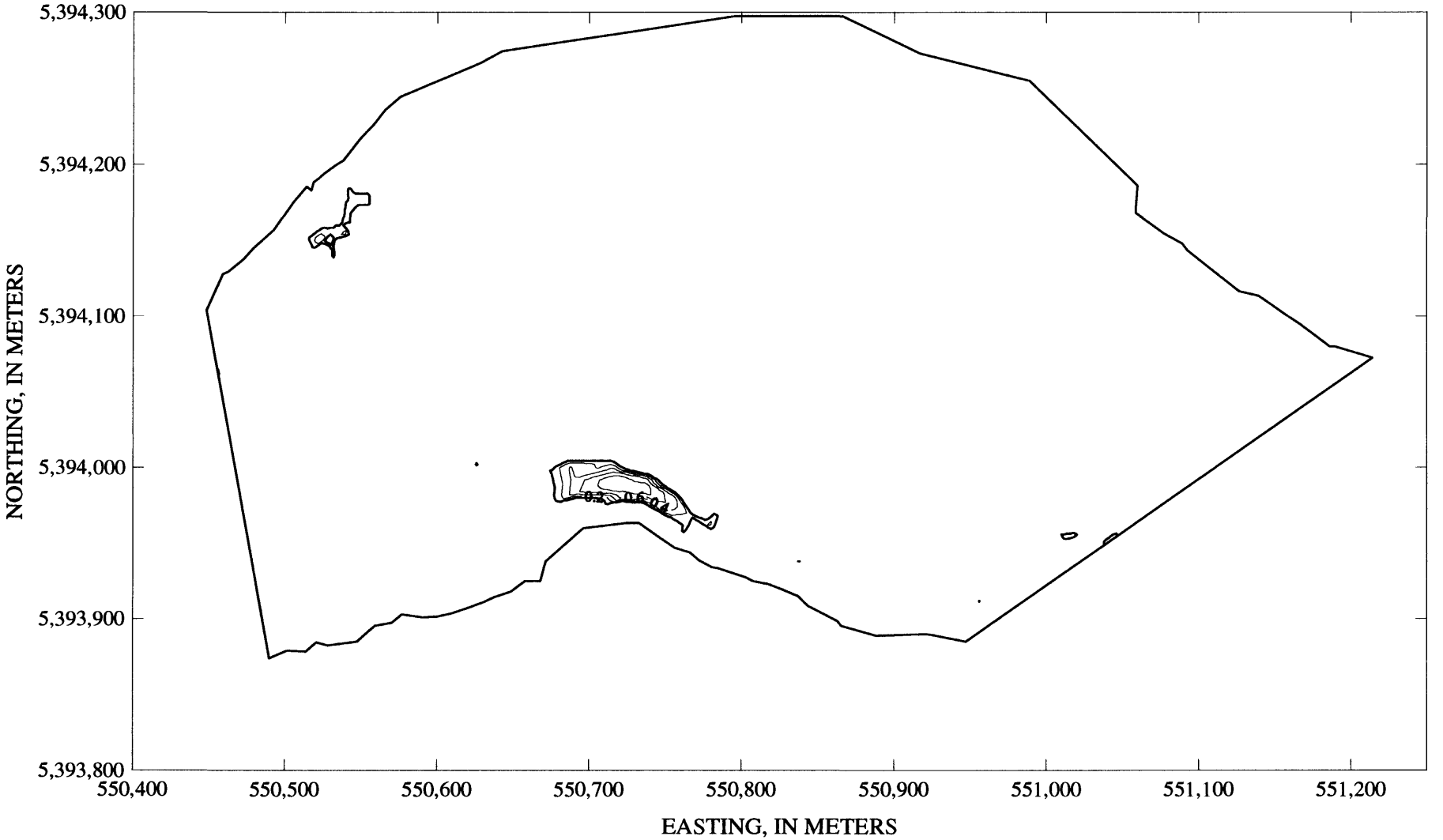

Figure 121. Plan view of velocity contours for Kootenai River reach 3 at a 7.82-meter depth, June 12, 1997. (Contours in meters per second)

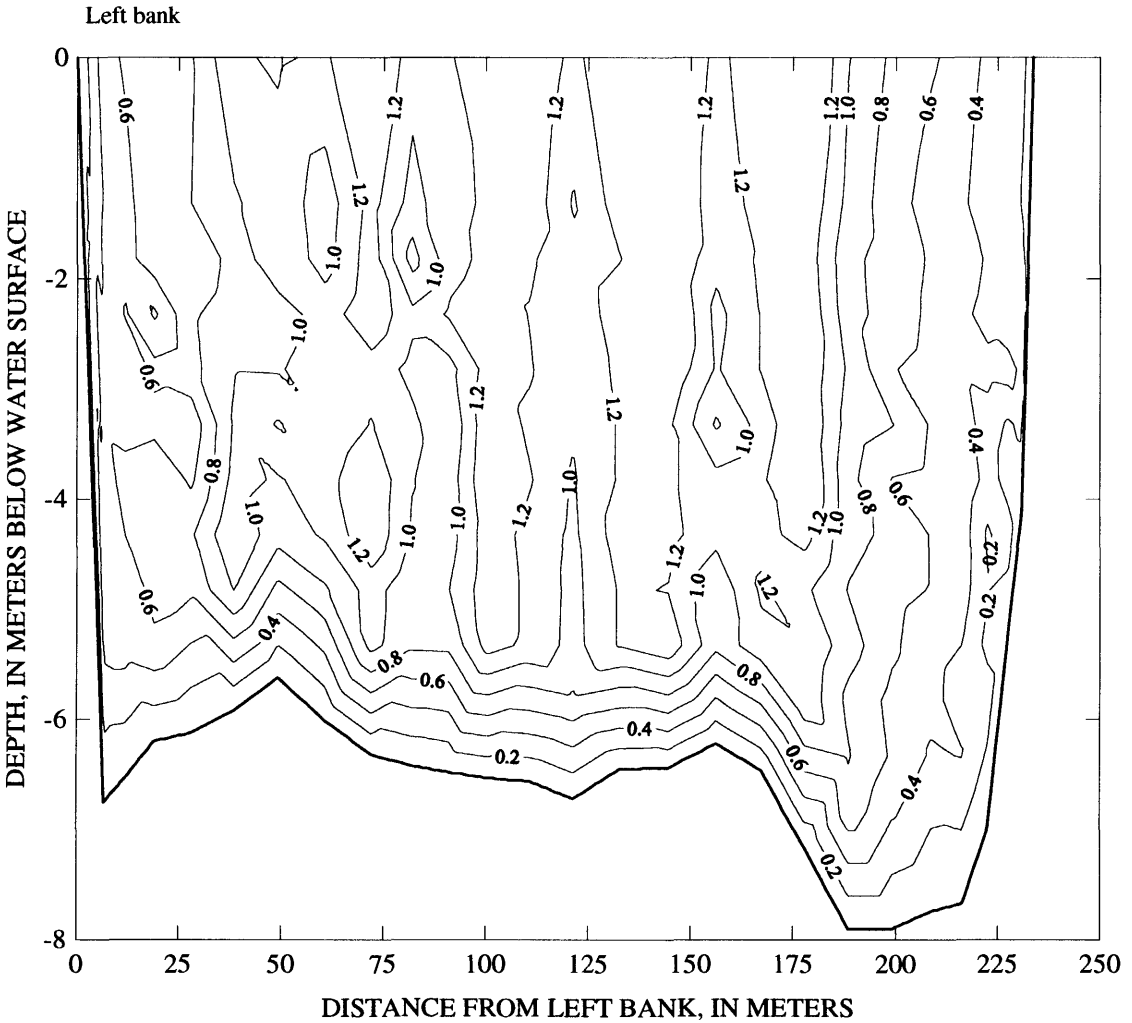

Figure 122. Velocity contours for Kootenai River reach 3, cross-section 1, June 12, 1997. (Contours in meters per second)

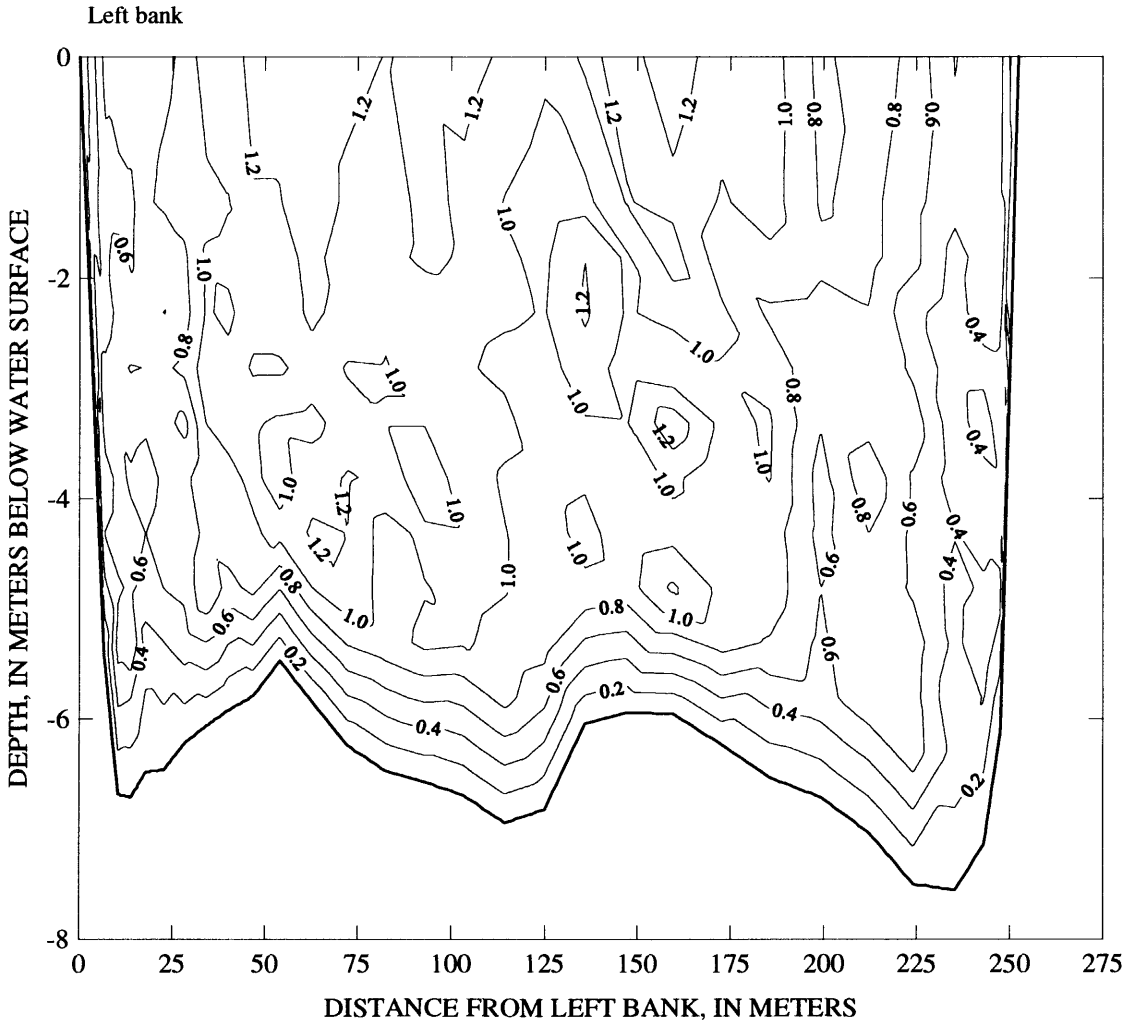

Figure 123. Velocity contours for Kootenai River reach 3, cross-section 2, June 12, 1997. (Contours in meters per second)

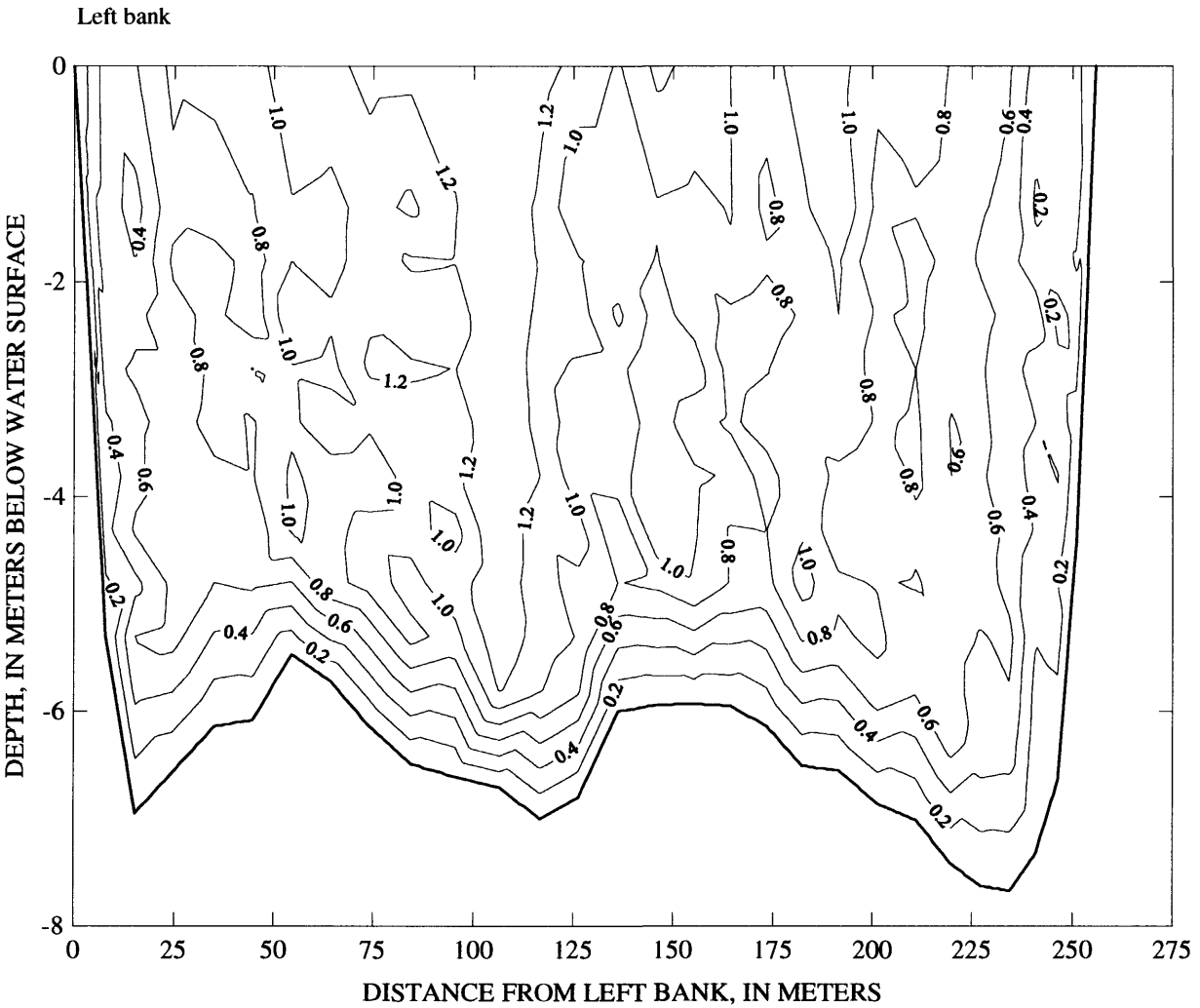

Figure 124. Velocity contours for Kootenai River reach 3, cross-section 3, June 12, 1997. (Contours in meters per second)

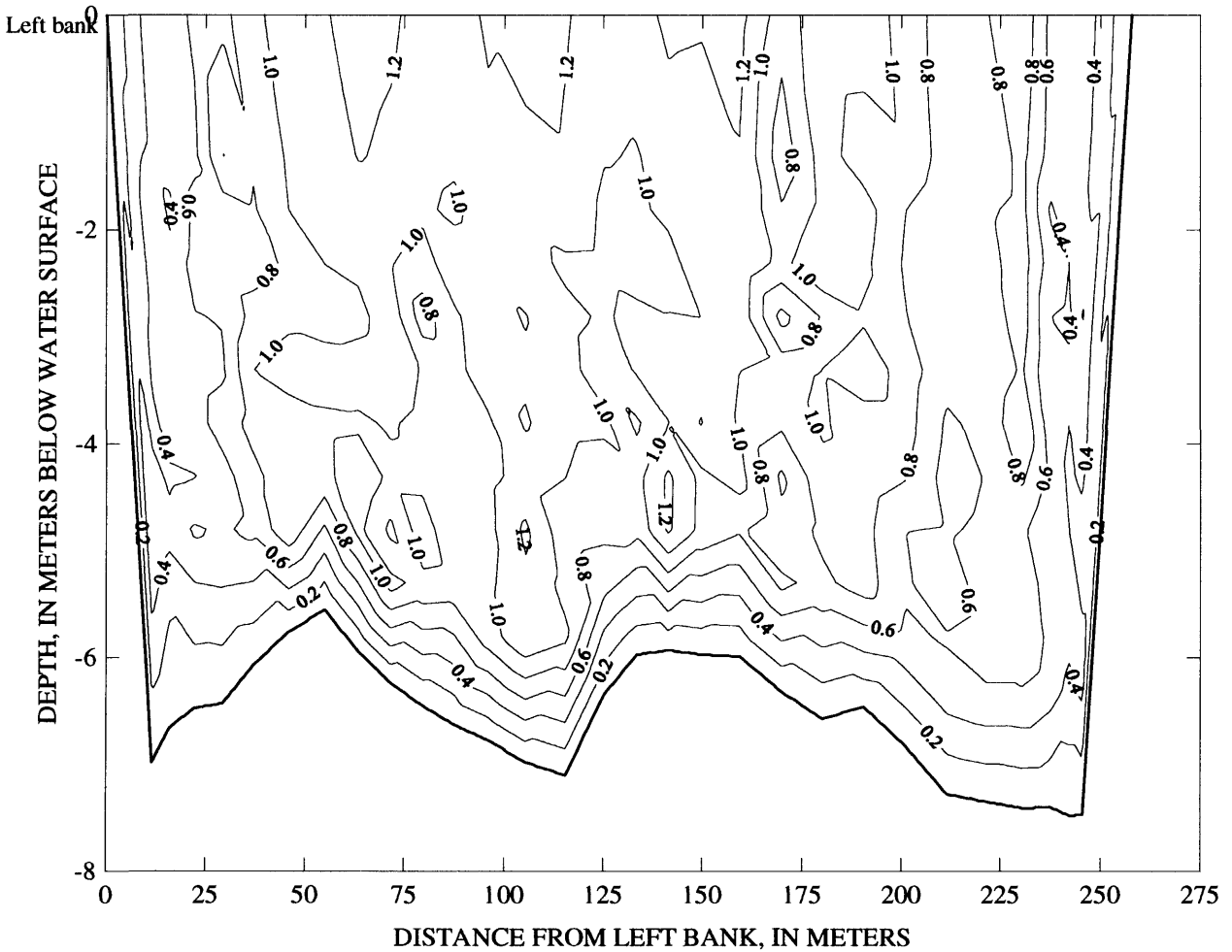

Figure 125. Velocity contours for Kootenai River reach 3, cross-section 4, June 12, 1997. (Contours in meters per second)

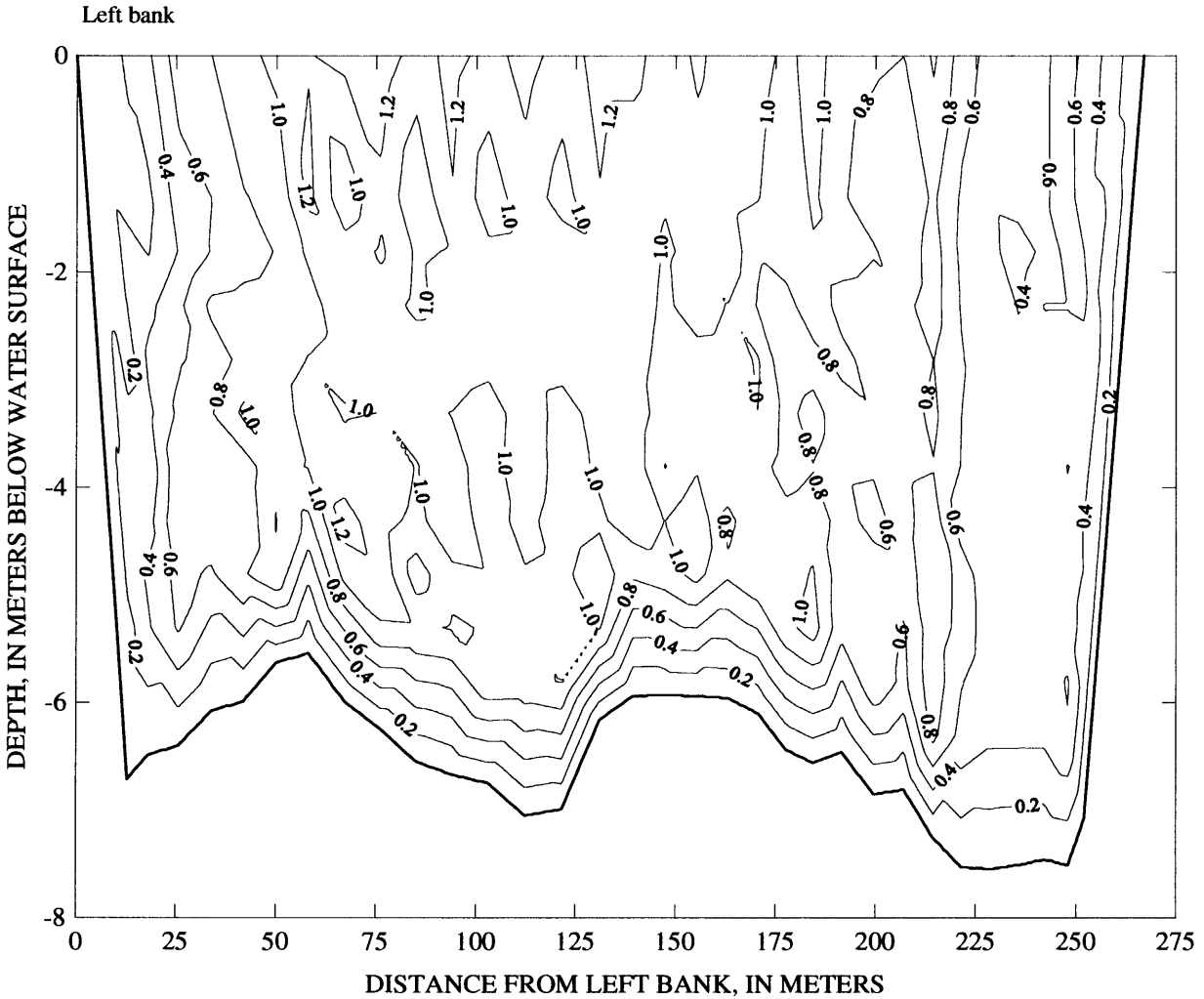

Figure 126. Velocity contours for Kootenai River reach 3, cross-section 5, June 12, 1997. (Contours in meters per second)

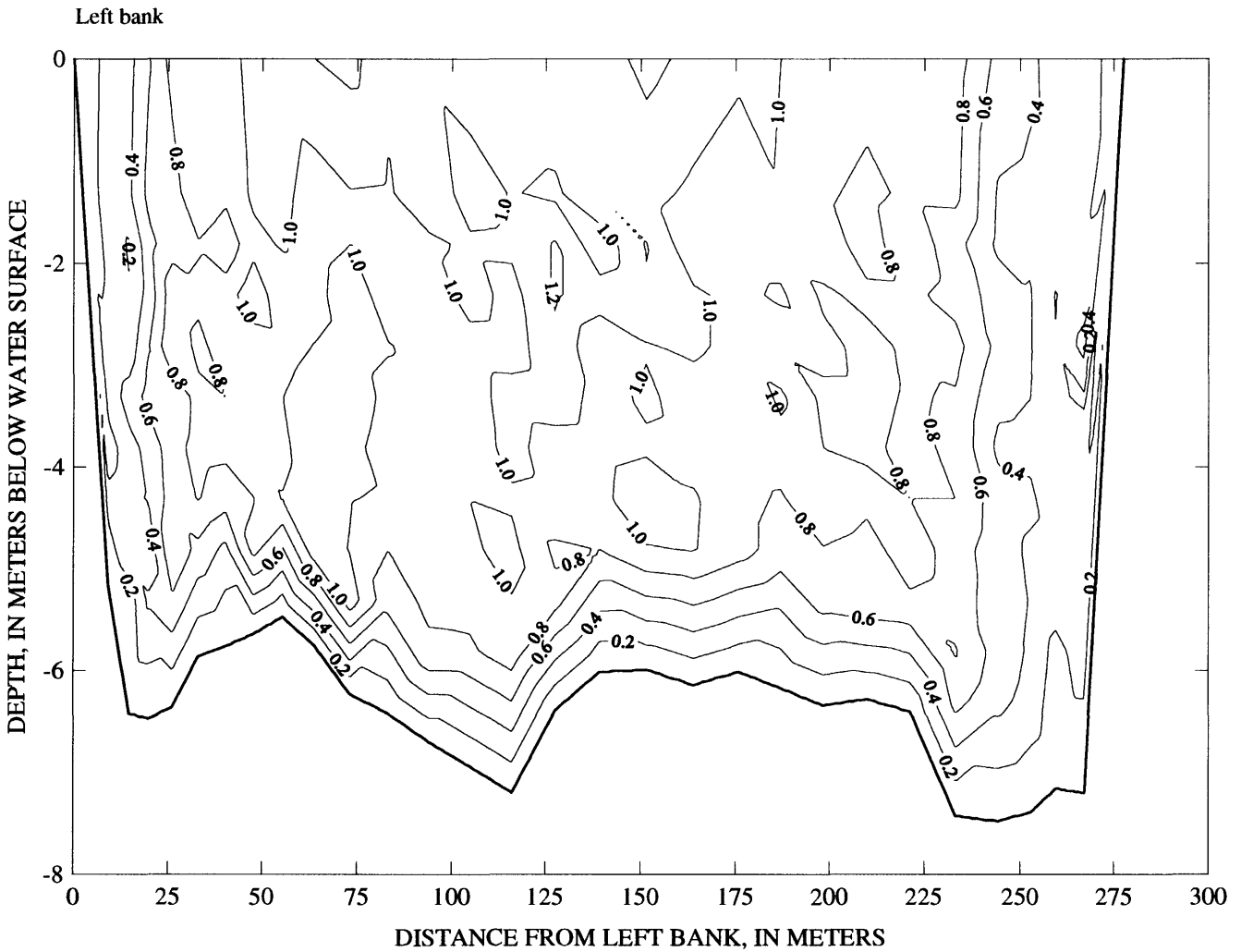

Figure 127. Velocity contours for Kootenai River reach 3, cross-section 6, June 12, 1997. (Contours in meters per second)

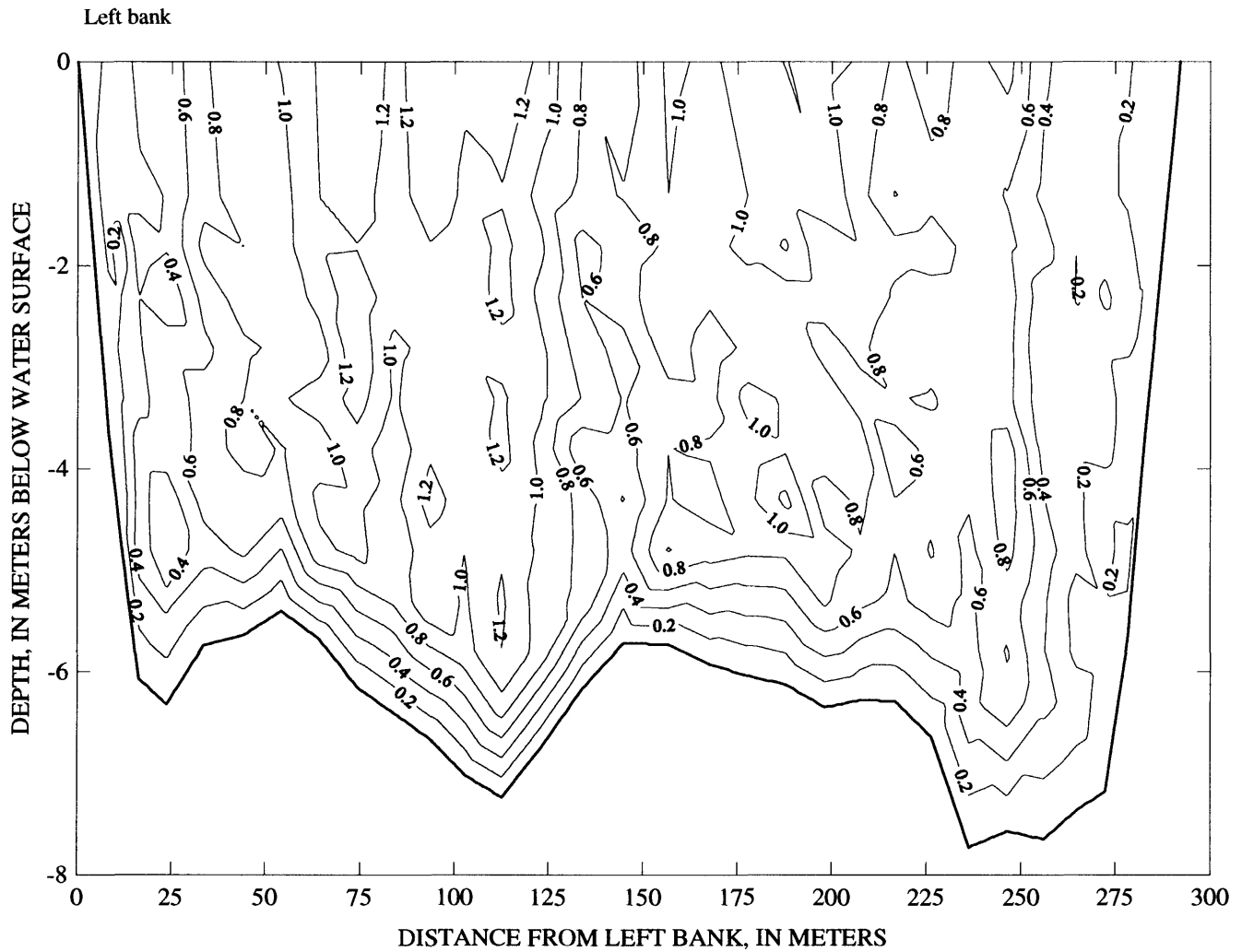

Figure 128. Velocity contours for Kootenai River reach 3, cross-section 7, June 12, 1997. (Contours in meters per second)

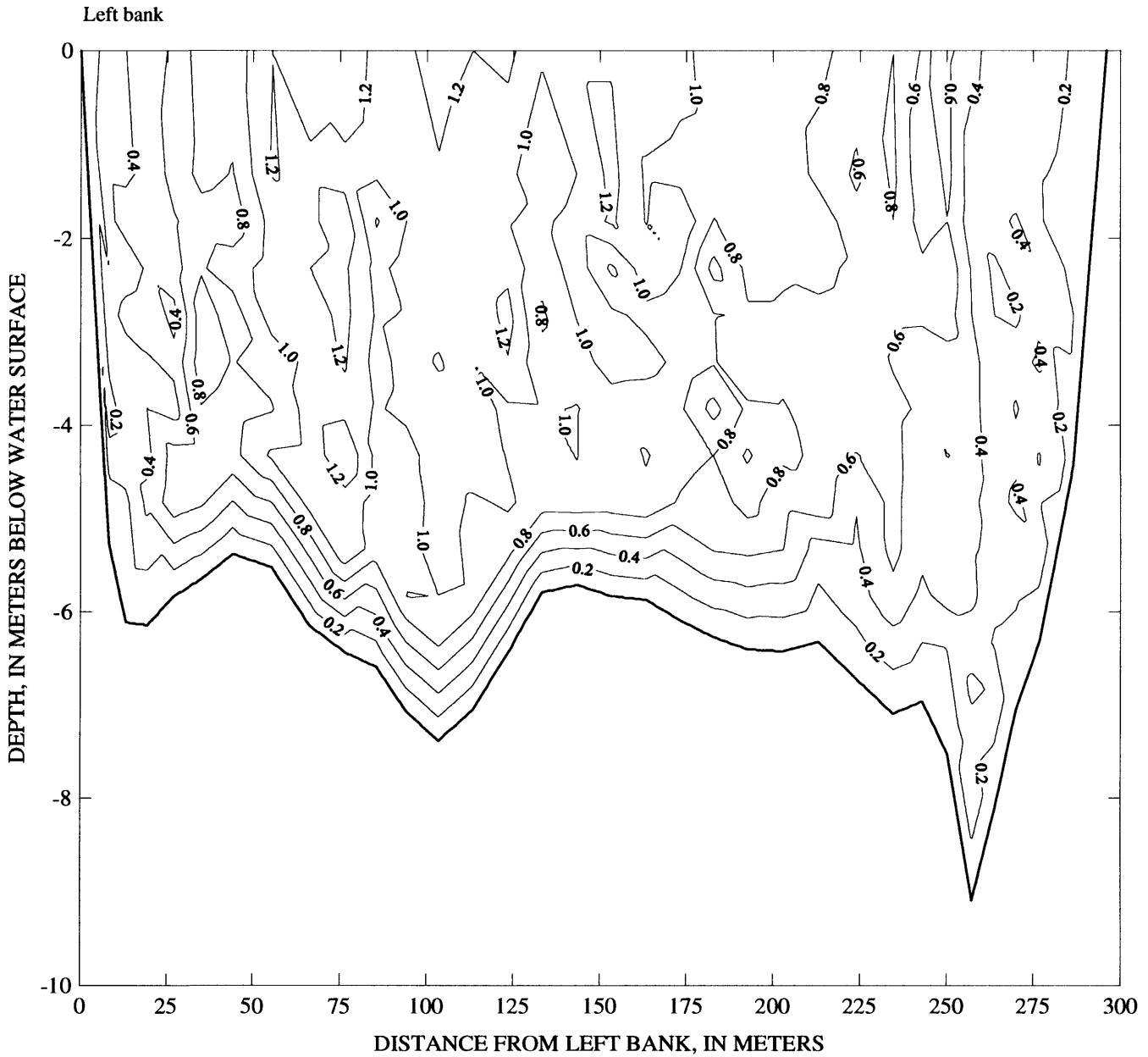

Figure 129. Velocity contours for Kootenai River reach 3, cross-section 8, June 12, 1997.
(Contours in meters per second)

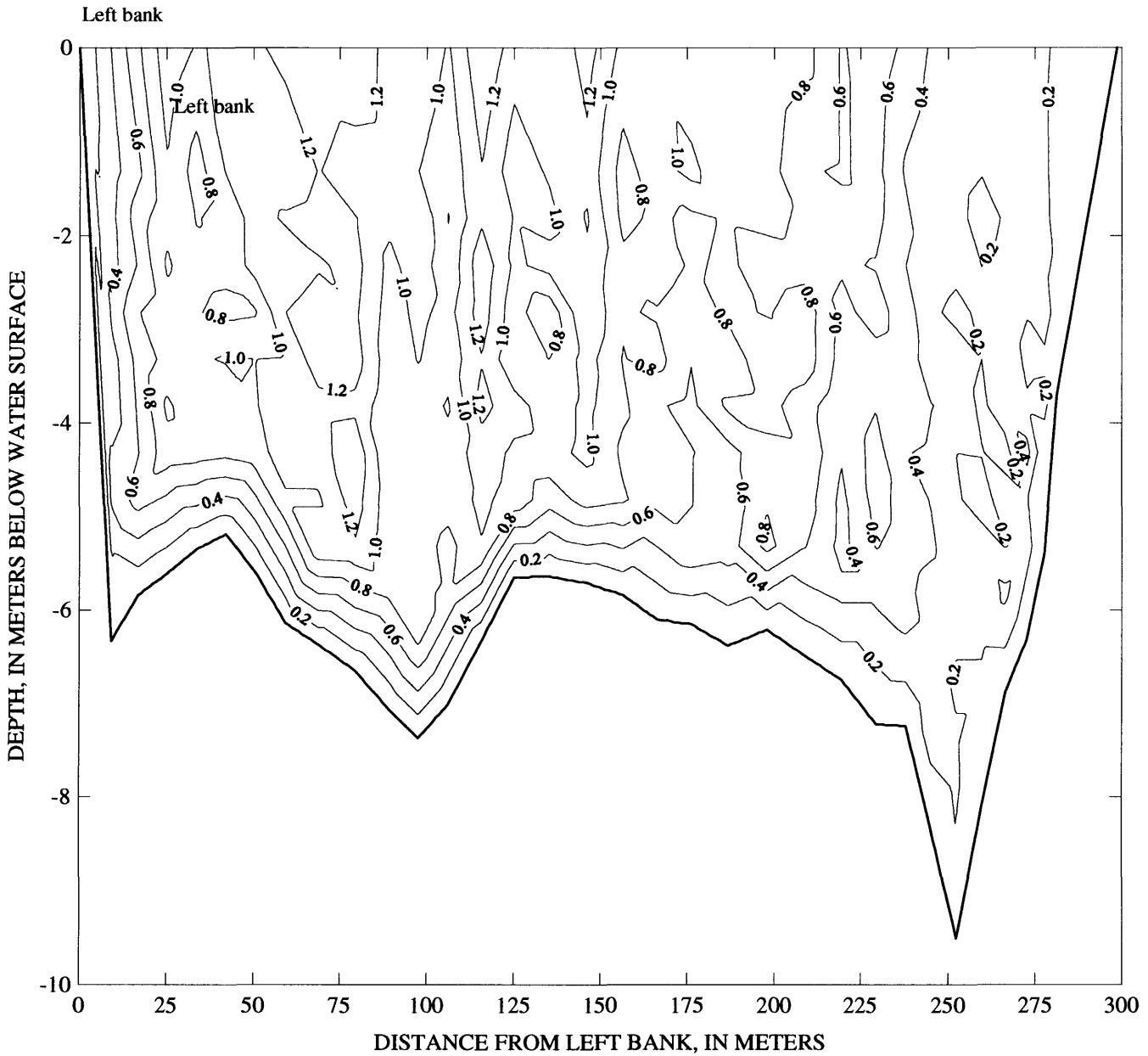

Figure 130. Velocity contours for Kootenai River reach 3, cross-section 9, June 12, 1997. (Contours in meters per second)

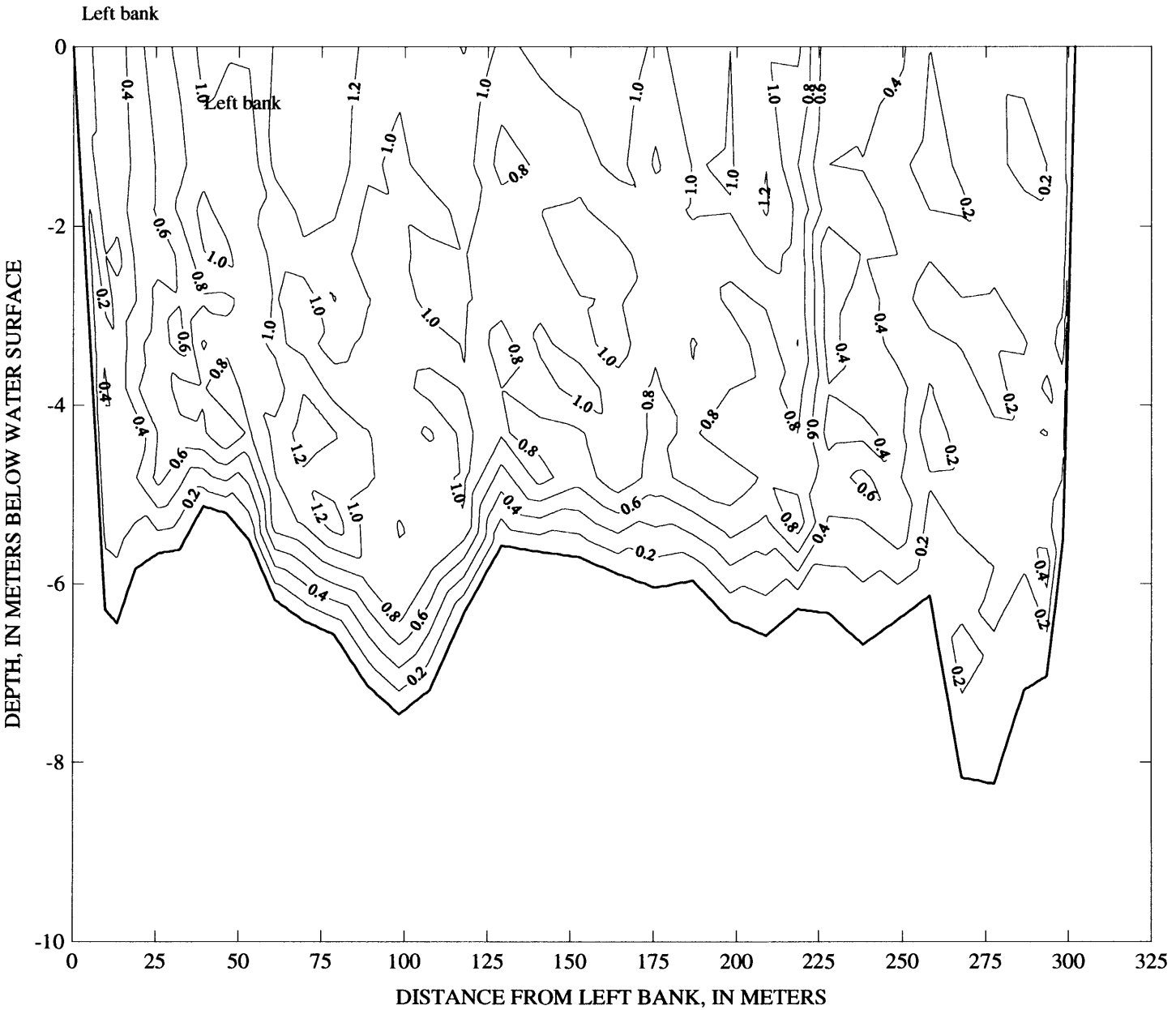

Figure 131. Velocity contours for Kootenai River reach 3, cross-section 10, June 12, 1997. (Contours in meters per second)

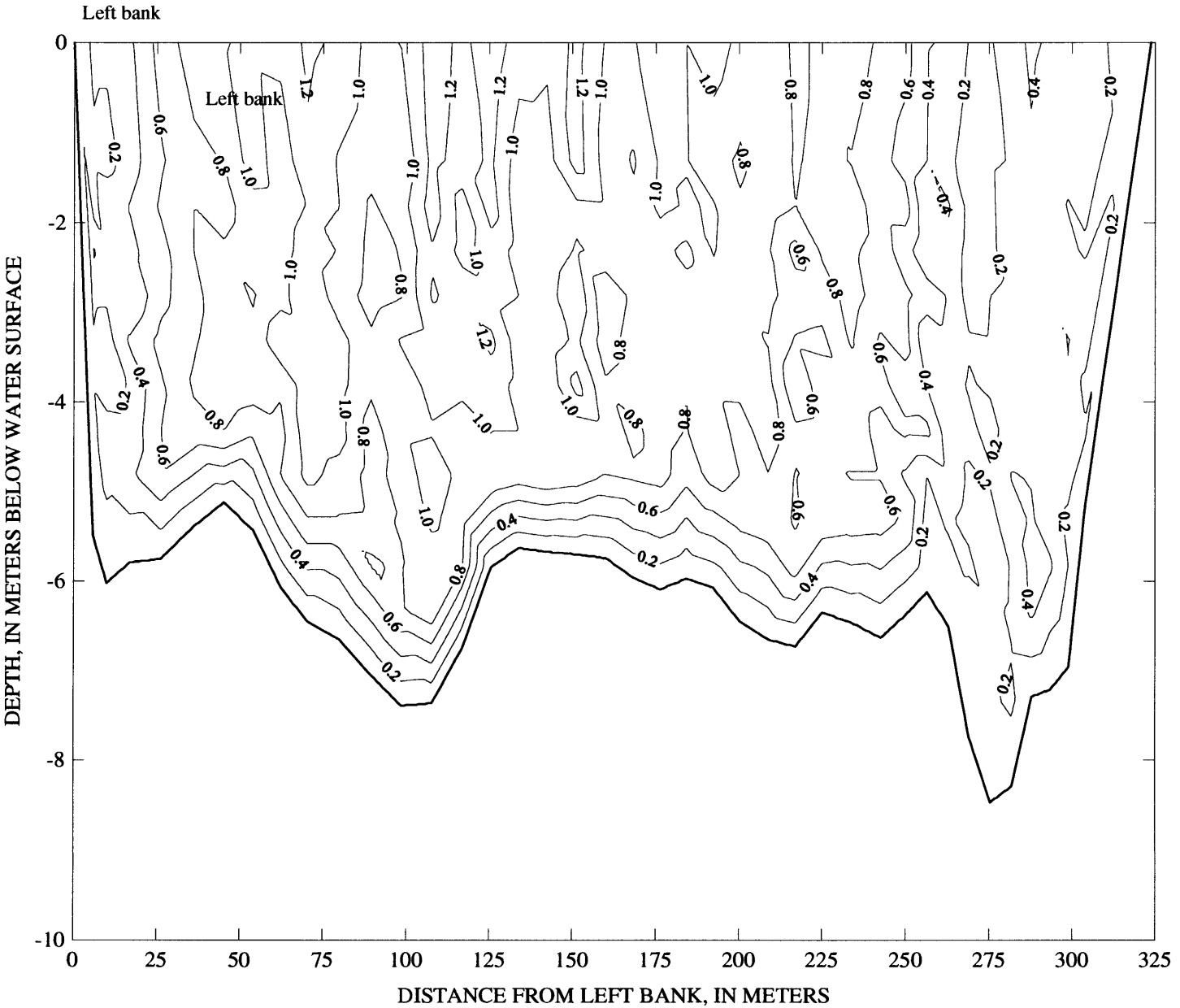

Figure 132. Velocity contours for Kootenai River reach 3, cross-section 11, June 12, 1997. (Contours in meters per second)

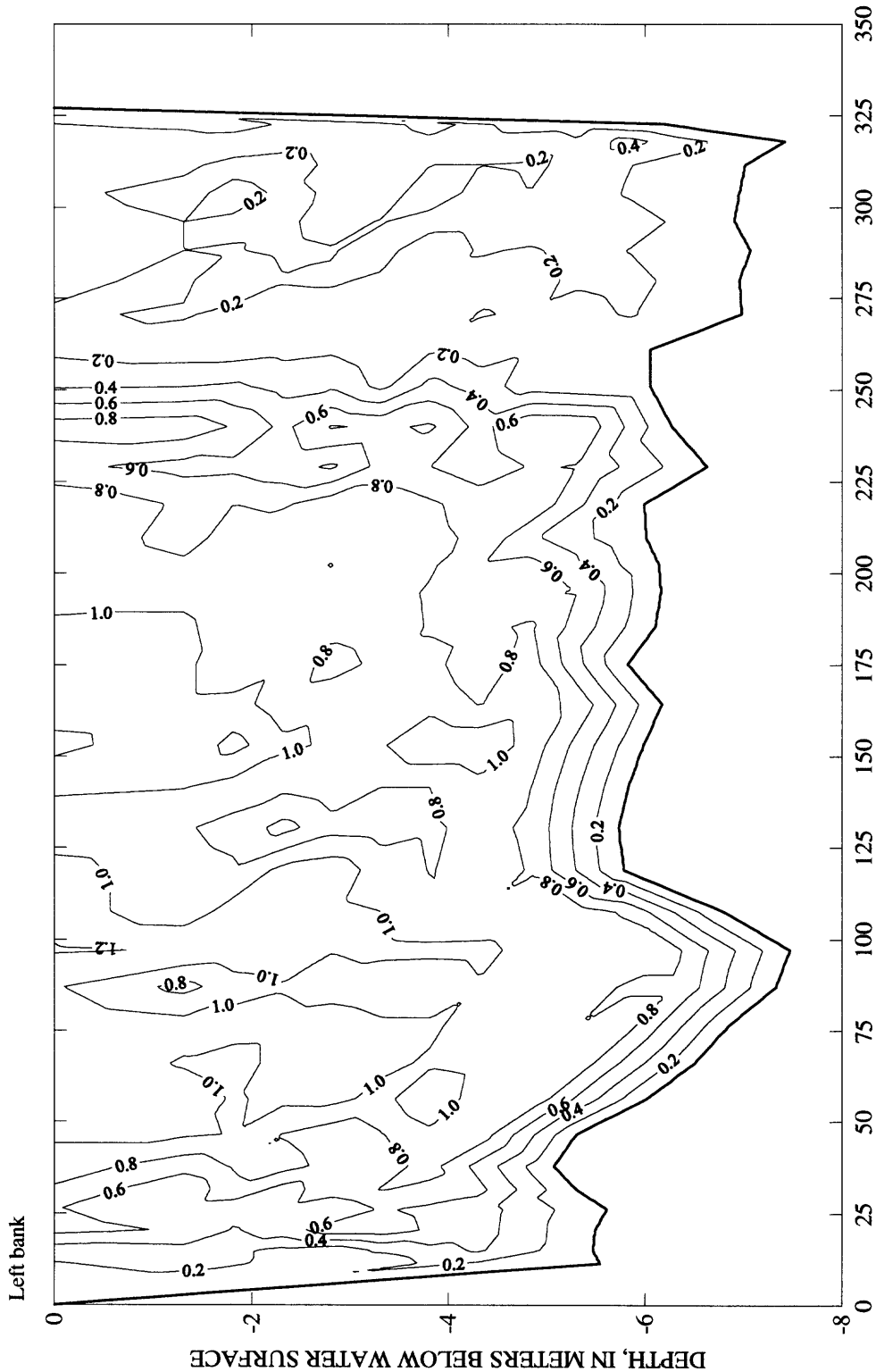

Figure 133. Velocity contours for Kootenai River reach 3, cross-section 12, June 12, 1997.
(Contours in meters per second)

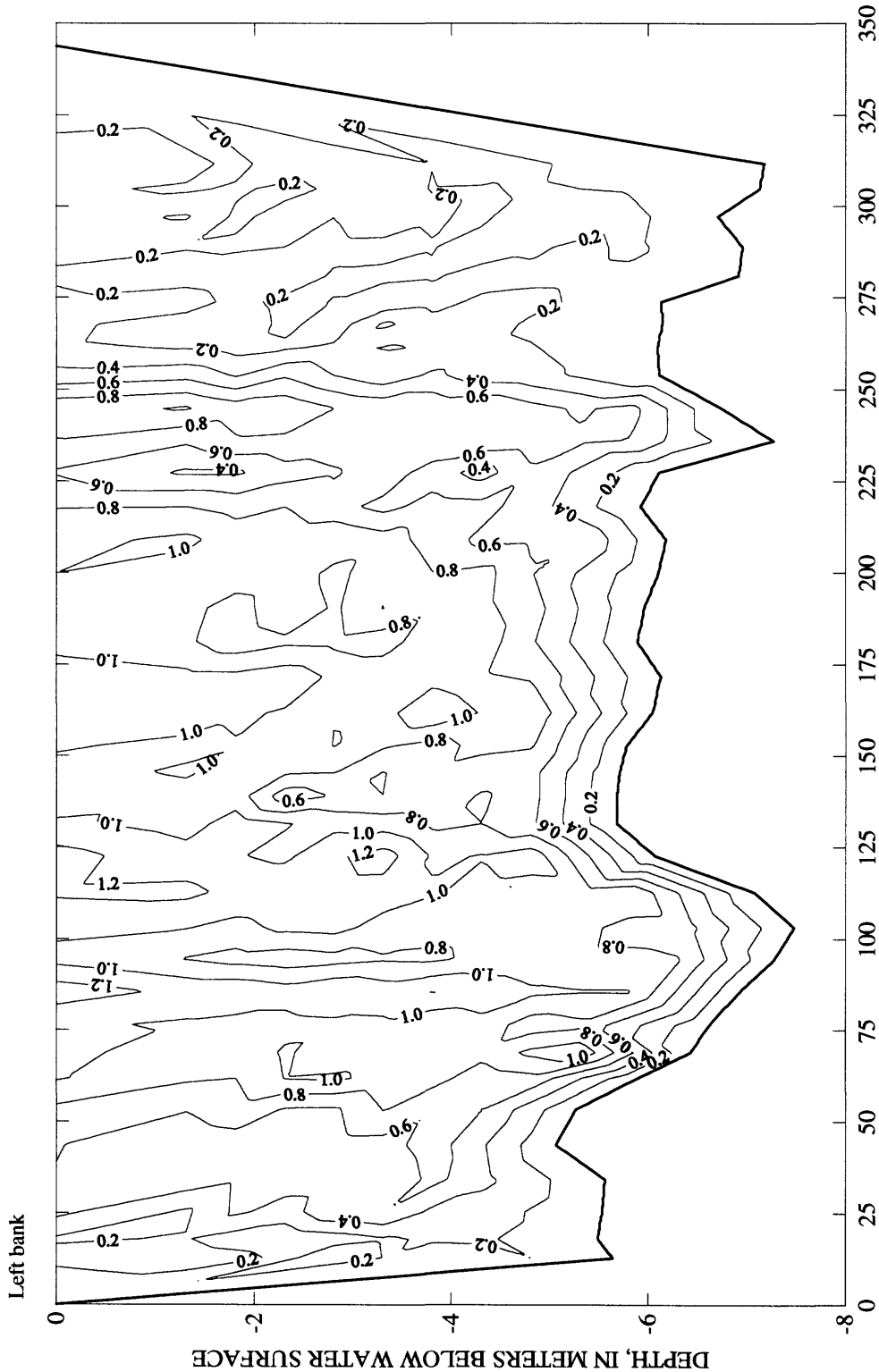

Figure 134. Velocity contours for Kootenai River reach 3, cross-section 13, June 12, 1997.
(Contours in meters per second)

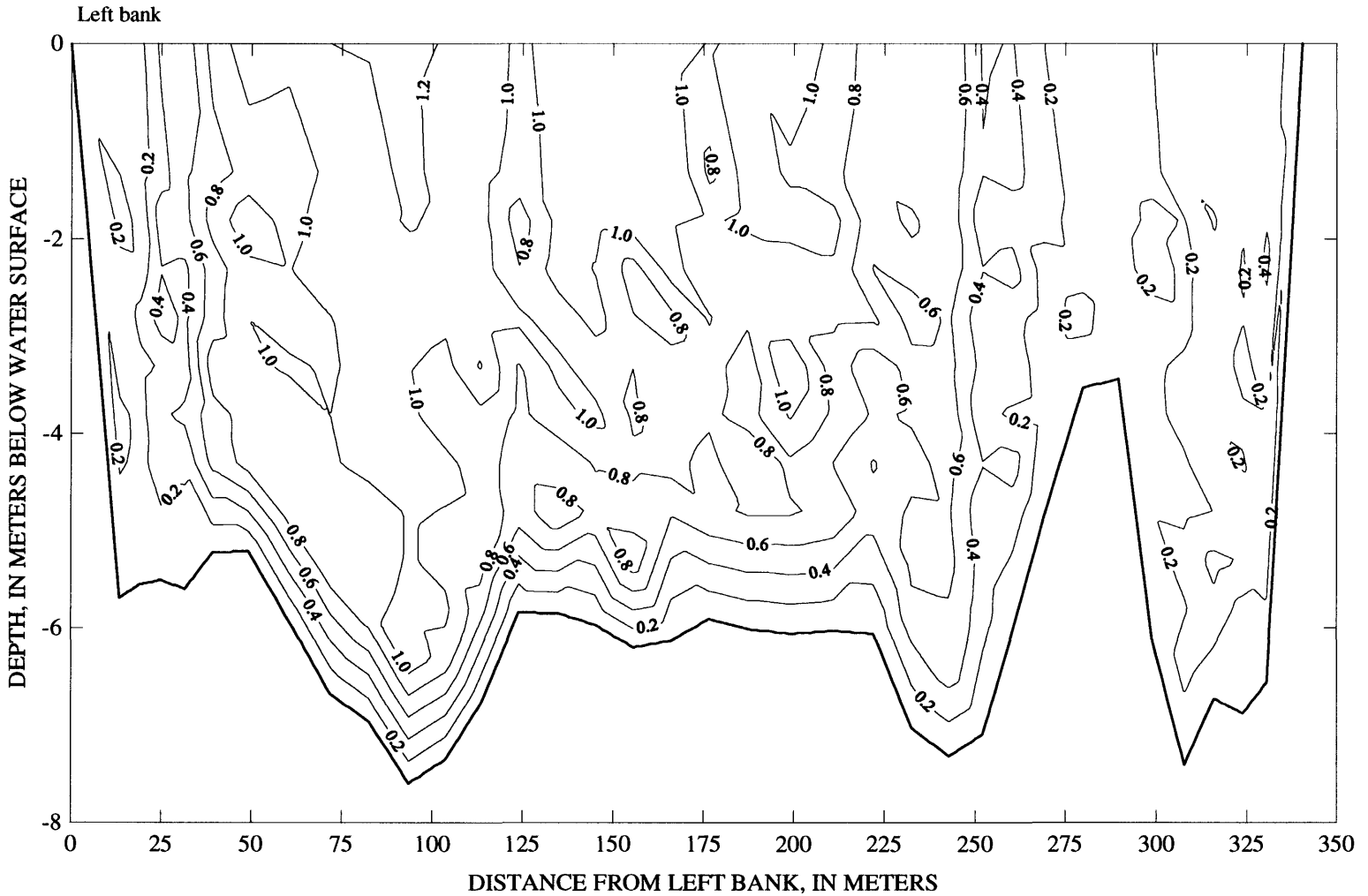

Figure 135. Velocity contours for Kootenai River reach 3, cross-section 14, June 12, 1997. (Contours in meters per second)

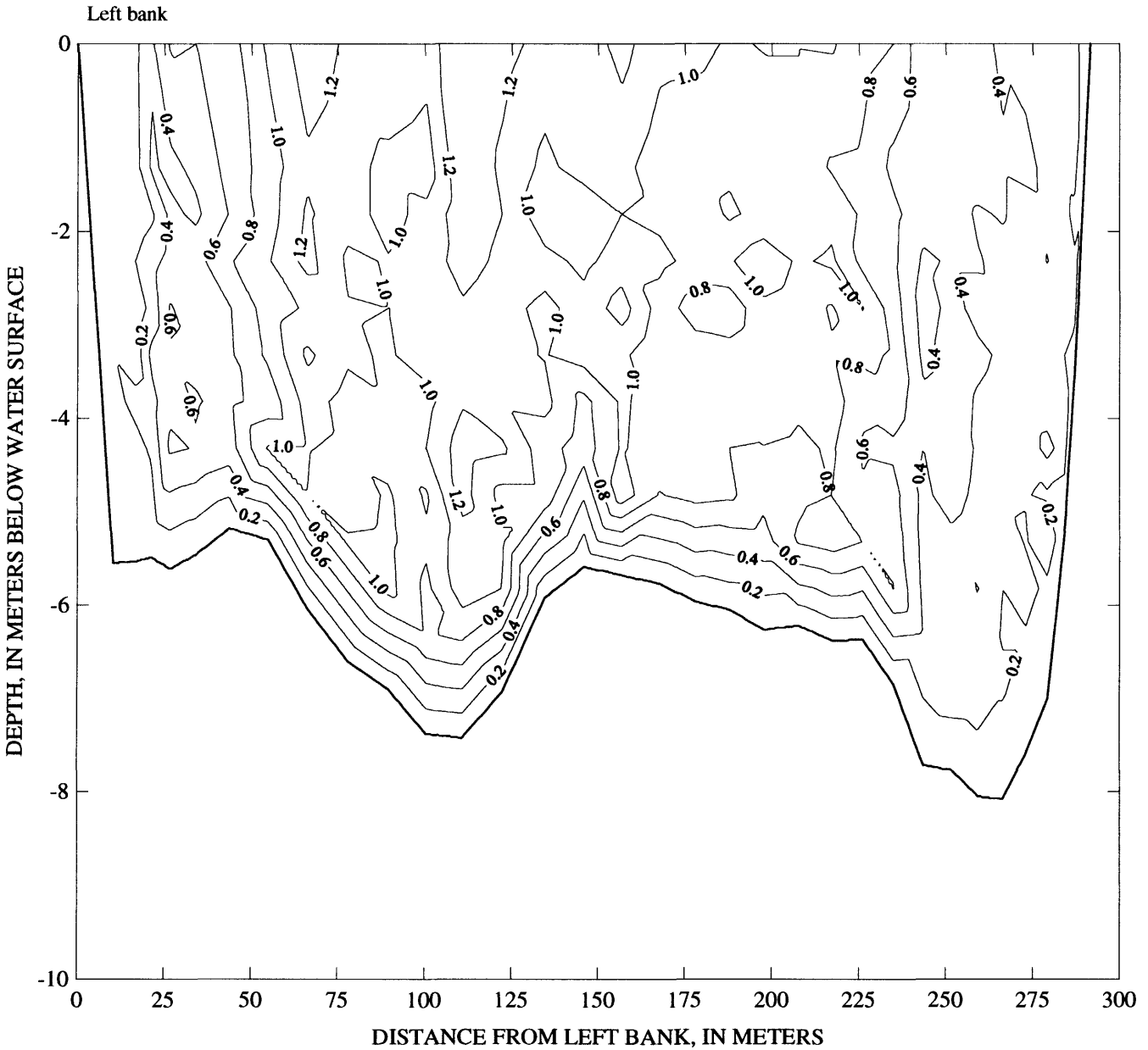

Figure 136. Velocity contours for Kootenai River reach 3, cross-section 15, June 12, 1997. (Contours in meters per second)

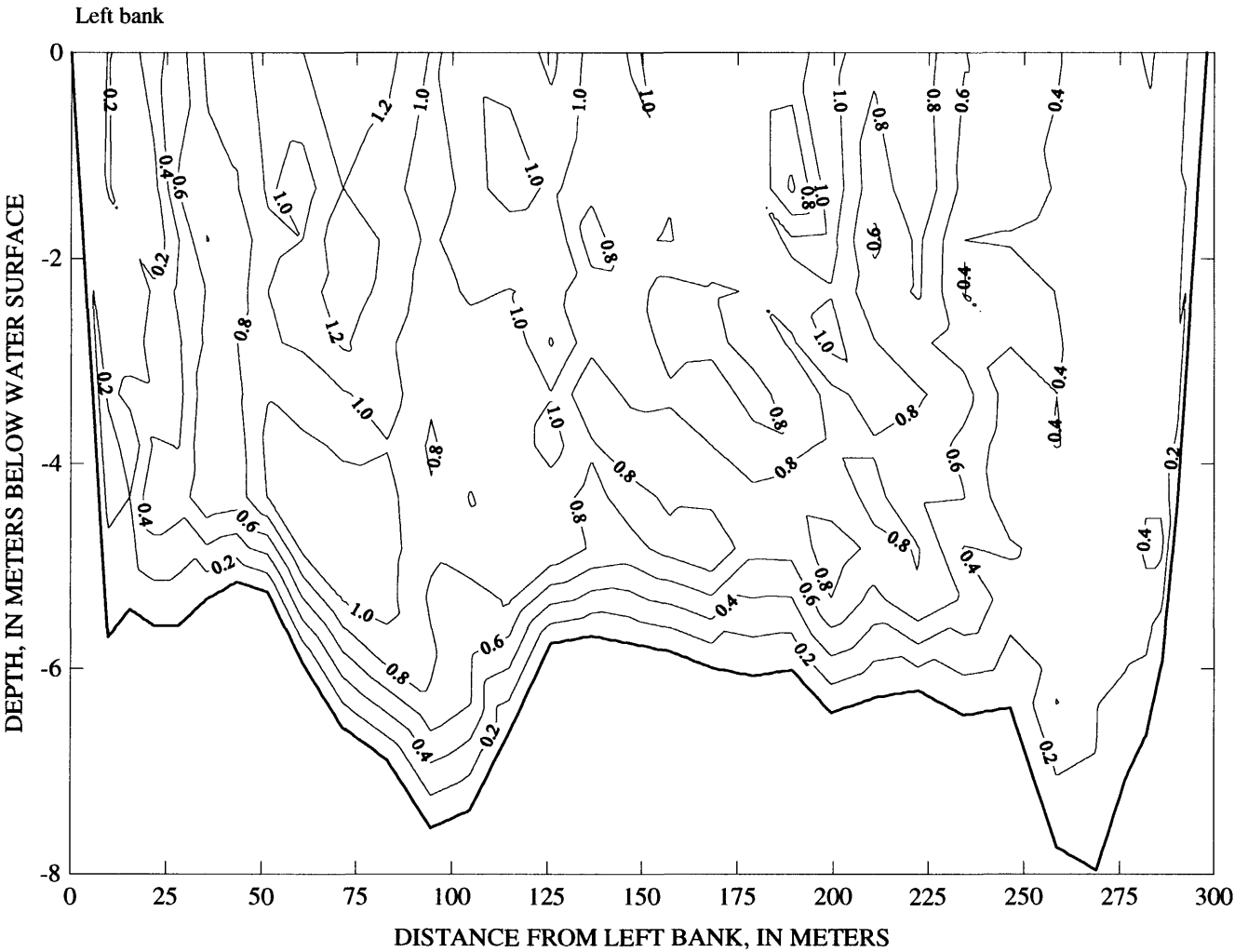

Figure 137. Velocity contours for Kootenai River reach 3, cross-section 16, June 12, 1997. (Contours in meters per second)

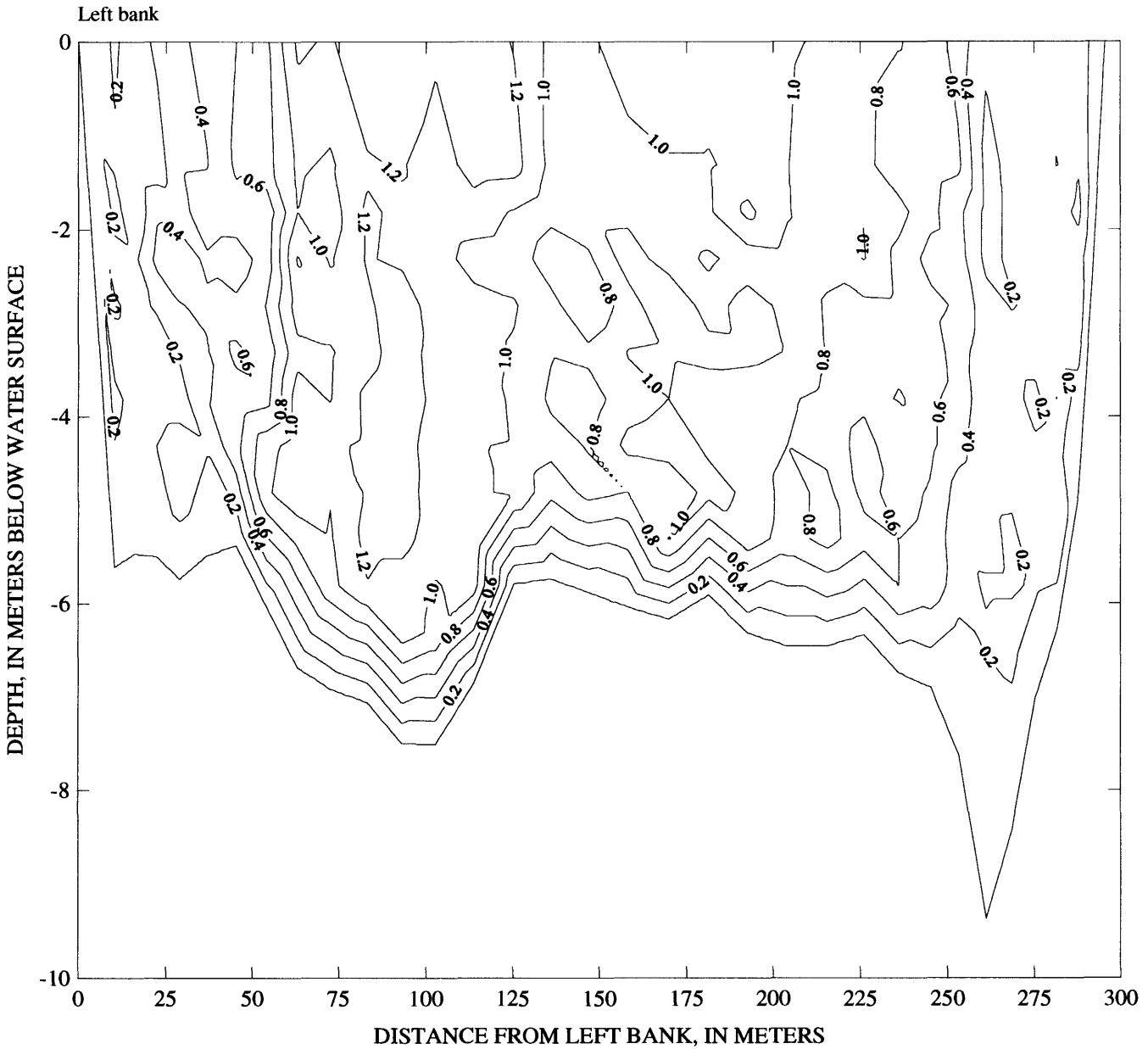

Figure 138. Velocity contours for Kootenai River reach 3, cross-section 17, June 12, 1997. (Contours in meters per second)

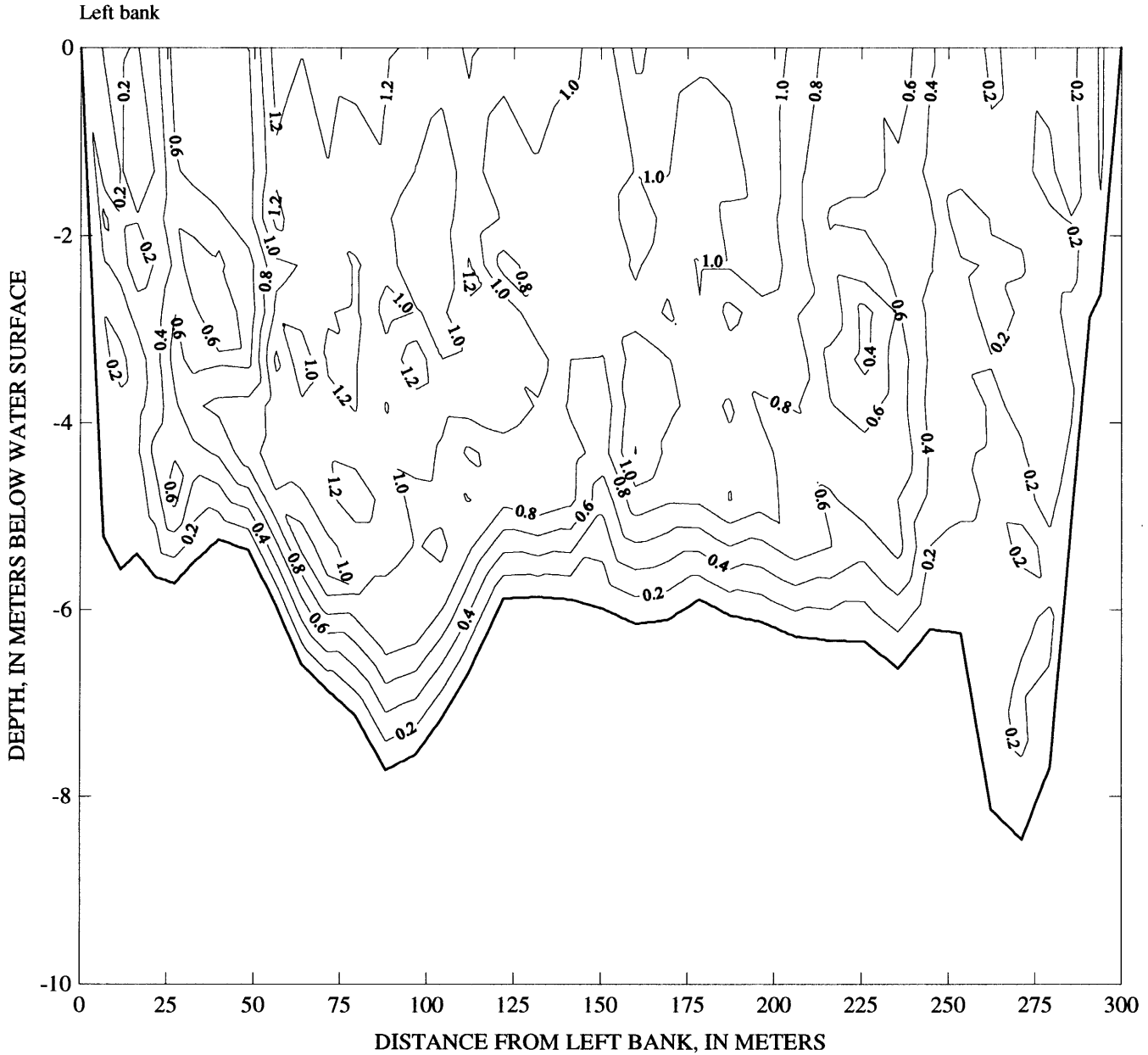

Figure 139. Velocity contours for Kootenai River reach 3, cross-section 18, June 12, 1997. (Contours in meters per second)

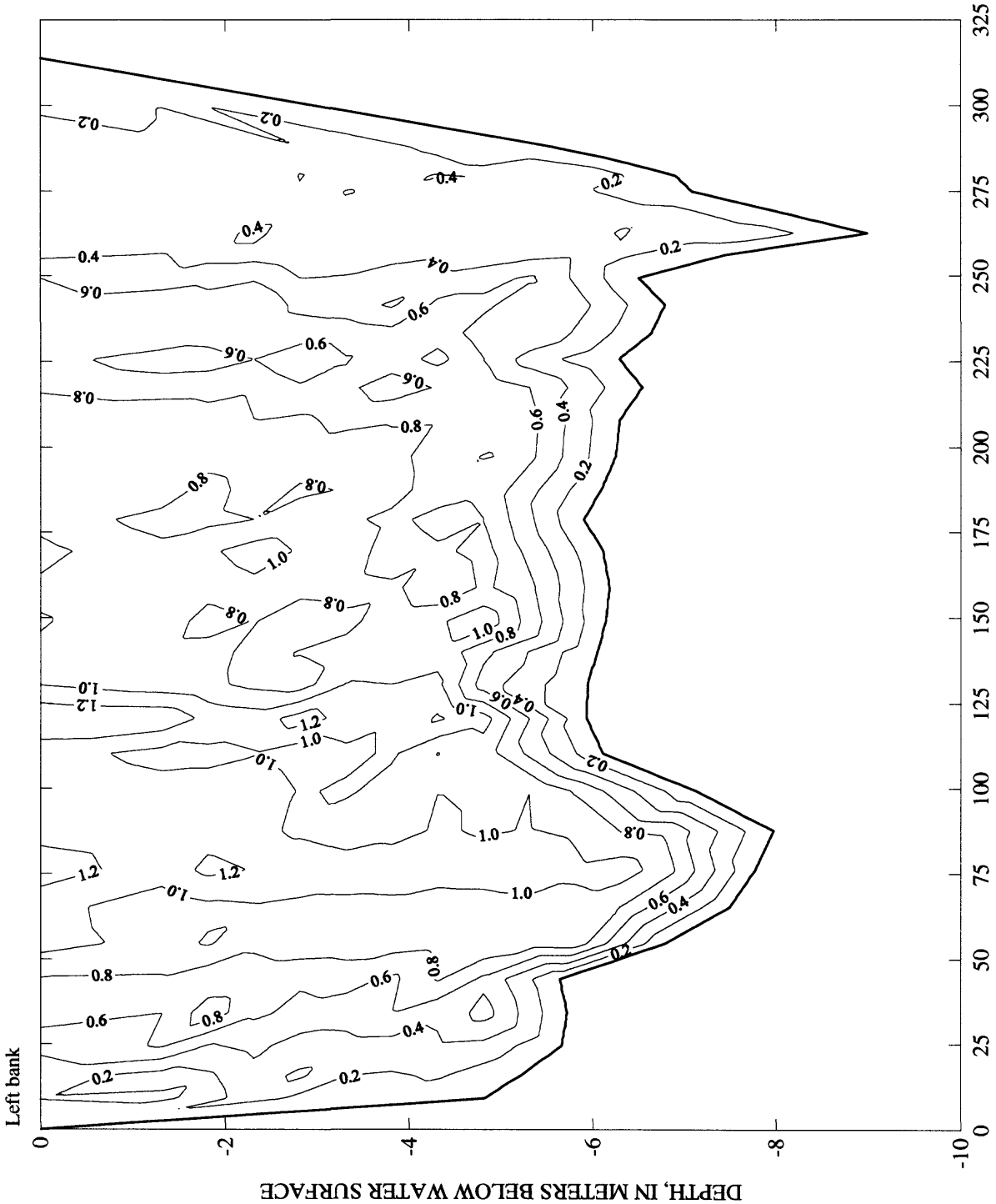

Figure 140. Velocity contours for Kootenai River reach 3, cross-section 19, June 12, 1997.
(Contours in meters per second)

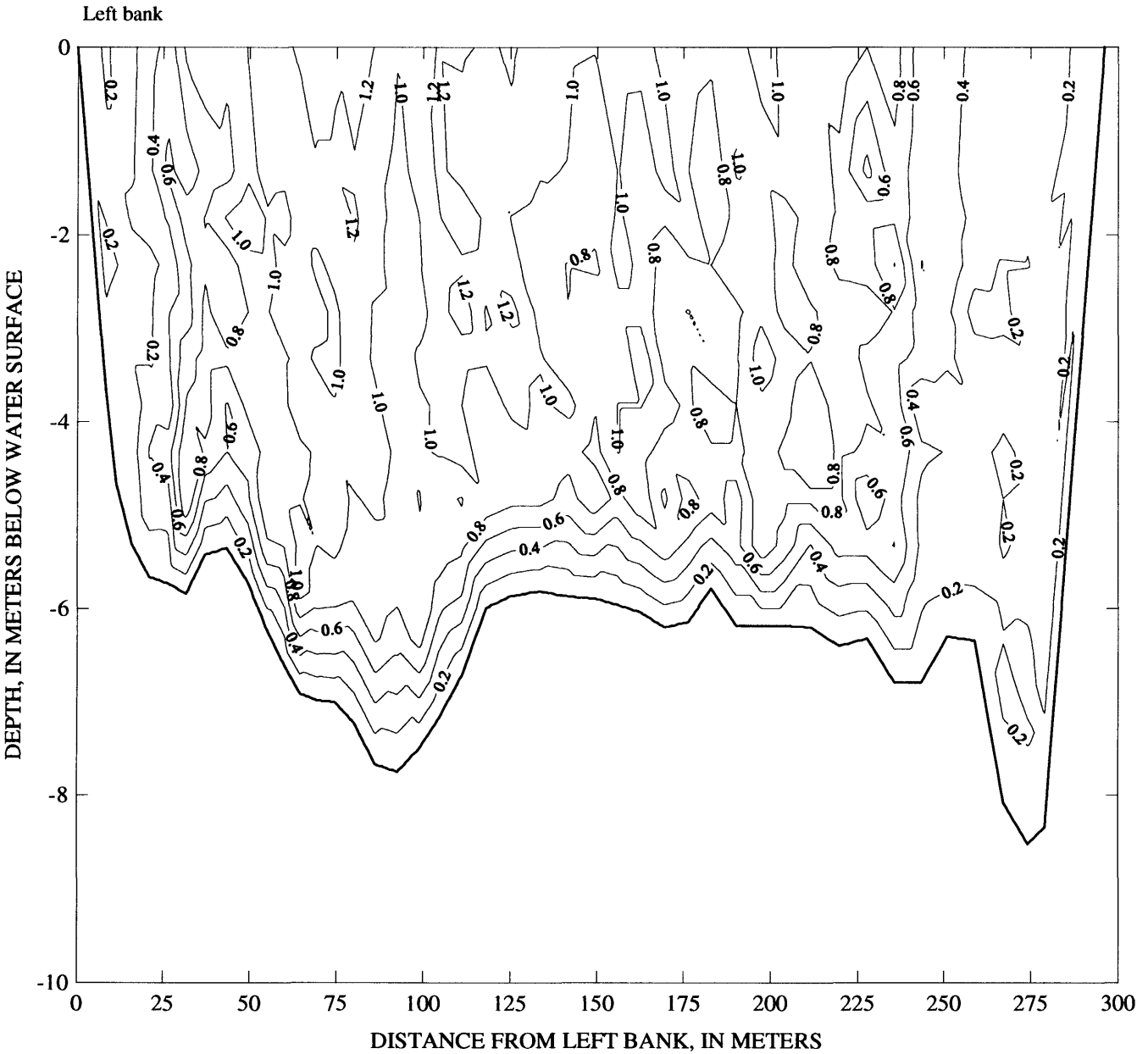

Figure 141. Velocity contours for Kootenai River reach 3, cross-section 20, June 12, 1997. (Contours in meters per second)

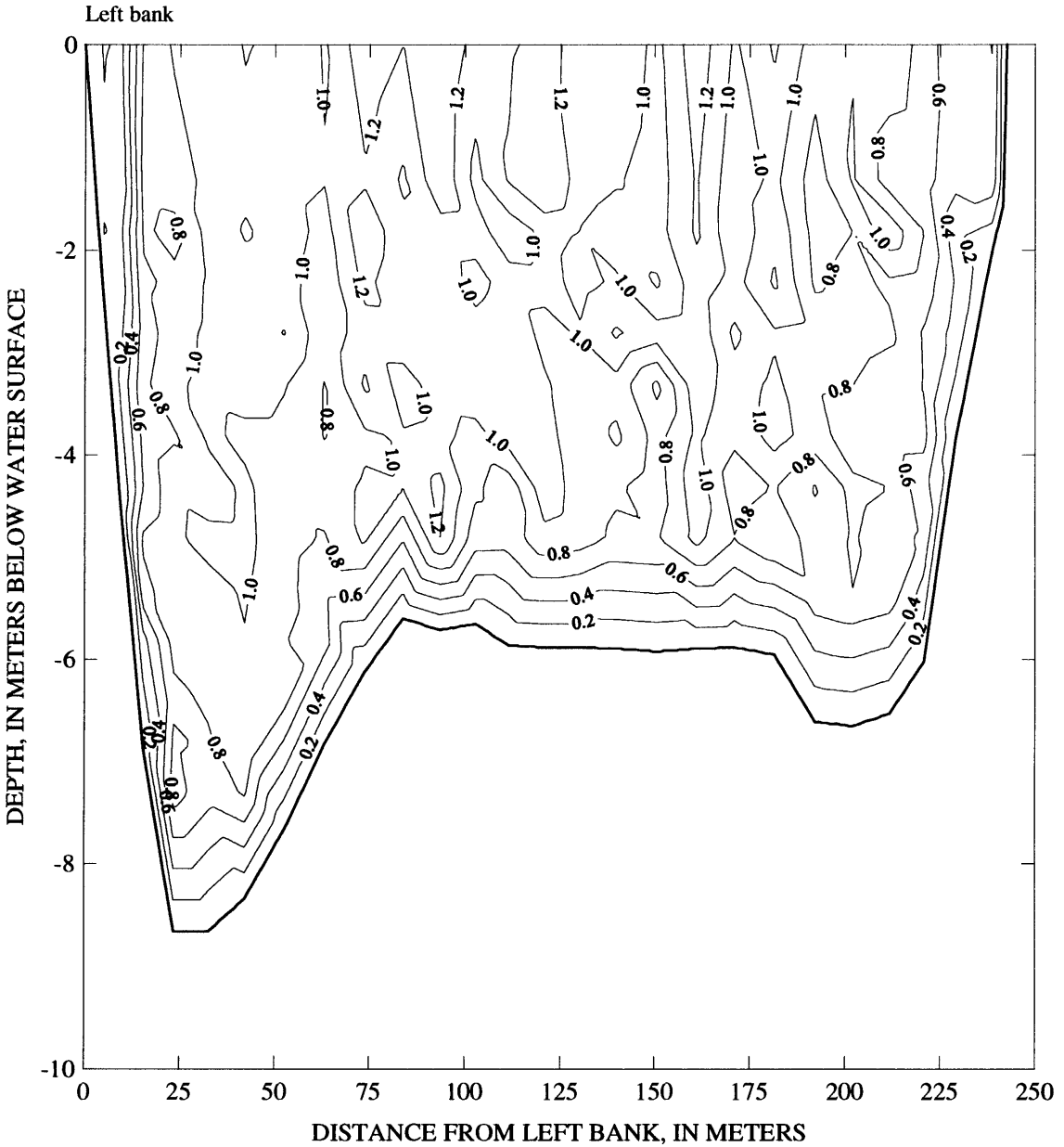

Figure 142. Velocity contours for Kootenai River reach 3, cross-section 25, June 12, 1997. (Contours in meters per second)

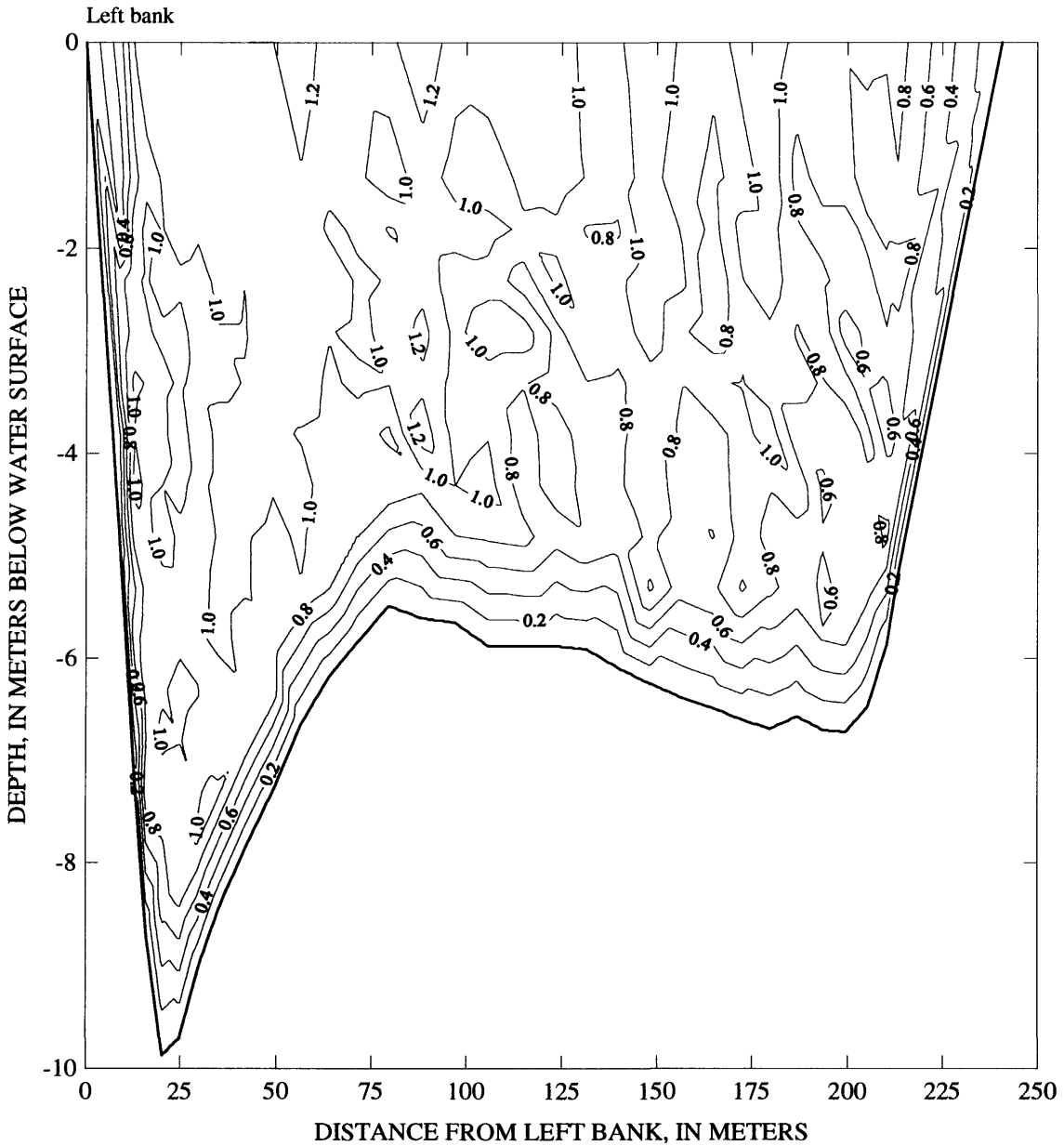

Figure 143. Velocity contours for Kootenai River reach 3, cross-section 26, June 12, 1997. (Contours in meters per second)

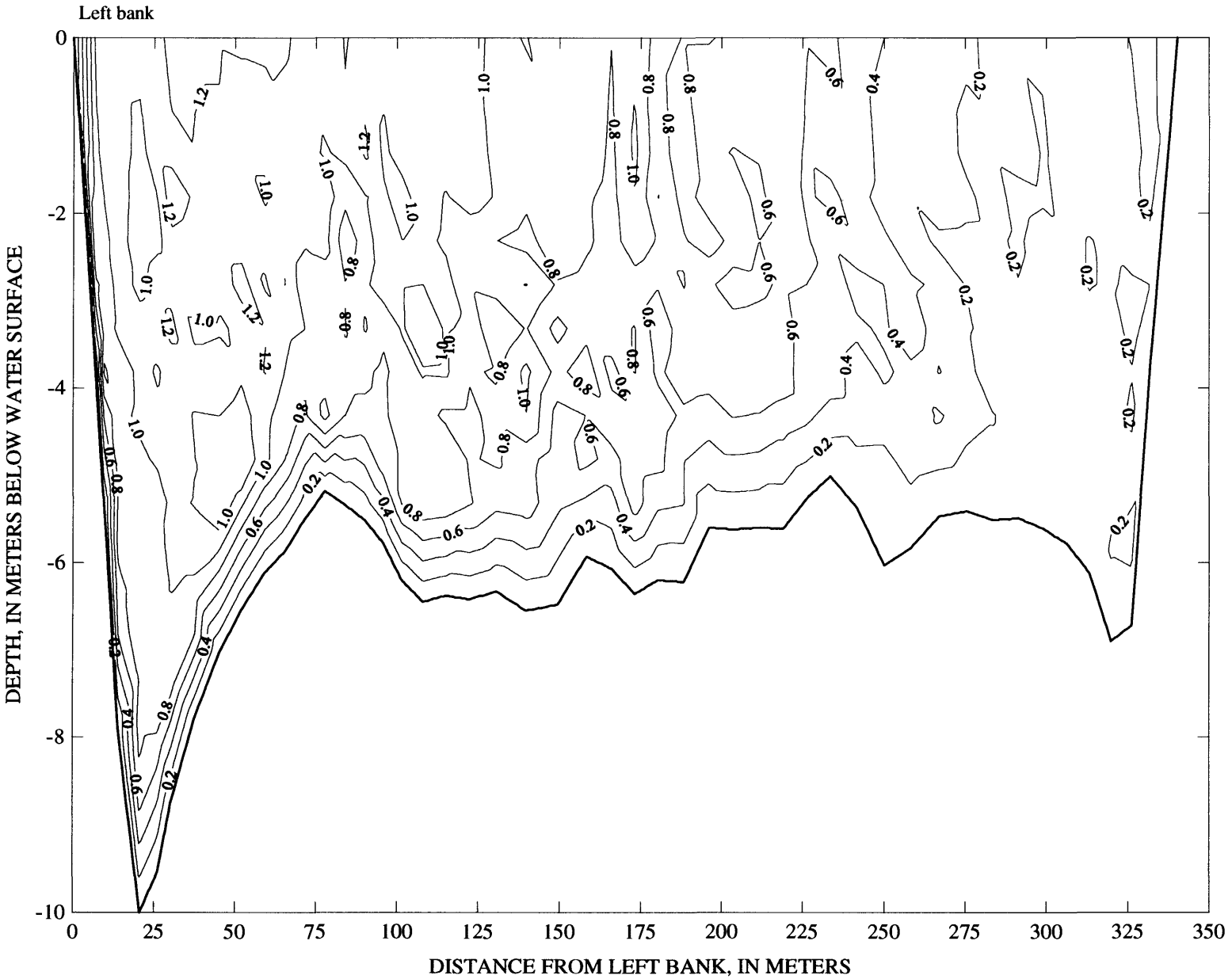

Figure 144. Velocity contours for Kootenai River reach 3, cross-section 27, June 12, 1997. (Contours in meters per second)

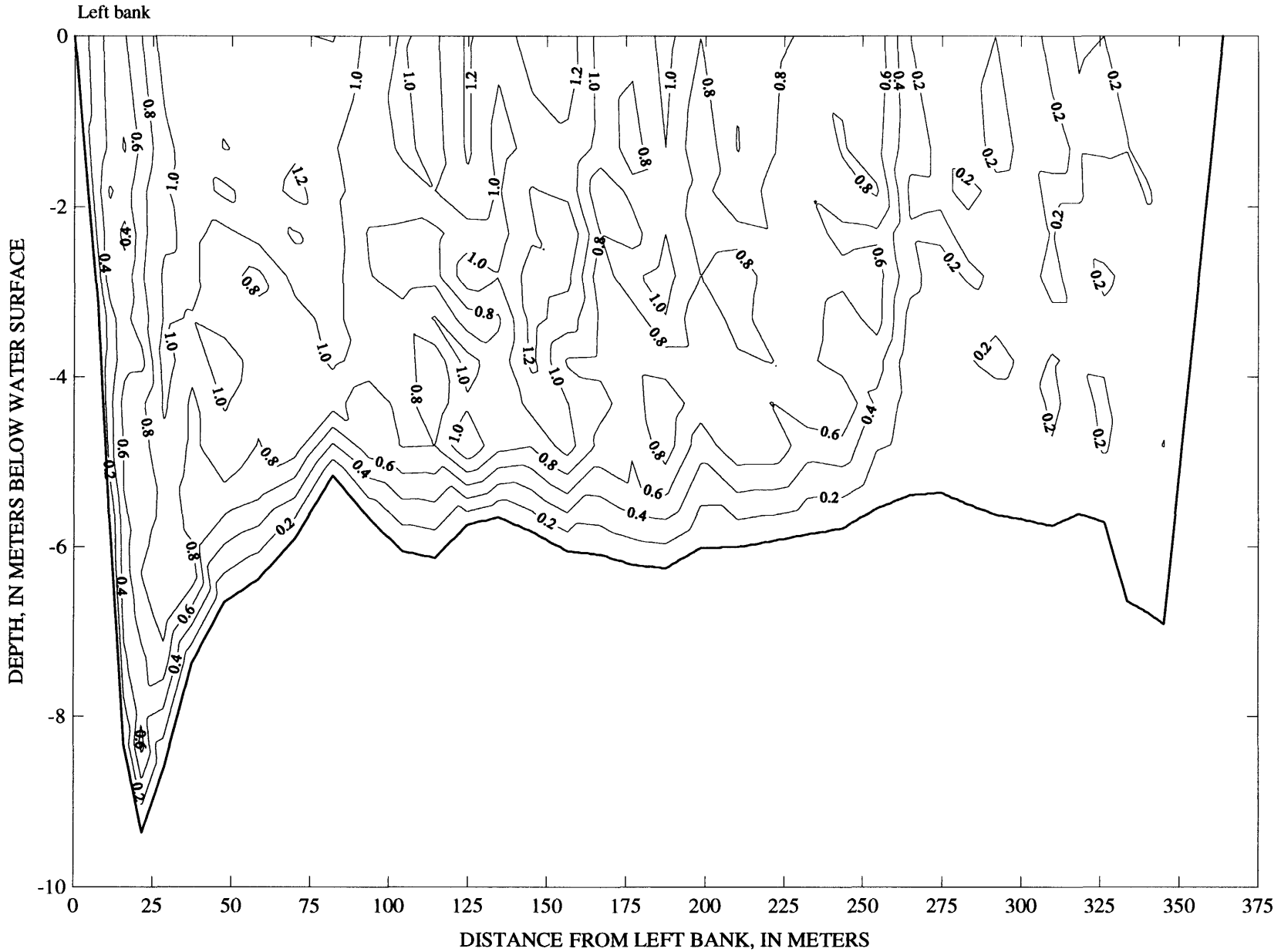

Figure 145. Velocity contours for Kootenai River reach 3, cross-section 28, June 12, 1997. (Contours in meters per second)

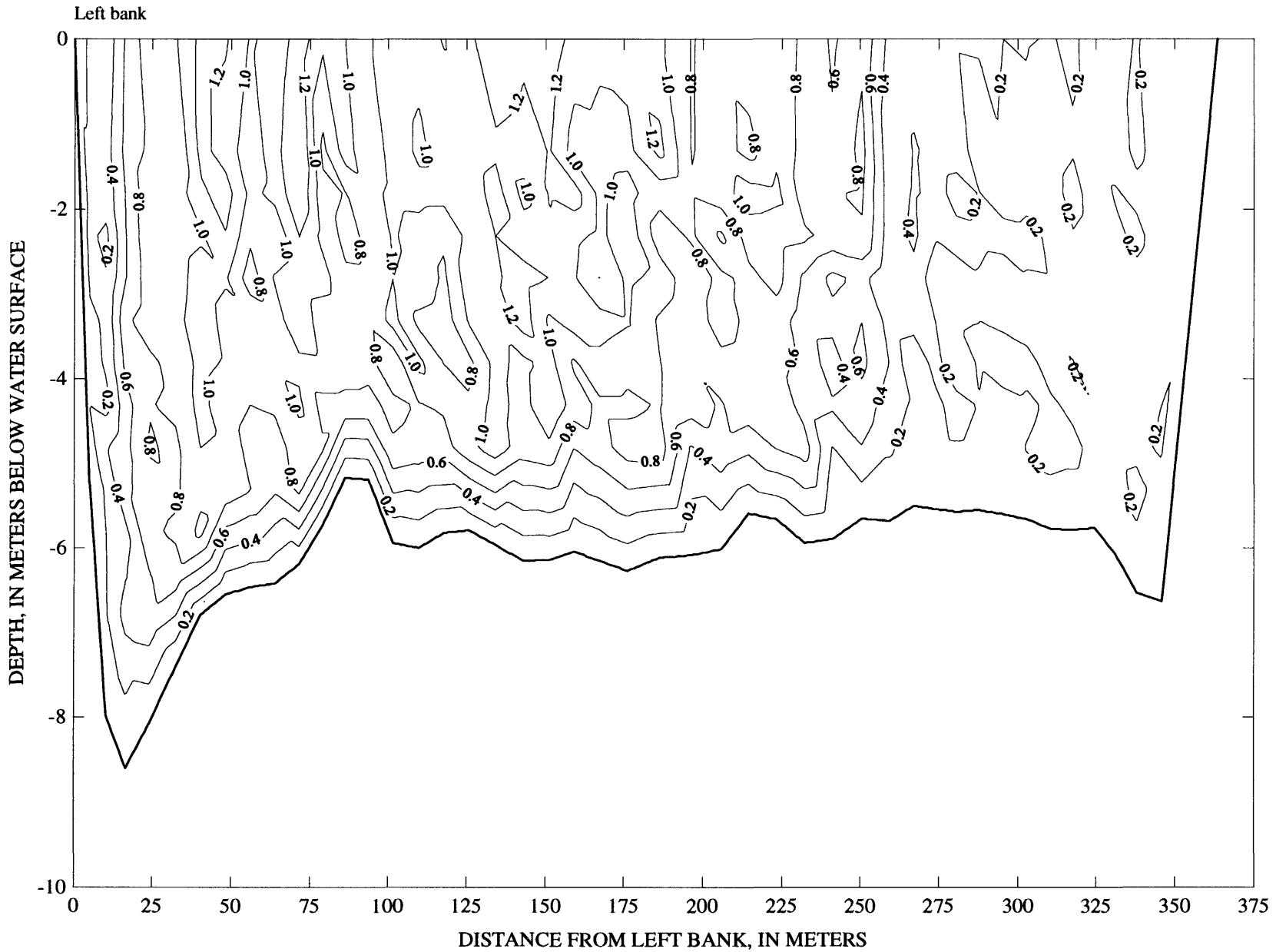

Figure 146. Velocity contours for Kootenai River reach 3, cross-section 29, June 12, 1997. (Contours in meters per second)

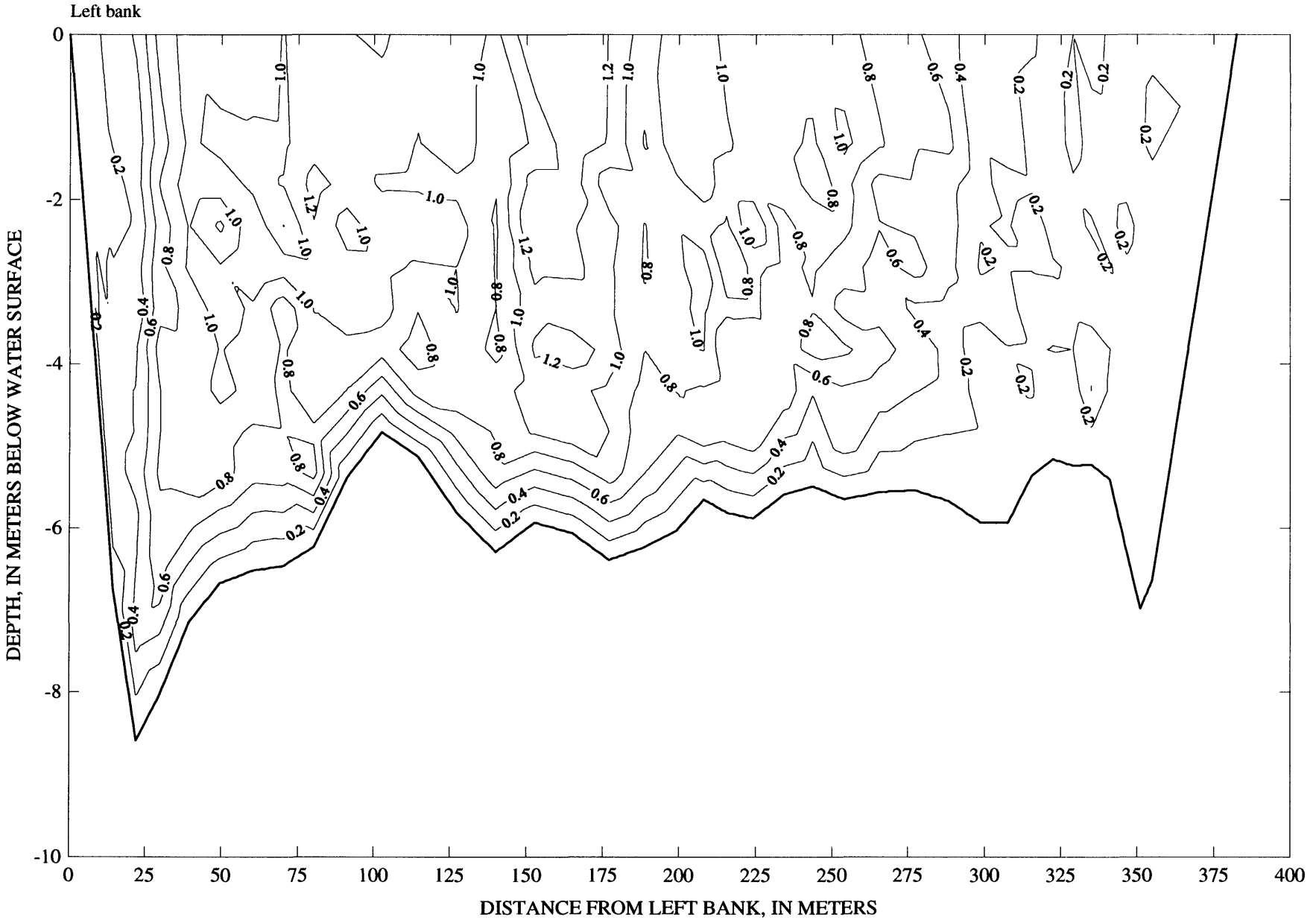

Figure 147. Velocity contours for Kootenai River reach 3, cross-section 30, June 12, 1997. (Contours in meters per second)

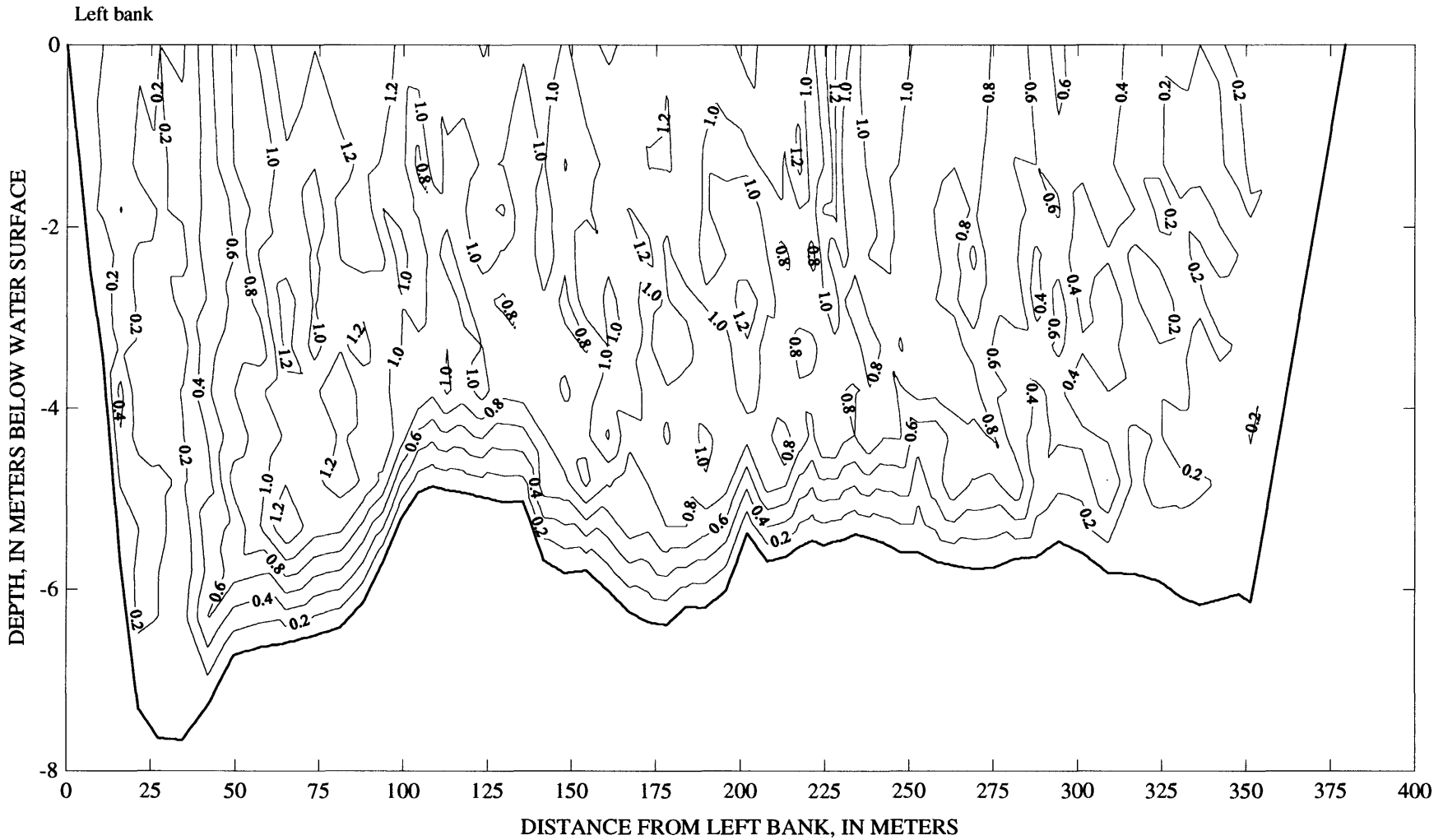

Figure 148. Velocity contours for Kootenai River reach 3, cross-section 31, June 12, 1997. (Contours in meters per second)

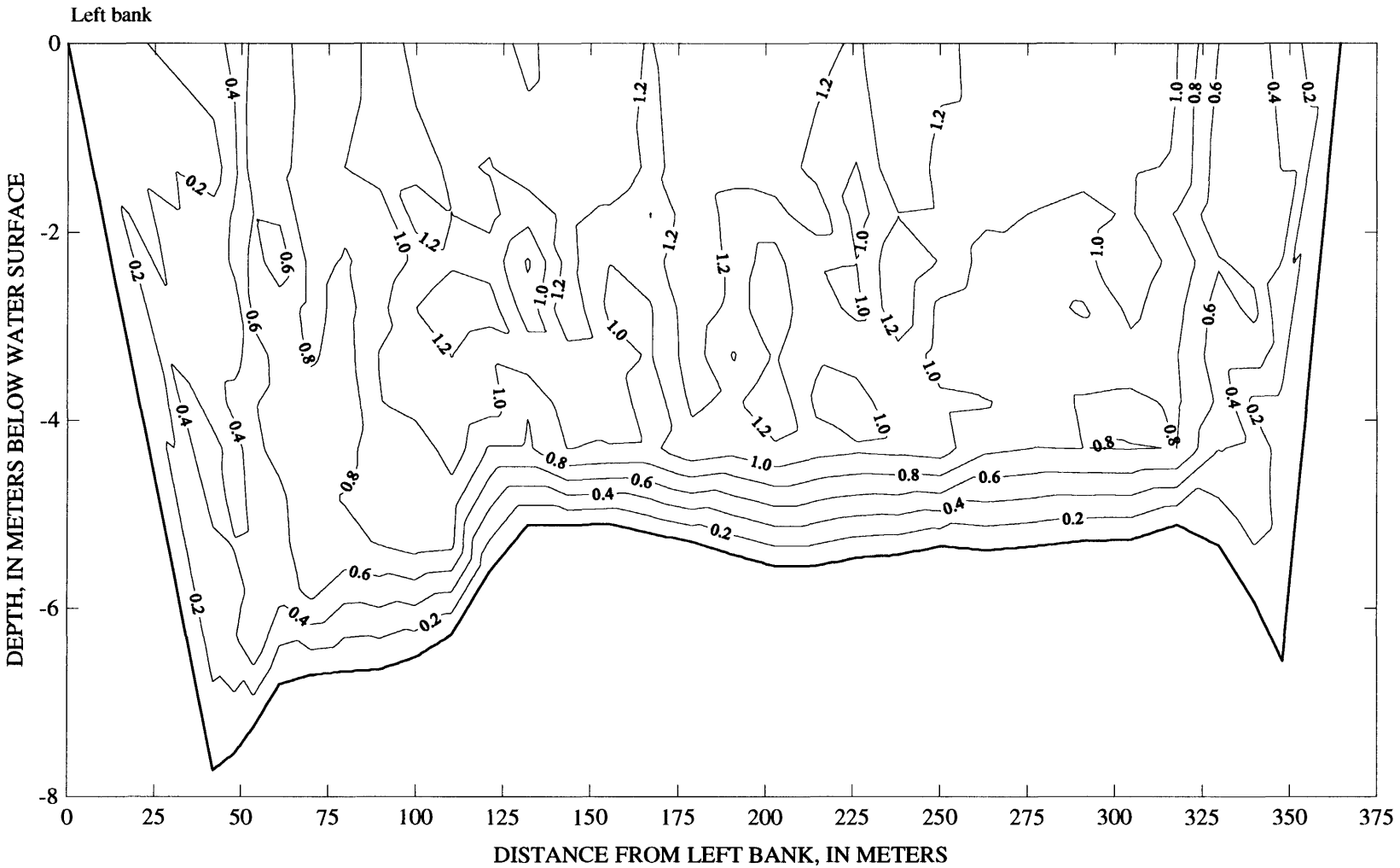

Figure 149. Velocity contours for Kootenai River reach 3, cross-section 32, June 12, 1997. (Contours in meters per second)

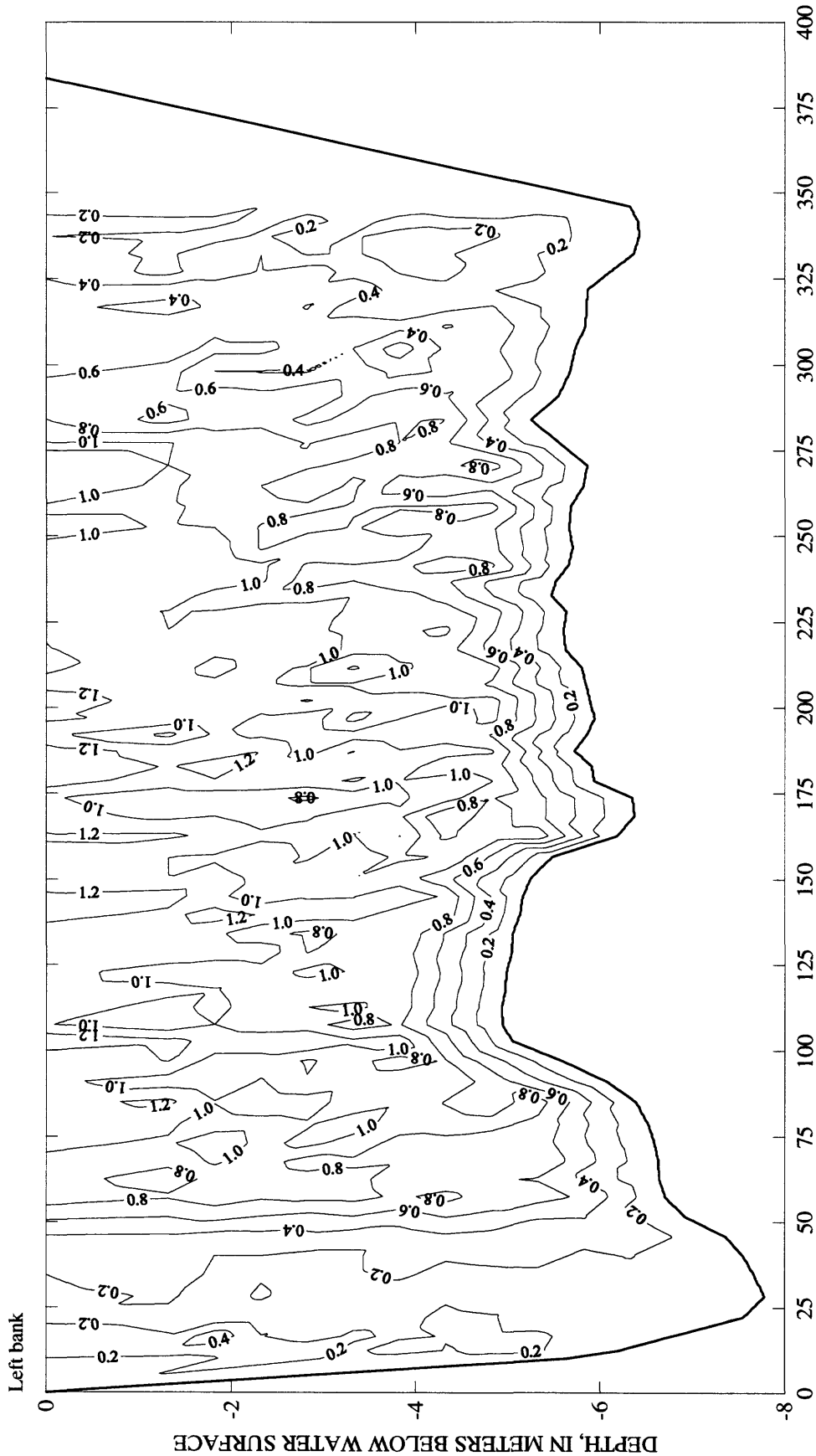

Figure 150. Velocity contours for Kootenai River reach 3, cross-section 33, June 12, 1997.
(Contours in meters per second)

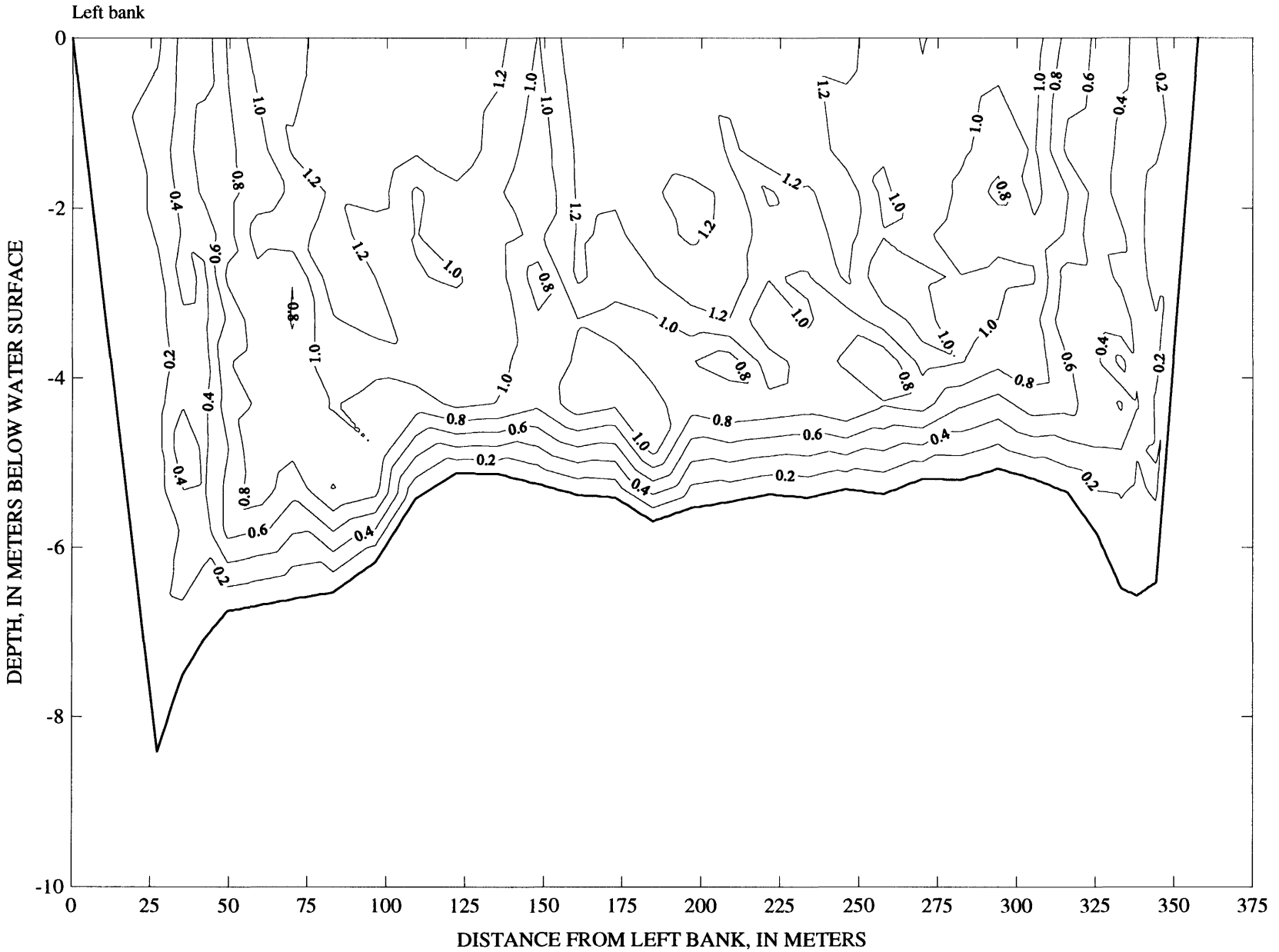

Figure 151. Velocity contours for Kootenai River reach 3, cross-section 34, June 12, 1997. (Contours in meters per second)

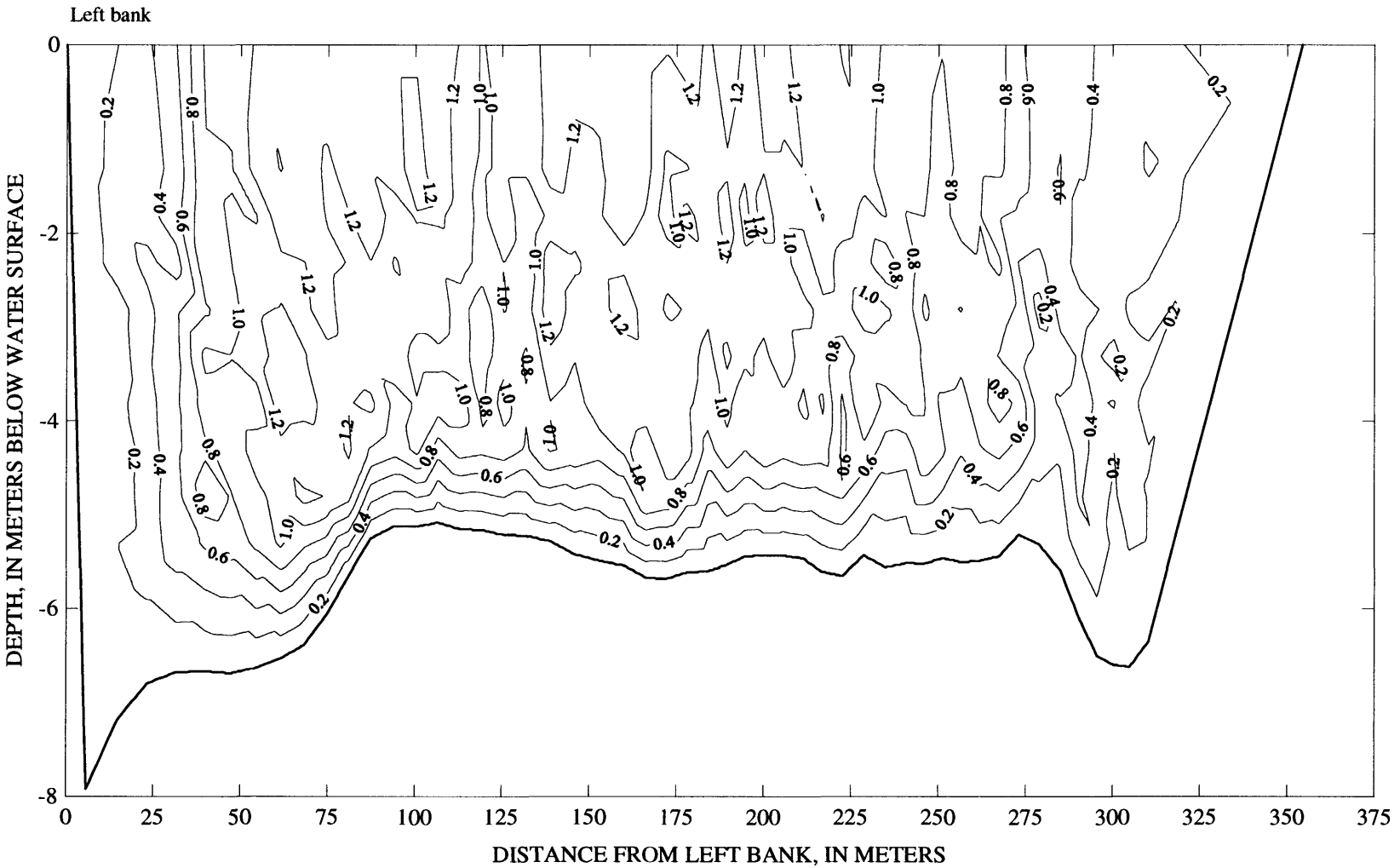

Figure 152. Velocity contours for Kootenai River reach 3, cross-section 35, June 12, 1997. (Contours in meters per second)

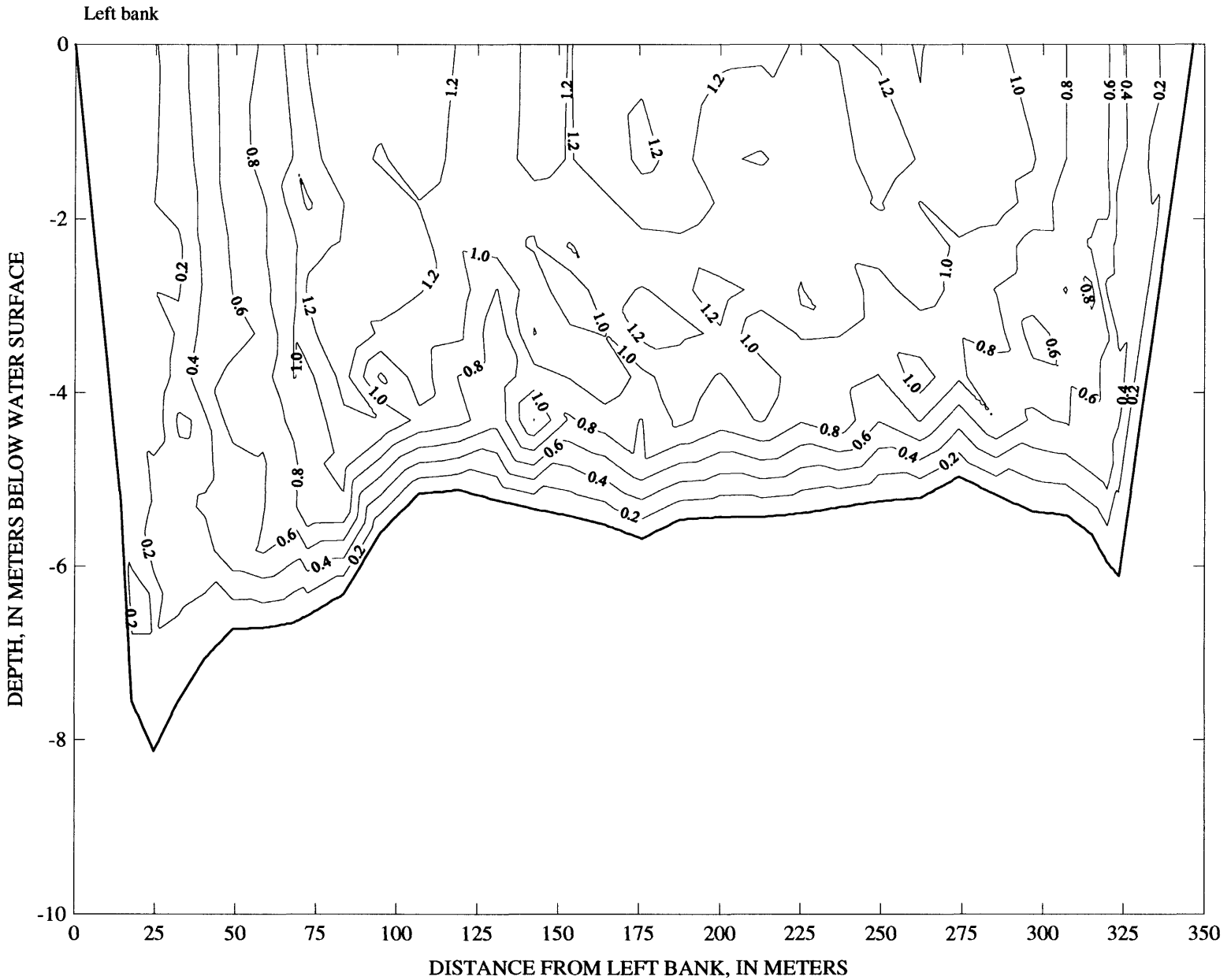

Figure 153. Velocity contours for Kootenai River reach 3, cross-section 36, June 12, 1997. (Contours in meters per second)

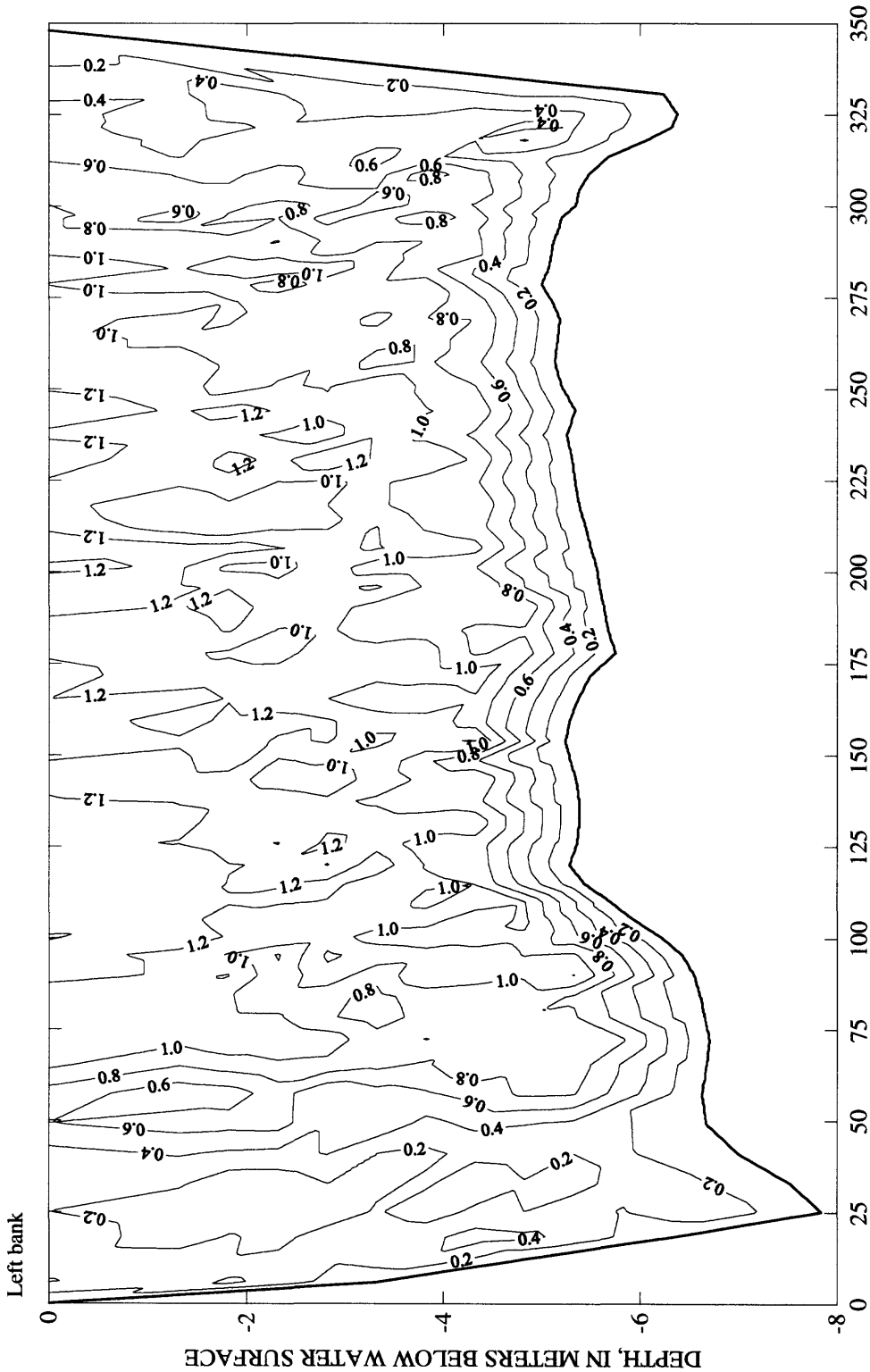

Figure 154. Velocity contours for Kootenai River reach 3, cross-section 37, June 12, 1997.
(Contours in meters per second)

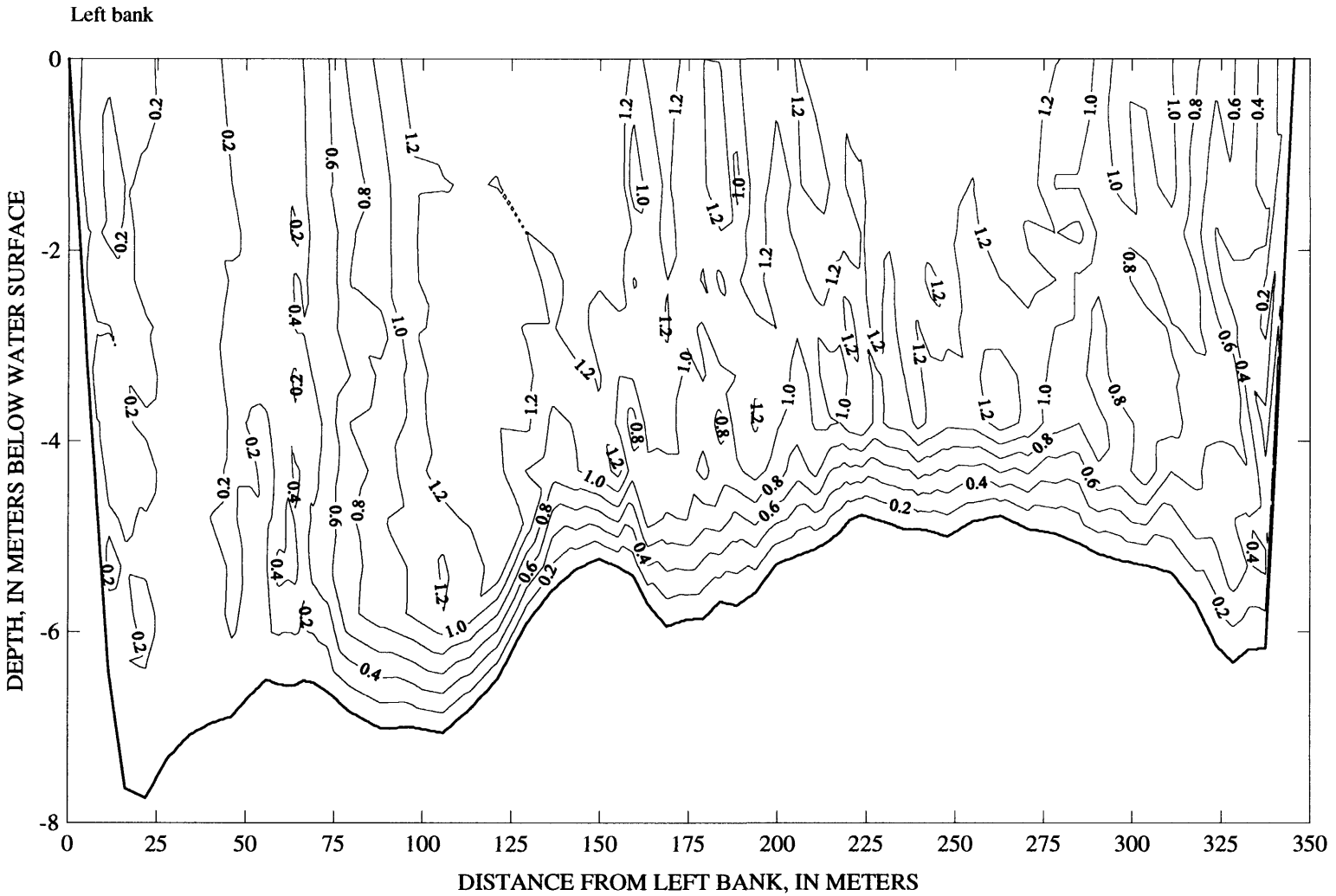

Figure 155. Velocity contours for Kootenai River reach 3, cross-section 38, June 12, 1997. (Contours in meters per second)

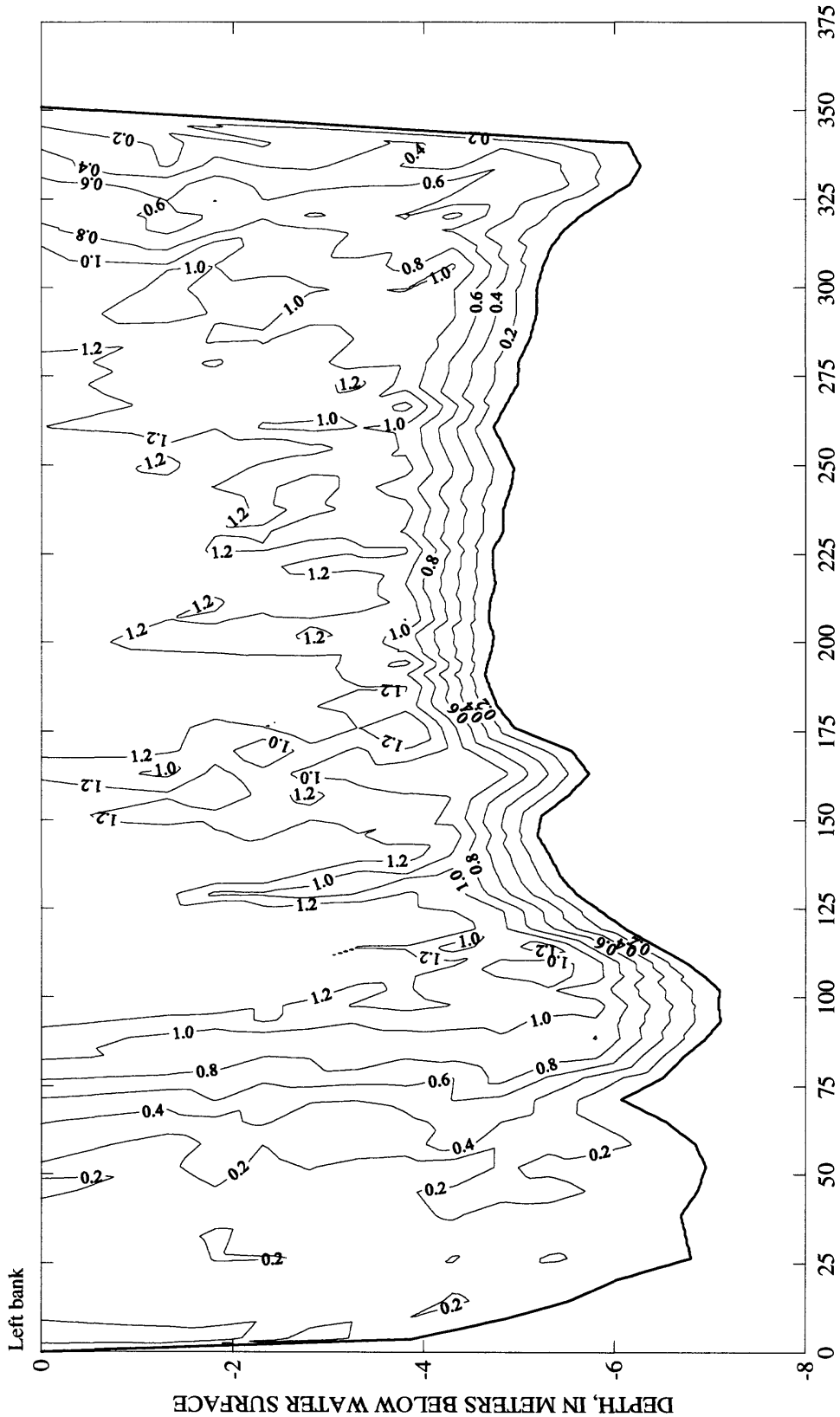

Figure 156. Velocity contours for Kootenai River reach 3, cross-section 39, June 12, 1997.
(Contours in meters per second)

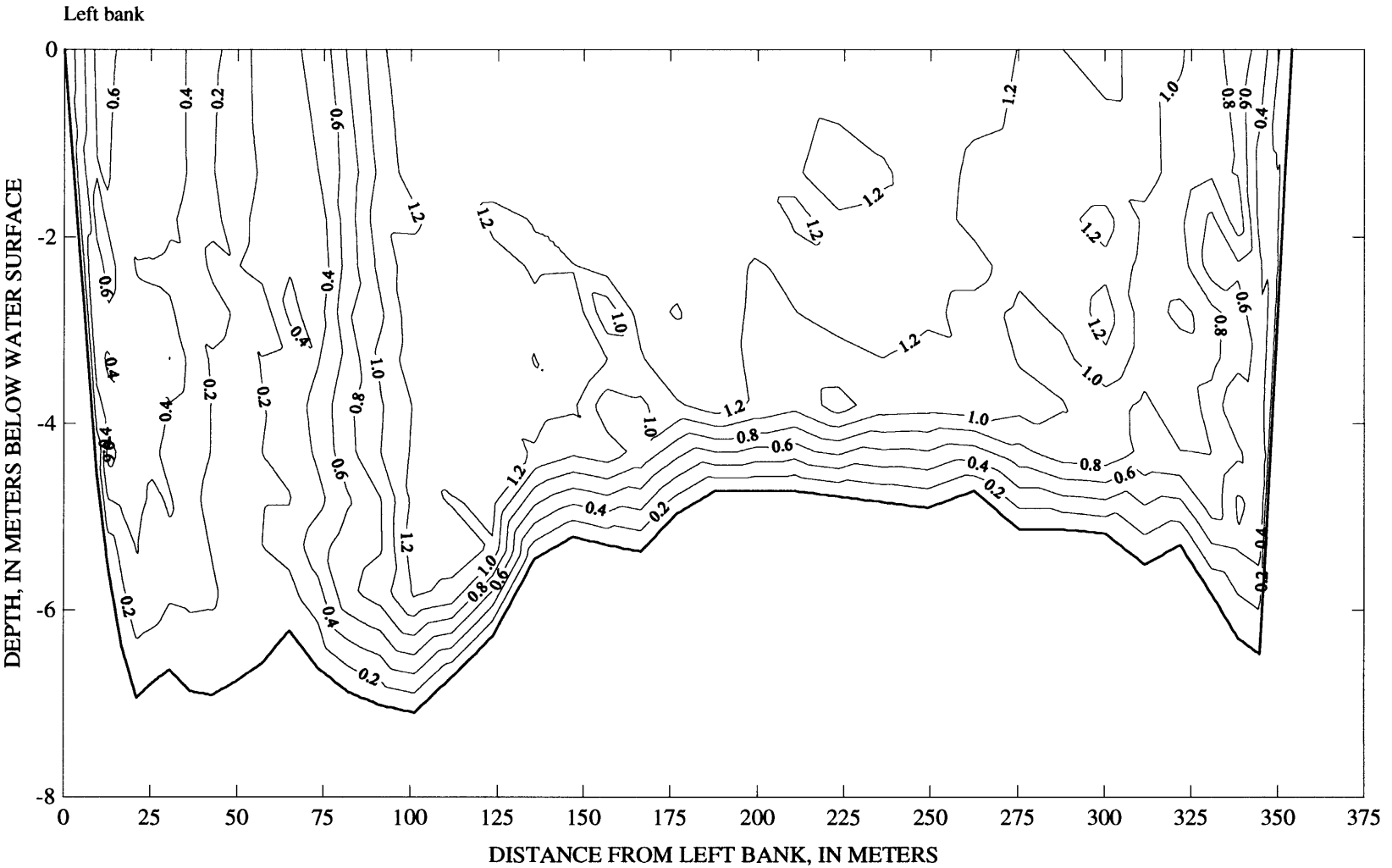

Figure 157. Velocity contours for Kootenai River reach 3, cross-section 40, June 12, 1997. (Contours in meters per second)

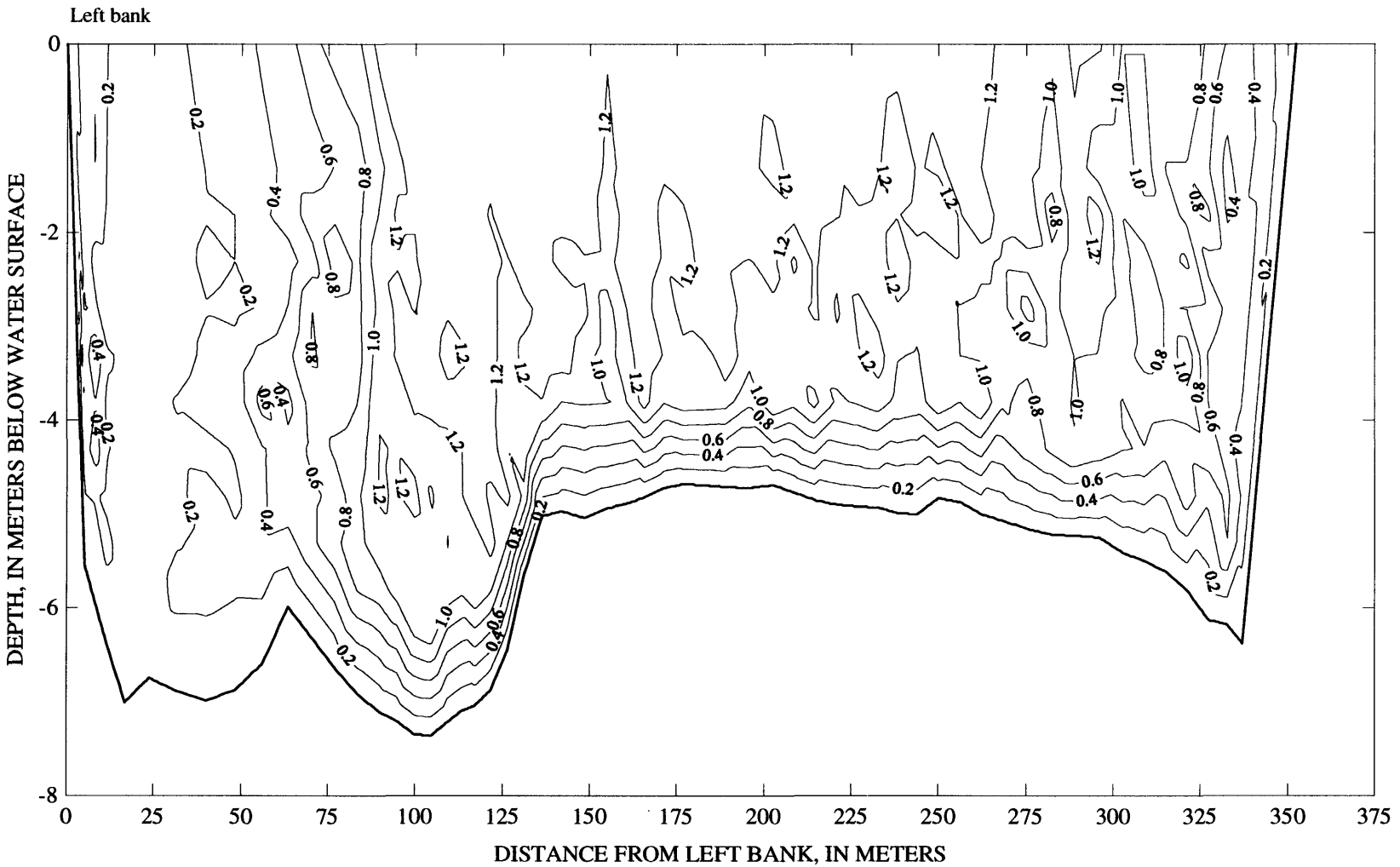

Figure 158. Velocity contours for Kootenai River reach 3, cross-section 41, June 12, 1997. (Contours in meters per second)

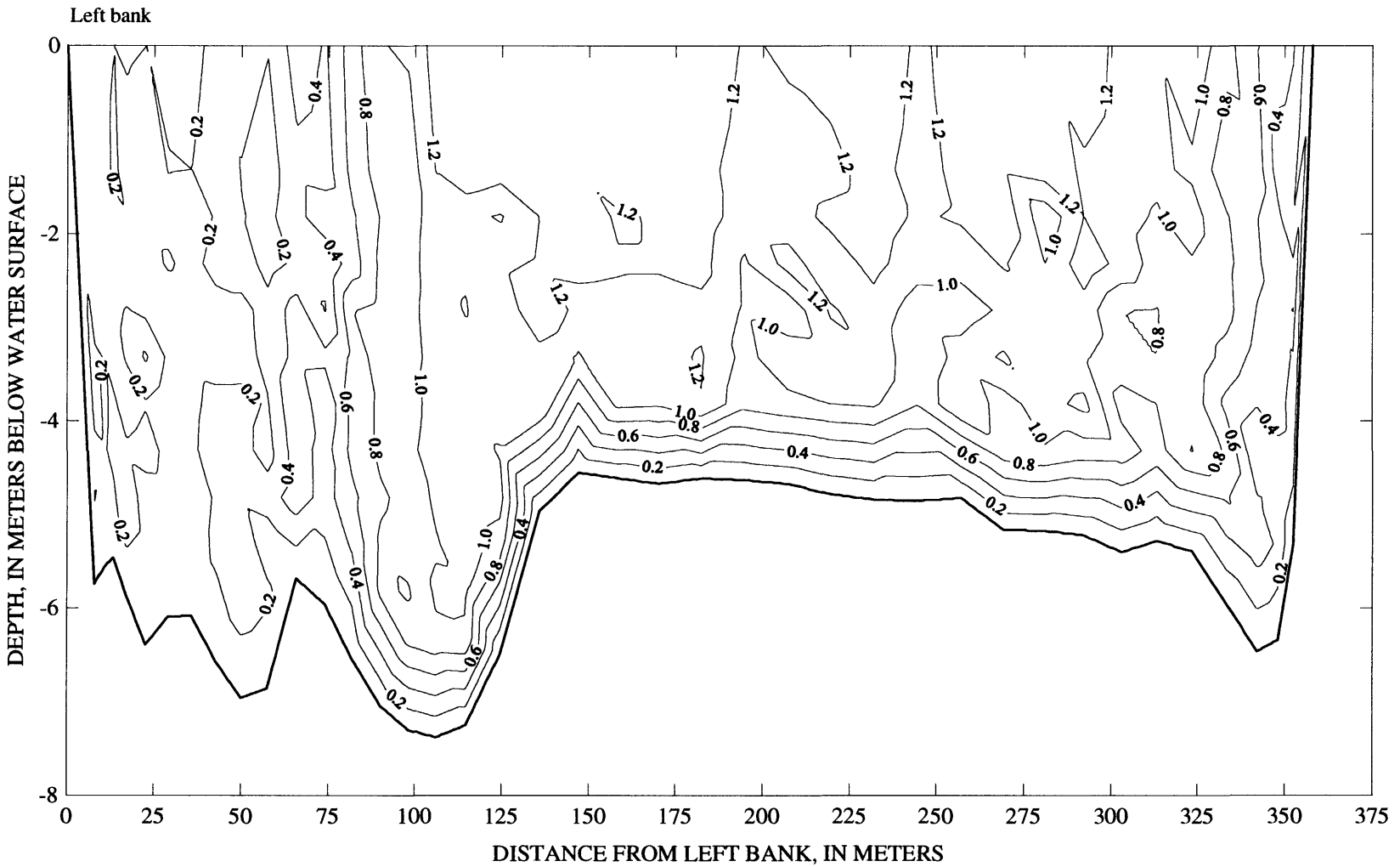

Figure 159. Velocity contours for Kootenai River reach 3, cross-section 42, June 12, 1997. (Contours in meters per second)

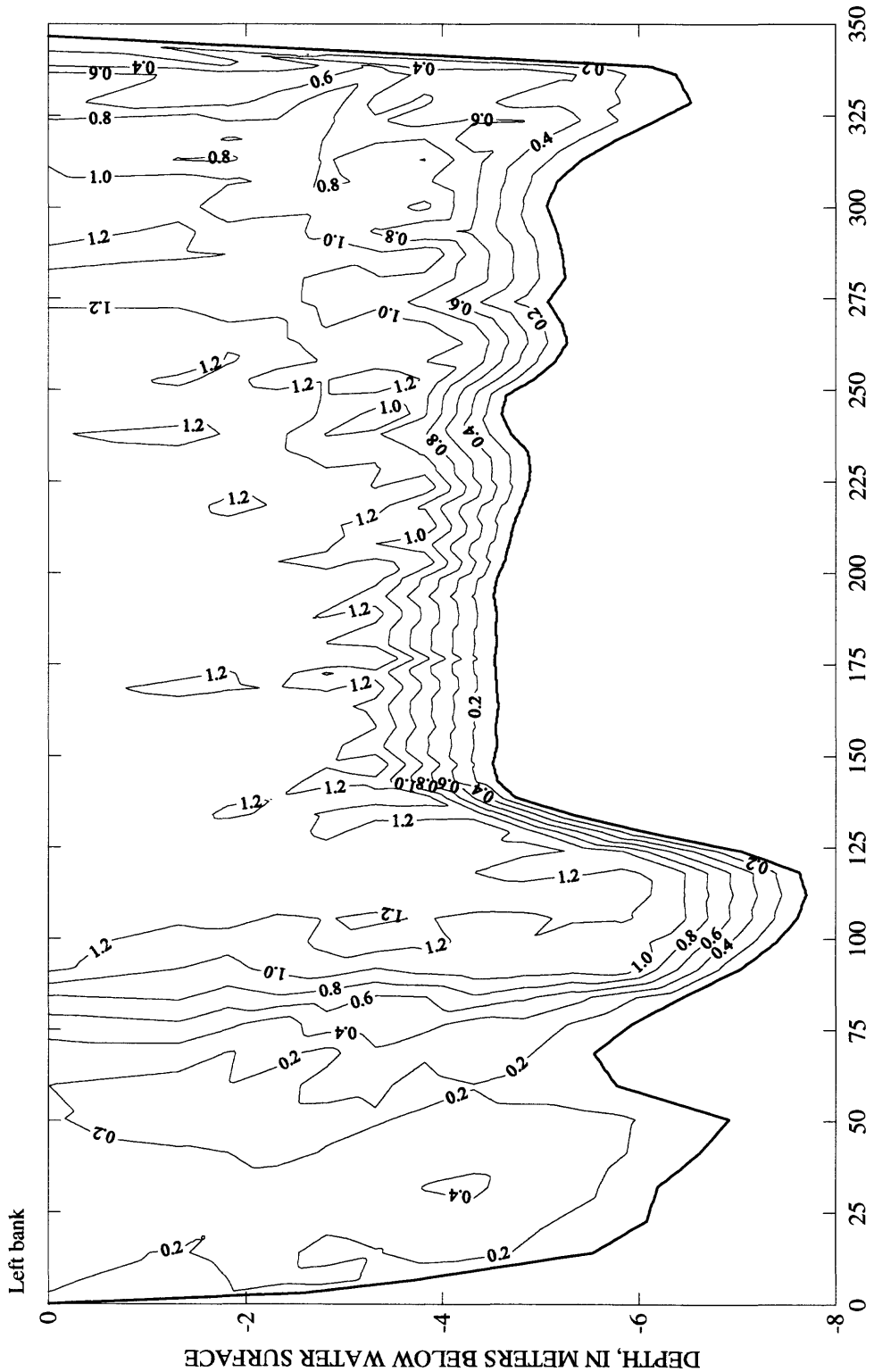

Figure 160. Velocity contours for Kootenai River reach 3, cross-section 44, June 12, 1997.
(Contours in meters per second)

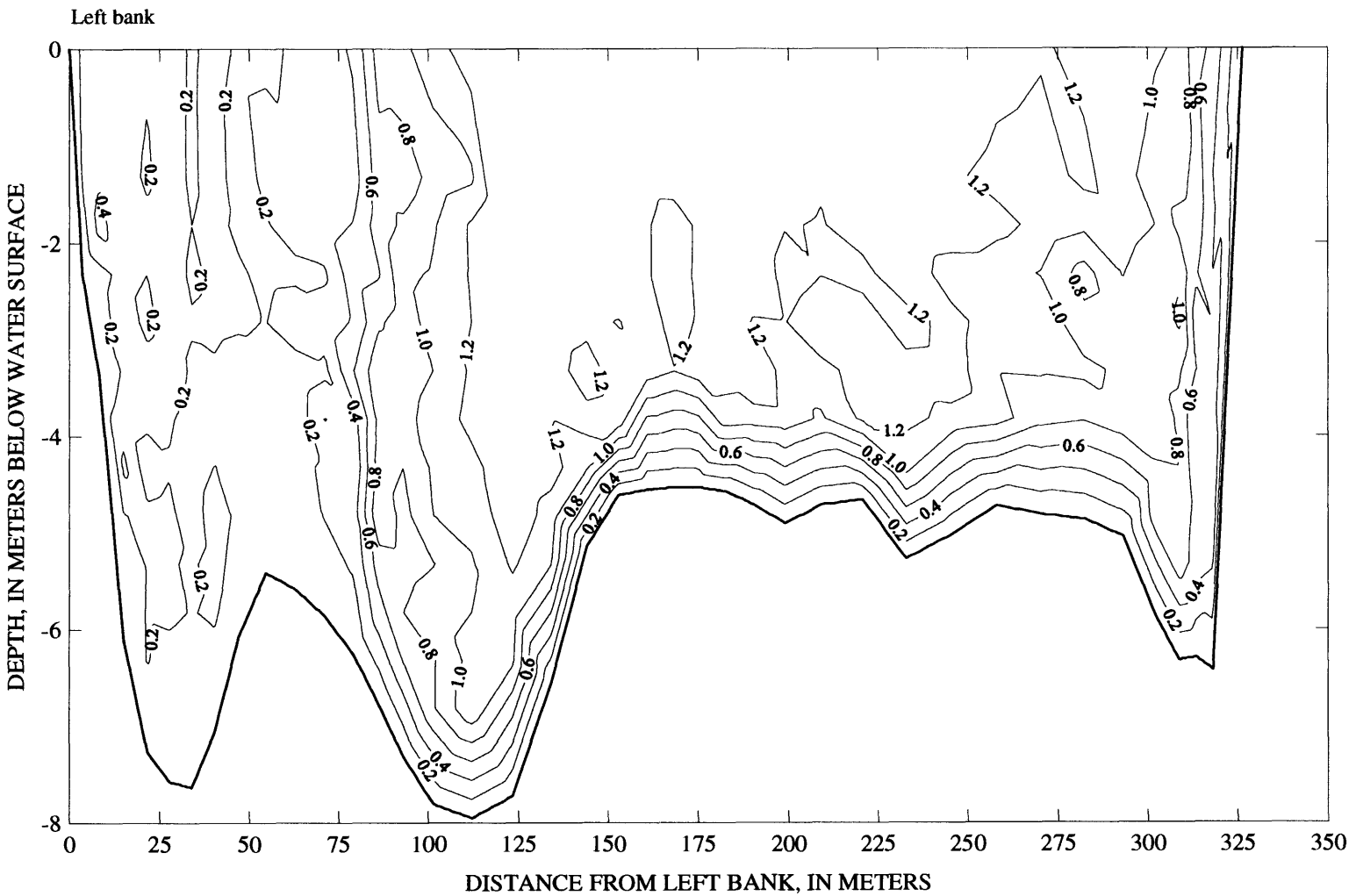

Figure 161. Velocity contours for Kootenai River reach 3, cross-section 46, June 12, 1997. (Contours in meters per second)

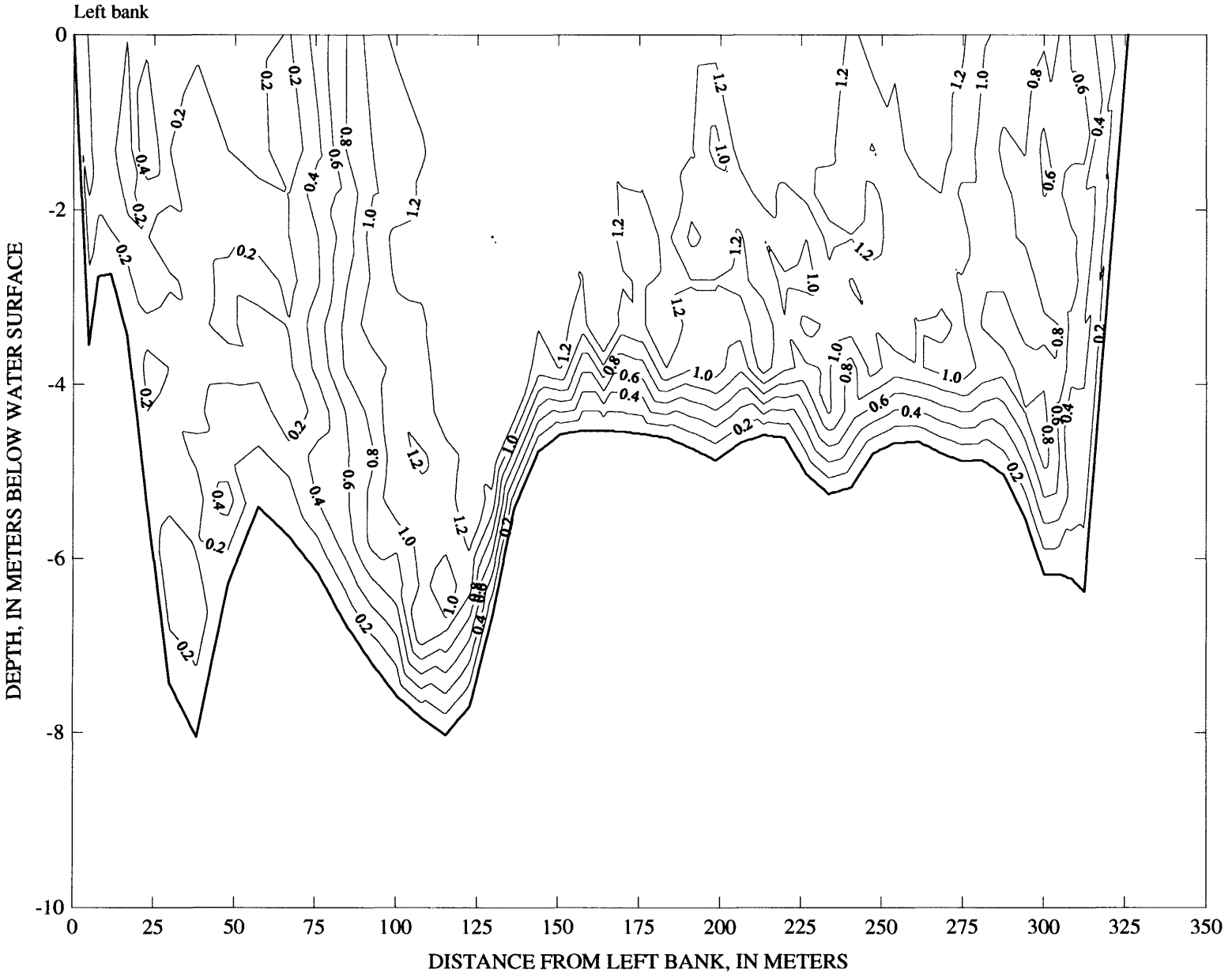

Figure 162. Velocity contours for Kootenai River reach 3, cross-section 48, June 12, 1997. (Contours in meters per second)

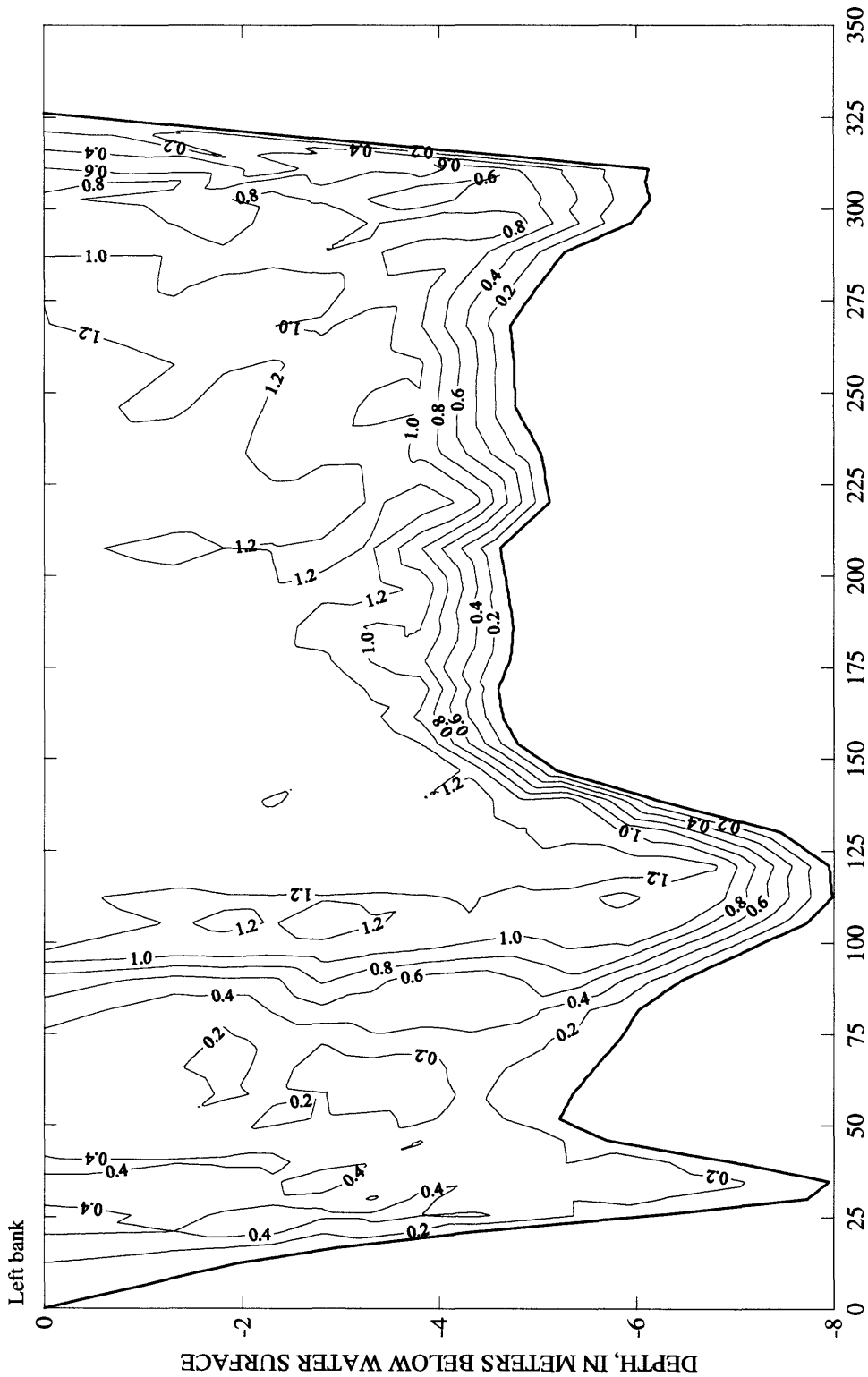

Figure 163. Velocity contours for Kootenai River reach 3, cross-section 50, June 12, 1997.
(Contours in meters per second)