Water-Surface Elevations and Boundaries of the 100-Year and 500-Year Floods and Floodway for the Jocko River, Western Montana

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Introduction

The Jocko River flows across the Flathead Indian Reservation in western Montana and provides irrigation water for several thousand acres of hay and grain that are produced throughout the Jocko River valley. The Jocko River also is an important trout fishery and a tributary to the Flathead River. Much of the agricultural land along the Jocko River is being considered for residential and commercial development. This development has the potential to affect the Jocko River and the fishery. In addition, proposed levee modifications and stream-restoration work could further affect the Jocko River channel and its aquatic habitat.

The Confederated Salish and Kootenai Tribes of the Flathead Nation (CSKT) needed information for assessing the effects of proposed development and stream-restoration work on the Jocko River channel and fishery. The potential for increased development and stream-restoration work highlighted the need for a better understanding of the boundaries of the 100-year and 500-year floods. To that end, the U.S. Geological Survey (USGS), in cooperation with CSKT, conducted hydrologic and hydraulic analyses of the Jocko River to identify areas along the river that are subject to flooding.

This report presents water-surface elevation data for flood discharges having recurrence intervals of 100 and 500 years and depicts mapped flood and floodway boundaries. The flood boundaries show the extent of flooding under existing (1999-2001) conditions from flood discharges having recurrence intervals of 100 and 500 years. The mapped floodway boundaries show the area within the boundaries of the 100-year flood discharge that is reserved for the passage of flood flows under Montana Administrative Rule 36.15.502 (1995). The hydrologic analysis is based on recorded annual-peak discharge data for various years from 1907 to 1998 at four streamflow-gaging stations within or near the study area that extends from the fish hatchery near Arlee to the mouth of the Jocko River near Dixon. The hydraulic analysis is based on channel- and bridge-geometry data collected between 1999 and 2001.

Description of Study Area

The Jocko River and its major tributaries, Finley Creek, Spring Creek, and Valley Creek, are perennial streams. The Jocko River originates in the Mission Mountains east and north of Arlee and flows through a relatively narrow valley corridor in Lake and Sanders Counties before joining the Flathead River near Dixon (fig. 1, sheet 1). The Jocko River valley is bounded by the Mission Range on the east and mountains along the Reservation Divide on the south and west. Elevations in the basin range from more than 7,700 ft (NGVD 29) in the mountains to 2,800 ft (NGVD 29) along the valley floor (Kendy and Tresch, 1996).

The river channel is incised in some reaches and braided across the valley floor in other reaches within the study area. Several abandoned meander channels form depressions along the river in the braided reaches. In addition, irrigation-canal berms and flood-protection levees have been constructed on one or both sides of the river along much of the study area. The study area was divided into eight reaches, based on hydraulic conditions and the influence of the berms and levees (fig. 1).

The climate in the Jocko River basin is characterized by warm summers, cold winters, and moderate precipitation. Based on climate data from 1896 to 2003 at St. Ignatius, about 5 mi northeast of Ravalli, mean monthly temperatures range from a minimum of 17.1°F in January to a maximum of 84.3°F in July (Western Regional Climate Center, 2003a). The average annual precipitation at St. Ignatius is 15.9 in. However, the average annual precipitation increases dramatically with altitude in the basin and probably reaches a value of about 80 in. in the Mission Mountains (Western Regional Climate Center, 2003b).

Rangeland and irrigated hay and grain production are the predominant land uses throughout the study area. The Flathead Agency Irrigation Division manages an elaborate system of canals that divert and distribute water from the Jocko River and its tributaries (Kendy and Tresch, 1996). Only the largest canal (the K Canal) is shown on figure 1. The only incorporated towns in the valley are Arlee (population 602) and Dixon (population 216) (U.S. Census Bureau, 2005).

Flood Conditions and History

Most flood runoff in the Jocko River basin results from spring snowmelt, spring snowmelt mixed with rain, or spring rains. Recorded flood-discharge data for the Jocko River are available for sites near Arlee, Ravalli, and Dixon.

Flood-discharge data are available for two streamflow-gaging stations in the study area and for two located upstream from the study area. A streamflow-gaging station on the Jocko River at Dixon (fig. 1, station 12388200) has been operated by the USGS since 1990. The CSKT operated a peak-discharge gaging station (crest-stage gage) at the same location from 1986 to 1989. The USGS also operated a streamflow-gaging station at Jocko River at Ravalli (station 12388000) from 1906-1914. Annual-peak discharge data for this site are available from 1907-1910 and 1948 and are considered to be equivalent to peak-discharge data at the current site at Dixon. Annual-peak discharge data for stations 12388200, 12388000, and the CSKT crest-stage gage were combined for analysis and the combined data will hereafter be referred to as annual-peak discharges for the Jocko River at Dixon.

Upstream from the study area, the CSKT have operated a streamflow-gaging station on the Jocko River below the intake to K Canal near Arlee since 1990 (fig. 1). Also upstream from the study area, the USGS operated a streamflow-gaging station, Jocko River below Big Knife Creek, near Jocko (station 12384500), from 1909-1916. Annual-peak discharge data for 1909, 1916, and 1948 are available for this station. Annual-peak discharge data for station 12384500 are considered to be equivalent to those at the CSKT site near Arlee. Annual-peak discharge data for station 12384500 and the CSKT site below the intake to K Canal also were combined for analysis and the combined data will hereinafter be referred to as annual-peak discharges for the Jocko River near Arlee.

Large floods on the Jocko River are known to have occurred in 1908, 1948, 1964, and 1997. The largest known peak discharge on the Jocko River was estimated to be 7,500 ft^3/s in 1908 at Dixon (table 1, sheet 1). Peak discharge upstream near Arlee on the same date was estimated to be 6,200 ft^3/s. During the 1948 flood, peak discharges at the same sites at Dixon and near Arlee were estimated to be 3,700 ft^3/s and 2,660 ft^3/s, respectively. Although peak-discharge data are not available for the Jocko River for 1964, the flood of June 7-9, 1964, is remembered by long-time residents in the area as one of the largest (Seth V. Makepeace, Confederated Salish and Kootenai Tribes of the Flathead Nation, written commun., 2005). The most recent flood on the Jocko River produced a peak discharge of 2,710 ft^3/s (the station at Dixon, station 12388200) on May 18, 1997. The peak discharge on this date upstream near Arlee was 2,300 ft^3/s.

Hydrologic Analysis

The annual-peak discharge that has a 1-percent chance of exceedance in any year was selected by the CSKT for analysis to be consistent with other flood studies in Montana. This peak discharge is exceeded, on average, once in any 100-year period and commonly is referred to as the 100-year flood discharge. However, larger floods can occur at shorter intervals. To indicate the flood limits associated with an even rarer flood discharge than the 100-year flood, the CSKT also selected the 500-year flood discharge (0.2-percent chance of exceedance) for analysis.

The 100- and 500-year flood discharges for the Jocko River at Dixon were estimated by applying the log Pearson Type III probability distribution to the recorded and estimated annual-peak discharges for the period of record from 1907-1910, 1948, and 1986 to 2001 using methods described by the Interagency Advisory Committee on Water Data (1982). The peak discharges for 1908 (7,500 ft^3/s) and 1948 (3,700 ft^3/s) are considered to be the largest during the entire period from 1907 to 2001; thus, these values were treated as historic peak discharges (largest peak discharges in 94 years) as described by the Interagency Advisory Committee on Water Data (1982).

The 100- and 500-year flood discharges for Jocko River near Arlee were estimated by applying the log Pearson Type III probability distribution to the recorded and estimated peak discharges at the USGS and CSKT gaging stations for the period of record from 1908, 1916, 1948, and 1990 to 2001. The peak discharges for 1908 (6,200 ft^3/s) and 1948 (2,660 ft^3/s) also were treated as historic peak discharges (largest peak discharges in 94 years).

Flood discharges on the Jocko River change between Dixon and Arlee as Valley Creek and Finley Creek join the river. From the mouth of the Jocko River to Valley Creek (fig. 1), the 100- and 500-year flood discharges were assumed to be the same as those determined from the gaged data at Jocko River at Dixon. Upstream from Valley Creek to Finley Creek, the 100-year and 500-year flood discharges were estimated based on a linear interpolation between logarithms of flood discharges at Jocko River at Dixon and logarithms of flood discharges at Jocko River near Arlee using logarithms of drainage area as the basis for interpolation (Parrett and Johnson, 2004). The 100- and 500-year flood discharges upstream from Finley Creek to the upstream limits of the study area were assumed to be the same as those determined from the gaged data near Arlee. Drainage area and selected flood-frequency data for the Jocko River are summarized in table 2 (sheet 1). Recorded and estimated peak-flow discharges for May 18, 1997, also are included in table 2.

Hydraulic Analysis

Methods

HEC-RAS, version 3.1.1, a one dimensional, hydraulic-flow model developed by the U.S. Army Corps of Engineers (2001a,b,c), was used to calculate water-surface elevations at cross sections for the 100-year and 500-year flood discharges and for the 1997 peak discharge. Channel and flood-plain geometry for 113 cross sections were surveyed between 1999 and 2001 for use in the model. Bridge geometries at 9 of the 113 sections located just downstream from bridge crossings were surveyed. Data from surveyed cross sections downstream from the bridges were used to estimate channel and flood-plain geometry at the upstream and downstream edges of the bridges for use in the HEC-RAS model. For clarity, only the surveyed cross section immediately downstream from each bridge is shown on the map segments. Data from interpolated cross sections were used at 15 more locations where the hydraulic-model results indicated that additional channel and flood-plain geometry were required. For clarity, only 5 of the 15 interpolated sections are shown on the map segments. Overall, a total of 146 cross sections (113 surveyed cross sections, 15 interpolated cross sections, and 18 cross sections at the upstream and downstream bridge edges) were used for hydraulic analyses. Data for the cross sections are available in files at the USGS Montana Water Science Center office in Helena, Mont.

Cross sections are numbered in increasing order upstream. The interpolated cross sections are designated on the maps and tables with a whole number and two digits following the decimal point. The whole number corresponds to that of the closest downstream surveyed cross section, and the digits after the decimal point are numbered in upstream order. For example, four cross sections were interpolated between cross sections 17 and 18 (Map segment 1). The cross section farthest downstream was designated as 17.01, while the cross section farthest upstream was designated as 17.04. To describe the hydraulic analysis, the Jocko River was divided into eight reaches (fig. 1). All study reaches, except the first, begin halfway between the first cross section in the reach and the next downstream cross section outside the reach. Likewise, all study reaches, except the last, end halfway between the last cross section in the reach and the next upstream cross section outside the reach. The first study reach begins at the first (farthest downstream) cross section in the study area, and the last reach ends at the last cross section (farthest upstream) in the study area. Study reaches are described in upstream order in subsequent sections of the report.

Manning's roughness coefficients (Henderson, 1966) were noted in the field at the time of the survey. The roughness coefficients were subsequently checked and adjusted for consistency during the hydraulic analysis. The elevations of high-water marks, such as debris deposits, from the 1997 and earlier floods were surveyed where marks could be found. These high-water mark elevations were compared with water-surface elevations initially calculated by the model. The comparisons were used to verify the roughness coefficients, which ranged from 0.035 to 0.130 for the flood plain and from 0.035 to 0.050 for the main channel. Both ranges are similar to values for Manning's roughness coefficients that were calculated from measured discharge and channel-geometry and flood-plain data for similar streams (Barnes, 1967; Arcement and Schneider, 1989; and Coon, 1998).

Field surveys and elevations were referenced to National Geodetic Survey bench marks along the Jocko River valley (Map segments 1-3). Information about the bench marks can be obtained from the National Geodetic Survey at *http://www.ngs.noaa.gov* (accessed July 2005). Additional elevation-control points were obtained from the CSKT (Map segments 1-3).

Split-Flow Estimation

At many locations along the Jocko River, the 100- and 500-year flood discharges can overtop channel banks. At most of these locations, water on the flood plain flows in the same direction as that in the channel, and the water-surface elevation is the same on both sides of the flood plain, as measured on a line perpendicular to the flow direction. However, along Reaches 2, 3, 5, and 7 (fig. 1), floodwater on the left-flood plain (left and right defined by looking downstream; for example, the left bank is on the south or western side of the Jocko River) can move independently from floodwater in the main channel for a substantial distance along the channel, creating a split-flow condition. Consequently, the water-surface elevations can differ substantially from one side of the flood plain to the other. In these split-flow reaches, discharge in the main channel and discharge on the left-flood plain were analyzed separately.

The methods used to estimate the distribution of flood discharges in the split-flow reaches (table 3, sheet 1) are described in the following sections. In Reaches 2, 3, and 5, the split-flow conditions were, at least partly, the result of berms and levees on the left bank (Map segment 1). Although berms and levees are present in all reaches of the Jocko River, only in Reaches 2, 3, and 5 are they long enough and high enough to create split-flow conditions. The berms and levees

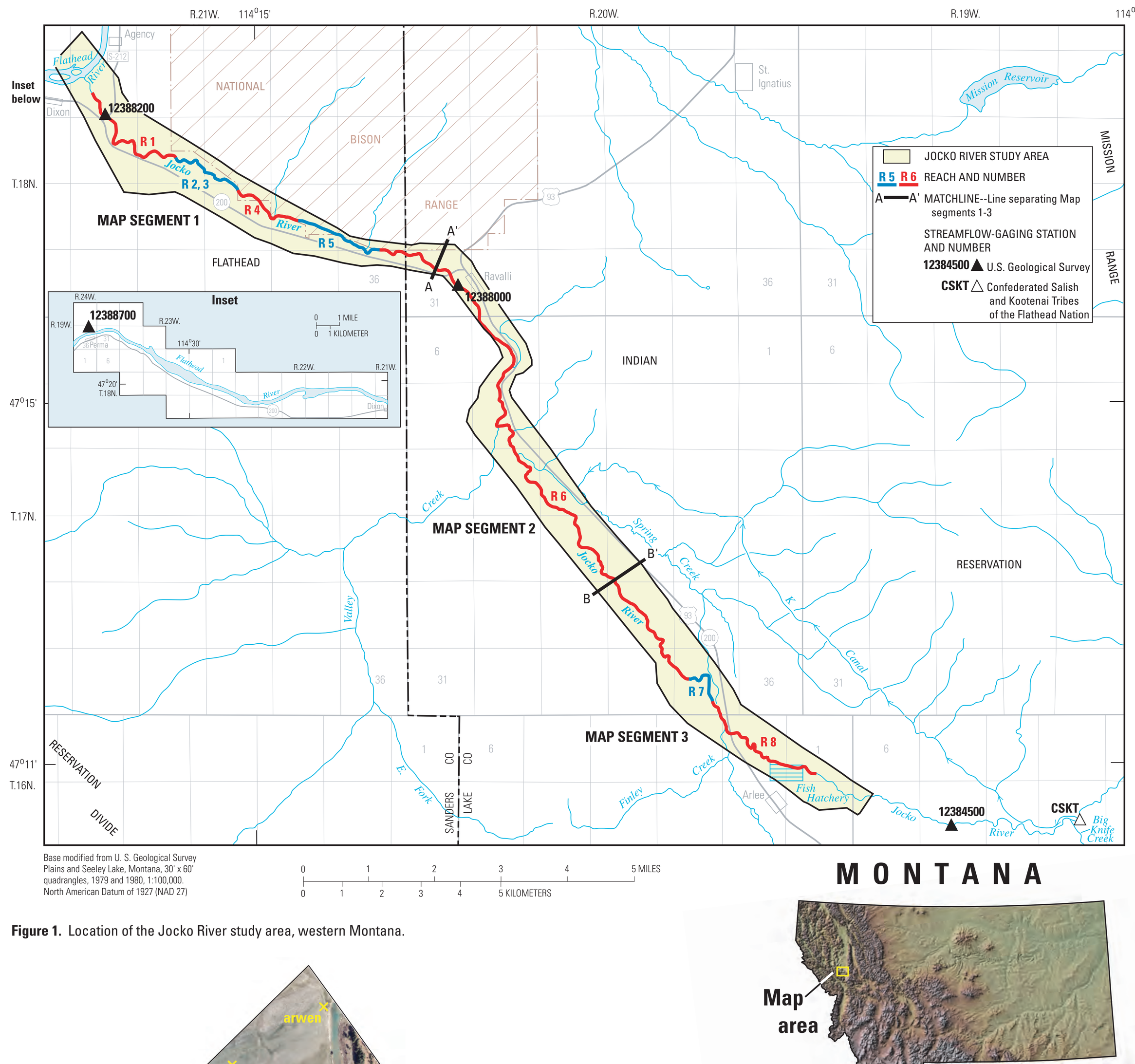


Figure 1. Location of the Jocko River study area, western Montana.

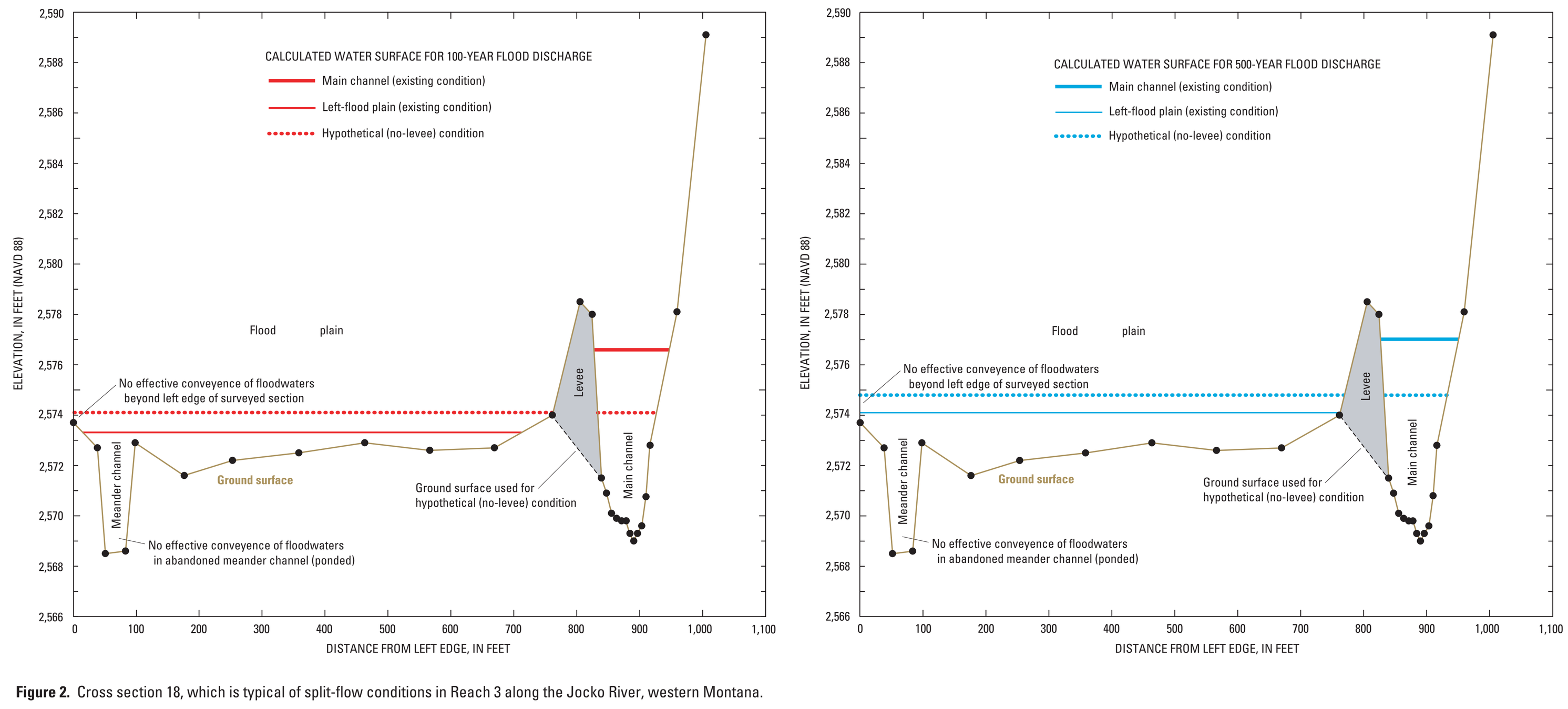


Figure 2. Cross section 18, which is typical of split-flow conditions in Reach 3 along the Jocko River, western Montana.

DIAGRAM SHOWING RELATIVE POSITION OF MAP SEGMENTS AND MATCHLINES ALONG THE JOCKO RIVER

EXPLANATION
JOCKO RIVER STUDY AREA
1 MAP SEGMENT NUMBER--Red segment number represents segments shown on this sheet
A—A' MATCHLINE--Line separating Map segments 1-3

Table 5. Streambed- and calculated water-surface elevation data for split-flow reaches for the 100-year flood discharge on the Jocko River, western Montana.

[Table 5 continued on sheet 3. Distance upstream from cross section 1 measured along channel centerline shown on U.S. Geological Survey 7.5-minute quadrangle maps. Vertical coordinate information referenced to North American Vertical Datum of 1988 (NAVD 88)]

Cross section	Distance upstream from cross section 1, in thousands of feet	Minimum streambed elevation, in feet	Main channel: Existing condition (with levee)	Main channel: Hypothetical condition (no levee)	Left-flood plain: Existing condition (with levee)	Left-flood plain: Hypothetical condition (no levee)
Reach 2—Split-Flow 1 (Map segment 1)						
17.02	11.46	2,563.4	2,571.0	2,569.7	2,571.0	2,569.7
17.03	12.17	2,566.0	2,572.8	2,571.4	2,571.3	2,571.4
17.04	12.57	2,567.5	2,574.9	2,572.8	2,571.7	2,572.8
Reach 3—Split-Flow 2 (Map segment 1)						
18	12.98	2,569.0	2,576.6	2,574.1	2,573.3	2,574.1
19	14.51	2,576.5	2,584.6	2,582.7	2,583.8	2,582.7
20	15.95	2,580.0	2,591.0	2,590.5	2,591.3	2,590.5
21	17.14	2,586.6	2,594.6	2,594.0	2,595.7	2,594.0
22	18.02	2,589.0	2,597.5	2,598.6	2,598.7	2,598.6
23	18.78	2,594.4	2,601.0	2,600.3	2,599.3	2,600.3
Reach 5—Split-Flow 3 (Map segment 1)						
28	26.23	2,622.2	2,630.7	2,630.4	2,630.8	2,630.4
29	27.12	2,627.1	2,633.8	2,633.0	2,634.1	2,633.0
30	27.84	2,630.8	2,637.7	2,638.2	2,640.0	2,638.2
31	28.16	2,629.0	2,638.5	2,639.2	2,640.1	2,639.2
32	28.60	2,632.2	2,641.2	2,640.5	2,640.2	2,640.5
33	29.50	2,634.8	2,644.3	2,644.6	2,644.4	2,644.6
34	30.91	2,641.5	2,650.5	2,650.7	2,652.5	2,650.7

Table 4. Streambed- and calculated water-surface elevation data for the main channel of the Jocko River, western Montana.

[Table 4 continued on sheets 2 and 3. Distance upstream from cross section 1 measured along channel centerline shown on U.S. Geological Survey 7.5-minute quadrangle maps. Vertical coordinate information referenced to North American Vertical Datum of 1988 (NAVD 88). Abbreviations: DS, downstream side of bridge; US, upstream side of bridge]

Cross section[1]	Distance upstream from cross section 1, in thousands of feet	Minimum streambed elevation, in feet	100-year flood discharge: Existing condition (with levee)	100-year flood discharge: Hypothetical condition (no levee)	500-year flood discharge: Existing condition (with levee)	500-year flood discharge: Hypothetical condition (no levee)
Reach 1 (Map segment 1)						
1	0.00	2,513.2	2,518.0	2,518.0	2,518.7	2,518.7
2	.42	2,511.0	2,519.4	2,519.4	2,520.4	2,520.4
2 DS[2]	.43	2,511.0	2,520.2	2,520.2	2,521.1	2,521.1
2 US[2]	.45	2,511.0	2,520.4	2,520.4	2,521.7	2,521.7
3	.63	2,514.7	2,521.8	2,521.8	2,523.7	2,523.7
4	1.68	2,514.5	2,523.0	2,523.0	2,524.5	2,524.5
5	2.05	2,519.4	2,524.5	2,524.5	2,525.7	2,525.7
6	2.44	2,520.4	2,528.2	2,528.2	2,529.5	2,529.5
6 DS[2]	2.45	2,520.4	2,528.1	2,528.1	2,529.3	2,529.3
6 US[2]	2.47	2,520.4	2,528.3	2,528.3	2,529.8	2,529.7
7	2.69	2,519.9	2,529.2	2,529.2	2,531.1	2,531.1
8	3.01	2,523.0	2,531.5	2,531.5	2,533.0	2,533.0
9	3.29	2,524.3	2,531.9	2,531.9	2,533.8	2,533.8
9 DS[2]	3.29	2,524.3	2,533.1	2,533.1	2,533.8	2,533.8
9 US[2]	3.32	2,524.3	2,533.5	2,533.5	2,537.6	2,537.6
10	3.59	2,525.6	2,535.7	2,535.7	2,540.9	2,540.9
11	4.88	2,533.5	2,539.3	2,539.4	2,541.2	2,541.2
12	6.73	2,545.9	2,553.8	2,553.8	2,555.5	2,555.5
13	7.76	2,550.6	2,556.8	2,556.8	2,558.3	2,558.3
14	8.91	2,553.0	2,559.4	2,559.4	2,560.3	2,560.3
15	10.00	2,554.9	2,563.8	2,563.8	2,564.5	2,564.5
16	10.35	2,559.4	2,565.0	2,565.0	2,566.1	2,566.1
16 DS[2]	10.35	2,559.4	2,565.4	2,565.4	2,566.7	2,566.7
16 US[2]	10.37	2,559.4	2,565.4	2,565.4	2,566.7	2,566.7
17	10.95	2,561.4	2,568.7	2,568.7	2,570.4	2,570.4
17.01	11.36	2,562.9	2,569.3	2,569.3	2,570.8	2,570.8
Reach 2—Split-Flow 1 (Map segment 1)						
17.02	11.46	2,563.4	[3]2,571.0	[3]2,569.7	[3]2,572.6	[3]2,570.8
17.03	12.17	2,566.0	[3]2,572.8	[3]2,571.4	[3]2,573.2	[3]2,572.3
17.04	12.57	2,567.5	[3]2,574.9	[3]2,572.8	[3]2,574.9	[3]2,573.6
Reach 3—Split-Flow 2 (Map segment 1)						
18	12.98	2,569.0	[3]2,576.6	[3]2,574.1	[3]2,577.0	[3]2,574.8
19	14.51	2,576.5	[3]2,584.6	[3]2,582.7	[3]2,585.8	[3]2,584.2
20	15.95	2,580.0	[3]2,591.0	[3]2,590.5	[3]2,592.0	[3]2,591.2
21	17.14	2,586.6	[3]2,594.6	[3]2,594.0	[3]2,595.9	[3]2,596.0
22	18.02	2,589.0	[3]2,597.5	[3]2,598.6	[3]2,598.8	[3]2,599.5
23	18.78	2,594.4	[3]2,601.0	[3]2,600.3	[3]2,602.1	[3]2,600.9
Reach 4 (Map segment 1)						
24	20.90	2,600.3	2,608.3	2,608.3	2,609.0	2,609.0
25	22.26	2,607.5	2,613.9	2,613.0	2,614.9	2,614.1
26	23.33	2,614.5	2,620.5	2,620.6	2,621.8	2,621.8
27	25.06	2,619.2	2,627.9	2,627.9	2,628.6	2,628.6
Reach 5—Split-Flow 3 (Map segment 1)						
28	26.23	2,622.2	[3]2,630.7	[3]2,630.4	[3]2,632.1	[3]2,631.7
29	27.12	2,627.1	[3]2,633.8	[3]2,633.0	[3]2,635.4	[3]2,634.4
30	27.84	2,630.8	[3]2,637.7	[3]2,638.2	[3]2,639.1	[3]2,639.7
31	28.16	2,629.0	[3]2,638.5	[3]2,639.2	[3]2,639.6	[3]2,641.1
32	28.60	2,632.2	[3]2,641.2	[3]2,640.5	[3]2,643.7	[3]2,641.6
33	29.50	2,634.8	[3]2,644.3	[3]2,644.6	[3]2,645.9	[3]2,645.7
34	30.91	2,641.5	[3]2,650.5	[3]2,650.7	[3]2,652.0	[3]2,651.8
Reach 6 (Map segment 1)						
35	32.22	2,648.6	2,655.6	2,655.8	2,657.4	2,657.3
36	33.59	2,651.7	2,661.4	2,661.4	2,663.0	2,662.1
37	34.45	2,658.0	2,664.5	2,664.5	2,665.2	2,665.7
38	36.04	2,664.0	2,671.0	2,671.0	2,671.8	2,671.7
39	37.18	2,666.4	2,673.5	2,673.3	2,674.2	2,674.1

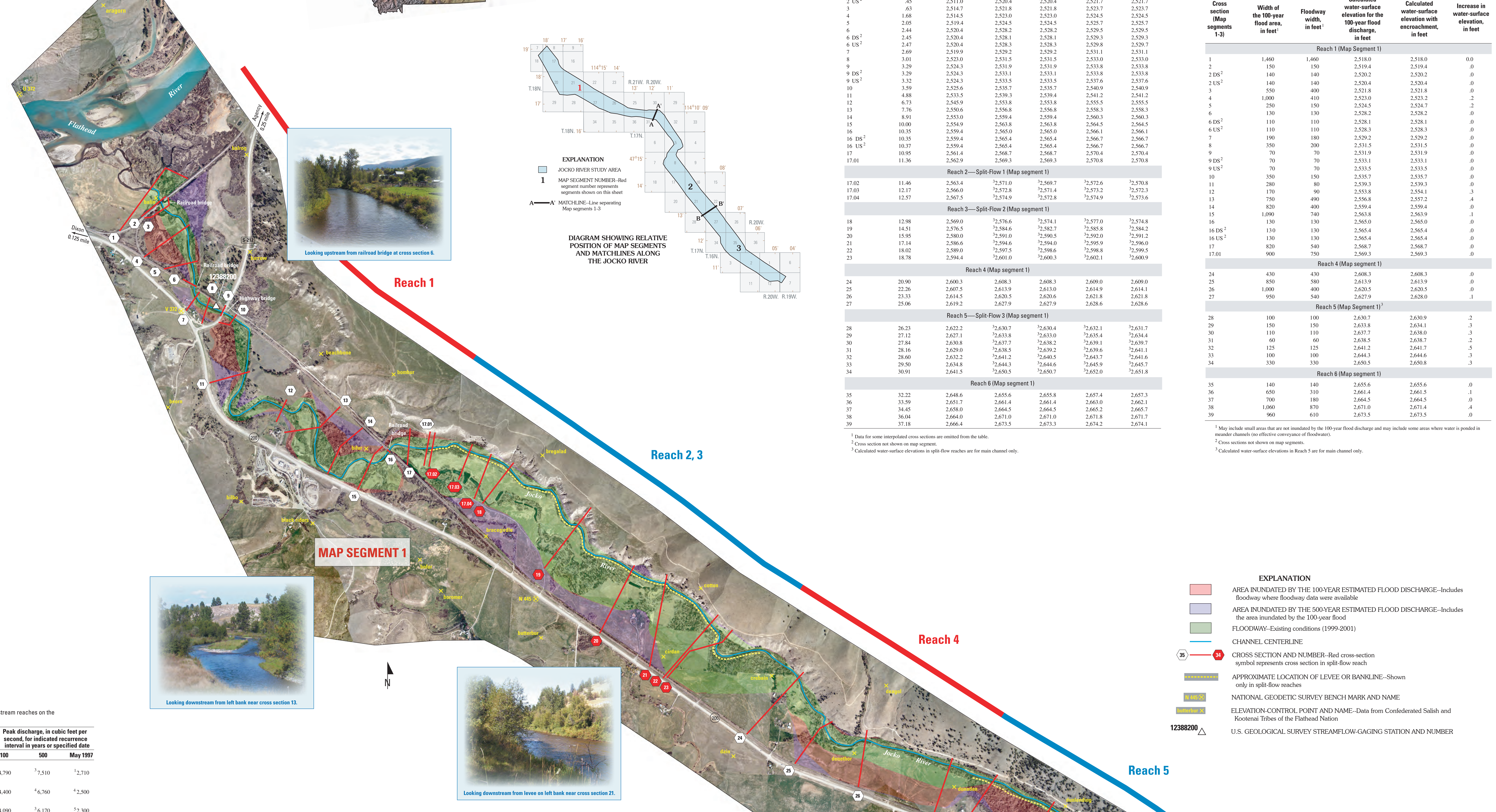
[1] Data for some interpolated cross sections are omitted from the table.
[2] Cross section not shown on map segment.
[3] Calculated water-surface elevations in split-flow reaches are for main channel only.

Table 6. Floodway data for the Jocko River, western Montana.

[Table 6 continued on sheets 2 and 3. Floodway determined for Reaches 1, 4, 5, 6, and 8 for existing (1999-2001) conditions. Floodway width was expanded to equal the width of the 100-year flood area at all cross sections in split-flow Reaches 2, 3, and 7. Vertical coordinate information referenced to North American Vertical Datum of 1988 (NAVD 88). Abbreviations: DS, downstream side of bridge; US, upstream side of bridge]

Cross section (Map segments 1-3)	Width of the 100-year flood area, in feet[1]	Floodway width, in feet[1]	Calculated water-surface elevation for the 100-year flood discharge, in feet	Calculated water-surface elevation with encroachment, in feet	Increase in water-surface elevation, in feet
Reach 1 (Map Segment 1)					
1	1,460	1,460	2,518.0	2,518.0	0.0
2	150	150	2,519.4	2,519.4	.0
2 DS[2]	140	140	2,520.2	2,520.2	.0
2 US[2]	140	140	2,520.4	2,520.4	.0
3	550	400	2,521.8	2,521.8	.0
4	1,000	410	2,523.0	2,523.2	.2
5	250	150	2,524.5	2,524.7	.2
6	130	130	2,528.2	2,528.2	.0
6 DS[2]	110	110	2,528.1	2,528.1	.0
6 US[2]	110	110	2,528.3	2,528.3	.0
7	190	180	2,529.2	2,529.2	.0
8	350	200	2,531.5	2,531.5	.0
9	70	70	2,531.9	2,531.9	.0
9 DS[2]	70	70	2,533.1	2,533.1	.0
9 US[2]	70	70	2,533.5	2,533.5	.0
10	350	150	2,535.7	2,535.7	.0
11	280	80	2,539.3	2,539.3	.0
12	170	90	2,553.8	2,554.1	.3
13	750	490	2,556.8	2,557.2	.4
14	820	400	2,559.4	2,559.4	.0
15	1,090	740	2,563.8	2,563.9	.1
16	130	130	2,565.0	2,565.0	.0
16 DS[2]	130	130	2,565.4	2,565.4	.0
16 US[2]	130	130	2,565.4	2,565.4	.0
17	820	540	2,568.7	2,568.7	.0
17.01	900	750	2,569.3	2,569.3	.0
Reach 4 (Map segment 1)					
24	430	430	2,608.3	2,608.3	.0
25	850	580	2,613.9	2,613.9	.0
26	1,000	400	2,620.5	2,620.5	.0
27	950	540	2,627.9	2,628.0	.1
Reach 5 (Map Segment 1)[3]					
28	100	100	2,630.7	2,630.9	.2
29	150	150	2,633.8	2,634.1	.3
30	110	110	2,637.7	2,638.0	.3
31	60	60	2,638.5	2,638.7	.2
32	125	125	2,641.2	2,641.7	.5
33	100	100	2,644.3	2,644.6	.3
34	330	330	2,650.5	2,650.8	.3
Reach 6 (Map segment 1)					
35	140	140	2,655.6	2,655.6	.0
36	650	310	2,661.4	2,661.5	.1
37	700	180	2,664.5	2,664.5	.0
38	1,060	870	2,671.0	2,671.4	.4
39	960	610	2,673.5	2,673.5	.0

[1] May include small areas that are not inundated by the 100-year flood discharge and may include some areas where water is ponded in meander channels (no effective conveyance of floodwater).
[2] Cross sections not shown on map segments.
[3] Calculated water-surface elevations in Reach 5 are for main channel only.



Looking upstream from railroad bridge at cross section 6.

Looking downstream from left bank near cross section 13.

Looking downstream from levee on left bank near cross section 21.

Table 1. Largest estimated and recorded annual-peak discharges for the Jocko River, western Montana.

[Abbreviation: e, estimated. Symbol: --, no data]

Year	Discharge of Jocko River, in cubic feet per second: At Dixon	Near Arlee
1907	[1]1,860	--
1907	[1]1,540	--
1908	[1]7,500e	[2]6,200e
1909	[1]1,540	[2]1,480
1910	[1]1,590	--
1916	--	[2]1,630
1948	[3]3,700e	[2]2,660e
1997	[4]2,710	[5]2,300

[1] Data for streamflow-gaging station 12388000 from U.S. Geological Survey (1955).
[2] Data for streamflow-gaging station 12384500 from U.S. Geological Survey (1955).
[3] Data for streamflow-gaging station 12388000 from Rantz and Riggs (1949).
[4] Data for streamflow-gaging station 12388200 from U.S. Geological Survey (2004).
[5] Data for Confederated Salish and Kootenai Tribes gaging station below the intake to K Canal (Seth V. Makepeace, Confederated Salish and Kootenai Tribes of the Flathead Nation, written commun., 2003).

Table 2. Drainage-area, flood-frequency, and May 1997 peak flow data for selected stream reaches on the Jocko River, western Montana.

Stream reach (fig. 1)	Drainage area, in square miles	Cross section numbers	Peak discharge, in cubic feet per second, for indicated recurrence interval in years or specified date: 100	500	May 1997
Mouth of Jocko River to Valley Creek (includes reaches 1-5 and part of reach 6)	[1]380	[2]1-71	[3]4,790	[3]7,510	[1]2,710
Valley Creek to Finley Creek (includes part of reach 6, reach 7, and part of reach 8)	236	72-101	[4]4,400	[4]6,760	[4]2,500
Finley Creek to upstream study area boundary (includes part of reach 8)	[5]157	102-112	[3]4,090	[3]6,170	[5]2,300

[1] Drainage area and peak discharges are the same as those determined for streamflow-gaging station Jocko River at Dixon (station 12388200).
[2] Valley Creek channel joins the Jocko River channel between cross sections 68 and 69. Flood discharges from Valley Creek mix with flood discharges on Jocko River upstream to about cross section 71.
[3] Estimated by applying the log Pearson Type III probability distribution to the recorded and estimated peak discharges at U.S. Geological Survey and Confederated Salish and Kootenai Tribes of the Flathead Nation gaging stations.
[4] Estimated based on linear interpolation between logarithms of flood discharges at Jocko River at Dixon and logarithms of flood discharges at Jocko River at Arlee using logarithms of drainage area as the basis for interpolation (Parrett and Johnson, 2004).
[5] Drainage area and peak discharges are the same as those determined for streamflow-gaging station Jocko River below Big Knife Creek, near Jocko (station 12384500).

Table 3. Estimated distribution of flood discharge between the main channel and the left part of the flood plain for split-flow reaches on the Jocko River, western Montana.

Stream reach	Cross section numbers	100-year recurrence interval: Main channel	100-year: Left-flood plain	500-year recurrence interval: Main channel	500-year: Left-flood plain	May 1997: Main channel	May 1997: Left-flood plain
Reach 2—split-flow 1	17.02-17.04	Varies[1]	Varies[1]	Varies[1]	Varies[1]	2,710	0
Subreach 17.02	17.02	2,910	1,880	2,910	4,600	2,710	0
Subreach 17.03	17.03	3,710	1,080	3,710	3,800	2,710	0
Subreach 17.04	17.04	3,890	900	4,410	3,100	2,710	0
Reach 3—split-flow 2	18-23	3,890	900	5,070	2,440	2,710	0
Reach 5—split-flow 3	28-34	4,390	400	6,590	920	2,710	0
Reach 7—split-flow 4	92-93	2,940	1,460	3,300	3,460	2,380	120

Peak discharge, in cubic feet per second.

[1] Distribution of discharge between the main channel and left-flood plain changes throughout the reach.

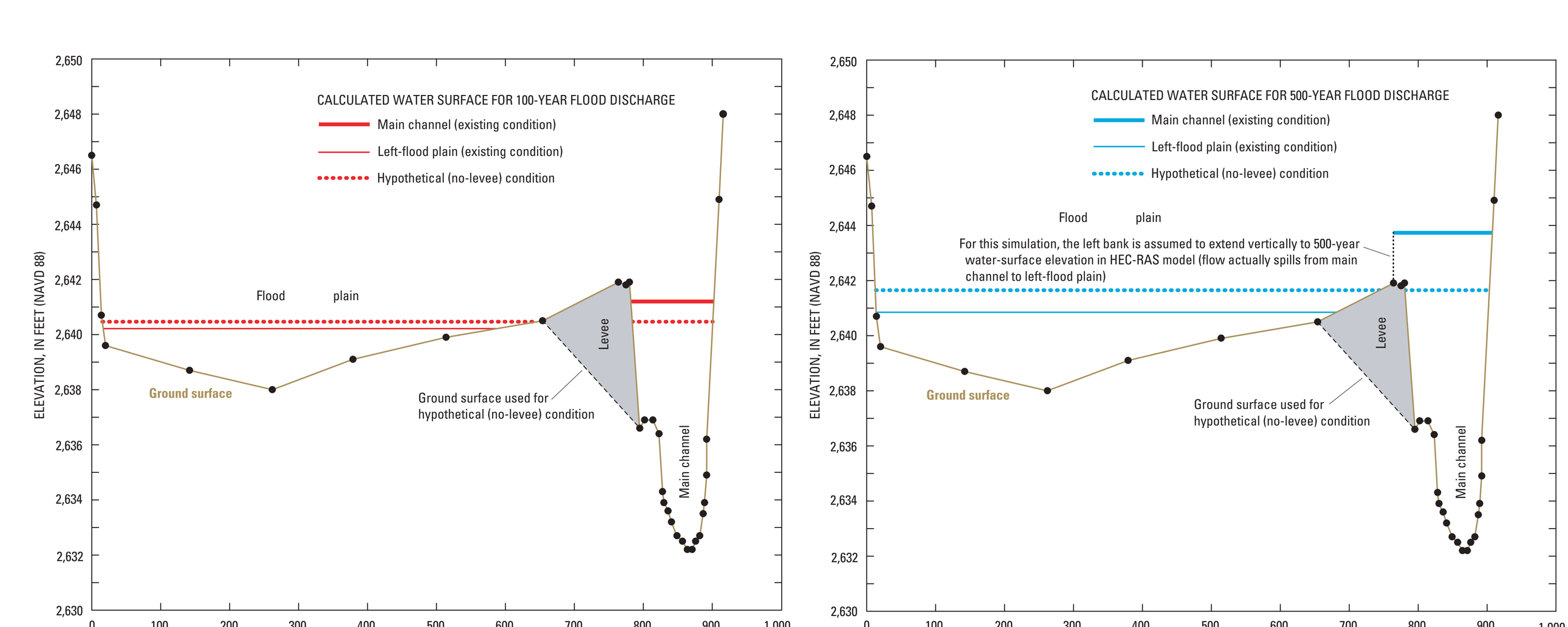


Figure 3. Cross section 32, which is typical of channel and flood-plain conditions in Reach 5 along the Jocko River, western Montana.