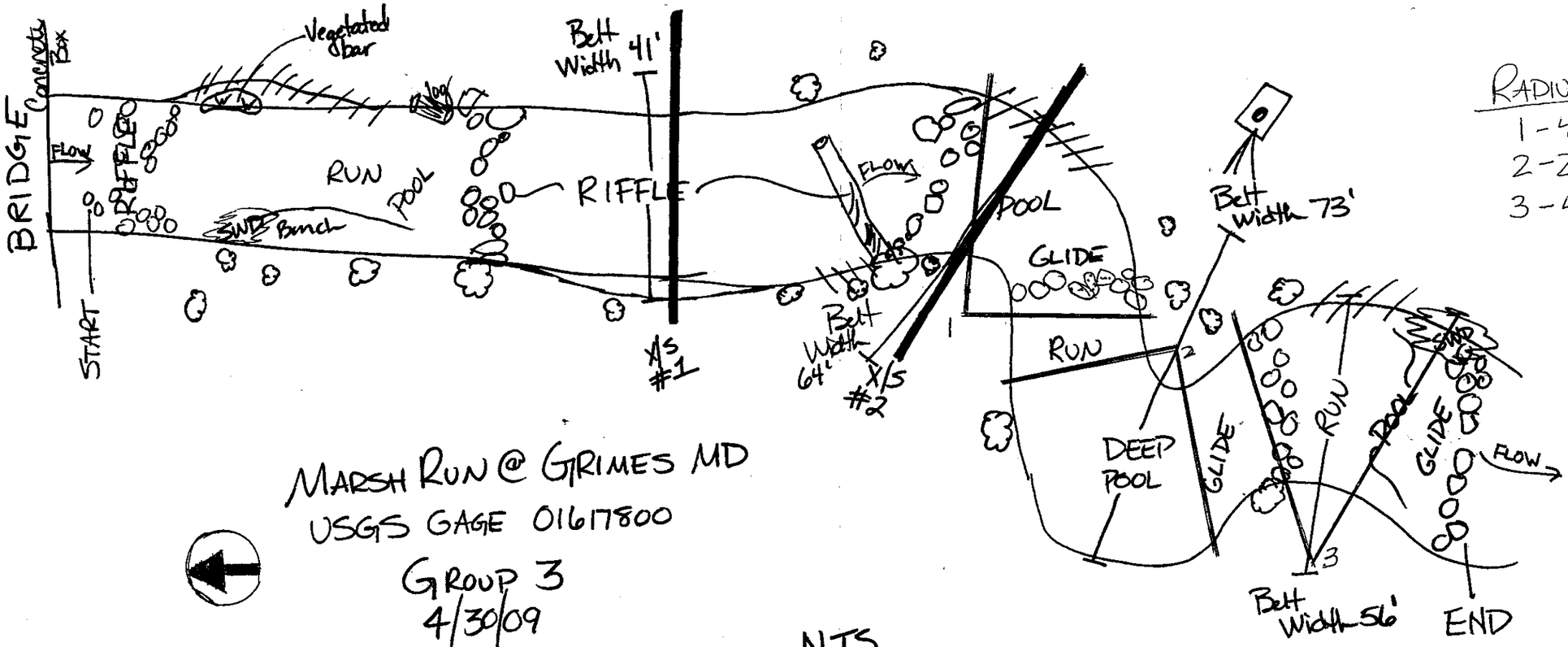
TEAM #3

Field Day 2 Presentation Order: Gage Station
River Morphology and Applications

- **Sketch Map** Gabby
- **Cross-sections**
  - Riffle cross-section
  - Pool cross-section
- **Longitudinal Profile**
- **Pebble Counts**
  - Representative pebble count
  - Riffle pebble count
- **Velocity (Worksheet B-2)**
- **Stream Classification (Worksheet B-1)**
- **Dimensionless Ratios (Worksheet B-3)**

valley profile



MARSH RUN @ GRIMES MD
USGS GAGE 01617800
GROUP 3
4/30/09

NTS

RADIUS OF CURVATORE

1 - 43.5		
2 - 28.5		40.3 AVG
3 - 49		

BELT WIDTHS

41	64	56
44	73	

55.6 AVG

SURVEY DATA → LONGITUDINAL PROFILE 1

SITE: Date: 4/30/09

Location: paul, lowell, beau

Party / Notes: GROUP 3 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	
1	0	2.92	10292	6.64		6.18				4.65	Roadcut	Top Riffle
2	28			7.39		6.67						
3	64			7.90		7.17				2.92		Top Run
4	76			8.52		7.18		5.88				1.3 bf:gws
5	73			8.47		7.19				3.38		Top Pool
6	87			8.14		7.19				3.74		Top Glide
7	94			8.06		7.16				3.28		Top Riffle
8	114			8.04		7.44				4.28		
9	138			8.07		7.42		6.09		4.76		Riffle Cross 1.33 bf:w
10	165			7.97		7.50				4.02		
11	190					7.73		6.92		4.18		bfull
12	215.4			8.61		7.91				5.20		
13	220.7			8.99		8.0				5.38		top run
14	239			9.47		7.99				4.80		
15	242			9.88		7.95						top pool
16	245			10.24		8.05						
17	253			9.63		7.95						
18	259			9.96		7.94						Pool Section
19	262			9.78		7.92				5.31		End Pool
20	263			8.91		7.94						Top Glide
21	269			8.92		7.93		6.63				Top Riffle
22	274			9.50	9.15	8.23						Top Run
23	280			10.11		8.24						Top Pool
24	~~281~~											
25	013			10.36		8.18						
26	048							7.07				
27	049							7.19				

32

R - riffle
U - run
G - glide
P - pool

8.61
7.91
.70

300
313
348
349

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SURVEY DATA → LONGITUDINAL PROFILE 2

SITE: Date: 4/30/09

Location:

Party / Notes: group 3 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	
3+ 28	058			9.84		8.25				5.50		top Glide
29	069			9.18		8.19						Top Riffle
30	078			9.56		8.45						Top Run
31	083			10.166		8.35						MPT
32	092			11.03		8.41						Top Pool
33	095			11.60		8.36						End Pool
34	097			10.28		8.45						Top Glide
3+ 35	118			9.28		8.48				5.03		Top Riffle
36												
37	BM Team 3											
38		4.44										
39												
40	BM Team 2											
41		1.47										
42												
43	BM Team 3 Original			2.94								
44												
45												
46												
bankfull 47	measurements											
48	69					6.65		5.45				
49	267							6.81				
50	262											
51	268					7.96		7.03				rich bf
tape+ 52	348					8.2		7.35				dave bf
53												
54												

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Cross-Section Forms

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SURVEY DATA ⟹ **CROSS - SECTION** 1

SITE: Team 3 Date: 4-30-09

Location: (Riffle) Sta 138

Party / Notes: HUC:

Item	Distance, Point, or STATION ft	Back-Sight BS ft	Height of Instrument HI ft	Fore-Sight FS ft	Elevation ft	REMARKS / COMMENTS / NOTES
1	0			3.70		LB
2	2			4.10		
3	4			4.18		
4	6			4.34		
5	10			4.76		
6	12			4.78		
7	14			4.76		
8	16			4.82		Top Left Bank
9	17			5.10		Slope Break
10	18			5.60		
11	21			7.19		
12	31.3			7.32		EW
13	23			7.79		
14	24			7.98		
15	26			7.98		
16	28			8.06		
17	29			8.09		
18	33			7.94		
19	34			7.94		
20	36			7.97		
21	38			7.92		
22	40			7.87		
23	42			7.88		
24	44			7.48		EW
25	45			7.00		Break
26	45.75			6.66		BF
27	46			6.31		BF
28	46.75			6.05		BF
	48			5.73		Slope Break
	50			5.12		

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SURVEY DATA ⟹ **CROSS - SECTION 2**

SITE: Pool sta 259.3 Team 3 Date: 4-30-09

Item	STATION ft	BS ft	HI ft	FS ft	Elevation ft	NOTES / COMMENTS / REMARKS
29						
30	0			5.38		
31	2			5.3		
32	4			4.98		
33	6			4.92		
34	8			4.92		
35	10			5.39		
36	11			5.41		LOBK (left)
37	13			7.46		
38	14			7.95		EW (L)
39	15			8.31		
40	16			9.2		
41	18			9.6		
42	20			9.96		
43	22			9.7		
44	24			9.15		
45	26			8.99		
46	28			8.65		
47	30			8.44		
48	32			8.56		
49	33.4			7.91		EW (R)
50	34.4			7.48		
51	35			6.73		BKF
52	37			5.45		low BK (Right)
53	39			5.16		
54						
55						
56						
57						
58						
59						

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0.98 tape

SURVEY DATA ⟹ **CROSS - SECTION** 1

SITE: Marsh Run (Team 3) Below bridge Date: 4-30-09

Location: Sta 1388.4

Party / Notes: Pawel, Tracy, Casey HUC:

Item	Distance, Point, or STATION ft	Back-Sight BS ft	Height of Instrument HI ft	Fore-Sight FS ft	Elevation ft	REMARKS / COMMENTS / NOTES
1	~~5~~	4.5	5.2 105.2	(-)	1	
2	2			0.76		
3	3			0.79		
4	4			0.88		
5	5			0.9		
6	6			0.96		
7	7			1.06		
8	8			1.16		
9	9			1.2		
10	10			1.3		
11	11			1.36		
12	12 13			1.37 1.31		
13	14 15			1.32 1.29		
14	16 17			1.32 2.1		
15	18 20			2.7 3.23		18.5' LowBank 1.8
16	21 23			3.8 4.88		24' EW 3.87
17	25 26			4.5 4.47		
18	27 29			4.49 4.52		
19	30 31			4.42 4.39		
20	32 33			4.23 4.32		
21	34 35			4.38 4.25		
22	36 37			4.37 4.4		
23	38 39			4.35 4.33		
24	40 41			4.2 4.28		
25	~~43~~ 46			3.94 2.94		EW
26	465 48			2.46 2.22		BKF
27	49 50			1.92 1.52		
28	51 52			1.00 0.070		
	54			0.06		
	56			0.0		
	59			0.24		
	40			0.32		

from tape top

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Worksheet B-2. Computations of velocity and discharge using various methods.

Bankfull VELOCITY / DISCHARGE Estimates

Site:	Marsh Run	Location:	Grimes, MD
Date:	4/30/09	Stream Type:		Valley Type:	VIII
Observers:	Group 3	HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Cross-sectional AREA	38.56	A_{bkf} (ft^2)	Bankfull Mean DEPTH	1.7	d_{bkf} (ft)
Bankfull WIDTH	26.66	W_{bkf} (ft)	Wetted PERIMETER ~ $2 * d_{bkf} + W_{bkf}$	27.36	W_p (ft)
D_{84} @ Riffle	109.25	Dia. (mm)	D_{84} mm / 304.8 =	0.3420	D_{84} (ft)
Bankfull SLOPE	0.005	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	1.41	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R (ft) / D_{84} (ft)	4.123	
Drainage AREA	18.9	DA (mi^2)	Shear Velocity $u^* = \sqrt{gRS}$	0.477	u^* (ft / sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 \text{ Log}\{R/D_{84}\}]u^*$ (4.123, 0.476)	3.0	ft / sec	115.8	cfs
2. Roughness Coefficient: a) Manning's 'n' from friction factor / relative roughness $u = 1.4865 * R^{2/3} * S^{1/2} / n$ n = 0.06	2.20	ft / sec	84.9	cfs
2. Roughness Coefficient: $u = 1.4865 * R^{2/3} * S^{1/2} / n$ b) Manning's 'n' from Jarrett (USGS): $n = 0.39 S^{.38} R^{-.16}$ n = .065 Note: This equation is for applications involving steep, step-pool, high boundary roughness, cobble- and boulder-dominated stream systems; i.e., for stream types A1, A2, A3, B1, B2, B3, C2 and E3.	2.03	ft / sec	78.4	cfs
2. Roughness Coefficient: $u = 1.4865 * R^{2/3} * S^{1/2} / n$ c) Manning's 'n' from Stream Type n = 0.062	2.26	ft / sec	87.15	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach	3.21	ft / sec	123.69	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$ Return Period for Bankfull Discharge Q = 1.7 Year	2.149	ft / sec	77.8	cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$ (82.87 / 36.2)	2.29	ft / sec	82.87	cfs

Options for using the D_{84} term in the relative roughness relation (R/D_{84}), when using estimation method 1.

Option 1. For **sand-bed** channels: Measure the **"protrusion height"** (h_{sd}) of sand dunes above channel bed elevations. Substitute an average sand dune protrusion height (h_{sd} in ft) for the D_{84} term in estimation method 1.

Option 2. For **boulder-dominated** channels: Measure several **"protrusion heights"** (h_{bo}) of boulders above channel bed elevations. Substitute an ave. boulder protrusion height (h_{bo} in ft) for the D_{84} term in estimation method 1.

Option 3. For **bedrock-dominated** channels: Measure several **"protrusion heights"** (h_{br}) of rock separations/steps/joints/ uplifted surfaces above channel bed elevations. Substitute an average bedrock protrusion height (h_{br} in feet) for the D_{84} term in estimation method 1.

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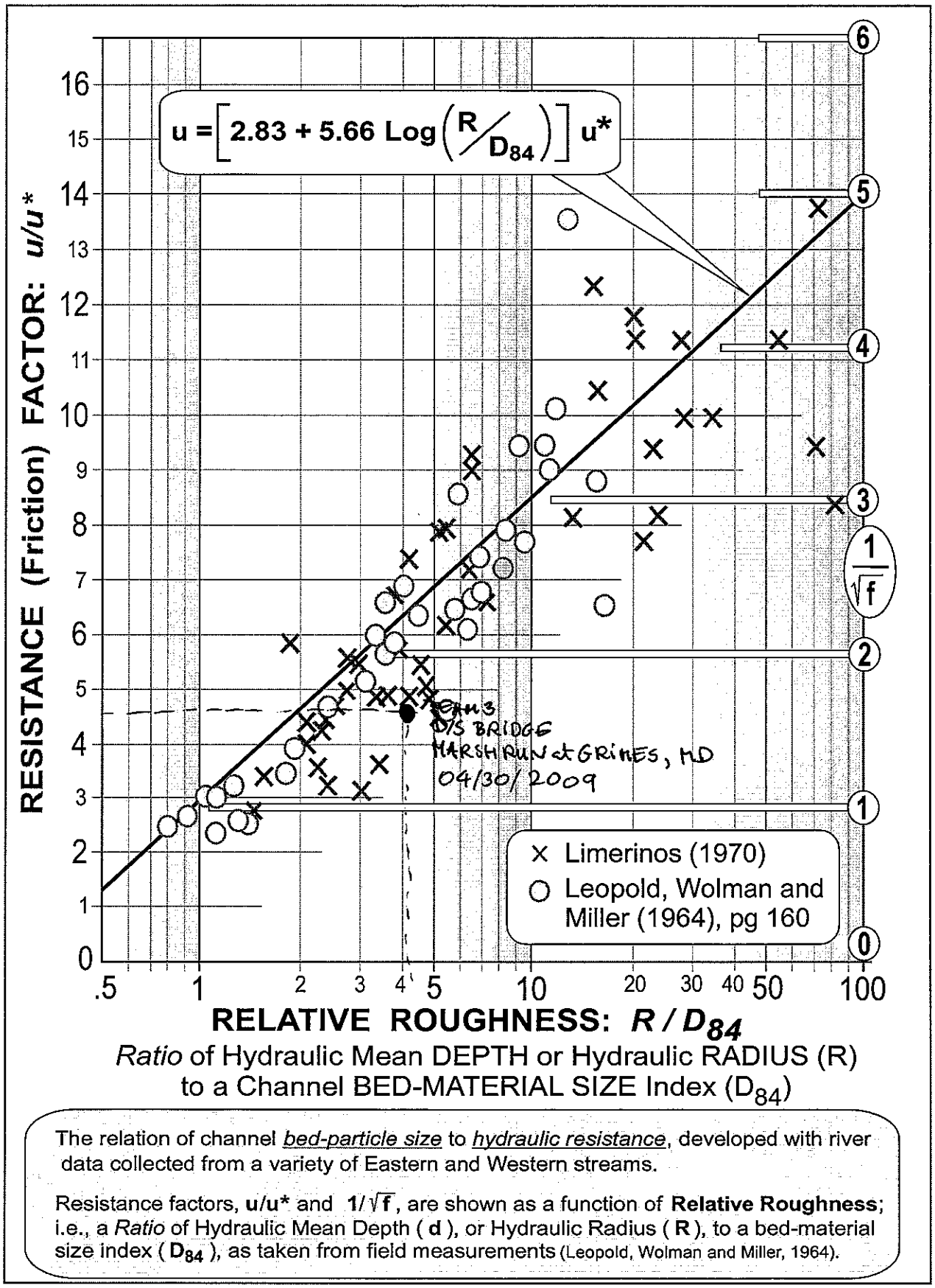

Figure B-2. Relative roughness (R/D_{84}) vs. friction factor (u/u*) (Rosgen, 2006b; Rosgen and Silvey, 2007).

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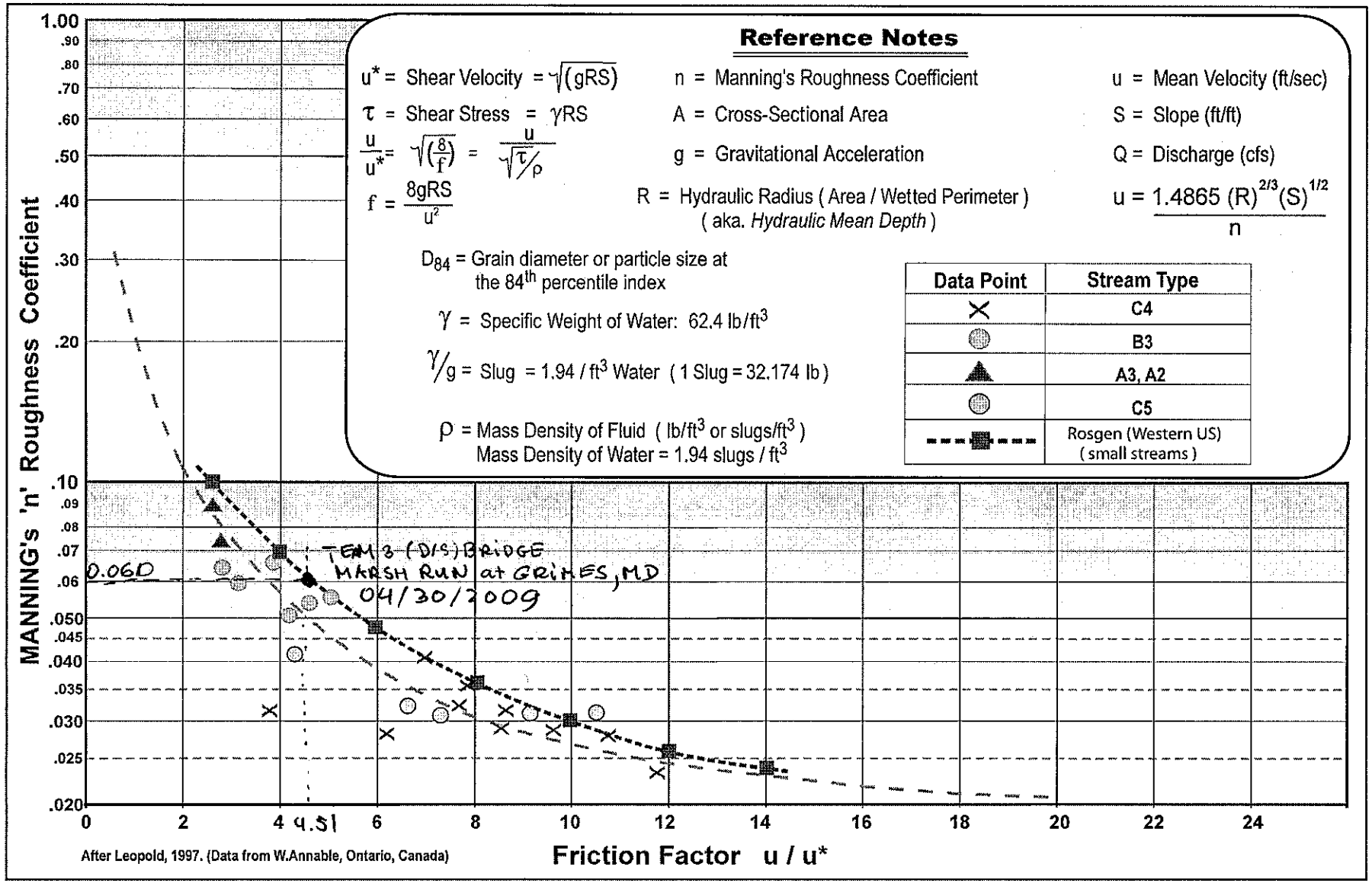

Figure B-3. Friction factor (u/u*) vs. Manning's roughness coefficient "n" (Rosgen, 2006b; Rosgen and Silvey, 2007).

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Marsh Run Team #3 4/30/09

Table A-7. Procedure to validate hydraulic relations using gage station data from the West Fork San Juan River, Colorado.

Validation of Hydraulic Relationships Using Gaging Station Data

1. Obtain the drainage area associated with the gaging station.
2. Obtain the field-determined bankfull discharge at the gaging station(s) (**Figure A-22**).
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: $n = (1.49R^{2/3}S^{1/2})/u$ (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: 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 A-16**) (Example in **FigureA-19**).
14. Plot Manning's "n" by friction factor (**Figure A-17**) (Example in **Figure A-20**).
15. Plot Manning's "n" by stream type (**Figure A-18**) (Example in **Figure A-21**).

GAGING STATION NAME: MARSH RUN AT GERMES, MARYLAND GAGING STATION: 01617800

1	2	3a	3b	3c	3d	4	5	6	7	8	9	10	11
Drainage Area (mi^2)	Bankfull Discharge Q_{bkf} (cfs)	Bankfull Width W_{bkf}	Bankfull Mean Depth d_{bkf} (ft)	Bankfull Area A_{bkf} (ft^2)	Bankfull Velocity 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 u/u^*
18.9	83	22.5	1.6	36.2	2.2	0.0056	104.28	0.342	F6/1	0.0616	4.123	0.504	4.42

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d84

98.69

velocity @ our site = Q/A where q is from gage station which is 82.87

area cross-section @ riffle = ~~27.76~~ 38.56

= 82.87 / 38.56 = 2.149

bf slope = 0.00557

water surf slope = 0.0055

wp = (2 × d) + w = 27.36 hyd. rad = 1.41

d_{84} protrusion = 104.25 mm = 0.3420 ft

back calculate mannings "n" w_{bf} = 26.66

$$v = \frac{1.4865 (R)^{2/3} (S)^{1/2}}{n}$$

$$v = \frac{1.4865 (1.41)^{2/3} (0.005)^{1/2}}{n}$$

$$v = \frac{1.4865 (1.2589)(0.0707)}{n}$$

$$2.149 = \frac{0.05798}{n} \quad 0.1323$$

.06

$$n = 0.02698 \quad 0.06156$$

Relative Q:

relative roughness:

$R/D_{84} = 1.41/0.3420$

$= 4.123$

Friction Factor = u/u^*

$u = 2.149$

$u^* = (gRS)^{1/2}$

$= (32.2 \times 1.41 \times 0.005)^{1/2}$

$= (0.22701)^{1/2}$

$= 0.4765$

$u/u^* = 2.149 / 0.4765 = 4.50996$

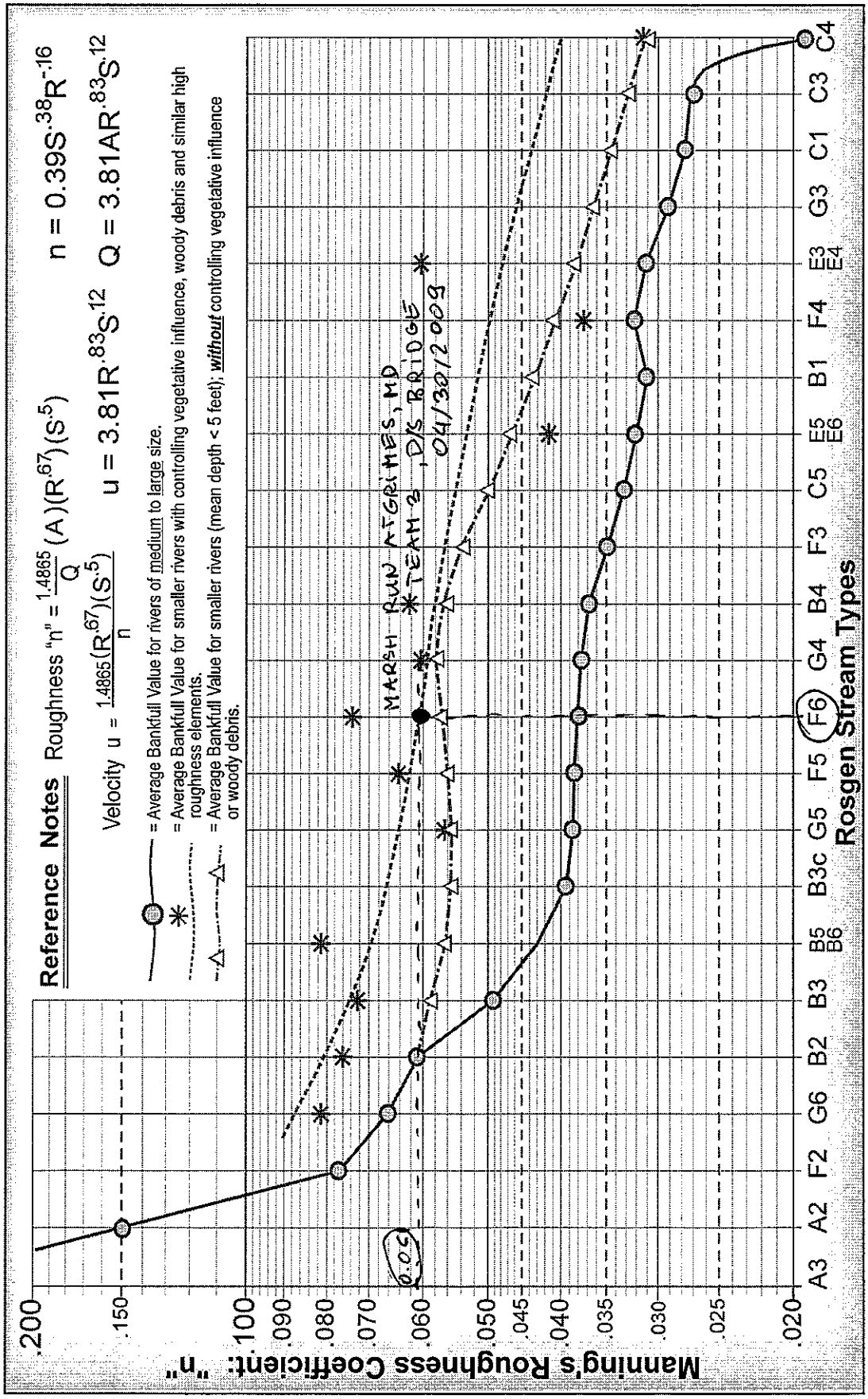

Figure B-4. Manning's "n" by stream type (Rosgen and Silvey, 2007).

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Step 14

Summarize USGS gage data: Team 3 4/30/2009

Summary....*USGS GAGE STATION* Data / Records for STREAM CHANNEL CLASSIFICATION

Station NAME:	Marsh Run			Station Number:	01617800
LOCATION:	Washington County, MD				
Period of Record:	44	yrs		Mean Annual DISCHARGE:	cfs
Drainage AREA:	acres	18.9	mi²	Drainage Area Mn Elev:	ft
Reference REACH SLOPE:	.006	ft/ft		Valley Type:	~~VH~~
Stream Type:	F 6/1			HUC:	

"BANKFULL" CHARACTERISTICS

Determined from FIELD MEASUREMENT			Determined from GAGE DATA Analysis		
Bankfull WIDTH (W_{bkf})	26.66	ft	Bankfull WIDTH (W_{bkf})	22.5	ft
Bankfull Mean DEPTH (d_{bkf})	1.6	ft	Bankfull MEAN DEPTH (d_{bkf})	1.6	ft
Bankfull Xsec AREA (A_{bkf})	38.56	ft²	Bankfull Xsec AREA (A_{bkf})	36.2	ft²
Wetted PERIMETER (W_P)	27.36	ft	Wetted PERIMETER (W_P)	25.7	ft
Bankfull STAGE (Gage Ht)	2.15	ft	Bankfull STAGE (Gage Ht)	1.9	ft
Est. Mean VELOCITY (u)	2.2	ft/sec	Mean VELOCITY (u)	2.2	ft/sec
Est. Bkf. DISCHARGE (Q_{bkf})	84.8	cfs	Bankfull DISCHARGE (Q_{bkf})	83	cfs
Bankfull DISCHARGE associated with **"field-determined"** Bankfull STAGE (From Gage Height reading at Staff Plate and tabular Stage-Discharge curve data)				8.3	cfs
Recurrence Interval (Log-Pearson) associated with **"field-determined"** Bankfull Discharge				1.7	yrs

From the *Annual Peak Flow Frequency Analysis* data for the Gage Station, determine:

1.5 Year R.I. Discharge =	70	cfs	**10** Year R.I. Discharge =	300	cfs
2.0 Year R.I. Discharge =	100	cfs	**25** Year R.I. Discharge =	450	cfs
5.0 Year R.I. Discharge =	200	cfs	**50** Year R.I. Discharge =	506	cfs

MEANDER GEOMETRY Team 3 Site 10.3

Meander Wavelength (L_m)	104.8	ft	Radius of Curvature (R_C)	~~[redacted]~~	ft
Belt Width (W_{blt})	55.6	ft	Meander Width Ratio (W_{blt}/W_{bkf})	2.47	ft/ft

HYDRAULIC GEOMETRY

Based on *USGS Discharge Summary Notes* data (Form 9-207) and regression analyses of measured discharge (**Q**) with the hydraulic parameters of Width (**W**), Area (**A**), Mean Depth (**d**) & Mean Velocity (**u**), determine the *intercept coefficient* (**a**) and the *slope exponent* (**b**) values for a power function of the form $Y = aX^b$, when **Y** is one of the selected hydraulic parameters and **X** is a given discharge value (**Q**).

	Width (W)	Depth (d)	Area (A)	Velocity (u)
Intercept Coefficient **a**)	9.4161	0.4077	3.8388	0.2638
Slope Exponent **b**)	0.1968	0.3111	0.508	0.487

Hydraulic Radius $R = A / W_P$	1.41	ft	Manning's "n" at Bankfull Stage	0.06	Coeff.

$$"n" = 1.4895\ [(\text{Area})\ (\text{Hydraulic Radius}^{2/3})\ (\text{Slope})^{1/2}] / Q_{bkf}$$

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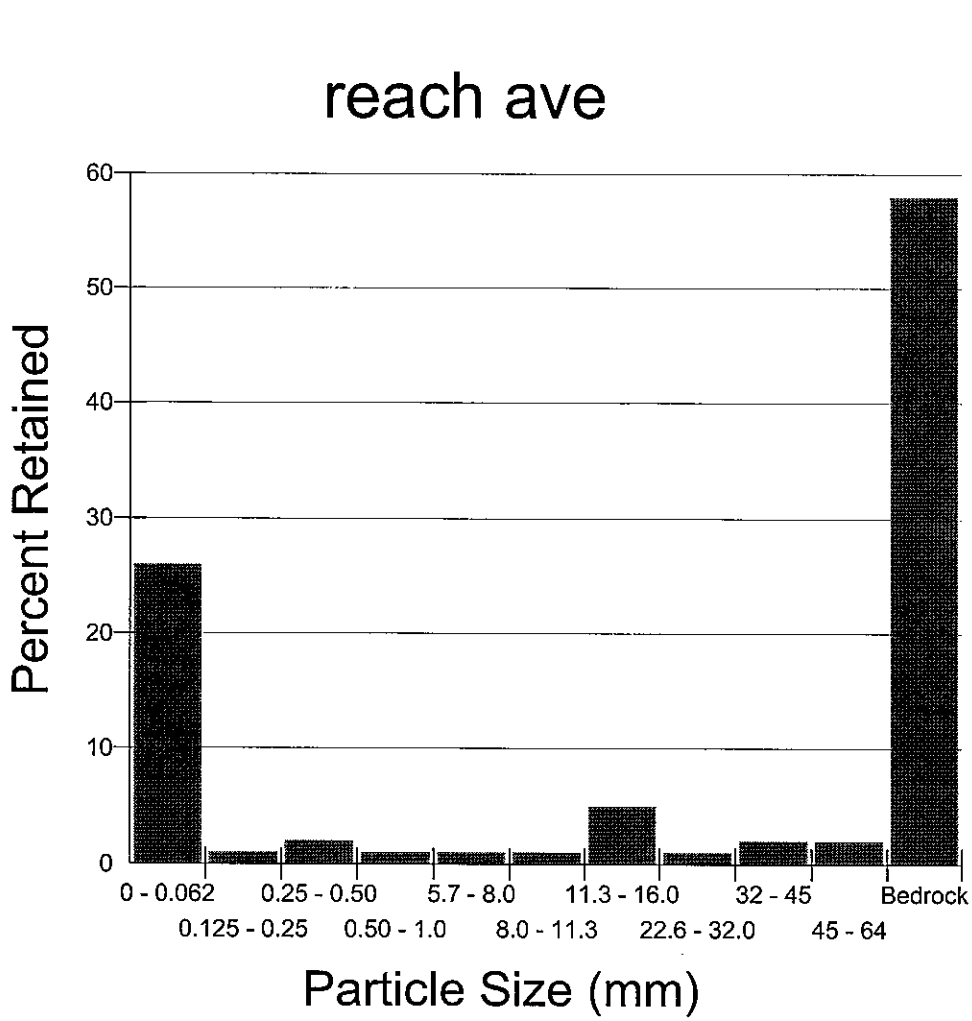
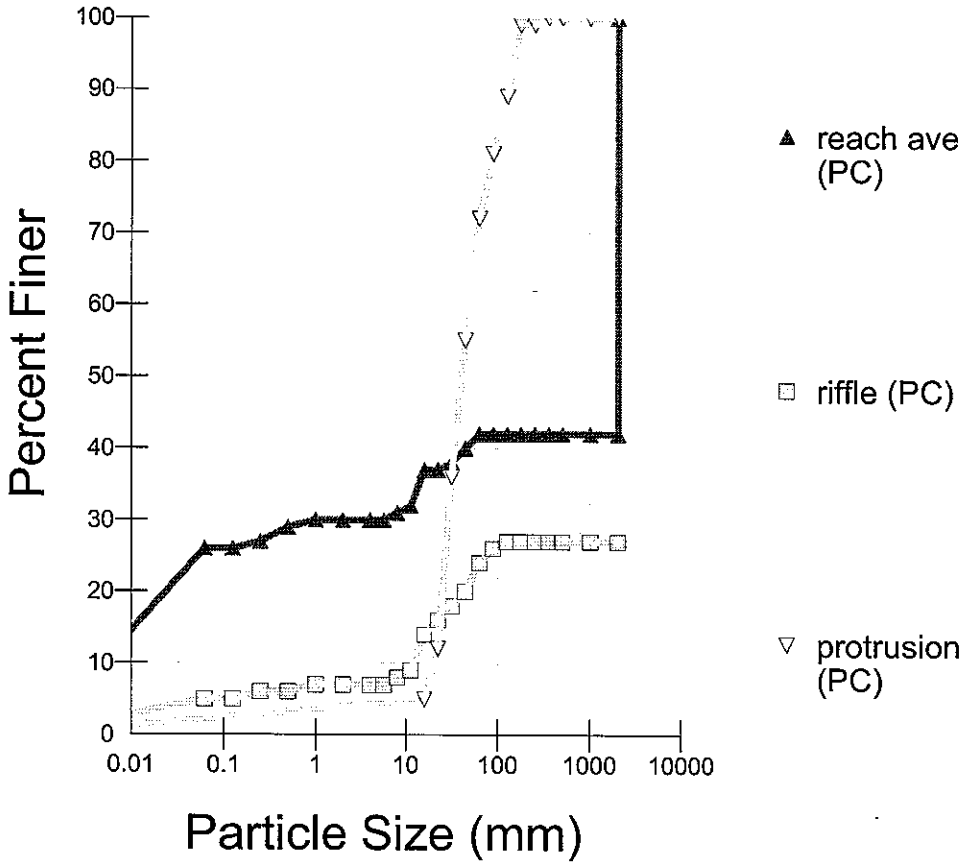
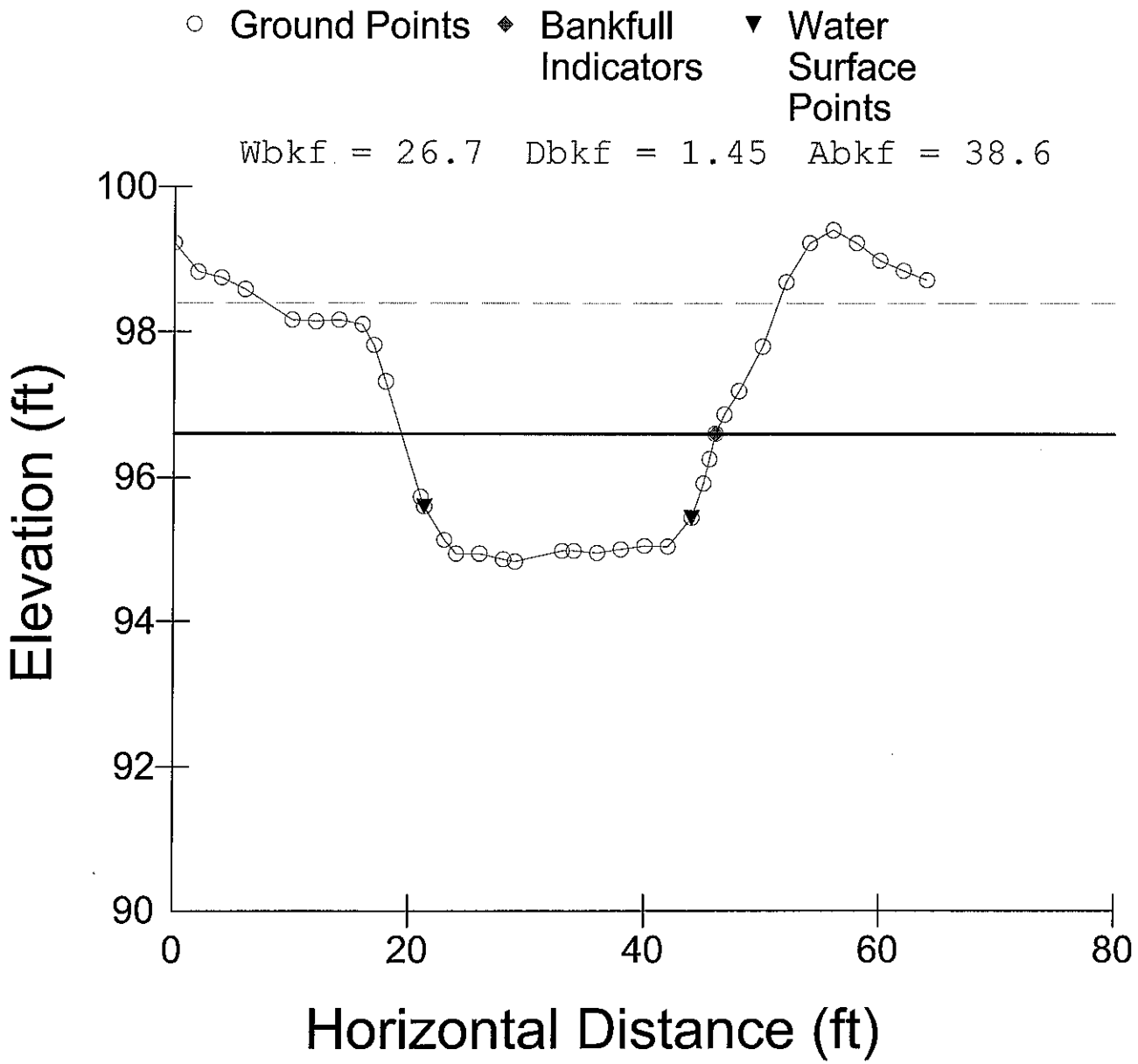

reach ave
Percent Retained
60
50
40
30
20
10
0
0 - 0.062
0.125 - 0.25
0.25 - 0.50
0.50 - 1.0
5.7 - 8.0
8.0 - 11.3
11.3 - 16.0
22.6 - 32.0
32 - 45
45 - 64
Bedrock
Particle Size (mm)

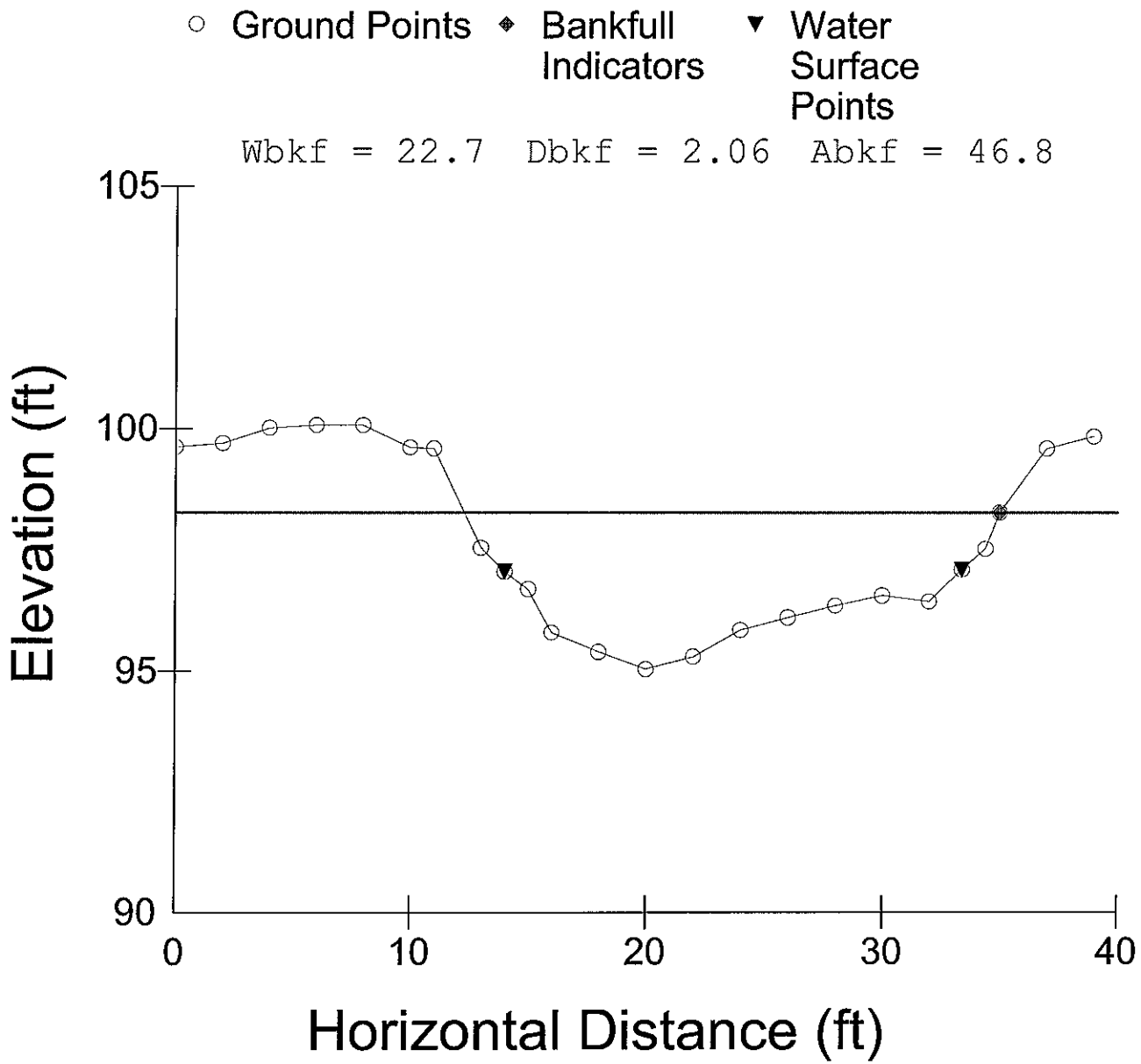
particle size distribution



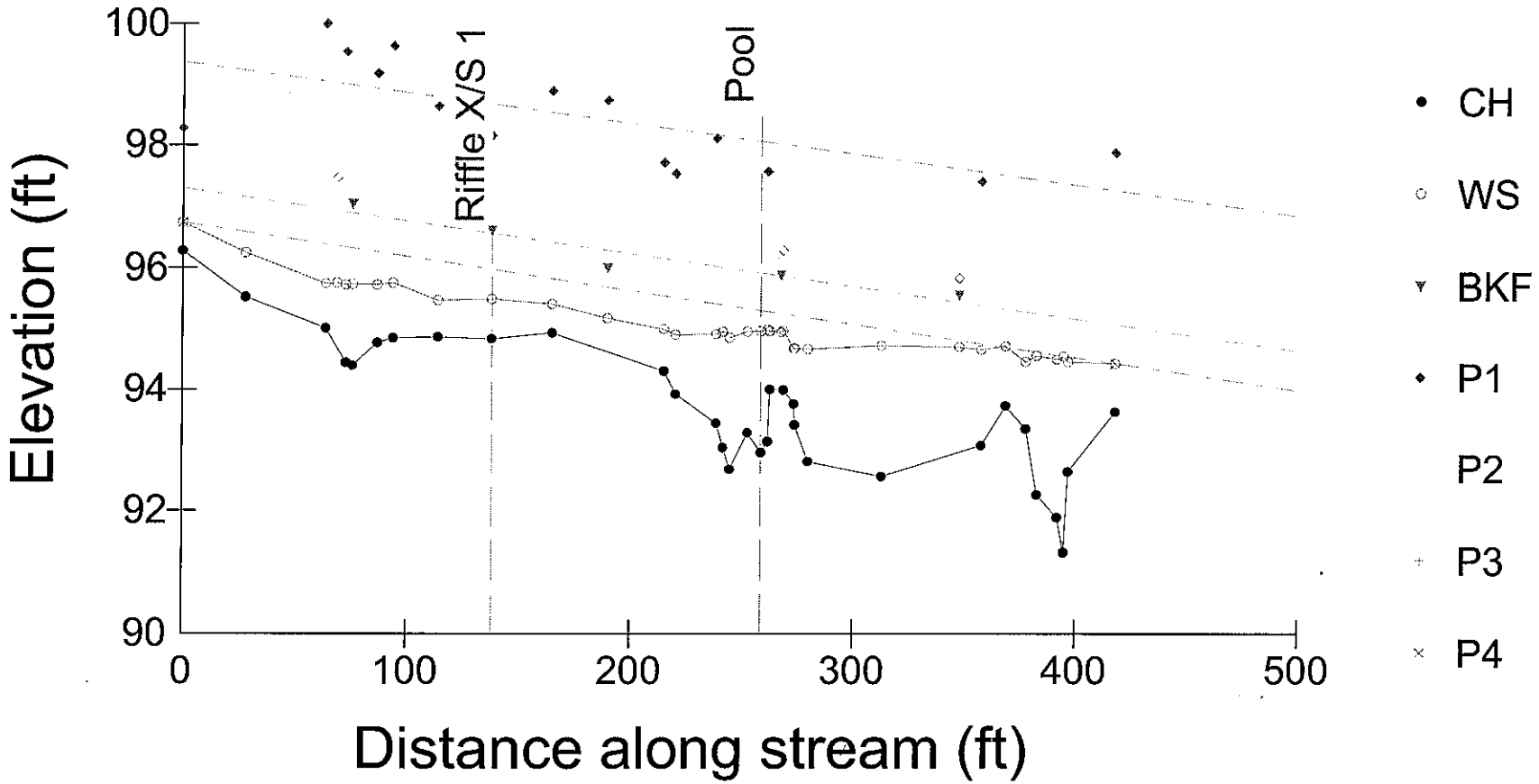
Riffle X/S 1


Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 26.7 Dbkf = 1.45 Abkf = 38.6
100
98
96
94
92
90
Elevation (ft)
0
20
40
60
80
Horizontal Distance (ft)

Pool


Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 22.7 Dbkf = 2.06 Abkf = 46.8
105
100
95
90
Elevation (ft)
0
10
20
30
40
Horizontal Distance (ft)

Team 3


Elevation (ft)
100
98
96
94
92
90
0
100
200
300
400
500
Distance along stream (ft)
Riffle X/S 1
Pool
CH
WS
BKF
P1
P2
P3
P4