FALL CREEK

Site Information

Site Location: Willamette NF, S Willamette Valley, Fall Cr Rd west of Eugene

Year Installed: Circa 1999

Lat/Long: 122°22"3.96"W
43°59"56.83"N

Watershed Area (mi²): 3.55

Stream Slope (ft/ft)[1]: 0.0359

Channel Type: Step-pool

Bankfull Width (ft): 21

Survey Date: April 4, 2007

[1]*Water surface slope extending up to 20 channel widths up and downstream of crossing.*

Culvert Information

Culvert Type: Open-bottom arch

Culvert Material: Annular CMP

Culvert Width: 19 ft

Outlet Type: Mitered

Culvert Length: 80 ft

Inlet Type: Mitered

Pipe Slope (structure slope): 0.03

Culvert Bed Slope: 0.037

(First hydraulic control upstream of inlet to first hydraulic control downstream of outlet.)

Culvert width as a percentage of bankfull width: 0.9

Alignment Conditions: Appears to be in good alignment with stream channel.

Bed Conditions: Large cobble to small boulder sized material forming very small steps and plane-bed conditions.

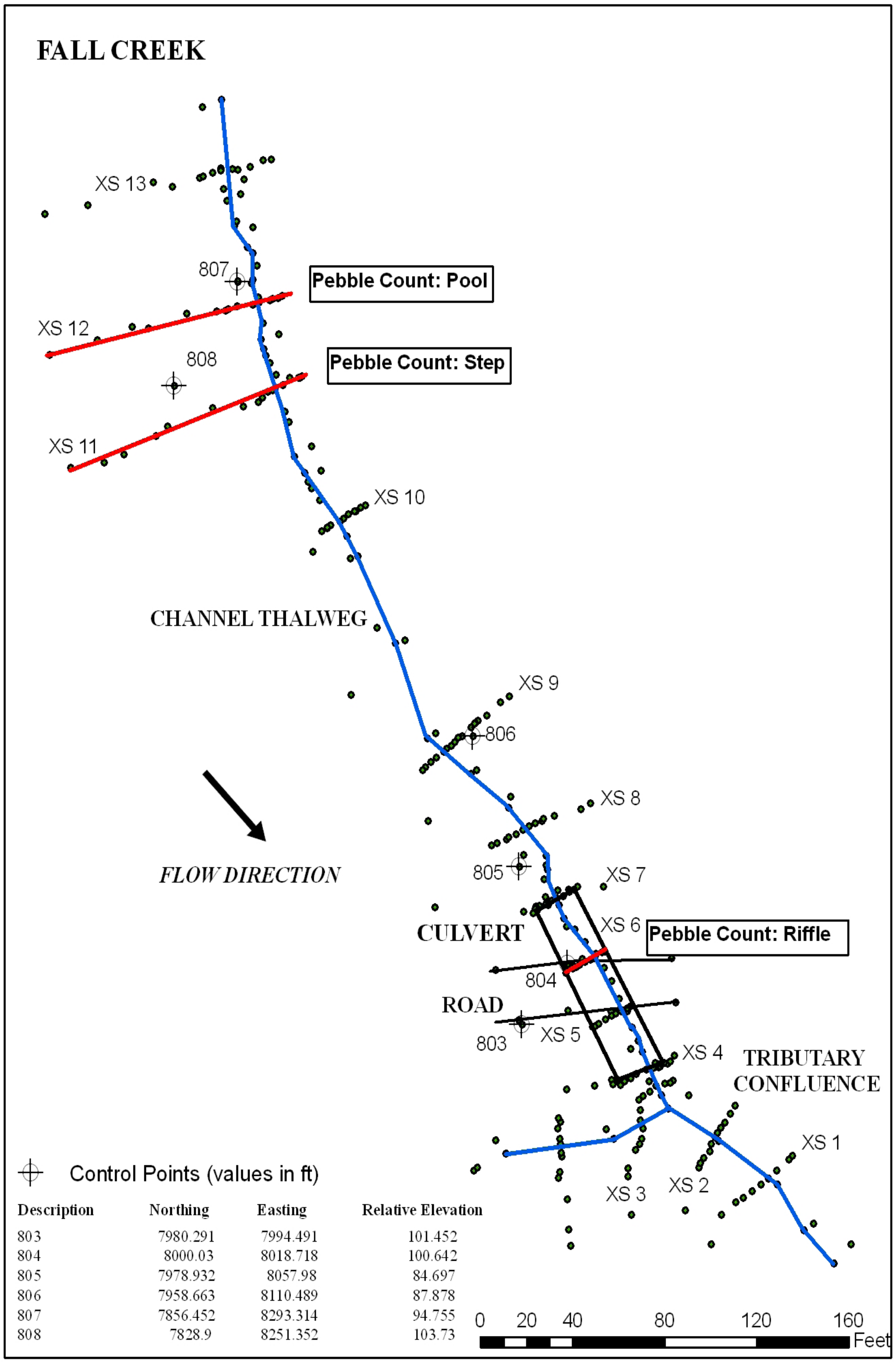
Pipe Condition: Good condition. Minor rust in places.

Hydrology

Discharge (cfs) for indicated recurrence interval

25% 2-yr	Q_{bf}[2]	2-year	5-year	10-year	50-year	100-year
67	180	269	401	491	689	774

[2]*Bankfull flow estimated by matching modeled water surface elevations to field-identified bankfull elevations.*



Description	Northing	Easting	Relative Elevation
803	7980.291	7994.491	101.452
804	8000.03	8018.718	100.642
805	7978.932	8057.98	84.697
806	7958.663	8110.489	87.878
807	7856.452	8293.314	94.755
808	7828.9	8251.352	103.73

Points represent survey points

Figure 1—Plan view map.

HISTORY
There is no information available for site history.

SITE DESCRIPTION
The Fall Creek culvert is a bottomless arch mitered to conform to the slope of the road fill. The bed is composed of sequences of small steps (less than 1 foot in height), but can be considered fairly uniform and plane-bed overall. It is assumed that stable step structures were not constructed within the culvert, although it is possible that constructed bedforms have washed out. Flow was wide and shallow and extended from wall to wall in the culvert at the time of the survey. There are no concentrations of flows (e.g., pools and chutes) as there are in the natural channel. Footings were not visible inside the culvert. Large boulders lined the banks both upstream and downstream of the culvert.

A series of boulder steps/cascades begin just upstream of the culvert and continue through the inlet. Just downstream of the inlet, the gradient flattens. In the pipe, oversized angular bed material creates a riffle interspersed by backwatered pools during low flows. Grade through the culvert is controlled by the downstream aggradation of material. Downstream of this deposition area is a drop in channel elevation, which begins at the outlet.

Most likely as a result of its proximity to a dispersed camping area, roughly 150 feet of the channel upstream of the culvert is impacted by engineered structures, including logs and a riprapped bank. There are a total of approximately eight pieces of large woody debris (LWD) that have been cabled to boulders in this reach. The upstream representative reach is located out of the impact of both the culvert and these impacts. The representative segment is characterized by a bedrock wall along the left bank. The right bank has a small flood plain surface which rises to an active terrace. As a moderate gradient step-pool reach, the upstream reach mainly consists of a bedrock-controlled step followed by a long deep pool and then dropping off into a steep riffle.

There are signs of incision upstream of the culvert inlet. This may be related to the elevation of the culvert inlet or could also be related to the previous installation. The presence of the riprap bank suggests that bank erosion may have been an issue on the right bank upstream of the culvert. This could potentially have been related to backwater-related material deposition upstream of the outlet due to a previous culvert that was undersized for the stream.

SURVEY SUMMARY
Fourteen cross sections and a longitudinal profile were surveyed along Fall Creek in April 2007 to characterize the culvert and an upstream reference reach. No downstream reference reach was established due to the proximity of a tributary. In the culvert, representative cross sections were taken through a riffle and a backwatered pool. Two additional cross sections were surveyed upstream to characterize the inlet as well as the contraction of flow. Another cross section was surveyed downstream of the culvert to characterize the outlet. In order to capture the full expansion of flow, cross sections were surveyed along the tributary upstream of the confluence, at the confluence, and below. Representative cross sections in the upstream reach were taken through a pool and steep riffle. Two additional sections were taken to characterize the upstream and downstream ends of the reach.

PROFILE ANALYSIS SEGMENT SUMMARY
The profile analysis resulted in a total of nine profile segments. Segments upstream of the inlet with similar gradients were not combined in order to keep separate the upstream transition segment (segment E) and to remove a segment influenced by riprap (segment F) from the upstream

representative segments. The culvert consisted of three profile segments. The downstream and upstream segments in the culvert each have comparable gradients to a representative profile segment in the upstream channel. The middle segment in the culvert is comparable to two representative profile segments in the upstream channel. The upstream transition segment was comparable to one representative profile segment in the upstream channel. The downstream transition segment included a portion of the channel downstream of the confluence of the north fork tributary and so was not used for comparative analysis.

SCOUR CONDITIONS

Observed conditions

Footing scour – There was no observed scour undermining footings or threatening structure integrity.

Culvert-bed adjustment – The culvert bed shows no obvious signs of adjustment Some gravel and cobble material appears to have recently aggraded in the pipe but it is unknown whether the bulk of the streambed material observed during the survey was placed in the pipe or recruited from upstream. It is assumed that the larger material found in the culvert (small boulders) was placed there during construction.

Profile characteristics – The profile has a uniform shape through the crossing (figure 2). There is a valley transition in this area where the Fall Creek valley widens as it approaches the tributary junction located just downstream of the culvert.

Residual depths – Culvert-residual depths are at the lower end of the range or lower than residual depths in corresponding profile segments (figure 21).

Substrate – The culvert bed material distribution is similar to the downstream sample site in the upstream channel. The upstream sample in the upstream channel exhibits a greater proportion of sand and bedrock. These differences can be attributed to the habitat unit (pool in the upstream channel) and the location adjacent to a bedrock wall along the left bank. Pebble count data is presented at the end of this site summary.

Predicted conditions

Cross-section characteristics – Cross-section flow characteristics are affected by the culvert, particularly with respect to the width-related measures top width and wetted perimeter (figures 5 through 9 and 12 through 17). This is true for culvert segments (B, C, and D) and the upstream transition segment (E).

Shear stress – Shear stress in the culvert is mostly within the range of that found in the natural channel except for at the downstream end of the culvert where shear stress spikes sharply and the maximum values exceed those in corresponding profile segments (figures 10 and 19). Shear stress in the upstream transition segment (E) is within the range of the corresponding profile segment (G).

Excess shear – The excess shear in the culvert is greater than the excess shear in the natural channel (figure 20). This is mainly attributable to low applied shear values from the model at the sample site in the upstream channel. Critical shear-stress values are similar, and based on the similar range of applied shear-stress values in the culvert and the natural channel, excess shear would be expected to be relatively similar as a whole.

Velocity – Model results suggest that velocity in the culvert is mostly within the range of the natural channel except for at the downstream end of the culvert where velocity rises and values exceed that of corresponding channel profile segments (figures 11 and 18). Velocity in the upstream transition segment (E) is within the range of the corresponding profile segment (G).

Scour summary

There were no signs of scour within the pipe or at inlet or outlet transition areas. Hydraulic modeling suggests that hydraulics are relatively similar between the culvert and the natural channel except at the downstream end of the culvert where velocity and shear stress increase to levels above that found in the upstream channel. These increases may result from expansion losses and an increase in gradient as the channel drops to meet the tributary junction. Scour at the inlet and along the right bank at the upstream transition area is protected by riprap.

AOP CONDITIONS

Cross-section complexity – The sum of squared height differences in the culvert cross sections are smaller than those in the channel cross sections (table 3).

Profile complexity – Vertical sinuosity in the culvert segments are all lower than the values in corresponding profile segments (table 4).

Depth distribution – Depth distribution results indicate that the culvert is at the lower end of the range (0) of the values in the upstream channel (table 5).

Habitat units – The culvert is dominated by one long riffle, whereas the upstream channel exhibits more of a pool-riffle morphology (table 6). The riffles in the upstream channel are steep riffles that could also be characterized as small steps.

Residual depths – Culvert residual depths are at the lower end of the range or lower than residual depths in corresponding profile segments (figure 21).

Substrate – The culvert bed-material distribution is similar to the downstream sample site in the upstream channel. The upstream sample in the upstream channel exhibits a greater proportion of sand and bedrock. These differences can be attributed to the habitat unit (pool in the upstream channel) and the location adjacent to a bedrock wall along the left bank. Pebble count data is presented at the end of this site summary.

Large woody debris – There was no LWD present in the culvert (table 8). The natural channel had low to moderate LWD abundance. LWD formed occasional steps and scour pools in the channel outside the crossing. Some wood was placed and cabled in the stream upstream of the culvert and helped to form steps and to provide habitat complexity in this area. Features in the culvert did not mimic the role of wood in the natural channel.

AOP summary

Complexity measures indicate low cross-section and profile complexity in the culvert. This matches well the site observations of a plane-bed uniform channel through the culvert. The culvert bed does not exhibit the same pool-riffle/step type morphology of the upstream representative channel. There are fewer protruding roughness elements (i.e., boulders) and less pools that may provide velocity refuge for passage of migrating fish. There are also no concentrations of flows (e.g., pools and chutes) as there are in the natural channel. Flow was wide and shallow and extended from wall to wall in the culvert at the time of the survey. Passage may be a concern at low flows because of the large width-to-depth ratio. There are no exposed banks for terrestrial organism passage.

Culvert Scour Assessment

DESIGN CONSIDERATIONS

This installation appears to be a good design with respect to scour resistance. There is material throughout the culvert and no signs of scour in the pipe or at inlet or outlet transition areas. The installation is not as favorable for aquatic organism passage (AOP). The uniform channel and wall-to-wall flow may create conditions in the pipe that are less suitable for AOP than what is found in the upstream representative channel. Creating pool-riffle/step sequences, channel banks, and protruding roughness elements (i.e., boulders) would enhance fish passage at low and high flows and would also allow for passage of terrestrial organisms.

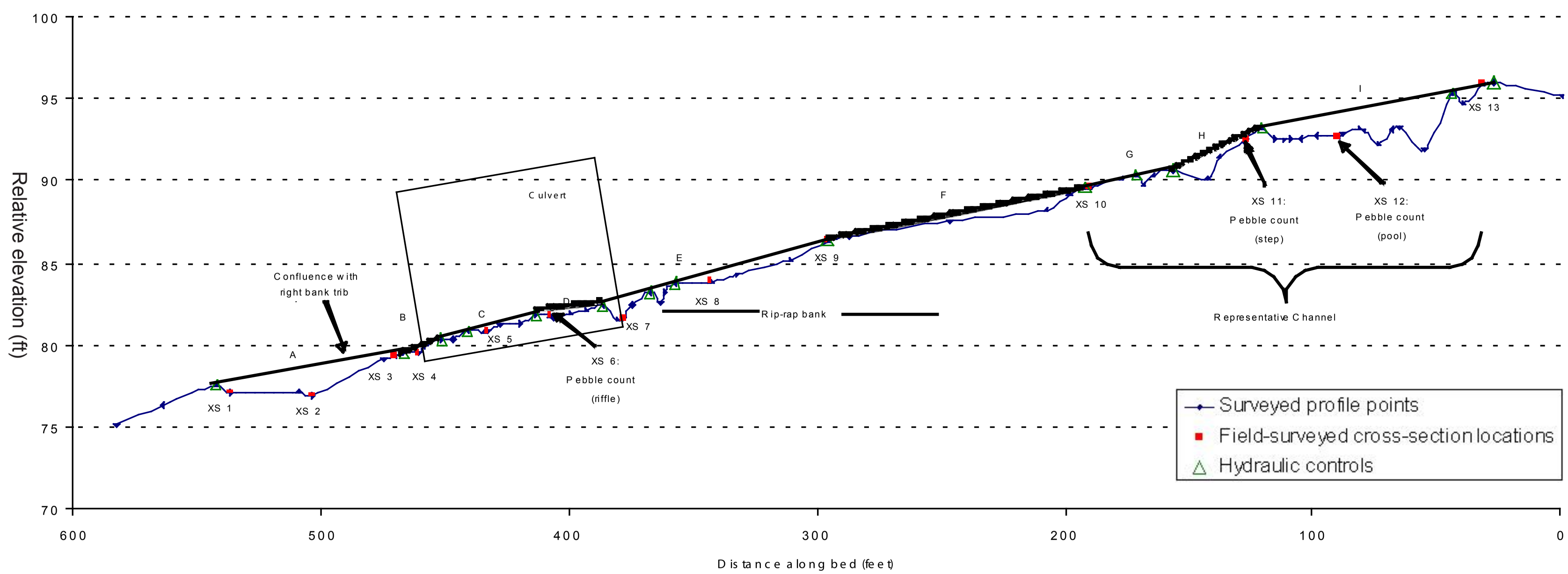


Figure 2—Fall Creek longitudinal profile.

Table 1—Segment Comparisons

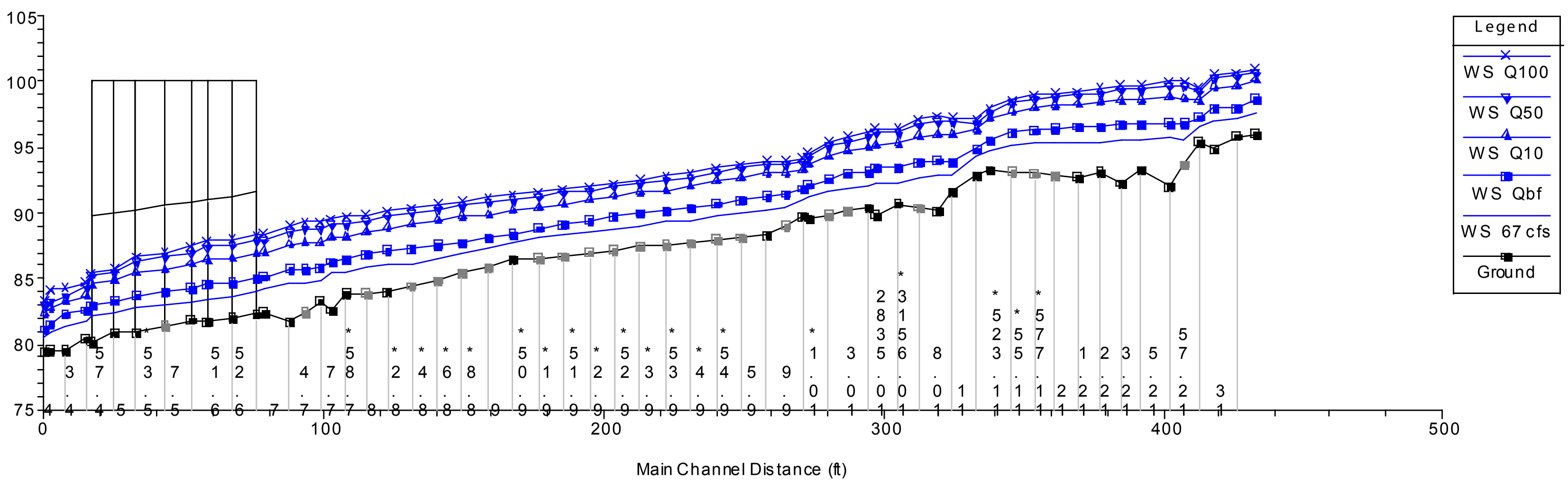
Culvert Segment	Representative Channel Segment	% Difference in Gradient
B	H	18.7%
C	G	20.8%
C	I	22.2%
D	I	32.1%
Upstream Transition		
E	G	29.2%

Segment	Segment Length (ft)	Segment Gradient
A	75	0.026
B	15	0.057
C	38	0.039
D	27	0.020
E	90	0.043
F	104	0.032
G	35	0.031
H	36	0.070
I	93	0.030

Table 2—Summary of segments used for comparisons

Segment	Range of Manning's n values[1]	# of measured XSs	# of interpolated XSs
B	0.0937-0.1057	1	2
C	0.0961-0.1057	1	5
D	0.0958-0.1064	2	8
E	0.1025-0.1078	2	6
G	0.1008-0.1016	1	6
H	0.1008-0.1049	1	5
I	0.1027-0.1120	2	12

[1]Obtained using equation from Jarrett (1984): n = 0.39S0.38R-0.16, where S=stream slope; R=hydraulic radius. Jarrett's equation only applied within the following ranges: S = 0.002 to 0.08, R = 0.5 ft to 7 ft. For cross sections outside these ranges, n was computed either from adjacent sections that fell within the ranges, using the guidance of Arcement and Schneider (1987), or from the HEC-RAS recommendations for culvert modeling.



Stations with decimal values are interpolated cross sections placed along the surveyed profile.

Figure 3—HEC-RAS profile.

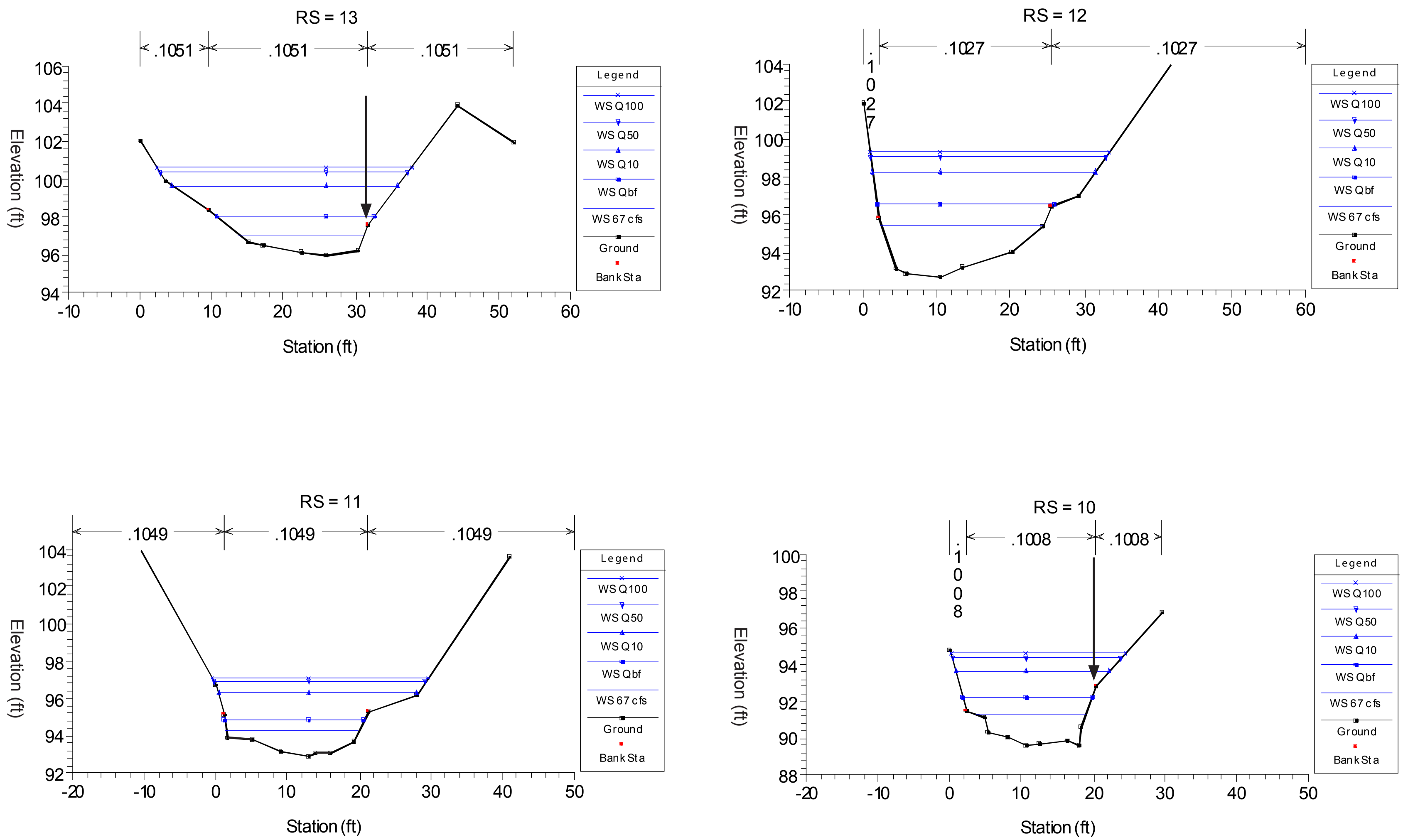
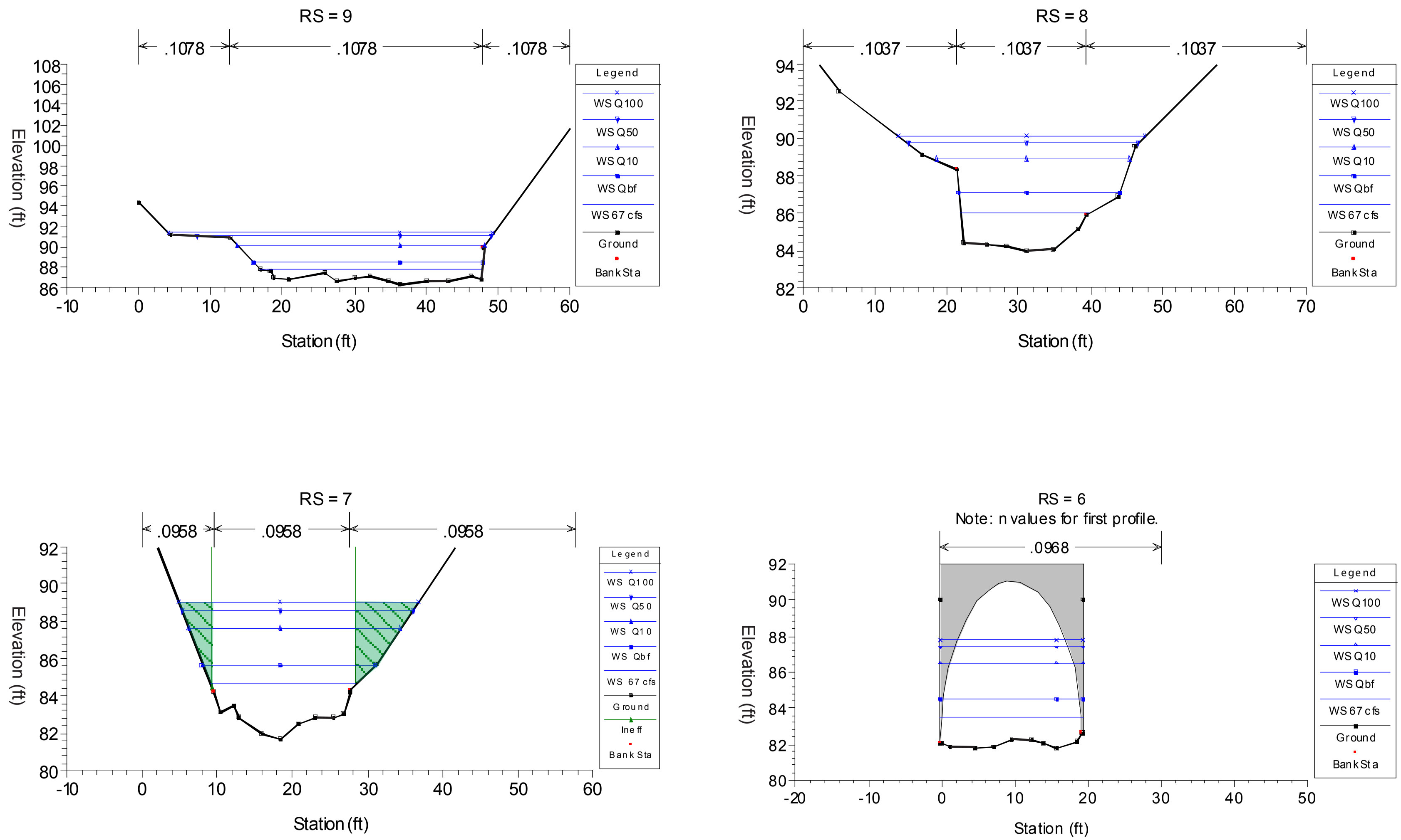


Figure 4—Cross-section plots. Only measured cross sections are included. Manning's n values are included at the top of the cross section. The stationing (RS) corresponds to the stationing on the HEC-RAS profile. Green arrows define the ineffective flow areas. Black arrows represent points identified in the field as the bankfull channel boundary. Only those points identified in the field and supported by hydraulic and topographic analyses are shown below.



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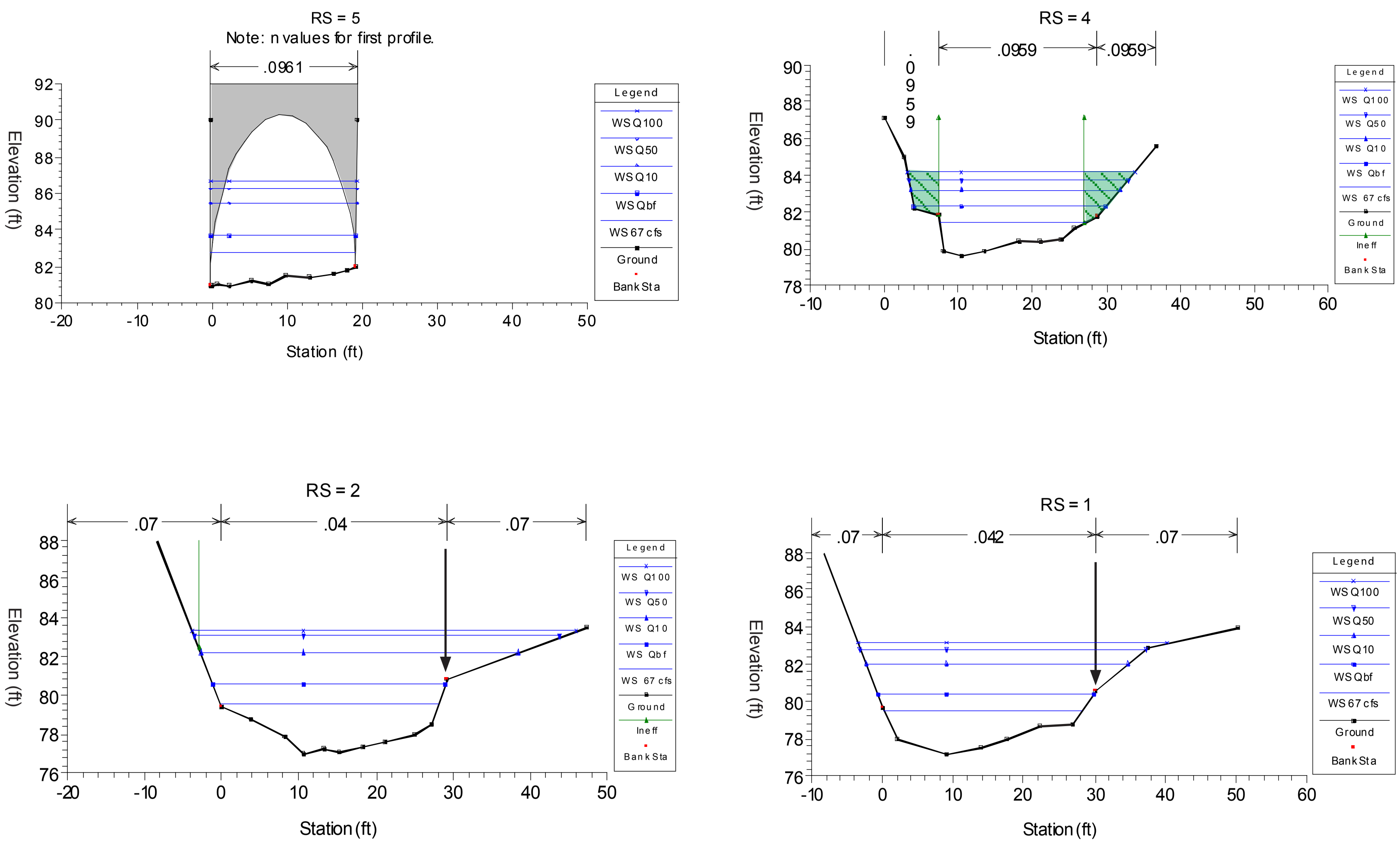

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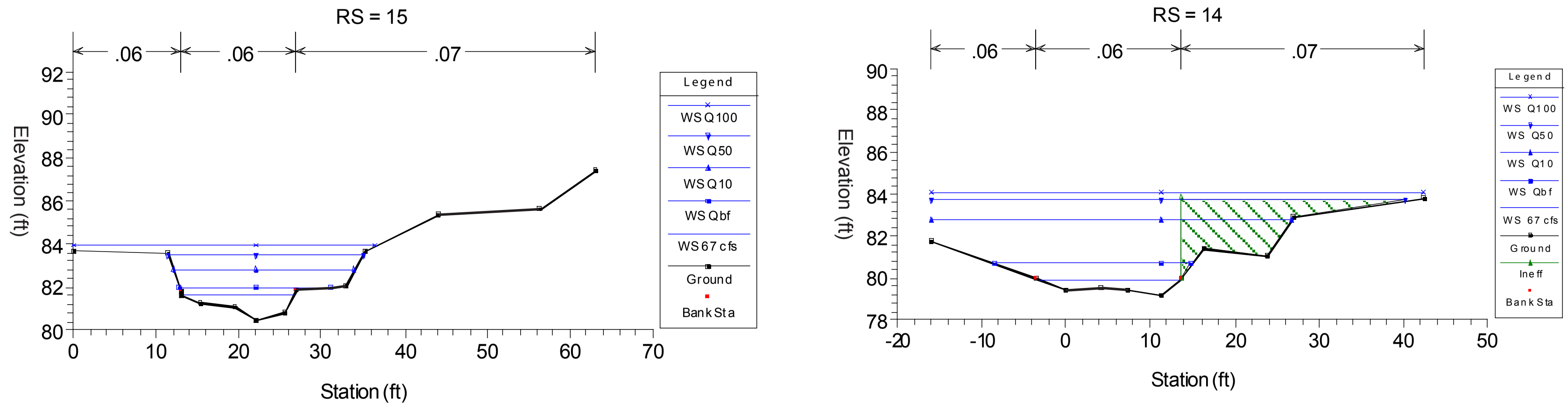


River Stations 15 and 14 represent the tributary which enters below the culvert between sections 3 and 2

Figure 4—Cross-section plots. Only measured cross sections are included. Manning's n values are included at the top of the cross section. The stationing (RS) corresponds to the stationing on the HEC-RAS profile. Green arrows define the ineffective flow areas. Black arrows represent points identified in the field as the bankfull channel boundary. Only those points identified in the field and supported by hydraulic and topographic analyses are shown below. (continued)

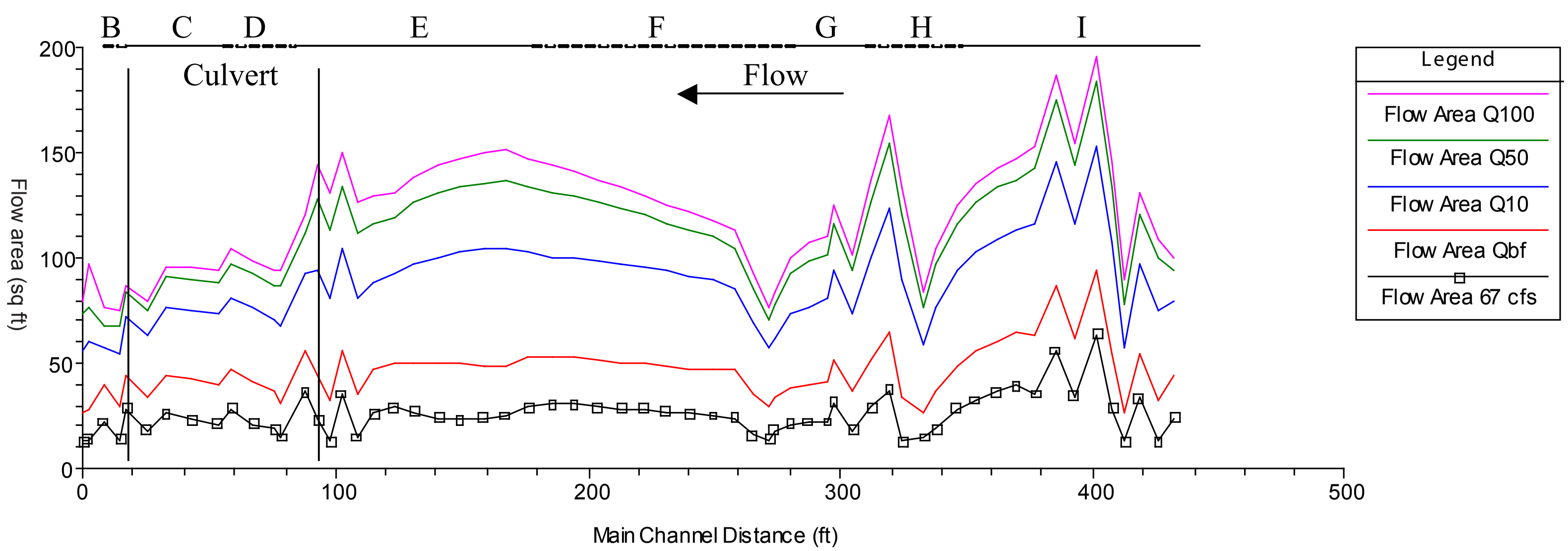


Figure 5—Flow area (total) profile plot.

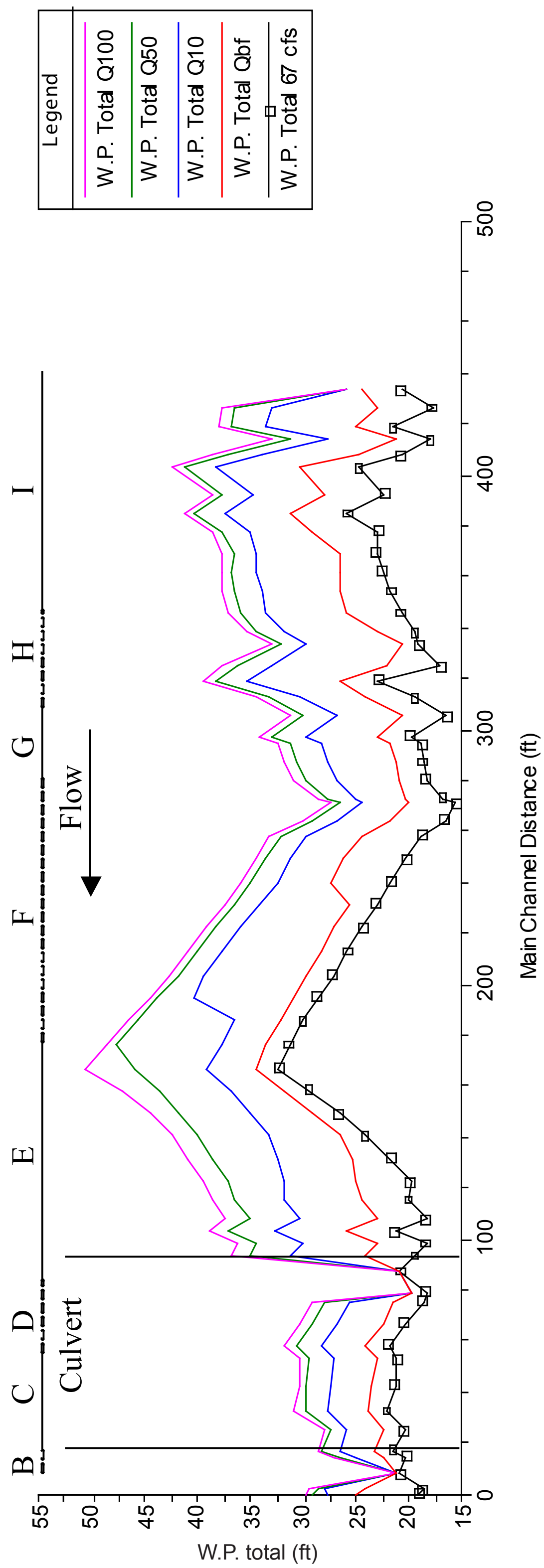


Figure 6—Wetted perimeter.

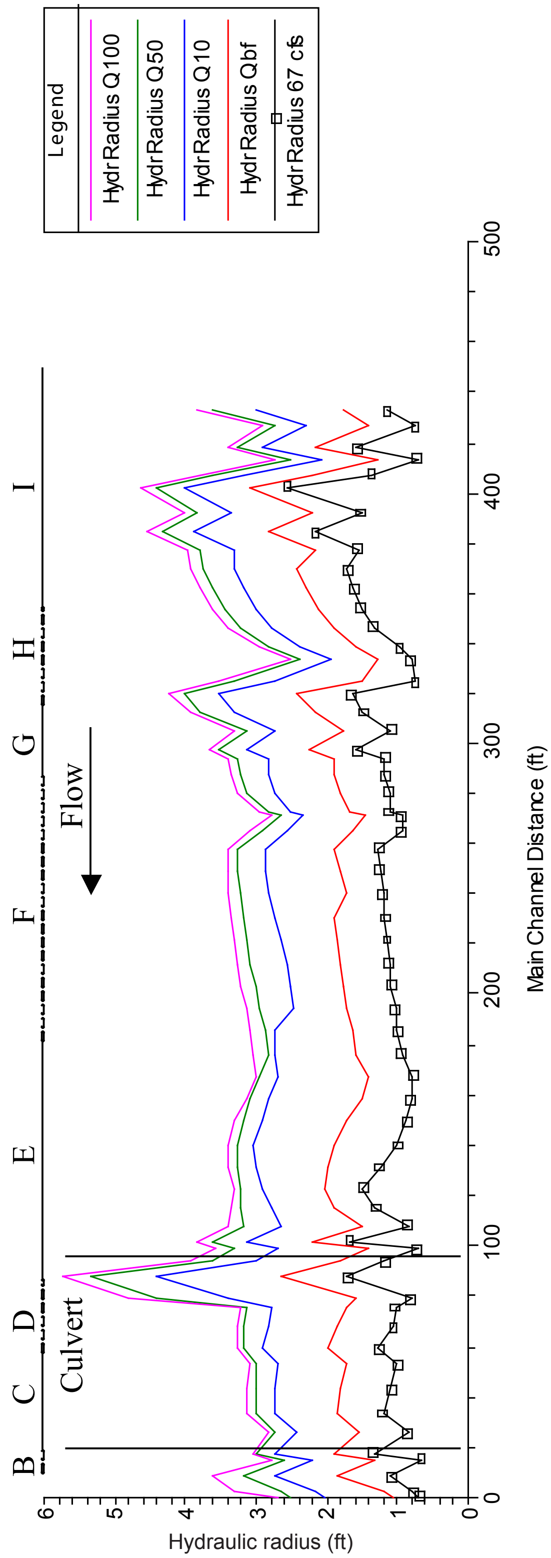


Figure 7—Hydraulic radius.

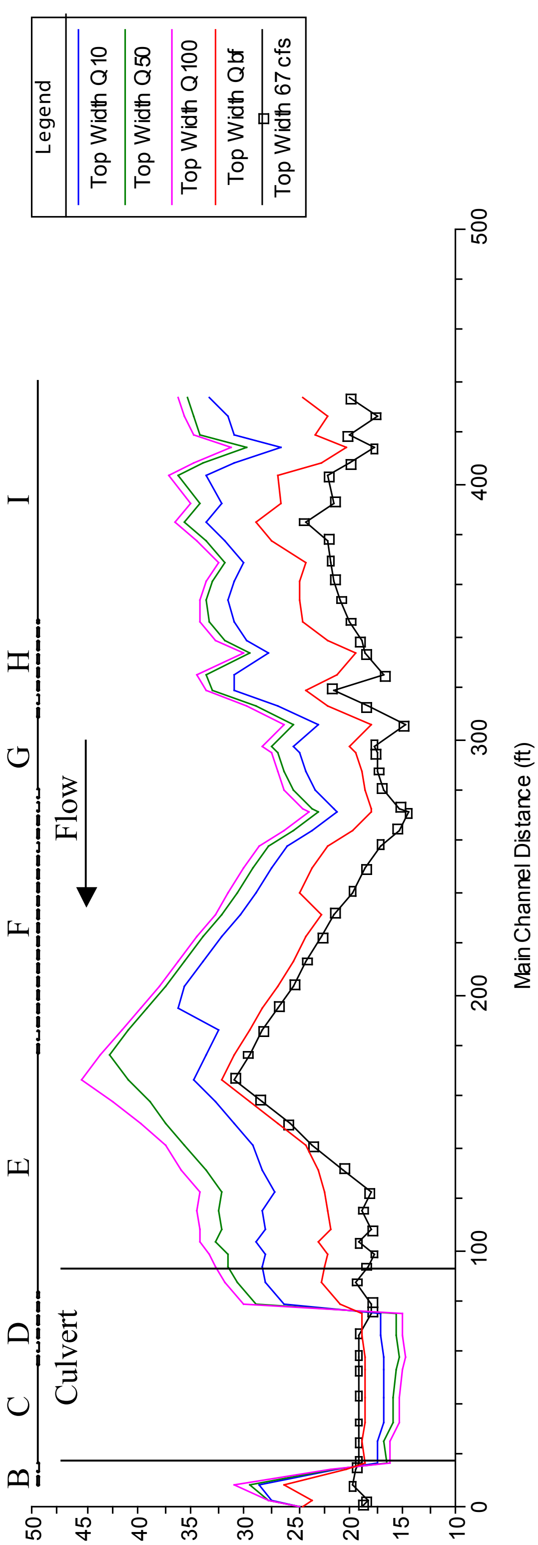


Figure 8—Top width.

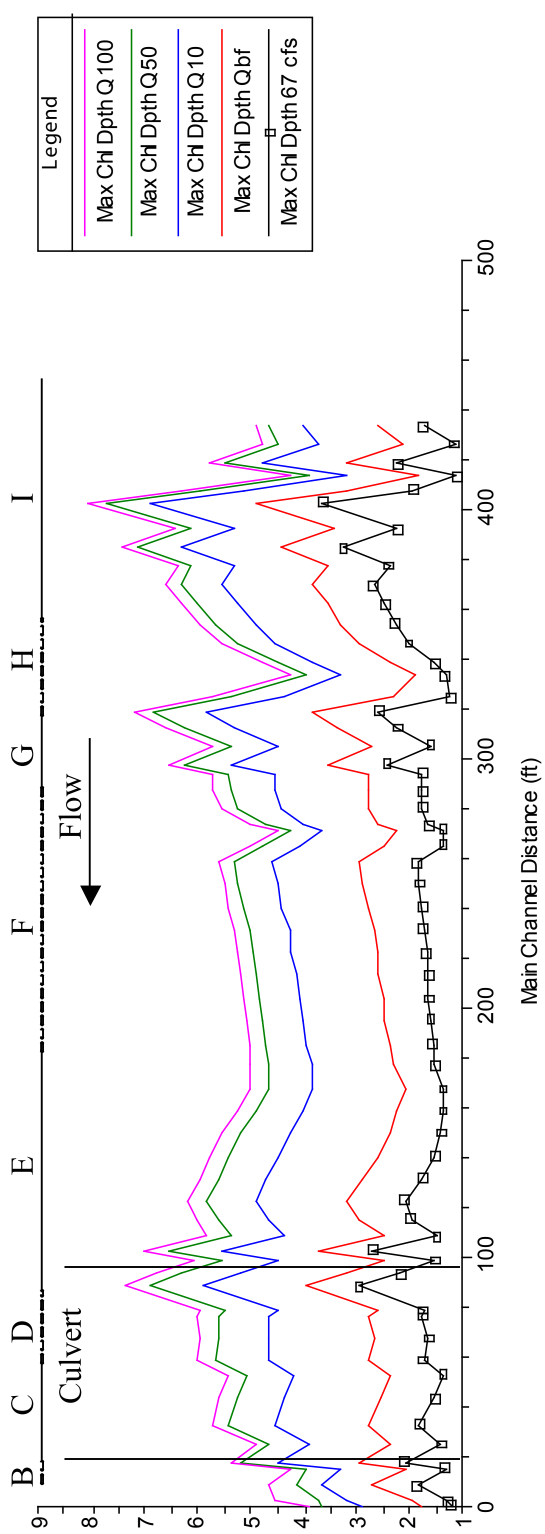


Figure 9—Maximum depth.

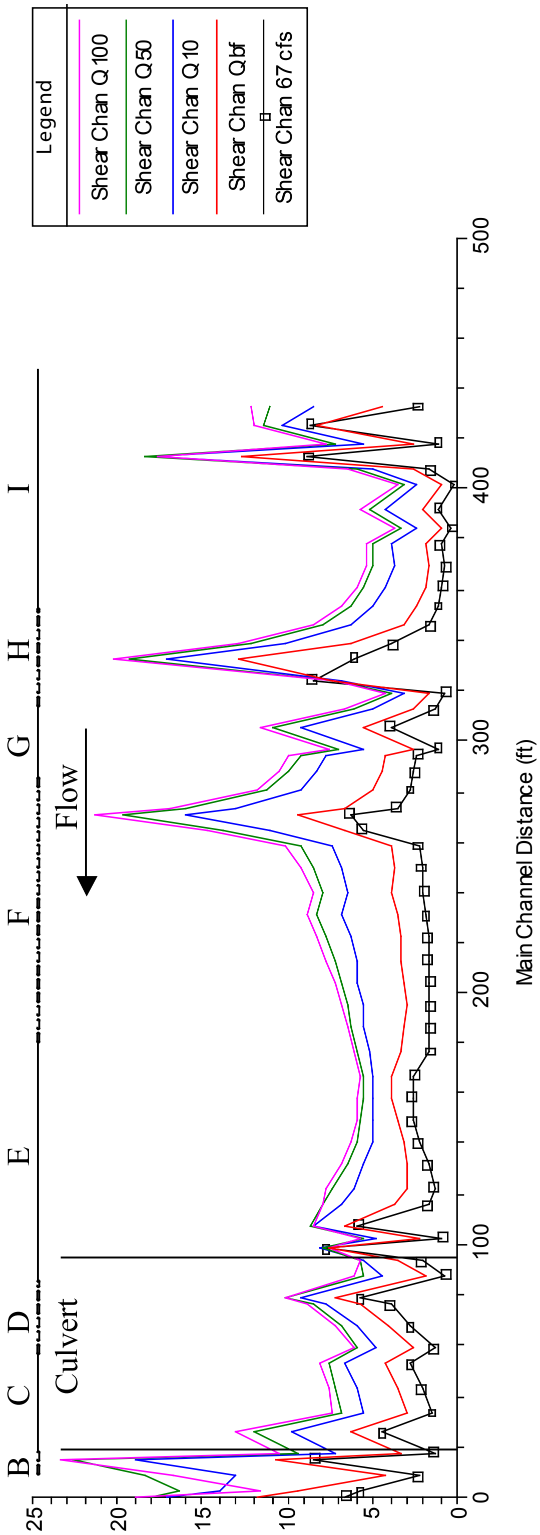


Figure 10—Shear stress (channel) profile.

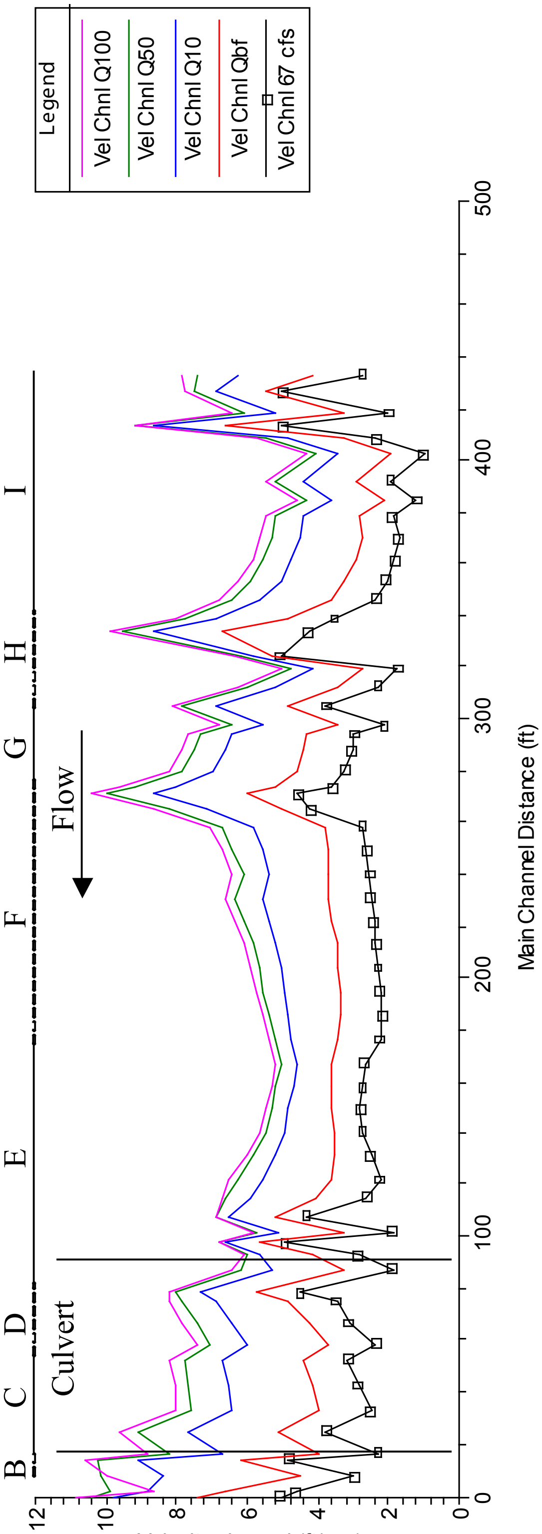
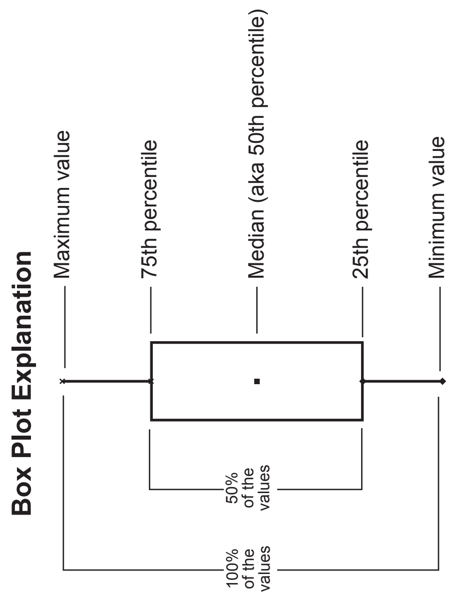


Figure 11—Velocity (channel) profile plot.



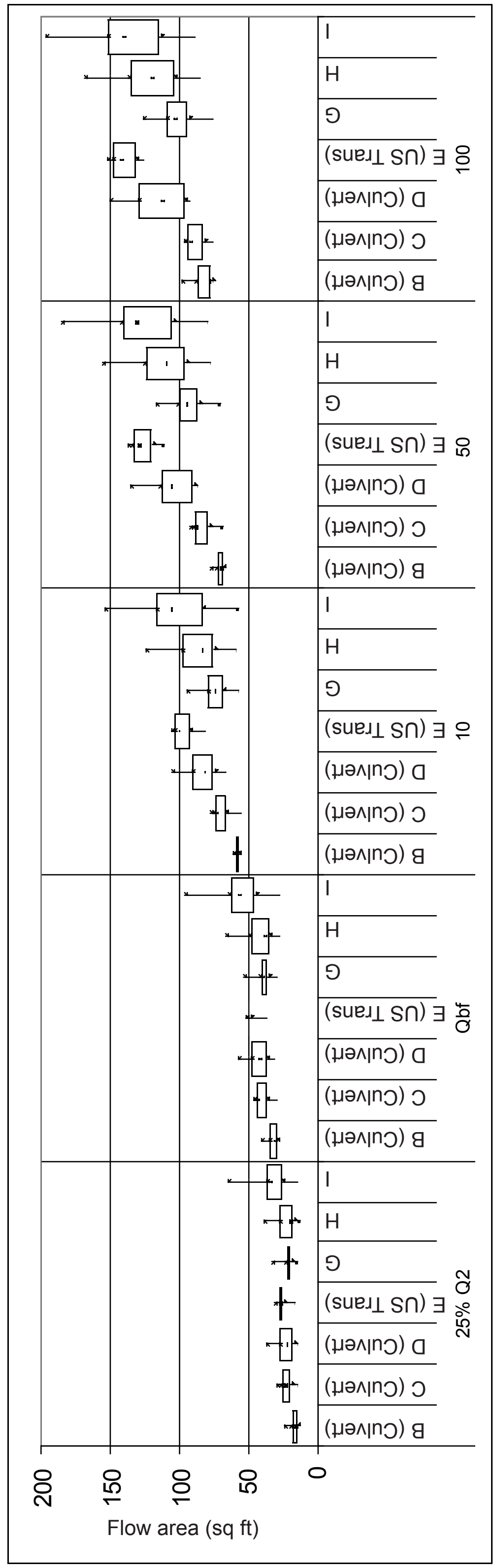


Figure 12—Flow area (total).

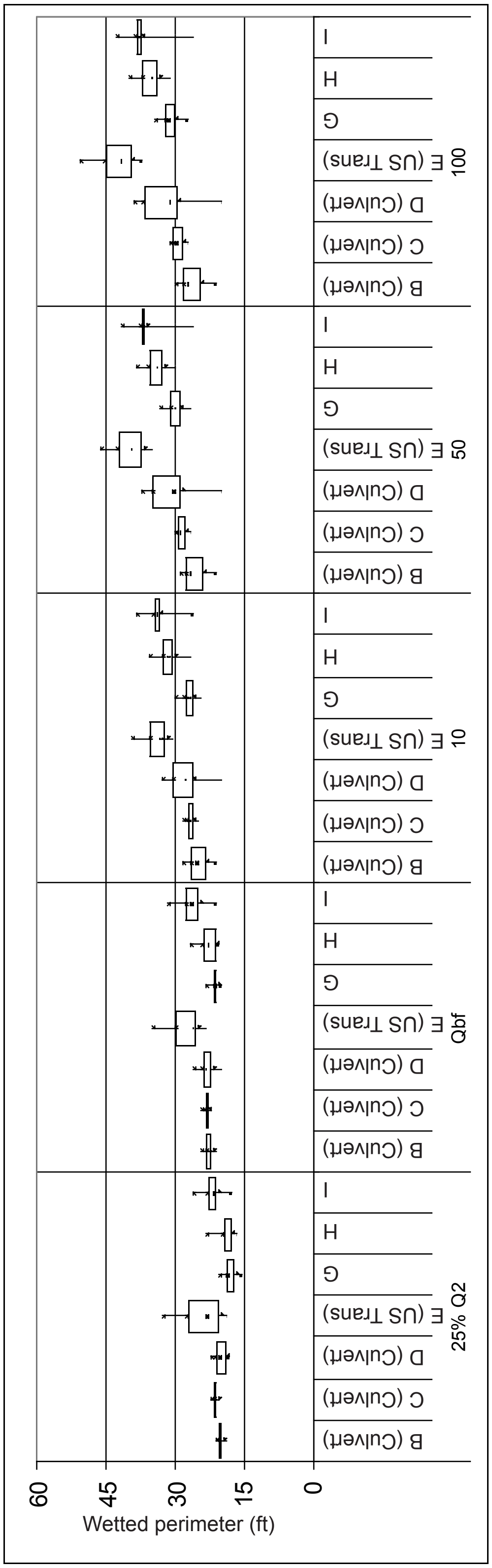


Figure 13—Wetted perimeter.

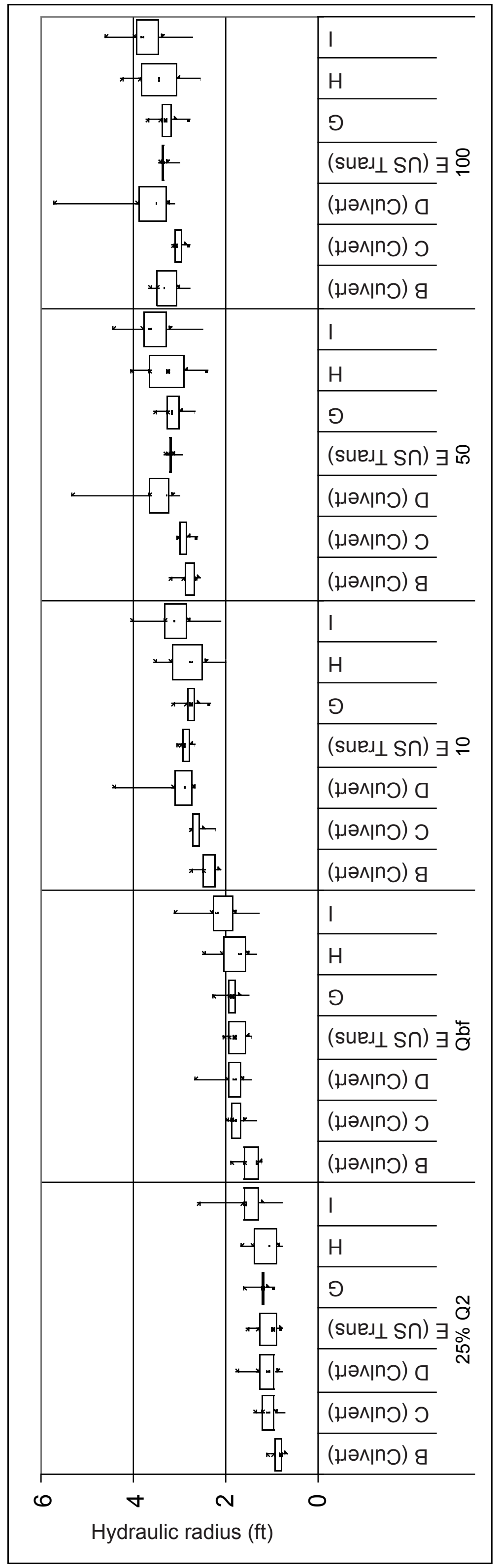


Figure 14—Hydraulic radius.

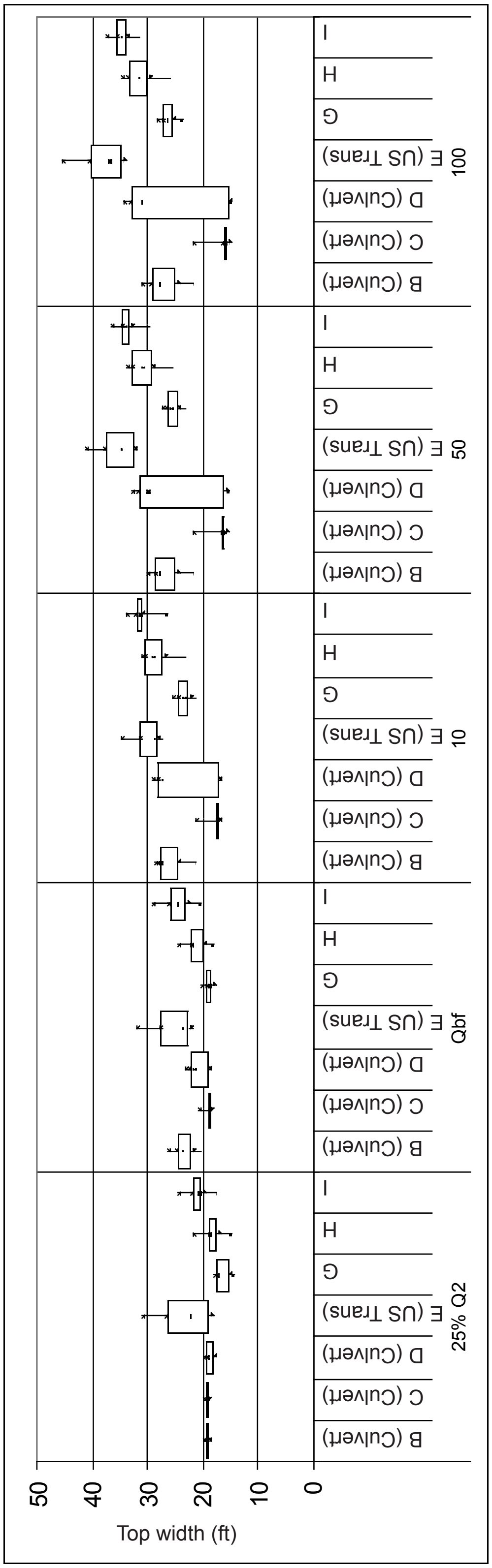


Figure 15—Top width.

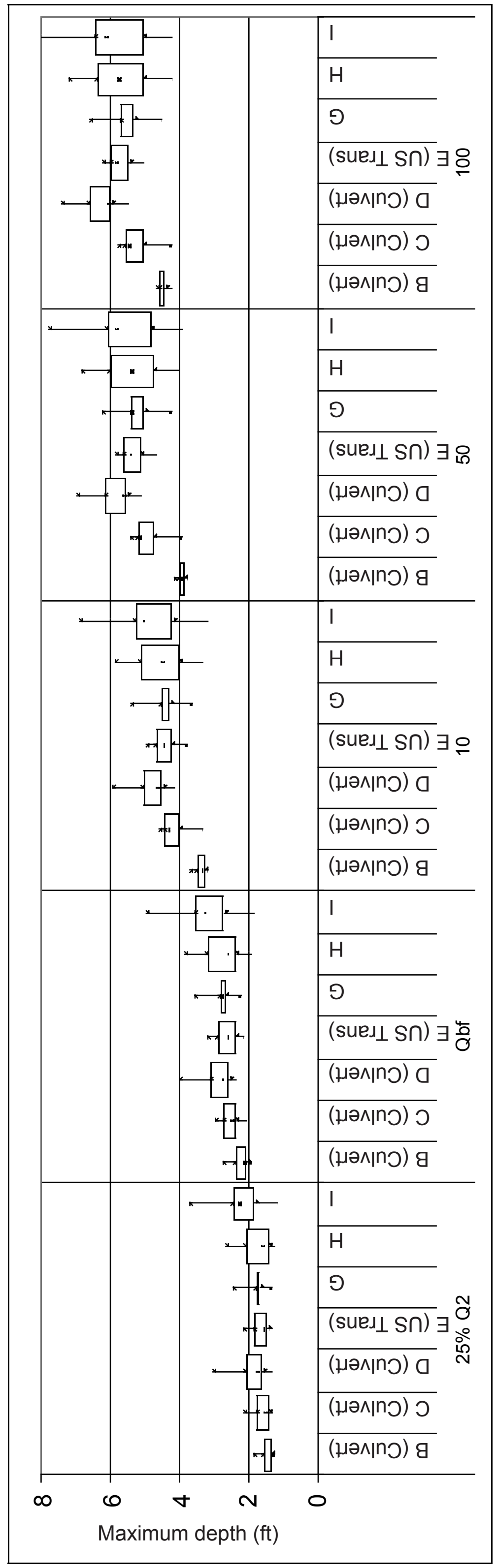


Figure 16—Maximum depth.

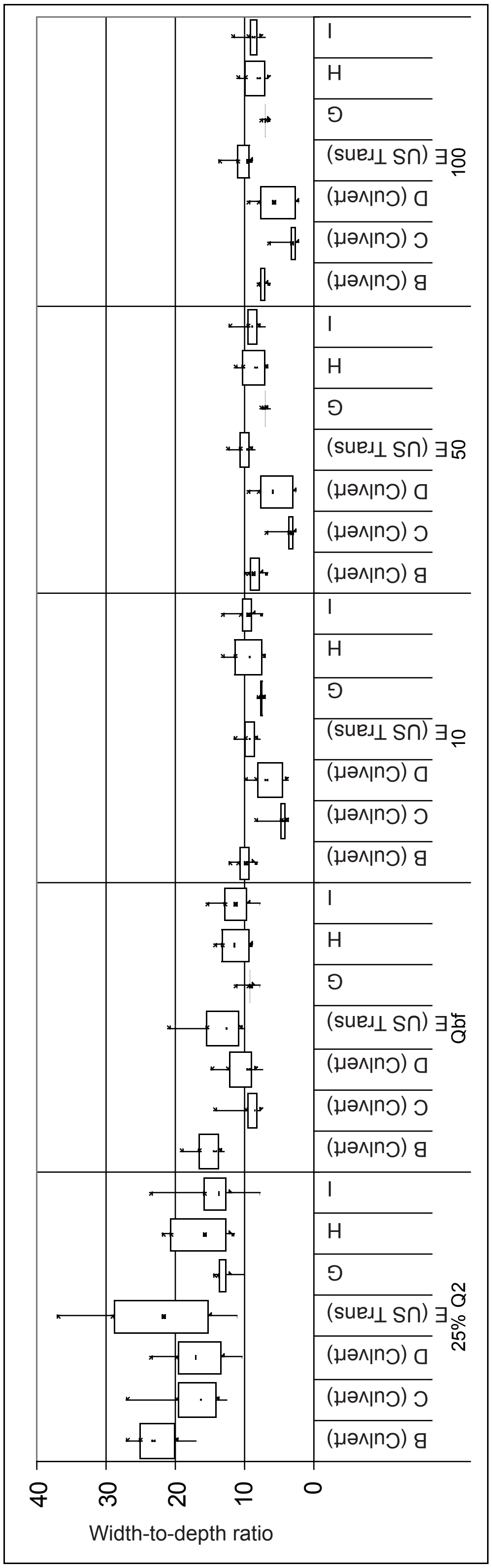


Figure 17—Width-to-depth ratio.

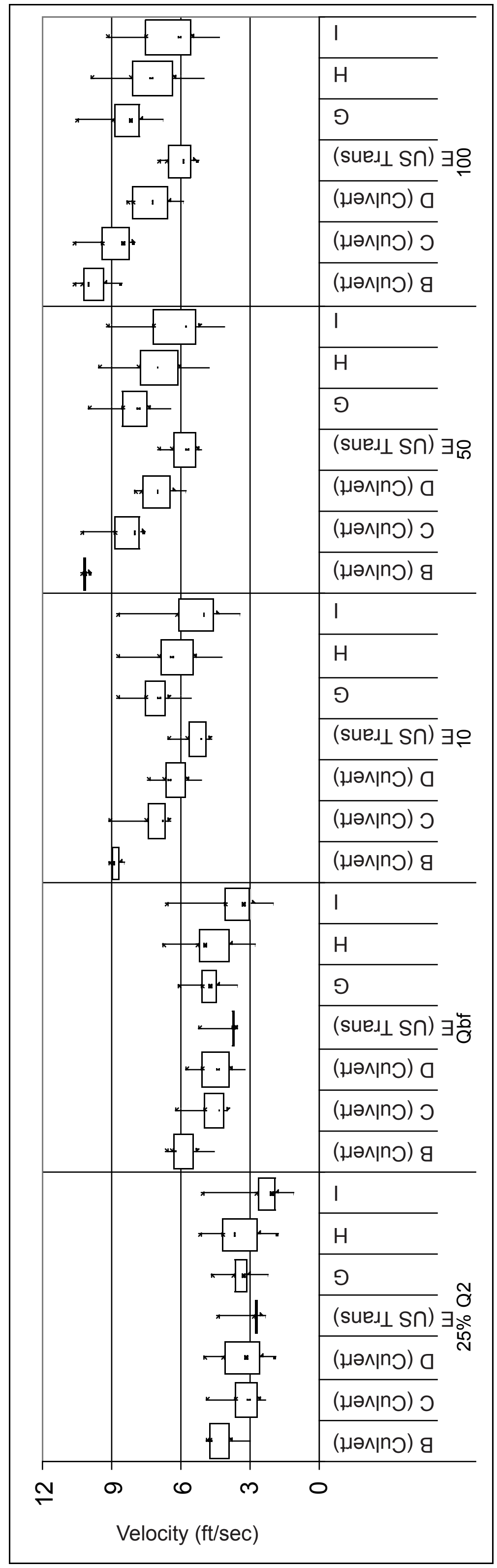


Figure 18—Velocity (channel).

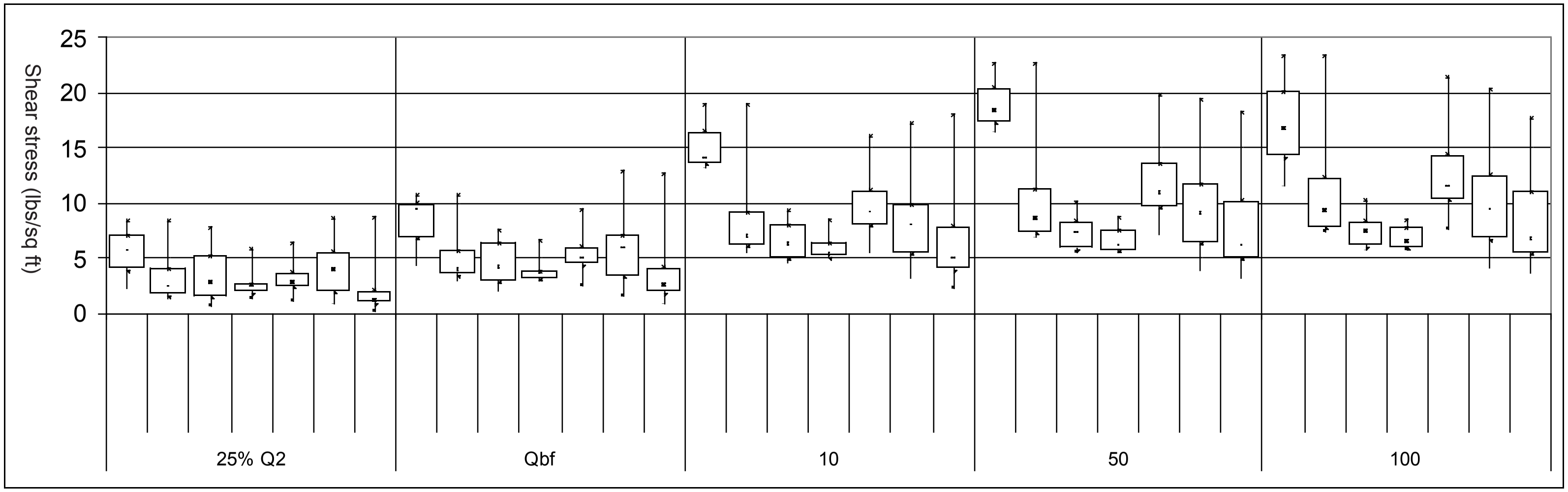
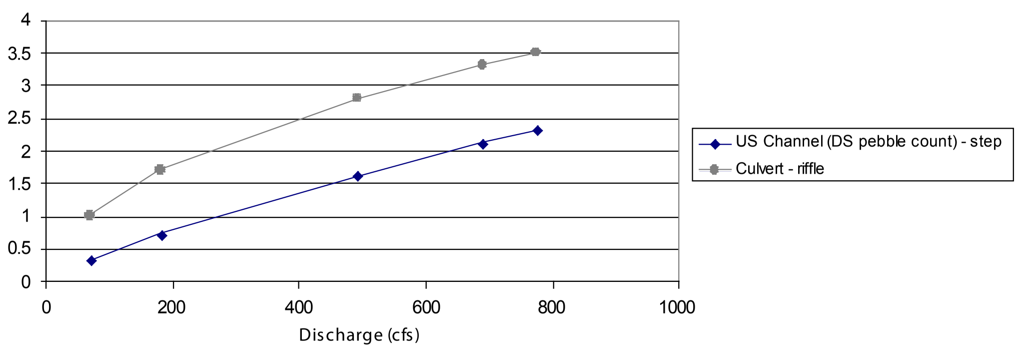


Figure 19—Shear stress (channel).



Excess shear stress is the channel shear divided by the critical shear for bed entrainment of the D84 particle size. Values of excess shear greater than 1 indicate bed movement for the D84 particle size.

Figure 20—Excess shear stress.

Table 3—Sum of squared height difference

Reach	XS Location	Unit type	Sum of squared height difference	Within range of channel conditions?
Culvert	US	Riffle	0.03	No
	DS	Riffle	0.03	No
Upstream	US	Pool	0.13	
	DS	Step	0.05	

Table 4—Vertical sinuosity

Segment	Location	Vertical Sinuosity (ft/ft)
A	DS transition	1.002
B	Culvert	1.003
C	Culvert	1.001
D	Culvert	1.001
E	US transition	1.005
F	US channel	1.001
G	US channel	1.003
H	US channel	1.008
I	US channel	1.010

Table 5—Depth distribution

Reach	XS Location	25% Q_2	Within range of channel conditions?
Culvert	US	0	Yes
	DS	0	Yes
Upstream	US	2	
	DS	0	

Table 6—Habitat unit composition

	Percent of surface area			
Reach	Pool	Glide	Riffle	Step
Culvert	10%	0%	86%	0%
Upstream Channel	41%	0%	50%	0%

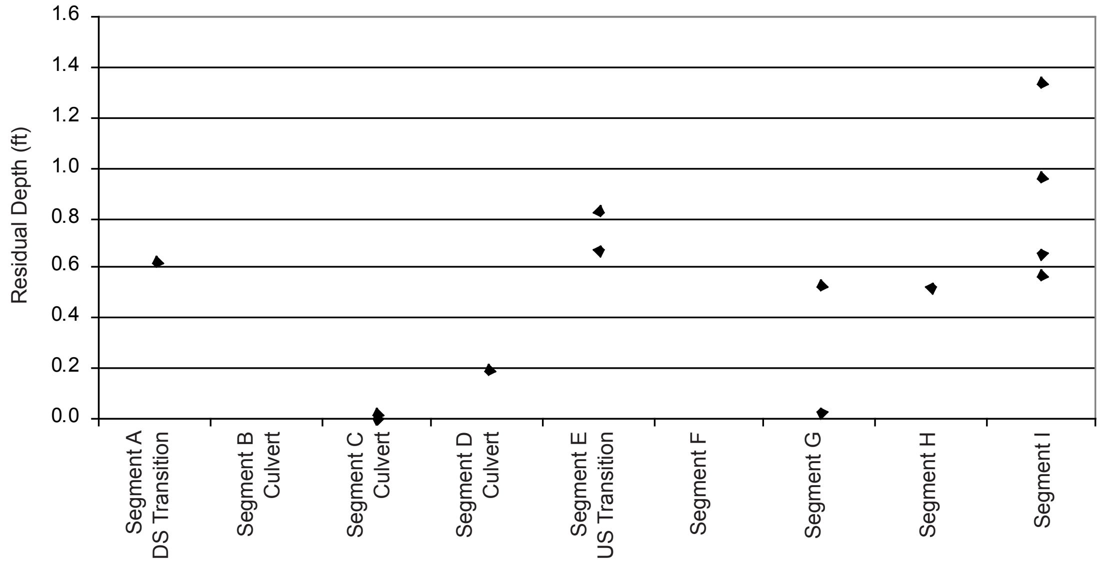


Figure 21—Residual depths.

Table 7—Bed material sorting and skewness

Reach	XS Location	Unit Type	Sorting	Within range of channel conditions?	Skewness	Within range of channel conditions?
Culvert	US	Riffle	1.59	Yes	0.15	Yes
Upstream	US	Pool	2.69		0.38	
	DS	Step	1.54		0.04	

Table 8—Large woody debris

Reach	Pieces/Channel Width
Culvert	0
Upstream	0.81

Terminology:
US = Upstream
DS = Downstream
RR = Reference reach
XS = Cross section

View upstream through culvert.

View downstream through culvert.

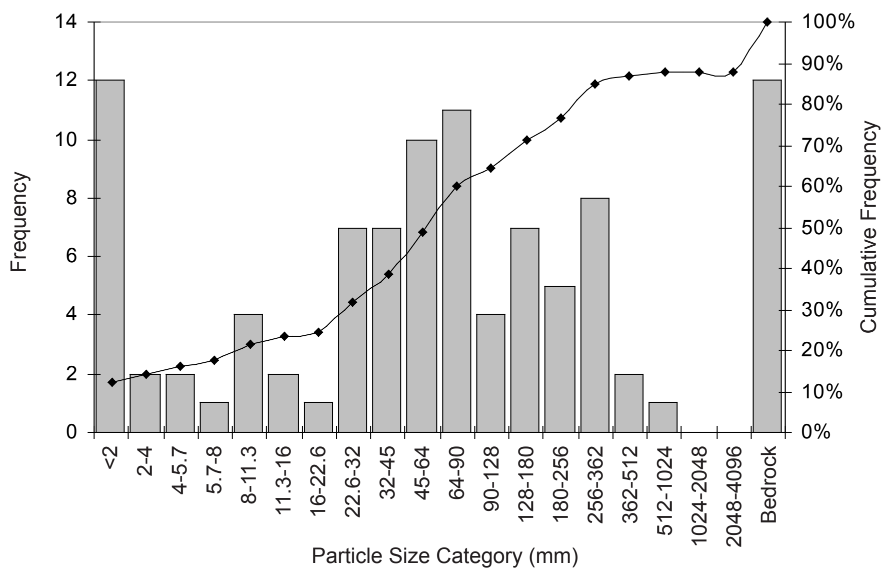
Upstream reference reach – upstream pebble count, pool.

Upstream reference reach – downstream pebble count, steep riffle/step.

View downstream from outlet at confluence with tributary on right.

Cross section : Upstream Reference Reach – Upstream Pebble Count

Material	Size Range (mm)	Count	Item %	Cumulative %
sand	<2	12	12%	12%
very fine gravel	2 - 4	2	2%	14%
fine gravel	4 - 5.7	2	2%	16%
fine gravel	5.7 - 8	1	1%	17%
medium gravel	8 - 11.3	4	4%	21%
medium gravel	11.3 - 16	2	2%	23%
coarse gravel	16 - 22.6	1	1%	24%
coarse gravel	22.6 - 32	7	7%	32%
very coarse gravel	32 - 45	7	7%	39%
very coarse gravel	45 - 64	10	10%	49%
small cobble	64 - 90	11	11%	60%
medium cobble	90 - 128	4	4%	64%
large cobble	128 - 180	7	7%	71%
very large cobble	180 - 256	5	5%	77%
small boulder	256 - 362	8	8%	85%
small boulder	362 - 512	2	2%	87%
medium boulder	512 - 1024	1	1%	88%
large boulder	1024 - 2048		0%	88%
very large boulder	2048 - 4096	0	0%	88%
bedrock	> 4096	12	12%	100%



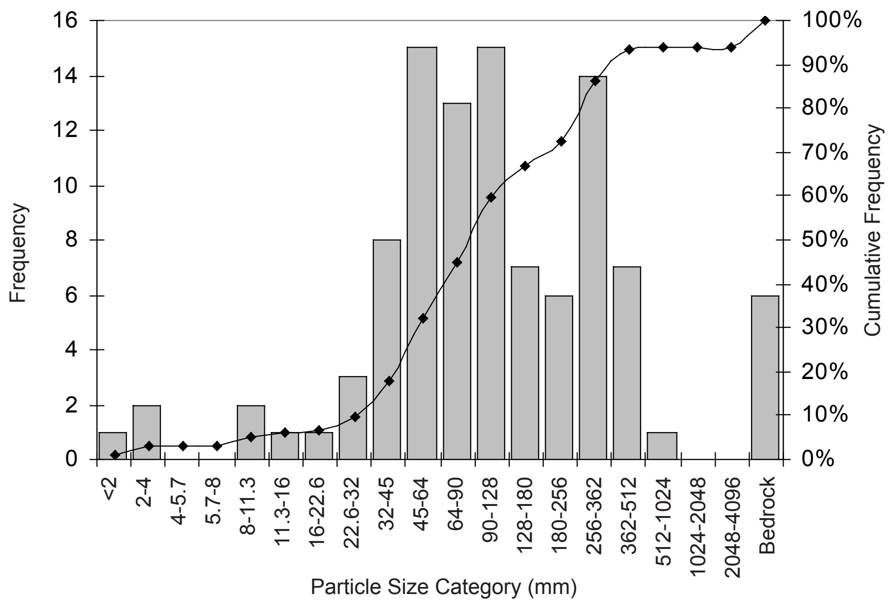
Size Class	Size percent finer than (mm)
D5	1
D16	4
D50	60
D84	210
D95	350
D100	570

Material	Percent Composition
Sand	12%
Gravel	37%
Cobble	28%
Boulder	11%
Bedrock	12%

Sorting Coefficient: 2.69
Skewness Coefficient: 0.38

Cross section : Upstream Reference Reach – Downstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	1	1%	1%
very fine gravel	2 - 4	2	2%	3%
fine gravel	4 - 5.7	0	0%	3%
fine gravel	5.7 - 8	0	0%	3%
medium gravel	8 - 11.3	2	2%	5%
medium gravel	11.3 - 16	1	1%	6%
coarse gravel	16 - 22.6	1	1%	7%
coarse gravel	22.6 - 32	3	3%	10%
very coarse gravel	32 - 45	8	8%	18%
very coarse gravel	45 - 64	15	15%	32%
small cobble	64 - 90	13	13%	45%
medium cobble	90 - 128	15	15%	60%
large cobble	128 - 180	7	7%	67%
very large cobble	180 - 256	6	6%	73%
small boulder	256 - 362	14	14%	86%
small boulder	362 - 512	7	7%	93%
medium boulder	512 - 1024	1	1%	94%
large boulder	1024 - 2048		0%	94%
very large boulder	2048 - 4096		0%	94%
bedrock	Bedrock	6	6%	100%



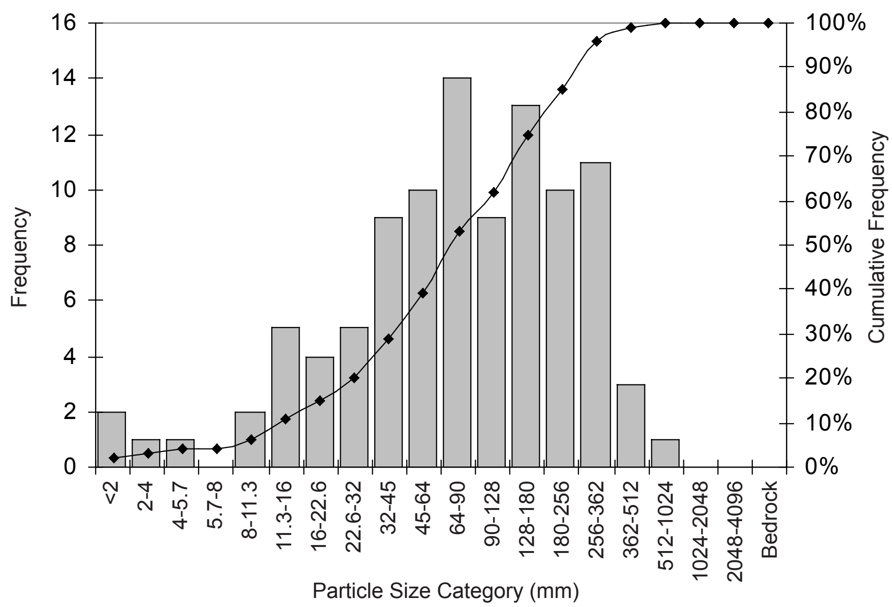
Size Class	Size percent finer than (mm)
D5	12
D16	40
D50	100
D84	308
D95	450
D100	520

Material	Percent Composition
Sand	1%
Gravel	31%
Cobble	40%
Boulder	22%
Bedrock	6%

Sorting Coefficient: 1.54
Skewness Coefficient: 0.04

Cross section : Culvert – Upstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	2	2%	2%
very fine gravel	2 - 4	1	1%	3%
fine gravel	4 - 5.7	1	1%	4%
fine gravel	5.7 - 8	0	0%	4%
medium gravel	8 - 11.3	2	2%	6%
medium gravel	11.3 - 16	5	5%	11%
coarse gravel	16 - 22.6	4	4%	15%
coarse gravel	22.6 - 32	5	5%	20%
very coarse gravel	32 - 45	9	9%	29%
very coarse gravel	45 - 64	10	10%	39%
small cobble	64 - 90	14	14%	53%
medium cobble	90 - 128	9	9%	62%
large cobble	128 - 180	13	13%	75%
very large cobble	180 - 256	10	10%	85%
small boulder	256 - 362	11	11%	96%
small boulder	362 - 512	3	3%	99%
medium boulder	512 - 1024	1	1%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	Bedrock	0	0%	100%



Size Class	Size percent finer than (mm)
D5	10
D16	25
D50	85
D84	242
D95	341
D100	600

Material	Percent Composition
Sand	2%
Gravel	37%
Cobble	46%
Boulder	15%
Bedrock	0%

Sorting Coefficient: 1.59
Skewness Coefficient: 0.15