HYDRAULIC DATA REQUIREMENTS

Bridges

(updated February 2017)

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Typical Hydraulic Data Summary

Drainage Area
Q100
Elevation @ Q100
Backwater
Velocity @ Q100
Gross Waterway Opening Required Below Q100 Elevation (Structure)
Waterway Opening Over Road
Minimum Low Structure Elevation
Approximate Skew
Existing Waterway Opening Below Q100 Elevation (Structure)
Existing Waterway Opening Road
Existing Low Structure
Existing Backwater

Determining Drainage Area

- Digital Elevation Modeling (DEM)
- USGS Quadrangle Topographic Maps
- USGS Streamstats
- L-THIA (Purdue)
- Field Investigation
- Drainage Areas of Indiana Streams

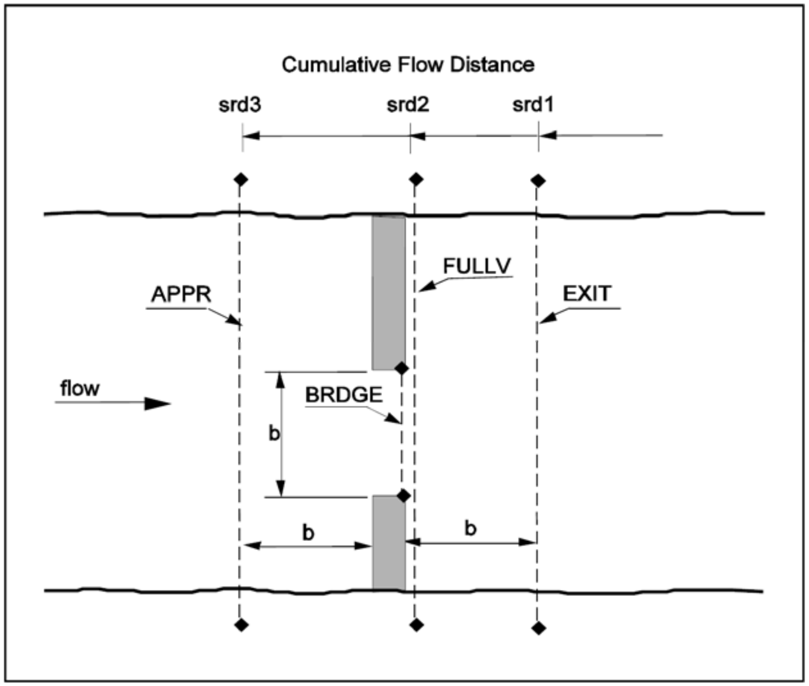
Determining Q100

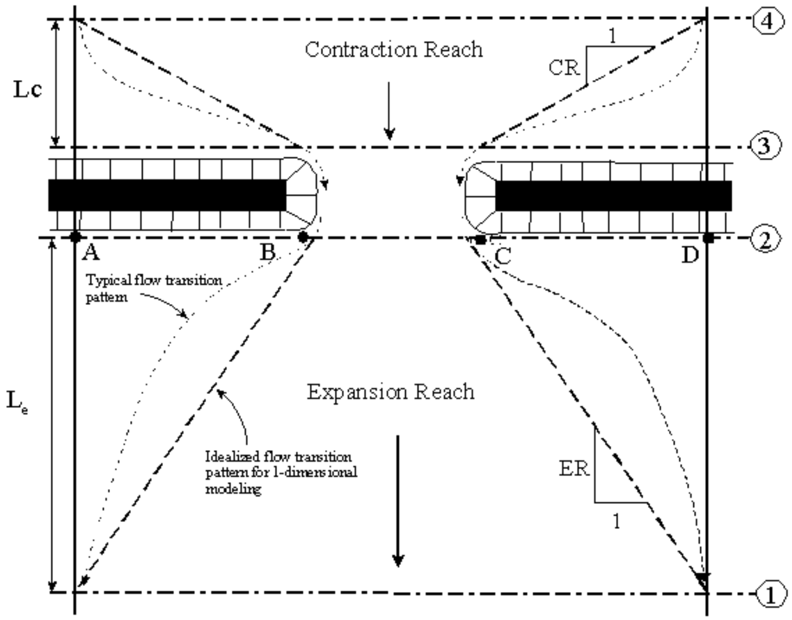
- Selection of Discharge Table (Figure 202-3A)
- IDNR Discharge Letter
- Coordinated Discharges
- Gage Stations
- Similar Streams
- TR-20
- StreamStats & Purdue Regression Equations
- IDNR Discharge Tool (used for evaluation only)

Determining Q100 Elevation

- Determined at the downstream bridge face location of natural conditions
- What is natural conditions?
  - A model removing water surface impacts from the bridge of interest
- Why downstream?
  - Consistent with past projects
  - Former modeling done in WSPRO

WSPRO vs HEC-RAS





Determining Q100 Elevation

River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev
			(cfs)	(ft)	(ft)	(ft)	(ft)
4	PF 1	Existing	1500.00	800.67	809.61		809.64
4	PF 1	Proposed	1500.00	800.67	809.13		809.16
4	PF 1	Natural	1500.00	800.67	808.27		808.34
3	PF 1	Existing	1500.00	800.47	809.57	806.71	809.59
3	PF 1	Proposed	1500.00	800.47	808.67	806.75	808.97
3	PF 1	Natural	1500.00	800.47	808.07		808.14
2.5			Bridge				
2	PF 1	Existing	1500.00	800.40	807.87	806.56	808.69
2	PF 1	Proposed	1500.00	800.40	807.99	806.66	808.53
2	PF 1	Natural	1500.00	800.40	808.00		808.07
1	PF 1	Existing	1500.00	800.00	807.60	806.32	807.67
1	PF 1	Proposed	1500.00	800.00	807.60	806.32	807.67
1	PF 1	Natural	1500.00	800.00	807.60	806.32	807.67

- For HEC-RAS, interpolate between cross-section #2 and #3 (natural conditions) to the downstream bridge face location
- May use cross-section #2 (natural conditions) if #2 is within 0.1 ft of cross-section #3 (natural conditions)

Determining Gross Waterway Opening of Bridge

- Should be determined from downstream bridge opening cross-section
- Should be based on previously determined Q100 Elevation
- Should include the area of the piers
- Determined from model output

Determining Gross Waterway Opening of Bridge

- HEC-RAS determines Net Waterway Opening, so adjustments have to be made for it to become Gross Waterway.

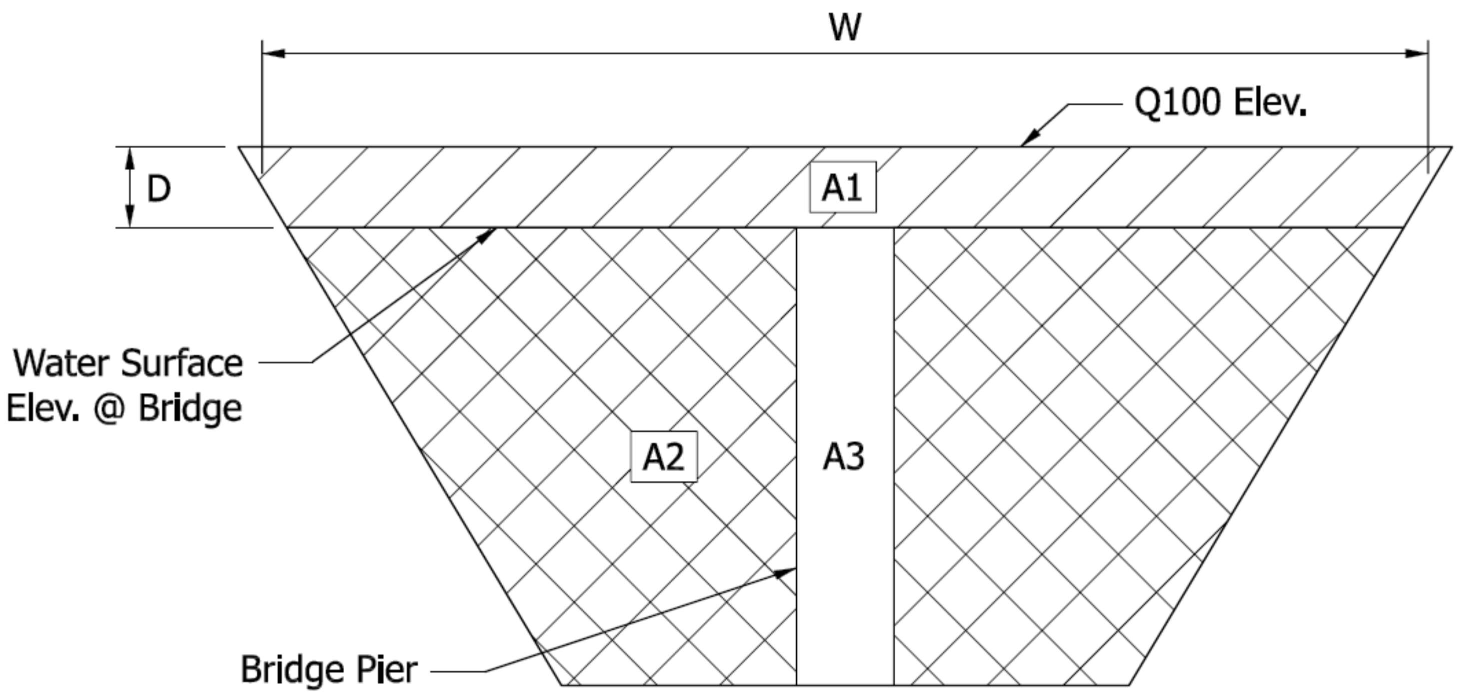
- Why not just use Net Waterway?
  - WSPRO used Gross Waterway
  - Stay consistent with past projects

Determining Gross Waterway Opening of Bridge (HEC-RAS)

E.G. US. (ft)	808.97	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	808.67	E.G. Elev (ft)	808.86	808.72
Q Total (cfs)	1500.00	W.S. Elev (ft)	808.02	807.83
Q Bridge (cfs)	1500.00	Crit W.S. (ft)	806.65	806.57
Q Weir (cfs)		Max Chl Dpth (ft)	7.55	7.43
Weir Sta Lft (ft)		Vel Total (ft/s)	6.84	7.06
Weir Sta Rgt (ft)		Flow Area (sq ft)	219.42	212.45
Weir Submerg		Froude # Chl	0.64	0.68
Weir Max Depth (ft)		Specif Force (cu ft)	946.34	930.34
Min El Weir Flow (ft)	812.01	Hydr Depth (ft)	4.20	4.13
Min El Prs (ft)	810.00	W.P. Total (ft)	76.72	75.04
Delta EG (ft)	0.44	Conv. Total (cfs)	23170.1	22304.7
Delta WS (ft)	0.69	Top Width (ft)	52.19	51.44
BR Open Area (sq ft)	330.55	Frctn Loss (ft)	0.13	0.09
BR Open Vel (ft/s)	7.06	C & E Loss (ft)	0.01	0.11
Coef of Q		Shear Total (lb/sq ft)	0.75	0.80
Br Sel Method	Energy only	Power Total (lb/ft s)	5.12	5.64

- Start with Flow Area of downstream bridge
- Add the Pier Area from the ground to waterway surface elevation of the bridge
- Add or subtract water surface elevation difference between Q100 elevation and bridge, multiplied by the water surface width at the bridge

Determining Gross Waterway Opening of Bridge (HEC-RAS)



A1 + A2 + A3 = Gross Waterway Area

Determining Road Overflow (HEC-RAS)

METHODS

- Subtract out appropriate bridge area from the total flow area given in the bridge output or
- Determine Weir Flow Area over the road
- May also figure out graphically

- Exact value is not critical to design
- Stay consistent with chosen method for both existing and proposed conditions

Determining Road Overflow (HEC-RAS)

E.G. US. (ft)	816.92	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	816.77	E.G. Elev (ft)	816.92	816.92
Q Total (cfs)	1850.00	W.S. Elev (ft)	816.77	816.77
Q Bridge (cfs)	1827.87	Crit W.S. (ft)	811.82	811.82
Q Weir (cfs)	21.93	Max Chl Dpth (ft)	9.87	9.87
Weir Sta Lft (ft)	-250.03	Vel Total (ft/s)	8.04	8.04
Weir Sta Rgt (ft)	150.03	Flow Area (sq ft)	230.02	230.02
Weir Submerg	0.00	Froude # Chl	0.51	0.51
Weir Max Depth (ft)	0.14	Specif Force (cu ft)	1839.70	1839.70
Min El Weir Flow (ft)	816.79	Hydr Depth (ft)		
Min El Prs (ft)	814.02	W.P. Total (ft)	72.34	72.34
Delta EG (ft)	1.70	Conv. Total (cfs)		
Delta WS (ft)	1.80	Top Width (ft)		
BR Open Area (sq ft)	203.60	Frctn Loss (ft)		
BR Open Vel (ft/s)	8.98	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)		
Br Sel Method	Press/Weir	Power Total (lb/ft s)	-700.00	-700.00

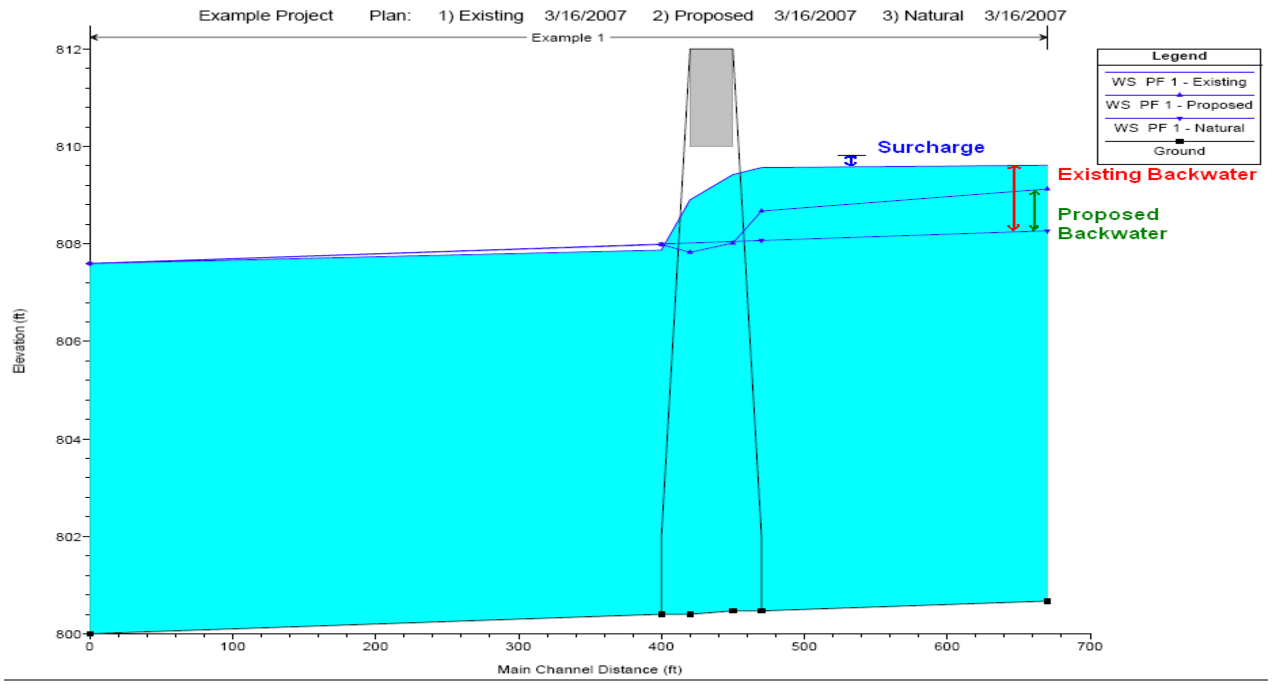
- When bridge is submerged, BR Open Area is the same as the Net Bridge Waterway Opening
- Flow Area includes all net flow through bridge and over the roadway
- Simply subtract the two, to get the Road Overflow Area

Determining Road Overflow (HEC-RAS)

- Choose "Bridge Only" option from Standard Tables
- Add "Weir Flow Area" column from Define Tables option
- Use Weir Flow Area data from Profile Output Table

River Sta	Profile	E.G. US.	Min El Prs	BR Open Area	Prs O WS	Q Total	Min El Weir Flow	Q Weir	Delta EG	Weir Flow Area
		(ft)	(ft)	(sq ft)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(sq ft)
310	Q 10	590.43	590.00	212.55	590.19	1120.00	592.01		0.11	
310	Q 100	593.75	590.00	212.55		2800.00	592.01	732.56	1.06	212.06
310	Q 500	595.86	590.00	212.55		4760.00	592.01	2404.89	1.12	470.41

Backwater and Surcharge



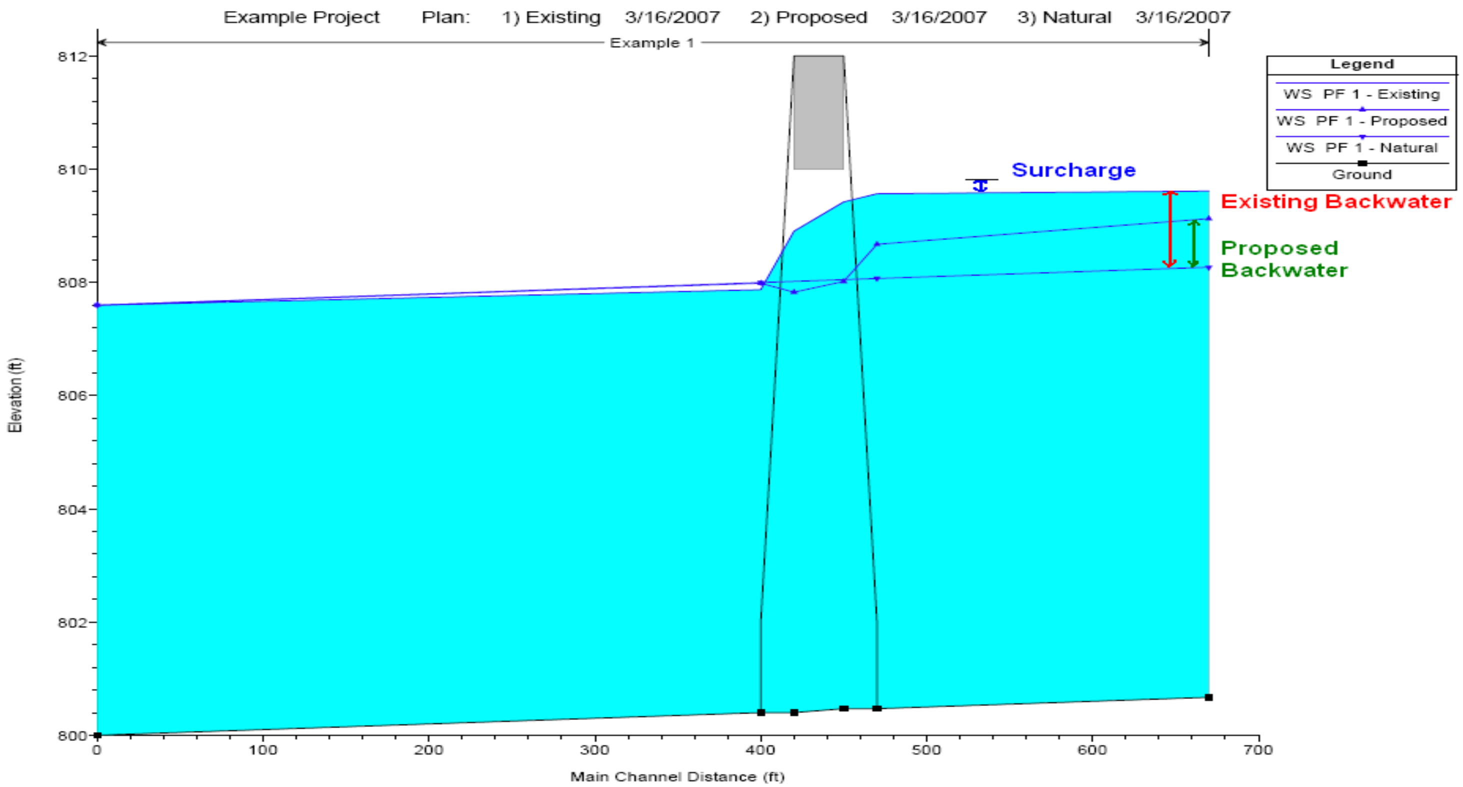
- Backwater is the difference between the water surface elevation upstream caused by the bridge and the natural water surface elevation (no bridge of interest)
- Surcharge is the increase in water surface elevation over existing conditions

Determining Backwater

- IDNR is mostly concerned with the effects of proposed condition verses existing (surcharge)

- INDOT is concerned with the same plus the effects compared to natural conditions (no bridge of interest)

Backwater and Surcharge



- Use cross-section with highest proposed backwater for calculation of both existing and proposed

Determining Backwater

- If existing structure creates backwater > 1.0 ft., the proposed structure must have backwater equal to or less than 1.0 ft.

- If existing structure creates backwater < 1.0 ft., the proposed structure must be equal to or less than existing backwater except...

- If existing structure creates backwater < 0.14 ft., the proposed structure may have backwater up to 0.14 ft.

- For new road alignment, the proposed bridge must have surcharge no greater than 0.14 ft.

Determining Backwater (HEC-RAS)

River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev
			(cfs)	(ft)	(ft)
4	PF 1	Existing	1500.00	800.67	809.61
4	PF 1	Proposed	1500.00	800.67	809.13
4	PF 1	Natural	1500.00	800.67	808.27
3	PF 1	Existing	1500.00	800.47	809.57
3	PF 1	Proposed	1500.00	800.47	808.67
3	PF 1	Natural	1500.00	800.47	808.07
2.5			Bridge		
2	PF 1	Existing	1500.00	800.40	807.87
2	PF 1	Proposed	1500.00	800.40	807.99
2	PF 1	Natural	1500.00	800.40	808.00
1	PF 1	Existing	1500.00	800.00	807.60
1	PF 1	Proposed	1500.00	800.00	807.60
1	PF 1	Natural	1500.00	800.00	807.60

- Exist BW = 809.61-808.27= 1.34 ft.
- Prop BW = 809.13-808.27= 0.86 ft.

Determining Outlet Velocity (HEC-RAS)

Plan: Proposed Example 1 RS: 2.5 Profile: PF 1

E.G. US. (ft)	808.97	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	808.67	E.G. Elev (ft)	808.86	808.72
Q Total (cfs)	1500.00	W.S. Elev (ft)	808.02	807.83
Q Bridge (cfs)	1500.00	Crit W.S. (ft)	806.65	806.57
Q Weir (cfs)		Max Chl Dpth (ft)	7.55	7.43
Weir Sta Lft (ft)		Vel Total (ft/s)	6.84	7.06
Weir Sta Rgt (ft)		Flow Area (sq ft)	219.42	212.45
Weir Submerg		Froude # Chl	0.64	0.68
Weir Max Depth (ft)		Specif Force (cu ft)	946.34	930.34
Min El Weir Flow (ft)	812.01	Hydr Depth (ft)	4.20	4.13
Min El Prs (ft)	810.00	W.P. Total (ft)	76.72	75.04
Delta EG (ft)	0.44	Conv. Total (cfs)	23170.1	22304.7
Delta WS (ft)	0.69	Top Width (ft)	52.19	51.44
BR Open Area (sq ft)	330.55	Frctn Loss (ft)	0.13	0.09
BR Open Vel (ft/s)	7.06	C & E Loss (ft)	0.01	0.11
Coef of Q		Shear Total (lb/sq ft)	0.75	0.80
Br Sel Method	Energy only	Power Total (lb/ft s)	5.12	5.64

- Use Velocity Total on the downstream side.
- Do not use the Continuity Equation

Riprap Sizing (Figure 203-2D)

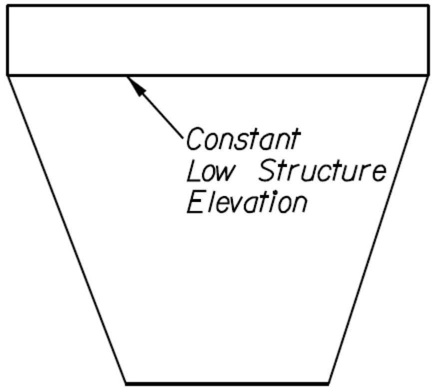
- Riprap size will be based on outlet velocity
- Riprap protection should be shown on plans sent for hydraulic review
- Upgrade one riprap size for scour protection on an outside bend

Outlet velocity	**Riprap size**
< 6.5 ft/s	Revetment
6.5 ft/s to 10 ft/s	Class 1
10 ft/s to 13 ft/s	Class 2

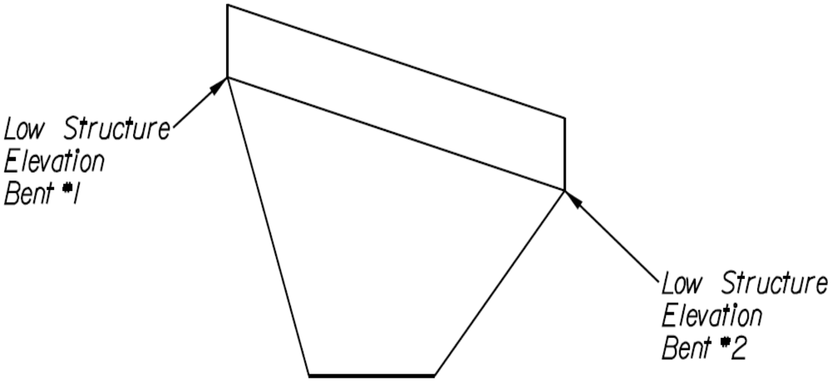
Determining Low Structure Elevation

- It is desired to have at least 2.0 ft. of structure freeboard over Q100 Elevation
- Exceptions are case by case
- Low structure elevation given in data will be determined by bridge geometry shape

Determining Low Structure Elevation

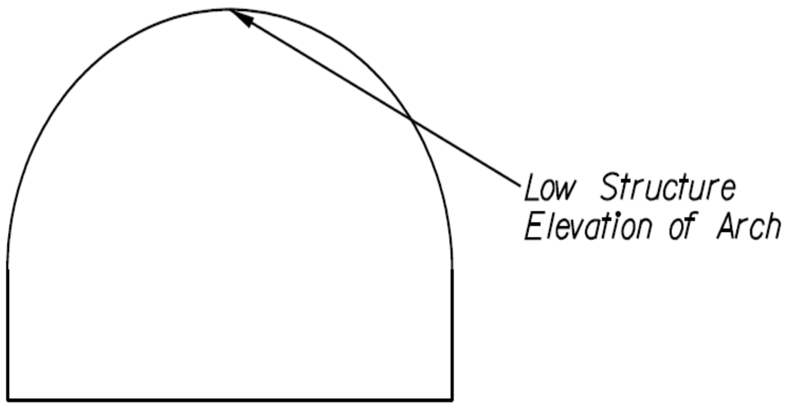


- A flat deck should give the low structure elevation that is constant across the bottom



- A deck on a grade should give low structure elevations for both end bents.

Determining Low Structure Elevation



- Low structure elevation of an arch structure should be given at the highest point of the arch

Determining Skew

- More important to be lined up with the stream on the inlet than the outlet
- Compromises may be needed on severe bends
- Make sure calculated waterway opening is normal to the direction of flow
- Areas change very little on skews less than 15 degrees

SCOUR DATA REQUIREMENTS

New Bridges

Typical Scour Data Summary

Q100 Discharge
Elevation @ Q100
Velocity @ Q100
Contraction Scour Depth
Total Scour Depth
Low Scour Elevation

Q500 Discharge
Elevation @ Q500
Velocity @ Q500
Contraction Scour Depth
Total Scour Depth
Low Scour Elevation

Flowline Elevation

Determining Scour Data

- Compute Scour for new bridges using both the Q100 & Q500 Discharge

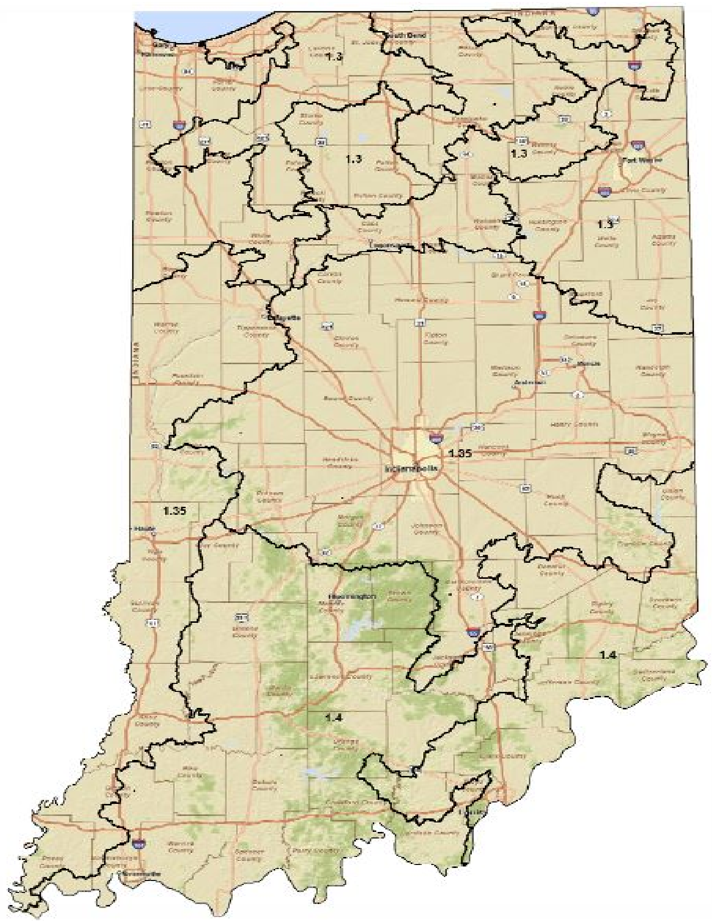
- Q100 & Q100 Elevation previously determined during the hydraulics bridge design

Determining Q500

- Q500 determined by the following options: (see IDM 202-3.03 for more information)
  - From a FEMA Flood Insurance Study (FIS)
  - Derived from a Discharge Curve
  - Using a Indiana State Map multiplier (Figure 202-3C)
  - Do not use the 1.7 multiplier anymore

- Q500 Elevation is determined by running model using Q500 storm event and using cross-section #2 (natural conditions) water surface elevation or interpolate to downstream face of the bridge

Determining Q500



REGIONAL MULTIPLIERS FOR DETERMINATION OF 0.2% ANNUAL EP

Figure 202-3C

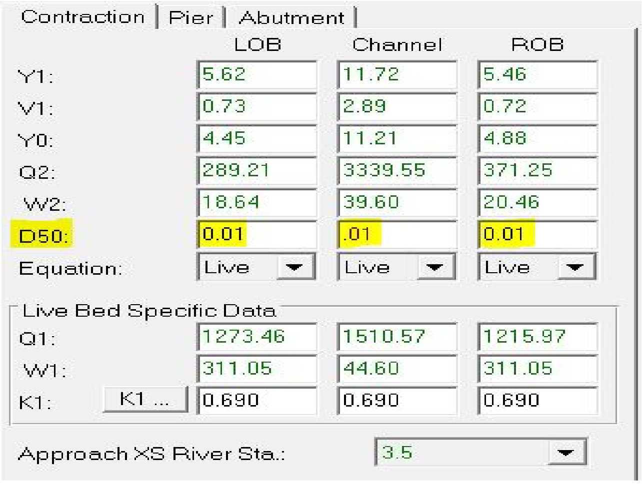
Determining Maximum Velocity(HEC-RAS)

Plan: PropBrFW9-26 RIVER-1 Reach-1 RS: 35.71 BR U Profile: Design

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)
1	LOB	1131.03	1172.60	40.89	29.75	25.92	0.31	1.87	1.37
2	LOB	1172.60	1214.17	681.28	194.61	41.72	5.24	4.68	3.50
3	LOB	1214.17	1255.74	579.14	188.42	49.09	4.45	4.76	3.07
4	Chan	1255.74	1264.05	207.86	47.57	8.53	1.60	5.72	4.37
5	Chan	1264.05	1272.37	409.31	74.24	9.40	3.15	8.93	5.51
6	Chan	1272.37	1280.68	629.27	91.55	8.32	4.84	11.01	6.87
7	Chan	1280.68	1288.99	667.81	94.87	8.32	5.14	11.41	7.04
8	Chan	1288.99	1297.31	699.85	97.55	8.32	5.38	11.73	7.17
9	Chan	1297.31	1305.62	189.54	74.26	29.84	1.46	11.76	2.55
10	Chan	1305.62	1313.93	702.84	97.78	8.31	5.41	11.76	7.19
11	Chan	1313.93	1322.25	702.85	97.79	8.31	5.41	11.76	7.19
12	Chan	1322.25	1330.56	702.84	97.78	8.31	5.41	11.76	7.19
13	Chan	1330.56	1338.88	702.85	97.79	8.31	5.41	11.76	7.19
14	Chan	1338.88	1347.19	702.85	97.79	8.31	5.41	11.76	7.19
15	Chan	1347.19	1355.50	695.43	97.20	8.32	5.35	11.69	7.15
16	Chan	1355.50	1363.82	653.04	93.63	8.33	5.02	11.26	6.97
17	Chan	1363.82	1372.13	588.77	88.38	8.42	4.53	10.63	6.66
18	Chan	1372.13	1380.44	435.84	74.18	8.53	3.35	8.92	5.88

- Cross-section Tables>Type>Flow Distribution in Cross-sections
- Find maximum velocity for both 100 & 500-yr storms from the velocity distribution output
- Look at upstream and downstream bridge face locations

Contraction Scour Input Variables (HEC-RAS)



- Insert D50 based on soil boring or geotechnical report, otherwise use small value (that produces a K1 of 0.69)

- Do not use less than 0.01 for D50 as HEC-RAS will consider it 0 and there will be no scour in the output

Contraction Scour Input Variables (HEC-RAS)

Contraction | Pier | Abutment

	LOB	Channel	ROB
Y1:	5.62	11.72	5.46
V1:	0.73	2.89	0.72
Y0:			
Q2:	289.21	3339.55	371.25
W2:			
D50:	0.01	.01	0.01
Equation:	Live	Live	Live

Live Bed Specific Data

	LOB	Channel	ROB
Q1:	1273.46	1510.57	1215.97
W1:	311.05	44.60	311.05
K1: (K1 ...)	0.690	0.690	0.690

Approach XS River Sta.: 3.5

- If bridge is submerged, HEC-RAS may leave these cells blank
- Fill in cells with appropriate bridge dimensions

Contraction Scour Input Variables (HEC-RAS)

Contraction | Pier | Abutment

	LOB	Channel	ROB
Y1:	5.62	11.72	5.46
V1:	0.73	2.89	0.72
Y0:	4.45	11.21	4.88
Q2:	289.21	3339.55	371.25
W2:	18.64	39.60	20.46
D50:	0.01	0.01	0.01
Equation:	Live	Live	Live

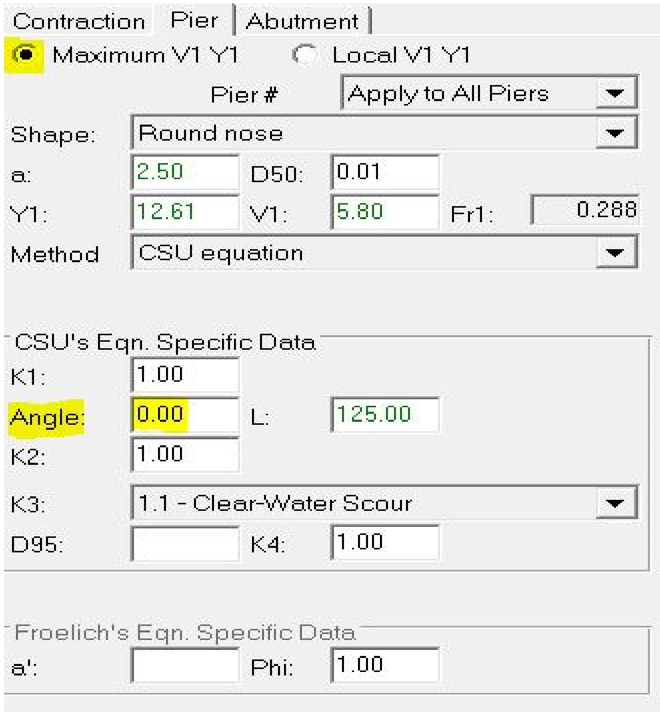
Live Bed Specific Data

	LOB	Channel	ROB
Q1:	1273.46	1510.57	1215.97
W1:	311.05	44.60	311.05
K1: (K1 ...)	0.690	0.690	0.690

Approach XS River Sta.: 3.5

- Approach section should be the first one upstream of the bridge that is fully expanded (no ineffective flow)

Pier Scour Input Variables (HEC-RAS)



- Choose Maximum (flow) button for velocity to be used in pier scour calculation
- Usually no angle should be needed with new bridges
- Angle may be needed for rehab bridges

Determining Contraction Scour & Pier Scour (HEC-RAS)

Contraction Scour			
	Left	Channel	Right
Ys (ft):	6.55	13.90	8.04
Vc (ft/s):			
Equation:	Live	Live	Live
Pier Scour			
All Piers:	Ys (ft):	5.67	
	Froude #:	0.29	

- Values come straight from scour output

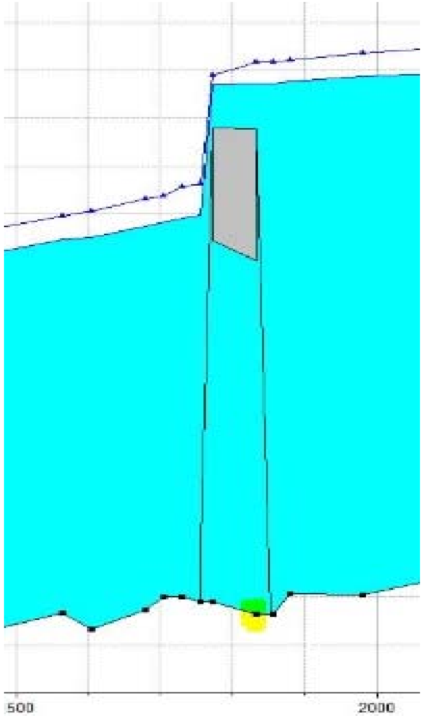
Total Scour (HEC-RAS)

Combined Scour Depths

Pier Scour + Contraction Scour (ft):
Channel: 19.57

- Total Scour = Contraction + Pier Scour
- Subtract total scour from flowline elevation to determine low scour elevation

Flowline Elevation (HEC-RAS)



- Flowline used for scour should be based on the lowest elevation through the bridge

Modeling Scour with Road Overflow

- With road overflow, maximum scour may occur at a lower storm event
- Check scour when water surface is just about to overtop to see if scour values are higher

SCOUR DATA REQUIREMENTS

Rehabilitation Bridges

Scour Data for Rehab Bridges

- Scour data needed only for 100-year storm unless foundation is changed
- Include bottom of foundation elevations

The End