

***Chemical, Petroleum and Environmental Engineering***

**prediction Capacity of Euphrates River at Assamawa City**

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**ABSTRACT**

The reduction in the rivers capacity is one the most important issue to give the decision maker an idea during the flood season. The study area included the rivers of the Al Atshan, Al Sabeel and Euphrates, which are surveyed with a length of 21, 5 and 20 km respectively. The Euphrates , the Atshan and Al Sabeel rivers were simulated by using HEC-RAS 5.0.3 software to study the real condition within the city of Assamawa. As well as the simulation was implemented by modifying the cross sections of the Euphrates and Al Sabeel rivers to increase their capacity to 1300 and 1200 m<sup>3</sup>/s respectively which are a flood discharges 100 year return periods. The results showed that the maximum discharge capacity under real conditions of Euphrates River is 750 m<sup>3</sup>/s and both Al Atshan and Al Sabeel arms are 500 m<sup>3</sup>/s.

**Keywords:** Euphrates River, Assamawa City, HEC-RAS, Flood.

**أستيعابية نهر الفرات في مدينة السماوة**

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**الخلاصة**

أن دراسة استيعابية المجاري المائية او الانهار تعطي تصورا لمتخذ القرار وتمكنه من ادارة الفيضان . وشملت منطقة الدراسة أنهار العطشان والسبيل والفرات التي تم مسحها بمسافة 21، 5 و 20 كم على التوالي. وقد تم محاكاة انهار الفرات والعطشان والسبيل وباستخدام برنامج HEC-RAS بالاصدار 5.0.3 لدراسة الاستيعابية الحالية داخل مدينة السماوة. كذلك تم تنفيذ محاكاة عن طريق توسيع المقاطع العرضية لانهار الفرات والسبيل لزيادة قدرتها الى 1300 و 1200 متر مكعب/ثانية علي

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التوالي ، وهي فيضانات لفترات عودة 100 سنة عوده. وأظهرت النتائج ان الاستيعابية القصوى للتصريف في ظل الظروف السائدة في نهر الفرات هو 750 متر مكعب/ثانيه وان كلا من ذراعيه العطشان والسبيل يبلغ 500 متر مكعب/ثانيه. الكلمات الرئيسية: نهر الفرات ، مدينه السماوة ، HEC-RAS ، الفيضان.

## 1. INTRODUCTION

Euphrates River is one of the largest rivers in south-western Asia. The river is originating from the Taurus Mountains in Turkey and consists of two rivers in Asia Minor Murad Sow in the east, and its source is Lake Wan in Armenia and Kora Sow in the west and its source in north-eastern Anatolia. The river flows to the south-east and joins many branches before passing through the Syrian territories. After that enters the Iraqi border at Anbar province from Al-Qaim city and it passed with the several provinces before entering the city of Assamawa. The Euphrates River is dividing upstream of Al Gharb village, located 24 km from Shinafiyah town, to the two branches of Al-Sabeel (Abu Rafoush) and Al-Atashan branch. Furthermore, the Al-Atashan branch connects again in Shatt Al Sabeel upstream of the Assamawa city at 5 km. Component the Euphrates River, which continues towards southern to Annassiriyah city at 148 km from the Assamawa city. Sulibat channel branched from right of the Al Atshan arm only about 9 km upstream its confluence with the Abu Rifush branch, which is about 58 km long, the flow of the Sulibat discharged into the sulibat depression (natural depression).

The shortage of maintenance and sedimentation and the large number of meandering in the mainstream of the Euphrates River and its both arms of the Al Atshan and the Al Sabeel within the study area during the past years reduce the capacity of these rivers to pass high discharges. This leads to the risk of flooding in the city of Assamawa. Therefore, hydraulic analysis is necessary to assess the risk of flooding in the city of Samawa and to find the best possible solution. In this part of the paper, some previous studies on the Euphrates River and others that adopted the HEC-RAS software will be mentioned. (**Consulting Engineering Bureau, 2017**), prepared a report "Samawa Combined Cycle Power Plant: Hydrological Study". This study aimed at evaluates the flood risk of the nearby Euphrates River. The Power Plant is located just in southeast of Iraq, about 10 km south west Assamawa City within the Al Muthana Governorate. The power plant lies on the right side of Sulibat Channel at about 11.5km from its origin. The hydraulic analysis to simulate used of river reach which was 21km along Atshan arm and 5km of along Abu Rifush arm before their confluence. 20km along the Euphrates River at by using HEC RAS Software, The obtained maximum discharge capacities of the reaches are 400m<sup>3</sup>/s for both the Atshan and Alsabeel arms and 600m<sup>3</sup>/s for the Euphrates River within Assamawa City. (**Hamdan, 2016**), conducted a study on the Shatt al-Arab south of Iraq, which extends from the city of Qurna northern Basra city till its outfalls in the Arabian Gulf by using the mathematical model HEC-RAS software to design a dam with sluice gates at the upstream of Shatt al-Arab for the purpose to store and regulator water to use in agriculture and drinking. In addition, to prevent the mixing of fresh river water with saline sea water. The results showed that the rise in water levels due to construction of the dam leads to the feeding of the branched rivers that are used to irrigate agricultural land. Furthermore, the construction of the dam prevents saline water from being connected with the river freshwater. (**Hameed and Mohammed, 2014**), studied Al-Kufa River in Al-Kufa city, Iraq. By using HEC\_RAS software for unsteady flow model to calibration and verification of Manning roughness coefficient "n". The results showed that the value of the Manning roughness coefficient "n" which give a good agreement between observed and computed of water surface profile is 0.032. (**Ahmad, et al., 2016**), conducted a study on the Wadi Jahlum River in Kashmir, India. One Dimensional Steady Flow Analysis by using HEC- RAS software to estimate flood levels for the return period of 50 years and above. The results showed that water



levels along the river have crossed the safe border. (Patel, et al., 2018), studied the Ambica River east of the city of Navasari in India, By using a mathematical model HEC-RAS software 1-D steady flow state to estimate the level of flood events based on data from previous years 1984, 1994 and 2004 and with discharges are 11,000, 6500 and 5000 m<sup>3</sup>/s. The results showed that both the right and left banks along the reach of the Ambica River will be inundated.

The objectives of this research are to develop a one-dimensional hydraulic model to predict the water levels and estimate the discharge capacity of Euphrates, Al Atshan, and Al Sabeel rivers within Assamawa City during floods . Moreover, increase the discharge capacity of Euphrates and Al Sabeel Rivers by river development of its mainstream to 1300, 1200 m<sup>3</sup>/s respectively to achieve the requirements of **the study of Strategy for Water and Land Resources in Iraq, 2014 conducted by the Ministry of Water Resources.**

## 2. DESCRIPTION OF THE REACHS UNDER STUDY

The study area located on the main stream of Euphrates River and both its arms of Al Atshan and Al Sabeel within Assmawa Governorate. **Fig. 1.**The Euphrates River is divided into two arms at the downstream of the city of Shinafiyah, the arm of Abu Rafash, known as the Sabeel, which branches from the left of the Euphrates River, it is the main stream. The Al Atshan arm which branches from the right of the Euphrates River. These arms of the Euphrates are re-joined at just few kilometres west of Assmawa city. Firstly, the reach of Al Atshan arm extends about 21 km within the study area upstream its confluence with Al Sabeel arm, located at 514305 m, Easting and 3461052 m, Northing in UTM coordinate system, till its confluence with Al Sabeel arm, its located about 5 km West Assmawa city having a UTM coordinates of 523407 m, Easting and 3466341 m, Northing. Secondly, the reach of Al Sabeel arm extends with long 5 km starts upstream its confluence with Al Atshan arm, located at 521980 m, Easting and 3469047 m, Northing in UTM coordinate system, till its confluence with Al Sabeel arm. Finally, the reach of Euphrates River extends with long 20 km starts at Al Atshan confluence with Al Sabeel, till of east Assmawa city having a UTM coordinates of 523407 m, Easting and 3466341 m, Northing. Additionally, the reach of the Sulibat channel branched from Atshan arm at just about 9 km upstream its confluence with the Al Sabeel arm ,extend 56.824km located at 520116 m, Easting and 3463721 m, Northing in UTM coordinate system, till outfall into the Sulibat depression which is located at the right side of the Euphrates River (west side), 25 km away from Al-Khader village having a UTM coordinates of 562399 m, Easting and 3427980 m, Northing. The Sulibat depression extends 70 km length and 20 km width south-eastern.

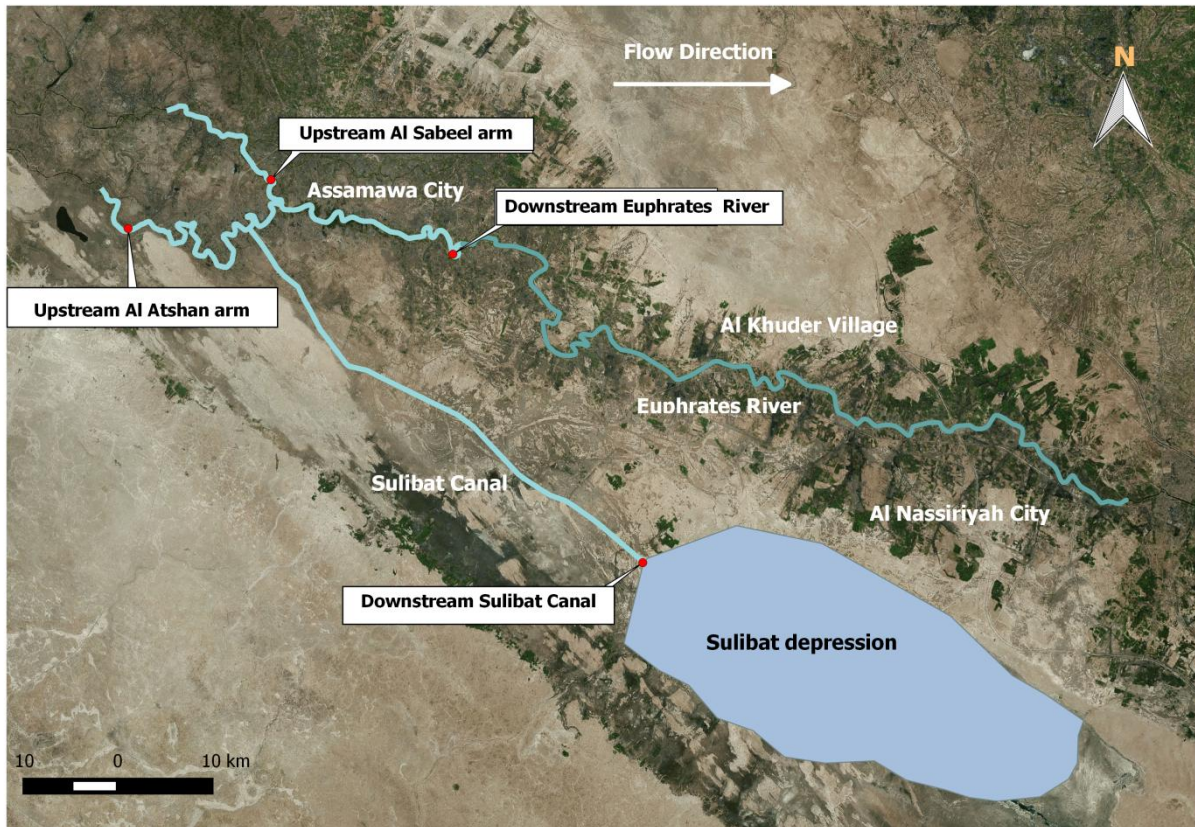


Figure 1. General layout of Euphrates River within the study Area, by Arc GIS 10. , ESRI.

### 3. Theoretical Basis

#### 3.1 Equations of 1-D Steady Flow Model

Water surface profiles are computed from one cross-section to the next by solving the energy equation. The energy equation is:

$$Z_2 + Y_2 + a_2 \frac{V_2^2}{2g} = Z_1 + Y_1 + a_1 \frac{V_1^2}{2g} + h_e \quad (1)$$

Where  $Z_1$  and  $Z_2$  are the elevation of the main channel inverts ( $m$ ),  $Y_1$  and  $Y_2$  are the depth of water at cross section ( $m$ ),  $V_1$  and  $V_2$  are the average velocities (total discharge/ total flow area)  $m/s$ ,  $a_1$  and  $a_2$  are the velocity weighting coefficients,  $g$  is the gravitational acceleration ( $m^2/s$ ),  $h_e$  is energy head loss ( $m$ ).

The energy head loss ( $h_e$ ) between two cross sections is comprised of friction losses and contraction or expansion losses. The equation for the energy head loss is as follows:

$$h_e = LS_f + C \left( a_2 \frac{V_2^2}{2g} - a_1 \frac{V_1^2}{2g} \right) \quad (2)$$

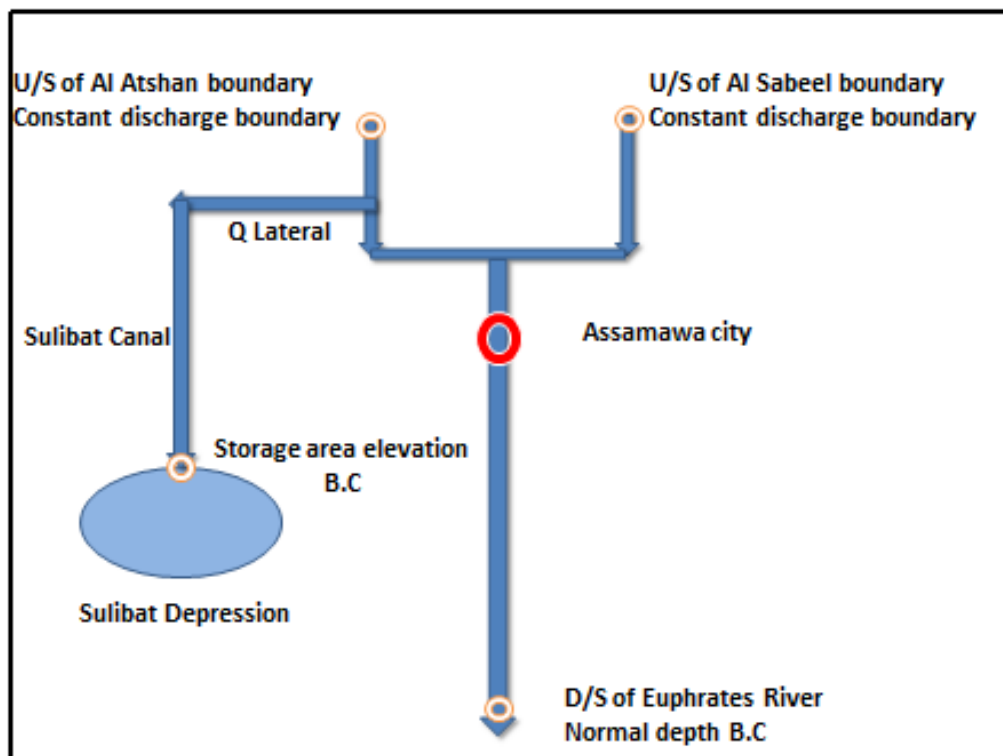
Where  $L$  is discharge weighted reach length,  $S_f$  is representative friction slope between two sections,  $C$  is expansion or contraction loss coefficient.



### 3.2 IMPLEMENTATION OF ONE DIMENSIONAL HYDRAULIC MODEL

The software of HEC-RAS was used to simulate the reach of Euphrates River and both arms of Al Atshan and Al Sabeel within Assmawa city under various conditions.

Data of 81 Cross sections survey of the mainstream of the reaches of Euphrates River, Atshan arm, Sabeel arm and Sulibat Channel were provided by **Consulting Engineering Bureau, 2017**. The survey was carried out during April 2017. The survey covers 21 km along Atshan arm and 5 km of along Abu Rifush arm before their confluence. Then 20 km along the Euphrates River and 56.824 km along Sulibat canal. The cross sections survey was conducted at each 1km along Atshan arm, Abu Rifush arm, and the Euphrates River. The cross sections survey was conducted at each 1km along the first 20 km of Sulibat canal, then at each 2 km along the second 20 km, and at each 3.36 km for the last reach of the canal. These cross sections were used in modeling of the reaches by using the HEC RAS 5.0.3 software. **Fig.2** shows the schematic diagram of the simulated flow network of Euphrates River, the Atshan arm and al Sabeel arm and the boundary conditions used in the simulation.



**Figure 2. Schematic Diagram of simulated system, and boundary condition.**

Different values of discharge were assumed at upstream boundary of reach of rivers Al Atshan, Al sabeel, Euphrates and Sulibat Canal for steady state. These discharges ranged between 500 to 700 m<sup>3</sup>/s of Al Atshan Arm, 500 to 1200 m<sup>3</sup>/s of Al sabeel arm, 750 to 1300 m<sup>3</sup>/s of Euphrates River. The upper limit represents flow of flood wave probability for a period of 100 years, while, the lower limit is the actual capacity of the rivers. The boundary condition at downstream end of the reach of Euphrates River is adopted a normal depth and at downstream end of the reach of Sulibat Canal is adopted a storage area elevation.



Due to the absence of the gauge station of the Euphrates River and Al Atshan and Al sabeel arms in the study area and the difficulty of obtaining the data of the water level and discharge for its adoption in the calibration and verification of the value of the manning coefficient n. Therefore, the values of manning coefficient n evaluated from previous studies for similar stream conditions were used. (Al Thamiry, et al., 2013), conducted a hydraulic study on the Euphrates River with 117 km length between Al Shanafiyah and Assamawa cities, south of Iraq by using HEC-RAS software to compute the value of the roughness coefficient n for the river reach. It was found that the value of the roughness coefficient which it gives the best agreement between the observed and computed the water surface levels for the main stream is 0.023. These value of the roughness coefficient was used for the main stream of Euphrates River and both of its arms Al Atshan and Al Sabeel. The values of Manning's n for the floodplain estimated from previous experimental studies for similar stream conditions were used as guides in selecting n values, Chow, 1959. Manning coefficient values of the floodplain of Euphrates River were used as 0.04.

**4. SIMULATION SCENARIOS**

Two sets of scenarios were simulated as presented in Table 1. The first set includes three scenarios were implemented to simulate the water levels of three rivers under the existing conditions. The second set includes two scenarios with the required development in these rivers.

**Table 1.** Description of the scenarios.

Scenario	Description
<b>Scenarios with existing condition</b>	
<b>E 1</b>	Al Atshan arm capacity
<b>E 2</b>	Al Sabeel arm capacity
<b>E 3</b>	Euphrates River capacity.
<b>Scenarios with development condition</b>	
<b>D 1</b>	Al Sabeel capacity
<b>D 2</b>	Euphrates River capacity

The first set includes three scenarios that are encoded by **E1**, **E2** and **E3**. E1 Scenario represents a modeling case of the Euphrates River and both of the arms of the Atshan and Al Sabeel, in this scenario the capacity of the Atshan arm was determined only. E2 scenario is represented to assess the capacity of Al Sabeel arm only without considering capacity of the Atshan arm and the Euphrates River. Finally the E3 scenario is represented to predict the capacity of Euphrates River only.

The second group includes two scenarios of developments of cross sections of Al Atshan and Al Sabeel rivers as **D1** and **D2** respectively.

Free board is used to allow for uncertain in the selection of different parameters and disturbances which happened on the water surface profile, (Chaudhry, 2008). The free board of the channel has more than discharge of 10 m<sup>3</sup>/s must be 1m according to the **pencol Engineering consultants, Design manual for irrigation and drainage, Ministry of water resources**. Therefore, 1m free board has been adopted ..

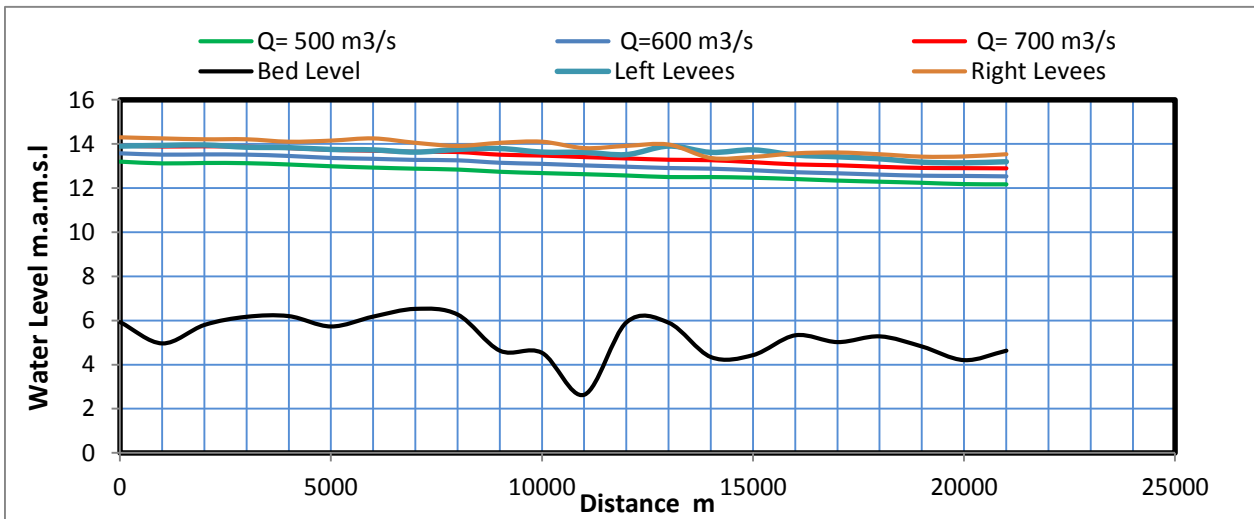


### 5. RESULTS AND DISCUSSION

In this part of the research paper, the results obtained for discharges and water levels of the Euphrates River and both Al atshan and Al Sabeel arms of the existing and developed situation will be presented and analysed below.

**Fig. 3** shows the longitudinal section of the reach of Al atshan arm that includes the river bed level, sides levees levels and the water levels profile at different discharges 500, 600 and 700 m<sup>3</sup>/s as **E1** scenario. Obviously the discharge over 500 m<sup>3</sup>/s will not be safe. The right and left levees along Al Atshan arm will be critical at 600 m<sup>3</sup>/s. At discharge 700 m<sup>3</sup>/s the right and left levees along reach of Al Atshan arm will be critical also. However, the left levees will be inundated at upstream of Al Atshan arm until station 0+07 km. As a result, the maximum discharge capacity in Atshan arm under the existing condition is 500 m<sup>3</sup>/s.

**Fig. 4** shows the longitudinal section of the reach of Al Sabeel arm that includes the river bed level, sides' levees levels and the water levels profile at multi rates of discharges 500, 600 and 700 m<sup>3</sup>/s under the **E2** scenario. Although, both the right and left levees along reach of Al Sabeel arm was above the water level at the discharge 600 m<sup>3</sup>/s But it was a critical situation because the free board lower than 1m. At discharge 700 m<sup>3</sup>/s, the left levees will be over flood along of Al Sabeel arm unless the reach from station 1+00 until 2+00. On the other hand the right levees will be over flood from station 2+500 until 3+500. As a result, the maximum discharge capacity in Al Sabeel arm under the real condition is 500 m<sup>3</sup>/s.



**Figure 3.** Water levels profile of Atshan arm in E1 scenario.

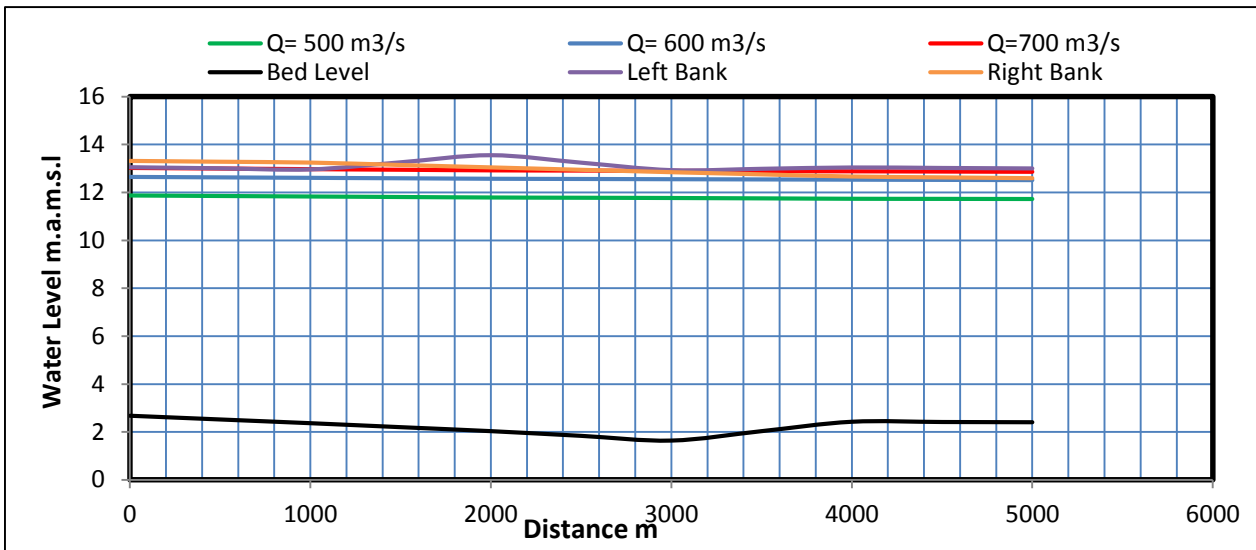


Figure 4 . Water levels profile of Al Sabeel arm in E2 scenario.

The longitudinal section of the reach of Euphrates River that includes the river bed level, sides' levees levels and the water levels profile at multi rates of discharges 750, 850 and 950 m<sup>3</sup>/s under the **E3** scenario are shown in **Fig. 5**. At discharge 850 m<sup>3</sup>/s ,it's clear that the water level along the reach of Euphrates River was lower than the both right and left levees elevation unless the reach between station 0+00 and 6+00 it was at critical situation. The left levees will be flooded upstream the reach until station 2+00 at discharge 950 m<sup>3</sup>/s. The longitudinal levees elevations of Euphrates River are higher than the water levels along the reach with the discharge of 750 m<sup>3</sup>/s and it was safe. As a result, the maximum discharge capacity in the Euphrates River at this scenario is 750 m<sup>3</sup>/s.

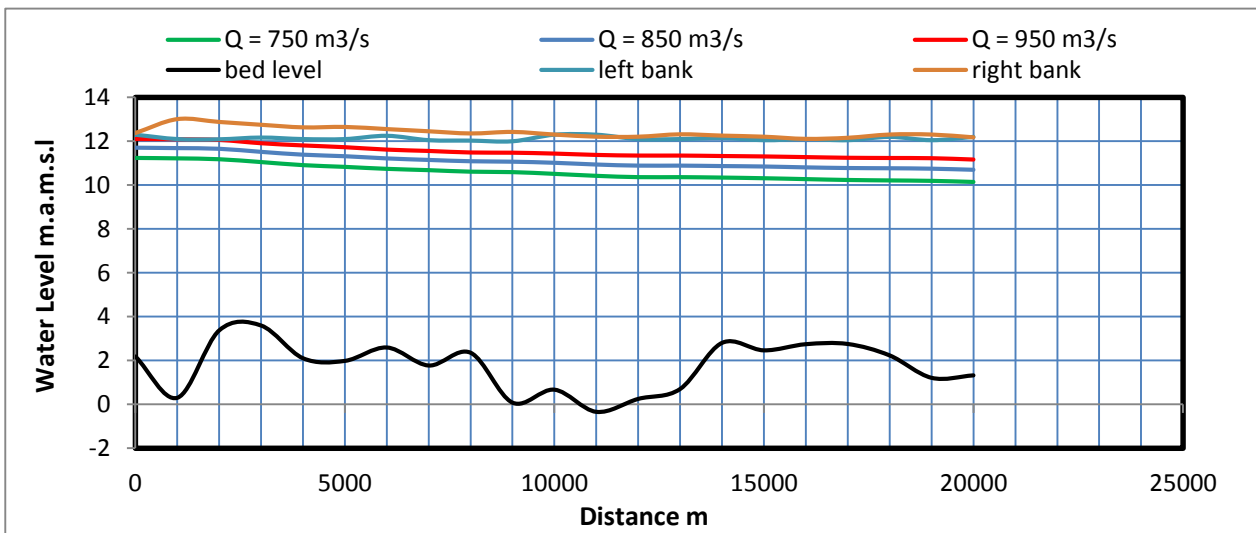


Figure 5. Water levels profile of Euphrates River in E3 scenario.

It is worth mentioning that during reviewing the results of the current capacity of the Atshan River there is no need to develop the cross sections as the current capacity is capable of carrying the flood discharge.



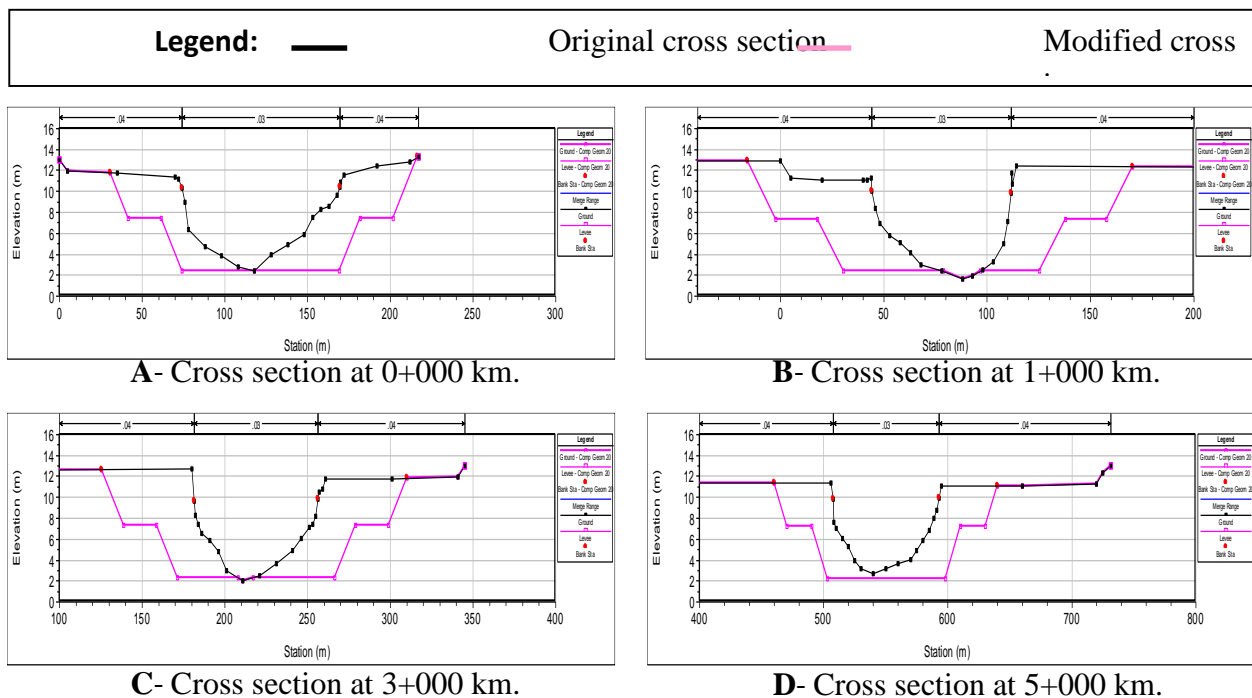


**Fig. 6** shows The cross sections of Al Sabeel arm original and modified. The cross sections of the mainstream of the Al Sabeel arm that caused choking in the flow in the river reach, that it was developed by using a trapezoidal shape was adopted at these cross-sections. The development along Al Sabeel arm extended to 5 km from the upstream river at station 0 + 000 until its confluence with the Atshan arm at station 0+05. The total volume of the quantities that are cut for these cross sections are about 0.325 Million m<sup>3</sup> and its cost is 0.65 billion IQD. The total cut volumes were calculated by HEC-RAS software. As well as the costs of the cut volumes of earthworks were provided by the *Ministry of Water Resources*. The cost of the 1 m<sup>3</sup> modification cross section of the main stream of rivers is 2000 IQD.

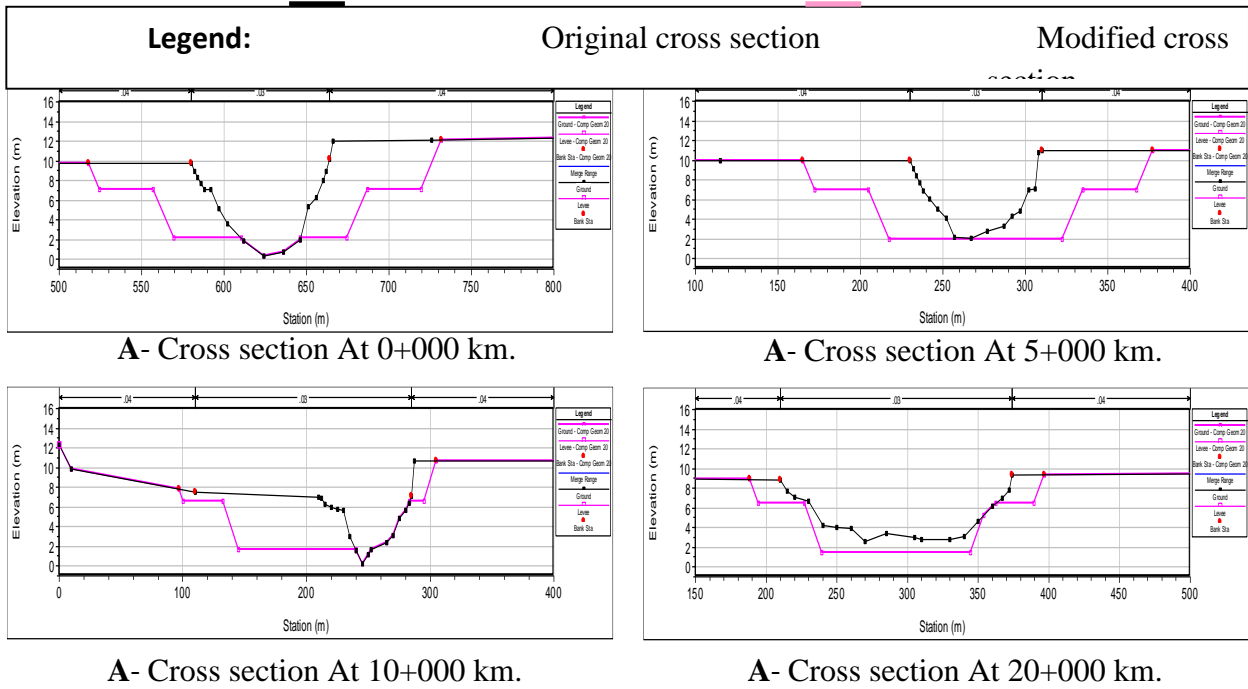
The results of the inundation water levels of D1 scenario are shown in **Fig. 8**. Obviously the longitudinal levees levels more than inundation water level everywhere of the reach, the river cannot carry more than 1200 m<sup>3</sup>/s. In this scenario the discharge capacity of Al Sabeel arm is increased 140% compare with E2 scenario.

The cross sections of the Euphrates River original and modified are showed in **Fig. 7**. The same method that used to develop the cross sections of the Asabeel arm was used in the development the cross sections of the Euphrates River. The development along Euphrates River extended to 21 km at upstream the river at just confluence of both the Atshan and Al Sabeel arms until its downstream the reach of river at station 21+00 km. The total volume of the quantities that are cut for these cross sections are about 9.789 Million m<sup>3</sup> and its cost is 19.58 billion IQD.

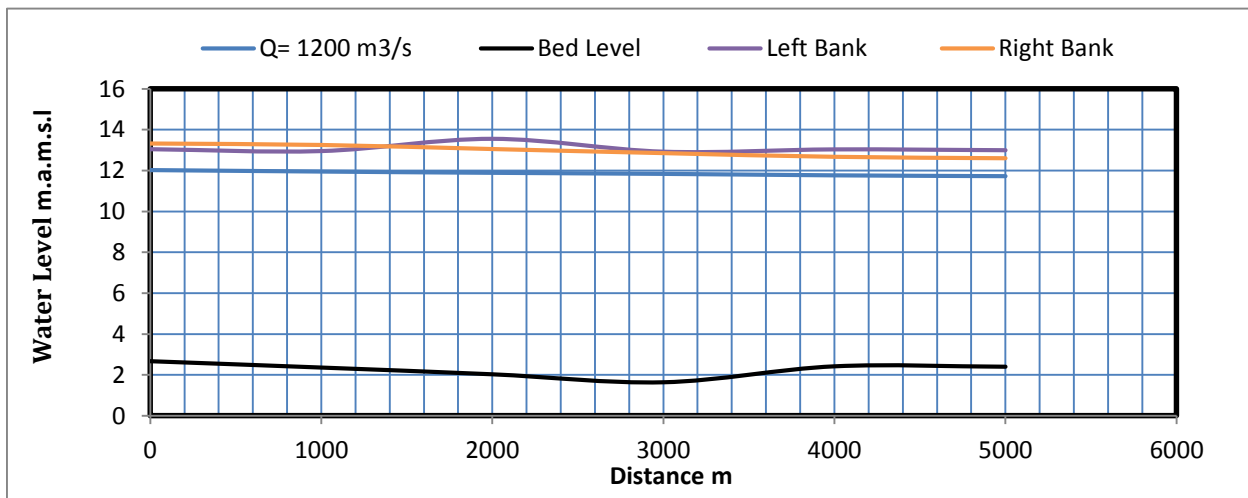
**Fig. 9** shows the inundation water levels for D2 scenario. It showed that the inundation water level along the reach of Euphrates River lower than the longitudinal levees levels and safe at discharge 1300 m<sup>3</sup>/s. Moreover, in this scenario the discharge capacity of Euphrates River is increased 73% compare with E3 scenario.



**Figure 6.** The original and cross sections of Al Sabeel arm after development of its reach (from 0 to 5 km station ).



**Figure 7.** The original and cross sections of Euphrates river after development of its reach (from 0 to 20 km station ).



**Figure 8.** Water levels profile of Al Sabeel arm in D1 scenario.

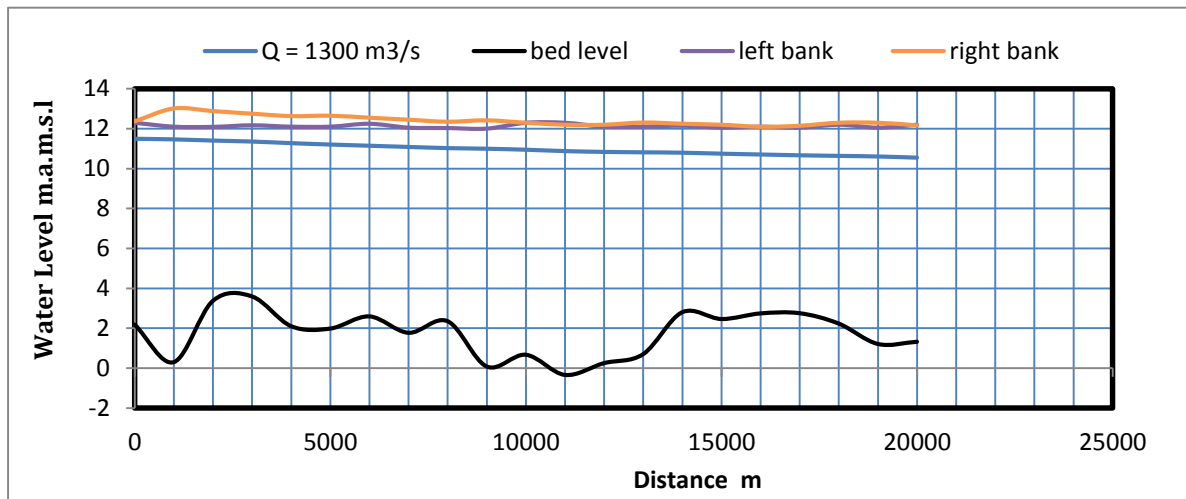


Figure 9. Water levels profile of Euphrates River in D2 scenario.

## 6. CONCLUSIONS

Based on the analysis of the results, the following main conclusions are made:

1. The maximum real capacity of the both surveyed reaches of Al Atshan and Al Sabeel arms within Assamawa City are 500 m<sup>3</sup>/s and 750 m<sup>3</sup>/s for the reach of Euphrates River.
2. The Euphrates and Al Sabeel river can carry discharges 1300 and 1200 m<sup>3</sup>/s respectively, it is a 100-year return period flood with need to develop many cross sections.
3. The discharge capacity of the Euphrates and Al Sabeel rivers after cross sections development is increased 73 and 140% respectively.
4. Cost of needed dredging per 1 km is about 0.325 and 0.98 billion IQD for Al Sabeel and Euphrates respectively.

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