Deadwood Creek Tributary South

Site Information

Site Location: Coast Range, S Willamette Valley, Deadwood Road

Year Installed: 2000

Lat/Long: 123°41'19.22"W 44°13'11.30"N

Watershed Area (mi²): 0.21

Stream Slope (ft/ft)[1]: 0.0932

Channel Type: Step-pool

Bankfull Width (ft): 6.6

Survey Date: March 7, 2007

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

Culvert Information

Culvert Type: Circular

Culvert Material: Annular CMP

Culvert Width: 7.5 ft

Outlet Type: Projecting

Culvert Length: 63 ft

Inlet Type: Projecting

Pipe Slope (structure slope): 0.126

Culvert Bed Slope: 0.066

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

Culvert width as a percentage of bankfull width: 1.13

Alignment Conditions: On-line with natural channel.

Bed Conditions: Material scoured out of upstream 1/2 of pipe. Coarse material remaining in pipe.

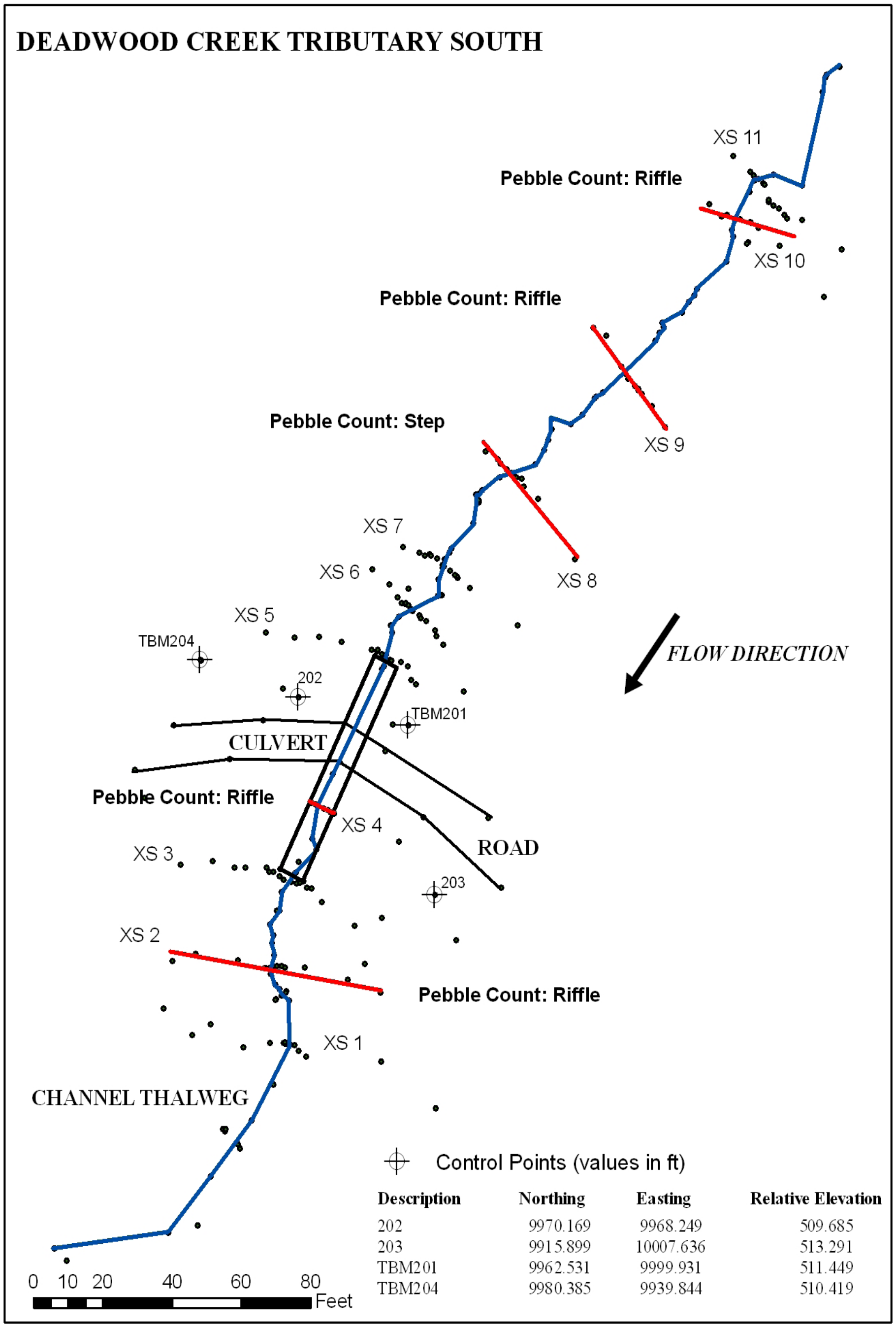
Pipe Condition: Some structure joints slightly open but no leaking. Minor rust.

Hydrology

Discharge (cfs) for indicated recurrence interval

25% 2-yr	2-year	Q_{bf}[2]	5-year	10-year	50-year	100-year
5	18	18	26	32	46	52

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



Points represent survey points

Figure 1—Plan view map.

HISTORY

The Deadwood Tributary South culvert was installed in August 2000. Material was placed in the culvert by hand using a wheelbarrow. The material was 8-inch minus, well-graded, and consisted of a full range of sizes. No significant material sorting or bedform construction was conducted, except for the creation of a minor (3- to 4-inch) thalweg.

The original channel alignment was directly on the original stream channel. No change in alignment was made but the channel was widened upstream for construction access. The crossing was located at a dual grade break; steeper upstream, large scour pool downstream, and a steeper average gradient downstream. The downstream channel was poorly defined.

Construction-related alterations changed the upstream channel from a confined, wood grade controlled, and heavily vegetated channel to a flattened, exposed, and wider channel. The downstream channel was disturbed by equipment due to the need for access to reach the scour pool.

No significant maintenance of the site has occurred since construction. Branches from road clearing were dumped at the inlet and apparently plugged it during a storm/sediment transport event. Maintenance activities related to this event are unknown. Wood and rocks were hand placed after construction to help define the channel within the “delta” area.

The above information furnished by Kim Johansen, USFS.

The flood history at a nearby gauge with a drainage area of 5.7 square miles (USGS #14306340) indicates that the largest event since construction was an approximately 2-year recurrence interval event in 2006.

SITE DESCRIPTION

The Deadwood Creek South Tributary culvert is a closed round pipe that projects from the road fill. The culvert showed signs of adjustment postconstruction. The upper half of the pipe has scoured to the culvert base. About 30 feet down the pipe, large angular material remains in place, presumably from the initial installation. Towards the outlet, material from upstream has deposited on top of the original fill, altering the grade. As a result, the conveyance through the outlet has decreased due to the adjustment in the invert. There was supercritical flow in the upstream half of the culvert at the time of the survey and the modeling suggests that this condition persists even at high flows.

The upstream representative channel consisted of a high gradient step-pool channel with a narrow and low active flood-plain surface. The presence of large wood in the stream provides structure to the channel, making up the majority of the grade control. In addition to wood, large boulders also add to the structure of the steps. Plunge pools follow most steps and are interspersed by steep riffles.

At the outlet to the culvert, the channel drops over a steep riffle. Downstream of the outlet there is a steep riprap step/cascade possibly built during or following construction to control the grade up to the outlet. After the step, the stream flattens out before entering the flood plain of Deadwood Creek. Large quantities of brush from roadside clearing were present downstream of the crossing.

SURVEY SUMMARY

Eleven cross sections and a longitudinal profile were surveyed along Deadwood Creek South Tributary in March 2007 to characterize the culvert and an upstream reference reach. No downstream reference reach was established due to the proximity of the crossing with the confluence of Deadwood Creek. Lacking bed material and therefore bedforms, only one reference section was taken through the culvert. Two additional cross sections were surveyed downstream of the culvert to characterize the outlet as well as the expansion of flow. Another two cross sections were surveyed upstream to characterize the inlet as well as the contraction of flow.

Five cross sections were surveyed to characterize the upstream reach; one at the upstream and downstream boundary, two through steps and one through a riffle.

A single representative cross section and pebble count were taken through a downstream riffle below the riprap step but these were not used in the analysis because of potential influence from backwater from Deadwood Creek.

PROFILE ANALYSIS SEGMENT SUMMARY

The profile analysis resulted in a total of 14 profile segments. The culvert consisted of two profile segments. The upstream segment in the culvert was comparable to two different representative profile segments in the upstream channel. The downstream segment in the culvert had no measured cross sections so was not used for comparisons. The upstream transition segment was comparable to two representative profile segments in the upstream channel. Three different downstream transition segments were comparable to a total of four different representative profile segments in the upstream channel. This downstream transition area consisted of three distinct profile segments where the stream falls off quickly from the culvert outlet to the mainstem valley floor of Deadwood Creek. See figure 2 and table 1.

SCOUR CONDITIONS

Observed conditions

Structure scour – The upstream half of the pipe was scoured to the culvert base. Supercritical flow was present along the exposed culvert base at the time of the survey.

Culvert bed adjustment – The culvert bed has scoured placed material out of the upstream half of the pipe. This has resulted in a slope adjustment of the culvert bed, which is now about half of the slope of the structure itself. Material still remains in the downstream portion of the pipe, some of the material appears to have aggraded in the downstream portion and may have been sourced from the scour in the upstream portion.

Profile characteristics – The profile is concave at the crossing but convex downstream of the outlet (figure 2). The profile was described as a “dual grade break” by the designer (see History section). The site is located at the transition from the small, confined valley of the tributary to the broader valley of mainstem Deadwood Creek. The profile shape is very likely an artifact of the previous culvert at this site, which had a large scour pool at the outlet and then dropped off steeply to Deadwood Creek. The steep downstream segment is now a steep riprap step.

Residual depths – The one residual depth in the culvert is located in a profile segment that has no comparable profile segment in the natural channel; however, this depth is at the lower end of the range of residual depths found within all the profile segments in the channel outside the crossing (figure 21). Transition segments have residual depths that do not vary substantially from corresponding profile segments.

Substrate – The culvert bed material distribution (downstream half) has less sand and fine gravel than the bed material in the natural channel. The amount of coarse material is within the range of the natural channel. The skewness value is within the range of the natural channel. The culvert sorting value is less poorly sorted than the natural channel, indicating that it has less representation of the range of size classes.

Predicted conditions

Cross-section characteristics – Cross-section characteristics in the culvert are very different in the upstream (scoured) portion of the culvert versus the downstream portion of the culvert (figures 5 through 9). In general, the upstream portion of the pipe has dramatically reduced flow area, wetted perimeter, hydraulic radius, top width, and maximum depth. The downstream portion has conditions that are more similar to the natural channel but generally have less variability. The box plots (figures 12 through 17) do not fully exhibit this pattern because the upstream profile segment in the culvert (F) extends downstream beyond the scoured portion of the pipe. The upstream transition segment has similar conditions to corresponding profile segments except for depth and hydraulic radius, which are greater in the transition segment. The downstream transition segments are mostly within the range of their natural counterparts except for top width, for which they have greater values.

Shear stress – Modeled shear stress in the culvert has a greater range than the natural channel at the Q_{10} and above, with more extreme (lower as well as higher) values (figure 19). Transition segments do not differ significantly from the natural channel.

Excess shear – The excess shear analysis suggests that bed material in the culvert is mobilized less frequently than material in the natural channel (figure 20). Past scour of culvert material may have served to stabilize the bed by scouring out smaller material and leaving larger material that is capable of withstanding high flows.

Velocity – Velocity in the upper portion of the culvert is extremely high in relation to the natural channel (figure 11). The downstream portion of the culvert and the transition segments have velocities that are more in line with the channel outside the crossing.

Scour summary

This site has very high gradient (up to 12 percent) that likely pushes the limits of the HEC-RAS model; and so results need to be interpreted accordingly. However, the flow conditions modeled in the culvert at this site appear to match well the observations of flow conditions at the time of the survey with respect to the rapid shallow flow in the scoured portion of the pipe.

The scoured upper portion of the pipe is likely related to the steepness of the culvert (12 percent compared to average reach slope of 9 percent) and the size of the material that was placed during construction. Material placement at this site was conducted by hand using a wheelbarrow and this may have limited the size of material that was able to be placed inside the structure.

AOP CONDITIONS

Cross-section complexity – The sum of squared height difference is greater in the culvert than in the channel cross sections (table 3).

Profile complexity – Vertical sinuosity in the culvert is considerably less than corresponding profile segments (H and J) (table 4). The upstream transition segment (G) is also less than corresponding profile segments. The downstream transition segments (B, C, and D) have vertical sinuosities that are similar to or above those found in their natural channel counterparts.

Depth distribution – The availability of shallow channel margin habitat in the culvert at the 25 percent Q_2 is within the range of that found in the channel outside the crossing (table 5).

Habitat units – The culvert is nearly all riffle, whereas the channel outside the crossing has 20-percent pool habitat (table 6).

Residual depths – The one residual depth in the culvert is located in a profile segment that has no comparable profile segment in the natural channel; however, this depth is at the lower end of the range of residual depths found within all the profile segments in the channel outside the crossing (figure 21). Transition segments have residual depths that do not vary substantially from corresponding profile segments.

Substrate – The culvert bed material distribution (downstream half) has less sand and fine gravel than the bed material in the natural channel. The amount of coarse material is within the range of the natural channel. The skewness value is within the range of the natural channel. The culvert sorting value is less poorly sorted than the natural channel, indicating that it has less representation of the range of size classes.

Large woody debris – There was a small amount of LWD present in the culvert at the downstream end (Table 8). The representative channel had high LWD abundance. LWD was the primary factor forming steps and scour pools in the channel outside the crossing and played a primary role in habitat unit creation and complexity. Features in the culvert did not mimic the role of wood in the natural channel.

AOP summary

Upstream of the culvert, the step-pool channel has high complexity that is driven by the abundance of woody debris that forms the steps. If fish could pass the reach at the crossing, there is high quality and passable habitat upstream. In the current condition, fish passage would be blocked by the scour in the upstream portion of the pipe. The downstream riprap step is also likely to present a barrier to upstream fish migration. Even in the downstream portion of the pipe where material remains, the bed is fairly uniform, and lacks the step-pool character and complexity of the natural channel. There are also no channel banks in the culvert that would allow for terrestrial organism passage.

DESIGN CONSIDERATIONS

This is a steep stream and an even steeper culvert, and a very challenging installation to keep from scouring. Regrading the profile to eliminate the dual grade break may avoid the steeper sections that currently pose a passage issue for migrating fish. Using an open-bottom pipe and constructing stable steps through the crossing may provide more stability and scour resistance. Constructing channel banks within the pipe would allow for terrestrial organism passage. A series of wood and rock steps between the outlet and Deadwood Creek similar to those above the culvert would also improve passage conditions.

Vegetation-clearing activities along the road should avoid depositing material in the inlet or outlet areas. This material can plug the culvert and can affect fish passage conditions.

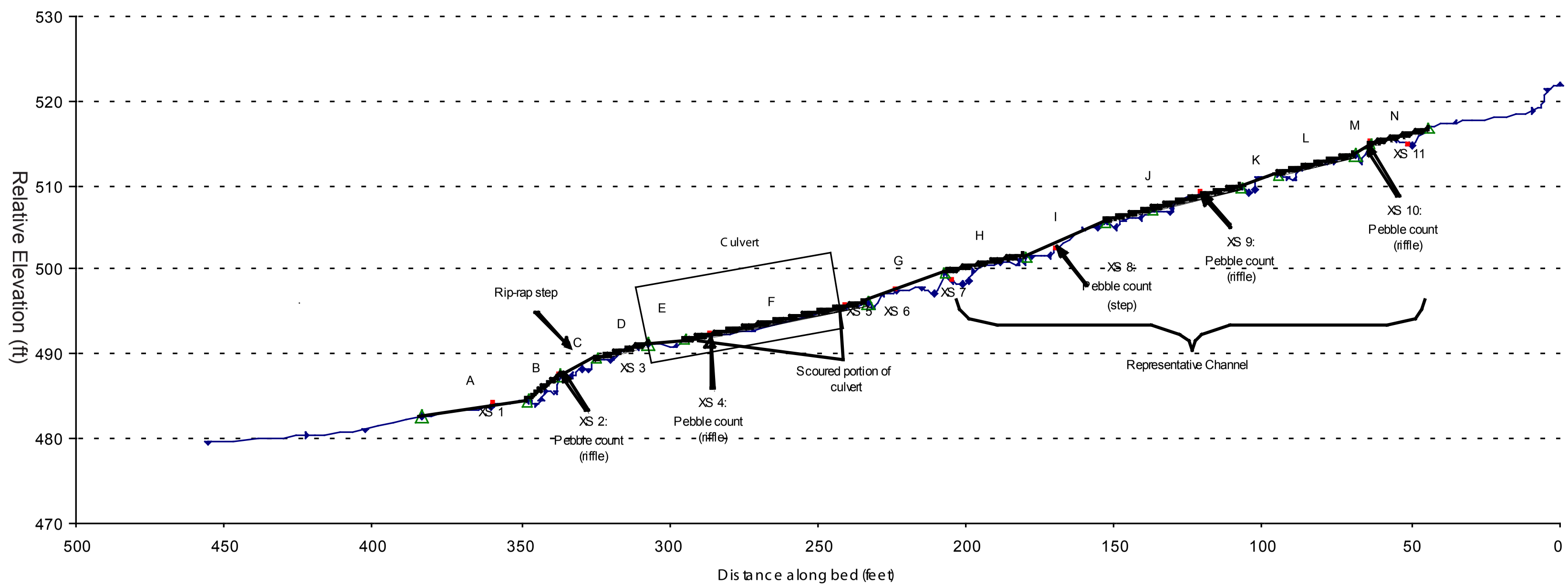


Figure 2—Deadwood Creek Tributary South longitudinal profile.

Table 1. Segment comparisons

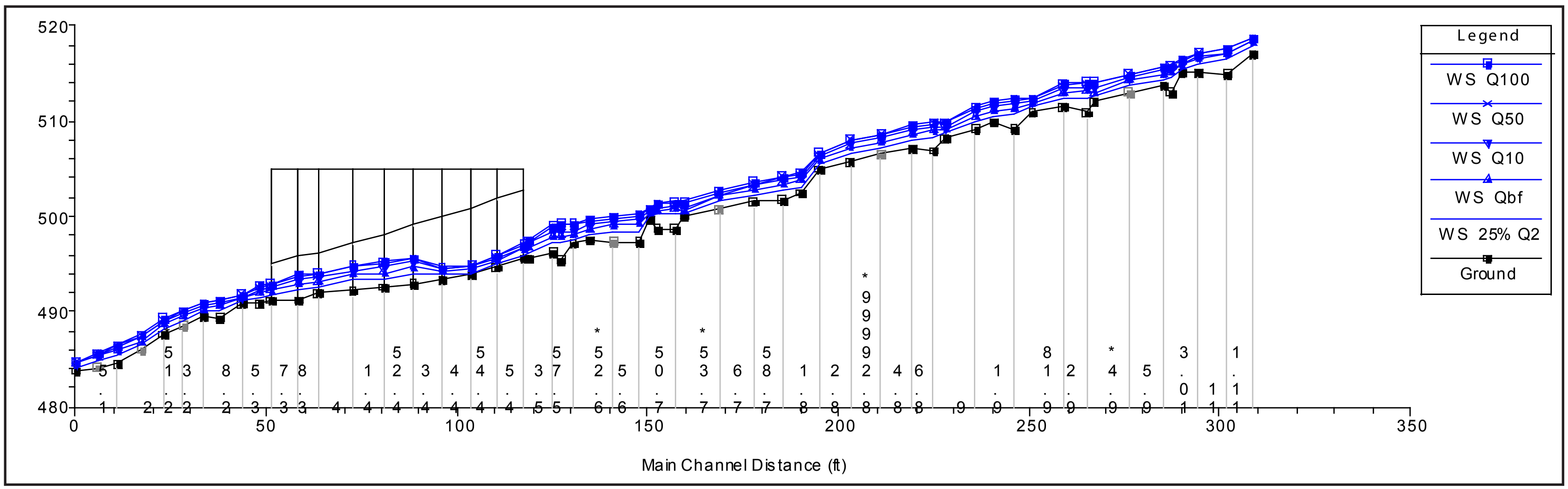
Culvert Segment	Representative Channel Segment	% Difference in Gradient
F	H	3.9%
F	J	23.9%
Upstream Transition		
G	I	15.4%
G	N	25.8%
Downstream Transition		
B	M	0.1%
C	I	2.8%
D	J	11.0%
D	N	4.3%

Segment	Segment Length (ft)	Segment Gradient
A	36	0.054
B	11	0.269
C	12	0.159
D	17	0.102
E	12	0.054
F	62	0.069
G	26	0.131
H	28	0.072
I	27	0.155
J	46	0.091
K	12	0.126
L	26	0.089
M	5	0.269
N	20	0.097

Table 2—Summary of segments used for comparisons

Segment	Range of Manning's n values[1]	# of measured XSs	# of interpolated XSs
B	0.1597	1	2
C	0.1597	1	2
D	0.1516-0.1597	1	4
F	0.0240-0.1597	2	8
G	0.1597	1	6
H	0.1597	1	5
I	0.1597	1	4
J	0.1597	1	6
M	0.1597	1	2
N	0.1597	2	2

[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.

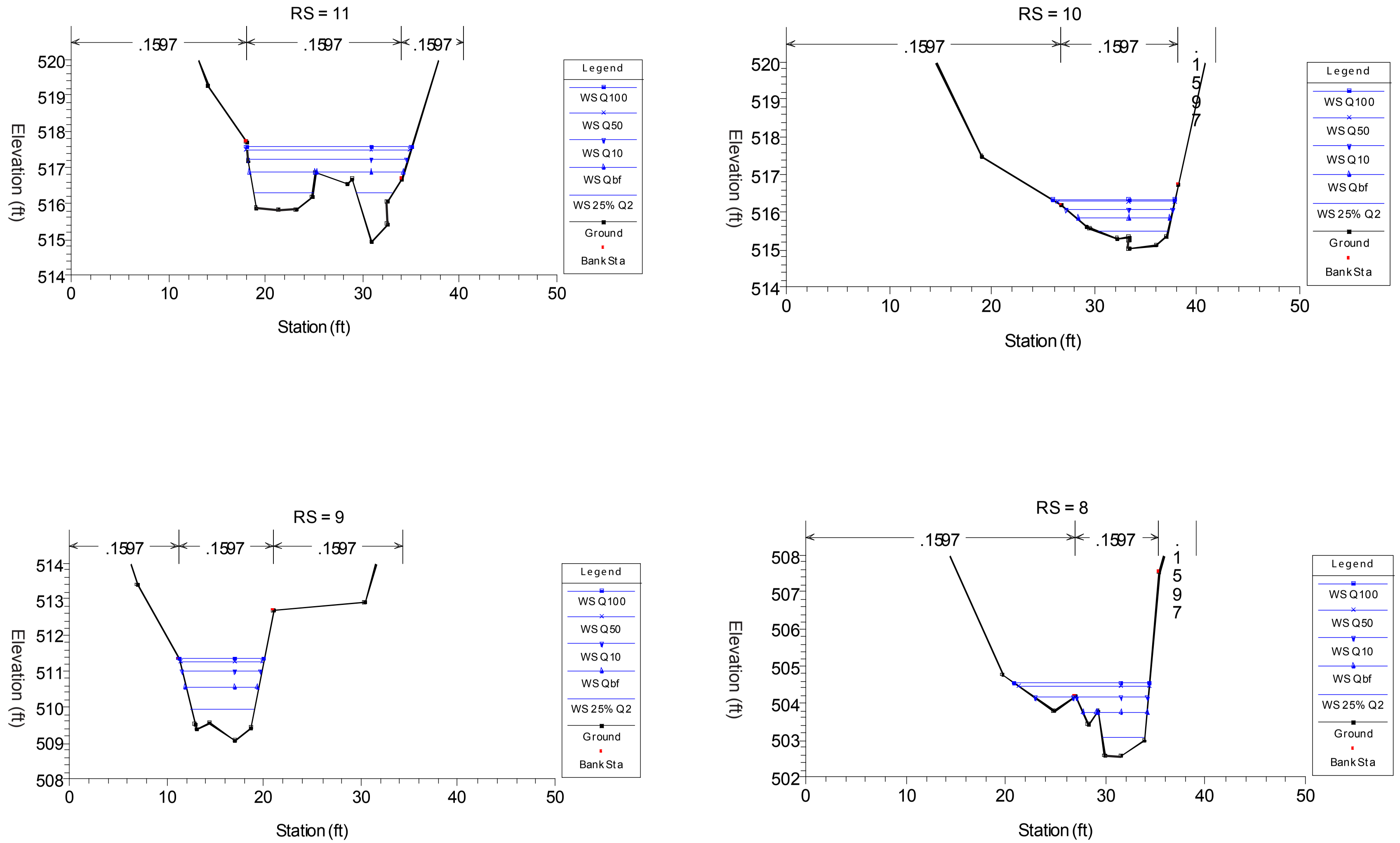
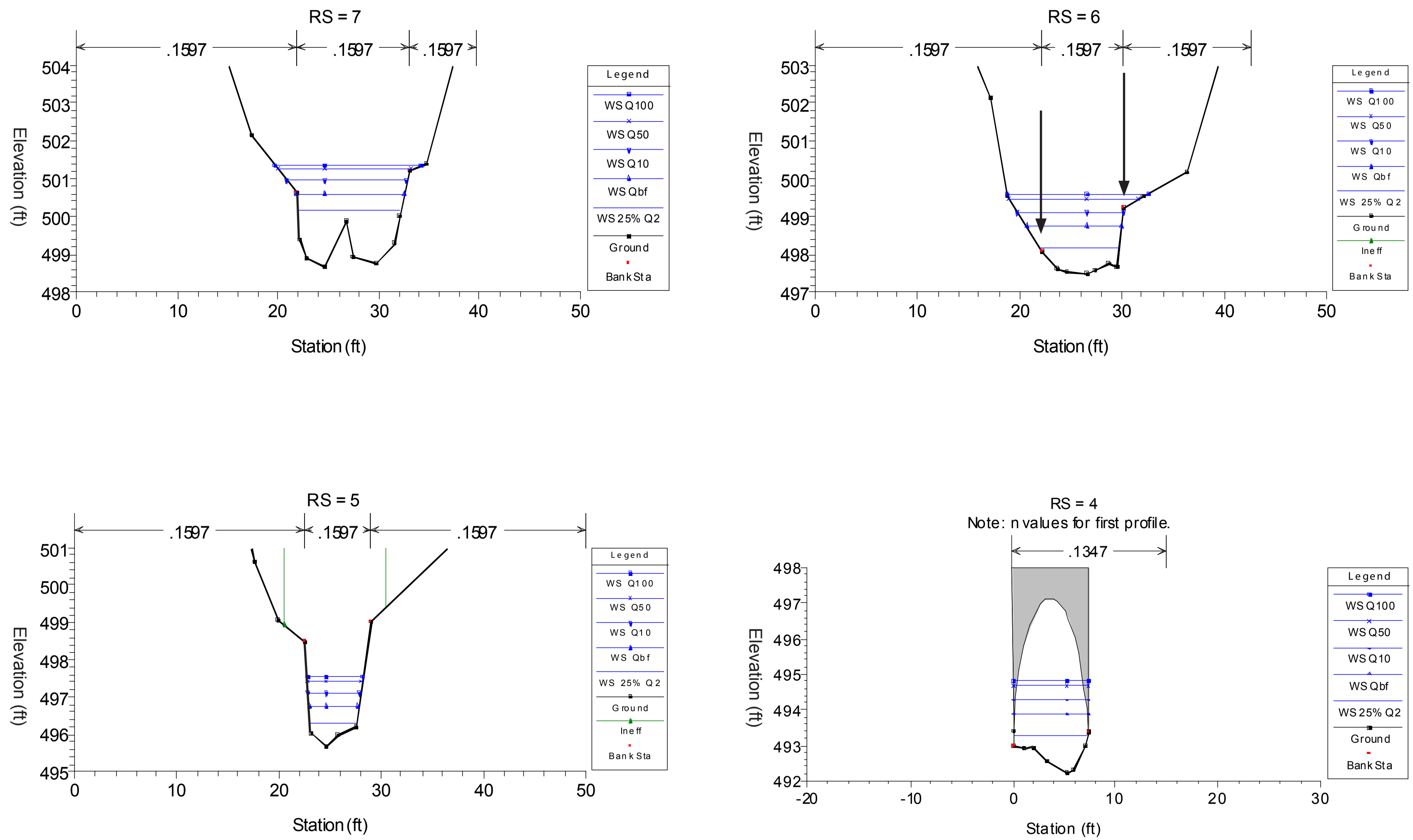


Figure 4—Cross-section plots. Only measured cross sections are included. Manning's n values are included at the top of the cross-section. The stationing (RS) corresponds to the stationing on the HEC-RAS profile. Green arrows define the ineffective flow areas. Black arrows represent points identified 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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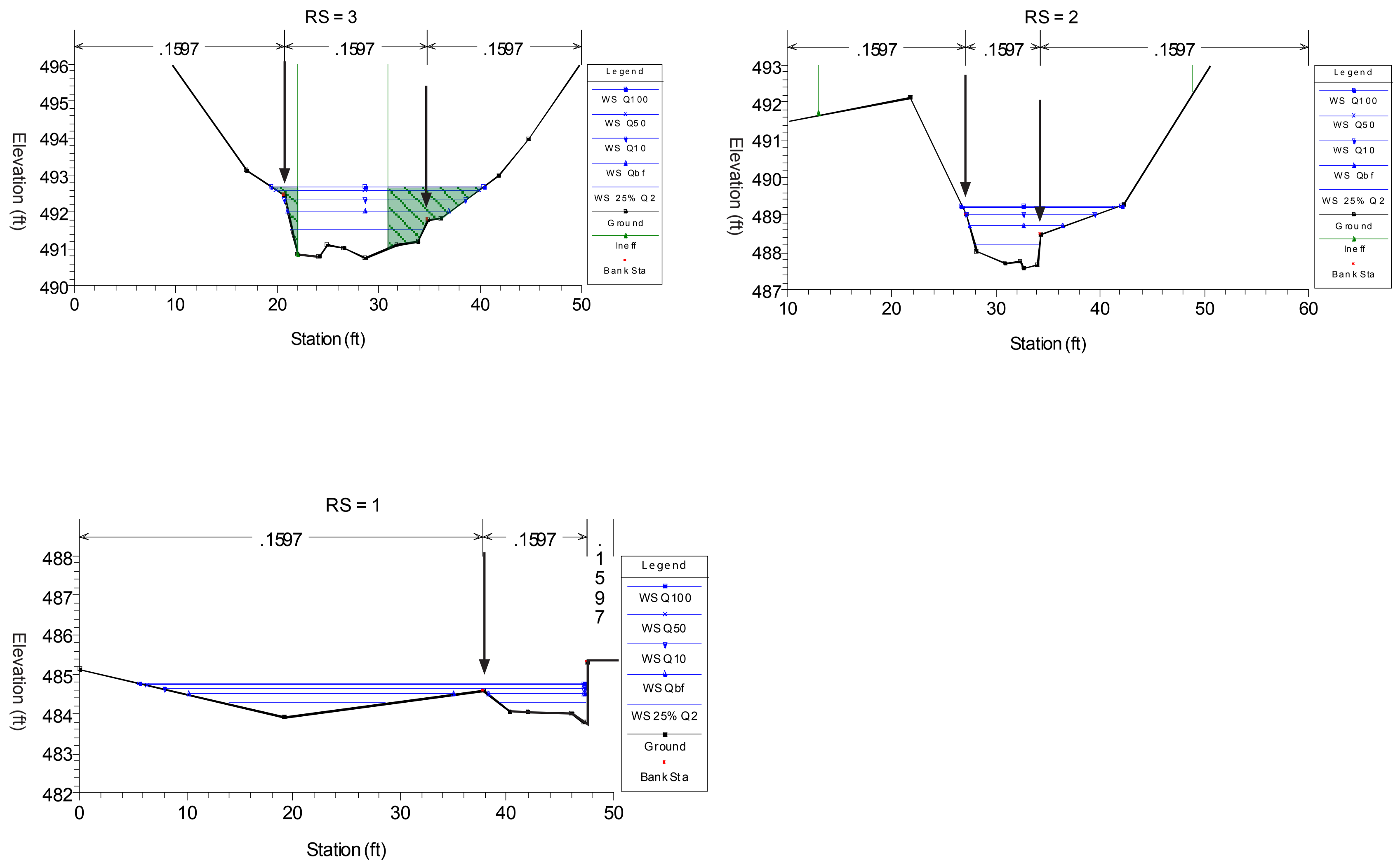

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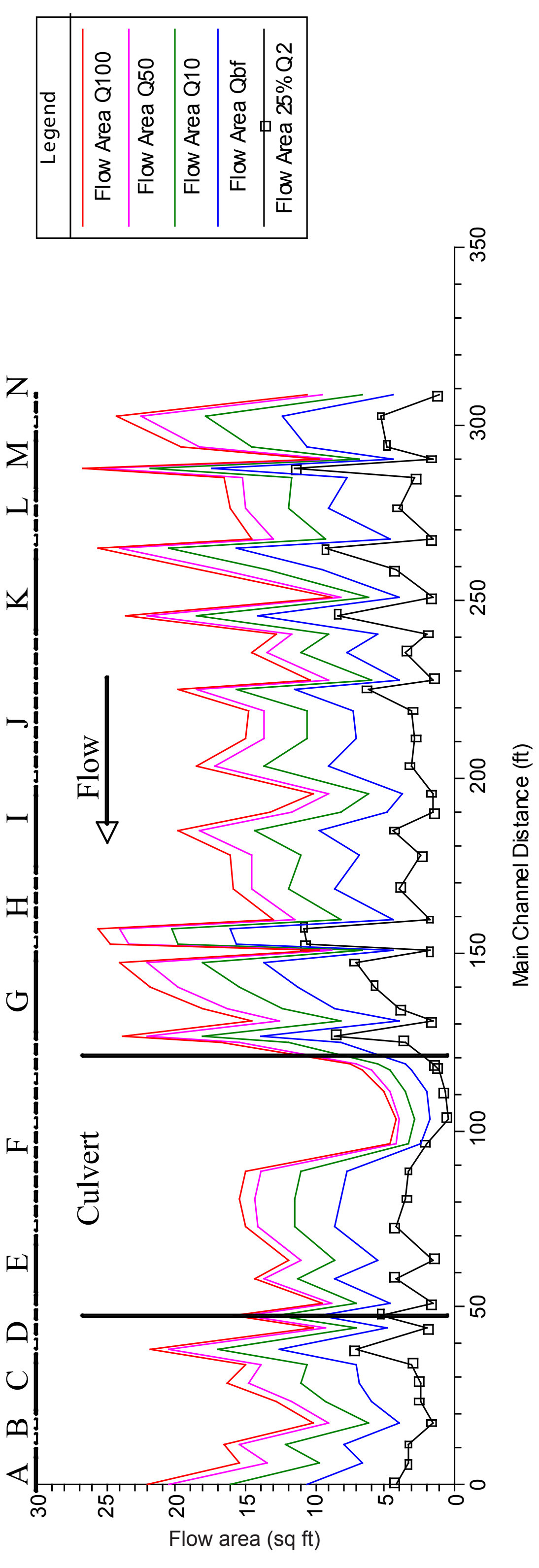


Figure 5—Flow Area (total) profile plot.

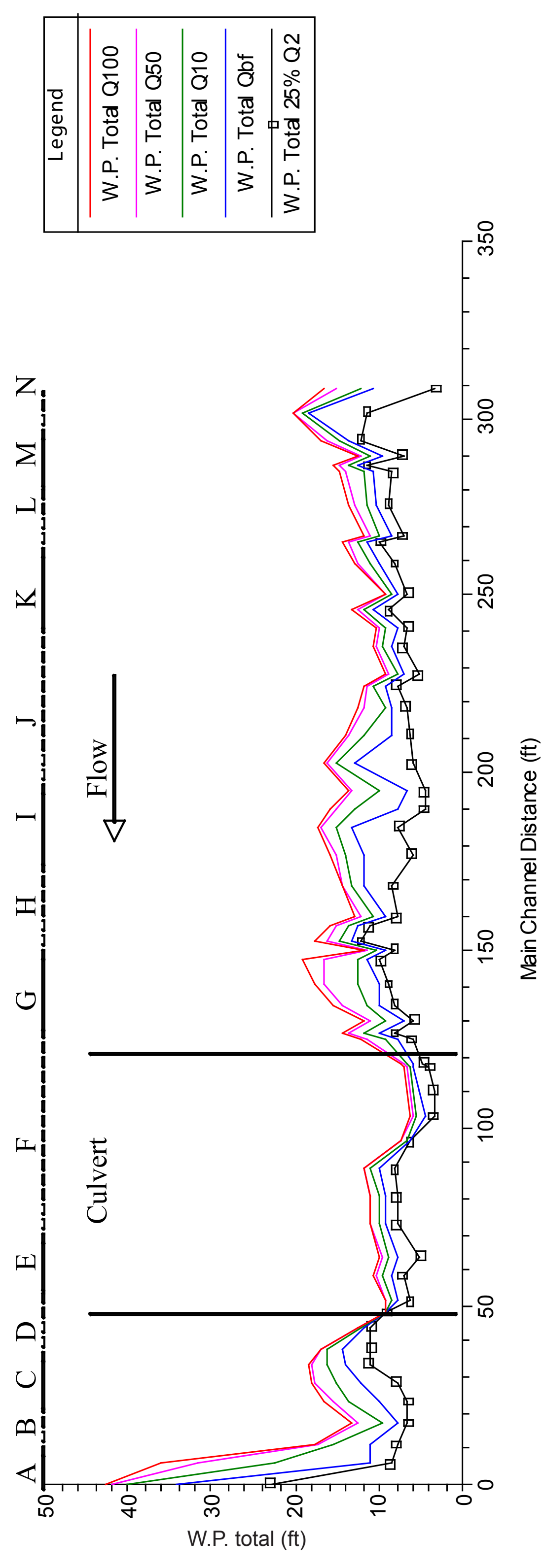


Figure 6—Wetted perimeter.

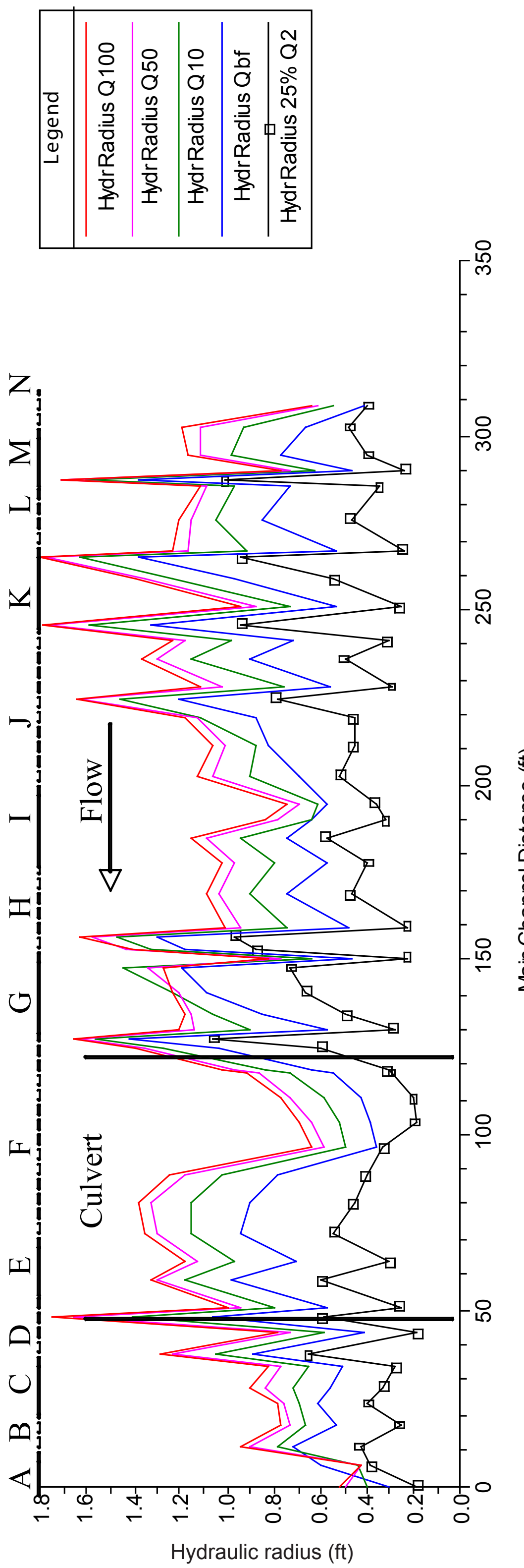


Figure 7—Hydraulic radius.

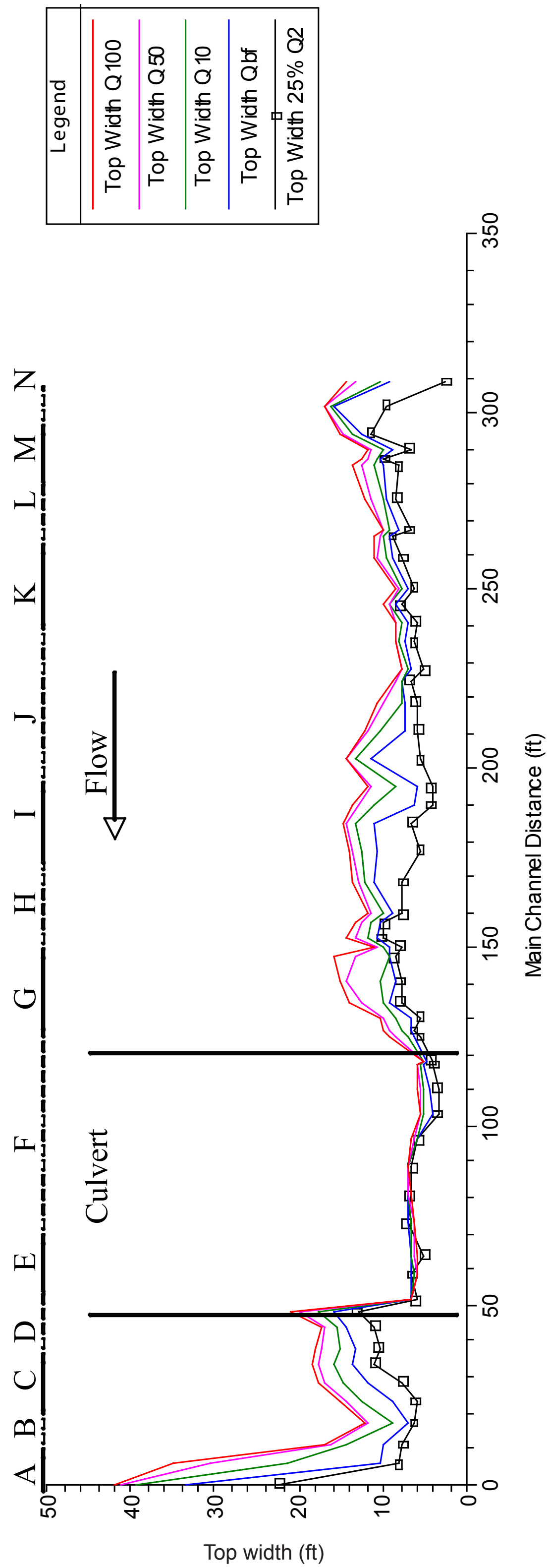


Figure 8—Top width.

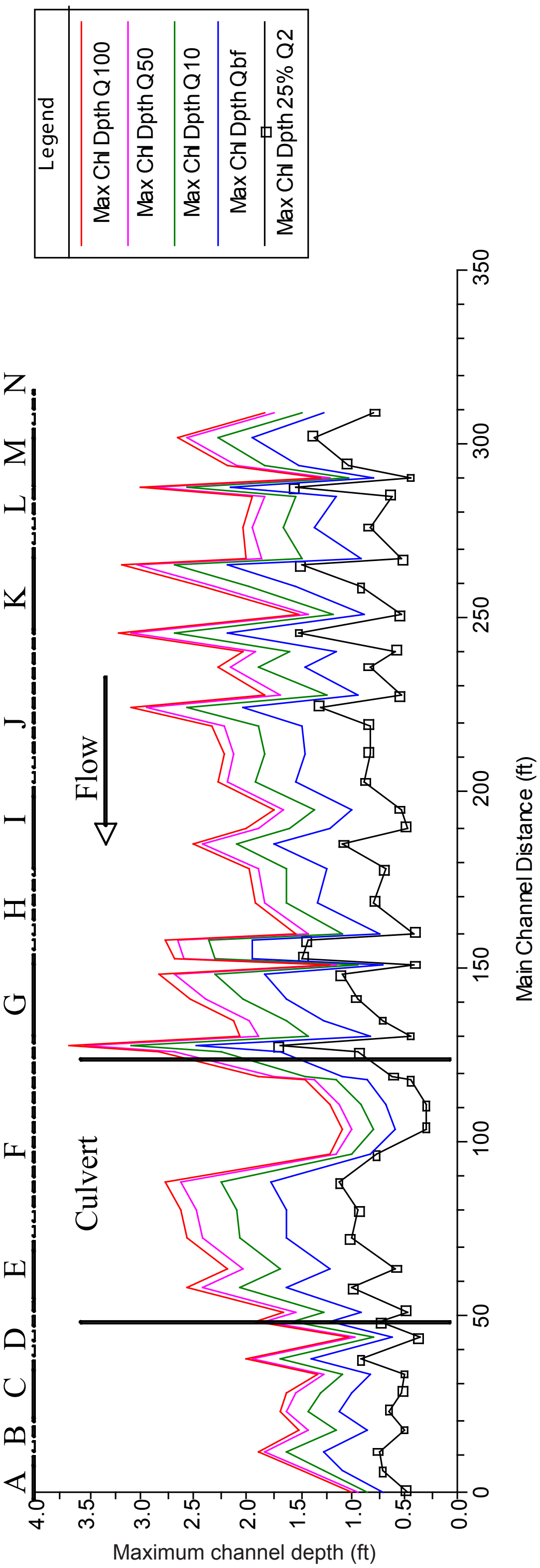


Figure 9—Maximum depth.

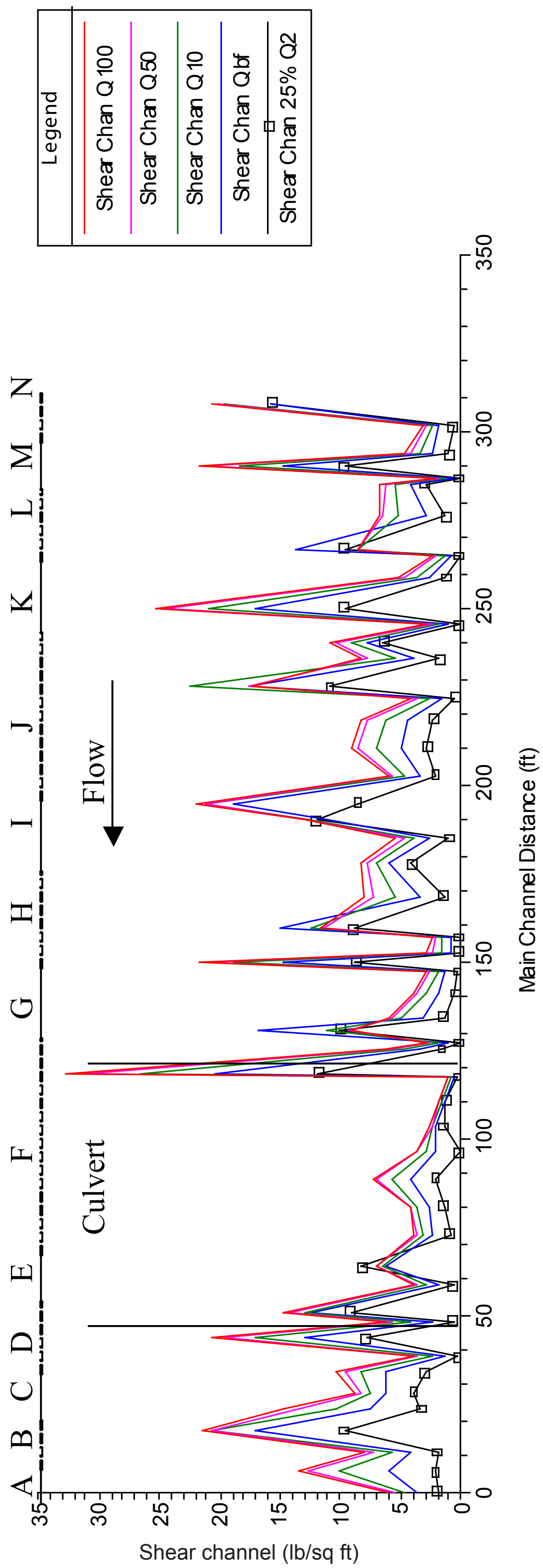


Figure 10—Shear stress (channel) profile.

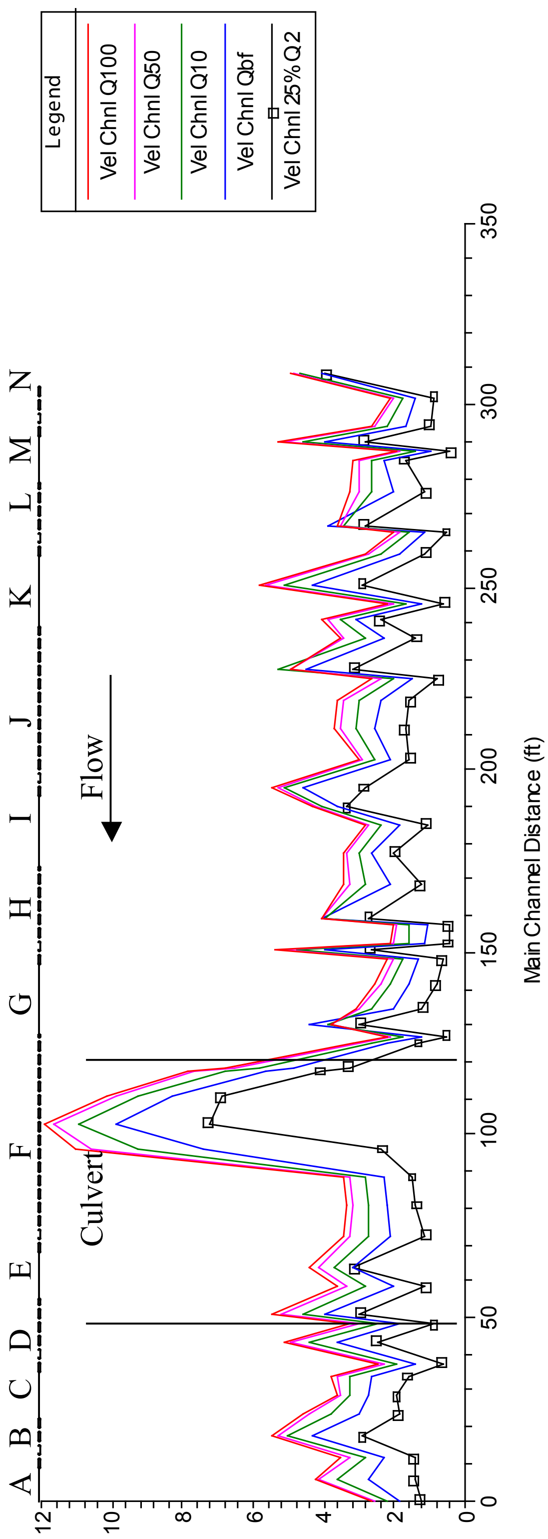
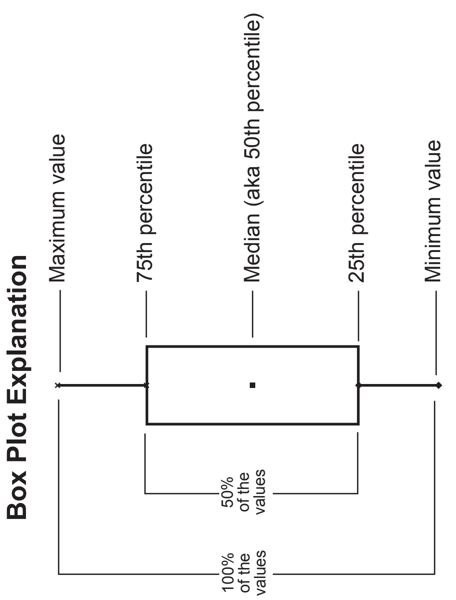


Figure 11—Velocity (channel) profile plot.



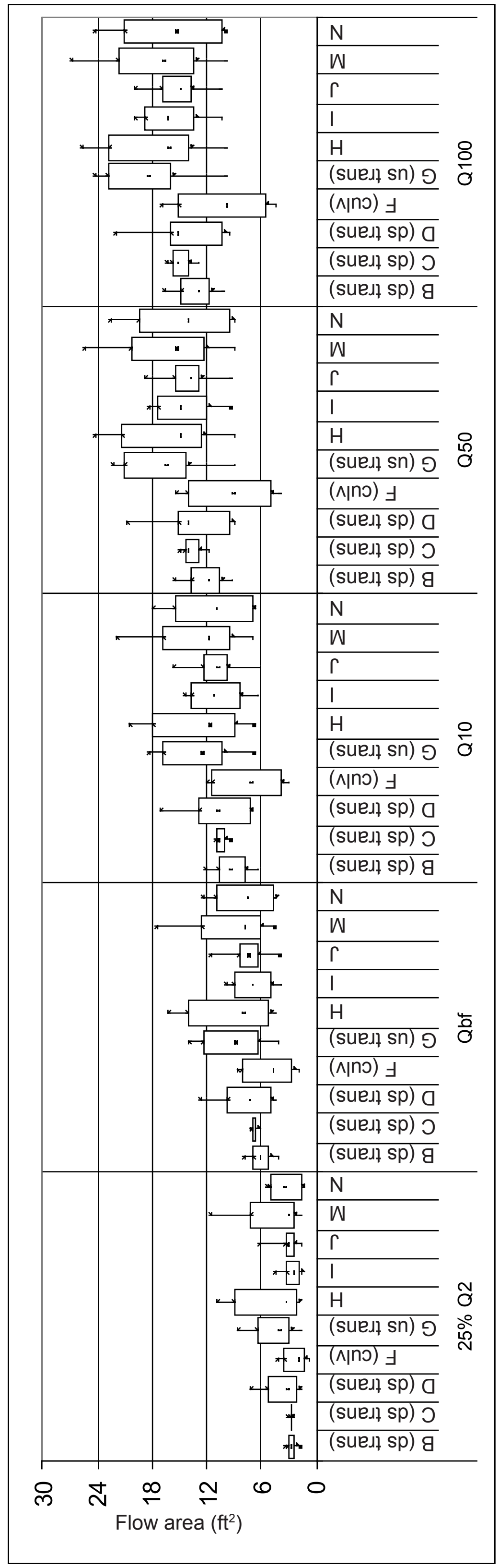


Figure 12—Flow area (total).

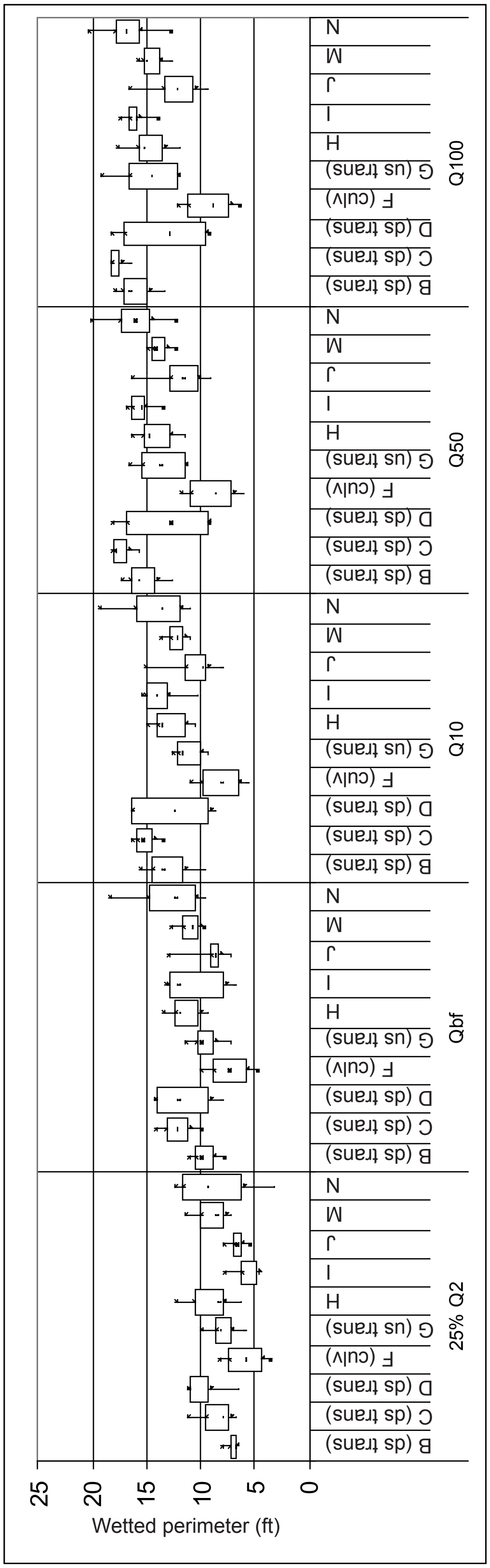


Figure 13—Wetted perimeter.

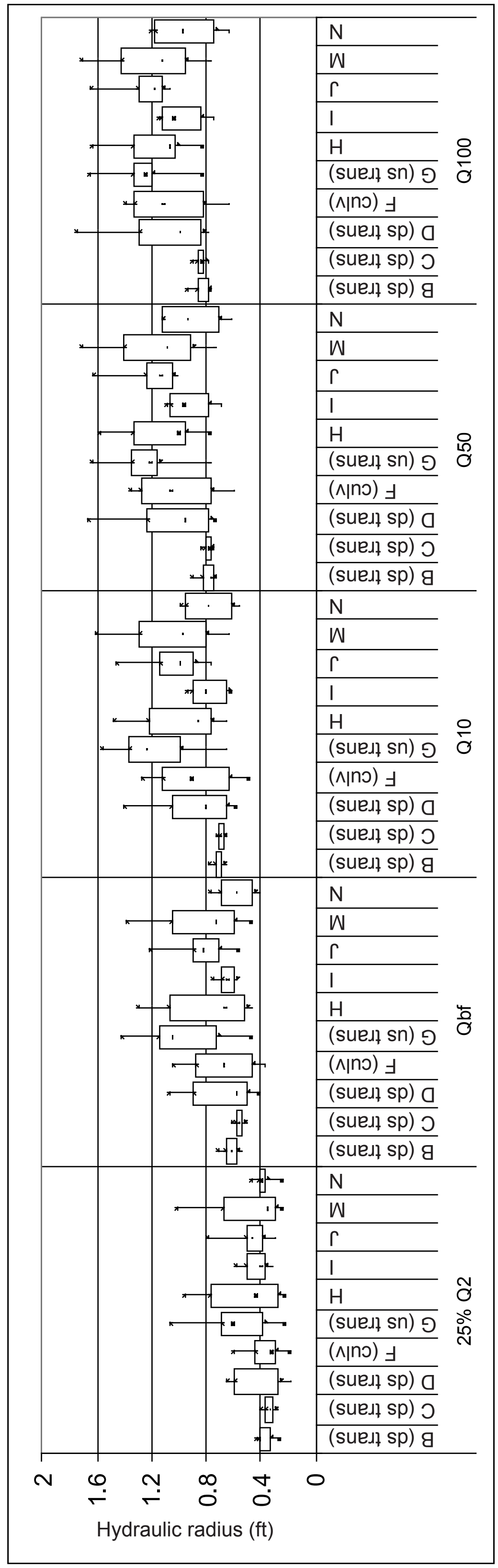


Figure 14—Hydraulic radius.

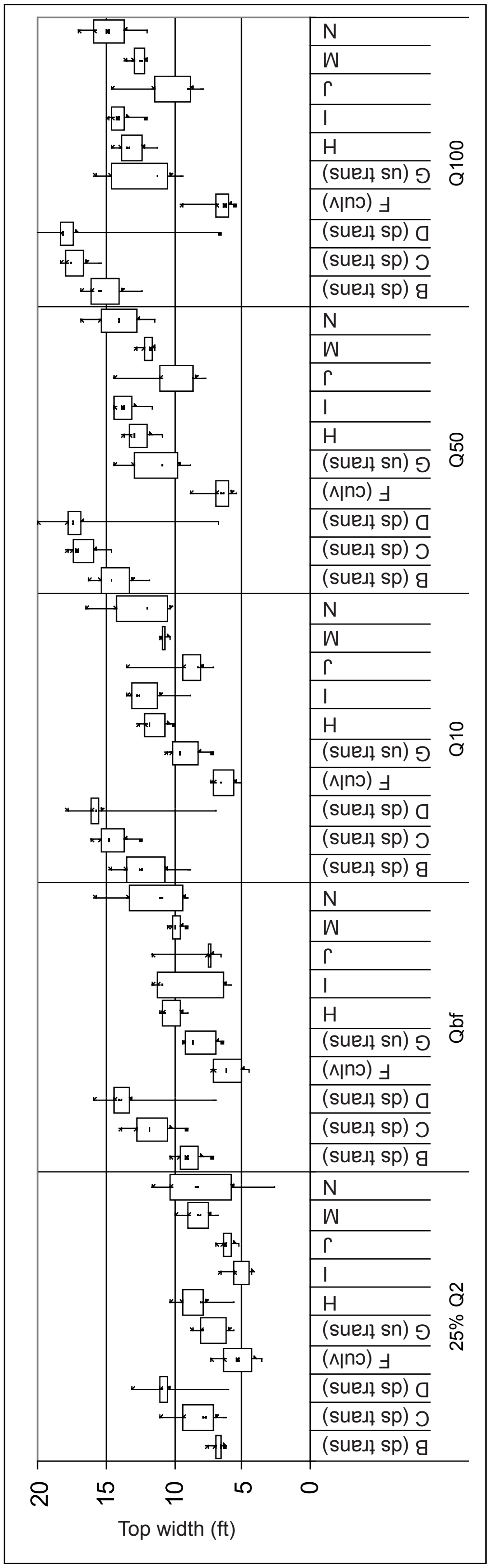


Figure 15—Top width.

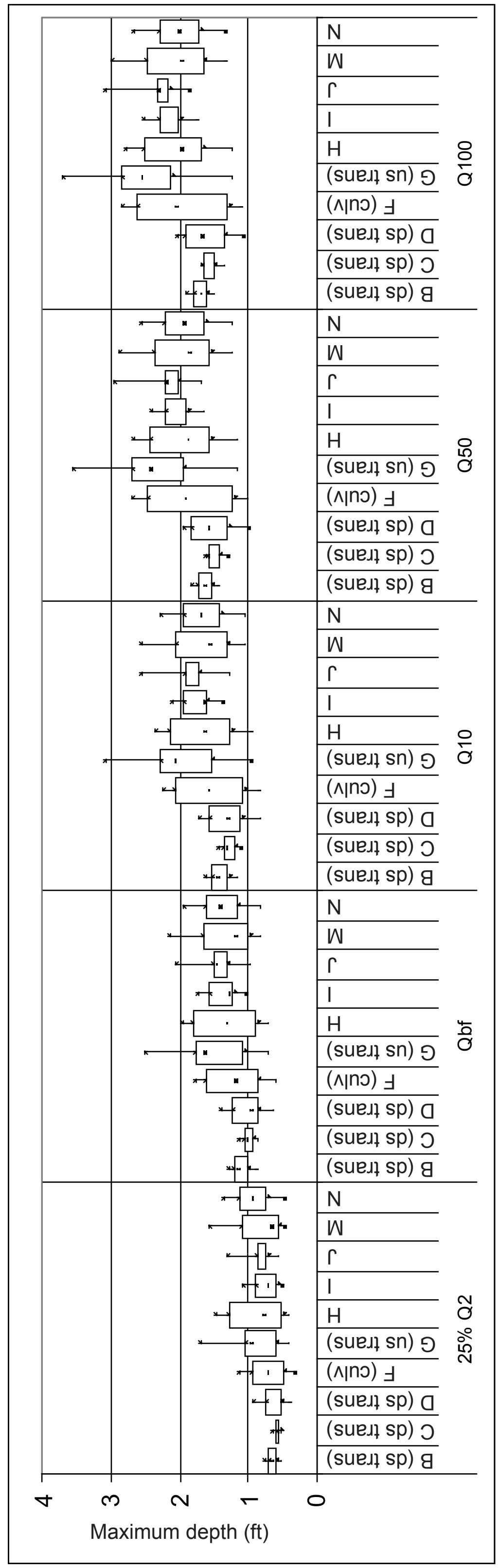


Figure 16—Maximum depth.

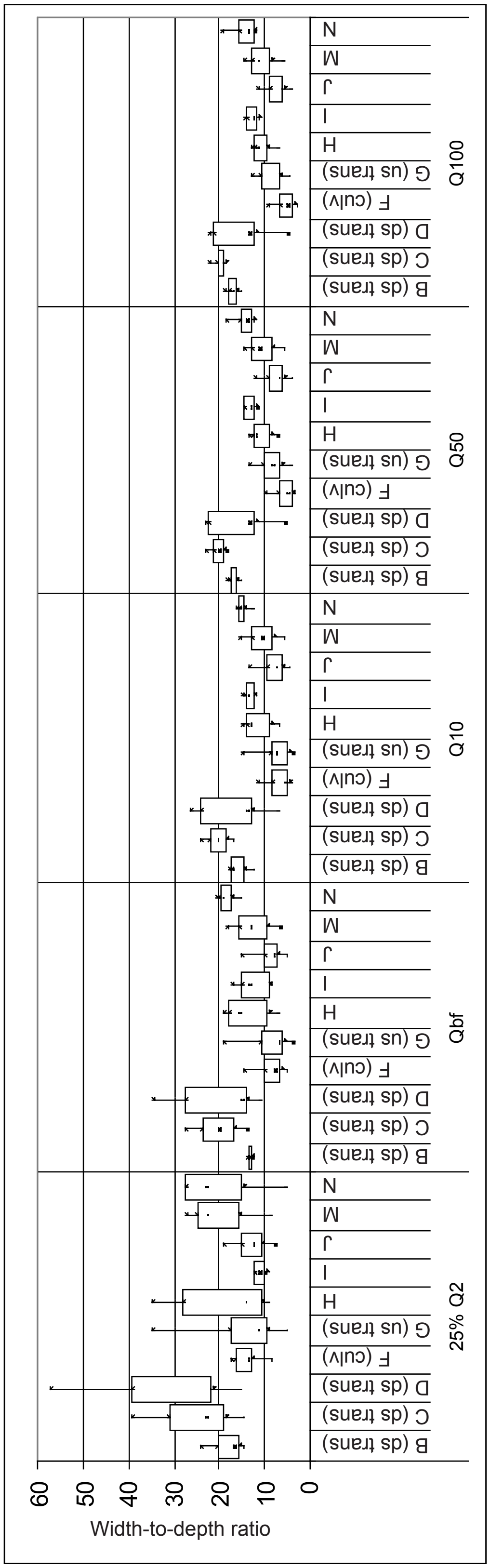


Figure 17—Width-to-depth ratio.

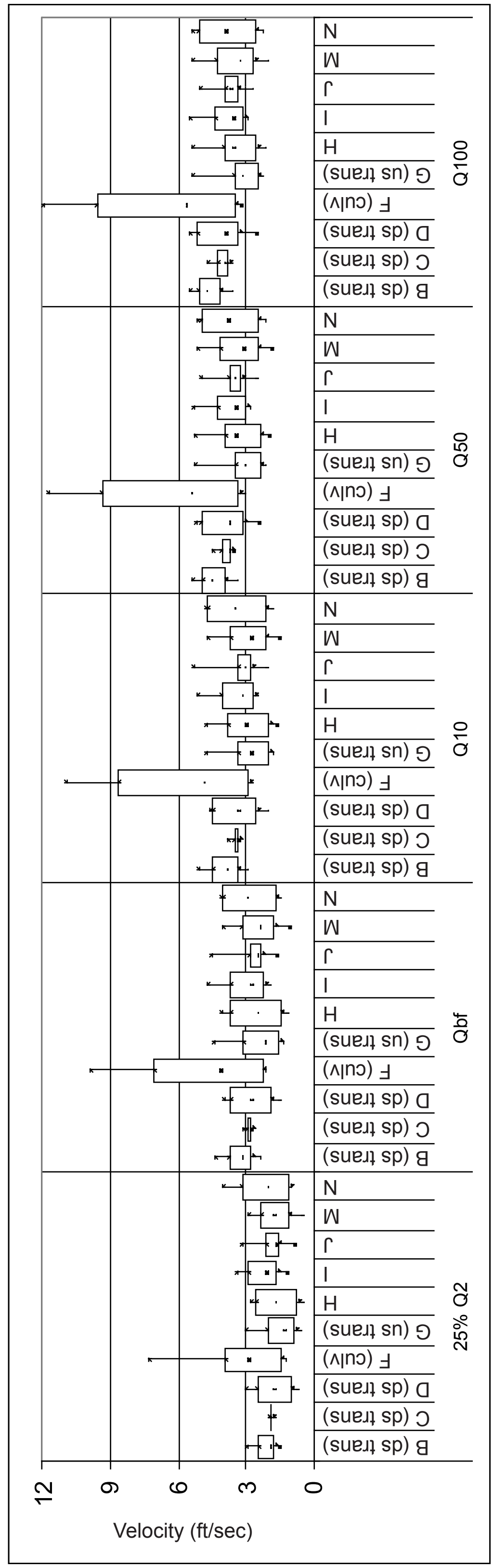


Figure 18—Velocity (channel).

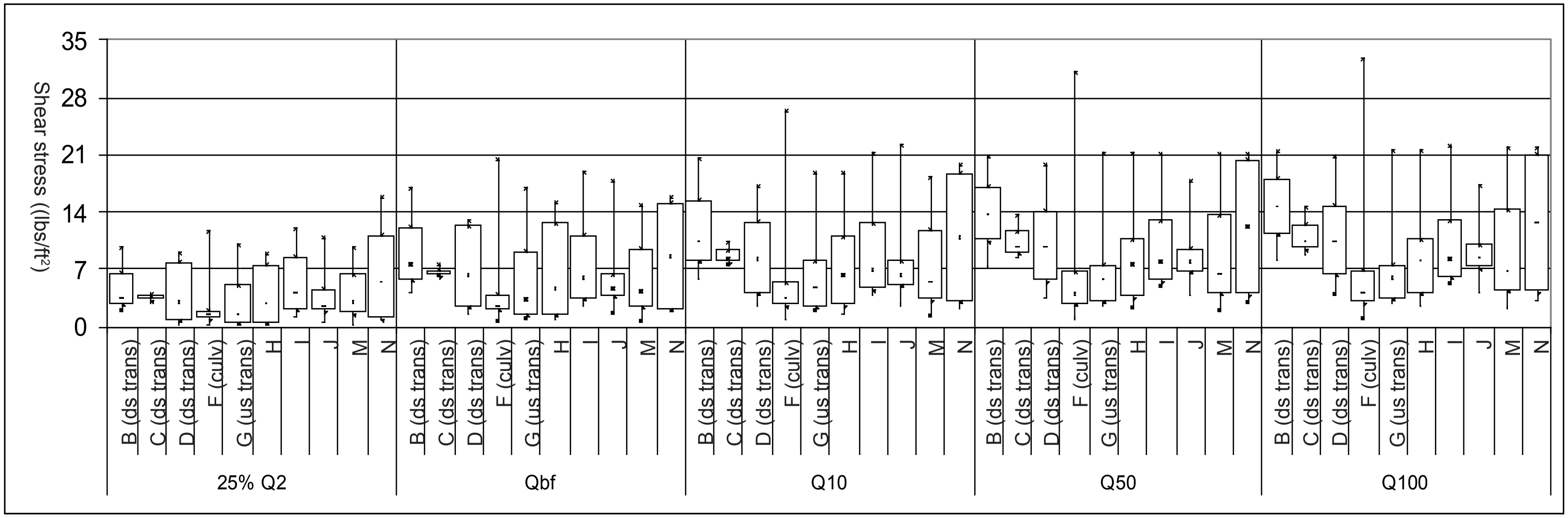
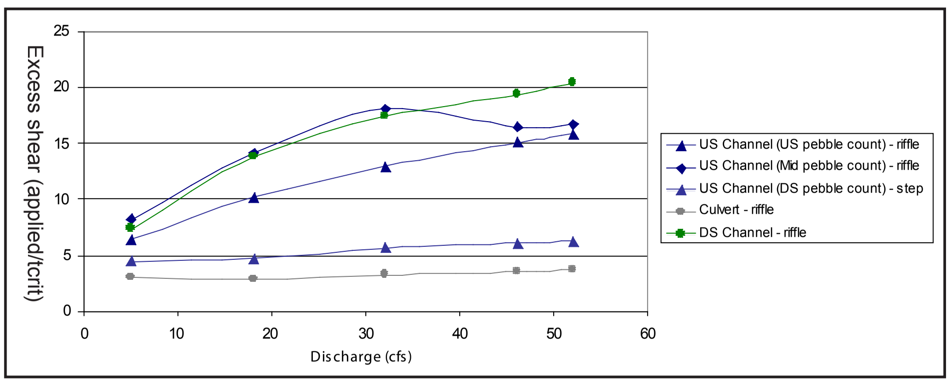


Figure 19—Shear stress (channel).



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		Riffle	0.09	No
Upstream	US	Riffle	0.03	
	Middle	Riffle	0.06	
	DS	Step	0.05	
Downstream		Riffle	0.02	

Table 4—Vertical sinuosity

Segment	Location	Vertical Sinuosity (ft/ft)
A	DS channel	1.003
B	DS transition	1.024
C	DS transition	1.094
D	DS transition	1.032
E	Culvert	1.003
F	Culvert	1.005
G	US transition	1.020
H	US channel	1.057
I	US channel	1.029
J	US channel	1.021
K	US channel	1.036
L	US channel	1.015
M	US channel	1.028
N	US channel	1.042

Table 5—Depth distribution

Reach	XS Location	25% Q_2	Within range of channel conditions?
Culvert		5	Yes
Upstream	US	4	
	Middle	0	
	DS	2	
Downstream		6	

Table 6—Habitat unit composition

Reach	Percent of surface area			
	Pool	Glide	Riffle	Step
Culvert	0%	0%	95%	5%
Upstream Channel	20%	0%	75%	1%

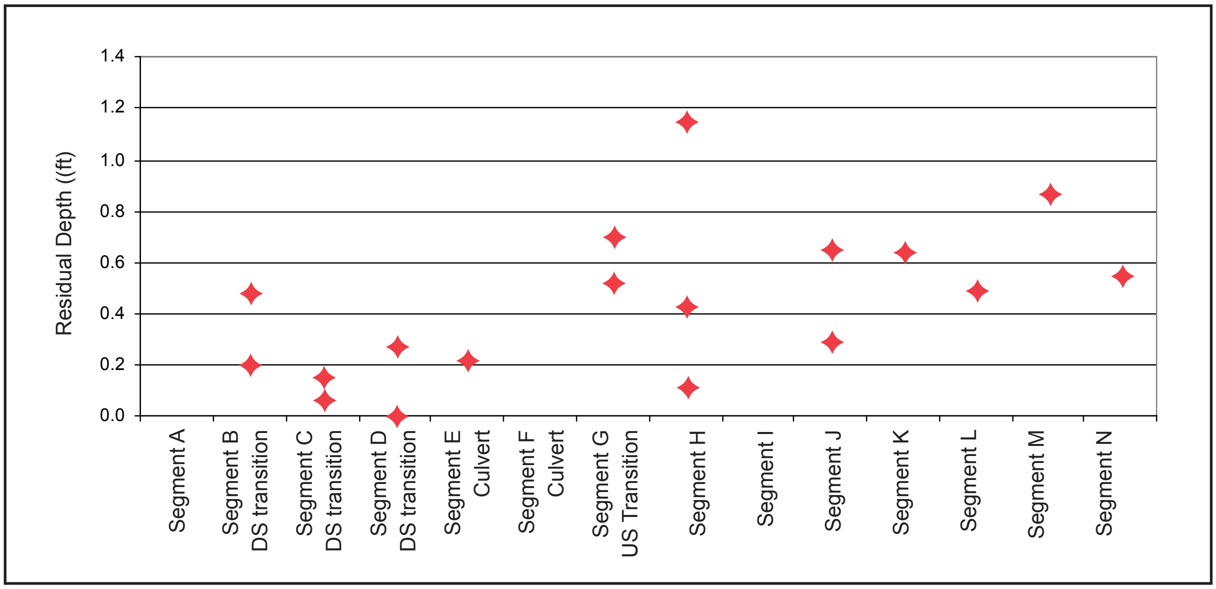


Figure 21—Residual depths.

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		Riffle	1.57	No	0.29	Yes
Upstream	US	Riffle	2.05		0.44	
	Middle	Riffle	2.01		0.25	
	DS	Step	2.53		0.28	
Downstream		Riffle	1.80		0.34	

Table 8—Large woody debris

Reach	Pieces/Channel Width
Culvert	0.21
Upstream	2.01

Terminology:

US = Upstream

DS = Downstream

RR = Reference reach

XS = Cross section

View upstream through culvert.

View downstream through culvert.

View upstream in culvert.

View downstream in culvert.

View downstream from upstream end of upstream reference reach.

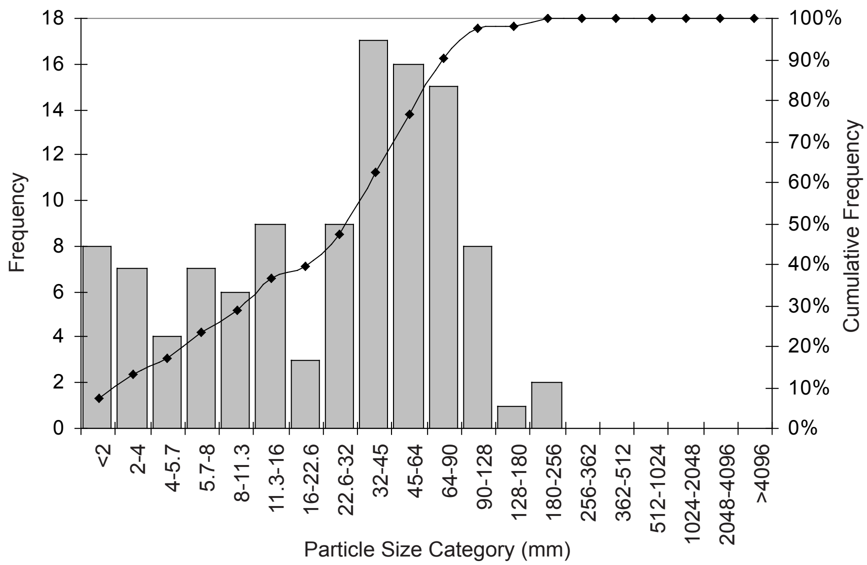
View upstream near downstream end of upstream reference reach.

Upstream reference reach – middle pebble count location.

View downstream from road.

Cross Section: Upstream Reference Reach – Upstream Pebble Count

Material	Size Range (mm)	Count	Item %	Cumulative %
sand	<2	8	7%	7%
very fine gravel	2 - 4	7	6%	13%
fine gravel	4 - 5.7	4	4%	17%
fine gravel	5.7 - 8	7	6%	23%
medium gravel	8 - 11.3	6	5%	29%
medium gravel	11.3 - 16	9	8%	37%
coarse gravel	16 - 22.6	3	3%	39%
coarse gravel	22.6 - 32	9	8%	47%
very coarse gravel	32 - 45	17	15%	63%
very coarse gravel	45 - 64	16	14%	77%
small cobble	64 - 90	15	13%	90%
medium cobble	90 - 128	8	7%	97%
large cobble	128 - 180	1	1%	98%
very large cobble	180 - 256	2	2%	100%
small boulder	256 - 362	0	0%	100%
small boulder	362 - 512	0	0%	100%
medium boulder	512 - 1024	0	0%	100%
large boulder	1024 - 2048	0	0%	100%
very large boulder	2048 - 4096	0	0%	100%
bedrock	> 4096	0	0%	100%



Size Class	Size percent finer than (mm)
D5	1
D16	5
D50	35
D84	80
D95	120
D100	200

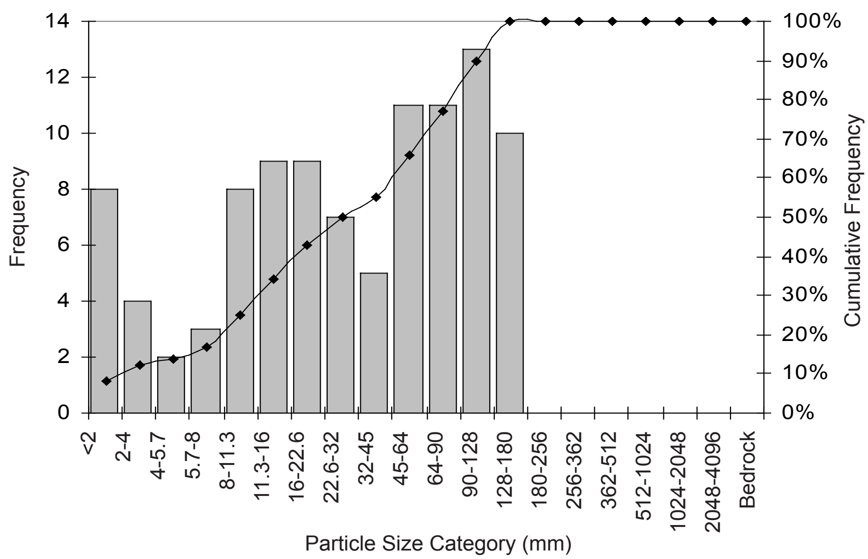
Material	Percent Composition
Sand	7%
Gravel	70%
Cobble	23%
Boulder	0%
Bedrock	0%

Sorting Coefficient: 2.05

Skewness Coefficient: 0.44

Cross Section: Upstream Reference Reach – Middle Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	8	8%	8%
very fine gravel	2 - 4	4	4%	12%
fine gravel	4 - 5.7	2	2%	14%
fine gravel	5.7 - 8	3	3%	17%
medium gravel	8 - 11.3	8	8%	25%
medium gravel	11.3 - 16	9	9%	34%
coarse gravel	16 - 22.6	9	9%	43%
coarse gravel	22.6 - 32	7	7%	50%
very coarse gravel	32 - 45	5	5%	55%
very coarse gravel	45 - 64	11	11%	66%
small cobble	64 - 90	11	11%	77%
medium cobble	90 - 128	13	13%	90%
large cobble	128 - 180	10	10%	100%
very large cobble	180 - 256	0	0%	100%
small boulder	256 - 362	0	0%	100%
small boulder	362 - 512	0	0%	100%
medium boulder	512 - 1024	0	0%	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	1
D16	8
D50	33
D84	100
D95	150
D100	180

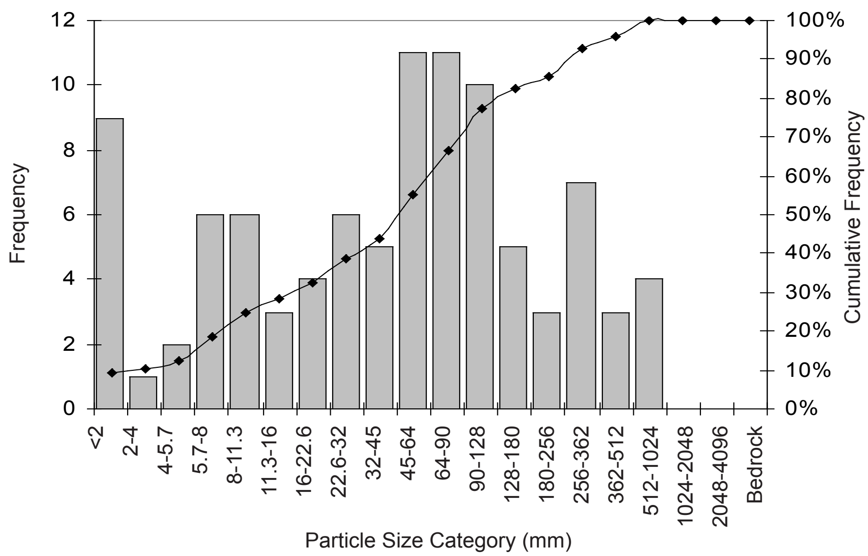
Material	Percent Composition
Sand	8%
Gravel	58%
Cobble	34%
Boulder	0%
Bedrock	0%

Sorting Coefficient: 2.01

Skewness Coefficient: 0.25

Cross Section: Upstream Reference Reach – Downstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	9	9%	9%
very fine gravel	2 - 4	1	1%	10%
fine gravel	4 - 5.7	2	2%	13%
fine gravel	5.7 - 8	6	6%	19%
medium gravel	8 - 11.3	6	6%	25%
medium gravel	11.3 - 16	3	3%	28%
coarse gravel	16 - 22.6	4	4%	32%
coarse gravel	22.6 - 32	6	6%	39%
very coarse gravel	32 - 45	5	5%	44%
very coarse gravel	45 - 64	11	11%	55%
small cobble	64 - 90	11	11%	67%
medium cobble	90 - 128	10	10%	77%
large cobble	128 - 180	5	5%	82%
very large cobble	180 - 256	3	3%	85%
small boulder	256 - 362	7	7%	93%
small boulder	362 - 512	3	3%	96%
medium boulder	512 - 1024	4	4%	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	1
D16	8
D50	60
D84	202
D95	508
D100	813

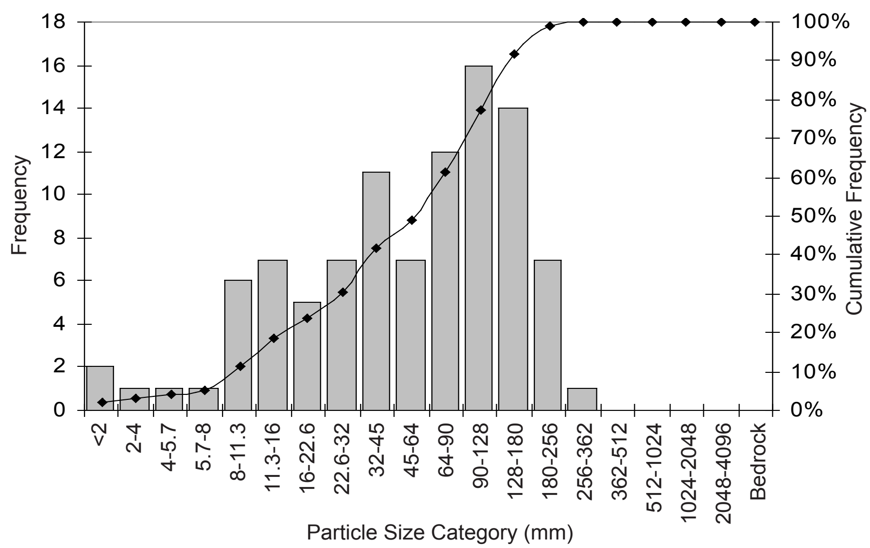
Material	Percent Composition
Sand	9%
Gravel	46%
Cobble	30%
Boulder	15%
Bedrock	0%

Sorting Coefficient: 2.53

Skewness Coefficient: 0.28

Cross Section: Culvert – Downstream 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	1	1%	5%
medium gravel	8 - 11.3	6	6%	11%
medium gravel	11.3 - 16	7	7%	18%
coarse gravel	16 - 22.6	5	5%	23%
coarse gravel	22.6 - 32	7	7%	31%
very coarse gravel	32 - 45	11	11%	42%
very coarse gravel	45 - 64	7	7%	49%
small cobble	64 - 90	12	12%	61%
medium cobble	90 - 128	16	16%	78%
large cobble	128 - 180	14	14%	92%
very large cobble	180 - 256	7	7%	99%
small boulder	256 - 362	1	1%	100%
small boulder	362 - 512	0	0%	100%
medium boulder	512 - 1024	0	0%	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	8
D16	14
D50	66
D84	151
D95	214
D100	309

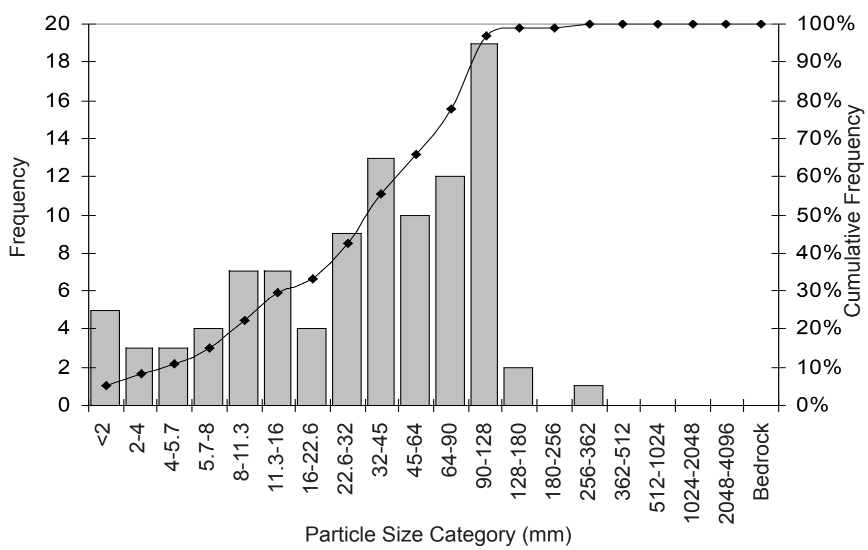
Material	Percent Composition
Sand	2%
Gravel	47%
Cobble	50%
Boulder	1%
Bedrock	0%

Sorting Coefficient: 1.57

Skewness Coefficient: 0.29

Cross Section: Downstream of Culvert – Only Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	5	5%	5%
very fine gravel	2 - 4	3	3%	8%
fine gravel	4 - 5.7	3	3%	11%
fine gravel	5.7 - 8	4	4%	15%
medium gravel	8 - 11.3	7	7%	22%
medium gravel	11.3 - 16	7	7%	29%
coarse gravel	16 - 22.6	4	4%	33%
coarse gravel	22.6 - 32	9	9%	42%
very coarse gravel	32 - 45	13	13%	56%
very coarse gravel	45 - 64	10	10%	66%
small cobble	64 - 90	12	12%	78%
medium cobble	90 - 128	19	19%	97%
large cobble	128 - 180	2	2%	99%
very large cobble	180 - 256	0	0%	99%
small boulder	256 - 362	1	1%	100%
small boulder	362 - 512	0	0%	100%
medium boulder	512 - 1024	0	0%	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	2
D16	8
D50	40
D84	102
D95	124
D100	309

Material	Percent Composition
Sand	5%
Gravel	61%
Cobble	33%
Boulder	1%
Bedrock	0%

Sorting Coefficient: 1.80

Skewness Coefficient: 0.34

**This pebble count was not used in the analysis because the downstream reach was not used as a reference reach*