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Application and performance of Culvert design by using HY8 Model: Case Study Al-Musayab canal, Iraq

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ABSTRACT: Box culverts represent one of the most important water conveyance structures. Their hydraulic design requires hydrological information, including available discharges and water levels at the upstream and downstream ends of the structure. The hydraulic performance represented by the box culvert design dimensions was examined using HY-8 software, a versatile tool from the U.S. Federal Highway Administration for analyzing various culvert shapes and configurations. This study investigated the hydraulic design of a culvert by using HY-8 software to design and analyze the box culvert while accounting for the hydraulic behavior of the Al Musayab project surrounding area, Babil City, Iraq. HY-8 can model box culverts in a horizontal path to approximate the behavior of hydraulic structures, according to the available discharges, upstream and downstream water levels of the structure, several box culvert simulations that includes (2x2) m, (2.5x2.5) m, (3x3) m, and (4x4) m were tested to select the optimal box design. The design discharge of 35 m^3/s for the culvert's incapacity to carry the design flow, the design considered a 4×4 m box shape, the headwater elevation is 31.9 m, which is below the roadway elevation of 33 m. The results of this study provided an evaluation and selection of the best dimensions for the box culvert according to the available discharges. Furthermore, the results shows how to improve the shortage by using an inflatable weir at the exit of the structure so as to increase the water levels along the structure.

Keywords: HY-8; box culvert; Submerge culverts, Roadway Discharge, Overtopping

1. INTRODUCTION

Conveyance structures are structures built along the canal's route to transport water from one location to another across various existing obstructions along the canal's path. They come in various types, including culverts, syphons, and aqueducts. Road barrages (also known as low-head weirs or cross-drainage structures) are hydraulic structures built across rivers or streams to regulate water flow, prevent erosion, and maintain road embankment stability. Unlike culverts, barrages are designed to partially or fully obstruct flow, creating upstream ponding while allowing controlled discharge downstream. Culverts were deemed an essential structure for avoiding the flash flood and controlling the storm water runoff, by allowing the water to pass beneath roads and other buildings. A proper design of the culvert contributes to reducing the risk of infrastructure damage and best effectively transporting water, hence mitigating flooding [1]. In hydraulic engineering, the design and analysis of box and pipe culverts are extremely important, particularly in flood-prone locations. Concrete, metal, or plastic are common materials used to build culverts, which vary in size and shape according to the location's particular needs [2]. A thorough analysis of a number of variables, such as the catchment area, natural stream patterns, intersections with roads, soil properties, the study region's climate, and land use, is necessary for the hydraulic structures' design [3]. The significant economic design occurs through estimating the peak flows that aid in

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avoiding the utilization of large hydraulic structures, which caused an increase in the costs of road construction unduly [4]. HY-8, THYSYS Culvert, Culvert Analysis Program, HEC-RAS, FishX-ing, and Culvert Master are popular programs for culvert design and analysis, these software tools were created to help engineers build and analyze culverts in road construction [5]. Numerous research projects have examined the application of Culvert software for hydraulic analysis and design. for example, Rowley, et al. (2007) used a number of computer programs, such as HY-8, Culvert Master, and the Hydrologic Engineering Center River Analysis System (HEC-RAS), to perform a study on the numerical modeling of culvert hydraulics [6].

The work was to evaluate the accuracy of the hydraulic features provided by these programs. Test cases were created to assess the program's correctness, specifically with regard to outflow velocities, headwater depths, and flow controls. Abdelkarim (2019) carried out a study with the goal of estimating the likelihood of flooding along the Kingdom of Saudi Arabia's Jizan–Abha Highway. They also used Culvert Master Program to assess the effectiveness and capacity of the current floodwater drainage systems, including culverts, bridges, and dry communication infrastructure situated beneath the Highway of Jizan–Abha, to handle ultimate flows. The work help decision maker in the city and other parts of Saudi Arabia kingdom by offering understandings on other solutions that may be researched and put into practice in order to safeguard roadways from expected future floods [7]. The study by Adeogun, et al. (2019) showed the hydraulics of a few culverts along the Ilorin-Jebba road in Kwara state, Nigeria, Culvert Master and HY-8 software were used in their investigation [8].

Mamoon et al. (2022) used a number of computer tools, including as THYSYS and Culvert Master, to analyze the functioning of culverts in Bangladesh [5]. They used the logical formula and in situ site data to perform hydrologic-hydraulic assessments of a few chosen culverts. All of the selected culverts were found to be vulnerable to future climatic scenarios, according to the study, which made the design of new culverts necessary. Alqreai and Altu waijri (2023) used Culvert Master Program to carry out analysis pertaining to the hydraulic investigation and design of culverts beneath the railway and highway track for a 100 year return period hydrology in Wadi Malham, Saudi Arabia [9].

To improve the hydraulic performance of water flow in rivers, canals, and streams, it is necessary to construct suitable hydraulic structures. Hydraulic structures are used for many purposes, such as controlling the water level. One of an economic hydraulic structure used to control the water level is the inflatable weir. An inflatable weir is a simple barrier made of a flexible membrane, therefore, reusable, air-filled molds used to create concrete pipes, tunnels, and hollow structures. Serving as temporary internal formwork, they inflate to shape concrete and deflate for removal after curing, offering a faster, more cost-effective alternative to traditional methods, which is controlled the upstream water levels by injecting and discharging air or water and fixed across the canal Alhamati, (2005) [10].

HY-8, or HYDRAIN tools, is a Federal Highway Administration software designed and analysis for culvert. It automates hydraulic computations and analyzes culvert performance, multiple barrels at single or multiple crossings, and roadway overtopping. HY-8 generates performance tables, graphs, and input variable documentation [11].

The aim of this study is to use and application of HY-8 software to typical design and analyze the box culvert whereas accounting for the hydraulic behavior of the Al Musayab project canal, of Babil city, which is situated where the main route between Babil and Baghdad intersects the primary valley. On the other hand, HY-8 was selected due to automated profile computations and accurate modelling of complex tailwater conditions. Its dual analysis of inlet and outlet control is crucial for this canal's downstream constraints, preventing culvert under-design, a common error in manual calculations or less specialized software. This ensures the canal's water level will not cause flooding of the adjacent area and main road.

2. FLOW THROUG THE CULVERT

A culvert is a relatively short segment of conduit structure that is typically used to convey flow beneath a roadway. The culvert consists of an entrance, an outlet, and a culvert barrel. Common culvert shapes include circular pipes, rectangular boxes, ellipses, and arches. The entrance will only be submerged if the headwater exceeds a critical value of H, whereas the outlet is not submerged were $1.2D \leq H \leq 1.5D$ and D present the height of culvert

A square edge culvert at the top of the entrance will not flow full even if the entrance is less headwater level when the outlet is not submerged as displayed in Figure 1.

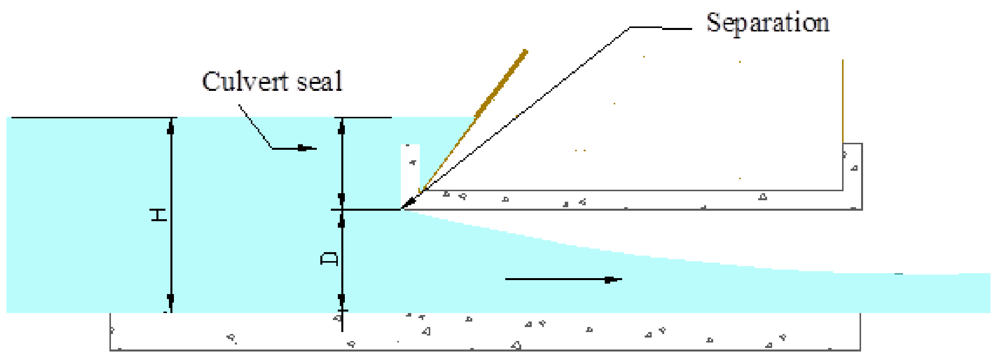

FIGURE 1 Culvert with submerged inlet and unsubmerged outlet [12]

For practical purposes, culverts flow may be categorized into six kinds of water flow within two classify groups [12]. Group (A) when free surface flow (inlet and outlet) throughout (neither end submerged).

- Critical depth at inlet (inlet control) where H < 1.2D and yt < yc Culverts on supercritical slopes, inlet not submerged, free outlet, control at inlet, flow is supercritical (Figure 2), where y_c critical depth, y_t tailwater depth

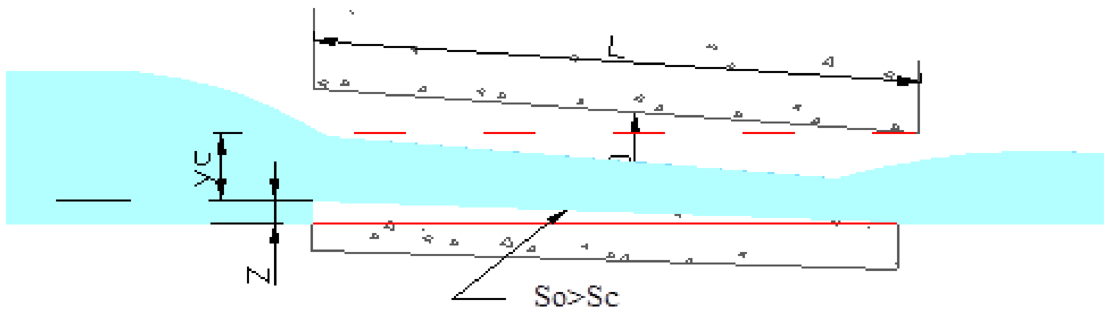

FIGURE 2 Culvert with inlet control [12]

- Critical depth at outlet (outlet control):

Culvert on subcritical or horizontal slope, henceforward the control section is at the exit were H < 1.2D and yt < y as presents in Figure 3

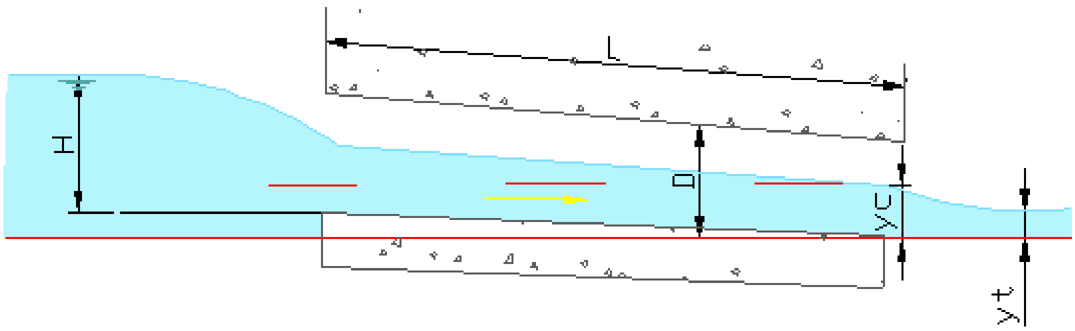

FIGURE 3 Culvert with outlet control [12]

- Subcritical flow occurs when H < 1.2D and yt > yc (Figure 4)

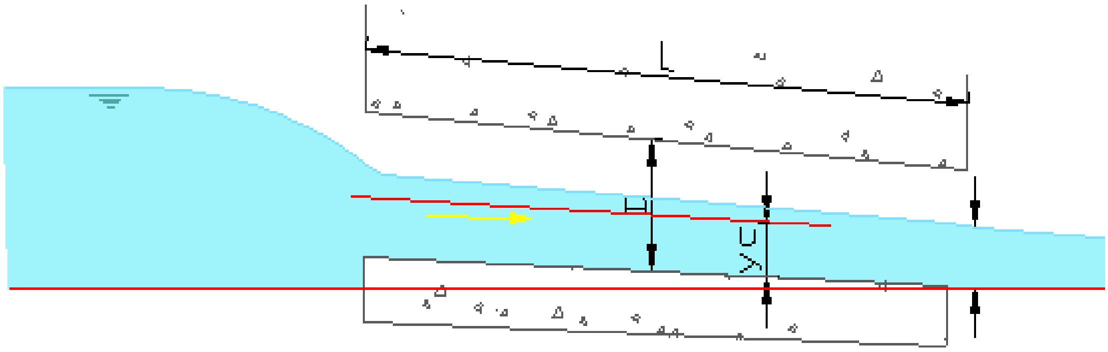

FIGURE4 **Culvert with subcritical flow [12]**

Group (B): Upstreamend are always submerged

- Inlet and outlet are submerged. It is the most economical case, which is usually in design. The conduit is flowing full Submerged inlet were H>1.2D and flow full yt > D (Figure 5)

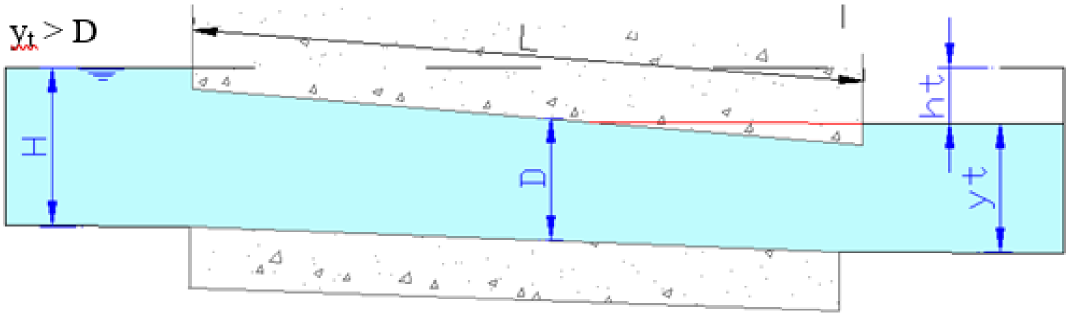

FIGURE 5 **Culvert with Inlet and outlet are submerged [12]**

- Submerged inlet, full flow, free outlet, culvert on mild (sub critical) or horizontal slopes, were H > 1.2D and yt < D (Figure 6)

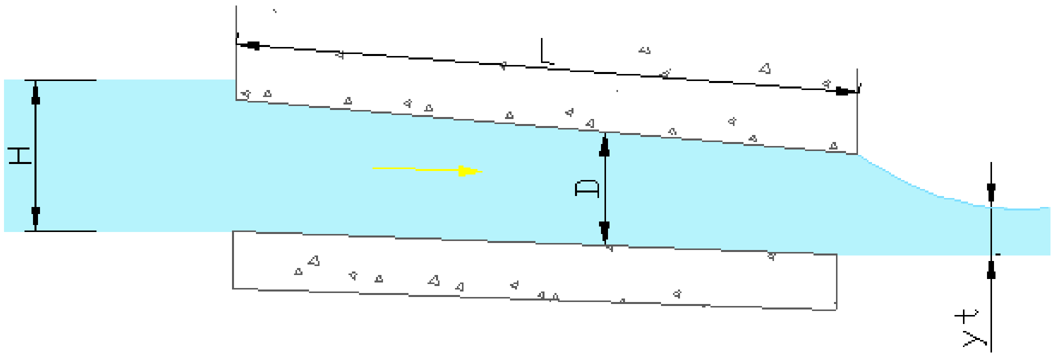

FIGURE 6 **Culvert with Submerged inlet, full flow, and free outlet [12]**

- Partially full flow with submerged inlet, rapid inlet flow, free outlet, hydraulically short, and inlet control as shown in Figure 7.

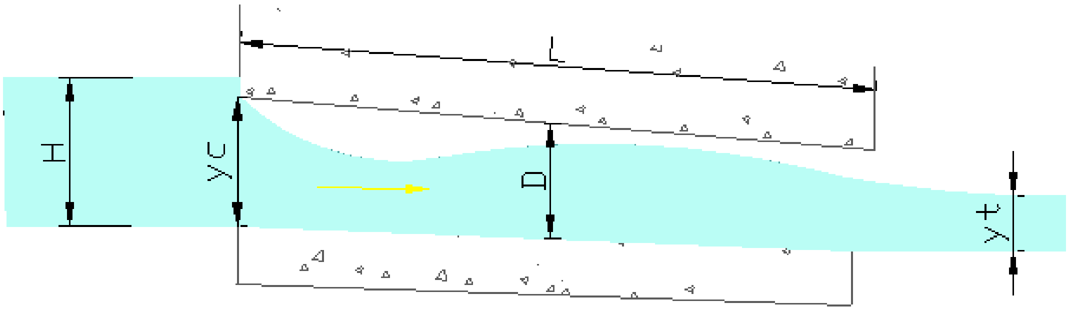

FIGURE 7 Culvert with partially full flow with submerged inlet [12]

- For discharges up to about 2.5 m^3/ sec. Pipes can be used, but for larger discharges a box section is preferred [13].

For most canal culverts where head loss is to be kept to a minimum, the culvert is assumed to flow full and the discharge is a function of the difference between headwater and tailwater, if this difference is ΔH and the culvert is of depth D than the general culvert equation is given by: -

$$2g(\Delta H) = \left(k1 + k2 + \frac{2gn^2L}{R_h^{4/3}}\right)\left(\frac{Q}{A}\right)^2 \qquad (1)$$

Where:

K1 = inlet loss coefficient, K2 = exit loss coefficient, Rh = Hydraulic radius (m), n = manning's roughness coefficient, L = length of the culvert (m), A = area of the culvert (m^2)

3. METHODOLOGY

Study area

Al Musayab project is located to the north of Babil city, in Iraq. The project branch from the left bank of Euphrates River at km 588 about 49.5 km length feed the urban and agriculture area approximately 335000 dunams. Box culvert were established in the upstream of the project at longitude 44 E and latitude 34 N about 100 m from the bank of the river. It served as a strategic road connecting Babil and Baghdad. At the same time, the hydraulic structure utilized to pass water discharge of the project more than 50 m^3/s as shown in figure 8.

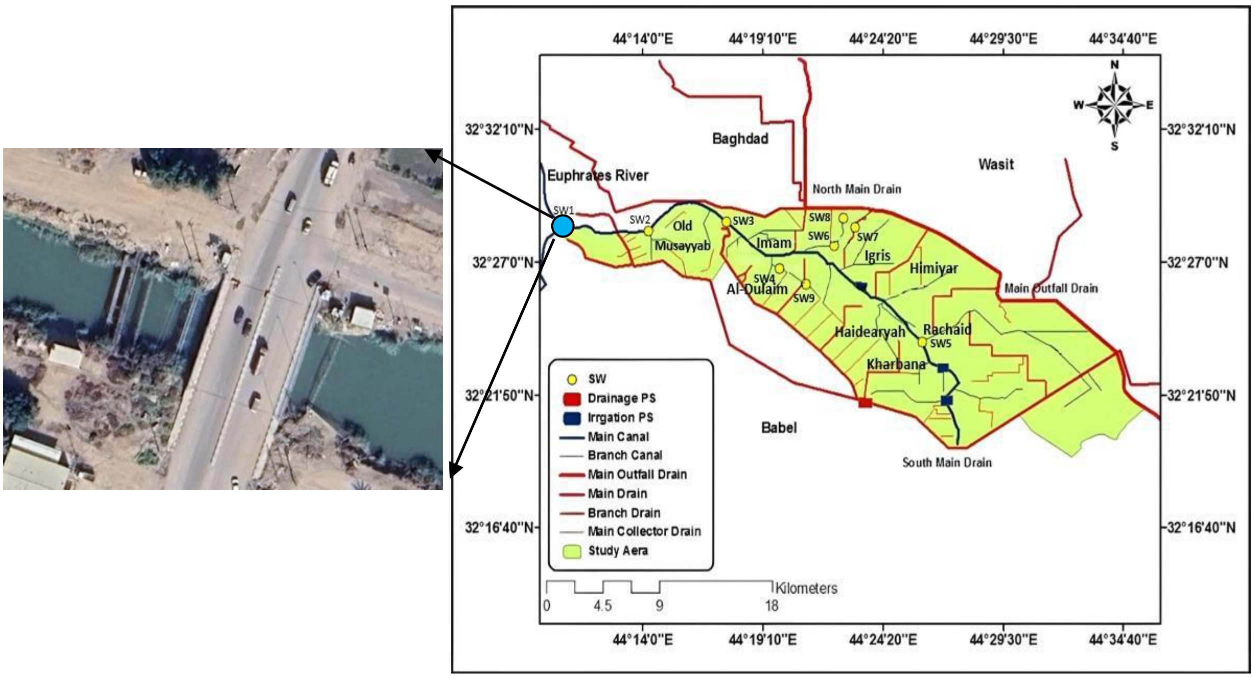

FIGURE 8 Area of the case study with the culvert location

Data collection

The climate in the Al Musayab region resembles that of Babil city, which is regarded as by a transition between a desert environment and Mediterranean climate. It experiences lower temperatures and humidity in winter and high weather in summer. The study area has an arid to semi-arid climate with an average annual rainfall of 250 mm and is prone to flooding, as evidenced by the event on December 9-12, 2019. The minimum and maximum design discharges equal to 15 and 50 m3/sec. The water surface elevations range (26 and 33) m above mean sea level (m.a.m.s.l) were obtained from [14].

Hydraulic data

Recently, the discharge of the Al Musayab project ranged between 29 to 32 m3/sec, and the average velocity of flow is 0.44 m/s. At the upstream of the Al-Musayyab canal, measurements taken at the canal indicate a longitudinal slope of the canal is 10 cm/km, the canal width varying between 10.45 and 25 m, and its depth ranging from 1.8 to 2.45 m [14]. Based on the hydrometer investigation and particle size distribution analysis, the unified arrangement system for soils has classified the soil in the area as sandy clay bed material, as demonstrated by laboratory experiments [15]. The longitudinal section of the river suffered from erosion and deposition processes due to the flow variation. Likewise, it shows the elevation of the channel bed approximately 20 m a.m.s.l. Although the elevation of the bank is 32.2 m.a.m.s.l. Generally, the water level range is 30 to 31m at the upstream of the steady area.

Work Methodology

By simulating flow regimes, headwater heights, and scour possibilities, the hydraulic design calculations for the box culverts in the study area were performed using the HY-8 program and the program results were compared with the culvert design calculations using the basic equations. This study investigates the limits of HY-8, its potential applications in road barrage hydraulic design, and supplementary techniques for precise design. Figure 9 illustrated methodology of the case study.

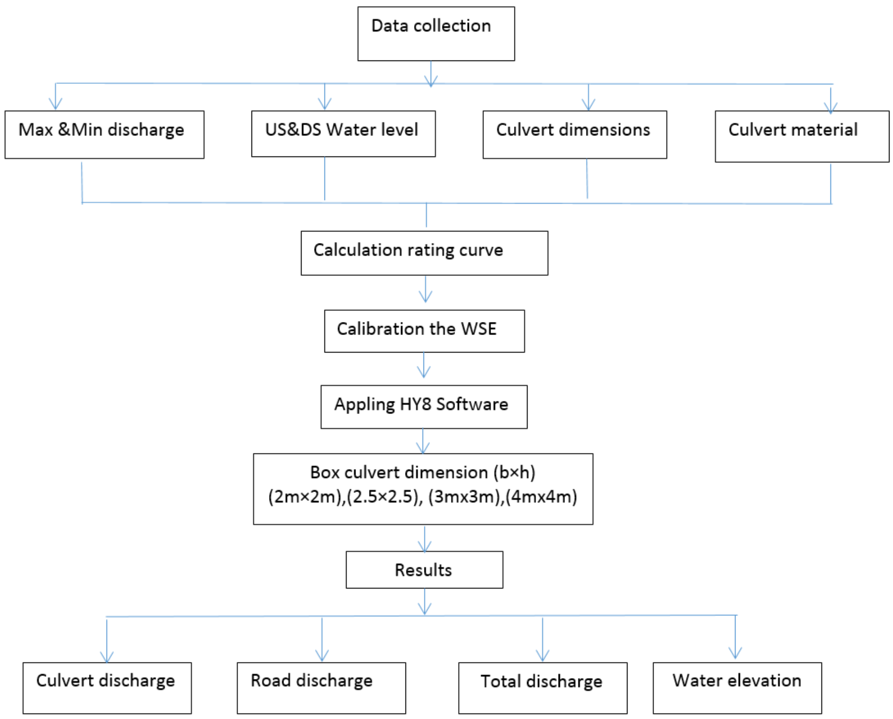

FIGURE 9 Flowchart for the methodology of the case study

HY-8 software description:

The Federal Highway Administration (FHWA), USA, received Hy-8, a culvert hydraulic modeling tool established by Philip Thompson, for distribution in the early 1980s. Understanding of culvert hydraulics has greatly expanded since the hydraulic model was developed, which has resulted in the creation of more widely accepted modeling approaches. The model has been used by numerous government agencies and organizations for the design and analysis of culverts along roads. Because the model was easy to use and efficient, as stated in some pervious study [5, 11], it was selected. Additionally, in Nigeria has recommended the HY-8 tool for culvert analysis, which includes water profile computation and inlet and outlet control [16]. Additionally, the software enables the determination of the culvert's water surface profile and flow regime (Figure 10). The Step-by-Step HY-8 Analysis is requirement

Input Geometry:
- Define a "boxculvert" with a wide span (equal to barrage width).
- Set culvert slope to zero (horizontal).
- Adjust inlet loss coefficients for weir-like conditions.

Flow Conditions:
- Enter design discharge (Q).
- Define upstream and downstream channel cross-sections.

Headwater Analysis:
- HY-8 computes upstream water elevation (similar to barrage headwater).
- Compare with allowable flood levels near the bank level.

Limitations of HY-8 for Barrage Design

HY-8 uses culvert hydraulics, not standard weir formulas (e.g., Broad-Crested Weir equation)

$$Q = C\ L\ H^{3/2} \qquad (2)$$

Where:
Q = flowrate (m^3/sec.), C = discharge coefficient, L = Weir length (m), H = head of water upstream the weir (m).

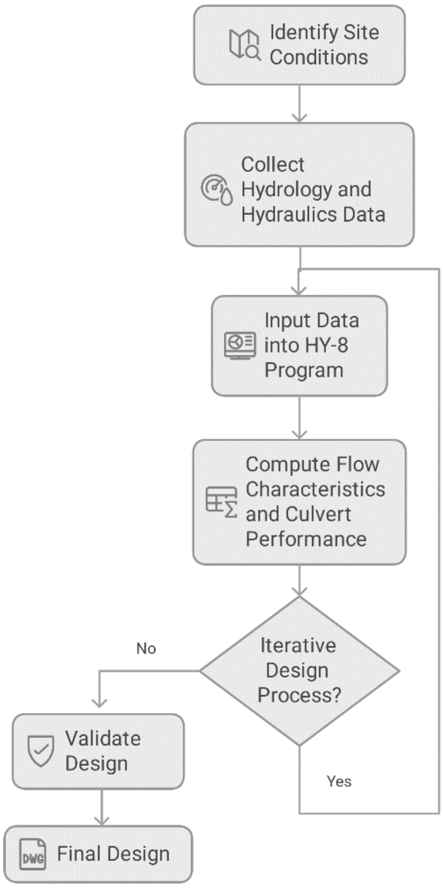

FIGURE 10 Flow Chart for HY-8 Software

4. RESULTS AND DISCUSSIONS

4.1 Model running

Using the culvert data window, all the parameters required to define crossing and culvert data are set. Moreover, it is followed by the culvert's hydraulic study, which includes the balancing of flow over the road and via several culverts. The analysis of the culverts includes the required hydraulic calculation. Therefore, water surface profiles can be displayed. After analysis, if culverts overtop, the culvert can be reanalyzed by either enlarging the hydraulic culvert or adding several barrels until the design flow is completely supported. Figure 11 is the rating curve for the Al Musayab project canal boxculverts. The plots of Headwater elevations against flow, with the design flow inclusive is critical for determining the culvert's performance limits. The curve helps determine flow through the culvert based on a given headwater elevation.

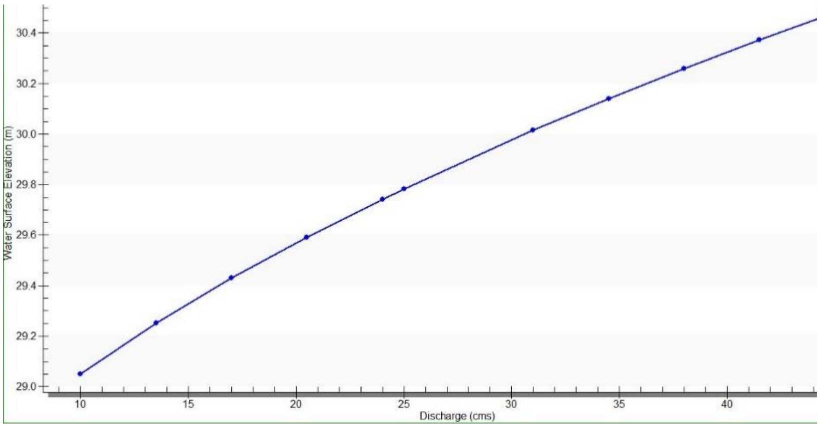

FIGURE 11 Downstream rating curve

Accounting for hydraulic sensitivity by analyzing the relationship between Manning's values is crucial for distinguishing inlet and outlet control in the Al-Musayab canal, as Manning's n significantly affects WSE during outlet control. This analysis also ensures the roadway remains protected from overtopping, even with increased canal roughness, providing a safety margin against backwater effects and preventing localized flooding near the intersection. In general, several measurement were taking in the field site that the results of the squar of coefficient (R2) ranged between 0.937,0.913 and 0.891 for n manning 0.025,0.03, and 0.035 respectivily as shown in Figure 12 of the water surface elevation WSE and discharge through the boxculvert

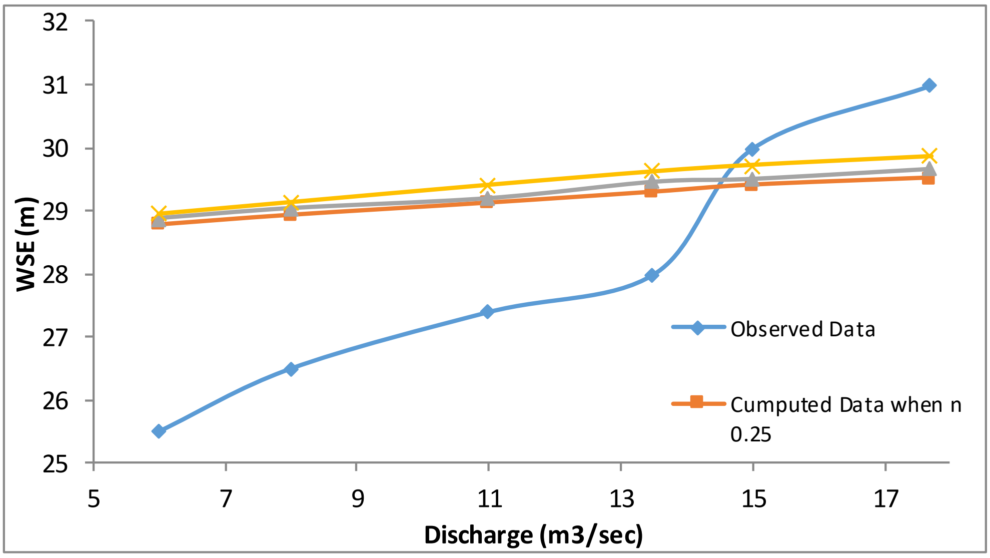

FIGURE 12 Calibration the WSE with different n manning numbers

The statistical parameters values containing root mean square error were represented. According to the results it is clear that the RMSE between the values predicted by simulation model and those acquired from the developed formulas ranged (0.55-3.33) cm/sec.

4.2 Water surface profile (WS)

Using the HY-8 tool, the water profile was planned in each direction using the direct step method, along with the subsequent depth for each step. The length of the hydraulic jump is determined from the point at which the subsequent depth associated with the forward profile and the depth along the backward profile through the culvert match. Figures

13–16 depict the longitudinal view of water surface profiles (headwater elevation) and roadway elevation of the (2x2) m, (2.5x2.5) m, (3x3) m, and (4x4) m simulated dimensions of the box culvert.

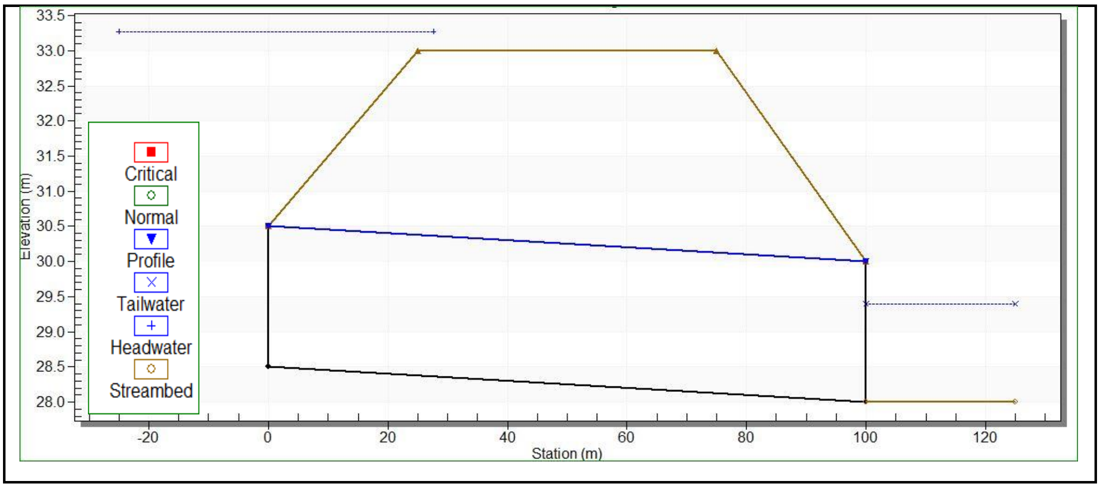

FIGURE 13 Longitudinal water surface profile for Box culvert with dimension 2m

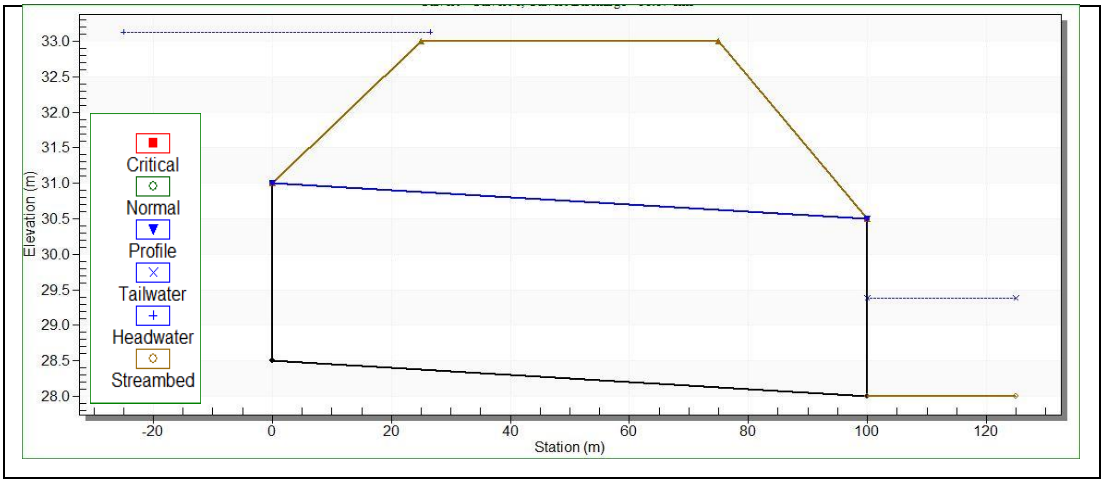

FIGURE 14 Longitudinal water surface profile for Box culvert with dimension 2.5m

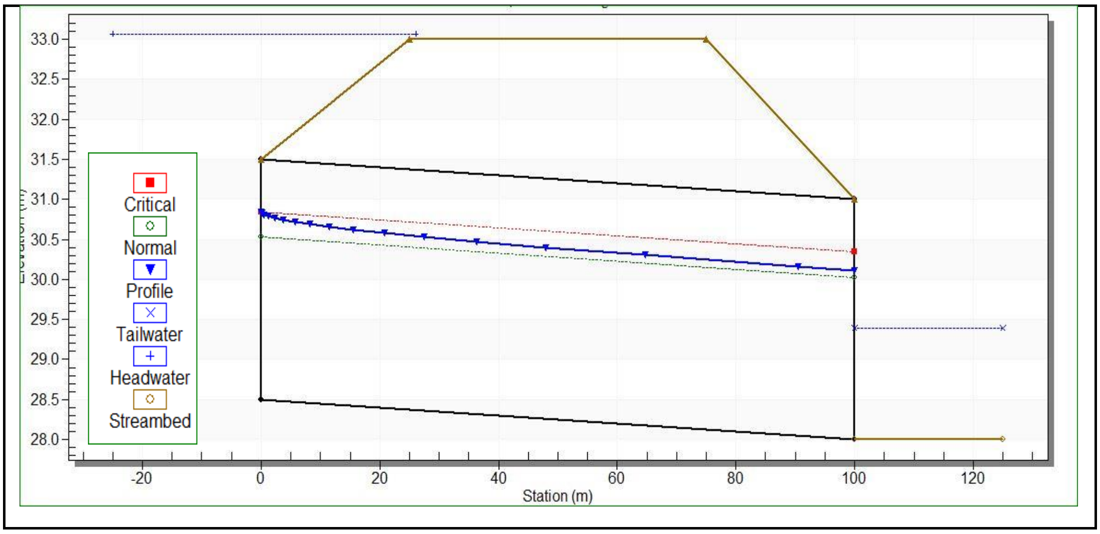

FIGURE 15 Longitudinal water surface profile for Box culvert with dimension 3m

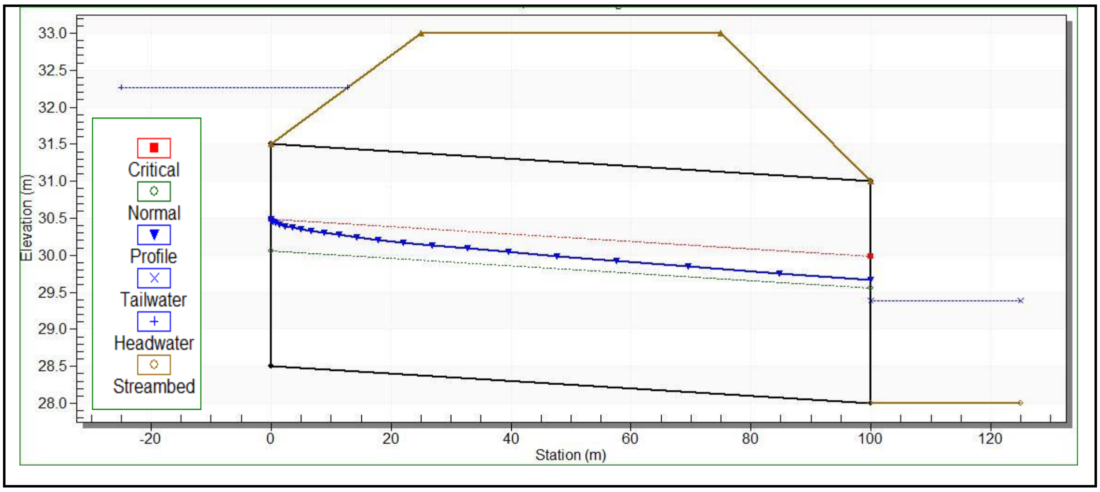

FIGURE 16 Longitudinal water surface profile for Box culvert with dimension 4m

4.3 Hydraulic Anlysis

Tables 1-4 presents the results from the hydraulics examination of the culverts. It includes information on headwater elevation and the sizes of the proposed culverts. Moreover, the table's status column conveys the design flow by providing details on the culvert's and the roadway's discharge. Culverts that were determined to be insufficient were reanalysed, and the current culvert's size was increased to accommodate the design flow. Several culvert sizes were determined to have sufficient capacity to support the design flow, whereas others analysis were establish to be insufficient. Overall the overtopping happened at the lowest elevation of 33m for all simulated dimensions.

For box culvert design with square size dimension (2mx2m) as presented in the table (1) and figure (13) for longitudinal water surface profile. It showed that the total discharge ranged from 15 m3/s to 50 m3/s, corresponding to Headwater Elevation 31.5m and 33.46 m, respectively. Similarly, changes occur between the total discharge overcome the culvert discharge at each elevation. Moreover, the total discharge exceeded the culvert discharge at each elevation, ranging from 33 to 33.46, which satisfied the maximum overtopping discharge (Roadway Discharge) 26.31 m3/s. Finally, when overtopping occurs, that causes the submergence and failure.

Table 1 Crossing side box Culvert with dimension 2m*2m

Headwater elevation (m)	Total discharge(m^3/s)	Culvert discharge(m^3/s)	Roadway discharge (m^3/s)	Iterations
31.5	15	15	0	1
32.18	18.5	18.5	0	1
33	22	21.97	0.02	21
33.11	25.5	22.38	3.11	6
33.18	29.00	22.67	6.35	5
33.24	32.50	22.85	9.63	4
33.27	35.00	22.99	12	4
33.34	39.50	23.22	16.27	4
33.38	43.00	23.38	19.61	4
33.42	46.50	23.54	22.61	4
33.46	50.0	23.68	26.31	4
33	21.95	21.95	0	overtopping

On the other hand, the box culvert design with dimension (2.5mx2.5m) as presented in the table (2) and figure (14) for longitudinal water surface profile. The overtopping happened at lowest elevation 33m. It showed that the total discharge ranged from 15 m3/s to 50 m3/s corresponding Headwater Elevation 33.12m and 33.39m respectivlly. Besides, change occur between the total discharge overcome the culvert discharge at each elevation. Moreover, the total discharge overcome the culvert discharge at elevation 33.06, to 33.39m. The range of water elevation about (31.12-32.64) m without overtopping therefore the maximum overtopping discharge (Roadway Discharge) 20.47 m3/s that causes the submergence and failure.

Table 2 Crossing Side trapped box culvert size 2.5m*2.5m

Headwater elevation (m)	Total discharge (m^3/s)	Culvert discharge (m^3/s)	Roadway discharge (m^3/s)	Iterations
31.12	15	15	0	1
31.58	18.5	18.5	0	1
32.08	22	22	0	1
32.64	25	25	0	1
33.06	29.00	27.81	1.19	9
33.14	32.50	28.23	4.26	5
33.18	35.00	28.46	6.53	5
33.25	39.50	28.84	10.65	4
33.3	43.00	29.08	13.91	4
33.35	46.50	29.31	17.18	4
33.39	50.0	29.52	20.47	4
33	27.5	27.5	0	Overtopping

In a less influential direction than previous designs, the hydraulic analysis in the model simulation of the (3mx3m) design was more acceptable and yielded the lowest overtopping discharge that started at elevation 33.09m (Table 3). The range of water elevation is about (30.81-32.87) m without overtopping. Furthermore, the maximum overtopping discharge (Roadway Discharge) is 11.36 m3/s, which causes the submergence and failure.

Table 3 Crossing Side trapped box culvert size 3m x 3m

Headwater elevation (m)	Total discharge (m^3/s)	Culvert discharge (m^3/s)	Roadway discharge (m^3/s)	Iterations
30.81	15	15	0	1
31.15	18.5	18.5	0	1
31.48	22	22	0	1
31.82	25.5	25.5	0	1
32.28	29.00	29	0	1
32.54	32.50	32.5	0	1
32.87	35.00	35	0	1
33.09	39.50	37.23	2.27	5
33.16	43.00	37.77	5.22	5
33.21	46.50	38.22	8.25	4
33.26	50.0	38.62	11.36	4
33	36.48	36.48	0	Overtopping

Finally, the optimum box culvert design results when with dimensions (4mx4m) as presented in the table (4) and figure (16) for longitudinal water surface profile. Therefore wide range of water elevation about (30.41-32.8) m without overtopping. The maximum total discharge is 50 m3/s, corresponding Headwater Elevation of 33.85m, where overtopping is simulated to occur.

Table 4 Crossing Side trapped box culvert size 4m*4m

Headwater elevation (m)	Total discharge (m^3/s)	Culvert discharge (m^3/s)	Roadway discharge (m^3/s)	Iterations
30.41	15	15	0	1
30.69	18.5	18.5	0	1
30.96	22	22	0	1
31.21	25.5	25.5	0	1
31.46	29.00	29	0	1
31.71	32.50	32.5	0	1
31.9	35.00	35	0	1

32.24	39.50	39.5	0	1
32.52	43.00	43	0	1
32.8	46.50	46.5	0	1
33.85	50.0	49.16	0.86	6
33	48.64	48.64	0	Overtopping

4.4 Validation of the results

To calibrate the results of the HY-8 simulation model, the data collected from the Ministry of Water Resources that are listed in paragraphs 2.1 and 2.2 were used, and equation (1) was adopted, as shown below: K1 = 0.5 square entrance, K2 = 1.0, Rh = D/4 (m), n = 0.015, L = 100 m and A= D2, By applying equation (1), Assuming one opening (Q= 35 m3/sec.) and using many trails the area is A=D×D = 4×4 m2 for one opening, But H/D = 2.45/4 = 0.6125 < 1.2 that mean the inlet of the culvert is not submerged.

Assuming two openings (Q 17.5 m3/sec.) and using many trials, A=D×D =3×3 m2 or 4×4 m2, and could lower the culvert bed by (1-1.25) m. The roadway overtopping entails the box culvert headwater elevation being greater than the roadway crest [13]. On the other hand, the design discharge of 35 m3/s for (2mx2m) and (2.5mx2.5m) dimensions, the flow accommodated by the culvert is 22.99 m3/s and 28.46 m3/s respectively, instead of 35 m3/s. The lasting flow goes over the road as Roadway discharge.

Accordingly noted that the existing culvert lacked the hydraulic capacity to convey the design flow. Therefore, this design causes a flood after rainfall incidence. Consequently, due to the culvert's inability to convey the design flow, the design considered a 4x4 m box shape, and the summary of the results is presented in Table 4. It was detected that at design discharge of 35 m3/s, the headwater level is 31.9 m, which is below the roadway elevation of 33 m. The selected size defines the culvert outline, resolving water flow issues in the canal of the Al Musayab project area.

4.5 Improvements the hydraulic performance

Irrigation projects, such as rivers and canals, suffer from water scarcity. Therefore, when using a hydraulic structure such as culverts, and after designing it based on the available data and design discharge, it is crucial to operate the structure at optimum efficiency, especially during periods of water scarcity. The use of an inflatable weir at the end of the culvert was proposed in this study. This inflatable weir addresses the lack of water level within the culvert and prevents the undesirable flow conditions mentioned in paragraph 3.1. The inflatable weir is used at various heights depending on the available water quantity to Improvements the hydraulic performance inside the culvert. The equation (2) that relates the water depth above the inflatable weir to the discharge was adopted. Table 5 show the relation between the operational discharges, the calculations were performed using Excel sheet. Head of water above the exit inflatable weir, and inflatable weir depth. Studies recommend using a freeboard 0.6 meters at least, and therefore according to the table 5 at high discharges it is not necessary to use an inflatable weir. Inflatable weirs are proposed hydraulic structures designed to raise water level downstream of a box culvert. They are not an integral part of the box culvert design. However, during periods of low water flow, inflatable baffles can be used at the downstream of any hydraulic structure, even if they are not included in the basic design. They can be used or positioned at a distance from the end of the structure to avoid affecting the hydraulic performance of the box culvert.

Table 5 Operational discharge and head of water above the inflatable weir relation

Headwater Elevation	culvert Discharge(m^3/s)	Head of water above the inflatable wier (m)	inflatable wier depth (m)
30.41	15	1.2	1.8
30.69	18.5	1.4	1.6
30.96	22	1.5	1.5
31.21	25.5	1.7	1.3
31.46	29.00	1.8	1.2
31.71	32.50	2.0	1.0
31.9	35.00	2.1	0.9
32.24	39.50	2.3	0.7
32.52	43.00	2.4	0.6
32.8	46.50	2.5	0.5
33.85	50.0	2.7	0.3

5. CONCLUSIONS

Constructed on the result of this study, the boxculvert designed using HY-8 software, analysed to ascertain if they have the capacity to convey water flow in the Al Mussaib project canal. In comparison, as a result of the headwater elevation, the dimension (4mx4m) of the box culvert selected was hydraulically viable than the other three size designs (2mx2m), (2.5mx2.5m), and (3mx3m). HY-8 should be considered a supporting tool rather than a primary design model. Due to the culvert's incapacity to carry the design flow of 35 m3/s, a selected 4x4 m boxculvert was considered, resulting in 31.9 m a headwater, which is below the roadway elevation of 33 m. Moreover, the inflatable weir was investigated at various heights depending on the available water quantity to improve the hydraulic performance inside the culvert; therefore, at high discharges, it is not necessary to use a sunken dam. For future consideration, a combination of sediment transport modules with HY-8. Furthermore, there could be improved HY-8 updates for weir/barrage modelling. Finally, energy dissipation, like baffles, stilling basins, and riprap to prevent scour, can be simulated through HY-8.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest

REFERENCES

[1] V. K. Sissakian, N. Al-Ansari, N. Adamo, I. D. A. Ahad, and S. A. Abed, “Flood Hazards in Erbil City Kurdistan Region Iraq, 2021: A Case Study,” *Engineering*, vol. 14, no. 12, pp. 591–601, Dec. 2022, doi: https://doi.org/10.4236/eng.2022.1412044.
[2] B. Hauser, Practical Hydraulics Handbook. S.L.: Crc Press, 2019
[3] E. W. Tollner, Engineering Hydrology for Natural Resources Engineers. John Wiley & Sons, 2016.
[4] A. H. Dawood and D. K. Mawlood, “Flood Inundation Modelling and Reduction by Dike Construction in Urban Areas: A Case Study in Erbil, Iraqi Kurdistan,” Journal of Studies in Science and Engineering, vol. 4, no. 2, pp. 122–135, Dec. 2024, doi: https://doi.org/10.53898/josse2024427
[5] W. B. Mamoon, A. K. M. S. Islam, K. Shadman, T. I. GM, and K. B. Sujit. “Performance Analysis of Culverts Along The N105 Bypass Road Using Hy-8 Software for Future Climate Scenario” In 6th International Conference on Civil Engineering for Sustainable Development. KUET, Bangladesh. 2022.
[6] B. J. Rowley, E. A. Thiele, R. H. Hotchkiss, and E. J. Nelson, “Numerical Modeling of Culvert Hydraulics: Modernization of Existing HY8 Software,” pp. 1–10, May 2006, doi: https://doi.org/10.1061/40856(200)51.
[7] A. Abdelkarim, “Assessment of the Expected Flood Hazards of the Jizan-Abha Highway, Kingdom of Saudi Arabia by Integrating Spatial-Based Hydrologic and Hydrodynamic Modeling,” Jul. 2019.
[8] A. G. Adeogun, M. A. Akinpelu, M. A. Yusuf, and R. A. Animashaun, “EVALUATION OF HY-8 MODELING TOOL FOR HYDRAULIC ANALYSIS OF SELECTED CULVERTS ALONG ILORIN -JEBBA ROAD, KWARA STATE, NIGERIA,” DOAJ (DOAJ: Directory of Open Access Journals), Mar. 2019.
[9] F. N. Alqreai and H. A. Altuwaijri, “Hydrological Modeling and Evaluation of the Efficiency of Culverts in Drainage Basins Affecting the North Railway in Wadi Malham,” Sustainability, vol. 15, no. 19, pp. 14489–14489, Oct. 2023, doi: https://doi.org/10.3390/su151914489.
[10] A. Nasser, T. A. Mohammed, and Jamalodin Norzaie, “DETERMINATION OF COEFFICIENT OF DISCHARGE FOR AIR-INFLATED DAM USING PHYSICAL MODEL,” Jan. 2005.
[11] I. L. Nwaogazie and G. C. Agiho, “Performance analysis of box and circular culverts using HY8 software for Aluu Clan, Port Harcourt,” Nigerian Journal of Technology, vol. 38, no. 1, p. 22, Jan. 2019, doi: https://doi.org/10.4314/njt.v38i1.4.
[12] T. A. Endreny, “Land Use and Land Cover Effects on Runoff Processes: Urban and Suburban Development,” Oct. 2005, doi: https://doi.org/10.1002/0470848944.hsa122
[13] H. M. Elbadry, Structural Design of Box Culverts. 2023.
[14] Ministry of Water Resources MOWR, 2019-2021. Data on the water levels and hydraulic information of Al-Musayyab canal.

[15] H. K. Razzaq, B. Sh. Abed, and A. J. J. Al-Saadi, "Simulation of Bed Change in Al-Musayyab Canal using HEC-RAS Software," Journal of Engineering, vol. 30, no. 05, pp. 114–131, May 2024, doi: https://doi.org/10.31026/j.eng.2024.05.08.

[16] Y. Hamzat, "An assessment of road transport infrastructure development in Kaduna State, Nigeria" Unpublished master's thesis, Department of Geography, Faculty of Science, Amadu Bello University, Zaria. 2016.