APPENDIX J

DESIGN EXAMPLE - HYDRAULIC DESIGN OPTION (REHABILITATE CULVERT WITH BAFFLE)

Hydraulic Baffle Design Tutorial

Project Description - Fish Passage Improvement Route 125

In Ventura County, adult steelhead are unable to move through an existing corrugated metal culvert under a 4-lane highway at Ripple Creek. The existing culvert is in good condition; however, the depth of flow is too shallow for the adult steelhead to pass. A current concern is localized scour on the creek banks is occurring near the culvert inlet. Within the project scope, Maintenance Design will provide rock slope protection on the creek banks and bed to control future scour and protect the culvert facility. Also, the existing culvert is believed to have more than adequate hydraulic capacity, and again is not subjected to heavy or damaging bed loads.

In order to improve fish passage through the Ripple Creek culvert and protect the culvert inlet, Caltrans District Maintenance Design will dedicate Minor B funds and apply to CA Fish & Game for a matching grant. The design and construction management of this cooperative project will be performed by Caltrans.

Data for Forms 1-4 have been provided for informational purposes only. For this tutorial, *Form 6D – Hydraulic Baffle Design Option* will be the only form filled out.

Form 1 - Existing Data and Information Summary

The Engineer collected all existing data prior to going to the field.

Existing Data:

- As-built drawings
- FEMA Flood Insurance hydrologic, hydraulic, and floodplain mapping
- USGS topographic DEM
- Surveyed cross-sections
- Stream flow gage data available from nearby watershed
- Right-of-Entry is not required

Form 2 - Site Visit Summary

The Engineer and project team visited the project site and collected existing conditions data.

Inlet Characteristics:

- Confined Spaces: able to see and feel breeze through culvert
- Inlet Type: projecting
- Inlet Condition: no issues
- Inlet Apron: None Applicable
- Skew Angle: 0º
- Upstream Invert Elevation: 518.48 ft (NAVD 88)

Barrel Characteristics:

- Diameter: 90 in
- Fill height above culvert: 8 ft
- Length: 120 ft
- Number of Barrels: 1
- Culvert Type: Circular
- Culvert Material: CMP
- Barrel Condition: good condition, none applicable

Outlet Characteristics:

- Outlet Type: Projecting
- Outlet Condition: good condition, none applicable
- Outlet Apron: none applicable
- Skew Angle: 0º
- Downstream Invert Elevation: 515.48 ft (NAVD 88)

Structure Characteristics:

- Corrugated Metal Pipe (CMP): n = 0.024

Active Channel Width Measurements:

1	2	3	4	5	Average
10.2 ft	17.3 ft	18.5 ft	12.3 ft	16.1 ft	14.9 ft

Bankfull Channel Width Measurements:

1	2	3	4	5	Average
18.3 ft	19.9 ft	23.5 ft	27.3 ft	19.1 ft	21.6 ft

Boundary Conditions:

- Downstream slope = 0.026, normal depth is appropriate

Form 2b – Manning's n-value Computation

Manning's n-values:

Factor	Left Overbank	Main Channel	Right Overbank
n-value	0.040	0.030	0.040

Form 3 - Guidance on Selection of Fish Passage Design Option

The Engineer completed Form 3 to determine which design option was most appropriate for the project site.

Site Characteristics:

- Retrofit culvert installation
- Structurally sound culvert
- Little bead load material movement
- Target species identified for passage
- Channel Slope is Less Than 3%

Hydraulic Baffle Design Option was selected.

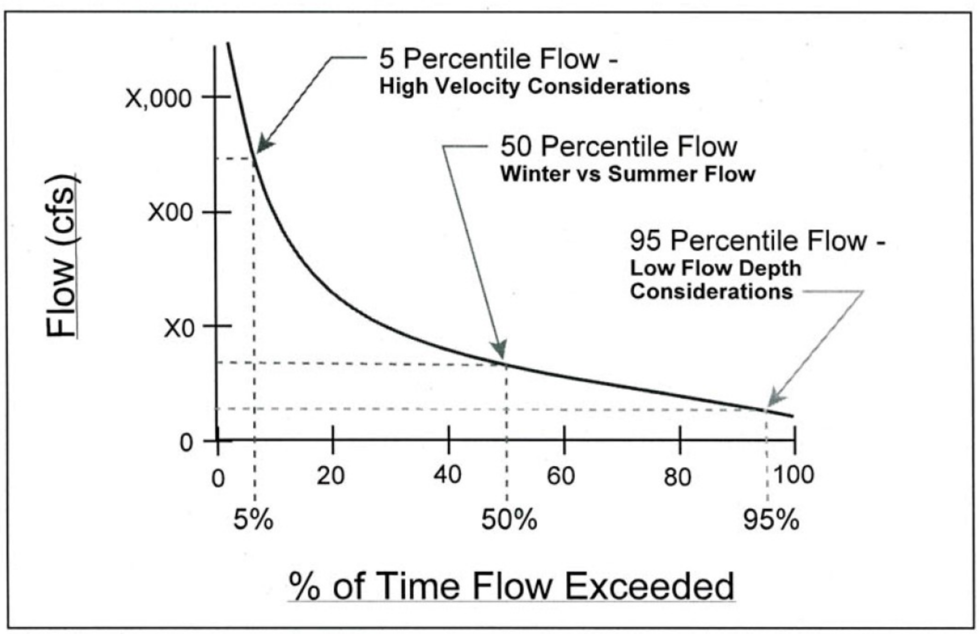
Form 4 - Guidance on Methodology for Hydrologic Analysis

The Engineer calculates peak discharges using Basin Transfer methodology for the low and high fish passage flows and accepts effective FEMA 100-Year peak discharge.

Step 1: Calculate Low and High Fish Passage Design Flows.

Upper fish passage flow limit for adult anadromous salmonids equals the 1% exceedance flow.

Lower fish passage flow equals the 50% exceedance flow.



Basin Parameters:

- Sunny Creek drainage area = 4.0 mi^2
- No gage data available on Ripple Creek
- Gage data available on nearby Cloudy Creek
- Cloudy Creek drainage area = 65 mi^2

- USGS gage number 11132500 with daily average stream flow
- Period of Record: 10/01/1987 to 10/01/2002
- 5480 data points

Flows were ranked from highest to lowest (a rank of i=1 given to the highest flow). The lowest flow will have a rank of *n*, which equals the total number of flows considered. The 50-percent and 1-percent exceedance flows were linked to a particular rank using the following equations:

$$i_{50\%} = 0.50(n+1) \qquad\qquad i_{1\%} = 0.01(n+1)$$

The corresponding flow rates at these rankings are:

$$Q_{50\%} = 146 \text{ cfs (Low Fish Passage Flows)}$$

$$Q_{1\%} = 585 \text{ cfs (High Fish Passage Flows)}$$

These flows were applied to the ungaged stream by multiplying the flows obtained in the above step, $Q_{50\%}$ and $Q_{1\%}$, by the ratio of the gaged stream's drainage area (DA) to the drainage area of the ungaged stream at the stream crossing. Multiplying by this ratio adjusts for differences in drainage area between watersheds.

$$Q_{50\%\_Gage} = 146\text{cfs}\left(\frac{4.0\text{ mi}^2}{65.0\text{ mi}^2}\right) = Q_{50\%\_Gage} = \underline{9\text{ cfs}} \text{ (Low Flow)}$$

$$Q_{1\%\_Gage} = 585\text{cfs}\left(\frac{4.0\text{ mi}^2}{65.0\text{ mi}^2}\right) = Q_{1\%\_Gage} = \underline{36\text{ cfs}} \text{ (High Flow)}$$

Low Fish Passage Flows	High Fish Passage Flows	100-Year Event
9 cfs	36 cfs	400 cfs

Form 6D – Hydraulic Baffle Design Option

Form 6D provides a guidance to correctly design a structure that meets specific fish passage design criteria, while also considering hydraulic impacts.

The Engineer selects HEC-RAS for design modeling and FishXing for assessing existing conditions to conduct the hydraulic modeling.

Step 2: Using FishXing software, identify and assess existing fish passage obstructions. (Note, if FishXing software is not used to analyze existing conditions, HEC-RAS could be used to identify velocity and depth shortfalls based on selected known species and life stage. The Engineer must determine shortfalls manually by comparison of HEC-RAS results to fish data.).

Model Existing Conditions within FishXing and analyze results.

FishXing modeling has already been completed. Results have been provided below.

Low Fish Passage Barrier: Depth

High Fish Passage Barrier: EB – Fish exhausted at burst speed

Uniform Flow Output for Ripple Creek

Project Name: test
Culvert Name: Ripple Creek
Culvert Type: 90 in Circular
Construction: CMP (2 2/3 X 1/2 in corr.)
Culvert Length: 120 ft
Culvert Slope: 2.50%
Countersunk Depth: 0 ft

Fish Characteristics
Adult Steelhead
Migration Period: January to April
Fish Length: 450 mm

Swimming Abilities
Burst Speed: 8.3 ft/s
Burst Time to Exhaustion: 5 sec

Fish Passage Requirements
Max. Allowable Water Velocity 5.9 ft/s
Min. Required Water Depth 1.0 ft

Max Leap Speed: 8.3 ft/s
Prolonged Speed: 6.00 ft/s
Prolonged Time to Exhaustion: 30 min

Discharge (cfs)	Velocity (ft/s)	Normal Depth (ft)	Critical Depth (ft)	Outlet Velocity (ft/s)	Tailwater Depth (ft)	Pool Depth (ft)	Min Rqd. Leap Velocity (ft/s)	Vert. Leap Distance (ft)	Comments
0.00	0.00	0.00	0.00	0.00	1.32	1.80			
0.18	1.61	0.10	0.10	0.04	1.32	1.80	0.00	0.00	Depth
0.82	2.54	0.20	0.22	0.16	1.32	1.80	0.00	0.00	Depth
1.96	3.32	0.30	0.34	0.38	1.32	1.80	0.00	0.00	Depth
3.63	4.00	0.40	0.47	0.69	1.32	1.80	0.00	0.00	Depth
5.84	4.62	0.50	0.59	1.12	1.32	1.80	0.00	0.00	Depth
8.60	5.19	0.60	0.72	1.64	1.32	1.80	0.00	0.00	Depth
9.00	5.27	0.61	0.74	1.72	1.32	1.80	0.00	0.00	LPF; Depth
11.91	5.73	0.70	0.85	2.27	1.32	1.80	0.00	0.00	Depth
15.76	6.24	0.80	0.98	3.01	1.32	1.80	0.00	0.00	Depth; Vel
20.17	6.72	0.90	1.11	3.85	1.32	1.80	0.00	0.00	Depth; Vel
25.12	7.17	1.00	1.24	4.80	1.32	1.80	0.00	0.00	Vel
30.60	7.61	1.10	1.37	5.84	1.32	1.80	0.00	0.00	Vel
36.00	7.98	1.19	1.49	6.88	1.32	1.80	0.00	0.00	HPF; Vel
36.61	8.02	1.20	1.50	6.99	1.32	1.80	0.00	0.00	Vel
43.15	8.43	1.30	1.63	8.24	1.32	1.80	0.00	0.00	Vel
50.20	8.81	1.40	1.76	8.81	1.32	1.80	0.00	0.00	Vel
57.75	9.18	1.50	1.90	9.18	1.32	1.80	0.00	0.00	Vel
65.79	9.54	1.60	2.03	9.54	1.32	1.80	0.00	0.00	Vel

Comment Codes:
LPF - Low Passage Flow, HPF - High Passage Flow, Depth - Insufficient Depth
Vel - Excessive Velocity, Leap - Excessive Leap, Pool - Shallow Leap Pool

Show Graphs | Close

Step 3: Create HEC-RAS model for Existing Conditions Plan using 100-Year flow to assess existing capacity.

Hinge Point Elevation = 529.07 ft (100-Yr water surface elevation cannot exceed HP elevation.)

Roadway centerline elevation = 532.0 ft

Create Existing Conditions HEC-RAS model and analyze results. Parameters are shown below.

HEC-RAS Modeling Parameters

Culvert Characteristics:

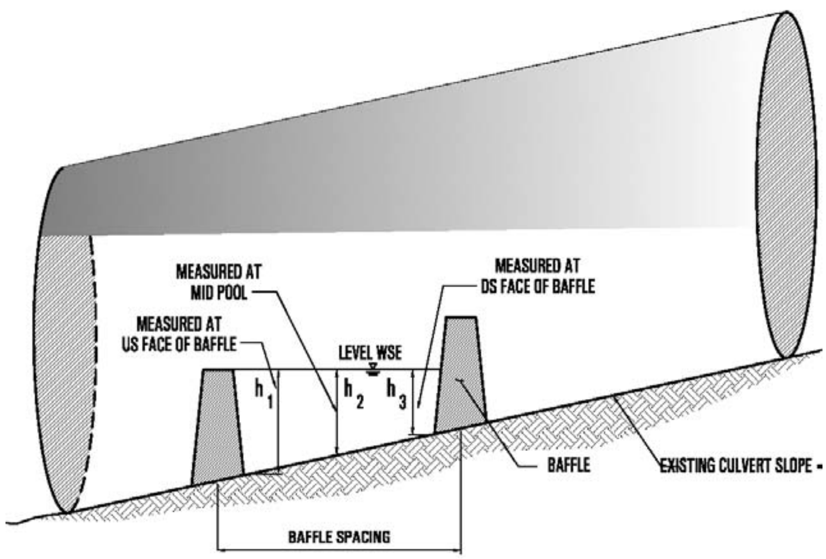
- Construction: CMP (2- 2/3 x 1/2 in corr.)
- Installation: At grade
- Culvert Start Station: 259
- Culvert Diameter 90 in
- Culvert Length: 60 ft
- Inlet Bottom Elevation (Upstream Invert Elevation): 518.48 ft

- Outlet Bottom Elevation (Downstream Invert Elevation): 515.48 ft
- Upstream Centerline Station: 24.08 ft
- Downstream Centerline Station: 24.08 ft
- Inlet Condition: Projected
- Inlet Head Loss Coefficient: 0.9

Baffle Design Criteria for Adult Steelhead that must be met:

Velocity Maximum average velocity is 5 ft/s during high fish passage flows	Depth Minimum 1-ft flow depth within step pools during low fish passage flows
Outlet Drop (if unavoidable) Maximum 1-ft drop depth	

Step 4: Determine baffle retrofit type, baffle height, and spacing for proposed low flow hydraulic model. (For this design example, use Corner Baffles)



Tips

Estimate h_1 = 1.5 ft

h_3 = minimum pool depth according to design life stage and species = 1 ft minimum for adult steelhead

slope = 0.025 ft/ft

Baffle spacing = (h_1-h_3)/slope = 20 ft (Select a more realistic spacing for modeling and design, if needed.) (Alternative equation: $h_3 = h_1$ – baffle spacing * slope)

$h_2 = h_1$ - [(baffle spacing / 2) * slope)] = 1.25 ft

h_1 = 1.5 ft
h_2 = 1.25 ft
h_3 = 1 ft (minimum criteria depth)
Baffle Spacing = 20 ft
Width of Baffle = 1 in

Step 5: Prepare proposed conditions for Low Fish Passage flow events in HEC-RAS by using inline weirs within semicircular open channel, which will be Proposed Conditions-Low Flow Plan, and determine weir coefficient through iterative process (calibrate with Low Fish Passage Flow).

Due to limitations of HEC-RAS, corner baffles will be modeled as a Broad-Crested Weir using a breadth of crest of weir equal to 0.5 ft (minimum value from HEC-22 broad-crested weir table).

A. Estimate the highest weir coefficient using the highest head for the previously calculated crest width (breadth of crest of weir) from the HEC-22 Broad Crested Weir Coefficient Table. C = 3.32 $ft^{0.5}$/sec

B. Run the proposed HEC-RAS model and find the average head (weir average depth) over a baffle for the Low Fish Passage Flow from HEC-RAS results. Weir Average Depth = 0.55 ft

C. Given the average head (weir average depth) from the HEC-RAS results and the crest width (breadth of crest of weir), find a second weir coefficient from the HEC-22 Broad Crested Weir Coefficient Table. C = 3.04 $ft^{0.5}$/sec

D. Run the proposed HEC-RAS model with the second weir coefficient from Step C and find the average head (weir average depth) over a baffle for the Low Fish Passage Flow from HEC-RAS results. Weir Average Depth = 0.58 ft

E. Given the average head (weir average depth) from the HEC-RAS results and the crest width (breadth of crest of weir), find a third weir coefficient from the HEC-22 Broad Crested Weir Coefficient Table. C = 3.06 $ft^{0.5}$/sec

F. Compare weir coefficient from Step C and Step E. If weir coefficients are close in value, then use Step E weir coefficient for remaining HEC-RAS modeling. If weir coefficients are not close in value, repeat Steps C-F until an appropriate weir coefficient is found.

Fill in results in Form 6D.

Broad-Crested Weir Coefficient C Values as a Function of Weir Crest Breadth and Head (coefficient has units of $ft^{0.5}/sec$).(1)

Head(2) (ft)	Breadth of Crest of Weir (ft)										
	0.50	0.75	1.00	1.5	2.0	2.50	3.00	4.00	5.00	10.00	15.00
0.2	2.80	2.75	2.69	2.62	2.54	2.48	2.44	2.38	2.34	2.49	2.68
0.4	2.92	2.80	2.72	2.64	2.61	2.60	2.58	2.54	2.50	2.56	2.70
0.6	3.08	2.89	2.75	2.64	2.61	2.60	2.68	2.69	2.70	2.70	2.70
0.8	3.30	3.04	2.85	2.68	2.60	2.60	2.67	2.68	2.68	2.69	2.64
1.0	3.32	3.14	2.98	2.75	2.66	2.64	2.65	2.67	2.68	2.68	2.63
1.2	3.32	3.20	3.08	2.86	2.70	2.65	2.64	2.67	2.66	2.69	2.64
1.4	3.32	3.26	3.20	2.92	2.77	2.68	2.64	2.65	2.65	2.67	2.64
1.6	3.32	3.29	3.28	3.07	2.89	2.75	2.68	2.66	2.65	2.64	2.63
1.8	3.32	3.32	3.31	3.07	2.88	2.74	2.68	2.66	2.65	2.64	2.63
2.0	3.32	3.31	3.30	3.03	2.85	2.76	2.72	2.68	2.65	2.64	2.63
2.5	3.32	3.32	3.31	3.28	3.07	2.89	2.81	2.72	2.67	2.64	2.63
3.0	3.32	3.32	3.32	3.32	3.20	3.05	2.92	2.73	2.66	2.64	2.63
3.5	3.32	3.32	3.32	3.32	3.32	3.19	2.97	2.76	2.68	2.64	2.63
4.0	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.70	2.64	2.63
4.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	2.88	2.74	2.64	2.63
5.0	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.64	2.63
5.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	2.88	2.64	2.63

(1) Table is taken from reference 49.

Create Low Flow Proposed Condition HEC-RAS model.

Step 6: Select C and a parameters according to the baffle retrofit type from the Experimental "C" and "a" Parameter table for use in the effective roughness method of developing high fish passage flow and 100-year models. If the effective roughness method cannot be used, go to Step 8.

From table, circular culvert with corner baffles: **C = 7.81** **a = 2.63**

Step 7: Calculate y_o for High Fish Passage and 100-Year flows. Verify streaming flow conditions: y_o is equal to or greater than $0.75z_{max}$ (corner baffles) or $1.1z_{max}$ (all other baffle types). Determine effective roughness (n_{eff}) for High Fish Passage and 100-Year flows.

$$y_o = D\left[\frac{Q}{C\sqrt{gS_oD^5}}\right]^{1/a}$$

Where: y_o = Water Depth (ft)
Q = Flow (cfs)
D = Culvert Diameter (ft)
G = Gravity (32.2 ft/s^2)
S_o = Long. Slope (ft/ft)
C & a = Experimental Parameters

$$n_{eff} = 1.486(R)^{2/3}(S)^{1/2}(v)^{-1}$$

Where: n_{eff} = Effective Roughness
R = Hydraulic Radius (ft)= A_{wet}/P_{wet}
V = Velocity (ft/s)= Q/A_{wet}
A_{wet} = Wetted Area (ft^2) considering y_o
P_{wet} = Wetted Perimeter (ft) considering y_o

Variables/Parameters	High Fish Passage Condition	100-Year Condition
Q (cfs)	36	400
D (ft)	7.5	7.5
S_o (ft/ft)	0.025	0.025
g (ft/s^2)	32.2	32.2
C	7.81	7.81
a	2.63	2.63
z_{max} (ft)	1.50	1.50
y_o (ft)	2.10	5.10
y_o>0.75z_{max} (Corner Baffle)	Yes	Yes
Is y_o>0.8D? If so, calculate n_{eff} using y_o=0.8D	No	No
A_{wet} (ft^2)	10.10	31.66
P_{wet} (ft)	8.36	14.46
R (ft)	1.21	2.19
v (ft/s)	3.56	12.63
n_{eff}	0.075	0.031

Note: The design baffle height and corresponding spacing combination can vary to achieve acceptable depth and velocity, which means that multiple solutions or combinations can exist for a given site. The combination with the lowest height and maximum spacing that will achieve appropriate depth and velocity should be first consideration since it will have the least effect on culvert headwater, capacity, and sediment transport.

Another consideration in choosing design baffle height and spacing combination is the suggested combinations in the Experimental C and a Parameters table. When using the effective roughness research method for analyzing baffled culverts under higher flows, the greater difference in the suggested height and spacing combination values compared to the design combination, the greater potential for inaccuracy is introduced into the analysis. In other words, the closer the design and suggested height/spacing combination are to each other, the more accurate the modeling results. Given the limitations of the alternative method for modeling high fish passage and flood flows in Appendix F commonly used in the fish passage design community, the effective roughness method may be the better choice even when the design baffle height/spacing combination is not that close to the combination developed from the research study.

EXPERIMENTAL "C" AND "a" PARAMETERS

Culvert Shape	Retrofit Type	Baffle Height (ft)	Baffle Spacing (ft)	Wall Angle in Plan View (Degrees)	C	a
Box	High Height, Close-Spaced, Full Span, Top Angled Baffle	z_{min} = 0.13W z_{max} = 0.20W	0.5W	60	0.122	1.85
Box	Medium Height, Close-Spaced, Full Span, Top Angled Baffle	z_{min} = 0.09W z_{max} = 0.16W	0.5W	60	0.123	1.70
Box	Low Height, Close-Spaced, Full Span, Top Angled Baffle	z_{min} = 0.05W z_{max} = 0.11W	0.5W	60	0.113	1.64
Box	High Height, Intermediate-Spaced, Full Span, Top Angled Baffle	z_{min} = 0.13W z_{max} = 0.20W	0.75W	60	0.139	1.82
Box	Medium Height, Intermediate-Spaced, Full Span, Top Angled Baffle	z_{min} = 0.09W z_{max} = 0.16W	0.75W	60	0.125	1.82
Box	Low Height, Intermediate-Spaced, Full Span, Top Angled Baffle	z_{min} = 0.05W z_{max} = 0.11W	0.75W	60	0.119	1.68
Box	High Height, Far-Spaced, Full Span, Top Angled Baffle	z_{min} = 0.13W z_{max} = 0.20W	W	60	0.169	1.79
Box	Medium Height, Far-Spaced, Full Span, Top Angled Baffle	z_{min} = 0.09W z_{max} = 0.16W	W	60	0.166	1.73
Box	Low Height, Far-Spaced, Full Span, Top Angled Baffle	z_{min} = 0.05W z_{max} = 0.11W	W	60	0.180	1.64
Circular	Corner Baffle	z = 0.10D z_{max} = 0.15D	0.5D	90	7.81	2.63

W = Box Culvert Width D = Circular Culvert Diameter

Step 8: Model proposed conditions for High Fish Passage and 100-Year events in separate HEC-RAS plans using the respective effective roughness values selected in Step 7. (Note: If effective roughness values cannot be used, see Appendix F Hydraulics of Baffles for an alternative method of modeling high fish passage and 100-year flows.)

Create HEC-RAS plans: Proposed Conditions – High Fish Flow Plan and Proposed Conditions - 100-Year Plan. Insert culvert into HEC-RAS model at River Station 319. Enter Selected Roughness Coefficients that were determined in Step 7 into Culvert Data Editor and run both plans in HEC-RAS.

Culvert Characteristics:

- Construction: CMP
- Installation: At grade
- Culvert Start Station: 319
- Culvert Diameter 90 in
- Culvert Length: 120 ft
- Inlet Bottom Elevation (Upstream Invert Elevation): 518.48 ft
- Outlet Bottom Elevation (Downstream Invert Elevation): 515.48 ft
- Upstream Centerline Station: 24.08 ft
- Downstream Centerline Station: 24.08 ft
- Hinge Point Elevation = 529.07 ft (Water surface elevation cannot exceed HP elevation.)
- Roadway Centerline Elevation = 532.0 ft

Step 9: Calculate Energy Dissipation Factor (EDF) using y_o for High Fish Passage flows from Step 7 to calculate A_{wet} between baffles.

Q = High Fish Passage Flow, 36 ft^3/s

EDF = $\gamma QS/A_{wet}$

γ = Water density, 62.4 lbm/ft^3

Q = High Fish Passage Flow, 36 ft^3/s

S = Culvert Slope, 0.025 ft/ft

A_{wet} = 10.10 ft^2 (Step 7)

EDF = 5.5 lbm/ft^3

Check to confirm that calculated EDF value for baffles is between 3-5 lbm/ft^3. EDF is a little over the maximum value.

Fill in EDF results in Form 6D.

Step 10: Find velocity (Proposed Conditions - High Fish Flow HEC-RAS Plan) and depth (Proposed Conditions - Low Fish Flow HEC-RAS plan) at appropriate x-sections from HEC-RAS. If velocity, depth or EDF are not met, change baffle spacing and/or height to ultimately meet design criteria. Check culvert capacity based on proposed conditions for the 100-Year event. Re-run HEC-RAS models as needed. Once criteria have been met, summarize calculated depths in *Depth Criteria Versus Design* and velocities in *Velocities Criteria Versus Design* tables in Form 6D – Hydraulic Baffle Design Option.

Fill in results in Form 6D.

Step 11: Complete sections *Allowable Hydraulic Impacts* and *Depth Impacts at 100-Yr Flood Flow* in Form 6D.

Hinge Point Elevation = 529.07 ft (Water surface elevation cannot exceed HP elevation.)

Roadway centerline elevation = 532.0 ft

Fill in results in Form 6D.

BAFFLE BASIC DESIGN STEPS

Step 1: Calculate Low and High Fish Passage Design Flows.

Step 2: Using FishXing software, identify and assess existing fish passage obstructions. (Note: If FishXing software is not used to analyze existing conditions, HEC-RAS could be used to identify velocity and depth shortfalls based on selected known species and life stage. The Engineer must determine shortfalls manually by comparison of HEC-RAS results to fish data).

Step 3: Create HEC-RAS model for Existing Conditions Plan using 100-Year flow to assess existing capacity.

Step 4: Determine baffle retrofit type, baffle height, and spacing for proposed low flow hydraulic model.

Step 5: Prepare proposed conditions for Low Fish Passage flow events in HEC-RAS by using inline weirs within semicircular, semi-box, or semi-arch open channel, which will be Proposed Conditions-Low Flow Plan, and determine weir coefficient through iterative process (calibrate with Low Fish Passage Flow).

Step 6: Select appropriate C and a parameters according to baffle retrofir type for use in the effective roughness method of developing high fish passage flow and 100-year models. If the effective roughness method cannot be used, go to Step 8.

Step 7: Calculate y_o for High Fish Passage and 100-Year flows. Verify streaming flow condition: y_o is equal to or greater than $0.75z_{max}$ (corner baffles) or $1.1z_{max}$ (all other baffle types). Determine effective roughness (n_{eff}) for High Fish Passage and 100-Year flows.

Step 8: Model proposed conditions for High Fish Passage and 100-Year events in separate HEC-RAS plans using the respective effective roughness values selected from Step 7. (Note: If effective roughness values cannot be used, see Appendix F Hydraulics of Baffles for an alternative method of modeling High Fish Passage and 100-Year flows.)

Step 9: Calculate Energy Dissipation Factor (EDF) using y_o for High Fish Passage flow from Step 7 to calculate A_{wet} between baffles.

Step 10: Find velocity (Proposed Conditions - High Fish Flow HEC-RAS Plan) and depth (Proposed Conditions - Low Fish Flow HEC-RAS plan) at appropriate x-sections from HEC-RAS. If velocity, depth or EDF are not met, change baffle spacing and/or height to ultimately meet design criteria. Check culvert capacity based on proposed conditions for the 100-Year event. Re-run HEC-RAS models as needed. Once criteria have been met, summarize calculated depths in *Depth Criteria Versus Design* and velocities in *Velocities Criteria Versus Design* tables in Form 6D – Hydraulic Baffle Design Option.

Step 11: Complete sections *Allowable Hydraulic Impacts* and *Depth Impacts at 100-Yr Flood Flow* in Form 6D from Appendix D.

COMPLETED FORMS

FISH PASSAGE: HYDRAULIC BAFFLE DESIGN OPTION — FORM 6D

Project Information: Fish Passage Improvement Route 125		Computed: EKB	Date: 6/25/08
		Checked: JJL	Date: 6/26/08
Stream Name: Ripple Creek	County: Ventura County	Route: 125	Postmile: 28

General Considerations - Baffles shall be used in the design retrofitted culverts in order to meet the hydraulic design criteria.

Hydrology Results - Peak Discharge Values

2-Year Flood Event (50% Annual Probability)	- cfs	Low Fish Passage Design Flow	9 cfs
100-Year Flood Event (1% Annual Probability)	400 cfs	High Fish Passage Design Flow	36 cfs

Summarize Retrofitted Culvert Physical Characterstics

Inlet Characteristics - Retrofitted design to inlet: ☐ Yes ☒ No

Inlet Type	☒ Projecting	☐ Headwall	☐ Wingwall
	☐ Flared end section	☐ Segment connection	☐ Skew Angle: °

Barrel Characteristics - Retrofitted design to barrel: ☒ Yes ☐ No

Diameter:	90 in	Fill height above culvert:	8 ft
Height/Rise:	- ft	Length:	120 ft
Width/Span:	- ft	Number of barrels:	1

Culvert Type	☐ Arch	☐ Box	☒ Circular
	☐ Pipe-Arch	☐ Elliptical	
Culvert Material	☐ HDPE	☐ Steel Plate Pipe	☐ Concrete Pipe
	☒ Spiral Rib / Corrugated Metal Pipe		

Horizontal alignment breaks:	- ft	Vertical alignment breaks:	- ft

Outlet Characteristics - Retrofitted design to outlet: ☐ Yes ☒ No

Outlet Type	☒ Projecting	☐ Headwall	☐ Wingwall
	☐ Flared end section	☐ Segment connection	Skew Angle: °

Proposed Baffle Settings and Dimensions

Baffle height:	1.5 ft	Baffle width:	0.083 ft

FISH PASSAGE: HYDRAULIC BAFFLE DESIGN OPTION — FORM 6D

Baffle spacing (along longitudinal axis): 20 ft	

Selecting Weir Coefficient, C

1) Estimate the highest weir coefficient using the highest head for the previously calculated crest width (breadth of crest of weir) from the HEC-22 Broad Crested Weir Coefficient Table.	C = 3.32	$ft^{0.5}$/sec
2) Run the proposed HEC-RAS model and find the average head (weir average depth) over a weir for the Low Fish Passage Flow from HEC-RAS results.	Weir Average Depth = 0.55	ft
3) Given the average head (weir average depth) from the HEC-RAS results and the crest width (breadth of crest of weir), find a second weir coefficient from the HEC-22 Broad Crested Weir Coefficient Table.	C = 3.04	$ft^{0.5}$/sec
4) Run the proposed HEC-RAS model with the second weir coefficient from Step C and find the average head (weir average depth) over a weir for the Low Fish Passage Flow from HEC-RAS results.	Weir Average Depth = 0.58	ft
5) Given the average head (weir average depth) from the HEC-RAS results and the crest width (breadth of crest of weir), find a third weir coefficient from the HEC-22 Broad Crested Weir Coefficient Table.	C = 3.06	$ft^{0.5}$/sec
6) Compare weir coefficient from Step C and Step E. If weir coefficients are close in value, then use Step E weir coefficient for remaining HEC-RAS modeling. If weir coefficients are not close in value, repeat Steps C-F until an appropriate weir coefficient is found.	Modeled broad-crested weir coefficient: 3.06	$ft^{0.5}$/sec

Verify High Design Flow for Fish Passage - Depending on species, develop high design flows:

Species/Life Stage	Percent Annual Exceedance Flow	Percentage of 2-Yr Recurrence Interval Flow	Design Flows (cfs)
☒ Adult Anadromous Salmonids	1%	50%	36
☐ Adult Non-Anadromous Salmonids	5%	30%	
☐ Juvenile Salmonids	10%	10%	
☐ Native Non-Salmonids	5%	30%	
☐ Non-Native Species	10%	10%	

Verify Low Design Flow for Fish Passage - Depending on species, develop low design flows:

Species/Life Stage	Percent Annual Exceedance Flow	Alternate Minimum Flow (cfs)	Design Flow (cfs)
☒ Adult Anadromous Salmonids	50%	3	9
☐ Adult Non-Anadromous Salmonids	90%	2	
☐ Juvenile Salmonids	95%	1	
☐ Native Non-Salmonids	90%	1	
☐ Non-Native Species	90%	1	

FISH PASSAGE: HYDRAULIC BAFFLE DESIGN OPTION — FORM 6D

Verify Maximum Average Water Velocity (at High Design Flow) and Minimum Flow Depth in Culvert (at Low Design Flow) - Depending on culvert length and/or species, select Maximum Average Water Veolcity and Minimum Flow Depth.

Species/Life Stage	Maximum Average Water Velocity at High Fish Design Flow (ft/sec)		Minimum Flow Depth at Low Fish Design Flow (ft)
☒ Adult Anadromous Salmonids	6	(Culvert length <60 ft)	1.0
	5	(Culvert length 60-100 ft)	
	4	(Culvert length 100-200 ft)	
	3	(Culvert length 200-300 ft)	
	2	(Culvert length >300 ft)	
☐ Adult Non-Anadromous Salmonids	4	(Culvert length <60 ft)	0.67
	4	(Culvert length 60-100 ft)	
	3	(Culvert length 100-200 ft)	
	2	(Culvert length 200-300 ft)	
	2	(Culvert length >300 ft)	
☐ Juvenile Salmonids	1		0.5
☐ Native Non-Salmonids	Species specific swimming performance data is required for the use of the hydraulic design option for non-salmonids. Hydraulic design is not allowed for these species without this data.		
☐ Non-Native Species			

Verify Maximum Outlet Drop - Hydraulic drops between the water surface in the culvert to the pool below the culvert should be avoided for all cases. Where fish passage is required and a hydraulic drop is unavoidable, it's magnitude should be evaluated for both high design flow and low design flow and shall not exceed the values shown below. If a hydraulic drop occurs at the culvert outlet, a jump pool of at least 2 feet in depth shall be provided.

Species/Life Stage	Maximum Drop (ft)
☒ Adult Anadromous Salmonids	1
☐ Adult Non-Anadromous Salmonids	1
☐ Juvenile Salmonids	0.5
☐ Native Non-Salmonids	Where fish passage is required for native non-salmonids no hydraulic drop shall be allowed at the culvert outlet unless data is presented which will establish the leaping ability and leaping behavior of the target species of fish.
☐ Non-Native Species	

Develop and run hydraulic models to compute water surface elevations, flow depths, and velocities for Low Fish Design Flow, High Fish Design Flow, and the 100-Year peak or design discharge reflecting existing and proposed conditions. Evaluate results.

Maximum average velocity in culvert at High Fish Design Flow: 3.6 ft/s

FISH PASSAGE: HYDRAULIC BAFFLE DESIGN OPTION			FORM 6D
Does the velocity exceed the maximum allowable for the culvert length and design species? ☐ Yes ☒ No			
If yes, modify design to comply and rerun hydraulic anaylses to verify.			
Minimum flow depth in culvert at Low Fish Design Flow:			1.0 ft
Does the depth equal or not exceed the mimimum allowable for the culvert length and design species? ☐ Yes ☒ No			
If yes, modify design to comply and rerun hydraulic anaylses to verify.			
Depth impacts at 100-Year Flood Flow:			
If water surface elevations increase, does the increase exceed the maximum elevation? ☐ Yes ☒ No			Maximum elevation: HP=529.07 ft
If yes, revise the design and rerun hydraulic analyses to verify.			
Allowable Hydraulic Impacts:			
Is the crossing located within a floodplain as designated by the Federal Emergency Management Agency or another responsible state or local agency? ☐ Yes ☒ No			
If yes, establish allowable hydraulic impacts and hydraulic design requirements with the appropriate agency. Attach results.			
Will the project result in the decrease capacity of an existing crossing? ☐ Yes ☒ No			
If yes, will it significantly increase upstream backwater effects due to the reduced upstream attenuation? ☐ Yes ☒ No			
If yes, consult District Hydraulics. Further analysis may be needed.			
Drop between the water surface elevation in the culvert and the outlet channel:			
Low Fish Design Flow Drop Length: 0 ft			
Does the drop between the water surface in the culvert and the outlet channel at high or low design fish flows exceed the maximum allowable for the design species? ☐ Yes ☒ No			
If yes, modify design to avoid a drop if possible. If a drop is unavoidable modify design to meet criteria and provide a jump pool at least two feet in depth. Rerun hydraulic analyses to verfiy.			
Calculate Energy Dissipation Factor (EDF)			
Water Density, γ = 62.4 lbm/ft^3	High Fish Flow, Q: 36 cfs	Culvert Slope, S: 0.025 ft/ft	X-sectional flow area in between baffles, A: 10.10 ft^2
EDF = γQS / A : 5.5 ft-lb/ft^3/s			
Velocity Criteria Versus Design (High Fish Passage Flow)			

FISH PASSAGE: HYDRAULIC BAFFLE DESIGN OPTION — FORM 6D

Culvert Velocity	Design Flow Velocity (ft/s)	Criteria Flow Velocity (ft/s)
Culvert Inlet Velocity (evaluated at x-section immediately located upstream of culvert)	1.86	5.0
Culvert Barrel Velocity (evaluated through Culvert Output in HEC-RAS)	3.56 - 5.79	5.0
Culvert Outlet Velocity (evaluated at x-section immediately located downstream of culvert)	5.09	5.0

Depth Criteria Versus Design (Low Fish Passage Flow)

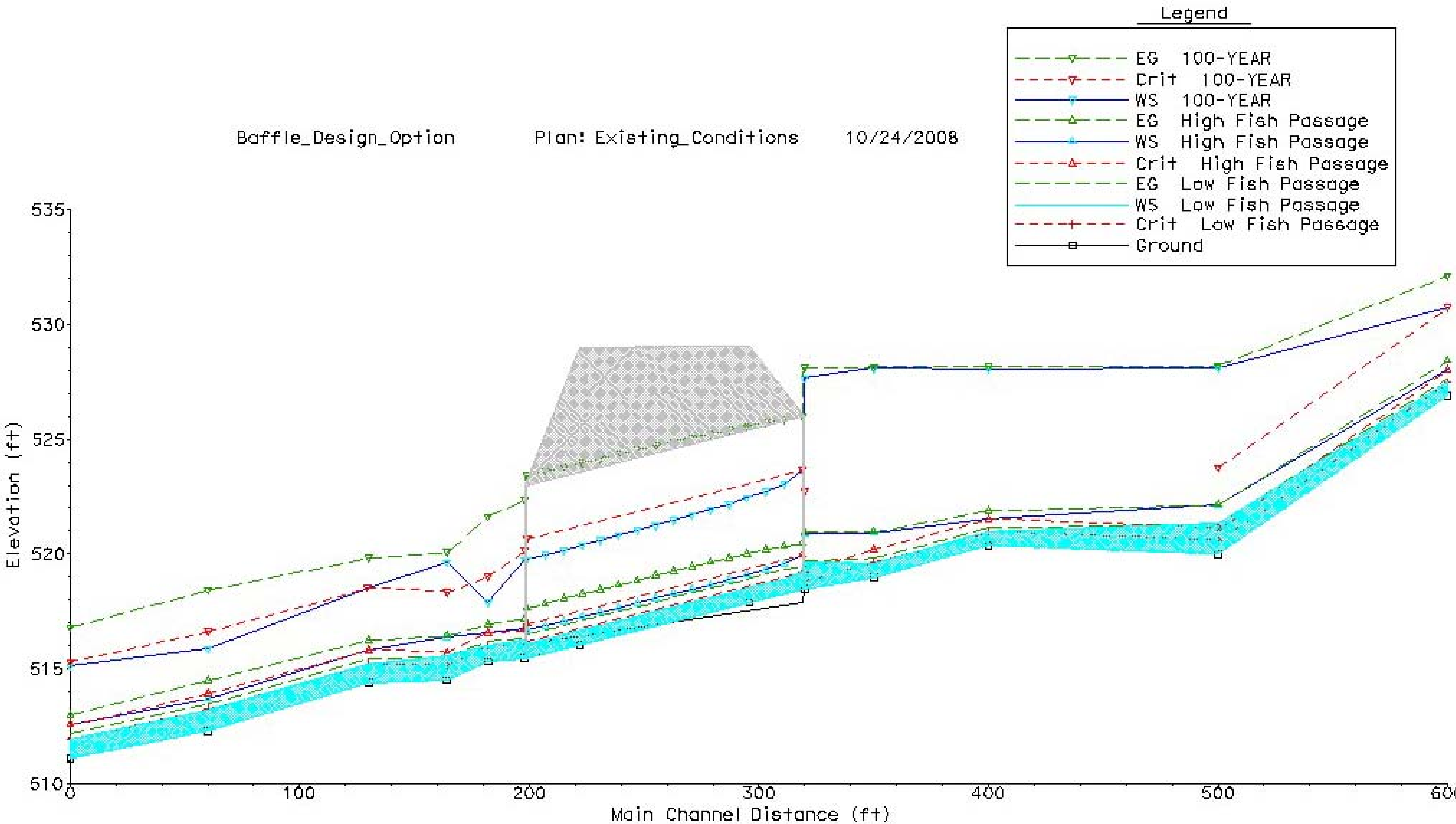
Cross-Section	Design Flow Depth (ft)	Criteria Flow Depth (ft)
298	1.65	1.0
278	1.65	1.0
258	1.70	1.0
238	1.65	1.0

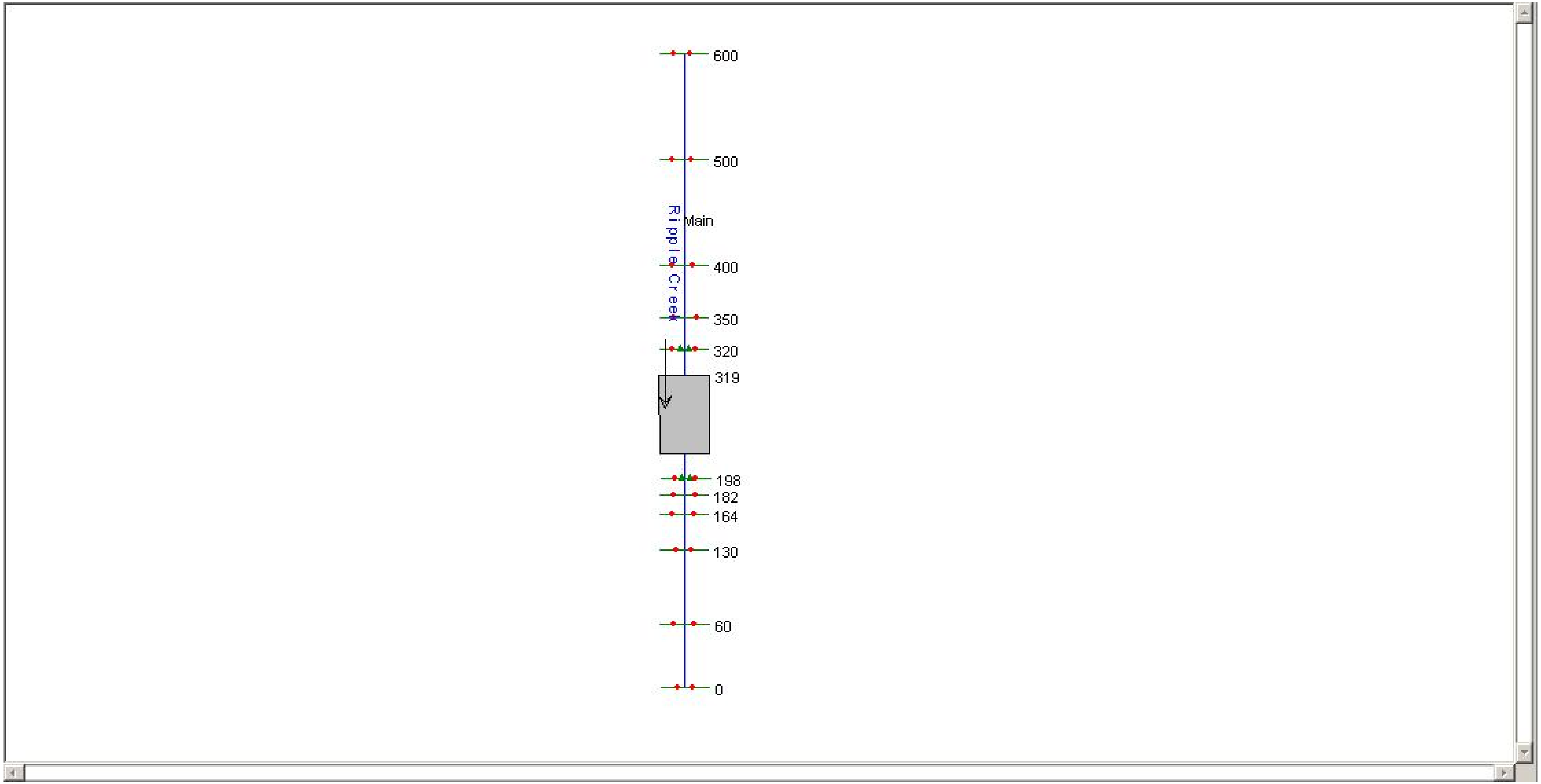
Proposed Plan and Profile Drawing Attached ☒ Yes ☐ No

Hydraulic Analysis Index Sheet Attached ☒ Yes ☐ No

HEC-RAS MODELLING RESULTS

EXISTING CONDITIONS


Baffle_Design_Option Plan: Existing_Conditions 10/24/2008
Legend
EG 100-YEAR
Crit 100-YEAR
WS 100-YEAR
EG High Fish Passage
WS High Fish Passage
Crit High Fish Passage
EG Low Fish Passage
WS Low Fish Passage
Crit Low Fish Passage
Ground
Elevation (ft)
535
530
525
520
515
510
0
100
200
300
400
500
600
Main Channel Distance (ft)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500
Ripple Creek
Main
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350
320
319
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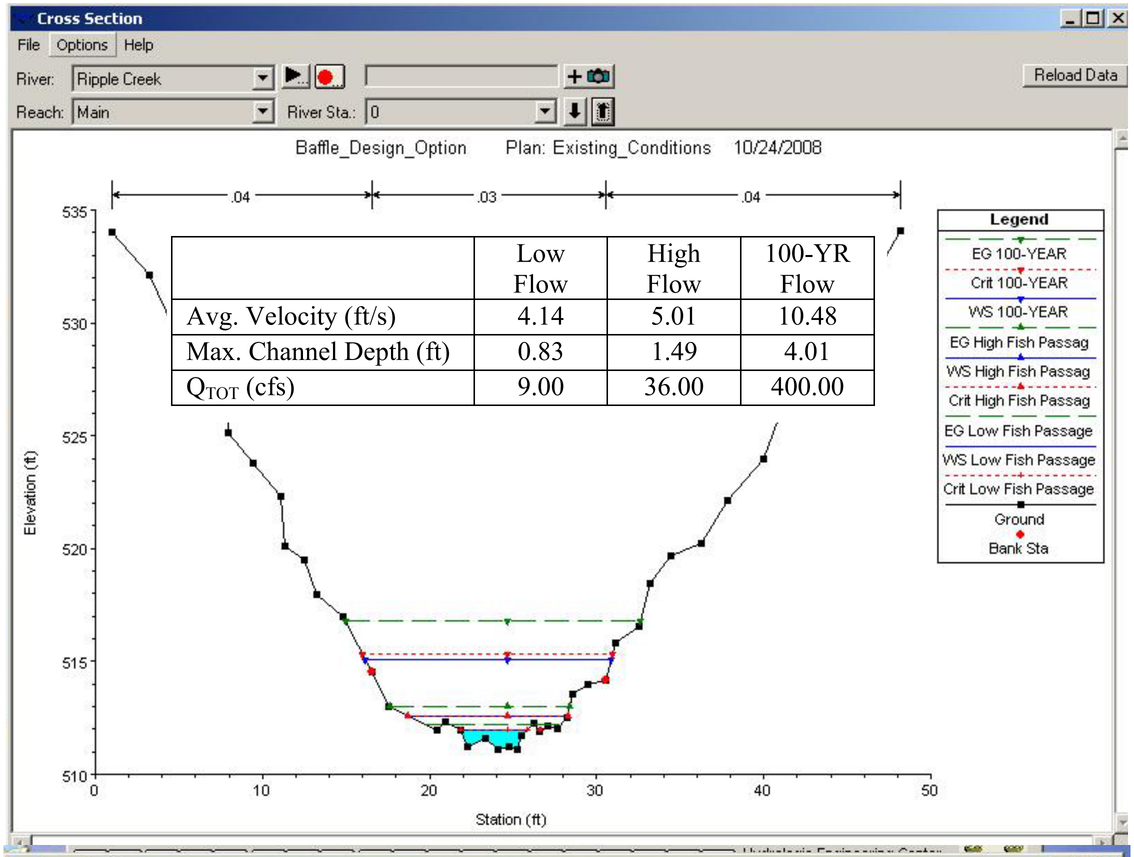
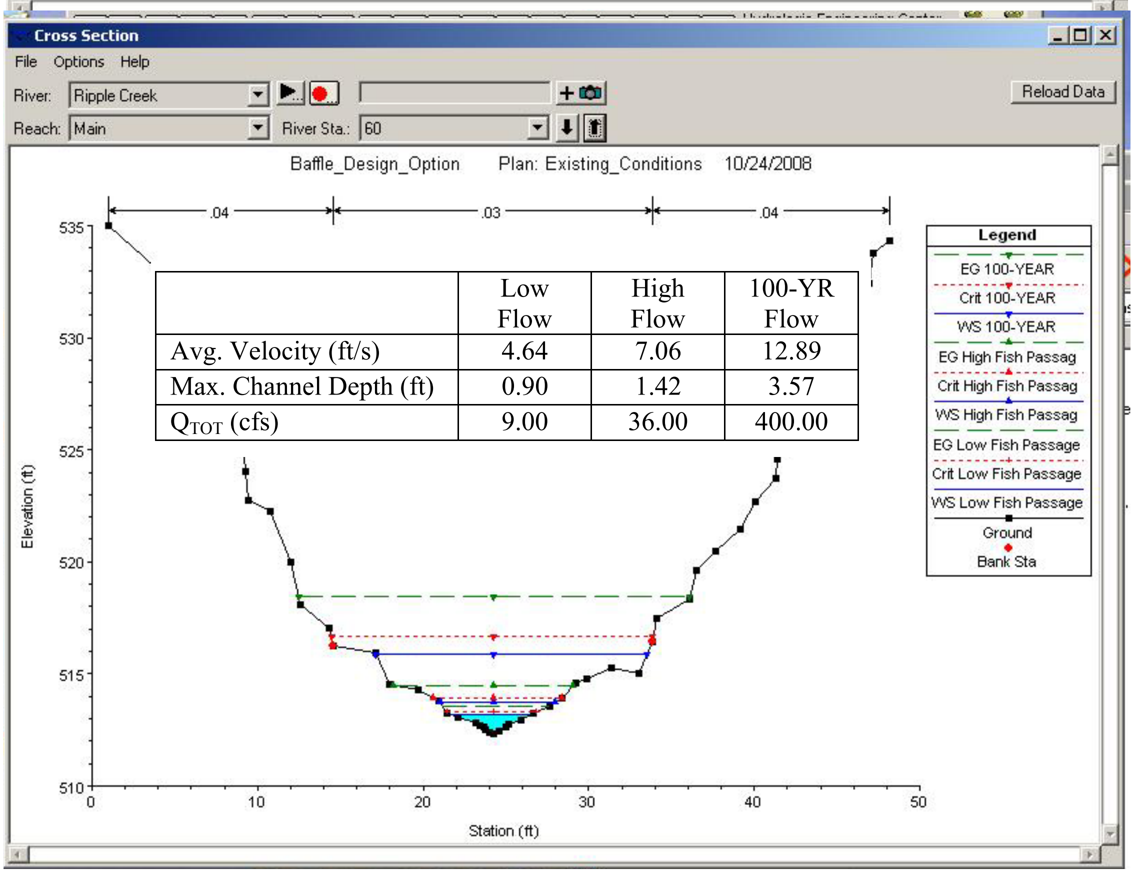
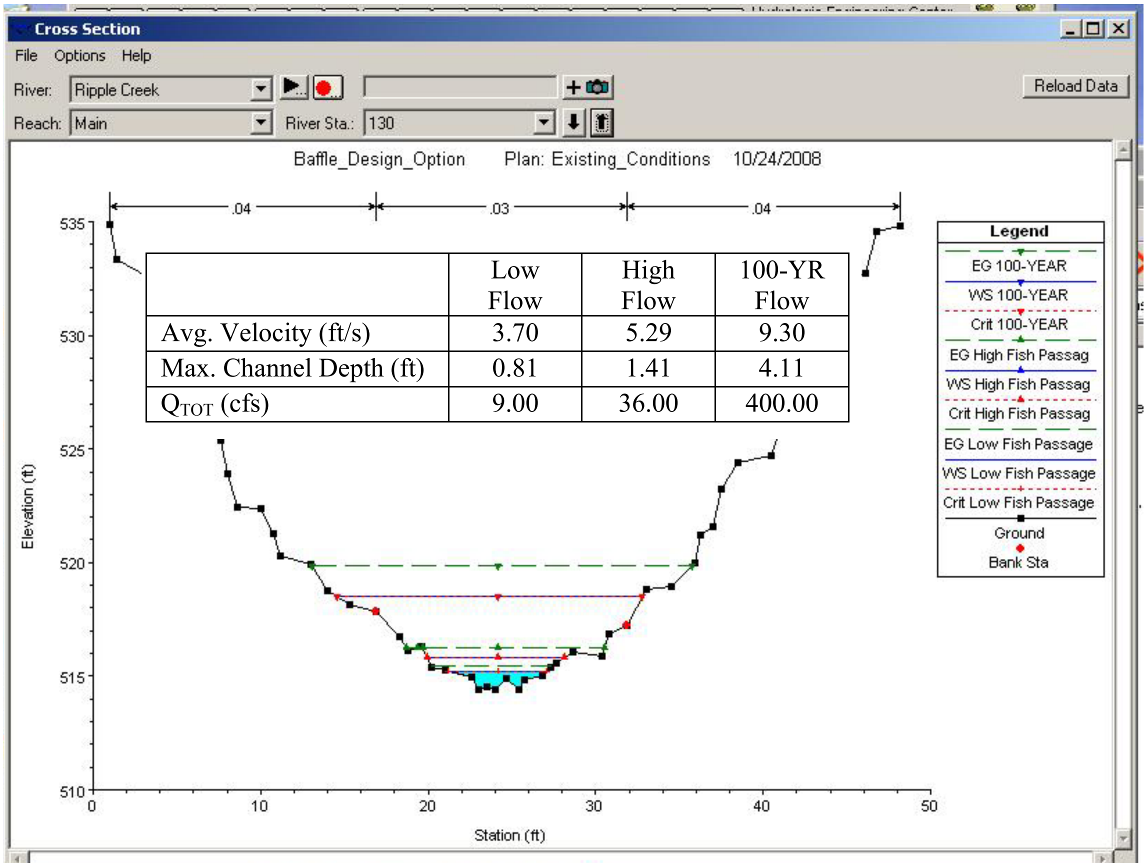
182
164
130
60
0



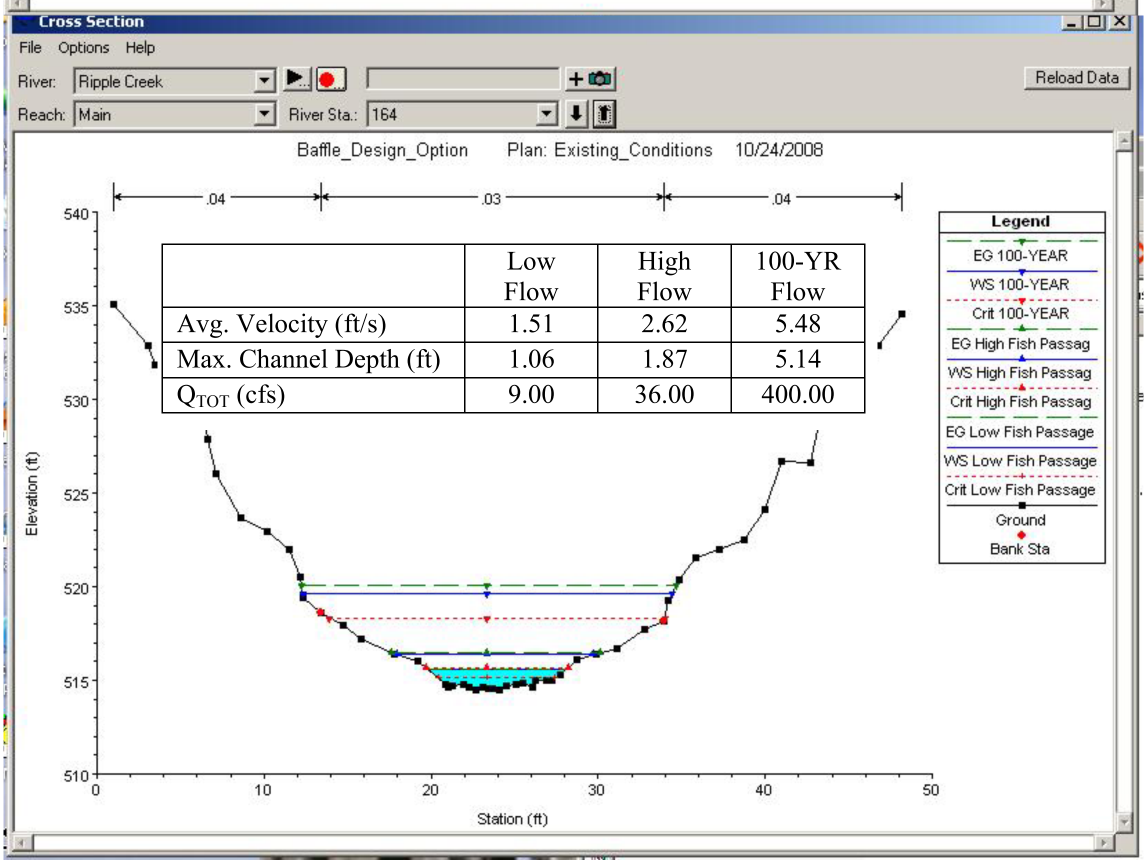
	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	4.14	5.01	10.48
Max. Channel Depth (ft)	0.83	1.49	4.01
Q_{TOT} (cfs)	9.00	36.00	400.00



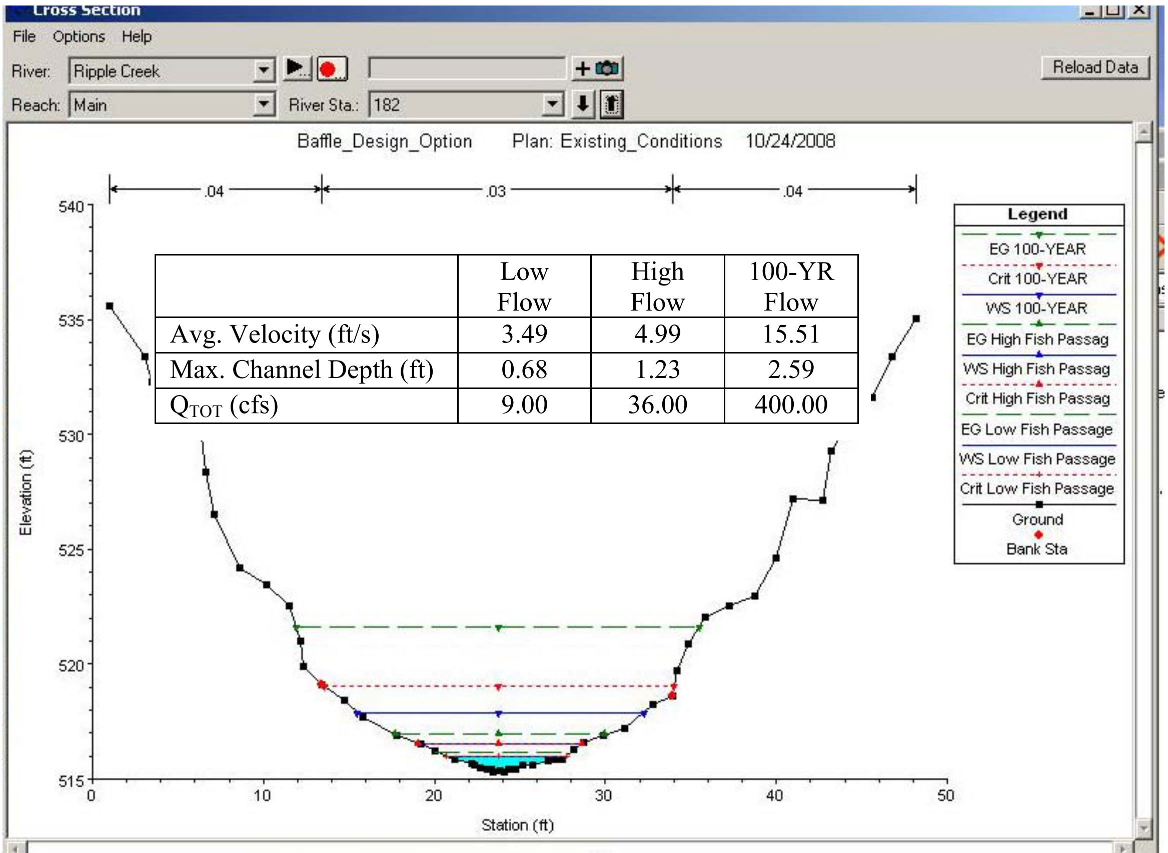
	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	4.64	7.06	12.89
Max. Channel Depth (ft)	0.90	1.42	3.57
Q_{TOT} (cfs)	9.00	36.00	400.00



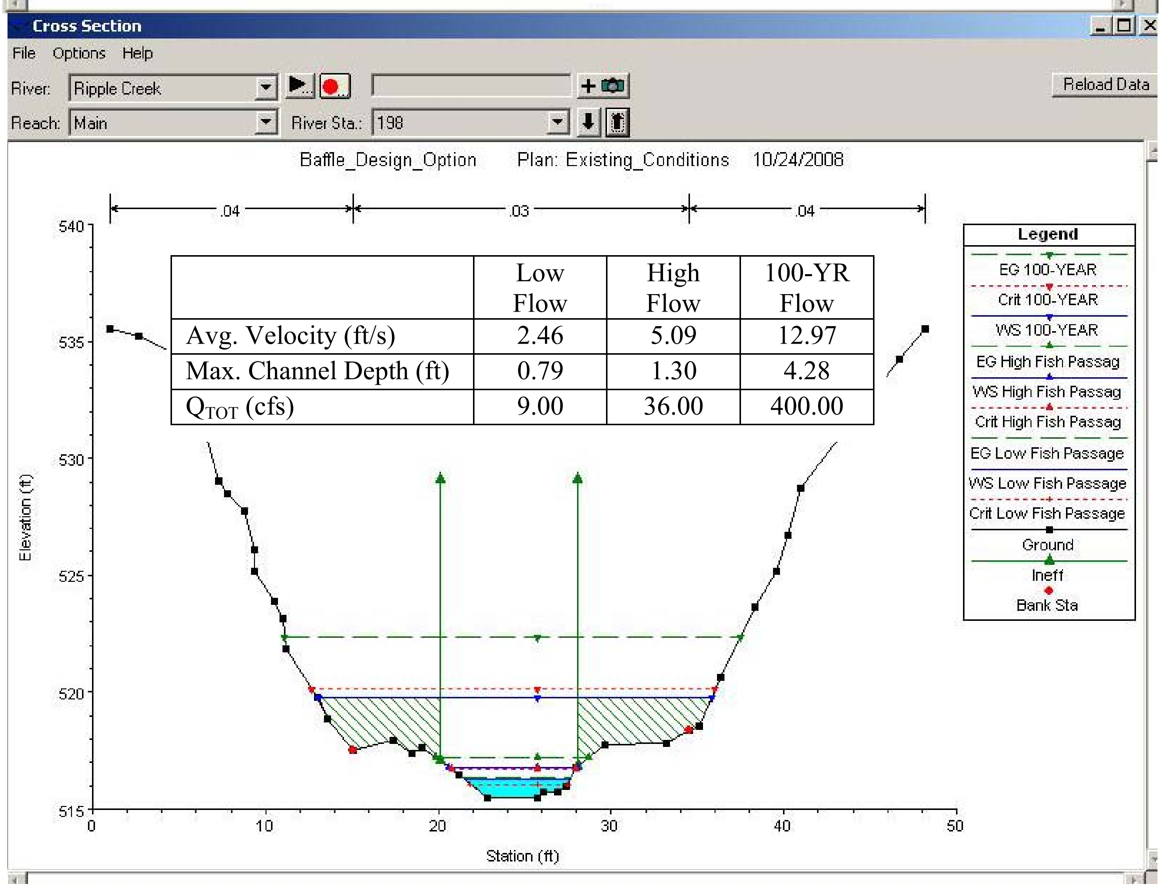
	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	3.70	5.29	9.30
Max. Channel Depth (ft)	0.81	1.41	4.11
Q_{TOT} (cfs)	9.00	36.00	400.00



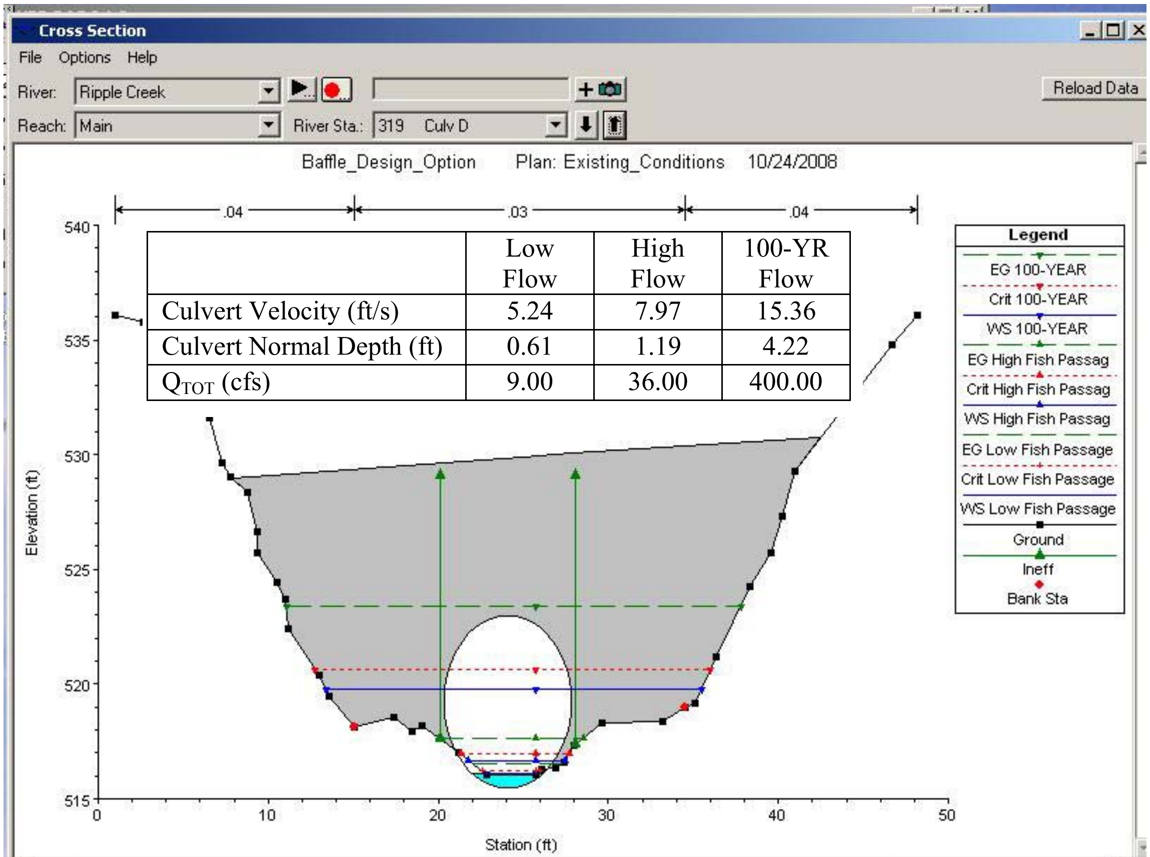
	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	1.51	2.62	5.48
Max. Channel Depth (ft)	1.06	1.87	5.14
Q_{TOT} (cfs)	9.00	36.00	400.00



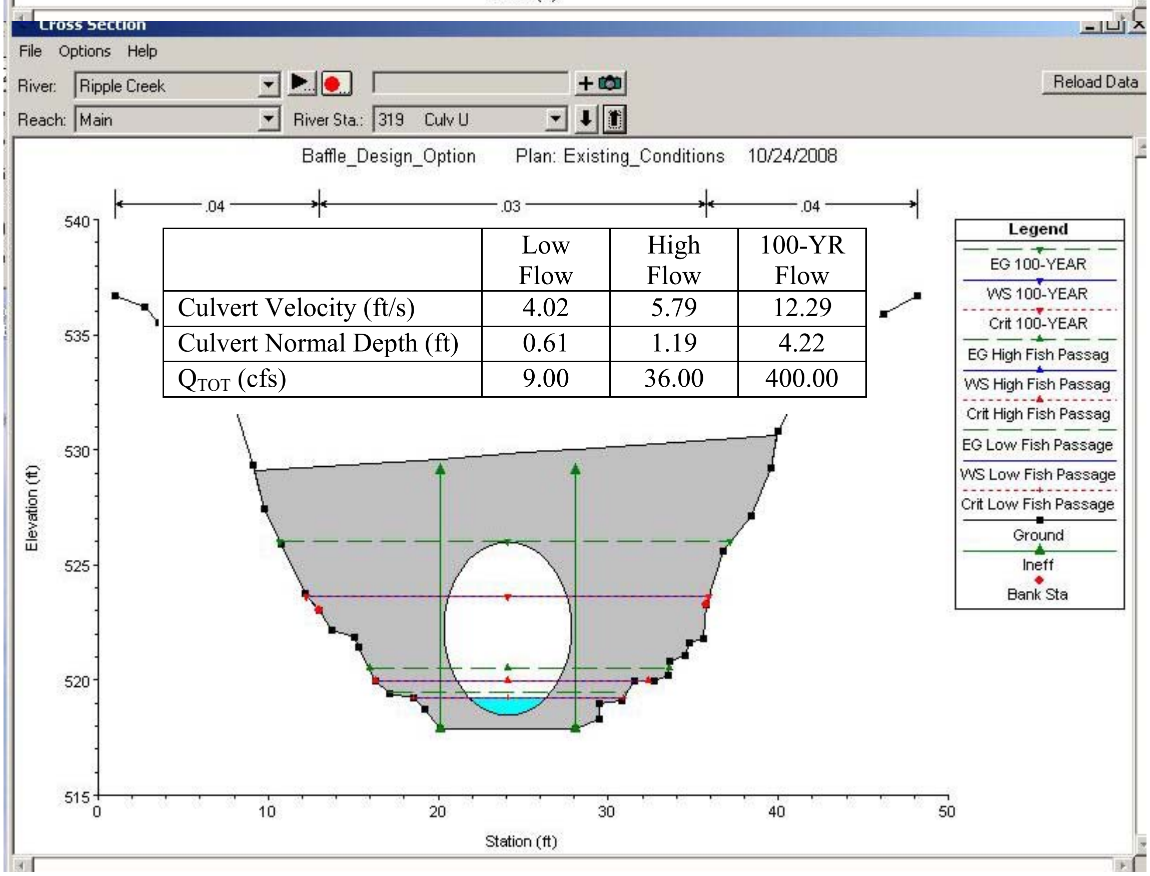
	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	3.49	4.99	15.51
Max. Channel Depth (ft)	0.68	1.23	2.59
Q_{TOT} (cfs)	9.00	36.00	400.00



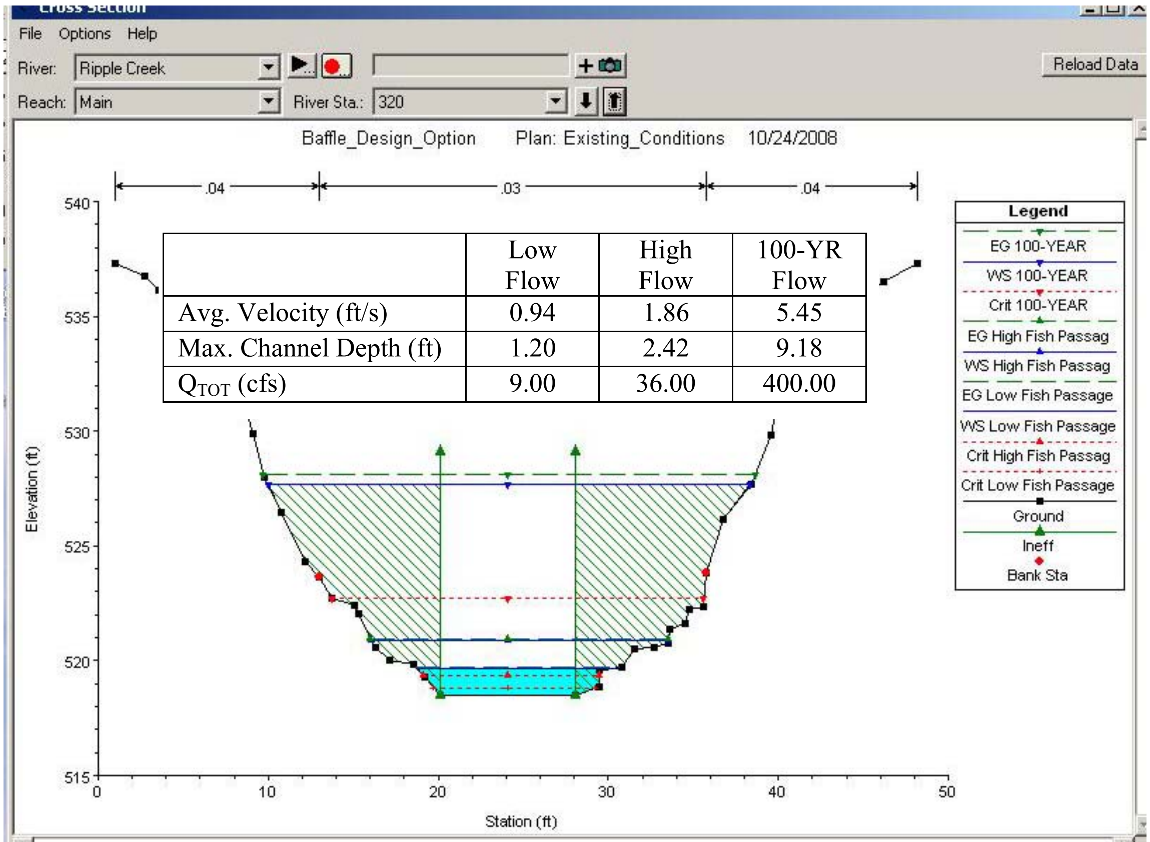
	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	2.46	5.09	12.97
Max. Channel Depth (ft)	0.79	1.30	4.28
Q_{TOT} (cfs)	9.00	36.00	400.00



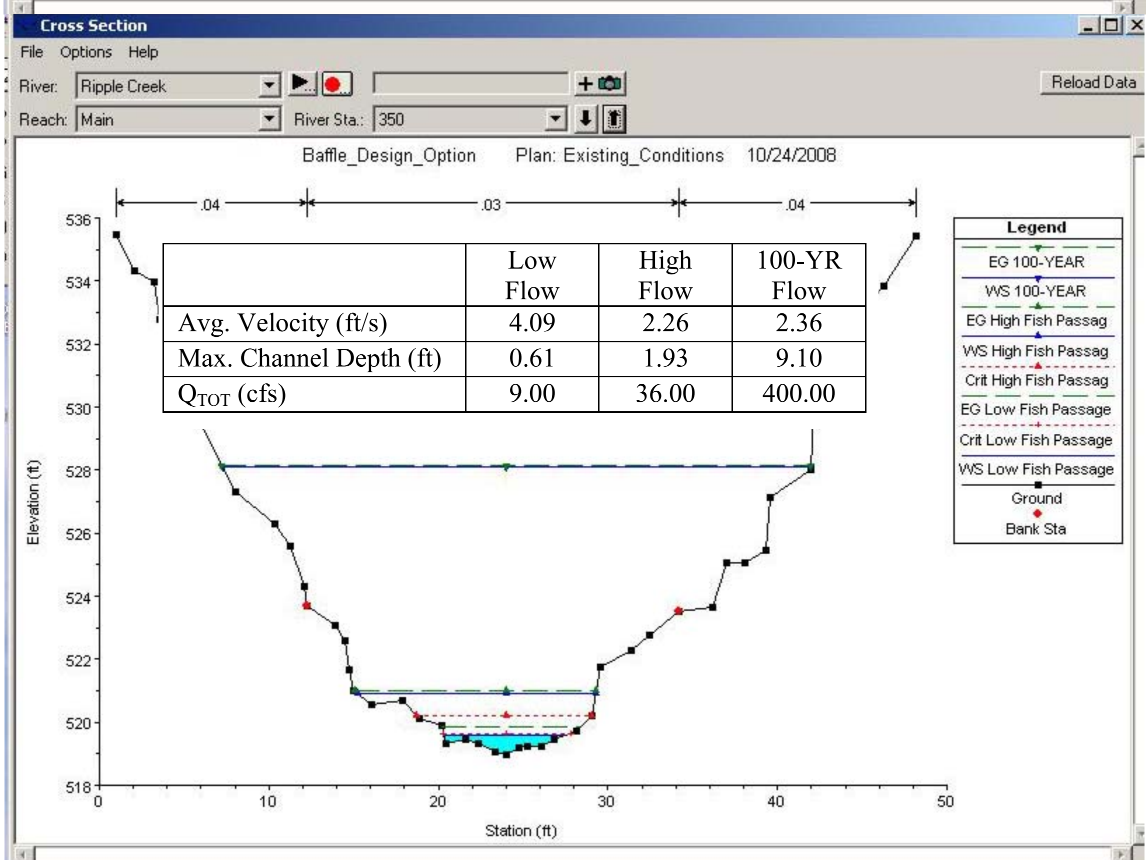
	Low Flow	High Flow	100-YR Flow
Culvert Velocity (ft/s)	5.24	7.97	15.36
Culvert Normal Depth (ft)	0.61	1.19	4.22
Q_{TOT} (cfs)	9.00	36.00	400.00



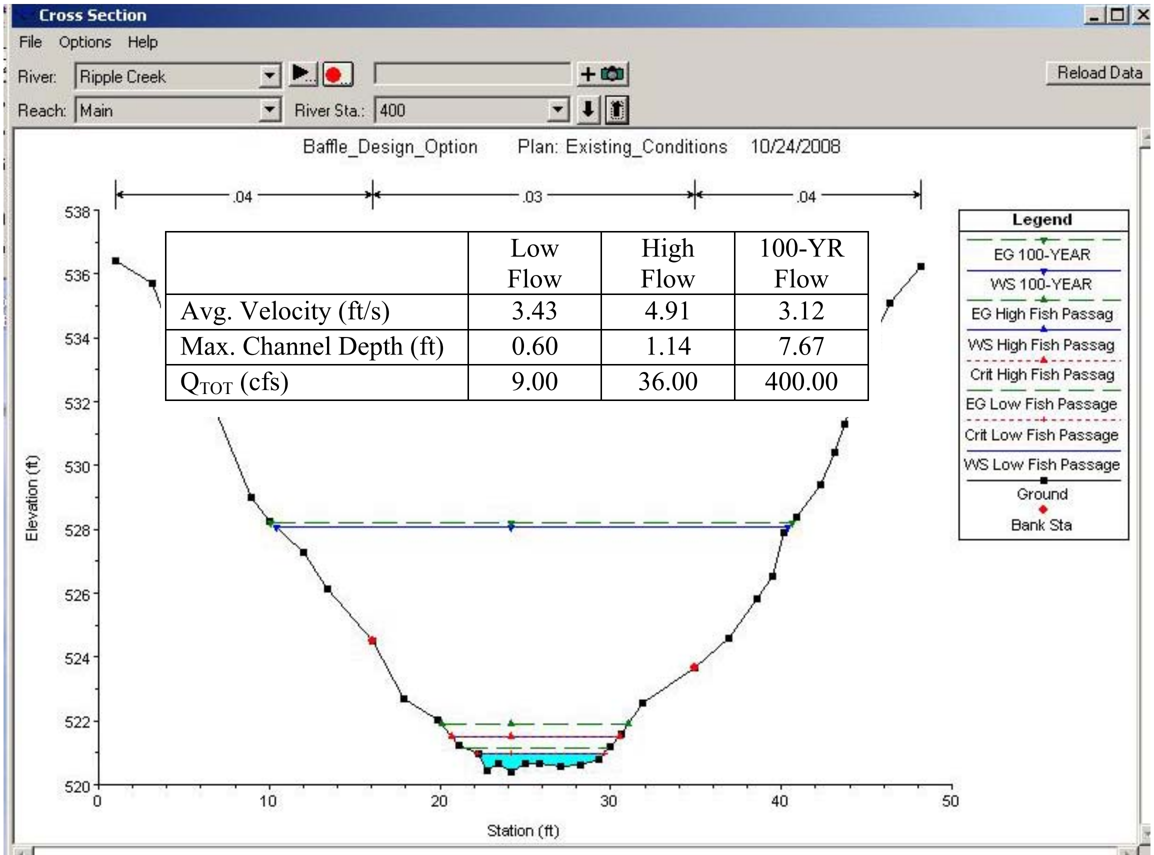
	Low Flow	High Flow	100-YR Flow
Culvert Velocity (ft/s)	4.02	5.79	12.29
Culvert Normal Depth (ft)	0.61	1.19	4.22
Q_{TOT} (cfs)	9.00	36.00	400.00



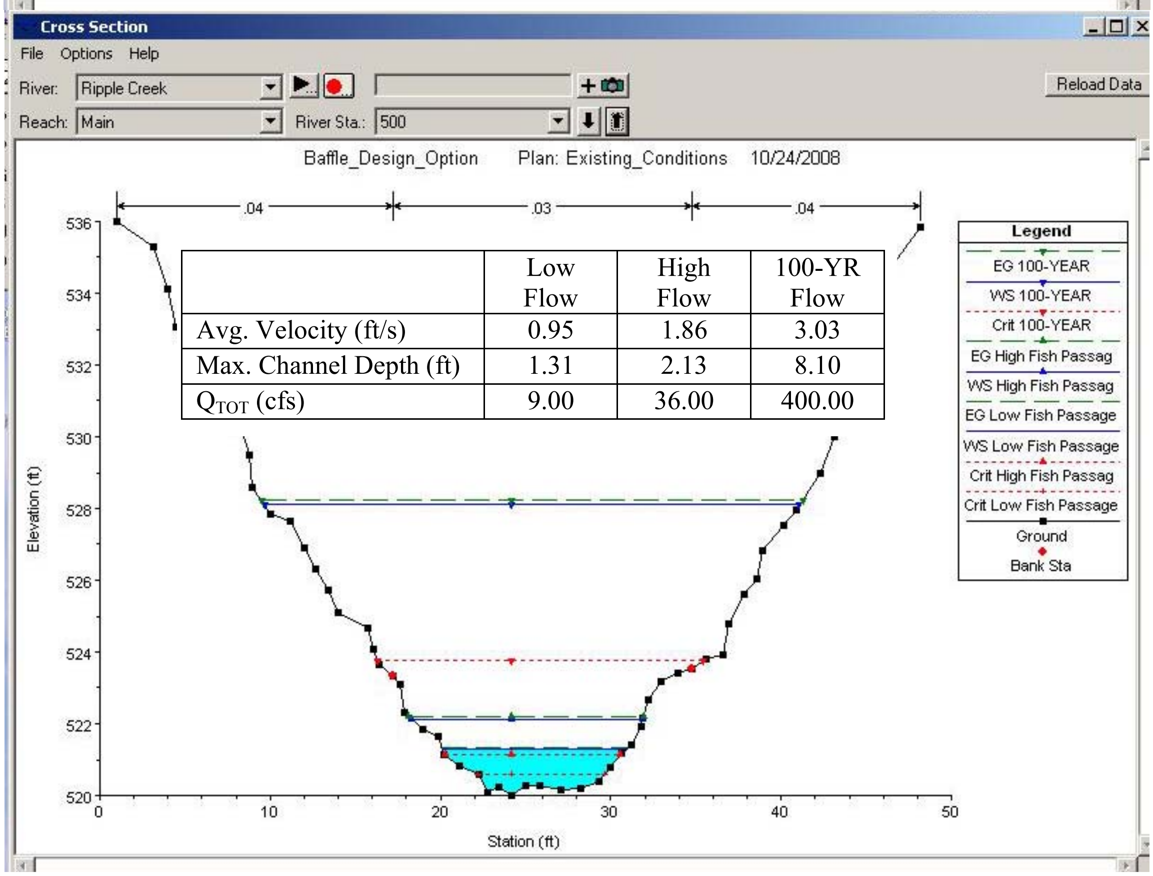
	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	0.94	1.86	5.45
Max. Channel Depth (ft)	1.20	2.42	9.18
Q_{TOT} (cfs)	9.00	36.00	400.00



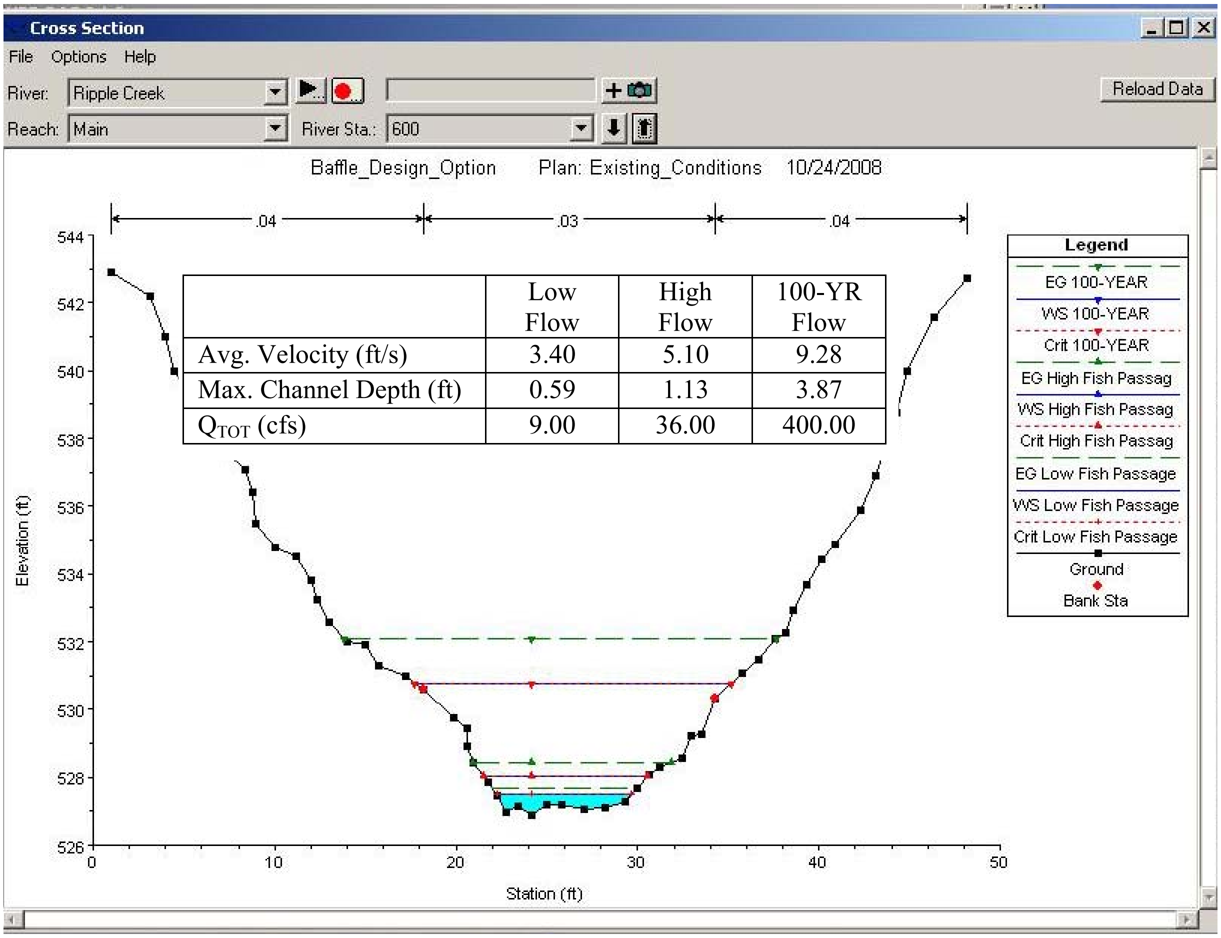
	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	4.09	2.26	2.36
Max. Channel Depth (ft)	0.61	1.93	9.10
Q_{TOT} (cfs)	9.00	36.00	400.00



	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	3.43	4.91	3.12
Max. Channel Depth (ft)	0.60	1.14	7.67
Q_{TOT} (cfs)	9.00	36.00	400.00



	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	0.95	1.86	3.03
Max. Channel Depth (ft)	1.31	2.13	8.10
Q_{TOT} (cfs)	9.00	36.00	400.00

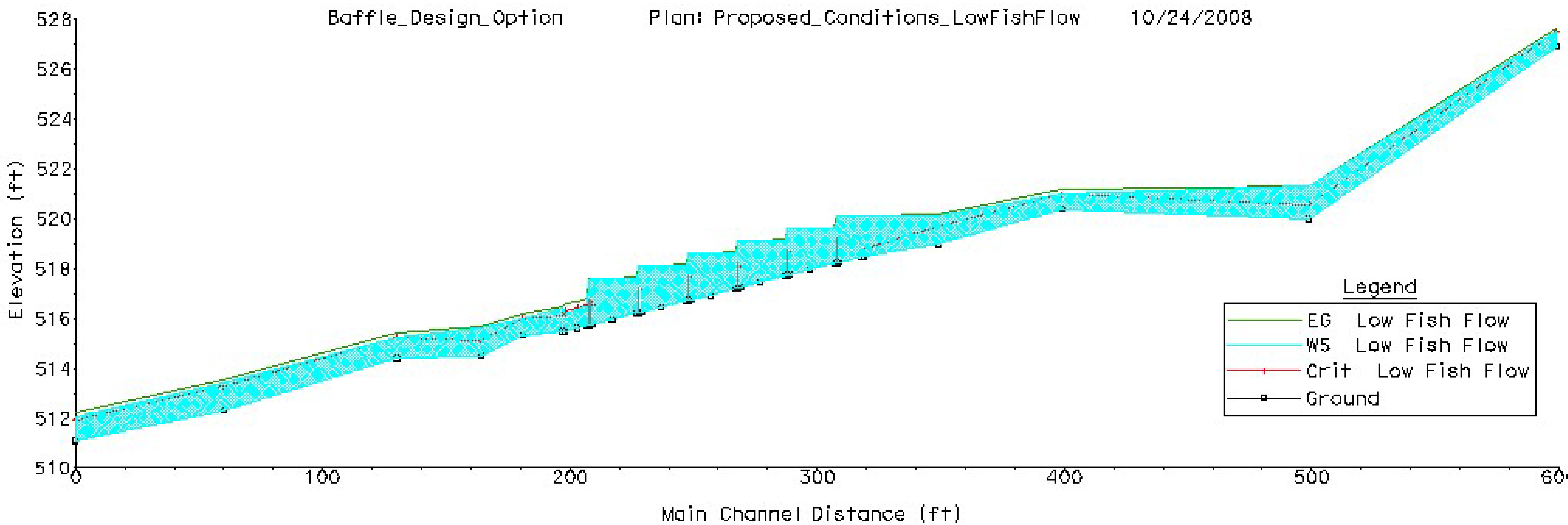


	Low Flow	High Flow	100-YR Flow
Avg. Velocity (ft/s)	3.40	5.10	9.28
Max. Channel Depth (ft)	0.59	1.13	3.87
Q_{TOT} (cfs)	9.00	36.00	400.00

PROPOSED DESIGN

PROPOSED DESIGN

LOW FLOW FISH PASSAGE RESULTS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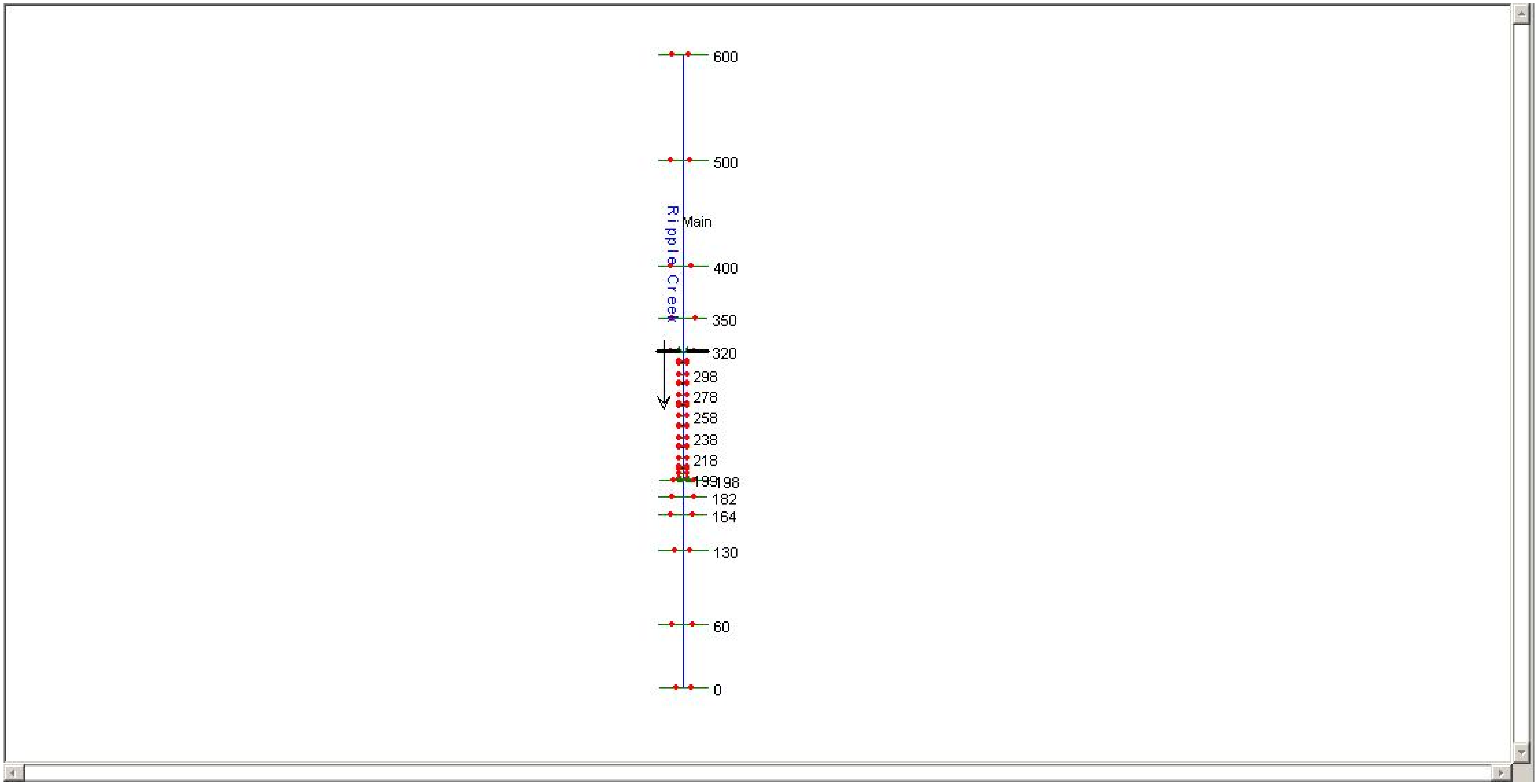
Plan: Proposed_Conditions_LowFishFlow
10/24/2008
Elevation (ft)
528
526
524
522
520
518
516
514
512
510
0
100
200
300
400
500
600
Main Channel Distance (ft)
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground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500
Main
Ripple Creek
400
350
320
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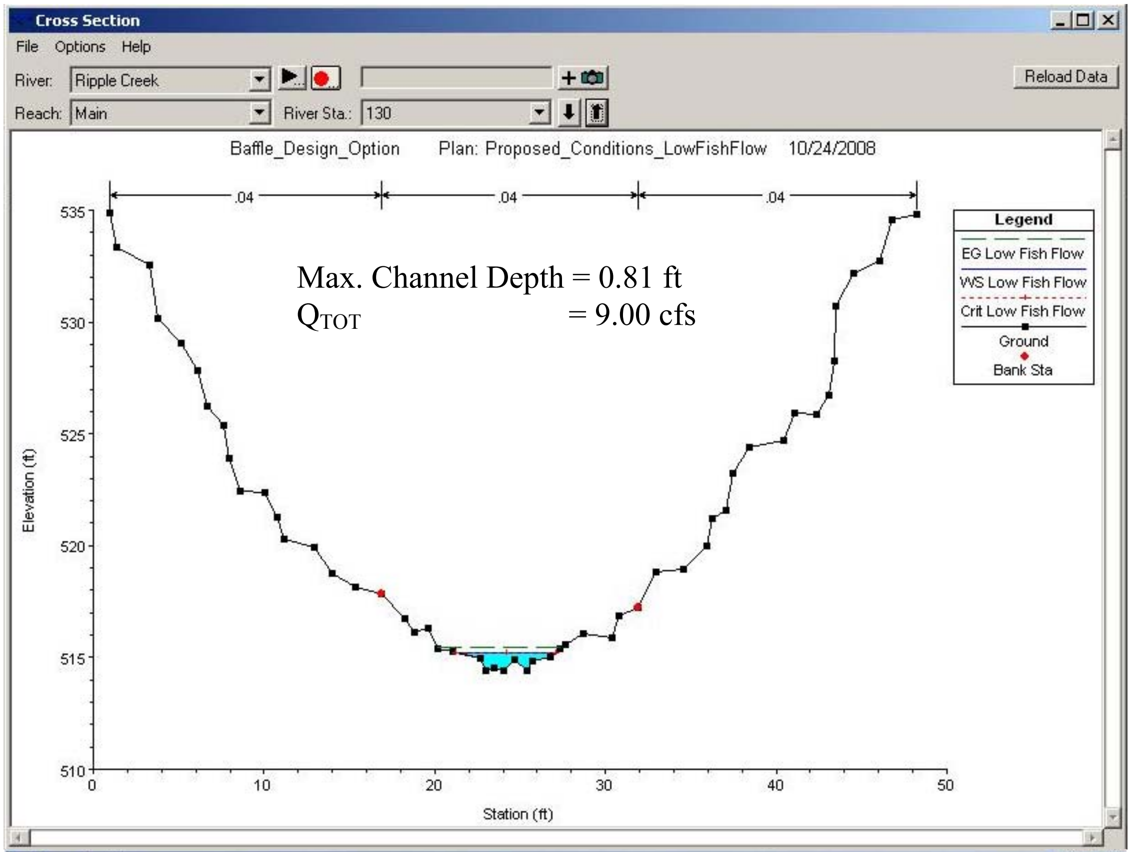
278
258
238
218
199
198
182
164
130
60
0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River: Ripple Creek
Reach: Main
River Sta.: 130
Reload Data
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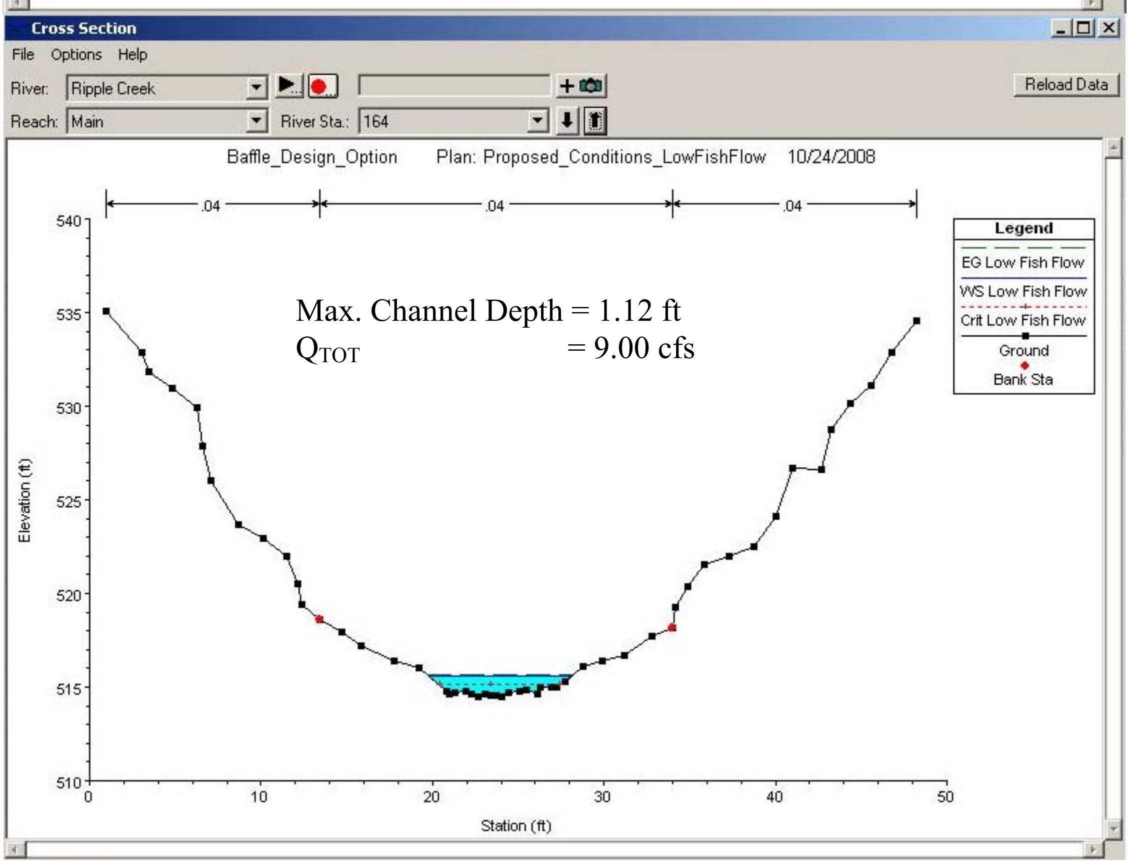
.04
.04
.04
Max. Channel Depth = 0.81 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
535
530
525
520
515
510
0
10
20
30
40
50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Reach: Main
River Sta.: 164
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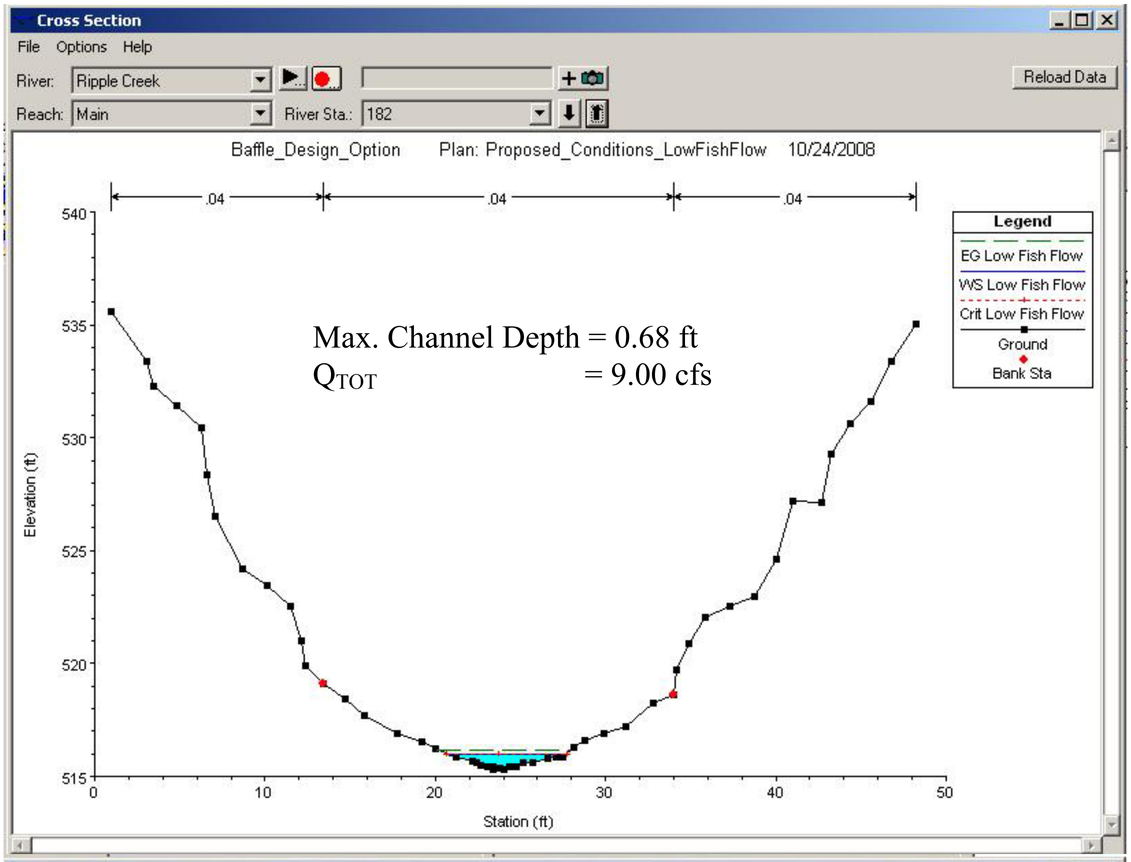
.04
.04
.04
Max. Channel Depth = 1.12 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
540
535
530
525
520
515
510
0
10
20
30
40
50


Cross Section
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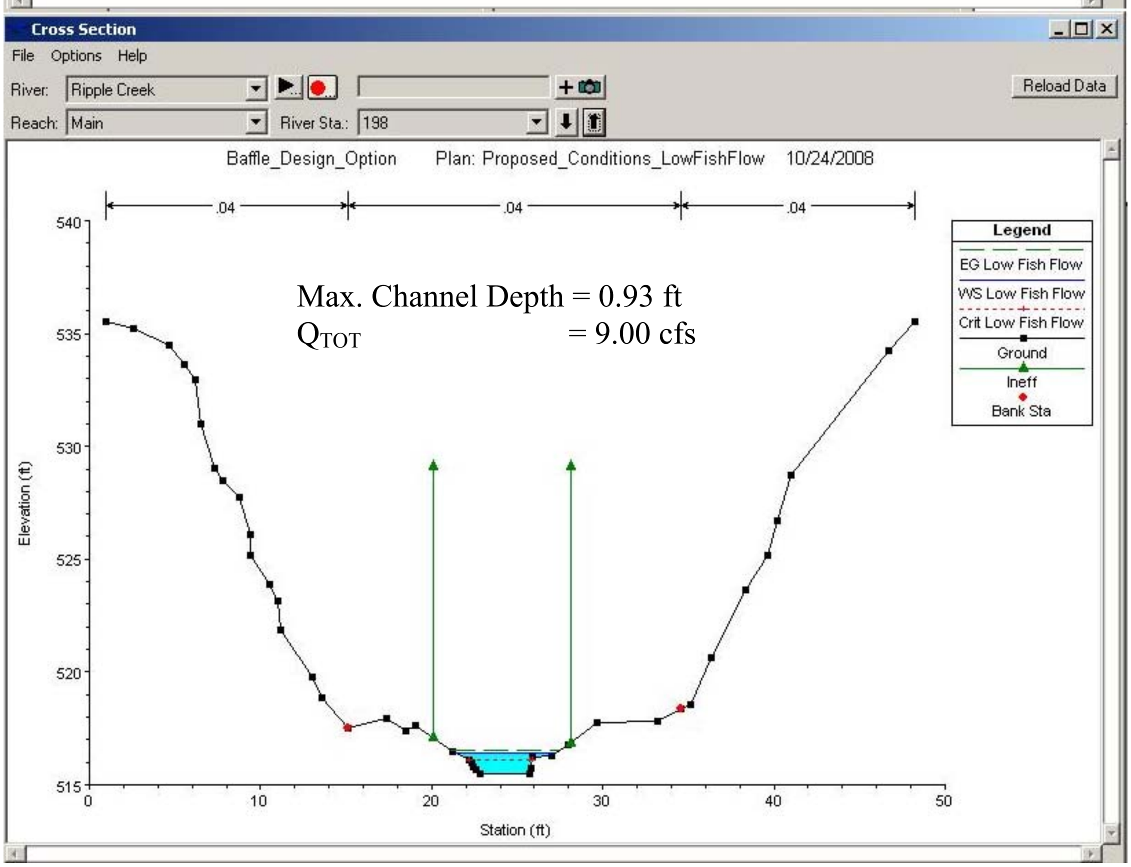
River: Ripple Creek
Reach: Main
River Sta.: 182
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.04
.04
.04
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 0.68 ft
QTOT = 9.00 cfs
Elevation (ft)
Station (ft)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File Options Help
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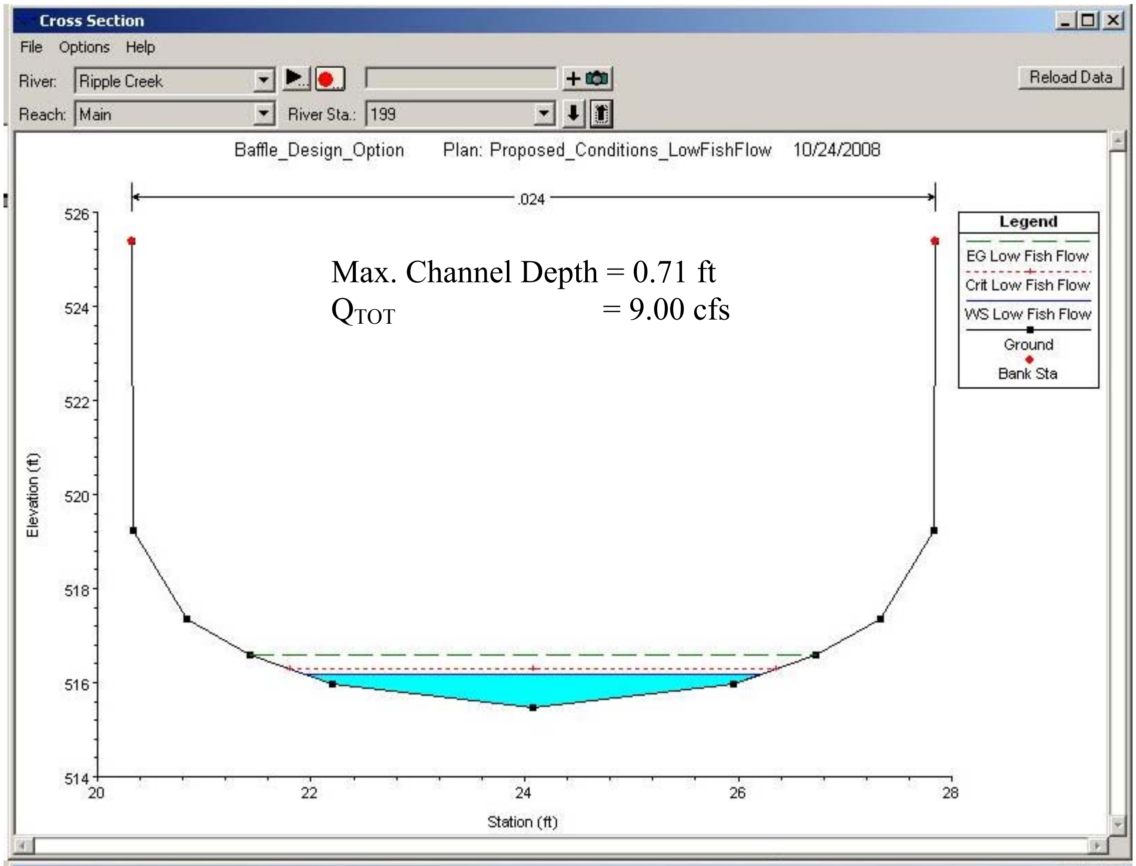
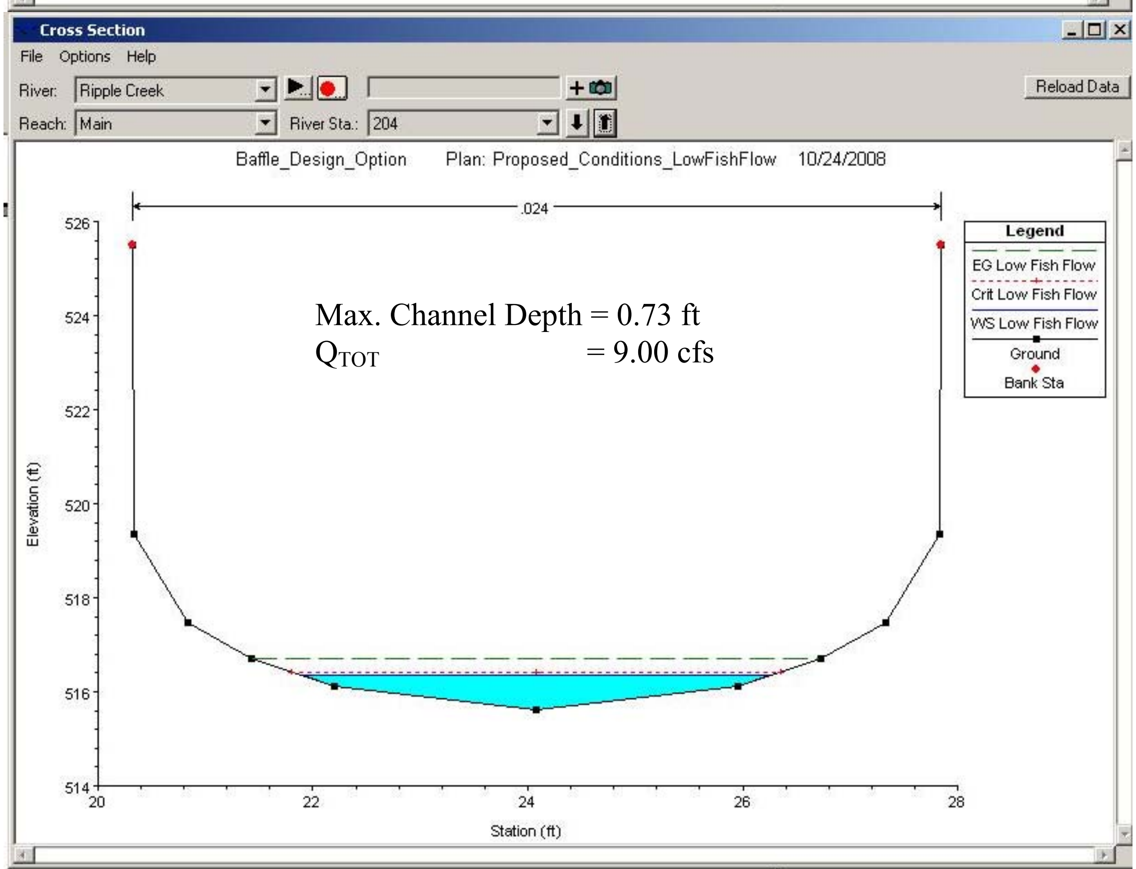
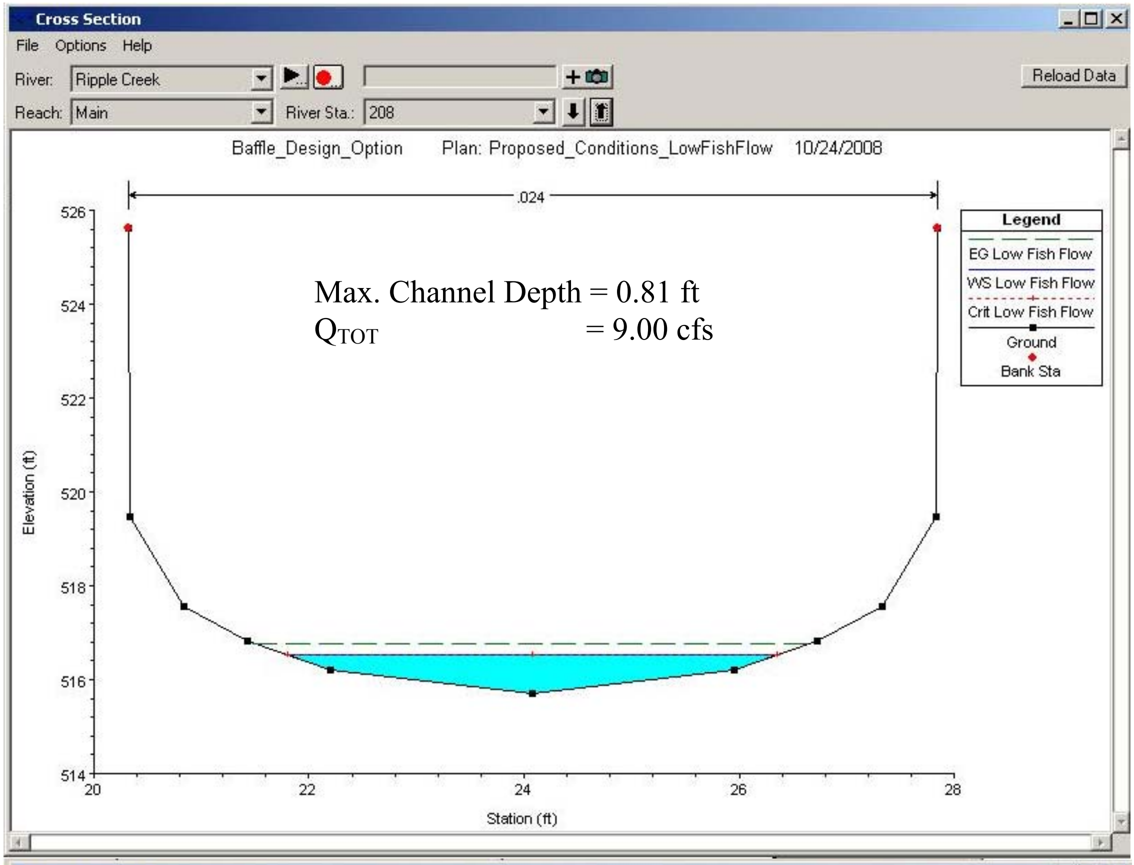
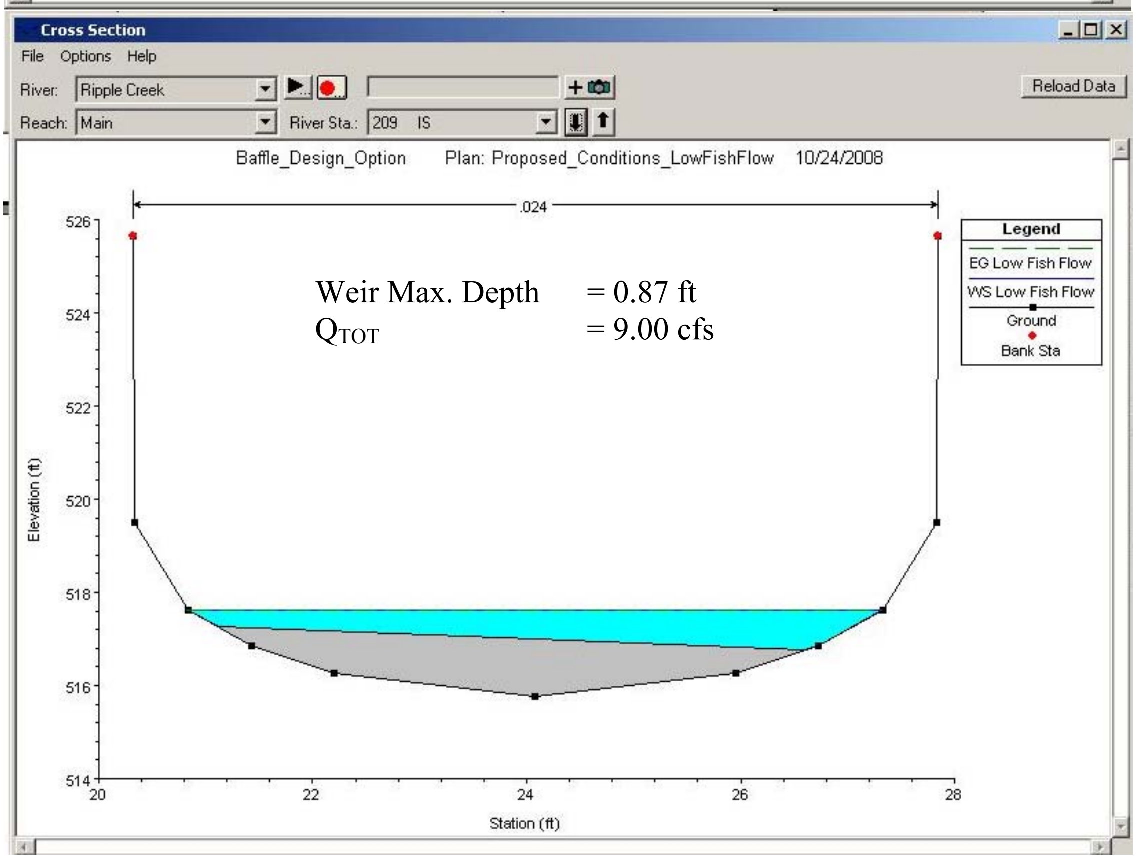
Reach: Main
River Sta.: 198
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.04
.04
.04
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Ineff
Bank Sta
Max. Channel Depth = 0.93 ft
QTOT = 9.00 cfs
Elevation (ft)
Station (ft)


Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 199
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 0.71 ft
Q_{TOT} = 9.00 cfs
Legend
EG Low Fish Flow
Crit Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
514
516
518
520
522
524
526
20
22
24
26
28


Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 204
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 0.73 ft
Q_{TOT} = 9.00 cfs
Legend
EG Low Fish Flow
Crit Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)
514
516
518
520
522
524
526
20
22
24
26
28


Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 208
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 0.81 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Elevation (ft)
526
524
522
520
518
516
514
20
22
24
26
28
Station (ft)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River Sta.: 209 IS
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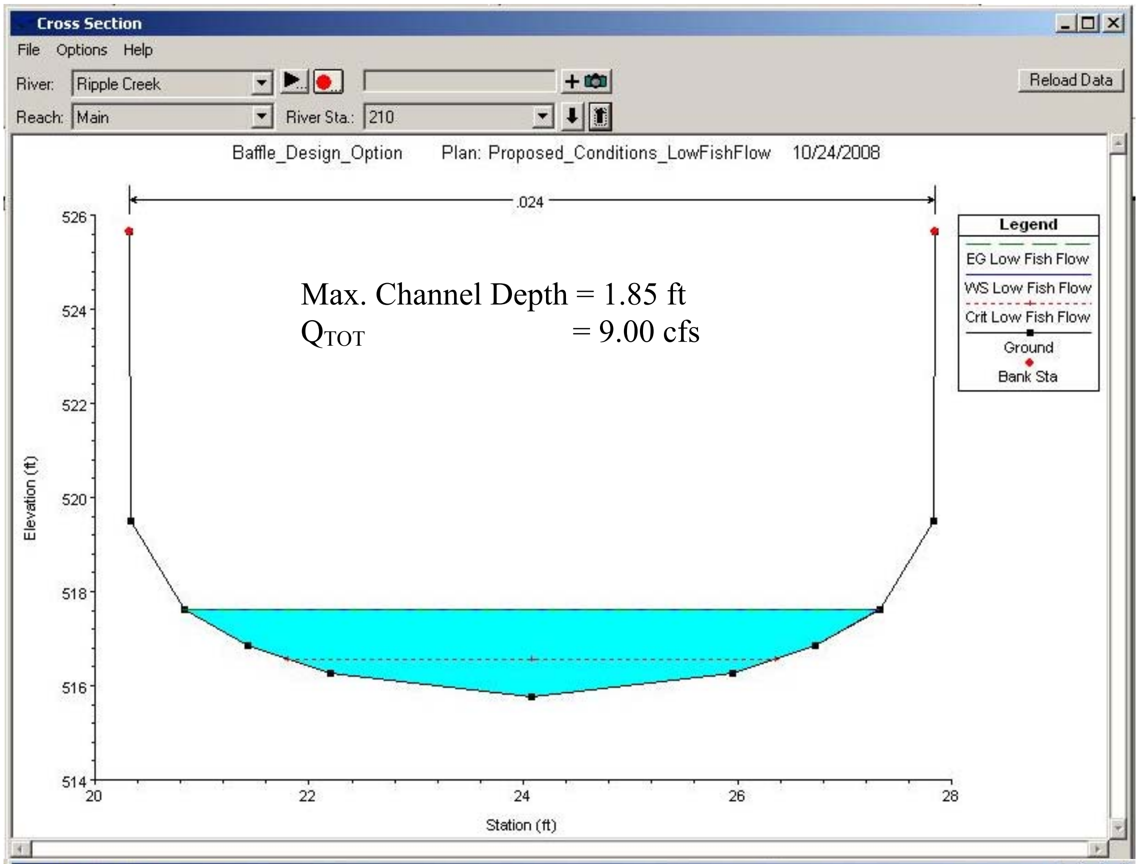
.024
Weir Max. Depth = 0.87 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Elevation (ft)
526
524
522
520
518
516
514
20
22
24
26
28
Station (ft)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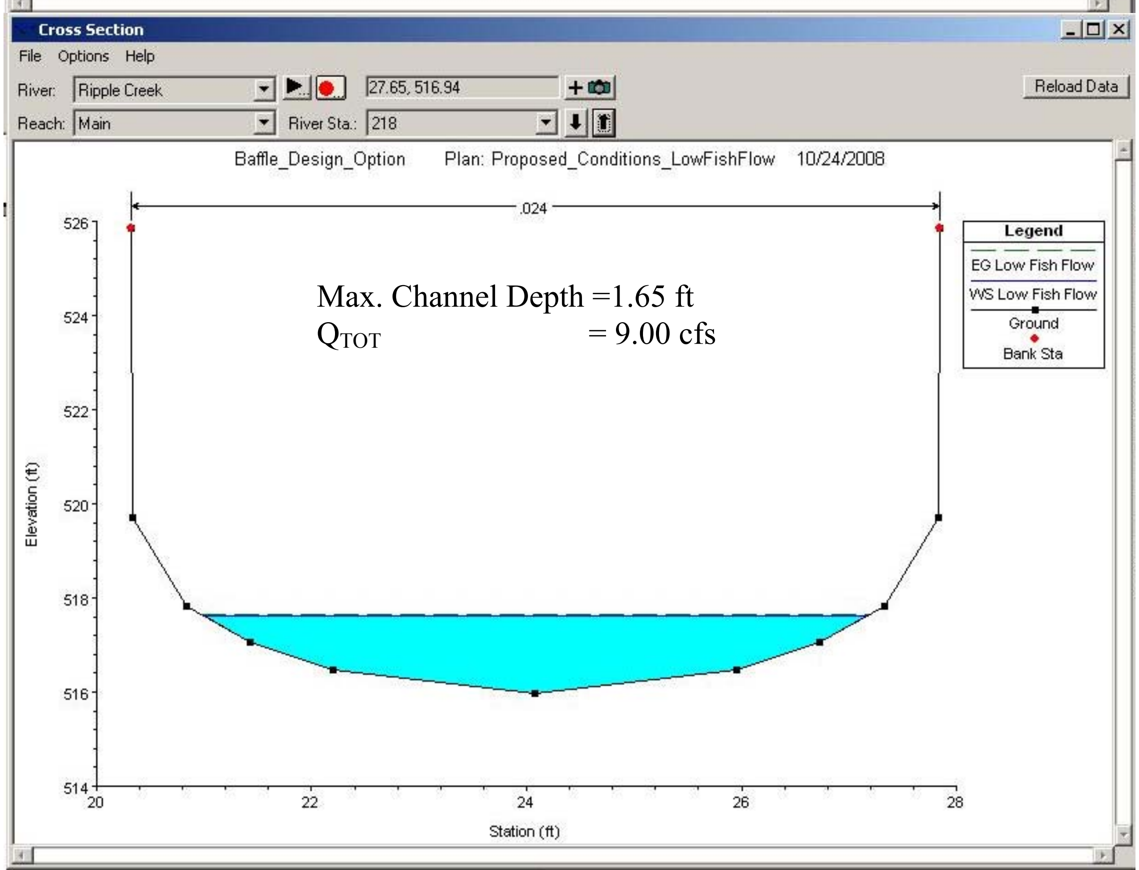
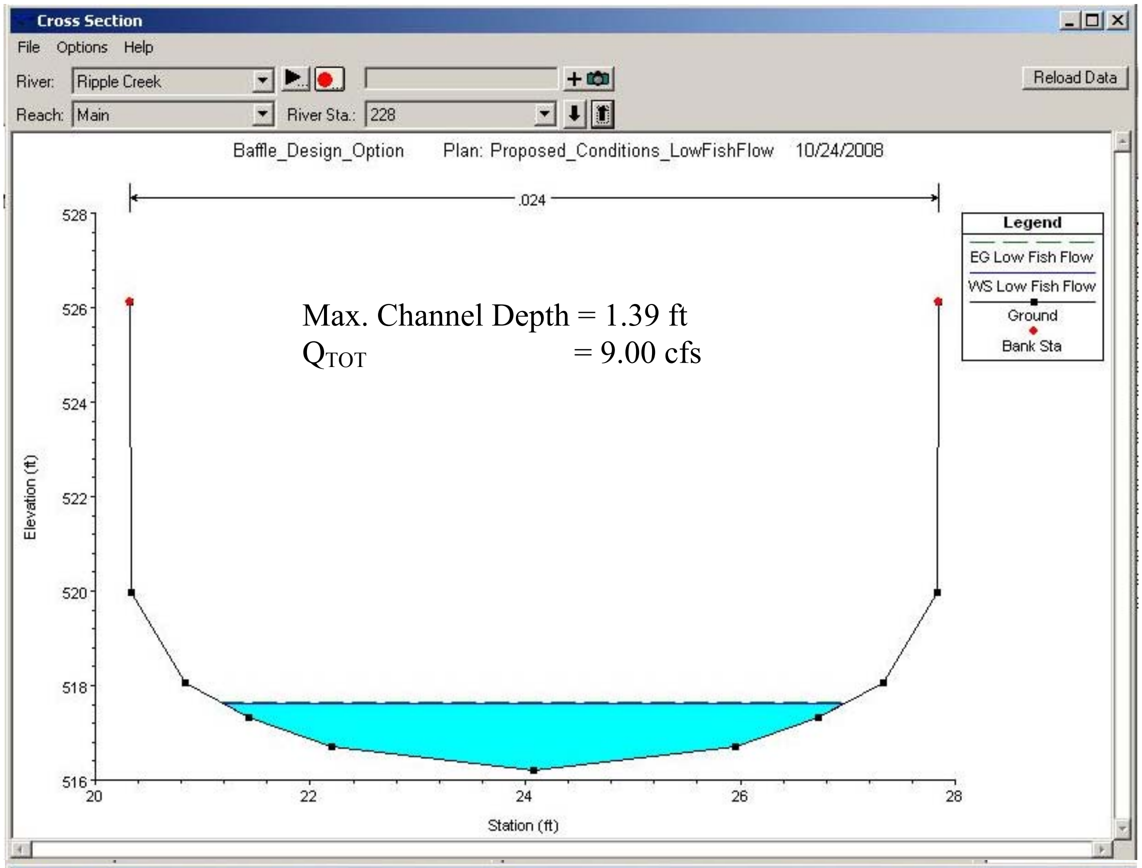
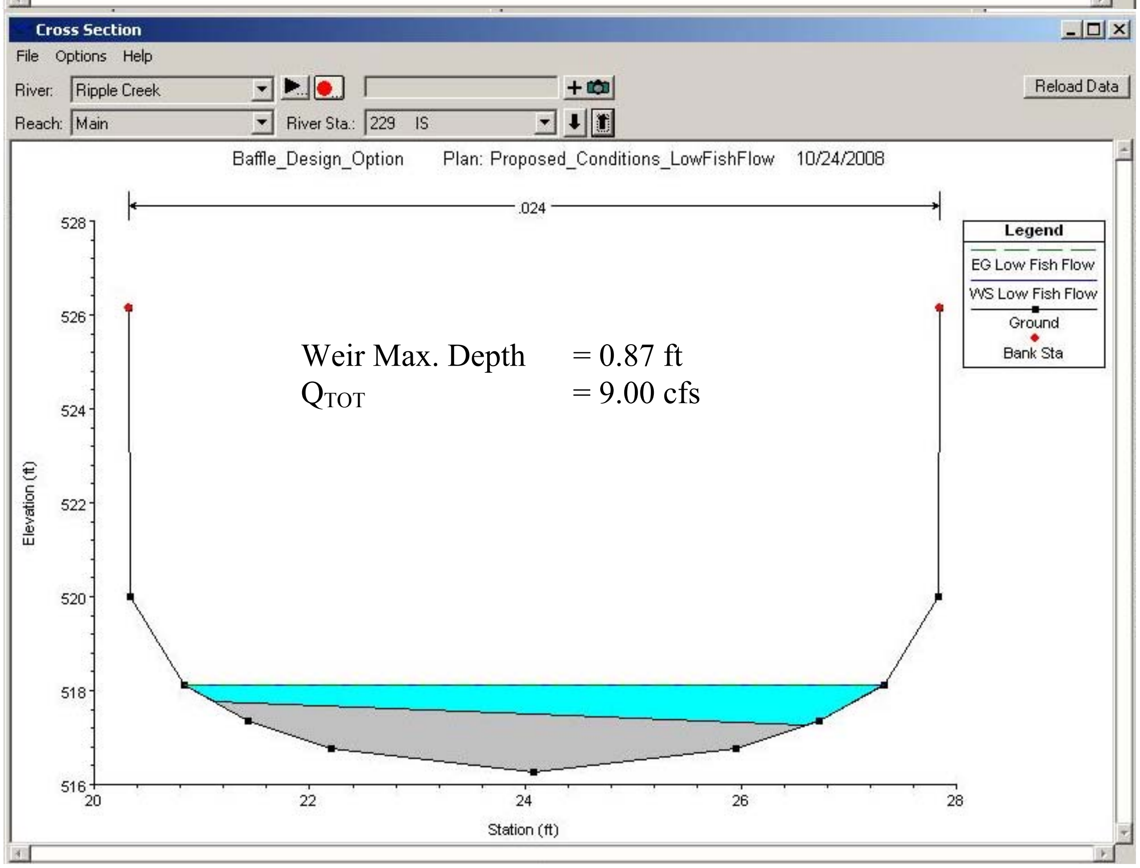
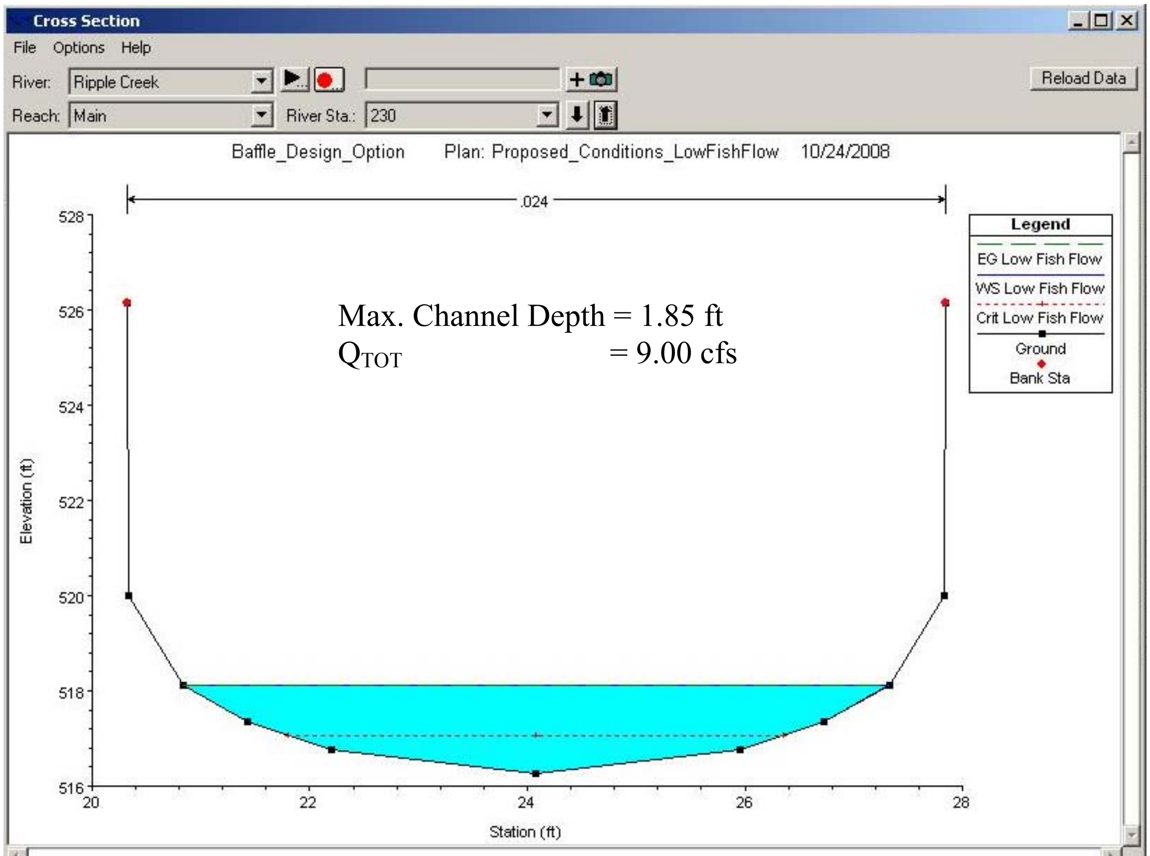
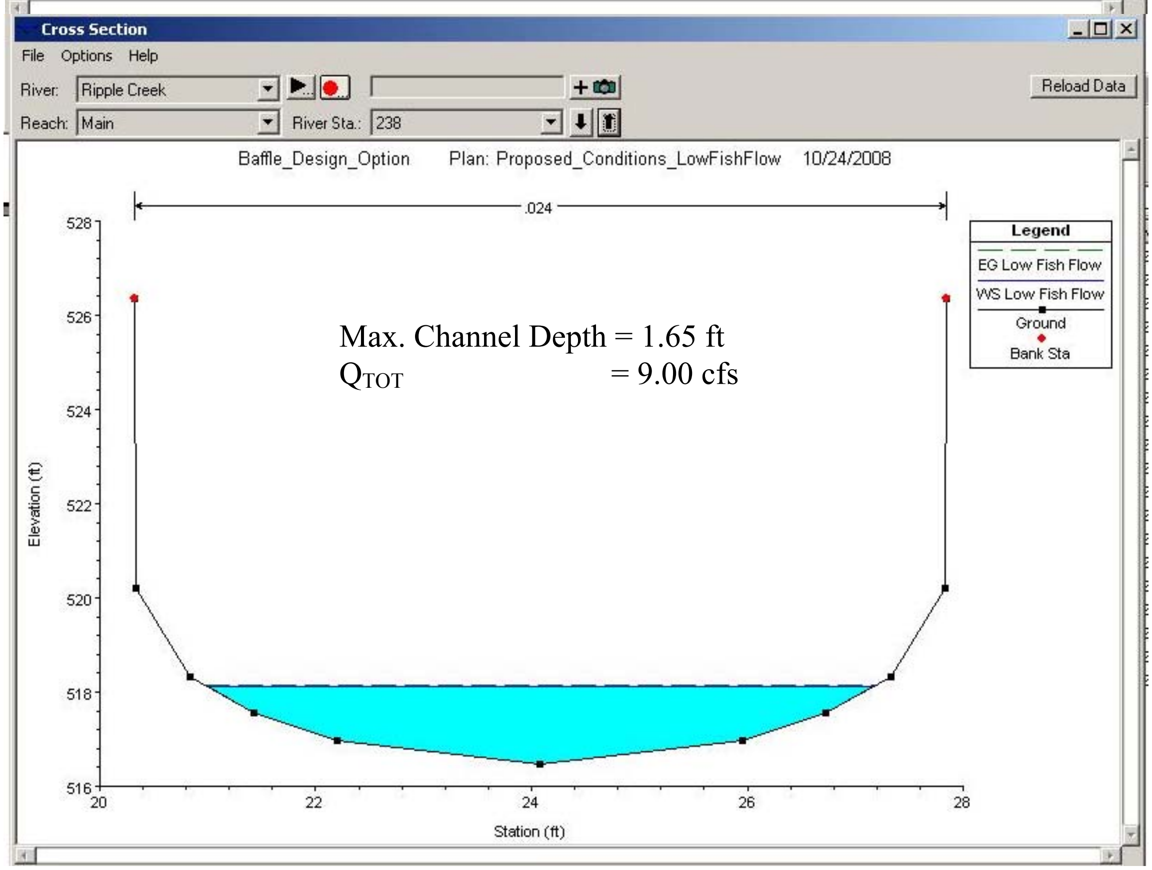
Reach: Main
River Sta.: 210
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 1.85 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Elevation (ft)
526
524
522
520
518
516
514
20
22
24
26
28
Station (ft)

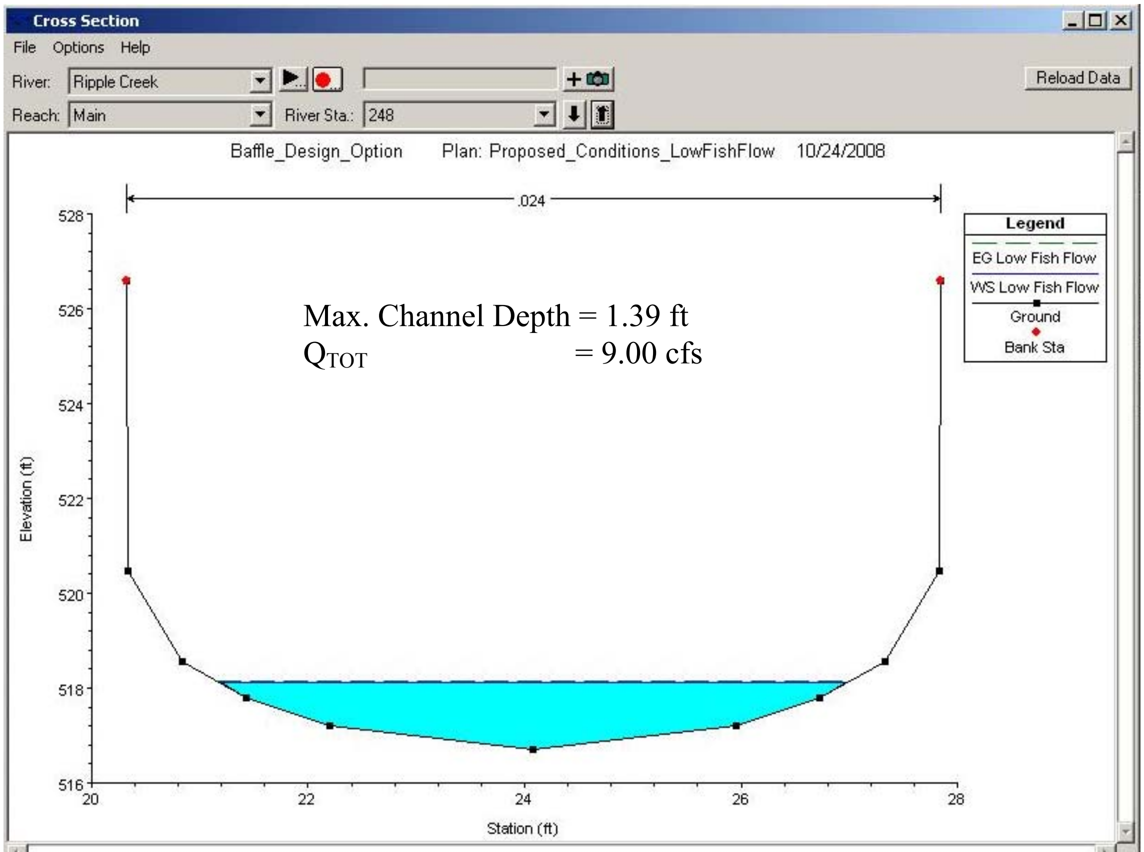

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
27.65, 516.94
River Sta.: 218
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth =1.65 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Elevation (ft)
526
524
522
520
518
516
514
20
22
24
26
28
Station (ft)

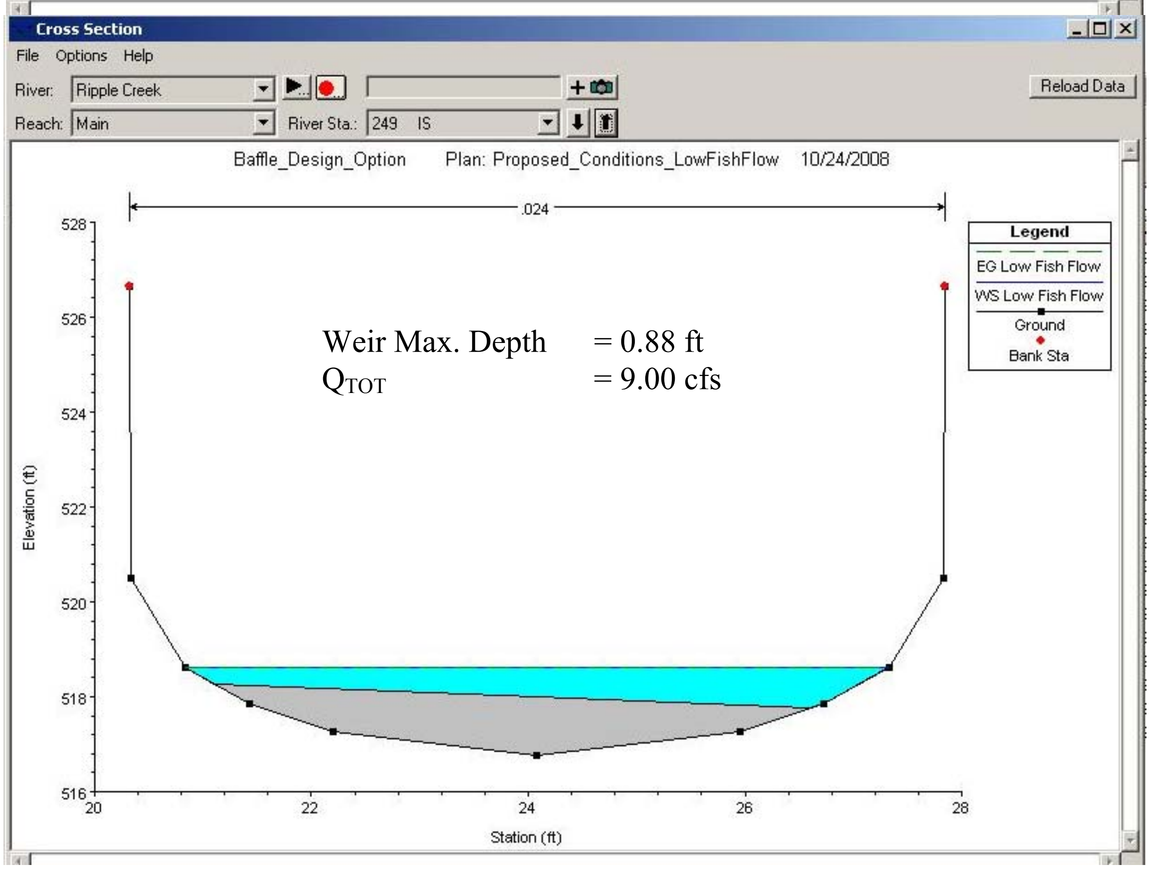

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 228
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 1.39 ft
QTOT = 9.00 cfs
Elevation (ft)
528
526
524
522
520
518
516
Station (ft)
20
22
24
26
28

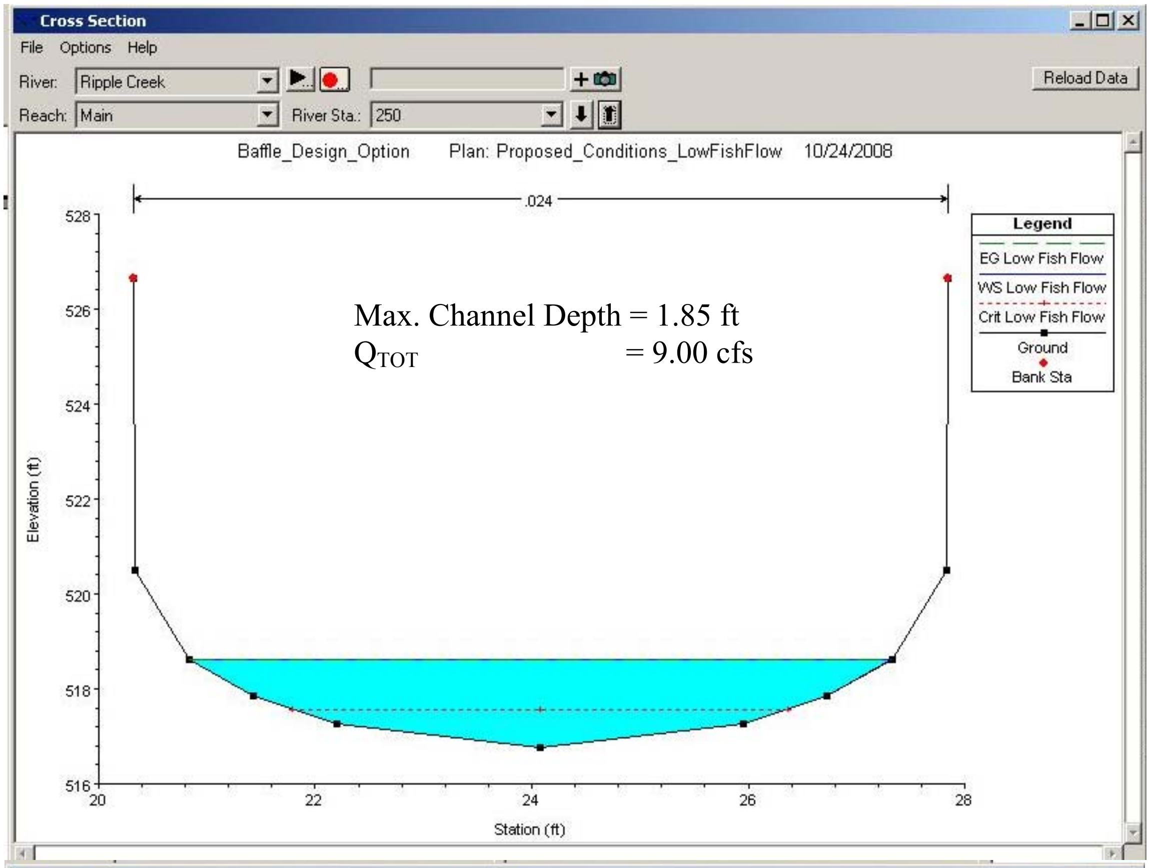

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 229 IS
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Weir Max. Depth = 0.87 ft
QTOT = 9.00 cfs
Elevation (ft)
528
526
524
522
520
518
516
Station (ft)
20
22
24
26
28

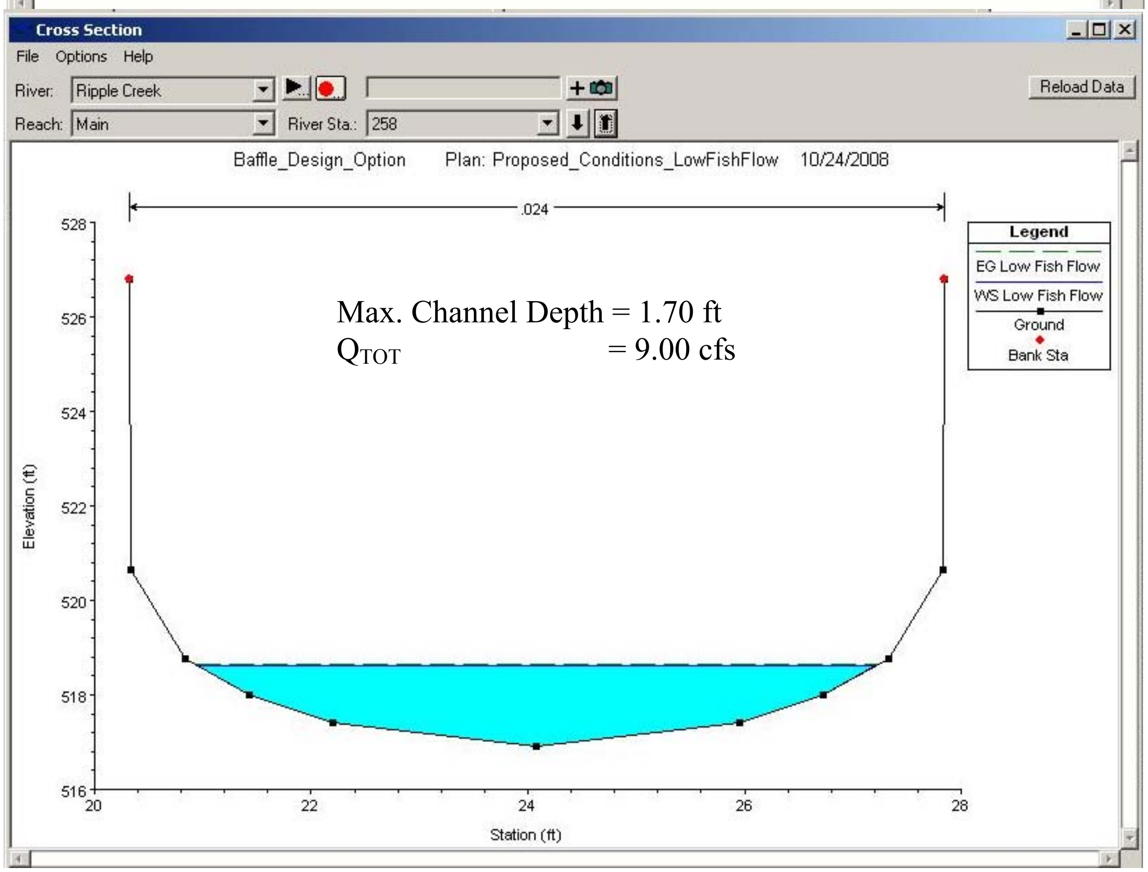

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 230
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 1.85 ft
Q_{TOT} = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

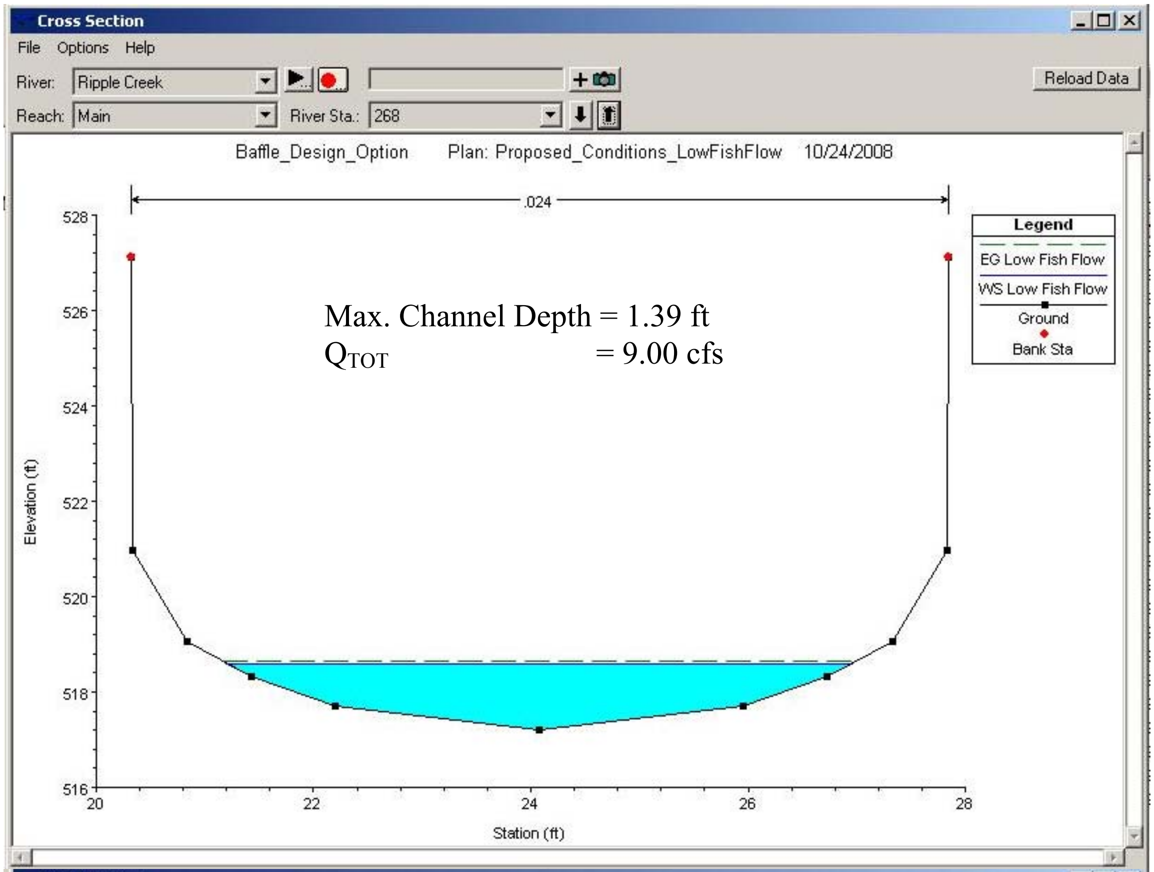

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 238
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 1.65 ft
Q_{TOT} = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

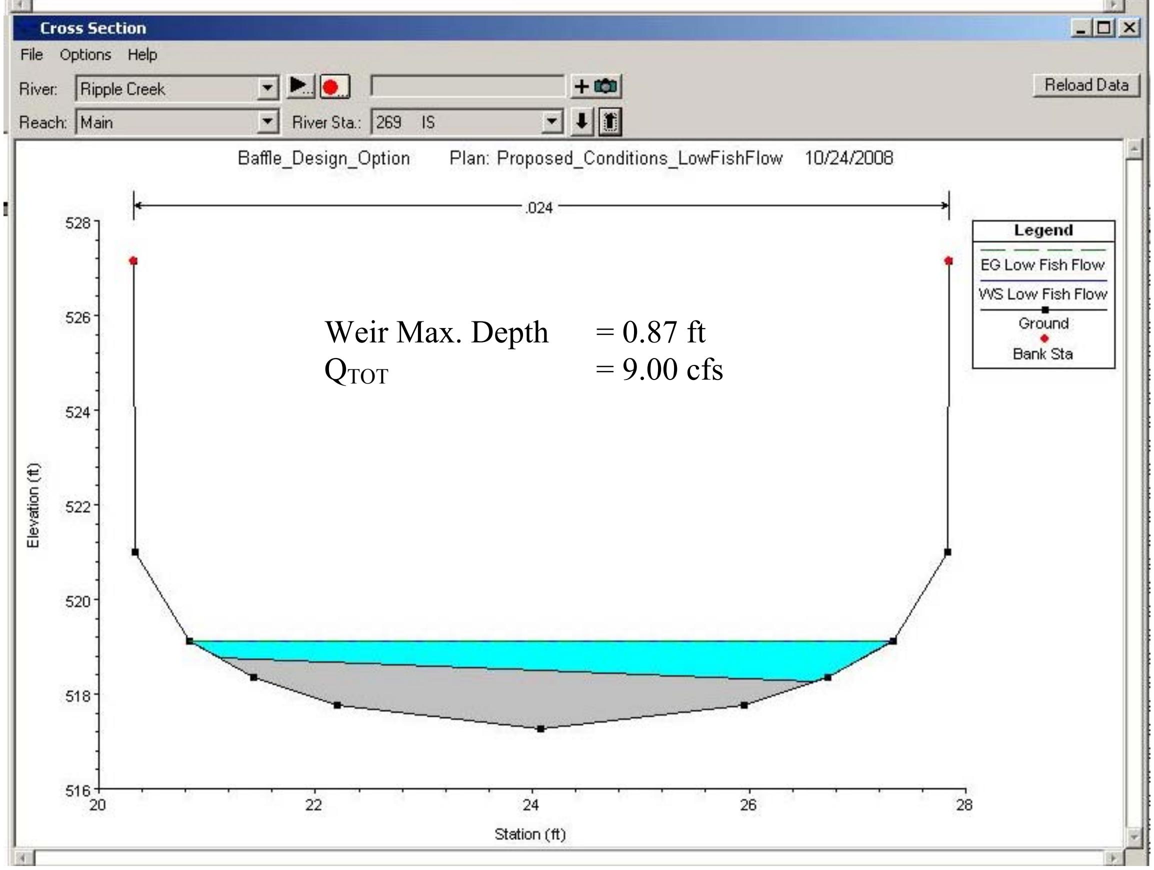

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 248
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 1.39 ft
QTOT = 9.00 cfs
Elevation (ft)
528
526
524
522
520
518
516
20
22
24
26
28
Station (ft)

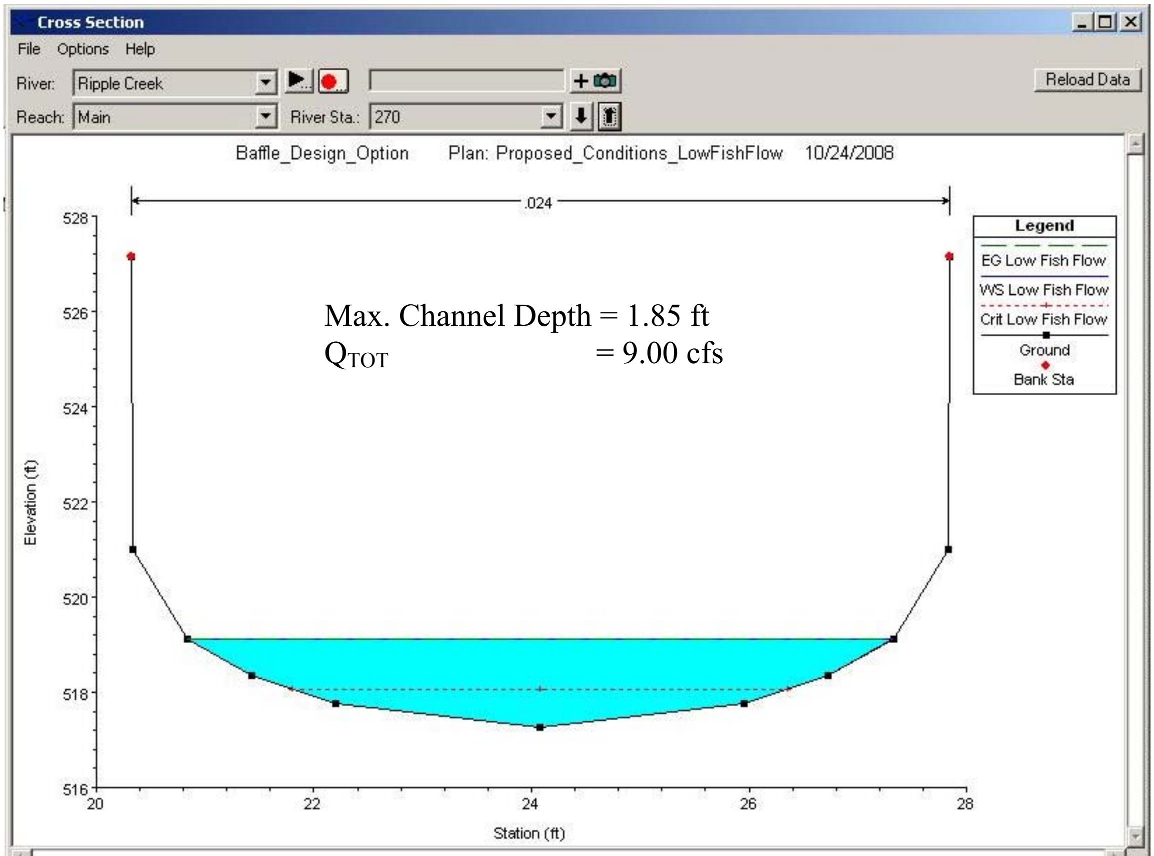

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 249 IS
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Weir Max. Depth = 0.88 ft
QTOT = 9.00 cfs
Elevation (ft)
528
526
524
522
520
518
516
20
22
24
26
28
Station (ft)

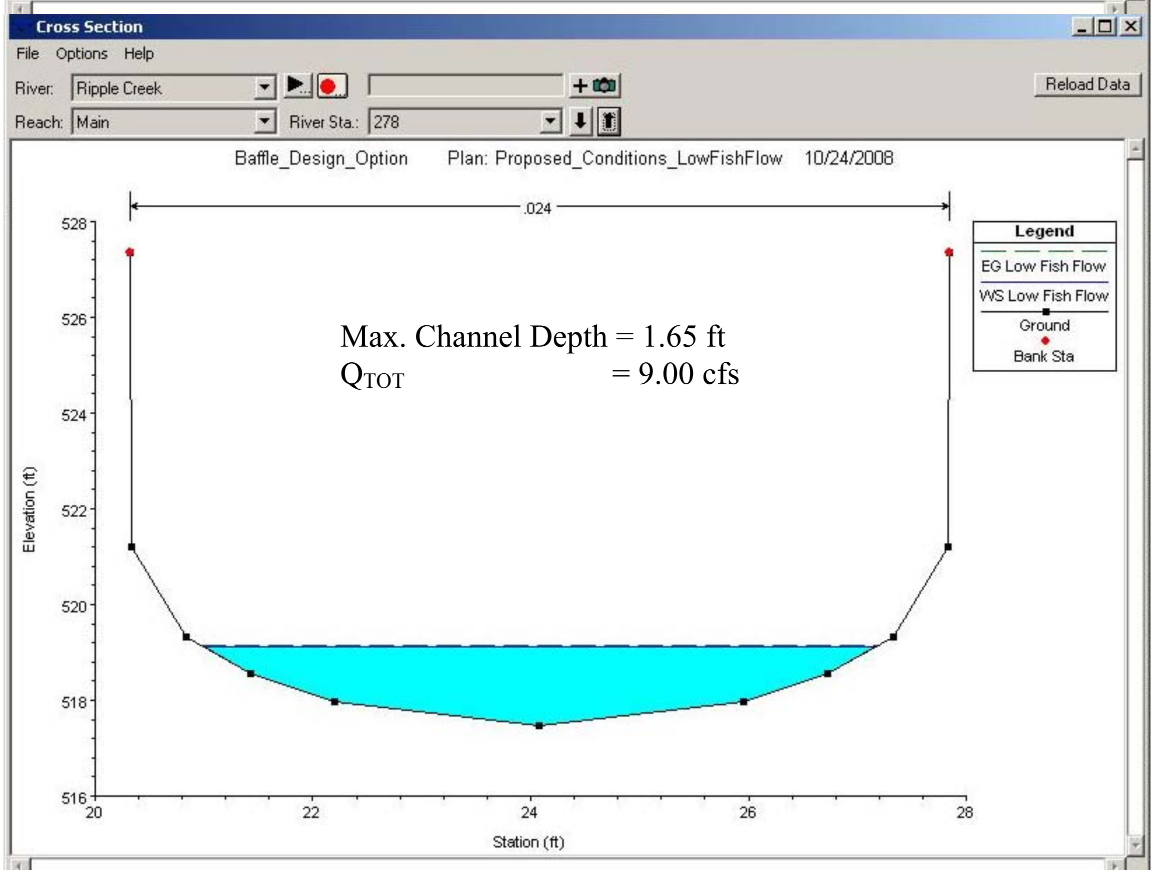

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 250
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 1.85 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

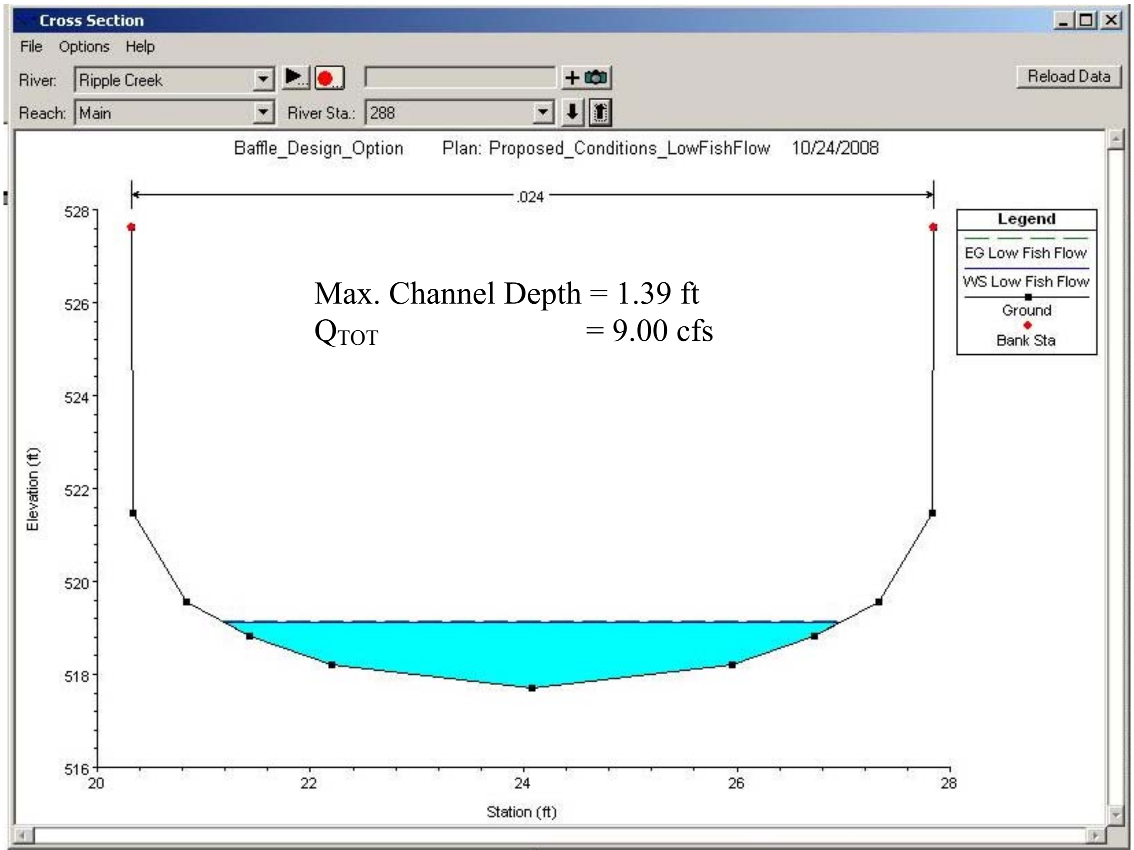

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 258
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 1.70 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

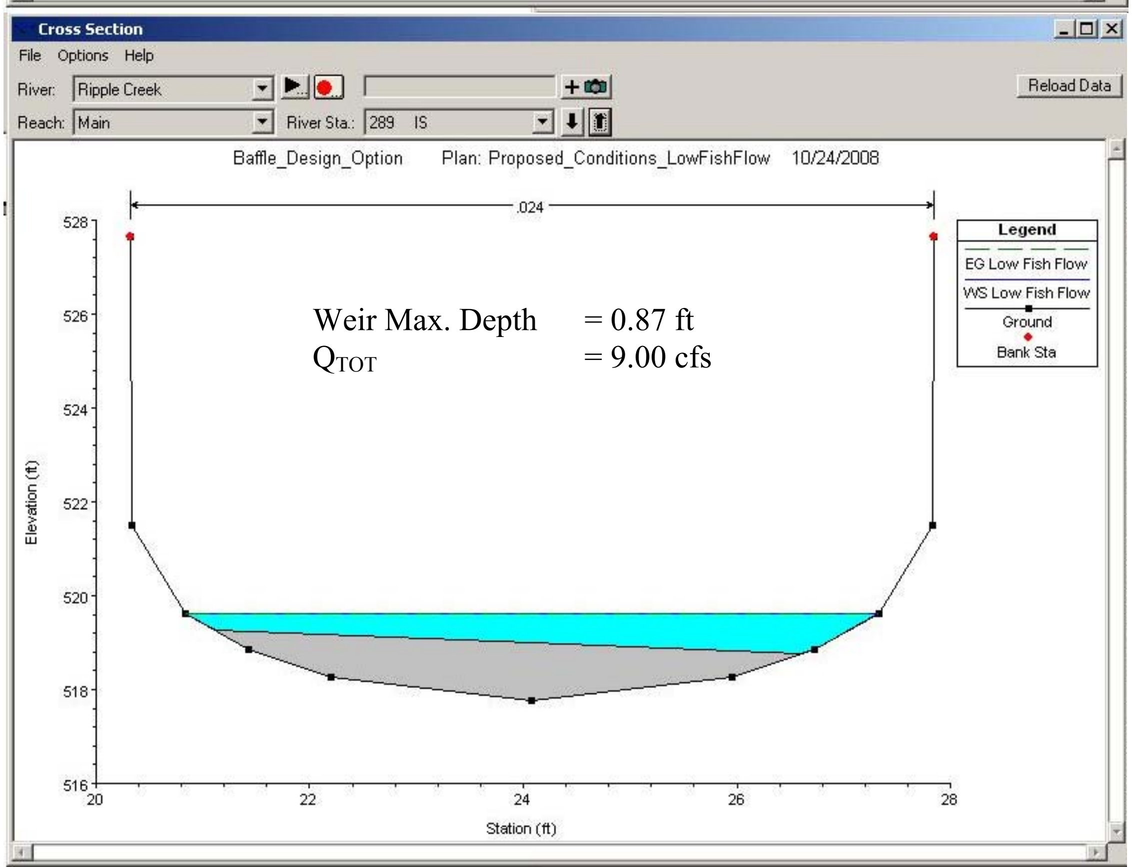

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 268
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 1.39 ft
Q_{TOT} = 9.00 cfs
Elevation (ft)
Station (ft)

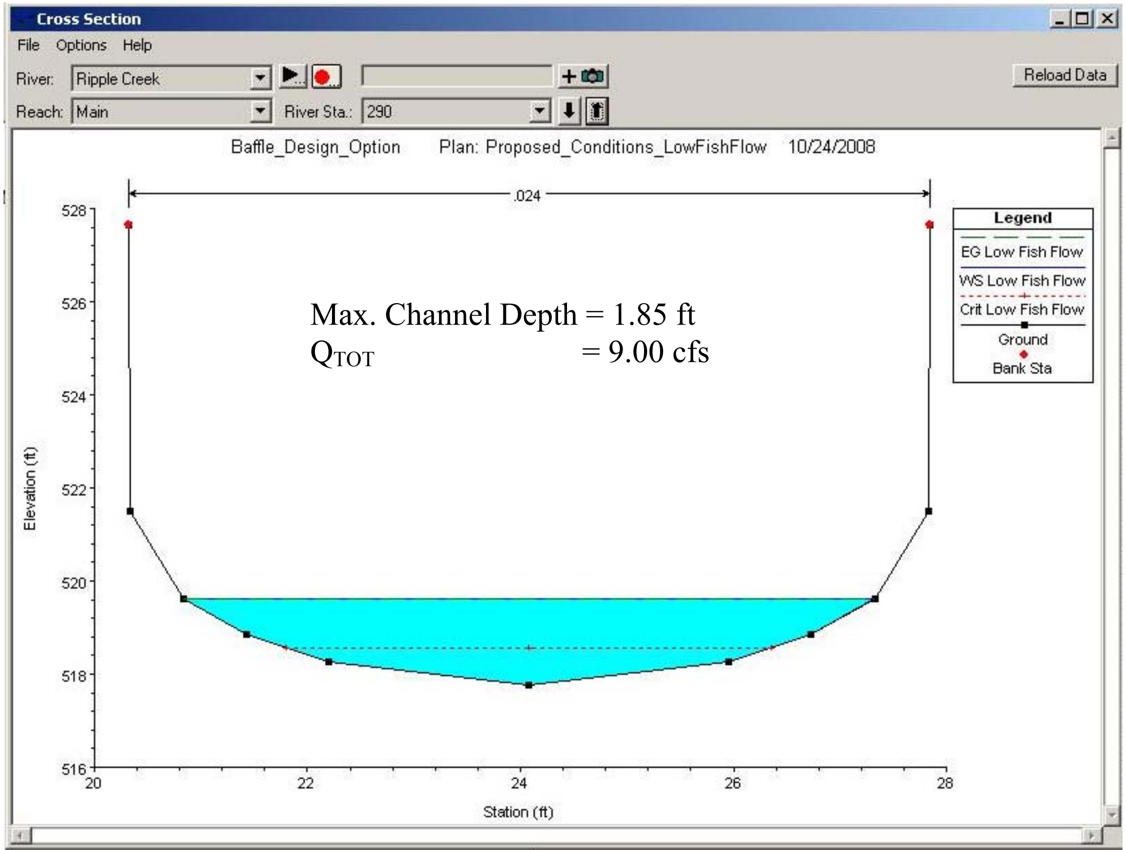

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 269 IS
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Weir Max. Depth = 0.87 ft
Q_{TOT} = 9.00 cfs
Elevation (ft)
Station (ft)

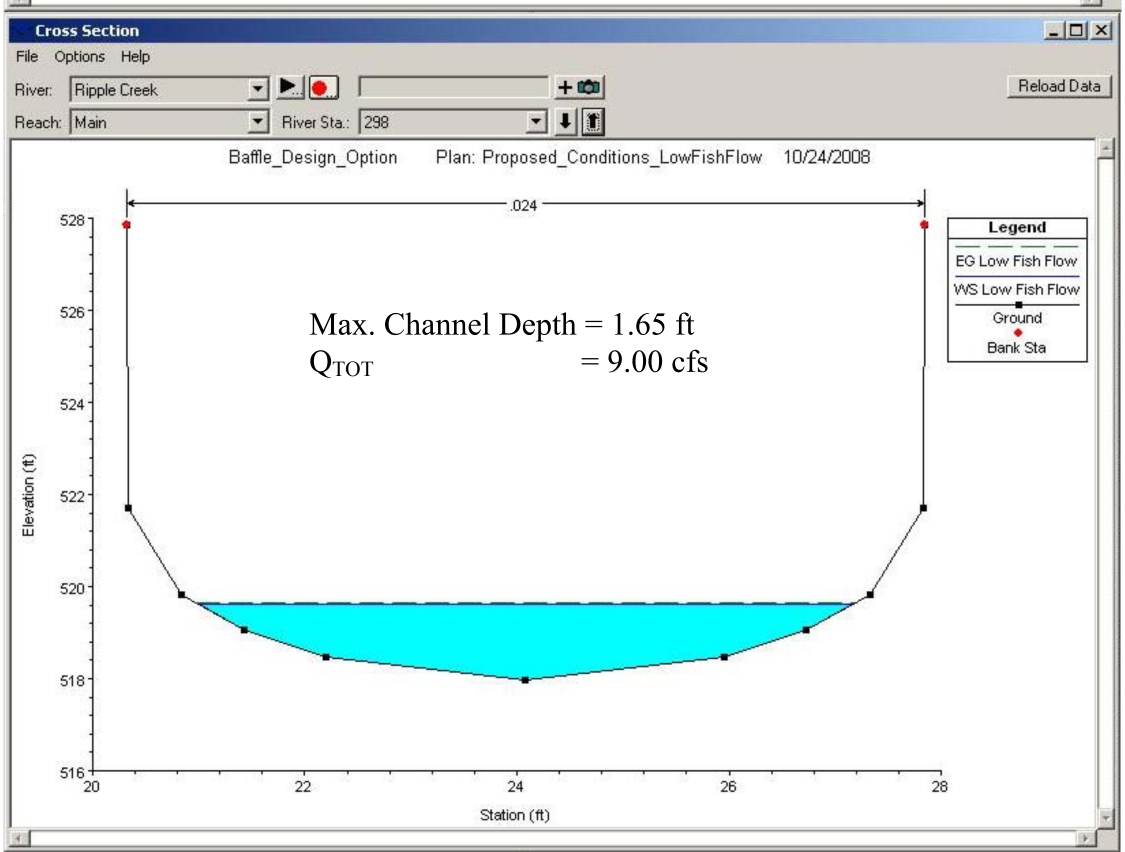

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 270
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 1.85 ft
Q_TOT = 9.00 cfs
Elevation (ft)
528
526
524
522
520
518
516
20
22
24
26
28
Station (ft)

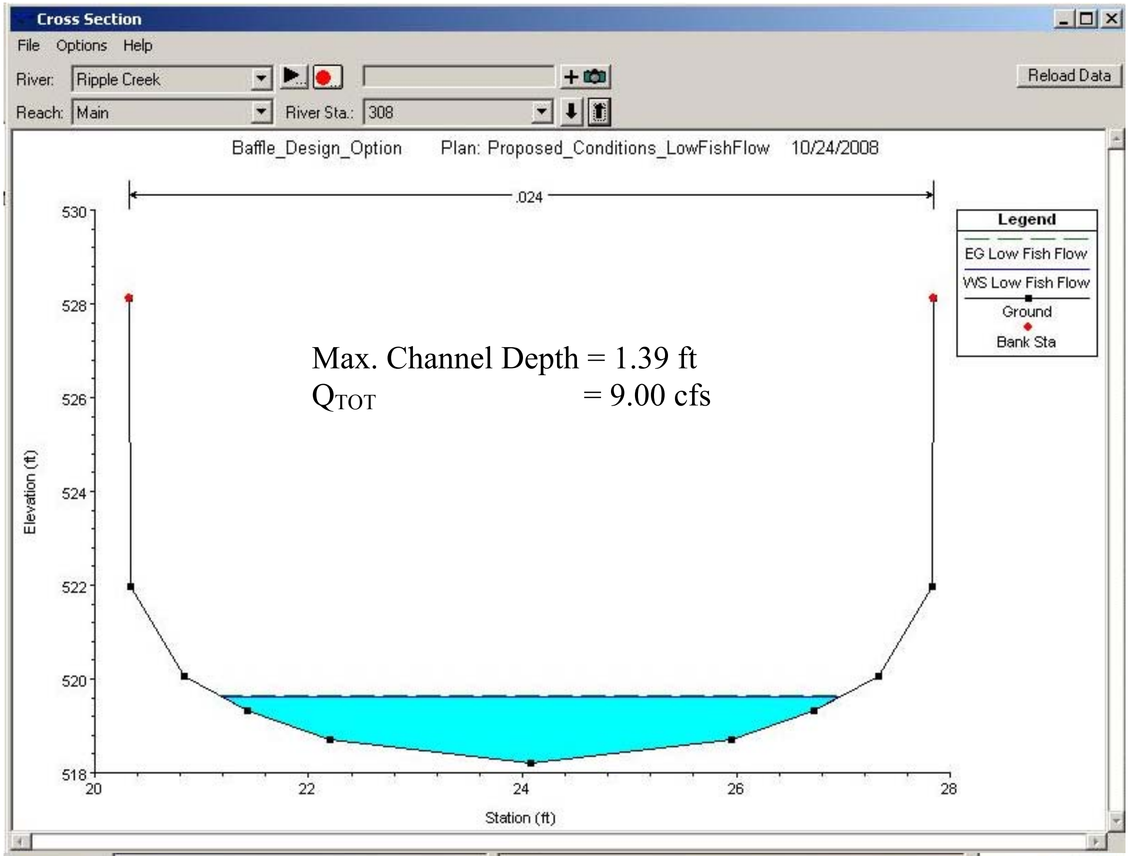

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 278
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 1.65 ft
Q_TOT = 9.00 cfs
Elevation (ft)
528
526
524
522
520
518
516
20
22
24
26
28
Station (ft)

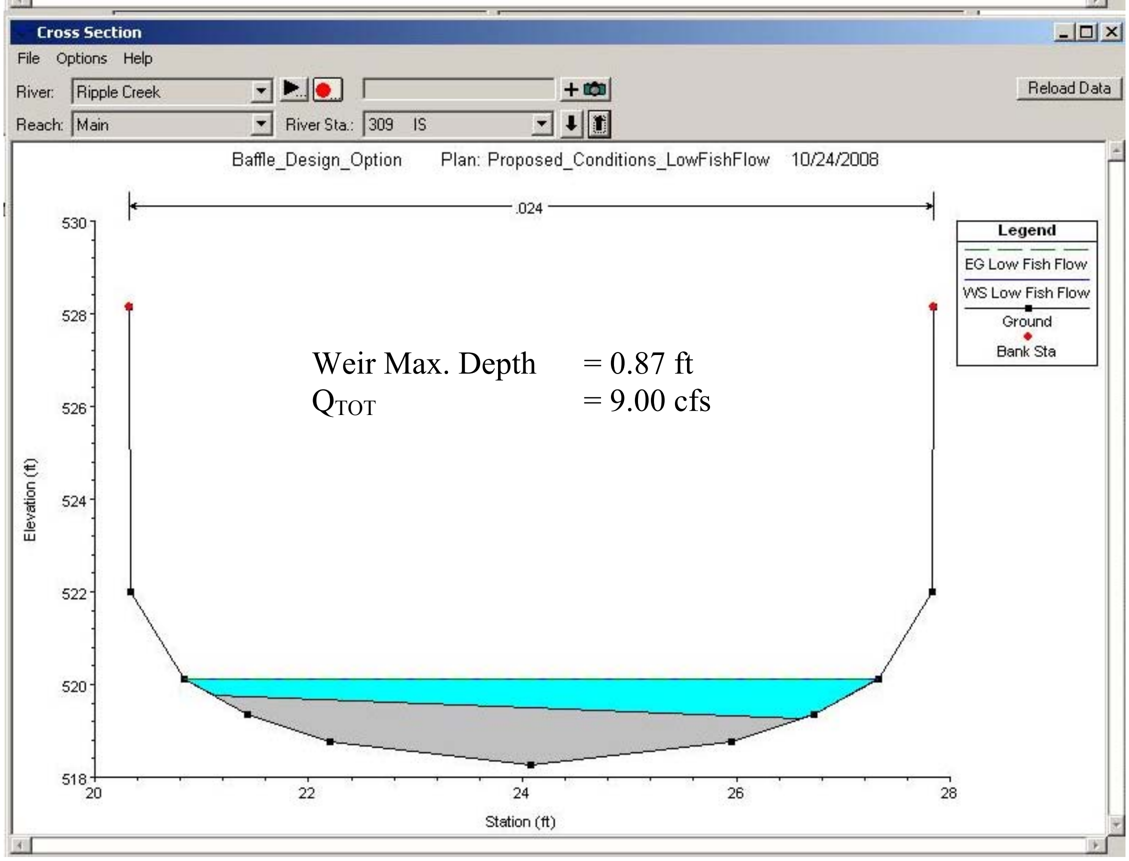

Cross Section
File Options Help
River: Ripple Creek
Reach: Main River Sta.: 288
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 1.39 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

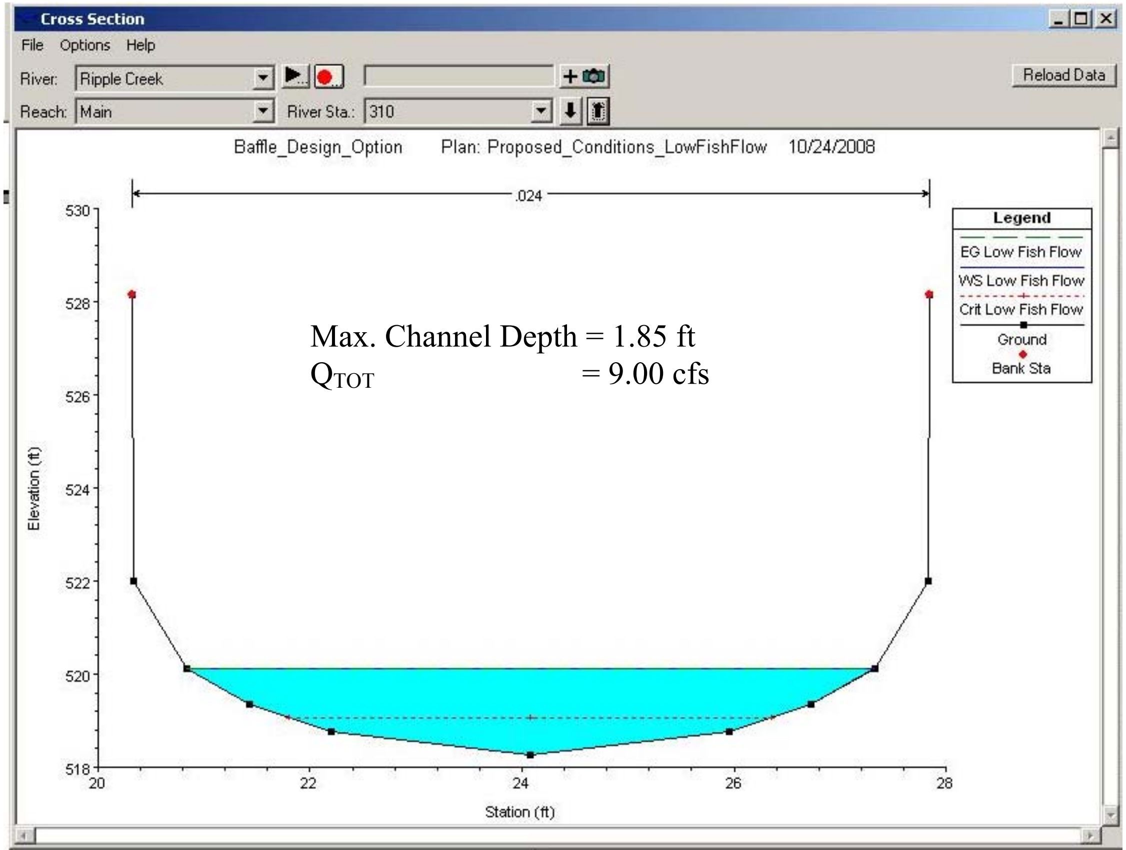

Cross Section
File Options Help
River: Ripple Creek
Reach: Main River Sta.: 289 IS
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Weir Max. Depth = 0.87 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

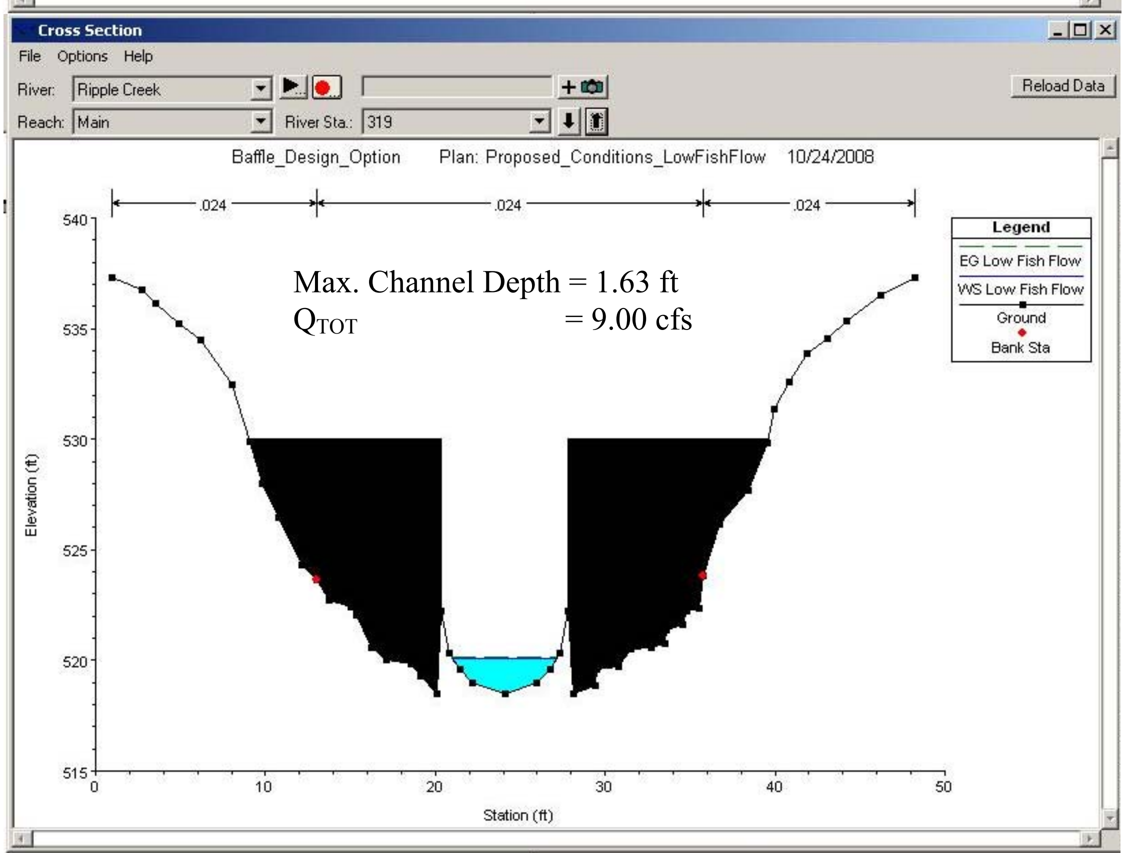

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 290
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 1.85 ft
QTOT = 9.00 cfs
Elevation (ft)
Station (ft)

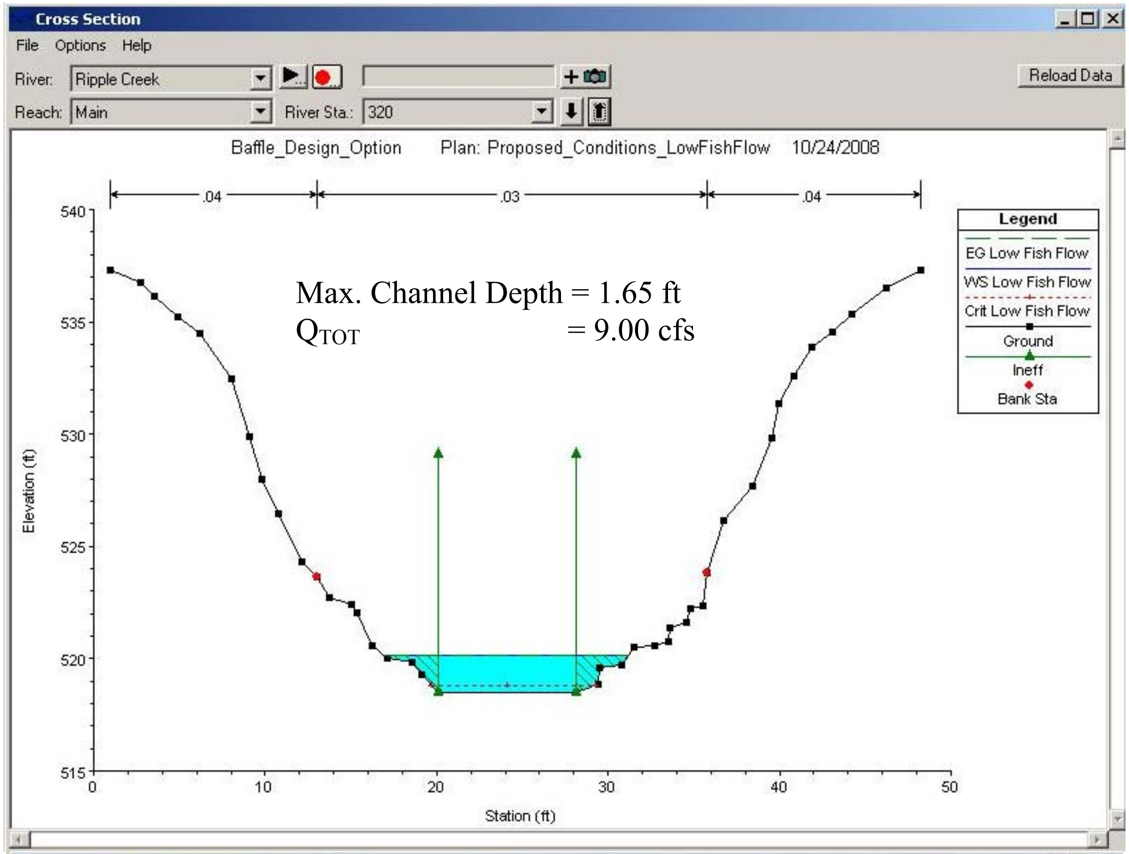

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 298
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 1.65 ft
QTOT = 9.00 cfs
Elevation (ft)
Station (ft)

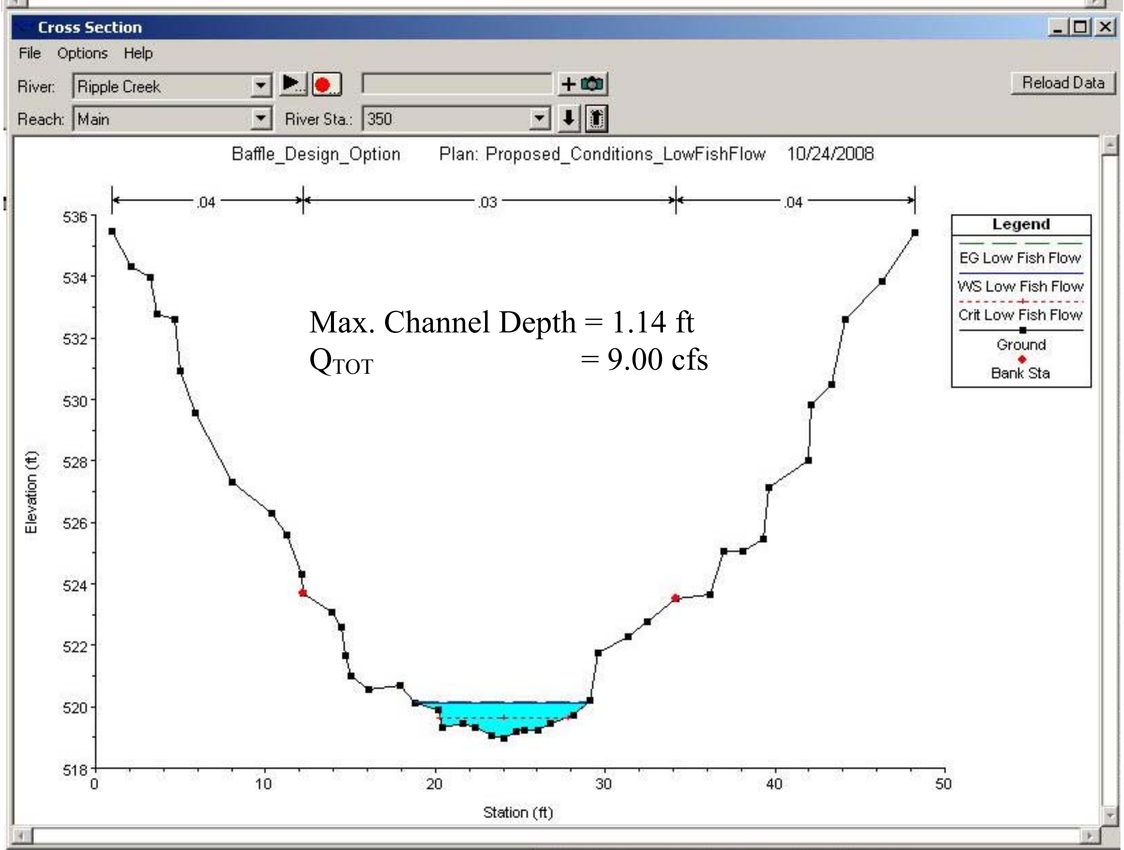

Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 308
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 1.39 ft
QTOT = 9.00 cfs
Elevation (ft)
530
528
526
524
522
520
518
20
22
24
26
28
Station (ft)

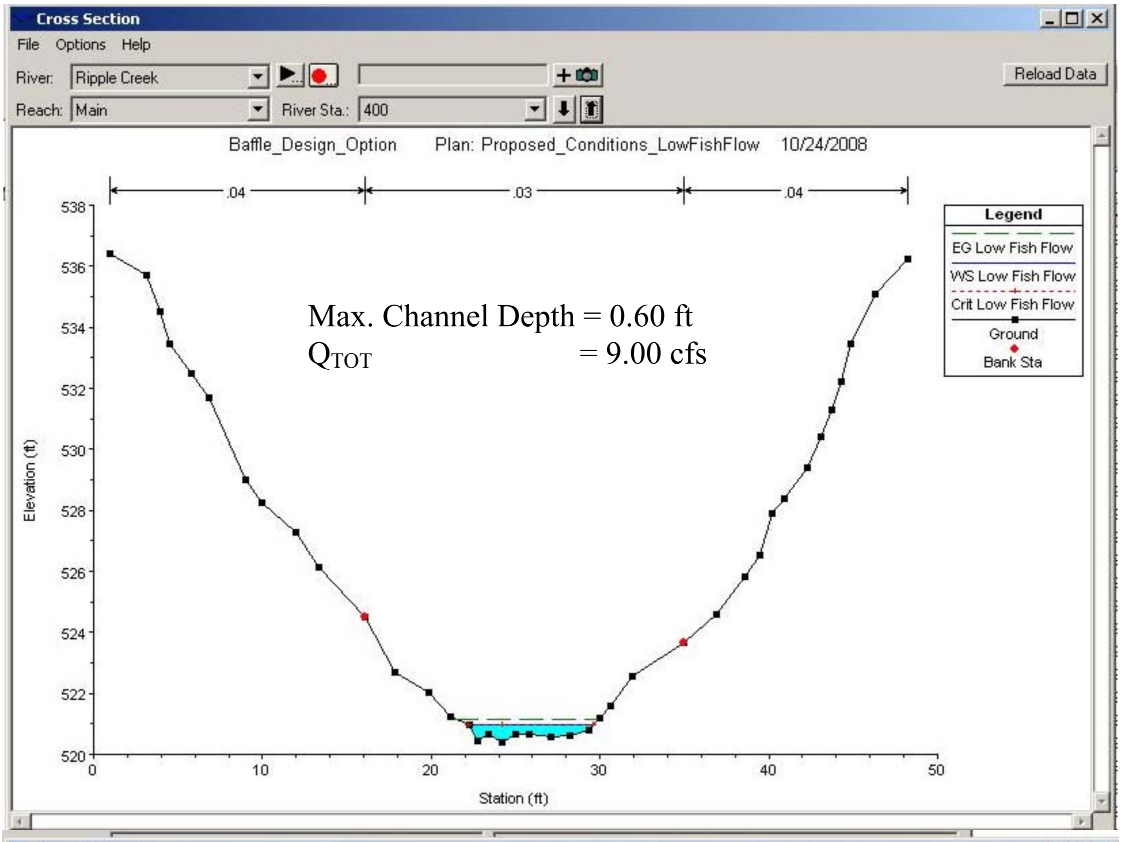

Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 309 IS
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Weir Max. Depth = 0.87 ft
QTOT = 9.00 cfs
Elevation (ft)
530
528
526
524
522
520
518
20
22
24
26
28
Station (ft)

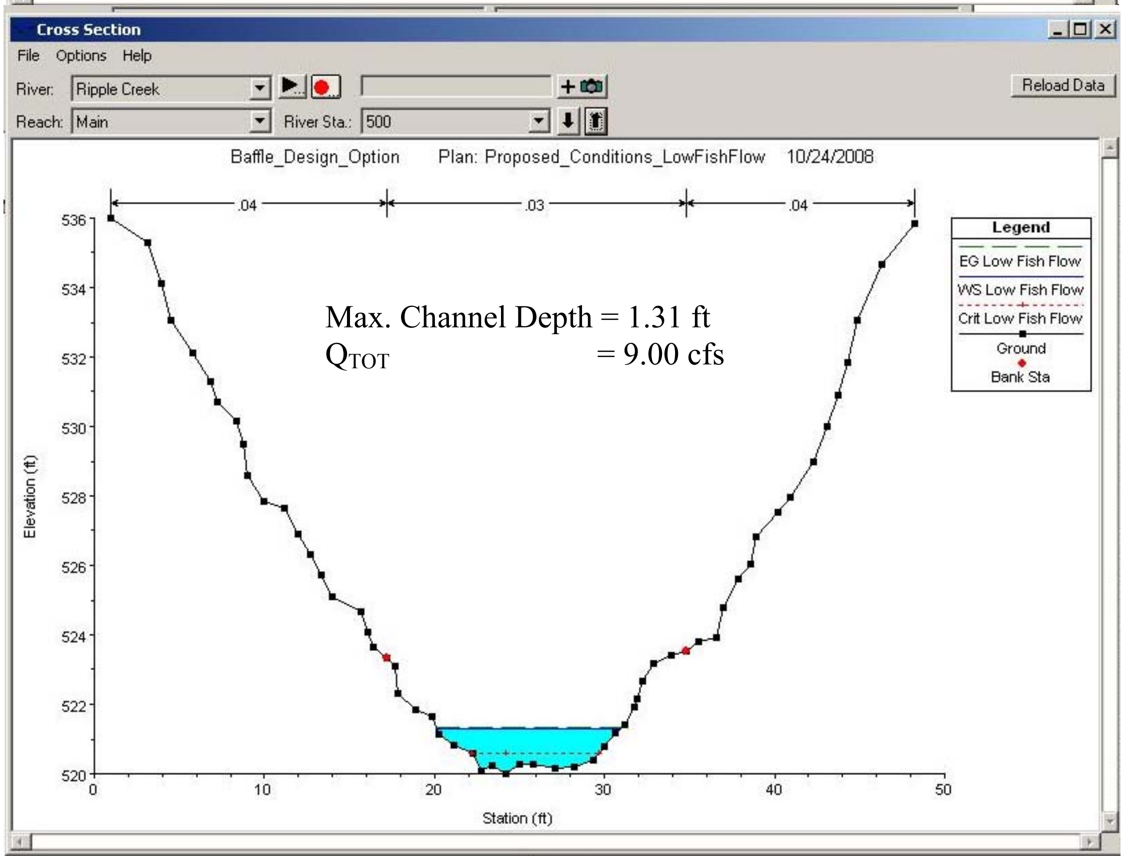

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 310
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
Max. Channel Depth = 1.85 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Elevation (ft)
530
528
526
524
522
520
518
Station (ft)
20
22
24
26
28


Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 319
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.024
.024
.024
Max. Channel Depth = 1.63 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Ground
Bank Sta
Elevation (ft)
540
535
530
525
520
515
Station (ft)
0
10
20
30
40
50


Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 320
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.04
.03
.04
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Ineff
Bank Sta
Max. Channel Depth = 1.65 ft
QTOT = 9.00 cfs
Elevation (ft)
Station (ft)

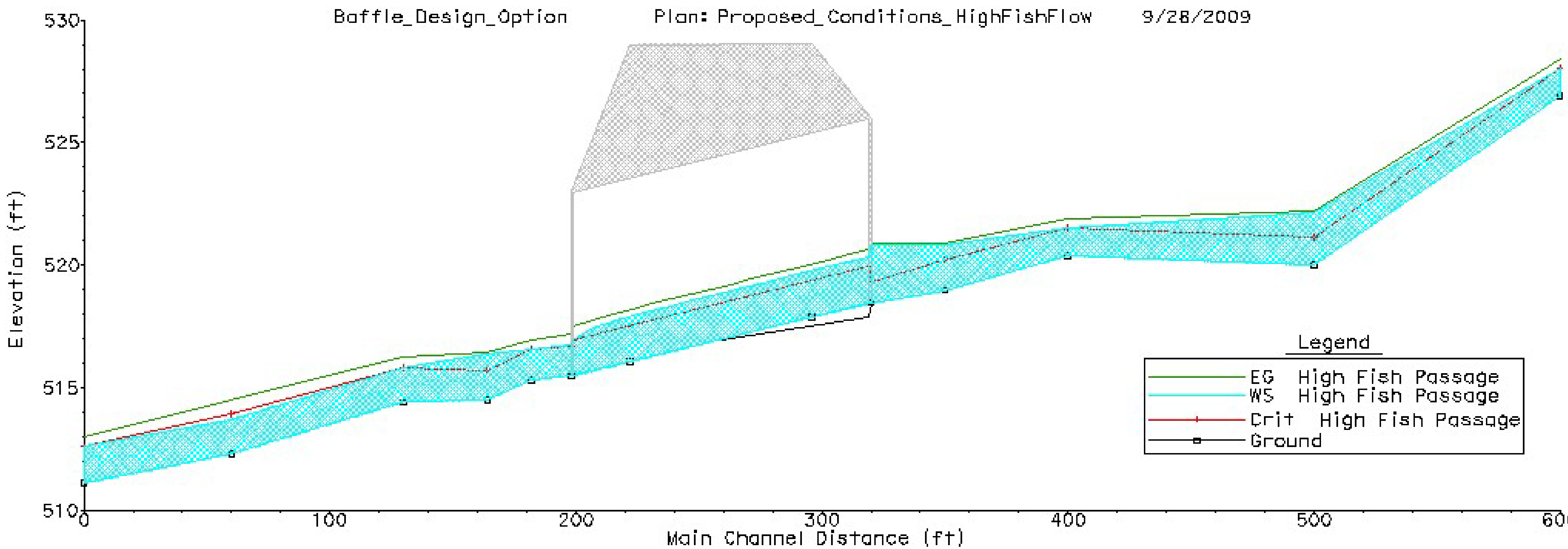

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 350
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.04
.03
.04
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Max. Channel Depth = 1.14 ft
QTOT = 9.00 cfs
Elevation (ft)
Station (ft)

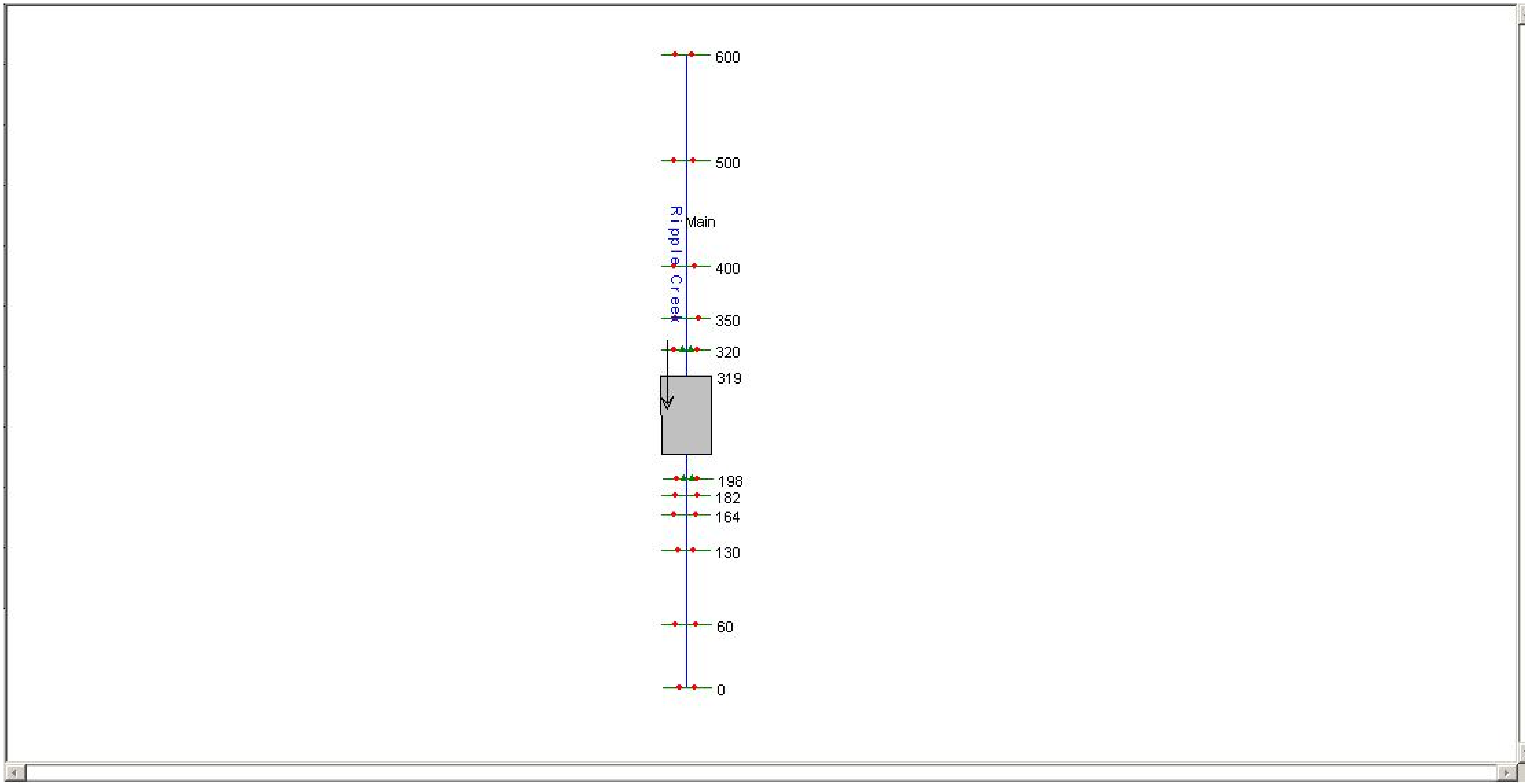

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 400
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.04
.03
.04
Max. Channel Depth = 0.60 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

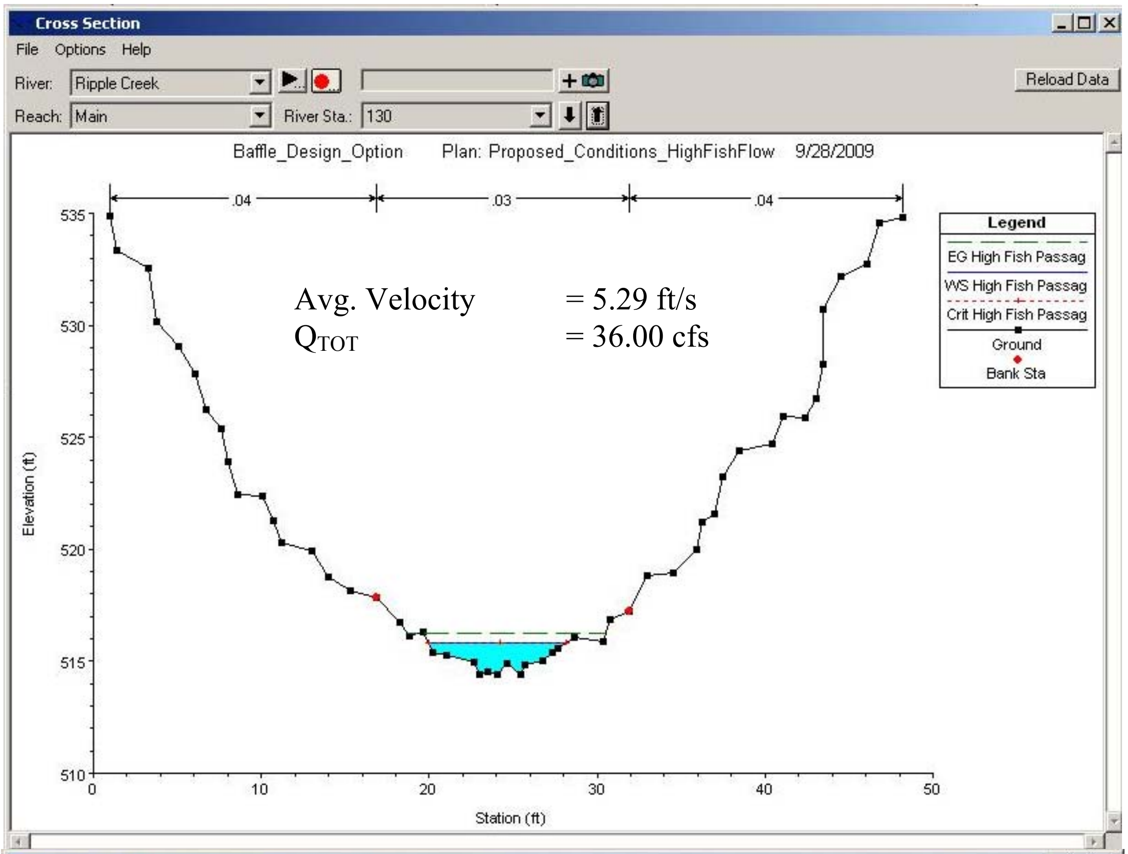

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 500
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_LowFishFlow 10/24/2008
.04
.03
.04
Max. Channel Depth = 1.31 ft
QTOT = 9.00 cfs
Legend
EG Low Fish Flow
WS Low Fish Flow
Crit Low Fish Flow
Ground
Bank Sta
Elevation (ft)
Station (ft)

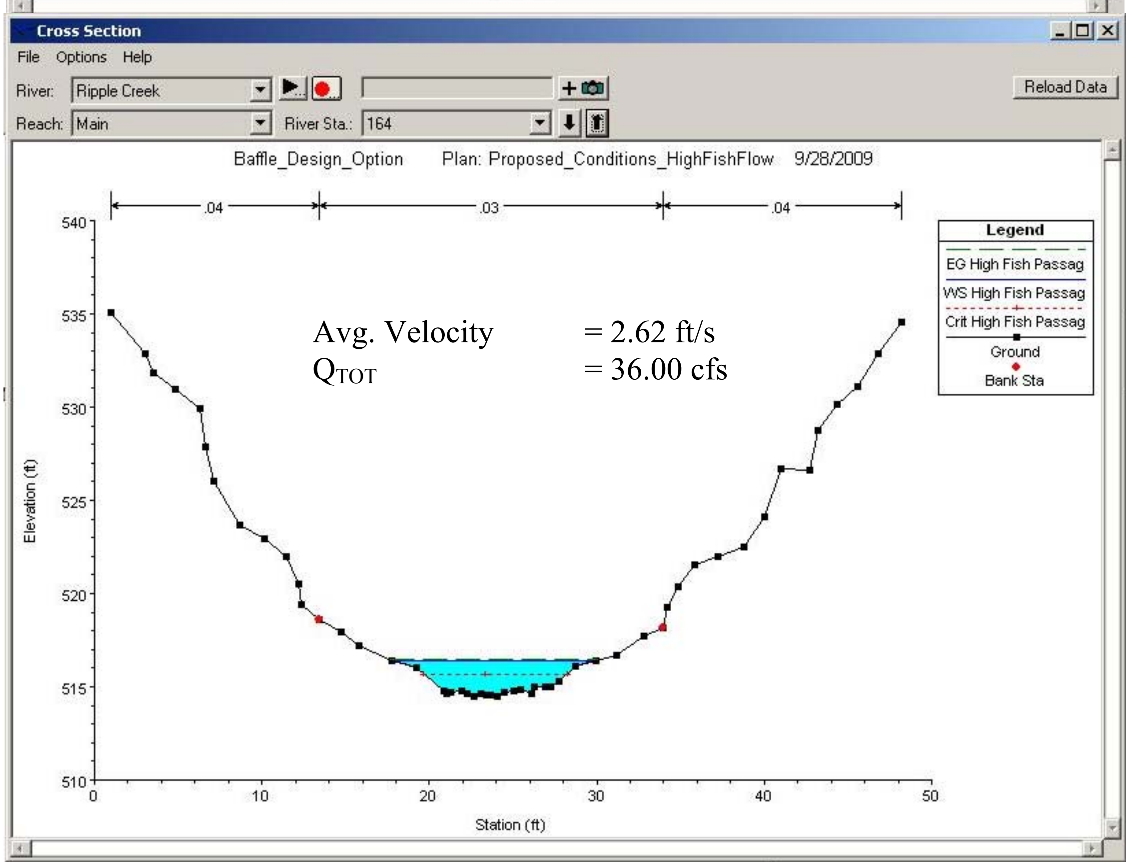
PROPOSED DESIGN

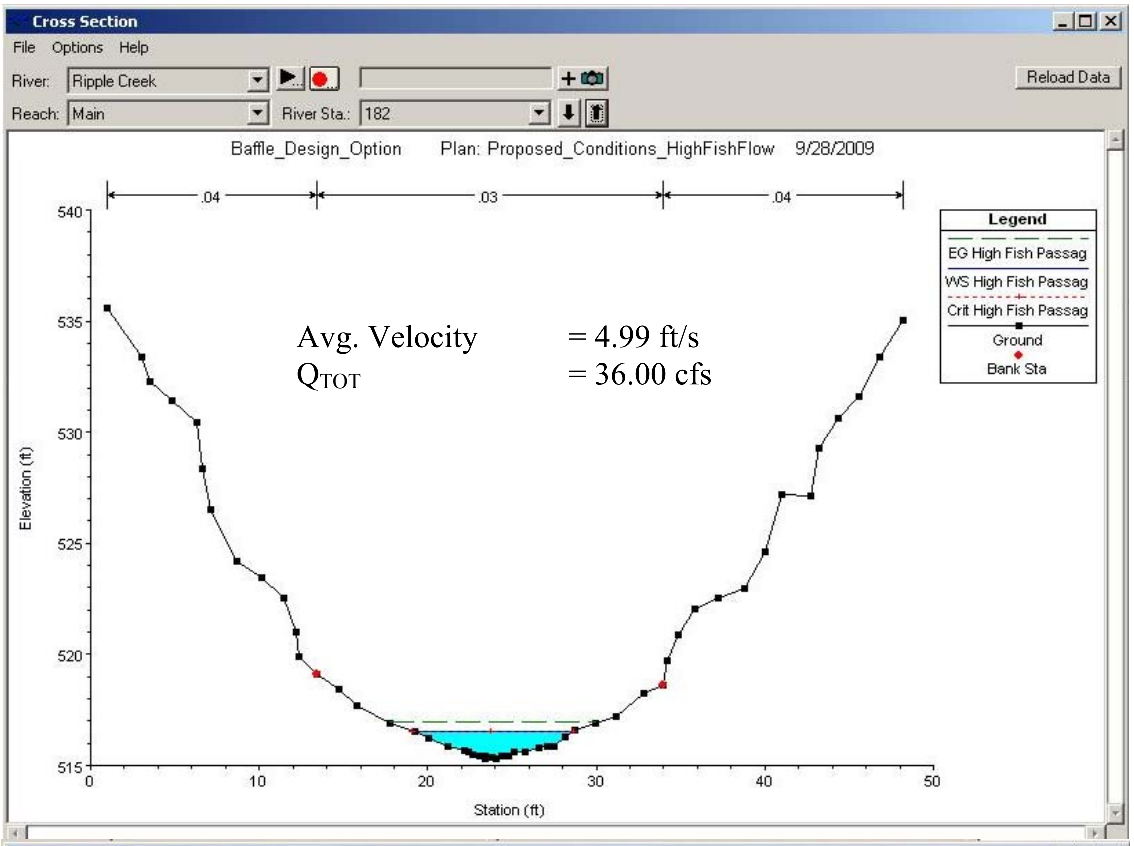
HIGH FLOW FISH PASSAGE RESULTS

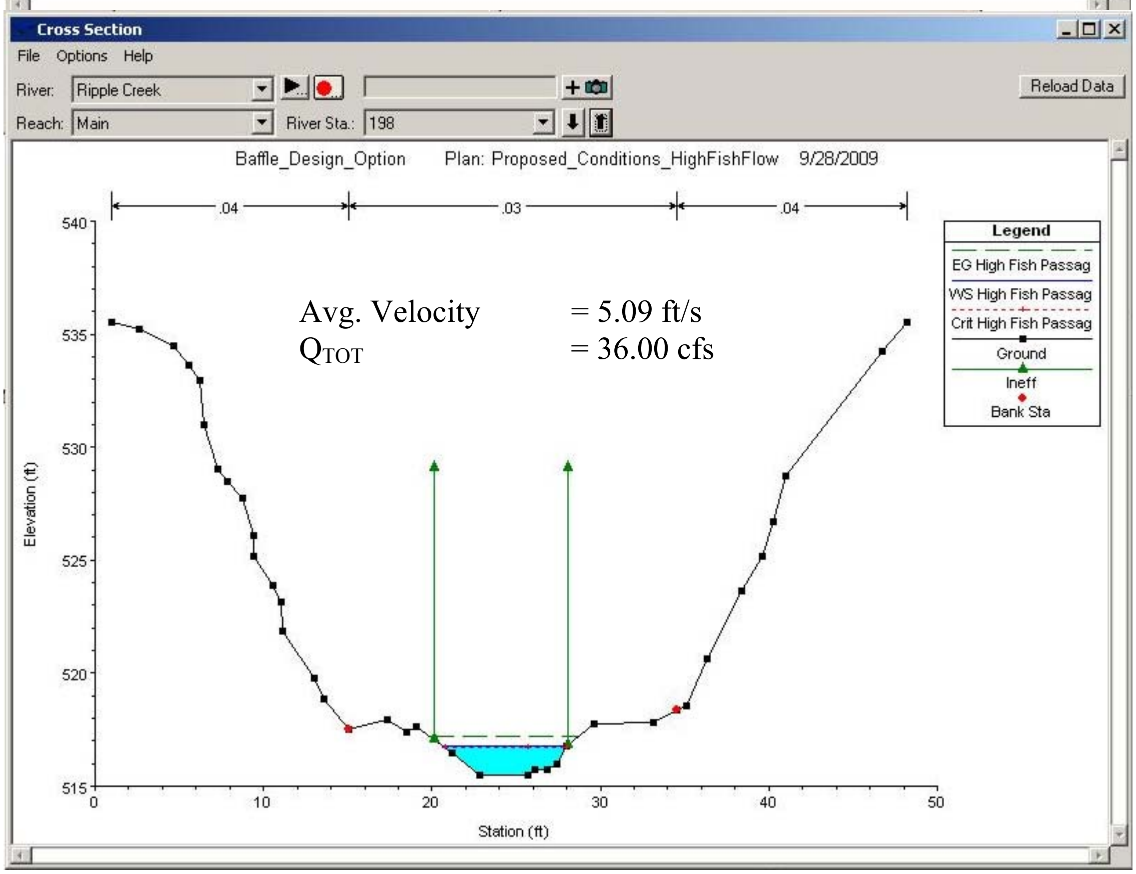

Baffle_Design_Option
Plan: Proposed_Conditions_HighFishFlow
9/28/2009
Elevation (ft)
530
525
520
515
510
0
100
200
300
400
500
600
Main Channel Distance (ft)
Legend
EG High Fish Passage
WS High Fish Passage
Crit High Fish Passage
Ground

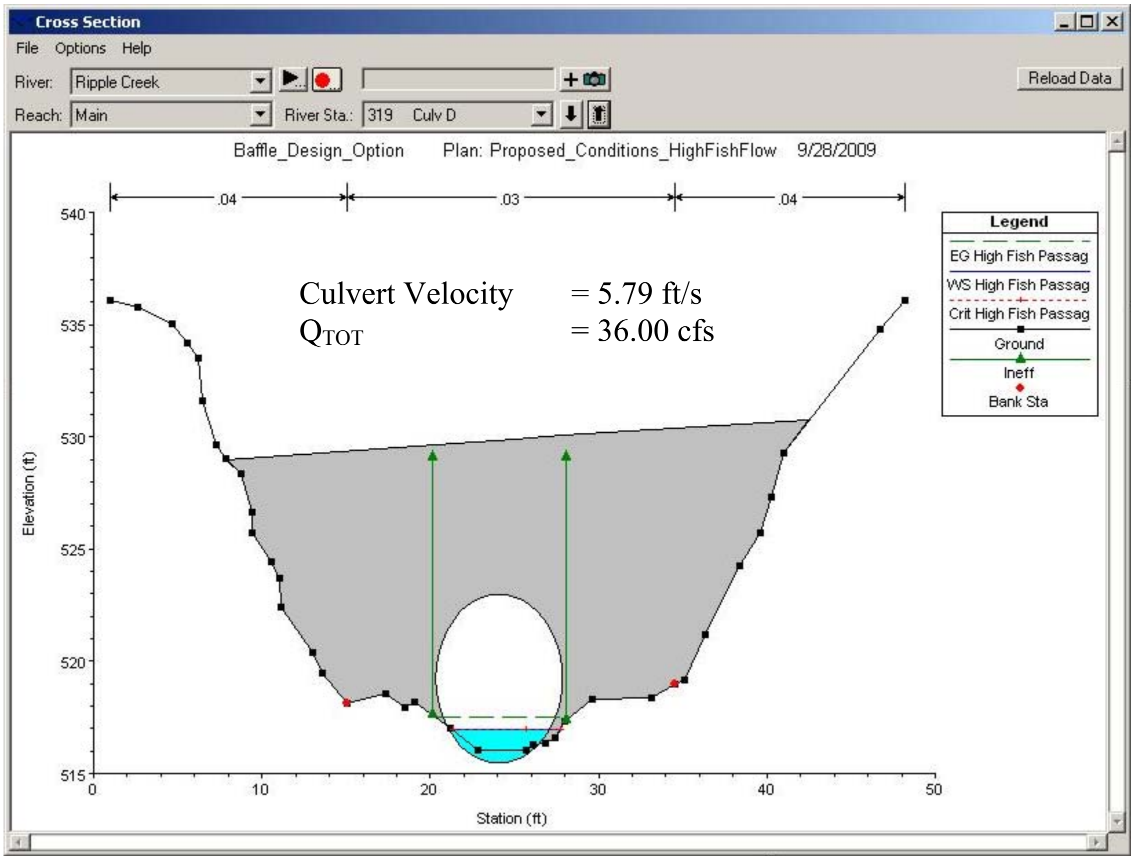

600
500
Main
Ripple Creek
400
350
320
319
198
182
164
130
60
0

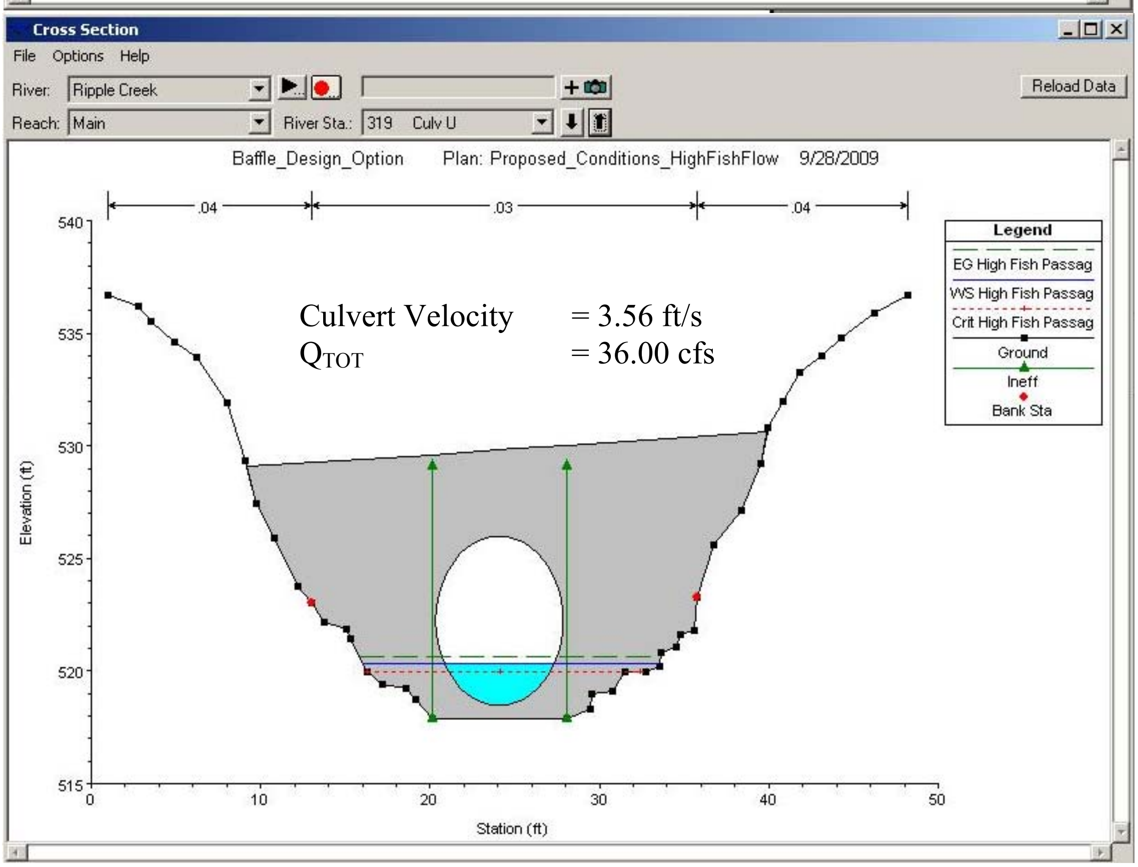

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 130
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Avg. Velocity = 5.29 ft/s
QTOT = 36.00 cfs
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Bank Sta
Elevation (ft)
Station (ft)
535
530
525
520
515
510
0
10
20
30
40
50

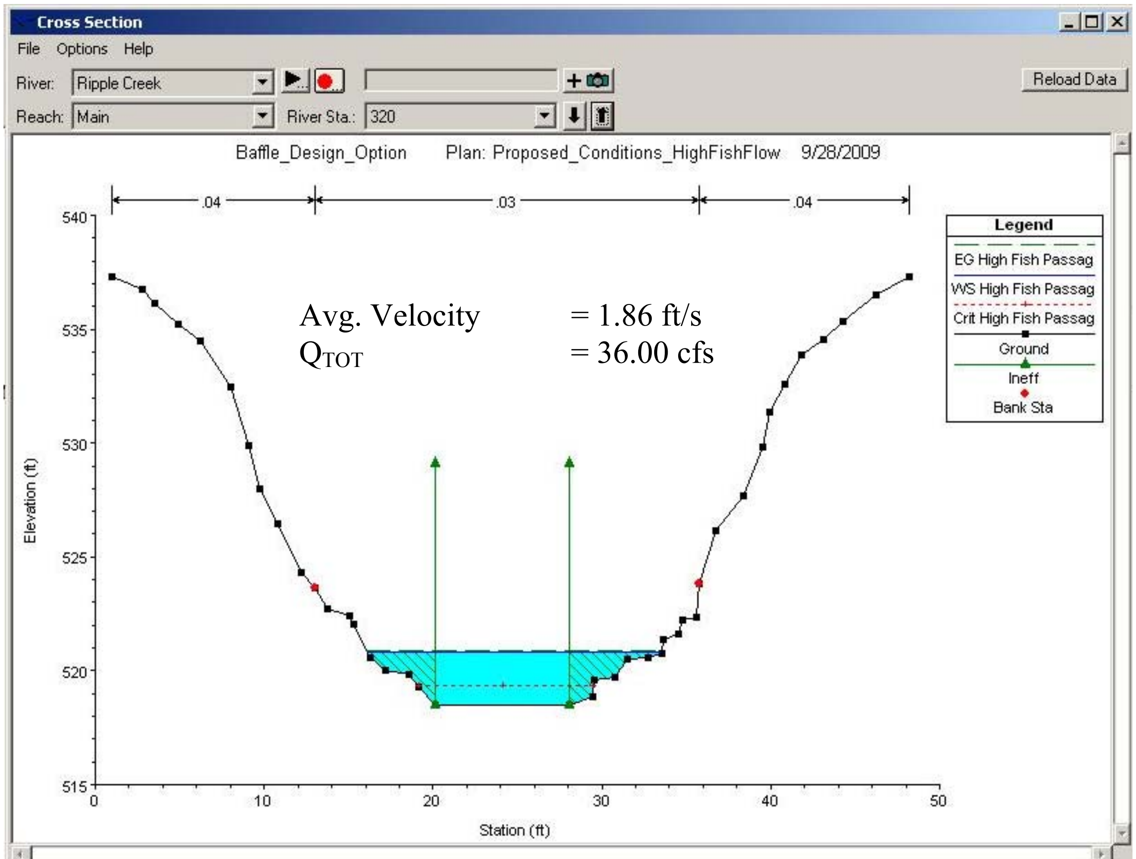

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 164
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Avg. Velocity = 2.62 ft/s
QTOT = 36.00 cfs
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Bank Sta
Elevation (ft)
Station (ft)
540
535
530
525
520
515
510
0
10
20
30
40
50

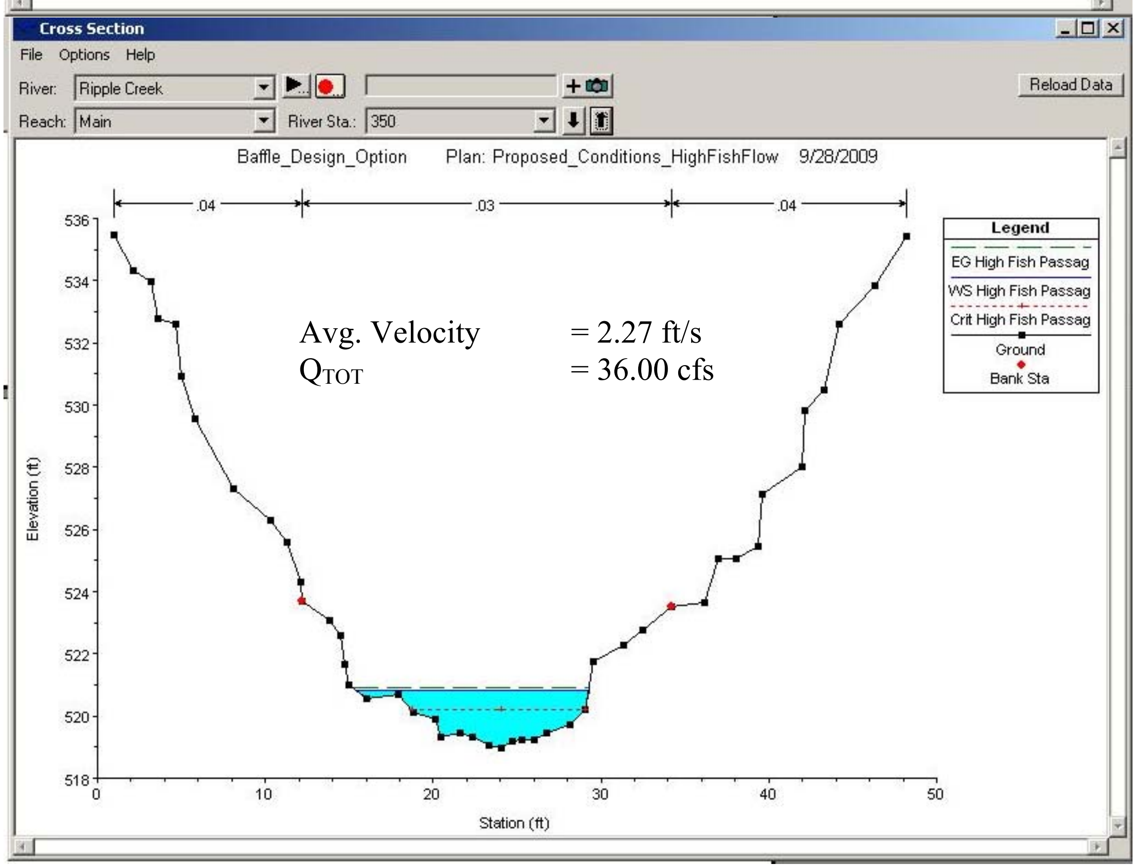

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 182
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Bank Sta
Avg. Velocity = 4.99 ft/s
QTOT = 36.00 cfs
Elevation (ft)
Station (ft)

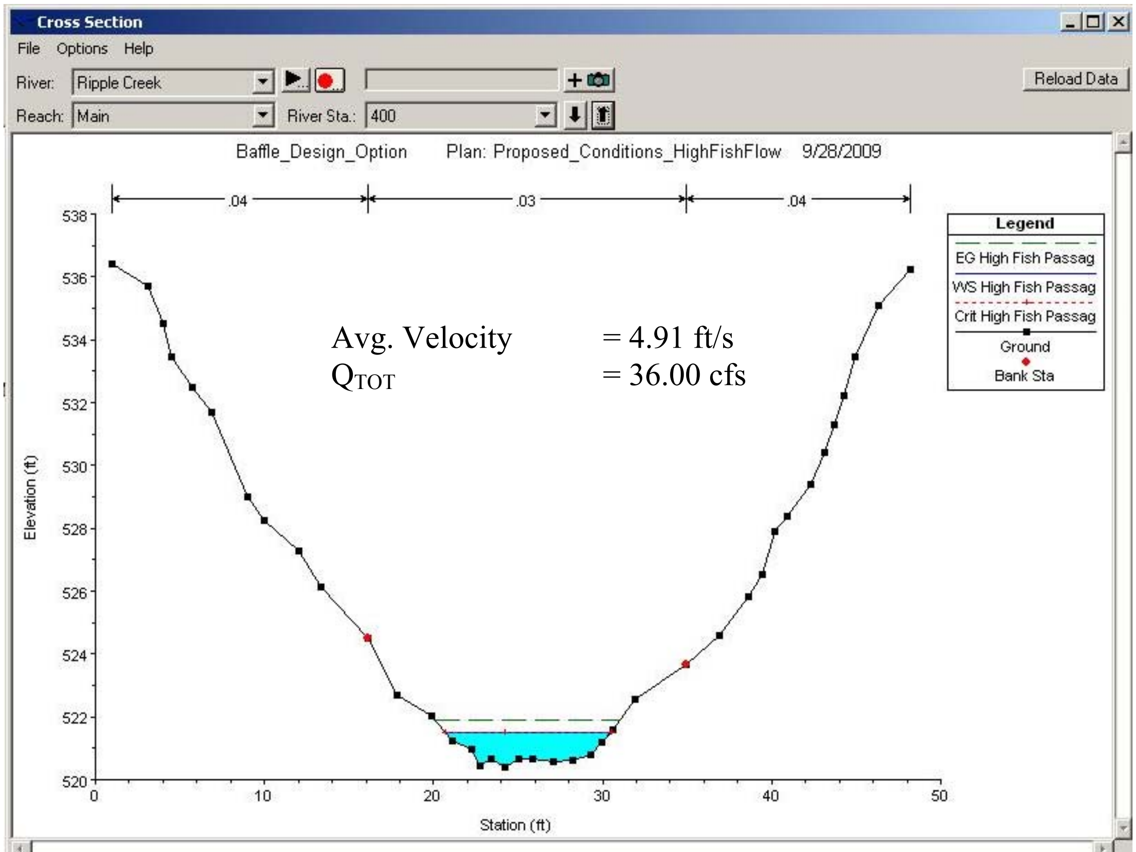

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 198
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Ineff
Bank Sta
Avg. Velocity = 5.09 ft/s
QTOT = 36.00 cfs
Elevation (ft)
Station (ft)

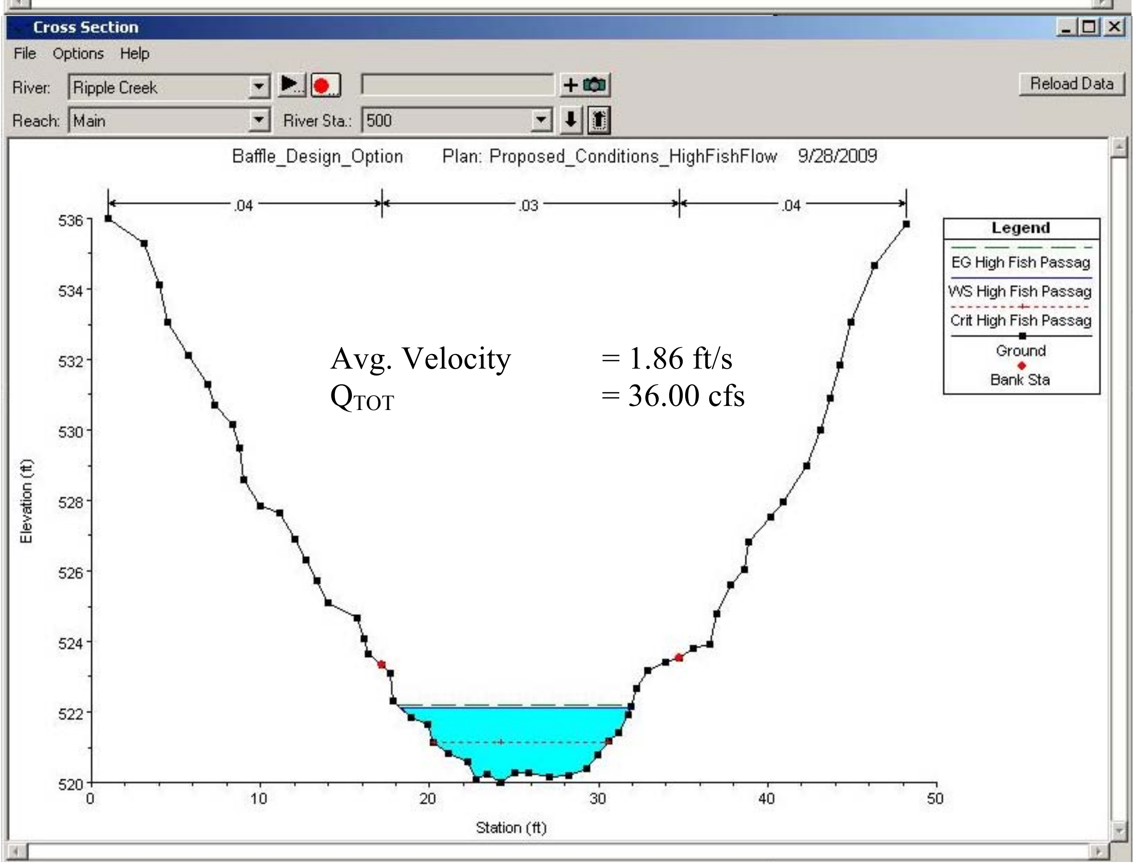

Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 319 Culv D
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Culvert Velocity = 5.79 ft/s
QTOT = 36.00 cfs
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 319 Culv U
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Culvert Velocity = 3.56 ft/s
QTOT = 36.00 cfs
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 320
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Avg. Velocity = 1.86 ft/s
Q_{TOT} = 36.00 cfs
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
540
535
530
525
520
515
0
10
20
30
40
50

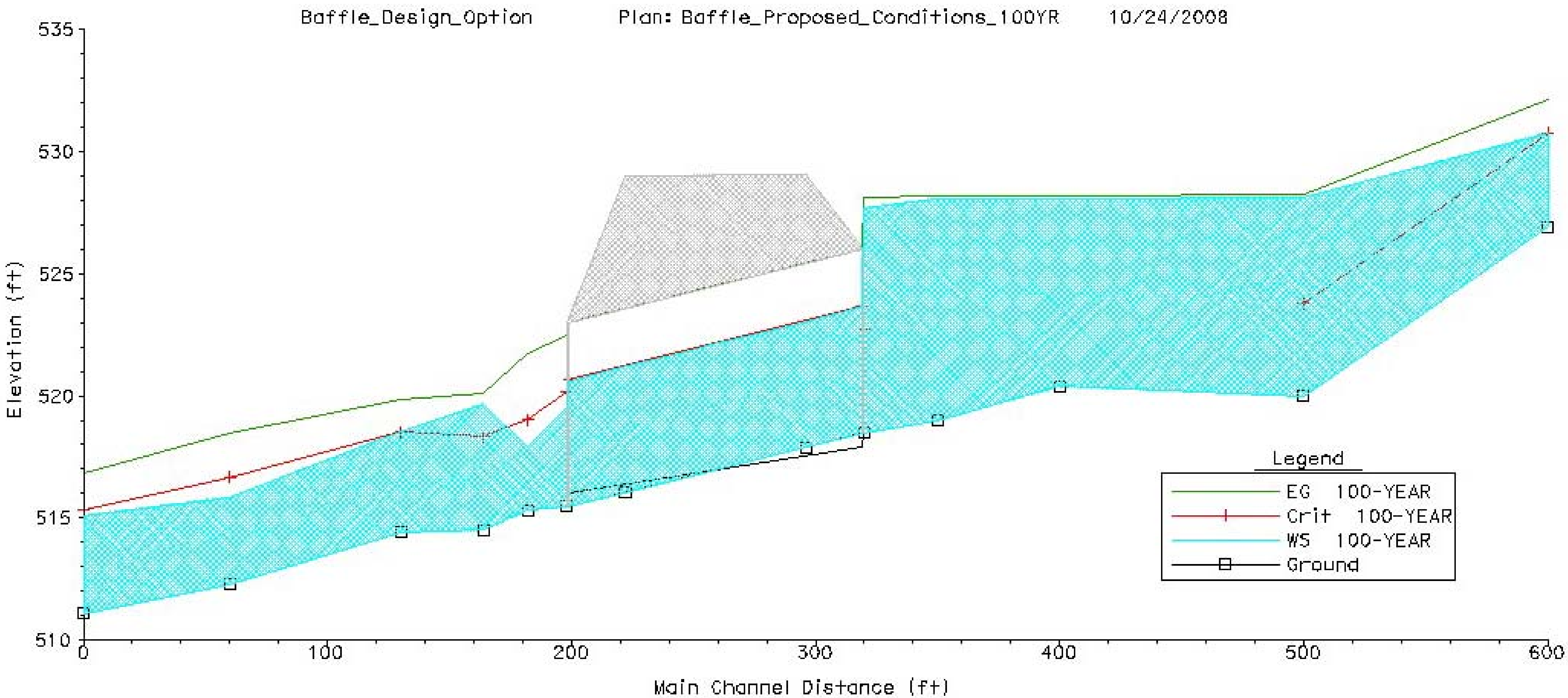

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 350
Reload Data
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Avg. Velocity = 2.27 ft/s
Q_{TOT} = 36.00 cfs
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Bank Sta
Elevation (ft)
Station (ft)
536
534
532
530
528
526
524
522
520
518
0
10
20
30
40
50

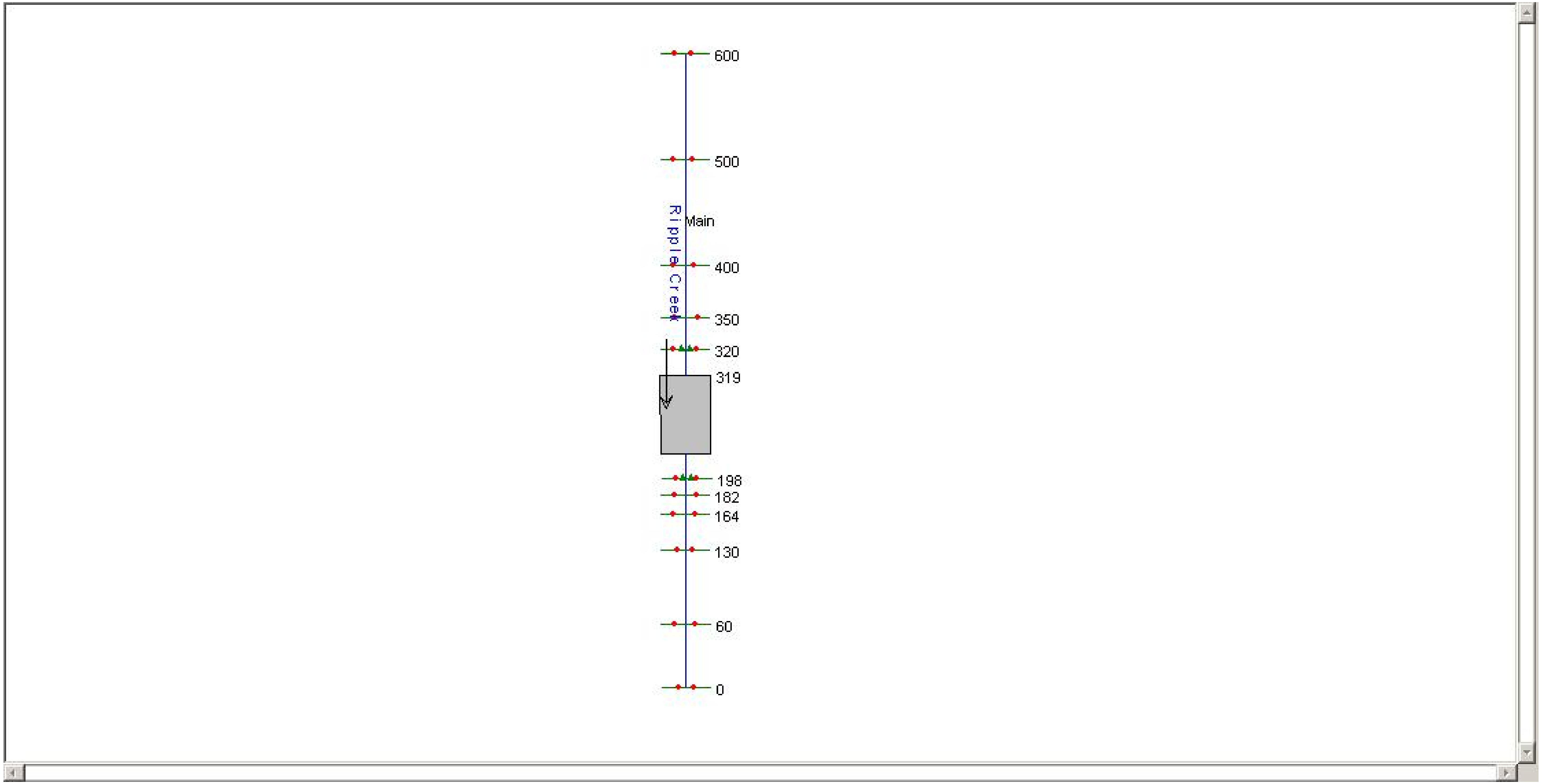

Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 400
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Bank Sta
Avg. Velocity = 4.91 ft/s
Q_{TOT} = 36.00 cfs
Elevation (ft)
538
536
534
532
530
528
526
524
522
520
0
10
20
30
40
50
Station (ft)

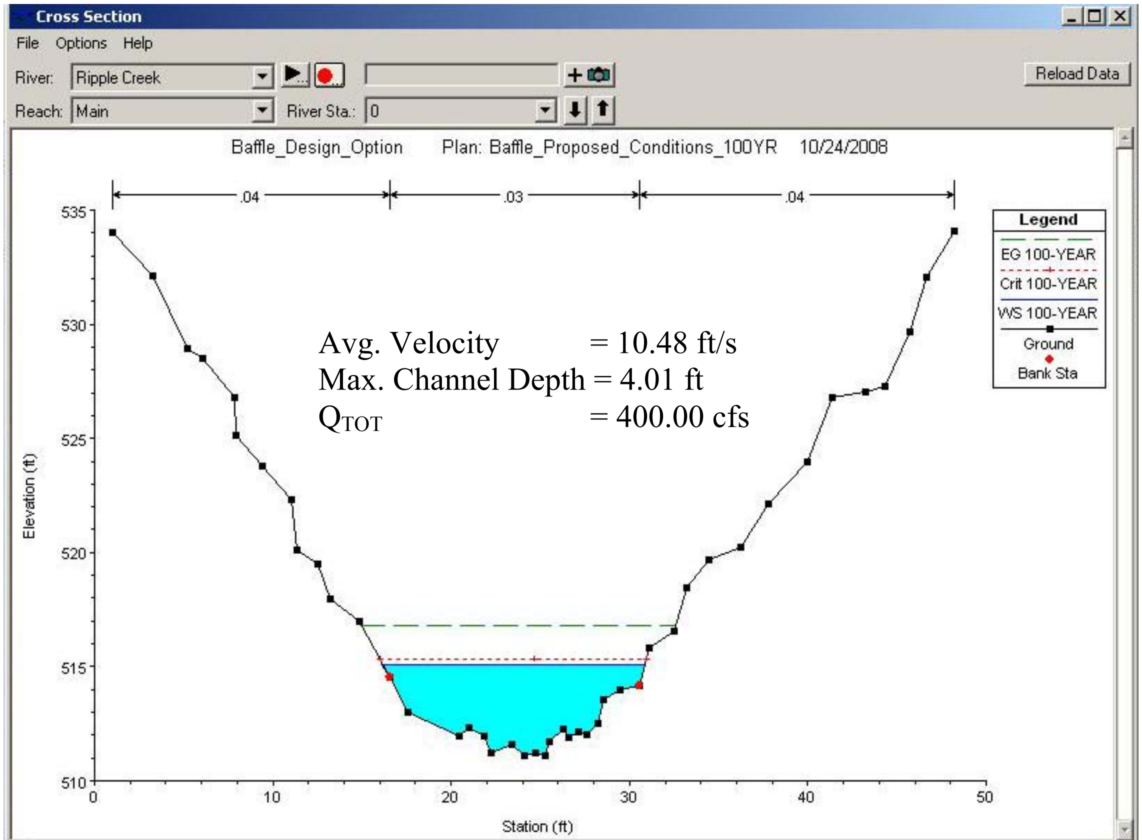

Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 500
Baffle_Design_Option Plan: Proposed_Conditions_HighFishFlow 9/28/2009
.04
.03
.04
Legend
EG High Fish Passag
WS High Fish Passag
Crit High Fish Passag
Ground
Bank Sta
Avg. Velocity = 1.86 ft/s
Q_{TOT} = 36.00 cfs
Elevation (ft)
536
534
532
530
528
526
524
522
520
0
10
20
30
40
50
Station (ft)

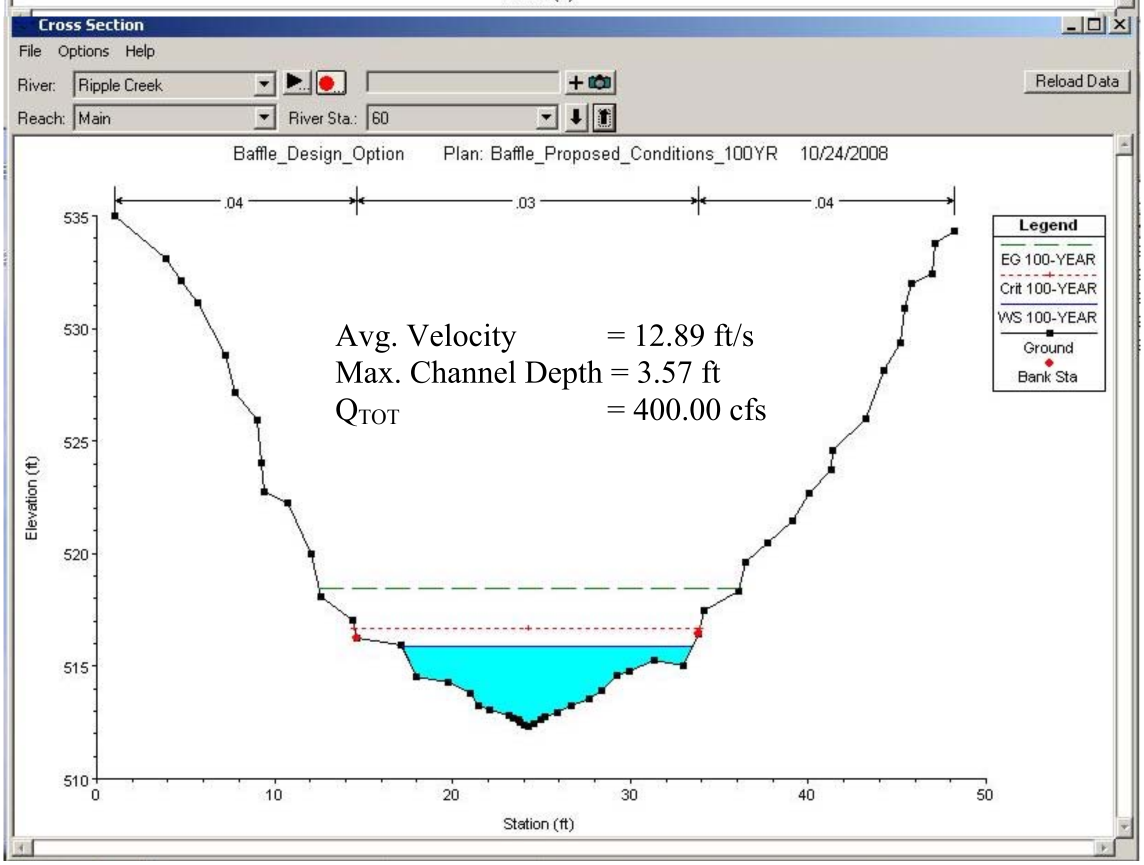
PROPOSED DESIGN

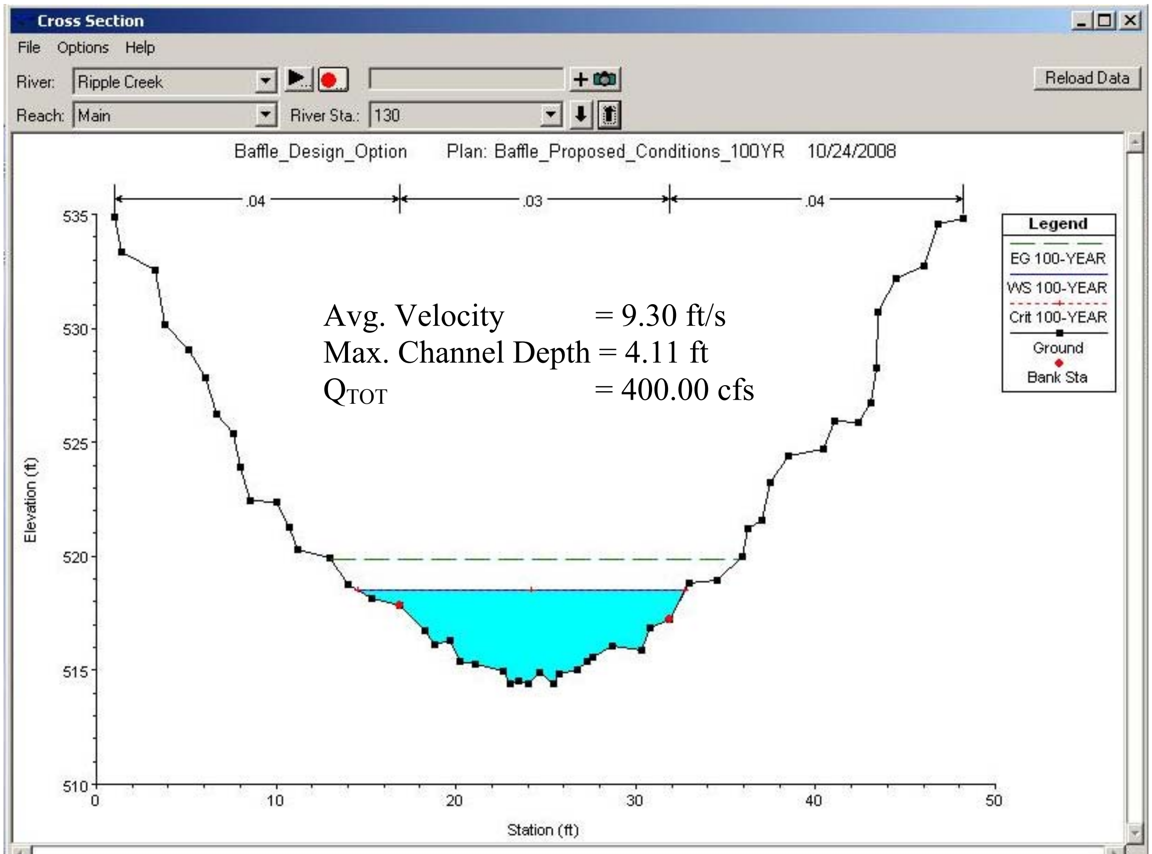
FLOOD FLOW FISH PASSAGE RESULTS

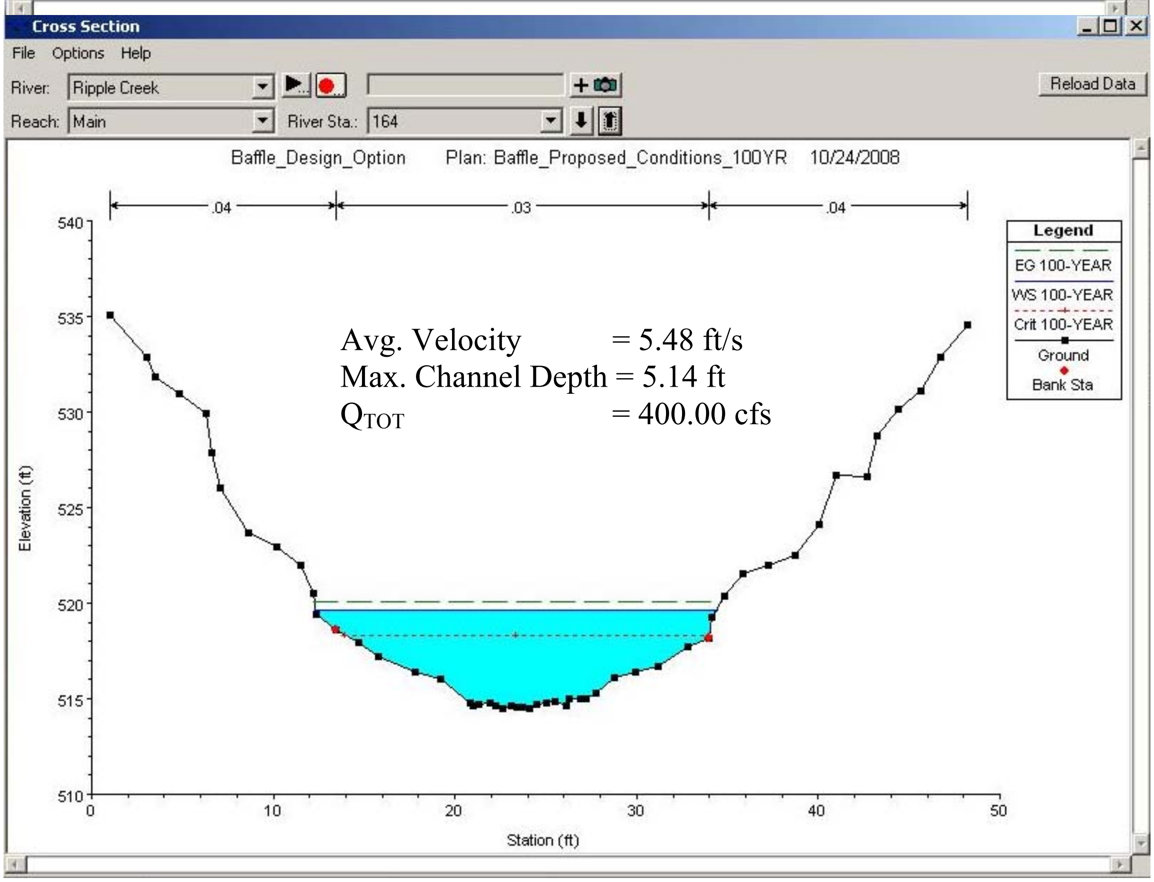

Baffle_Design_Option   Plan: Baffle_Proposed_Conditions_100YR   10/24/2008
Elevation (ft)
535
530
525
520
515
510
0
100
200
300
400
500
600
Main Channel Distance (ft)
Legend
EG 100-YEAR
Crit 100-YEAR
WS 100-YEAR
Ground

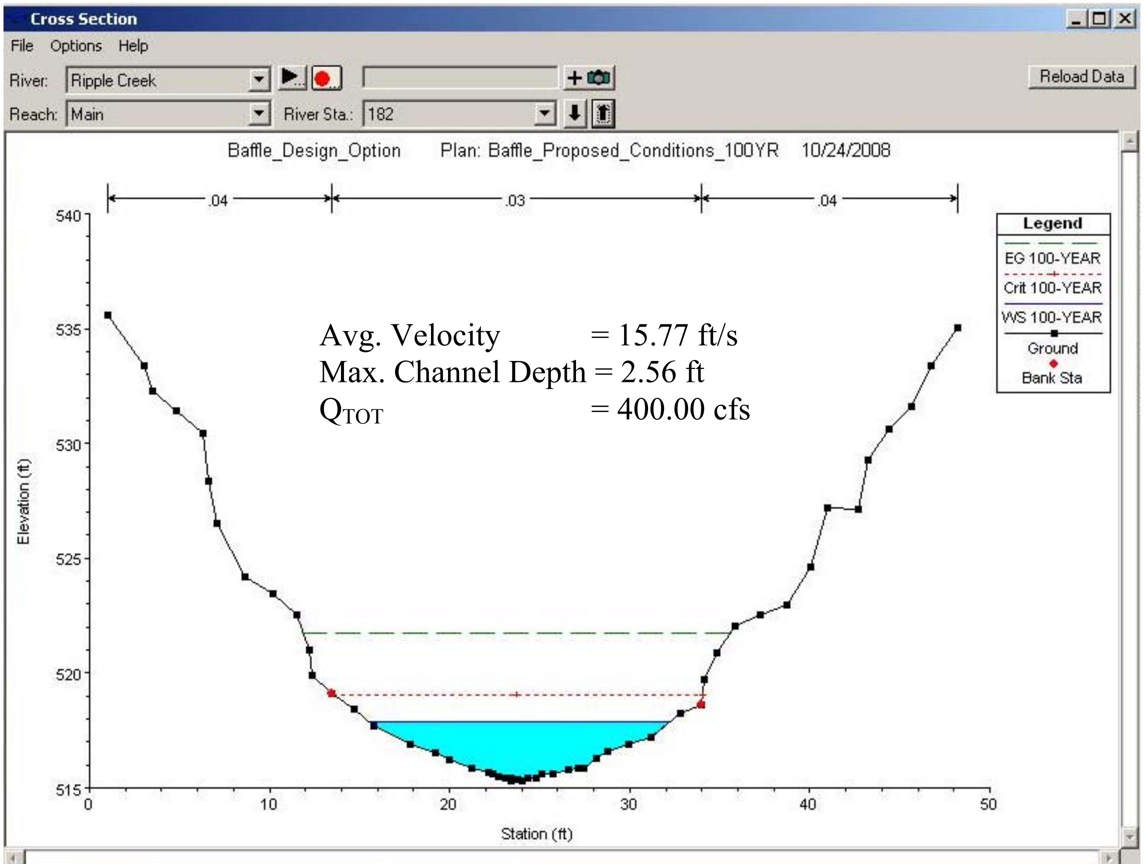

600
500
Ripple Creek
Main
400
350
320
319
198
182
164
130
60
0

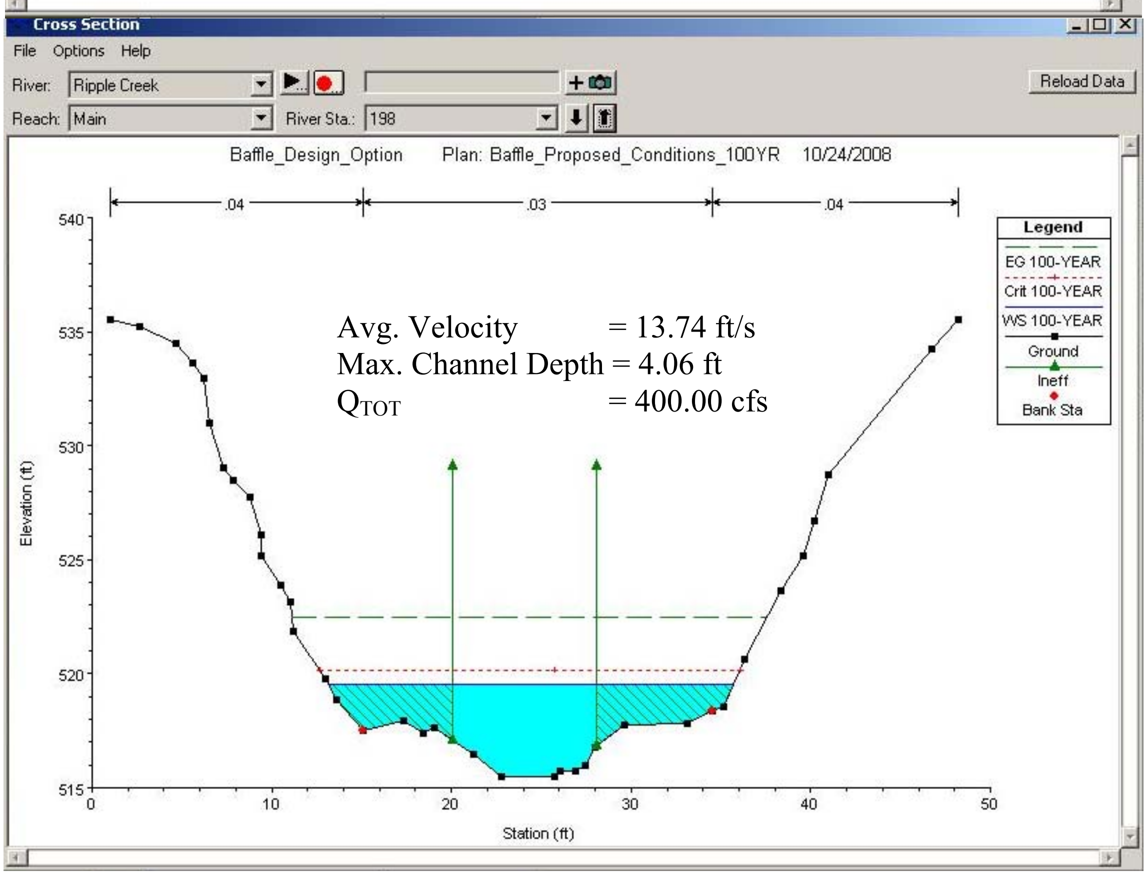

Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 0
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Legend
EG 100-YEAR
Crit 100-YEAR
WS 100-YEAR
Ground
Bank Sta
Avg. Velocity = 10.48 ft/s
Max. Channel Depth = 4.01 ft
QTOT = 400.00 cfs
Elevation (ft)
Station (ft)

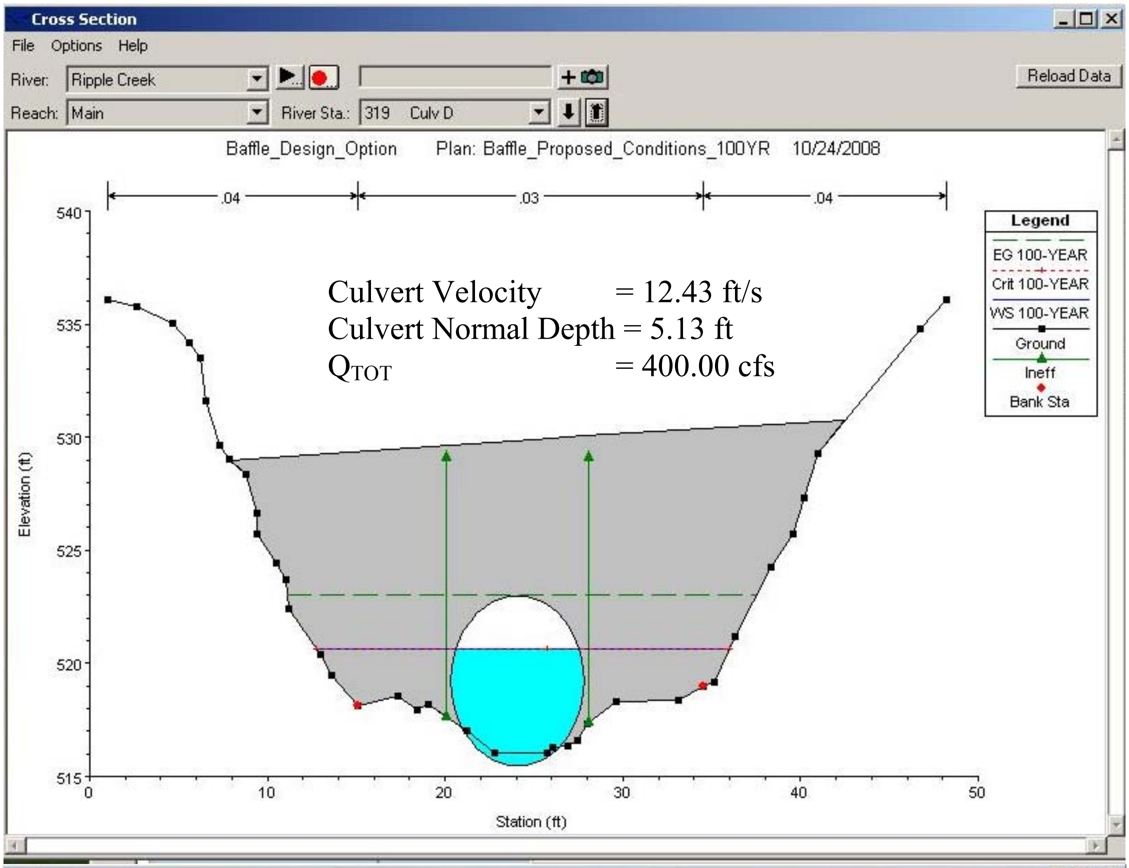

Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 60
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Legend
EG 100-YEAR
Crit 100-YEAR
WS 100-YEAR
Ground
Bank Sta
Avg. Velocity = 12.89 ft/s
Max. Channel Depth = 3.57 ft
QTOT = 400.00 cfs
Elevation (ft)
Station (ft)

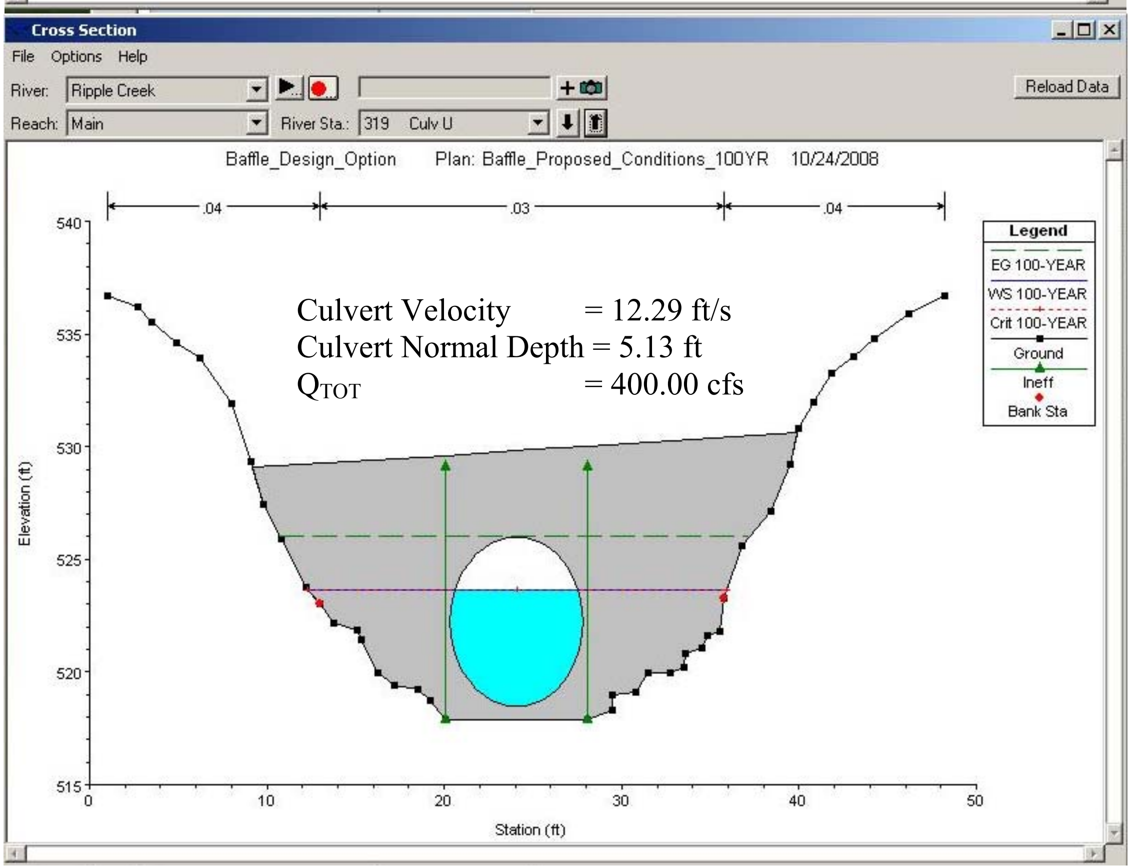

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 130
Reload Data
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Legend
EG 100-YEAR
WS 100-YEAR
Crit 100-YEAR
Ground
Bank Sta
Avg. Velocity = 9.30 ft/s
Max. Channel Depth = 4.11 ft
QTOT = 400.00 cfs
Elevation (ft)
Station (ft)

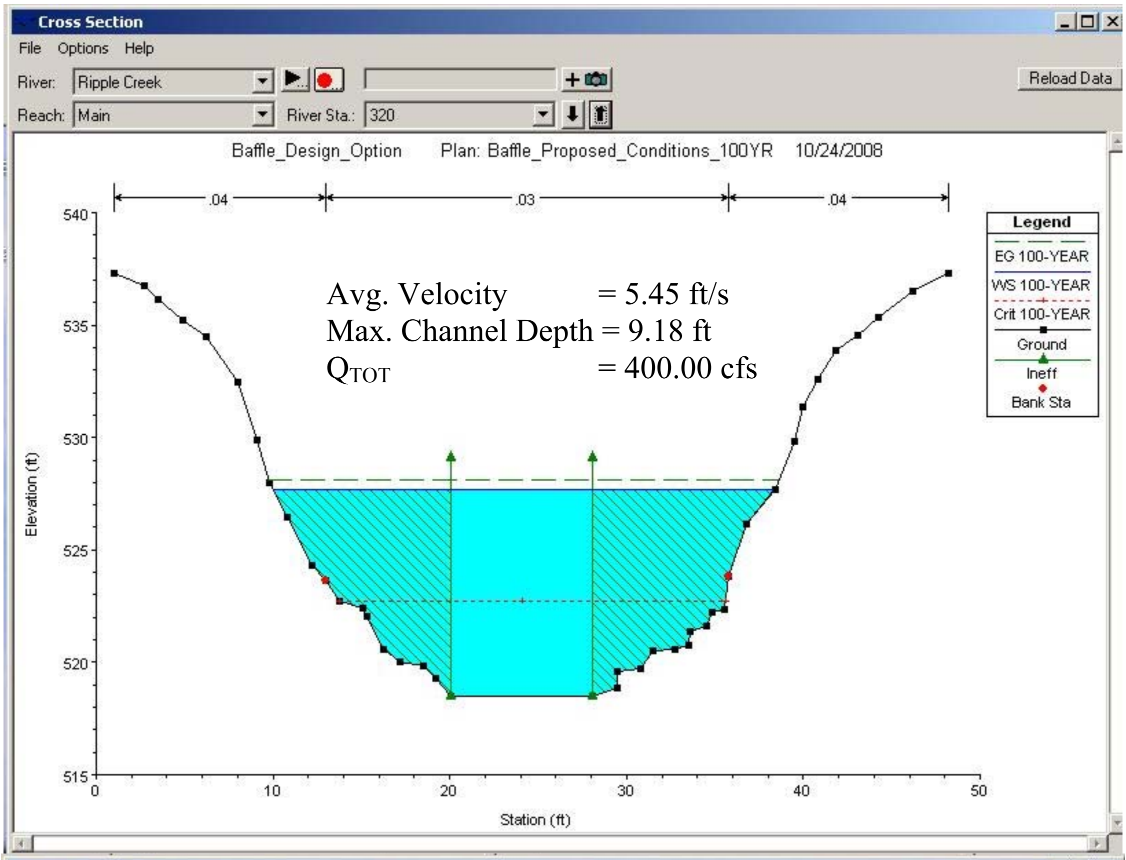

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 164
Reload Data
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Legend
EG 100-YEAR
WS 100-YEAR
Crit 100-YEAR
Ground
Bank Sta
Avg. Velocity = 5.48 ft/s
Max. Channel Depth = 5.14 ft
QTOT = 400.00 cfs
Elevation (ft)
Station (ft)

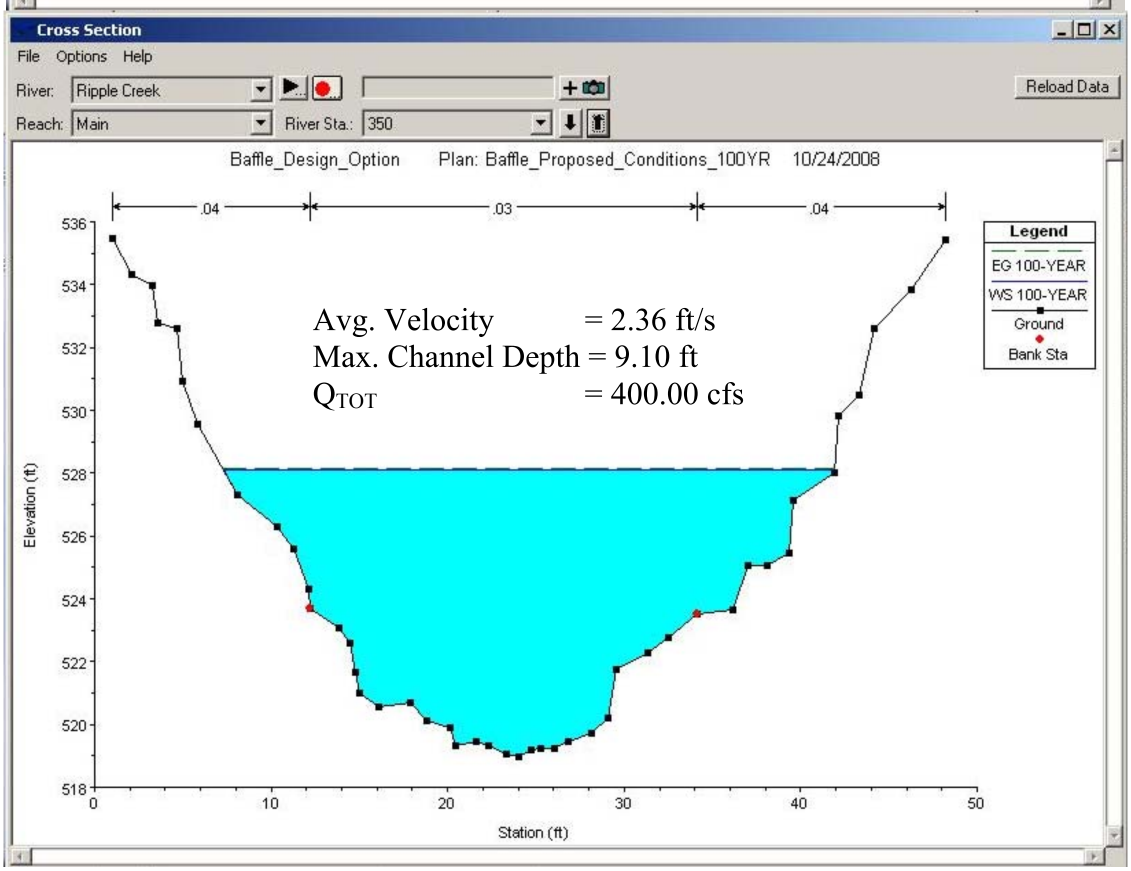

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 182
Reload Data
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Legend
EG 100-YEAR
Crit 100-YEAR
WS 100-YEAR
Ground
Bank Sta
Avg. Velocity = 15.77 ft/s
Max. Channel Depth = 2.56 ft
QTOT = 400.00 cfs
Elevation (ft)
Station (ft)

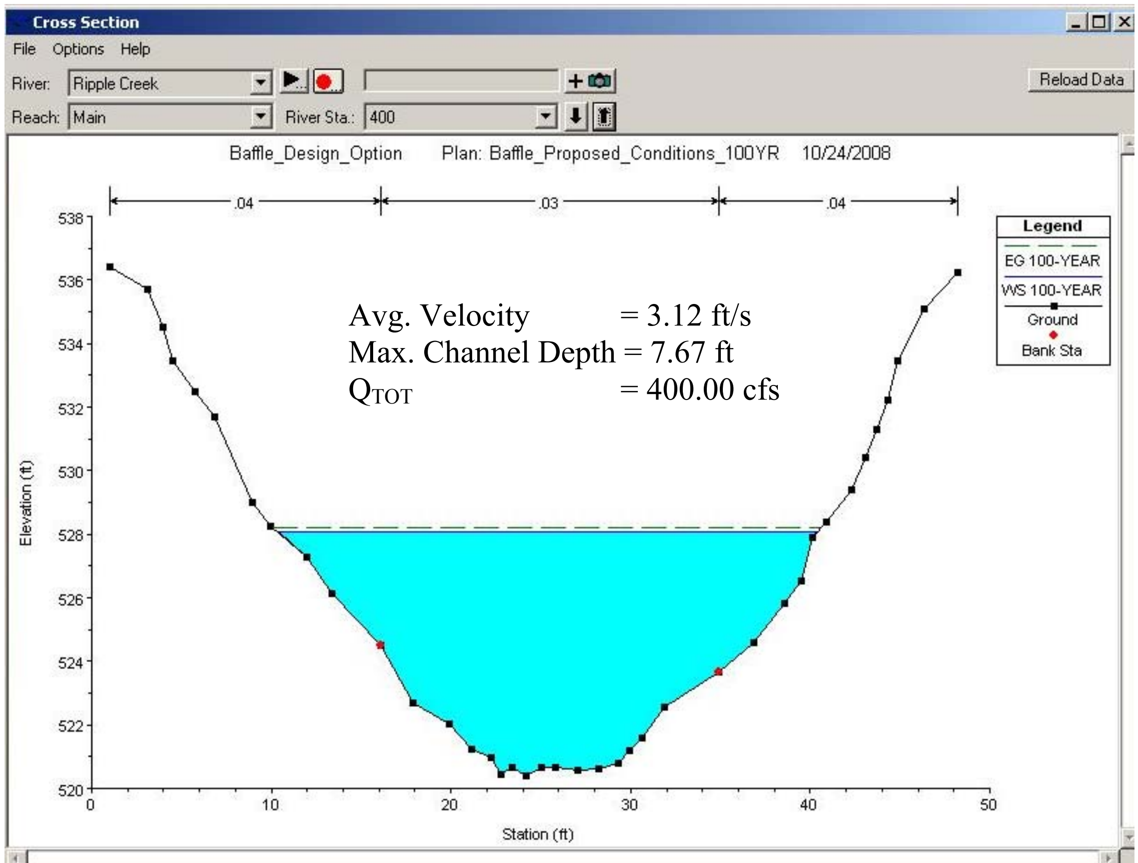

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 198
Reload Data
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Legend
EG 100-YEAR
Crit 100-YEAR
WS 100-YEAR
Ground
Ineff
Bank Sta
Avg. Velocity = 13.74 ft/s
Max. Channel Depth = 4.06 ft
QTOT = 400.00 cfs
Elevation (ft)
Station (ft)

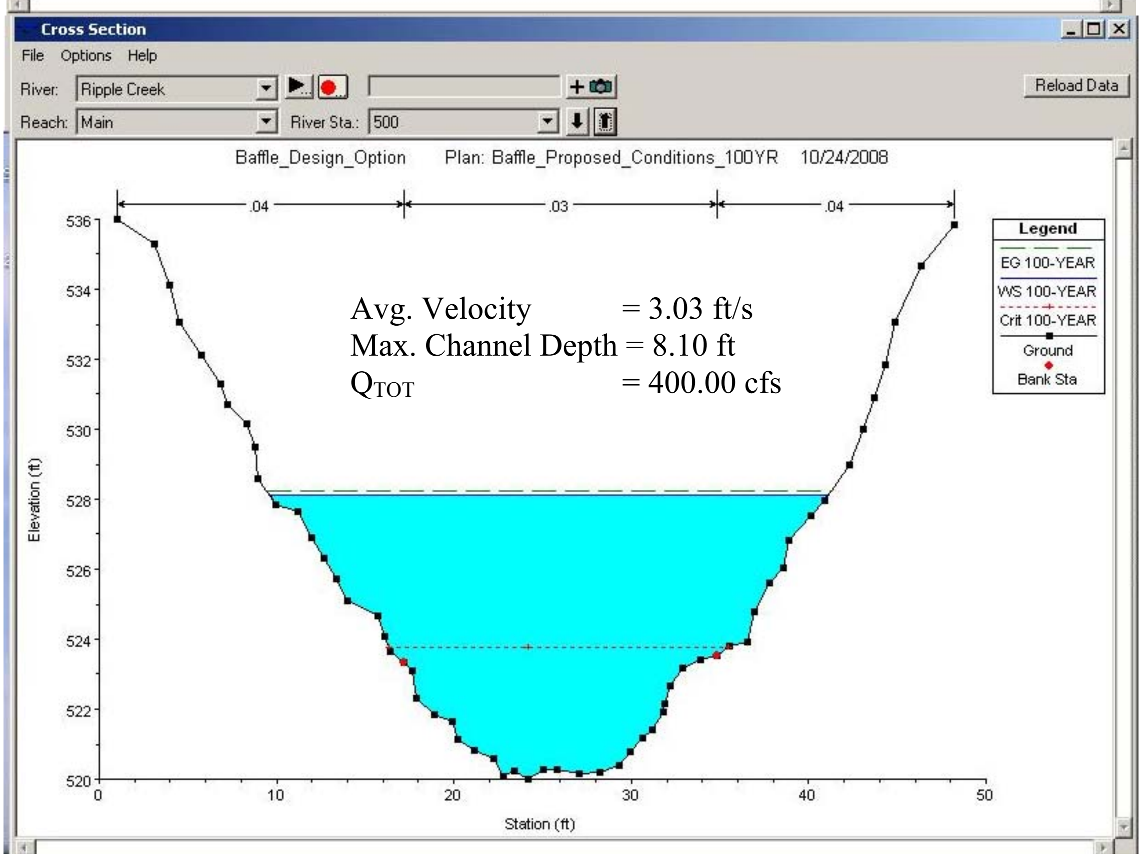

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 319 Culv D
Reload Data
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Culvert Velocity = 12.43 ft/s
Culvert Normal Depth = 5.13 ft
QTOT = 400.00 cfs
Legend
EG 100-YEAR
Crit 100-YEAR
WS 100-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

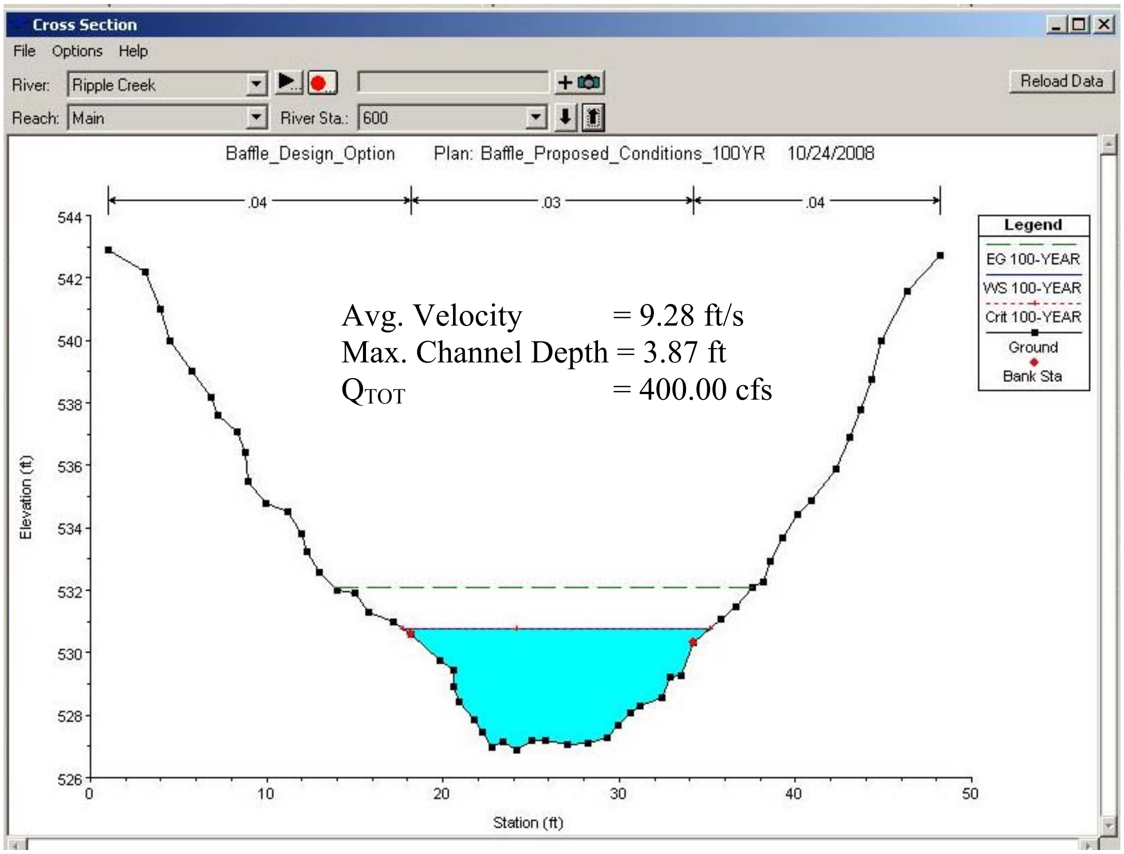

Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 319 Culv U
Reload Data
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Culvert Velocity = 12.29 ft/s
Culvert Normal Depth = 5.13 ft
QTOT = 400.00 cfs
Legend
EG 100-YEAR
WS 100-YEAR
Crit 100-YEAR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 320
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Legend
EG 100-YEAR
WS 100-YEAR
Crit 100-YEAR
Ground
Ineff
Bank Sta
Avg. Velocity = 5.45 ft/s
Max. Channel Depth = 9.18 ft
QTOT = 400.00 cfs
Elevation (ft)
Station (ft)
540
535
530
525
520
515
0
10
20
30
40
50


Cross Section
File Options Help
River: Ripple Creek
Reload Data
Reach: Main
River Sta.: 350
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Legend
EG 100-YEAR
WS 100-YEAR
Ground
Bank Sta
Avg. Velocity = 2.36 ft/s
Max. Channel Depth = 9.10 ft
QTOT = 400.00 cfs
Elevation (ft)
Station (ft)
536
534
532
530
528
526
524
522
520
518
0
10
20
30
40
50


Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 400
Reload Data
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Avg. Velocity = 3.12 ft/s
Max. Channel Depth = 7.67 ft
QTOT = 400.00 cfs
Legend
EG 100-YEAR
WS 100-YEAR
Ground
Bank Sta
Elevation (ft)
538
536
534
532
530
528
526
524
522
520
0
10
20
30
40
50
Station (ft)


Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 500
Reload Data
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Avg. Velocity = 3.03 ft/s
Max. Channel Depth = 8.10 ft
QTOT = 400.00 cfs
Legend
EG 100-YEAR
WS 100-YEAR
Crit 100-YEAR
Ground
Bank Sta
Elevation (ft)
536
534
532
530
528
526
524
522
520
0
10
20
30
40
50
Station (ft)


Cross Section
File Options Help
River: Ripple Creek
Reach: Main
River Sta.: 600
Reload Data
Baffle_Design_Option Plan: Baffle_Proposed_Conditions_100YR 10/24/2008
.04
.03
.04
Avg. Velocity = 9.28 ft/s
Max. Channel Depth = 3.87 ft
QTOT = 400.00 cfs
Legend
EG 100-YEAR
WS 100-YEAR
Crit 100-YEAR
Ground
Bank Sta
Elevation (ft)
544
542
540
538
536
534
532
530
528
526
0
10
20
30
40
50
Station (ft)