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# **STEADY FLOW ANALYSIS FOR SHATT AL- HILLA USING HEC-RAS PROGRAM**

### Zainab Ali Omran, Nariman Yahya Othman and Zahra Abd Saleh

University of Babylon, Department of Civil Engineering, Iraq

#### ABSTRACT

Hec-Ras 5.0, 2016 program is an applied software package for simulation of river network in steady and unsteady flow regime. In this paper the model simulation with field survey for Shatt Al-Hilla is verify with different types of outputs resulted in both tabular and graphical, results were showed using different effective elements like discharge, velocity, elevation, Stations. In this paper, HEC - RAS program is applied to analysis Shatt Al Hilla for 51.100 km length of it for each 100 m long and herein illustration of the calculation results, results showed that at downstream max. water surface elevation for discharge 70 m<sup>3</sup>/s is 4.19 m and hydraulic depth is 3.47 m while; for 170 m<sup>3</sup>/s is 6.10 m and 5.21m which means that each 10 m<sup>3</sup>/s discharge is raising water surface elevation about average 18 cm, which made the expectation of water surface elevation in meter increase with the increase of discharge in Shatt Al-Hilla and the velocity of the river changes according to the cross section and can be noticed that the velocity increased when the river pass inside center of Al-Hilla city from the beginning of the specific researched area.

Key words: HEC-RAS Program, Shatt Al- Hilla, water.

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# **1. INTRODUCTION**

Flow dynamics understanding in a river system is an essential step to the water needs agreement (*Traore Vieux Boukhaly, et. al., (2015)*). This representation documentations by the assessment essential factors of flow like water surface, Froude number, velocity of water flow... In this paper, we focus on the Shatt Al- Hilla within hilla city( K. N. Kadhim and Ahmed H).

When the various parameters at any point do not change with time, this flow is called Steady flow. unsteady (non-steady) is the flow in which changes with time do occur. In practice, steady flow is the exception rather than the rule, but many problems may be studied effectively by supposing that the flow is steady (K.N.Kadhim, 2018).

Hec-Ras 5.0, 2016 program is an applied software package for simulation of river network in steady and unsteady flow regime which is based on hydraulic routing. This program is commonly mentioned in hydraulic systems analysis. (*Gary W. Brunner, 2016 and Hassan &K.N.Kadhim, 2018*).

# 2. MATERIAL AND METHOD

# 2.1. The Case Study

The selected project is Shatt Al-Hilla , it's the main channel that branches from left side of Euphrates river just at the upstream of the new Hindiya Barrage. It's total length equal to (101 km), beginning from its head regulator, km (00.000), to Daghara head regulator, km (101.000), Hilla city is located at about (100 km) south of Baghdad city. Shatt Al-Hilla passes through the city, dividing it into two parts (See Figure (1)). Hilla city depends solely on it for maintaining all its water needs.



Figure 1 Site plan of Shatt Al-Hilla within Hilla city by google earth website

# 2.2. Methodology

# HEC-RAS Software

HEC-RAS (where H refer to Hydrologic, E : Engineering, C : Center, R : River, A: Analysis and S: System) is numerical program for flow river hydraulic calculations. In this program three hydraulic components for flow analysis: Steady flow; unsteady flow; and sediment transport computations (*Ahmad Hakim Farooq et. al., (2016)*). One-dimensional flow characteristics calculations is usually used containing water surface profiles, energy grade line, depth of water, velocity, wetted perimeter for steady and unsteady river flow. These calculations are necessary in the analysis of various problems. In this paper, to perform flow parameters, the steady flow component was used of the Shatt Al Hilla to analyze this hydraulic system. The basic records wants for simulation are involved: geometric data, schematic of river, length of the reach, coefficient of Manning, contraction coefficient and expansion coefficient. (*Gary W. Brunner, 2016*).

# 2.3. Constraints which are used in HEC-RAS (5.0, 2016) software

Table 1 below shows The input parameters which were used in the program. Each constraint was either measured directly or calculated from hydrologic equations or was already patterned in the model.

Symbol	Description	Determination
n	Manning coefficient	(0.035) for straight, full no rifts or deep
	(Constant depends on	pool.
	type of channel and	
	description)	
$Q_1(m^3/s)$	Minimum Discharge of	70 (m <sup>3</sup> /s) From "Iraqi Meteorological Office
	water	of Water Source, Babylon governorate"
$Q_2(m^3/s)$	Maximum Discharge	170 (m³/s) From "Iraqi Meteorological
	of water	Office of Water Source, Babylon
		governorate"
Cont.	Contraction coefficient	0.1 for gradual transitions
	of flow	
Exp.	Expansion coefficient	0.3 for gradual transitions
	of flow	

Table 1 Input constraints which are used in HEC-RAS

The cross section of Shatt Al-Hilla that is used in this paper at 51+100 Km from the barrage, the cross section geometry for the section has been considered as a trapezoidal shape (see Fig. (2)).



Figure 2 the cross section of Shatt Al\_Hilla

# **3. SIMULATION USING HEC-RAS MODEL**

For this paper, steady flow simulation was developed for 51.100 km length for each 100 m in Shatt Al Hilla using HEC-RAS [Version 5.0,(2016)] Figure (3) shows the main window of the HEC-RAS program.

HEC-RAS 5.	0.0	×
File Edit Ru	un View Options GIS Tools Help	
	<u>5-7-0 700 4522</u>	◕▾◾◾੫ਖ਼ਙ।
Project:	Shatt AL_Hilla	C:\Users\WINDOWS\Documents\ShattAL_Hilla.prj
Plan:	Plan 01	C:\Users\WINDOWS\Documents\ShattAL_Hilla.p01
Geometry:	Geom .	C:\Users\WINDOWS\Documents\ShattAL_Hilla.g01
Steady Flow:	Flow Data	C:\Users\WINDOWS\Documents\ShattAL_Hilla.f01
Unsteady Flow:		
Description :		💲 🛄 SI Units

Figure 3 Chief menu of HEC-RAS program

Two essential files are required for making a simulation: (The geometric file and flow file) (*Khassaf Saleh I. and Shakir Saleh I.*, (2013))

The following sections are presented the input records essential for running a steady HEC-RAS software.

# **3.1. Geometric File**

To progress HEC-RAS program, the first step for generating a HEC-RAS geometric file. which involves of founding how the different river reaches are linked; data of cross section; length of the river reach; energy loss coefficients); stream junction information. Records were entered to the program via the menu of cross section geometrical records (see Figure (4)).

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File E	lit Opti	ons Vie	w Tab	les Tools GIS	Tools He	lp					
Tools Editors	River Reach →	Storage Area	2D Flow Area	SA/2D Area SA/2D Are Conn BC Lines	a 2D Area BreakLines	20 Area Mann n Regions	Pump Station	RS • <u>12.99</u>	<b>2</b> 2	Description :	
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Pump											

Figure 4 Input menu of cross section data for Shatt Al-Hilla

# 3.2. Geometry of the Cross Section

Boundary geometry is definite in terms of cross sections, it is labeled by the stations and their elevations records from left to the right, Figure (5) shows some of cross sections.



Exit Edit Options Plot Help		
River: Shatt Al-Hilla	Apply Data	📔 <u>Plot Options</u> 🔲 Keep Prev XS Plots Clear Prev   🔽 Plot Terrain (if avail
Rivers	Jula.:  902.71"	Shatt AL_Hilla Plan: Plan 01 14/05/2018
Description	÷	
Del Row Ins Row	Downstream Reach Lengths	5 Legend
Cross Section Coordinates	82 707 982 707 982 707	
1 0 5	Manning's p Values	
2 15 0	LOB Channel ROB	
3 63.2 0 0.	.035 0.035	
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	.1 0.3	
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#### Steady Flow Analysis for Shatt Al- Hilla Using HEC-RAS Program

Figure 5 Different Cross sections

# 3.3. Steady Flow Data

为 Steady Flow Analysis		
File Options Help		
Plan : Plan 01	Short ID	Plan 01
Geometry File :	Geom .	•
Steady Flow File :	Flow Data	▼
Flow Regime © Subcritical © Supercritical © Mixed Optional Programs □ Floodplain Mapping	Plan Description :	
	Compute	

Figure 6 Steady flow analysis for Shatt Al-Hilla

HEC-RAS is capable for performance profile of water surface calculation for steady flow in normal or constraxted channels, subcritical, supercritical and mixed flow regime water surface profile can be calculayed. This paper, subcritical flow performed for steady flow analysis foe Shatt Al-Hilla as shown in Fig. 6

Fig. (7) show the steady flow data menua for Shatt Al-Hilla with two discharge values (Q1, Q2 which are minimum and maximum discharge) with length equal to 100 m for each reach.

$\frac{\pi}{\eta \rightarrow}$ Steady Flow Data	- Flow Data				and the second second second		
File Options Help	)						
Enter/Edit Number of P	rofiles (32000 max)	: 2	Reach B	oundary Cond	ditions Apply Data		
	Loca	ations of Flo	ow Data Chan	iges			
River: Shatt Al-Hilla	-				Add Multiple		
Reach: reach	▼ Ri	ver Sta.: 5	1100	▼ A	dd A Flow Change Location		
Flow Ch	nange Location				Profile Names and Flov	v Rates	
River	Reach	RS	Q1	Q2			
1 Shatt Al-Hilla	reach	51100	70	170			
Edit Steady flow data for	or the profiles (m3/	5)					

Figure 7 Steady flow data menua for Shatt Al-Hilla

# 4. RESULTS AND DISCUSSION

In this paper, after completed inserting steady flow data in the suitable places and clicked on "Run" button in the steady flow analysis, the program completed simulating the steady flow data and showed the result in View/ Steady flow Output (see figure 8).

HEC-RAS Finished Computations		
Write Geometry Information		
Layer: Complete		
Steady Flow Simulation	DC. 51100	
River: Snatt Al-Hilla	KS: SILUU Nede Turce Creat Section	
Reach: reach	Node Type: Cross section	
Profile: Q2		
Simulation: 2/2		
Computation Messages		
Writing Geometry Completed Writing Geometry Writing Event Conditions Event Conditions Complete Steady Flow Simulation HEC-RAS 5.0.0 Finished Steady Flow Simulation Computations Summary Computation Task Computation Geometry	February 2016       Time(hh:mm:ss)	E
Steady Flow Computations	<1	
	<1	-
Pause Take Snapshot of Resu	ts	Close

Figure 8 HEC-RAS Finished menua for Shatt Al-Hilla

So the HEC-RAS program results showed that the velocity of the river changes according to the cross section and can be noticed that the velocity increased when the river pass inside center of Al- Hilla city from the beginning of the specific researched area as shown in Figure (9).

#### Steady Flow Analysis for Shatt Al- Hilla Using HEC-RAS Program



Figure 9 The relationship between velocity and its station

The water surface elevation in meter increase with the increase of discharge in Shatt Al-Hilla as shown in the rating curve



Figure 10 Rating curve plot.

HEC-RAS results showed that at downstream max. water surface elevation for discharge 70 m<sup>3</sup>/s is 4.19 m and hydraulic depth is 3.47 m while; for 170 m<sup>3</sup>/s is 6.17 m and 5.21m which means that each 10 m<sup>3</sup>/s discharge is raising water surface elevation about average 18 cm, as shown in figures (11 and 12); which made the expectation of water surface elevation for each discharge ranged between (70 - 170) m<sup>3</sup>/s is easy.

River: Shatt Al-Hilla	▼ Profi	le: Q1	-		
Reach reach	▼ RS:	51100 👻	↓ ↑ Plan: Plan	01	•
	Plan: Plan	01 Shatt Al-Hilla reach RS: 5	1100 Profile: Q1		
E.G. Elev (m)	4.20	Element	Left OB	Channel	Right OB
Vel Head (m)	0.00	Wt. n-Val.		0.035	
W.S. Elev (m)	4.19	Reach Len. (m)	982.69	982.69	982.69
Crit W.S. (m)		Flow Area (m2)		254.85	
E.G. Slope (m/m)	0.000018	Area (m2)		254.85	
Q Total (m3/s)	70.00	Flow (m3/s)		70.00	
Top Width (m)	73.36	Top Width (m)		73.36	
Vel Total (m/s)	0.27	Avg. Vel. (m/s)		0.27	
Max Chl Dpth (m)	4.19	Hydr. Depth (m)		3.47	
Conv. Total (m3/s)	16498.9	Conv. (m3/s)		16498.9	
Length Wtd. (m)	982.69	Wetted Per. (m)		74.72	
Min Ch El (m)	0.00	Shear (N/m2)		0.60	
Alpha	1.00	Stream Power (N/m s)		0.17	
Frctn Loss (m)	0.02	Cum Volume (1000 m3)		10335.39	
C & E Loss (m)	0.00	Cum SA (1000 m2)		3516.41	
		Errors, Warnings and Note	s		

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Figure 11 Cross section output for minimum discharge.

Cross Section Output					. 🗆 X
File Type Options	Help				
River: Shatt Al-Hilla	▼ Profi	le: Q2	•		
Reach reach	▼ RS:	51100 💌	↓ ↑ Plan: Plar	101	•
	Plan: Plan	01 Shatt Al-Hilla reach RS: 511	100 Profile: Q2		
E.G. Elev (m)	6.18	Element	Left OB	Channel	Right OB
Vel Head (m)	0.01	Wt. n-Val.		0.035	
W.S. Elev (m)	6.17	Reach Len. (m)	982.69	982.69	982.69
Crit W.S. (m)		Flow Area (m2)		407.79	
E.G. Slope (m/m)	0.000025	Area (m2)		407.79	
Q Total (m3/s)	170.00	Flow (m3/s)		170.00	
Top Width (m)	78.20	Top Width (m)		78.20	
Vel Total (m/s)	0.42	Avg. Vel. (m/s)		0.42	
Max Chl Dpth (m)	6.17	Hydr. Depth (m)		5.21	
Conv. Total (m3/s)	33898.5	Conv. (m3/s)		33898.5	
Length Wtd. (m)	982.69	Wetted Per. (m)		82.17	
Min Ch El (m)	0.00	Shear (N/m2)		1.22	
Alpha	1.00	Stream Power (N/m s)		0.51	
Frctn Loss (m)	0.02	Cum Volume (1000 m3)		16614.38	
C & E Loss (m)	0.00	Cum SA (1000 m2)		3896.63	

Figure 12 Cross section output for maximum discharge.

The fact of Shatt Al- Hilla is alluvial river, and the slow velocities ranged (0.71 - 0.27) m/s for discharge 70 m<sup>3</sup>/s from upstream to downstream calculated by HEC-RAS, with low shear stress 0.60 N/m<sup>2</sup> and low Froude No. ranged (0.18 - 0.05) figure (13) assured that the river had risked of high cumulative of sedimentation loads. Even results for 170 m<sup>3</sup>/s (at the same figures) are not so different from the first one were the velocities ranged (1.08 - 0.42) m/s which considered slow velocity too, low shear stress 1.22 N/m<sup>2</sup> and low Froude No. (0.22 - 0.06).

The difference between the height of water levels for the two chosen discharges, the cumulative volumes of water  $(10335.39 \text{ and } 16614.38)*10^3 \text{ m}^3$ , stream powers (0.17 - 0.51)

N/m s and the mentioned shear stress figure (13) referred to high probability of embankments erosion and may cause natural series of frequently shifting bends.

Profile Output Table - Standard Table 1												
File Op	otions Sto	l. Tables	Locations	Help								
									HEC-RA	S Plan: Pla	n 01 River	: Shatt Al-Hilla
Reach	River Sta	Profile	O Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Ch
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
reach	51100	Q1	70.00	0.00	4.19		4.20	0.000018	0.27	254.85	73.36	0.05
reach	51100	Q2	170.00	0.00	6.17		6.18	0.000025	0.42	407.79	78.20	0.06
reach	50117.3*	Q1	70.00	0.00	4.18		4.18	0.000018	0.28	253.54	73.25	0.05
reach	50117.3*	Q2	170.00	0.00	6.15		6.16	0.000026	0.42	405.83	78.20	0.06
reach	49134.6*	Q1	70.00	0.00	4.16		4.16	0.000019	0.28	252.21	73.14	0.05
reach	49134.6*	Q2	1/0.00	0.00	6.12		6.13	0.000026	0.42	403.85	/8.20	0.06
reach	49151.0*	01	70.00	0.00	4.14		4.14	0.000010	0.29	250.97	72.02	0.05
reach	49151.9*	02	170.00	0.00	6.10		6.11	0.000019	0.20	200.87	73.03	0.05
reach	-0151.5	<u> <u>v</u><sup>2</sup></u>	170.00	0.00	0.10		0.11	0.000020	0.12	101.05	70.20	0.00
reach	47169.2*	01	70.00	0.00	4.12		4.12	0.000019	0.28	249.50	72.92	0.05
reach	47169.2*	Q2	170.00	0.00	6.07		6.08	0.000027	0.43	399.78	78.20	0.06
		-										
reach	46186.5*	Q1	70.00	0.00	4.10		4.10	0.000019	0.28	248.11	72.81	0.05
reach	46186.5*	Q2	170.00	0.00	6.04		6.05	0.000027	0.43	397.70	78.20	0.06
reach	45203.8*	Q1	70.00	0.00	4.08		4.09	0.000020	0.28	246.71	72.69	0.05
reach	45203.8*	Q2	170.00	0.00	6.02		6.03	0.000028	0.43	395.58	78.20	0.06
		-										
reach	44221.1*	Q1	70.00	0.00	4.06		4.07	0.000020	0.29	245.28	72.57	0.05
reach	44221.1*	Q2	1/0.00	0.00	5.99		6.00	0.000028	0.43	393.43	/8.20	0.06
reach	43238 4*	01	70.00	0.00	4 04		4.05	0.000021	0.29	243.92	72.45	0.05
reach	43238 4*	02	170.00	0.00	5.06		5.07	0.000021	0.29	243.02	72.43	0.05
reacti	10200.1	<u> <u>v</u></u>	1/0.00	0.00	3.30		3.37	0.000025	0.45	351.23	70.20	0.00
reach	42255.7*	01	70.00	0.00	4.02		4.03	0.000021	0.29	242.35	72.33	0.05
reach	42255.7*	Q2	170.00	0.00	5.93		5.94	0.000029	0.44	389.00	78.20	0.06
		-										
reach	41273.0*	Q1	70.00	0.00	4.00		4.00	0.000021	0.29	240.85	72.20	0.05
reach	41273.0*	Q2	170.00	0.00	5.90		5.91	0.000030	0.44	386.72	78.20	0.06
reach	40290.3*	Q1	70.00	0.00	3.98		3.98	0.000022	0.29	239.32	72.08	0.05
reach	40290.3*	Q2	170.00	0.00	5.87		5.88	0.000030	0.44	384.41	78.20	0.06
												-
reach	39307.6*	Q1	70.00	0.00	3.96		3.96	0.000022	0.29	237.77	71.95	0.05

Figure 13 Portion of profile output.

# **5. CONCLUSIONS**

In this paper, HEC - RAS program is applied to analysis Shatt Al -Hilla for 51.100 km length of it for each 100 m long with min. and max. discharge equal to 70 and 170 m<sup>3</sup>/sec, the steady flow analysis is carried out successfully for Shatt Al-Hilla located along Hilla city for it's cross section and herein illustration of the calculation results:

- Shatt Al- Hilla is alluvial river, and the slow velocities ranged (0.71 0.27) m/s for discharge 70 m<sup>3</sup>/s from upstream to downstream calculated by HEC-RAS, with low shear stress 0.60 N/m<sup>2</sup> and low Froude No. ranged (0.18 0.05) figure (13) assured that the river had risked of high cumulative of sedimentation loads. Even results for 170 m<sup>3</sup>/s (at the same figures) are not so different from the first one were the velocities ranged (1.08 0.42) m/s which considered slow velocity too, low shear stress 1.22 N/m<sup>2</sup> and low Froude No. (0.22 0.06).
- High probability of embankments erosion and may cause natural series of frequently shifting bends.
- The velocity of the river changes according to the cross section and can be noticed that the velocity increased when the river pass inside center of Al- Hilla city from the beginning of the specific researched area

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