

Using HEC-RAS 1D for Flood Hazard Estimation For Building Construction in the Upstream of the AL Kut Barrage

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ABSTRACT

The construction of buildings and recreational facilities in urban river basins is a well-documented problem that is having a devastating impact on urban infrastructure and human lives due to the increased frequency and severity of extreme rainfall and flooding. The likelihood of flooding cannot be eliminated, although it can be mitigated to some extent. Consequently, future flood control initiatives must priorities integrated strategies that account for both risk uncertainty and flood projections. In order to assess the potential harm, it is crucial to develop a solid approach for flood modeling and mapping. The goal of this study was to develop a flood projection zone by integrating hydrological models with geographic information systems. at the mouth of the Tigris River at Kut in central Iraq, at the front and rear of the dam. This was accomplished by making use of the hydrological models HEC-Geo RAS and HEC-RAS. located areas that are at risk of flooding due to varying flow rates. To generate the DEM, a high-resolution topographic scan of the intended area—including the front and rear of the embankment—was employed. The dam was constructed using 6-kilometer-long front and 12-kilometer-long rear cross sections. In order to ascertain the depths of the terrain and its variations, GIS technology was employed. Several areas in the study area experienced flooding. A number of drainages were used to validate the model calibration, and the suitable Manning coefficient for the area was determined by utilizing statistical estimations (NSE, RMSE, MAE). This production quantity corresponds to a maximum flood depth of 17.5 meters. Based on the findings from the analysis using HEC-RAS, it is clear that structures situated in river basins have a significant influence, and a discharge of 2250 m³/s might cause flooding.

Keywords: HEC-RAS1, Prediction of floods, Hydrostatic Module, Impact of structures on the river basin,

1. Introduction

When compared to other natural disasters, floods are typically thought of as the most devastating since they affect more people and happen more often than any other form of natural disaster. [1, 2] One such thing that may happen as a result of climate change is that floods would become more often and more destructive [3]. Social and civic group conflicts [4], environmental issues [5], financial losses [6], and more. The southern part of Turkey is the primary source of the Tigris River, the biggest river in Western Asia [7]. A lesser fraction is located in Syria and Iraq, but the total area encompassed in its catchment is around 473,103 square km [8]. Not only are floods one of the worst natural catastrophes that may happen, but they also do a lot of damage to infrastructure and kill a lot of people. More lives are lost as a result of it than any other natural disaster, and it also has a major influence on people's social and economic life. Partially avoiding floods is possible, but completely avoiding flood dangers is not possible. Nevertheless, plans to avoid such disasters in the future are necessary. More weight should be given to integrated approaches that account for risk uncertainty and flood projections. Consequently, a suitable method of flood modeling and mapping is necessary for assessing the likelihood of flooding. Assessing flooded regions with the use of engineering data generated in HEC-Geo RAS,

Many different kinds of HEC-RAS simulations were run[9]. There are three separate phases to the process: planning, executing, and verifying. The geographic coordinate system (GCS_WGS_1984) was used to georeference the acquired satellite image in HEC-RAS for the verification and flood risk mapping phase. The geometry data provided by ArcGIS was imported by a program called HEC-GeoRAS. Hydrological data provision, boundary condition establishment, and beginning state establishment are the major duties of HEC-RAS. Constructing a flood prevention map Hydrological models reveal flood conditions, which are used to construct the Flood Hazard Map. People's exposure to danger should be seen as a whole, including both their susceptibility and the risk they face[10]. The built-up areas along the banks of the Tigris River altered the river's flow pattern. Buildings and recreational amenities are being constructed in river basins within metropolitan centers, which is producing floods and peak rainfall[11, 12]. The primary goal of the research was to determine how the Tigris River's man-made infrastructure affects the flow characteristics of the river as it travels between the Kut barrage's upper and lower levels as well as al-maftah. This river runs for 5 km and is home to several establishments, such as the Water City Resort and the Iraqi-German School. Additional facilities currently being built[13, 14].

2.The Aims of the Research Project

The main objective of this study is to create a mathematical model that can mimic the flow of the Tigris River between the al-maftah and the upper and lower parts of the Kut barrier. Fine-tune and validate a computational model for the purpose of simulating the flow of the Tigris River segment spanning the distance from the Kut crossing to al-Maftah. investigate how the Tigris River's infrastructure has altered its flow characteristics between the Kut barrage's upper and lower parts and al-maftah..

2.1.Methodolog

In order to accomplish the goals listed above, the following procedures were followed: Looking over relevant prior research and data that pertain to the Tigris River within the context of the study. Research on the Tigris River will include collecting all available hydrological data and river cross-section data, among other things. Taking note of the river's present condition by going to its actual site[[15].We are now working on a one-dimensional HEC-RAS model of the Tigris to simulate its flow in the study area. Validating and calibrating the HEC-RAS model is an important step. discover how the top and lower parts of the Kut barrage and al-maftah have changed the flow characteristics of the Tigris River due to the man-made structures that line it monitoring work hours The cross sections of the study area included river bed levels above sea level according to specific stations for each section, some of which exceeded a station by means of the Doppler device at specific distances between one section and another. After that, the station levels for all sections were arranged in an Excel sheet file and the file was retrieved from The cross-sections are illustrated in the figures (4,5,6,7) provided below [1].

2.2.Description of the Reach study

A roughly 5-kilometer-long portion of the Tigris River may be seen in Figure (1) between the region including Al-Muftah and the Kut Barrage. The main cross-regulator for controlling the flow of the Tigris River is the Kut Barrage. See Figure(2) Latitudes $32^{\circ}29'55.79''\text{N}$ and $45^{\circ}49'4.22''\text{E}$ to $32^{\circ}31'43.59''\text{N}$ and $45^{\circ}46'17.40''\text{E}$ make up the research area. The Water City Resort and the Iraqi German School are two of the most notable establishments in the vicinity.

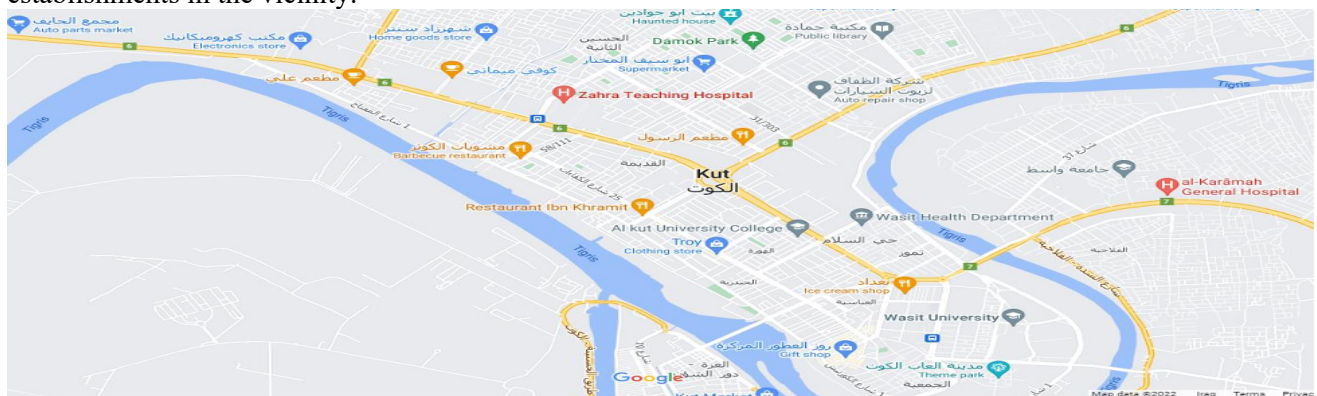


Figure 1. The section of the Tigris River that lies between Al Muftah and the Kut Barrage from its upstream end (map of Google)



Figure 2. The section of the Tigris River that Al-kut Barrage.

3. Input data

A digital elevation model (DEM), river flow, and impacted length cross-sections were all included as part of the geometric information for the study reach.

3.1. Modelling of Digital Elevation (DEM)

Digital elevation models (DEMs) are three-dimensional computer representations of land surfaces created using data on the terrain's elevation. This information is crucial for building the mathematical models used in the study. By determining their heights, the DEM data helps determine the Earth's major and natural features. Due to its stability, homogeneity, and availability, data from the Shuttle Radar Topography Mission (SRTM) has emerged as the go-to global elevation dataset in the past 10 years. Our focus here is on using the SRTM DEM for hydrological modeling [16]. In this investigation, a raster version of the DEM picture acquired on April 14, 2017, from the SRTM website is utilised. The digital elevation model (DEM) of the Tigris River upstream of the Kut Barrage and between Al-Muftah is shown in Figure (3).

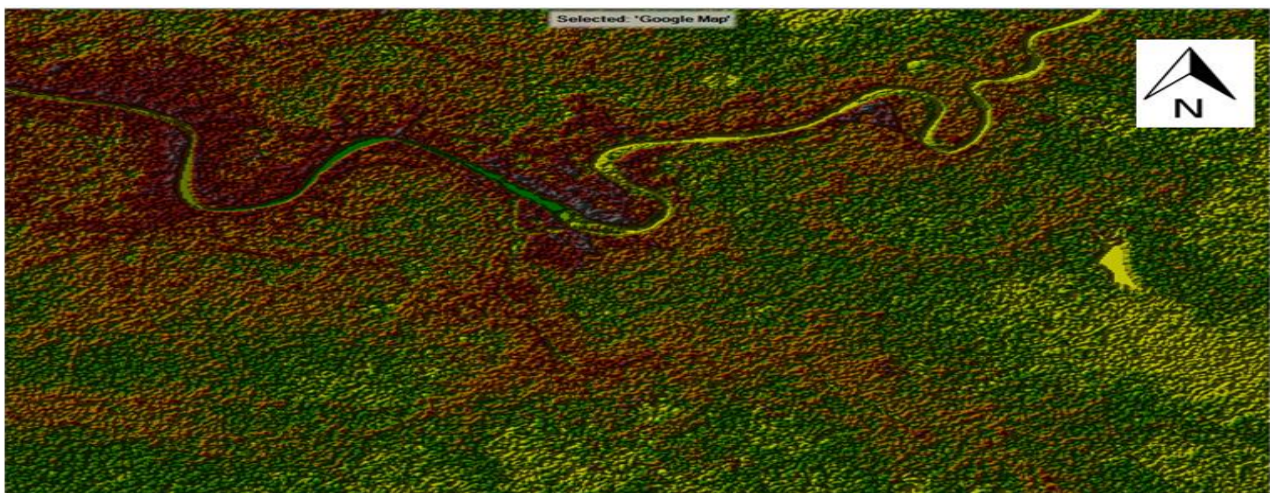


Figure 3. DEM for the study area

3.3. Cross-section

Data was imported into the HEC-RAS program via the Edit Geometry window from the Irrigation department in Kut. The data included cross-sections from the Tigris River upstream of Al-Muftah to the Kut Barrage, as a sheet file. The cross sections of the study area included river bed levels above sea level according to specific stations for each section, some of which exceeded a station by means of the Doppler device at specific distances between one section and another. After that, the station levels for all sections were arranged in an Excel sheet file and the file was retrieved from The cross-sections are illustrated in the figures (4,5,6,7) provided below [1] .

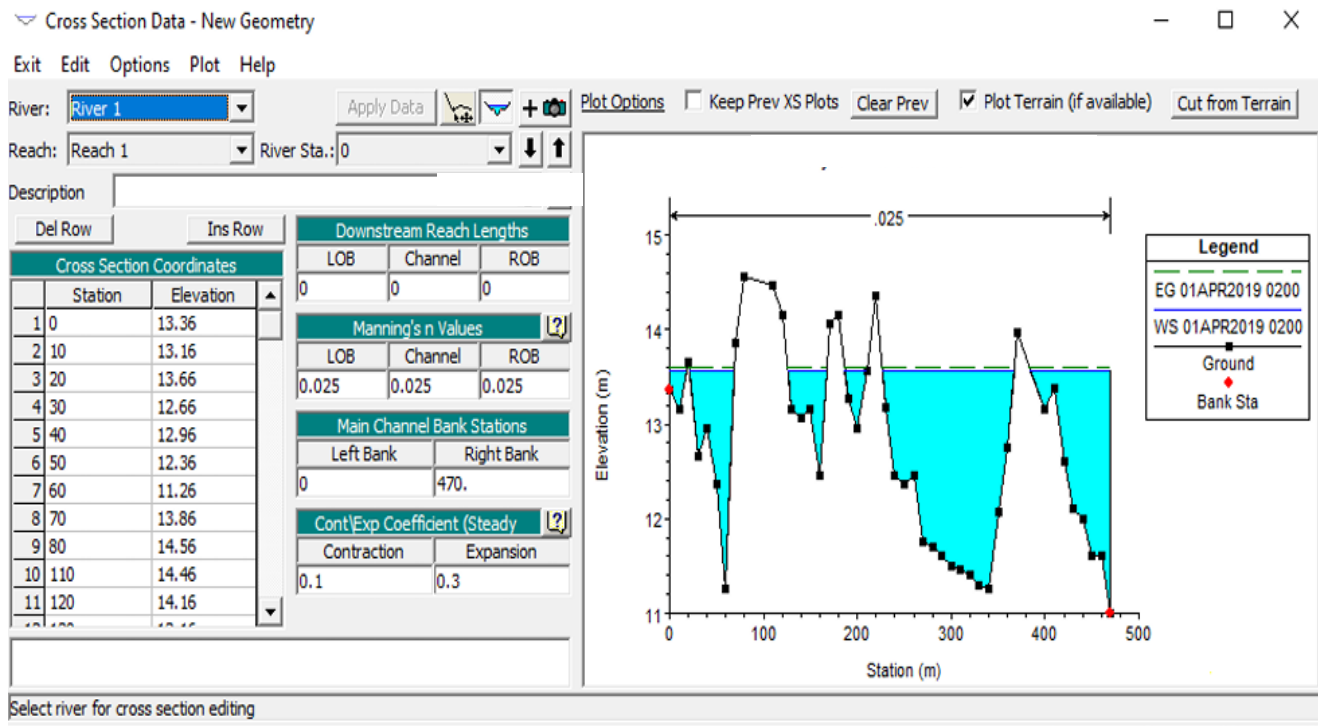


Figure 4. cross-section situated at station (0+0)

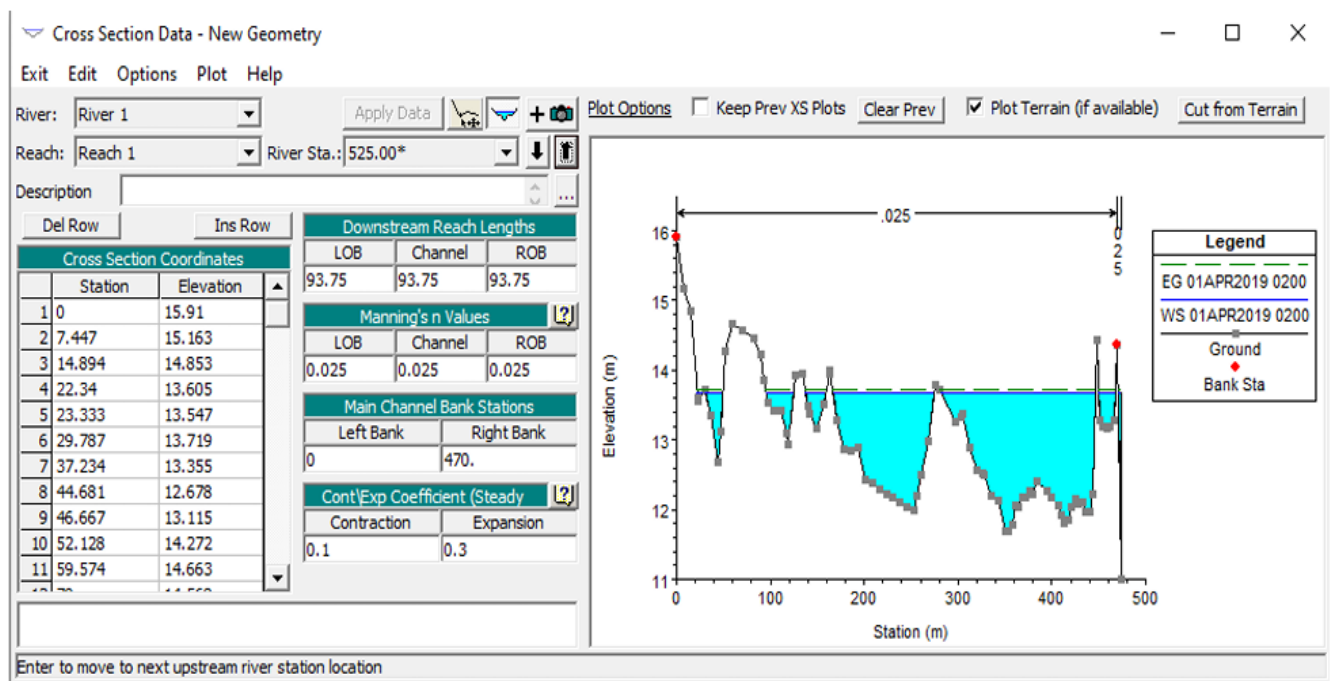


Figure 5. cross-section located at the station(0+525)

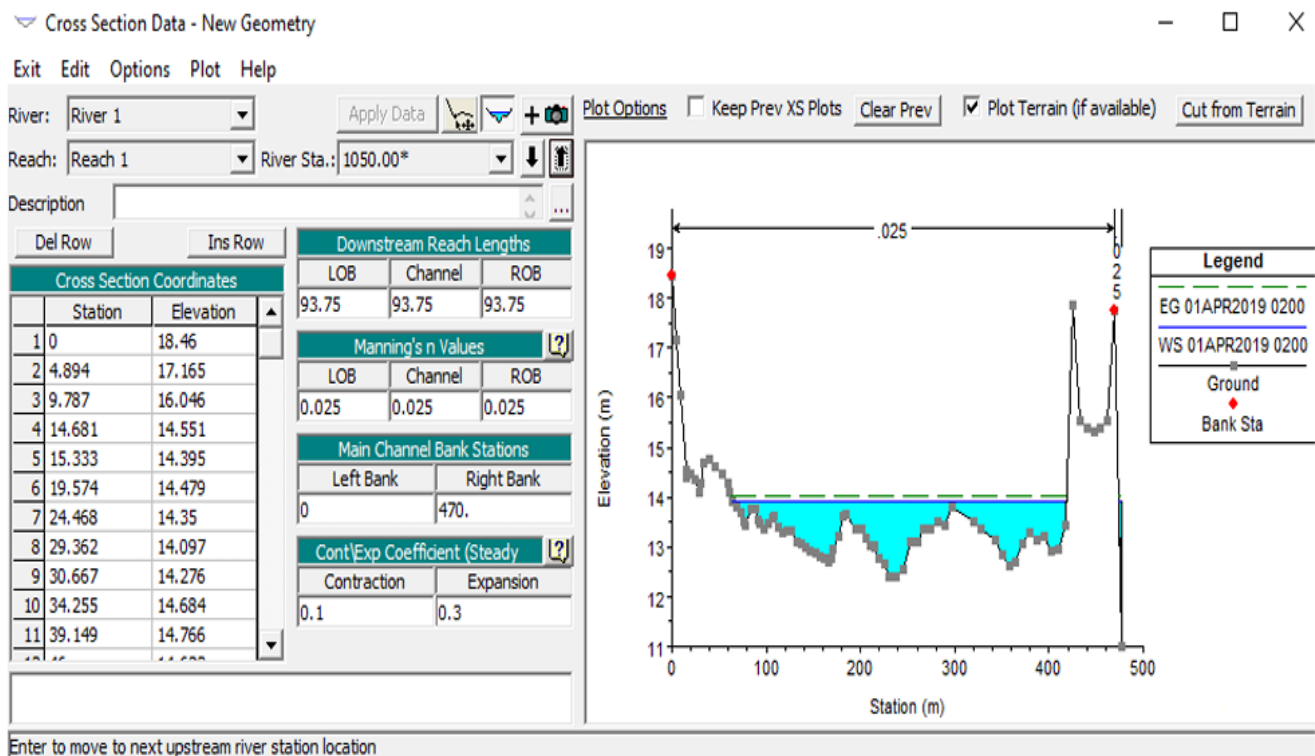


Figure 6. cross-section situated at station (0+1050)

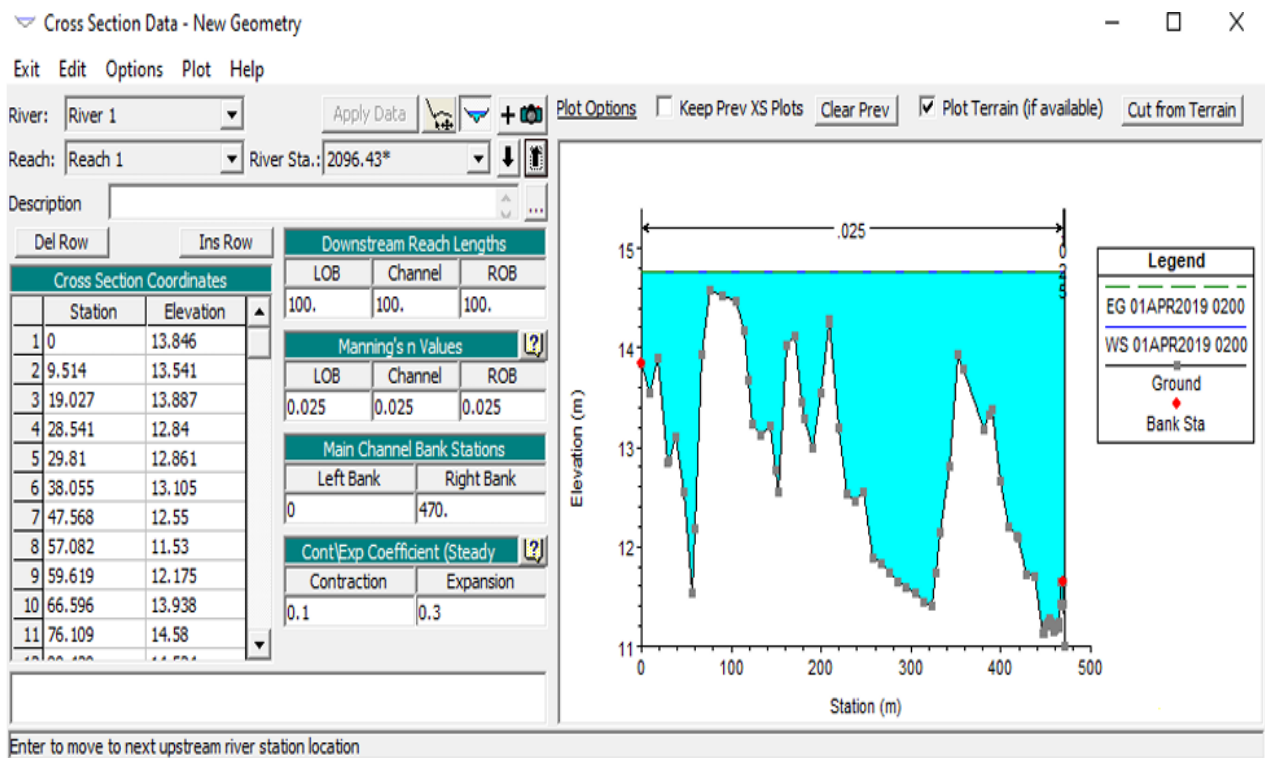


Figure 7. cross-section situated at station (0+2200)

3.4. Interpolation of the Cross-section

Important cross-sectional data may be derived by extrapolating from any two survey sections. To produce consistent intervals, interpolated cross-sections are used when a large change in the velocity head makes it impossible to evaluate the energy gradient shift.

3.5. Create Terrain

A terrain is created in the RasMapper window by downloading the DEM. The projection file for the project is downloaded from the spatial reference website for WGS84/UTM ZONE 38N.

3.6 Boundary conditions (unsteady flow data)

Some boundary conditions that could be directly associated with one- or two-dimensional flow regions include stage hydrographs, flow hydrographs, rating curves, precipitation, and normal depth. To set the limits of the research, the Al-Kut Water Resources Division used one hydrograph that they obtained in April 2019 as their boundary condition. Figure (8) shows the hydrograph of the flow in the study area. Upstream boundary conditions are depicted by this hydrograph, whereas downstream boundary conditions are defined by a normal flow with a slope of 0.0004 [1].

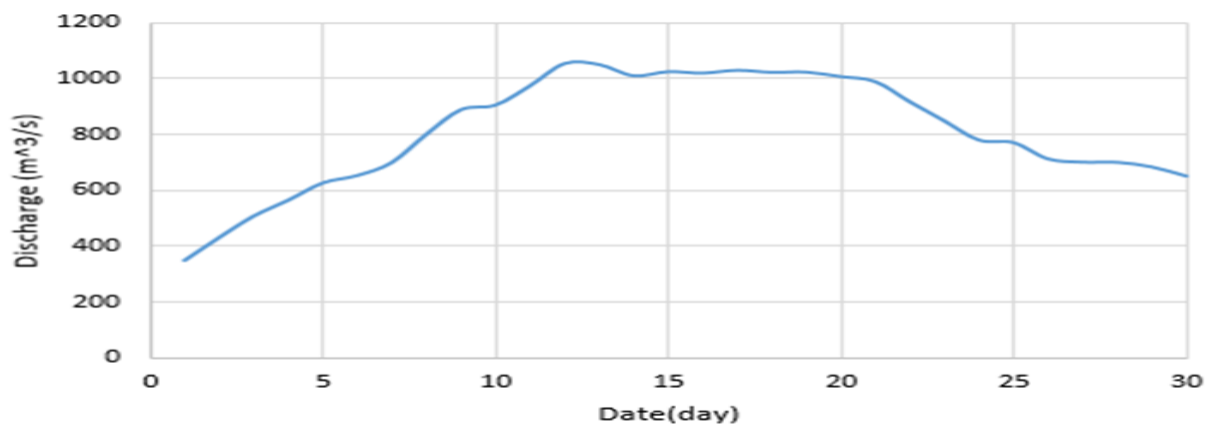


Figure 8. Flow measurements taken along the Tigris River

3.7. One-dimensional HEC-RAS model

The HEC-RAS hydraulic modeling process begins with data management. In this step, the real geographical features are shown using the GIS techniques of georeferencing and spatial registration. The processes for data calibration and compilation are improved, and the intrinsic properties of the geographical feature under study are preserved (8). Using Ras Mapper, which is part of HEC-RAS 5.0.7, the GIS operations were completed. Next, you'll need to enter the data. The model was originally provided data on the river system's spatial geometry. A digital elevation model (DEM) of the watershed, the channel, the cross-sectional geometry of the river, and the surface roughness of the floodplain as determined by Manning's roughness coefficient are all part of the geographical input data. Survey cross-sections and the resultant digital elevation model were the main geometric data used to run the hydraulic model. In the Geometry Edit box, 126 more cross-section geometries were linked to create a river network, as shown in Figure (9), which runs from upstream to downstream.



Figure 9. Editing Geometry in the HEC-RAS Models

3.8. Model Calibration for HEC-RAS

The most sensitive parameter in river modeling is Manning's roughness coefficient. In order to attempt to calibrate the river's Manning's roughness coefficient value, these flows must be simulated using HEC-RAS modeling and the study distance. Calibration is an inverse mathematics issue since it seeks to identify the independent variables that determine the original and local arguments of a function given a specific set of measurement data. Calibration of hydrodynamic models has always been a manual process. This calibration method minimizes the goal function by displaying the river, adjusting the parameter sets, and considering the ranges of parameter values for the flow scenario. R, the correlation value between the two data sets (simulated and observed) [17]. The statistical measurements used include the root-mean-square error (MAE), the Nash-Sutcliffe efficiency coefficient (NSE), and the root-mean-square error (RMSE).

$$MAE = \frac{\sum_{i=1}^N |O_i - F_i|}{N} \quad (1)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^N (O_i - F_i)^2}{N}} \quad (2)$$

$$NSC = 1 - \frac{\sum_{i=1}^N (O_i - F_i)^2}{\sum_{i=1}^N (O_i - \bar{O})^2} \quad (3)$$

the number of data points (N), the mean of the predicted water demand (F_i), the average of the actual water consumption (O_i), and the number of observations (N).

4. Results

4.1. HEC-RAS Calibration and Validation

In order to investigate and evaluate their impact on the level of the water's surface, several It was determined that Manning's n values applied to the primary channel and associated flood plain. The tested values for the Tigris River vary from 0.025 to 0.033. The rest was used to compare the virtual and actual flows. Various values of Manning's n are compared with their actual and projected flows in Tabel (1). When Manning measured the Tigris River, he discovered that its roughness coefficient, or "n," was 0.03. With an R-value of 0.998, the results were excellent. The model did an excellent job of fitting correlation, as seen graphically in Figures (10,11) which compares the observed and simulated flow data.

N value	NSE	RMSE	MAE
0.025	0.181	0.301	0.097
0.027	0.115	0.26	0.0102
0.029	0.508	0.194	0.128
0.03	0.998	0.008	0.008
0.031	0.987	0.031	0.031
0.033	0.932	0.071	0.066

Table 1. Estimates from statistics

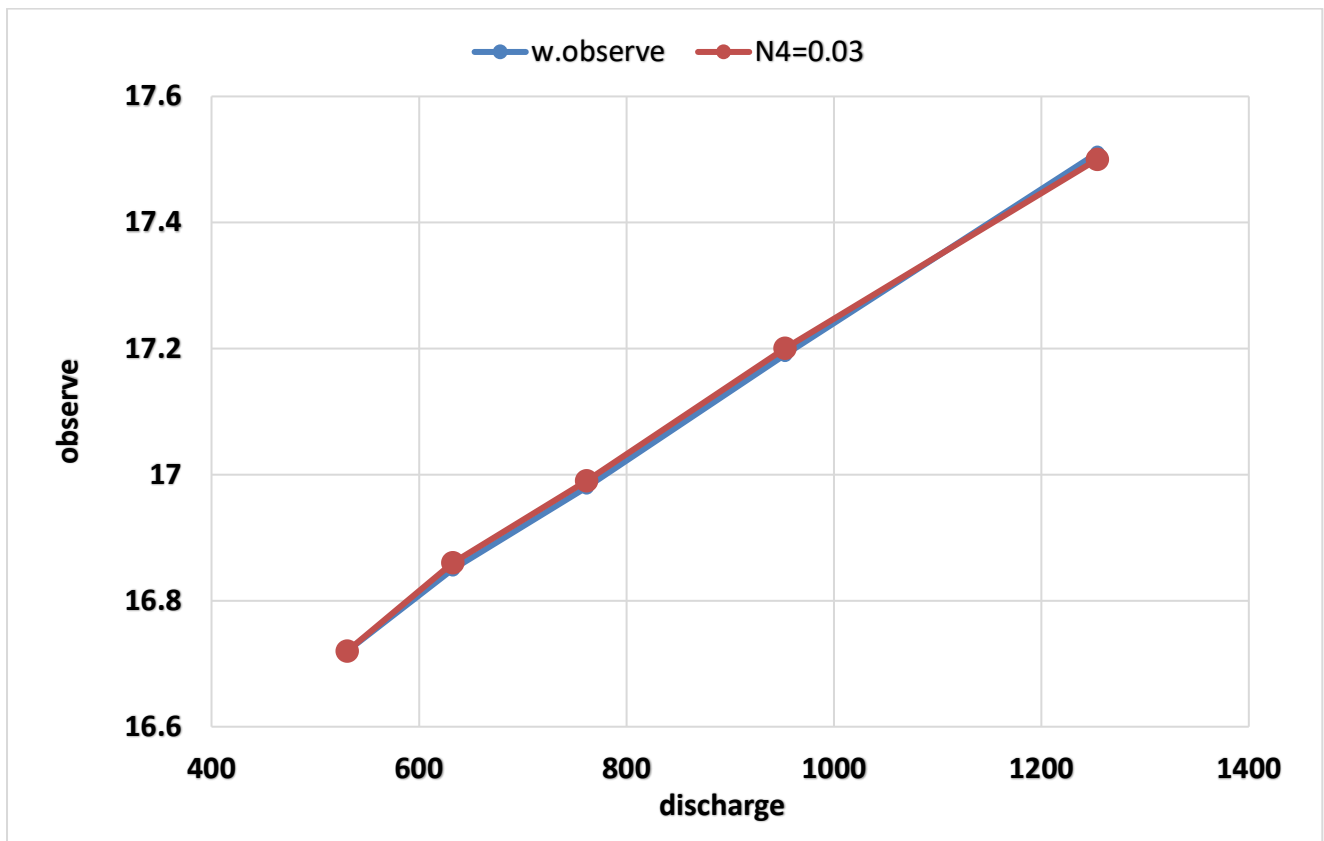


Figure 10. data that has been simulated

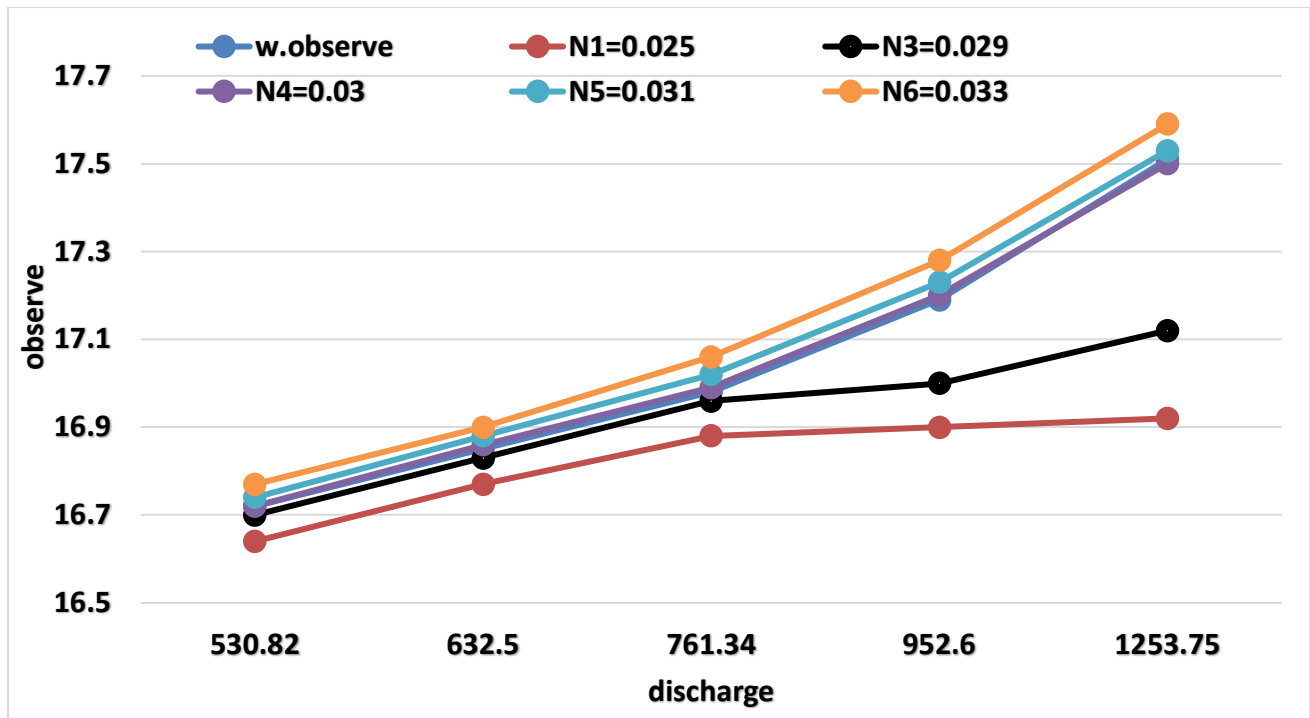


Figure 11. simulated data

4.2.Stage and flow hydrographs for study area Without the facilities erected on both banks of the river

Figures (12) and (13) reveal the stage and flow hydrographs for the D/S station (0+0) last station and U/S station (0+5000) first station. At station 0+0 the maximum stage value is 14.77 m on April 12, 2019 with the maximum flow value of 1051.10 m³/s on April 12, 2019; at station 0+5000 the maximum stage value is 16.44 m on April 12, 2019 with the maximum flow value of 1051.55 m³/s on April 12, 2019.

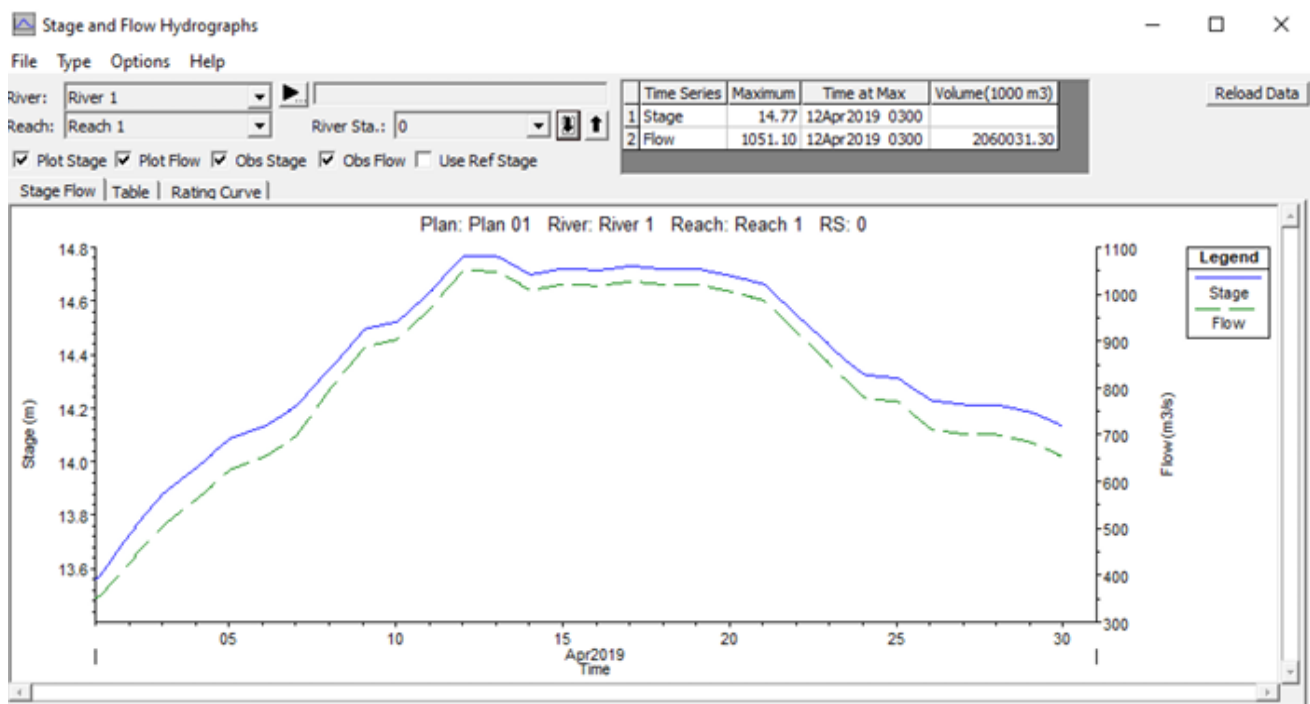


Figure 12. The stage and flow hydrographs at the station 0+0

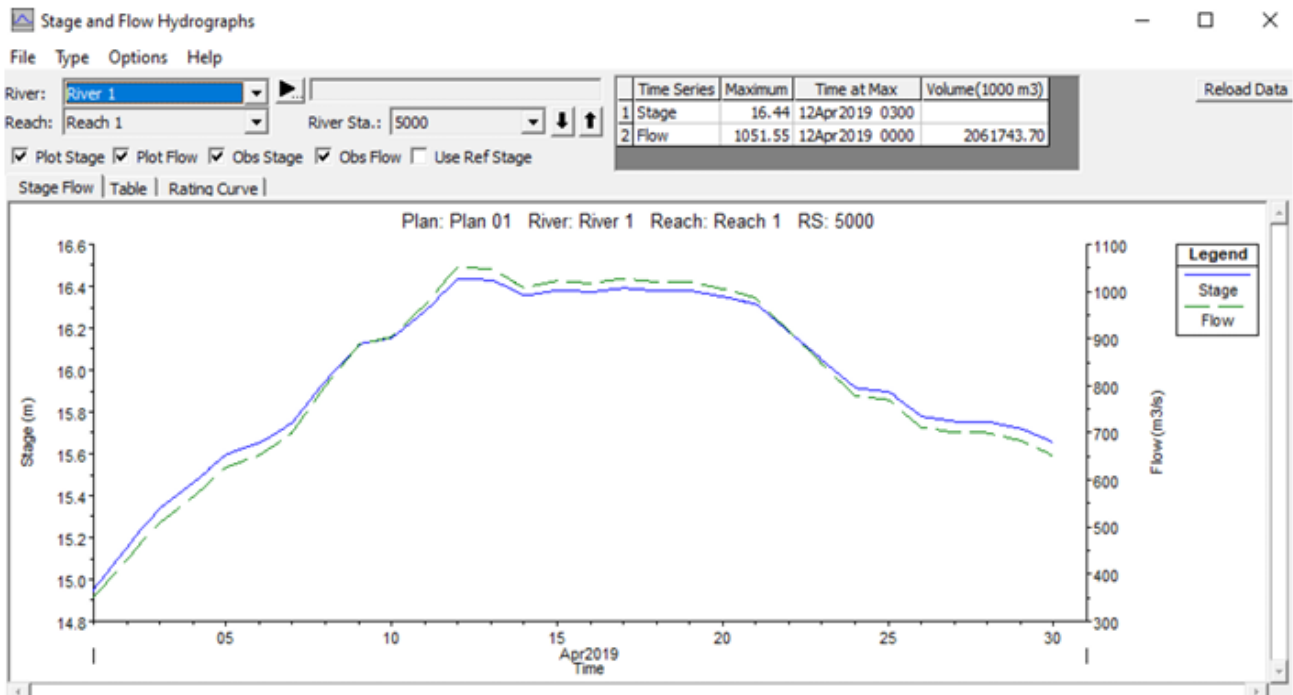


Figure 13. Hydrographs of the stage and flow at the 0+5000 station

We note that the exchange value did not change between the first and the last syllables of the study space, because the school space is so small, about a 5 kilometer only. Finding out how much of an influence the facilities constructed inside the research area on the Tigris River's two sides., for this we will introduce cross sections that include the facilities by extending the cross-section with a distance that includes them through the rasmapper window. The rasmapper window works similar to that of the GIS program, but it is within the hecras program. Figure (14) shown rasmapper window with download dem image from google map.

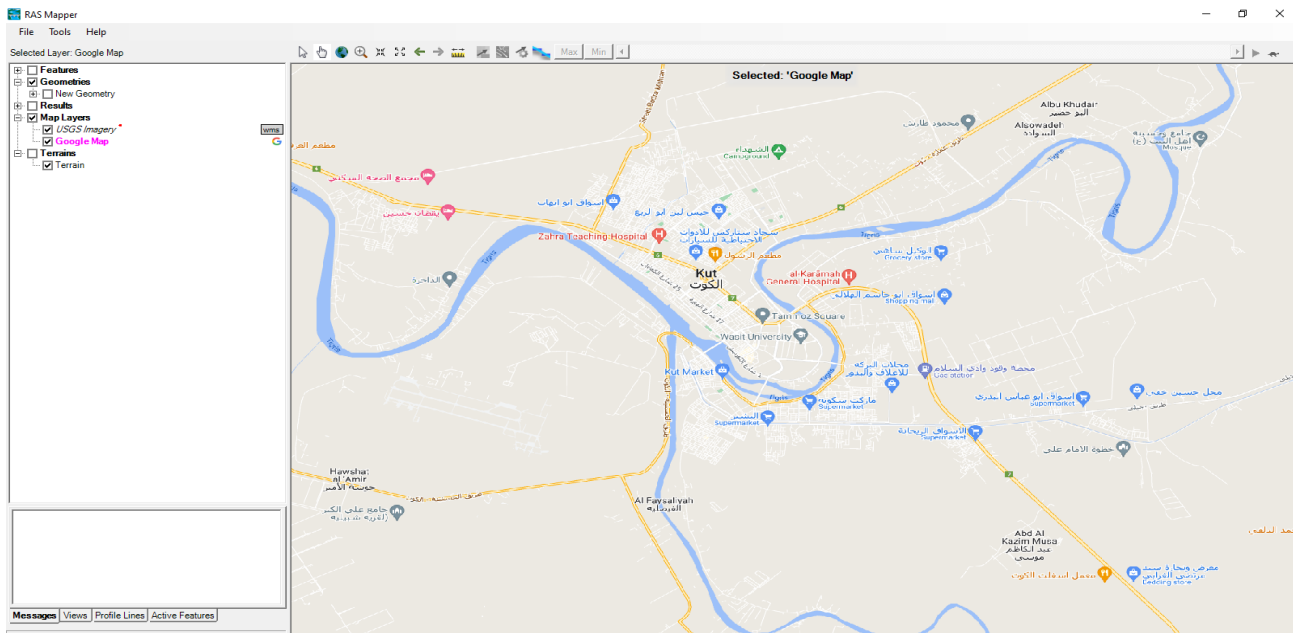


Figure 14. rasmapper window with download Dem image from google map

4.3 Edit geometry data

To modify the cross-sections in the Ras mapper window, we go to the icon on the left of the window and choose the edit cross-section option, then we erase the original cross-section and draw in its place the new section that extends to the origin whose effect we want to know (the German school - the Olympic pool - some small facilities). Figure (15) shows the cross-section after modifying them.

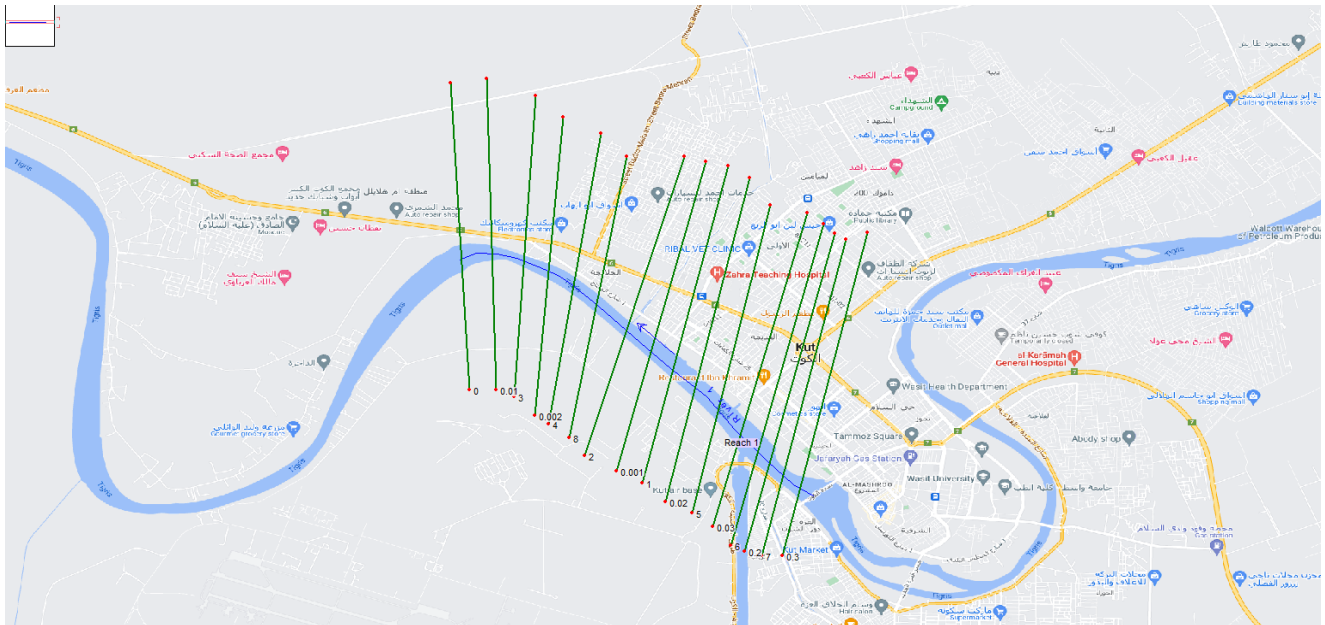


Figure 15. The cross-section after modification

Figures (16) and (17) reveal the stage and flow hydrographs for the D/S station (0+0) last station and U/S station (0+5000) first station. At station 0+0 the maximum stage value is 14.69 m on April 20, 2019 with the maximum flow value of 1004.74 m³/s on April 20, 2019; at station 0+5000 the maximum stage value is 16.33m on April 20, 2019 with the maximum flow value of 1005.00 m³/s on April 20, 2019.

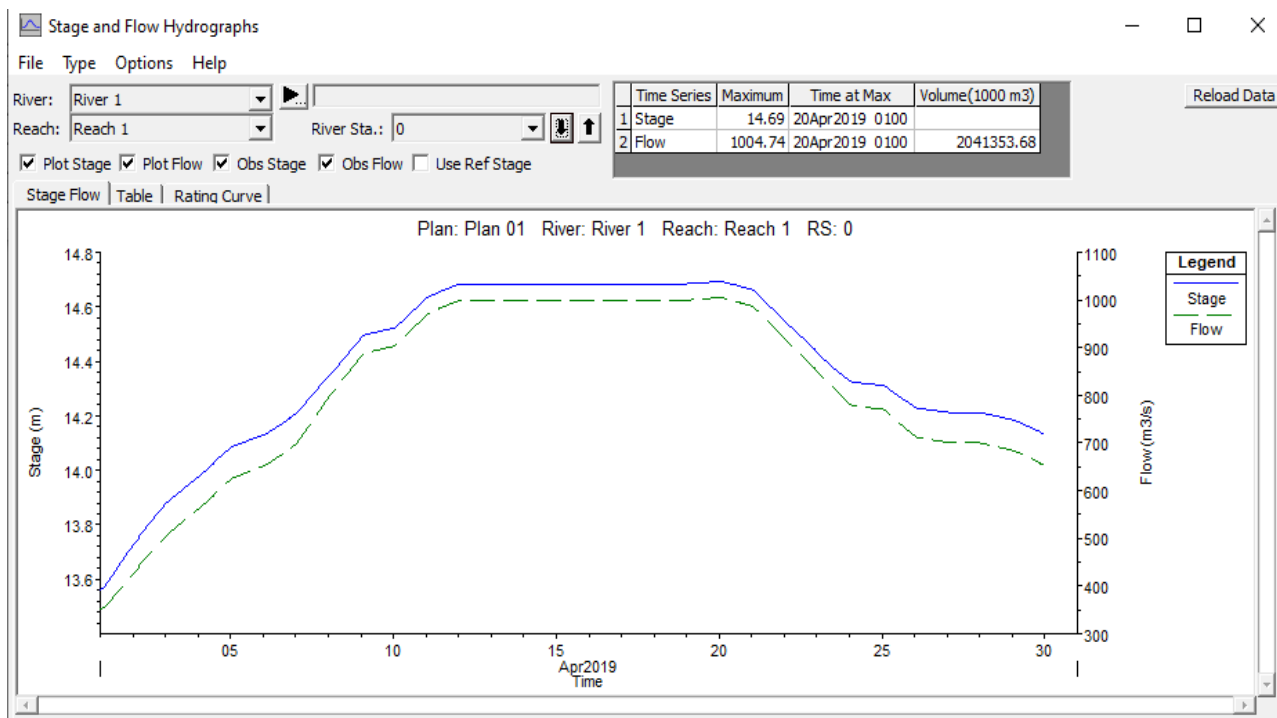


Figure 16. Hydrographs of the stage and flow at the 0+0 station

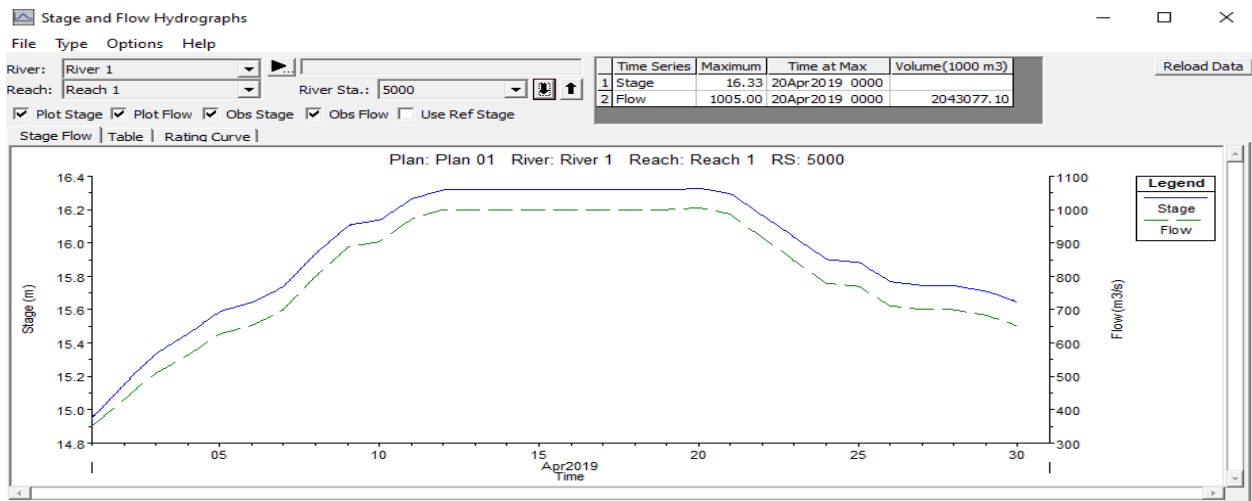


Figure 17. Hydrographs of the stage and flow at the 0+5000 station

We also note that the amount of expenditures did not change between the first and the last section, but it decreased by 50 m³/s compared to the previous results, due to the absence of facilities on both banks of the River Tigris. We also note that the course of the river has narrowed, as well as the speed and flow of flow, as the first case was delayed to April 12, but in this case it was delayed until April 20, which proves that it hindered the speed and flow of flow.

5. Conclusions

Finding out how much of an influence the facilities built on the two banks Inside the research area, this section of the Tigris River is of 5km in length. using the HEC-RAS software.

The following deductions were made in light of the current study's findings:

- The flow measurements of the Tigris River were used for validation and calibration purposes. A strong relationship formed between the predicted and actual flow rates as a result of this. With a Manning's roughness coefficient 'n' of 0.03 for the Tigris River, the results of the simulations and the observations of the river's flow were well correlated. At 0.998, the calibration correlation coefficient (r) and the validation correlation coefficient (r) were determined to be within the acceptable range.
- The amount of expenditures did not change between the first and the last section, but it was reduced by 50 compared to the results that did not include the facilities on both banks concerning the Tigris River.
- The river's path has gotten smaller, and the speed and flow of flow, as the first case was delayed until April 12, but in this case, it was delayed until April 20, which proves that it hindered the speed and flow of flow.
- Likewise, in general, the facilities constructed along the Tigris River's banks impact the quantity of water consumed, as well as impede the flow as they act as fenders and change the course and may reduce the speed of the flow, thus giving a greater opportunity for sedimentation and island formation, thus impeding the flow of water again

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 study problem was proposed by the author to Dr. Ali N. Hillo. Apart from the writer, Sajjad Inhayyir Abuthena gathered up-to-date articles and arranged them in straightforward formats Dr. Ali N. Hillo was discussed by the writers. The design, findings, and completed version of this work were all suggested by Sajjad Inhayyir Abuthena Al-Saray.

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