

# Applying the HEC-RAS Model to the Investigation of the Tigris River's Impact from a Proposed Bridge North of the Al Kut Barrage

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## ABSTRACT

This study investigates the hydraulic impacts of constructing a planned bridge north of Al Kut Barrage on the Tigris River using the HEC-RAS v6.6 model. The research assesses how the proposed bridge affects river behavior under three discharge scenarios (500, 1050, and 3000 m<sup>3</sup>/s) by comparing conditions with and without the bridge. The analysis focused on key hydraulic parameters including bridge scour, backwater effect, and velocity profiles. Field and laboratory data, combined with geometric and hydrological inputs, were used to calibrate the model. Results indicate that scour depth increases significantly with discharge, reaching up to 7.87 m at piers and 5.90 m at abutments under peak flow. However, the backwater effect remained negligible, with only a 1 cm rise detected during the highest flow scenario due to the minimal obstruction (4.36%) posed by the bridge. Similarly, no significant changes in upstream and downstream velocity profiles were observed. These findings demonstrate that while localized scour presents a notable risk, the overall impact on river hydraulics remains limited due to the bridge's optimized design.

**Keywords:** HEC-RAS, Bridge Construction, Tigris River, Scour, Backwater Effect, Hydraulic modelling

## 1. Introduction

Since ancient times, rivers have attracted human settlement due to their vital role in providing water for drinking, agriculture, and daily needs. Early civilizations emerged near rivers, leading to the construction of bridges for communication, trade, and transport. Human interaction with rivers has long influenced their natural and hydraulic behavior. As populations and economies grew, the demand for efficient transportation increased, resulting in a significant rise in the number of bridges. Today, bridges are essential infrastructure worldwide [1]. Due to the expansion of the city, the increase in population and the scarcity of bridges, there is an urgent need to build more bridges on the Tigris River and its branches in the city to ensure the continuity of the development wheel and to accommodate this population and urban growth. Accordingly, a group of bridges were designed, some of which were implemented, and the bridge under study was designed but not implemented yet. The construction of these bridges will undoubtedly affect the hydraulic, geomorphological and hydrological properties of the river both during and after construction. Determining the extent of the severity of the changes in river properties (such as sediment properties, water surface profile, velocity profile, and the possibility of backwater and scour at the piers and abutments of these bridges) on the health of the river and the safety of the structures built on it, is the problem of this study. Construction bridges necessarily means embedding their foundations and structural structures across waterways or floodplains, which directly impacts the hydrological and environmental nature of these rivers and negatively impacts these structures, leading to damage and even failure and collapse [2]. Many studies, research, investigations and experiments

have been conducted to identify the impact of construct bridges and other hydraulic structures on the properties and specifications of the rivers and channels on which they are built. One of these studies have indicated that the construction of bridges over rivers and waterways can change their hydrological, hydraulic and morphological properties and can have a negative impact on the health of the river, its water and its environment [3]. Another study have confirmed that these bridges and other structures built on waterways are in turn negatively affected by the turbulent flow at their structures placed in the riverbed, which causes problems for these structures, the most important of which is scour at bridge piers and abutments, “Scour can be defined as (The erosion or removal of streambed or bank material from bridge foundations due to flowing water) according to the Federal Highway Administration (FHWA)” which is considered a major cause of damage and even failure of many bridges around the world [4]. There is almost consensus among researchers, authors and hydrologists that the impacts of bridges and other structures on rivers and waterways are mostly result due to that bridge piers and abutments obstacle water flow and constrict the flow area of the channel, therefore we can consider them harmful (negative) impacts, so authors and researchers have gone to different ways to study these effects and how to mitigate them. Some have gone to rely on comparing the condition of the waterway before and after the construction of the structure on it based on previous and current data (before and after the structure) available for the river by use common and approved mathematical equations [5]. While another have gone to create experimental models in the laboratory to study the impacts of bridge piers on rivers [6] and other have used numerical models or computer programs to simulate what the condition of the river will be after the construction of the structure or what it was before construction, such as HEC-RAS software [7]. This study was conducted to investigated the impact of constructing new bridge north of the Kut Barrage in Al Kut city on the hydraulic properties of the Tigris River, in addition to studying the effect of the river on the structures of this bridge and calculating the scour that the piers and abutments of this bridge will be exposed to.

## 2. Material and methods

### 2.1. Study Area

The study area is located on the Tigris River in the city of Kut, the center of Wasit Governorate, for an area extending for about six km upstream of the Kut Barrage, which was built in 1934 for the purpose of regulating the distribution of water between the Tigris River towards the city of Amara and the Dijla River, which feeds the lands in the Wasit District, and the Gharraf River, which feeds the lands towards Dhi Qar Governorate. The proposed bridge (subject of the study) is located at station 4+200 approximately north of Al Kut Barrage as shown in the Fig. 1,



Figure 1. Tigris River North of Kut Barrage, Showing the Bridge the Subject of the Study (Google Earth)

## 2.2. Data Collection

The data required for the study were obtained via the following:

A- Field and laboratory work:-

1-Three samples of the bed material were taken from the proposed bridge site of the Tigris River in the field on 21/2/2025. Fig. 2-A, illustrates the sampling process. Where a sample was taken at the bridge site, a sample at a distance of approximately 100 meters upstream the bridge and a third sample at 100 meters downstream the bridge, and from different areas of the river (right, middle, left).

2-After collecting and numbering the samples, a gradation test was conducted on them (sieve analysis, hydrometer) in the Soil Laboratory, College of Engineering, University of Wasit to extract ( $d_{50}$ ,  $d_{95}$ ) which was later entered into the HEC-RAS program to calculate the scour of the bridge piers and abutments, as shown in the Fig. 2- (B, C, D, E and F)



A



B



C



D



E



F

Figure 2. Field and Laboratory Work: A: Sampling process, C+D+E and F: laboratory work.

B- Geometry, hydrological and hydraulic data for the study site of the Tigris River (discharge, water surface level, cross-sections of the river) obtained from the Directorate of Water Resources in Kut.

C- The data on the coordinates and location of the bridge, its architectural and structural designs, and all the required plans, information, and data for the bridge under study were obtained from the Wasit University Consulting Office (the office that designed the bridge).

### 3. Methodology

The methodology of this paper relied on utilizing the data collected from the field and from relevant departments to create a computer model using the HEC-RAS-v-6.6 program to simulate the condition of the river in two cases: the first without the presence of bridge and the second after the construction of bridge and with three discharge scenarios (500, 1050 and 3000) m<sup>3</sup>/s. Then, the results obtained from the two cases were compared to determine the impact of constructing the bridge on the river's properties.

#### 3.1. Numerical Simulation

The HEC-RAS-v-6.6 program is based on the principles and equations of the version 2001 of the FHWA HEC No. 18 manual in the way it simulates hydraulic models and the results it extracts [8].

##### 3.1.1 Steady flow: basic equations

Brunner and Gary used the equations below to model steady flow condition:

1- Energy equation:

$$y_1 + Z_1 + (\alpha v_1^2/2g) + h_e = y_2 + Z_2 + (\alpha v_2^2/2g) \quad (1)$$

2- Manning formula:

$$Q = \frac{1}{n} A R^{2/3} S_f^{0.5} \quad (2)$$

Where :-  $h_e$  is head loss energy (m),  $y_1$ & $y_2$ : height (m),  $z_1$ & $z_2$ : channel bed elevation (m),  $v_1, v_2$ : velocity (m/s),  $\alpha$ : velocity coefficient,  $g$ : gravity acceleration (m/s<sup>2</sup>),  $Q$ : discharge (m<sup>3</sup>/s),  $A$ : area (m<sup>2</sup>),  $R$ : hydraulic radius (m),  $n$ : coefficient of Manning roughness,  $S_f$ : slope [9].

##### 3.1.2 Unsteady flow: basic equations

In the case of one-dimensional unsteady flow modeling, the equations of Saint-Venant below were used:

1- Continuity equation

The continuity equation is based on the principle of conservation of mass within a certain controlled volume and can be written in its one-dimensional form as follows:

$$\frac{\delta A}{\delta T} + \frac{\delta Q}{\delta x} = q \quad (3)$$

2- Momentum equation

$$\frac{\delta Q}{\delta t} + \frac{\delta Qv}{\delta x} + gA \left( \frac{\delta z}{\delta x} + S_0 + S_f \right) = 0 \quad (4)$$

Where :  $q$  is lateral inflow (m<sup>3</sup> /s),  $A$ : cross-section area (m<sup>2</sup>) ,  $x$ : the distance along the channel (m),  $v$ : velocity (m/s),  $g$ : gravity acceleration (m/s<sup>2</sup>),  $Q$ : discharge (m<sup>3</sup>/s),  $z$  : water depth (m) ,  $S_0$  : bed slope and  $S_f$  : friction slope [9].

#### 3.2. HEC -RAS Model Development

HEC-RAS (The Engineers Army Corps implemented) is integrated hydraulic software that allows users to simulate, estimate and calculate a wide range of hydraulic and hydrological parameters for waterways, watersheds, main and secondary waterway-based structures and more. NASA website was used to import an aerial image of the target area, after which this image was processed using GIS ArcMap10.8 to convert it to the digital elevation model (DEM) format as shown in Fig. 3, which can be imported into the (RAS Mapper) window in the HEC-RAS v-6.6 program to create and draw a river reach [10]. From the (geometric data window) the area under study was drawn (Tigris, Gharraf and Dijaila rivers). From the same window and using the collected data, the following were entered: the cross section of river from (Cross Section icon). The Kut Barrage, the Gharraf and Dijaila regulators from (Inline Structure icon) and (Lateral Structure icon) respectively. Then the bridge data was entered and drawn from the (Bridge/Culvert Data window) within the geometric data window [11]. As shown in Fig. 4,

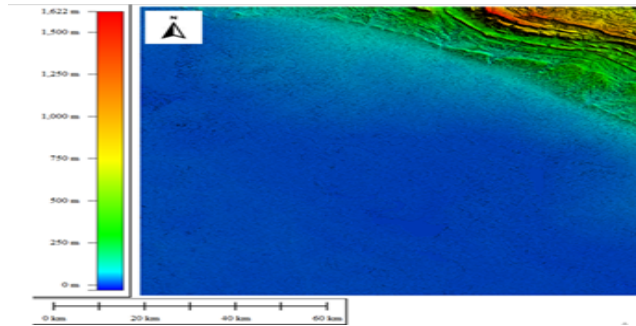
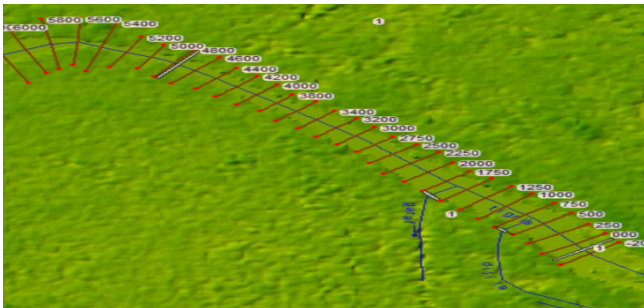
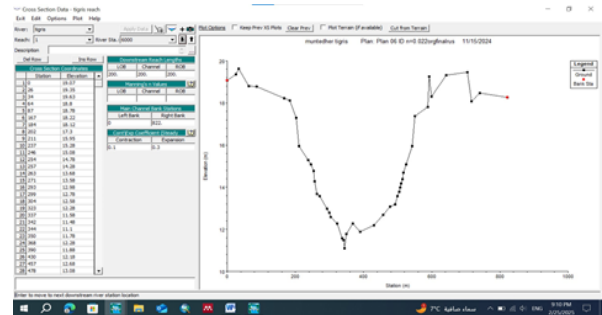


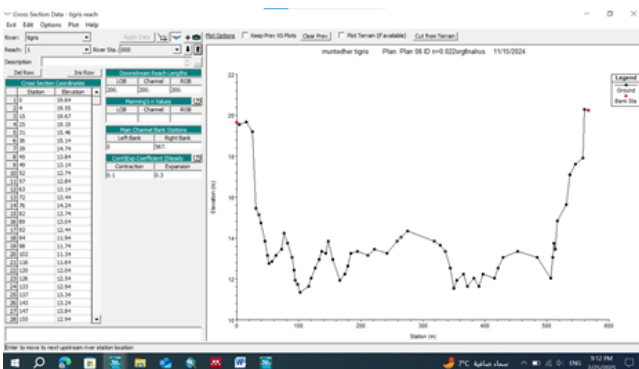
Figure 3. DEM for the Study Area (Global Mapper).



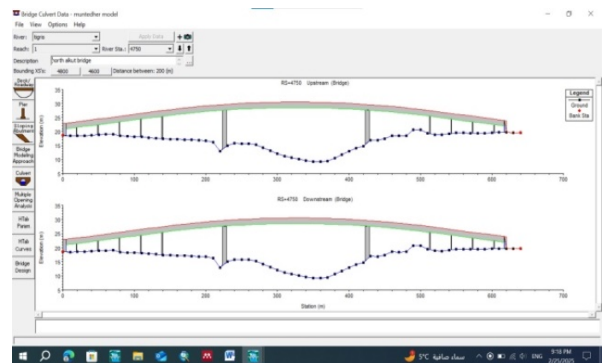
A



B



C

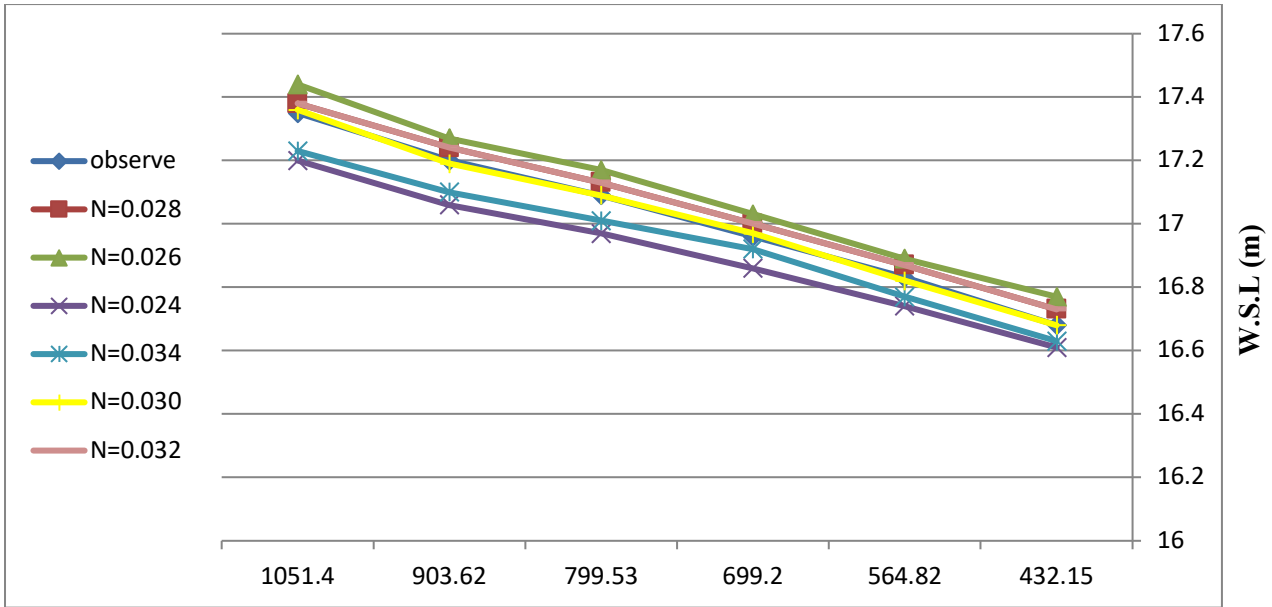


D

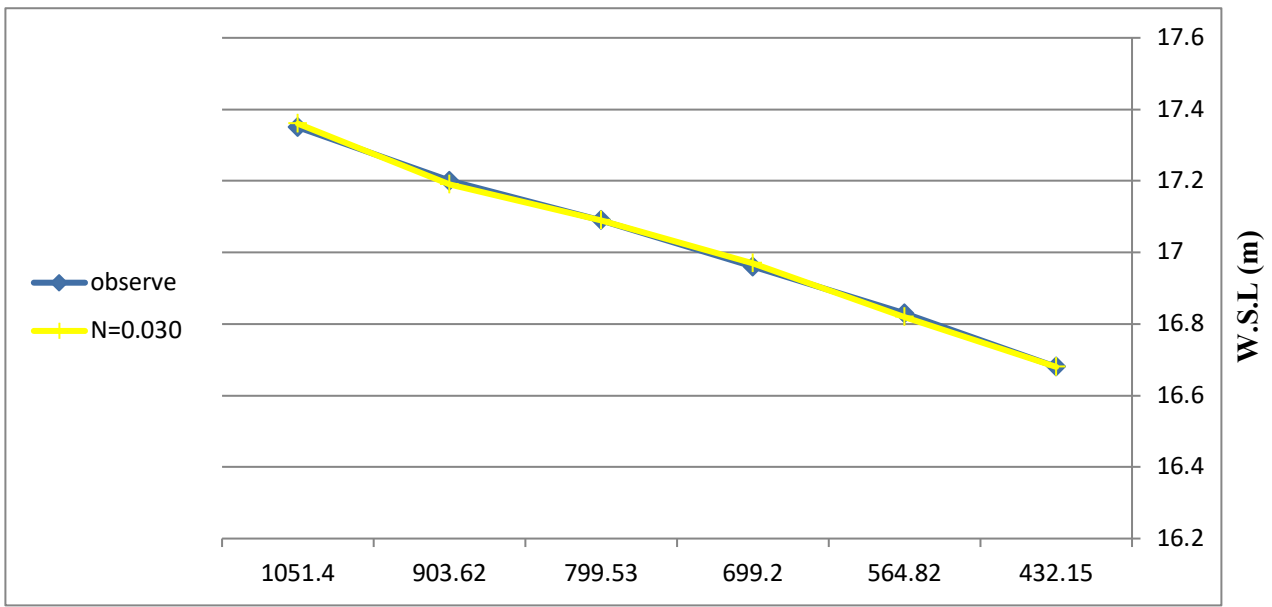
Figure 4. Data Entry Process A: River Reach, B&C: Cross-Sections, D: Bridge

### 3.3. HEC -RAS Model Calibration

Calibrating the model is very important because it ensures extracting results that are as close to reality as possible. In the HEC-RAS program, the roughness factor (Manning's factor(n)) is the most important factor that must be dealt with very sensitively because it is directly related to the discharge, hydraulic depth and the water surface level [9, 12]. This factor must be adjusted to the closest possible value to what is found on the ground and verified throughout the study area. The value of (n) was calibrated in this study based on the observed data at the front of the Kut Barrage for the month of April 2019. Six values of the Manning coefficient (n) were tested ( $n= 0.024$ ,  $n=0.026$ ,  $n=0.028$ ,  $n=0.030$ ,  $n=0.032$  and  $n=0.034$ ). According to the results in Fig. 5, below and the statistical parameters used: the root mean square error (RMSE) and the Nash-Sutcliffe efficiency coefficient (NSE) showed in Fig. 6, and Table 1. The results showed that the  $n = 0.03$  was the closest to the actual, this value for the Manning coefficient is very close to what a previous researcher has reached, who dealt with the section of the Tigris River at the downstream of the Kut Barrage[13, 14].

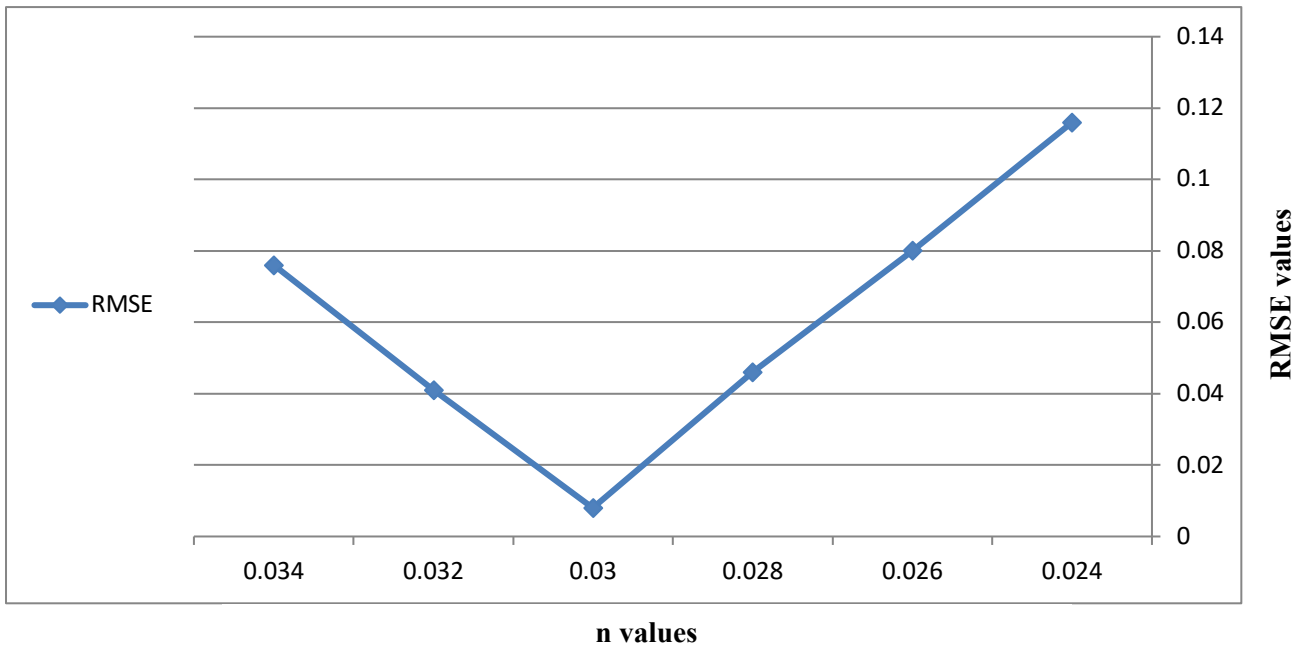


A

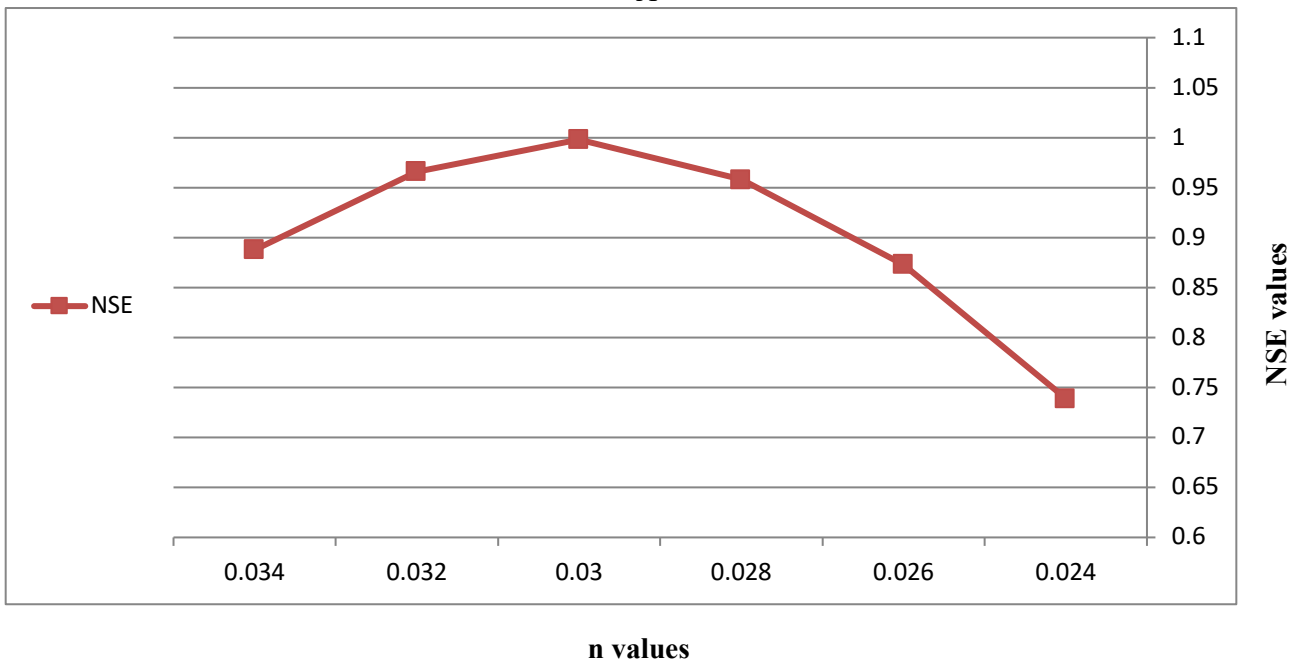


B

Figure 5. (A and B): The relation between n values and water surface elevation



A



B

Figure 6. Statistical parameter of Manning coefficient calibration

A: The relation Between NSE Values and n Values, B: The Relation Between RMSE Values and n Values.

Table 1. Root Mean Square Error (RMSE) and the Nash-Sutcliffe Efficiency Coefficient (NSE) for n Values.

N Value	NSE	RMSE
0.024	0.739	0.116
0.026	0.873	0.08
0.028	0.958	0.046
0.030	0.998	0.008
0.032	0.966	0.041
0.034	0.888	0.076

Table 1. shows the statistical coefficients for each value of the Manning coefficient (n) that was tested and the extent of the correlation of the results we obtained using these values with the actual values observed for the water surface level, as the Root mean square error (RMSE) for any variable to be tested gives the best result when it approaches zero, while with regard to the Nash-Sutcliffe Efficiency Coefficient (NSE), where the result is better the closer we get to one.

## 4. Results

### 4.1. HEC-RAS Model Running

The model was run according to three scenarios related to the amount of discharge passing through the section of the river studied, which were (500, 1050, 3000) m<sup>3</sup>/s, where the first discharge (500) m<sup>3</sup>/s represents an approximate rate of discharge at the time of preparing the study, while (1050) m<sup>3</sup>/s represents the highest discharge of the flood wave that was recorded in April 2019 [15]. Finally, (3000) m<sup>3</sup>/s is the highest discharge recorded for this part from river in the 1988 flood [16]. The flow was considered steady flow due to lack of sufficient data to run the unsteady flow, with the same boundary conditions for the three scenarios.

### 4.2. HEC-RAS Model Results

After completing the calibration process for the model and for the two stages (the first stage without the presence of bridges and the second stage with the presence of bridges within the model) and for the three scenarios of the flow amount referred to in the methodology, the following results were obtained:

#### 4.2.1. First Scenario with Q = 500 m<sup>3</sup>/s

1- Bridge scour: The scour at bridge piers and abutments at 500 m<sup>3</sup>/s discharge was as shown below:

- Contraction Scour: The contraction scour results for flow rate equal to 500 m<sup>3</sup>/s was as shown in Table 2.

Table 2. The Contraction Scour Results at 500 m<sup>3</sup>/s Discharge.

Parameter	Left Overbank	Channel	Right Overbank
Ys (m)	/	0.23	/
Vc (m/s)	/	0.48	/
Equation	/	Clear	/

Where Ys: is mean the contraction scour depth in meter, Vc: mean the critical velocity in (m/s), Equation: the equation used by program to calculate the contraction scour was here ( Clear water equation).

- Pier Scour:

Was equal to (1.34 m) for numbered piers (1, 2, 3, 4, 9, 10, 11)  
(1.75m) for piers (5 &8) and (4.16 m) for piers (6 &7).

- Combined Scour Depths:

(1.57m) for numbered piers (1, 2, 3, 4, 9, 10, 11)  
(1.98m) for piers (5 &8) and (4.39 m) for piers (6 &7).

The Fig. 7, below shows the scour at the bridge piers and abutments at a discharge of 500 m<sup>3</sup>/s.

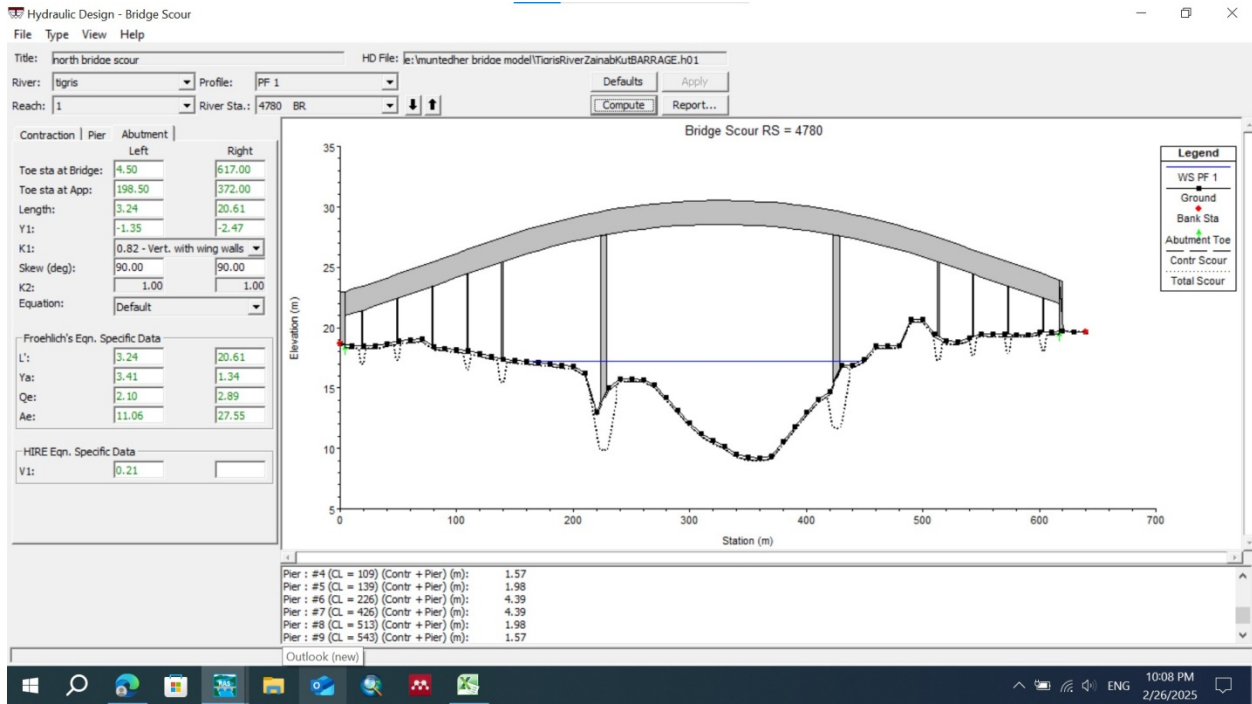


Figure7. Bridge scour at 500 m<sup>3</sup>/s discharge

2- Backwater: It was noted that no backwater occurred at a flow rate of 500 m<sup>3</sup>/s at the upstream of the bridge, as the water surface level was the same in both cases (presence of a bridge and its absence), reached (14.92) m at the bridge upstream.

3- Velocity profiles: There is no alteration in velocity profiles when comparing the two cases before and after the construction of the bridge according to the simulation results. Where the velocity was equal to (0.97) m/s for both cases and the velocity at abridge piers was (0.99) m/s at a discharge of 500 m<sup>3</sup>/s.

#### 4.2.2 Second Scenario with Q =1050 m<sup>3</sup>/s

1- Bridge scour: The scour at bridge piers and abutments at 1050 m<sup>3</sup>/s discharge was as shown below:

- Contraction Scour: The contraction scour results for flow rate equal to 1050 m<sup>3</sup>/s was as shown in Table 3.

Table 3. The contraction scour results at 500 m<sup>3</sup>/s discharge

Parameter	Left Overbank	Channel	Right Overbank
Ys	/	1.42	/
Vc	/	0.49	/
Equation	/	Live	/

$Y_s$  : the contraction scour depth (m),  $V_c$ : the critical velocity in (m/s), Equation: the equation used by program to calculate the contraction scour was here (Live bed equation).

- Pier Scour:

(1.72 m) for numbered piers (1, 2, 3, 4, 9, 10, 11)  
 (2.24m) for piers (5 &8) and (5.32 m) for piers (6 &7).

- Combined Scour Depths:

(3.14m) for piers (1, 2, 3, 4, 9, 10, 11)  
 (3.65m) for piers (5 &8) and (6.74 m) for piers (6 &7).

The Fig. 8, below shows the scour at the bridge piers and abutments at a discharge of 1050 m<sup>3</sup>/s.

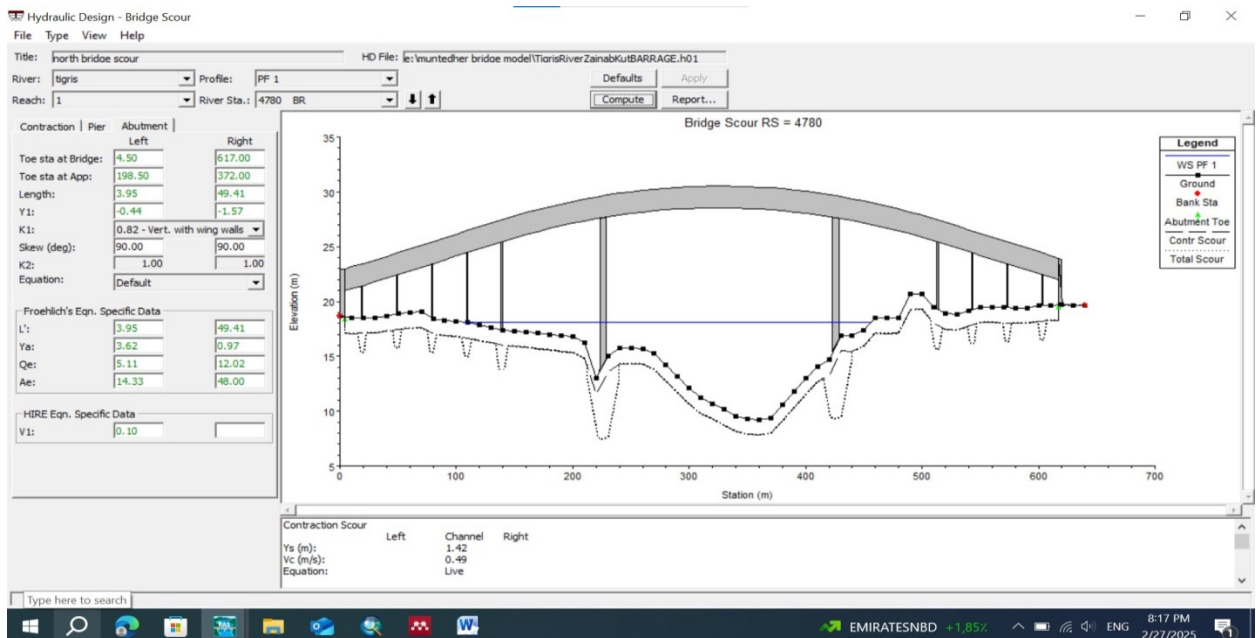


Figure 8. Bridge scour at 1050 m<sup>3</sup>/s discharge

2- Backwater : It was noted that no backwater occurred at a flow rate of 1050 m<sup>3</sup>/s at the upstream of the bridge, as the water surface level was the same in both cases (presence of a bridge and its absence), reached (16.04) m at the bridge upstream.

3- Velocity profiles : There is no alteration in velocity profiles when comparing the two cases before and after the construction of the bridge according to the simulation results. Where the velocity was equal to (1.44) m/s for both cases and the velocity at abridge piers was (1.47) m/s at a discharge of 1050 m<sup>3</sup>/s.

#### 4.2.3 Third Scenario with Q =3000 m<sup>3</sup>/s

1- Bridge scour : The scour at bridge piers and abutments at 3000 m<sup>3</sup>/s discharge was as shown below:

- Contraction Scour : The results of contraction scour were as listed in the Table 4.

Table 4. The contraction scour results at 3000 m<sup>3</sup>/s discharge

Parameter	Left Overbank	Channel	Right Overbank
Ys	/	1.99	/
Vc	/	0.51	/
Equation	/	Live	/

Ys : the contraction scour depth (m), Vc: the critical velocity in (m/s), Equation: the equation used by program to calculate the contraction scour was here (Live bed equation).

- Pier Scour:

(2.22 m) for numbered piers (1, 2, 3, 4, 9, 10, 11)

(2.89m) for piers (5 &8) and (5.32 m) for piers (6 &7).

- Abutment Scour: Abutment scour was as listed in the Table 5.

Table 5. The abutment scour results at 3000 m<sup>3</sup>/s discharge

Parameter	Left Abutment	Right Abutment
Ys	4.92	1.50
Froude	0.14	0.15
Equation	HIRE	HIRE

Where Ys: is meaning the abutment scour depth in meter, Froude: mean Froude number for flow at abutment, Equation: mean the equation used by program to calculate the abutment scour was here (HIRE equation).

- Combined Scour Depths:

(3.21m) for piers (1, 2, 3, 4, 9, 10, 11).

(3.88m) for piers (5 &8) and (7.87 m) for piers (6 &7).

Left abut + contr (m): 5.90 m

Right abut + contr (m): 2.48 m

The scour at the bridge piers and abutments at a discharge of 3000 m<sup>3</sup>/s can be seen in Fig. 9, below.

2- Backwater: It can be observed that stagnant water with a height of 1 cm occurs at the source of the bridge, extending to about 600 meters (3 stations) before its effect disappears at station 4+800 in the case of the presence of the bridge compared to the absence of the bridge, as shown in Table 6. Below.

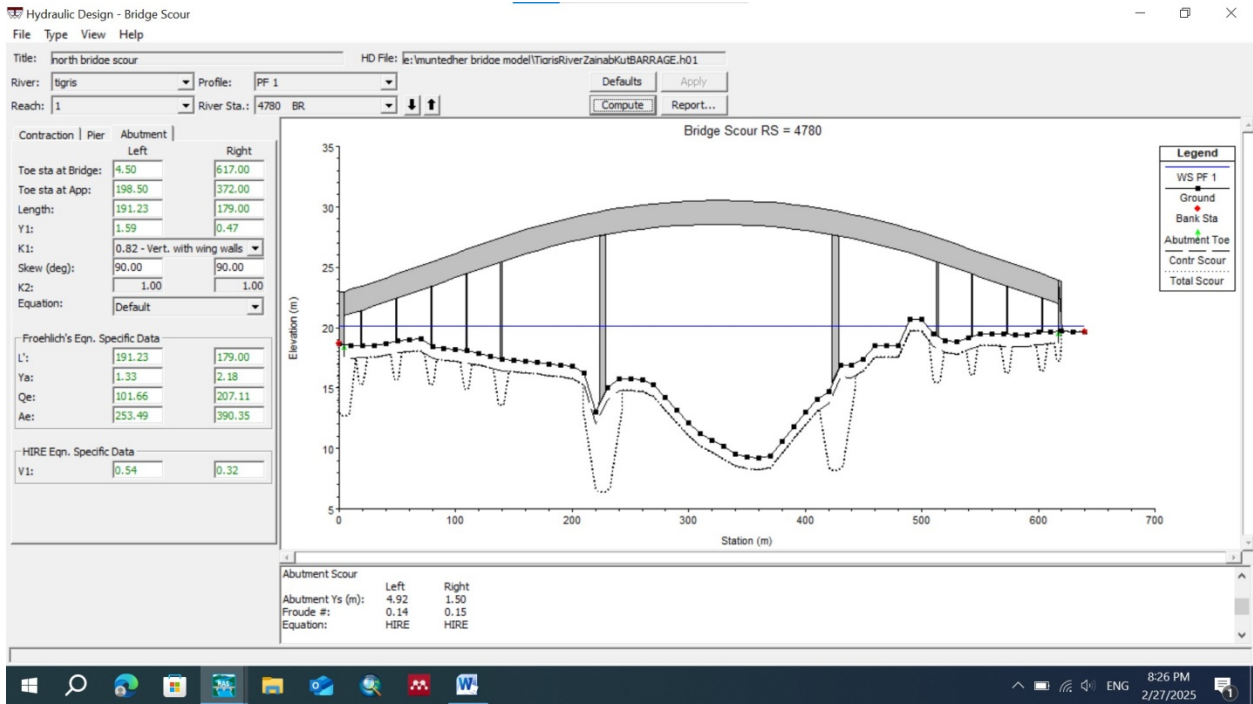


Figure 9. Bridge Scour Simulation Results at 2800 m<sup>3</sup>/s Discharge.

Table 6. Water Surface Elevation Values for Station 4+200 to 4+800.

Station	W.S.E.(with bridge)	W.S.E.(without bridge)
4+200	18.95	18.94
4+400	19.08	19.07
4+600	19.16	19.15
4+800	19.22	19.22

3- Velocity profiles: There is no alteration in velocity profiles when comparing the two cases before and after the construction of the bridge according to the simulation results. Where the velocity was equal to (1.83) m/s for both cases and the velocity at abridge piers was (1.9) m/s at a discharge of 3000 m<sup>3</sup>/s.

## 5. Discussion

When considering the results extracted from the simulation process for the two models (with and without the bridge) and the three discharge scenarios, some essential points can be noted:

- 1- Regarding scour at the bridge piers, it was observed that the scour phenomenon occurred for all the piers and for all scenarios, but with noticeable variation, as scour is directly proportional to the discharge and the width of the piers, meaning that scour increases as the flow rate increases as a result of the increase in flow velocity, turbulence and vortex size with the increase in the discharge rate, which increases the depth of the scour hole at the bridge piers. As for the width of the piers, increasing the width leads to an increase in the area of flow that is obstructed, and as a result, an increase in the flow velocity and turbulence around these piers, and thus an increase in scour there. On the other hand, no scour at the abutments was observed except in the third case (Q=3000 m<sup>3</sup>/s). The reason is clear and simple, considering that the water does not reach the abutments in the first and second scenarios, but at high flows (the third scenario), the water reached the foundations of the abutments, which led to the scour there [17].

Although the maximum scour pit depth was 7.87 meters on piers 6 and 7 during the peak discharge scenario ( $3,000\text{m}^3/\text{s}$ ), it is considered non-hazardous and does not require preventative measures for the bridge piers and abutments as long as the discharge does not exceed  $3,000\text{m}^3/\text{s}$ . This is because scour becomes dangerous when the depth of the excavation reaches the depth of the foundation (pile). In other words, scour becomes dangerous when the soil around the piles erodes so that the pile becomes visible without any burial and exposed to flow completely or nearly so, due to the possibility of the phenomenon of buckling occurring and thus failure occurring. Regarding the bridge under study, its piles are 40 meters long, so the problem of buckling is not an issue [8].

- 2- As for Backwater effect, the results did not record the appearance of backwater in the first and second scenarios at all. As for the third scenario, when the discharge was ( $3000$ )  $\text{m}^3/\text{s}$ , it was noted that there was a slight rise in the water level by 1 cm for a short distance extending to less than 600 meters, which can be considered negligible due to its negligible effect on the water level and the risk of flooding even with such a high discharge. The reason for the lack of backwater effect is due to the design of the bridge, as the area obstructed by the bridge piers and its abutments ( $71.63\text{m}^2$ ) represents a very small part compared to the cross-sectional area of the river in that area ( $1643.09\text{m}^2$ ) Which represents no more than (4.36%) of the original flow area of the section [18].
- 3- The reason for not getting any change in the velocity profile between the two models (before and after the bridge construction) and for the three scenarios is due to the same reason regarding the backwater, which is the small flow area that was obstructed by the bridge piers and abutments. Therefore, there was no change in the velocity profile for the sections upstream and downstream of the bridge. However, an increase in the flow velocity was observed within the bridge structure due to the obstruction, which in turn is considered one of the main causes of scour.

## 6. Conclusion and Recommendations

This study utilized the HEC-RAS v6.6 model to assess the hydraulic impacts of a proposed bridge located north of Al Kut Barrage on the Tigris River. The investigation was conducted under three discharge scenarios ( $500$ ,  $1050$ , and  $3000\text{ m}^3/\text{s}$ ) and considered two modeling conditions: with and without the bridge. Based on the simulation outcomes and detailed analysis, the following conclusions are drawn:

1. **Model Calibration:**  
The model was successfully calibrated using observed data, with a Manning's roughness coefficient of  $n = 0.03$  yielding optimal agreement between simulated and observed water surface elevations.
2. **Bridge Scour:**  
Scour occurred at all bridge piers across all flow scenarios, with a direct correlation between scour depth and discharge magnitude. The maximum recorded scour depth reached 7.87 meters at piers 6 and 7 during the peak discharge scenario ( $3000\text{ m}^3/\text{s}$ ). Scour at abutments was only observed under this extreme flow condition, confirming that scour development is highly dependent on flow intensity and structural exposure. In general, the scour recorded in this study does not pose a threat to the integrity of the bridge structures and does not require any measures for flows not exceeding  $3,000\text{ m}^3/\text{s}$ .
3. **Backwater Effects:**  
No backwater impact was observed at low and moderate discharges ( $500$  and  $1050\text{ m}^3/\text{s}$ ). A minor increase in water surface elevation (1 cm) was detected upstream of the bridge during the high-flow scenario ( $3000\text{ m}^3/\text{s}$ ), extending approximately 600 meters. This rise is deemed negligible and does not pose a significant flood hazard, due to the limited obstruction posed by the bridge structure (approximately 4.36% of the cross-sectional area).
4. **Velocity Profiles:**  
The analysis showed no significant change in upstream or downstream velocity profiles before and after bridge construction in any of the tested scenarios. The minimal structural encroachment into the flow area explains this stability. However, localized increases in velocity were noted near the piers, which are closely linked to scour formation.

Finally, future research is encouraged to address current limitations in modeling capabilities by exploring alternative tools and methodologies. Specifically, since the current version of HEC-RAS (v6.6) does not support the simulation of long-term scour or degradation, it is recommended that future studies utilize alternative mathematical models or software platforms to estimate long-term channel changes more accurately and enhance the overall risk assessment. Additionally, it is advisable that forthcoming investigations gather sufficient temporal data to facilitate unsteady flow simulations, which are essential for capturing the dynamic behavior of rivers during flood events and improving the reliability of predictive hydrodynamic models.

### Declaration of Competing Interest

Regarding the publishing of this paper, the authors affirm that there are no conflicts of interest.

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### Author Contributions

The author Muntedher Abbas Shilib proposed the research problem to Professor Dr. Ali Nasser Hilo. The author Muntedher Abbas Shilib collected the latest research and studies related to the subject and arranged them in a simplified manner. Then proposed, designed, and created the model for the study, extracted the results, and completed this research in its final form under the supervision and guidance of Professor Dr. Ali Nasser Hilo.

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### References

- [1] Hamill, L., 1999. *Bridge Hydraulics*. Routledge, London.
- [2] M. A. Merrill, "The Effects of Culverts and Bridges on Stream Geomorphology," 2005.
- [3] K. Vui Chua, B. Fraga, T. Stoesser, S. Ho Hong, and T. Sturm, "Effect of Bridge Abutment Length on Turbulence Structure and Flow through the Opening," 2019. doi: 10.1061/(asce)hy.1943-7900.0001591.
- [4] M. Ardicioglu, A. M. W. M. Hadi, E. Periku, and A. Kuriqi, "Experimental and Numerical Investigation of Bridge Configuration Effect on Hydraulic Regime," *Int. J. Civ. Eng.*, vol. 20, no. 8, pp. 981–991, 2022, doi: 10.1007/s40999-022-00715-2.
- [5] Uddin, Md Jahir, Ahmed Shakik, and Fauzia Barraah Mim. "Understanding the impact of bridge structure on river morphology through geospatial techniques: case on Teesta River, Bangladesh." *Discover Environment* 2.1 (2024): 91.
- [6] M. S. Mondal and C. Author, "Impact of Bridge Construction on Morphology of Major Rivers in Bangladesh," 2024.
- [7] Espinoza Vigil, Alain Jorge, and Julian Booker. "Hydrological vulnerability assessment of riverine bridges: The Bajo Grau bridge case study." *Water* 15.5 (2023): 846.
- [8] Richardson and Davis, "Evaluating scour at bridges, Report No. FHWA-IP-90-017," *Fed. Highw. Adm. U.S. Dep. Transp. Washington, D.C., U.S.A.*, vol. FHWA-IP-90, no. 18, pp. 377–383, 2001.
- [9] G. W. Brunner, "HEC-RAS river analysis system 2D modeling user's manual," *US Army Corps of Engineers—Hydrologic Engineering Center*, pp. 1-171, 2016.
- [10] T. W. Mahdi and A. N. Hilo, "Estimation of Flood Hazards Using Hec-Ras 1D: The Case of Al-Musandaq Escape," 2021 International Conference on Advance of Sustainable Engineering and its Application (ICASEA), Wasit, Iraq, 2021, pp. 131-136, doi: 10.1109/ICASEA53739.2021.9733085.
- [11] E. US Army Corps, "HEC-RAS 5.0 Users Manual.pdf," 2016. [Online]. Available: [www.hec.usace.army.mil](http://www.hec.usace.army.mil).
- [12] Ismail, Sherine. "Evaluation of local scour around bridge piers (River Nile Bridges as Case Study)." *Thirteenth International Water Technology Conference, IWTC. Vol. 13. 2009.*
- [13] T. W. Mahdi and A. N. Hillo, "Flood Control by Weir Design Using HEC-RAS Model: The Case of Al-Musandaq Escape," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 877, no. 1, 2021, doi: 10.1088/1755-

- 1315/877/1/012025.
- [14] Auad, Maryam, Maryam Ouid, and Mohammed S. Shamkhi. "Study effect of slope change on sediment transport in the Dujila irrigation canal." *Wasit Journal of Engineering Sciences* 11.1 (2023): 116-125.
- [15] MoWR, Ministry of Water Resources, 2019, The Recorded Discharges and Water Level, Unpublished Documents.
- [16] IMI, Ministry of Irrigation previously, MoWR, Ministry of Water Resources, 1988, The Flood of Tigris and Euphrates Rivers in 1987-1988, Arabic version.
- [17] Rath, Aparna, and H. M. Patel. "Estimation of Bridge Scour Using HEC-RAS—A Case Study of Orsang Aqueduct." *International Conference on Hydraulics, Water Resources and Coastal Engineering*. Singapore: Springer Nature Singapore, 2023.
- [18] Shamkhi, Assist Prof Mohammed S. "Experimentall study of the effect of contraction ratio on backwater by using bridge pier as flow obstruction." *UEMK 2018 BİLDİRİ ÖZETLERİ KİTABI* 18-19 Ekim 2018 Hukuk Fakültesi (2018): 614.