CALIFORNIA TROUT

APPENDIX I: WETTED PERIMETER ANALYSIS

Prepared by:
California Trout North Coast Region
Humboldt State University Institute for River Ecosystems

Prepared for:
North Coast Regional Water Quality Control Board and State Water Resources Control Board
Grant Agreement No. 14-420-251

Funding for this project has been provided in part through an Agreement with the State Water Resources Control Board and the US Environmental Protection Agency under the Federal Nonpoint Source Pollution Control Program (Clean Water Act Section 319). The contents of this document do not necessarily reflect the views and policies of the State Water Resources Control Board, nor does mention of the trade names or commercial products constitute endorsement or recommendations for use.

SEPTEMBER 1, 2017

Introduction

This appendix to the Instream Flow Study on Sproul Creek in the South Fork Eel River Basin provides wetted perimeter data and streamflows (Table 1). These data were used to plot wetted perimeter curves (Figures 1 through 8) for the eight wetted perimeter cross sections in the two Sproul Creek study reaches, Upper Mainstem (UMS, 17 mi^2) and the Upper South Fork (USF, 5 mi^2). The corresponding bed elevation profiles for selected cross sections appear in Figures 9-14. Photographs of wetted perimeter cross sections appear in Figures 15-35, with each cross section photographed during flows ranging from 0 to 116 cfs.

The term *wetted perimeter* refers to the length of wetted channelbed along a cross sectional area of a streambed, where water depth is measurable to at least 0.01 feet. The Wetted Perimeter method uses the relation between channel geometry and flow to help determine maintenance flow needs for productive riffle habitats. This method is “not applicable in determining salmonid rearing flows or identifying trade-offs between flow levels and specific biological functions, water quality, or geomorphic processes” (CDFW 2013).

Methods

Wetted perimeter curves were developed for Sproul Creek using CDFW’s Wetted Perimeter Method (CDFW-IFP-004, 2013). The wetted perimeter - discharge curve was then used to identify the curve’s first point of maximum curvature (breakpoint) and a second inflection point (incipient asymptote). Eight riffles within the study reaches were chosen by CalTrout during field reconnaissance in early spring of 2016 for wetted perimeter analysis. All riffles were well defined, low gradient (<4%) with gravel to cobble dominated substrates and roughly rectangular in cross section. The wetted perimeter riffle sites generally represented the geomorphic structure and shape of the overall reach. Meso-habitat unit mapping encompassing the study sites was carried out in 2016 by CaTrout personnel. Fortuna CDFW staff also conducted habitat mapping which included the whole stream on Sproul Creek in 2016. Habitat mapping and reach selection is discussed in Appendix A.

Once wetted perimeter sites were identified, transects were established across the channel from bank to bank. Transects included the riffle-crest thalweg point (hydraulic control of the pool/riffle) or as close to it as feasibly possible. Head-pins and tail-pins (0.5 inch diameter rebar) were placed on the bank above active channel, flagged and labeled. The headpin for each wetted perimeter transect was located on the left bank looking downstream, and the tail-pin on right bank. The head-pin served as the starting reference point for each wetted perimeter water depth measurement, starting from zero feet, and the tail-pin served as the end reference point of the measurements. Transects were then photographed and stations along each were measured for water depth, water surface elevation, and left and right edges of water were recorded over a wide range of flows. Water depths were measured to the nearest 0.01 ft with a stadia rod.

Data was collected from April 2016 to November 2016. A discharge measurement was taken before transect measurement, and a water level logger recorded the stage at the beginning and end of each data collection event. Streamflows were measured for the Upper Mainstem study site at station 7+80. Streamflows were taken 70 ft upstream of the West Branch of South Fork confluence for the Upper South Fork study site (station 0+70). Stage-discharge rating curves were used for Wetted Perimeter curves. Streamflow measurements and rating curve development is discussed in detail in Appendix C.

Wetted perimeter was plotted against streamflow at each cross-section (Table 1, Figures 1-8) to identify the breakpoint and incipient asymptote. Analysis of these wetted perimeter curves revealed breakpoint and incipient asymptote thresholds related to stream-flow and channel geometry. These thresholds become more defined as the number of flow measurements near the threshold value increases (CDFW 2013). Thus, breakpoint and incipient asymptote thresholds presented here could change slightly if more data were collected.

Results

Wetted Perimeter curve breakpoints were readily identifiable for all cross sections. The incipient asymptote could not be detected at a single Upper Mainstem (UMS) sites (cross section 7+70). Some incipient asymptote breakpoints were relatively arbitrary to define.. Streamflows at the Wetted Perimeter breakpoint for the Upper Mainstem ranged from 2.0 to 3.3 cfs (mean=2.8 cfs), and breakpoints for the Upper South Fork ranged from 1.4 to 2.0 cfs (mean=1.6 cfs, see Table 2). Streamflows at the incipient asymptote for the Upper Mainstem ranged from 6.6 to 14.0 cfs (mean=11.5). Streamflows at the incipient asymptote for the Upper South Fork ranged from 6.0 to 8.0 cfs (mean=7.2 cfs). Photographs of wetted perimeter cross sections appear in Figures 15-38.

Median RCT curves for reach study reach, presented in Appendix D, were used to predict the mRCT depth for each Wetted Permiter inflection. For the Upper Mainstem reach, the breakpoint and incipient asympotote had mRCT depths of 0.47 ft, and 0.73 ft, respectively. For the Upper South Fork the breakpoint and incipient asympotote had mRCT depths of 0.41 ft, and 0.64 ft, respectively.

Table I-1. Streamflow and wetted perimeter (WP) for the Upper Mainstem (UMS< 17 mi^2) reach of Sproul Creek.

UMS Cross section 7+70		UMS Cross section 10+10		UMS Cross section 15+90		UMS Cross section 21+50	
Streamflow (cfs)	WP (ft)	Streamflow (cfs)	WP (ft)	Streamflow (cfs)	WP (ft)	Streamflow (cfs)	WP (ft)
17.55	22.83	92.75	47.46	92.75	32.32	17.55	31.20
10.16	22.14	17.55	35.58	17.55	26.37	10.16	27.62
6.60	21.44	14.06	34.80	10.16	24.93	6.60	25.77
3.41	20.78	10.16	33.00	6.60	24.56	3.41	22.50
1.70	17.71	6.60	30.19	3.41	24.43	1.70	22.16
0.27	9.18	3.41	29.36	1.70	23.16	0.27	14.41
		1.70	22.70			0.10	7.81
		0.27	13.26				

Table I-2. Streamflow and wetted perimeter (WP) for Upper South Fork (USF, 5 mi^2)) reach of Sproul Creek.

USF Cross section 4+00		USF Cross section 5+00		USF Cross section 7+50		USF Cross section 10+00	
Streamflow (cfs)	WP (ft)	Streamflow (cfs)	WP (ft)	Streamflow (cfs)	WP (ft)	Streamflow (cfs)	WP (ft)
13.46	22.92	13.46	25.46	13.46	24.09	26.06	44.06
7.96	20.84	7.96	24.68	7.96	22.99	13.46	38.52
6.72	19.21	6.72	22.50	2.85	19.23	10.24	37.67
4.06	15.85	2.85	22.03	1.44	19.04	7.96	37.21
3.01	14.43	1.44	19.21	0.85	17.39	5.39	36.70
1.44	14.20	0.87	11.90	0.27	17.19	4.06	15.65
0.85	12.25	0.85	11.64	0.03	16.75	2.85	15.30
0.27	10.23	0.27	11.33			1.44	14.84
0.03	8.14	0.03	10.61			0.85	12.98
						0.27	12.58
						0.03	11.76

Table I-3. Streamflows where Breakpoints and Incipient Asymptotes occur on wetted perimeter curves, along with reach averages. An "N/A" indicates that the asymptote could not be identified from the wetted perimeter curve. The Upper Mainstem (UMS, 17 mi^2) and Upper South Fork (USF, 5 mi^2) reach averages are shown.

Reach	Cross Section	Breakpoint (cfs)	Incipient Asymptote (cfs)
UMS	7+70	2.5	N/A
UMS	10+10	3.3	14.0
UMS	15+90	3.3	14.0
UMS	21+50	2.0	6.6
UMS	UMS Average	2.8	11.5
USF	4+00	1.4	7.3
USF	5+00	2.0	7.4
USF	7+50	1.4	8.0
USF	10+00	1.4	6.0
USF	USF Average	1.6	7.2

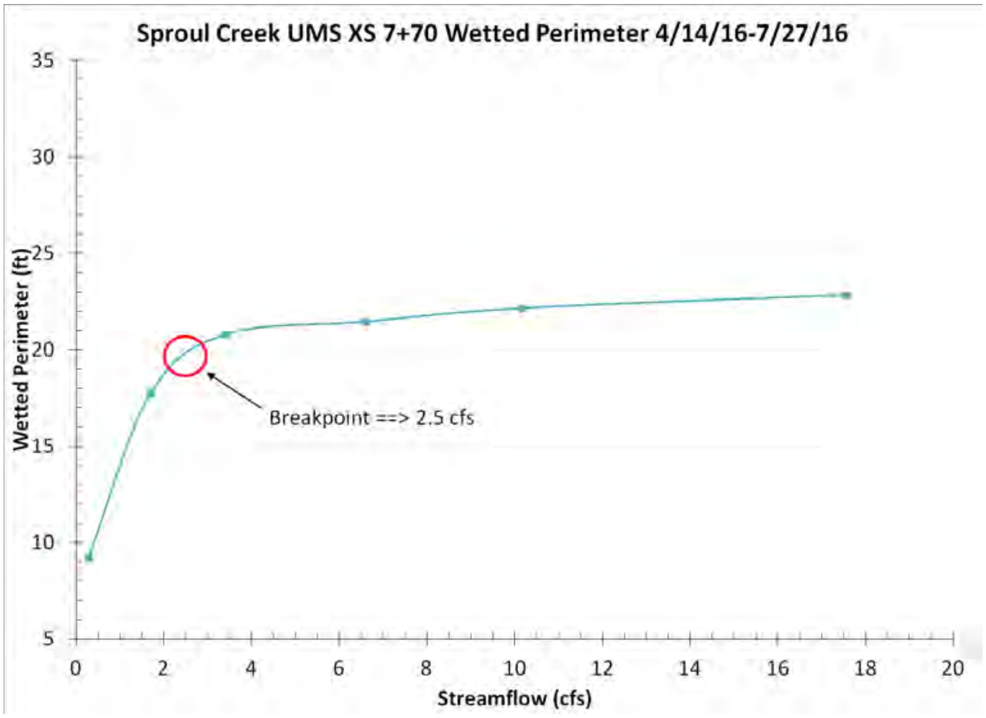

Figure I-1. Wetted perimeter curve of cross section 7+70 in Upper Mainstem (UMS) Sproul Creek with breakpoint.

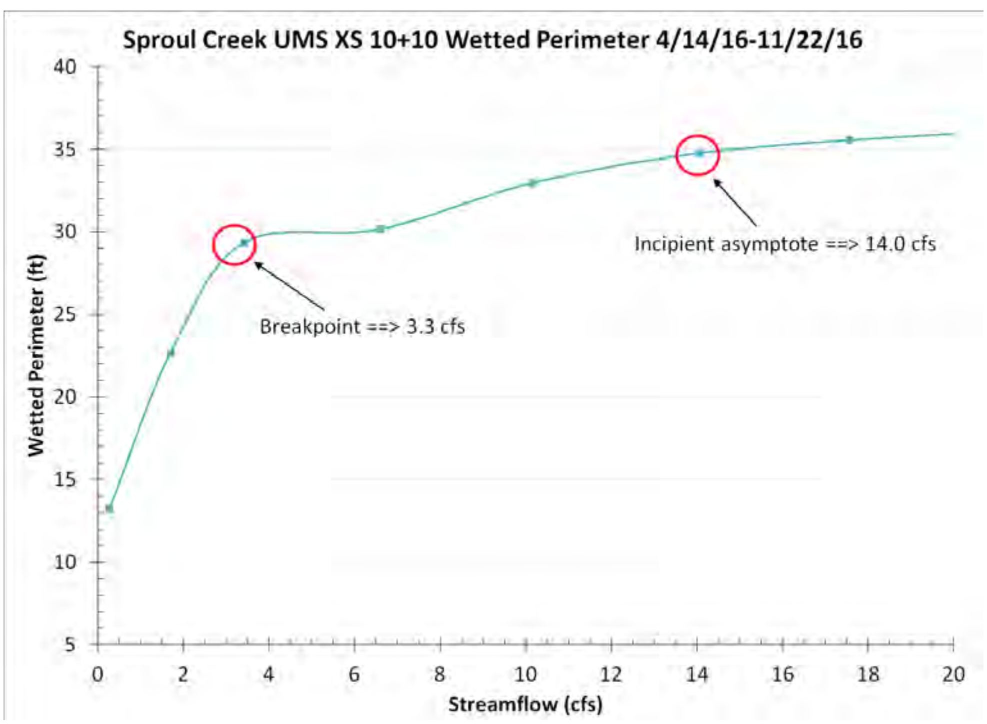

Figure I-2. Wetted perimeter curve of cross section 10+10 in Upper Mainstem (UMS) Sproul Creek with breakpoint and incipient asymptote.

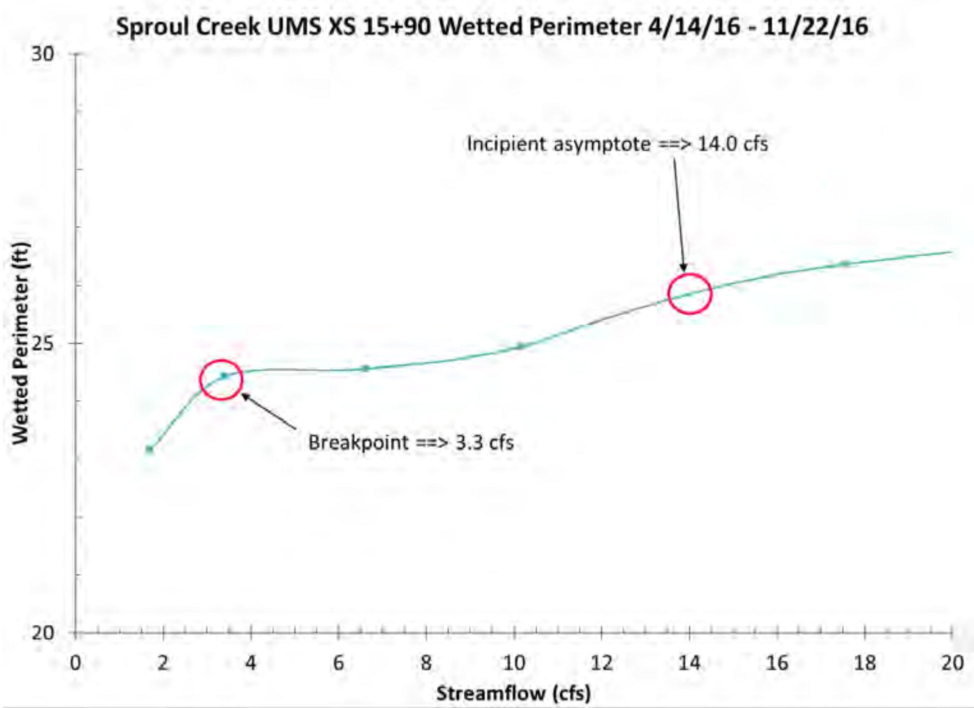

Figure I-3. Wetted perimeter curve of cross section 15+90 in Upper Mainstem (UMS) Sproul Creek with breakpoint and incipient asymptote.

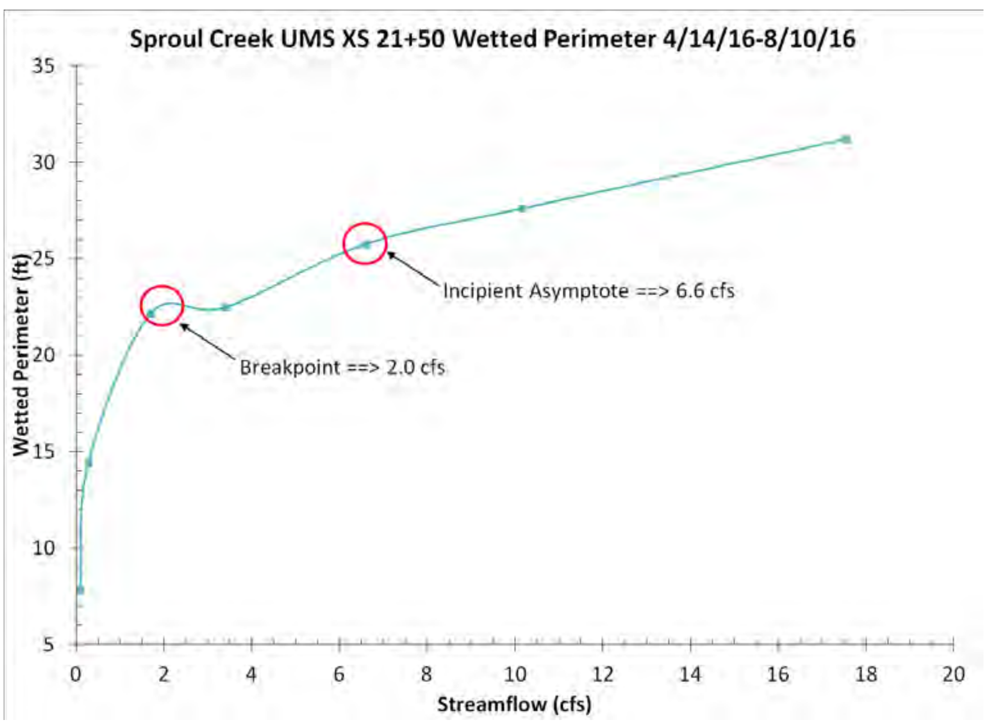

Figure I-4. Wetted perimeter curve of cross section 21+50 in Upper Mainstem (UMS) Sproul Creek with breakpoint and incipient asymptote.

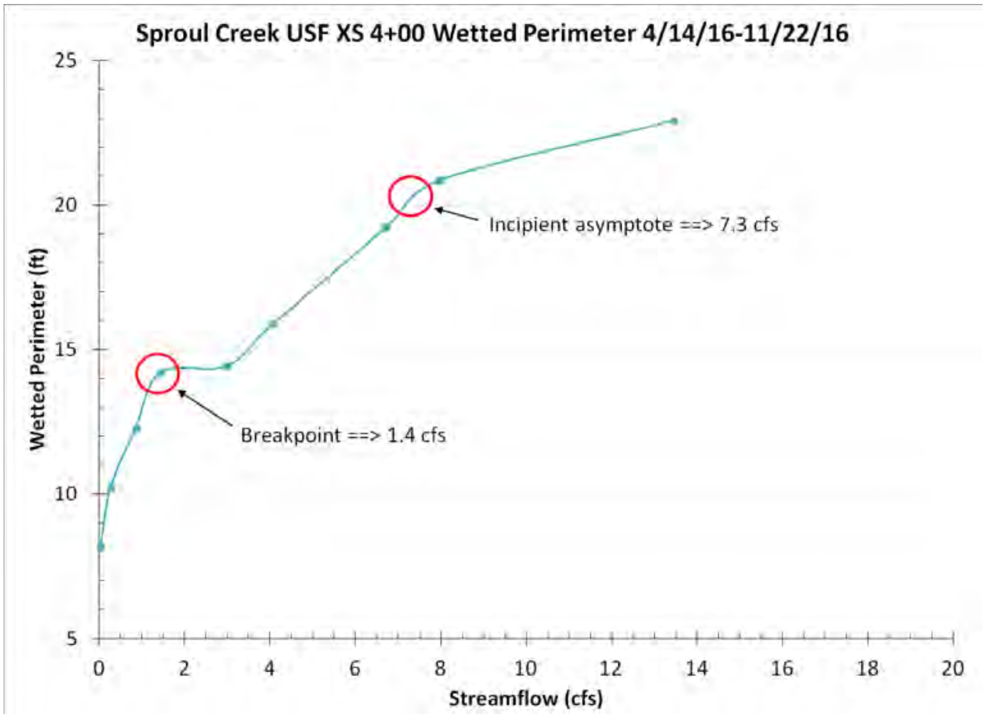

Figure I-5. Wetted perimeter curve of cross section 4+00 in Upper South Fork (USF) Sproul Creek with breakpoint and incipient asymptote.

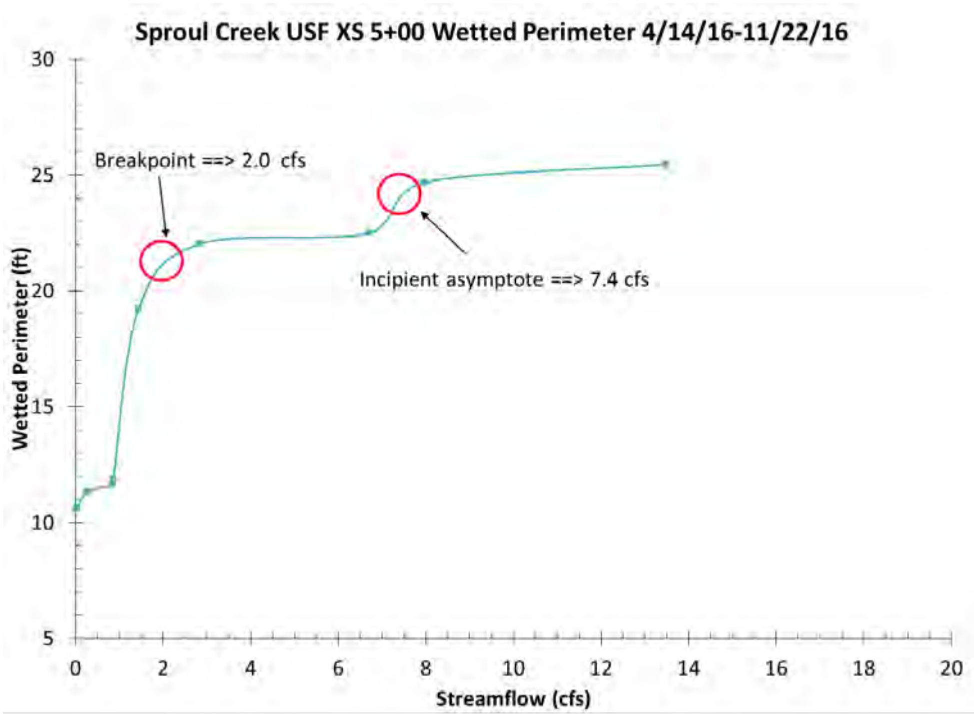

Figure I-6. Wetted perimeter curve of cross section 5+00 in Upper South Fork (USF) Sproul Creek with breakpoint and incipient asymptote.

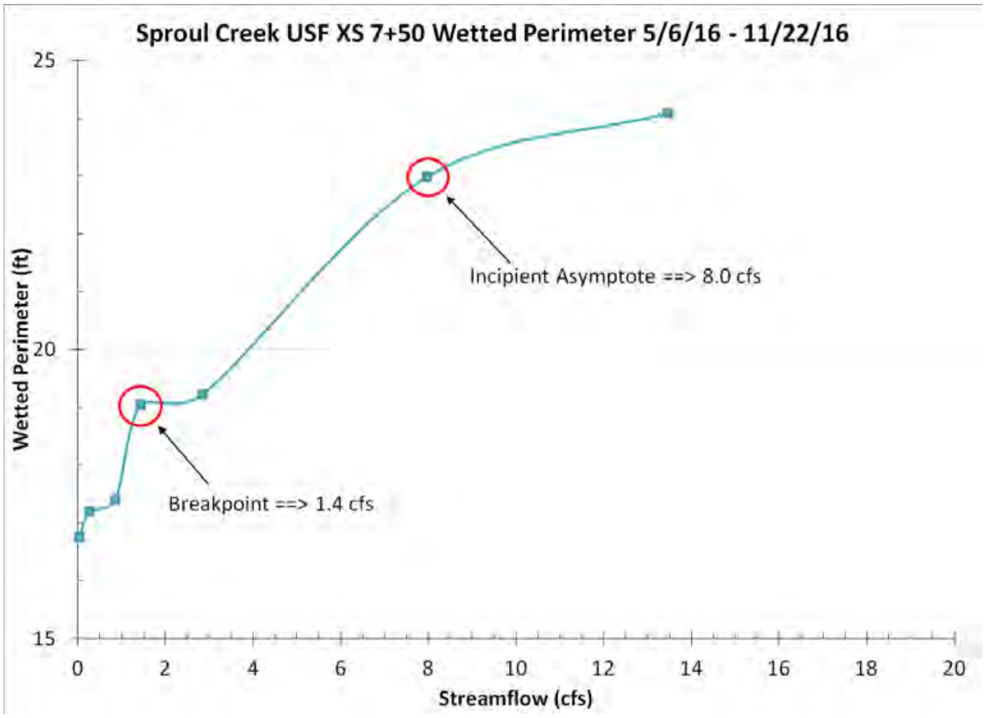

Figure I-7. Wetted perimeter curve of cross section 7+50 in Upper South Fork (USF) Sproul Creek with breakpoint and incipient asymptote.

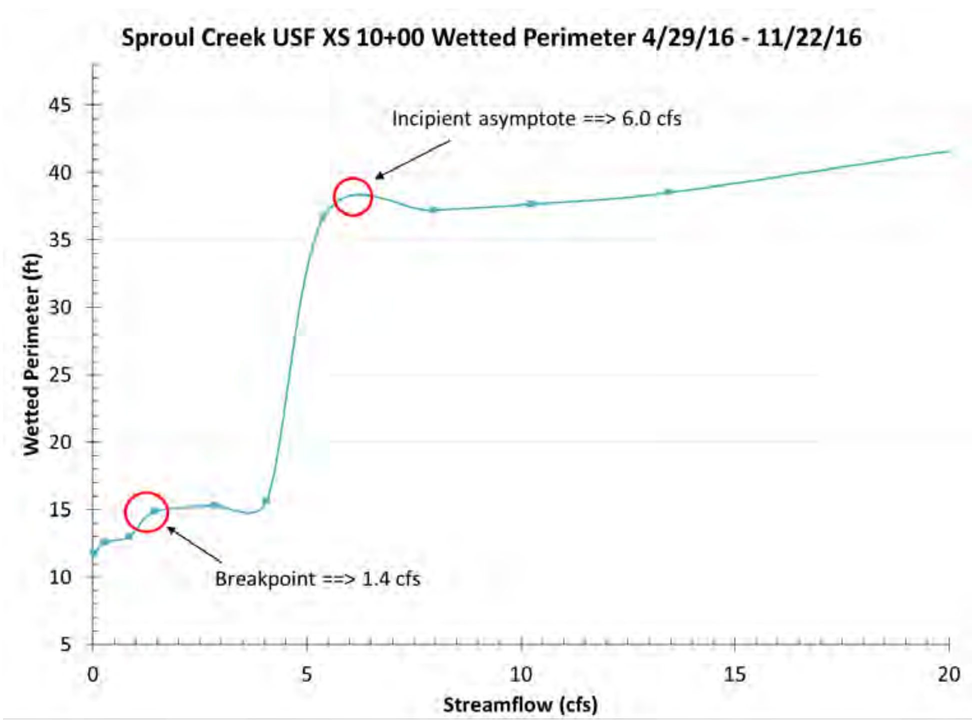

Figure I-8. Wetted perimeter curve of cross section 10+00 in Upper South Fork (USF) Sproul Creek with breakpoint and incipient asymptote.

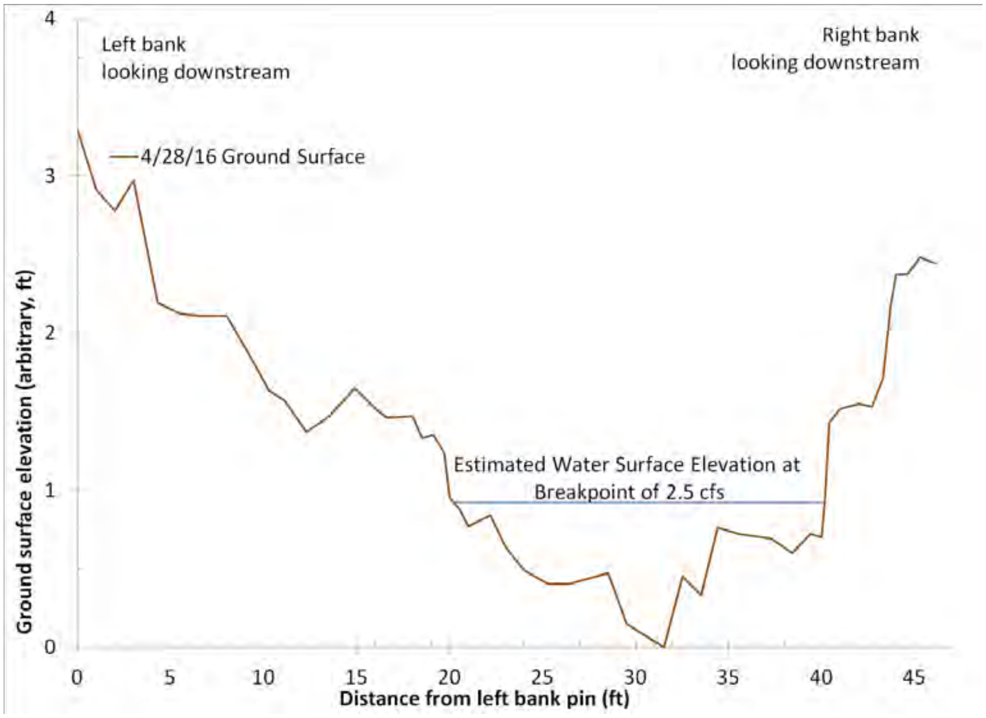

Figure I-9. Bed elevation profile of cross section UMS XS 7+70, showing estimated water surface elevation at wetted perimeter breakpoint.

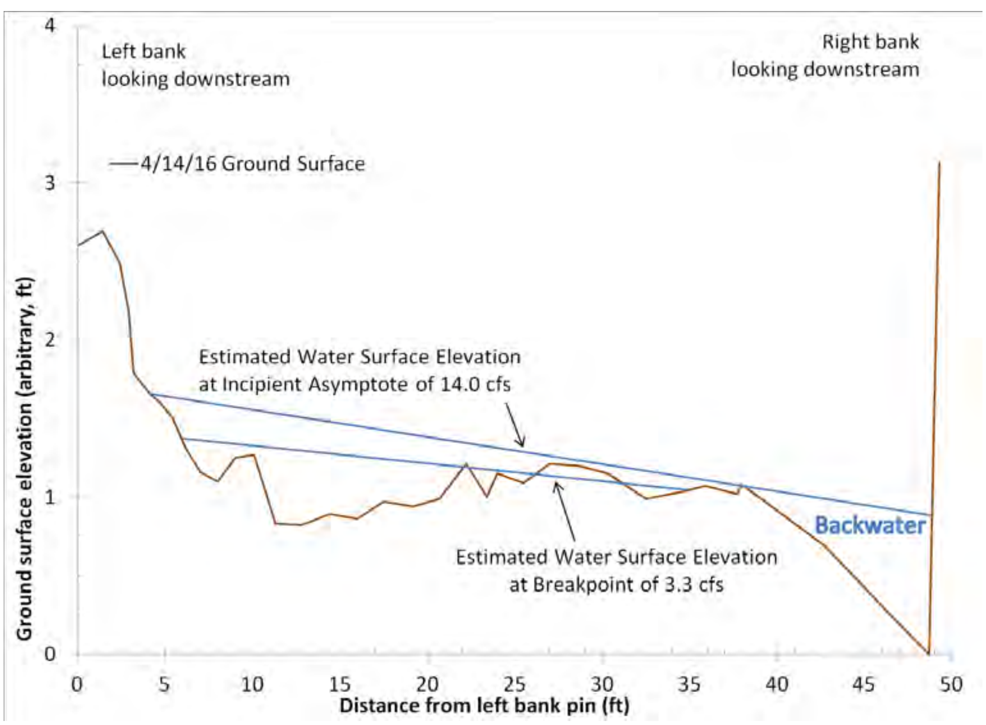

Figure I-10 Bed elevation profile of cross section UMS 10+10, showing estimated water surface elevation at wetted perimeter breakpoint and incipient asymptote.

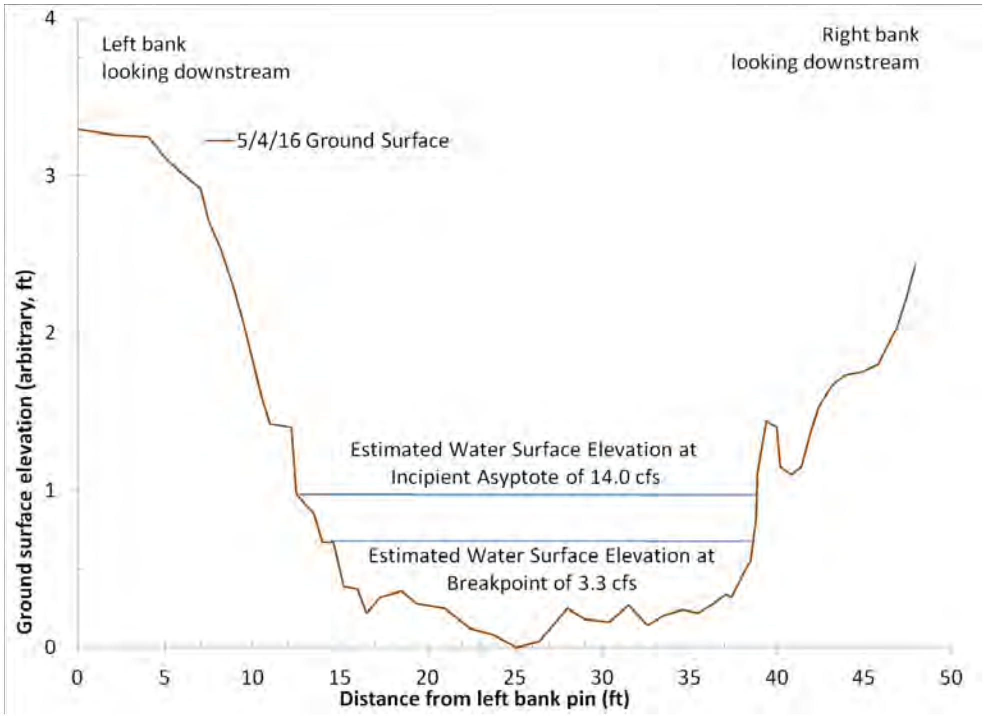

Figure I-11. Bed elevation profile of cross section UMS 15+90, showing estimated water surface elevation at wetted perimeter breakpoint and incipient asymptote.

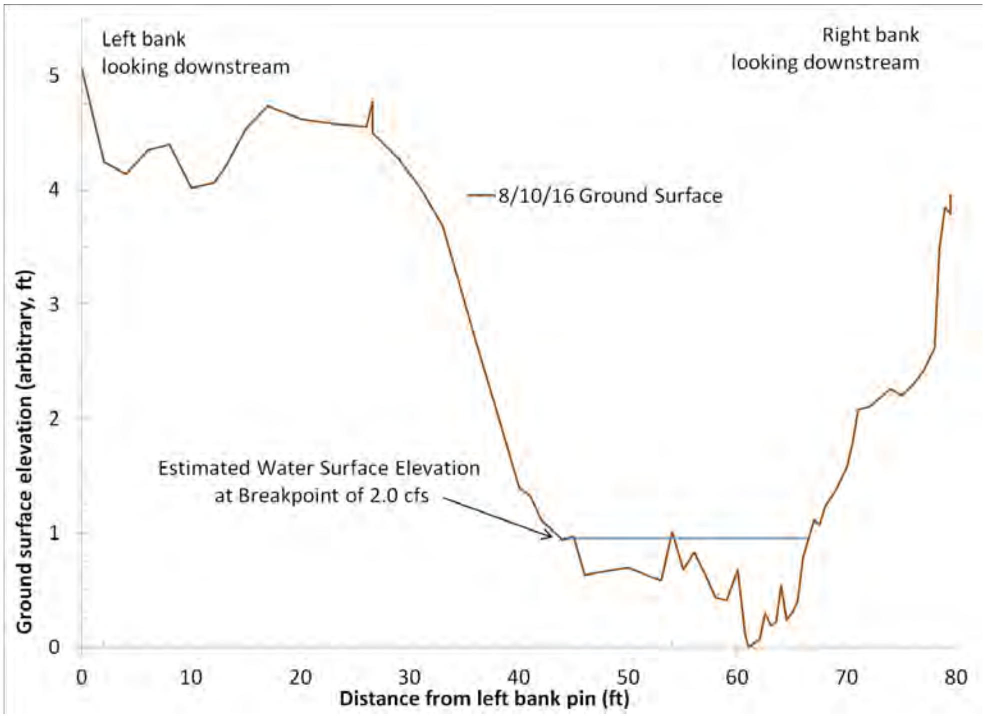

Figure I-12. Bed elevation profile of cross section UMS 21+50, showing estimated water surface elevation at wetted perimeter breakpoint.

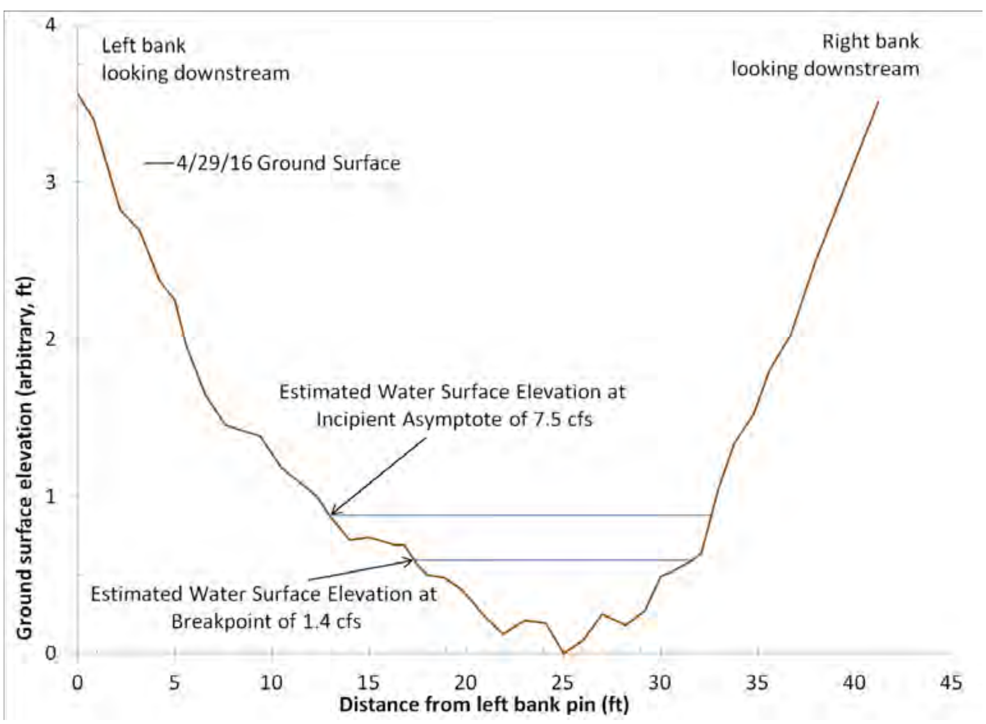

Figure I-13. Bed elevation profile of cross section USF 4+00, showing estimated water surface elevation at breakpoint and incipient asymptote streamflows.

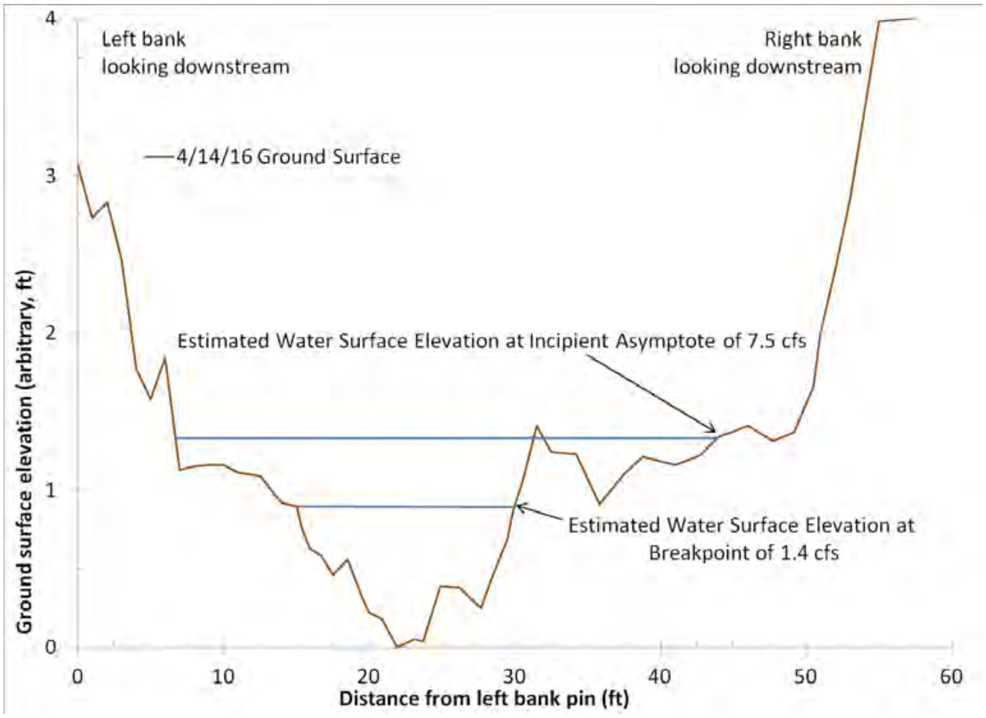

Figure I-14. Bed elevation profile of cross section USF 10+00, showing estimated water surface elevation at breakpoint and incipient asymptote streamflows.

Figure I-15. Photograph of cross section UMS 7+70, at 17.55 cfs on April 14, 2016. The WP cross section is visible to the left of the tape, which is stretched across the discharge measurement site. Flow direction is from right to left.

Figure I-16. Photograph of cross section UMS 7+70 (tape on left), at 10.16 cfs on Oct 1, 2016. The streamflow measurement for the UMS reach was taken at the cross section on the right. Flow direction is from right to left.

Figure I-17. Photograph of cross section UMS 7+70, at 3.41 cfs on May 16, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from right to left.

Figure I-18. Photograph of cross section UMS 7+70, at 0.27 cfs on July 27, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from left to right.

Figure I-19. Photograph of cross section UMS 10+10, at 92.75 cfs on November 22, 2016. Flow direction is from right to left.

Figure I-20. Photograph of cross section UMS 10+10, at 46.8 cfs on November 4, 2016. The tape is stretched across a Critical Riffle cross section.The Wetted Perimeter was not measured at this flow. Flow direction is from right to left.

Figure I-21. Photograph of cross section UMS 10+10, at 3.41 cfs on June 16, 2016. Flow direction is from right to left.

Figure I-22. Photograph of cross section UMS 10+10, at 0 cfs on August 17, 2016. Flow direction is from right to left.

Figure I-23. Photograph of cross section UMS 15+90, at 17.55 cfs on April 14, 2016. Flow direction is from right to left.

Figure I-24. Photograph of cross section UMS 15+90, at 3.41 cfs on June 16, 2016. Flow direction is from left to right.

Figure I-25. Photograph of cross section UMS 15+90, at 1.70 cfs on July 6, 2016. The tape is stretched across the wetter perimeter cross section. Flow direction is from left to right.

Figure I-26. Photograph of cross section UMS 21+50, at 6.60 cfs on May 25, 2016. The tape is stretched across the wetter perimeter cross section. Flow direction is from left to right.

Figure I-27. Photograph of cross section UMS 21+50, at 1.70 cfs on July 6, 2016. The tape is stretched across the wetter perimeter cross section. Flow direction is from left to right.

Figure I-28. Photograph of cross section UMS 21+50, at 0.10 cfs on August 10, 2016. Flow direction is from left to right.

Figure I-29. Photograph of cross section USF 4+00, at 3.01 cfs on May 5, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from right to left.

Figure I-30. Photograph of cross section USF 4+00, at 0.851 cfs on June 15, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from right to left.

Figure I-31. Photograph of cross section USF 4+00, at 0.27 cfs on July 7, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from right to left.

Figure I-32. Photograph of cross section USF 5+00, at 0.851 cfs on June 15, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from right to left.

Figure I-33. Photograph of cross section USF 5+00, at 0.27 cfs on July 7,2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from left to right.

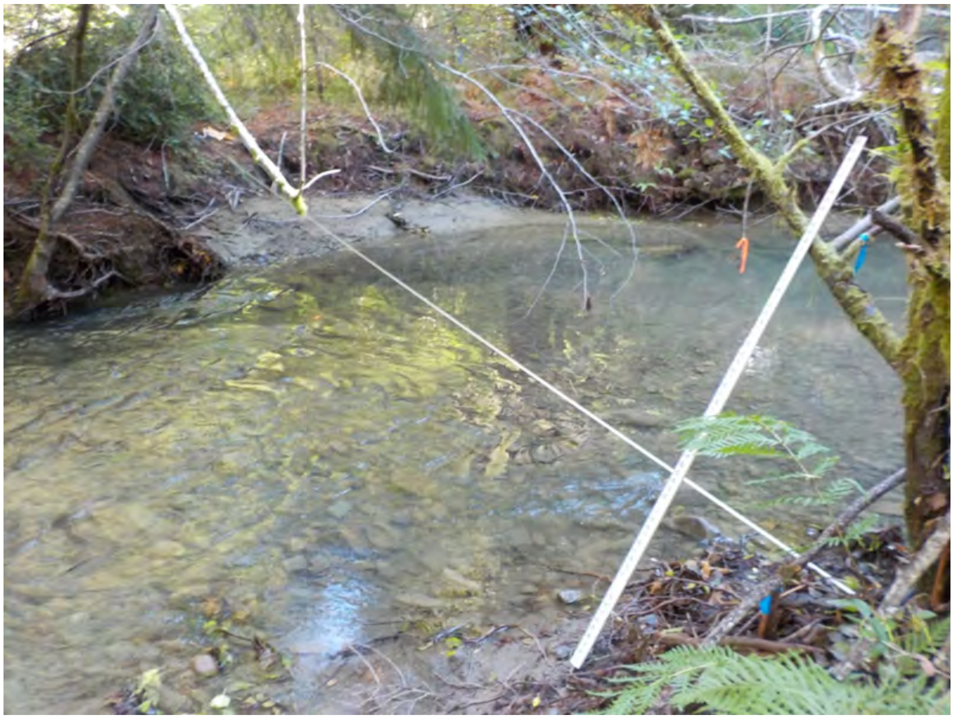

Figure I-34. Photograph of cross section USF 7+50, at 13.46 cfs on November 22, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from right to left.

Figure I-35. Photograph of cross section USF 7+50, at 2.85 cfs on May 6, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from right to left.

Figure I-36. Photograph of cross section USF 7+50, at 0.27 cfs on July 7, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from right to left.

Figure I-37. Photograph of cross section USF 7+50, at 0.033 cfs on July 28, 2016. The tape is stretched across the wetted perimeter cross section. Flow direction is from right to left.

Figure I-38. Photograph of cross section USF 7+50, at 0 cfs on August 17, 2016. Flow direction is from left to right.

Literature Cited

California Department of Fish and Wildlife. 2013. Standard Operating Procedure for the Wetted Perimeter Method in California (CDFW-IFP-004). California Department of Fish and Wildlife – Instream Flow Program, Sacramento, CA