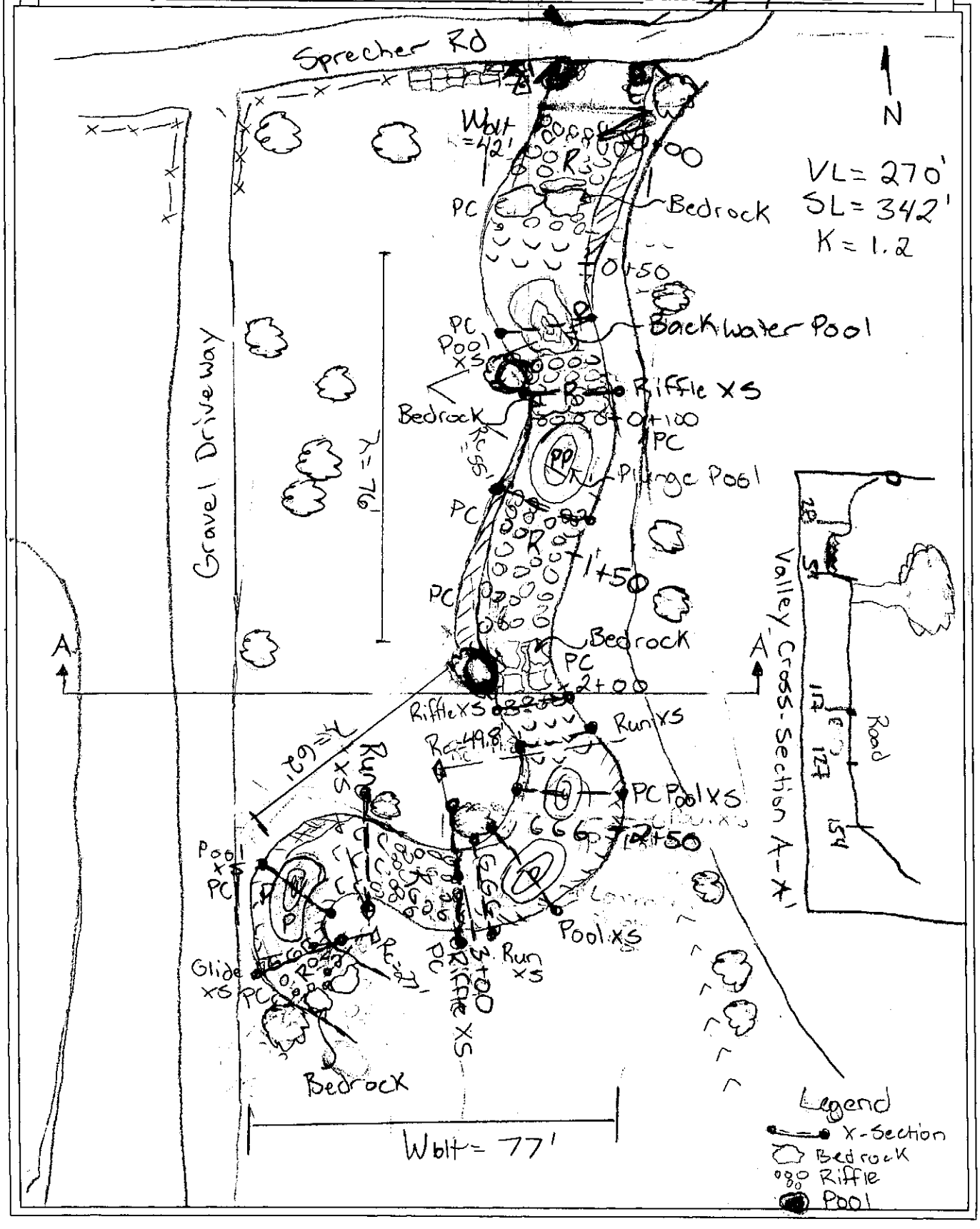
AREA-SITE LOCATION....REACH MAP

Stream/Drainage: MARSH RUN Site/Reach: TEAM 2

Drawn By: Team 2 Date: 4/21/2016



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Linear Wavelength

62 Ft

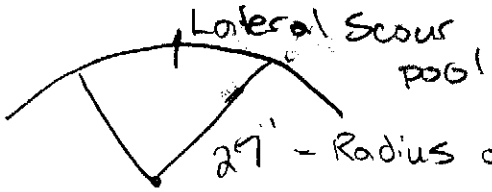
22.6ft

Meander Length

$L_m =$

Radius of Curvature

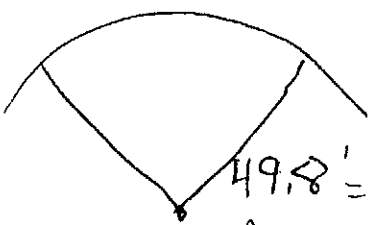
Bend #1 (D.S. to U.S.)



27' - Radius of Curv. $\lambda = 22.6'$

Arc length = 81' $W_{belt} = 32'$

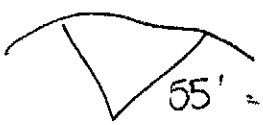
Bend #2



49.8' = radius of curv. $\lambda = 62'$

Arc length = 72' $W_{belt} = 77'$

Bend #3



55' = radius $\lambda = 32'$

87' = Arc length $W_{belt} = 48'$

Bend #4

55' RADIUS $\lambda = 76'$

61' Arc l. $W_{belt} = 42'$

SURVEY DATA ⟹ **CROSS - SECTION** 1

SITE: MARSH RUN Date: 4/21/16

Location: STATION 111+00 RIFFLE

Observers: HUC:

Item	Distance, Point, or STATION ft	Back-Sight BS ft	Height of Instrument HI ft	Fore-Sight FS ft	Elevation ft	NOTES / COMMENTS / REMARKS
1	BM	2.29	102.29		100.00	
2	1190.00			3.61	98.68	
3	10.8			4.35	97.94	
4	12.0			4.88	97.41	
5	12.8			5.41	96.88	
6	14.0			6.04	96.25	
7	15.0			6.75	95.54	
8	15.9			7.15	95.14	
9	16.5			7.38	94.91	
10	17.2			7.53	94.76	LEW
11	18.1			7.75	94.54	
12	23.1			8.09	94.20	
13	26.2			8.17	94.12	
14	30.3			8.25	94.04	
15	31.2			8.14	94.15	
16	32.6			7.62	94.67	
17	33.6			7.41	94.88	
18	33.2			7.54	94.75	REW
19	34.3			7.33	94.96	
20	34.8			6.97	95.32	
21	35.5			6.44	95.85	BKF
22	36.2			6.38	95.91	
23	37.5			6.23		
24	39.10			4.61		
25	42.8			3.67		
26	44.3			3.26		
27	49.8			3.42		
28	59.7			3.89		
	71.6			3.59		

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SURVEY DATA ⟹ **CROSS - SECTION 2**

SITE: STA. 201+00 RIFFLE Date: 4/24/16

Item	STATION ft	BS ft	HI ft	FS ft	Elevation ft	NOTES COMMENTS REMARKS
1	0.0	2.29	102.29	4.20		
2	6.7			5.42		
3	12.8			5.44		
4	17.0			5.03		
5	22.5			5.39		
6	23.6			5.57		
7	24.7			5.93		
8	25.5			6.21		
9	26.0			6.65		
10	26.7			7.12		
11	27.6			7.43		
12	28.4			7.61		
13	27.1			7.17		BKF, BEST FEATURE OBSERVED
14	30.4			8.04		LEW
15	31.0			8.34		
16	34.0			8.56		
17	35.6			8.34		
18	37.6			8.65		
19	39.3			8.85		
20	41.2			8.93		
21	43.0			8.51		
22	44.6			8.59		
23	45.6			8.12		REW
24	49.0			5.01		
25	53.0			4.16		
26	55.6			3.87		
27	59.0			3.96		
28	66.0			4.61		
29	71.0			4.95		
30	74.3			4.8		
31						

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SURVEY DATA → **CROSS - SECTION 3**

SITE: 227+00 POOL Date: 4/21/16

Item	STATION ft	BS ft	HI ft	FS ft	Elevation ft	NOTES COMMENTS REMARKS
1	0	2.29	102.29	4.47	100.0	
2	13.4			5.38		
3	23.9			5.08		
4	24.5			5.13		
5	25.4			5.69		
6	25.8			6.10		
7	26.4			6.49		
8	27.1			6.95		
9	27.7			7.25		BKF
10	28.0			7.42		
11	28.7			7.89		
12	29.7			8.13		LEW
13	30.7			8.57		
14	32.1			9.20		
15	34.6			9.68		
16	37.9			9.58		
17	39.8			9.30		
18	43.2			9.04		
19	46.0			8.91		
20	48.0			8.47		
21	49.5			8.24		REW
22	50.4			7.96		
23	51.6			7.15		
24	52.8			5.33		
25	53.5			5.01		
26	66.1			4.94		
27	75.0			4.33		
28	80.0			4.67		
29						
30						
31						

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SURVEY DATA ⟹ **CROSS - SECTION** 4

SITE: STA. 284+00 GLIDE Date: 4/21/16

Item	STATION ft	BS ft	HI ft	FS ft	Elevation ft	NOTES COMMENTS REMARKS
1	0	2.29	102.29	5.54	100.00	
2	8.9			5.51		
3	9.7			5.81		
4	11.0			6.31		
5	12.0			7.19		BKF
6	13.0			7.42		
7	14.0			7.66		
8	15.1			8.09		
9	15.7			8.18		LEW
10	16.5			8.59		
11	19.0			8.95		
12	21.5			9.09		
13	22.9			8.75		
14	24.0			8.98		
15	25.7			8.91		
16	28.0			8.46		
17	29.1			8.43		
18	30.7			8.21		REW
19	31.7			8.04		
20	32.9			7.28		
21	34.5			6.44		
22	35.7			5.84		
23	38.5			5.53		
24	42.7			4.84		
25	45.4			4.80		
26						
27						
28						
29						
30						
31						

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SURVEY DATA ⟹ **CROSS - SECTION 5**

SITE: 297+00 RIFFLE Date: 4/21/16

Item	STATION ft	BS ft	HI ft	FS ft	Elevation ft	NOTES COMMENTS REMARKS
1	0	2.29	102.29	4.53	100.0	
2	4.6			4.70		
3	5.5			5.65		
4	7.3			7.37		LOG PRESENT ALONG BANK
5	8.1			7.31		
6	8.4			7.99		
7	9.4			8.28		LEW
8	10.7			8.55		
9	11.6			9.22		
10	12.7			9.16		
11	13.7			8.86		
12	16.0			8.85		
13	17.4			9.35		
14	19.0			9.36		
15	20.6			9.10		
16	21.5			8.87		
17	22.9			8.61		
18	24.4			8.35		REW
19	26.3			7.54		BKF
20	27.4			7.02		
21	29.7			6.61		
22	30.9			6.13		
23	34.4			5.60		
24	41.1			5.25		
25						
26						
27						
28						
29						
30						
31						

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SURVEY DATA ⟹ **CROSS - SECTION** 6

SITE: STA. 309 +00 RUN Date: 4/21/16

Item	STATION ft	B S ft	H I ft	F S ft	Elevation ft	NOTES COMMENTS REMARKS
1	0	2.29	102.29	5.88	100.0	
2	5.0			5.66		
3	5.7			6.20		
4	6.0			6.38		
5	6.5			7.33		
6	7.6			8.15		
7	8.4			8.30		LEW
8	9.5			8.39		
9	10.0			8.84		
10	11.0			9.06		
11	11.2			8.73		
12	12.8			8.79		
13	13.1			9.38		
14	14.0			9.25		
15	15.3			9.58		
16	16.9			9.73		
17	17.4			9.63		
18	18.6			9.22		
19	20.1			8.79		
20	20.9			8.49		
21	21.4			8.36		REW
22	22.0			8.17		
23	22.7			7.48		
24	23.5			7.21		BKF
25	24.9			6.92		
26	26.3			6.83		
27	28.0			6.92		
28	31.5			5.61		
29	34.2			5.27		
30	36.3			5.16		
31	43.0			5.12		

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SURVEY DATA ⟹ **CROSS - SECTION** 7

SITE: STA. 322+00 POOL **Date:** 4/21/16

Item	STATION ft	B S ft	H I ft	F S ft	Elevation ft	NOTES COMMENTS REMARKS
1	0		102.29	5.90		
2	3.8			6.08		
3	6.0			6.84		
4	7.3			7.08		BKF, POSSIBLE?
5	8.7			7.46		
6	9.4			8.12		
7	10.6			8.44		LEW
8	11.5			8.64		
9	12.7			9.19		
10	13.6			9.97		
11	15.5			10.55		
12	17.2			10.35		
13	19.8			10.45		
14	21.2			10.41		
15	21.8			10.16		
16	22.7			9.91		
17	23.3			8.86		
18	24.4			8.48		
19	25.5			8.30		REW
20	26.6			7.79		
21	27.6			6.78		
22	28.5			5.93		
23	29.8			5.38		
24	30.7			5.26		
25	45.0			5.03		
26						
27						
28						
29						
30						
31						

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SURVEY DATA ⟹ **CROSS - SECTION** 8

SITE: STA. 330+00 GLIDE **Date:** 4/21/16

Item	STATION ft	B S ft	H I ft	F S ft	Elevation ft	NOTES COMMENTS REMARKS
1	0.0		102.29	5.68		
2	2.0			5.35		
3	3.1			7.02		
4	3.8			8.46		LEW
5	5.3			8.74		
6	11.6			9.04		
7	13.9			9.00		
8	17.0			8.93		
9	19.8			8.75		
10	22.3			8.30		REW
11	23.2			8.00		
12	24.0			6.94		
13	25.3			5.87		
14	27.0			5.43		
15	33.0			5.42		
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						

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SURVEY DATA ⟹ **CROSS - SECTION** 89

SITE: STA. 336+00 RIFFLE **Date:**

Item	STATION ft	B S ft	H I ft	F S ft	Elevation ft	NOTES COMMENTS REMARKS
1	0		102.29	5.90		
2	4.0			6.28		
3	6.0			6.86		
4	7.0			8.33		LEW
5	7.2			8.86		
6	10.4			8.83		
7	13.5			8.89		
8	14.2			9.33		
9	16.4			9.24		
10	17.7			8.87		
11	19.5			8.87		
12	20.1			8.55		REW
13	21.2			7.5		
14	23.6			7.26		BKF, ?
15	25.2			6.63		
16	28.0			5.44		
17	32.0			5.13		
18	36.0			5.24		
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						

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SURVEY DATA ⟹ **CROSS - SECTION** 8 10

SITE: ℄ Run XS @ ZZZ **Date:**

Item	STATION ft	BS ft	HI ft	FS ft	Elevation ft	NOTES COMMENTS REMARKS
1	0	3.26	103.26			
2	0			6.56		
3	5			6.27		
4	7			6.16		TOB L
5	7.7			6.42		
6	10			7.86		[illegible]
7	11.3			8.78		T IB L
8	12.2			9.07		
9	12.7			9.19		L EOW
10	14.0			9.48		
11	15.6			10.37		
12	18.0			10.69		Thalwg? Bkf
13	19.6			10.50		
14	21.0			10.06		Bedrock influence bottom xsec
15	23.3			10.00		
16	25.5			10.08		
17	28			9.95		
18	29.3			9.87		
19	30.9			9.55		
20	32.0			9.51		
21	32.9			9.19		R EOW
22	33.7			8.78		T IB R
23	34.5			8.27		
24	36.0			6.38		
25	36.9			6.06		TOB R
26	39.0			6.01		
27	41.0			6.04		
28	45.0			6.05		
29						
30						
31						

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SURVEY DATA → LONGITUDINAL PROFILE 1

SITE: Date:

Location:

Observers: HUC:

3.26 ↗ Bench mark

	Distance, Point, or STATION (ft)	Back-Sight BS (ft)	Height of Instrument HI (ft)	Thalweg Fore-Sight FS (ft)	Thalweg Elevation Elev. (ft)	Water Surface Fore-Sight FS (ft)	Water Surface Elevation Elev. (ft)	Bankfull Fore-Sight FS (ft)	Bankfull Elevation Elev. (ft)	Low Bank HI Fore-Sight FS (ft)	Low Bank HI Elevation Elev. (ft)	NOTES e.g. Riffle Run Pool Glide	high bank L	high bank R
1	0	3.26	103.26									TR		
2	0			7.91		7.17								
3														
4	10			8.53		7.57						MR		
5														
6	36			8.60		7.95		6.75						4.21
7														
8	46			8.79		8.20						BR		
9														
10	54			8.75		8.18						TU		
11														
12	57			9.16	D=	0.95						MU		
13														
14	65			9.34	D=	1.15		6.91		392	R	TBWP		
15														
16	70			9.45	D=	1.26								
17	77 XS-BKP			9.46		8.21 D	1.25 D	7.12						
18	89			9.30	D=	1.06								
19														
20	90			9.09		8.24						checkP		
21				↑	BedRock		STEP/check	Grade	control			↗		
22	93			9.04		8.54						TPP		
23				passant	Plung	pool		PP=	Plunge	pool				
24	98			9.30		8.57								
25												[illegible]		
26	101			9.17		8.56						TG		
27	106			9.20		8.51						MG		

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SURVEY DATA → LONGITUDINAL PROFILE 2

SITE: Date:

Location:

Observers: HUC:

	Distance, Point, or STATION (ft)	Back-Sight BS (ft)	Height of Instrument HI (ft)	Thalweg Fore-Sight FS (ft)	Thalweg Elevation Elev. (ft)	Water Surface Fore-Sight FS (ft)	Water Surface Elevation Elev. (ft)	Bankfull Fore-Sight FS (ft)	Bankfull Elevation Elev. (ft)	high ~~Low~~ Bank HI Fore-Sight FS (ft)	high ~~Low~~ Bank HI Elevation Elev. (ft)	NOTES e.g. Riffle Run Pool Glide
28	111	3.26	103.26	9.25		8.45		7.44		4.28	R	TOR
29				← Representative			X-section		Riffle ↑			
30								7.32 →	AISJ measured			for bankful
31												
32	119		103.26	9.24		8.55		7.34		5.45	L	BKF
33												
34	159			9.15		8.64						MOR
35												
36	178			9.27		8.91						
37												
38	190			9.58		8.95						
39												
40	200			9.53		9.05						RU
41												
42	207			10.22		9.17						RI
43												
44	219			10.07		9.18						TOU
45												
46	222		thalweg?	10.06 or 10.57		9.22						MOU
47												
48	227			10.68		9.36		8.18		6.13	L	TOP-LS
49												
50	239			11.35		9.32						PDMAX 1?
51												
52	252			10.53		9.36						P hump
53												
54	266			11.07		9.21						PDMAX 2?

XS-R ✓ ? ✓ ✓ Ri XS → U XS → PXS → PXS

team 3 laser 8.06
team 2 laser 8.97

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SURVEY DATA ⟶ **LONGITUDINAL PROFILE 3**

SITE: Date:

Location:

Observers: HUC:

	Distance, Point, or STATION ft	Back-Sight BS ft	Height of Instrument HI ft	Thalweg Fore-Sight FS ft	Thalweg Elevation Elev. ft	Water Surface Fore-Sight FS ft	Water Surface Elevation Elev. ft	Bankfull Fore-Sight FS ft	Bankfull Elevation Elev. ft	Left Bank HI Fore-Sight FS ft	Left Bank HI Elevation Elev. ft	NOTES e.g. Riffle Run Pool Glide
55	272			10.08		0.90 D						TOG
56												
57	279			10.02		0.85 D						MOG
58												
59	284			9.89		9.21		8.29		6.53	L	TOR
60												
Rxs 61	297			10.46		9.35						MOR
62												
63	302			10.84		9.39						TOU
64												
65	307			10.81		9.42		8.26				MOU
66												
67	310			10.70		9.39						TOP-45
68												
69	316			11.35		2.00 D		7.21 above water surface		6.05 R		
70												PLMAX
71	321			11.46		2.09 D						PDMAX
72												
Pxs → 73	325			11.17		1.79 D		8.31 R		6.56 R		
74								8.30 L				
75	327			11.07		1.68 D						TOG
76												
77	329			10.30		0.9 D						MOG
78												
R xs → 79	336			9.79		9.49						TOR
80												
81	338			10.04		9.48						MOR

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SURVEY DATA → LONGITUDINAL PROFILE 4

SITE: Date:

Location:

Observers: HUC:

	Distance, Point, or	Back-Sight	Height of Instru-ment	Thalweg		Water Surface		Bankfull		Low Bank HI		NOTES
				Fore-Sight	Elevation	Fore-Sight	Elevation	Fore-Sight	Elevation	Fore-Sight	Elevation	e.g. Riffle Run Pool Glide
	STATION	BS	HI	FS	Elev.	FS	Elev.	FS	Elev.	FS	Elev.	
	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	
82	342			10.01		9.61						TOU
83												
84												
85												
86												
87												
88												
89												
90												
91												
92												
93												
94												
95												
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102												
103												
104												
105												
106												
107												
108												

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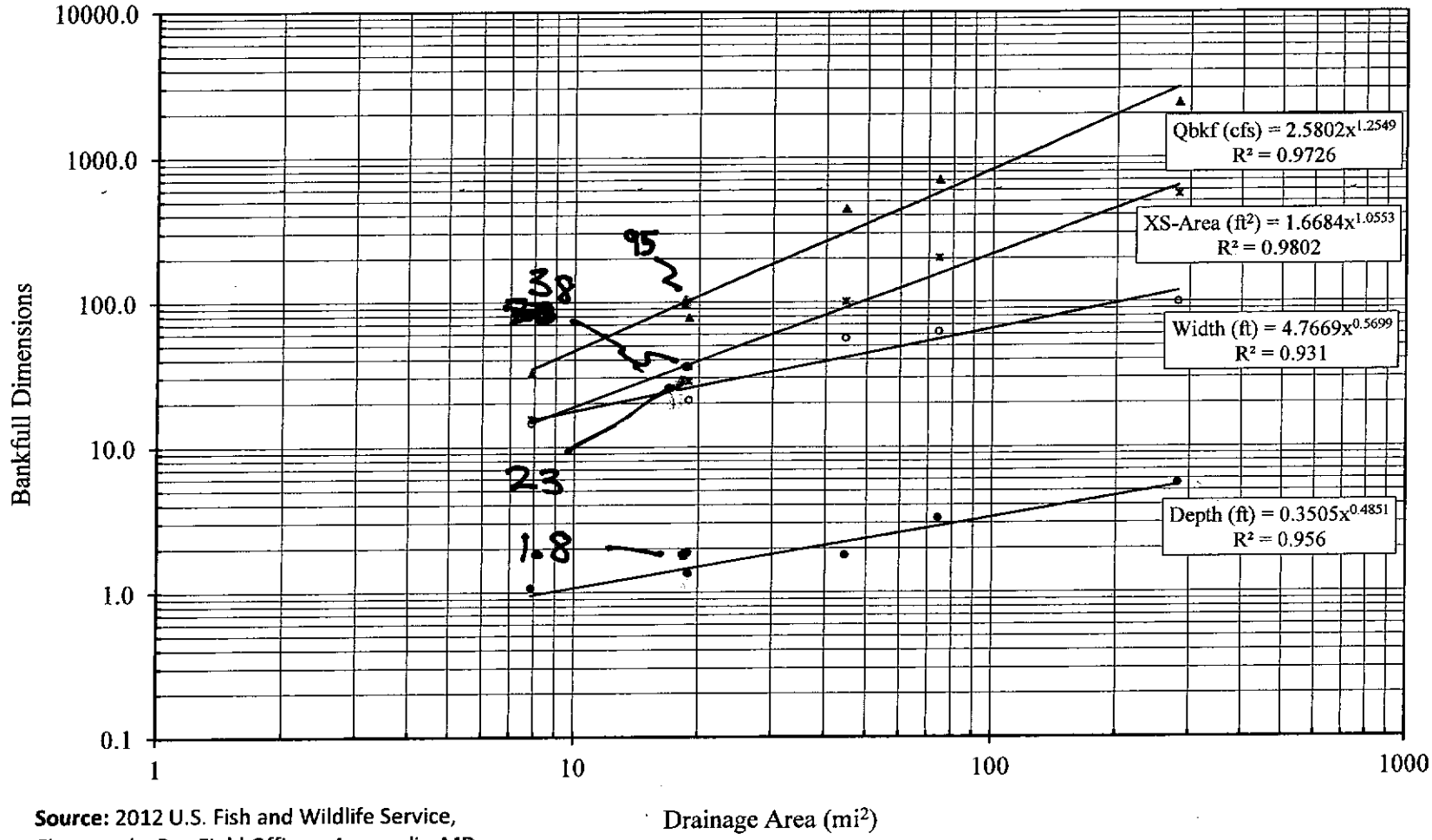
Bankfull Characteristics for Selected USGS Gages in the PA and MD Carbonate Great Valley Section of the Ridge and Valley Province



Source: 2012 U.S. Fish and Wildlife Service, Chesapeake Bay Field Office - Annapolis, MD

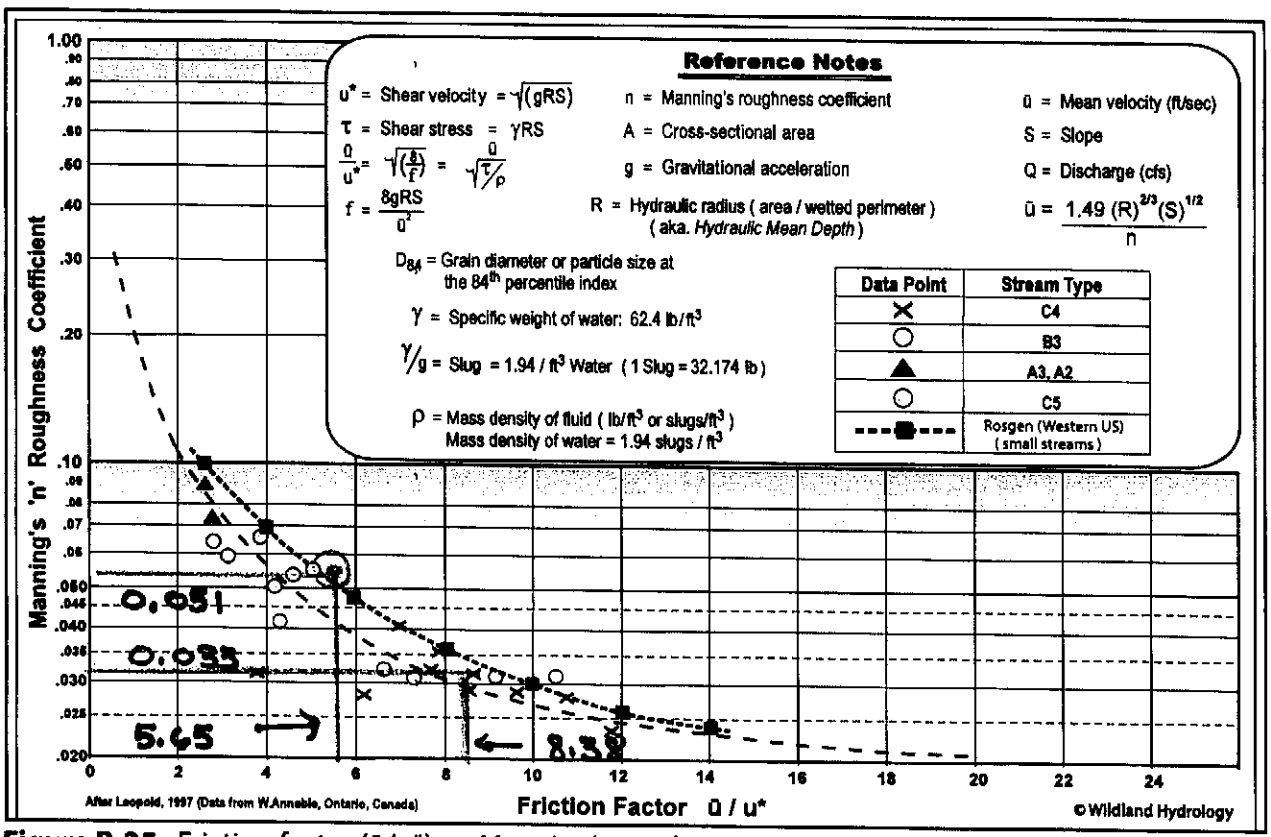


Figure B-35. Friction factor (ū/u*) *vs.* Manning's roughness coefficient 'n' (Rosgen, 2006b).

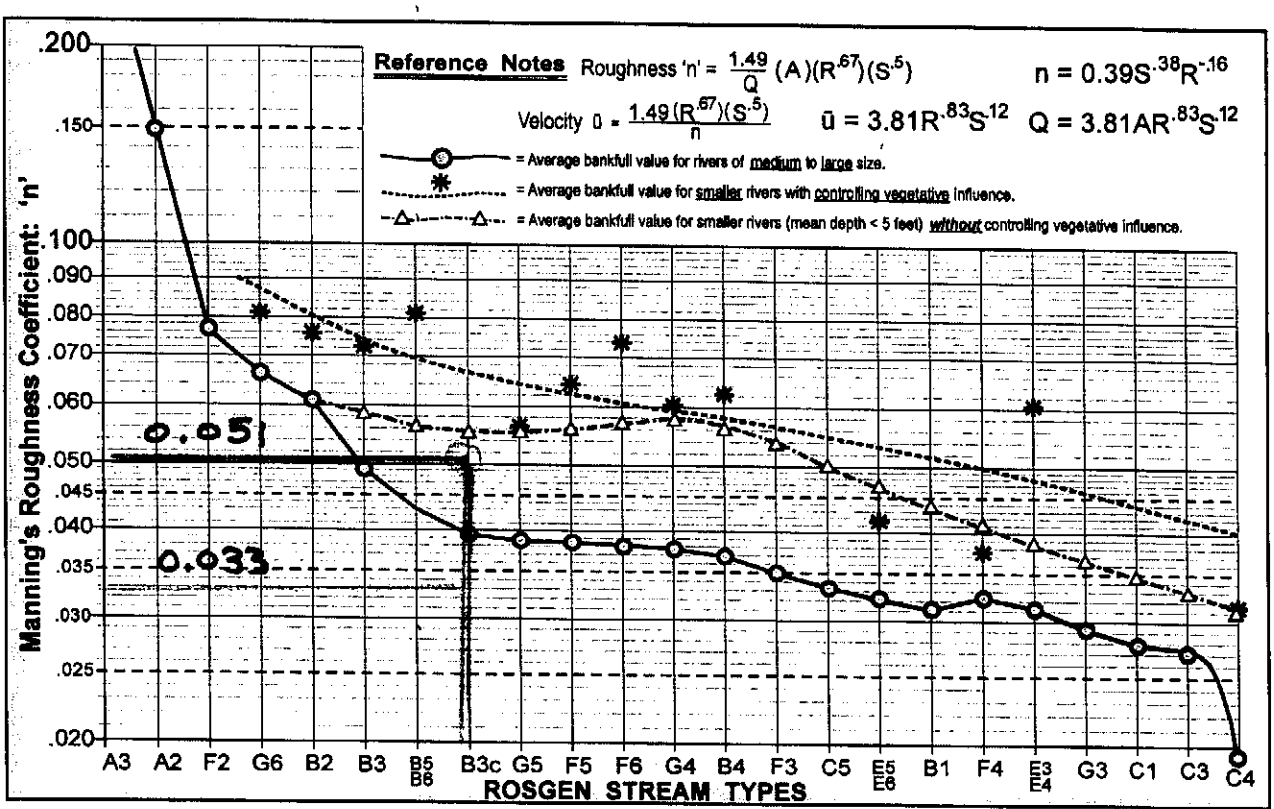


Figure B-36. Manning's 'n' by stream type.

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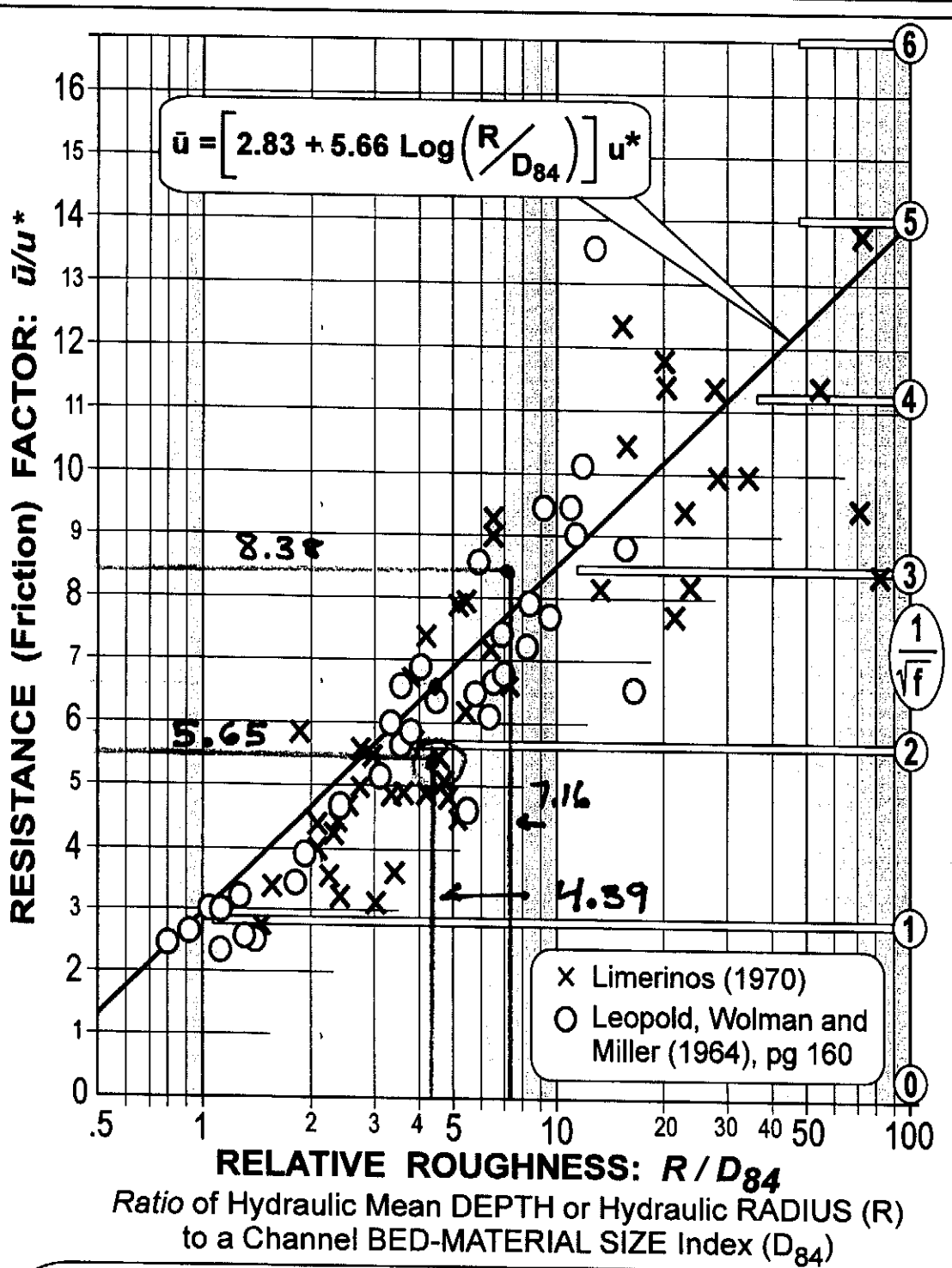

Ratio of Hydraulic Mean DEPTH or Hydraulic RADIUS (R) to a Channel BED-MATERIAL SIZE Index (D_{84})

The relation of channel *bed-particle size* to *hydraulic resistance*, developed with river data collected from a variety of Eastern and Western streams.

Resistance factors, $\bar{u}/u^*$ and $1/\sqrt{f}$, are shown as a function of **Relative Roughness**; i.e., a *Ratio* of Hydraulic Mean Depth (**d**), or Hydraulic Radius (**R**), to a bed-material size index (D_{84}), as taken from field measurements (Leopold, Wolman and Miller, 1964).

Figure B-34. Relative roughness (R/D_{84}) *vs.* friction factor ($\bar{u}/u^*$) (Rosgen, 2006b).

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Worksheet B-5. Procedure to validate hydraulic relations using gage station data.

1. Obtain the drainage area associated with the gaging station.
2. Obtain the field-determined bankfull discharge at the gaging station (**Figure B-43**).
3. Obtain the bankfull channel dimensions from the gaging station hydraulic geometry relationships (discharge *vs.* width, depth, area, and velocity).
4. Measure the average water surface slope.
5. Perform an active bed pebble count on the riffle to obtain D_{84}.
6. Determine the stream type.
7. Solve for Manning's 'n' at the bankfull stage: $n = (1.49R^{2/3}S^{1/2})/\bar{u}$ (use the bankfull mean velocity from Step 3).
8. Calculate relative roughness: R/D_{84}. Make sure that D_{84} is converted from millimeters to feet. Hydraulic radius (R) and mean depth (d_{bkf}) are often used interchangeably when width/depth ratios are greater than 12.
9. Calculate shear velocity: $u^* = (gRS)^{1/2}$.
10. Calculate friction factor: $\bar{u}/u^*$.
11. Plot bankfull discharge as a function of drainage area on the appropriate regional curve.
12. Plot bankfull channel dimensions as a function of drainage area on the appropriate regional curve (note stream type of plotted values using unique symbols).
13. Plot relative roughness by friction factor (**Figure B-34**) (Example in **Figure B-39**).
14. Plot Manning's 'n' by friction factor (**Figure B-35**) (Example in **Figure B-40**).
15. Plot Manning's 'n' by stream type (**Figure B-36**) (Example in **Figure B-41**).

Gaging Station Name: Marsh Run at Grimes **Gaging Station Number:** 01617800

Drainage Area (mi²)	Bankfull Discharge Q_{bkf} (cfs)	Bankfull Width W_{bkf}	Bankfull Mean Depth d_{bkf} (ft)	Bankfull Area A_{bkf} (ft²)	Bankfull Velocity $\bar{u}_{bkf}$ (ft/s)	Ave. Water Surface Slope S (ft/ft)	D_{84} (mm)	D_{84} (ft)	Stream Type	Manning's 'n'	Relative Roughness R/D_{84} (ft/ft)	Shear Velocity u* (ft/s)	Friction Factor $\bar{u}/u^*$
19.02	95	23	1.8	38	2.6	.00365	125	0.41	B3c/1	0.051	4.39	0.46	5.65
		20.9	1.36	28.4	3.35	.00365	D_{35} 58.86	0.19	-	0.033	7.16	0.40	8.38

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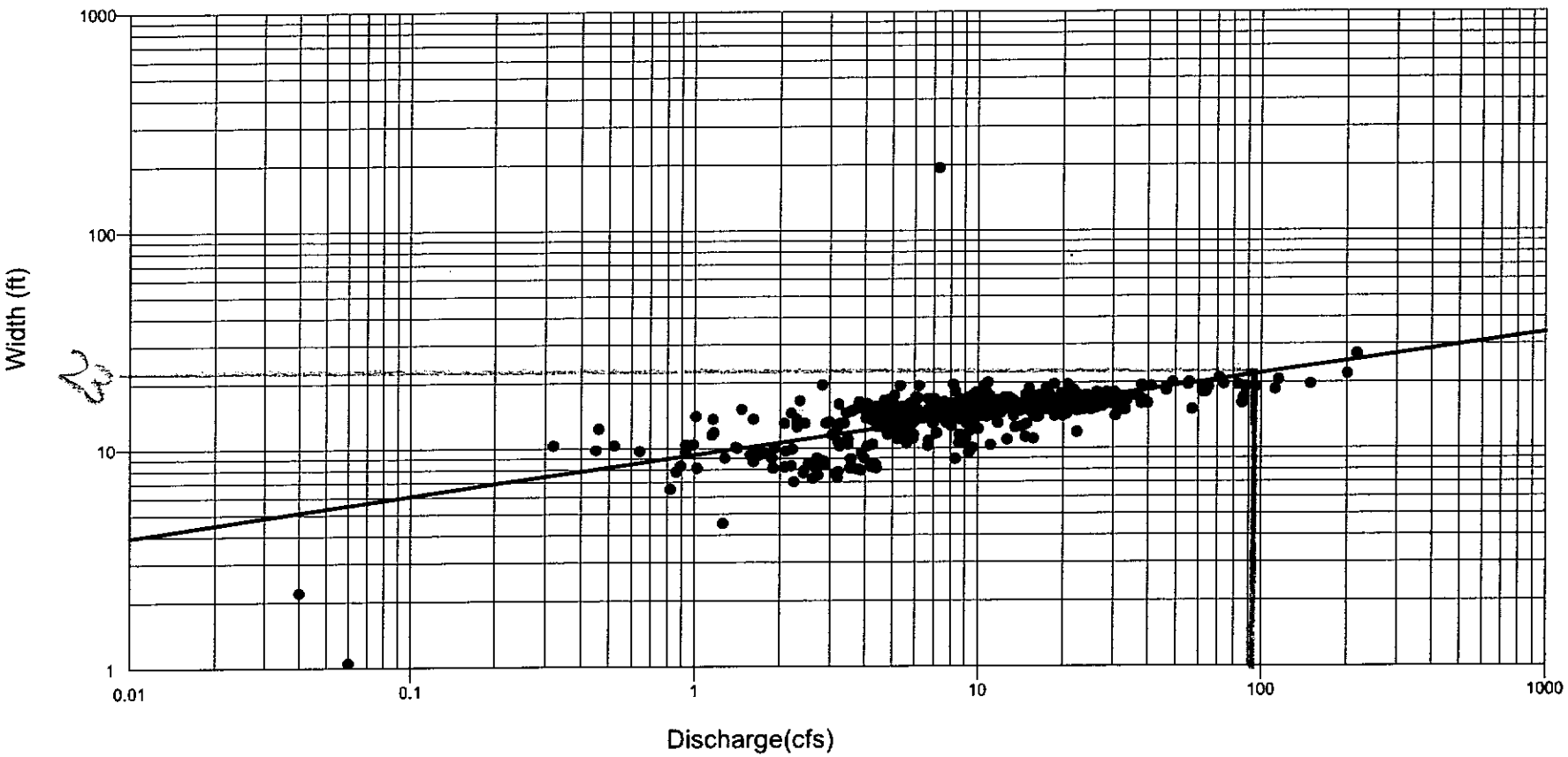
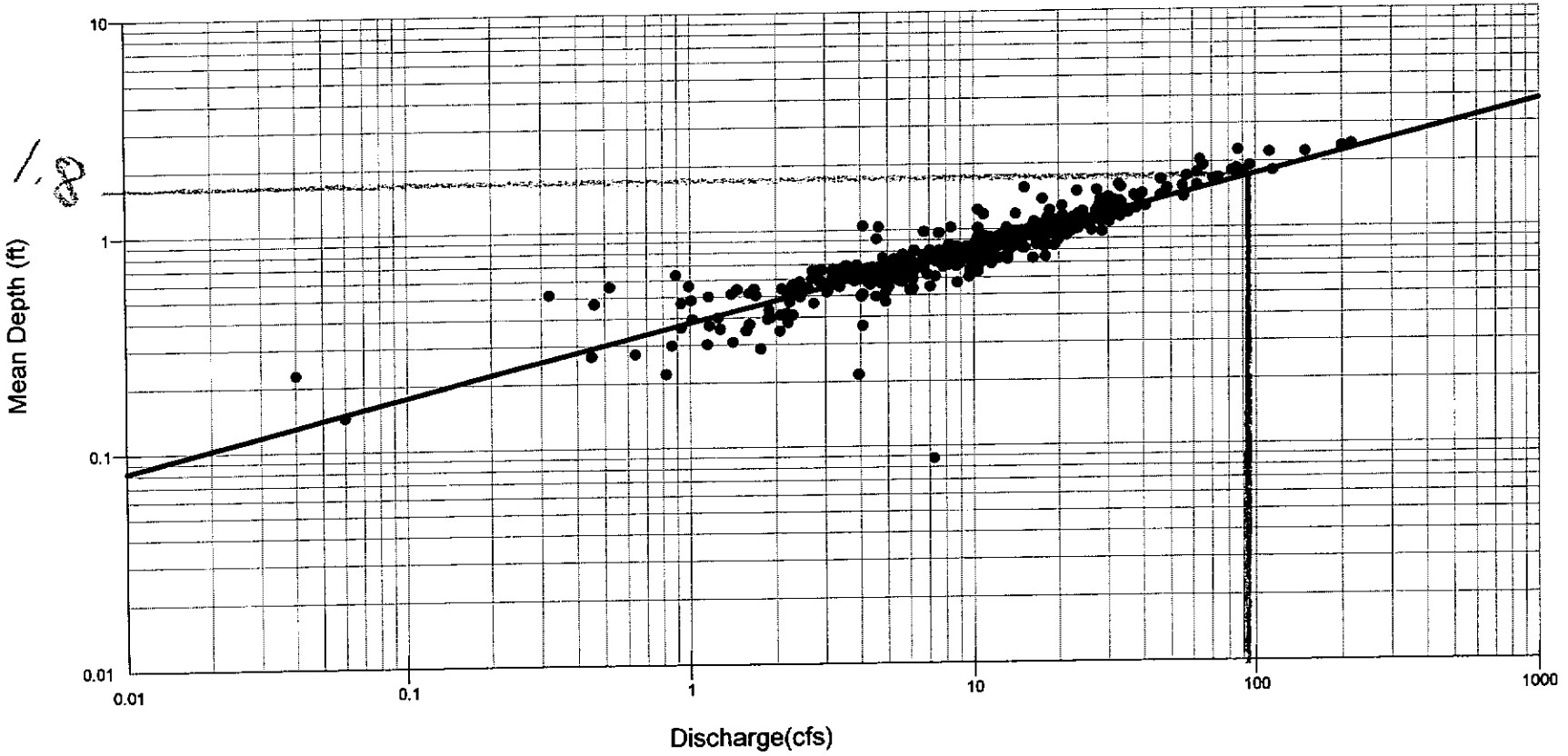
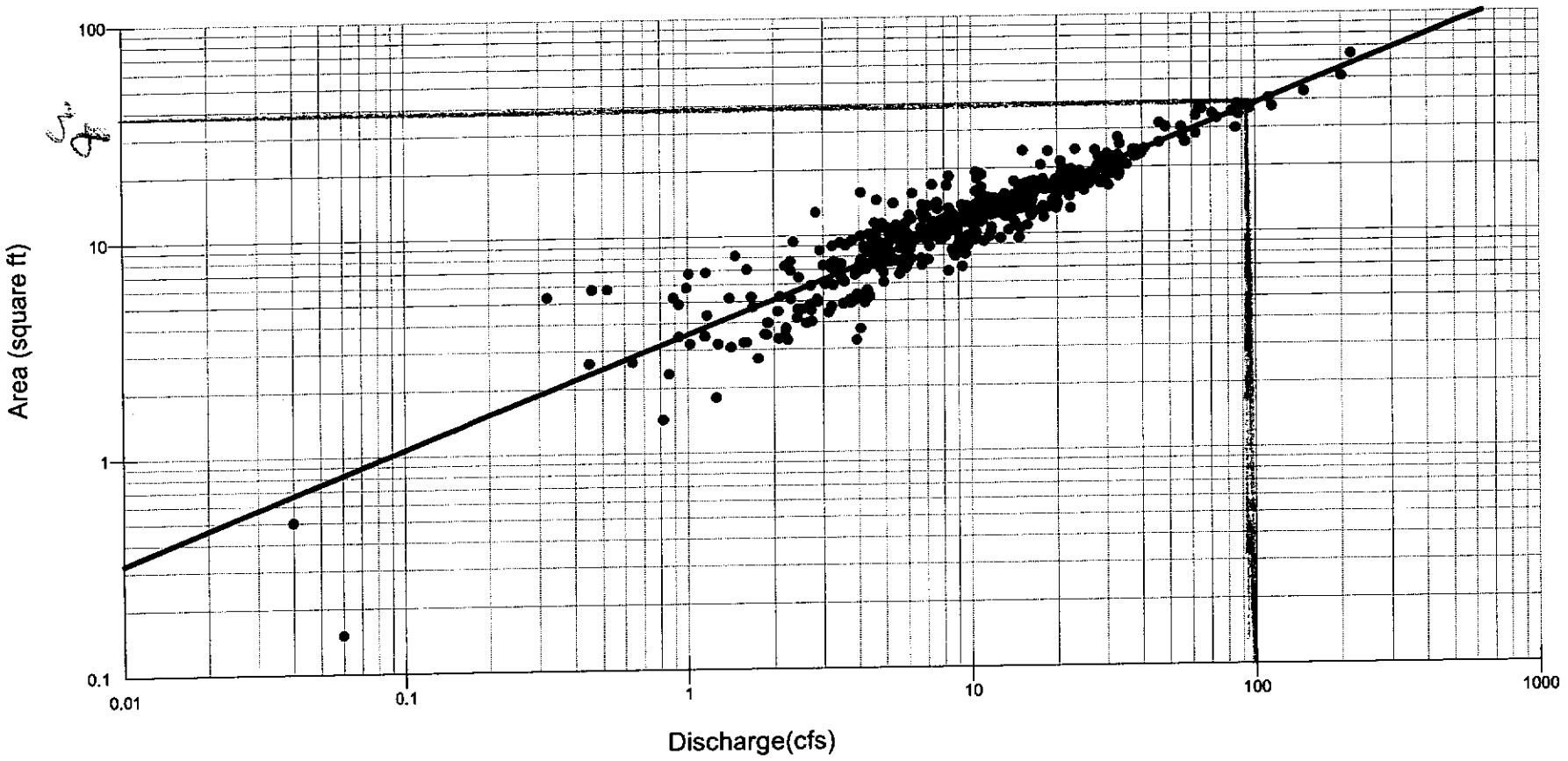
Hydraulic Geometry - Marsh Run at Grimes



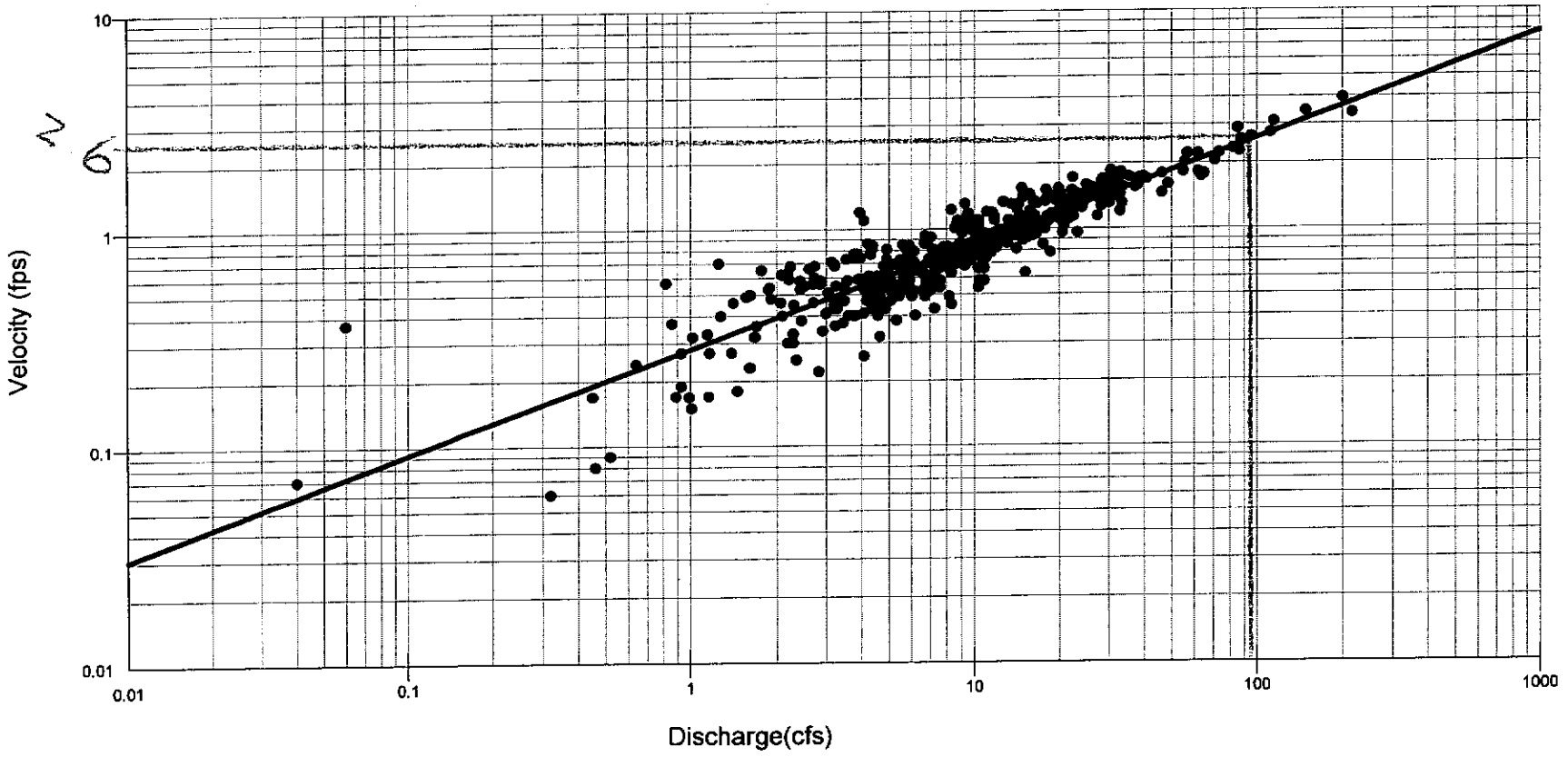
Hydraulic Geometry - Marsh Run at Grimes



Hydraulic Geometry - Marsh Run at Grimes



Hydraulic Geometry - Marsh Run at Grimes



Worksheet B-4. Dimensionless ratios of the ten pool types (*Second Field Day*).

Stream: Marsh Run Location: Washington Co., MD

Observers: Team 2 Stream Type: Landscape Type: U-AL-FD Date: 4-21-16

Pool Type		Dimensional Values: Pool Length (L_p)	Dimensional Values: Pool Max Depth (d_{maxp})	Dimensional Values: Pool Slope (S_p)		Dimensionless Ratios: Pool Length to Riffle Width (L_p/W_{bkf})	Dimensionless Ratios: Pool Max Depth to Riffle Mean Depth (d_{maxp}/d_{bkf})	Dimensionless Ratios: Pool Slope to Average Slope (S_p/S)
1. Lateral Scour Pool (LSP)	Mean	9	3.49	0.0017	Mean	0.414	2.056	0.466
	Min.	13	3.4	0.0011	Min.	0.599	1.947	0.301
	Max.	45	3.57	0.0023	Max.	2.072	2.169	0.630
2. Contraction Scour Pool (CSP)	Mean				Mean			
	Min.				Min.			
	Max.				Max.			
3. Step/Pool (SP)	Mean				Mean			
	Min.				Min.			
	Max.				Max.			
4. Backwater Pool (BWP)	Mean				Mean			
	Min.				Min.			
	Max.				Max.			
5. Plunge Pool (PP)	Mean				Mean			
	Min.				Min.			
	Max.				Max.			
6. Pocket Water Pool (PWP)	Mean				Mean			
	Min.				Min.			
	Max.				Max.			
7. Lateral Protrusion Pool (LPP)	Mean				Mean			
	Min.				Min.			
	Max.				Max.			
8. Straight Dissipator Pool (SDP)	Mean				Mean			
	Min.				Min.			
	Max.				Max.			
9. Converging Confluence Pool (CCP)	Mean				Mean			
	Min.				Min.			
	Max.				Max.			
10. Compound Pool (CP)	Mean				Mean			
	Min.				Min.			
	Max.				Max.			

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Worksheet B-2. Computations of velocity and discharge using various methods (*Second Field Day*).

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	Marsh Run	Location:	Grimes, Washington Co., MD
Date:	4/21/16	Landscape Type:	U - AL - FD
Observers:	Team 2	HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional Area		A_{bkf} (ft^2)	Bankfull Riffle Mean Depth		d_{bkf} (ft)
Bankfull Riffle Width		W_{bkf} (ft)	Wetted Perimeter $\approx (2 * d_{bkf}) + W_{bkf}$		W_p (ft)
D_{84} Particle Size at Riffle		D_{84} (mm)	D_{84} Particle Size in Feet D_{84} (mm) / 304.8		D_{84} (ft)
Bankfull Slope		S_{bkf} (ft / ft)	Hydraulic Radius A_{bkf} / W_p		R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R (ft) / D_{84} (ft)		R / D_{84} (ft / ft)
Drainage Area		DA (mi^2)	Shear Velocity $u^* = (gRS)^{1/2}$		u^* (ft / sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $\bar{u} = [\,2.83 + 5.66 * Log\{R / D_{84}\}\,]\,u^*$		ft / sec		cfs
2. Roughness Coefficient: a) Manning's n from Friction Factor/Relative Roughness (Figs. B-34, B-35) $\bar{u} = 1.49*R^{2/3}*S^{1/2}/n$ $n =$		ft / sec		cfs
2. Roughness Coefficient: b) Manning's n from Stream Type (Fig. B-36) $\bar{u} = 1.49*R^{2/3}*S^{1/2}/n$ $n =$		ft / sec		cfs
2. Roughness Coefficient: c) Manning's n from Jarrett (USGS): $\bar{u} = 1.49*R^{2/3}*S^{1/2}/n$ $n = 0.39*S^{0.38}*R^{-0.16}$ Note: This equation is applicable to steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems; i.e., for $n =$		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) USGS Gage Data $\bar{u} = Q / A$ Return Period for Bankfull Q Q = year		ft / sec		cfs
4. Continuity Equations: b) Regional Curves $\bar{u} = Q / A$		ft / sec		cfs

Protrusion Height Options for the D_{84} Term in the Relative Roughness Relation (R/D_{84}) – Estimation Method 1

Option 1.	For **sand-bed** channels: Measure 100 **"protrusion heights"** of sand dunes from the downstream side of feature to the top of feature. Substitute the D_{84} sand dune protrusion height in ft for the D_{84} term in method 1.
Option 2.	For **boulder-dominated** channels: Measure 100 **"protrusion heights"** of boulders on the sides from the bed elevation to the top of the rock on that side. Substitute the D_{84} boulder protrusion height in ft for the D_{84} term in method 1.
Option 3.	For **bedrock-dominated** channels: Measure 100 **"protrusion heights"** of rock separations, steps, joints or uplifted surfaces above channel bed elevation. Substitute the D_{84} bedrock protrusion height in ft for the D_{84} term in method 1.
Option 4.	For **log-influenced** channels: Measure **"protrusion heights"** proportionate to channel width of log diameters or the height of the log on upstream side if embedded. Substitute the D_{84} protrusion height in ft for the D_{84} term in method 1.

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