Culvert Analysis Workshop Solution

The design requirements state that the one-percent flow profile (4,000 cfs) should not increase more than one foot above base conditions and that the maximum flood (6,500 cfs) should not overtop the roadway.

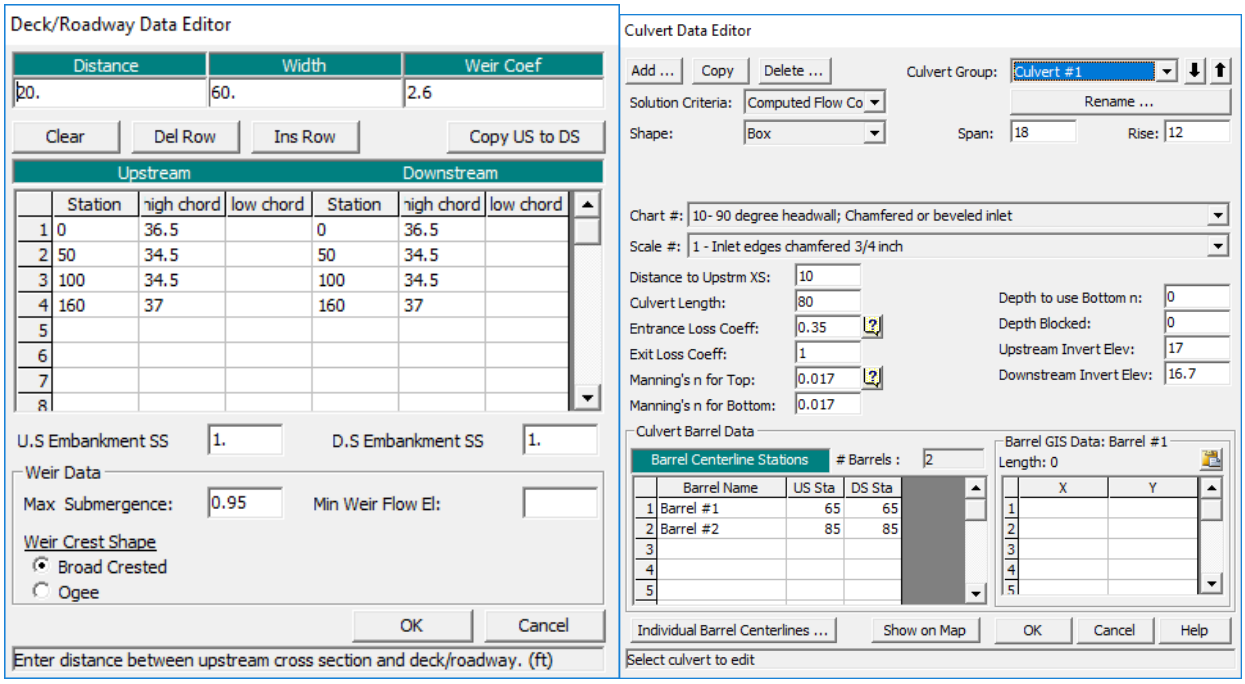
Tasks

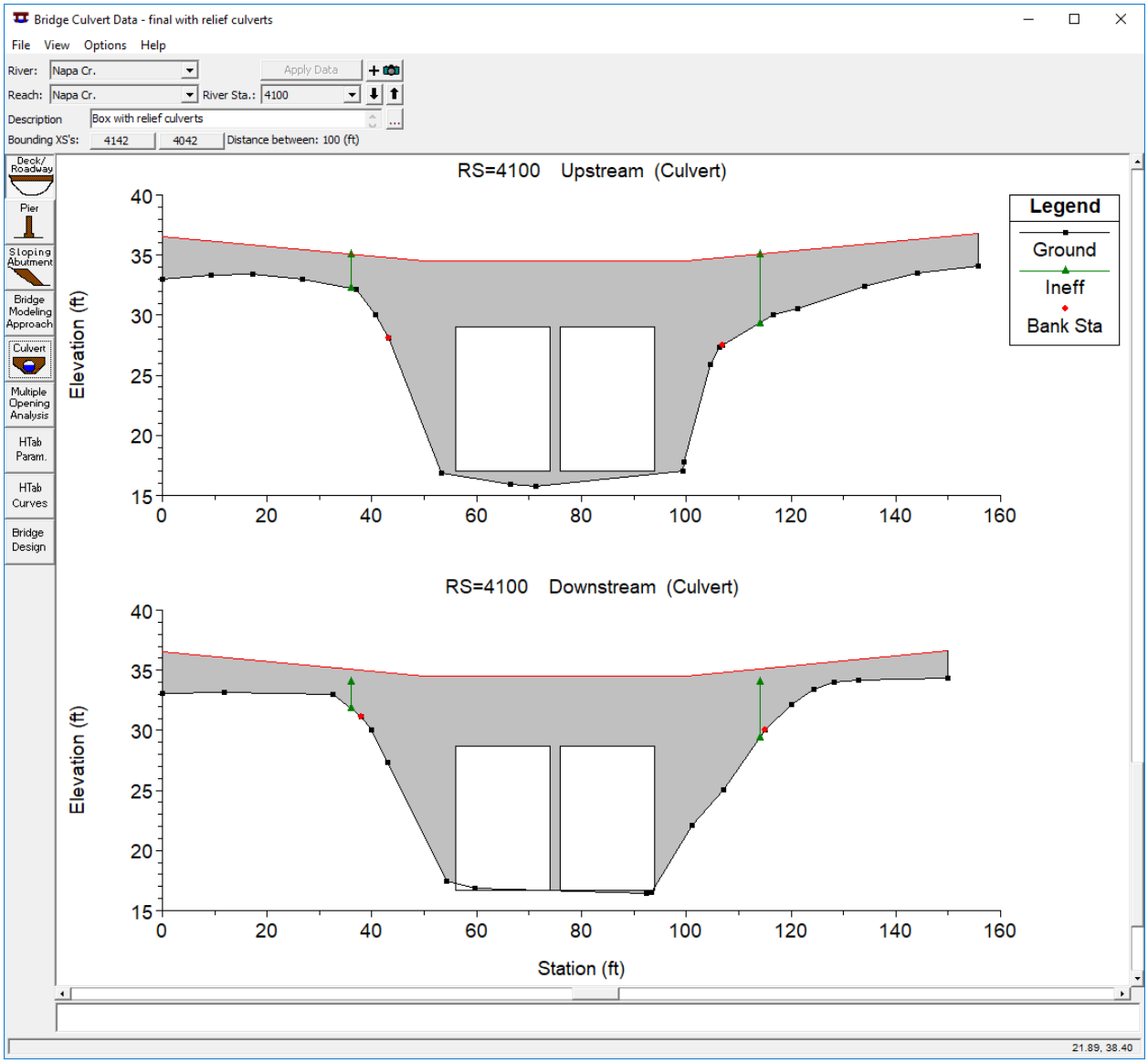
Part 1.

1. Assemble the necessary added data and run the model with culverts. Don't forget to set the effective-area option on the adjacent cross sections. Save the geometry file under a new name.

The deck/roadway and culvert editors show the primary culvert input. The deck/roadway data only defines the top-of-road. The low chord is left blank, filling the area from the roadway elevation to the ground.

The culvert data defines the size, shape and location of the culverts. The inlet control is defined by Chart # and Scale. The outlet control information includes culvert length, n value, entrance and exit loss coefficients. The entrance loss coefficient was set to 0.35, halfway between the square and rounded entrance coefficient. The effective area option is input with the bounding cross sections.





After the data are entered, the Bridge/culvert editor shows the culverts and roadway along with the bounding cross-sectional data. Note the Effective area option is indicated by the green lines with vertical arrows in the display.

2. Start a new plan and run the model with the same flow and starting conditions applied to the geometry file with culverts. This will facilitate evaluation.

3. Evaluate the model results for completeness and accuracy. Make necessary corrections and run again until satisfied with the results. Then evaluate based on design criteria.

a. Does the maximum flow exceed the roadway? *The Culvert Summary Table shows the culvert solution for all profiles. It indicates a small amount of weir flow for the maximum flow.*

Profile Output Table - Culvert Only

File Options Std. Tables Locations Help

HEC-RAS Plan: culverts River: Napa Cr. Reach: Napa Cr. Reload Data

Reach	River Sta	Profile	E.G. US. (ft)	W.S. US. (ft)	E.G. IC (ft)	E.G. OC (ft)	Min El Weir Flow (ft)	Q Culv Group (cfs)	Q Weir (cfs)	Delta WS (ft)	Culv Vel US (ft/s)	Culv Vel DS (ft/s)
Napa Cr.	4100 Culvert #1	PF 1	26.28	25.90	25.70	26.28	34.51	2500.00		1.47	9.29	8.98
Napa Cr.	4100 Culvert #1	PF 2	29.62	29.09	28.91	29.62	34.51	4000.00		2.10	11.04	10.79
Napa Cr.	4100 Culvert #1	PF 3	35.19	34.53	34.88	35.19	34.51	6409.11	90.90	4.38	14.84	14.84

Upstream energy grade elevation at bridge or culvert (specific to that opening, not necessarily the weighted average).

b. Does the upstream water surface profile exceed the one-foot criterion? *The Four section culvert summary table will show the water surface calculations in the vicinity of the culvert. By requesting the two plans, one can see the differences between the two models. The water is about 1.8' higher at RS 4200.*

Profile Output Table - Four XS Culvert

File Options Std. Tables Locations Help

HEC-RAS River: Napa Cr. Reach: Napa Cr. Profile: PF 2 Reload Data

Reach	River Sta	Profile	Plan	E.G. Elev (ft)	W.S. Elev (ft)	Vel Head (ft)	Frctn Loss (ft)	C & E Loss (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Top Width (ft)
Napa Cr.	4200	PF 2	existing	28.68	26.95	1.73	0.19	0.31		4000.00		45.07
Napa Cr.	4200	PF 2	culverts	29.92	28.76	1.15	0.11	0.19		3999.90	0.10	52.60
Napa Cr.	4142	PF 2	existing	28.18	27.48	0.70	0.23	0.05		4000.00		63.18
Napa Cr.	4142	PF 2	culverts	29.62	29.09	0.53				4000.00		71.25
Napa Cr.	4042	PF 2	existing	27.90	27.05	0.85	0.11	0.00		4000.00		67.02
Napa Cr.	4042	PF 2	culverts	27.90	26.99	0.91	0.11	0.01		4000.00		66.87
Napa Cr.	4000	PF 2	existing	27.78	26.92	0.87	0.33	0.03		4000.00		60.22
Napa Cr.	4000	PF 2	culverts	27.78	26.92	0.87	0.33	0.03		4000.00		60.22

Energy gradeline for given WSEL.

c. Is the culvert solution based on inlet or outlet control?

The Culvert Table, shown under question a, displays inlet and outlet EG. The higher controls; therefore, the solutions are outlet control (E.G.US = E.G.OC) *for the first two profiles, and outlet control and weir flow for the third..*

d. Is the solution sensitive to the culvert Manning's n value or inlet condition?

Given the outlet control solution, the culvert n value, exit loss and entrance loss coefficients will affect the solution. The values could be easily changed to test the sensitivity of the solution to assumptions of coefficients.

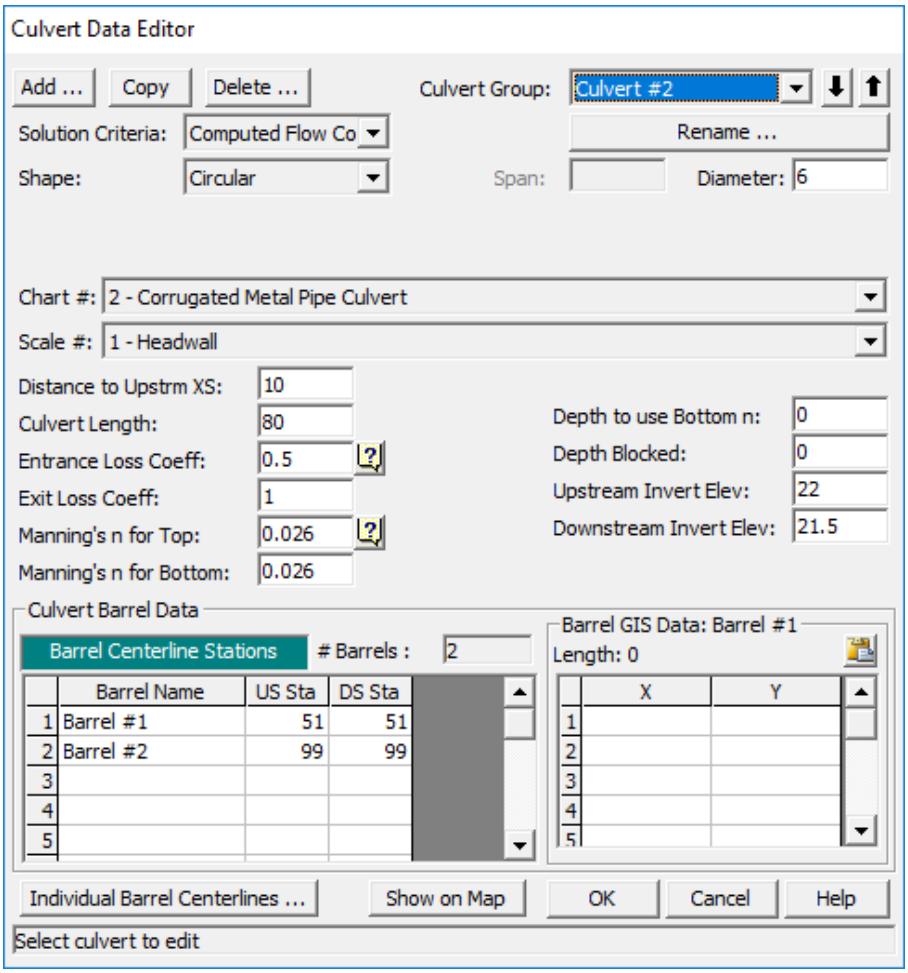
Part 2.

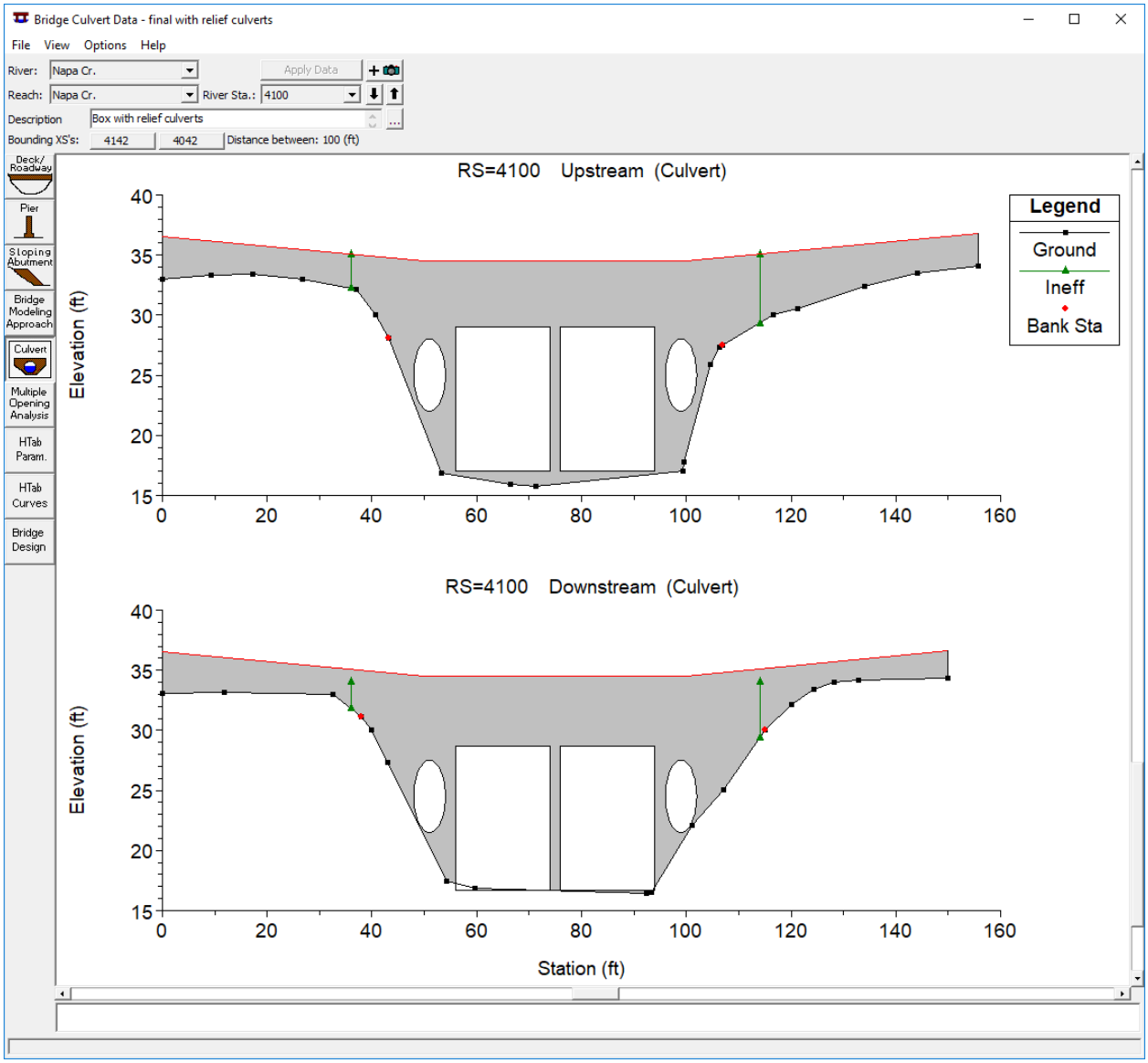
If after completing Part 1 you find that the design criteria are not met, a second option includes adding two corrugated metal culverts to provide added high-flow capacity. Add two 6 foot culverts, one on either side of the box culverts, so they fit within the natural cross section and increase high flow capacity sufficiently to meet the criteria. Assume the added culverts will fit into the 90 degree head wall. Culverts should have a slope of 0.5 feet over their 80 foot length.

Again, be sure to save the new geometry file and run under a new plan label to facilitate comparison between base conditions and the new model.

Were you able to meet requirements? Record the centerline stationing and invert elevations for your report.

The culvert data for Culvert group #2 are shown in the editor, adjacent figure. Also, the location of the effective area option was shifted to approximately 10 feet outside of the added culverts. Once the data are entered, the new culverts are displayed in the Bridge editor, as shown on the next page.





The model was run again with the new geometry. A review of the Culvert Only Table indicates the maximum flood produces a minor amount of weir flow.

Profile Output Table - Culvert Only

File Options Std. Tables Locations Help

HEC-RAS Plan: relief culv River: Napa Cr. Reach: Napa Cr. Profile: PF 3 | Reload Data

Reach	River Sta	Profile	E.G. US. (ft)	W.S. US. (ft)	E.G. IC (ft)	E.G. OC (ft)	Min El Weir Flow (ft)	Q Culv Group (cfs)	Q Weir (cfs)	Delta WS (ft)	Culv Vel US (ft/s)	Culv Vel DS (ft/s)
Napa Cr.	4100 Culvert #2	PF 3	34.62	34.01	30.43	34.64	34.51	603.00	5.06	3.64	10.66	10.66
Napa Cr.	4100 Culvert #1	PF 3	34.62	34.01	33.32	34.62	34.51	5891.95	5.06	3.64	13.64	13.64

Upstream energy grade elevation at bridge or culvert (specific to that opening, not necessarily the weighted average).

A review of the Culvert cross-section table (see next page) shows this model <u>does not meet design criteria.</u> The relief culverts significantly lower the maximum flood profile and the one-percent chance flood is approximately 1.2 feet (28.18-26.95~1.2) above the base profile at

section 4200. The only way to meet the one-foot rise criterion is to lower the losses (e.g., improved inlet) or increase culvert size. Additionally, the maximum profile is still overtopping the roadway. The profile plots, below, show the existing and final model results for the 1 percent chance event.

Profile Output Table - Four XS Culvert

File Options Std. Tables Locations Help

HEC-RAS River: Napa Cr. Reach: Napa Cr. Profile: PF 3 Reload Data

Reach	River Sta	Profile	Plan	E.G. Elev (ft)	W.S. Elev (ft)	Vel Head (ft)	Frctn Loss (ft)	C & E Loss (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Top Width (ft)
Napa Cr.	4200	PF 3	relief culv	34.85	33.74	1.10	0.08	0.15	83.24	6198.13	218.63	136.74
Napa Cr.	4200	PF 3	existing	32.31	29.92	2.39	0.20	0.41		6482.25	17.75	72.72
Napa Cr.	4142	PF 3	relief culv	34.62	34.01	0.61			28.48	6404.30	67.22	153.55
Napa Cr.	4142	PF 3	existing	31.70	30.69	1.01	0.23	0.02	3.55	6475.58	20.88	82.99
Napa Cr.	4100			Culvert								
Napa Cr.	4042	PF 3	relief culv	31.45	30.37	1.08	0.11	0.01		6500.00		76.68
Napa Cr.	4042	PF 3	existing	31.45	30.37	1.08	0.11	0.01		6499.95	0.05	76.70
Napa Cr.	4000	PF 3	relief culv	31.33	30.13	1.19	0.33	0.02	0.03	6499.97		70.80
Napa Cr.	4000	PF 3	existing	31.33	30.13	1.19	0.33	0.02	0.03	6499.97		70.81

Energy gradeline for given WSEL.