Schafer Creek Stream Simulation Practicum

USFS Rd 22 (Wynoochee Rd) crosses the tributary to Schafer Creek about 1.2 miles from the stream's confluence with Schafer Creek and approximately 5 miles from the Wynoochee River. The existing culvert at the crossing is undersized, in a deteriorated condition, and is a partial barrier to anadromous fish at various life stages and flows. The culvert is a round corrugated pipe with a diameter of 1.52 m (6 ft) diameter and a length of 30.5 m (100 ft) long corrugated pipe. There is a 0.4 to 0.5 m drop at the culvert outlet, high velocities in the culvert, sediment accumulation at the culvert inlet, and the sharp channel bend at the culvert inlet.

From field surveys and local fish biologist knowledge, existing fish passage needs at the crossing include adult and juvenile steelhead trout, coho salmon, and resident cutthroat trout. Between the USFS Rd 22 crossing and a railroad culvert barrier upstream there is approximately 0.30 km of spawning and rearing habitat for adult and juvenile steelhead trout, coho salmon, and resident cutthroat trout. Habitat quality in the stream is in good condition.

A wedge of gravel/cobble-sized sediments has accumulated upstream of the culvert. There is a deep plunge pool at the culvert outlet and the downstream channel has incised about 0.5 to 1.0 m. This conclusion is based on evidence such as increased bank heights, undercut banks, and localized bank failures. There is no evidence of channel incision upstream.

Schafer Creek information provided:

A. Schafer Creek background information
B. Photos
C. Plan sketch map
D. Plan contour map
E. Surveyed longitudinal profile
F. Surveyed channel cross-sections
G. Pebble count data at 4 cross-sections
H. Hydrology

These steps have already been completed:

A. Site assessment survey: geomorphic characteristics, topo survey, longitudinal profile, pebble count

B. Site data assessed: channel cross sections, channel-bed material, channel responses

C. Project profile and alignment have been selected

Tasks to be completed:

D. Design bed mix, key features, and bed/bank or edge structure

E. Design the initial stream sim channel

F. Modify bed design with mobility analysis

G. Make initial estimate of width of new culvert. Determine floor and soffitt elevations of new culvert

D - Design bed mix, key features, and bed/bank or edge structure

Reference Reach Bed Material Size

Particle sizes were measured using the grid count method at 4 locations (XS2, XS4, XS10, XS11).

a. **Calculate and plot the particle-size distribution for cross-section XS11. Use the particle distribution graph form. From the graph, determine the D95, D84, and D50 particle sizes for the cross section. Fill in the first part of the Reference Reach Bed Material table on page 3 of the Stream Simulation Design Data Checklist.**

b. Compare how the bed material sizes vary upstream and downstream of the crossing. Why do they vary?

c. XS11 is chosen as the reference reach. What are the characteristics that make it suitable and for the reference reach.

d. Describe the geomorphic controls influencing the particle sizes and their affect on particle size distribution along the channel.

e. Are there key features present near XS10 and XS11? Fill in the first part of the Reference Reach Bed Material table on page 3 of the Stream Simulation Design Data Checklist.

Bed material design

f. Provide an initial recommendation for grain size mix of the alluvial portion of the stream simulation bed. Use the Fuller-Thompson equation for fines. Fill in the Stream Simulation Bed Material table on page 4 of the Stream Simulation Design Data Checklist.

g. Provide an initial recommendation for the sizes of key pieces, bank material, and rock bands. Describe spacing and size of these features. Fill in the Additional Features table on page 5 of the Stream Simulation Design Data Checklist.

h. Make a preliminary recommendation for structure or bed material that will compensate for any colluvium and other roughness elements you observed in the reference reach.

E - Stream Sim Channel

Channel width

a. Chose the width of the stream simulation channel. Make it equal to the bankfull width of the reference reach.

F - Bed Mobility / Stability Analysis

Stability of the stream simulation alluvial bed material

a. Estimate the flow at which D84 is mobilized in the reference channel. Use XS-11 as the reference reach.

b. What combination of bed material, bed width, and slope in the stream simulation channel will cause D84 to be moved at that flow?

c. Are there other flows that should be modeled for mobility?

Key pieces

d. Estimate the size of key pieces such as bank for the stream simulation channel.

e. Chose design flow recurrence and estimate the discharge for design of the key pieces.

f. Calculate the size of material needed.

G - Initial Estimate of Culvert Width and Floor and Soffitt Elevations

Culvert width

a. Based on channel cross-sections and bed design, make a first estimate of the culvert width.

Culvert elevations

b. From the vertical adjustment potential shown in the long profile and the bed material design, select the elevation of the floor of the culvert at the outlet.

B1. Photographs of site.


XS2-XS3; ds view of channel, XS3


XS2-XS3; ds view of channel, XS3


XS2-XS3; us view of pool btwn XS2-XS3


S3-XS4; ds view of channel, XS4, XS5, and debris jam

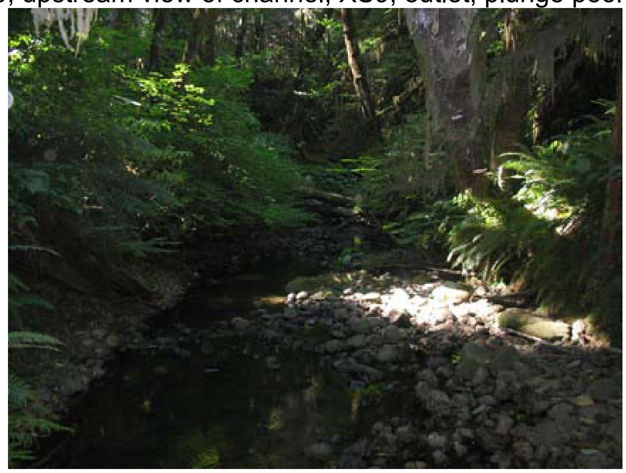

XS7; ds view of channel, XS8, inlet

B2. Photographs of site (continued).

XS11; upstream view of channel, flagging delineates XS10

XS9-XS10; upstream view of channel, XS9, outlet, plunge pool

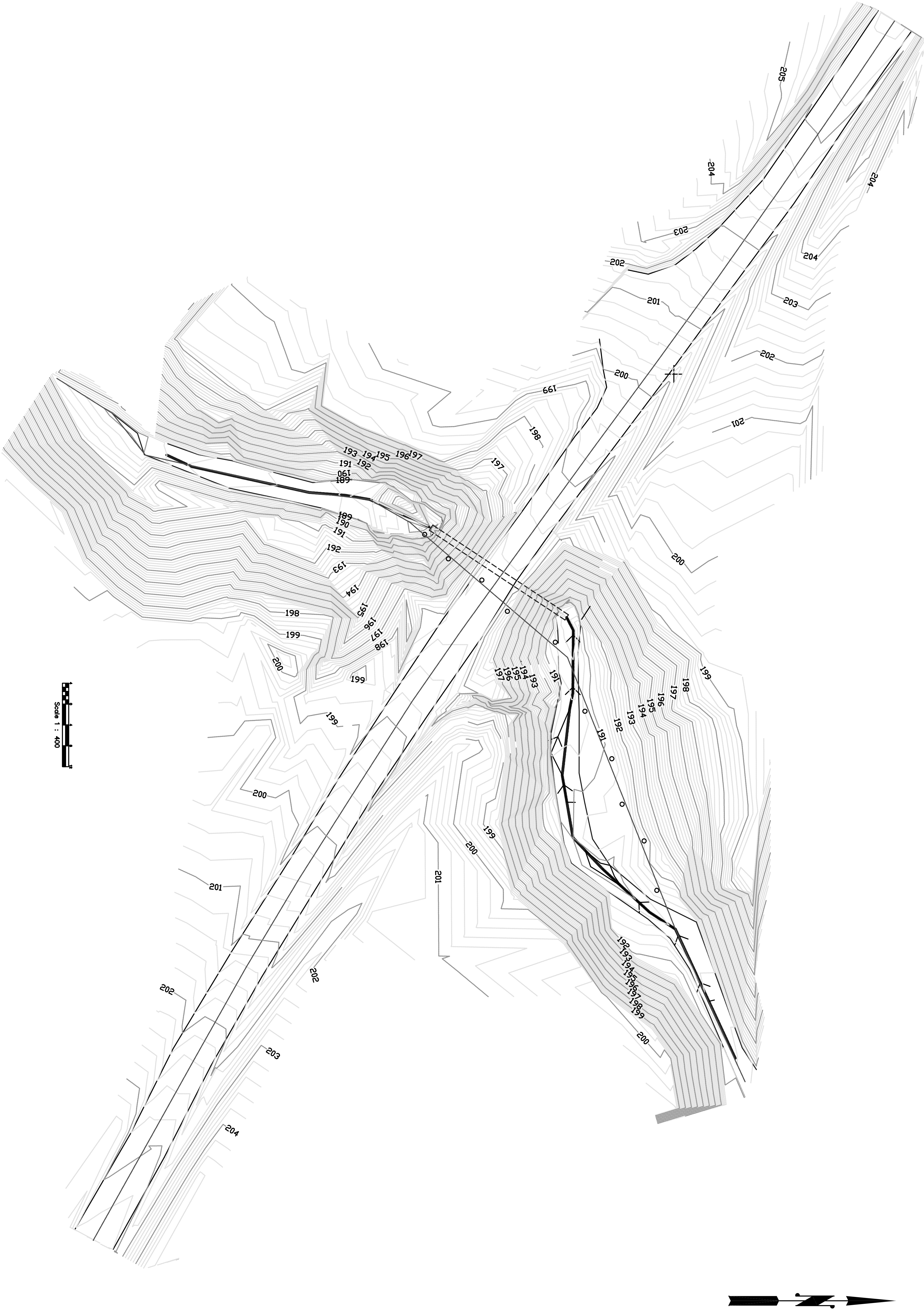
XS10; us view of channel, XS9, plunge pool, outlet



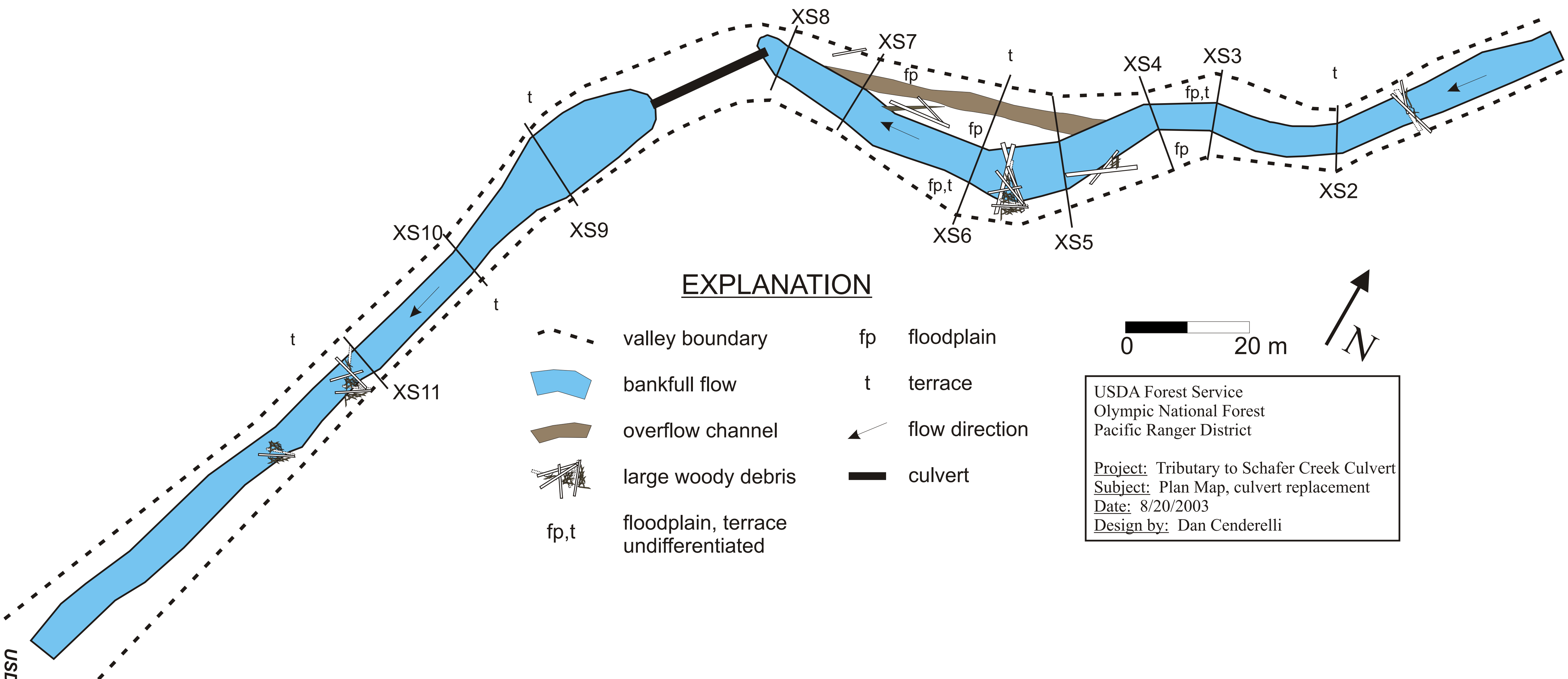
XS10; ds view of channel, XS11, debris jam

XS10; closeup of channel bed at XS10

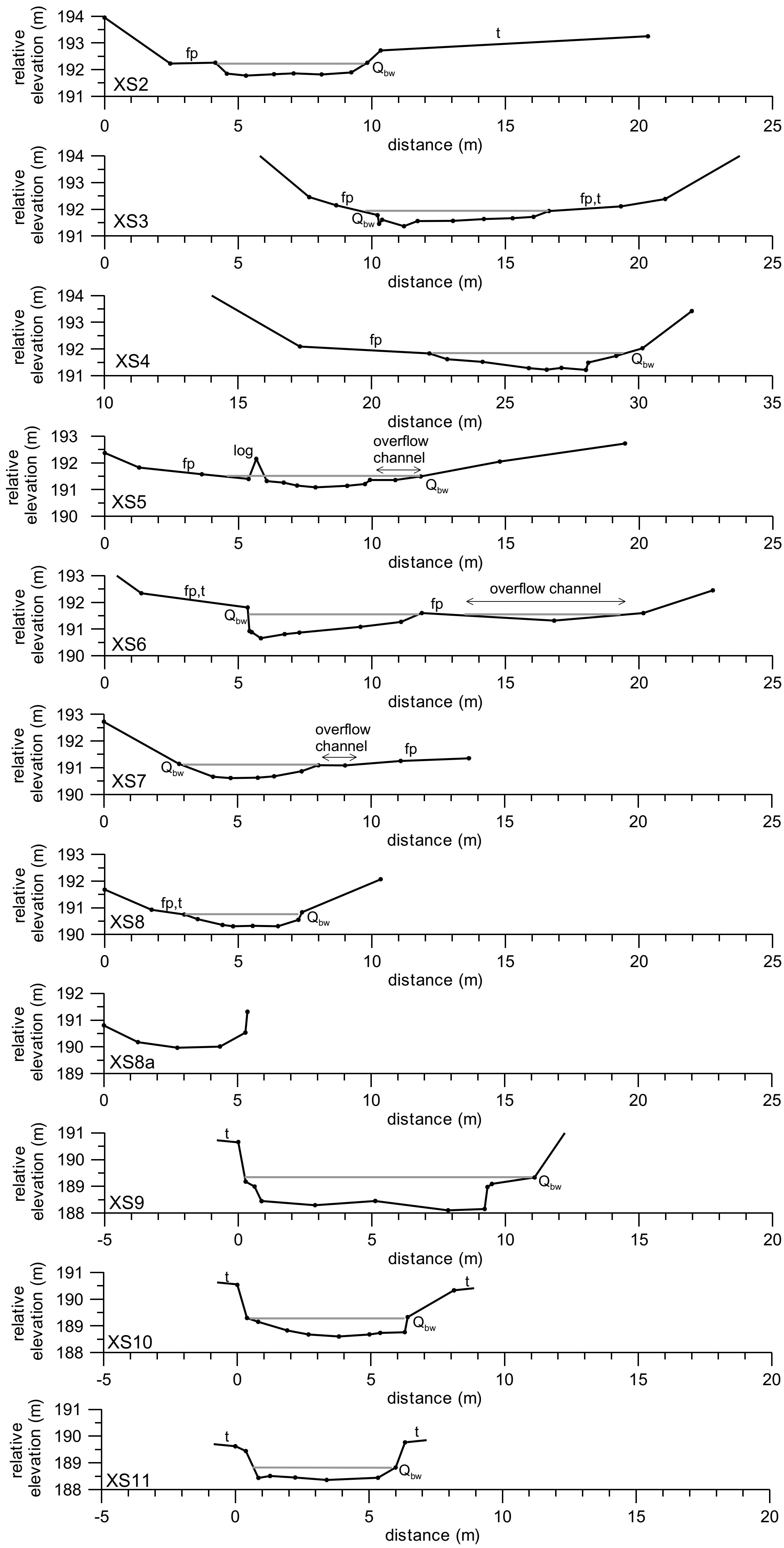
XS11; downstream view of channel and debris jam from XS11


Scale 1 : 400

C. Schafer Tributary Plan Map



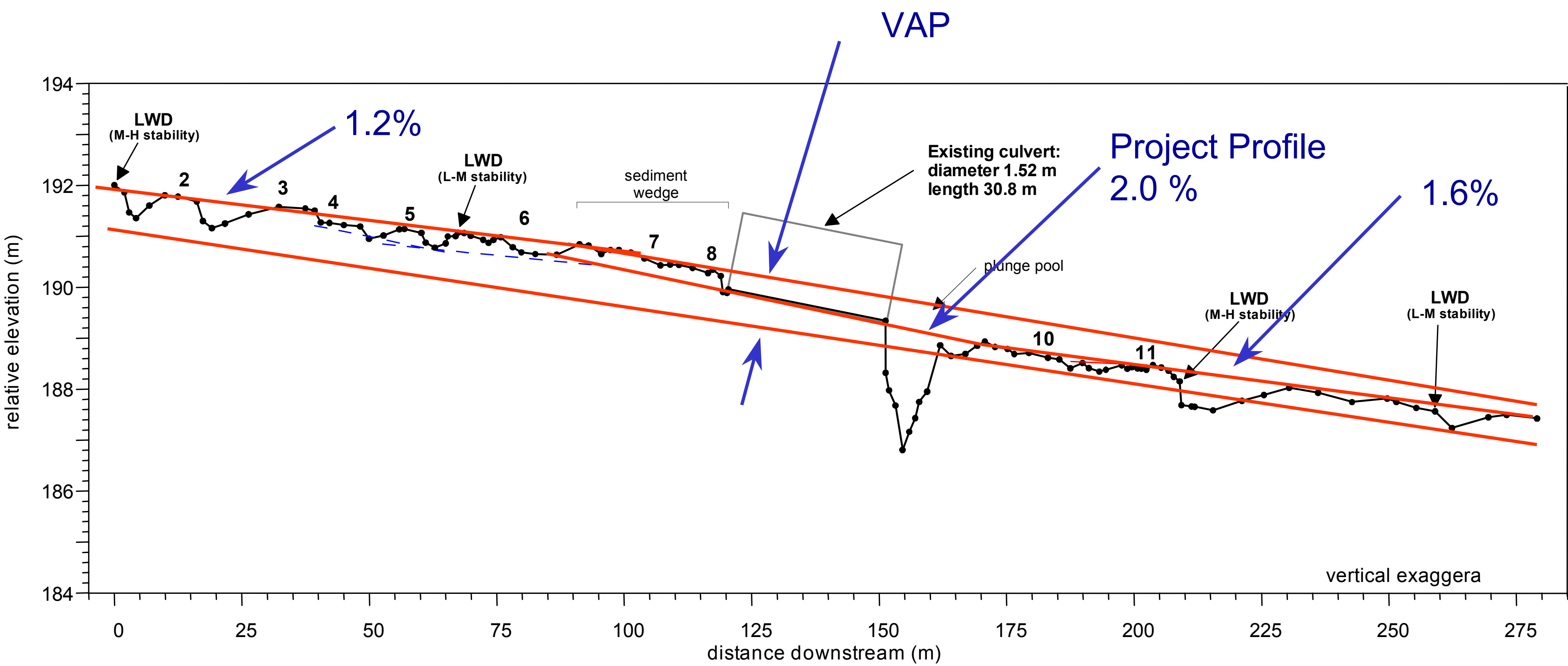
F. Schafer Tributary Plan Map



scale: 1 cm = 1.97 m
no vertical exaggeration
XS scale is 4x larger than plan map scale

Explanation

Q_{bw}	bankfull flow width
fp	floodplain
fp,t	floodplain, terrace undifferentiated
t	terrace



VAP
1.2%
Project Profile
2.0 %
1.6%
LWD
(M-H stability)
LWD
(L-M stability)
sediment
wedge
Existing culvert:
diameter 1.52 m
length 30.8 m
plunge pool
2
3
4
5
6
7
8
10
11
relative elevation (m)
distance downstream (m)
vertical exaggera

E<<

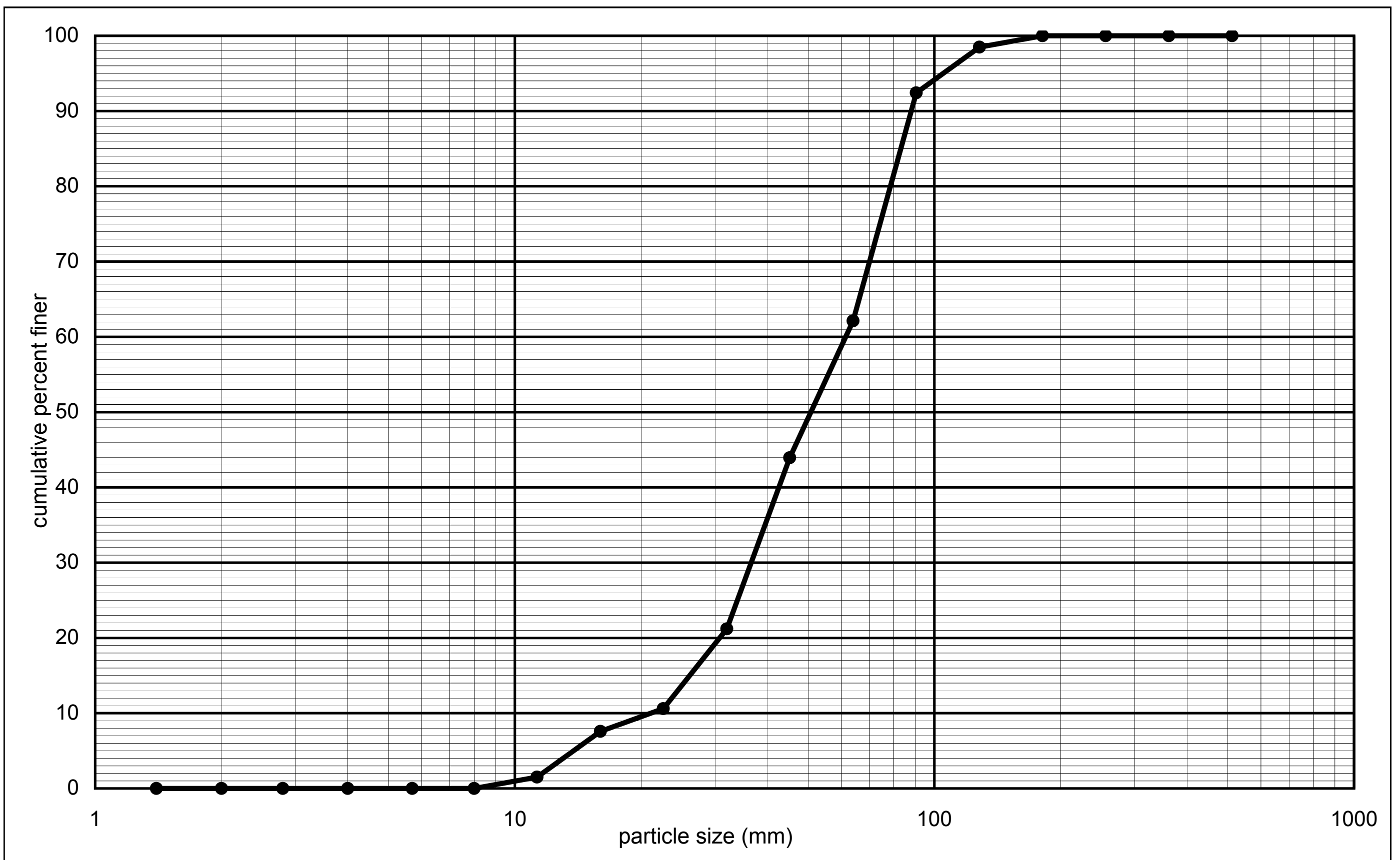
G1. Schafer Tributary pebble count data, XS2 site location.

particle size interval name	size interval (mm)	count or frequency	percent frequency	cumulative percent finer
medium boulders	512 to 724			100
	362 to 512			100
small boulders	256 to 362			100
	181 to 256			100
large cobbles	128 to 181	1	2	98
	90.5 to 128	4	6	92
small cobbles	64.0 to 90.5	20	30	62
	45.2 to 64.0	12	18	44
very coarse gravel	32.0 to 45.2	15	23	21
	22.6 to 32.0	7	11	11
coarse gravel	16.0 to 22.6	2	3	8
	11.3 to 16.0	4	6	2
medium gravel	8.0 to 11.3	1	2	
	5.7 to 8.0			
fine gravel	4.0 to 5.7			
	2.8 to 4.0			
very fine gravel	2.0 to 2.8			
sand, silt, or clay	< 2			
	Total count	66	100	

Project Name:	Schafer Tributary
Sample ID:	PC (XS2 channel, 8-20-03)
Sample Date:	8/20/2003
Sampler Name:	Cenderelli
Sample Locaton:	Riffle just ds from XS2
Sample Method:	grid method, 15 cm interval, 1 m spacing between transects, perpendicular to flow, bankfull.

percentile	particle size (mm)
d95	100
d84	85
d50	52
d16	27
d5	13

% boulders	
% cobbles	
% gravels	
% sands,silts,clays	



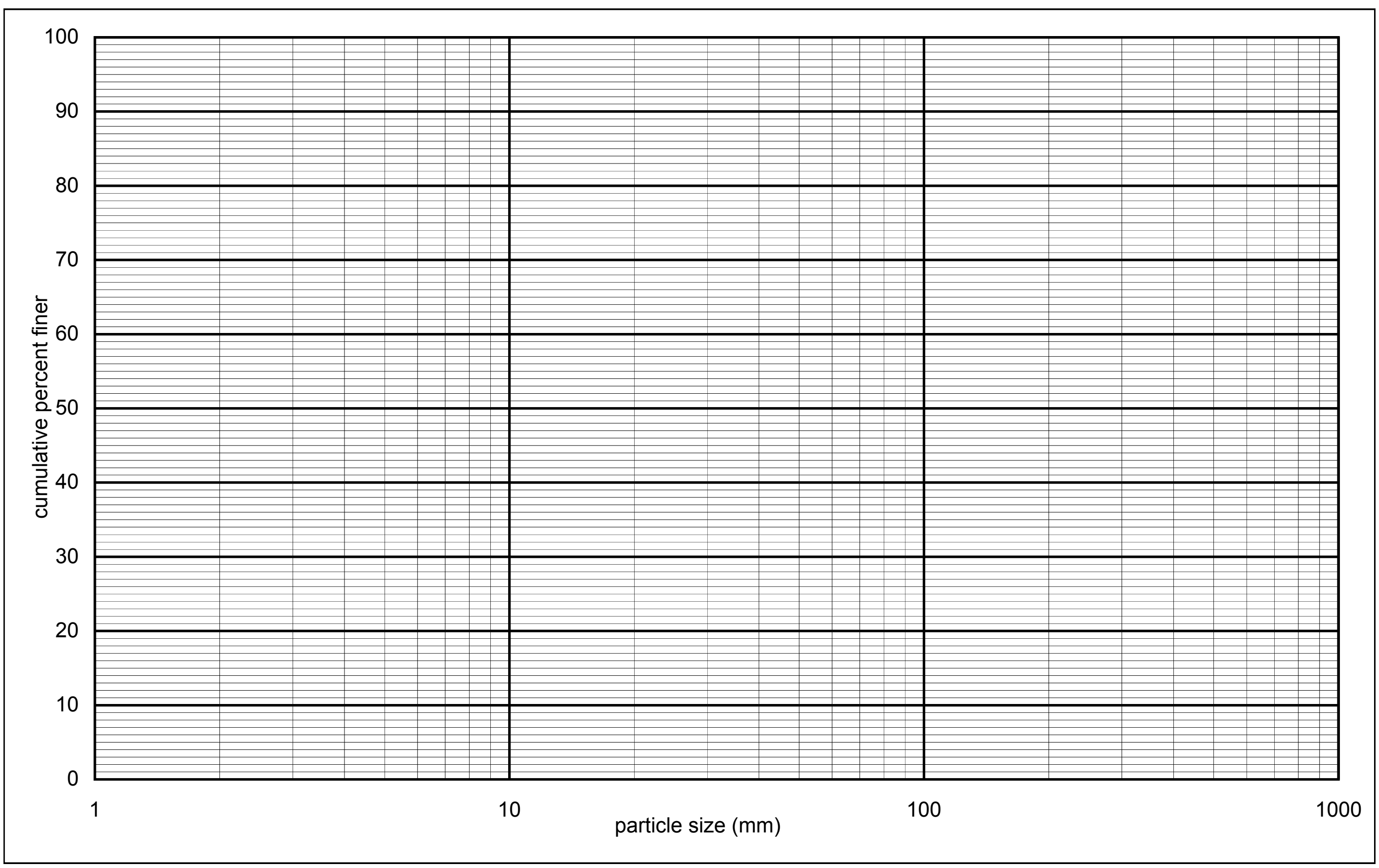
G5. Schafer Tributary pebble count data, XS11 site location.

particle size interval name	size interval (mm)	count or frequency	percent frequency	cumulative percent finer
medium boulders	512 to 724	2		
	362 to 512			
small boulders	256 to 362	1		
	181 to 256	3		
large cobbles	128 to 181	16		
	90.5 to 128	12		
small cobbles	64.0 to 90.5	11		
	45.2 to 64.0	7		
very coarse gravel	32.0 to 45.2	6		
	22.6 to 32.0	2		
coarse gravel	16.0 to 22.6			
	11.3 to 16.0	2		
medium gravel	8.0 to 11.3			
	5.7 to 8.0			
fine gravel	4.0 to 5.7			
	2.8 to 4.0			
very fine gravel	2.0 to 2.8	2		
sand, silt, or clay	< 2	1		
	Total count	65		

Project Name:	Schafer Tributary
Sample ID:	PC (XS11 channel, 8-22-03)
Sample Date:	8/22/2003
Sampler Name:	Cenderelli
Sample Locaton:	Riffle at XS11
Sample Method:	grid method, 20 cm interval, 1 m spacing between transects, perpendicular to flow, bankfull.

percentile	particle size (mm)
d95	
d84	
d50	
d16	
d5	

% boulders	
% cobbles	
% gravels	
% sands,silts,clays	



Trib to Schafer Creek
Hydrology

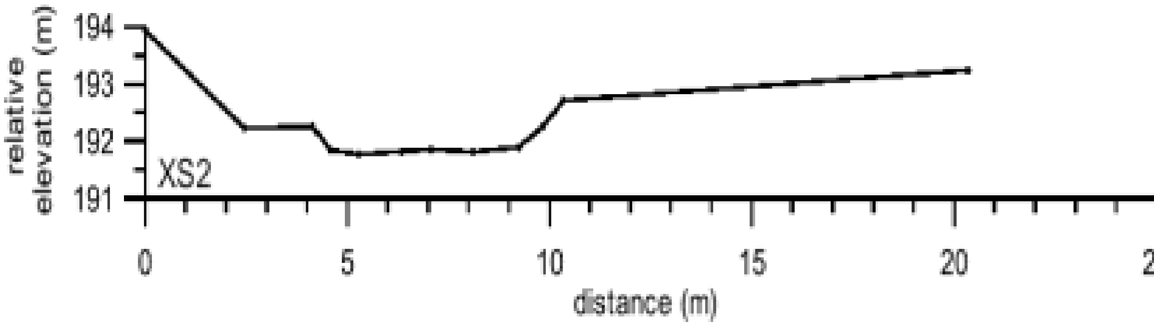
Hydrology
Using Washington State Magnitude and Frequency of Floods, USGS

$Q = aA^b P^c$

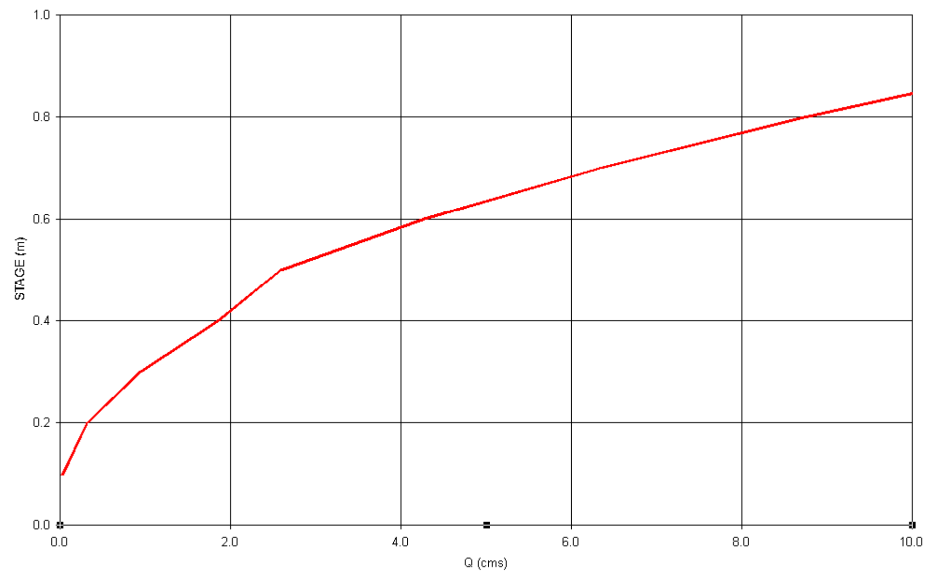
Q = flow (cfs)
A = basin area (sq miles)
P = mean annual precipitation (inches)
a, b, c = regression coefficients

Trib to Schafer Creek
Drainage area: A = 1.16 sq miles
Mean annual precip: P = 130 inches

Recurrence interval	a	b	c	**Q (cms)**	Std Error (%)
2	0.350	0.923	1.240	**4.22**	32
10	0.520	0.921	1.260	**6.66**	33
25	0.590	0.921	1.260	**7.83**	34
50	0.666	0.921	1.260	**8.84**	36
100	0.745	0.922	1.260	**9.89**	37

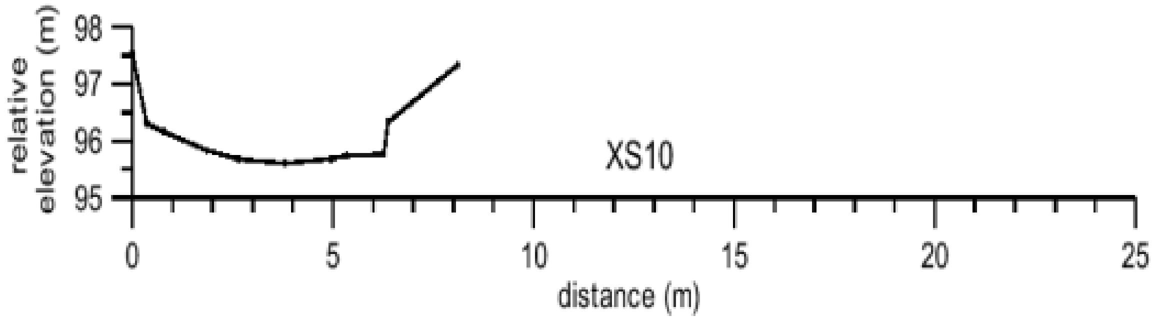


Sta	Elev
0.0	193.9
2.5	192.2
4.1	192.3
4.6	191.8
5.3	191.8
6.3	191.8
7.1	191.9
8.1	191.8
9.2	191.9
9.8	192.3
10.3	192.7
20.3	193.2



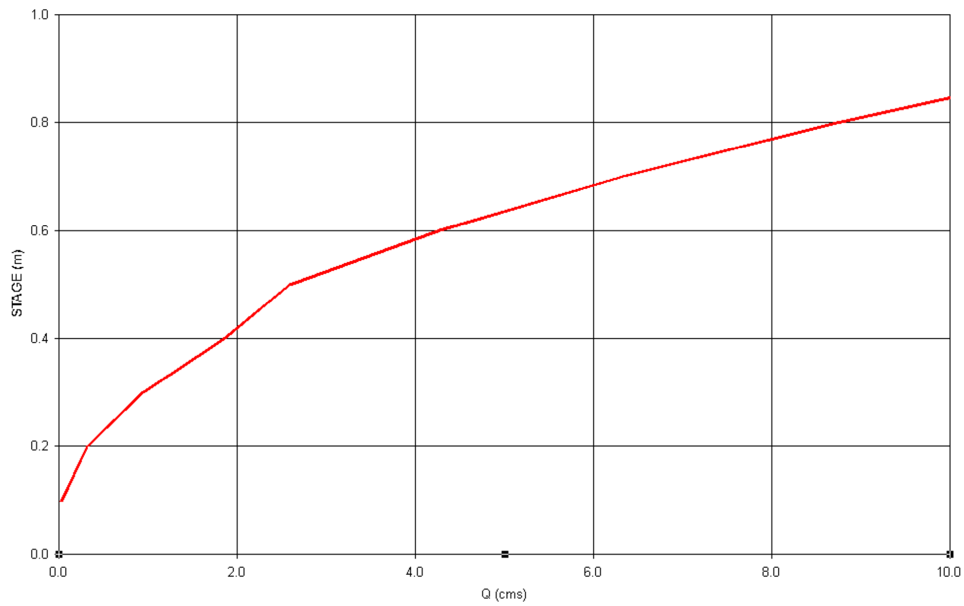
X-Section 2
Win XSPro results

STAGE (m)	AREA (sq m)	PERIM (m)	WIDTH (m)	R (m)	DHYD (m)	SLOPE (m/m)	n	VAVG (m/s)	Q (cms)	SHEAR (N/sq m)	FROUDE
0.10	0.20	4.31	4.29	0.05	0.05	0.015	0.102	0.15	0.03	6.69	0.23
0.20	0.67	4.98	4.90	0.13	0.14	0.015	0.070	0.46	0.31	19.72	0.40
0.30	1.17	5.32	5.17	0.22	0.23	0.015	0.056	0.80	0.94	32.38	0.54
0.40	1.70	5.66	5.45	0.30	0.31	0.015	0.051	1.09	1.85	44.22	0.62
0.50	2.31	7.74	7.45	0.30	0.31	0.015	0.049	1.12	2.59	43.93	0.64
0.60	3.07	8.06	7.70	0.38	0.40	0.015	0.046	1.39	4.27	55.99	0.70
0.70	3.85	8.38	7.95	0.46	0.48	0.015	0.045	1.64	6.33	67.56	0.75
0.80	4.66	8.70	8.20	0.54	0.57	0.015	0.043	1.87	8.73	78.70	0.79
0.90	5.49	9.03	8.45	0.61	0.65	0.015	0.042	2.09	11.47	89.46	0.83
1.00	6.38	10.32	9.70	0.62	0.66	0.015	0.042	2.14	13.63	90.85	0.84
1.10	7.45	12.38	11.72	0.60	0.64	0.015	0.041	2.12	15.77	88.47	0.85
1.20	8.72	14.44	13.74	0.60	0.63	0.015	0.041	2.14	18.69	88.82	0.86
1.30	10.20	16.49	15.77	0.62	0.65	0.015	0.041	2.20	22.41	90.89	0.87
1.40	11.87	18.5	17.79	0.64	0.67	0.015	0.040	2.27	26.98	94.11	0.89
1.50	13.75	20.14	19.34	0.68	0.71	0.015	0.040	2.40	32.96	100.38	0.91



Sta	Elev
0.000	97.540
0.360	96.300
0.780	96.158
1.864	95.837
2.663	95.682
3.802	95.606
4.943	95.687
5.347	95.742
6.264	95.768
6.373	96.331
8.108	97.335

X-Section 10
Win XSPro results



STAGE (m)	AREA (sq m)	PERIM (m)	WIDTH (m)	R (m)	SLOPE (m/m)	n	VAVG (m/s)	Q (cms)	SHEAR (N/sq m)	FROUDE
0.10	0.14	2.53	2.52	0.06	0.015	0.155	0.12	0.02	8.14	0.16
0.20	0.49	4.27	4.22	0.11	0.015	0.103	0.28	0.14	16.75	0.26
0.30	0.93	4.77	4.62	0.19	0.015	0.066	0.63	0.59	28.65	0.45
0.40	1.41	5.22	4.98	0.27	0.015	0.072	0.71	1.00	39.69	0.43
0.50	1.93	5.68	5.33	0.34	0.015	0.065	0.92	1.77	49.89	0.49
0.60	2.48	6.11	5.67	0.41	0.015	0.060	1.11	2.75	59.61	0.54
0.70	3.06	6.51	5.96	0.47	0.015	0.057	1.29	3.96	69.10	0.58
0.80	3.66	6.79	6.13	0.54	0.015	0.055	1.48	5.42	79.34	0.61
0.90	4.28	7.09	6.33	0.60	0.015	0.053	1.65	7.07	88.86	0.64
1.00	4.93	7.39	6.53	0.67	0.015	0.052	1.81	8.92	98.01	0.67
1.10	5.59	7.69	6.73	0.73	0.015	0.051	1.96	10.96	106.82	0.69
1.20	6.27	8.00	6.93	0.78	0.015	0.050	2.10	13.19	115.33	0.71
1.30	6.98	8.30	7.13	0.84	0.015	0.049	2.24	15.62	123.58	0.72
1.40	7.70	8.60	7.33	0.89	0.015	0.048	2.37	18.24	131.58	0.74
1.50	8.44	8.90	7.53	0.95	0.015	0.048	2.49	21.05	139.37	0.75

Stream Simulation bed by Bathurst critical unit discharge

Reference channel | **Stream sim channel**

$$Q_{c84} = \left[\frac{0.15 g^{0.5} D_{50}^{1.5}}{S^{1.12}}\left(\frac{D_{84}}{D_{50}}\right)^{b}\right] w + Q_{FP}$$

equals

$$Q_{c84} = \left[\frac{0.15 g^{0.5} D_{50}^{1.5}}{S^{1.12}}\left(\frac{D_{84}}{D_{50}}\right)^{b}\right] w + Q_{FP}$$

$$b = 1.5\left[\frac{D_{16}}{D_{84}}\right]$$

$$b = 1.5\left[\frac{D_{16}}{D_{84}}\right]$$

Given

Reference channel:

D95		mm
D84		mm
D50		mm
D16		mm
S		%
w		m active channel width
Qfp	0	cms active floodplain flow
g	9.8	m/s/s

Stream sim channel:

	Initial est		Multiplier	Resulting	
D95		mm	1.00	0	mm
D84		mm		0	mm
D50		mm		0	mm
D16		mm		0	mm
S		%			
w		m active channel width			
Qfp	0	cms active floodplain flow			
g	9.8	m/s/s			

Compare Q ____________ cfs | ____________ cms

D = particle median diameter
S = energy slope
w = active channel width
Qfp = floodplain flow

- Assumes D84 mobility equal in both channels
- Change variables to make total flow equal in both channels

CAUTION: Review Corps and Maynard references for limitations of source data

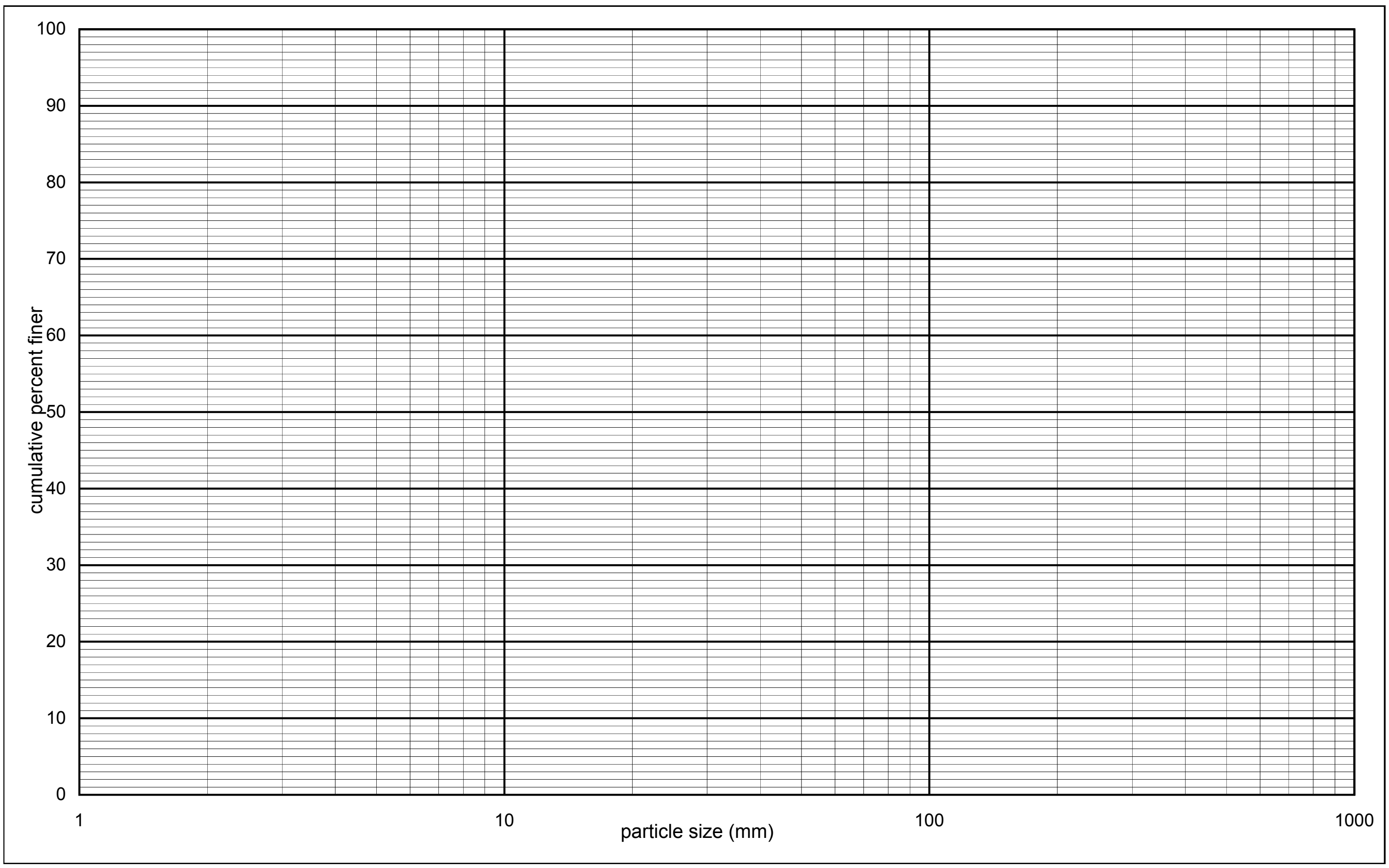
Stream / Location:

particle size interval name	size interval (mm)	tally	count	percent frequency	cumulative percent finer
Bedrock					
medium boulders	512 to 724				
	362 to 512				
small boulders	256 to 362				
	181 to 256				
large cobbles	128 to 181				
	90.5 to 128				
small cobbles	64.0 to 90.5				
	45.2 to 64.0				
very coarse gravel	32.0 to 45.2				
	22.6 to 32.0				
coarse gravel	16.0 to 22.6				
	11.3 to 16.0				
medium gravel	8.0 to 11.3				
	5.7 to 8.0				
fine gravel	4.0 to 5.7				
	2.8 to 4.0				
very fine gravel	2.0 to 2.8				
sand, silt, or clay	< 2				
	Total count			100.00	

Project Name:	
Sample ID	
Sample Date	
Sampler Name	
Sample Locaton	
Sample Method	

Particle sizes from plotted data (mm)	
D95	
D84	
D50	
D16	
D5	

Sample site descriptions by observation	
Channel type	
D100 (mm)	
Colluvium	
Debris	
Other	



Stream Simulation Design Data Checklist

This is a guide and summary for design and review of a stream simulation road / steram crossing. Data is summarized to show design milestones, assumptions, and conclusions. This isn't necessarily all of the data required for a design.

A plan view sketch and a long profile should be attached to this design data form. See the design guide for background for all data and details recommended on sketches.

Project name and ID	
Stream	
Road, location	
ID Team members	
Date	

Long Profile, Plan View Sketch

Provide long profile and plan view sketch on separate sheets.

Is there an existing Culvert(s)? Y / N Length ________ Size ________

Characteristics of pre-project site

Existing culvert perched? Y / N Height of perch ________

Downstream channel incised? Y / N Depth of incision ________

Evidence of incision ____________________

____

Upstream backwater deposition Y / N

Evidence and extent ____________________

____

Downstream segment slopes Average ________ Range ________

Upstream segment slopes Average ________ Range ________

Project ________________________________ Project ID _______________

Date _______________

Proposed Project Profile and Alignment

Show proposed project profile on long profile plot.

Proposed new channel within crossing. Slope ________ Length ________

Upstream channel within project Slope ________ Length ________

Downstream channel within project Slope ________ Length ________

Channel elevations at ends of proposed culvert:

	Downstream end	Upstream end
At low potential profile		
At high potential profile		
At proposed constructed profile		

Proposed culvert skew Channel to culvert (parallel is 0) ________________

Road to culvert (perpendicular is 90) ________________

Proposed alignment, transition changes ____

____

Reference Reach

Description of reference reach

Location of reference reach (e.g.; "150' upstream from crossing)

____

Show location of reference reach on plan view sketch and profile.

Length of reference reach ____________________

Reference reach channel types (e.g.; 75% pool-riffle, 25% plane bed)

____

____

Key bed features, function, and spacing (debris, steps, bends, etc)

____

____

Bed mobilitiy and how it was determined

____

____

Key bank features and frequency

____

____

Reference reach cross sections

Cross section labels and locations			
Bankfull width			
Bankfull depth			
Floodprone width			
Depth to high water mark			

Reference reach slope Average _______________ Range _______________

Reference reach bed material

	Particle size (inches or mm)	How was particle size determined?
D95		
D84		
D50		
D16		
D5		
Fines		

	Size (inches or mm)	Function	Spacing	dh	Permanence, mobility, condition
Debris and live wood					
Colluvium					
Bedrock					
Steps, clusters					

Function: Profile control, Roughness, Confinement, Bank stability

Project Design

Mobility / stability analysis

Purpose of mobility / stability analysis:

Floodplain contraction.
Widths, entrenchment ratio with culvert: ________________

Culvert slope greater than reference reach.
Slopes, ratio (stream simulation / reference): ________________

Culvert length greater than reference reach.
Lengths, ratio (stream simulation / reference): ________________

Design flows

Design Flows	Return period (years)	Flow (cfs or cms)	How was flow estimated, certainty
Floodplain contraction			
Stability of key features			
Flood capacity			
Headwater depth			

Stream simulation bed material

	Particle size (inches or mm)	How was particle size determined? (what model, observations)
D95		
D84		
D50		
D16		
D5		

Additional features if included in the design

	Particle size (inches or mm)	Frequency, spacing	How identified, designed
Bands			
Banklines			
Key features			

Proposed structure

Description, dimensions ______________________________

Span ______________ Rise ______________

Length ______________ Slope ______________

Culvert floor elevations

Upstream end ______________ Downstream end ______________

Headwater depth (and how was it determined)?

At flood capacity flow ______________________________

At headwater depth flow ______________________________

Other special considerations, recommendations ______________________________

____

____

____

____