

DRAINAGE DESIGN MANAGEMENT SYSTEM FOR WINDOWS VERSION 5.6.0

Tutorial # 21 Pressure Flow Scour Analysis HEC-18 Procedure



KVL Consultants, Inc.

PRESSURE FLOW SCOUR ANALYSIS (HEC-18 PROCEDURE)

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1.0 PROBLEM STATEMENT

A pressure flow scour depth under the bridge inundation conditions is computed using equation developed by FHWA (2012). Based on the transport of bed material, there are two conditions for pressure flow scour: live-bed condition and clear-water condition. A typical bridge inundation flow is shown below.

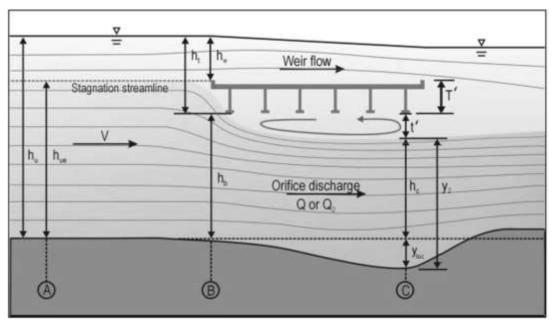


Figure 1: Vertical contraction under the bridge (FHWA, 2012)

2.0 PRESSURE FLOW SCOUR FOR LIVE-BED CONDITION

To estimate the pressure flow scour using HEC-18 procedure use the following given conditions:

- The Cross Section "BRIDGE_SEC"
 - Parameters for Hydraulics and Geometry:

 Design Flow Rate (cfs): 	600
 Dominant Flow Rates (cfs): 	800
 Channel Slope for Design Flow (ft/ft): 	0.005
Channel Slope for Dominant Flow (ft/ft):	0.005
Channel Manning's n for Design Flow:	0.035
 LOB Manning's n for Design Flow: 	0.035
ROB Manning's n for Design Flow:	0.035
Channel Manning's n for Dominant Flow:	0.035
LOB Manning's n for Dominant Flow:	0.035
ROB Manning's n for Dominant Flow:	0.035

Station (X)	Elevation (Y)	Notes
0	30	
5	23	Left Bank Station
10	12	
15	11	
18	14	
22	22	Right Bank Station
25	30	

• The geometric data (station and elevation) of the cross section:

The Cross Section "UPSTREAM_SEC"

Parameters for Hydraulics and Geometry:

•	Design Flow Rate (cfs):	900
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- Channel Slope for Design Flow (ft/ft): 0.012
- Channel Manning's n for Design Flow: 0.040
- LOB Manning's n for Design Flow: 0.040
- ROB Manning's n for Design Flow: 0.040
- The geometric data (station and elevation) of the cross section:

Station (X)	Elevation (Y)	Notes
0	25	
6	18	Left Bank Station
8	16	
14	13	
22	14	
28	18	Right Bank Station
35	19	
41	25	

- Parameters for *live-bed condition and non-overtopping case calculation*:
 - Particle size D₅₀ (ft): 20.00
 - Bottom width of upstream channel, W₁ (ft): 210.00
 - Bottom width of contraction less piers, W₂ (ft): 40.00
 - Vertical size of the bridge opening, h_b (ft): 3.00
 - Height of the obstruction, T (ft): 0.50

2.1 Step-by-Step Procedures

- Step 1: Establish a New River Mechanics Project and Defaults Set-up
- Step 2: Prepare cross section hydraulics data
- Step 3: Calculate Pressure Flow Scour
- Step 4: Report and Document the results

2.1.1 Step 1 - Establish a New Project and Defaults Set-up

(a) Click the **DDMSW** icon on the Desktop or Program menu to launch the **DDMSW**. Click the **OK** button to accept the software disclaimer as shown in the following figure.



After the **DDMSW** is launched, the **SELECT PROJECT** window is automatically opened as shown in the following figure.

	List		Dețulis	
Look for				
Reference +	Date	10	Title	7
BANKPROTECTIONFCD	01/01/2012	00049	River Mechanics Example - Bank Protection	T
BRIDGEPIERFCD	01/01/2012	00011	River Mechanics Example - Bridge Pier	1
EXAMPLE1	01/01/2010	00001	Clark, Green Ampt, Single, 6 Hour	1
EXAMPLE2	01/01/2010	00002	S-Graph, Green-Ampt, Single, 24 Hour	1
EXAMPLE3	01/01/2010	00003	S-Graph, Green-Ampt, Multiple, 6 Hour	1
EXAMPLE4	01/01/2010	00004	Clark, Init and Uniform, Single, 6 Hour	1
KVLEXAMPLE1	01/01/2011	00005	Example 1 HEC-1 tutorial project	11
KVLEXAMPLE10	01/10/2014	00025	HEC-1 Tutorial - Import HEC-1 File	1
KVLEXAMPLE11	01/10/2014	00029	FCDMC Hydraulics Manual Design Example 4.6	1
KVLEXAMPLE12	01/10/2014	00030	Street Drainage Example	l
KVLEXAMPLE2	01/01/2011	00021	Example 2 using Shape flies and NOAA 14	U
KVLEXAMPLE3	01/01/2011	00024	Example 3 Rational Method tutorial project	
KVLEXAMPLE5	01/01/2011	00017	HEC-1 Tutorial - Clark Unit Hydrograph	
KVLEXAMPLE6	01/01/2011	00018	HEC-1 Tutonal - S-Graph Unit Hydrograph	
KVLEXAMPLE7	01/01/2011	00019	Rational Method Tutorial	1
KVLEXAMPLEB	01/01/2011	00820	Street Drainage Examples	1
·	Rf.		- A second s	

- (b) Click the Add button on the SELECT PROJECT window to start a new project (Or File → New Project → Add).
- (c) Select **River Mechanics** checkbox and click the **OK** button on the **New Project Options** form.
- (d) Type "*PRESSURE_SCOUR*" into the **Reference** textbox. This is the name of this newly created project. Users can choose any name for the Reference textbox as long as it does not exist in the current **DDMSW** project database.
- (e) Type into the **Title** textbox a brief descriptive title for this project. (Optional)
- (f) Type into the Location textbox the location of this project. (Optional)
- (g) Type into the **Agency** textbox the agency or company name. (Optional)
- (h) Check **River Mechanics Only** checkbox for this project.
- (i) Type a detailed description of this project into the comment area under the **Project Reference** frame. *(Optional)*
- (j) Set the Modification Date using today's date by clicking on the Calendar icon.
- (k) Click the **Save** button to save the entered data.
- (I) Click the **OK** button on the **SELECT PROJECT** window, and click the **OK** button on the pop-up message box. The following figure shows what the window looks like.

Select Project	t					
	List	D	e <u>t</u> ails			
Project R	eference	Project D	efaults			
Project ID	00060 Reference PRESSURE_SCOUR					
Title	Pressure Flow Scour using HEC-18 Procedure	S	oils FCDMC			
Location	Maricopa County, Arizona	Land	Jse FCDMC	\sim		
Agency	Flood Control District of Maricopa County					
	River Mechanics Only					
This is a tutorial project about the guide bank scour using HEC-18 rocedure.						
Modificatio	n Date 05/15/2018	P <u>r</u> int	<u>D</u> elete <u>A</u> dd	<u>0</u> K		

Note: the **Project ID** "00060" in the above figure is the unique database record identifier for the project, which is automatically generated by the program when a new project is created. When users create a new project, the **Project ID** of the new project will not be the same as the **Project ID** shown in the above figure.

2.1.2 Step 2 - Prepare cross section hydraulics Data

From the menu bar of main application window, click **River Mechanics → Cross Section** Hydraulics, to open **River Mechanics – Cross Section Hydraulics** form.

🛃 Flood Co	ontrol District of Maricopa County Version: 5.6.0 - PRESSURE	_SCOUR
File Edit	River Mechanics Help	
00	Scour	
	<u>R</u> iprap	
	Launchable Riprap	
	La <u>t</u> eral Erosion	
	Sediment Yield	
	<u>C</u> ross Section Hydraulics	
	Cross Section <u>G</u> eometry	
	Import Cross Sections from Another Project	

2.1.2.1 Entering Data for "BRIDGE_SEC" cross section

- (a) Type "*BRIDGE_SEC*" into the blue textbox inside **Section ID** frame.
- (b) Check both **Design** and **Dominant** check boxes.
- (c) Enter $= 0^{"}$ into the **Flow Rate (cfs)** textbox under **Design** check box column.
- (d) Enter "=" into the **Flow Rate (cfs)** textbox under **Dominant** check box column.
- (e) Enter "0.005" into the **Slope (ft/ft)** textbox under **Design** check box column.
- (f) Enter "0.005" into the **Slope (ft/ft)** textbox under **Dominant** check box column.
- (g) Enter "0.035" into Manning's n Channel textbox under Design check box column.
- (h) Enter "0.035" into Manning's n LOB textbox under Design check box column.
- (i) Enter "0.035" into Manning's n ROB textbox under Design check box column.
- (j) Enter "0.035" into Manning's n Channel textbox under Dominant check box column.
- (k) Enter "0.035" into Manning's n LOB textbox under Dominant check box column.
- (I) Enter "0.035" into Manning's n ROB textbox under Dominant check box column.
- (m) Click the **Save** button to save the entered data.
- (n) Click on "<u>X</u> Section" button <u>Section</u> at the bottom to enter x and y ordinates for channel cross section.
- (0) Enter first X and Y values (X: 0 and Y: 25) from the following table in X (ft) and Y (ft) text box of "Natural Cross Sections – Edit" window. After entering the data click on "Save & Add Record" button. Now enter all values of X and Y from following table.

Station (X)	Elevation (Y)	Notes
0	30	
5	23	Left Bank Station
10	12	
15	11	
18	14	
22	22	Right Bank Station
25	30	

- (p) After entering all X and Y values set left and right over bank by selecting the row with X value of "5" on X and Y table on the left and then clicking a "Selection" button next to left text box in "Natural Cross Sections" window to set left over bank and by selecting the row with X value of "22" and then clicking a "Selection" button next to right text box in "Natural Cross Sections" window to set right over bank
- (q) Once all X and Y values are entered along with LOB and ROB station, the "Natural Cross Sections" window should look like following:

Natural Cross Sections		
X ▲ Y 0.00 30.00 5.00 23.00 10.00 12.00 15.00 11.00 18.00 14.00 22.00 22.00 25.00 30.00	Overbank Left 5.00 2 Right 22.00 2	33.00 30.00 24.00 24.00 15.00 9.00 -6 -3 0 3 6 9 12 15 18 21 24 27 30 33
	Adjustments Elevation Adjustment (ft)	Cross Section ID BRIDGE_SEC X (ft) 25.00 Y (ft) 30.00 Save & Add Record
Overbank		Print Delete Add OK

- (r) Click on "OK" button to close the "Natural Cross Sections" window.
- (s) Click on "Update" button to update the hydraulics for the "BRIDGE_SEC".
- (t) After the update is complete, the *"River Mechanics Cross Section Hydraulics"* window should look like the following:

River Mechanics - Cross Section Hydraulics								
BRIDGE_SEC		Source		ata 💌	V D	esign	Dominant	
		Total Scour	FI	ow Rate (cf	s)	2400	2600]
Cross Section ID 🔺	-			Slope (ft/	/ft) 0.0	05000	0.005000	
BRIDGE_SEC			Manning	g's n Chann	el	0.035	0.035	Man's n
			Mar	nning's n LC	в	0.035	0.035	
			Man	ning's n RC	в	0.035	0.035	1
	=		Flo	w Area (sq	ft)	227.00	240.17	
	- 11		Wetted	Perimeter ((ft)	44.50	45.22	1
			Aver	age Width ((ft)	13.72	14.02	1
				Top Width ((ft)	22.33	22.96	1
	-		Hydra	ulic Depth ((ft)	10.17	10.46	1
	-		Normal or	Max Depth ((ft)	16.55	17.13	1
4			V	elocity (ft/se	c)	10.57	10.83	
	*							
Info Print	Copy	Delete	Add	Graph	X Section	Detai	I Update	<u>о</u> к

2.1.2.2 Entering Data for "UPSTREAM_SEC" cross section

- (a) Now click on "Add" button in "River Mechanics Cross Section Hydraulics" window to add data for "UPSTREAM_SEC".
- (b) Type "UPSTREAM_SEC" into the blue textbox inside Section ID frame.
- (c) Check both **Design** check box only.
- (d) Enter "="" into the **Flow Rate (cfs)** textbox under **Design** check box column.
- (e) Enter "0.012" into the **Slope (ft/ft)** textbox under **Design** check box column.
- (f) Enter "0.040" into Manning's n Channel textbox under Design check box column.
- (g) Enter "0.040" into Manning's n LOB textbox under Design check box column.
- (h) Enter "0.040" into Manning's n ROB textbox under Design check box column.
- (i) Click the **Save** button to save the entered data.
- (j) Click on "<u>X</u> Section" button <u>Section</u> at the bottom to enter x and y ordinates for channel cross section.
- (k) Enter first X and Y values (X: 0 and Y: 25) from the following table in X (ft) and Y (ft) text box of "Natural Cross Sections – Edit" window. After entering the data click on "Save & Add Record" button. Now enter all values of X and Y from following table.

Station (X)	Elevation (Y)	Notes
0	25	
6	18	Left Bank Station
8	16	
14	13	
22	14	
28	18	Right Bank Station
35	19	
41	25	

(I) After entering all X and Y values set left and right over bank by selecting the row with X value of "6" on X and Y table on the left and then clicking a "Selection" button next to left text box in "Natural Cross Sections" window to set left over bank and by selecting

the row with X value of "28" and then clicking a "Selection" button next to right text box in "Natural Cross Sections" window to set right over bank

(m) Once all X and Y values are entered along with LOB and ROB station, the "Natural Cross Sections" window should look like following:

Natural Cross Sections		
X ▲ Y 0.00 25.00 6.00 18.00 8.00 16.00 14.00 13.00 22.00 14.00 28.00 18.00 35.00 19.00 41.00 25.00	Overbank Left 6.00 20 Right 28.00 20 Graph current record Adjustments Elevation Adjustment (ft)	28.00 m
Overbank		Print Delete Add OK

- (n) Click on "OK" button to close the "Natural Cross Sections" window.
- (o) Click on "Update" button to update the hydraulics for the "BRIDGE_SEC".
- (p) After the update is complete, the *"River Mechanics Cross Section Hydraulics"* window should look like the following:

Section ID		Entire Cross	Section —					
UPSTREAM_SEC		Source	Calculate D	ata	-	🔽 Design	Dominant	
		Total Scour	F F	low Rate	(cfs)	3800]	
Cross Section ID A	*			Slope	(ft/ft)	0.012000		
BRIDGE_SEC			Mannin	g's n Cha	annel	0.040		Man's n
UPSTREAM_SEC	_			- nning's n		0.040		
	-			nning's n		0.040		
				ow Area (262.46		
	-1			Perimet		46.37		
	- 11			rage Wid		24.25		
	Ξ			Top Wid		38.81		
			Hydra	aulic Dep		6.76		
	- 11		Normal or			10.82		
	-			/elocity (ft		14.48		
٠				elocity (it	isec)	14.40		
	-							
Info Print	Cop	y Delete	Add	Graph		ection Deta	il <u>U</u> pdate	<u>0</u> K

2.1.3 Step 3 - Calculate the Pressure Flow Scour

(a) From the menu bar of main application window, click **River Mechanics → Scour**, to open the **Total Scour** form.

ile Edit	River Mechanics Help	_
00	<u>S</u> cour	1
	<u>R</u> iprap	
	Launchable Riprap	
	Lateral Erosion	
	Sediment Yield	
	Cross Section Hydraulics	1
	Cross Section <u>G</u> eometry	
	Import Cross Sections from Another Project	

List	<u>T</u> otal	Long T <u>e</u> rm	<u>G</u> eneral	L <u>o</u> cal	<u>B</u> edfor	m Lo	w Flow	Pier Ir	nfluence
ID 🔺	Cr	oss Section ID	Long Term Scour	General Scour	Local Scour	Bedform Scour	Bend Scour	Low Flow Scour	Total Scour
		III							•
				-					

- (b) Click the **Add** button to activate the necessary data entry fields.
- (c) Type "*PRESS01*" into the **ID** textbox.
- (d) Check the **General** Checkbox only.
- (e) Click the browse button in the **Method** column across **General** check box to launch local scour method select menu.

Sel	ect Method	
	Lacey	
	Neill and HEC-18	
	Neill and HEC-18 With Pressure Flow	
	Blench	
	OK Cancel	
		.:

Select the "*Neill and HEC-18 With Pressure Flow*" from the **Select Method** window, and click **OK** to close the **Select Method** window

(f) Click the **Save** button to save the entered data. The **TOTAL SCOUR – MB: 01 – ID** window shows up like following figure.

Total Scour	- MB: 01 - ID): E	dit											
<u>L</u> ist	<u>T</u> otal		Long T <u>e</u> r	m	<u>G</u> ener	al	L	. <u>o</u> cal	<u>B</u> edfo	rm	Low Flor	N	Pier Influ	uence
ID Majo	r Basin ID ID	01 PRES	<mark>)</mark> S01]										
Scour	Depth —													
	In	clude	Calc	<u>FS</u>	Value	Custo Calc		Method						
1	_ong Term													
	General	V	0.00		0.00			Neill and	d HEC-18	3 With P	ressure Flo	w		
	Bedform													
	Low Flow													
	Headcut													
	Tailcut													
	Total (ft)													
Pie	r Influence													Ŧ
									.)[1		
			<u> </u>	ave	<u>C</u> ancel	P <u>r</u>	rint	Dele	ete	Add	MB	Updat	e <u>(</u>	<u>0</u> K

- (g) Click the **General** tab
- (h) Select "BRIDGE_SEC" for "Bridge Section ID" inside "Sections" frame.
- (i) Select "UPSTREAM_SEC" for "Upstream Section ID" inside "Sections" frame.
- Under "Neill Parameters (use Bridge Section)" frame, select "Sand" for Exponent m textbox and select "Straight Reach" for Bend Factor Z textbox.
- (k) Enter *"20"* into the **D50 (mm)** textbox.

- (I) Enter "210" into the **Bottom width of upstream channel, W1 (ft)** textbox.
- (m) Enter "40" into the Bottom width of contraction less piers, W2 (ft) textbox.
- (n) Enter into the **Vertical size of the bridge opening, hb (ft)** textbox.
- (o) Enter "=" into the **Height of the obstruction**, **T (ft)** textbox.
- (p) Click the **Save** button to save the entered data.
- (q) Click the **Update** button to update the data.
- (r) Select "*This Record*" from the **SELECTION OPTION** window, and click **Yes** from the confirmation message to proceed.

Select Option	
Option This Record This Major Basin All	Calculate Local Scour This will calculate the Local Scour for the current record. If you want to calculate the Total Scour, Click 'Update' on the Total Tab. Do you want to continue?
OK <u>C</u> ancel	Yes No

(s) After the update the window looks like what is shown in the following figure

List	Total		Long Taxes	General	Beth	perty.	Lawfree .	Parints	10.000
Sections	6			HEC-18 Pressure Flow Upstream F					
Bridge Section ID BRIDGE_SEC				Manual Input Parameters		Hydraulic Depth (ft)	6.75		
Upstream Section ID UPSTREAM_SEC					Avg Velocity (It/s)	14.48			
				D50 (mm) 20.000	4	Critical Velocity (file)	6.19	Live Bed	
Neill Paramete	rs (use Bridge	Concernance of the second second		No Overtopping - Live Bed					
		Design	Dominant	Flow in upstream channel, G1 (d	3249.00	Vertical s	ize of the bri	dge opening, hb (ft)	6.5
Design	Flow Rate (cfs)	2400	2600	Flow in the contracted channel, Q2 (c	2400.00	Upst	ream chann	el flow depth, hu (ft)	6.7
Hyd	Faulic Depth (ft)	10.17	10.46	Bottom width of upstream channel, W1	10 210.00	Distance from wat	er to lower t	ace of girders, ht (ft)	0.2
A	erage Width (ft)	13.72	14.02	Bottom width of contraction less piers.W2	40.00		Height of th	e obstruction, T (ft)	3.00
	Slope (NR)	0.005000	0.005000	Water Temp (C) 20	and the second se		r flow height, hw (ft)	0.0
	Exponent m	0.67	P	Exponent,	(1 0.64	- County		low separation, t (ft)	1.6
	Bend Factor 2	0.50	2	Average depth in upstream channel, Y1	ft) 6.76			Scour depth, ys (ff)	10.2
Scour Depth (Ind	uding Bend) (ff)	5.03		Average depth in contraction Y2	in the second second				
Scour Depth (ft	6								
And a second	S	-							
Final G	eneral Scour (π)	10.25	1						
				ØHelp	@jeto	Print. Delete	Ädd	MB Update	U OK

2.1.4 Step 4 - Report and Document the Results

In this section, the instruction will be given on how to view, print, and export the calculation results of the guide bank scour.

(a) To view the results on the screen, click the Print ... button on the Local Tab of TOTAL SCOUR – MB: 01 – ID: PRESS01 window, a report will be generated as is shown in the following figure.

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200.00		de.Ne	MAL SCOUR	NELL V	NADE DEPEN	National Street	NO OVERTOP PR	NO - LI	2 820		syntrativ
Page 1				гторя	OR IN MINISTER CA	PRESSURE	accom				- S/1/204
(D; 4	RESSO										
Bridge Section ID: 8											
Upstream Section ID: 1	PSTREA	M_SE	c								
Nell Parameters											
			Design	D	minant						
	r. Flow Rat		2.400		2.890						
	ytrautic De: Kierage Wil		43.17 12.72		现税 14.02						
	Espor		0.07								
Scour Depth (includ	Band Fa		2.00								
	0.2000	6360									
HEC-18 Pressure Flow No	Overtop	ping -	Live Bet								
Hpt	alic Depth	18	\$.76								
	g Vencity i		14.46								
Crites	DS0 (8,19 23.95								
Fine in Upstware C			3.248.00				bridge opening. H		8.90		
Flow in Contracted			2,403,50				nnel flux depth, h		0.76		
Bottom Witth of Upstream Battom Witth of Cantablen 1			210.00	- 1	stants for		i face of girdens, h		8.25		
manage walk of Cantables 1	Espoce		-2.04				f the observation, 1 are flow height, to		0.00		
Analisia Depth in Uppress			6.70		Rasingen		e for separator.		1.05		
Average Depth in C			12.07				our Depth, ys		10.25		
Final Genera	I Scou	r (ft)	10.25								
											performance and particular

- (b) To print out the results on a printer, click the printer symbol (B).
- (c) To export the results in PDF format or other formats, click the export symbol (🊵)

This concludes tutorial for Pressure Flow Scour.