One dimensional model to study hydrodynamics properties for north part of Shatt Al Arab River (south Iraq)

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ABSTRACT

Mike 11 hydrodynamic (HD) modeling is used for simulating hydrodynamic behavior of northern part of Shatt Al Arab which has 64 Km length starts from Qurna confluence (upstream river) toward Basrah city at Maqal port (downstream river). Mike 11 is river modeling system developed by Danish Hydrologic Institute, (DHI). Its performed an implicit finite difference computation of unsteady flow in rivers based on the saint Venant equations. The process of simulation has achieved in Marine Science Center, Basra University in Iraq, where the package softwere is introduced. The study area grid has created by TM Landsate Satellite image, and five of cross sections distributing along studied river part, which necessary data to make network file for simulation processes, as well as, It is open boundary type of upstream and downstream, where the discharge(Q) value at upstream is constant that equals 300 m3/s. And the time series file of water level (H) of Shatt Al Arab downstream was created with 30 days period, which started 01 /03 / 2009 to 31 /03 / 2009. The model relationship of (Q&H) appears a change zone in river discharge levels at starting the chainage (45000 m), where fluctuate between (200-400)m3/s., but as 55500 of chainage, the Discharge levels obviously is change between (2000 – 2500) m3/s. with average (50 -500)m3/s. The max. Conveyance value was 12600 m3 at 41000 m of chainage as 3312m2 of cross-section area and 3.61meter of water level. But min. Conveyance value was 7000 m3 at 64000 chainage as cross-section area equaling 2000 m2 and 2 meter of water level. Cross sections models appear asymmetrical shapes, where begin with shallow depths between (1.5-3.5m) at right bank – towards downstream-. These depths continue to mid of channel, then started the deep levels continue to end of width of cross section.

Shatt Al Arab channel is characterize with some complex hydraulic properties difficulty made for which complex conditions to create a model to it, In spite of that Mike11 model have been reflected actual results, user friendly model and feasibility to interpret it. The flexible and visible results of model are a very useful as an application that can be helpful for decision support tool for designing of large hydraulic constructions as dams, regulators, weirs or canals due to the simulation of hydrodynamic parameters and predicting of river behavior is being used in forecasting of hydrological changes at the same model in the future.

Introduction

Shatt Al Arab is a river formed from a confluence of Euphrates and Tigris rivers in Qurna city, north of Basrah Governorate. The river considers the old stage of Euphrates and Tigers, where pouring in the Arabian Gulf after that its flowing more than 190 Km from Qurna to Fao city, southern Basrah (Fig-1).

Shatt Al Arab water is mainly depended on discharges of water which supplying from Euphrates and Tigris Rivers. In the last two decades ago, it has subjected to high slow down water discharges which was coming to Shatt Al Arab. The figure (2) shows two time periods of Euphrates river discharges before and after 1973 (2594 m3/s) and (831 m^3/s) respectively (ACSAD, 2000 in UNEP, 2001). The reduction in discharge of Shatt Al Arab River is mainly due to construction projects in and out side of Iraq country. Subsequently, tidal waters from the gulf have become more influence to river water, where the salinity increases in the water e river (Al-Mansoury et al., 2007).

Mike 11 is river modeling system developed by Danish Hydrologic Institute, (HDI). The results from a MIKE 11 simulation are an easily assimilated and highly visual format, highly facilitating interpretation and analysis of potential impacts (Kjelds & Müller, 2008). The relationship between tidal water levels and the discharge is a basic phenomenon in Shatt Al Arab river because the river considers a transitional estuarine environment with tidal effects on the fluctuation of water levels of the river. Therefore modeling and predicating hydrodynamic behavior of this relation, which is Complex dynamics ecosystem, considers the mean important steps for assessment of hydraulic and water quality conditions where, the main aim of the present study is a simulation of hydrodynamic behavoir of northern part of Shatt Al Arab River by using program technique of Mike 11 hydrodynamic (HD) modeling.

Study area

The study area is the northern part of Shatt Al Arab channel from Qurna city to Basra City with a long 64000 m of distance, at about 47°30´-47º55´North and 31º10´-30º30´ East.

Available data

The north part of Shatt Al Arab has 64 Km length that starts from Qurna confluence (up stream river) toward Basrah city at Maqal port (down stream river).

The required data of model simulation file are (DHI, 2004):

Network file (ntwrk 11) : geometery of studied channel has created using network file (ntwrk 11). It deals with actual data grid, where Eastering and Northing points of study area (figure,1). So, TM Landsate Satellite image of study area was based to obtain actual coordinates grid of Network file. Satellite image at the 38 zone of southern Iraq was used. Figure (1) explains this corrected image and rearrangement it in GIS environment for preparing to export to Mike 11 Network.

- **Cross sections file** : there are (5) cross sections distributed along the northern river part have been measured during 2008 year. Then, cross sections file (xsc11) is created to input 5 sections data. It's necessary data to modeling and simulate morphological setting of river and then estimate hydraulic parameters for each 500 m. (fig.1), The accuracy of bathymetric data is directly reflected on the numerical model accuracy.

The boundary conditions file (bnd 11). It is open boundary type of upstream and downstream. At upstream the discharge value is constant that equals 300 m^3/s. A time series file of water level of Shatt Al Arab downstream was created with 30 days period, which started on 01 / 03 / 2009 to 31 /03 / 2009.

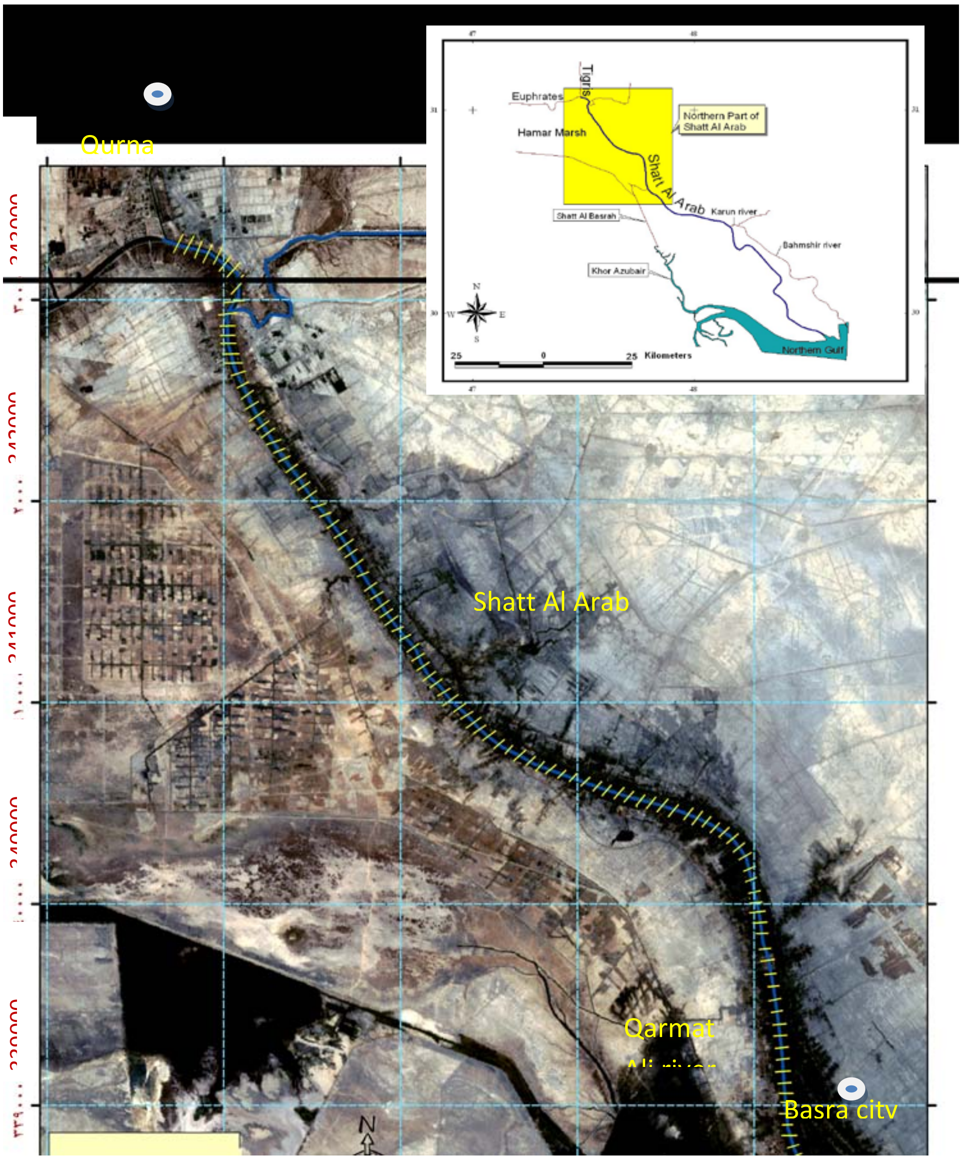

Figure (1) Map of northern part of Shatt Al Arab (studied segment).

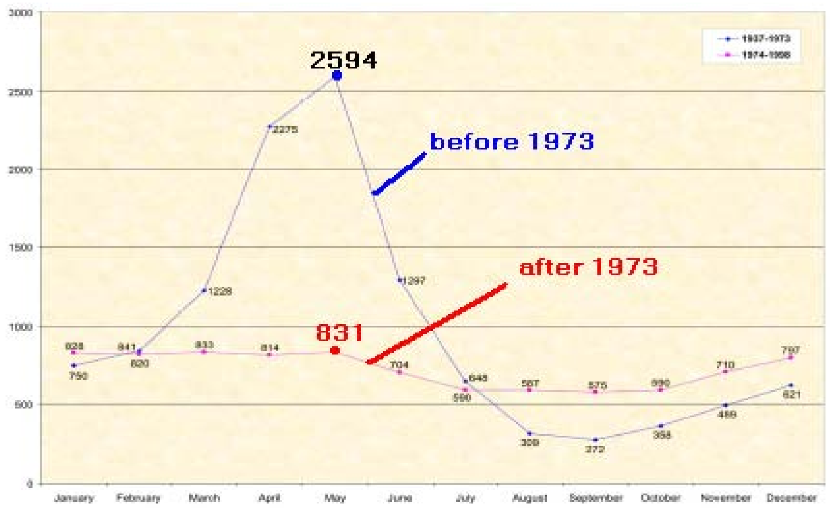

Figure (2) the discharge regime for the Euphrates river before and after 1973 periods (ACSAD, 2000 in UNEP, 2001).

MODEL DESCRIPTION

The hydrodynamic model is a one dimensional modeling system performing an implicit finite difference computation of unsteady flow in rivers based on the saint Venant equations (DHI, 2004; DHI, 2007).

Figure (3) shows the geometry shape of northern part of Shatt Al Arab. This segment was selected to simulate the hydrodynamic behavior of the river according to available data.

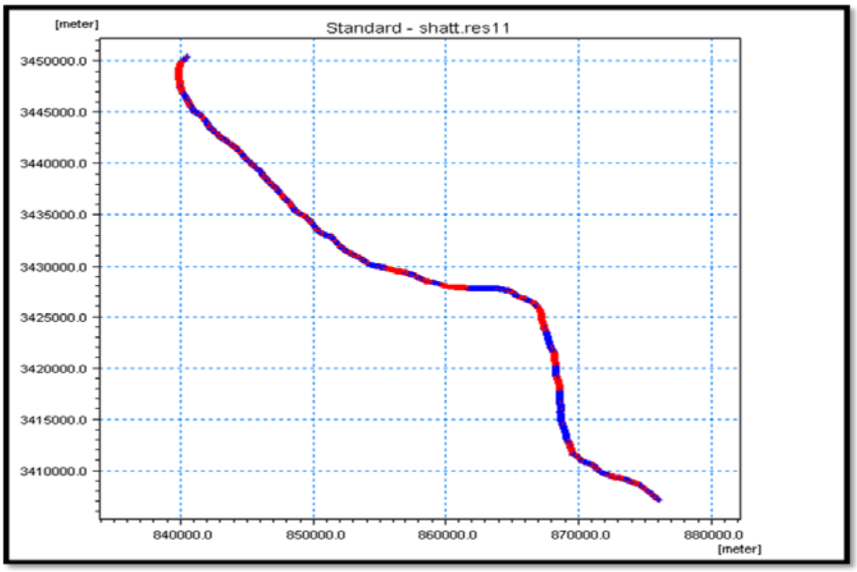

Figure (3) grid shape of northern part of Shatt Al Arab with actual coordinates lines.

The process of simulation has achieved in Marine Science Center, Basra university in Iraq, where the package software is introduced.

The word " chainage " is mean a release distance from upstream point (0.00 meter) to any point on a segment of the River by meter unit, where the initial point is considered as (zero meter) of distance at upstream.

RESULTS & DISCUSSION

The model begins from upstream at chainage 0.00 m (distance) and finish to downstream at (chainage 64000 m). Along this distance (64 Km) and during 30 days from time series of water level readings the hydrodynamic conditions were simulated. Figure (4- A, B, C, D, E) represent five important sites on the river could be reflected the variations, resulting from the interaction of influence between the discharge (Q) and water level (H), where : (A) the site at (0.0m) of chainage, (Qurna city) where no existence of water level influence, while it appears the tidal effect after chainage (55500 m), e.g. after confluence Shatt Al -Arab with Qarmat Ali river toward downstream. The model relationship of (Q&H) in figure (5) appears a change zone in river discharge levels at starting the chainage (45000 m), where the discharge fluctuates between (200-400)m3/s., but as chainage (55500m), the discharge levels obviously is change between (2000 – 2500) m3/s. The extremely of this range no due to the increase coming from the river but entrance of tidal water mass during flood period and it withdrawal at ebb period, anyway those the increase is no reflect realistic behavior of the river but it represents a condition extremely at limited short time series was rarely frequent as shown in Figure (4) at time 11/3/2009. The confluence zone Shatt Al Arab and Qarmat Ali Rivers largely slowdown the tide effect on fluctuation of water levels, so, it observed clearly very little fluctuation towards upstream after chainage (55,500 m), as well, (Al Badran, 2002) mentioned existence influence of confluence zone on the hydrological behavior of Shatt Al Arab by the sedimentation and erosion processes of the river. It can be performed relationship between water levels and the discharge a long the river (0.0 m – 64000 m) of chainges as shown in figure (7).

Regarding to one-dimensional numerical models along of channel, the bathymetric information is required in the form of cross-sections of the river segment within the model domain. The results of cross sections models at (500m, 54000, 55500, 64000 m of chainages) in Shatt Al Arab are explained in Figures (9A, 9B, 9C, 9D). Also, are found out to the figures show models of water levels ranges at selected cross sections during simulation period, (30) days.

Table (1) shows some processing hydrodynamic parameters, which have been simulated at each section model along the channel profile. It's estimated at each 1000m towards downstream to 64000 m of chainage.

The Conveyance is one of important hydraulic parameters which is consider an important function of Hydraulic capacity of the cross-section varies with the water level. Conveyance is equal ($r_f AR^{2/3}$) at selected water levels (DHI, 2007), where:

r_f: the resistance factor
A: cross-section area, m^2.
R: hydraulic Radius, m.

Figure (10) explains the relation between the Hydraulic capacity (Conveyance) with water level and the section area. Also, the variation of Conveyance along channel profile is represented in figure (11). The max. Conveyance value was 12600 m^3 at 41000 m of chainage as 3312m^2 of cross-section area at 3.61meter of water level. But min. Conveyance value was 7000 m^3 at 64000 chainage as cross-section area equaling 2000 m^2 and 2 meter of water level.

Generally, figures of cross sections models appear asymmetrical shapes, where begin with shallow depths between (1.5-3.5m) at left bank – towards downstream-. These depths continue to mid of channel, then started the deep levels continue to end of width of cross section.

Shatt Al Arab channel is characterize with some complex hydraulic properties difficulty make for which complex conditions to create an actual model to it, In spite of that Mike11 model have been reflected actual results, it's user friendly model and feasibility to interpret the results. The flexible and visible results of model are a very useful as an application that can be helpful for decision support tool for designing of large hydraulic constructions as dams, or canals due to the simulation and predicting of river behavior is being used in forecasting of hydrological changes at the same model in the future.

As well, Present results is consider main step to establish advanced steps for simulating another conditions relating with water quality and management planning of Shatt Al Arab water, as well as, establishment of monitoring program of hydrological conditions and their changes with benefits to all governmental and nongovernmental directions. It's concluded that Shatt Al Arab river needs to Mike 11 system for establishing long term monitoring program of hydrological parameters continuously in future. Also, present study is a useful as an basic project that can be used for adopting decisions of building a large hydraulic constructions and selective suitable locations on the river and then detection their environment impact.

REFRENCES

ACSAD (2000); " Surface water resources in Euphrates and Tigris rivers basins. Damascus.

Albadran, B., F. Y. Al-Mansory & N. K. Al-Bahily. (2002); " Erosion and sedimentation processes in the shat Al-Arab river, south of Iraq". Marina Mesopotamica, 17(2): 285-292).

Al-Mansoury, H. B., Wissam R. M., M. S. Hamady & Muhsen M. (2007); " Influence of Shatt Al Arab tidal upon the water of Hor Al-Hammar", Scientific Thi-Qar journal, Thi-Qar University.

DHI-water & environment, (2004); " Mike 11 a modeling system for rivers & channels, user guide of software". www.dhigroup.com.

DHI-water & environment, (2007); " Mike 11 a modeling system for rivers & channels, short introduction tutorial". www.dhigroup.com.

UNEP (2001); " Mesopotamian Marshlands, full report. http: www.grid.unep.ch/activites/sustainable/Tigris/marshlands.

Kjelds T . Jesper and Henrik G. Müller (2008);" Integrated Flood Plain & Disaster Management using the MIKE 11 Decision Support System", , Danish Hydraulic Institute, Agern Alle 5, DK-2970 Hørsholm, Denmark.

نموذج أحادي البعد لدراسة الخصائص الهيدروديناميكية للجزء الشمالي من شط العرب – جنوب العراق

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المستخلص

استخدمت النمذجة الهيدروديناميكية لبرنامج الـMike 11 لمحاكاة السلوك الهيدروديناميكي للجزء الشمالي من شط العرب الذي يبلغ طوله 64 كم ابتداءا من منطقة الالتقاء في مدينة القرنة والى ميناء المعقل في مدينة البصرة. يعد برنامج الـ Mike11 والمطور من قبل المعهد الهيدرولجي الدنماركي نظام نمذجة للقنوات والانهار والذي يعتمد على حل المعادلات التفاضلية الجزئية الضمنية للجريان الغير مستقر في الانهار على معادلات ساينت فينانت. انجزت عملية المحاكاة بأستخدام برنامج الـ Mike11 الموجود في مركز علوم البحار جامعة البصرة. كذلك استخدام المرئية الفضائية المصححة من القمر Landsat كأساس يحتاجها البرنامج لانشاء شبكة منطقة الدراسة ضمن الاحداثيات الحقيقية للارض، كما تم ادخال بيانات لخمس مقاطع عرضية، فضلا عن الشروط الحدودية التي كانت من النوع المفتوح عند نهايتي النهر، حيث افترضت قيمة التصريف ثابتة عند نقطة بداية النهر Upstream والتي كانت تساوي 300 متر3/ثا، واما عند نهاية النهر Downstream فقد انشئ ملف السلسة الزمنية لتذبذب مستوى ماء النهر حيث كانت فترة المحاكاة 30 يوما بدأت من 1أذار 2009 ولحد 30 أذار 2009. تظهر العلاقة بين التصريف النهري ومستوى الماء water level (H) بوجود نطاق تغير في مستويات التصريف عند المسافة 45000 متر من نقطة الانطلاق (0.0 متر) أي في موقع القرنة، حيث يتذبذب بين 2000-2500 متر مكعب بالثانية وبمعدل 50-500 متر مكعب بالثانية. اما السعة الهيدروليكية العظمى Conveyance فكانت 12600 متر مكعب عند المسافة 41000 متر عند مساحة مقطع 3312 متر مربع ومستوى ماء 61.3 متر. بينما السعة الهيدروليكية الدنيا كانت 7000 متر مكعب عند 64000 متر مكعب عند مساحة مقطع تساوي 2000 متر مربع ومستوى ماء 2 متر. اما موديل المقاطع العرضية التي تم محاكاتها فتظهر اشكال غير متناظرة تبدأ بأعماق ضحلة عند الضفة اليسرى، وتستمر الى منتصف مقطع القناة حيث بعدها تبدأ بالزيادة في الاعماق الى نهاية عرض القناة.

تتميز قناة شط العرب بخصائص هيدروليكية معقدة تجعل من الصعوبة محاكاة ظروفها الهيدروليكية، فبالرغم من ذلك فقد عكست نتائج المحاكاة للموديل المصمم للقناة بأستخدام تقنية برنامج الـ Mike 11 واقعية تميزت بسهولة عرضها والتعامل معها وعملية الربط بين المتغيرات الهيدروليكية، بالاضافة الى سهولة عرض البيانات بشكل مرئي للتغيرات الوقتية للمتغيرات الهيدروليكية طيلة فترة المحاكاة والذي يساعد كوسيلة فعالة وجيدة لاتخاذ القرارات وحلول تساعد في تصميم المنشأت الهيدروليكية والتنبأ بالسلوك النهري لذلك في نفس الموديل الحالي المصمم للقناة في المستقبل.

Table (1) some processed hydrodynamic parameter results of the north part of Shatt Al Arab.

Chainage (m)	Level	Cross-section Area	Radius	Storage width	conveyance
1000	4.671	3029.155	5.506	618.929	9444.699
2000	4.643	3033.011	5.539	617.857	9494.438
3000	4.614	3036.972	5.572	616.786	9545.409
4000	4.586	3041.037	5.607	615.714	9597.613
5000	4.557	3045.207	5.642	614.643	9651.048
6000	4.529	3049.482	5.678	613.571	9705.717
7000	4.5	3053.862	5.715	612.5	9761.617
8000	4.471	3058.346	5.752	611.429	9818.75
9000	4.443	3062.935	5.791	610.357	9877.114
10000	4.414	3067.629	5.83	609.286	9936.711
11000	4.386	3072.428	5.87	608.214	9997.54
12000	4.357	3077.331	5.91	607.143	10059.602
13000	4.329	3082.339	5.952	606.071	10122.897
14000	4.329	3082.339	5.952	606.071	10122.897
15000	4.271	3092.67	6.037	603.929	10253.19
16000	4.243	3097.992	6.08	602.857	10320.188
17000	4.214	3103.42	6.124	601.786	10388.422
18000	4.214	3103.42	6.124	601.786	10388.422
19000	4.157	3114.588	6.215	599.643	10528.599
20000	4.129	3120.33	6.262	598.571	10600.544
21000	4.1	3126.176	6.309	597.5	10673.728
22000	4.071	3132.127	6.357	596.429	10748.152
23000	4.043	3138.183	6.406	595.357	10823.817
24000	4.014	3144.343	6.455	594.286	10900.724
25000	3.986	3150.609	6.505	593.214	10978.875
26000	3.957	3156.979	6.556	592.143	11058.272
27000	3.929	3163.453	6.607	591.071	11138.915
28000	3.9	3170.033	6.659	590	11220.806
29000	3.871	3176.717	6.712	588.929	11303.949
30000	3.843	3183.506	6.766	587.857	11388.344
31000	3.814	3190.4	6.82	586.786	11473.995
32000	3.786	3197.399	6.875	585.714	11560.904
33000	3.757	3204.502	6.931	584.643	11649.074
34000	3.729	3211.71	6.987	583.571	11738.511
35000	3.7	3219.023	7.044	582.5	11829.218
36000	3.671	3226.44	7.102	581.429	11921.201
37000	3.648	3236.726	7.164	580.357	12028.307
38000	3.638	3255.382	7.236	579.286	12178.289
39000	3.629	3274.102	7.308	578.214	12329.681
40000	3.619	3292.886	7.381	577.143	12482.488
41000	3.61	3311.734	7.454	576.071	12636.719
43000	3.569	3277.15	7.536	559.385	12596.875
44000	3.538	3219.61	7.554	543.769	12395.735
45000	3.508	3158.026	7.58	528.154	12186.373
46000	3.477	3092.398	7.612	512.538	11966.553
47000	3.446	3022.725	7.649	496.923	11734.256
48000	3.415	2949.009	7.688	481.308	11487.621
49000	3.385	2871.248	7.73	465.692	11224.915
50000	3.354	2789.443	7.772	450.077	10944.502
51000	3.323	2703.594	7.813	434.462	10644.834
52000	3.292	2613.701	7.851	418.846	10324.43
53000	3.262	2519.764	7.885	403.231	9981.875
54000	3.231	2421.783	7.912	387.615	9615.809
56000	3.067	2278.216	7.847	359.144	8996.458
57000	2.933	2232.657	7.781	346.289	8766.604
58000	2.8	2183.081	7.728	333.433	8533.522
59000	2.667	2129.487	7.689	320.578	8295.525
60000	2.533	2071.876	7.66	307.722	8051.048
61000	2.4	2010.247	7.641	294.867	7798.627
62000	2.267	1944.601	7.63	282.011	7536.881
63000	2.133	1874.937	7.627	269.156	7264.506
64000	2	1801.256	7.629	256.3	6980.261

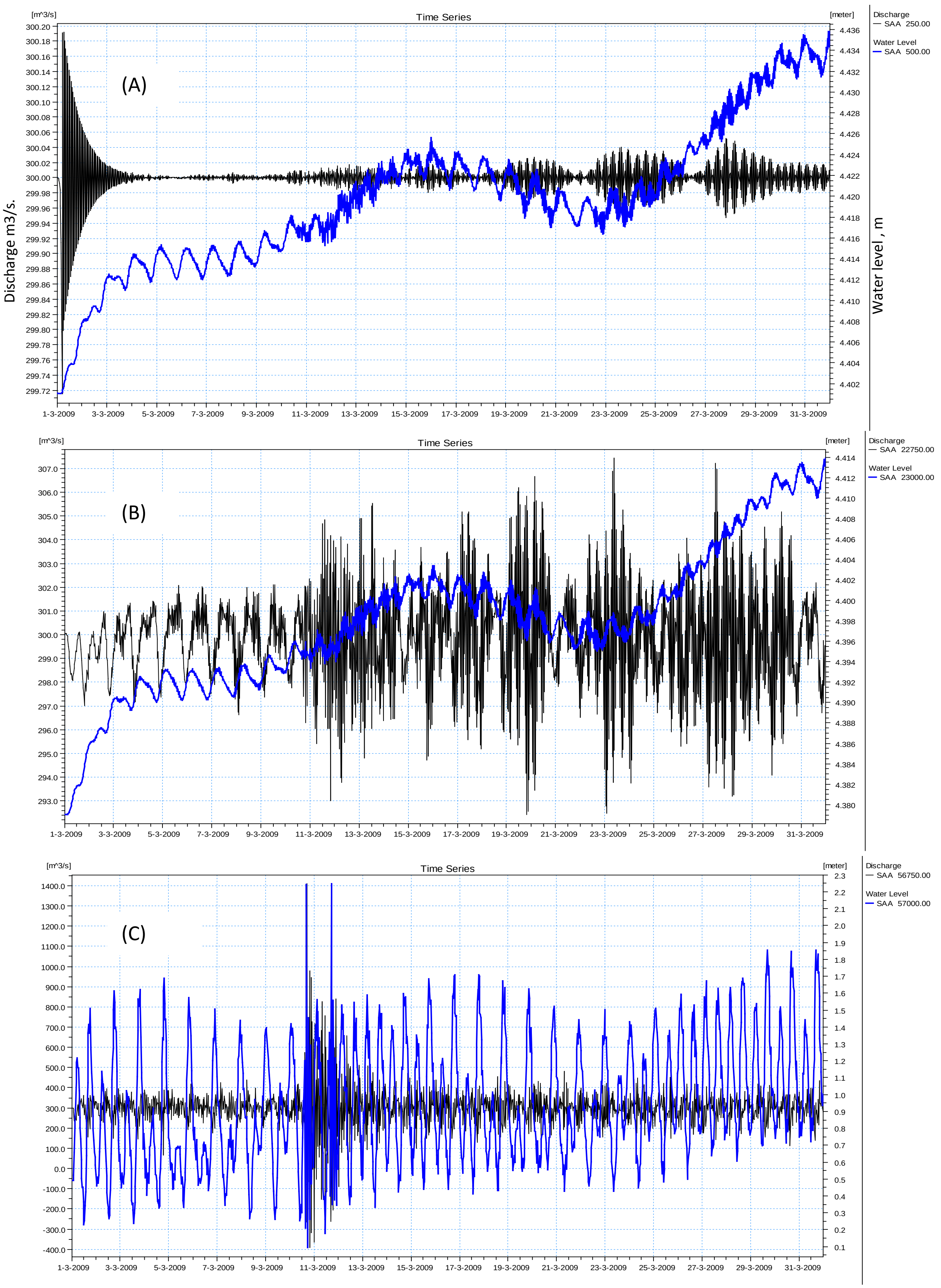

Figure (4) relation between discharge (Q) (black line) & water level (H) (blue line) at (A:500 m Chainage, B: 22000m chainage , C: 52000m chainage, D: 57000, E:64000m

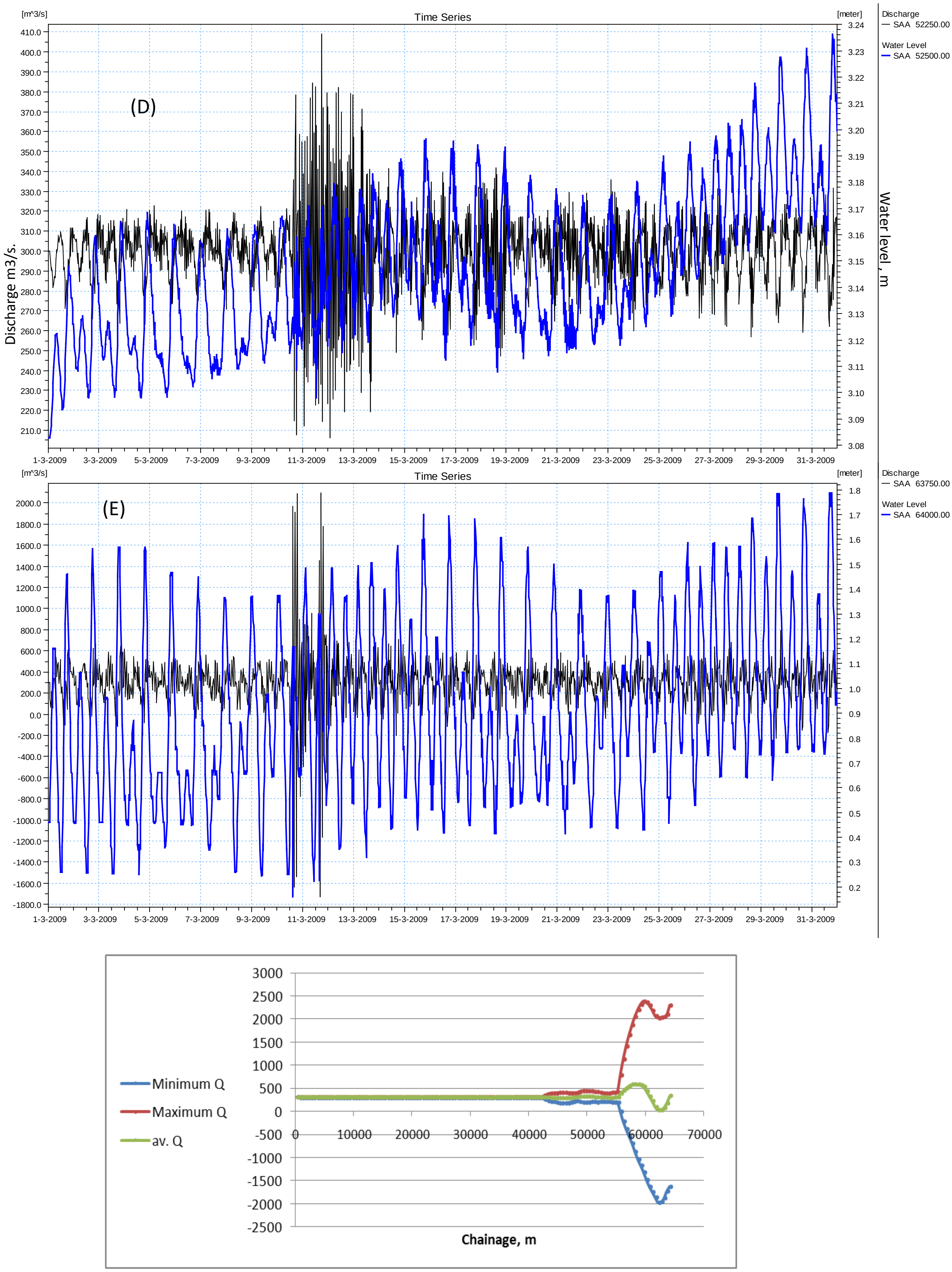

Figure (5) Discharge (m3/sec.) of the northern part of Shatt Al Arab

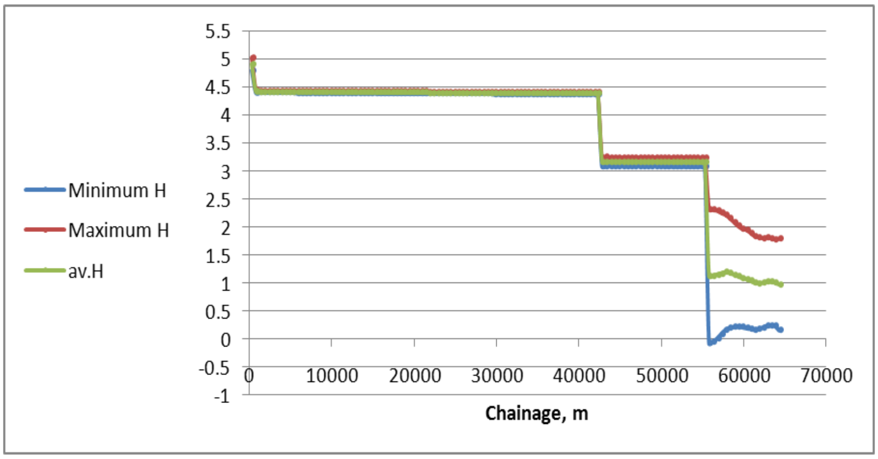

Figure (6) water level (m) of the northern part of Shatt Al Arab

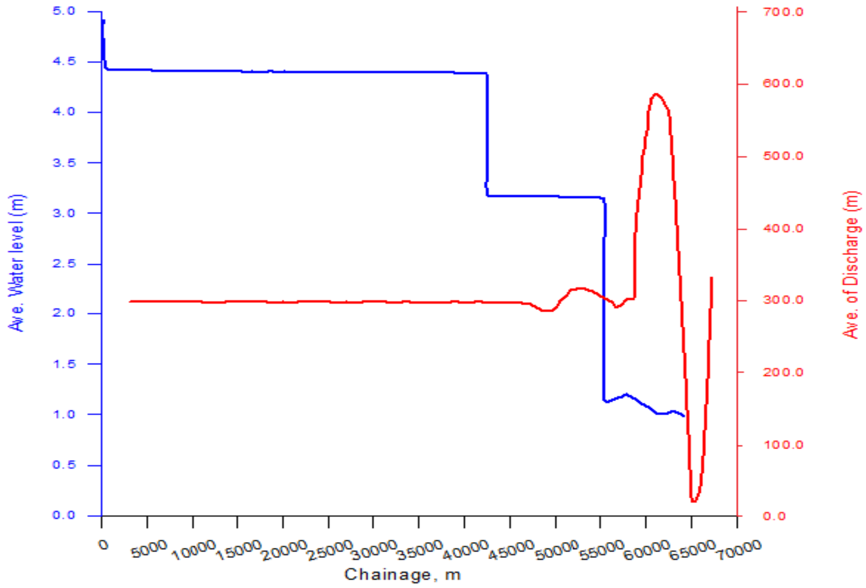

Figure (7) water level (H) and Discharge relationships of the northern part of Shatt Al Arab

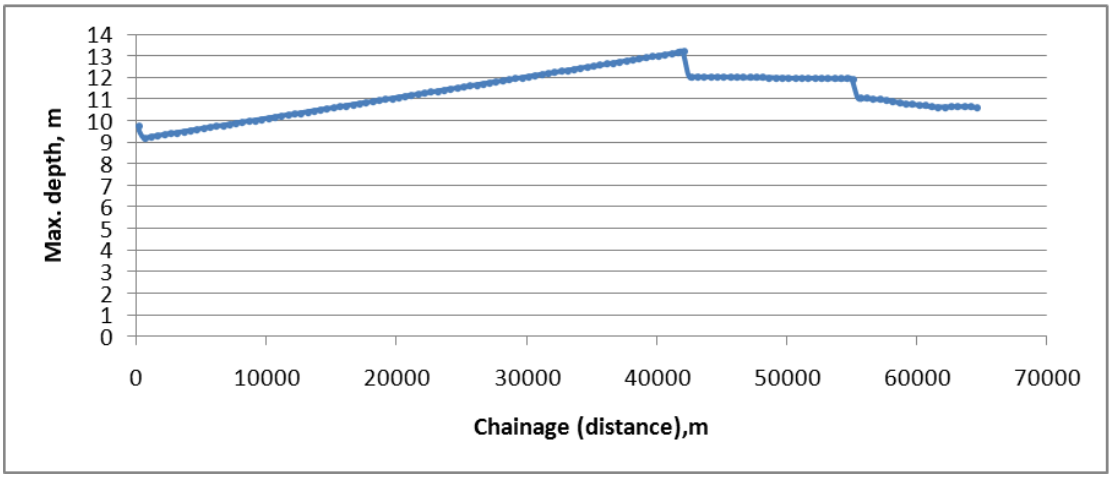

Figure (8) Max. of depth of the northern part of Shatt Al Arab

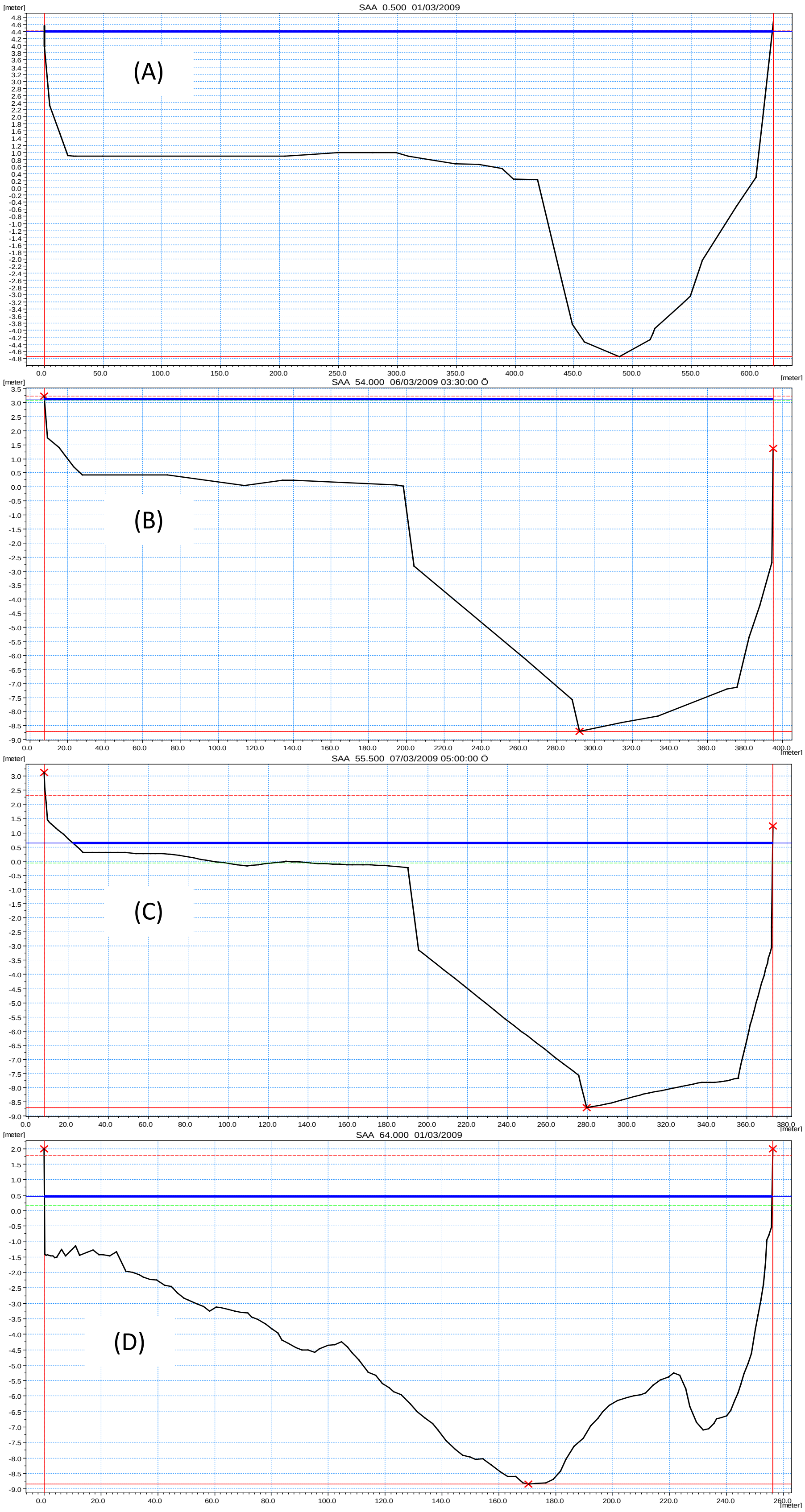

Figure (9) Sections models at (A): 500m, (B): 54000 m, (C) 55500m (D) : 64000 m of chainges,

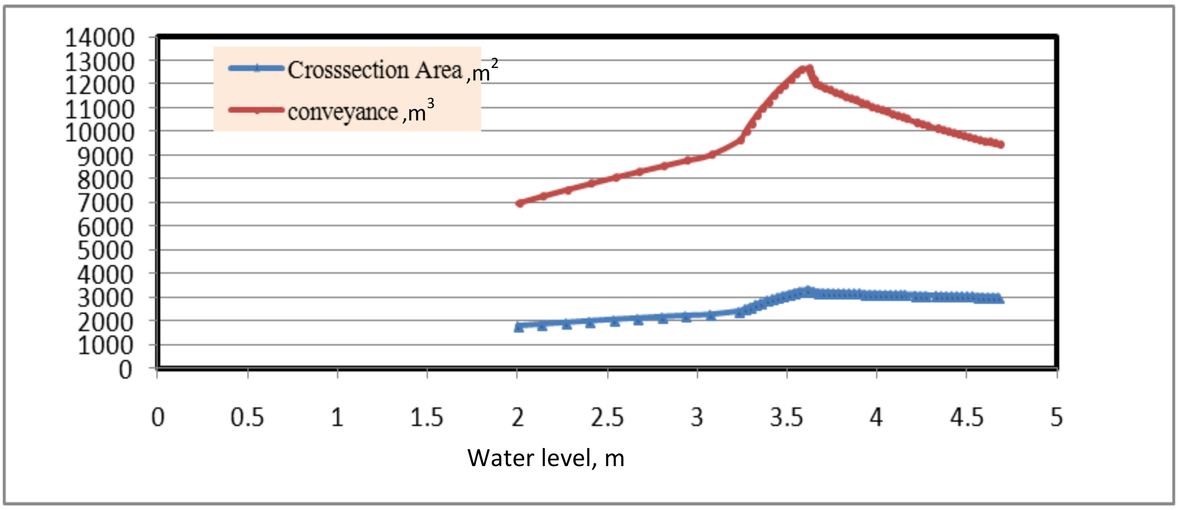

Figure (10) relations among water levels with sections area and Conveyance

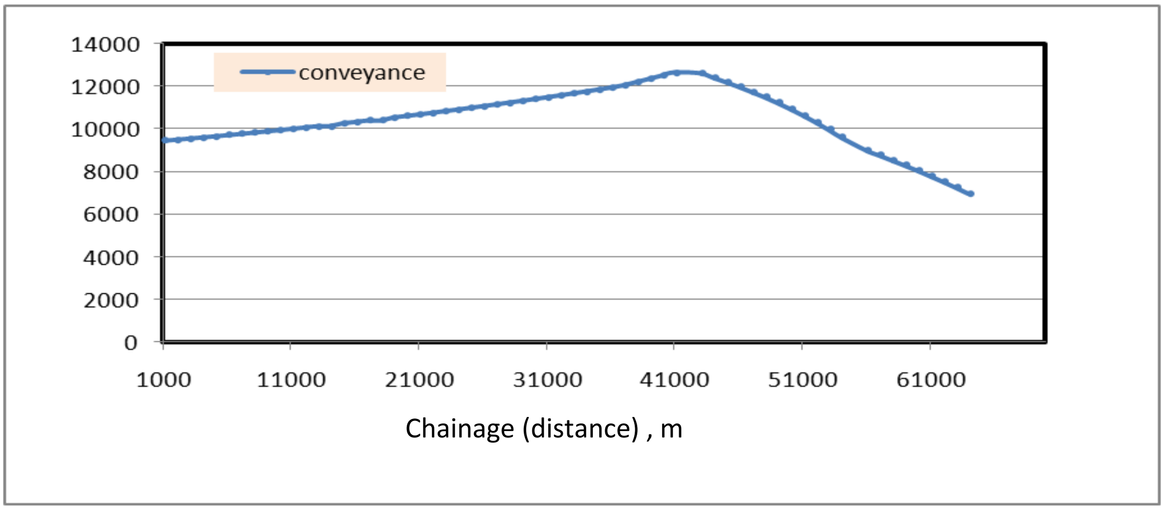

Figure (11) Conveyance curve of the north part of Shatt Al Arab.