DRAFT RECOMMENDATION – SUBJECT TO CHANGE

Mr. Rob Viehl
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, Colorado 80203

Dear Mr. Viehl:

The Bureau of Land Management (BLM) is writing this letter to formally communicate its recommendation for an increase to the instream flow water right on West Branch Willow Creek, located in Water Division 6.

Location and Land Status. West Branch Willow Creek originates on the south slope of Middle Mountain approximately 12 miles northwest of Steamboat Lake, and it flows into the main stem of Willow Creek approximately four miles south of the Colorado-Wyoming border. This recommendation addresses the portion of West Branch Willow Creek that starts at the headwaters (Latitude 40.89679 Longitude -107.18856) and extends downstream to the confluence with Willow Creek located in Section 6, T11N R87W, a distance of approximately 5.3 miles. The BLM manages 0.7 miles of this reach, while approximately 4.6 miles are in private ownership.

Biological Summary. West Branch Willow Creek is a cool water, low to moderate gradient stream. The reach that is the subject of this recommendation flows through a shallow valley that ranges from ¼ to ½ mile in width. The reach flows through lands primarily used for livestock grazing. Substrate is generally from small to medium in size, ranging from sands and gravels to eight-inch cobbles. Water quality is acceptable for supporting cool water fish species, but the creek does appear to be affected by excessive nutrient loading, a lack of riparian vegetation, and raw, eroding banks resulting in an incised channel.

Fish surveys have documented self-supporting populations of speckled dace, mountain sucker, creek chub, and fathead minnow. Spot surveys have indicated populations of mayfly, caddisfly, and other macroinvertebrate species that tolerate cool to warm water habitats.

The creek supports a sparse riparian community of willow, alder, sedges, and rush species, which are more abundant in areas that are not accessible to grazing. Bank stability is poor to fair, with less bank stability in areas of high livestock usage.

R2Cross Analysis. The BLM collected the following R2Cross data:

Cross Section Date	Discharge Rate	Top Width	Winter Flow Recommendation (meets 2 of 3 hydraulic criteria)	Summer Flow Recommendation (meets 3 of 3 hydraulic criteria)
06/13/2018 #1	0.56 cfs	6.86 feet	0.66 cfs	0.81 cfs
06/13/2018 #2	0.42 cfs	4.00 feet	0.39 cfs	1.44 cfs
		Averages:	0.52 cfs	1.12 cfs

BLM's analysis of this data indicates that the following flows are needed to protect the natural environment to a reasonable degree.

NOTE: THE RECOMMENDED FLOW RATES BELOW ARE SUBJECT TO FURTHER DATA COLLECTION, MODELING, AND WATER AVAILABILITY ANALYSIS.

1.1 cubic feet per second is recommended during the warm weather period, from April 1 to October 31. This recommendation is driven by the average velocity criteria and depth criteria. During the irrigation season, maintaining this flow rate in the creek would provide adequate habitat for maintaining fish species while irrigation diversions occur. This flow rate will maintain sufficient physical habitat in the creek for the fish population to complete important parts of their life cycle before cold temperatures reduce fish activity for the winter.

0.50 cubic feet per second is recommended during cold weather period, from November 1 through March 31. This recommendation meets two of three instream flow criteria and should prevent complete icing of the pools in this reach, allowing the fish population to overwinter.

Water Availability. The BLM recommends use of Streamstats and CSUFlows to provide an estimate of natural hydrology, because there are no present or historic stream flow gages on this creek. The BLM is not aware of any water rights in this stream reach.

Relationship to Land Management Plans. The BLM's management plan calls for improvement and recovery of current and historic fisheries as a means of increasing native fish populations. In addition, the BLM plan calls for making instream flow recommendations to the Colorado Water Conservation Board to meet minimum instream flow requirements to maintain native fisheries. Finally, the plan calls for maintaining and improving the function of riparian areas to achieve advanced ecological stage for the riparian community, and it also calls for protecting riparian and wetland systems from further sources of degradation. Establishing an instream flow water right would assist in meeting these objectives.

Data sheets, R2Cross output, fishery survey information, and photographs of the cross section were included with BLM's draft recommendation in February 2024. We thank both Colorado Parks and Wildlife and the Colorado Water Conservation Board for their cooperation in this effort.

If you have any questions regarding our instream flow recommendation, please contact Roy Smith at 303-239-3940.

Sincerely,

Alan Bittner

Deputy State Director
Resources

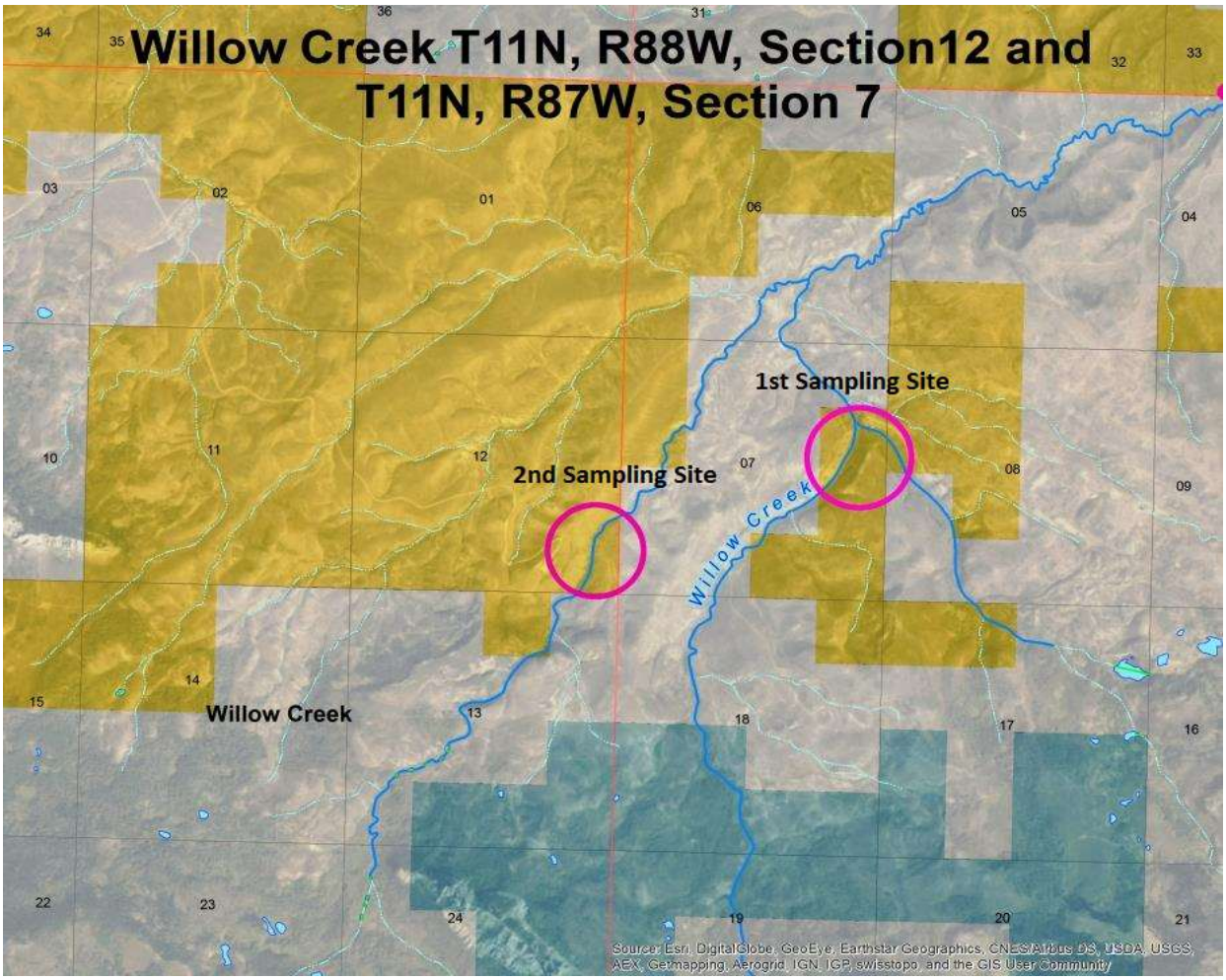
Cc: Kymm Gresset, Little Snake FO
Eric Scherff, Little Snake FO
Elijah Waters, Northwest District Manager

Little Snake Field Office

Stream Sampling July 2016

Willow Creek (NE of Craig) - Water Code: 22854

Introduction:
Willow Creek, located north of Hayden, Colorado on BLM lands managed by the Little Snake Field Office, was sampled on July 21, 2016. Willow Creek is tributary to the Little Snake River. Two branches of Willow Creek were sampled to obtain baseline information on fishery status and species composition, as well as stream and riparian habitat conditions. A one-pass sampling effort was completed at two sampling locations, one on each branch. One backpack shocker was used to sample each site. Only native Speckled Dace were seen or collected at site 1. Species present at site 2 included: Mountain Sucker, Creek Chub, Speckled Dace, and Fathead Minnow. Personnel present were Tom Fresques, Kristen Doyle, and Nate Higginson, BLM.



Willow Creek – note the "mushrooming" of the willow indicative of heavy grazing pressure (Site 1)

Representative habitat of unnamed Willow Creek tributary (Site 2)

Creek Chub

Speckled Dace in spawning coloration

Mountain sucker

Mountain sucker

Discussion:

Willow Creek Site 1

Willow Creek is a small perennial stream. Only native Speckled Dace were seen or collected at the sample site. Approximately 250 feet of stream was sampled. A few age classes were noted and fish appeared healthy. Fish were concentrated in the limited pools/shaded areas provided by limited alder and willow.

Riparian vegetation at the site consisted of limited, scattered willows, alder, twinberry, sedges, and riparian grasses. Thistle was common. Vegetation was in poor condition and alder and willow were sparse and were mushroomed – a sign of heavy grazing pressure. The stream has limited shading and cover for fish as the majority of the stream was exposed. Better riparian would likely reduce width to depth ratios and provide deeper, cooler water.

Stream habitat was comprised of a mix of riffles, small runs, and shallow pools. Large, deep pools were generally lacking and the stream appears to be wider and shallower than would be expected. Substrate was comprised of a mix of find sediments and gravel and cobble.

Willow Creek Branch Site 2

This branch of Willow Creek was small but perennial and contained native Speckled Dace and Mountain Sucker, and nonnative creek chub, and fathead minnow. Only one sucker was collected. Fish were concentrated in the best pools with some depth or cover.

Riparian vegetation was sparse at the sample site and consisted of some sedge and riparian grasses. Very few willow or alder were noted. And the riparian is in poor condition due to apparent excessive grazing. Areas of raw, trampled banks were common and the stream lacked shading and cover. Better riparian would likely reduce width to depth ratios and provide deeper, cooler water.

Stream habitats were comprised of a mix of riffle, run, and small to moderately deep (1-2 feet) pools. The stream appeared to be a bit wider and shallower than would be expected. Stream substrates were comprised of a mix of fine sediments, gravel, and cobble.

Recommendations:

- Look at Land Health Assessment information and assess grazing in the area and consider changes to improve stream and riparian habitat conditions
- Consider some fencing exclosures to reduce grazing pressure along the streams
- Periodically resample the streams to assess fishery status

COLORADO WATER CONSERVATION BOARD

FIELD DATA FOR INSTREAM FLOW DETERMINATIONS

LOCATION INFORMATION

STREAM NAME: West Branch Willow Creek						CROSS-SECTION NO.: 1
CROSS-SECTION LOCATION: 0.75 mile upstream from confluence with main stem						
DATE: 6-13-18	OBSERVERS: R. Smith, E. Scherff					
LEGAL DESCRIPTION	¼ SECTION: NW	SECTION: 7	TOWNSHIP: 11 (N)/S	RANGE: 87 E/(W)	PM: 6th	
COUNTY: Routt	WATERSHED: Little Snake R.	WATER DIVISION: 6	DOW WATER CODE:			
MAP(S): USGS:			GPS 315020			
USFS:			4533374			

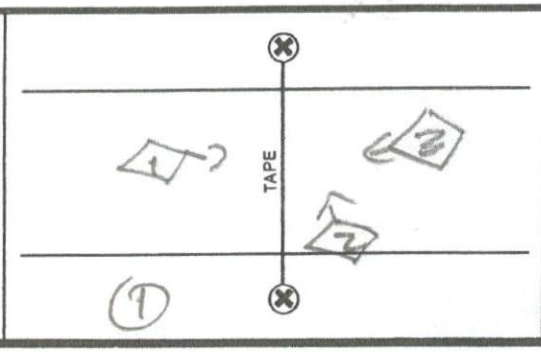
SUPPLEMENTAL DATA

SAG TAPE SECTION SAME AS DISCHARGE SECTION: (YES)/NO	METER TYPE: M-M			
METER NUMBER:	DATE RATED:	CALIB/SPIN: ____ sec	TAPE WEIGHT: surveyed ____ lbs/foot	TAPE TENSION: surveyed ____ lbs
CHANNEL BED MATERIAL SIZE RANGE: sand to 8" cobbles	PHOTOGRAPHS TAKEN: (YES)/NO	NUMBER OF PHOTOGRAPHS: 3		

CHANNEL PROFILE DATA

STATION	DISTANCE FROM TAPE (ft)	ROD READING (ft)
(X) Tape @ Stake LB	0.0	surveyed
(X) Tape @ Stake RB	0.0	surveyed
(1) WS @ Tape LB/RB	0.0	5.75/5.75
(2) WS Upstream	8.2'	5.42
(3) WS Downstream	12.7'	5.85'
SLOPE	0.43/20.9' = .021	

SKETCH



LEGEND:
- Stake (X)
- Station (1)
- Photo (1)
- Direction of Flow

AQUATIC SAMPLING SUMMARY

STREAM ELECTROFISHED: YES/(NO)	DISTANCE ELECTROFISHED: ____ft	FISH CAUGHT: YES/NO	WATER CHEMISTRY SAMPLED: (YES)/NO

LENGTH - FREQUENCY DISTRIBUTION BY ONE-INCH SIZE GROUPS (1.0-1.9, 2.0-2.9, ETC.)

SPECIES (FILL IN)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15	TOTAL

AQUATIC INSECTS IN STREAM SECTION BY COMMON OR SCIENTIFIC ORDER NAME:

COMMENTS

Riparian = willow-alder

DISCHARGE/CROSS SECTION NOTES

STREAM NAME: West Branch Willow Creek | CROSS-SECTION NO.: | DATE: 6/13/18 | SHEET ___ OF ___

BEGINNING OF MEASUREMENT | EDGE OF WATER LOOKING DOWNSTREAM: (0.0 AT STAKE) LEFT / RIGHT | Gage Reading: _____ ft | TIME: 14:00

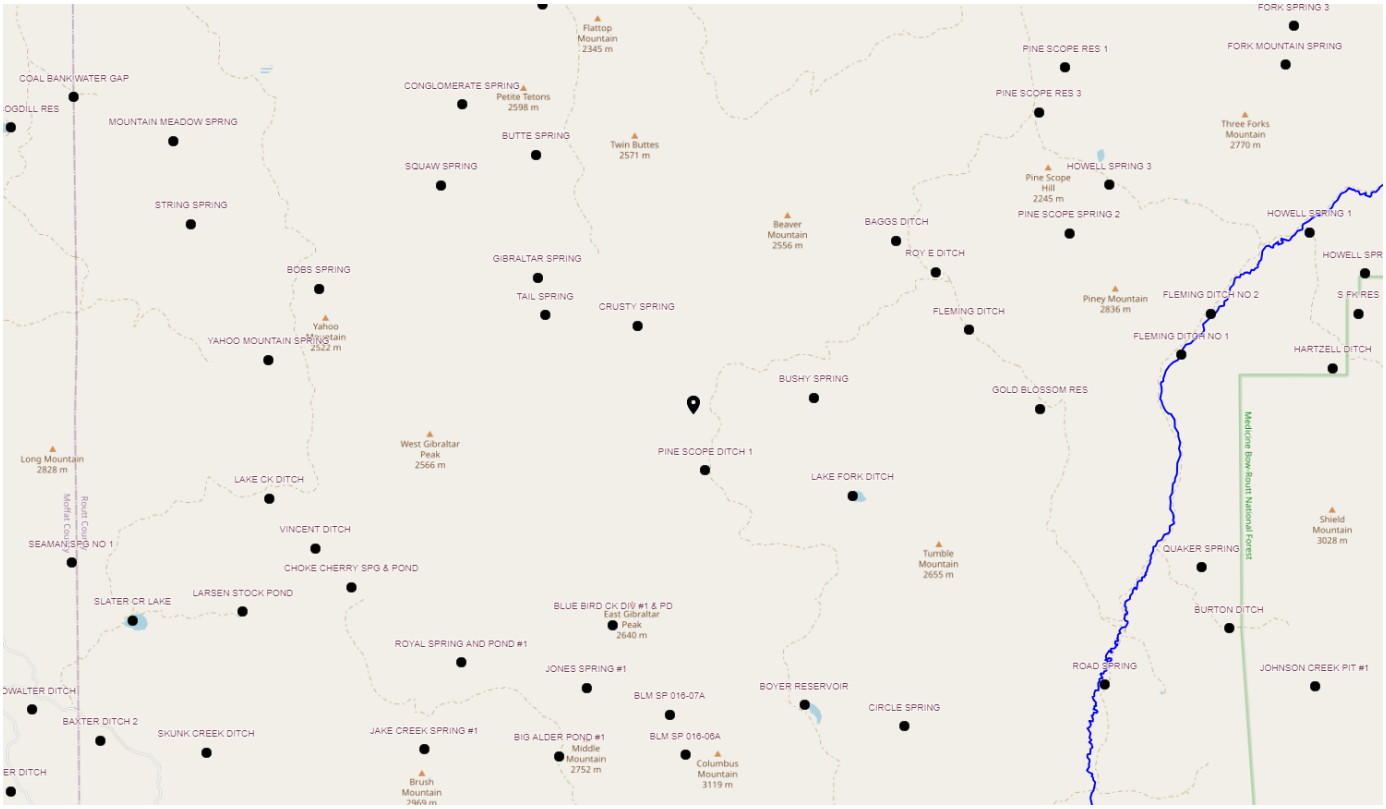
Features (Stake (S), Grassline (G), Waterline (W), Rock (R))	Distance From Initial Point (ft)	Width (ft)	Total Vertical Depth From Tape/Inst (ft)	Water Depth (ft)	Depth of Observation (ft)	Revolutions	Time (sec)	Velocity (ft/sec) At Point	Velocity (ft/sec) Mean in Vertical	Area (ft^2)	Discharge (cfs)
RLS	0.0		4.88								
G	1.5		4.96								
	3.4		5.24								
RW	4.0		5.75								
	4.4		5.95	0.20				0.17			
	4.6		6.0	0.25				0.30			
	4.8		5.95	0.20				0.50			
	5.0		6.0	0.25				0.81			
	5.2		6.0	0.25				0.84			
	5.4		5.95	0.20				0.99			
	5.6		5.90	0.15				1.40			
	5.8		5.95	0.20				0.97			
	6.0		5.95	0.20				1.11			
	6.2		5.95	0.20				0.85			
	6.4		5.95	0.20				0.83			
	6.6		5.95	0.20				0.82			
	6.8		5.95	0.20				1.13			
	7.0		5.95	0.20				1.20			
	7.2		6.0	0.25				1.41			
	7.4		5.9	0.15				0.13			
LW	7.7		5.75								
G&LS	8.5		4.98								
TOTALS:											

End of Measurement | Time: 14:10 | Gage Reading: _____ ft | CALCULATIONS PERFORMED BY: | CALCULATIONS CHECKED BY:

R2Cross RESULTS

Stream Name: West Branch Willow Creek
Stream Locations: 0.75 miles upstream from confluence with main stem Willow Creek
Fieldwork Date: 06/13/2018
Cross-section: 1
Observers: R. Smith, E. Scherff
Coordinate System: UTM Zone 13
X (easting): 315020
Y (northing): 4533374
Date Processed: 02/26/2024
Slope: 0.021
Discharge: R2Cross data file: 0.56 (cfs)
Computation method: Ferguson VPE
R2Cross data filename: West Branch Willow Creek 6-13-18 #1 ERAMS Data Sheet.xlsx
R2Cross version: 2.0.2

LOCATION



ANALYSIS RESULTS

Habitat Criteria Results

Bankfull top width (ft) = 6.86

	Habitat Criteria	Discharge (cfs) Meeting Criteria
Mean Depth (ft)	0.2	0.66
Percent Wetted Perimeter (%)	50.0	0.56
Mean Velocity (ft/s)	1.0	0.81

STAGING TABLE

Feature	Distance to Water (ft)	Top Width (ft)	Mean Depth (ft)	Maximum Depth (ft)	Area (sq ft)	Wetted Perimeter (ft)	Percent Wetted Perimeter	Hydraulic Radius (ft)	Manning's n	Mean Velocity (ft/s)	Discharge (cfs)
Bankfull	4.98	6.86	0.63	1.02	4.35	7.52	100.0	0.58	0.04	3.55	15.43
	5.0	6.71	0.63	1.0	4.21	7.36	97.8	0.57	0.04	3.51	14.8
	5.05	6.32	0.62	0.95	3.89	6.94	92.28	0.56	0.04	3.43	13.33
	5.1	5.93	0.6	0.9	3.58	6.53	86.76	0.55	0.04	3.35	12.01
	5.15	5.53	0.6	0.85	3.29	6.11	81.24	0.54	0.04	3.29	10.84
	5.2	5.14	0.59	0.8	3.03	5.7	75.73	0.53	0.04	3.24	9.8
	5.25	4.81	0.58	0.75	2.78	5.33	70.89	0.52	0.04	3.17	8.81
	5.3	4.69	0.54	0.7	2.54	5.18	68.81	0.49	0.05	2.97	7.54
	5.35	4.56	0.51	0.65	2.31	5.02	66.72	0.46	0.05	2.76	6.37
	5.4	4.44	0.47	0.6	2.09	4.86	64.63	0.43	0.05	2.54	5.3
	5.45	4.32	0.43	0.55	1.87	4.7	62.54	0.4	0.05	2.31	4.32
	5.5	4.2	0.39	0.5	1.65	4.55	60.46	0.36	0.05	2.08	3.44
	5.55	4.08	0.35	0.45	1.45	4.39	58.37	0.33	0.06	1.84	2.66
	5.6	3.96	0.31	0.4	1.24	4.23	56.28	0.29	0.06	1.59	1.98
	5.65	3.84	0.27	0.35	1.05	4.08	54.19	0.26	0.06	1.34	1.41
	5.7	3.72	0.23	0.3	0.86	3.92	52.11	0.22	0.07	1.08	0.93
Waterline	5.75	3.6	0.19	0.25	0.68	3.76	50.02	0.18	0.08	0.83	0.56
	5.8	3.43	0.15	0.2	0.5	3.56	47.34	0.14	0.1	0.58	0.29
	5.85	3.25	0.1	0.15	0.34	3.36	44.65	0.1	0.13	0.36	0.12
	5.9	3.08	0.06	0.1	0.18	3.16	41.97	0.06	0.21	0.15	0.03
	5.95	1.3	0.03	0.05	0.04	1.34	17.86	0.03	0.37	0.05	0.0
	5.99	0.53	0.01	0.01	0.01	0.54	7.22	0.01	0.86	0.01	0.0

This Manning's roughness coefficient was calculated based on velocity estimates from the Ferguson VPE method

MODEL SUMMARY

Measured Flow (Qm) =	0.56	(cfs)
Calculated Flow (Qc) =	0.56	(cfs)
(Qm-Qc)/Qm * 100 =	-0.02%	
Measured Waterline (WLm) =	5.75	(ft)
Calculated Waterline (WLc) =	5.75	(ft)
(WLm-WLc)/WLm * 100 =	0.00%	
Max Measured Depth (Dm) =	0.25	(ft)
Max Calculated Depth (Dc) =	0.25	(ft)
(Dm-Dc)/Dm * 100 =	-0.01%	
Mean Velocity =	0.83	(ft/s)
Manning's n =	0.083	
0.4 * Qm =	0.22	(cfs)
2.5 * Qm =	1.4	(cfs)

FIELD DATA

Feature	Station (ft)	Rod Height (ft)	Water depth (ft)	Velocity (ft/s)
	0	4.88		
Bankfull	1.5	4.96		
	3.4	5.24		
Waterline	4.1	5.75	0	0
	4.4	5.95	0.2	0.17
	4.6	6	0.25	0.3
	4.8	5.95	0.2	0.5
	5	6	0.25	0.81
	5.2	6	0.25	0.84
	5.4	5.95	0.2	0.99
	5.6	5.9	0.15	1.4
	5.8	5.95	0.2	0.97
	6	5.95	0.2	1.11
	6.2	5.95	0.2	0.85
	6.4	5.95	0.2	0.83
	6.6	5.95	0.2	0.82
	6.8	5.95	0.2	1.13
	7	5.95	0.2	1.2
	7.2	6	0.25	1.41
	7.4	5.9	0.15	0.13
Waterline	7.7	5.75	0	0
Bankfull	8.5	4.98		

COMPUTED FROM MEASURED FIELD DATA

Wetted Perimeter (ft)	Water Depth (ft)	Area (ft^2)	Discharge (cfs)	Percent Discharge
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.36	0.2	0.05	0.01	1.52
0.21	0.25	0.05	0.01	2.68
0.21	0.2	0.04	0.02	3.58
0.21	0.25	0.05	0.04	7.24
0.2	0.25	0.05	0.04	7.51
0.21	0.2	0.04	0.04	7.08
0.21	0.15	0.03	0.04	7.51
0.21	0.2	0.04	0.04	6.94
0.2	0.2	0.04	0.04	7.94
0.2	0.2	0.04	0.03	6.08
0.2	0.2	0.04	0.03	5.93
0.2	0.2	0.04	0.03	5.86
0.2	0.2	0.04	0.05	8.08
0.2	0.2	0.04	0.05	8.58
0.21	0.25	0.05	0.07	12.6
0.22	0.15	0.04	0	0.87
0.34	0	0	0	0
0	0	0	0	0

DISCLAIMER

"The Colorado Water Conservation Board makes no representations about the use of the software contained in the R2Cross platform for any purpose besides that for which it was designed. To the maximum extent permitted by applicable law, all information, modeling results, and software are provided “as is” without warranty or condition of any kind, including all implied warranties or conditions of merchantability, or fitness for a particular purpose. The user assumes all responsibility for the accuracy and suitability of this program for a specific application. In no event shall the Colorado Water Conservation Board or any state agency, official or employee be liable for any direct, indirect, punitive, incidental, special, consequential damages or any damages whatsoever including, without limitation, damages for loss of use, data, profits, or savings arising from the implementation, reliance on, or use of or inability to use the R2Cross platform.

COLORADO WATER CONSERVATION BOARD

FIELD DATA FOR INSTREAM FLOW DETERMINATIONS

COLORADO DIVISION OF WILDLIFE

LOCATION INFORMATION

STREAM NAME: West Branch Willow Creek						CROSS-SECTION NO.: 2	
CROSS-SECTION LOCATION: 0.75 mile upstream from confluence with main stem							
DATE: 6-13-18	OBSERVERS: R. Smith, E. Scherff						
LEGAL DESCRIPTION	¼ SECTION: NW	SECTION: 7	TOWNSHIP: 11 N/S	RANGE: 87 E/W	PM: 6th		
COUNTY: Routt	WATERSHED: Little Snake R.	WATER DIVISION: 6	DOW WATER CODE:				
MAP(S): USGS:						315020	
MAP(S): USFS:						4533374	

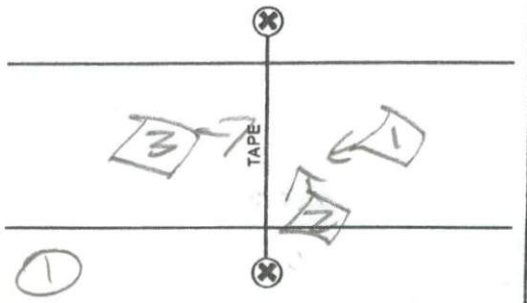
SUPPLEMENTAL DATA

SAG TAPE SECTION SAME AS DISCHARGE SECTION: YES / NO	METER TYPE: M-M			
METER NUMBER:	DATE RATED:	CALIB/SPIN: ____ sec	TAPE WEIGHT: surveyed ____ lbs/foot	TAPE TENSION: surveyed ____ lbs
CHANNEL BED MATERIAL SIZE RANGE: gravel to 6" cobbles	PHOTOGRAPHS TAKEN: YES/NO	NUMBER OF PHOTOGRAPHS: 3		

CHANNEL PROFILE DATA

STATION	DISTANCE FROM TAPE (ft)	ROD READING (ft)
⊗ Tape @ Stake LB	0.0	surveyed
⊗ Tape @ Stake RB	0.0	surveyed
① WS @ Tape LB/RB	0.0	6.20 / 6.20
② WS Upstream	10.0	5.90
③ WS Downstream	10.0	6.50
SLOPE	0.6 / 20.0 = .03	

SKETCH



LEGEND:
- Stake ⊗
- Station ①
- Photo ①→
- Direction of Flow

AQUATIC SAMPLING SUMMARY

STREAM ELECTROFISHED: YES/NO	DISTANCE ELECTROFISHED: ____ ft	FISH CAUGHT: YES/NO	WATER CHEMISTRY SAMPLED: YES/NO

LENGTH - FREQUENCY DISTRIBUTION BY ONE-INCH SIZE GROUPS (1.0-1.9, 2.0-2.9, ETC.)

SPECIES (FILL IN)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15	TOTAL

AQUATIC INSECTS IN STREAM SECTION BY COMMON OR SCIENTIFIC ORDER NAME:

mayfly, caddisfly, stonefly

COMMENTS

Water temp: 25.4 °C

SC 469 µS/cm

Salinity 0.2

pH 8.72

DISCHARGE/CROSS SECTION NOTES

STREAM NAME: West Branch Willow Ck. | CROSS-SECTION NO.: 2 | DATE: 6-13-18 | SHEET ___ OF ___

BEGINNING OF MEASUREMENT | EDGE OF WATER LOOKING DOWNSTREAM: (0.0 AT STAKE) LEFT / RIGHT | Gage Reading: _____ ft | TIME: 2:30 pm

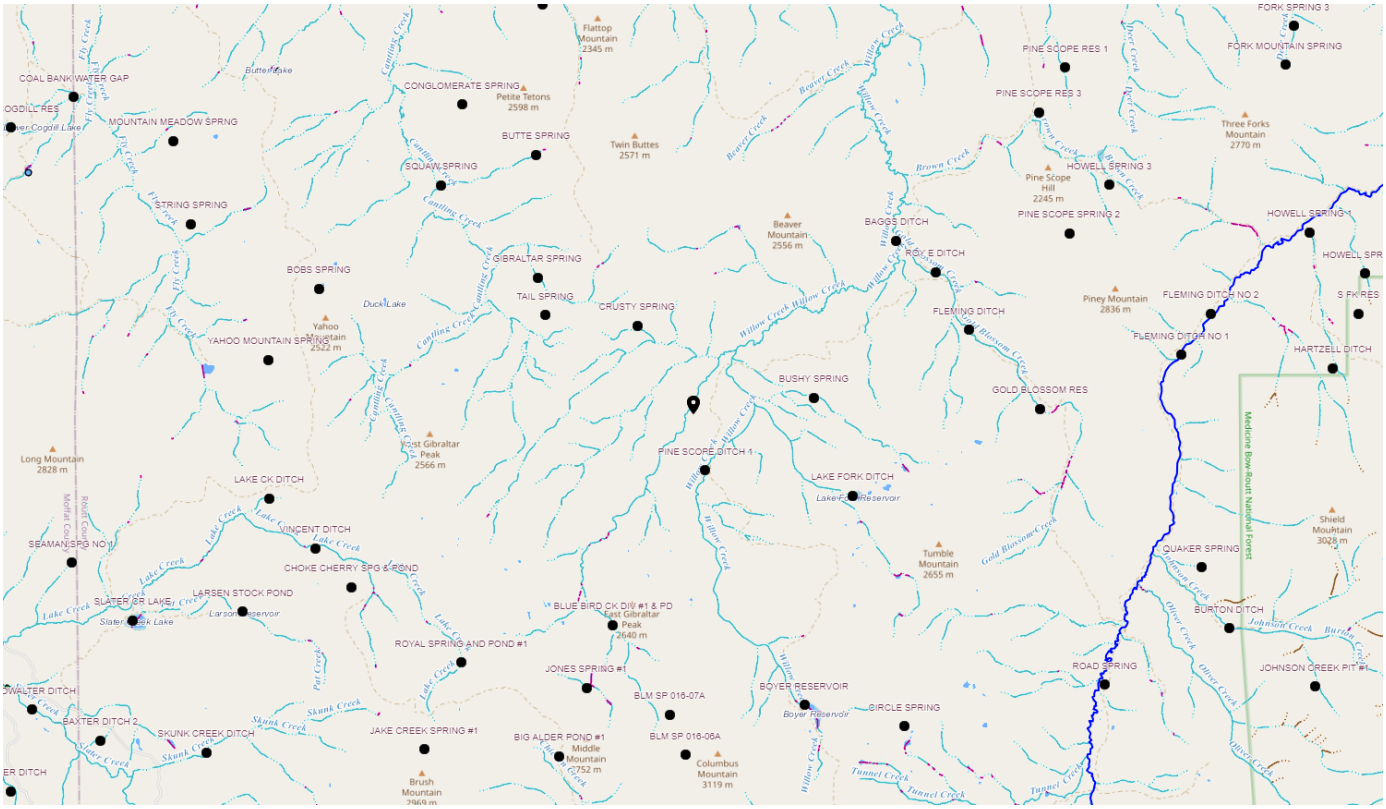
Features (Stake (S), Grassline (G), Waterline (W), Rock (R))	Distance From Initial Point (ft)	Width (ft)	Total Vertical Depth From Tape/Inst (ft)	Water Depth (ft)	Depth of Observation (ft)	Revolutions	Time (sec)	Velocity (ft/sec) At Point	Velocity (ft/sec) Mean in Vertical	Area (ft^2)	Discharge (cfs)
RS	0.0		4.54								
	0.7		4.90								
G	0.9		5.50								
RW	1.3		6.22								
	1.6		6.25	0.05				0.48			
	1.8		6.25	0.05				0.54			
	2.0		6.30	0.10				0.94			
	2.2		6.30	0.10				1.10			
	2.4		6.30	0.10				1.22			
	2.6		6.50	0.30				1.53			
	2.8		6.40	0.20				1.84			
	3.0		6.40	0.20				1.56			
	3.2		6.35	0.15				1.41			
	3.4		6.40	0.20				0.75			
	3.6		6.2	0.10				0.70			
	3.8		6.35	0.15				0.38			
	4.0		6.25	0.05				0.26			
	4.2		6.30	0.10				0.47			
	4.4		6.30	0.10				0.22			
	4.6		6.25	0.05				0.15			
LW	4.8		6.20								
G	4.9		5.50								
	5.0		5.22								
LS	6.0		4.58								
TOTALS:											

End of Measurement | Time: 1440 | Gage Reading: _____ ft | CALCULATIONS PERFORMED BY: | CALCULATIONS CHECKED BY:

R2Cross RESULTS

Stream Name: West Branch Willow Creek
Stream Locations: 0.75 miles upstream from confluence with main Stem Willow Creek
Fieldwork Date: 06/13/2018
Cross-section: 2
Observers: R. Smith, E. Scherff
Coordinate System: UTM Zone 13
X (easting): 315020
Y (northing): 4533374
Date Processed: 02/26/2024
Slope: 0.03
Discharge: R2Cross data file: 0.42 (cfs)
Computation method: Ferguson VPE
R2Cross data filename: West Branch Willow Creek 6-13-18 #2 ERAMS Data Sheet.xlsx
R2Cross version: 2.0.2

LOCATION



ANALYSIS RESULTS

Habitat Criteria Results

Bankfull top width (ft) = 4.0

	Habitat Criteria	Discharge (cfs) Meeting Criteria
Mean Depth (ft)	0.2	1.44
Percent Wetted Perimeter (%)	50.0	0.14
Mean Velocity (ft/s)	1.0	0.39

STAGING TABLE

Feature	Distance to Water (ft)	Top Width (ft)	Mean Depth (ft)	Maximum Depth (ft)	Area (sq ft)	Wetted Perimeter (ft)	Percent Wetted Perimeter	Hydraulic Radius (ft)	Manning's n	Mean Velocity (ft/s)	Discharge (cfs)
Bankfull	5.5	4.0	0.76	1.0	3.03	5.21	100.0	0.58	0.03	6.19	18.75
	5.55	3.96	0.71	0.95	2.83	5.11	97.93	0.55	0.03	5.96	16.85
	5.6	3.93	0.67	0.9	2.63	5.0	95.85	0.53	0.03	5.71	15.03
	5.65	3.89	0.63	0.85	2.44	4.89	93.78	0.5	0.03	5.45	13.27
	5.7	3.86	0.58	0.8	2.24	4.78	91.71	0.47	0.03	5.17	11.6
	5.75	3.82	0.54	0.75	2.05	4.67	89.64	0.44	0.03	4.88	10.0
	5.8	3.79	0.49	0.7	1.86	4.57	87.56	0.41	0.03	4.57	8.5
	5.85	3.75	0.45	0.65	1.67	4.46	85.49	0.37	0.03	4.23	7.08
	5.9	3.71	0.4	0.6	1.48	4.35	83.42	0.34	0.03	3.88	5.75
	5.95	3.68	0.35	0.55	1.3	4.24	81.34	0.31	0.03	3.49	4.53
	6.0	3.64	0.31	0.5	1.12	4.13	79.27	0.27	0.04	3.07	3.43
	6.05	3.61	0.26	0.45	0.94	4.03	77.2	0.23	0.04	2.62	2.45
	6.1	3.57	0.21	0.4	0.76	3.92	75.12	0.19	0.04	2.13	1.61
	6.15	3.54	0.16	0.35	0.58	3.81	73.05	0.15	0.05	1.6	0.92
Waterline	6.2	3.5	0.12	0.3	0.4	3.7	70.98	0.11	0.06	1.04	0.42
	6.25	2.8	0.09	0.25	0.24	2.99	57.36	0.08	0.07	0.69	0.17
	6.3	1.5	0.08	0.2	0.12	1.66	31.84	0.07	0.08	0.58	0.07
	6.35	1.05	0.05	0.15	0.05	1.16	22.25	0.05	0.1	0.32	0.02
	6.4	0.3	0.05	0.1	0.02	0.37	7.0	0.04	0.11	0.27	0.0
	6.45	0.15	0.03	0.05	0.0	0.18	3.5	0.02	0.2	0.1	0.0
	6.49	0.04	0.01	0.01	0.0	0.05	1.05	0.01	0.54	0.02	0.0

This Manning's roughness coefficient was calculated based on velocity estimates from the Ferguson VPE method

MODEL SUMMARY

Measured Flow (Qm) =	0.42	(cfs)
Calculated Flow (Qc) =	0.42	(cfs)
(Qm-Qc)/Qm * 100 =	-0.01%	
Measured Waterline (WLm) =	6.2	(ft)
Calculated Waterline (WLc) =	6.2	(ft)
(WLm-WLc)/WLm * 100 =	0.00%	
Max Measured Depth (Dm) =	0.3	(ft)
Max Calculated Depth (Dc) =	0.3	(ft)
(Dm-Dc)/Dm * 100 =	-0.00%	
Mean Velocity =	1.04	(ft/s)
Manning's n =	0.056	
0.4 * Qm =	0.17	(cfs)
2.5 * Qm =	1.05	(cfs)

FIELD DATA

Feature	Station (ft)	Rod Height (ft)	Water depth (ft)	Velocity (ft/s)
	0	4.54		
	0.7	4.9		
Bankfull	0.9	5.5		
Waterline	1.3	6.2	0	0
	1.6	6.25	0.05	0.48
	1.8	6.25	0.05	0.54
	2	6.3	0.1	0.94
	2.2	6.3	0.1	1.1
	2.4	6.3	0.1	1.22
	2.6	6.5	0.3	1.53
	2.8	6.4	0.2	1.84
	3	6.4	0.2	1.56
	3.2	6.35	0.15	1.41
	3.4	6.4	0.2	0.75
	3.6	6.3	0.1	0.7
	3.8	6.35	0.15	0.38
	4	6.25	0.05	0.26
	4.2	6.3	0.1	0.47
	4.4	6.3	0.1	0.22
	4.6	6.25	0.05	0.15
Waterline	4.8	6.2	0	0
Bankfull	4.9	5.5		
	5	5.22		
	6	4.58		

COMPUTED FROM MEASURED FIELD DATA

Wetted Perimeter (ft)	Water Depth (ft)	Area (ft^2)	Discharge (cfs)	Percent Discharge
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.3	0.05	0.01	0.01	1.43
0.2	0.05	0.01	0.01	1.29
0.21	0.1	0.02	0.02	4.48
0.2	0.1	0.02	0.02	5.24
0.2	0.1	0.02	0.02	5.81
0.28	0.3	0.06	0.09	21.86
0.22	0.2	0.04	0.07	17.52
0.2	0.2	0.04	0.06	14.86
0.21	0.15	0.03	0.04	10.07
0.21	0.2	0.04	0.03	7.14
0.22	0.1	0.02	0.01	3.33
0.21	0.15	0.03	0.01	2.71
0.22	0.05	0.01	0	0.62
0.21	0.1	0.02	0.01	2.24
0.2	0.1	0.02	0	1.05
0.21	0.05	0.01	0	0.36
0.21	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

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