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The Effects of Al Chibayish Weir and Proposed Gated hydraulic Structure on Flooding in the Euphrates River in Dhi Qar Province, Iraq

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Abstract

This study focuses on a 57 km reach of the Euphrates River in the Dhi Qar Governorate of Iraq, specifically from the confluence of the Majmaa River to the Al-Midaina district. The complex nature of the river system, characterized by various hydraulic structures on the main and side banks, including Al Chibayish Weir, prompted the use of a 1-D numerical model (HEC-RAS) to simulate water levels in the cities of Al-Chibayish and Al-Madina during flood season. The purpose of the study was to assess the impact of Al Chibayish Weir and nine regulators on the Euphrates River, as well as to evaluate the potential effects of replacing Al Chibayish Weir with a gated hydraulic structure in the city of Al-Madinah. Several scenarios were simulated to examine the influence of Al Chibayish Weir and the proposed gated hydraulic structure on the river system. The results of the model indicated that in the worst-case flood scenario, with the full operation of the nine regulators and water flowing to the marshes, the highest water level upstream of Al Chibayish Weir reached 3.75 m above mean sea level. The conclusion of the study was that the construction of a gated hydraulic structure could play a crucial role in controlling water levels of the Euphrates River during both drought and flood seasons.

Keywords: Euphrates River, HEC-RAS, Flood, Weir, Regulator

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تاثير سد الجبايش الغاطس وناظم الهيدروليكي المقترح على فيضانات نهر الفرات في محافظة ذي قار ، العراق

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الخلاصة

تم أعتماد مسافة 57 كيلومترا من نهر الفرات في محافظة ذي قار في العراق كدراسة حالة ، وتحديدا من ملتقى نهر المجمع إلى مدينة المدينة. دفعت الطبيعة المعقدة لنظام النهر، الذي يتميز بكثرة المنشات هيدروليكية المتنوعة على الضفاف الرئيسية والجانبية ، بما في ذلك سد الجبايش الغاطس ، إلى استخدام النموذج العددي أحادي الأبعاد (HEC-RAS) لمحاكاة مناسيب المياه في مدينتي الجبايش والمدينة خلال موسم الفيضان . كان الغرض من الدراسة هو تقييم تأثير سد الجبايش الغاطس وتسعة منشات هيدروليكية جانبية على نهر الفرات ، وكذلك تقييم الآثار المحتملة لاستبدال سد الجبايش الغاطس بناظم مبوب هيدروليكي قرب مدينة المدينة. تمت محاكاة عدة سيناريوهات لدراسة تأثير سد الجبايش الغاطس والناظم المبوب الهيدروليكي المقترح على نظام النهر. أشارت نتائج النموذج العددي إلى أنه في أسوأ سيناريو فيضان ، مع تشغيل كامل للنواظم الجانبية التسعة وتدفق المياه إلى الأهوار الوسطى وهور الحمار ، بلغ أعلى منسوب مياه في مقدم سد الجبايش الغاطس 3.75 مترًا فوق متوسط مستوى سطح البحر. لخصت الدراسة إلى أن إنشاء ناظم مبوب هيدروليكي يمكن أن يلعب دورًا مهمًا في التحكم في مناسيب المياه في نهر الفرات خلال موسمي الجفاف والفيضان.

الكلمات المفتاحية: نهر الفرات ،HEC-RAS ،سد غاطس ، فيضان ، ناظم الهيدروليكي

Introduction

The Euphrates River originates in the Eastern Mountains of Turkey and flows through Syrian territory before entering Iraq at Al Qaim City in Al Anbar Governorate. It then passes through several provinces until it reaches Dhi Qar Governorate. Before 2010, the Euphrates and Tigris rivers joined at Al Qurna City in southern Iraq to form the Shatt Al Arab. However, since 2010, the Euphrates River has not reached Al Qurna City due to the construction of a weir at the end of Al Chibayish Village (Shayea & Al Thamiry, 2019).

In the study region, the river system is quite complex due to the numerous hydraulic structures that have been constructed on the main and side banks of the river. One such structure is Al Chibayish Weir, located on the mainstream of the river. In addition, nine hydraulic regulators were constructed on the left bank of the river, known as Al-Khinzirii, Al-Sabaghia, Abu Joyalneh, Abu Nirsi, Abu Sobat, Abu Jathea, Al-Sabe, and Al-Badria. These structures serve as the outflow hydraulic structures of the Central marshes, directing water towards the Euphrates River with a design discharge of 720 m^3/s.

During the 2019 flood event, the water levels of the river was obstructed by Al Chibayish Weir, leading the water resources directorate to breach certain levees in order to facilitate the downstream flow of water and protect upstream cities from the potential impact of the flood.

Flooding is a frequent and destructive natural hazard that causes significant economic damage to human populations and infrastructure globally. There are numerous studies investigating the flood in the rivers with different software modelling tools. The simplified technique has been demonstrated to be effective and reliable for hydrodynamic flood modeling and sheet pile spurs on the river's banks along with earthen embankments on both banks have been recommended at vulnerable locations (Goswami et al., 2022). Several flood mitigation measures have been proposed to regulate the flow in the mainstream of the river (Mahdi & Hilo ,2021).

Limited research has been conducted on the hydraulic analysis of the Euphrates River reach in Nassiriyah. The Euphrates River in Annassiriyah City, Dhi Qar Governorate, Iraq has been the subject of numerous studies examining its discharge capacity and the impact of hydraulic structures on the river. Shayea & Al Thamiry, 2019, have simulated various scenarios to study the current conditions of the Euphrates River and to evaluate the potential

for improving its discharge capacity during flood seasons using HEC-RAS 5.0.3 software. Findings from this study have shown that the maximum discharge capacity of the Euphrates River in Annassiriyah City is 300 m^3/s. However, by implementing river training measures, it is possible to increase the river's capacity to 1300 m^3/s, which is the flood of a 100-year return period. This increase in capacity was only achievable when Al Chibayish Weir was hypothetically removed from the river system. When Al Chibayish Weir was taken into account, the river's capacity was reduced to 600 m^3/s, meaning that the 100-year flood discharge could not be achieved without removing the weir. These findings highlight the importance of considering the impact of hydraulic structures on the discharge capacity of the Euphrates River in Annassiriyah City, and the potential for implementing river training measures to increase capacity and reduce flood risk Village (Shayea and Al Thamiry, 2019).

Consulting Engineering Bureau, 2017 evaluate the flood risk of the nearby Euphrates River and to provide data and analysis of groundwater and weather conditions. The power plant is located approximately 500 meters from the right bank of the Euphrates River, at 613397 m Easting and 3433966 m Northing in the UTM coordinate system, just west of Annassiriyah City. Based on the hydraulic analysis of a 23 km reach of the river using HEC RAS software, it was found that the maximum current capacity of the reach within Annassiriyah City was 300 m^3/s. At this discharge, all water levels were lower than the levels of the left and right levees of the river. However, if the discharge exceeded 300 m^3/s, the water levels would rise above the left side levee, posing a threat to the left part of Annassiriyah City. The right side of Annassiriyah City, where the power plant is located, remained safe up to a discharge of 500 m^3/s.

The goal of this study is to use a 1-D numerical model to simulate the water levels of the Euphrates River in the cities of Al-Chibayish and Al-Madina during flood season, taking into account the influence of Al Chibayish Weir and the nine regulators on the levels of the Euphrates River. The study also aims to investigate the potential benefits of constructing a gated hydraulic structure as an alternative solution.

Research Methods

A one-dimensional numerical model was prepared for the unsteady flow of the Euphrates River. To simulate the flood levels of the Euphrates River, which extends from the confluence of the Majmaa River with the Euphrates up to the Al-Midaina district using the HEC-RAS (v 7.0.5) program under different operating conditions,see Figure (1) This software developed by the Hydrologic Engineering Center (HEC) of the United States Army Corps of Engineers for hydraulic and hydrologic analysis of rivers and streams. It is widely used software and has been continuously updated and improved over the years.

This study focused on a 57 km reach of the Euphrates River in the Dhi Qar Governorate of Iraq, specifically from the confluence of the Majmaa River to the Al-Midaina district,.

Data from 57 cross sections spaced 250-500 meters apart along the mainstream of the Euphrates River reach within Annassiriyah City were provided by the General Authority for Surveying of the Ministry of Water Resources. A bathymetric survey of the Euphrates River within Annassiriyah City was conducted in 2012, and these cross-sections were used in the modeling. The design characteristics of Al Chibayish Weir were entered into the model for simulation purposes.

The model was run in an unsteady state flow regime, using a 30-day time series as the boundary condition at the upstream. The maximum discharge, as determined by the Study of Strategy for Water and Land Resources in Iraq (2014), was set at 446 m^3/s. The nine hydraulic regulators were inputted into the model as a uniform lateral inflow hydrograph. The downstream boundary condition was defined as a normal depth with a slope of 30 cm/km, based on the bed levels of the last cross-section.

The calibration of the model is difficult because there is a lack of hydrological data and Chibayish Weir significantly affects the water level in the study area due to the backwater effect. As a result, the Manning coefficient values for the main channel of the river were set at 0.03 and the values for the right and left banks were set at 0.04 (Shayea & Al Thamiry, 2019; Consulting Engineering Bureau, 2017).

In February 2021, a site visit was conducted to assess the current state of the river system in Annassiriyah City. During the visit, measurements were taken regarding the dimensions of nine hydraulic structures. Figure (2) presents photographs of several of these structures.

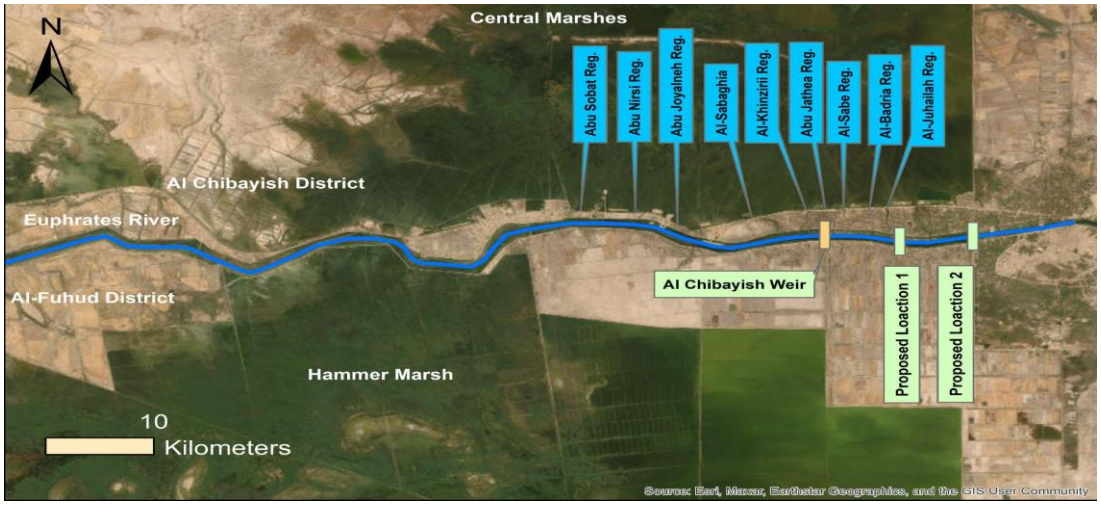

Figure (1): Layout of Euphrates River reach with hydraulic regulators, generated using Arc GIS 10.5.

Al Chibayish Weir

Right Levees with Low Elevation

Al-Khinzirii Regulator

Abu Jathea Regulator

Figure (2): Photographic survey of study area

Study scenarios

Three sets of scenarios were simulated. Each set consisted of three cases, as shown in Table (1) The first set represented the current state of the Euphrates river in the study area, including Al Chibayish Weir and the nine regulators. The second case represented the hypothetical situation in which Al Chibayish Weir was removed. The third case represented a future scenario in which Al Chibayish Weir was hypothetically removed and a proposed gated hydraulic structure was constructed at either Sadad 712,location 2, (with UTM coordinates of 712148 m Easting and 3426700 m Northing) or Al-Juhailah, location 1, (with UTM coordinates of 708354 m Easting and 3426499 m Northing). The design of the proposed gated hydraulic structure was based on the Al-Hafar regulator, which has seven radial gates with dimensions of 7 m in width and 4 m in height and an invert level of 0 m above mean sea level. Its gates are simulated as fully opened in the third set of scenarios. It is worth noting that the scenario names were chosen randomly.

Table (1): Description of the simulated scenarios.

Scenario	Description
Scenarios representing the current state	
CS 1	Neglecting the influence of the nine regulators.
CS 2	Considering the operation of half of the nine regulators, at a rate of 40 m^3/s each.
CS 3	Considering the operation of all nine regulators at a rate of 80 m^3/s each.
Scenarios in which Al Chibayish Weir was hypothetically removed	
R1	Neglecting the influence of the nine regulators.
R2	Considering the operation of half of the nine regulators, at a rate of 40 m^3/s each.
R3	Considering the operation of all nine regulators at a rate of 80 m^3/s each.
Scenarios featuring the proposed gated hydraulic structure	
P1	Neglecting the influence of the nine regulators.

P2	Considering the operation of half of the nine regulators, at a rate of 40 m^3/s each.
P3	Considering the operation of all nine regulators at a rate of 80 m^3/s each.

Results and Discussion

The results of The CS 1 Scenario, the average water level of the Euphrates River in its current state at the upstream of Al Chibayish Weir is 3.75 meters above sea level. The water levels for various operational cases of the nine regulators were similar, likely due to the constriction caused by the weir. The discharge at the upstream of Al Chibayish Weir, ignoring the impact of the nine regulators on the main course of the Euphrates River, is 200 m^3/s with an outflow from the low levels levees of 245 m^3/s, as illustrated in Figure (3).

The discharge at the upstream of Al Chibayish Weir is 232 m^3/s and the outflow from the low levels levees is 412.89 m^3/s when taking into consideration the effect of 50% of the effect of the nine regulators (the CS 2 Scenario) on the course of the river as a result of the bottlenecks, due to the effect of the total of five regulators located at the upstream of Al Chibayish Weir on the total discharge and the effect of the reverse flow due to the bottlenecks as in Figure (4).

The results of the CS 3 Scenario show that the discharge at the upstream of Al Chibayish Weir, taking into account the combined effect of the nine regulators on the main course of the Euphrates River, is 258.46 m^3/s, with an outflow from the low-level levees of 586.19 m^3/s as shown in Figure (5) It is notable that there is no significant effect on water levels in this case, likely due to the strong influence of Al Chibayish Weir. Additionally, there are four regulators located downstream of the weir, as well as a large discharge from the right level levees of the Euphrates River, contributing to this lack of change in water levels.

If Al Chibayish Weir were hypothetically removed from the river system (the R1 scenario) , the discharge of the Euphrates River at the site of the weir would be 443.15 m^3/s, neglecting the impact of the nine regulators on the main course of the river. In this scenario, there would be no outflow from the levees, as shown in Figure(6).

When considering the influence of 50% of the discharges from the nine regulators on the course of the river (the R2 scenario), the discharge at the upstream of Al Chibayish Weir is 621.10 m^3/s, with no outflow from the levees, as depicted in Figure (7).

The results of the R3 scenario shows the discharge at the upstream of Al Chibayish Weir, taking into consideration the total effect of the nine regular discharges on the main course of the Euphrates River, is 812.28 m^3/s, and there is no outflow from the levees as in Figure (8).

Figures(6, 7, and 8) show the water levels of the Euphrates River after the hypothetical removal of Al Chibayish Weir from the river system. These figures show that the water levels in case of all operational states of the nine regulators are lower than the level of their side levees.

The P1 Scenario, If the influence of the nine regulators on the main course of the Euphrates River is disregarded, the discharge at the proposed regulator at the site of Al-Juhailah is 342.14 m^3/s. The outflow discharge from the low-level levees was minimal, at 4.83 m^3/s, due to the non-operation of all the regulators, as shown in Figure (9).

When considering the influence of 50% of the effect of the nine regulators on the course of the river (the P2 scenario), the discharge at the upstream of the regulator is 458.58 m^3/s. The outflow from the levees is 339.68 m^3/s due to the combined effect of the nine regulators located upstream of the proposed regulator on the discharge and the backwater impact caused by the proposed regulator, as shown in Figure (10).

When considering the combined effect of the nine regulators on the main course of the Euphrates River (the P3 scenario), the discharge at the upstream of Al Chibayish Weir is 503.52 m^3/s. The outflow from the low-level levees is 657.18 m^3/s, due to the decrease in the right-level levees of the river adjacent to the Hammar Marsh at kilo (150+146) and (150 + 147), which are 3.5 and 2.8, respectively. These decreases have a clear impact on the discharges and water levels of the Euphrates River, resulting in a clear reverse flow when all nine regulators are in operation, with a rate of 140 m^3/s back in reverse, as shown in Figure (11).

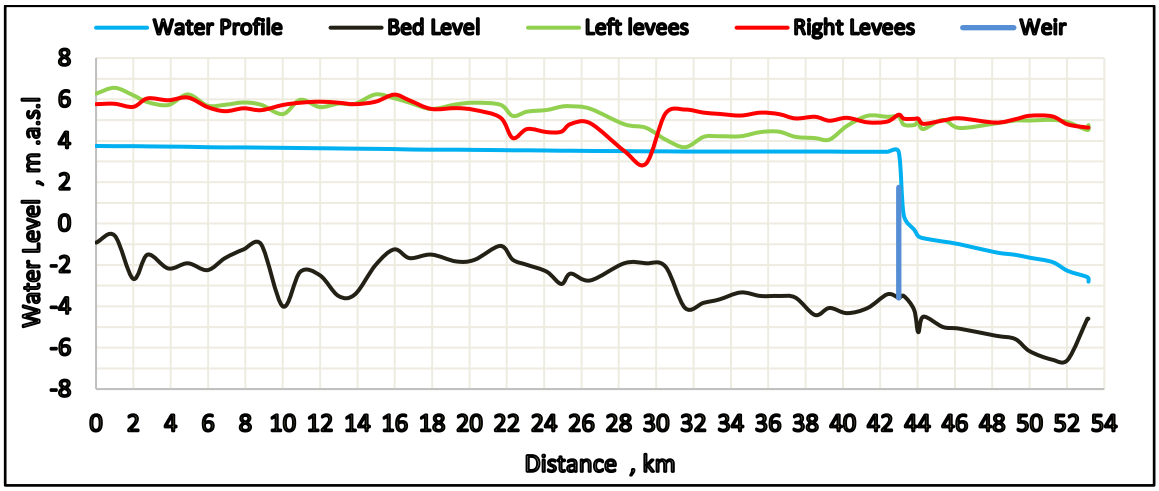

Figure (3): Longitudinal profile of the Euphrates River water levels under CS 1 Scenario.

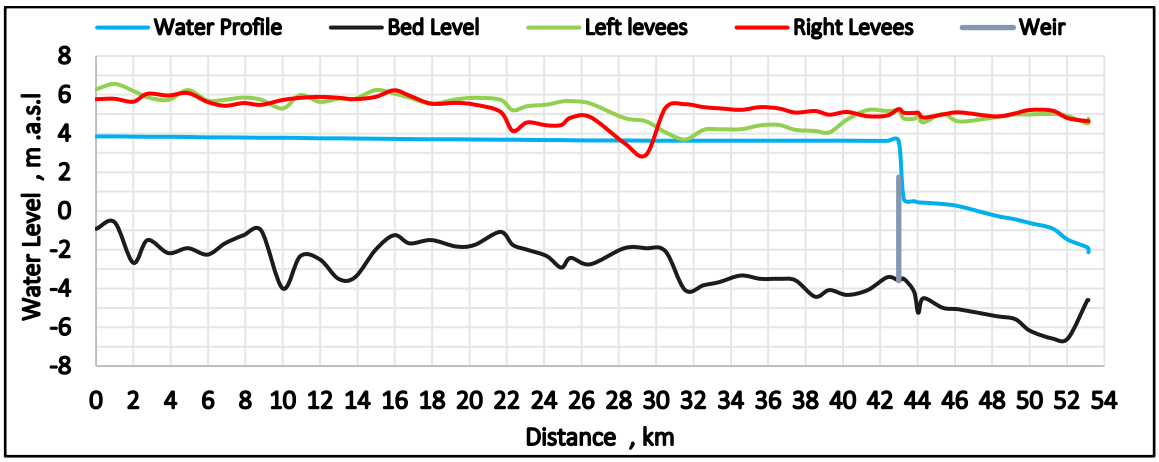

Figure (4): Longitudinal profile of the Euphrates River water levels under CS 2 Scenario.

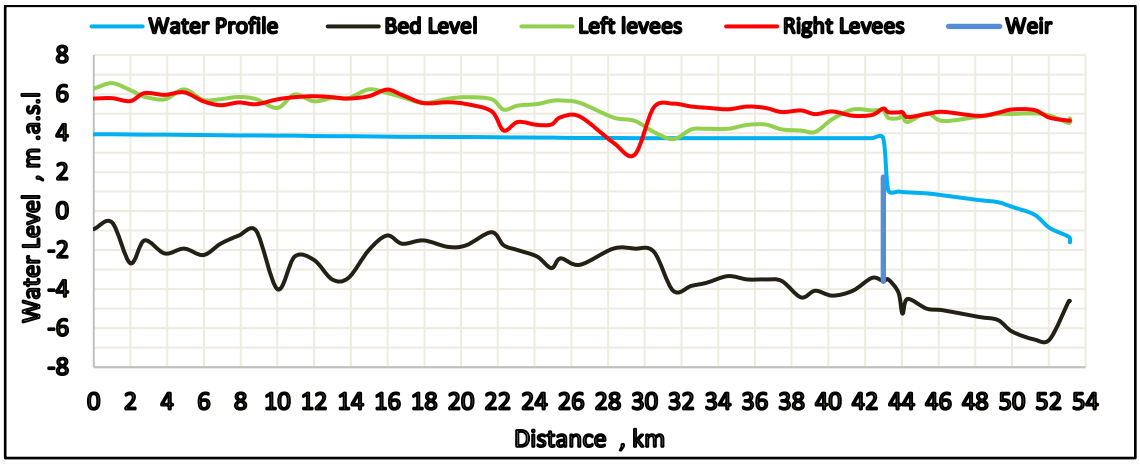

Figure (5): Longitudinal profile of the Euphrates River water levels under CS 3 Scenario.

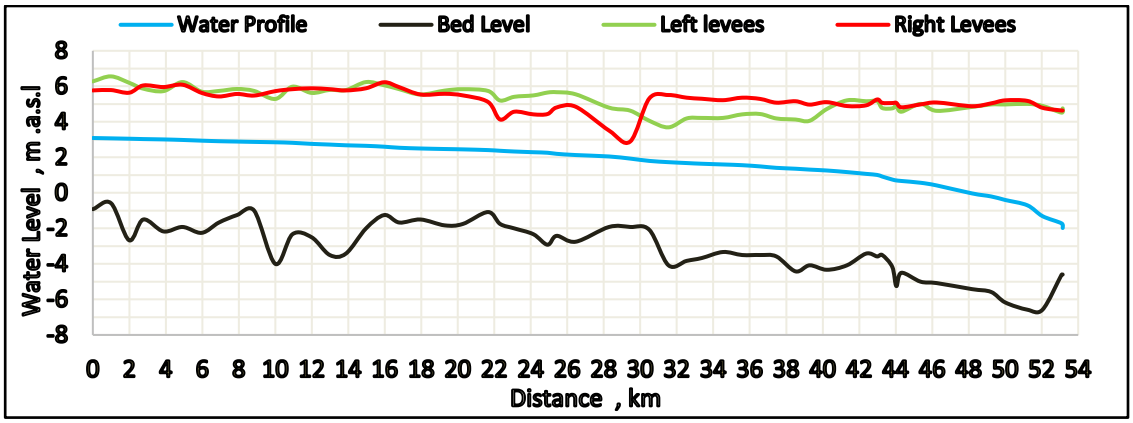

Figure (6): Longitudinal profile of the Euphrates River water levels under R1 Scenario.

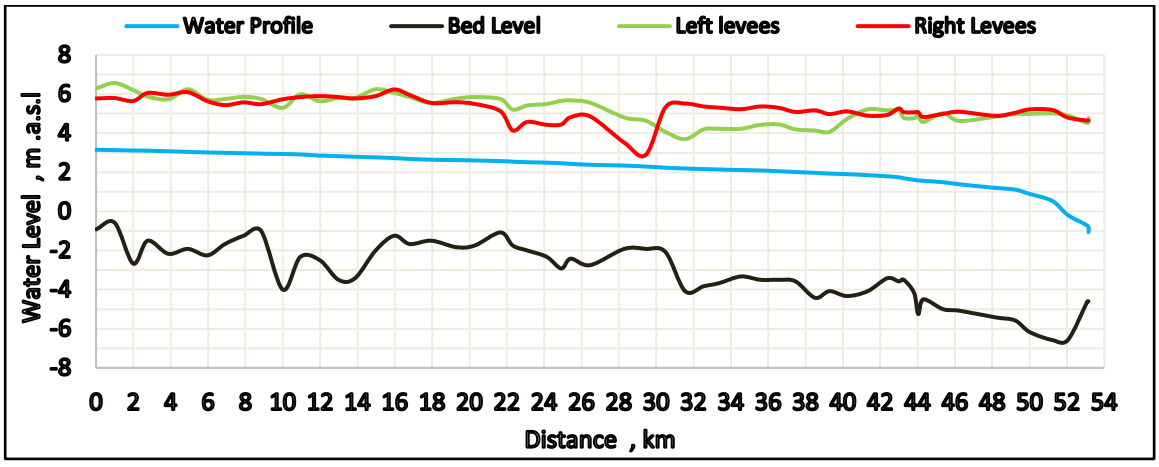

Figure (7): Longitudinal profile of the Euphrates River water levels under R2 Scenario.

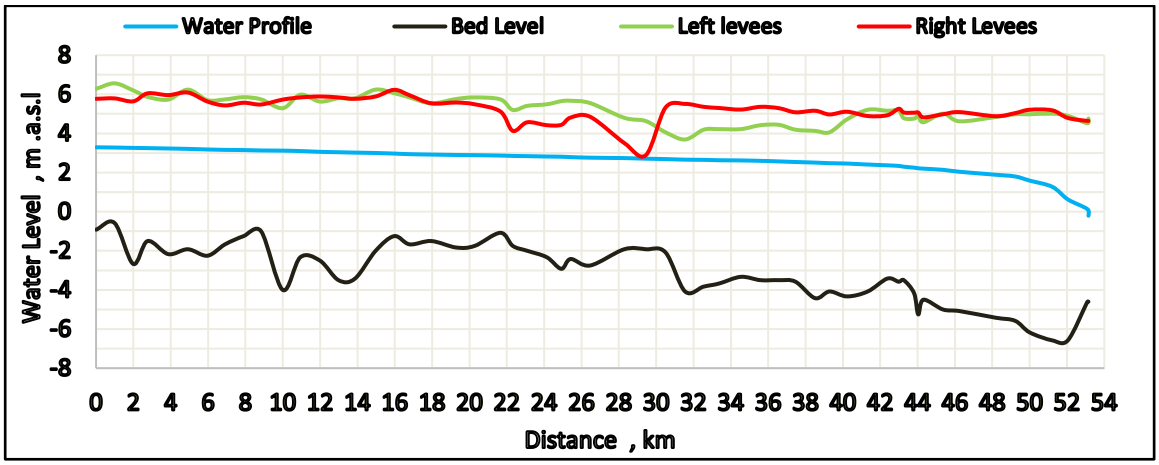

Figure (8): Longitudinal profile of the Euphrates River water levels under R3 Scenario.

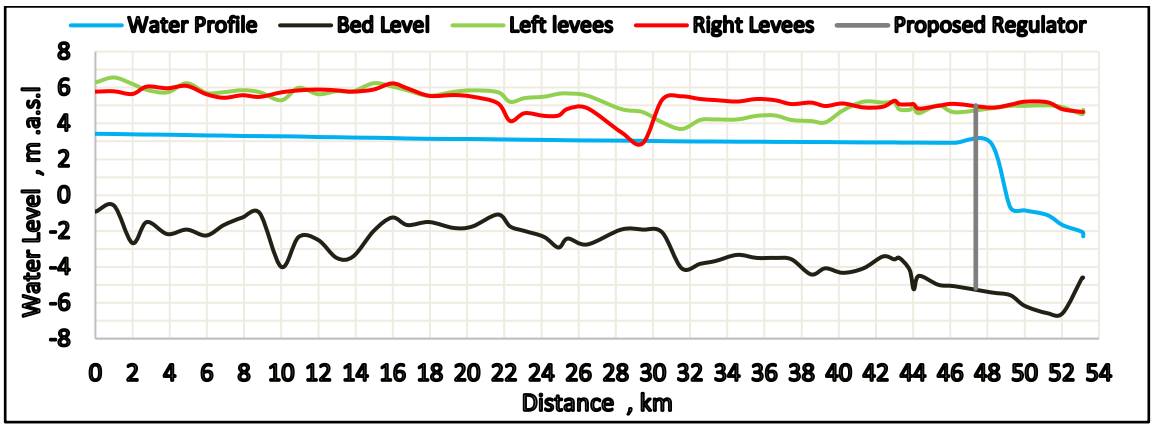

Figure (9): Longitudinal profile of the Euphrates River water levels under P1 Scenario.

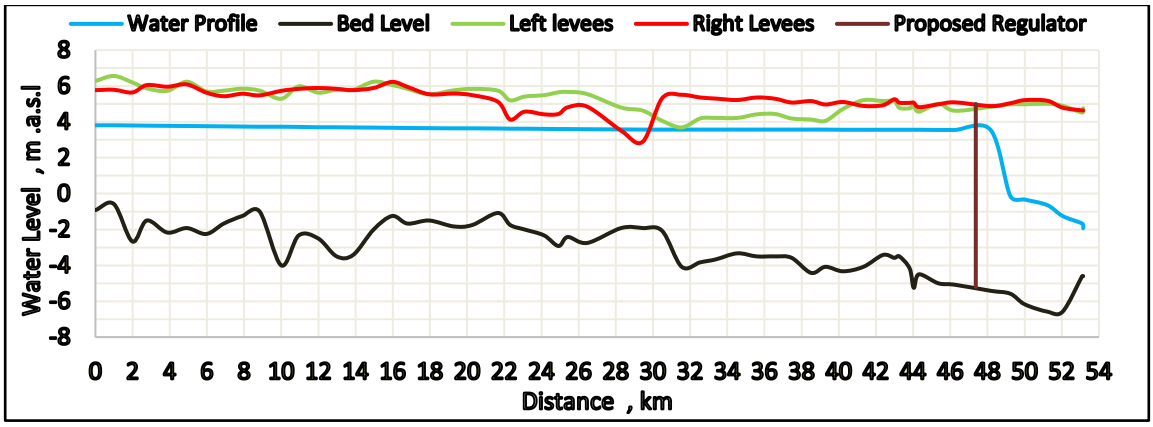

Figure (10): Longitudinal profile of the Euphrates River water levels under P2 Scenario.

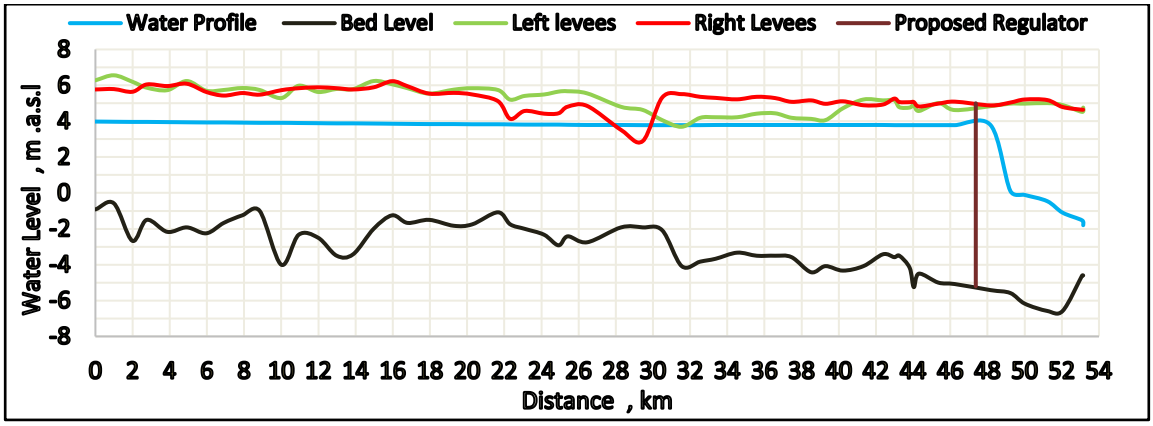

Figure (11): Longitudinal profile of the Euphrates River water levels under R3 Scenario.

Conclusions

In the worst-case flood scenario, with the full operation of the nine regulators and the outflow of water to the marshes, the highest water level upstream of Al Chibayish Weir is 3.75 m above mean sea level.

The decrease in water levels in the right channel of the river near Hammar Marsh at (150 + 146)km and 150 + 147 km (5.3 and 8.2, respectively) has a significant impact on the discharge and water levels of the Euphrates River. This decrease has also resulted in a clear reverse flow at the nine regulators, with a discharge rate of 140 m^3/s.

An analysis using a modeling approach was conducted to compare the potential effects of locating a regulator downstream at Al-Juhailah (location 1) or Sadad 712 (location 2). The

results indicated that there was no significant difference in water levels between the two proposed locations, likely due to their close proximity to one another (within 3 km). This finding suggests that the choice of location for the regulator may not significantly impact water levels in the region.

The proposed regulator, to be located downstream at either location 1 or 2 , aims to manage water levels in the Euphrates River system during both flood and drought periods.

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