Eames Creek

Site Information

Site Location: Coast Range, Upper Siuslaw Basin, Wolf Cr Trib, ~0.6hr from Eugene

Year Installed: Pre-1987

Lat/Long: 123°27'43.0"W 43°55'53.1"N

Watershed Area (mi²): 5.53

Stream Slope (ft/ft)[1]: 0.0083

Channel Type: Pool-riffle

Bankfull Width (ft): 31 ft

Survey Date: March 20, 2007

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

Culvert Information

Culvert Type: Bottomless arch

Culvert Material: Annular CMP

Culvert Width: 13 ft

Outlet Type: Mitered

Culvert Length: 55 ft

Inlet Type: Mitered

Pipe Slope (structure slope): 0.0003

Culvert Bed Slope: 0.0075

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

Culvert width as a percentage of bankfull width: 0.42

Alignment Conditions: Culvert moderately off-line with natural channel. Culvert should be at more of an angle to the road to reduce the bend at culvert inlet.

Bed Conditions: Scoured to sandstone bedrock.

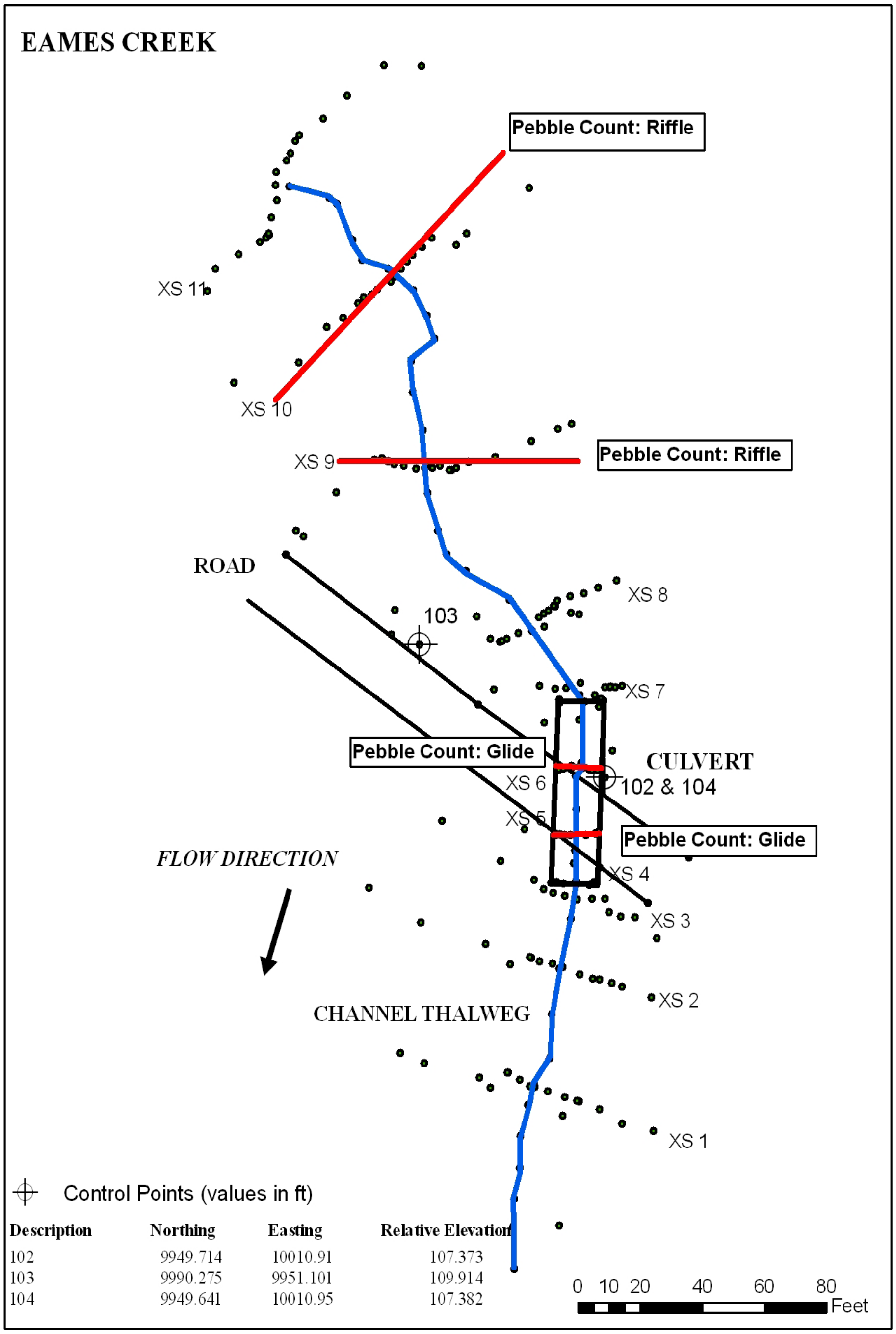
Pipe Condition: Three pieces of large wood at inlet could contribute to capacity and scour issues. Some undercutting has occurred at right bank footing at downstream end of pipe. The base (spread) footing is compromised in some areas.

Hydrology

Discharge (cfs) for indicated recurrence interval

25% 2-yr	Q_{bf}[2]	2-year	5-year	10-year	50-year	100-year
78	180	311	486	613	919	1060

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



Description	Northing	Easting	Relative Elevation
102	9949.714	10010.91	107.373
103	9990.275	9951.101	109.914
104	9949.641	10010.95	107.382

Points represent survey points

Figure 1—Plan view map.

HISTORY

An Eames Creek culvert was included in the 1987 Western Federal Lands Highway Division "Oregon Culvert Fish Passage Survey"; but from the location information and photographs provided, it was impossible to tell which of two nearby culverts was analyzed in the study.

SITE DESCRIPTION

The Eames Creek culvert is a bottomless arch with mitered ends that sits on a concrete foundation. The channel bed is sandstone bedrock. Three large logs have become lodged between the left bank upstream of the crossing and the inlet to the pipe. Additional smaller debris has been deposited around these pieces. Scour around the logs is apparent, notably in the form of a scour pool which extends from the upstream of the culvert through the inlet around the rootwad of one of the logs. Downstream of the influence of the wood, the channel consists of a bedrock (sandstone) glide. Small amounts of sand were deposited along the lower velocity margins of the culvert, but little to no gravels were present.

Log and rock grade control structures beginning roughly 215 feet upstream of the inlet restricted the location and length of the upstream representative reach to that section of channel immediately upstream of the culvert. The upstream representative reach consists of deep long pools with short, well-defined riffle units. The bed material in the channel is predominately gravels and cobbles with a significant presence of sand and fines. Fines line the banks and cover the bars. A few fallen trees, as a result of bank erosion along the outside of a bend, have resulted in a small in-channel wood jam.

SURVEY SUMMARY

Ten cross sections and a longitudinal profile were surveyed along Eames Creek in March 2007 to characterize the culvert and an upstream representative reach. No downstream representative reach was established due to the uncharacteristic reach downstream followed by the upstream, potential backwater, effects of another culvert. Two representative cross sections were taken through the culvert; one through the scour pool and the other through the glide. One additional cross section was surveyed upstream to characterize the inlet as well as the contraction of flow. Another two cross sections were surveyed downstream of the culvert to characterize the outlet and the expansion of flow.

In the upstream representative reach, representative cross sections were taken through a riffle and a pool. Two additional sections were surveyed to characterize the upstream and downstream ends of the reach.

PROFILE ANALYSIS SEGMENT SUMMARY

The profile analysis resulted in a total of five profile segments. There was only one suitable representative profile segment, located in the upstream channel. The culvert consisted of two profile segments, the upper one extending well upstream through the inlet transition area. The gradients of the culvert segments differed from the representative profile segment by greater than 20 percent but less than 40 percent. Because of the low slope and similar channel types, the two culvert segments were believed to be a reasonable comparison with the representative segment. The downstream transition segment was also compared to the upstream representative profile segment. There was no separate profile segment for the upstream transition. The upstream culvert segment represents conditions within the culvert and in the upstream transition area that is affected by the culvert.

SCOUR CONDITIONS

Observed conditions

Footing scour – The culvert has a 22-inch-wide spread footing that sites on top of the bedrock bed. An 18-inch-wide stem wall rises from the spread footing. The spread footing is scoured and undermined in a number of locations, including the upstream end right bank for 6-foot length (undercut depth 4 inches) and the downstream end right bank for 3- to 4-foot length (undercut depth 4 inches). In these cases it appears the sandstone bedrock has been scoured out beneath the footing at these locations. The concrete footings themselves also show minor signs of scouring.

Culvert bed adjustment – The culvert and culvert bed are both very near to zero slope. It is unknown whether streambed material was placed in the structure during construction.

Profile characteristics – The profile has a uniform slope through the crossing but drops off at a steeper gradient beginning 50 feet downstream of the outlet (figure 2).

Residual depths – The one culvert residual depth (in segment C) is just below the lower range of those in the corresponding profile segment (figure 21).

Substrate – The culvert bed consists of sandstone bedrock with only small occurrences of sand and fine gravels. The bed downstream of the culvert is also primarily bedrock with patches of sand and gravels. Bed material distributions in the upstream reference reach are very poorly graded with high sand content.

Predicted conditions

Cross-section characteristics – The culvert has a large effect on cross-section flow characteristics throughout the entire reach. The profile segments in the natural channel cannot be considered good reference conditions because they are impacted by backwater effects from the culvert. Because of the backwater impacts, flow geometry changes dramatically from the upstream reach, through the culvert, and into the downstream reach (figures 5 through 9 and 12 through 17).

Shear stress – Due to backwater effects, the culvert has a large effect on shear stress in the upstream and downstream channel, and these segments cannot be considered suitable reference conditions. The backwater reduces the energy slope upstream of the inlet and therefore reduced shear stress. Shear stress increases moderately within the culvert and then increases dramatically downstream of the outlet because of the sharp increase in energy slope (figure 10).

Excess shear – The excess shear analysis shows very little excess shear in the upstream channel because of the low shear stress values that result from the culvert backwater (figure 20). Excess shear could not be calculated in the culvert because of a lack of mobile bed material.

Velocity – Due to backwater effects, the culvert has a large effect on velocity in the upstream and downstream channel, and these segments cannot be considered suitable reference conditions. The backwater reduces the velocity upstream of the inlet (figure 11). Velocity increases within the culvert and then increases dramatically at the outlet and just downstream as the flow passes through critical depth.

Culvert Scour Assessment

Scour summary

Hydraulic model results indicate that above the Q_2, the entire upstream reference reach is backwatered by the culvert. The comparable slope segment in the upstream reach (E) is therefore not a suitable natural analog for the culvert reach. This limits the ability to evaluate culvert conditions in relation to natural channel conditions.

Severe backwatered conditions are a result of a combination of a low gradient reach and a significantly undersized culvert (less than half of bankfull width). These characteristics along with the recruitment and stabilization of large logs at the inlet of the crossing have resulted in scour. The culvert alignment may also be contributing to scour; the channel takes a sharp bend just upstream of the inlet and flow is concentrated along the left bank at the inlet area. Concrete footings have been scoured away and undercut through the scouring of the sandstone bedrock. Additionally, the base footing has been scoured along the downstream and upstream right edge of the pipe. It is unknown whether streambed material was originally placed in the pipe during construction; current hydraulic conditions will not allow material to remain in the pipe. Culvert hydraulics may also be responsible for the lack of streambed material in the reach downstream of the outlet. The sand deposits upstream of the culvert are a result of backwater influence.

AOP CONDITIONS

Cross-section complexity – The sum of squared height differences in the culvert cross sections are either greater than (upstream cross section) or lower than (downstream cross section) those found in the natural channel (table 3).

Profile complexity – Vertical sinuosity in the culvert is similar to that in the natural channel (table 4).

Depth distribution – There is less channel margin habitat in the culvert compared to the channel at the 25 percent Q_2 (table 5).

Habitat units – The culvert has much less habitat in pools (33 percent compared to 67 percent) than the upstream channel (table 6).

Residual depths – The one culvert residual depth (in segment C) is just below the lower range of those in the corresponding profile segment (figure 21).

Substrate – The culvert bed consists of sandstone bedrock with only small occurrences of sand and fine gravels. The bed downstream of the culvert is also primarily bedrock with patches of sand and gravels. Bed material distributions in the upstream reference reach are very poorly graded with high sand content.

Large woody debris – There were three pieces of LWD present in the upstream portion of the culvert (table 8). The wood in the culvert posed a plugging and scour risk to the culvert. The culvert was not large enough to transport this size of material through the pipe without risk of plugging. The representative channel had high LWD abundance. LWD formed small steps and scour pools in the channel outside the crossing and played a primary role in habitat-unit creation and complexity. Wood drop structures were present upstream of the representative channel.

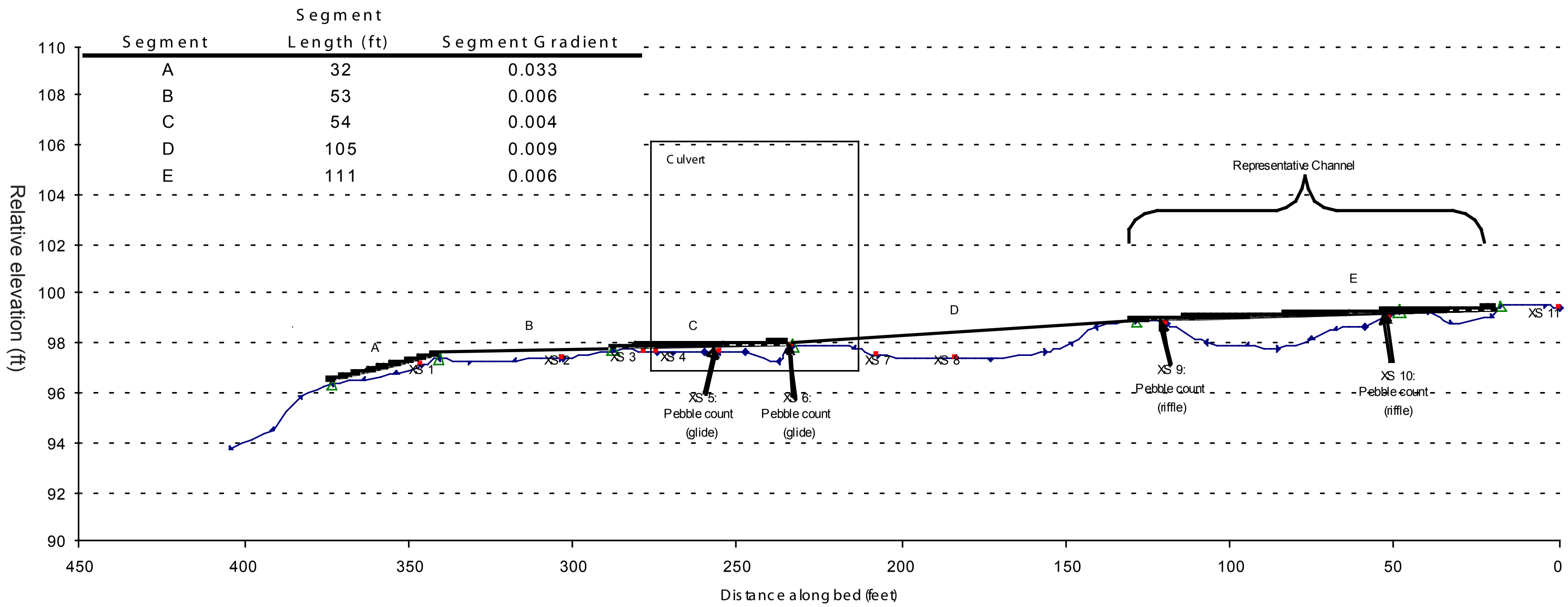
AOP summary

Although the complexity metrics do not capture it, site observations indicate that the bedrock bed of the culvert has much less complexity than the natural channel upstream of the culvert. Observations also suggest that complexity in the culvert is similar to the downstream channel that is also dominated by bedrock. There is some LWD at the inlet that would provide habitat complexity and velocity refuge, but the potential risk of culvert plugging probably outweighs these benefits.

The culvert is generally considered a poor design with respect to fish passage, with very little shallow channel margin habitat available and very little velocity refuge such as what is provided by substrate and pools and wood in the natural channel (except for some LWD near the inlet). The super-critical flow near the culvert outlet (which modeling shows occurs even at 25 percent Q_2) and associated high velocity and shear stress suggest that fish passage may be impaired at high flows. At low flows, shallow sheet flow over bedrock may present passage limitations. There are no streambanks to concentrate flows for passage or to allow for passage of terrestrial organisms.

DESIGN CONSIDERATIONS

This installation exhibits poor conditions with respect to scour and AOP. The footings are being undermined in places, there is no natural streambed material in the pipe, and AOP conditions are likely impaired. A larger culvert with greater capacity would reduce the backwater effects of the culvert and would prevent the high shear stress and velocity that occur within and at the outlet area of the pipe. It may also allow for bed material to remain within the pipe. Constructing banks using stable bed elements (i.e., boulders) within the culvert would protect the footings from being undermined by scour of the sandstone bedrock and would allow for passage of terrestrial organisms. A longer culvert that is more in line with the original stream channel may reduce the incidence of inlet scour.



Segment	Segment Length (ft)	Segment Gradient
A	32	0.033
B	53	0.006
C	54	0.004
D	105	0.009
E	111	0.006

Figure 2—Eames Creek longitudinal profile.

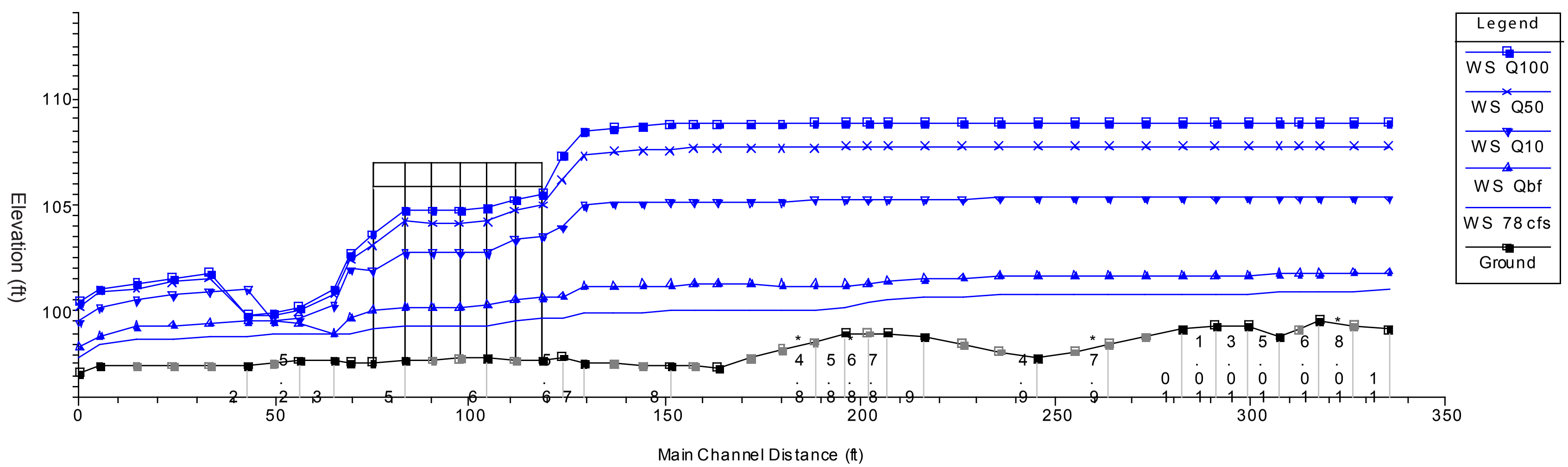
Table 1—Segment comparisons

Culvert Segment	Representative Channel Segment	% Difference in Gradient
C	E	32.0%
D	E	39.4%
Downstream Transition		
B	E	2.5%

Table 2—Summary of segments used for comparisons

Segment	Range of Manning's n values[1]	# of measured XSs	# of interpolated XSs
B	0.04	1	6
C	0.03 – 0.04	4	4
D	0.0294 – 0.04	3	13
E	0.04	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.

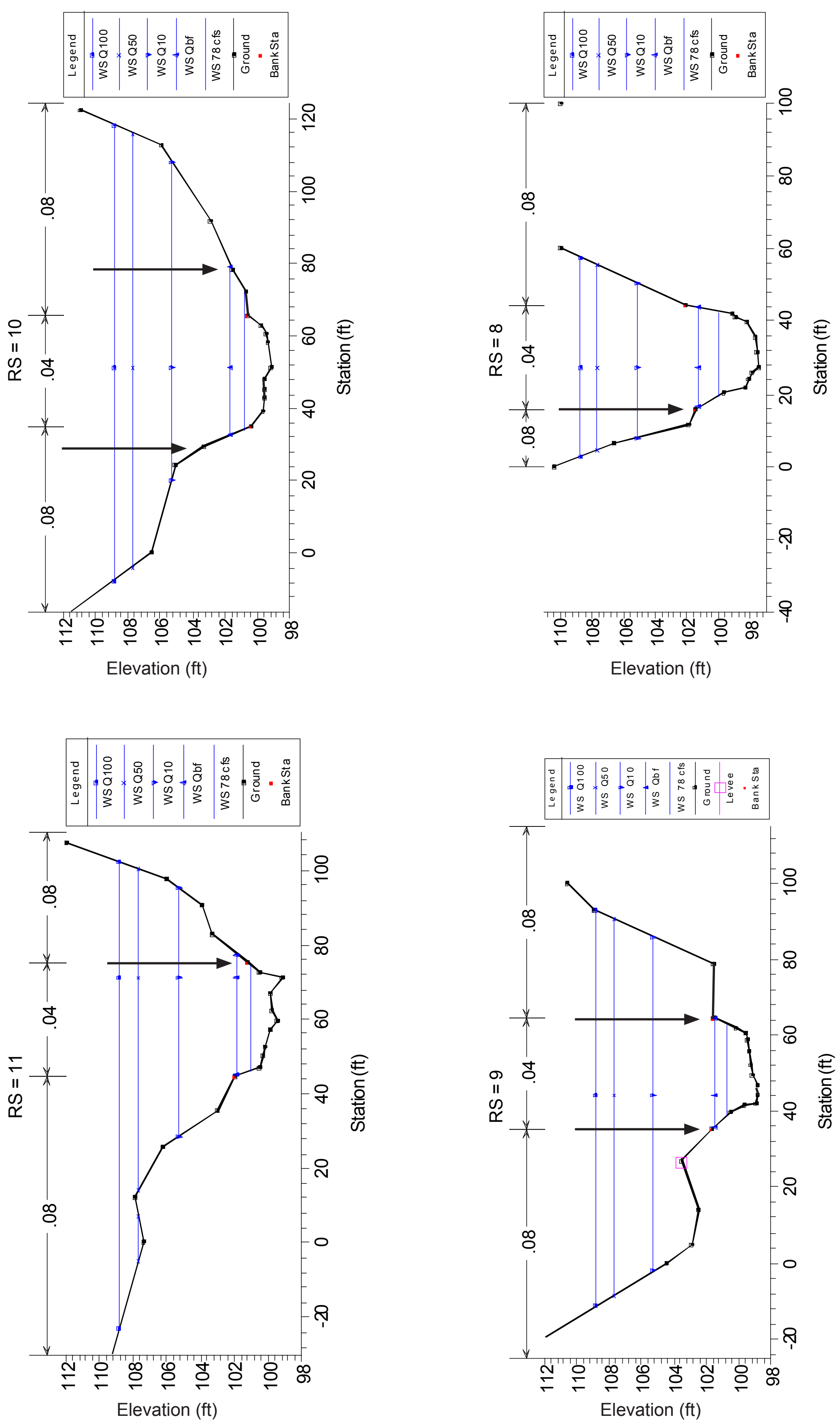
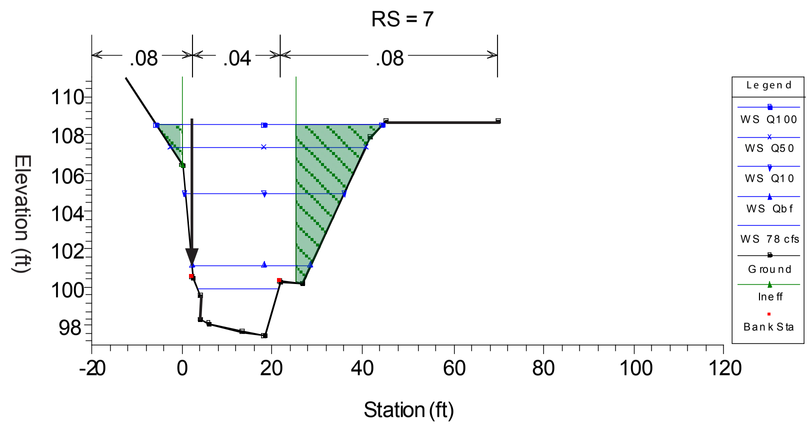
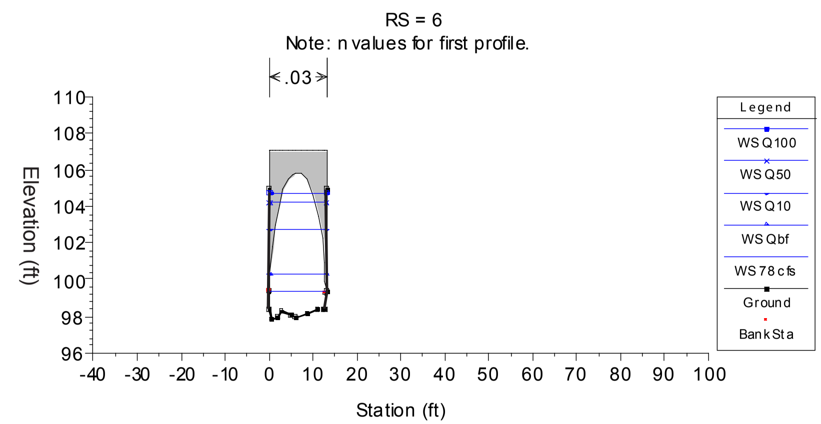
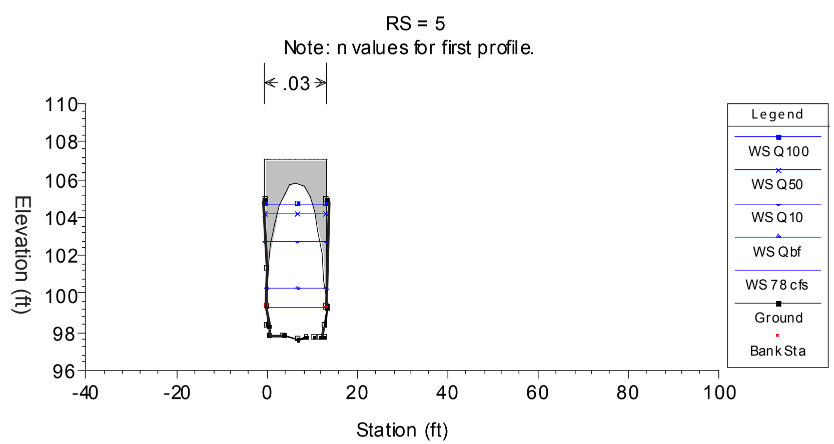
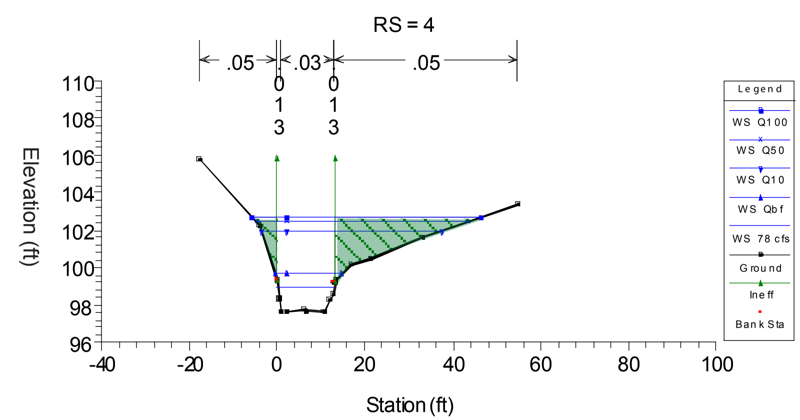


Figure 4—Cross-section plots. Only measured cross sections are included. Manning's n values are included at the top of the cross section. The stationing (RS) corresponds to the stationing on the HEC-RAS profile. Green arrows define the ineffective flow areas. Black arrows represent points identified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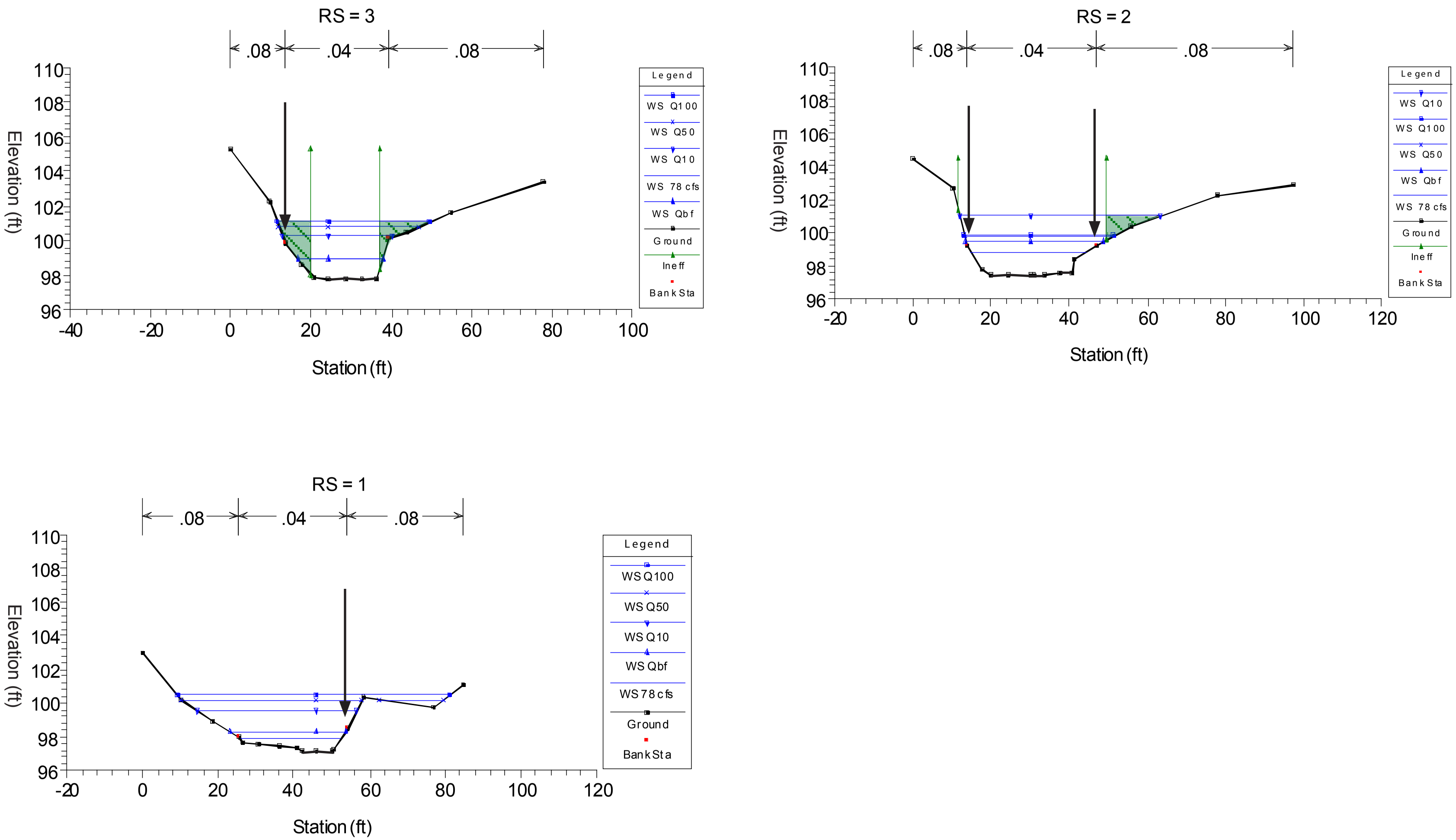

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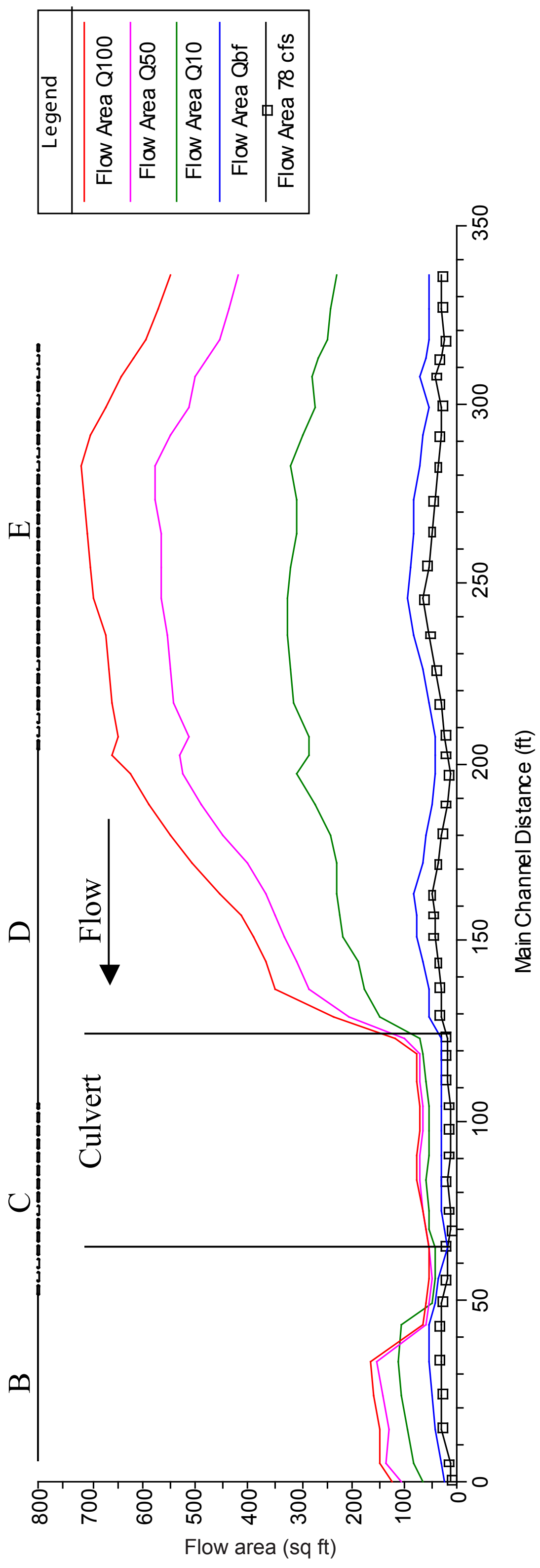


Figure 5—Flow area (total) profile plot.

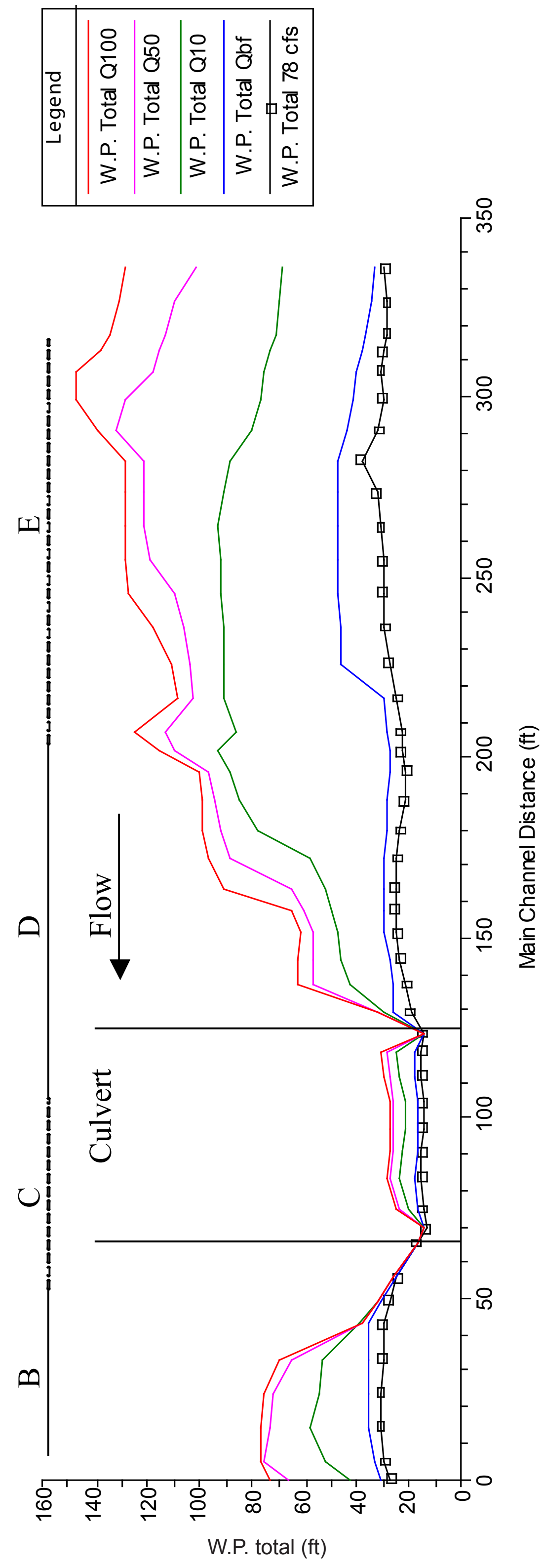


Figure 6—Wetted perimeter.

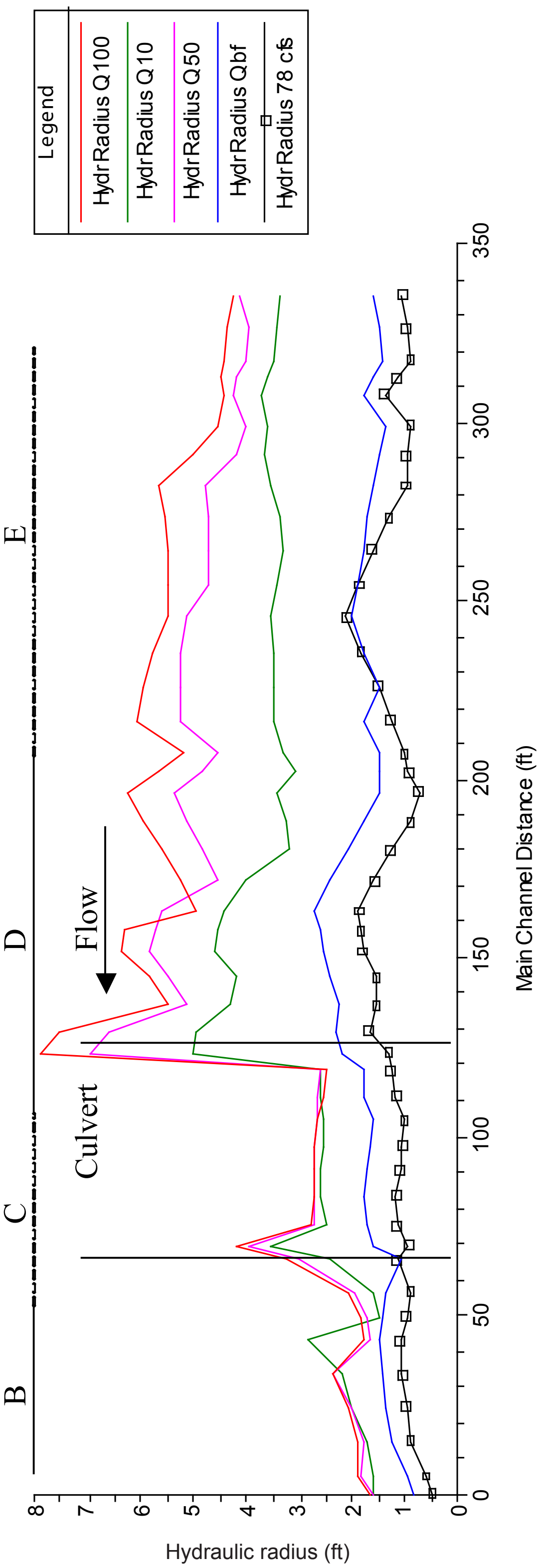


Figure 7—Hydraulic radius.

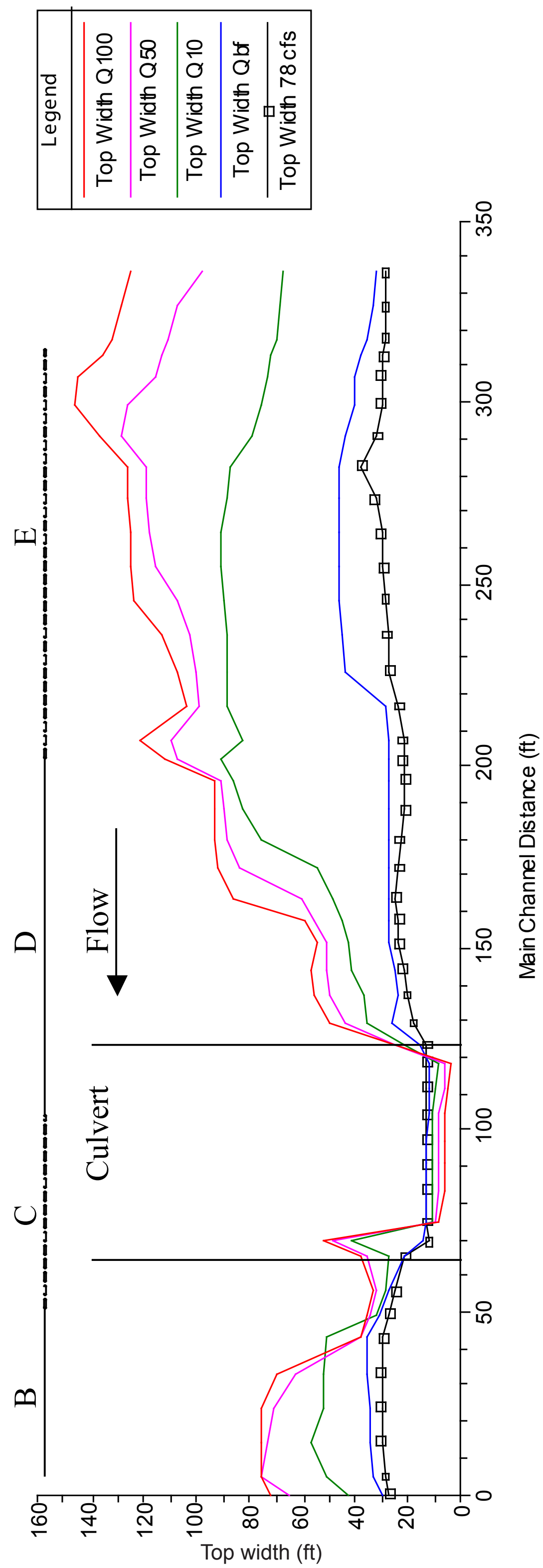


Figure 8—Top width.

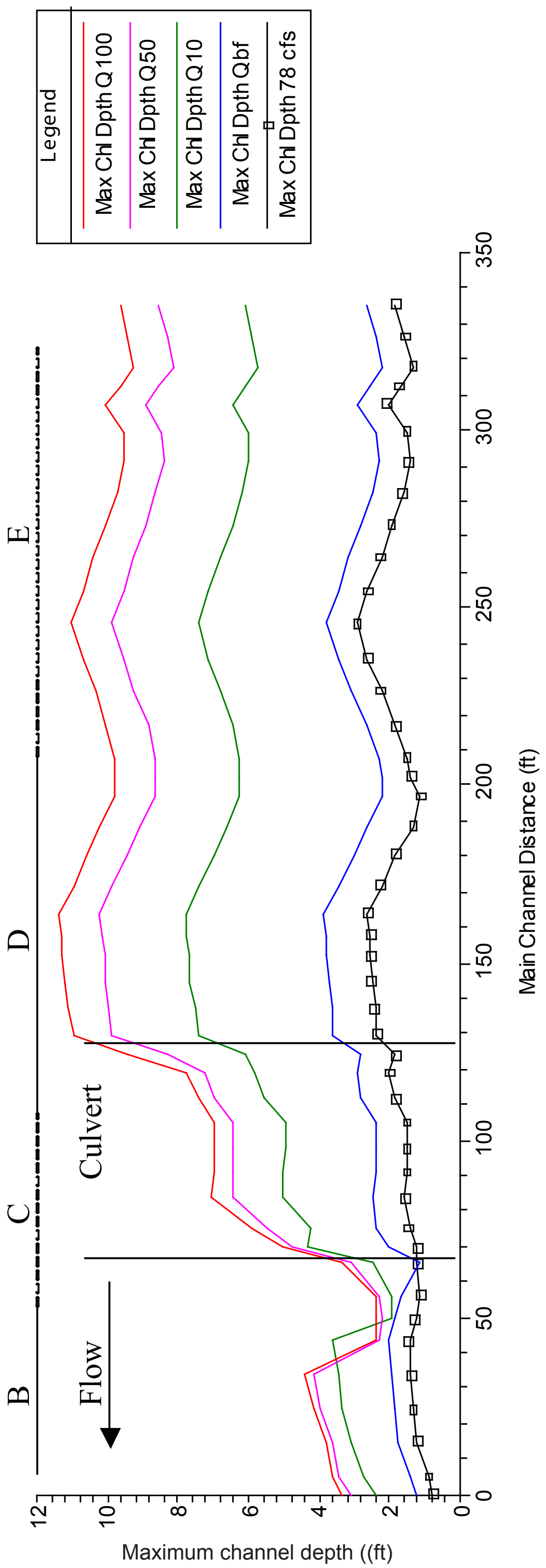


Figure 9—Maximum depth.

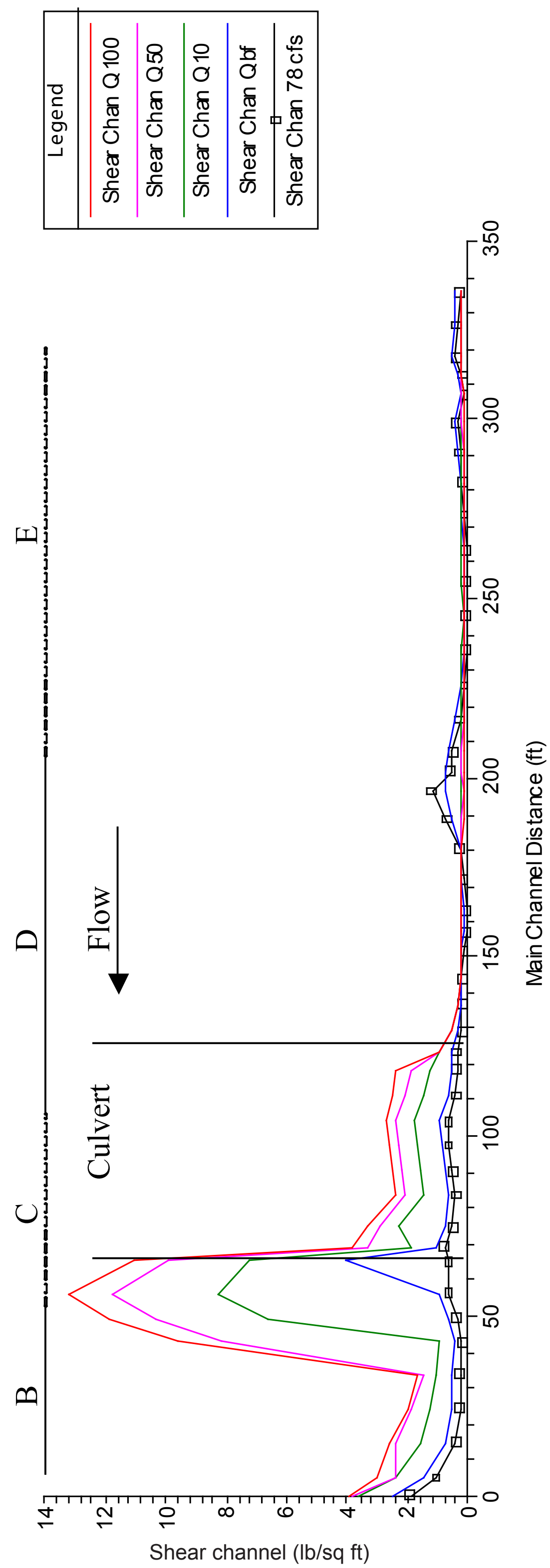


Figure 10—Shear stress (channel) profile.

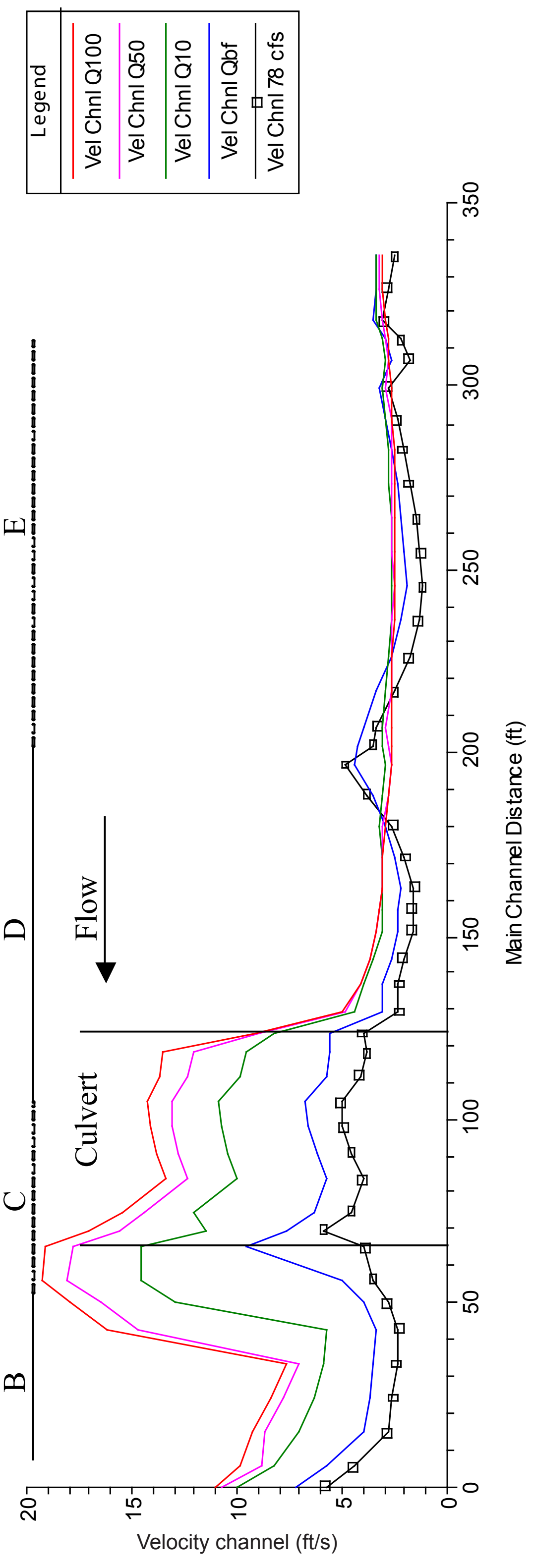
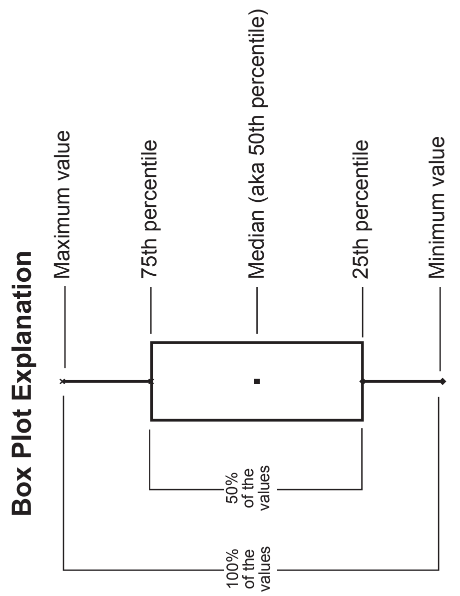


Figure 11—Velocity (channel) profile plot.



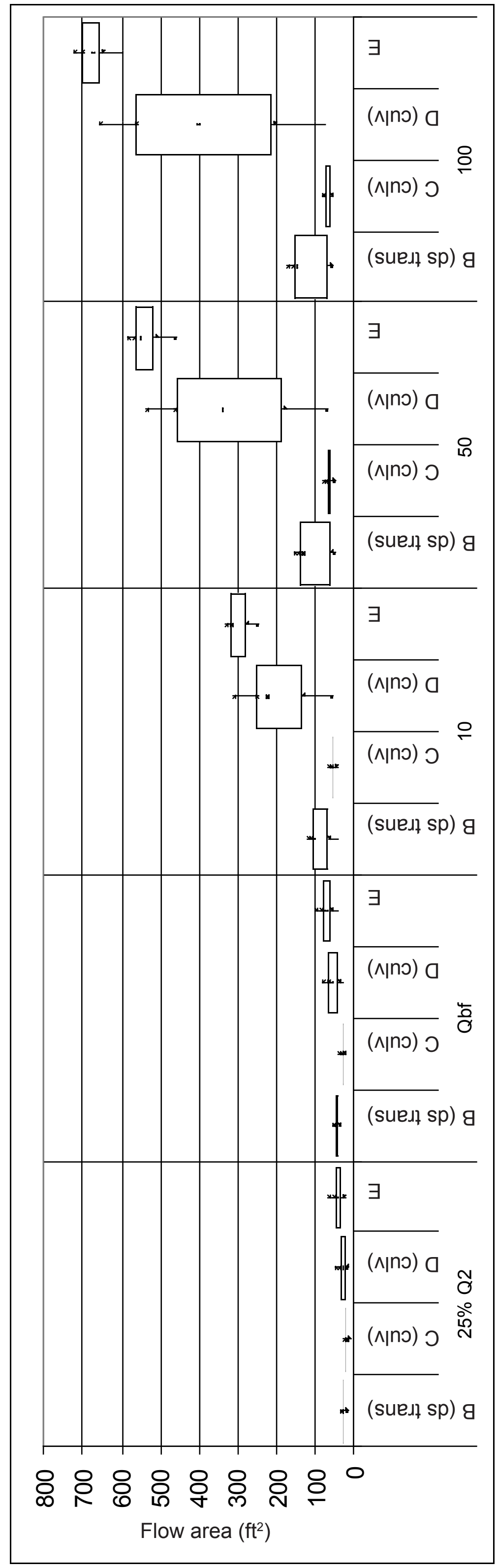


Figure 12—Flow area (total).

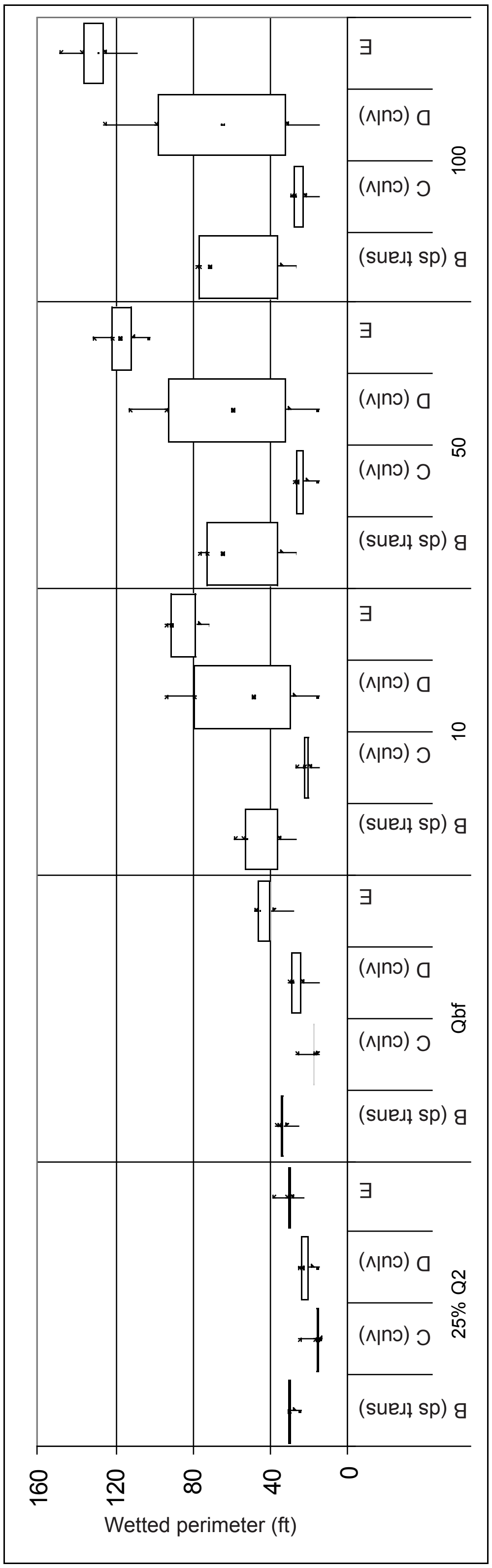


Figure 13—Wetted perimeter.

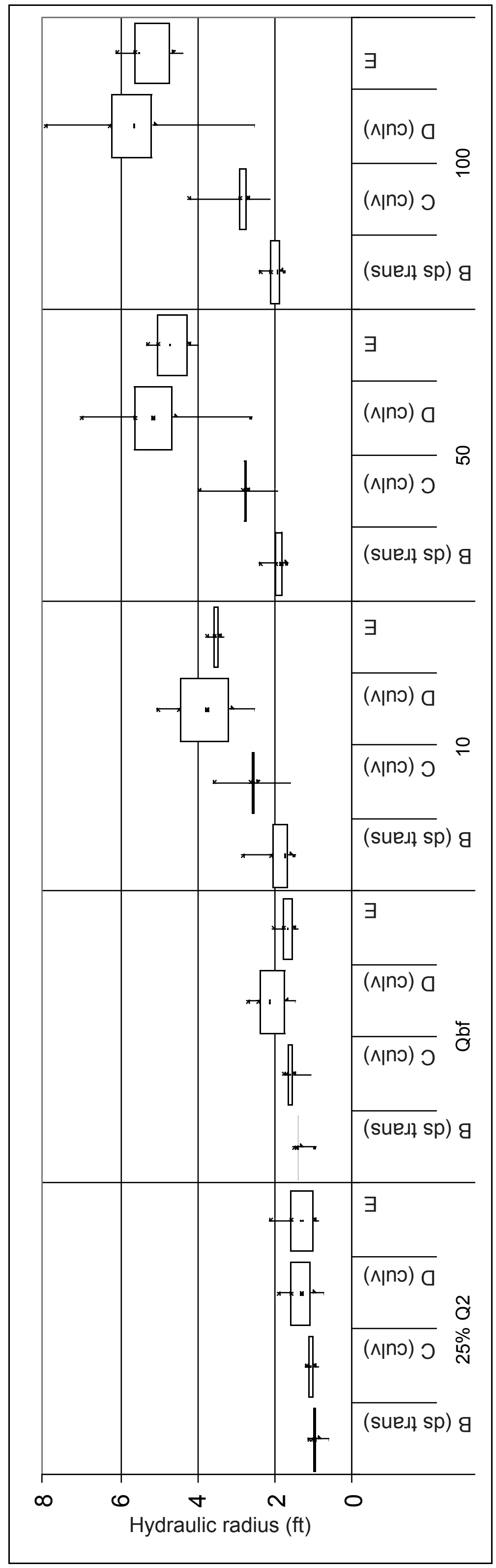


Figure 14—Hydraulic radius.

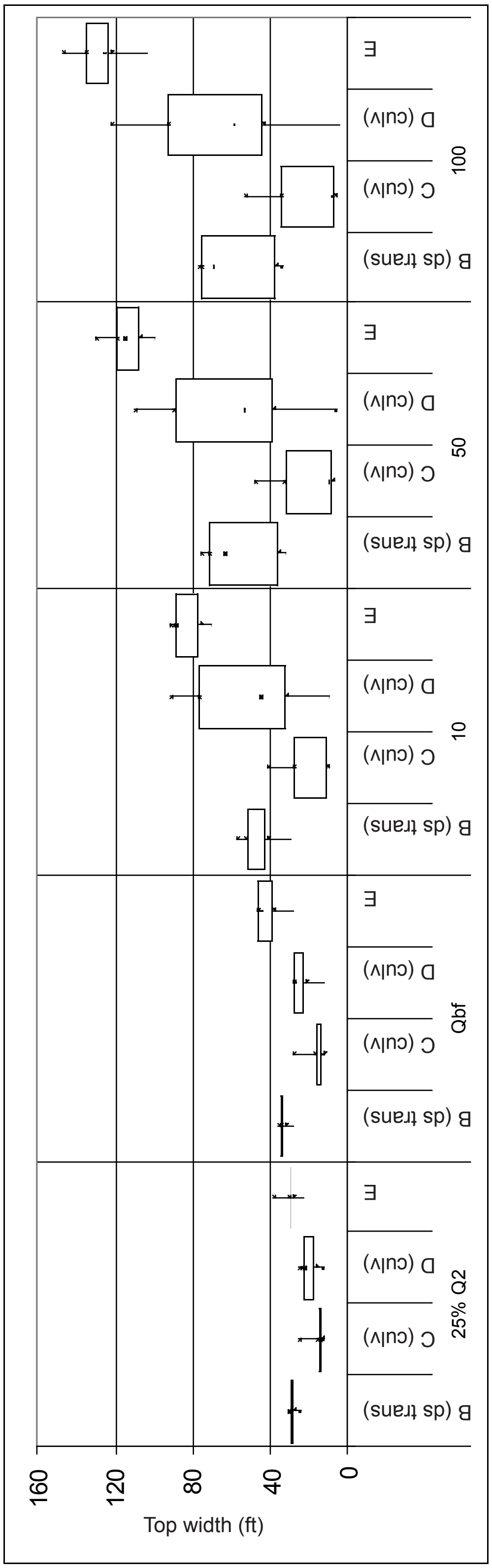


Figure 15—Top width.

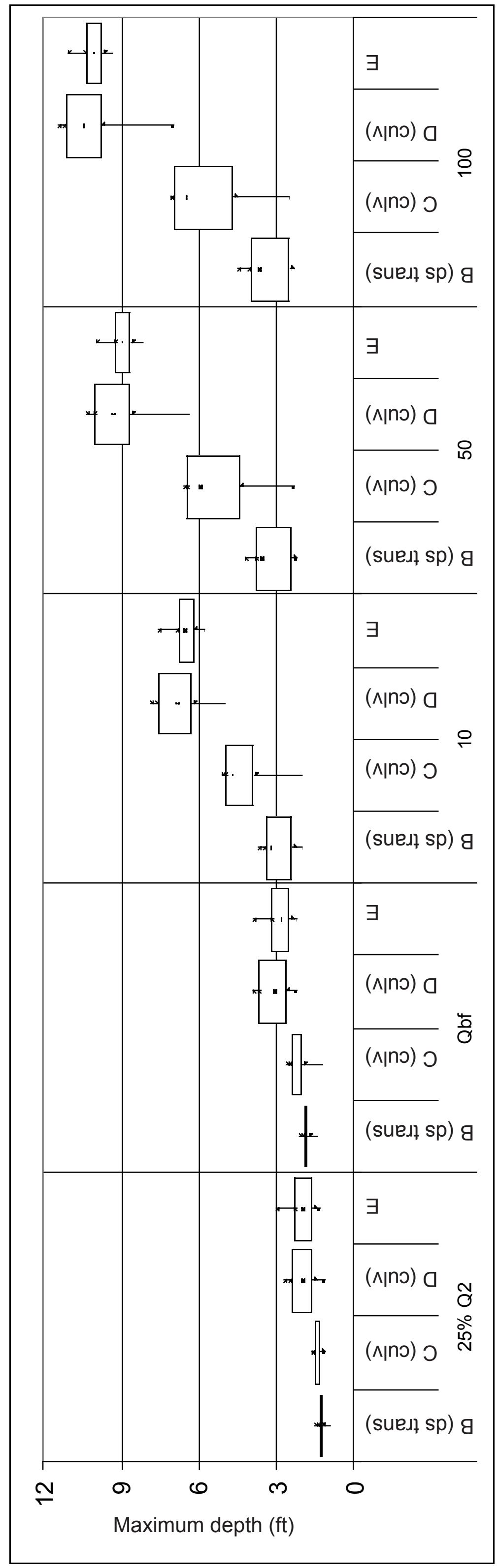


Figure 16—Maximum depth.

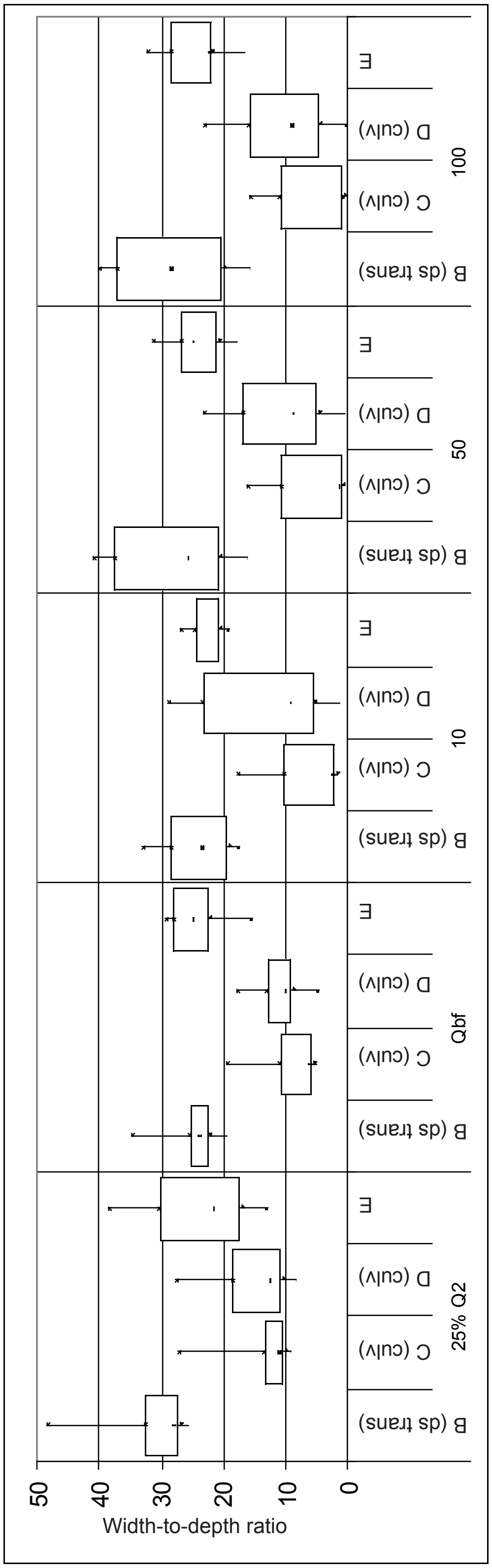


Figure 17—Width-to-depth ratio.

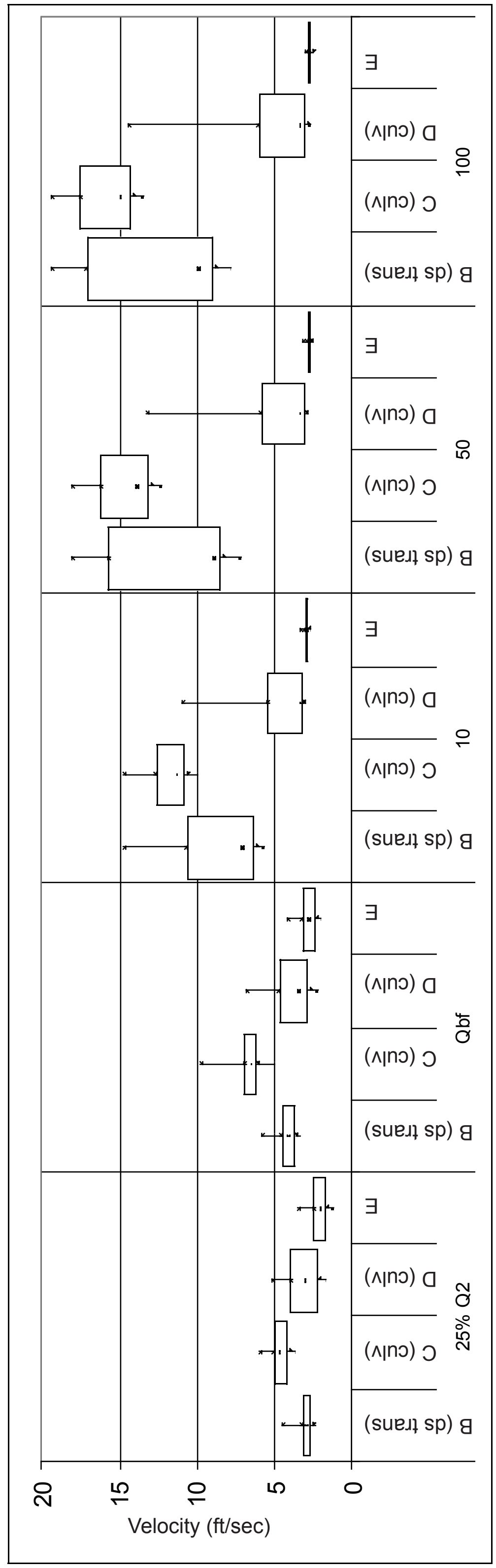


Figure 18—Velocity (channel).

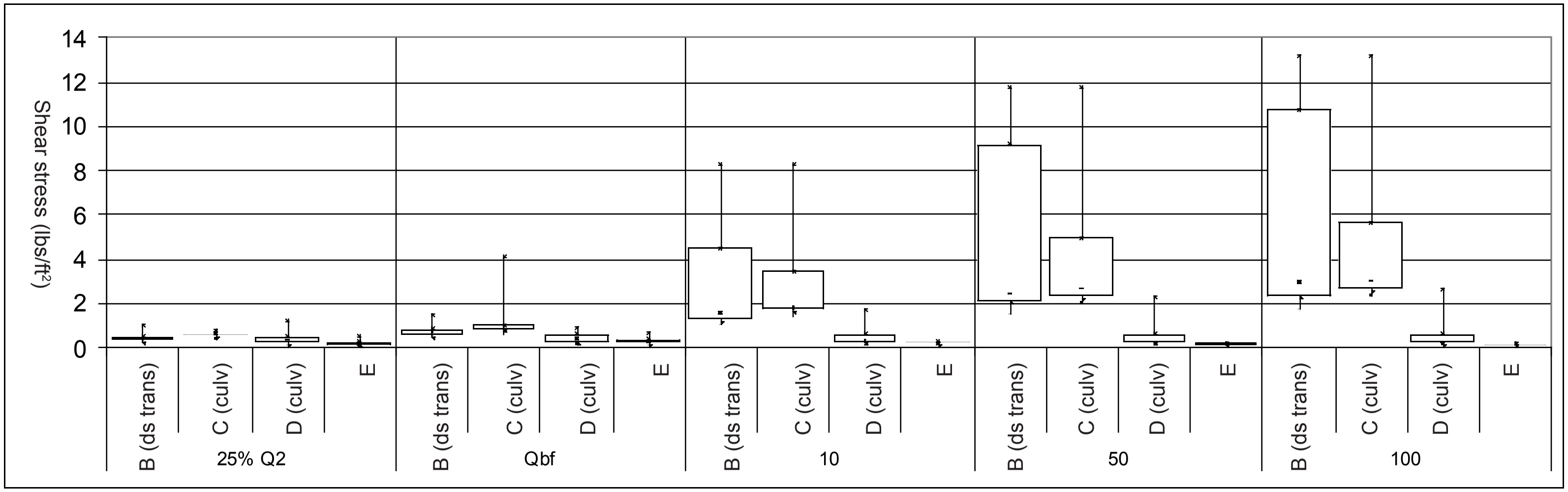
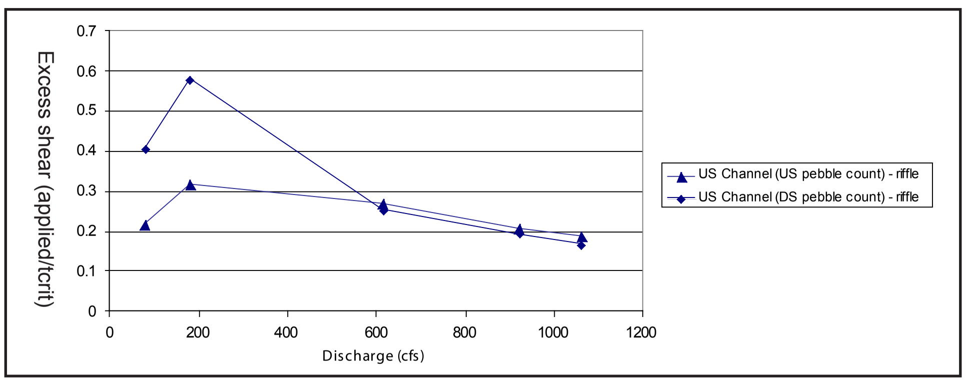


Figure 19—Shear stress (channel).



Excess shear stress is the channel shear divided by the critical shear for bed entrainment of the D_{84} particle size. Values of excess shear greater than 1 indicate bed movement for the D_{84} particle size.

Figure 20—Excess shear stress.

Culvert Scour Assessment

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	0.02	No
	DS	Riffle	0.003	No
Upstream	US	Glide	0.01	
	DS	Glide	0.01	

Table 4—Vertical sinuosity

Segment	Location	Vertical Sinuosity (ft/ft)
A	DS channel	1.001
B	DS transition	1.000
C	Culvert	1.001
D	Culvert + US transition	1.000
E	US channel	1.001

Table 5—Depth distribution

Reach	XS Location	25% Q_2	Within range of channel conditions?
Culvert	US	1	No
	DS	1	No
Upstream	US	16	
	DS	3	

Table 6—Habitat unit composition

	Percent of surface area			
Reach	Pool	Glide	Riffle	Step
Culvert	23%	77%	0%	0%
Upstream Channel	67%	0%	33%	0%

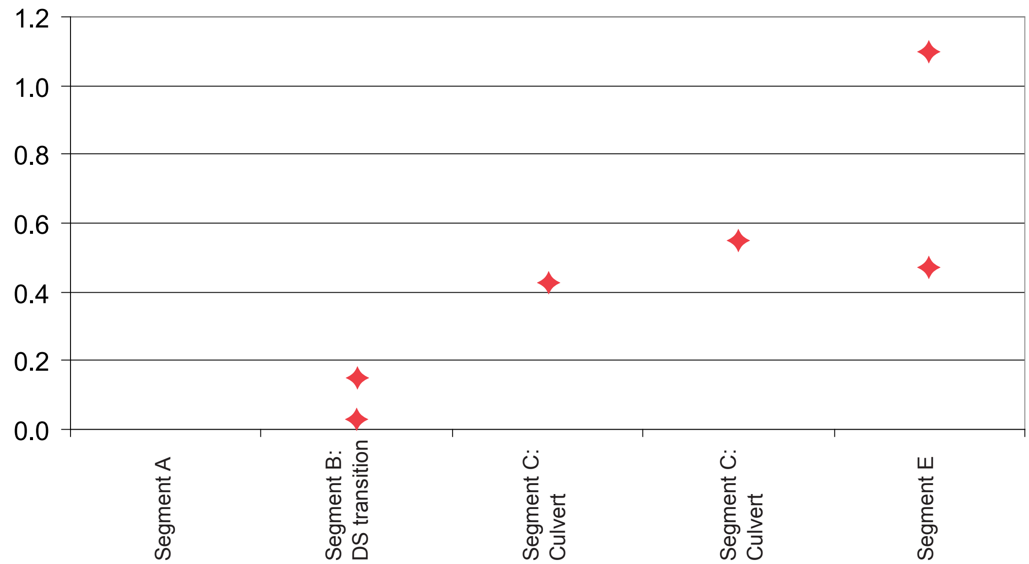


Figure 21—Residual depths.

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	NA	No	NA	No
	DS	Riffle	NA	No	NA	No
Upstream	US	Glide	2.46		0.30	
	DS	Glide	2.31		0.32	
Downstream			2.02		0.69	

Table 8—Large woody debris

Reach	Pieces/Channel Width
Culvert	1.69
Upstream	3.45

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


View downstream through culvert.


View upstream through culvert.


View of culvert inlet.


View of damaged footing along right side of culvert.


View downstream from road.

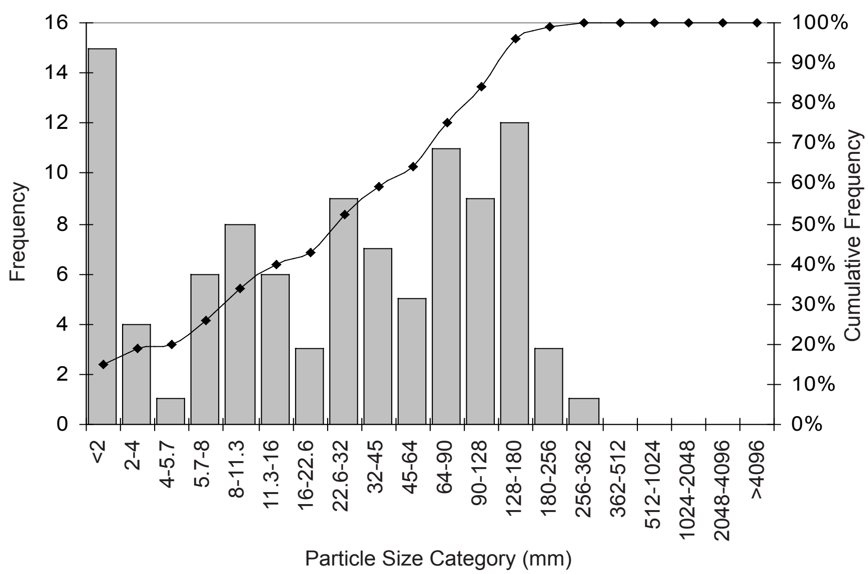

View upstream from road.

Downstream pebble count in upstream reference reach.

View upstream at upstream pebble count in upstream reference reach.

Cross section: Upstream Reference Reach – Upstream Pebble Count

Material	Size Range (mm)	Count	Item %	Cumulative %
sand	<2	15	15%	15%
very fine gravel	2 - 4	4	4%	19%
fine gravel	4 - 5.7	1	1%	20%
fine gravel	5.7 - 8	6	6%	26%
medium gravel	8 - 11.3	8	8%	34%
medium gravel	11.3 - 16	6	6%	40%
coarse gravel	16 - 22.6	3	3%	43%
coarse gravel	22.6 - 32	9	9%	52%
very coarse gravel	32 - 45	7	7%	59%
very coarse gravel	45 - 64	5	5%	64%
small cobble	64 - 90	11	11%	75%
medium cobble	90 - 128	9	9%	84%
large cobble	128 - 180	12	12%	96%
very large cobble	180 - 256	3	3%	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	> 4096	0	0%	100%



Size Class	Size percent finer than (mm)
D5	1
D16	3
D50	31
D84	122
D95	171
D100	290

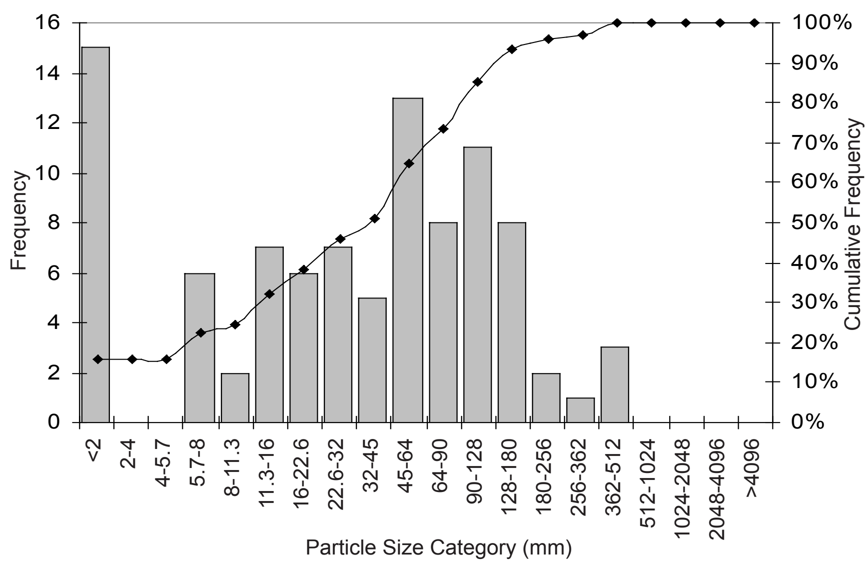
Material	Percent Composition
Sand	15%
Gravel	49%
Cobble	35%
Boulder	1%
Bedrock	0%

Sorting Coefficient: 2.46

Skewness Coefficient: 0.30

Cross section: Upstream Reference Reach – Downstream Pebble Count

Material	Size Class (mm)	Count	Item %	Cumulative %
sand	<2	15	16%	16%
very fine gravel	2 - 4	0	0%	16%
fine gravel	4 - 5.7	0	0%	16%
fine gravel	5.7 - 8	6	6%	22%
medium gravel	8 - 11.3	2	2%	24%
medium gravel	11.3 - 16	7	7%	32%
coarse gravel	16 - 22.6	6	6%	38%
coarse gravel	22.6 - 32	7	7%	46%
very coarse gravel	32 - 45	5	5%	51%
very coarse gravel	45 - 64	13	14%	65%
small cobble	64 - 90	8	9%	73%
medium cobble	90 - 128	11	12%	85%
large cobble	128 - 180	8	9%	94%
very large cobble	180 - 256	2	2%	96%
small boulder	256 - 362	1	1%	97%
small boulder	362 - 512	3	3%	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	5
D50	40
D84	125
D95	217
D100	450

Material	Percent Composition
Sand	16%
Gravel	49%
Cobble	31%
Boulder	4%
Bedrock	0%

Sorting Coefficient: 2.31

Skewness Coefficient: 0.32

Cross section: Culvert – Upstream Pebble Count

The culvert reach consists of a glide over bedrock. All of the mobile material was sand at the location of the upstream pebble count.

Cross section: Culvert – Downstream Pebble Count

The culvert reach consists of a glide over bedrock. There was only bedrock at the location of the downstream pebble count.

Cross section: Downstream Reference Reach – only Pebble Count

This reach consists of some mobile material over bedrock.

Size Class	Size percent finer than (mm)
D5	1
D16	49
D50	231
D84	370
D95	370
D100	370

These sizes are based on percentages of mobile particles only.