Hydraulic Geometry Relationships for Meadring River in Al Abbasia Reach in Euphrates River

Asst. Prof. Dr. Mohammed Shaker Mahmood,
Civil Engineering
University Of Kufa/Faculty Of Engineering
Najaf, Iraq

Asst. Prof. Dr. Kareem R. Almurshedi,
Civil Engineering
University Of Kufa/Faculty Of Engineering
Najaf, Iraq

Zaid Nori Hashim.
Civil Engineering
University Of Kufa/Faculty Of Engineering
Najaf, Iraq

***Abstract*—Meandering phenomenon is a bend in the course of a stream, usually occurring in a series. The river plan form movement is a process in the river that is associated with soil erosion on a riverbank on one side is accompanied by a sedimentation on the other side. Al-Abbasia reach, in the middle of the Euphrates river, Najaf governorate, was selected to investigate the meandering process. The study-reach is about six kilometers, it is divided into twenty one cross-sections. These sections represent the meanders and bends in the reach. Power functions were used and applied for modeling and predicting the hydraulic geometry (4 models) for the selected reach and comparing with other models in previous studies. The recent models aresuitableto be used in the natural channels design, hydraulic management and restoration.**

Keywords*— *Euphrates; Al Abbasia; Najaf; Channel morphology; River Geometry; River Hydraulics; River Meandering; River flow.

I. INTRODUCTION

River meandering geometry changes and trends are a very complex and complicated process. Although it is obvious that all rivers meander, it may be less obvious that there are consistent underlying relationships between different meander dimensions and discharges,[1]. The river plan form movement is a process in the river that is associated with soil erosion on a river bank on one side which is accompanied by a sedimentation on the other side .It was known as the instability of the river geometry, which became a threat to the safety of Hydraulic Structures, [2]. Figure (1-1) shown the processes on a meander bend. Hydraulic geometry is a quantitative way to understand characteristics of a river ,[3]. Hydraulic geometry includes parameters such as width, depth, cross sectional area, and meander length, and other hydraulic variables such as mean slope, friction, and mean velocity which depends on many factors like discharge, and type of bed material ,[4]. Most of the hydraulic geometry relationships derived under premises that there are direct or indirect relation, at least statistically, between meander geometry characteristics and some hydraulic variables as discharge and velocity. The mathematical and statistical methods that define these relations beginning in growing since (1953). Meandering river and Hydraulic geometry has been one of the most explored and investigated topics in hydraulic engineering. No less than Albert Einstein postulated in 1926 a theory explaining the process of meandering on the basis of simple physical laws. Since then understanding of the process has traversed from simple physics to equilibrium and geomorphic theories on one hand and from empiricism to complex mathematical modeling on the other, and yet without a final word as to-why and how rivers meander. The real impetus toward formulating a theory of hydraulic geometry was provided by the work of and Maddock (1953). A number of theories have since been proposed. All theories, however, assume that the river flow is steady and uniform and the river tends to attain a state of equilibrium or quasi-equilibrium. The differences are due to the differences in hydraulic mechanisms that the theories employ to explain the attainment of equilibrium by the river. Generally, all the theories can explain how the meandering rivers continue to meander but fail to explain how meanders initiate. Next one exhibits primal theories in hydraulic geometry, [4]. The recent paper focuses on examining the available formulas to link the different geometric characteristics of the river meanders with discharge in the selected river reach.

II. EUPHRATES RIVER

The Euphrates river flows within three of the Middle East countries: Turkey, Syria, and Iraq. It originates in the highlands of Eastern Turkey, flows through Syria and joins the Tigris in Iraq to form the Shatt al-Arab, which discharge into the Arabian Gulf, [5].The Euphrates Basin covers about (440,000 km2) of which 49% is located in Iraq; 23% in Syria, and 28% in Turkey, [6]. The Euphrates is the longest river in Western Asia with a total length of (3,000km), of which (1,230kilometers) falls in Turkey, (710 kilometers) in Syria and (1,086 kilometers) in Iraq, [7]. Its average annual inflow, up until 1989,was (27.4BCM). However, from 1989 till 2005 the average annual inflow at the Iraqi borders dropped to (17.4 BCM), [8].

III. METHOD

Selection of the Reach Al-Abbasia reach along the middle part of the Euphrates river was selected to investigate the different geometry hydraulic characteristics. This region is approximately (6000 m) located between Latitudes (32.04°- 32.03°) and Longitudes (44.26°- 44.29°). Plate (1) shows the phenomena of meandering in the selected reach.

IV. FIELD WORK

This selected reach was divided into 21 sections to perform the field work which included measurement of the hydraulic characteristics of the river sections and longitudinal slopes of the stream and soil sampling. Plate (1) shows the selected sections.

Plate (1): The Selected Reach and Sections.

V. EQUIPMENT, AND TECHNIQUES OF THE SURVEYING

The majority of the cross sections data were measured by using Acoustic Doppler Current Profiler (ADCP). Longitudinal surveys were conducted by using level with tripod, level rod, tapes, pins, and Laptop were used to log data. For bed material analysis, standard equipment such as cans tubes cutter were used. Additional standard equipment such as computer, internet , software, GPS and GIS technique were used to collect and analysis the meandering characteristics. The Acoustic Doppler Current Profiler (ADCP) are used to measure Water Velocity and Profiles. It sending sound waves along cross section of the river which collide by particles in the bed. Then, the device calculates the difference between the frequencies emitted and received and the change in speed and this difference represents the speed of the particles in the river water, which represents the speed of water flow in rivers,[8]. Figure (1) shows the principle of operation of the device.

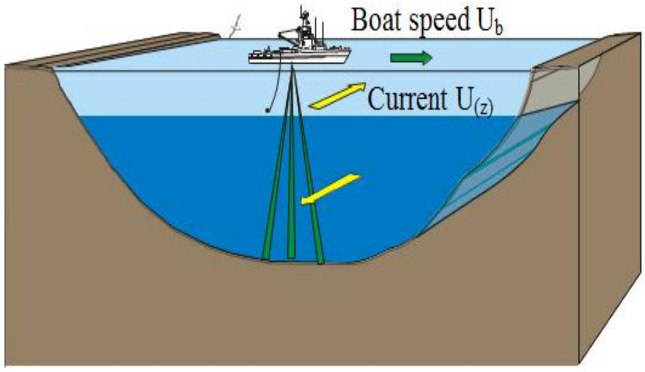

Figure (1): The Principle of Operation of The Device.

VI. RESULTS AND DISCUSSION

The cross-section survey involves of placing endpoints and a benchmark, stretching a tape, taking documentary photos, and measuring elevations. At least 20 measurements are recommended to accurately portray most channels [9]. Cross section observed at location to satisfy widely view to meander bend, straight reach between two meander bends. figures (2, 3, 4, 5 and 6) demonstrates the results of the measurement of discharge, reach width, mean depth, area mean and velocity. All of these results were obtained by using ADCP device. Figure (7) illustrates an example of measurement by ADCP (section No. 7).

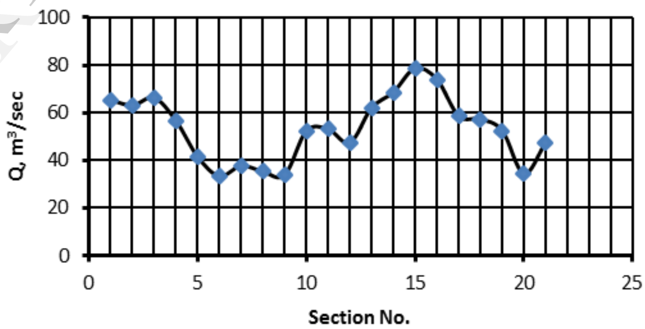

Figure (2): Results of the Discharge vs section.

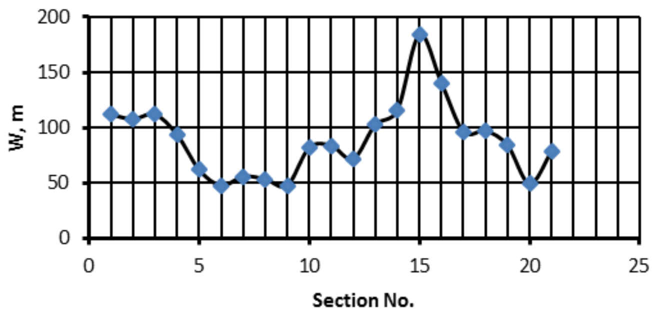

Figure (3): Results of the Reach Width vs section.

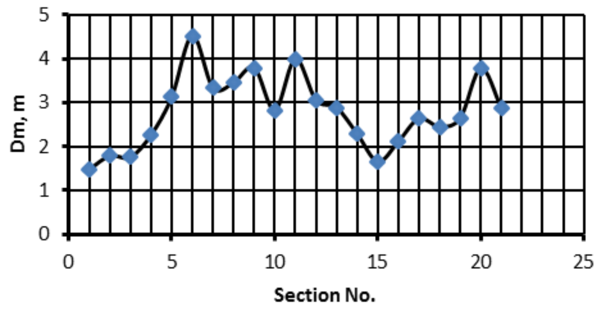

Figure (4): Results of the Mean Reach Depth vs section.

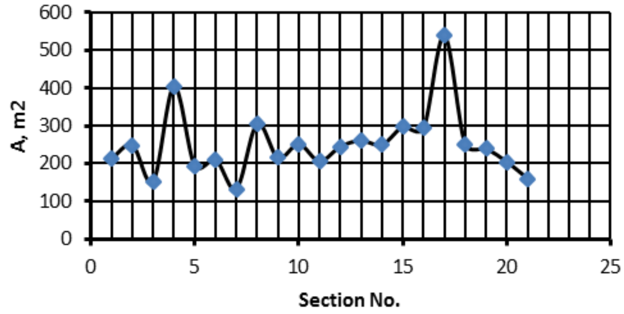

Figure (5): Results of the Sectional Area vs section.

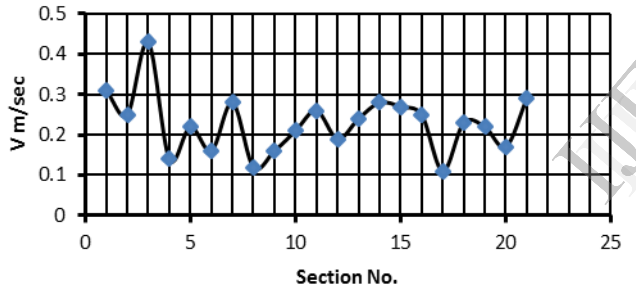

Figure (6): Results of the Velocity vs section.

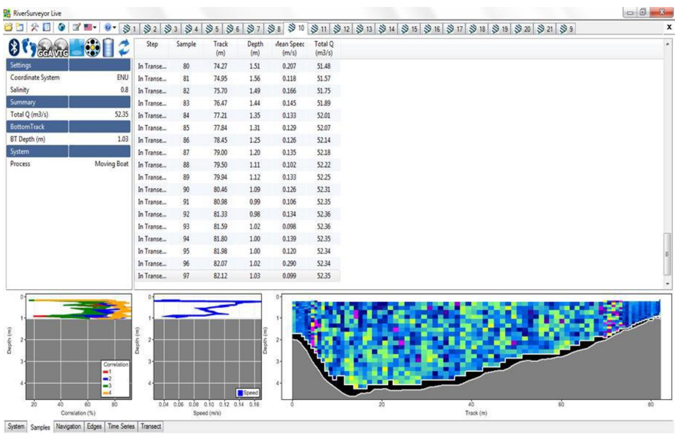

Figure (7) : Example of Measurement By ADCP

(Section No. 7).

VII. STATISTICAL ANALYSES

Hydraulic geometry relationships were developed by using parameters: area, width, mean depth, velocity and maximum depth against discharge. Twenty one sections were included in this analysis. MS Excel 2010 was used to produce new relations and compare with other relations in literature .

VIII. DATA LIMITATIONS

Table (1) lists the limitations of the different characteristics of the selected reach in Euphrates river in Al-Abbasia to perform the analysis in order to produce different models. These characteristics were including discharge (Q), velocity (V), area of cross-sections (A), width of water surface (W), mean depth (Dm), max. depth (Dmax), Main channel slopes (S), mean size of bed material (d50), specific gravity (Gs), and viscosity (v).

Table (1): Limitations of The Characteristics In Al-Abbasia Reach.

No.	Characteristics	Symbols	Limitations	Units
1	Mean Depth	D_m	1.7 –4.5	m
2	Discharge	Q	34 - 78	m^3/sec
3	Width of the river	W	48 - 184	m
4	Area of cross-sections	A	135 - 535	m^2
5	Average Flow Velocities	V	0.1 - 0.4	m/sec
6	Maximum Depth	D_{max}	2.5-9	m

Many parameters as (Ground acceleration , the density of water and others) were considered fixed within this analysis either because they are Low changes or that the change does not affect the results, therefore them fixed to facilitate the calculations and comparison. finally, steady flow assumed for analysis operations in this research.

IX. THE PREDICTED MODELS

Width - discharge model

Model (1) correlates the values of water surface width (W) with discharge (Q) which were observed through field work. This model revealed good relationship with R2 of 0.92. Figure (8) shows the results of the predicted model corresponding to the observed data.

$$W = 0.5.Q^{1.3} \quad \ldots (1)$$

Mean depth - discharge model

Model (2) correlates the values of mean depth (Dm) with discharge (Q) which were observed through field work. This model revealed good relationship with R2 of 0.87. Figure (9) shows the results of the predicted model corresponding to the observed data.

$$Dm = 99.Q\text{-}0.91 \quad \ldots (2)$$

Area - discharge model

Model (3) correlates the values of cross section area (A) with discharge (Q) which were observed through field work. This model revealed temperate relationship with R^2 of 0.52 . Figure (10) shows the results of the predicted model corresponding to the observed data.

$$A = 50.Q^{0.4} \quad \dots (3)$$

Velocity - discharge model

Model (4) correlates the values of mean velocity (V) with discharge (Q) which were observed through field work. This model revealed abstemious relationship with R^2 of 0.59 . Figure (11) shows the results of the predicted model corresponding to the observed data.

$$V = 0.02.Q^{0.61} \quad \dots (4)$$

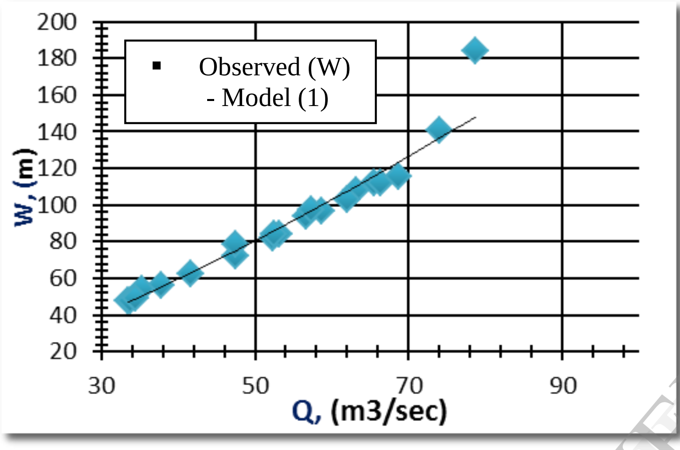

Figure (8): Results of Data Fitting, Model (1).

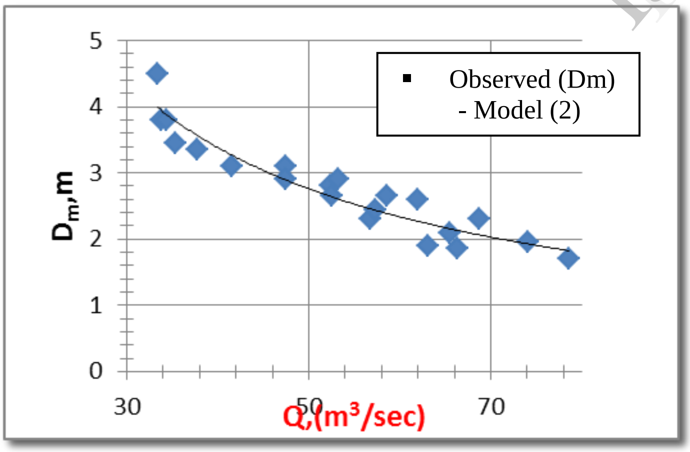

Figure (9): Results of Data Fitting, Model (2).

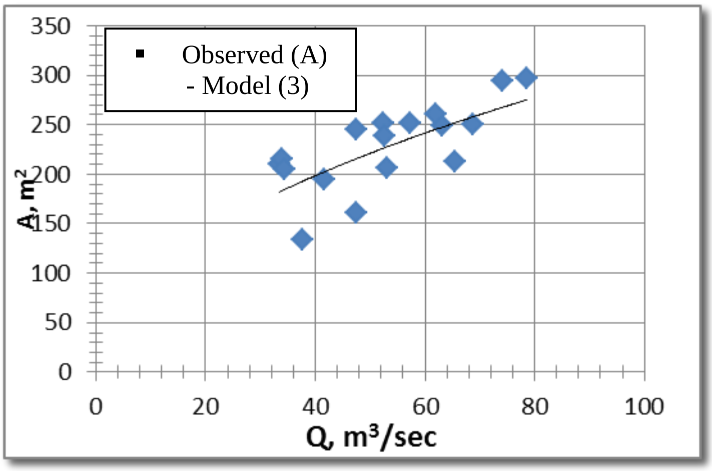

Figure (10): Results of Data Fitting, Model (3).

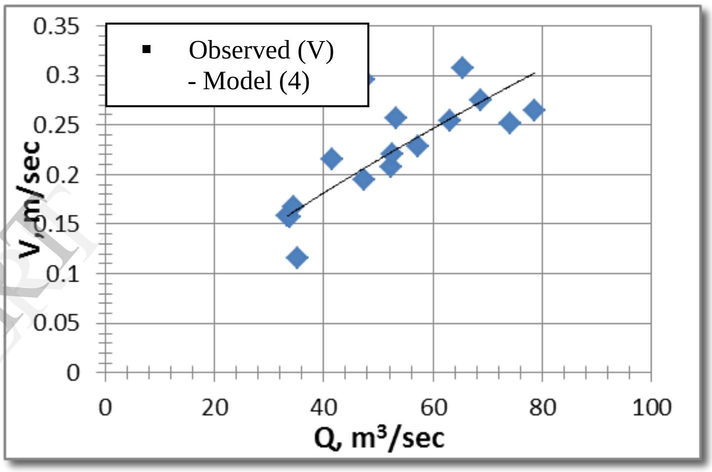

Figure (11): Results of Data Fitting, Model (4).

Figures (12, 13, 14 and 15) present the graphical comparisons of the different models with the available models in literature. One can notice that the recent predicted models are the best fit for the observed data for the Al Abbasia reach in Euphrates.

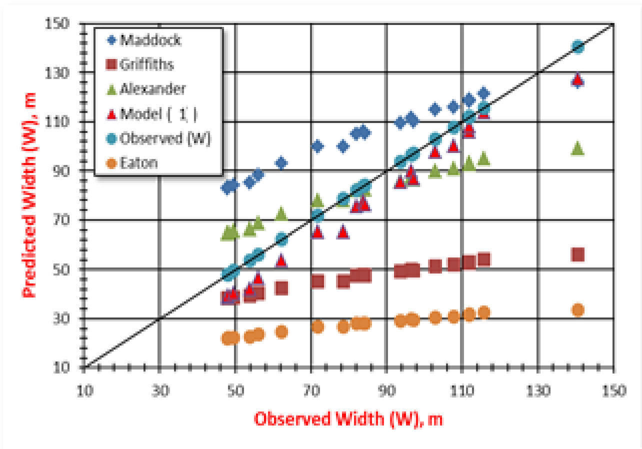

Figure (12): Graphical Comparisons of Model (1) with the Available Models in Literature.

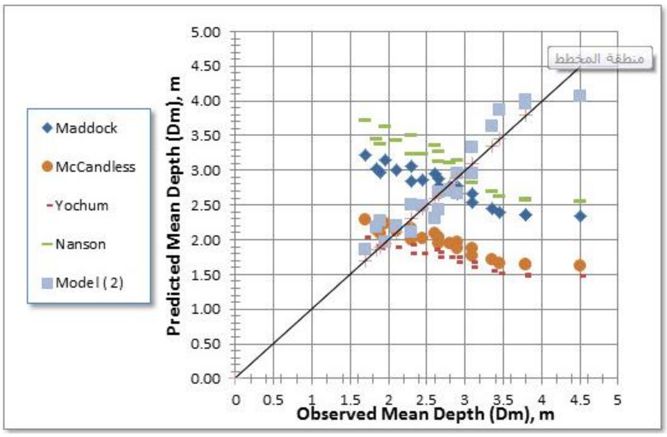

Figure (13): Graphical Comparisons of Model (2) with the Available Models in Literature.

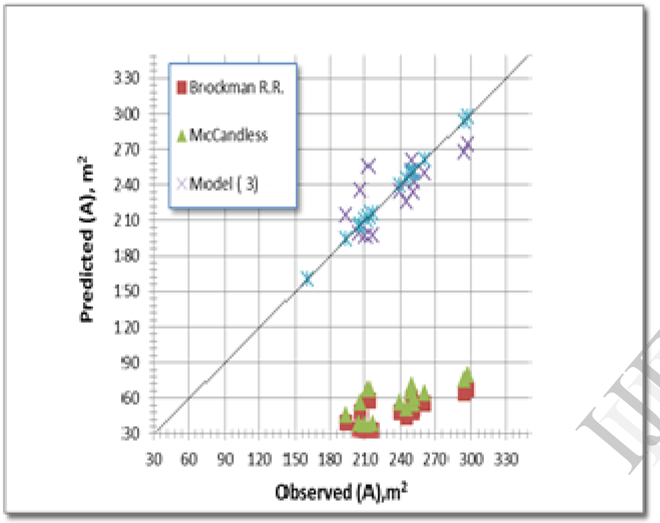

Figure (14): Graphical Comparisons of Model (3) with the Available Models in Literature.

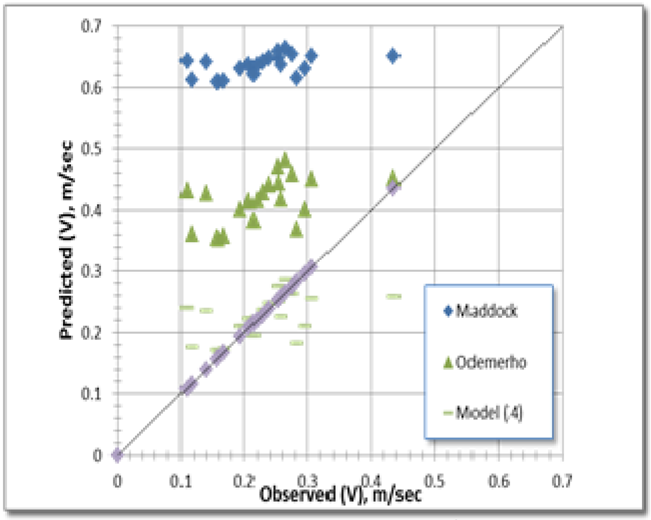

Figure (15): Graphical Comparisons of Model (4) with the Available Models in Literature.

X. Conclusions

from the recent research, we developed four available power functions models to fit the observed data in the Al Abbasia reach in Euphrates river. The recent models are more fit than the available models.

XI. Recommendations

For further research, we recommend to investigate other prediction models rather than power function

XII. Acknowledgment

The authors wish to thank the staff of Laboratory of Soil at university of Kufa / Faculty of Engineering for their help in laboratory work.

XIII. Natations

A : Area of cross-sections
Dm: Mean Depth of river
Dmax : Maximum Depth of cross-sections
Q : Discharge
V : Average Flow Velocities
W : Width of the river

REFERENCES

[1] Nalder, G., 1997. " ASPECTS OF FLOW IN MEANDERING CHANNELS" IPENZ Transactions, Vol. 24, No. 1/GEN.

[2] Kuntjoro, Bisri, M., and others., 2012. "EMPIRICAL MODEL OF RIVER MEANDERING GEOMETRY CHANGES DUE TO DISCHARGE FLUCTUATION", Journal of Basic and Applied Scientific Research 2(2)1027-1033, ISSN 2090-4304.

[3] Leopold, L. and Wolman, M. G., 1957. "RIVER CHANNEL PATTERNS: BRAIDED, MEANDERING, AND STRAIGHT" U.S. Geological Survey Professional Paper 282.B

[4] SINGH, V. P., 2003. "ON THE THEORIES OF HYDRAULIC GEOMETRY", International Journal of Sediment Research, Vol. 18, No. 3, pp. 196-218.

[5] AL-Bahrani, H.Sh., 2012. "A SATELLITE IMAGE MODEL FOR PREDICTING WATER QUALITY INDEX OF EUPHRATES RIVER IN IRAQ" . Ph.D. Thesis, Environmental Engineering Department, University of Baghdad, Baghdad, Iraq.

[6] UN-ESCWA,2013a. (United Nations Economic and Social Commission for Western Asia). "EUPHRATES RIVER BASIN". Inventory of Shared Water Resources in Western Asia. Beirut. Online Version.

[7] UN-ESCWA,2013b. (United Nations Economic and Social Commission for Western Asia). " SHARED TRIBUTARIES OF THE EUPHRATES RIVER ". Inventory of Shared Water Resources in Western Asia. Beirut. Online Version.

[8] MOWR, 2011. Ministry of Water Resources / the National Center for Water Resources Management / Course discharge monitoring (using a device ADCP / M9 .

[9] Harrelson, C., 1994" STREAM CHANNEL REFERENCE SITES: ANILLUSTRATED GUIDE TO FIELD TECHNIQUE" USDA Forest Service General Technical Report RM-245.