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Estimation of Manning's Roughness Coefficient for Tigris River by Using HEC-RAS model

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Abstract: Tigris River (downstream of the kut barrage reach) there is no study conducted on it to estimate its Manning n value. HEC-RAS was used to analysis study reach and calibrate n value of the study reach .filed data were collected during 2016-2017 (duration of study), eights data sets were observed included stage and discharge measurements. The discharge is controlled by Kut Barrage Operation. The range of water surface elevation is (+10.300 to +12.511) and flow discharge range is (202.7 - 355.280) m3/sec. The range of n value for study reach is (0.021-0.034). The calibration results provided suitable Manning n of 0.026 for downstream of Kut Barrage reach which represent mean value of results.

Keywords :Tigris River, Kut Barrage reach, *HEC-RAS model* .

تقدير معامل الخشونة مانينغ لنهر دجلة بأستخدام نموذج هيك-راس

محمد صيوان شمخي، زينب شاكر عطا

الخلاصة:نهر دجلة (مؤخر سدة الكوت) لا توجد دراسة أجريت عليه لتقدير قيمة معامل الخشونة(manning n). وقد تم استخدام نموذج هيك-راس لتحليل مجرى النهر ومعايرة قيمة n لبيانات الدراسة التي قد تم جمعها من القياسات الحقلية خلال 2016-2017 (مدة الدراسة)، قد لوحظت البيانات في ثماني مجموعات. يتم التحكم في التصريف من قبل ادارة سدة الكوت . مدى منسوب الماء هو (+10.300 إلى +12.511) وتصريف الماء هو (202.7 - 355.280).m3/sec) . مدى قيمة n للدراسة هو (0.021-0.034).. والقيمة السائدة)(0,026 الكلمات الدالة :نهر دجلة , مؤخر سدة الكوت , نموذج هيك –راس .

1. Introduction

The Tigris River is an important rivers in the Middle East. It stems from the Taurus Mountain south-eastern of Turkey and flows in direction of the southeast for 1580 km, running through Turkish-Syrian borders and accessing Iraq. In Iraq, it flows to the south until it unions with the Euphrates River at Qurnah, producing the Shatt Al-Arab River which discharges its water into the Arabian Gulf. Kut barrage (about 180km south of Baghdad) is most important regulator on Tigris river. It is regulates the flow for the sothern area of Iraq.

Roughness has an important role in the open Channel, Many of the applications and hydraulic models depended on coefficient of roughness. flow and channel factors affect the roughness coefficient , Determination of the Manning's *n* coefficient depends on these factors that have been explained by chow[1] . The coefficient of roughness varies according to these factors and their change with time and space .Estimating and selection the value of the Manning's *n* coefficient is considered a provocative and a creative and complex task at the beginning and requires expertise. Therefore, researchers need to know the various disciplines [2]. There are many studies around the world that related to Manning's *n* coefficient. The researchers followed several methods to predicate and evaluated the roughness coefficient for open channels. Earlier, HEC-RAS model have been used to predict" Manning's *n* coefficient" and calibrate it.

Ross Doherty [3] used HEC-RAS Model to calibrate the roughness of channel and develop rating curves for large number of Western Australia semiarid rivers.Timbadiya et al. [4] Calibrated Manning's n for Lower Tapi River, India and simulated its flood for year 2006 by using HEC-RAS model .Lower Tapi River n values for Kakrapar weir up and downstream were 0.035 and 0.025 respectively. Parhi et al. [5] used HEC-RAS model to calibrate Mahanadi River, Odisha "*n*" value and simulate River floods .they found that *n* value 0.032 of Mahanadi . Bordbar et al.[6] used HEC-RAS model to simulate the Bashar River. They calibrated separately and analyzed its hydraulic flood .they found the roughness coefficients 0.052 and 0.039, respectively. Hameed and Ali [7] used unsteady flow HEC-RAS model to predict and calibrate n value of for River at the upstream of Hilla city. They found that the Observed and computed hydrographs for Hilla River gave good agreement when value n 0.027. Abed (2014)[8] used Steady flow HEC-RAS model to analysis of Tigris River for started from" Numaniyah Kut Barrage reach. He calibrated and determined the value of n. he found that reach of Nu,maniyah Kut Barrage reach was 0.027.Sered et al. [9] used HEC-RAS model to calibrate n values of along the Thiba main canal reach and simulate its stages and discharge. They concluded that model gave best results "for both Link Canal II (LCII) and Thiba Main Canal (TMC) at values 0.023 and 0.016 respectively .Awad [10]

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used Steady flow HEC-RAS model to analysis" Shatt Al-Rumaith south of Iraq" and determine the proper value of n. she found that n values of Al-Rumaith River for channel and for floodplain were (0.023) and (0.04) respectively .Many formulas are available to estimate the Manning roughness coefficient, but they cannot be used with reality because these formulas were derived for specific streams which may not be suitable to other streams. The Previous studies reveal that calibration of HEC-RAS model was efficient tool to assess Manning roughness coefficient for the rivers. There is no study conducted on Tigris River downstream Kut Barrage to predict Manning coefficient

1.1 *The objectives of the research*

This study's aim is to develop Hec-Ras model to estimate and calibrate n value of (Tigris river) downstream kut barrage reach and analysis study reach spatially there is no study conducted on it.

2. *Study reach*

Downstream kut Barrage reach on the tigris river south-east of the kut city, Iraq. it lies between 3596013N to 3604899 N latitudes and 576826E to 614429E longitudes .the study reach is shown in figure 1..upper stream of study reach was located at downstream Kut Barrage and lower part of it on sheikh saad Bridge, the study reach length is 70 K.M. there are Discharge of study reach is doomed by Kut Barrage run, it is variable because of changes presence of pumping stations that with study reach bed bottom composed of clay, loam, silt, sand and loam.

Figure. 1. Downstream Kut Barrage reach (Tigris River).

3. FIELD DATA COLLECTION OF STUDY REACH

The Field work involved selection of study reach, established bench marks, survey of cross sections and observed stages and discharge. The geometric data of study reach included sixty three cross sections, while hydraulic data of stages and discharge were observed for seven cross sections; these data were included eight observations for period September 2016 to May 2017.the geometric and hydraulic data of filed that were input in HEC –RAS model. Bed elevation of study reach and its observed water level profiles are shown in Figure 2. The equipments that were used in filed are GPS, GR3, ADCP and Level And preinstalled vertical staff gages.

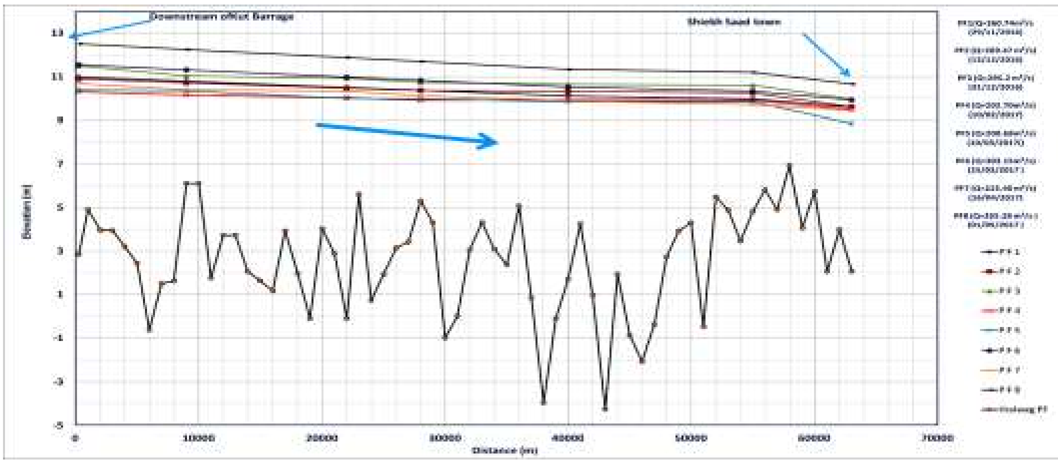


Figure. 2. Water surface profiles and bed elevation for downstream Kut Barrage reach.

4. HEC-RAS MODEL

Hydrologic Engineering Centre, River Analysis System (HEC-RAS) is developed by hydraulic engineer center". *Prorgram soft ware of(HEC-RAS) is design to estiblish and pross calculation of many hydrulic application*[11] . HEC-RAS modeling system philosophy are explained by hydruilic engneering center , they provided details of. HEC-RAS Features . Basic Computational procedure is depended on solution the energy equation , momentum equation, the sediment continuity and Sediment transport equations in in HEC-*RAS* [12]. The energy equation interprets the principle of water surface determination.

$$H = Z + y + \frac{\alpha v^2}{2g} \tag{1}$$

Where H is total head of water (m), α is kinetic energy correlation coefficient, Z is bed elevation at a cross-section (m), *y* is flow depth at a cross-section (m), *g* is acceleration of gravity (m2/s) and *v* is average velocity (m/s).
The energy losses are calculated based on friction loss, expansion and contraction. The head loss in a reach having length L may be calculated as:

$$h_e = LS_f + C\left[\frac{\alpha_2 v_2^2}{2g} + \frac{\alpha_1 v_1^2}{2g}\right] \tag{2}$$

(Timbadiya *et al.*, 2011)[4] stated that channel roughness is one of the sensitive parameters in hydraulic models development. Estimation of friction losses due to flow resistance are computed with a friction slope from Manning's equation:

$$Q = K S_f^{1/2} \tag{3}$$

Where: Qis the discharge ,K is conveyance for subdivision, $\bar{S}f$ representive friction slope between two sections,
4.1 *Development of downstream Kut Barrage reach Steady Flow HEC-RAS Model*
In present study, steady gradually flow stimulation Hec-Ras model (Version4.1.0) Software 2010*are used.* A number of studies of hydraulic calculations depended on HEC-RAS. Studies of Horritt and Bates, 2002[13]; Castellarin et al. 2008 [14] showed that suitable simulation of flow for natural rivers and streams in HEC- RAS software provided a reliable reproduction.
Development of downstream Kut Barrage reach Steady Flow HEC-RAS Model methodology is shown in Figure 3. Input data of Hec-Ras model have already been mentioned in experimental works .initially study reach *Schematic* was drawn as shown in Figure 4. Then information of 64 cross sections of Kut Barrage reach was entered as shown in Figures 5, 6. 7. The data of steady flow of study reach were input as shown in Figure 8.

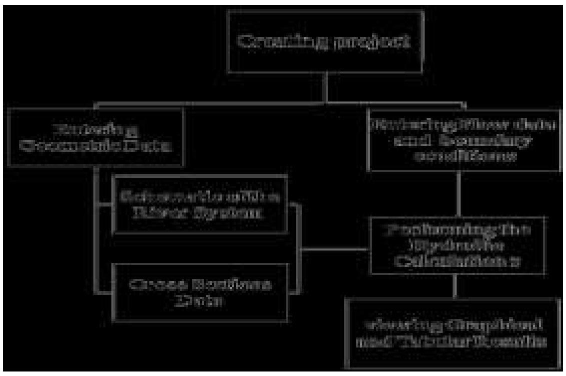


Figure .3.Schematic representation of developing HEC-RAS model.

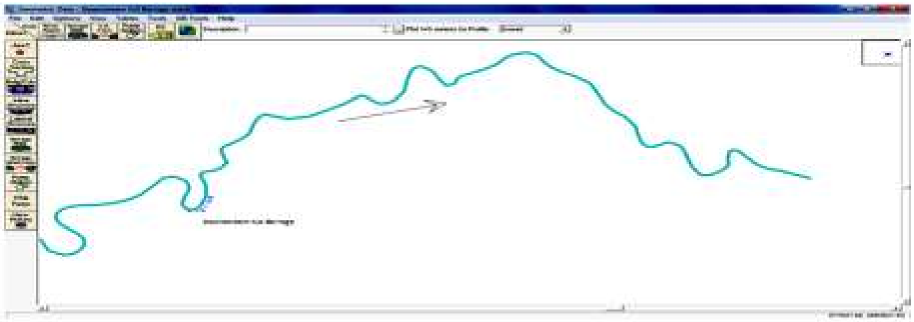


Figure .4. downstream of the Kut Barrage reach schematic .

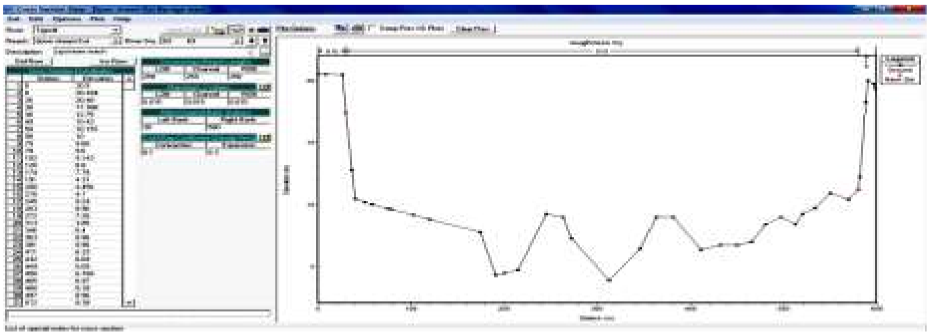


Figure .5. Data of cross section of study reach.

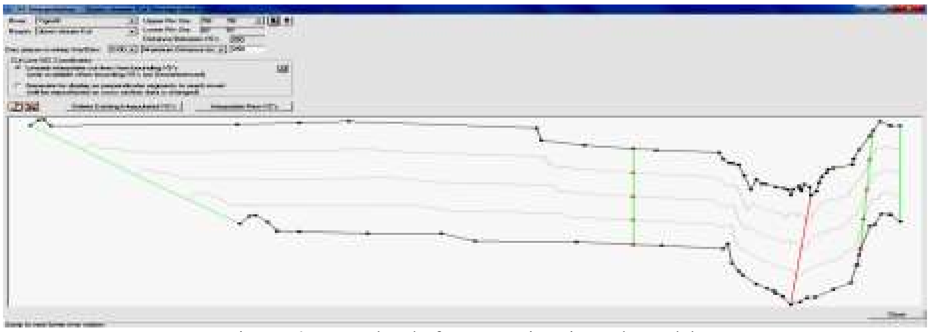


Figure. 6. Interpolated of cross sections in study model.

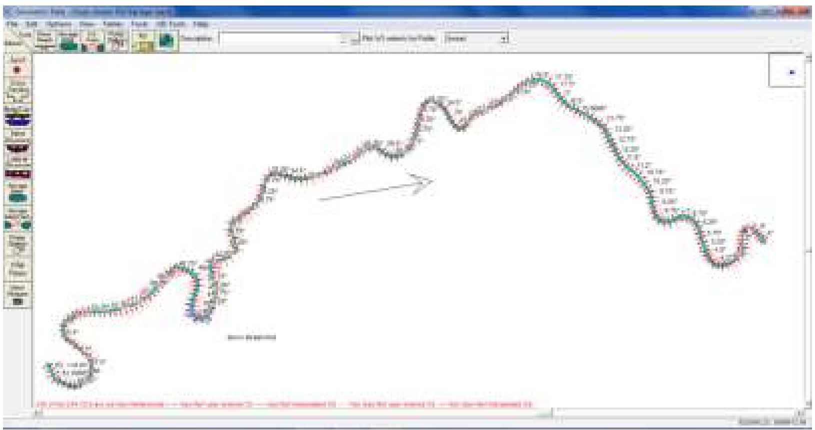
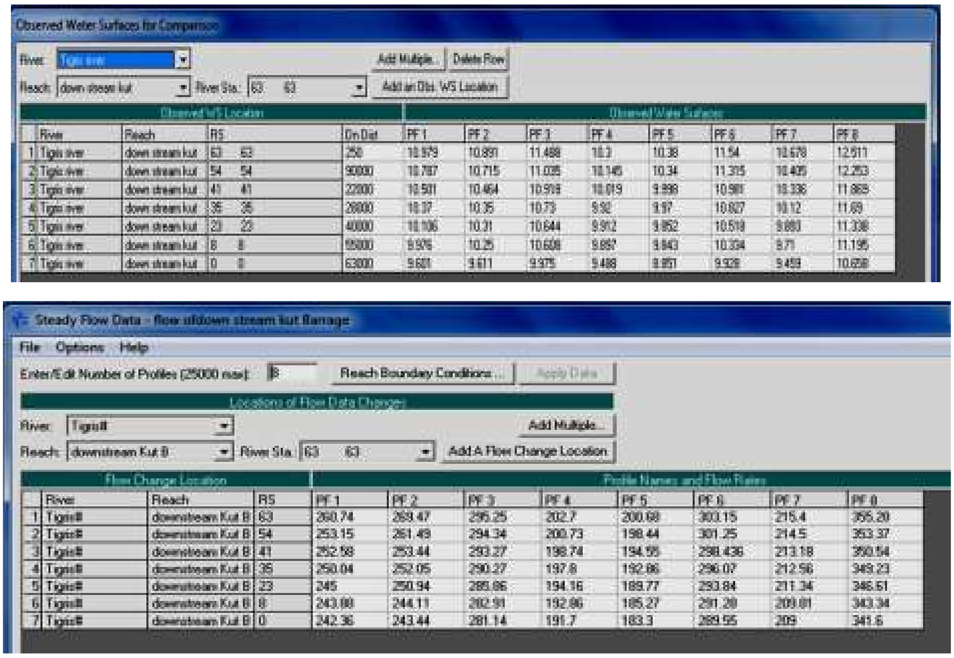


Figure.7 .Geometric data of whole reach in steady model.



Observed Water Surfaces for Comparison

	River	Reach	RS		Dn Dist	PF 1	PF 2	PF 3	PF 4	PF 5	PF 6	PF 7	PF 8
1	Tigris river	down stream kut	63	63	250	10.979	10.891	11.488	10.3	10.38	11.54	10.678	12.511
2	Tigris river	down stream kut	54	54	9000	10.787	10.715	11.035	10.145	10.34	11.315	10.405	12.253
3	Tigris river	down stream kut	41	41	22000	10.501	10.464	10.919	10.019	9.998	10.981	10.336	11.869
4	Tigris river	down stream kut	35	35	28000	10.37	10.35	10.73	9.92	9.97	10.827	10.12	11.69
5	Tigris river	down stream kut	23	23	40000	10.106	10.31	10.644	9.912	9.852	10.519	9.883	11.338
6	Tigris river	down stream kut	8	8	55000	9.976	10.25	10.608	9.897	9.843	10.334	9.71	11.195
7	Tigris river	down stream kut	0	0	63000	9.601	9.611	9.975	9.488	8.851	9.928	9.459	10.658

Steady Flow Data - flow of down stream kut Barrage

	River	Reach	RS	PF 1	PF 2	PF 3	PF 4	PF 5	PF 6	PF 7	PF 8
1	Tigris#	downstream Kut B	63	260.74	269.47	295.25	202.7	200.68	303.15	215.4	355.28
2	Tigris#	downstream Kut B	54	253.15	261.49	294.34	200.73	198.44	301.25	214.5	353.37
3	Tigris#	downstream Kut B	41	252.58	253.44	293.27	198.74	194.55	298.436	213.18	350.54
4	Tigris#	downstream Kut B	35	250.04	252.05	290.27	197.8	192.86	296.07	212.56	349.23
5	Tigris#	downstream Kut B	23	245	250.94	285.86	194.16	189.77	293.84	211.34	346.61
6	Tigris#	downstream Kut B	8	243.88	244.11	282.91	192.86	185.27	291.28	209.81	343.34
7	Tigris#	downstream Kut B	0	242.36	243.44	281.14	191.7	183.3	289.55	209	341.6

Figure .8 Flow and water surfaces (stages) data of eight sets of study model.

4.2 *HEC-RAS Calibration* of Downstream Kut Barrage reach *Hydraulic Model*

Calibration of n values for downstream Kut Barrage reach *Hydraulic Model* is based on input Manning n value for whole study reach. The n values used in model calibration range of (0.020 -0.0035). The *Root mean squared error (R.M.S.E)) which is defined in equation* employed as evaluation criteria to comparatve between simluated and obsorved stages of study reach[12, 15]. The minumum value of statical ((R.M.S.E)for eight observations are shown in table 1.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(Wo - Ws)^2}{n}} \qquad (4)$$

Where:-

Wo = observed water level (m)

Ws = simulated water level (m)

n = total no. of gage stations (reference data points

5. RESULTS

5.1 Simulation of Flood for Year 2017of *Downstream Kut Barrage reach*

Flood of study reach was observed on at PF8 on 1st of May 2017 for discharge of 355.280 (m^3/sec). The R.M.S.E values of simulation of flood in HEC-RAS model calibration as shown in Table 1. The HEC-RAS output plots showed the comparison of simulated and observed stages is shown in Figures 9, 10, 11.

Table1. the minimum (R.M.S.E) values of calibration

Profile	The minimum (R.M.S.E) value	Manning's *n*
PF1	0.0964	0.024
PF2	0.0606	0.024
PF3	0.0967	0.026
PF4	0.0473	0.021
PF5	0.0824	0.028
PF6	0.1150	0.024
PF8	0.0799	0.034

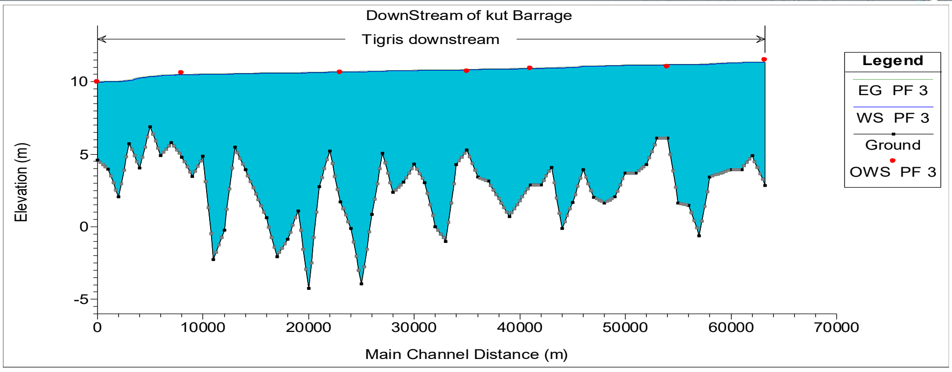


Figure. 9. Tigris River- HEC-RAS profile plot for PF3 and Manning's n =0.026 Observed and simulated water surface profile along reach.

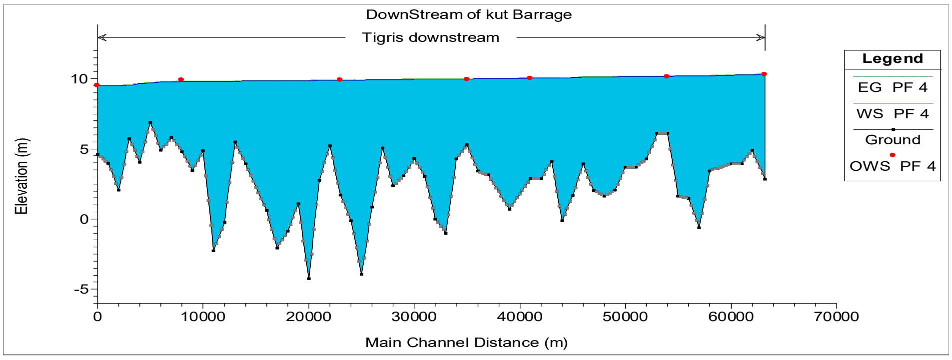


Figure.10. Tigris River -HEC-RAS profile plot for PF4 and Manning's n =0.021 Observed and simulated water surface profile along reach.

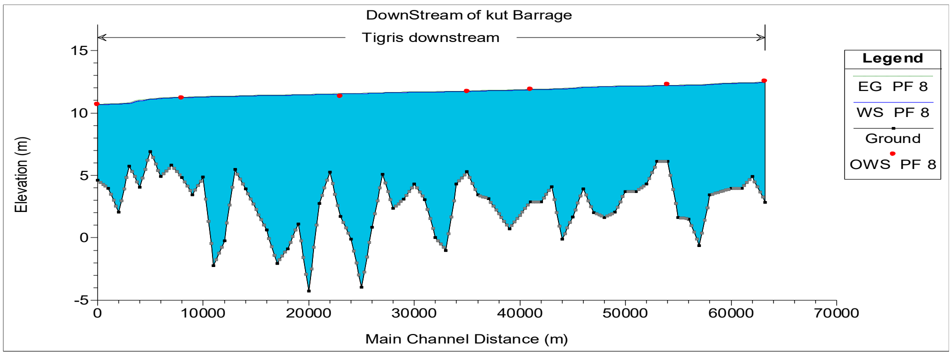


Figure. 11. Tigris River- HEC-RAS profile plot for PF8 and Manning's n =0.034 and simulated water surface profile along reach.

5.2 Model Verification

The verification process of steady flow model has been performed by using the data set which was recorded at PF6 (27/03/2017) during the period of study. The river discharges and water elevations along the Tigris River downstream of Kut Barrage use the global Manning's n value of 0.026 that gets from the calibration process. A comparison between the observed and model predicted water surface elevation was shown in Figure 12, which shows an acceptable agreement.

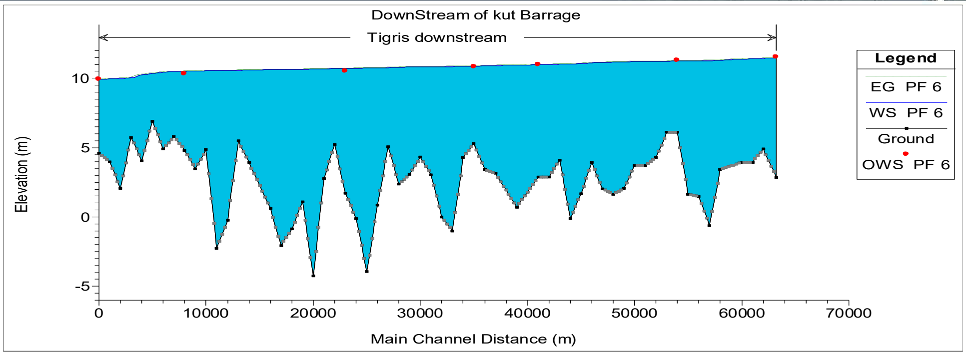


Figure .12.Observed water level with modeled water level profile along Tigris River downstream Kut barrage reach for PF6(n =0.026)

5.3 Profile and Manning's n values frequency of study reach

The frequency of profiles and n values during study duration, the frequency are calculated based on 180 filed data from the Department of Water Resources, Waist, Iraq. *The data* frequency of data is tabulated in table *.2. Figure* 13.show the frequency of profiles during study period.

Table .2 Observed data of station 0.0+250 and corresponded data of MOWR station 0.0+250

Observation date	Q m^3/s	Water elevation(m)	Calibrated Manning's n	No. of observation	Frequency %
29/11/2016	260.740	10.979	0.024	28	15.56
13/12/2016	269.470	10.891	0.024	24	13.33
31/12/2016	295.250	11.488	0.026	16	8.89
10/02/2017	202.700	10.300	0.021	15	8.33
10/03/2017	200.680	10.380	0.028	20	11.11
25/03/2017	303.150	11.540	0.026	18	10.00
16/04/2017	215.400	10.678	0.024	53	29.45
01/05/2017	355.280	12.511	0.034	6	3.33
$\sum$				180	100%

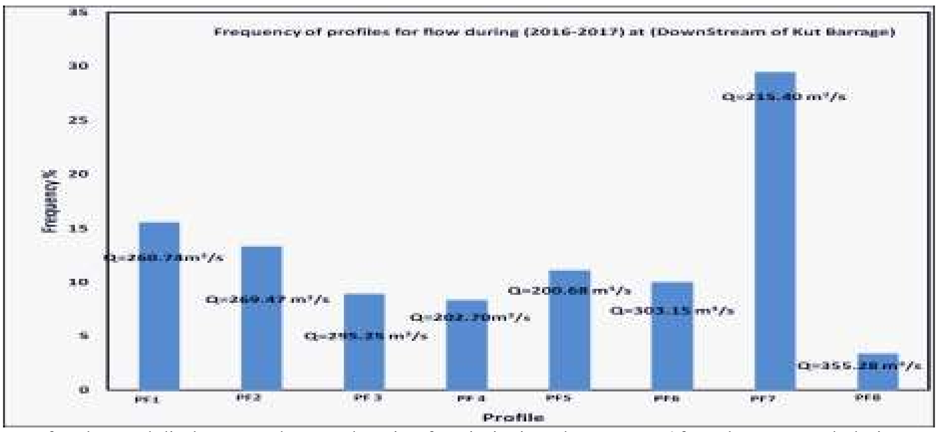


Figure.12. Frequency for observed discharges and water elevation for Tigris river downstream 0f Kut barrage reach during study period (2016-2017)

6. CONCLUSIONS

The results of calibration of HEC-RAS model were explained that the global value of Manning's roughness for Tigris river downstream Kut Barrage ranges between (0.021-0.034) with mean value equal to 0.026*while the range* of water surface level is (+10.300 to +12.511) and flow discharge range is (*202.7 - 355.280) m^3/sec*.

- Manning's n values of (0.024), (0.026), (0.028), (0.021), and (0.034) have frequencyof (58.34 %), (18.89%), (11.11 %), (8.33 %), (3.33 %) respectively at C.S.63(st.0+250) .

- The value of Manning n for study reach *during flood period of 2017 is 0.034.*

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