DRAFT INSTREAM FLOW RECOMMENDATION March 13, 2014 Version

Ms. Linda Bassi
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, Colorado 80203

Dear Ms. Bassi:

The Bureau of Land Management (BLM) is writing this letter to formally communicate its recommendation for an increase to existing instream flow water rights on East Douglas Creek, located in Water Division 6.

Location and Land Status. East Douglas Creek originates approximately seven miles east of Douglas Pass and flows into Douglas Creek. This recommendation covers two stream reaches:

> The first reach begins at the confluence with Bear Park Creek and extends to the confluence with Brush Creek. This stream reach covers a distance of approximately 1.5 miles. The BLM manages approximately 0.8miles of this stream reach, while).7 miles are in private ownership.
>
> The second reach begins at the confluence with Brush Creek and extends to the confluence with Cathedral Creek. This stream reach covers a distance of approximately 10.7 miles. The BLM manages approximately 5.0 miles of this stream reach, while 5.7miles are in private ownership.

Existing Instream Flow Water Rights. In 1985, the Colorado Water Conservation Board appropriated instream flow water rights on East Douglas Creek as follows:

> Headwaters to confluence with Brush Creek – 1.0 cfs January 1 to December 31
> Brush Creek to confluence with Cathedral Creek – 1.5 cfs January 1 to December 31

Biological Summary. East Douglas Creek is a cold-water, moderate to high gradient stream. It flows through a canyon with a valley floor approximately one-fourth mile in width. The stream cuts through alluvial deposits in the narrow valley and is not confined by bedrock in most locations. The stream generally has small substrate, consisting of sands, gravels, and cobbles. While riffle habitat is abundant, parts of the stream lack extensive pool habitat because of historic overgrazing and lack of woody vegetation.

Fisheries surveys have revealed a self-sustaining population of native cutthroat trout and speckled dace. The BLM is considering implementation of a project to reclaim a portion of the creek to support genetically pure native cutthroat trout. Intensive macro-invertebrate surveys have not been conducted, but spot samples have revealed various species of mayfly, caddisfly, and stonefly.

The riparian community along the portion of the creek between Bear Park Creek and Brush is generally comprised of a mix of blue spruce and douglas fir, with some open areas comprised of grasses and sedges. The riparian community between the confluence with Brush Creek and the confluence with Cathedral Creek is generally comprised of grasses and sedges. The riparian area between Bear Park Creek and Brush Creek is in good condition, while the lower portion of the creek is recovering from historic grazing practices. In the reach between Bear Park Creek and Brush Creek, cover and shading for the stream is good. In the lower part of the reach, portions of the creek have good width-to-depth ratios, while other portions of the reach are open and wide, which limits usable fish habitat.

R2Cross Analysis. The BLM collected the following R2Cross data from the reach between Bear Park Creek and Brush Creek:

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)
07/29/2009 #1	1.60 cfs	14.40 feet	1.11 cfs	2.33 cfs
07/29/2009 #2	1.55 cfs	13.10 feet	1.11 cfs	3.88 cfs
		Averages:	1.11 cfs	3.10 cfs

The BLM collected the following R2Cross data from the reach between Brush Creek and Cathedral Creek:

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)
07/29/2009 #1	2.38 cfs	19.0 feet	1.58 cfs	2.40 cfs
07/29/2009 #2	0.76 cfs	4.0 feet	1.19 cfs	1.57 cfs
		Averages:	1.38 cfs	1.99 cfs

BLM's analysis of this data, coordinated with Colorado Parks and Wildlife, indicates that the following flows are needed to protect the fishery and natural environment to a reasonable degree.

<u>East Douglas Creek between confluence with Bear Park Creek and Brush Creek</u>

> 3.1 cubic feet per second is recommended for the snowmelt runoff period from May 1 through July 15. Protecting 3.1 cubic feet per second will require an increase of 2.1 cfs to the existing instream flow water right. This recommendation is driven by the average velocity and wetted perimeter criteria. This creek experiences consistently low flows during late summer and fall, so it is important to protect as much physical habitat as possible during the limited time when snowmelt runoff flows are available.

1.5 cubic feet per second is recommended for the late summer and early fall period from July 16 through October 15. Protecting 1.5 cfs during this period will require an increase of 0.5 cfs to the existing instream flow water right. This recommendation is driven by water availability, but this flow rate comes very close to meeting two out of the three instream flow criteria. This flow rate is capable of maintaining pool habitat in the creek and preventing excessively water high temperatures.

The BLM recommends that the existing instream flow water right of 1.0 cfs remain unchanged for the time period between October 16 and April 30. It appears that the existing water right accurately reflects the limited water availability during the winter months.

East Douglas Creek between confluence with Brush Creek and Bear Park Creek

2.0 cubic feet per second is recommended for the snowmelt runoff period from May 1 through October 15. Protecting 2.0 cubic feet per second will require an increase of 0.5 cfs to the existing instream flow water right. This recommendation is driven by the average velocity and average velocity criteria. This flow rate will protect additional physical habitat during snowmelt runoff and should maintain adequate pool habitat and stream temperatures during the late summer and early fall months.

The BLM recommends that the existing instream flow water right of 1.5 cfs remain unchanged for the time period between October 16 and April 30. The BLM's data collection revealed that this flow rate will achieve two of the three instream flow criteria used by the CWCB.

Rationale For Enlargement of Instream Flow Water Right. The BLM does not consider the current instream flow water right to be fully protective of the natural environment in East Douglas Creek, pursuant to modern analytical procedures used by the CWCB. The current instream flow water right does not meet all three instream flow criteria during the spring and summer, which is a critical growth and spawning period for the fish population. Since the stream supports native cutthroat trout, the BLM considers a fully protective instream flow water right to be essential.

Water Availability. The BLM is not aware of any historic gage data within the East Douglas Creek watershed. The BLM does not recommend relying upon other gages that are within western Rio Blanco County because those gages measure watersheds with very different characteristics. For example, UGSG Gage 09306380 (Douglas Creek at Rangely) is located at the bottom of the very large Douglas Creek watershed, of which East Douglas Creek is a part. However, this watershed contains many square miles of low elevation terrain with low runoff per unit of area. In contrast, East Douglas Creek is located at the top of Douglas Creek watershed, with high runoff per unit of area. Historic gages in the Piceance Creek watershed to the east, such as USGS Gage 09306175 (Black Sulphur Creek), measure large watersheds with characteristics

similar to the large Douglas Creek watershed. Accordingly, the BLM recommends relying upon the StreamStats package developed jointly between the U.S. Geological Survey and the CWCB for the best flow estimates.

The BLM is not aware of any decreed water rights within the proposed instream flow reach between the confluence with Bear Park and Brush Creek.

The BLM is aware of the following water rights in the reach between the confluence with Brush Creek and Cathedral Creek:

Tipp Ditch – 3.36 cfs conditional, 1980 priority
Mitchell Ditch – 2.59 cfs, 1919 priority

The Mitchell is located very close to the lower terminus of the proposed instream reach. The diversion records for the structure indicate consistent diversions by this ditch during May, June, and July.

Relationship to Land Management Plans. This stream reach is located within BLM's "East Douglas Creek Area of Critical Environmental Concern." The BLM designated this area to protect important biologically diverse plant communities, riparian habitat, and cutthroat trout habitat. The BLM intends to continue management of this watershed for natural conditions and processes. Appropriation of increase to the existing instream flow water rights would assist BLM in long-term management of riparian values and important fishery values.

Data sheets, R2Cross output, fishery survey information, and photographs of the cross section were included with BLM's draft recommendation in February 2014. 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,

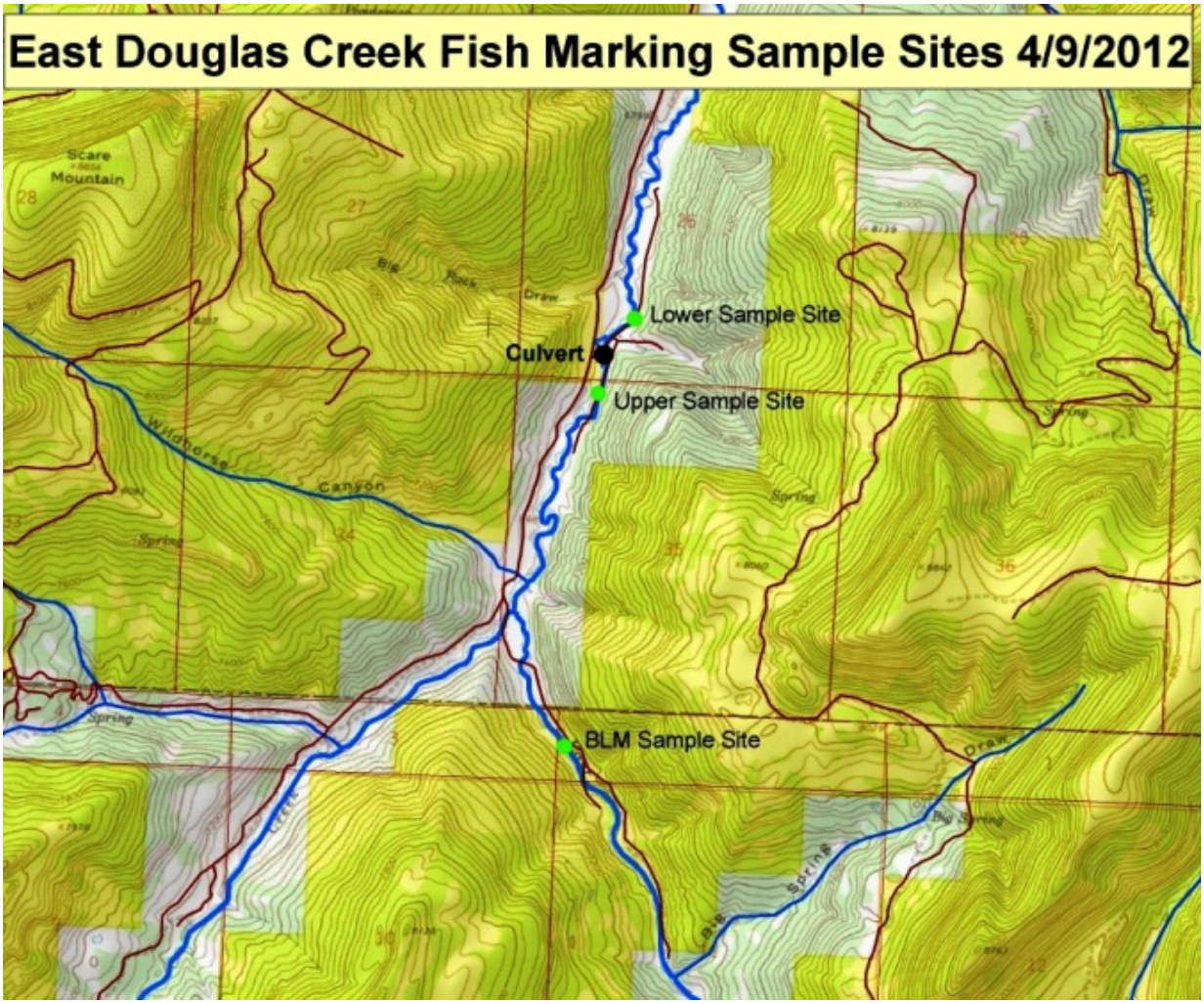
Leigh Espy
Deputy State Director
Resources and Fire

Cc: Kent Walter, White River FO
Bob Lange, White River FO
Ed Hollowed, White River FO

White River Field Office Stream Surveys
April 2012

East Douglas Creek - Water Code #25331

East Douglas Creek was sampled on April 9, 2012. The lower and upper sites identified below on the map are downstream from the confluence with Brush Creek, while the BLM site on the map below is above the confluence with Brush Creek. Fish sampling was conducted below and above the culvert identified as the terminus/barrier for possible future cutthroat trout reclamation efforts. Collected fish were marked with an upper caudal fin clip. A total of 60 fish were marked and placed downstream of the culvert to further assess and evaluate the structure as a barrier to upstream movement of fish. It was assumed that fish collected from above the culvert and placed below might have some site affinity and be more apt to try and move back upstream to preferred spawning habitat. Personnel present were Kyle Battige, Colorado Parks & Wildlife, Brian Hodge, Trout Unlimited, and Laura Dixon and Tom Fresques, BLM.



Cutthroat trout

Speckled dace

Young Cutthroat trout

STREAM SURVEY FISH SAMPLING FORM 2012

WATER: East Douglas Creek DATE: 4-9-2012 GEAR: BPE - 1

EFFORT STATION CREW: Battige, Hodge, Fresques, Dixon LOCATION:

#	Pass	species	length	weight		Pass	species	length	length
1	BC	CRN	205			BLM	CRN	137	123
2	BC	CRN	229			BLM	CRN	198	172
3	BC	CRN	212			BLM	CRN	154	224
4	BC	CRN	221			BLM	CRN	163	143
5	BC	CRN	227			BLM	CRN	176	173
6	BC	CRN	225			BLM	CRN	209	157
7	BC	CRN	186			BLM	CRN	203	196
8	BC	CRN	190			BLM	CRN	186	235
9	BC	CRN	221			BLM	CRN	110	242
10	BC	CRN	150			BLM	CRN	200	169
11	BC	CRN	118			BLM	CRN	125	192
12						BLM	CRN	163	129
13	AC	CRN	117			BLM	CRN	200	108
14	AC	CRN	125			BLM	CRN	107	116
15	AC	CRN	154			BLM	CRN	187	193
16	AC	CRN	137			BLM	CRN	139	188
17	AC	CRN	141			BLM	CRN	153	147
18	AC	CRN	84			BLM	CRN	105	113
19						BLM	CRN	211	
20						BLM	CRN	173	
21						BLM	CRN	205	
22						BLM	CRN	182	
23						BLM	CRN	182	
24						BLM	CRN	189	
25						BLM	CRN	153	

AC= Above Culvert
BC = Below Culvert
BLM = BLM Site

Notes: Stream Width _____ft. Sample Reach _____ft.
Conductivity: Electroshocker settings:

Discussion:
Eleven fish were collected and marked within 450 feet below the culvert. Six fish were collected within approximately 450 feet upstream of the culvert. The remaining 43 fish were collected from a 500 foot reach located further upstream on BLM lands above the Brush Creek confluence. Fish densities were low but increased as we moved upstream. The culvert is relatively close to what is currently considered the downstream distribution limit for trout in East Douglas Creek, although some beaver ponds located below the sample area could contain fish. In addition to cutthroat trout, speckled dace were noted within all sampled portions of the creek.

The FishXing model suggests that the culvert is a complete barrier to upstream movement of all size classes of fish at all anticipated flows. All of the fish collected and marked appeared to be cutthroat trout.

COLORADO WATER CONSERVATION BOARD
INSTREAM FLOW / NATURAL LAKE LEVEL PROGRAM
STREAM CROSS-SECTION AND FLOW ANALYSIS

LOCATION INFORMATION

STREAM NAME:	East Douglas Creek - above Brush Creek
XS LOCATION:	2/3 mile u/s fr conf. w/ Brush Creek
XS NUMBER:	1
DATE:	29-Jul-09
OBSERVERS:	R. Smith, P. Crowley
1/4 SEC:	SW
SECTION:	2
TWP:	5S
RANGE:	101W
PM:	Sixth
COUNTY:	Garfield
WATERSHED:	White River
DIVISION:	6
DOW CODE:	23127
USGS MAP:	0
USFS MAP:	0

SUPPLEMENTAL DATA

TAPE WT:	0.0106
TENSION:	99999

*** NOTE ***
Leave TAPE WT and TENSION at defaults for data collected with a survey level and rod

CHANNEL PROFILE DATA

SLOPE:	0.007

INPUT DATA CHECKED BY: .....DATE.....

ASSIGNED TO: ….....……..…….....DATE.....

STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: 2/3 mile u/s fr conf. w/ Brush Creek
XS NUMBER: 1

DATA POINTS= 21

VALUES COMPUTED FROM RAW FIELD DATA

	FEATURE	DIST	VERT DEPTH	WATER DEPTH	VEL	WETTED PERIM.	WATER DEPTH	AREA (Am)	Q (Qm)	% Q CELL
	RS	2.00	5.94			0.00		0.00	0.00	0.0%
1	G	3.80	7.50			0.00		0.00	0.00	0.0%
	W	9.90	8.07	0.00	0.00	0.00		0.00	0.00	0.0%
		10.30	8.30	0.25	0.50	0.46	0.25	0.10	0.05	3.1%
		10.70	8.35	0.30	0.93	0.40	0.30	0.09	0.08	5.2%
		10.90	8.40	0.35	1.24	0.21	0.35	0.07	0.09	5.4%
		11.10	8.40	0.35	1.29	0.20	0.35	0.11	0.14	8.5%
		11.50	8.40	0.35	1.41	0.40	0.35	0.14	0.20	12.4%
		11.90	8.40	0.35	1.53	0.40	0.35	0.14	0.21	13.4%
		12.30	8.40	0.35	1.27	0.40	0.35	0.14	0.18	11.1%
		12.70	8.35	0.30	1.30	0.40	0.30	0.12	0.16	9.8%
		13.10	8.35	0.30	1.41	0.40	0.30	0.12	0.17	10.6%
		13.50	8.35	0.30	1.26	0.40	0.30	0.12	0.15	9.5%
		13.90	8.25	0.20	1.22	0.41	0.20	0.08	0.10	6.1%
		14.30	8.20	0.15	0.84	0.40	0.15	0.06	0.05	3.2%
		14.70	8.15	0.10	0.65	0.40	0.10	0.04	0.03	1.6%
		15.10	8.15	0.10	0.00	0.40	0.10	0.04	0.00	0.0%
		15.50	8.15	0.10	0.00	0.40	0.10	0.03	0.00	0.0%
	W	15.70	8.04	0.00	0.00	0.23		0.00	0.00	0.0%
1	G	18.40	7.52			0.00		0.00	0.00	0.0%
	LS	24.00	7.21			0.00		0.00	0.00	0.0%
	TOTALS ----------					5.92	0.35 (Max.)	1.40	1.60	100.0%

Manning's n = 0.0415
Hydraulic Radius= 0.23561871

STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: 2/3 mile u/s fr conf. w/ Brush Creek
XS NUMBER: 1

WATER LINE COMPARISON TABLE

WATER LINE	MEAS AREA	COMP AREA	AREA ERROR
	1.40	1.37	-1.8%
7.81	1.40	3.34	139.3%
7.83	1.40	3.14	125.4%
7.85	1.40	2.96	111.9%
7.87	1.40	2.78	99.0%
7.89	1.40	2.60	86.4%
7.91	1.40	2.43	74.3%
7.93	1.40	2.27	62.7%
7.95	1.40	2.11	51.5%
7.97	1.40	1.96	40.8%
7.99	1.40	1.82	30.6%
8.01	1.40	1.68	20.8%
8.02	1.40	1.62	16.0%
8.03	1.40	1.55	11.4%
8.04	1.40	1.49	6.9%
8.05	1.40	1.43	2.5%
8.06	1.40	1.37	-1.8%
8.07	1.40	1.31	-6.0%
8.08	1.40	1.25	-10.1%
8.09	1.40	1.20	-14.2%
8.10	1.40	1.14	-18.3%
8.11	1.40	1.08	-22.3%
8.13	1.40	0.97	-30.3%
8.15	1.40	0.86	-38.2%
8.17	1.40	0.77	-45.1%
8.19	1.40	0.68	-51.4%
8.21	1.40	0.59	-57.5%
8.23	1.40	0.51	-63.3%
8.25	1.40	0.44	-68.8%
8.27	1.40	0.36	-74.0%
8.29	1.40	0.29	-79.1%
8.31	1.40	0.22	-84.0%

WATERLINE AT ZERO
AREA ERROR = 8.051

STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: 2/3 mile u/s fr conf. w/ Brush Creek
XS NUMBER: 1 Constant Manning's n

GL = lowest Grassline elevation corrected for sag
STAGING TABLE *WL* = Waterline corrected for variations in field measured water surface elevations and sag

	DIST TO WATER (FT)	TOP WIDTH (FT)	AVG. DEPTH (FT)	MAX. DEPTH (FT)	AREA (SQ FT)	WETTED PERIM. (FT)	PERCENT WET PERIM (%)	HYDR RADIUS (FT)	FLOW (CFS)	AVG. VELOCITY (FT/SEC)
GL	7.52	14.39	0.47	0.88	6.79	14.58	100.0%	0.47	12.24	1.80
	7.55	13.89	0.46	0.85	6.36	14.09	96.6%	0.45	11.21	1.76
	7.60	13.10	0.43	0.80	5.68	13.28	91.1%	0.43	9.67	1.70
	7.65	12.31	0.41	0.75	5.05	12.48	85.6%	0.40	8.27	1.64
	7.70	11.51	0.39	0.70	4.45	11.68	80.1%	0.38	7.01	1.58
	7.75	10.72	0.36	0.65	3.89	10.88	74.6%	0.36	5.89	1.51
	7.80	9.92	0.34	0.60	3.38	10.08	69.1%	0.34	4.89	1.45
	7.85	9.13	0.32	0.55	2.90	9.28	63.6%	0.31	4.01	1.38
	7.90	8.33	0.30	0.50	2.47	8.47	58.1%	0.29	3.25	1.32
	7.95	7.54	0.27	0.45	2.07	7.67	52.6%	0.27	2.59	1.25
	8.00	6.74	0.25	0.40	1.71	6.87	47.1%	0.25	2.03	1.19
WL	8.05	5.98	0.23	0.35	1.39	6.10	41.9%	0.23	1.56	1.12
	8.10	5.64	0.20	0.30	1.11	5.73	39.3%	0.19	1.11	1.00
	8.15	4.65	0.18	0.25	0.83	4.72	32.4%	0.18	0.78	0.94
	8.20	4.17	0.15	0.20	0.61	4.22	28.9%	0.14	0.50	0.83
	8.25	3.68	0.11	0.15	0.41	3.72	25.5%	0.11	0.29	0.69
	8.30	3.39	0.07	0.10	0.24	3.41	23.4%	0.07	0.12	0.51
	8.35	1.99	0.04	0.05	0.08	2.00	13.7%	0.04	0.03	0.36

STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: 2/3 mile u/s fr conf. w/ Brush Creek
XS NUMBER: 1

SUMMARY SHEET

MEASURED FLOW (Qm)=	1.60	cfs
CALCULATED FLOW (Qc)=	1.56	cfs
(Qm-Qc)/Qm * 100 =	2.0	%
MEASURED WATERLINE (WLm)=	8.06	ft
CALCULATED WATERLINE (WLc)=	8.05	ft
(WLm-WLc)/WLm * 100 =	0.1	%
MAX MEASURED DEPTH (Dm)=	0.35	ft
MAX CALCULATED DEPTH (Dc)=	0.35	ft
(Dm-Dc)/Dm * 100	0.3	%
MEAN VELOCITY=	1.12	ft/sec
MANNING'S N=	0.041	
SLOPE=	0.007	ft/ft
.4 * Qm =	0.6	cfs
2.5 * Qm=	4.0	cfs

RECOMMENDED INSTREAM FLOW:
============================

FLOW (CFS)	PERIOD
___________	___________
___________	___________
___________	___________
___________	___________

RATIONALE FOR RECOMMENDATION:
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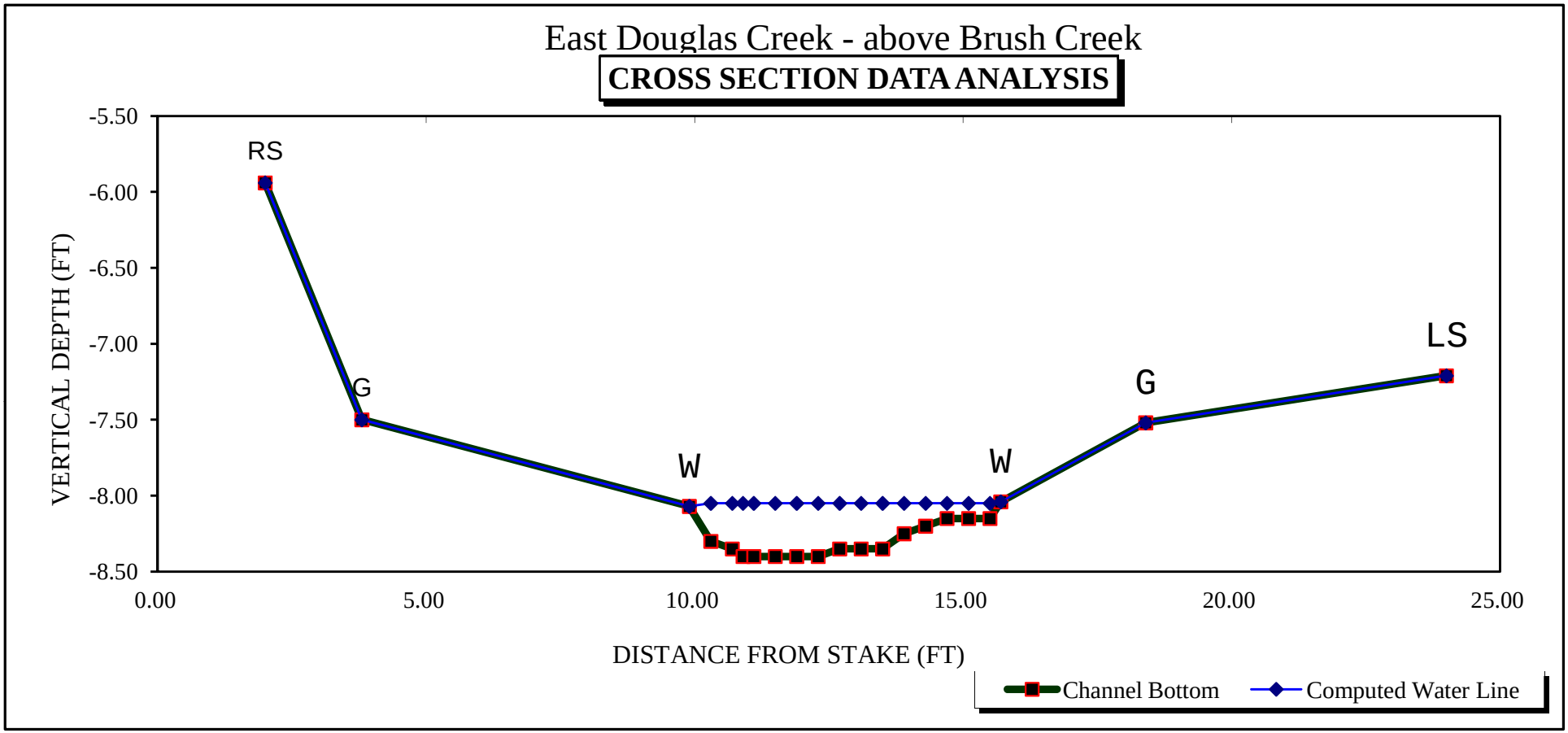
RECOMMENDATION BY: ………………...………..……............................... AGENCY...……………………......…....…....……...... DATE:......…..…......……………

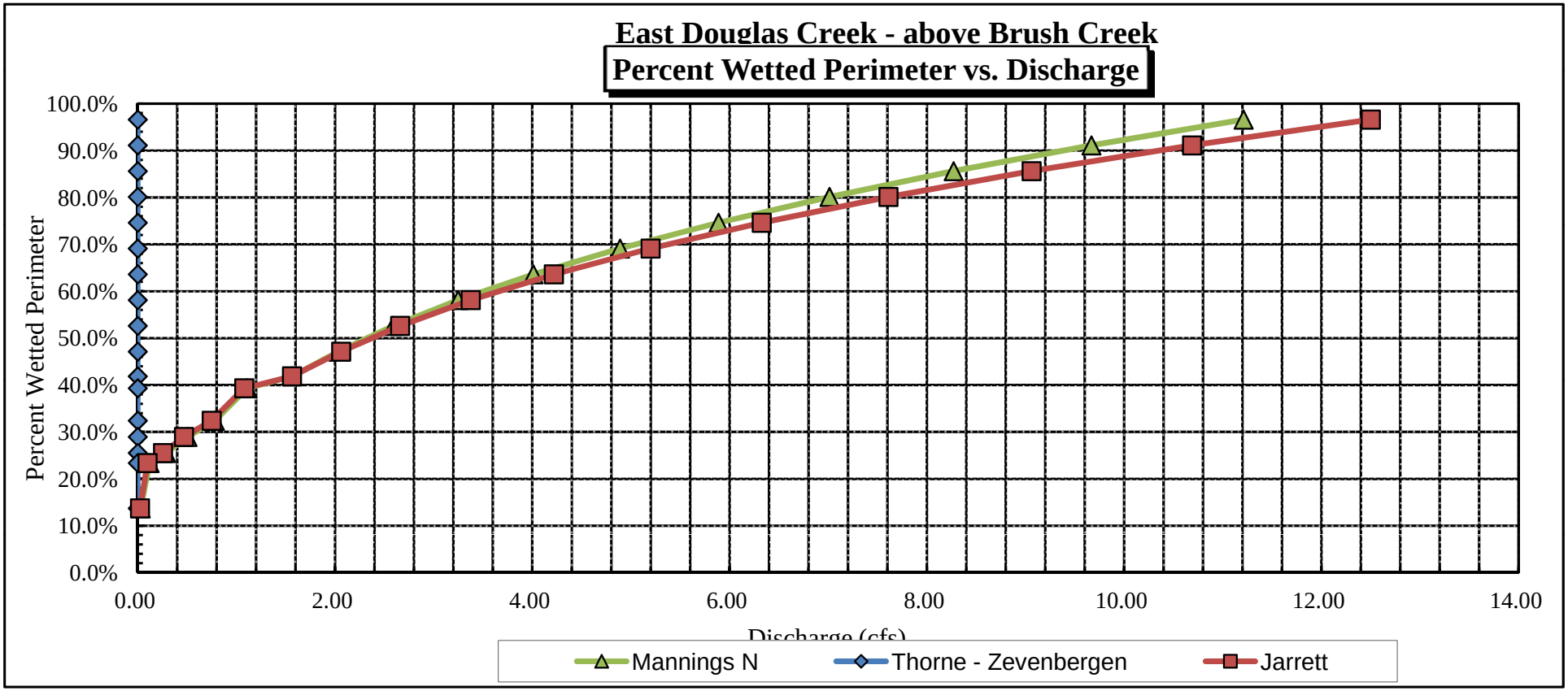
CWCB REVIEW BY: ..…………………………....………………………………………………...…............. DATE:.................…………….....

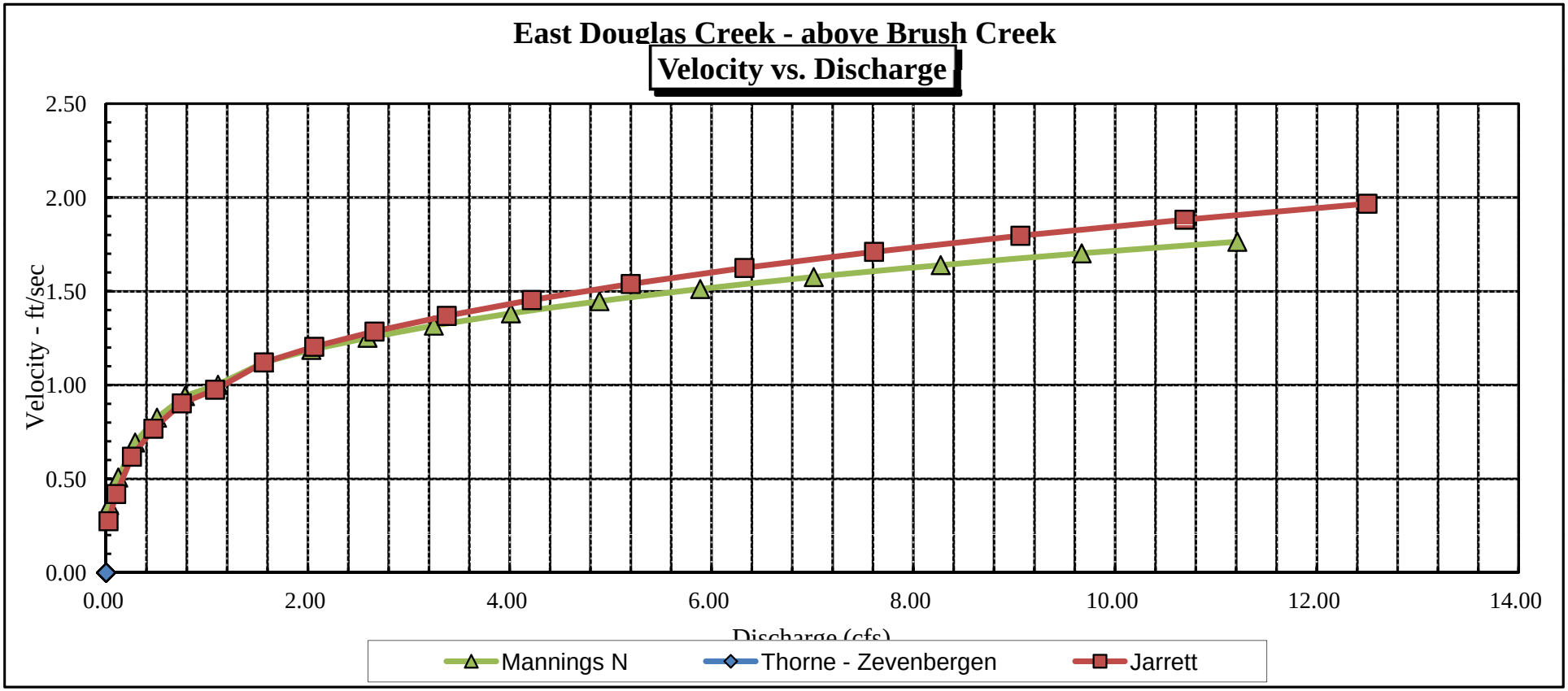
STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: 2/3 mile u/s fr conf. w/ Brush Creek
XS NUMBER: 1 Jarrett Variable Manning's n Correction Applied

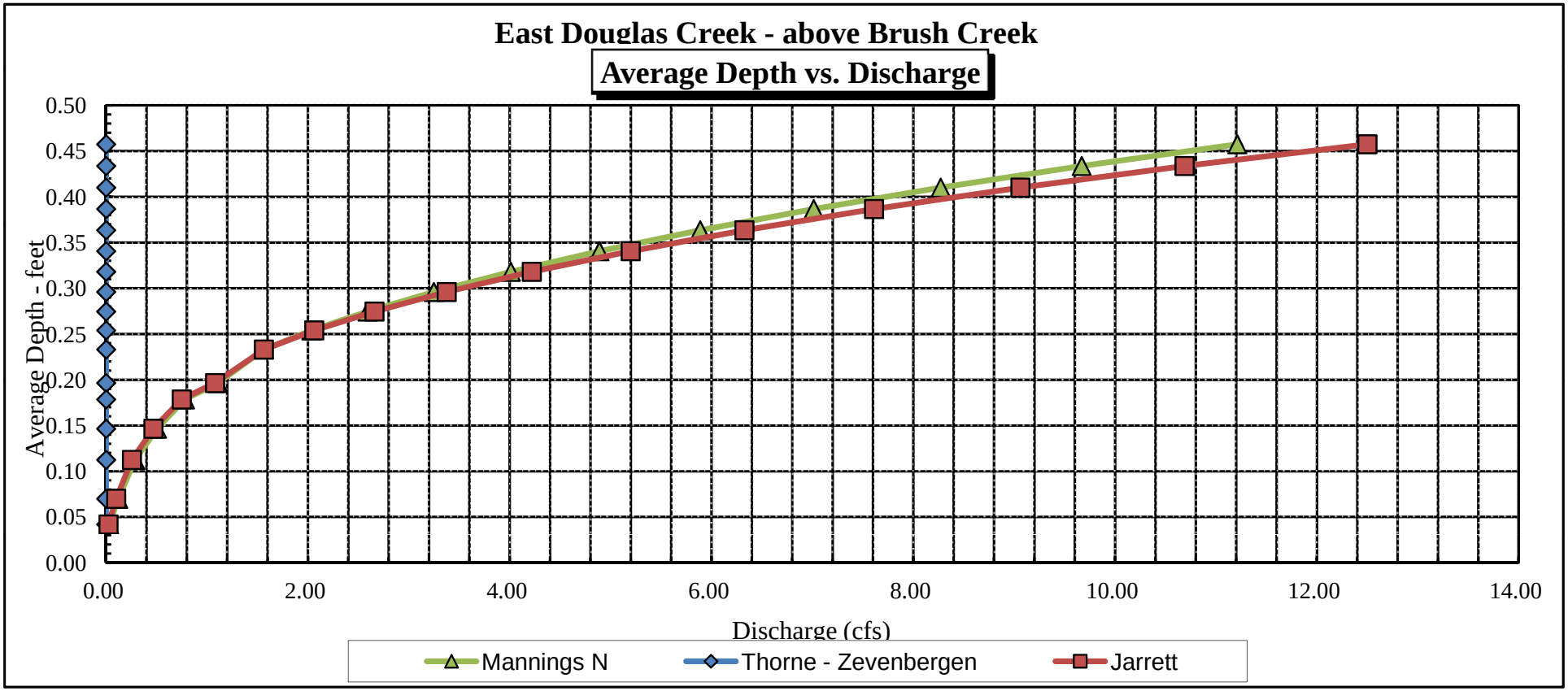
GL = lowest Grassline elevation corrected for sag
STAGING TABLE *WL* = Waterline corrected for variations in field measured water surface elevations and sag

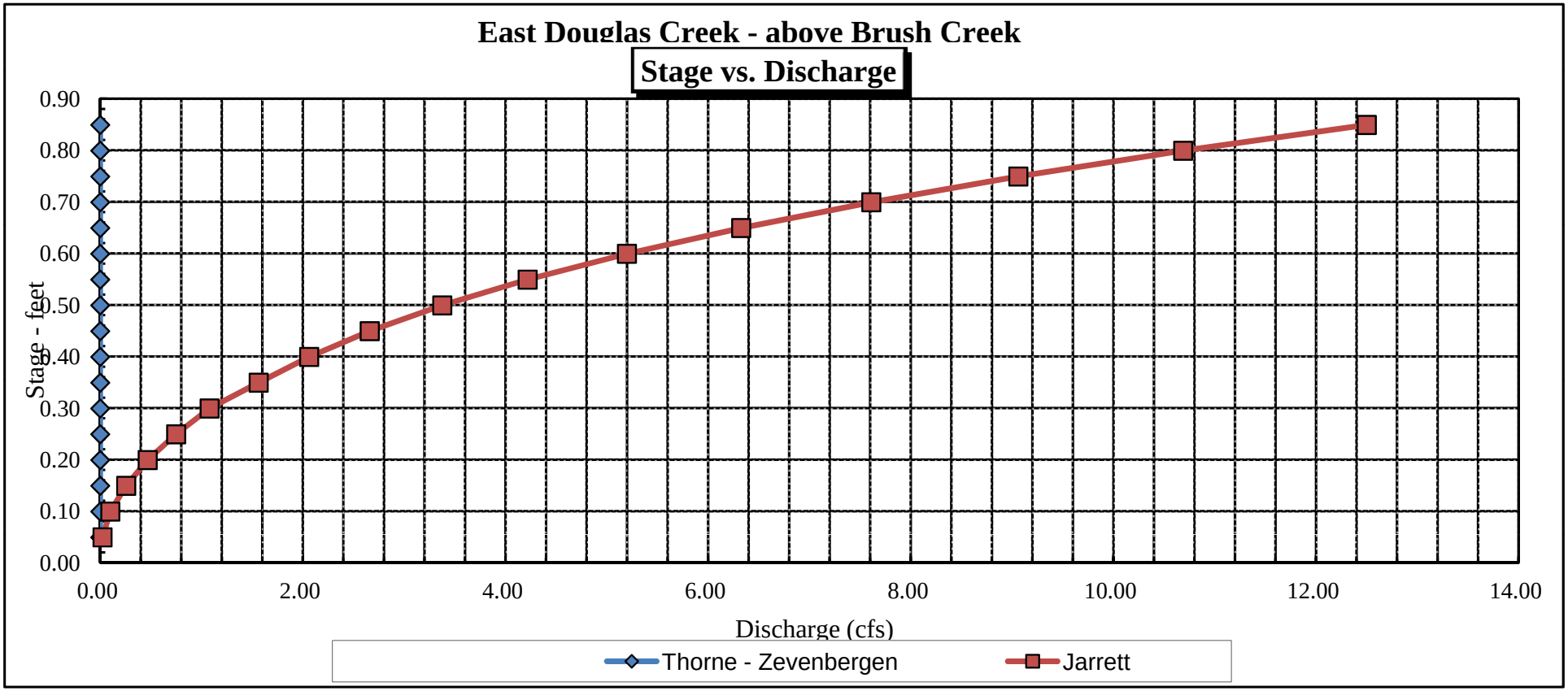
	DIST TO WATER (FT)	TOP WIDTH (FT)	AVG. DEPTH (FT)	MAX. DEPTH (FT)	AREA (SQ FT)	WETTED PERIM. (FT)	PERCENT WET PERIM (%)	HYDR RADIUS (FT)	FLOW (CFS)	AVG. VELOCITY (FT/SEC)
GL	7.52	14.39	0.47	0.88	6.79	14.58	100.0%	0.47	13.72	2.02
	7.55	13.89	0.46	0.85	6.36	14.09	96.6%	0.45	12.50	1.97
	7.60	13.10	0.43	0.80	5.68	13.28	91.1%	0.43	10.69	1.88
	7.65	12.31	0.41	0.75	5.05	12.48	85.6%	0.40	9.06	1.80
	7.70	11.51	0.39	0.70	4.45	11.68	80.1%	0.38	7.61	1.71
	7.75	10.72	0.36	0.65	3.89	10.88	74.6%	0.36	6.33	1.62
	7.80	9.92	0.34	0.60	3.38	10.08	69.1%	0.34	5.20	1.54
	7.85	9.13	0.32	0.55	2.90	9.28	63.6%	0.31	4.22	1.45
	7.90	8.33	0.30	0.50	2.47	8.47	58.1%	0.29	3.38	1.37
	7.95	7.54	0.27	0.45	2.07	7.67	52.6%	0.27	2.66	1.29
	8.00	6.74	0.25	0.40	1.71	6.87	47.1%	0.25	2.06	1.20
WL	8.05	5.98	0.23	0.35	1.39	6.10	41.9%	0.23	1.56	1.12
	8.10	5.64	0.20	0.30	1.11	5.73	39.3%	0.19	1.08	0.98
	8.15	4.65	0.18	0.25	0.83	4.72	32.4%	0.18	0.75	0.90
	8.20	4.17	0.15	0.20	0.61	4.22	28.9%	0.14	0.47	0.77
	8.25	3.68	0.11	0.15	0.41	3.72	25.5%	0.11	0.26	0.62
	8.30	3.39	0.07	0.10	0.24	3.41	23.4%	0.07	0.10	0.42
	8.35	1.99	0.04	0.05	0.08	2.00	13.7%	0.04	0.02	0.27


East Douglas Creek - above Brush Creek
CROSS SECTION DATA ANALYSIS
-5.50
-6.00
-6.50
-7.00
-7.50
-8.00
-8.50
VERTICAL DEPTH (FT)
RS
G
W
W
G
LS
0.00
5.00
10.00
15.00
20.00
25.00
DISTANCE FROM STAKE (FT)
Channel Bottom
Computed Water Line


East Douglas Creek - above Brush Creek
Percent Wetted Perimeter vs. Discharge
Percent Wetted Perimeter
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Discharge (cfs)
Mannings N
Thorne - Zevenbergen
Jarrett


East Douglas Creek - above Brush Creek
Velocity vs. Discharge
Velocity - ft/sec
2.50
2.00
1.50
1.00
0.50
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Discharge (cfs)
Mannings N
Thorne - Zevenbergen
Jarrett


East Douglas Creek - above Brush Creek
Average Depth vs. Discharge
Average Depth - feet
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Discharge (cfs)
Mannings N
Thorne - Zevenbergen
Jarrett


East Douglas Creek - above Brush Creek
Stage vs. Discharge
Stage - feet
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Discharge (cfs)
Thorne - Zevenbergen
Jarrett

COLORADO WATER CONSERVATION BOARD

FIELD DATA FOR INSTREAM FLOW DETERMINATIONS

COLORADO DIVISION OF WILDLIFE

LOCATION INFORMATION

STREAM NAME: East Douglas Creek - upper						CROSS-SECTION NO.: 1	
CROSS-SECTION LOCATION: Approx. 2/3 mile upstream from confluence w/ Krush Creek							
DATE: 7-29-09	OBSERVERS: R. Smith, P. Crowley						
LEGAL DESCRIPTION	¼ SECTION: SW	SECTION: 2	TOWNSHIP: 5 N(S)	RANGE: 101 E(W)	PM: 6th		
COUNTY: Garfield	WATERSHED: White River	WATER DIVISION: 6	DOW WATER CODE: 23127				
MAP(S): USGS:	7014 ft. GPS 125 0697162.						
USFS:	4391004						

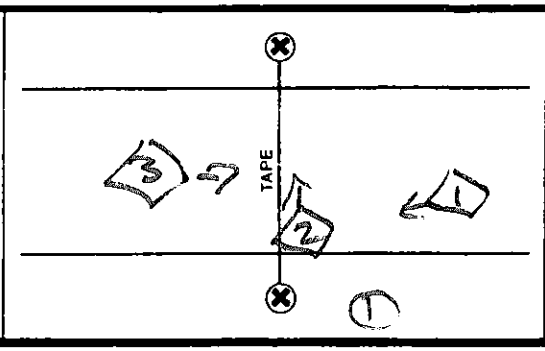
SUPPLEMENTAL DATA

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	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	8.07 / 8.04
(2) WS Upstream	21.5	7.98
(3) WS Downstream	12.5	8.21
SLOPE	0.23 / 34.0 = .007	

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:

stonefly abundant - caddisfly

COMMENTS

TDS = 520
ph = 8.4
Temp: 13°C

FORM #ISF ED 1 R5

DISCHARGE/CROSS SECTION NOTES

STREAM NAME: East Douglas Creek	CROSS-SECTION NO.: 1	DATE: 7-29-09	SHEET 1 OF 1
BEGINNING OF MEASUREMENT	EDGE OF WATER LOOKING DOWNSTREAM: (0.0 AT STAKE) LEFT / RIGHT	Gage Reading: ____ ft	TIME: 11:05 am

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	2.0		5.94								
G	3.8		7.50								
W	9.9		8.07								
	10.3		8.30	.25				0.50			
~~10.9~~ >	10.7	~~8.40~~ >	8.35	.30	< .35			0.93	< 1.24		
	11.1		8.40	.35				1.29			
	11.5		8.40	.35				1.41			
	11.9		8.40	.35				1.53			
	12.3		8.40	.35				1.27			
	12.7		8.35	.30				1.30			
	13.1		8.35	.30				1.41			
	13.5		8.35	.30				1.26			
	13.9		8.25	.20				1.22			
	14.3		8.20	.15				0.84			
	14.7		8.15	.10				0.63			
	15.1		8.15	.10				Ø			
	15.5		8.15	.10				Ø			
W	15.7		8.04								
G	18.4		7.52								
LS	24.0		7.21								
TOTALS:											

End of Measurement	Time:	Gage Reading: ____ ft	CALCULATIONS PERFORMED BY:	CALCULATIONS CHECKED BY:

COLORADO WATER CONSERVATION BOARD
INSTREAM FLOW / NATURAL LAKE LEVEL PROGRAM
STREAM CROSS-SECTION AND FLOW ANALYSIS

LOCATION INFORMATION

STREAM NAME:	East Douglas Creek - above Brush Creek
XS LOCATION:	Approx. 2/3 mile u/s fr. Conf. w/ Brush Creek
XS NUMBER:	2
DATE:	29-Jul-09
OBSERVERS:	R. Smith, P. Crowley
1/4 SEC:	SW
SECTION:	2
TWP:	5S
RANGE:	101W
PM:	Sixth
COUNTY:	Garfield
WATERSHED:	White River
DIVISION:	6
DOW CODE:	23127
USGS MAP:	0
USFS MAP:	0

SUPPLEMENTAL DATA

TAPE WT:	0.0106	*** NOTE *** Leave TAPE WT and TENSION at defaults for data collected with a survey level and rod
TENSION:	99999	

CHANNEL PROFILE DATA

SLOPE:	0.016

INPUT DATA CHECKED BY: .....DATE.....

ASSIGNED TO: ….....……..…….....DATE.....

STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: Approx. 2/3 mile u/s fr. Conf. w/ Brush Creek
XS NUMBER: 2

DATA POINTS= 28

VALUES COMPUTED FROM RAW FIELD DATA

	FEATURE	DIST	VERT DEPTH	WATER DEPTH	VEL	WETTED PERIM.	WATER DEPTH	AREA (Am)	Q (Qm)	% Q CELL
	LS	2.00	3.64			0.00		0.00	0.00	0.0%
1	G	6.10	5.98			0.00		0.00	0.00	0.0%
		6.80	6.32			0.00		0.00	0.00	0.0%
	W	7.50	6.67	0.00	0.00	0.00		0.00	0.00	0.0%
		8.00	6.75	0.10	0.00	0.51	0.10	0.05	0.00	0.0%
		8.50	6.85	0.20	1.19	0.51	0.20	0.10	0.12	7.7%
		9.00	7.05	0.40	1.10	0.54	0.40	0.20	0.22	14.2%
		9.50	7.15	0.50	1.19	0.51	0.50	0.19	0.22	14.4%
		9.75	7.15	0.50	1.38	0.25	0.50	0.13	0.17	11.1%
		10.00	7.10	0.45	1.43	0.25	0.45	0.11	0.16	10.4%
		10.25	7.15	0.50	1.12	0.25	0.50	0.13	0.14	9.0%
		10.50	7.05	0.40	1.09	0.27	0.40	0.15	0.16	10.6%
		11.00	6.95	0.30	0.03	0.51	0.30	0.15	0.00	0.3%
		11.50	6.95	0.30	0.54	0.50	0.30	0.15	0.08	5.2%
		12.00	6.90	0.25	0.44	0.50	0.25	0.13	0.06	3.6%
		12.50	6.80	0.15	0.18	0.51	0.15	0.08	0.01	0.9%
		13.00	6.85	0.20	0.00	0.50	0.20	0.10	0.00	0.0%
		13.50	6.90	0.25	0.25	0.50	0.25	0.13	0.03	2.0%
		14.00	6.85	0.20	0.96	0.50	0.20	0.10	0.10	6.2%
		14.50	6.75	0.10	0.56	0.51	0.10	0.05	0.03	1.8%
		15.00	6.80	0.15	0.34	0.50	0.15	0.08	0.03	1.6%
		15.50	6.80	0.15	0.20	0.50	0.15	0.08	0.02	1.0%
		16.00	6.70	0.05	0.00	0.51	0.05	0.03	0.00	0.0%
		16.50	6.70	0.05	0.00	0.50	0.05	0.02	0.00	0.0%
	W	16.80	6.66	0.00	0.00	0.30		0.00	0.00	0.0%
		17.80	6.44			0.00		0.00	0.00	0.0%
1	G	19.30	6.02			0.00		0.00	0.00	0.0%
	RS	23.40	5.25			0.00		0.00	0.00	0.0%
	TOTALS ----------					9.45	0.5 (Max.)	2.12	1.55	100.0%

Manning's n = 0.0950
Hydraulic Radius= 0.22437254

STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: Approx. 2/3 mile u/s fr. Conf. w/ Brush Creek
XS NUMBER: 2

WATER LINE COMPARISON TABLE

WATER LINE	MEAS AREA	COMP AREA	AREA ERROR
	2.12	1.99	-6.3%
6.42	2.12	4.51	112.9%
6.44	2.12	4.30	102.7%
6.46	2.12	4.08	92.5%
6.48	2.12	3.87	82.5%
6.50	2.12	3.66	72.7%
6.52	2.12	3.45	62.9%
6.54	2.12	3.25	53.3%
6.56	2.12	3.05	43.8%
6.58	2.12	2.85	34.4%
6.60	2.12	2.65	25.2%
6.62	2.12	2.46	16.0%
6.63	2.12	2.36	11.5%
6.64	2.12	2.27	7.0%
6.65	2.12	2.17	2.6%
6.66	2.12	2.08	-1.9%
6.67	2.12	1.99	-6.3%
6.68	2.12	1.89	-10.6%
6.69	2.12	1.80	-14.9%
6.70	2.12	1.71	-19.1%
6.71	2.12	1.63	-23.2%
6.72	2.12	1.55	-27.0%
6.74	2.12	1.39	-34.6%
6.76	2.12	1.23	-42.0%
6.78	2.12	1.08	-48.9%
6.80	2.12	0.95	-55.4%
6.82	2.12	0.83	-61.1%
6.84	2.12	0.72	-66.1%
6.86	2.12	0.62	-70.7%
6.88	2.12	0.53	-74.8%
6.90	2.12	0.46	-78.4%
6.92	2.12	0.39	-81.5%

WATERLINE AT ZERO
AREA ERROR = 6.651

STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: Approx. 2/3 mile u/s fr. Conf. w/ Brush Creek
XS NUMBER: 2 Constant Manning's n

GL = lowest Grassline elevation corrected for sag
STAGING TABLE *WL* = Waterline corrected for variations in field measured water surface elevations and sag

	DIST TO WATER (FT)	TOP WIDTH (FT)	AVG. DEPTH (FT)	MAX. DEPTH (FT)	AREA (SQ FT)	WETTED PERIM. (FT)	PERCENT WET PERIM (%)	HYDR RADIUS (FT)	FLOW (CFS)	AVG. VELOCITY (FT/SEC)
GL	6.02	13.12	0.71	1.13	9.26	13.50	100.0%	0.69	14.24	1.54
	6.05	12.94	0.68	1.10	8.85	13.31	98.6%	0.67	13.35	1.51
	6.10	12.66	0.65	1.05	8.21	13.02	96.4%	0.63	11.96	1.46
	6.15	12.38	0.61	1.00	7.59	12.72	94.2%	0.60	10.64	1.40
	6.20	12.10	0.58	0.95	6.98	12.42	92.0%	0.56	9.40	1.35
	6.25	11.82	0.54	0.90	6.38	12.12	89.7%	0.53	8.23	1.29
	6.30	11.54	0.50	0.85	5.79	11.82	87.5%	0.49	7.13	1.23
	6.35	11.26	0.46	0.80	5.22	11.52	85.3%	0.45	6.10	1.17
	6.40	10.98	0.43	0.75	4.67	11.22	83.1%	0.42	5.15	1.10
	6.45	10.69	0.39	0.70	4.13	10.91	80.8%	0.38	4.27	1.03
	6.50	10.36	0.35	0.65	3.60	10.57	78.3%	0.34	3.48	0.97
	6.55	10.03	0.31	0.60	3.09	10.22	75.7%	0.30	2.75	0.89
	6.60	9.71	0.27	0.55	2.60	9.88	73.2%	0.26	2.11	0.81
WL	6.65	9.38	0.23	0.50	2.12	9.53	70.6%	0.22	1.54	0.73
	6.70	8.30	0.20	0.45	1.66	8.45	62.6%	0.20	1.11	0.67
	6.75	7.73	0.16	0.40	1.26	7.87	58.3%	0.16	0.74	0.58
	6.80	5.98	0.15	0.35	0.91	6.10	45.2%	0.15	0.50	0.56
	6.85	4.73	0.14	0.30	0.64	4.83	35.8%	0.13	0.33	0.51
	6.90	3.37	0.13	0.25	0.44	3.45	25.5%	0.13	0.22	0.50
	6.95	2.24	0.13	0.20	0.29	2.31	17.1%	0.12	0.14	0.49
	7.00	1.87	0.10	0.15	0.18	1.92	14.2%	0.10	0.08	0.41
	7.05	1.49	0.07	0.10	0.10	1.53	11.4%	0.06	0.03	0.32
	7.10	1.11	0.03	0.05	0.03	1.14	8.4%	0.03	0.01	0.19

STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: Approx. 2/3 mile u/s fr. Conf. w/ Brush Creek
XS NUMBER: 2

SUMMARY SHEET

MEASURED FLOW (Qm)=	1.55	cfs
CALCULATED FLOW (Qc)=	1.54	cfs
(Qm-Qc)/Qm * 100 =	0.6	%
MEASURED WATERLINE (WLm)=	6.67	ft
CALCULATED WATERLINE (WLc)=	6.65	ft
(WLm-WLc)/WLm * 100 =	0.2	%
MAX MEASURED DEPTH (Dm)=	0.50	ft
MAX CALCULATED DEPTH (Dc)=	0.50	ft
(Dm-Dc)/Dm * 100	0.2	%
MEAN VELOCITY=	0.73	ft/sec
MANNING'S N=	0.095	
SLOPE=	0.016	ft/ft
.4 * Qm =	0.6	cfs
2.5 * Qm=	3.9	cfs

RECOMMENDED INSTREAM FLOW:
=============================

FLOW (CFS)	PERIOD
___________	________
___________	________
___________	________
___________	________

RATIONALE FOR RECOMMENDATION:
=============================

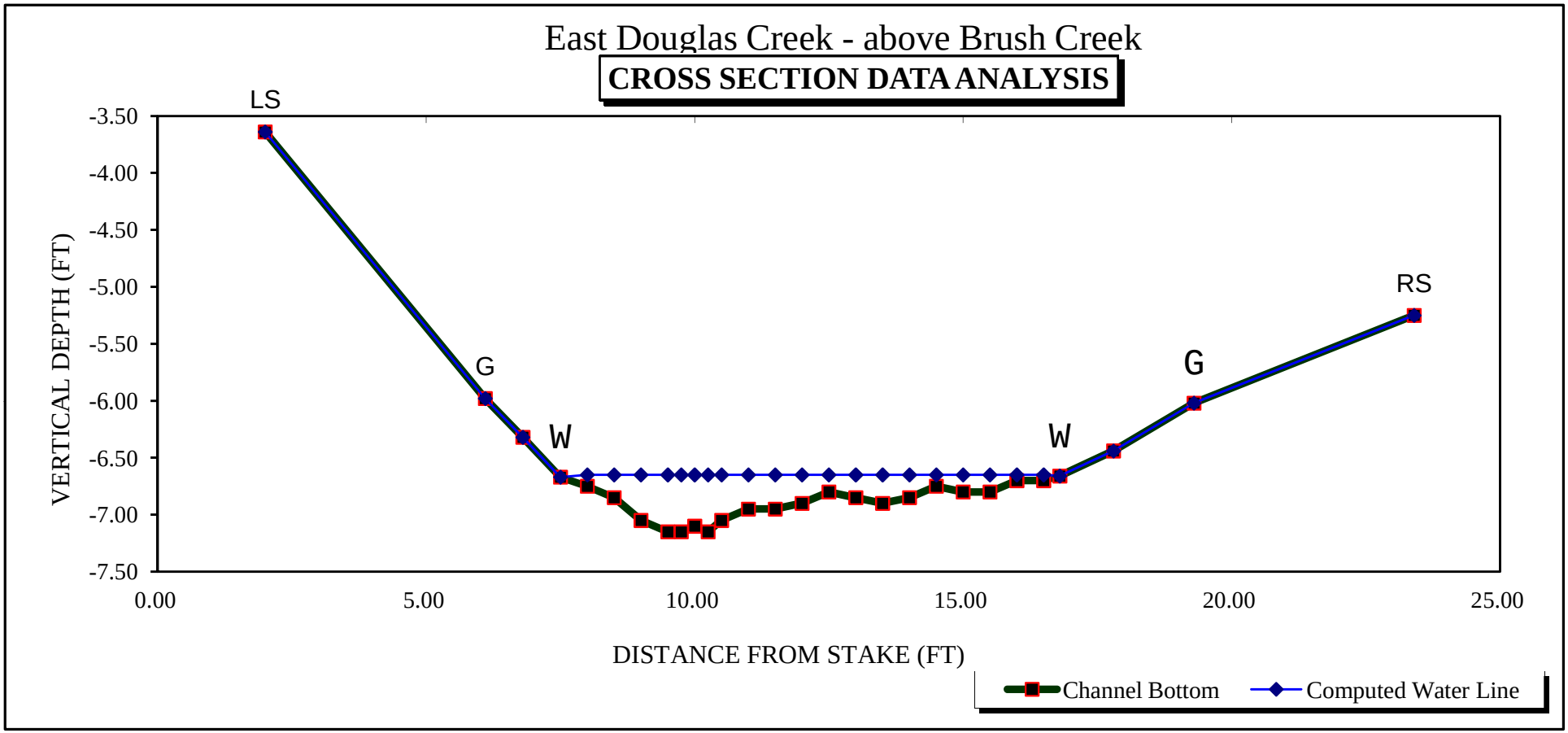
RECOMMENDATION BY: …………………….. AGENCY.. DATE:..................................

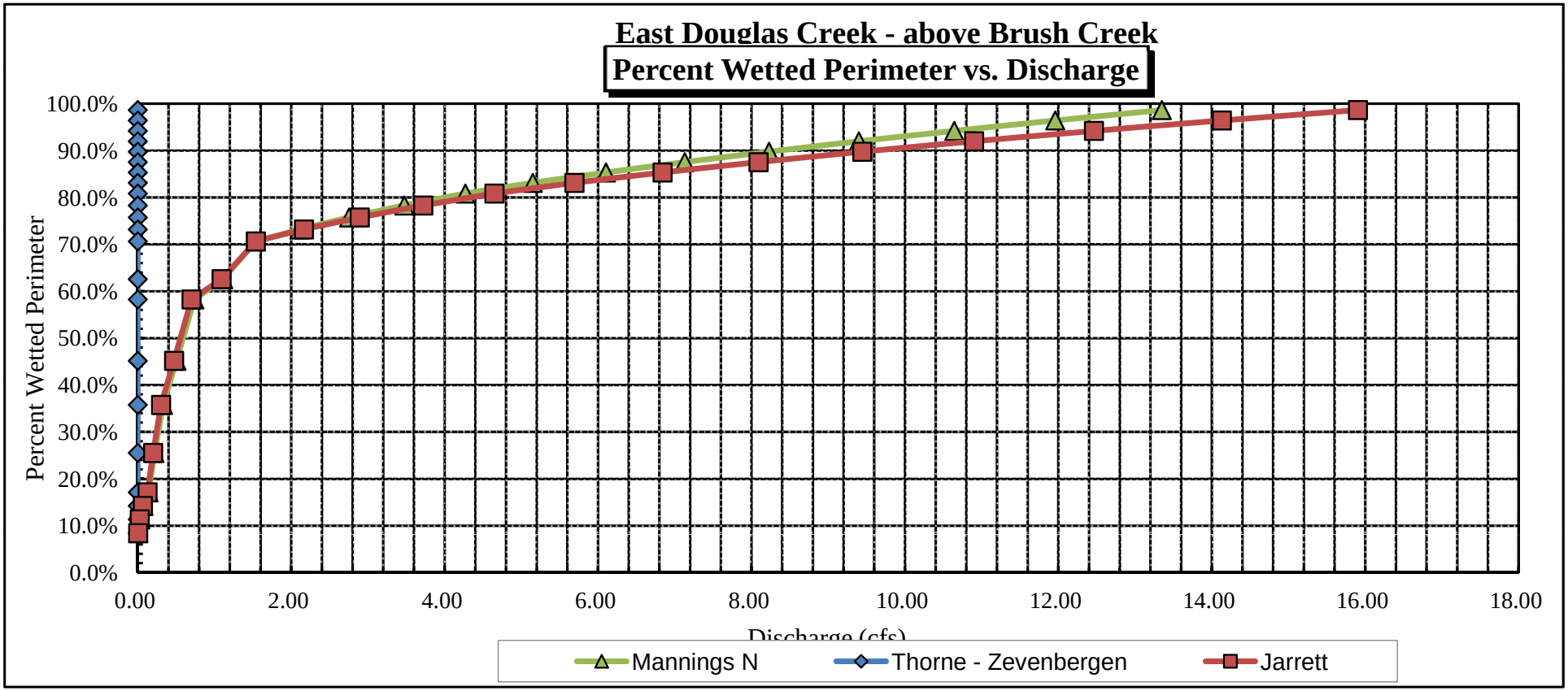
CWCB REVIEW BY: .... DATE:..................................

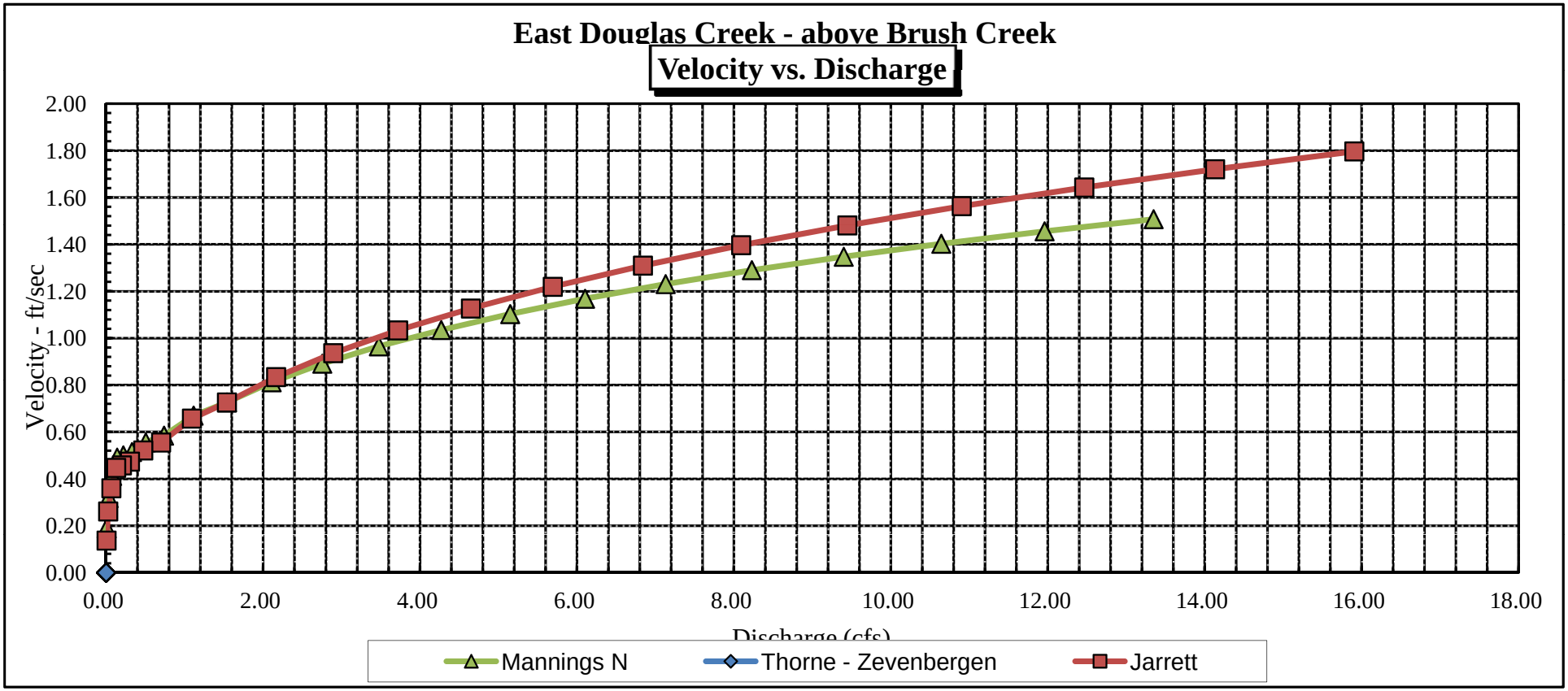
STREAM NAME: East Douglas Creek - above Brush Creek
XS LOCATION: Approx. 2/3 mile u/s fr. Conf. w/ Brush Creek
XS NUMBER: 2 Jarrett Variable Manning's n Correction Applied

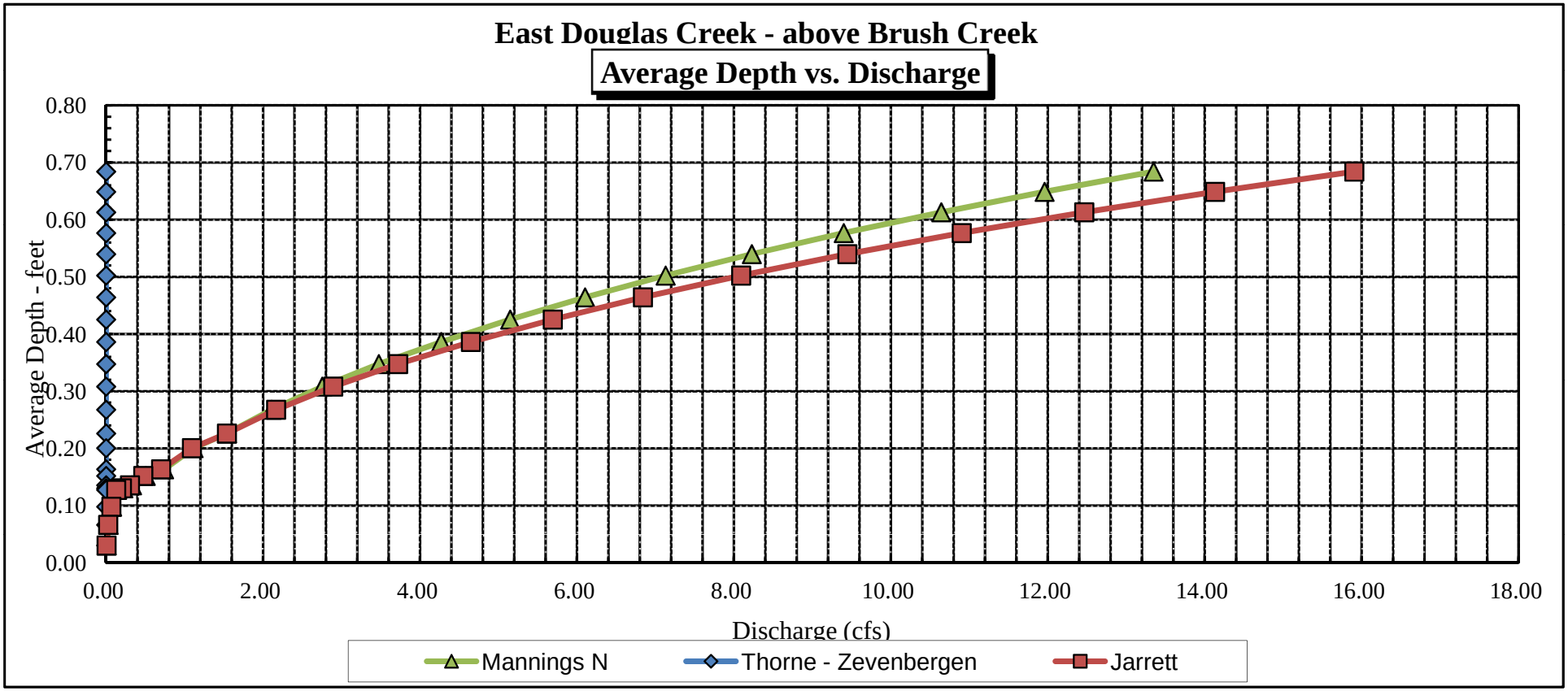
GL = lowest Grassline elevation corrected for sag
STAGING TABLE *WL* = Waterline corrected for variations in field measured water surface elevations and sag

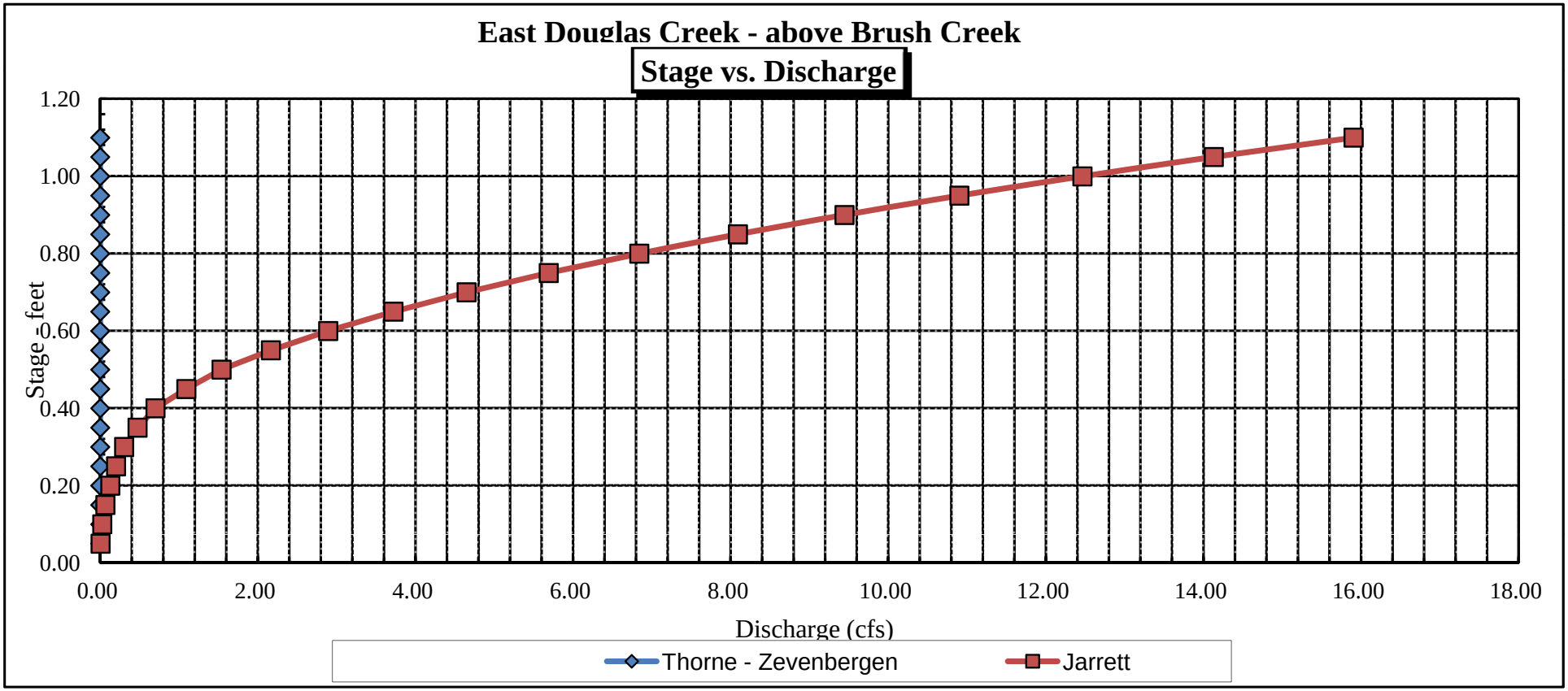
	DIST TO WATER (FT)	TOP WIDTH (FT)	AVG. DEPTH (FT)	MAX. DEPTH (FT)	AREA (SQ FT)	WETTED PERIM. (FT)	PERCENT WET PERIM (%)	HYDR RADIUS (FT)	FLOW (CFS)	AVG. VELOCITY (FT/SEC)
GL	6.02	13.12	0.71	1.13	9.26	13.50	100.0%	0.69	17.05	1.84
	6.05	12.94	0.68	1.10	8.85	13.31	98.6%	0.67	15.91	1.80
	6.10	12.66	0.65	1.05	8.21	13.02	96.4%	0.63	14.13	1.72
	6.15	12.38	0.61	1.00	7.59	12.72	94.2%	0.60	12.46	1.64
	6.20	12.10	0.58	0.95	6.98	12.42	92.0%	0.56	10.90	1.56
	6.25	11.82	0.54	0.90	6.38	12.12	89.7%	0.53	9.45	1.48
	6.30	11.54	0.50	0.85	5.79	11.82	87.5%	0.49	8.09	1.40
	6.35	11.26	0.46	0.80	5.22	11.52	85.3%	0.45	6.84	1.31
	6.40	10.98	0.43	0.75	4.67	11.22	83.1%	0.42	5.69	1.22
	6.45	10.69	0.39	0.70	4.13	10.91	80.8%	0.38	4.65	1.13
	6.50	10.36	0.35	0.65	3.60	10.57	78.3%	0.34	3.72	1.03
	6.55	10.03	0.31	0.60	3.09	10.22	75.7%	0.30	2.89	0.94
	6.60	9.71	0.27	0.55	2.60	9.88	73.2%	0.26	2.17	0.83
WL	6.65	9.38	0.23	0.50	2.12	9.53	70.6%	0.22	1.54	0.73
	6.70	8.30	0.20	0.45	1.66	8.45	62.6%	0.20	1.09	0.66
	6.75	7.73	0.16	0.40	1.26	7.87	58.3%	0.16	0.70	0.55
	6.80	5.98	0.15	0.35	0.91	6.10	45.2%	0.15	0.47	0.52
	6.85	4.73	0.14	0.30	0.64	4.83	35.8%	0.13	0.30	0.47
	6.90	3.37	0.13	0.25	0.44	3.45	25.5%	0.13	0.20	0.46
	6.95	2.24	0.13	0.20	0.29	2.31	17.1%	0.12	0.13	0.45
	7.00	1.87	0.10	0.15	0.18	1.92	14.2%	0.10	0.07	0.36
	7.05	1.49	0.07	0.10	0.10	1.53	11.4%	0.06	0.03	0.26
	7.10	1.11	0.03	0.05	0.03	1.14	8.4%	0.03	0.00	0.14


East Douglas Creek - above Brush Creek
CROSS SECTION DATA ANALYSIS
LS
G
W
W
G
RS
-3.50
-4.00
-4.50
-5.00
-5.50
-6.00
-6.50
-7.00
-7.50
VERTICAL DEPTH (FT)
0.00
5.00
10.00
15.00
20.00
25.00
DISTANCE FROM STAKE (FT)
Channel Bottom
Computed Water Line


East Douglas Creek - above Brush Creek
Percent Wetted Perimeter vs. Discharge
Percent Wetted Perimeter
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
Discharge (cfs)
Mannings N
Thorne - Zevenbergen
Jarrett


East Douglas Creek - above Brush Creek
Velocity vs. Discharge
Velocity - ft/sec
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
Discharge (cfs)
Mannings N
Thorne - Zevenbergen
Jarrett


East Douglas Creek - above Brush Creek
Average Depth vs. Discharge
Average Depth - feet
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
Discharge (cfs)
Mannings N
Thorne - Zevenbergen
Jarrett


East Douglas Creek - above Brush Creek
Stage vs. Discharge
Stage - feet
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
Discharge (cfs)
Thorne - Zevenbergen
Jarrett

COLORADO WATER CONSERVATION BOARD

FIELD DATA FOR INSTREAM FLOW DETERMINATIONS

COLORADO DIVISION OF WILDLIFE

LOCATION INFORMATION

STREAM NAME: East Douglas Creek - upper						CROSS-SECTION NO.: 2	
CROSS-SECTION LOCATION: Approx 2/3 mile upstream from confluence w/ Brush Creek							
DATE: 7-29-09	OBSERVERS: R. Smith, P. Crowley						
LEGAL DESCRIPTION	¼ SECTION: SW	SECTION: 2	TOWNSHIP: 5 N/S	RANGE: 101 E/W	PM: 6th		
COUNTY: Garfield	WATERSHED: White River	WATER DIVISION: 6	DOW WATER CODE: 23127				
MAP(S): USGS:	7014 ft. GPS 0697162						
USFS:	4391004						

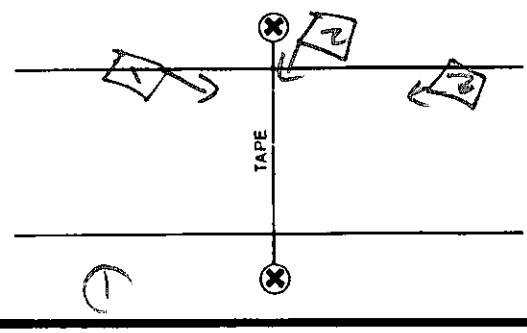
SUPPLEMENTAL DATA

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: silt to 1-foot boulders	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	6.67 / 6.66
② WS Upstream	11.3	6.62
③ WS Downstream	21.5	7.16
SLOPE	0.54 / 32.8 = .1016	

SKETCH



LEGEND:
Stake ⊗
Station ①
Photo ◇
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

stonefly + caddisfly - abundant

COMMENTS

TDS: 520
Ph: 8.4
Temp: 13°C

DISCHARGE/CROSS SECTION NOTES

STREAM NAME: East Douglas Creek | CROSS-SECTION NO.: 2 | DATE: 7-29-09 | SHEET ___ OF ___

BEGINNING OF MEASUREMENT | EDGE OF WATER LOOKING DOWNSTREAM: (0.0 AT STAKE) LEFT / RIGHT | Gage Reading: _____ ft | TIME: 11:40

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)
LS	2.0		3.64								
G	6.1		5.98								
	6.8		6.32								
W	7.5		6.67								
	8.0		6.75	.10				0			
	8.5		6.85	.20				1.17			
	9.0		7.05	.40				1.10			
9.75 >	9.5	7.15 >	7.15	.50	< .50			1.19	< 1.38		
< 10.25 >	10.0	7.15 >	7.10	.45	< .50			1.43	< 1.12		
	10.5		7.05	.40				1.09			
	11.0		6.95	.30				0.03			
	11.5		6.95	.30				0.54			
	12.0		6.90	.25				0.44			
	12.5		6.80	.15				0.18			
	13.0		6.85	.20				0			
	13.5		6.90	.25				0.25			
	14.0		6.85	.20				0.96			
	14.5		6.75	.10				0.56			
	15.0		6.80	.15				0.34			
	15.5		6.80	.15				0.20			
	16.0		6.70	.05				0			
	16.5		6.70	.05				0			
W	16.8		6.66								
	17.8		6.44								
G	19.3		6.02								
RS	23.4		5.25								
TOTALS:											

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