Water Resources of the Western United States

SURFACE-WATER FIELD TECHNIQUES

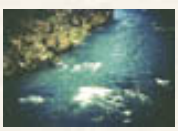
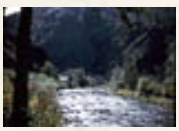
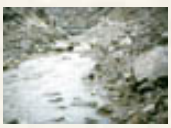
Verified Roughness Characteristics of Natural Channels

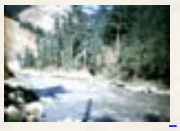
Most hydraulic computations related to indirect estimates of discharge require an evaluation of the roughness characteristics of the channel. In the absence of a satisfactory quantitative procedure this evaluation remains chiefly an art. The ability to evaluate roughness coefficients must be developed through experience. One means of gaining this experience is by examining and becoming acquainted with the appearance of some typical channels whose roughness coefficients are known.

The photographs and data linked to this page represent a wide range of channel conditions. Familiarity with the appearance, geometry, and roughness characteristics of these channels will improve your ability to select roughness coefficients for other channels. We will contiune to link descriptions of additional sites to this page as verification data become available. *(Text above modified from USGS Water Supply Paper 1849, by H.H. Barnes, Jr.))*

You can view data related to selected roughness coefficients by clicking on a site name, or photo, below:

Manning's n-value	Stream	Photo	
		Photo 1	Photo 2
0.024	Columbia River at Vernita, Washington		
0.028	Clark Fork at St. Regis, Montana		

0.030	Clark Fork above Missoula, Montana	 
0.032	Salt River below Stewart Mountain Dam, Arizona	 
0.033	Clearwater River at Kamiah, Idaho	 
0.036	West Fork Bitterroot River near Conner, Montana	 
0.037	Wenatchee River at Plain, Washington	 
0.038	Moyie River at Eastport, Idaho	 
0.038	Spokane River at Spokane, Washington	 
0.041	Middle Fork Flathead River near Essex, Montana	 
0.043	Catherine Creek near Union, Oregon	 
0.043	Chiwawa River near Plain, Washington	 
0.043	Grande Ronde River at La Grande, Oregon	 
0.045; 0.073	Provo River near Hailstone, Utah	 
0.050	Clear Creek near Golden, Colorado	 

0.051	South Fork Clearwater River near Grangeville, Idaho		
0.053; 0.079	Cache Creek near Lower Lake, California		
0.057	Mission Creek near Cashmere, Washington		
0.060	Rock Creek Canal near Darby, Montana		
0.065	Merced River at Happy Isles Bridge, near Yosemite, California		
0.073	Boundary Creek near Porthill, Idaho		
0.075	Rock Creek near Darby, Montana	(Missing)	

Return to AGENDA.

SURFACE-WATER FIELD TECHNIQUES

Columbia River at Vernita, Washington n = 0.024

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

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Site Description

○ Station name	Columbia River at Vernita, Washington
○ Station number	12-4645
○ Gage location	In sec. 11, T. 13 N., R. 24 E., at the Richmond ferry site, 0.5 mile north of Vernita station. Gage operated 50 miles upstream of station called Columbia River at Triniday, Wash. Section 1 is 5,000 feet upstream from cableway at Vernita gage.
○ Drainage area	89,700 sq mi
○ Date of flood	May 22, 1949

❍ Gage height	48.33 ft at Trinidad gage: 29.5 ft (different datum) at section 1.
❍ Peak discharge	406,000 cfs
❍ Computed roughness coefficient	Manning *n* = 0.024
❍ Description of channel	Bed consists of slime-covered cobbles and gravel. The straight and steep left bank is composed of cemented cobbles and gravel. The gently sloping right bank consists of cobbles set in gravel and is free of vegetation.

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Plan Sketch and Cross Sections || Site Photos

Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	47,100	1,800	26.2	26.16	8.65	.....	.....
2	49,000	1,650	29.7	29.56	8.28	2,500	0.48
3	49,600	1,760	28.2	28.10	8.17	2,500	.49

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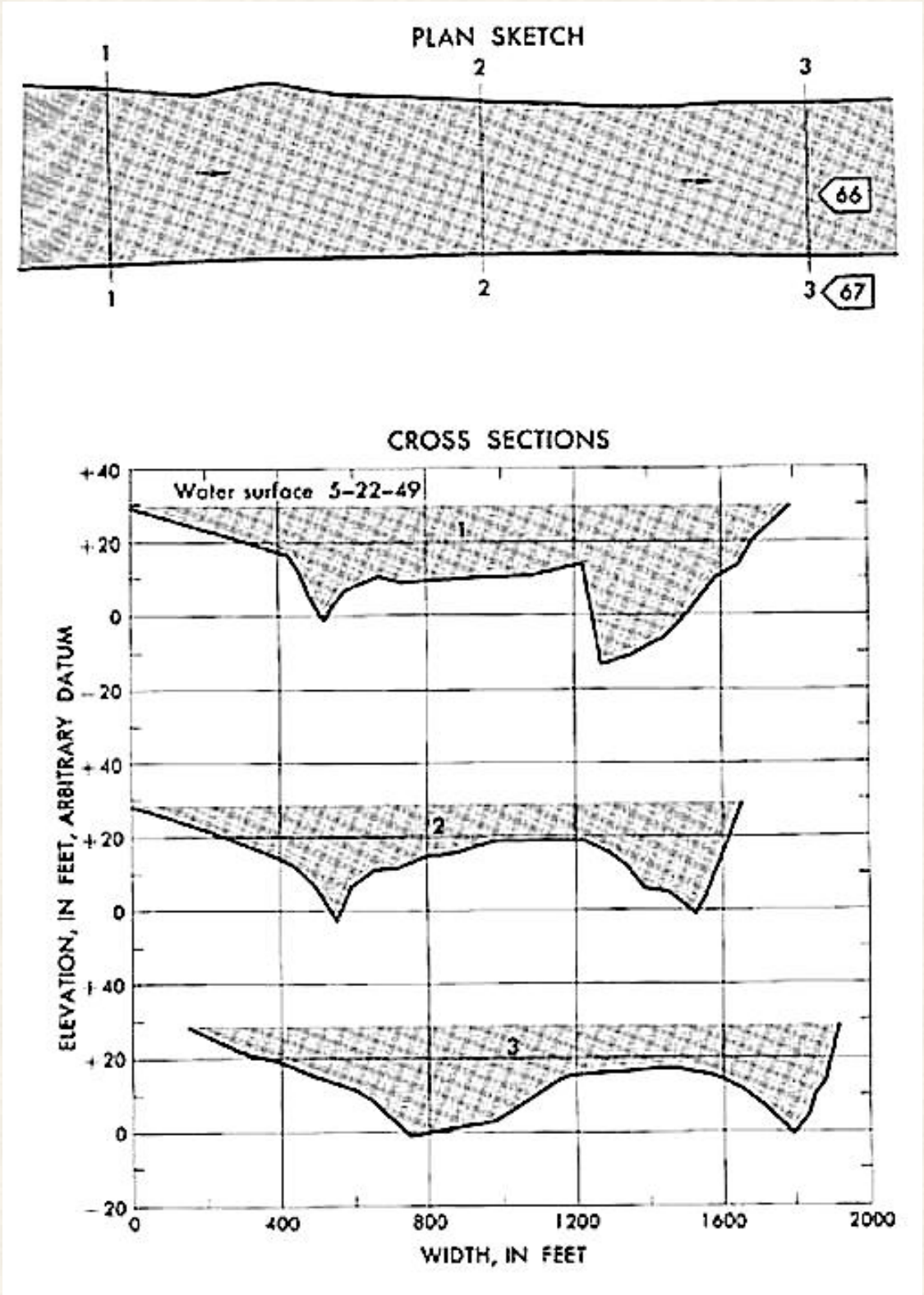
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



Plan sketch and cross sections, Columbia River at Vernita, Washington.

Introduction Page|| Site Description || Reach Properties

Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 66: Upstream view along right bank from section 3, Columbia River at Vernita, Washington.

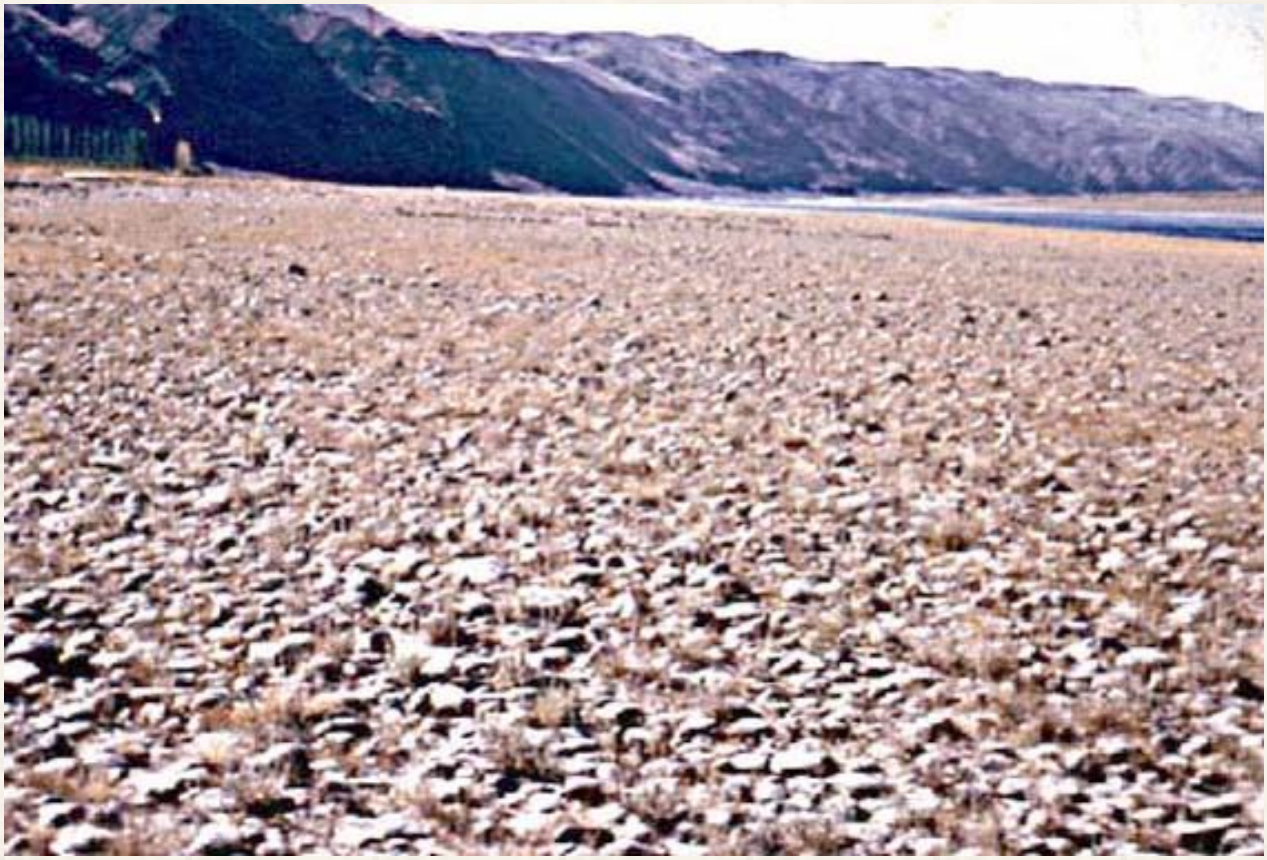


Photo 67: Upstream view from top of bank at section 3, Columbia River at Vernita, Washington.

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Plan Sketch and Cross Sections || Site Photos

SURFACE-WATER FIELD TECHNIQUES

Clark Fork at St. Regis, Montana - n = 0.028

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

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Site Description

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○ Station name	Clark Fork at St. Regis, Montana
○ Station number	12-3545
○ Gage location	Lat 47°18'05", long 115°05'15", in center of SW 1/4 sec. 19, T. 18 N., R. 27 W., on left bank at St. Regis. 0.5 mile downstream from St. Regis River. Section 1 is 660 ft upstream from gage.
○ Drainage area	10,709 sq mi
○ Date of flood	May 24, 1948
○ Gage height	19.96 ft at gage: 20.42 ft at section 1
○ Peak discharge	68,900 cfs
○ Computed roughness coefficient	Manning *n* = 0.028

- Description of channel: Bed consists of well-rounded boulders; d_{50} = 135 mm, d_{84} = 205 mm. Banks are composed of gravel and boulders, and have tree and brush cover.

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Plan Sketch and Cross Sections || Site Photos

Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	6,860	404	16.98	16.70	10.04	.....	.....
2	6,976	429	16.26	16.04	9.88	755	0.555
3	7,194	454	15.85	15.64	9.58	438	.32

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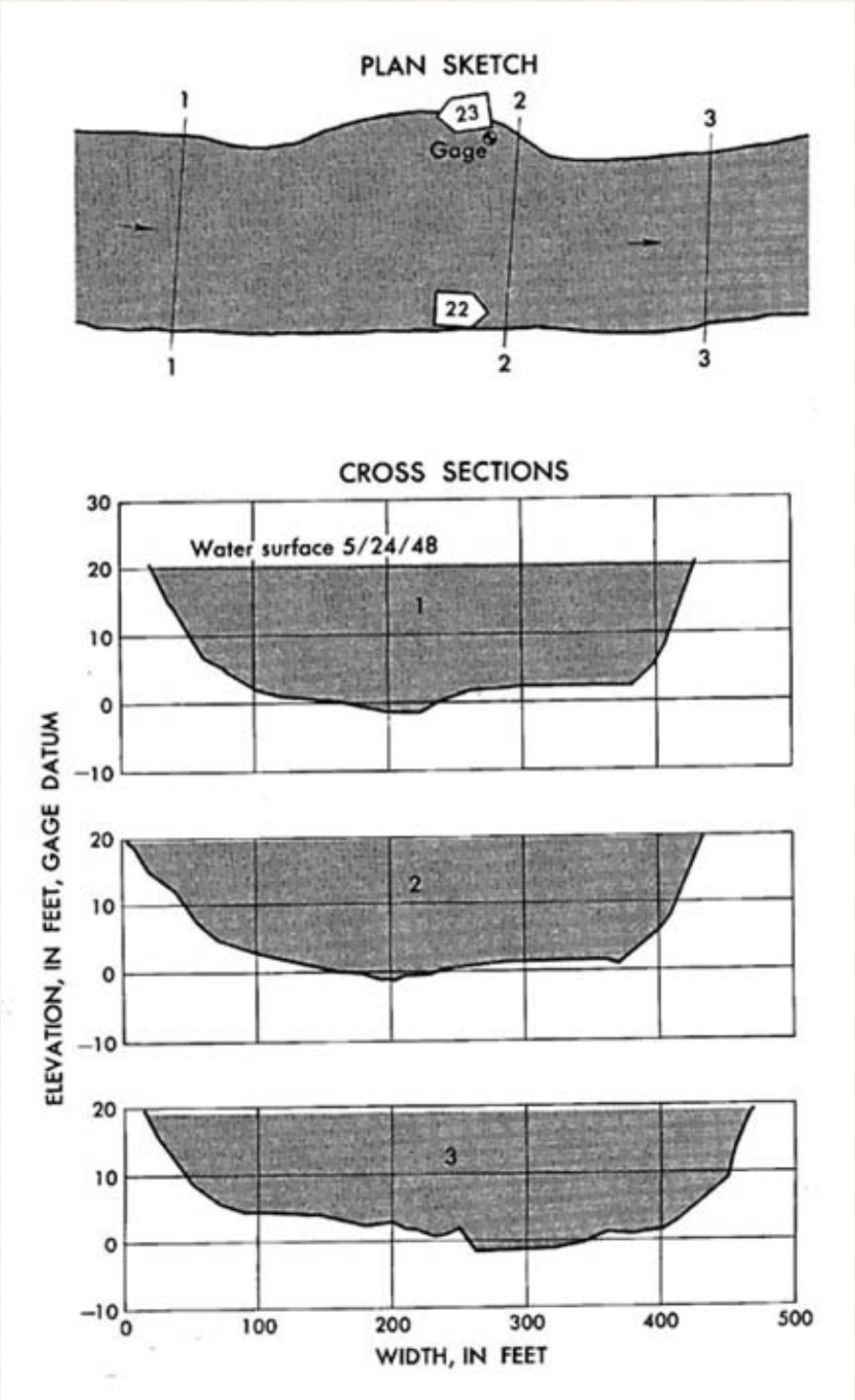
Plan Sketch and Cross Sections



Plan sketch and cross sections, Clark Fork at St. Regis, Montana.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 22: Downstream along right bank from section 2, Clark Fork at St. Regis, Montana.

Photo 23: Upstream along left bank from section 2, Clark Fork at St. Regis, Montana.

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Water Resources of the Western United States

SURFACE-WATER FIELD TECHNIQUES

Clark Fork at Missoula, Montana - n = 0.030

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

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Site Description

Station name	Clark Fork at Missoula, Montana
Station number	12-3405
Gage location	Lat 46°52'40", long 113°55'40", in NW 1/4 NW 1/4 sec. 19, T. 13 N., R. 18W., on right bank 3 miles downstream from Blackfoot River and 3 miles east of Missoula. Section 1 is 405ft upstream from gage.
Drainage area	5,999 sq mi
Date of flood	May 23, 1948
Gage height	13.07 ft at gage; 14.54 ft at section 1
Peak discharge	31.500 cfs
Computed roughness coefficient	Manning *n* = 0.030

- Description of channel: Bed is composed of sand, gravel, and boulders; d_{50} = 175 mm, d_{84} = 325 mm. Thick undergrowth is along right bank and along the left bank in the lower part of the reach.

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Plan Sketch and Cross Sections || Site Photos

Reach Properties

-

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	3,866	285	13.56	13.24	8.15	.....	.....
2	3,461	267	12.96	12.64	9.10	305	0.63
3	3,634	294	12.36	12.10	8.67	243	.25
4	3,798	312	12.17	11.95	8.29	297	.18

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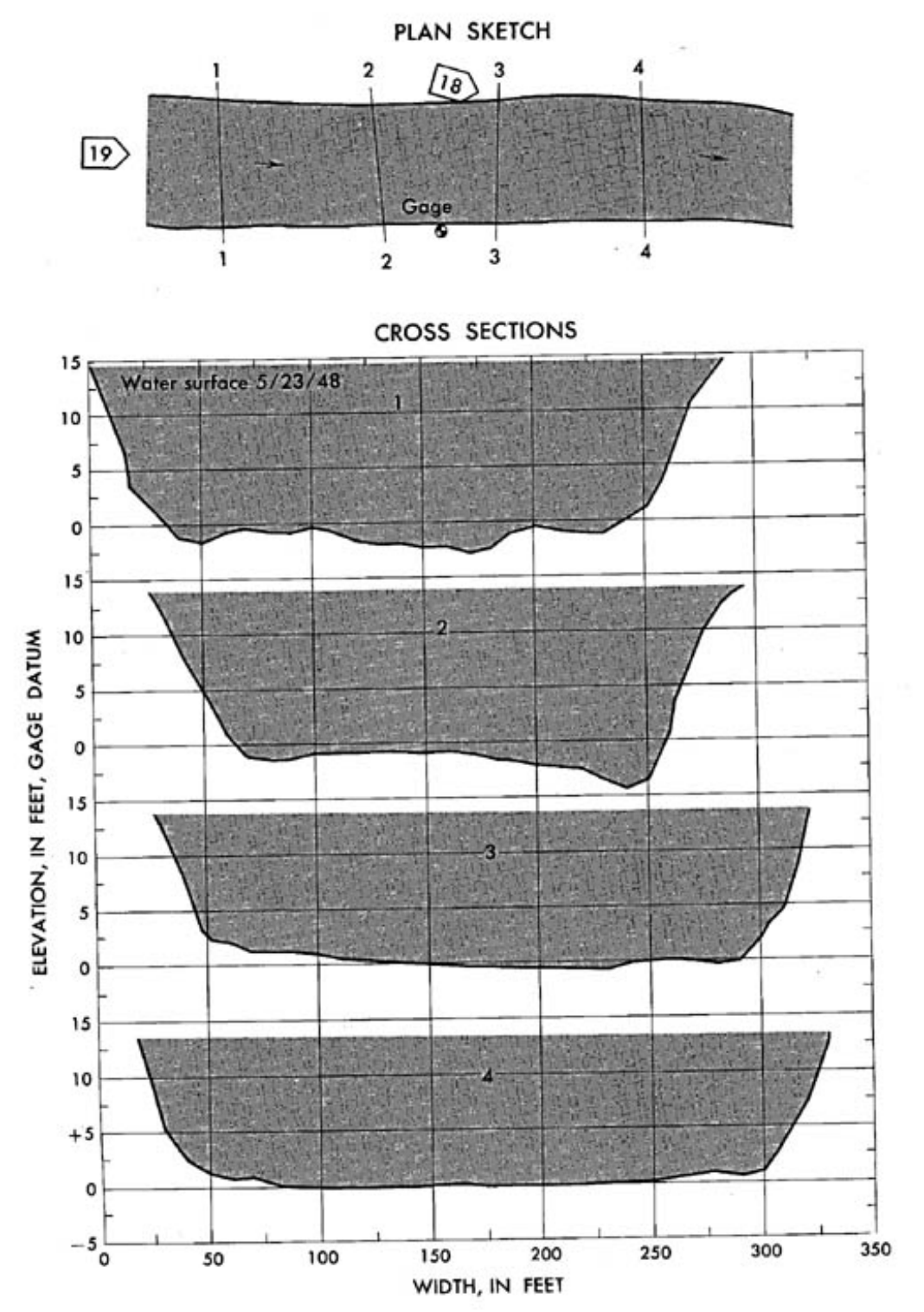
Plan Sketch and Cross Sections



Plan sketch and cross sections, Clark Fork above Missoula, Montana.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 18: Downstream along left bank from above section 3, Clark Fork above Missoula, Montana.

Photo 19: Downstream through reach from bridge 400 ft above section 1, Clark Fork above Missoula, Montana.

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SURFACE-WATER FIELD TECHNIQUES

Salt River below Stewart Mountain Dam, Arizona - n = 0.032

(Source: U.S.G.S Water Supply Paper 1849)

Site Description | Reach properties | Plan sketch and cross sections | Site photos

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Site Description

Station name	Salt River below Stewart Mountain Dam, Arizona
Station number	9-5020
Gage location	Lat 30°33'00", long 111°34'31", in N 1/2 NW 1/4 sec. 6, T. 2N., R. 8 E. (unserveyed), on left bank 3.5 miles downstream from Stewart Mountain Dam and 6 miles upstream from Verde River. Section 1 is about 2.25 miles downstream from gage.
Drainage area	6,230sq mi, of which 21 sq mi is below Stewart Mountain Dam.
Date of flood	Mar. 24, 1950

❍ Gage height	4.26 ft at gage; 99.26 ft (different datum) at section 1
❍ Peak discharge	1,280 cfs
❍ Computed roughness coefficient	Manning *n* = 0.032
❍ Description of channel	Bed and banks consist of smooth cobbles 4 to 10 inches in diameter, average diameter about 6 inches. A few boulders are as much as 18 inches in diameter.

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Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	484	189	2.6	2.55	2.65	.....	.....
2	408	192	2.1	2.12	3.14	258	0.37
3	384	154	2.6	2.49	3.34	317	.50
4	449	194	2.3	2.30	2.86	294	.31
5	420	204	2.1	2.06	3.05	370	.63
6	381	207	1.8	1.84	3.36	333	.72
7	308	191	1.6	1.61	4.16	314	1.06

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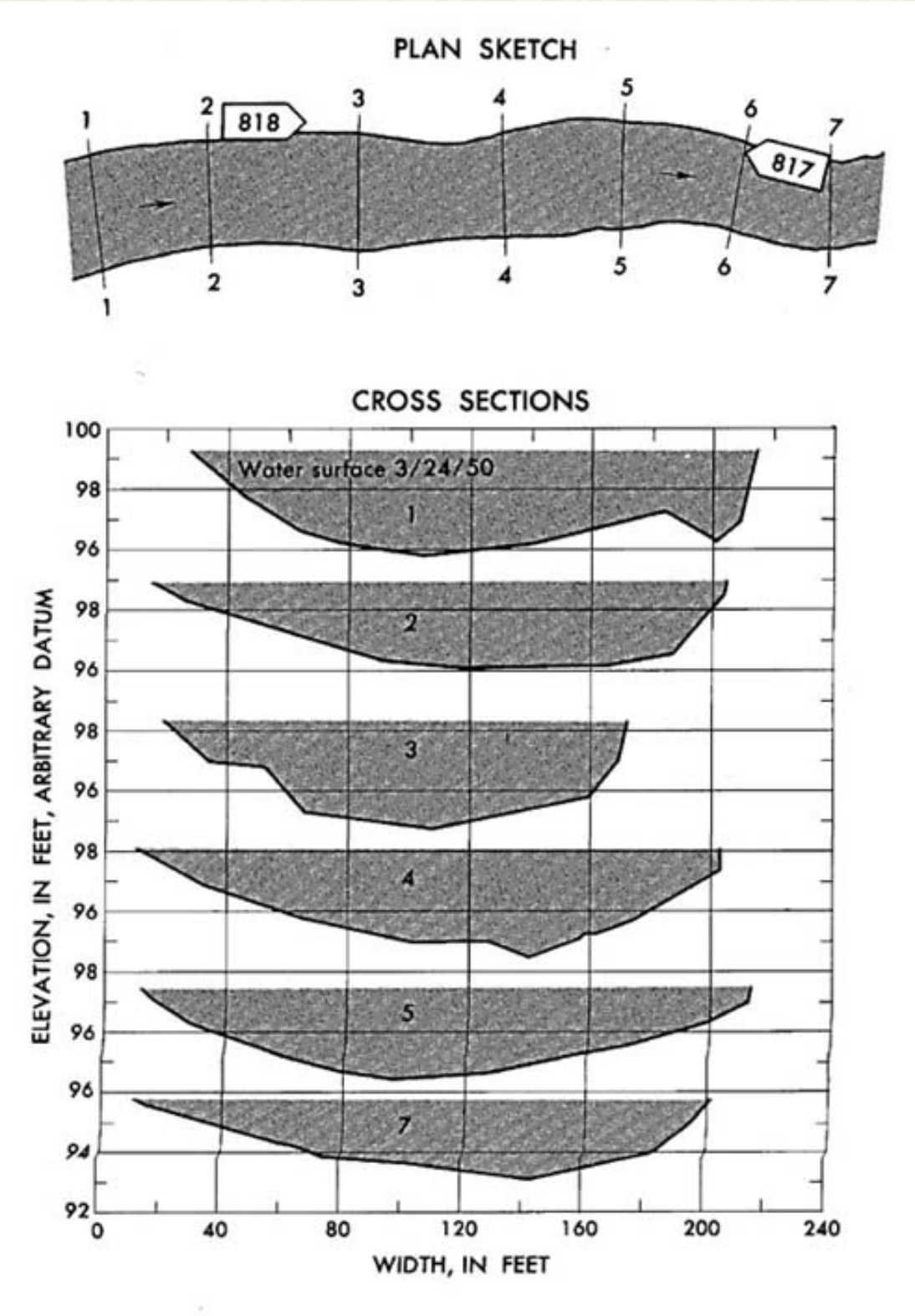
Plan Sketch and Cross Sections



Plan sketch and cross sections, Salt River below Stewart Mountain Dam, Arizona.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 817: Upstream along left bank from below section 6, Salt River below Stewart Mountain Dam, Arizona.

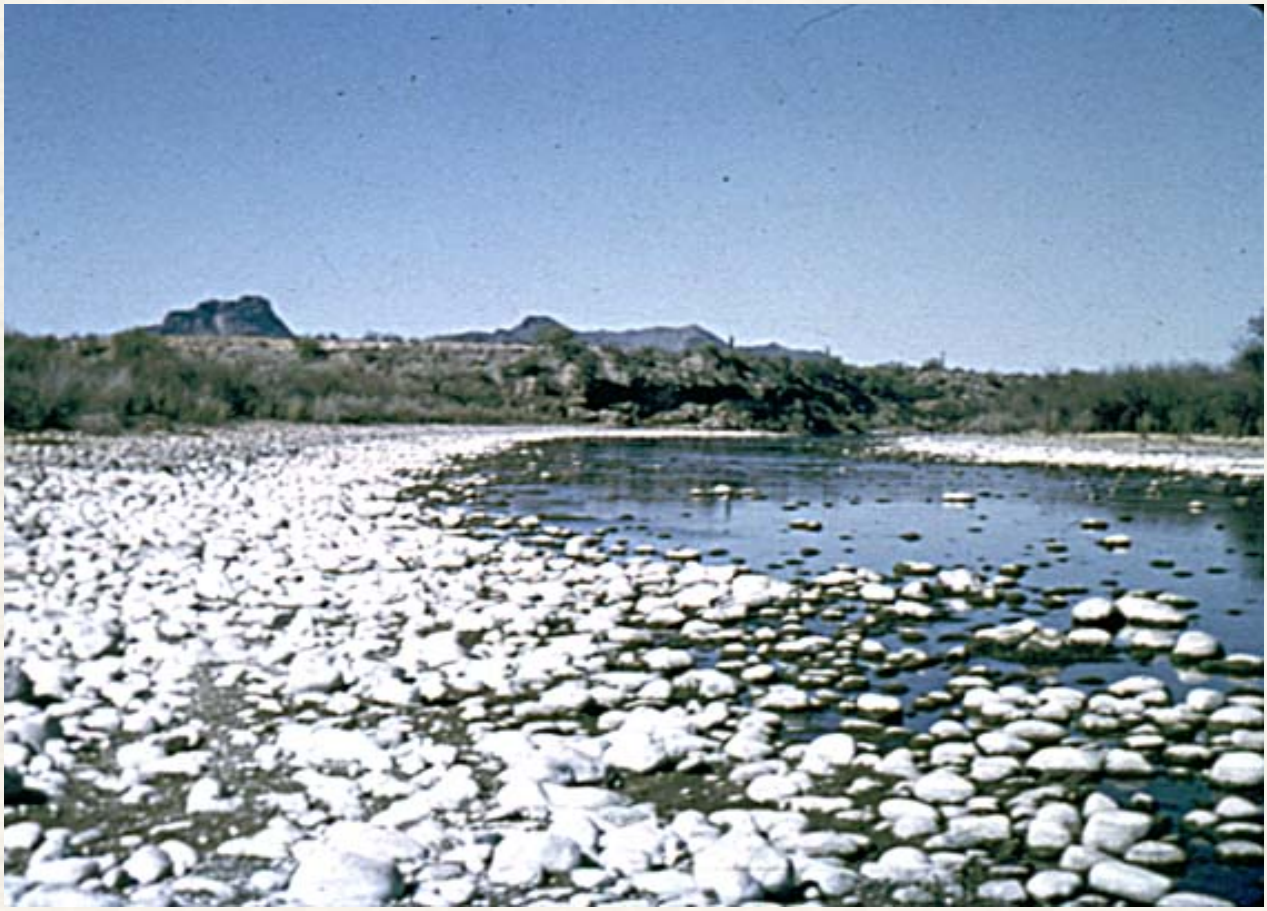

Photo 818: Downstream along left bank from section 2, Salt River below Stewart Mountain Dam, Arizona.

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SURFACE-WATER FIELD TECHNIQUES

Clearwater River at Kamiah, Idaho - n = 0.033

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

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Site Description

○ Station name	Clearwater River at Kamiah, Idaho
○ Station number	13-3390
○ Gage location	Lat 46°14', long 116°01', in sec. 1, T. 33 N., R. 3 E., on left bank 0.25 mile downstream from highway bridge at Kamiah, 0.75 mile downstream from Lawyer Creek, and 6 miles downstream from South Fork. Section 1 is about 5.8 miles downstream from gage.
○ Drainage area	4,850 sq mi, approximately.
○ Date of flood	May 29, 1948
○ Gage height	19.22 ft at gage: 46.17 ft at section 1
○ Peak discharge	99,000 cfs

❍ Computed roughness coefficient	Manning *n* = 0.033
❍ Description of channel	Bed is composed of gravel and boulders with some exposed bedrock. Channel is bordered by railroad on the right and highway on the left. Banks are gravel and rock and have light vegetation.

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Plan Sketch and Cross Sections || Site Photos

Reach Properties

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Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	11,100	562	19.25	19.45	8.92	.....	.....
2	11,603	593	19.58	19.34	8.53	732	0.35
3	10,937	538	20.32	20.04	9.05	560	.67

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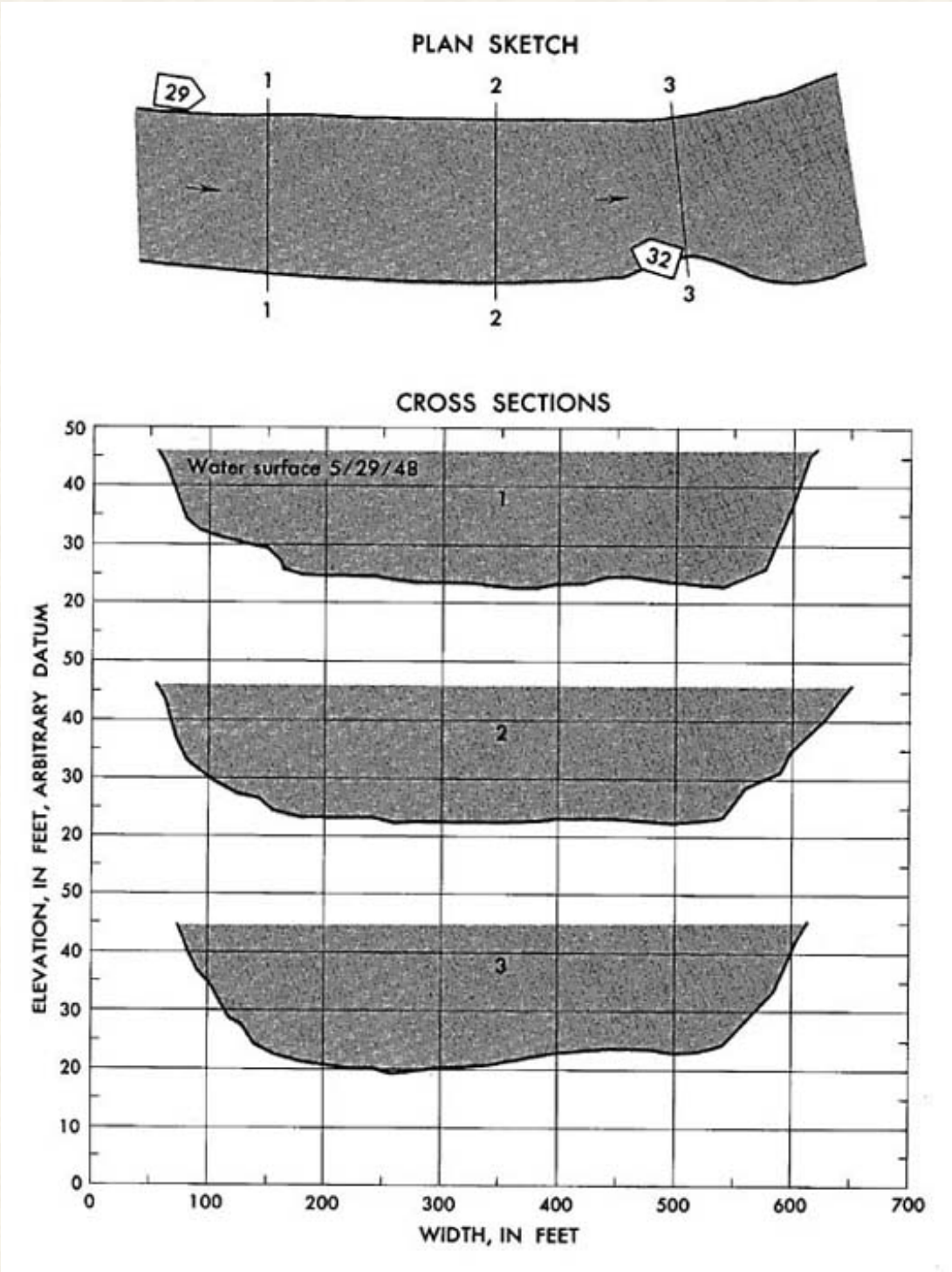
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



Plan sketch and cross sections, Clearwater River at Kamiah, Idaho

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 29: Downstream along left bank from above section 1, Clearwater River at Kamiah, Idaho.

Photo 32: Upstream from left bank at section 3, Clearwater River at Kamiah, Idaho.

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Plan Sketch and Cross Sections || Site Photos

SURFACE-WATER FIELD TECHNIQUES

West Fork Bitterroot River near Conner, Montana - n = 0.036

(Source: U.S.G.S Water Supply Paper 1849)

Site Description | Reach properties | Plan sketch and cross sections | Site photos

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Site Description

- Station name: West Fork Bitterroot River near Conner, Montana
- Station number: 12-3425
- Gage location: Lat 45°44', long 114°17', in NE 1/4 NW 1/4 sec. 26, T. 1 S., R. 22 W., on right bank 0.5 mile downstream from Painted Rocks Lake, 6 miles upstream from Nez Perce Creek, and 16 miles southwest of Conner. Section 1 is about 600 ft downstream from gage.
- Drainage area: 317 sq mi.
- Date of flood: May 29, 1948

❍ Gage height	6.08 ft at gage: 3.27 ft at section 1
❍ Peak discharge	3,880 cfs
❍ Computed roughness coefficient	Manning n = 0.036
❍ Description of channel	Bed is gravel and boulders;. d_{50} = 172 mm, d_{84} = 265 mm.The left bank is lined with overhanging bushes. The right bank is lined with trees.

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Reach Properties

-

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	504	107	4.7	4.62	7.70	.....	.....
2	494	105	4.7	4.57	7.85	222	1.02
3	516	103	5.0	4.82	7.52	302	1.40

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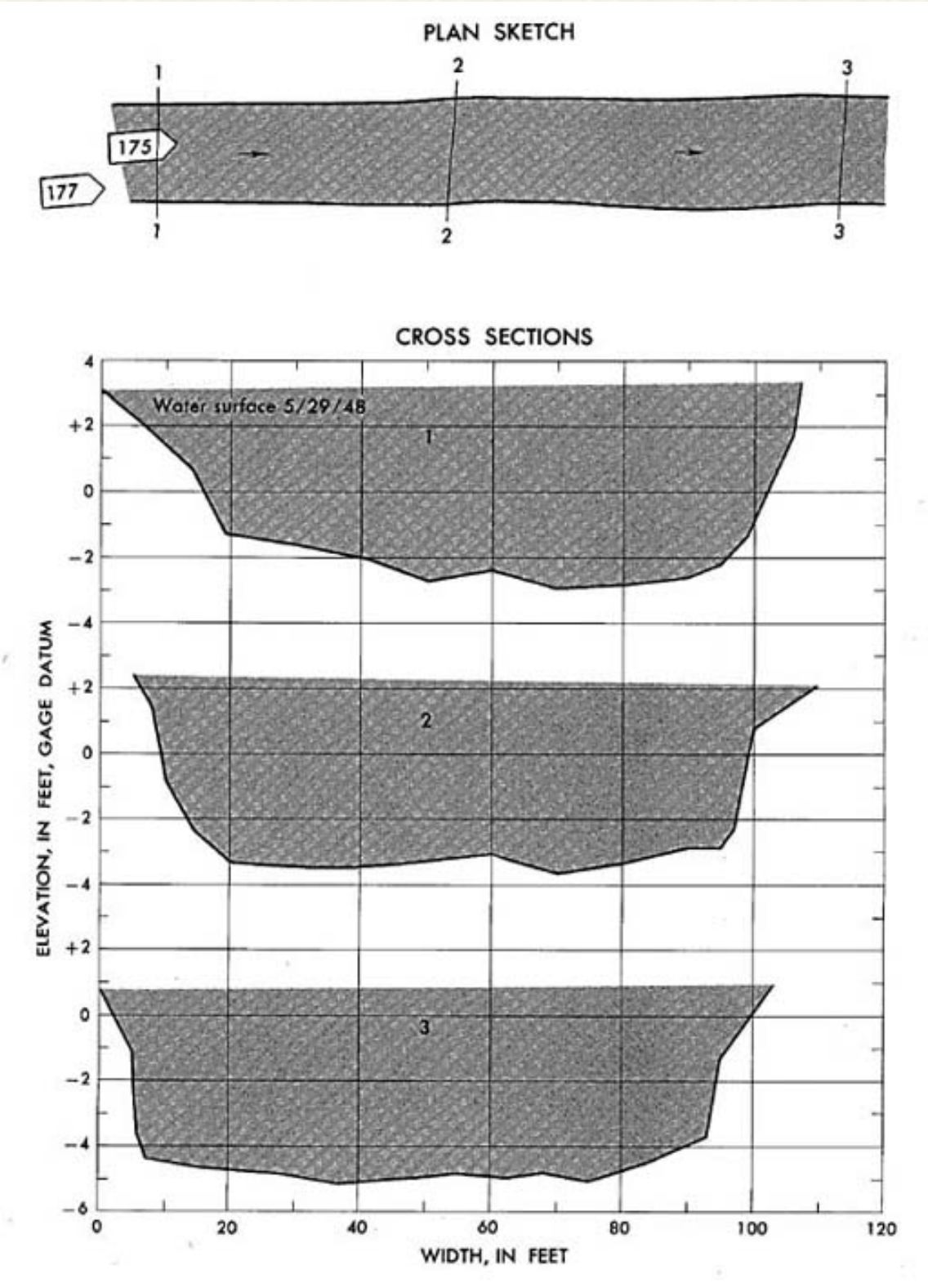
Plan Sketch and Cross Sections



Plan sketch and cross sections, West Fork Bitterroot River near Conner, Montana.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 175: Downstream from section 1, West Fork Bitterroot River near Conner, Montana.

Photo 177: Downstream from right bank above section 1, West Fork Bitterroot River near Conner, Montana.

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Plan Sketch and Cross Sections || Site Photos

SURFACE-WATER FIELD TECHNIQUES

Wenatchee River at Plain, Washington - n = 0.037

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

Site Description

❍ Station name	Wenatchee River at Plain, Washington
❍ Station number	12-4570
❍ Gage location	Lat 47°45'50", long 120°39'30", in lot 8, sec. 12, T. 26 N., R. 17 E., on left bank at Plain, 0.25 mile downstream from Beaver Creek, 7.5 miles downstream from Nason Creek, and 12 miles north of Leavensworth. Section 1 is about 1,360 ft upstream from gage.
❍ Drainage area	591 sq mi.
❍ Date of flood	May 29, 1948
❍ Gage height	12.43 ft at gage: 16.50 ft at section 1
❍ Peak discharge	22,700 cfs

- Computed roughness coefficient — Manning n = 0.037
- Description of channel — Bed is boulders; d_{50} = 162 mm, d_{85} = 320 mm. Bank are lined with trees and bushes.

Introduction Page || Site Description || Reach Properties

Plan Sketch and Cross Sections || Site Photos

Reach Properties

-

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	2,480	224	11.1	10.86	9.15	.....	.....
2	2,470	228	10.8	10.58	9.19	311	0.75
3	2,440	237	10.3	10.05	9.30	325	.75

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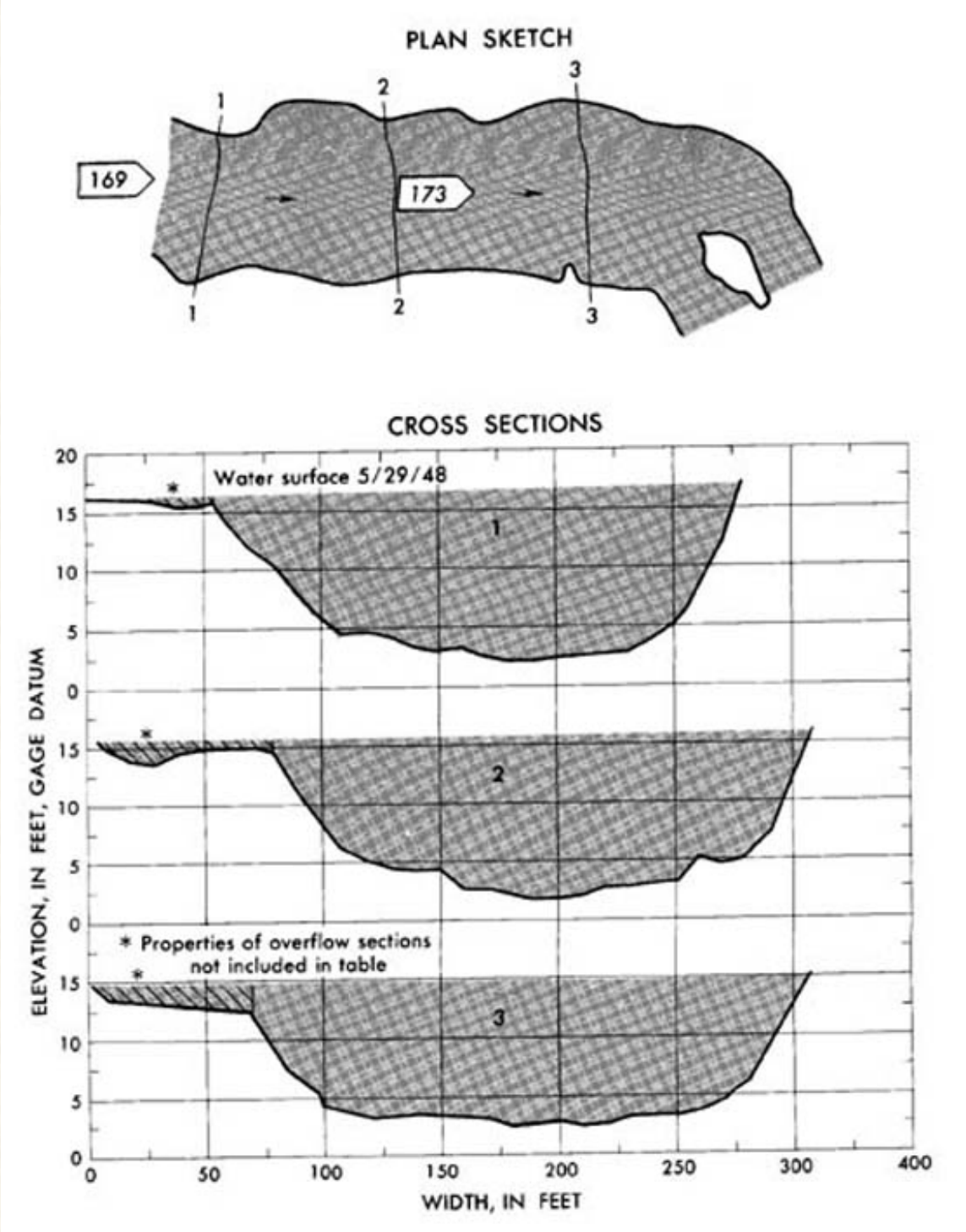
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



Plan and cross sections, Wenatchee River at Plain, Washington.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 169: Downstream from above section 1, Wenatchee River at Plain, Washington.

Photo 173: Downstream from section 2, Wenatchee River at Plain, Washington.

Introduction Page || Site Description || Reach Properties

SURFACE-WATER FIELD TECHNIQUES

Moyie River at Eastport, Idaho - n = 0.038

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

Site Description

Station name	Moyie River at Eastport, Idaho
Station number	12-3065
Gage location	Lat 47°49'00", long 116°11', in SE 1/4 sec. 10, T. 65 N., R. 2 E., on left bank at Eastport, 1000 ft downstream from international boundary. Section 1 is about 0.5 mile downstream from gage.
Drainage area	570 sq mi.
Date of flood	May 24, 1948
Gage height	10.25 ft at gage: 20.68 ft (different datum) at section 1.
Peak discharge	8,030 cfs

- Computed roughness coefficient — Manning n = 0.038
- Description of channel — Bed of gravel and well-rounded small boulders. Right bank is fairly steep and lined with trees and brush. Left bank slopes gently and has tree and brush cover below section 2.

Introduction Page || Site Description || Reach Properties

Plan Sketch and Cross Sections || Site Photos

Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	1,224	176	6.96	6.74	6.56	.....	.....
2	1,090	150	7.27	7.13	7.37	269	0.73
3	919	118	7.78	7.47	8.74	185	.68
4	944	145	6.51	6.38	8.51	226	1.07

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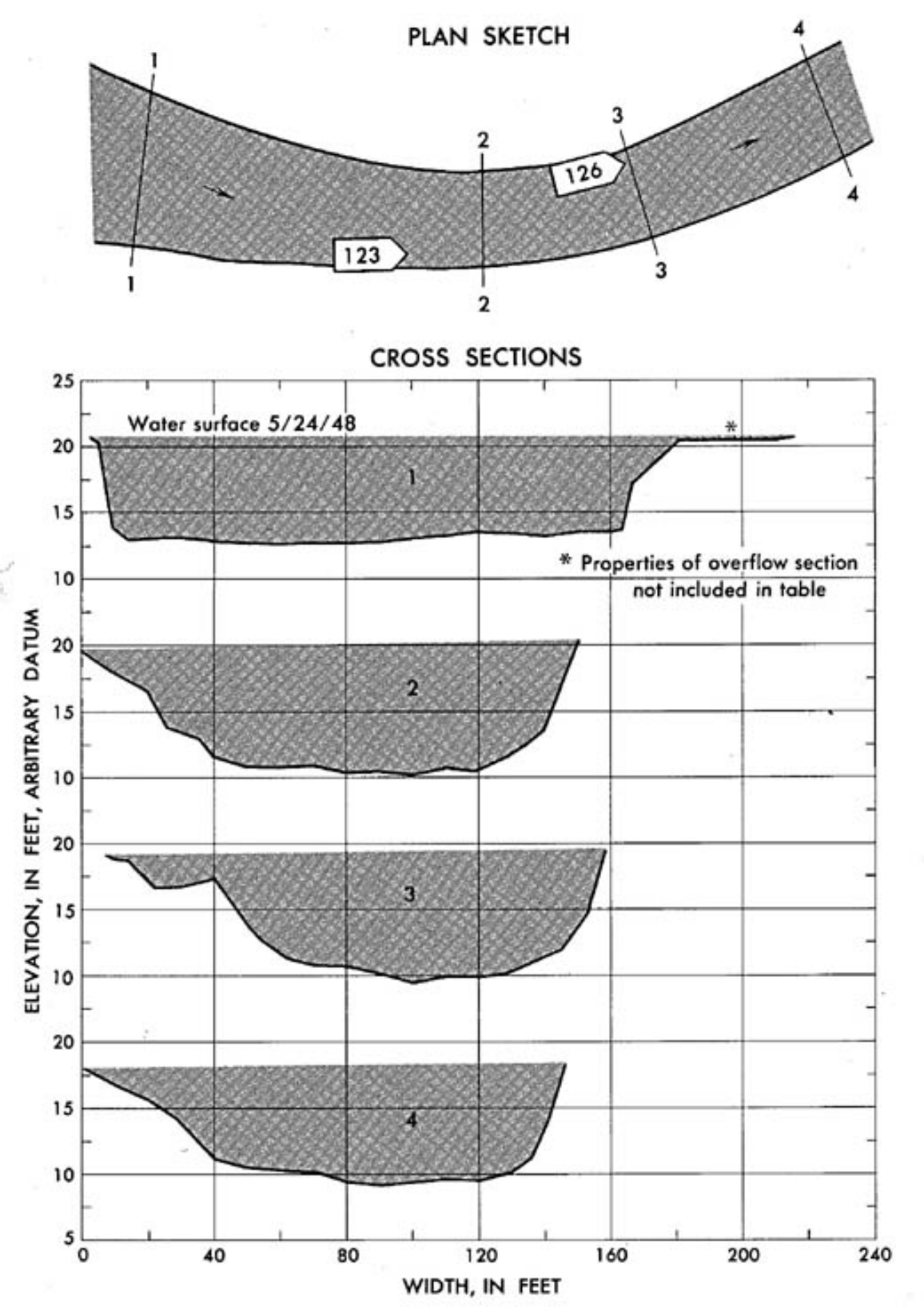
Plan Sketch and Cross Sections



Plan and cross sections, Moyie River at Eastport, Idaho.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 123: Downstream from right bank above section 2, Moyie River at Eastport, Idaho .

Photo 126: Downstream along left bank at section 3, Moyie River at Eastport, Idaho .

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Plan Sketch and Cross Sections || Site Photos

SURFACE-WATER FIELD TECHNIQUES

Spokane River at Spokane, Washington - n = 0.038

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

Site Description

Station name	Spokane River at Spokane, Washington
Station number	12-4225
Gage location	Lat 47°39'35", long 117°26'50", in SW 1/4 sec. 13, T. 25 N., R. 42 E., on right bank at Cochran street in Spokane, 0.5 mile upstream from Latah Creek. Section 1 is about 800 ft upstream from gage.
Drainage area	4,290 sq mi.
Date of flood	May 31, 1948
Gage height	28.35 ft at gage: 29.37 ft at section 1.
Peak discharge	39,600 cfs

- Computed roughness coefficient — Manning n = 0.038
- Description of channel — Bed is gravel and boulders; d_{50} = 195 mm, d_{84} = 360 mm.Banks are lined with trees and brush.

Introduction Page || Site Description || Reach Properties

Plan Sketch and Cross Sections || Site Photos

Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	4,350	305	14.3	14.03	9.10	.....	.....
2	4,370	298	14.7	14.38	9.06	202	0.44
3	4,290	285	15.1	14.71	9.23	268	.49
4	4,120	293	14.1	13.84	9.61	220	.29

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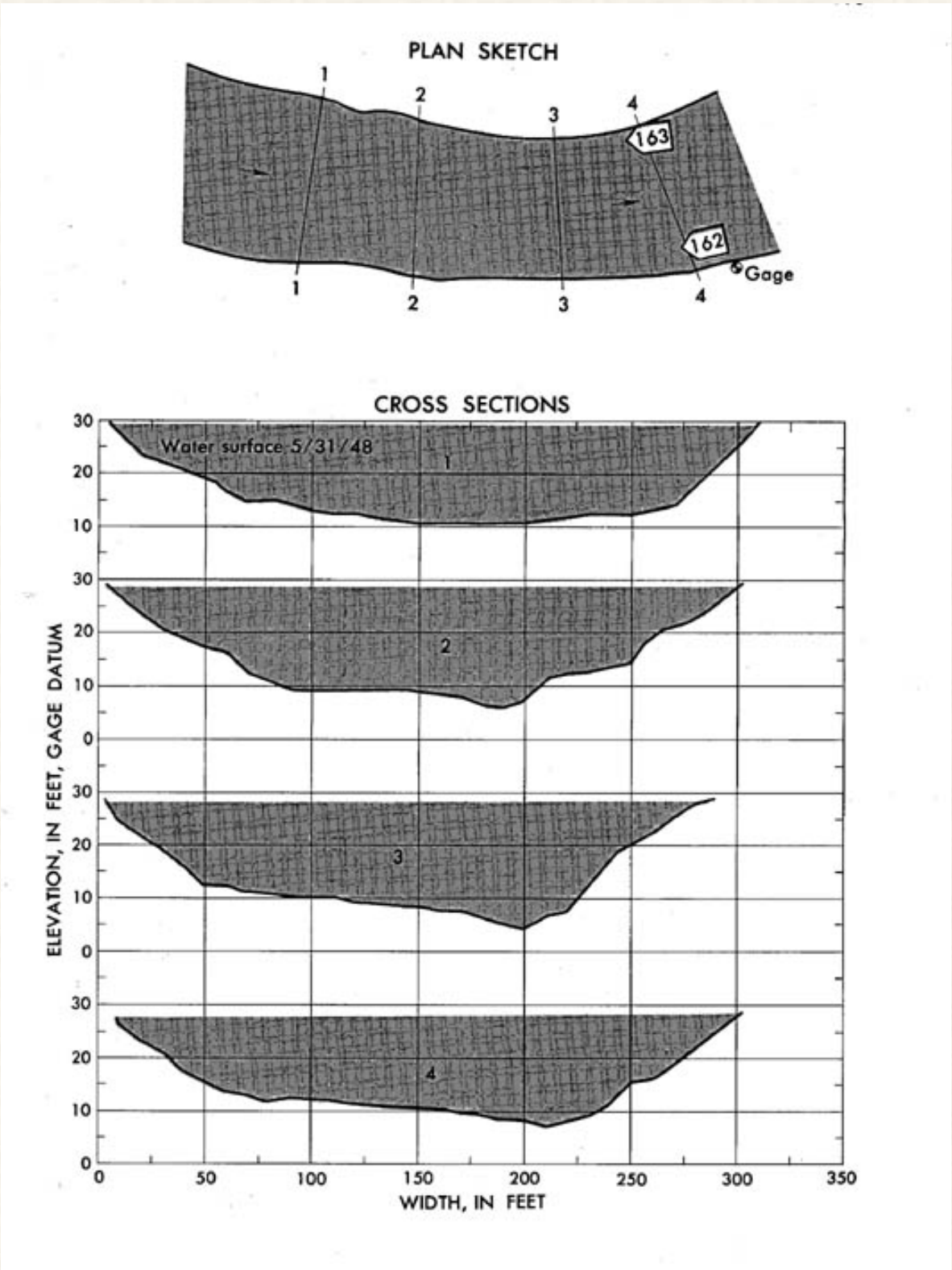
Plan Sketch and Cross Sections



Plan and cross sections, Spokane River at Spokane, Washington.

- Introduction Page|| Site Description || Reach Properties

Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 162: Upstream along right bank from section 4, Spokane River at Spokane, Washington.

Photo 163: Upstream along left bank from section 4, Spokane River at Spokane, Washington.

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Plan Sketch and Cross Sections || Site Photos

SURFACE-WATER FIELD TECHNIQUES

Middle Fork Flathead River near Essex, Montana - n = 0.041

(Source: U.S.G.S Water Supply Paper 1849)

Site Description | Reach properties | Plan sketch and cross sections | Site photos

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Site Description

Station name	Middle Fork Flathead River near Essex, Montana
Station number	12-3557
Gage location	Lat 48°10'20", long 113°32'40", near center of sec. 19, T. 28 N., R. 15 W., on right bank 0.25 mile downstream from Spruce Park Cabin, 1 mile downstream from Charlie Creek, and 7.5 miles southeast of Essex. Section 1 is 600 ft upstream from gage.
Drainage area	408 sq mi.
Date of flood	May 22, 1948
Gage height	10.95 ft at gage: 14.21 ft at section 1.
Peak discharge	14,500 cfs

Computed roughness coefficient	Manning n = 0.041
Description of channel	Bed consists of boulders; d_{50} = 142 mm, d_{84} = 285 mm.Banks are composed of gravel and boulders, and have trees and brush along the tops.

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Plan Sketch and Cross Sections || Site Photos

Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	1,745	208	8.39	8.23	8.31	.....	.....
2	1,658	187	8.87	8.73	8.75	291	1.07
3	1,504	150	10.03	9.35	9.64	109	.64
4	1,472	172	8.56	8.37	9.85	221	.88
5	1,601	191	8.38	8.22	9.06	346	.87

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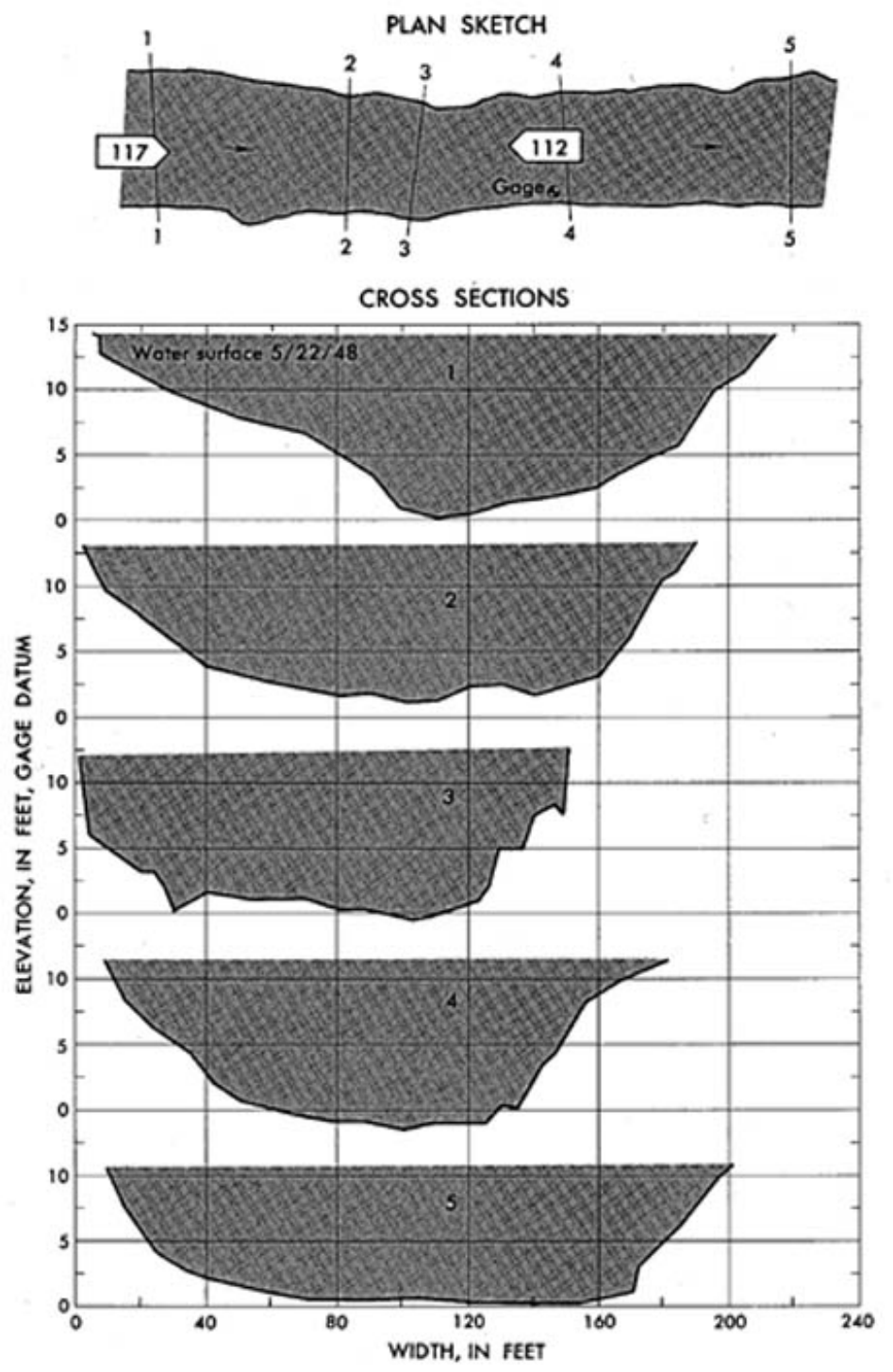
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



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Site Photos

Photo 112: Upstream from section 4, Middle Fork Flathead River near Essex, Montana.

Photo 117: Downstream from section 1, Middle Fork Flathead River near Essex, Montana.

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Plan Sketch and Cross Sections || Site Photos

SURFACE-WATER FIELD TECHNIQUES

Catherine Creek near Union, Oregon - n = 0.043

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

---

Site Description

Station name	Catherine Creek near Union, Oregon
Station number	13-3200
Gage location	Lat 45°09'20", long 117°46'40", in SE 1/4 sec. 2, T. 5 S., R. 40 E., on right bank 3 miles downstream from Little Catherine Creek and 6 miles southeast of Union. Section 1 is about 0.75 mile downstream from gage.
Drainage area	105sq mi
Date of flood	May 27, 1948
Gage height	4.57 ft at gage: 21.21 ft (different datum) at section 1

Peak discharge	1,740 cfs
Computed roughness coefficient	Manning *n* = 0.043
Description of channel	Bed consists of cobbles and small boulders. Banks are lined with small trees and brush, and limbs overhang along left bank.

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Plan Sketch and Cross Sections || Site Photos

Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	220	52	4.23	4.00	7.91	.....	.....
2	236	54	4.37	4.15	7.37	102	0.73
3	256	64	4.00	3.76	6.80	116	0.72

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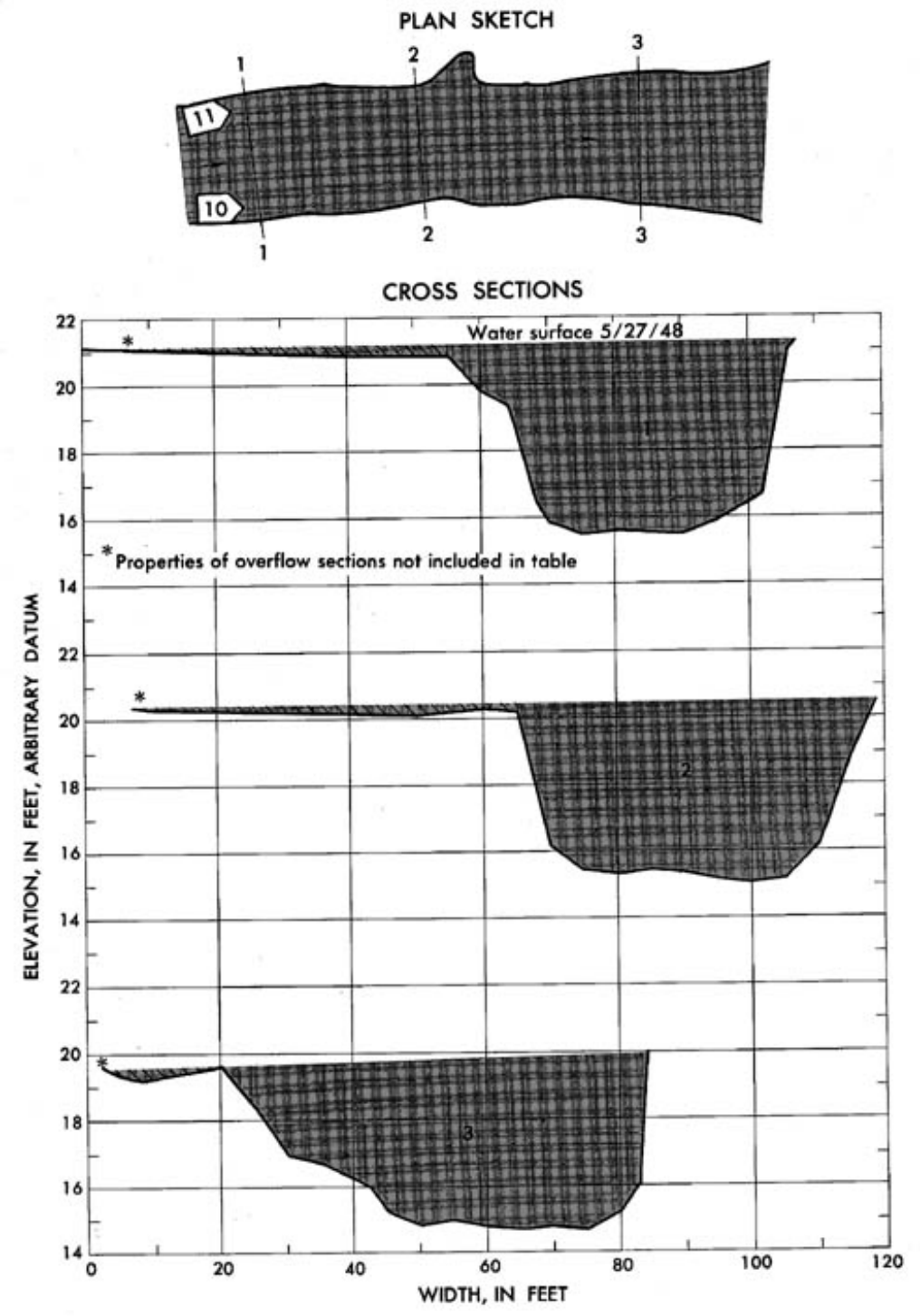
Plan Sketch and Cross Sections



Plan sketch and crocc sections, Catherine Creek near Union, Oregon

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 10: Downstream along right bank from above reach, Catherine Creek near Union, Oregon.

Photo 11: Downstream along left bank from above reach, Catherine Creek near Union, Oregon.

Introduction Page || Site Description || Reach Properties

SURFACE-WATER FIELD TECHNIQUES

Chiwawa River near Plain, Washington - n = 0.043

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

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Site Description

Station name	Chiwawa River near Plain, Washington
Station number	12-4565
Gage location	Lat 47°50'30", long 120°39'40", in SE 1/4 sec. 13, T. 27 N., R. 12 E., on right bank 0.5 mile upstream from Goose Creek, 6 miles north of Plain, 7 miles upstream from mouth, and 11 miles northeast of Chiwaukum. Section 1 is 90 ft downstream from gage.
Drainage area	170 sq mi
Date of flood	May 29, 1948
Gage height	9.17 ft at gage; 9.62 ft at section 1

Peak discharge	5,880 cfs
Computed roughness coefficient	Manning *n* = 0.043
Description of channel	Bed generally extends to bedrock throughout reach with cover of boulders as much as $1^1/_2$ ft in diameter in some places. Banks are mildly sloped and have trees along the top.

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Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	744	145	5.13	5.03	7.90	.....	.....
2	747	125	5.97	5.74	7.87	165	0.55
3	803	145	5.54	5.42	7.32	163	0.80
4	770	131	5.89	5.75	7.64	145	0.99

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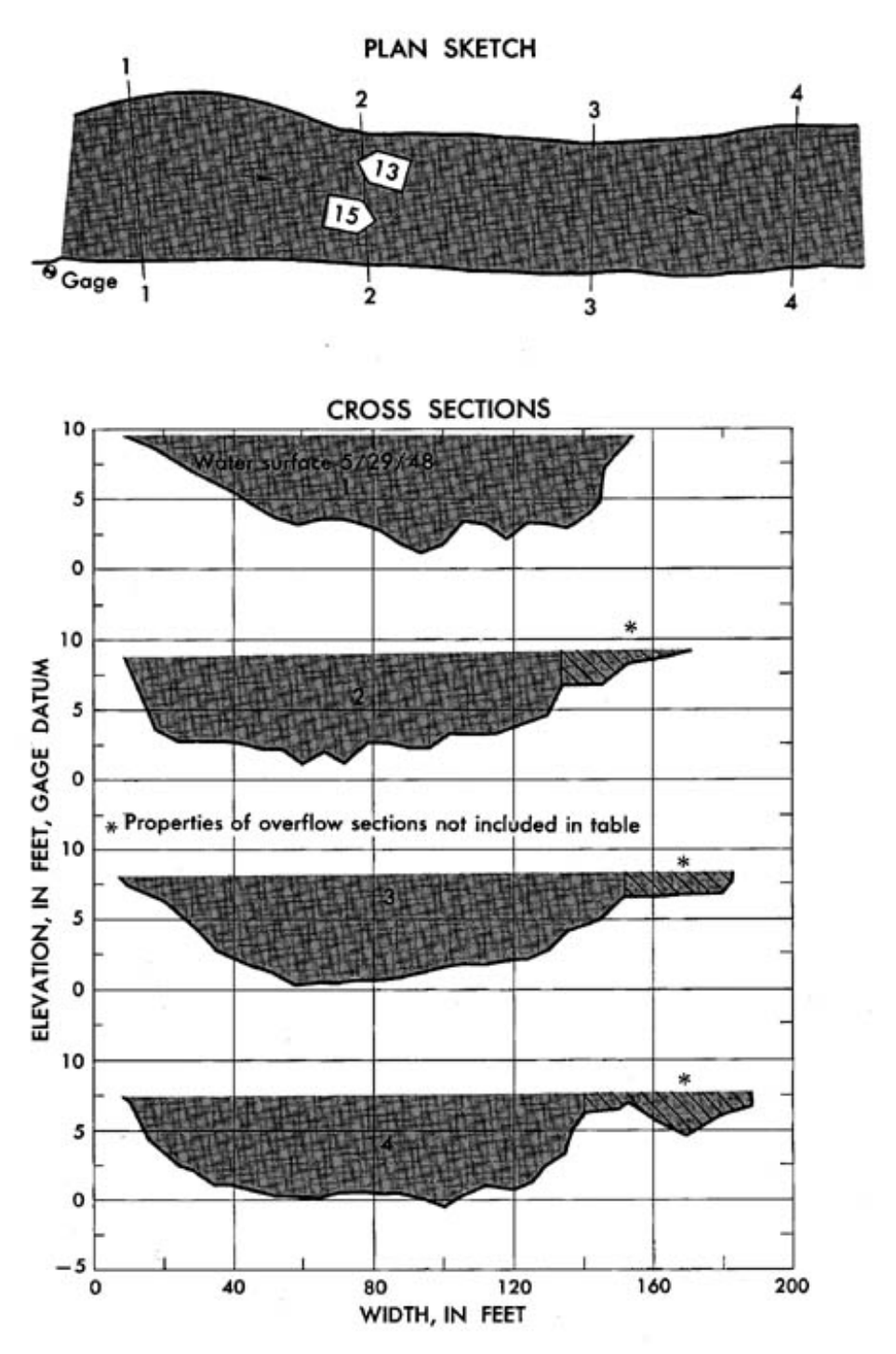
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



Plan sketch and cross sections, Chiwawa River near Plain, Washington.

Introduction Page|| Site Description || Reach Properties

Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 13: Upstream along left bank from section 2, Chiwawa River near plain, Washington.

Photo 15: Downstream along right bank from section 2, Chiwawa River near plain, Washington.

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Water Resources of the Western United States

SURFACE-WATER FIELD TECHNIQUES

Grande Ronde River at La Gande, Oregon - n = 0.043

(Source: U.S.G.S Water Supply Paper 1849)

Site Description | Reach properties | Plan sketch and cross sections | Site photos

Site Description

Station name	Grande Ronde River at La Gande, Oregon
Station number	13-3190
Gage location	Lat 45°21', long 118°08', near center of sec. 36, T. 2 N., R. 37E., on left bank 2 miles northwest of La Grande and 5 miles downstream from Fivepoint Creek. Section 1 is 0.65 mile downstream from gage.
Drainage area	678 sq mi
Date of flood	May 22, 1948
Gage height	7.04 ft at gage; 12.95 ft (different datum) at section 1
Peak discharge	4,620 cfs

Computed roughness coefficient	Manning n = 0.043
Description of channel	Bed consists of boulders; d_{50} = 93 mm, d_{84} = 157 mm. Right bank is fairly steep and has dense overhanging bushes.

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Plan Sketch and Cross Sections || Site Photos

Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	637	110	5.79	5.64	7.25	.....	.....
2	599	115	5.21	5.12	7.71	212	1.68
3	624	117	5.33	5.24	7.40	199	0.48

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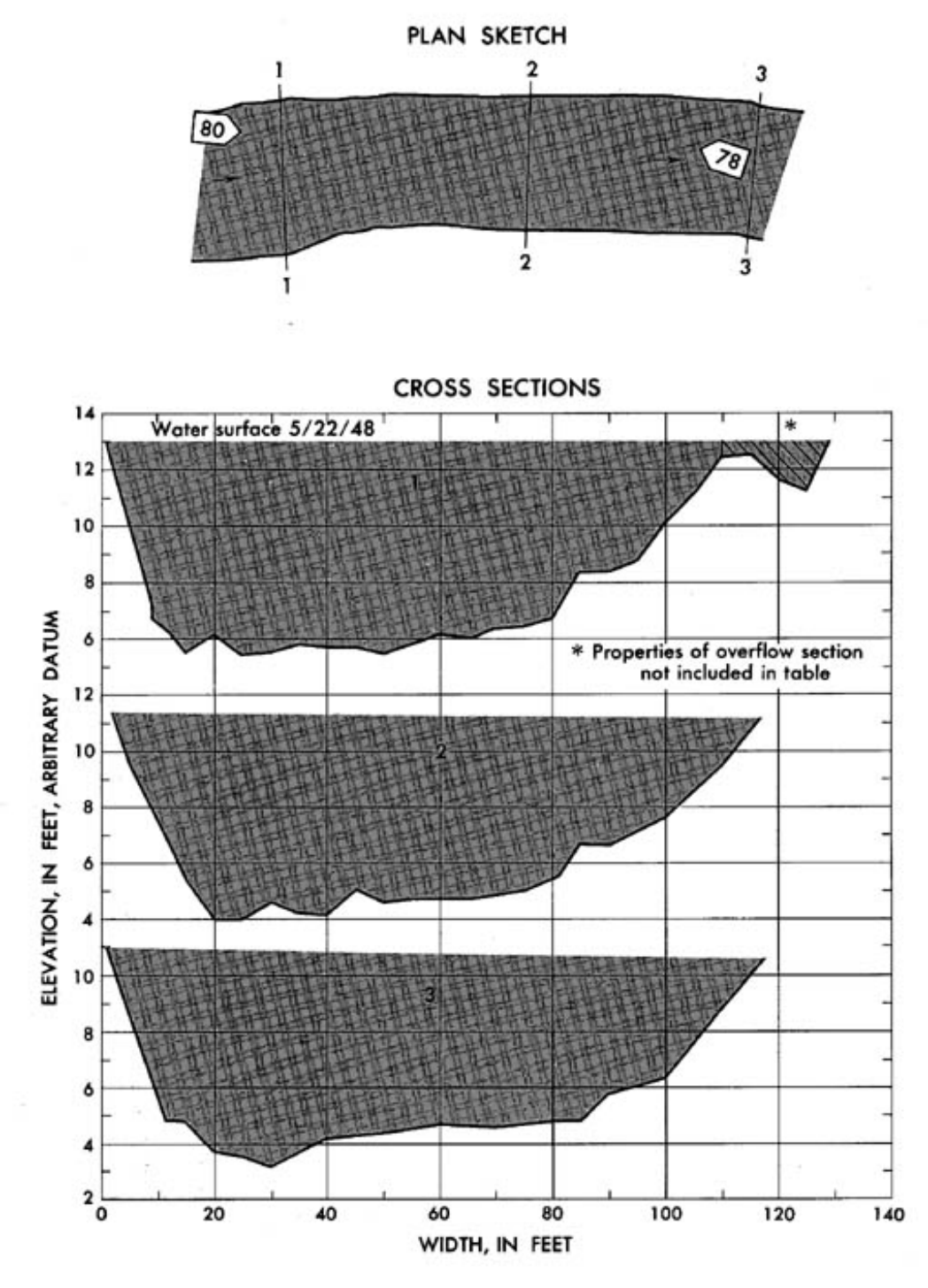
Plan Sketch and Cross Sections



Plan sketch and cross sections, Grande Ronde River at La Gande, Oregon.

Introduction Page|| Site Description || Reach Properties

Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 13: Upstream along left bank from channel below section 3, Grande Ronde River at La Gande, Oregon

Photo 15: Downstream from left bank above section 1, Grande Ronde River at La Gande, Oregon

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SURFACE-WATER FIELD TECHNIQUES

Provo River near Hailstone, Utah - n = 0.045; 0.073

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

---

Site Description

Station name	Provo River near Hailstone, Utah
Station number	10-1550
Gage location	Lat 40°36', long 111°22', in SE 1/4 sec. 34, T. 2 S., R. 5 E., on right bank 3 miles upstream from Ross Creek and Hailstone. Section 1 is about 120 ft upstream from gage.
Drainage area	233 sq mi
Date of flood	June 13, October 7, 1952
Gage height	4.66 ft at gage; 5.66 ft, 2.14 ft at section 1.
Peak discharge	1,200 cfs, 64.8 cfs
Computed roughness coefficient	Manning *n* = 0.045; *n* = 0.073

Description of channel	Bed and banks consist of smooth rounded rocks as much as 1 ft in diameter. Some undergrowth is below water elevatios of June 13.

Introduction Page || Site Description || Reach Properties
Plan Sketch and Cross Sections || Site Photos

Reach Properties

June 13, 1952

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	184	47	3.9	3.70	6.52	.....	.....
3	171	49	3.5	3.33	7.02	88	0.67
5	173	55	3.1	3.02	6.95	109	1.04
7	173	48	3.6	3.43	6.95	117	1.10
9	183	55	3.3	3.22	6.56	116	1.04

October 7, 1952

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	36	38	1.0	0.95	1.79	.....	.....
3	38	34	1.1	1.10	1.70	88	0.32
5	34	32	1.1	.82	1.90	109	0.40
7	34	39	.9	.86	1.91	117	1.28
9	31	41	.8	.76	2.08	116	1.12

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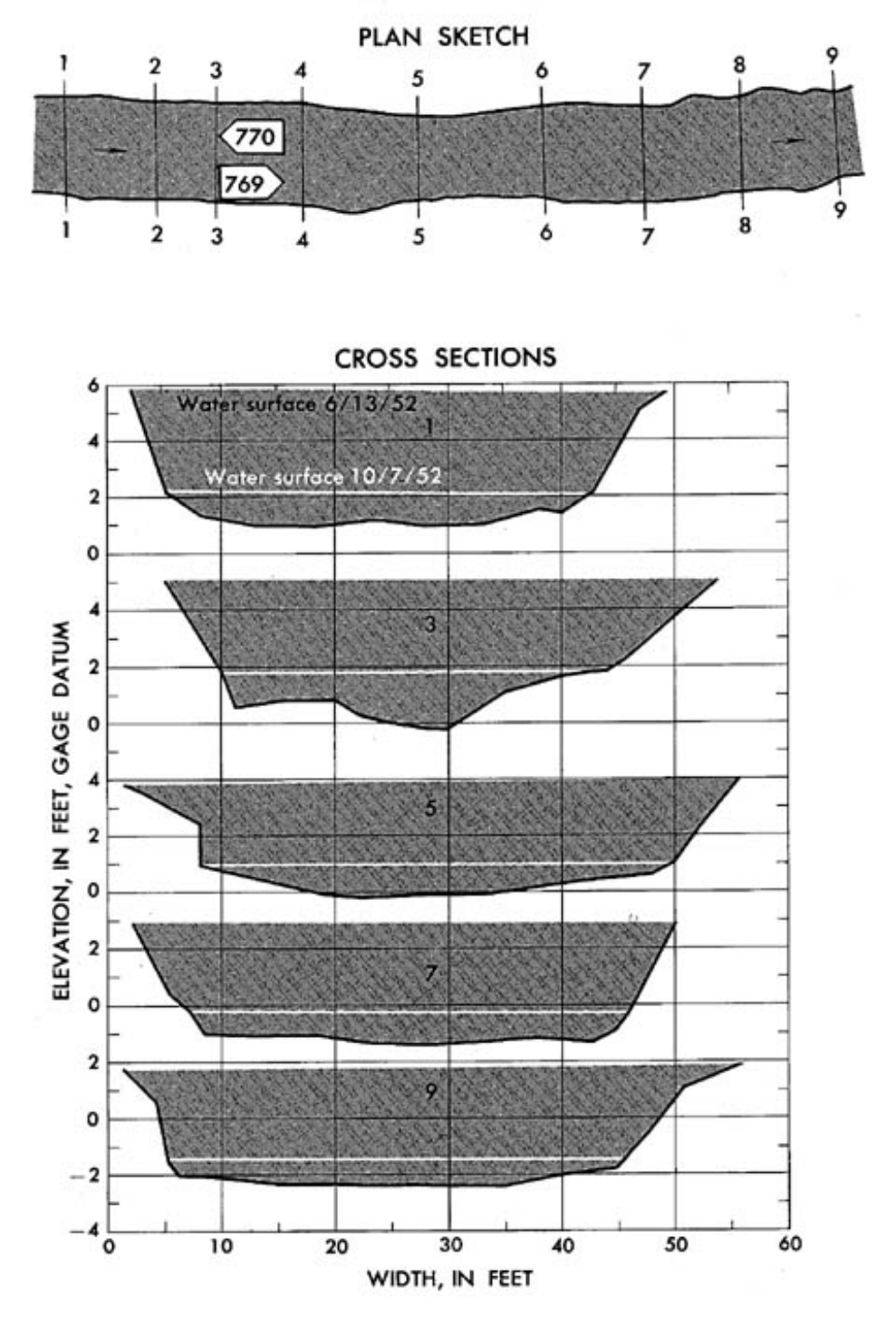
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



Plan sketch and cross sections, Provo River near Hailstone, Utah.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 13: Downstream from section 3, Provo River near Hailstone, Utah.

Photo 15: Upstreamfrom section 3, Provo River near Hailstone, Utah.

Introduction Page || Site Description || Reach Properties

SURFACE-WATER FIELD TECHNIQUES

Clear Creek near Golden, Colorado - n = 0.050

(Source: U.S.G.S Water Supply Paper 1849)

Site Description	Reach properties	Plan sketch and cross sections	Site photos

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Site Description

Station name	Clear Creek near Golden, Colorado
Station number	6-7195
Gage location	Lat 39°45'05", long 1105°14'55", in NE 1/4 sec. 32, T. 3 S., R. 70 W., on left bank 0.5 mile downstream from Golden Canal diversion and 1 mile west of Golden. Section 12 is about 3.5 miles upstream from gage.
Drainage area	399 sq mi
Date of flood	May 26, 1958
Gage height	5.25 ft at gage; 61.70 ft (different datum) at section 15.
Peak discharge	1,380 cfs

Computed roughness coefficient	Manning *n* = 0.050
Description of channel	Bed and banks are composed of angular boulders as much as 2 ft in diameter.

Introduction Page || Site Description || Reach Properties
Plan Sketch and Cross Sections || Site Photos

Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
12	200	43	4.6	4.22	6.90	.....	.....
13	206	50	4.1	3.83	6.70	47	0.85
14	183	52	3.5	3.29	7.54	39	.65
15	184	51	3.6	3.36	7.50	46	.65
16	184	55	3.3	2.69	7.50	32	.60

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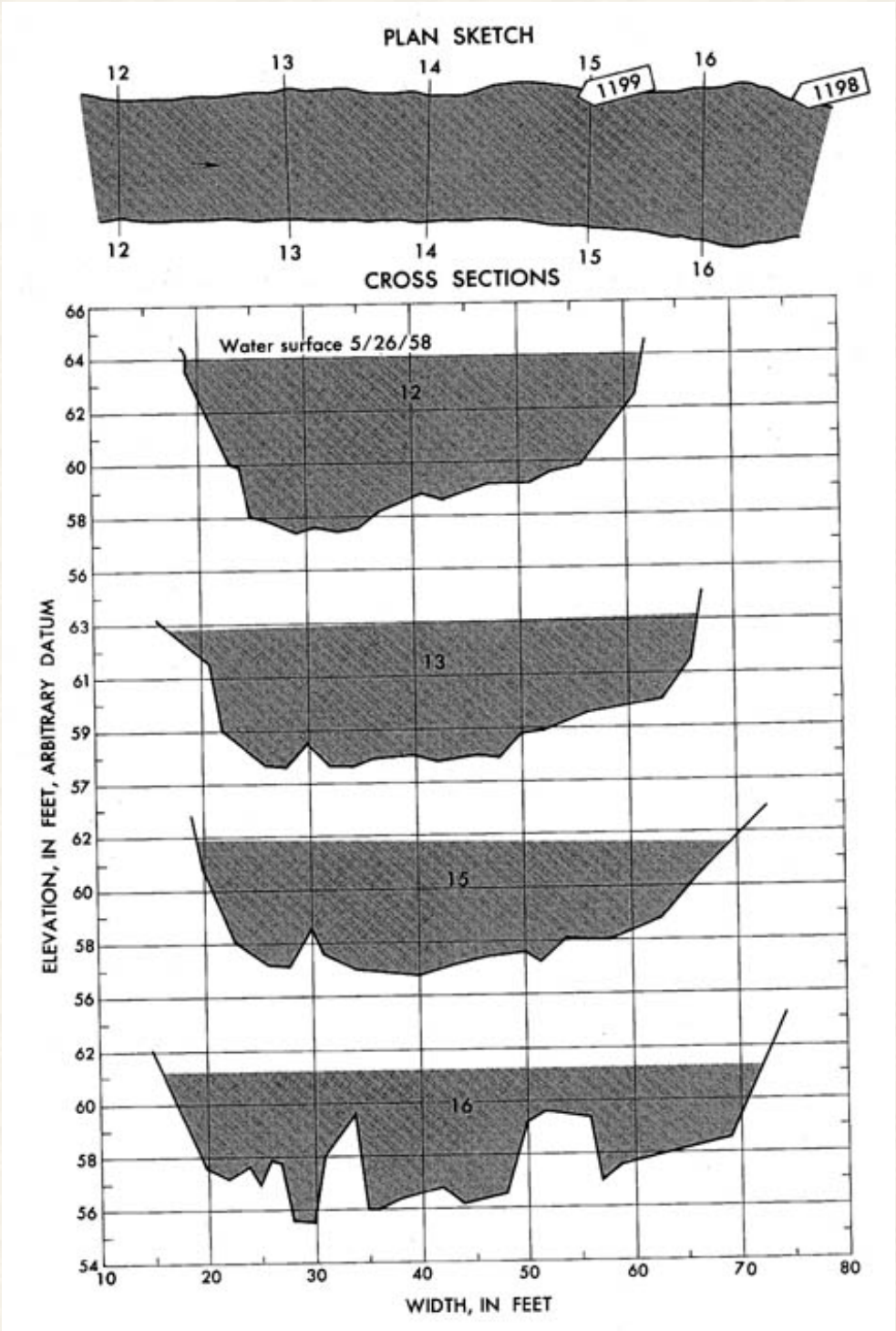
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



Plan sketch and cross sections, Clear Creek near Golden, Colorado

Introduction Page|| Site Description || Reach Properties

Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 1198: Upstream from section 16, Clear Creek near Golden, Colorado.

Photo 1199: Downstream from left bank at section 15, Clear Creek near Golden, Colorado

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Water Resources of the Western United States

SURFACE-WATER FIELD TECHNIQUES

South Fork Clearwater River near Grangeville, Idaho - n = 0.051

(Source: U.S.G.S Water Supply Paper 1849)

Site Description | Reach properties | Plan sketch and cross sections | Site photos

Site Description

Station name	South Fork Clearwater River near Grangeville, Idaho
Station number	13-3380
Gage location	Lat 45°55', long 116°01', in SE 1/4 NW 1/4 sec. 30, T. 30 N., R. 4 E., on right bank downstream from powerhouse of Washington Water Power Co.,6 miles east of Grangeville. Section 1 is about 1.8 miles upstream from gage.
Drainage area	865 sq mi
Date of flood	May 29, 1948
Gage height	12.50 ft at gage: 30.85 ft at section 1

Peak discharge	12,600 cfs
Computed roughness coefficient	Manning n = 0.051
Description of channel	Bed consists of rocks and boulders; d_{50} = 250 mm, d_{84} = 440 mm. Banks are mostly boulders and have trees and brush along top.

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Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	1,326	134	9.90	9.40	9.50	.....	.....
2	1,310	143	9.16	8.68	9.62	255	1.40
3	1,434	181	7.92	7.71	8.79	295	1.45
4	1,267	148	8.56	8.23	9.94	357	2.85

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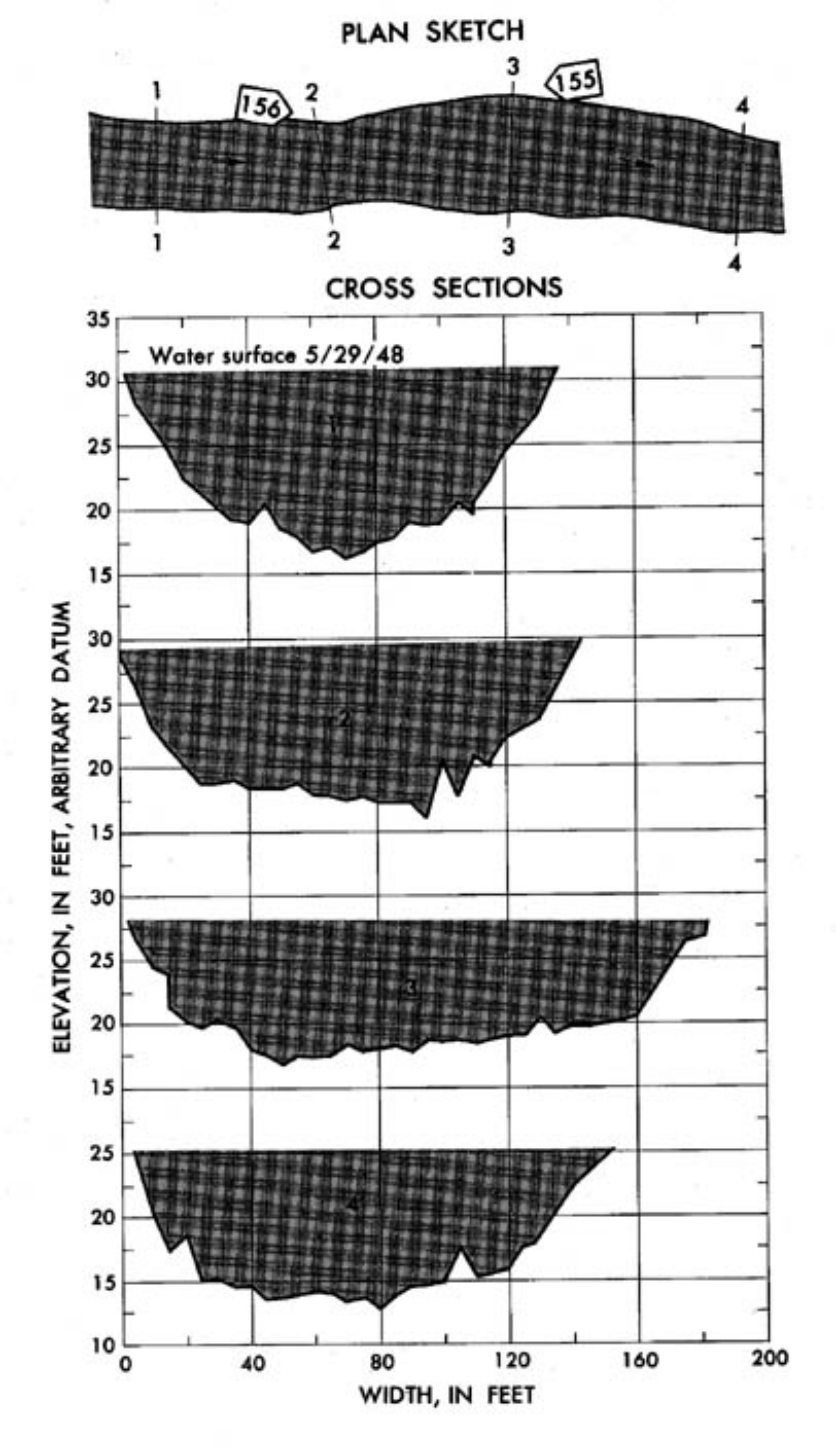
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



Plan and cross sections, South Fork Clearwater River near Grangeville, Idaho.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 155: Upstream from left bank at section 3, South Fork Clearwater River near Grangeville, Idaho.

Photo 156: Downstream from left bank at section 2, South Fork Clearwater River near Grangeville, Idaho.

Introduction Page || Site Description || Reach Properties

SURFACE-WATER FIELD TECHNIQUES

Cache Creek near Lower Lake, California - n = 0.053; 0.079

(Source: U.S.G.S Water Supply Paper 1849)

Site Description | Reach properties | Plan sketch and cross sections | Site photos

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Site Description

Station name	Cache Creek near Lower Lake, California
Station number	11-4510
Gage location	Lat 38°55'27", long 122°33'53", in sec. 6, T. 12 N., R. 6 W., on left bank 500 ft downstream from Clear Lake Dam, 1.9 miles downstream from Copsey Creek, and 2.5 miles northeast of Lower Lake. Section 1 is 350 ft upstream from gage.
Drainage area	528 sq mi
Date of flood	January 24-25, 1951
Gage height	7.80 ft at gage, 6.30 ft at gage; 13.35 ft, 11.70 ft at section 1

Peak discharge	3,840 cfs, 1,830 cfs
Computed roughness coefficient	Manning *n* = 0.053; 0.079
Description of channel	Bed is composed of large angular boulders. Banks consist of exposed rock, boulders, and trees.

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Plan Sketch and Cross Sections || Site Photos

Reach Properties

January 25, 1951

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	401	81	5.0	4.27	9.59	.....	.....
2	384	65	5.9	5.02	10.00	102	1.80
3	295	45	6.6	5.27	13.02	62	3.10

January 24, 1951

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	271	76	3.6	3.09	6.75	.....	.....
2	236	51	4.6	3.88	7.75	102	2.75
3	211	38	5.6	4.45	8.67	62	2.55

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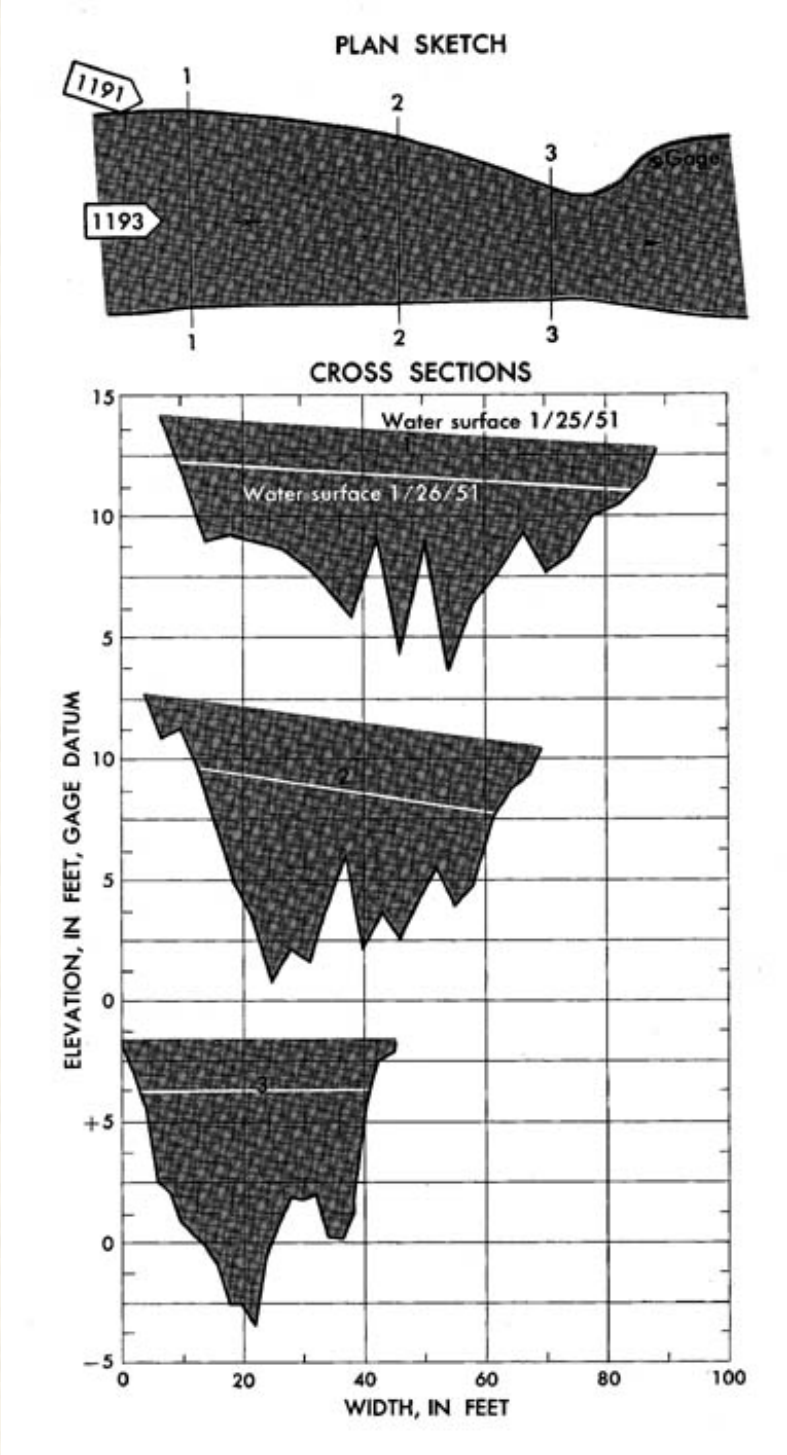
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



Plan and cross sections, Cache Creek near Lower Lake, California.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 1191: Downstream from left bank above section 1, Cache Creek near Lower Lake, California.

Photo 1193: Downstream from channel at section 1, Cache Creek near Lower Lake, California.

Introduction Page || Site Description || Reach Properties

SURFACE-WATER FIELD TECHNIQUES

Mission Creek near Cashmere, Washington - n = 0.057

(Source: U.S.G.S Water Supply Paper 1849)

Site Description | Reach properties | Plan sketch and cross sections | Site photos

Site Description

Station name	Mission Creek near Cashmere, Washington
Station number	12-4620
Gage location	Lat 47°30'15", long 120°28'30", in SE 1/4 NE 1/4 sec. 8, T. 23 N., R. 19 E., on right bank 1.5 miles upstream from mouth and 1.5 miles south of Cashmere. Section 1 is about 0.5 mile downstream.
Drainage area	79.1 sq mi
Date of flood	May 19, 1955
Gage height	1.73 ft at gage; 14.00 ft (different datum) at section 1
Peak discharge	123 cfs
Computed roughness coefficient	Manning *n* = 0.057

Description of channel	Bed angular-shaped boulders as much as 1 ft in diameter. Both banks are lined with overhanging bushes.

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Plan Sketch and Cross Sections || Site Photos

Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	34	22	1.54	1.50	3.64	.....	.....
2	28	22	1.27	1.24	4.39	44	0.82
3	31	20.5	1.53	1.46	3.92	51	.79

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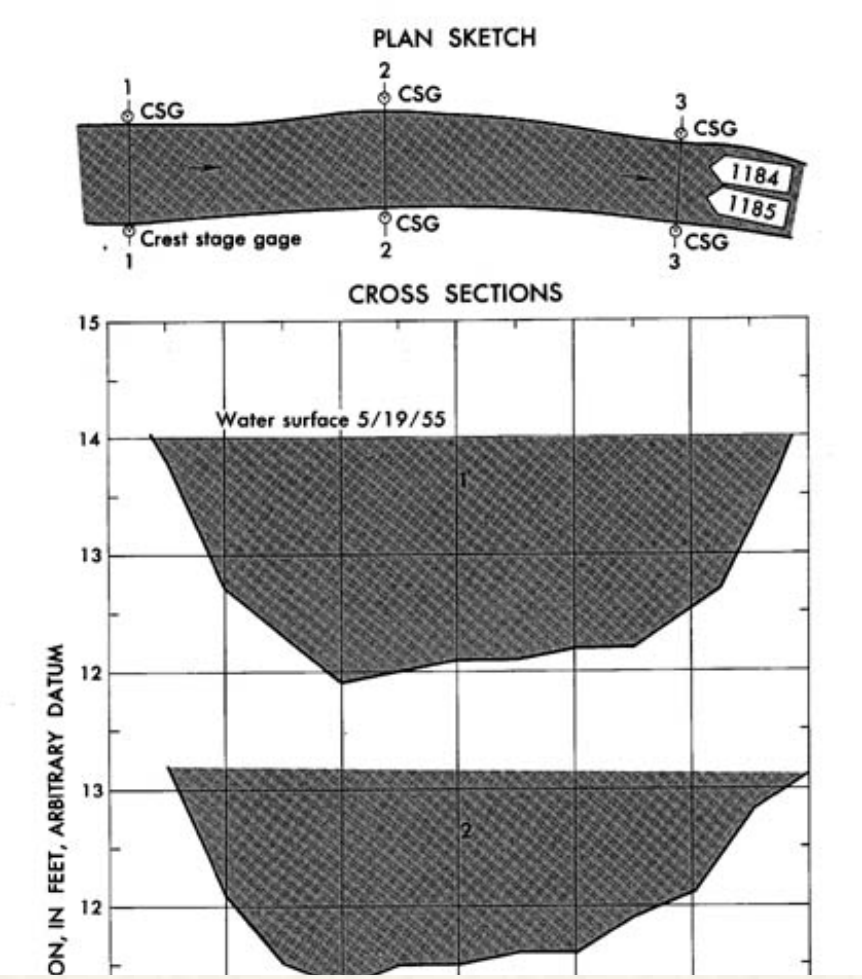
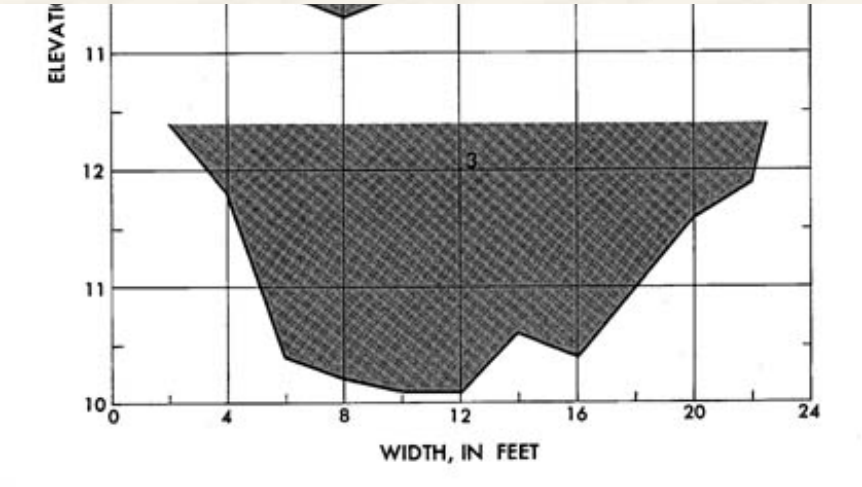
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections





Plan and cross sections, Mission Creek near Cashmere, Washington.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 1184: Upstream from below section 3, Mission Creek near Cashmere, Washington.

Photo 1185: Upstream from below section 3, Mission Creek near Cashmere, Washington.

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Plan Sketch and Cross Sections || Site Photos

SURFACE-WATER FIELD TECHNIQUES

Rock Creek Canal near Darby, Montana - n = 0.060

(Source: U.S.G.S Water Supply Paper 1849)

Site Description | Reach properties | Plan sketch and cross sections | Site photos

Site Description

Station name	Rock Creek Canal near Darby, Montana
Station number	12-2455
Gage location	Lat 46°04'40", long 120°28'30", in SW 1/4 sec. 28, T. 4 N., R. 21 W., on downstream side of footbridge, 0.25 mile downstream from diversion dam, 1.5 miles downstream from Como Lake, and 4 miles northwest of Darby. Section 1 is about 0.25 mile upstream from gage.
Date of flood	September 23, 1948
Gage height	3.34 ft at gage; 15.33 ft at section 1
Peak discharge	138 cfs

Computed roughness coefficient	Manning n = 0.060
Description of channel	Bed and bank consist of boulders ; d_{50} = 210 mm, d_{84} = 375 mm.

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Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	30	26	1.15	1.07	4.60	.....	.....
2	31	25	1.24	1.19	4.45	45	1.25
3	39	24	1.62	1.56	3.54	50	1.36
4	30	25	1.20	1.25	4.60	50	1.02
5	32	25	1.28	1.28	4.31	50	.93
6	37	26	1.42	1.37	3.73	50	.78
7	32	24	1.33	1.28	4.31	50	.85

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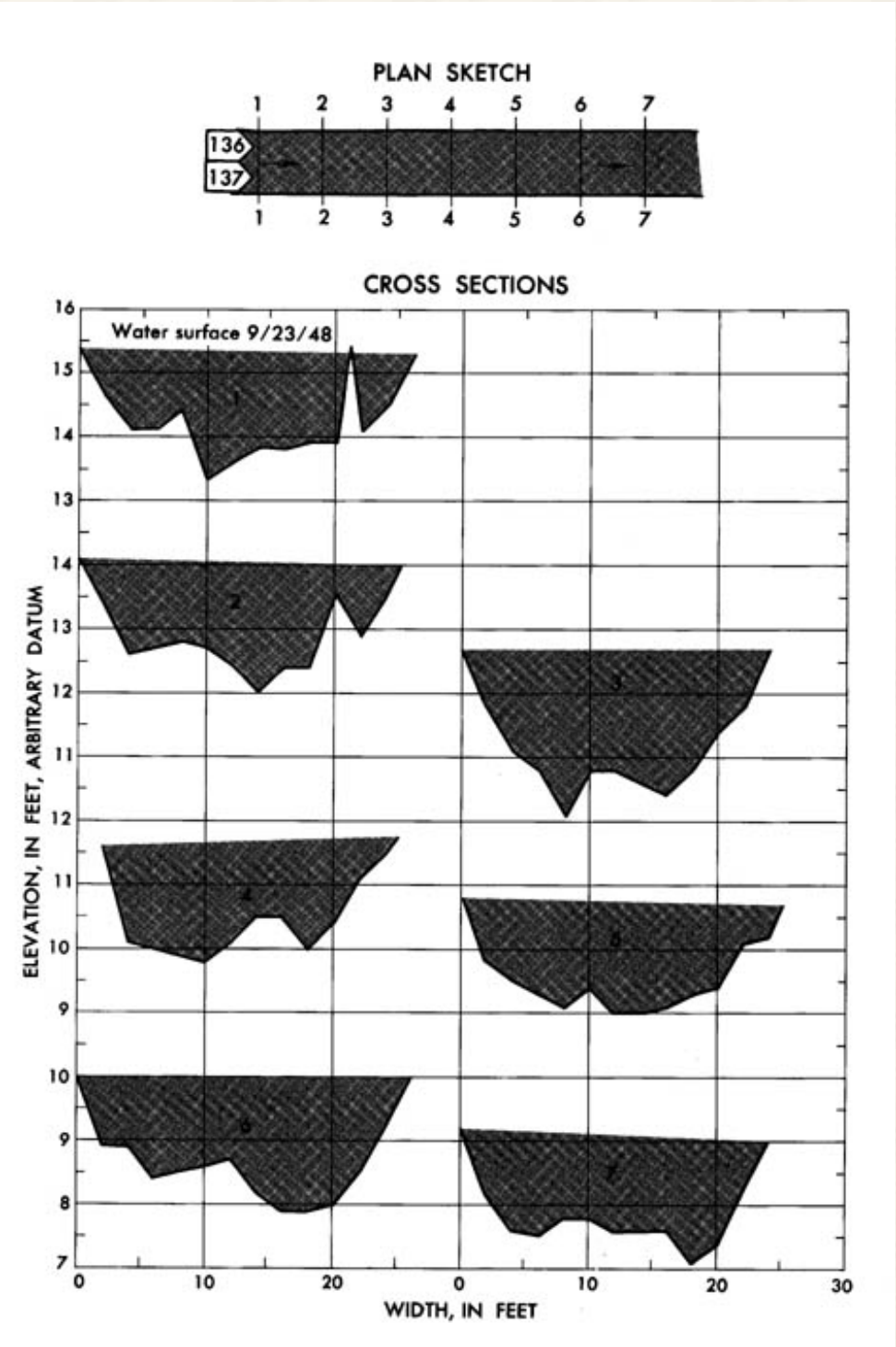
Plan Sketch and Cross Sections || Site Photos

Plan Sketch and Cross Sections



Plan and cross sections, Rock Creek Canal near Darby, Montana.

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Plan Sketch and Cross Sections || Site Photos

Site Photos

Photo 136: Downstream from above section 1, Rock Creek Canal near Darby, Montana.

Photo 137: Downstream from above section 1, Rock Creek Canal near Darby, Montana.

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Water Resources of the Western United States

SURFACE-WATER FIELD TECHNIQUES

Merced River at Happy Isles Bridge, near Yosemite, California - n = 0.065

(Source: U.S.G.S Water Supply Paper 1849)

Site Description | Reach properties | Plan sketch and cross sections | Site photos

Site Description

Station name	Merced River at Happy Isles Bridge, near Yosemite, California
Station number	11-2645
Gage location	Lat 37°43'54", long 119°33'28", on right bank 10 ft downstream from Illilouette Creek, and 2 miles southeast of Yosemite National Park Headquarters, Mariposa County. Section 1 is about 1,000 ft downstream from gage.
Drainage area	181 sq mi.
Date of flood	May 17, 1950
Gage height	6.06 ft at gage; 97.40 ft (different datum) at section 1

Peak discharge	1,950 cfs
Computed roughness coefficient	Manning n = 0.065
Description of channel	Fairly straight channel is composed of boulders with trees along top of banks; d_{50} = 253 mm, d_{84} = 550 mm. Banks are composed of boulders and have trees and brush.

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Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	308	78	4.0	3.90	6.33	.....	.....
2	263	64	4.1	3.98	7.41	200	3.40
3	309	63	4.9	4.68	6.31	40	0.50
4	327	78	4.2	4.09	5.96	180	1.55

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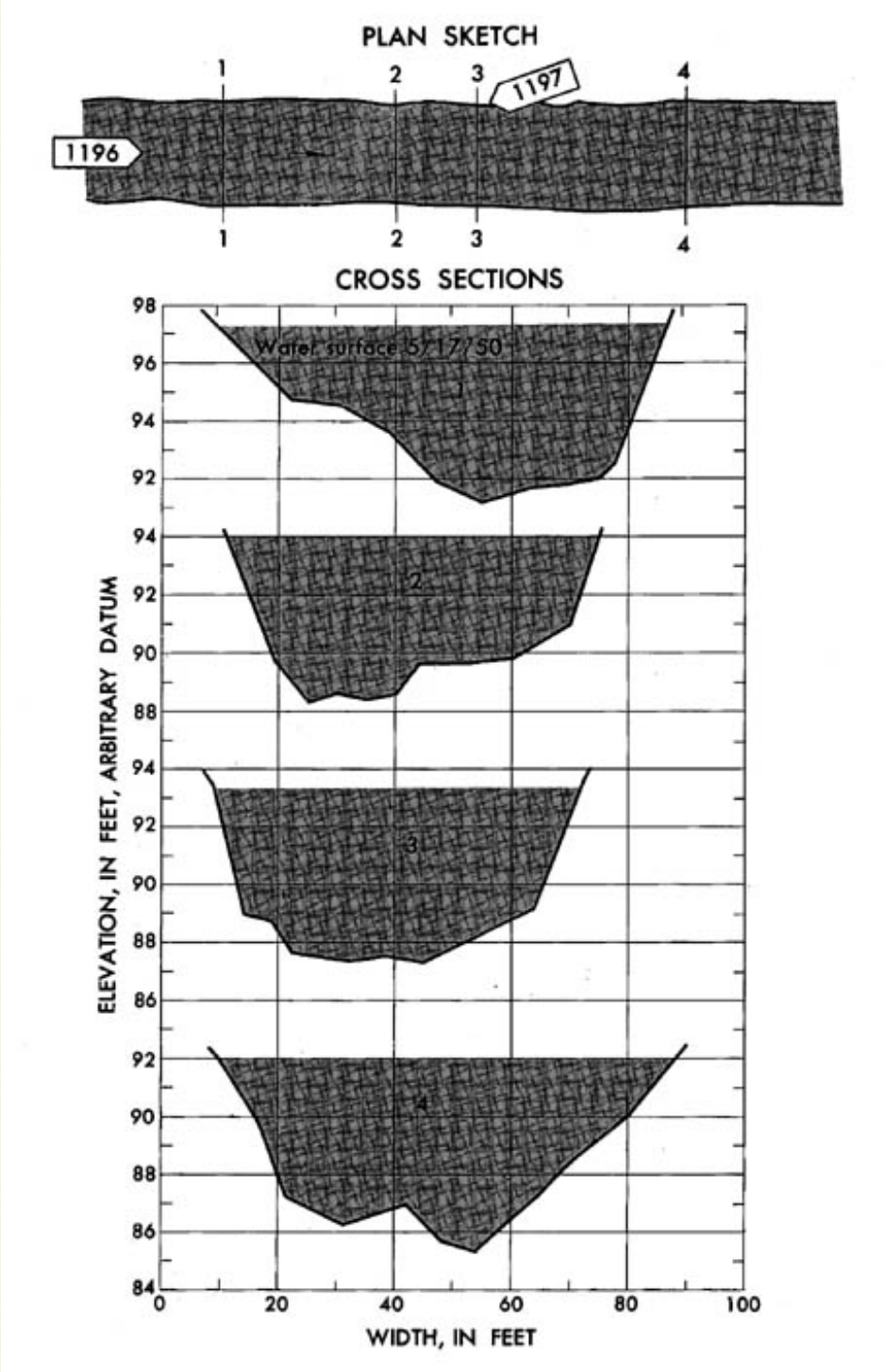
Plan Sketch and Cross Sections



Plan sketch and cross sections, Merced River at Happy Isles Bridge, near Yosemite, California.

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Photo 1196: Downstream from above section 2, Merced River at Happy Isles Bridge, near Yosemite, California

Photo 1197: Upstream from below section 3, Merced River at Happy Isles Bridge, near Yosemite, California.

SURFACE-WATER FIELD TECHNIQUES

Boundary Creek near Porthill, Idaho - n = 0.073

(Source: U.S.G.S Water Supply Paper 1849)

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Site Description

Station name	Boundary Creek near Porthill, Idaho
Station number	12-3215
Gage location	Lat 48°59'50", long 116°34'05", in SW 1/4 sec. 11, T. 65 N., R. 2 W., on left bank near muoth of canyon 0.2 mile south of international boundary, and 3 miles west of Porthill. Section 1 is about 413 ft upstream from gage.
Drainage area	97 sq mi, approximately.
Date of flood	May 28, 1948
Gage height	5.34 ft at gage; 13.60 ft at section 1
Peak discharge	2,530 cfs
Computed roughness coefficient	Manning *n* = 0.073

Description of channel	Bed consists of boulders; d_{50} = 210 mm, d_{84} = 375mm. Banks are composed of boulders and have trees and brush along top.

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Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	351	64	5.48	4.87	7.21	.....	.....
2	338	82	4.12	3.93	7.49	94	1.45
3	327	71	4.61	4.09	7.74	163	3.95
4	400	118	3.39	3.30	6.32	177	2.70

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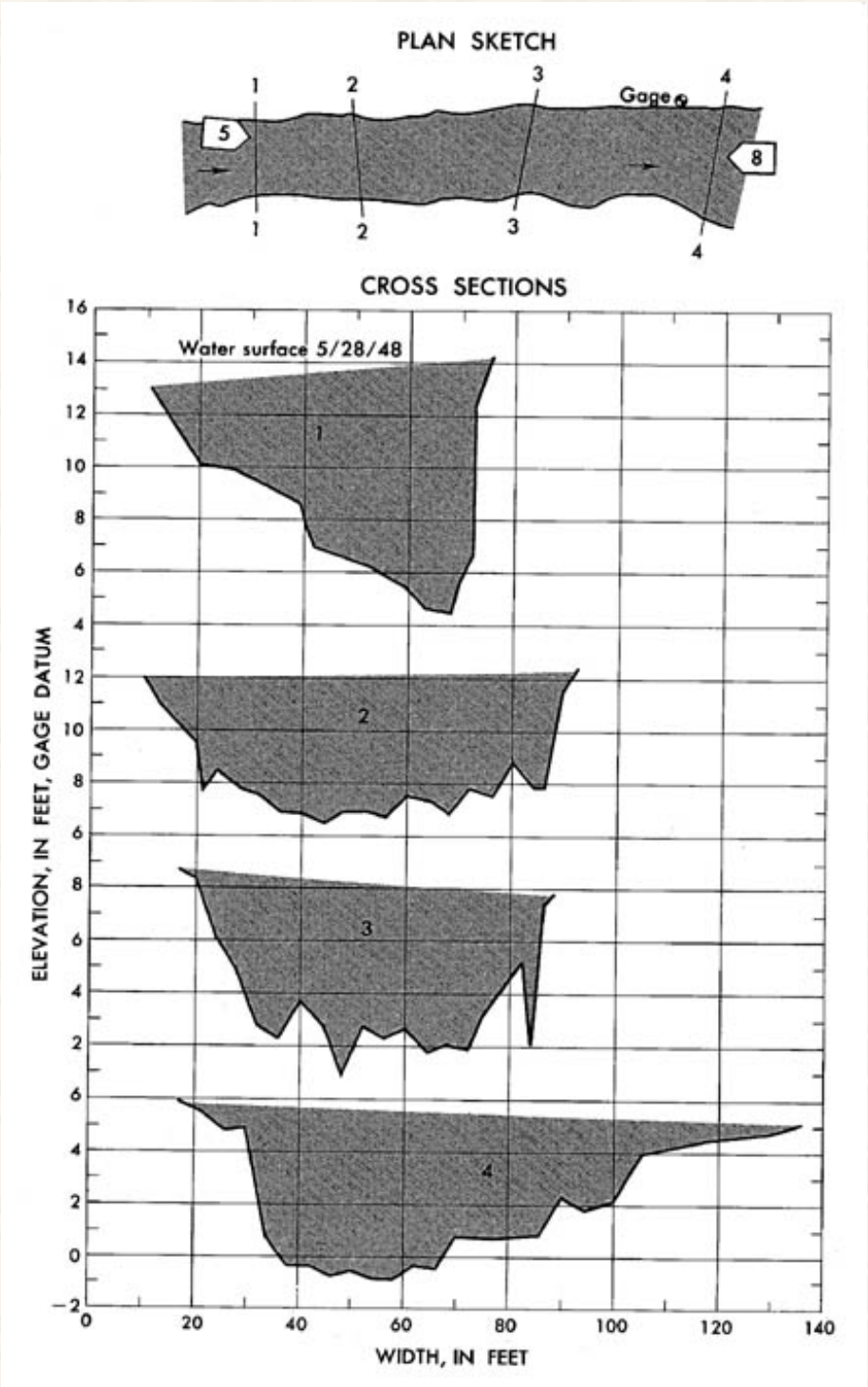
Plan Sketch and Cross Sections



Plan sketch and cross sections, Boundary Creek near Porthill, Idaho.

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Photo 5: Downstream from left bank above section 1, Boundary Creek near Porthill, Idaho.

Photo 8: Upstream from below section 4, Boundary Creek near Porthill, Idaho.

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Water Resources of the Western United States

SURFACE-WATER FIELD TECHNIQUES

Rock Creek near Darby, Montana - n = 0.075

(Source: U.S.G.S Water Supply Paper 1849)

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Site Description

Station name	Rock Creek near Darby, Montana
Station number	12-3450
Gage location	Lat 46°04'10", long 114°13'20", in SE 1/4 SE 1/4 sec. 29, T. 4 N., R. 21 W., on left bank 0.6 mile downstream from Como Lake, 0.7 mile upstream from Rock Creek Canal, and 4 miles northwest of Darby. Section 1 is about 0.25 mile upstream from gage.
Drainage area	55.4 sq mi
Date of flood	May 27, 1948
Gage height	5.78 ft at gage; 23.85 ft at section 1
Peak discharge	1,500 cfs

Computed roughness coefficient	Manning n = 0.075
Description of channel	Bed consists of boulders; d_{50} = 220 mm, d_{84} = 415 mm. Banks are composed of boulders and have trees and brush.

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Reach Properties

Section	Area (sq ft)	Top Width (ft.)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Lenght (ft) between sections	Fall (ft) between sections
1	214	51	4.20	3.96	7.01	.....	.....
2	203	54	3.76	3.50	7.39	79	2.65
3	134	43	3.12	2.91	11.19	47	2.45

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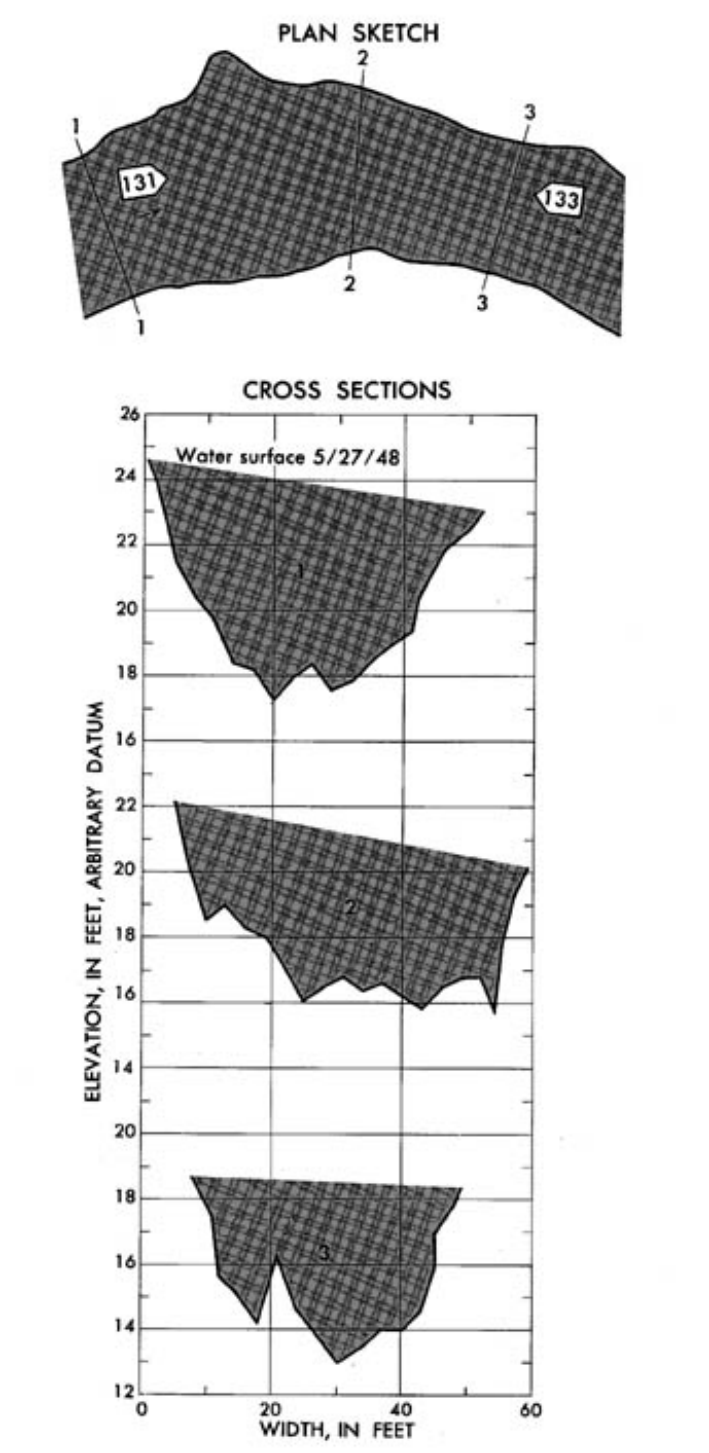
Plan Sketch and Cross Sections



Plan and cross sections, Rock Creek near Darby, Montana.

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Site Photos

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Photo 131: Downstream from above section 2, Rock Creek near Darby, Montana.

Photo 133: Upstream from below section 3, Rock Creek near Darby, Montana.

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