Improving Inland Navigation in Damietta Branch

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Abstract

Since the Nile River and its branched streams were formally assigned for irrigation and water supply, development of the waterway transport system becomes necessary for future. Improvements of the inland navigation system in Egypt to fulfill the required safety measures are being considered as an important factor for the waterway transport development. Inland navigation is the safest, cheapest, tourist attractive and the most environment friendly means. Waterway transport system depends mainly on the water depths of the river. This implies that it depends upon the morphological characteristics of the river and the water flow releases, which varies seasonally during the year.

A large project for the Damietta branch rehabilitation started since 1999 in Egypt. As a part of this project, a hydrographic survey was conducted for designing the waterway starting from Delta barrages and up to the Mediterranean Sea. In addition to dredging activities for fixing the low water channel to maintain the safe navigation depth at low water stage. The capital dredging for the entire branch was completed by the end of the year 2005.

A navigation problem represented by a drop in the design water level is reported downstream Zefta Barrage which threaten the satisfaction of 2.3 m water depth during the low water level seasons. The drop in the water level is evident as a result of dredging activities. The general objective of this study focused on improving the navigation conditions during minimum discharges by using spur dikes . Spur dikes are the most common river training works used to regulate rivers as they proved different functions all over the world. They have been recognized as hydraulic structures extending outward from the bank of stream for the purpose of deflecting or attracting the flow.

A one dimensional mathematical model (SOBEK) was used to study the reach from DS Zefta Barrage at km 93.5 to km 227.45 at Faraskour dam. A minimum discharge of 4.0 Million m3/day is used as a critical discharge to represent the navigation bottlneckes. Spur dikes are represented with different lengths according to the intensity of bottlneckes along the navigation reach. The sobek model was used to simulate nine scenarios to be proposed as different solutions. The study concluded that the spur dikes construction has resulted solving navigation bottlneckes where it provided an increase in the water levelwhich can be accepted for safe navigation.

The minimum discharge which should be released DS Zefta Barrage should not be less than nine Million m^3/day if it is not conflicting with irrigation requirements during this period of the year.Specific type of ships with less draft can be used during the minimum flow period.

Keywords**:** Navigation, bottlenecks, Dammietta, mathematical model

1. INTRODUCTION

Modern Egypt irrigation strategy has started by building the infrastructure of the irrigation and drainage network two centuries ago as a hard ware of the system. Now the existing strategy, which is a continuation of the previous one, is more of software development to improve the efficiency and the performance of the system to meet the increasing demands on the River Nile due to the increase in population and the increased demand on water uses. One of the software developments of the River Nile is the navigation system. Nile is now used as a waterway for both cargo and people. Ultimate development of the river for navigation requires enough depth for safe navigation of the ships having biggest draft along the course of Whole River. (M. Abu Zeid and A. Saleh, (2001)).

A large project for the Damietta branch rehabilitation started since 1999. As part of this project, a hydrographic survey was conducted for designing the waterway starting from Delta Barrages and up to the Mediterranean Sea. In addition to dredging activities for fixing the low water channel to maintain a depth of 2.3 m at low water stage.

The capital dredging for the entire branch was completed by the end of the year 2005.Anavigation hazard represented by a drop in the water level was evident in 2006 after the dredging works. The drop of water level was threatening the satisfaction of 2.3m water depth in some days within the year .This was attributed that the channel carrying capacity was increased after the dredging process. (K. Attia and A. Fahmy,(2006))

This study focused on the main navigation problems in Damietta branch for better understanding of main navigation hazard, which is the drop of water surface level downstream Zefta Barrage. In this study, this hazard problem was identified and a set of proposed different solution scenarios were investigated to solve the navigation bottlenecks in Damietta branch. Spur dikes as channel regyaltion works are introduced to be one of the prposed solutions to overcome navigation hazards.A spur dike can be defined as an elongated obstruction having one end on the bank of a stream and the other end projecting into the current. It may be permeable, allowing water to pass through it at a reduced velocity; or it may be impermeable, completely blocking the current.(Brown (1985))

2. METHODOLOGY

2.1 Data Collection

At a distance of 30 km north of Cairo, The River Nile segregates into two branches, Damietta and Rossetta. They are both discharge into the Mediterranean Sea. Both branches are used mainly for irrigation purposes however, rehabilitation work was undertaken in Damietta branch by the River Transport Authority (RTA) since 1999 to realize safe and reliable waterway between Cairo and the Mediterranean Egyptian Sea ports.Damietta branch is expected to play an important role in increasing the volume of cargo transported over water. It is considered the future cargo corridor between Cairo and Mediterranean Egyptian Sea ports, Damietta and Port Said.

Hydraulics Research Institute "HRI", National Water Research Center "NWRC" conducted a hydrographic field surveyfor the purpose of designing the navigation waterway. Data for bed slope and velocity measurements were used from survey 2005. The hydraulic investigation was conducted to study the reach and collect the required data to determine the flow discharges and the corresponding water surface levels. Daily monitoring of the released discharges was executed at the hydraulic structures (downstream the barrages, and at the location of gauge stations). The available hydraulic data were accumulated. Minimum and maximum discharges for the years from 1985 to 2012 downstream Zefta Barrage are presented in Table (1). Discharges DS Zefta Barrage ranged between a maximum value of 22 Million m3/day in 2007 and the minimum value of 0.2 Million m3/day in 1985. Figure (1) shows the maximum and minimum discharges downstream Zefta Barrage. Adischarge of 4.0 Million m3/day was chosen as acritical discharge to represent in this study after the construction of El-Salam canal in 2005.

Table 1: Discharges DS Zefta Barrage from 1985 to 2012

Year	Min. Q (Mm^3/d)	Max. Q Mm^3/d	Year	Min. Q (Mm^3/d)	Max. Q (Mm^3/d)
1985	0.2	9.60	1999	2.85	14.95
1986	0.2	12.52	2000	3.25	14.2
1987	0.6	12.38	2001	3.05	20
1988	0.3	11.45	2002	2.5	20
1989	1.05	11.45	2003	1.65	15.30
1990	1.4	13.80	2004	3.5	22
1991	1.05	11.45	2005	4	15.25
1992	1	10.70	2006	4.8	18.85
1993	1	12.03	2007	5.5	22
1994	0.3	11.45	2008	5.5	22.05
1995	1.4	11.90	2009	4.5	18.05
1996	0.5	9.30	2010	5.05	16.15
1997	2.5	11.40	2011	5.05	18.5
1998	0.9	17	2012	4.8	16.15

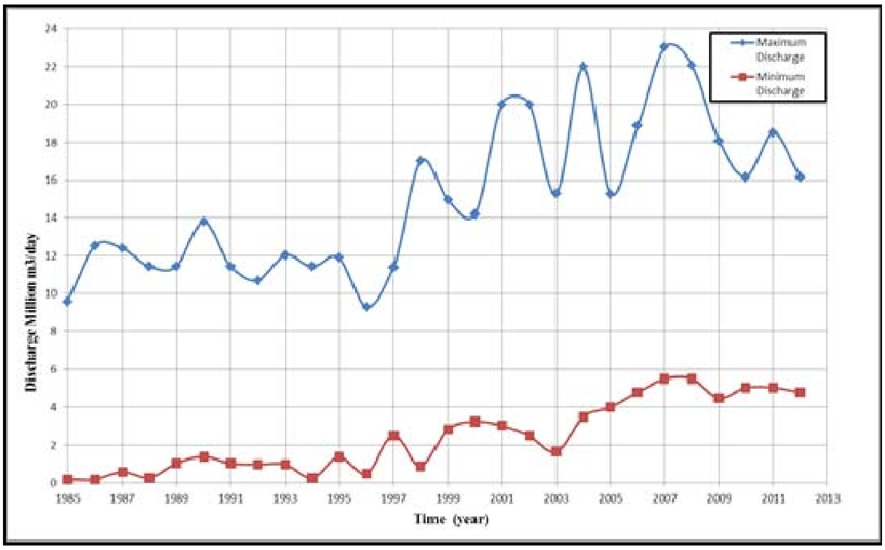

Figure 1: Maximum and Minimum Discharges DS Zefta Barrage

2.2 Mathematical Model

SOBEK is a one-dimensional model that can simulate the flow and water quality in river, and estuary systems. It was developed by "WL | Delft Hydraulics" in partnership with the "National Dutch Institute of Inland Water Management and Wastewater Treatment" (RIZA).The model is used to simulate water surface profile for the study area. It calculates (easily, accurately and fast) the flow in simple or complex channel networks, consisting of thousands of reaches, cross sections and structures.

The SOBEK-Flow-module uses the Chézy bed friction value in solving the water flow equations. The Chézy coefficient, C is computed as a function of Manning's roughness coefficient, nm:

$$C = \frac{R^{1/6}}{n_m} \tag{1}$$

The SOBEK model was used in the present study to simulate Damietta branch Figure (2) shows the simulated reach. The study reach was selected in such a way to identify navigation bottlenecks which occurred due to insufficient water depth available for safe navigation.

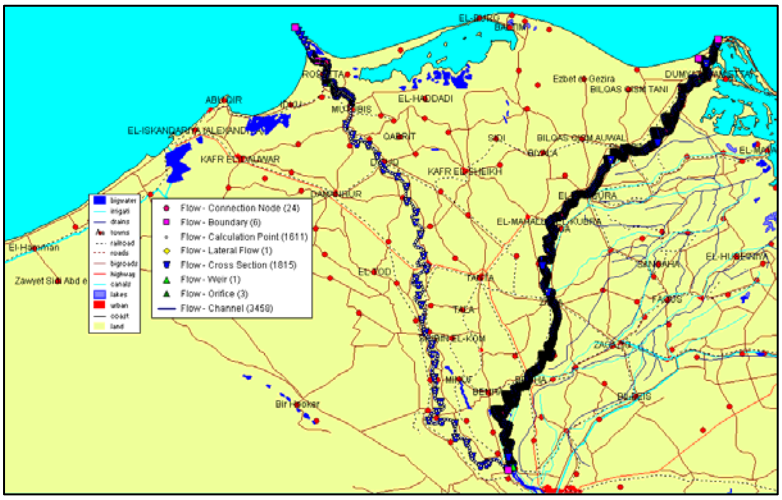

Figure 2: Location of Simulated Reach

For the Nile River, the Manning type roughness coefficient provides a good representation of hydraulic roughness for a wide range of discharges. Hydrographic data describe the geometry of the physical system including the assignment of the bed elevation to the study reach and evaluation of surface roughness to be used in estimating bed friction coefficients . The hydraulic data are used to establish the model boundary conditions, model calibration and model testing process.

The calibration and validation of the model of Damietta branch were performed using actual cross ssection data, discharge and water level . The measured disscharges and water levels (9-1-2005) were used to calibrate the reach . Boundries used for this calibration were:

US boundary condition: Discharge DS Zefta Barrage = 52.08 m^3/s

DS boundary condition: Water level US Farskour Dam = 1. 5 m

Assisting points for verification of manning along the reach were:

Water level DS Zefta Barrage = 3.05 m

Water level at km 149 DS Zefta Barrage = 1.65 m

Water level at km 172.64 DS Zefta Barrage = 1.60 m

The measured and simulated water level from the model are presented in Figure (3).The model calibrated showed the differences between measured and computed water levels are presented in table (2). These differences are ranged between (0.32% - 6%) in the simulated and measured values, based on the calibration process results, it was clear that the model could precisely simulate the branch with reasonable accuracy.

The average manning roughness cofficient for the reach is 0.028.it can be noticed that there are some sudden changes of water level slope, which is due to the irregularity of Damietta branch bed.

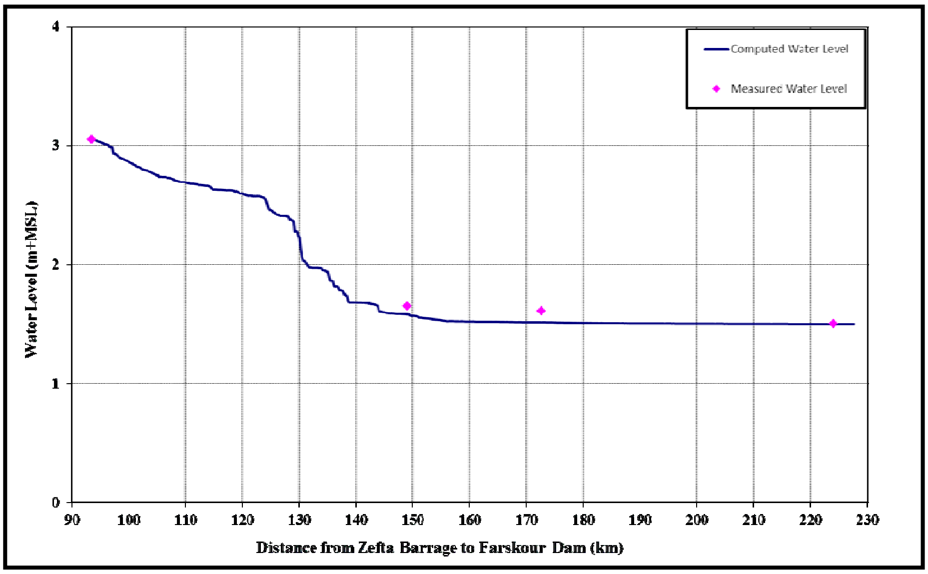

Figure 3: Actual Measured Water Levels and Simulated Water Levels at Damietta Branch between Zefta Barrage and Faraskour Dam

Table 2: Comparison of Measured and Simulated Water Level

		Water Level (m+MSL)		
Point No.	**Km from Delta Barrage**	**Measured (m)**	**Calculated (m)**	**Diff. (%)**
1	93.5	3.058	3.05	0.32%
2	149	1.65	1.58	4.24%
3	172.6	1.6	1.51	5.6%
4	227.45	1.5	1.49	0.66%

3. MODEL SCENARIOS

A number of model scenarios have been defined based on the collected data. The objective of the model scenarios is to prove that creating a safe navigation waterway would not be only through dredging, but there are other hydraulic aspects that should be taken into consideration to reduce and minimize the maintenance dredging costs.

Based on collected data sets a minimum discharge of 4.0 M m3/day is chosen as critical value which pass entire the reach after El-Salam canal construction in the year 2005. The frequent of passing the discharge of 4.0 M m3/day is about 1month/year. To satisfy the safe navigation depth, spur dikes was chosen as a river regulation works the main function of spur dikes in this study is to raising up the water level above the natural level in order to satisfy safe navigation. The safe navigation depth is 2.3m above bed level this depth is summation of 0.5 m clearancefor sandy bottom (River Nile) and 1.8 m for ship draught.Simulated longitudinal water surface profile before introducing any construction is plotted for the minimum discharge of 4.0 M m3/day see Figure (4).

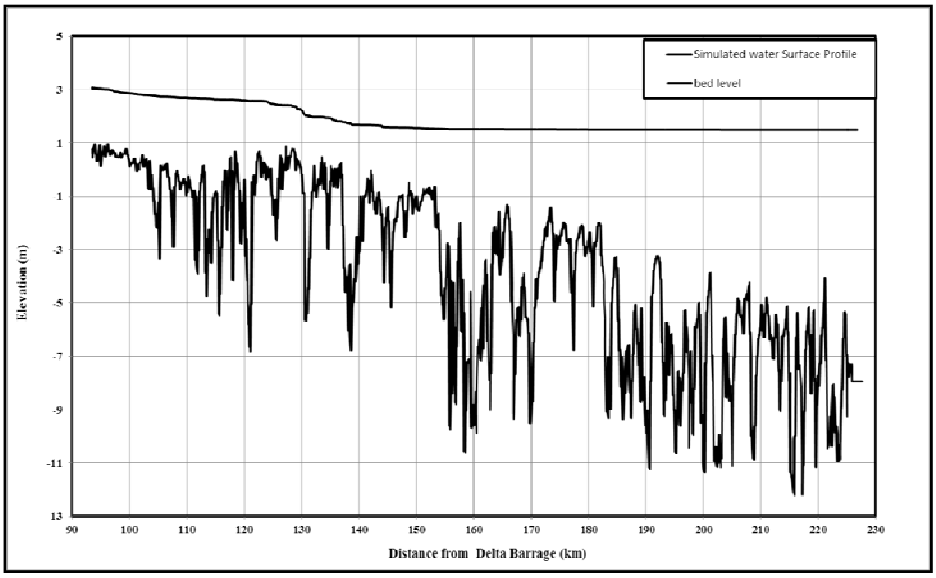

Figure 4: Predicted Water Surface Profile (Q= 4.0 Million m^3/day)

The model simulation process started with the initial condition where the study reach is simulated, this run is used as a reference to define the navigational bottlenecks. For the minimum simulated discharge 4.0 M m3/day three critical zones of navigation bottlenecks are defined in table (3) and Figure (5):

Table 3: Navigation Bottlenecks along Study Reach

Zone No.	From Km	To Km	Length (Km)
1	93.5	104	10.5
2	118.5	130	11.5
3	132	143	11

Note: Distances are measured from Delta Barrage

Zone 1: Begins from km 93.5 to km 104 measured from Delta Barrage. This zone shows clearly the navigation bottlenecks, where the water depth in it is insufficient for safe navigation the average of drop in safe navigation depth is about 50 cm. **Zone 2:**Begins from km 118.5 to km 130 measured from Delta Barrage. This zone shows clearly the navigation bottlenecks, where the water depth in it is insufficient for safe navigation the average of drop in safe navigation depth is about 37 cm. **Zone 3:**Begins from km 132 to km 143 measured from Delta Barrage. This zone shows clearly the navigation bottlenecks, where the water depth in it is insufficient for safe navigation the average of drop in safe navigation depth is about 30 cm.

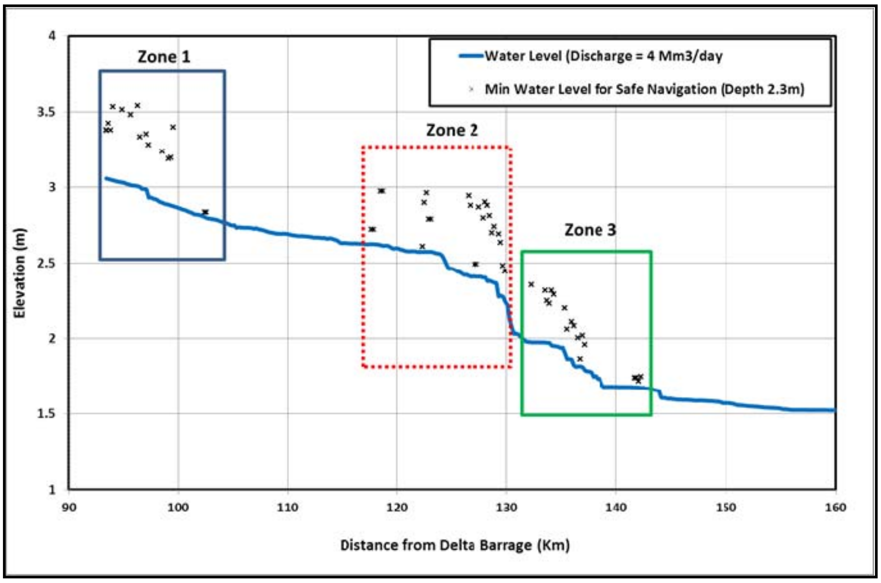

Figure 5: Navigation Bottlenecks Zones represented DS Zefta Barrage

4. RESULTS AND DISCUSSIONS

Spur dikes are used with different lengths along the study reach in the locations which has navigation bottlenecks by using spur dikes to solve the regions of bottlenecks, different alternatives are used to reach a suitable length which supports the rise of water level and solve the navigation bottlenecks. **First alternative** is using spur dikes in 3 scenarios with length 4% of river width, 6% of river width and 8% of river width applied on both sides of the cross section along the zones of navigation bottlenecks. **Second alternative** is using spur dike from km 93.5 to km 104 spur dike with length 8% of river width and from km 118.5 to km 143 DS Zefta barrage with length 15% of river width .**Third alternative** is using spur dike from km 93.5 to km 104 with length 8% of river width and from km 118.5 to km 130 with length 15% of river width and from Km 132 to km 143 with length 20% of river width.

4.1 Case 1

In this case three scenarios represented the construction of spur dikes in the locations which represent navigation bottlenecks along the simulated reach, with minimum flow discharge 4.0 M m^3/day. The length of spur dikes represent 4% , 6% and 8%from the river width applied on 2 sides of the cross section. The spur dikes length and spacing are represented as following:

L = 10 m, S = 25 m (scenario 1)
L = 15 m, S = 40 m (scenario 2)
L= 20 m, S= 50 m (scenario 3)
Where L= Length of spur dike in meter
S= Spacing between each spur dike in meter

Scenario (1) : Spur dikes with length 10m and spacing distance 25 m as shown in Figure (6) raises the water level approximately 24 cm from km 93.5 to km 104 , 14cm from km 118.5 to km 130 and 5cm from km 132 to km 143 DS Zefta Barrage. Comparing this scenario with the initial case; it is noticed that navigation bottlenecks DS Zefta Barrage increases with a percentage of 66% from km 93.5 to km 104, and with 58.33% from km 118.5 to km 130, and with 17.11% from km 132 to km 143.

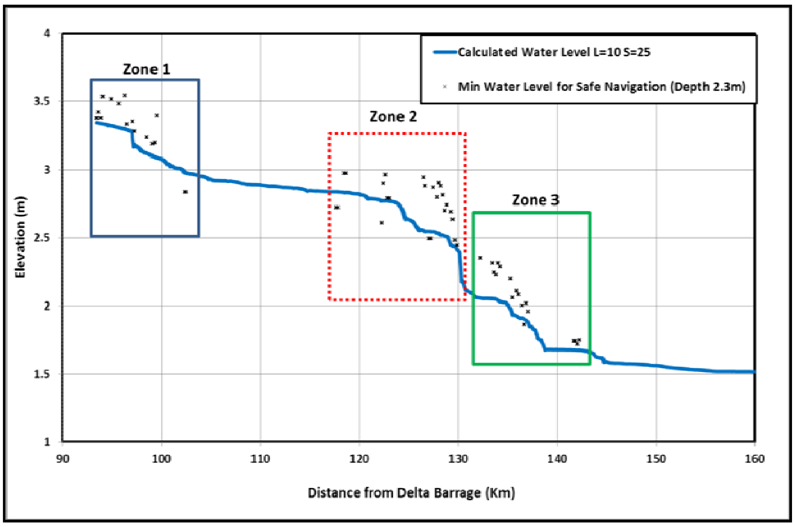

Figure 6: Comparing Calculated W.L after Installing Spur Dikes with Length=10m and Spacing Distance =25 m and Min W.L. Required for Safe Navigation

Scenario (2) : Spur dikes with length 15 m and spacing distance 40 m as shown in Figure (7) raises the water level approximately 27 cm from km 93.5 to km 104, and 11 cm from km 118.5 to km 130, and 10 cm from km 132 to km 143 DS Zefta Barrage. Comparing this scenario with the initial case; it is noticed that navigation bottlenecks DS Zefta Barrage increases with a percentage of 66% from km 93.5 to km 104, and with 75% from km 118.5 to km 130, and with 21.05% from km 132 to km 143 .

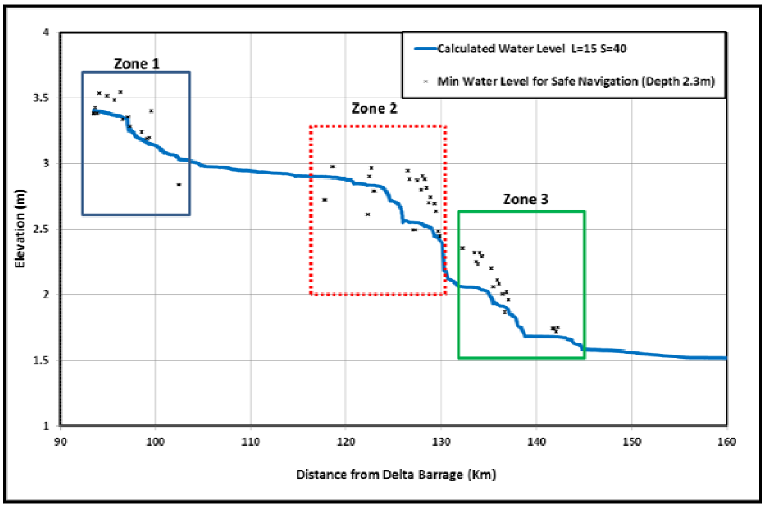

Figure 7: Comparing Calculated W.L after Installing Spur Dikes with Length 15 m and Spacing distance 40 m and Min W.L. Required for Safe Navigation

Spur dikes with length 20 m and spacing distance 50 m as shown in Figure (8) raises the water level approximately 28 cm from km 93.5 to km 104, and 11 cm from km 118.5 to km 130 , and 13 cm from km 132 to km 143 DS Zefta Barrage . Comparing this scenario with the initial case; it is noticed that navigation bottlenecks DS Zefta Barrage increases with a percentage 74% from km 93.5 to km 104, and with 72.22% from km 118.5 to km 130, and with 57.89% from km 132 to km 143.

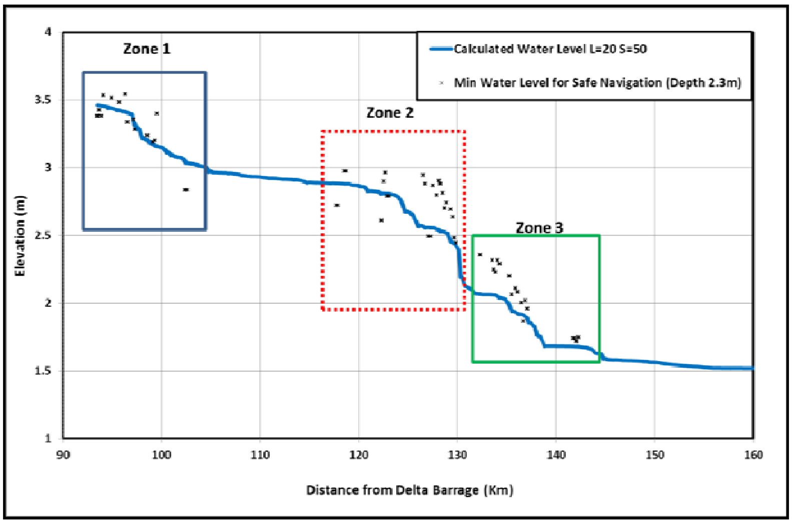

Figure 8: Comparing Calculated W.L after Installing Spur Dikes with Length 20 m and Spacing distance 50 m and Min W.L. Required for Safe Navigation

4.2 Case 2

Spur dikes with lengths 20 m & 40 m are constructed in navigation bottlenecks zones with different spacing distances. For length 20 m the spacing distance between spurs should be 50m and for length 40 m the spacing distance should be 100 m as shown in Figure (9).

Spur dikes with length 20m from Km 93.5 to km 104 with spacing distance 50 m and 40 m from km 118.5 to km 143 with spacing distance 100 m , raises the water level approximately 51cm from km 93.5 to km 104, 29 cm from km 118.5 to km 130, 21cm from km 132 to km 143 DS Zefta Barrage. Comparing this scenario with the initial case; it is noticed that navigation bottlenecks DS Zefta Barrage, which exist from km 93.5 to km 104 (zone 1) are solved, and with 86.11% from km 118.5 to km 130, and with 60.33% from km 132 to km 143.

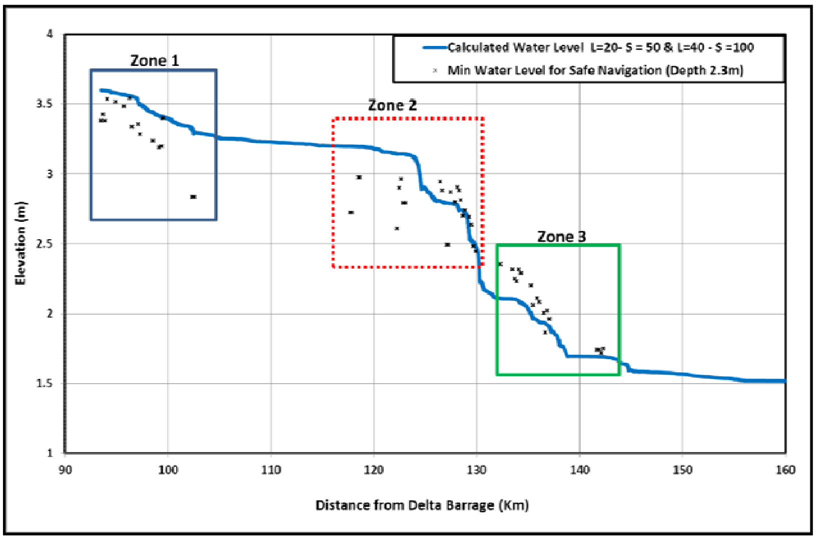

Figure 9: Comparing Calculated W.L after Constructing Spur Dikes with L=20 m – S = 50 m & L=40 m - S =100 m and Min W.L. Required for Safe Navigation

4.3 Case 3

Spur dikes with lengths 20 m and spacing distance 50 m from km 93.5 to km 104 , and with length 40 m and spacing distance 100 m from km 118.5 to km 130, and with length 50 m and spacing distance 125 m from km 132 to km 143 with spacing as shown in Figure (10). This scenario raises the water level approximately 54cm from km 93.5 to km 104, 38 cm from km 118.5 to km 130 and 31 cm from km 132 to km 143 DS Zefta Barrage. Comparing this scenario with the initial case; it is noticed that navigation bottlenecks DS Zefta Barrage which exist from km 93.5 to km 104 (zone 1), from km 118.5 to km 130 (zone 2) and from km 132 to km 143 (zone 3) are solved.

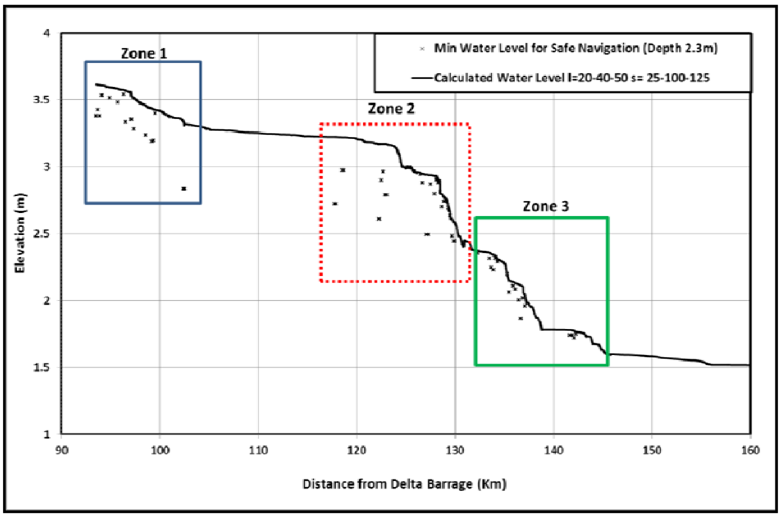

Figure 10: Comparing Calculated W.L after Installing Spur Dikes with L =20 m, 40 m &50 m for S =50 m- 100 m and 125 m respectively and Min W.L. Required for Safe Navigation

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Spur dikes can be used to improve the navigation conditions by raising the water levels to solve navigation bottlenecks. The selected case study resulted in several concluding remarks and points. The construction of spur dikes has an effect of raising the water level and solving the navigation bottlenecks. The simulated scenarios justified several results which represent the effect of length and spacing distance of spur dikes on enhancing the raise of water level. This leads to the decrease in navigation bottlenecks.

Construction of spur dikes with length 20 m and spacing distance 50 m from km 93.5 to km 104 , includes in the same scenario dikes with length 40 m and spacing distance 100 m from km 118.5 to km 130 and with length 50 m and spacing distance 125 m from km 132 to km 143, will cause a raise in w.l approximately 54cm from km 93.5 to km 104 and 38cm from km 118.5 to km 130 and 31cm from km 132 to km 143 compared to the initial case. By this all navigation bottlenecks which exist from km 93.5 to km 104 (zone1), from km 118.5 to km 130 (zone 2) and from km 132 to km 143 (zone 3) are solved. Construction of spur dikes with length 20 m from km 93.5 to km 104 and 40 m from km 118.5 to km 130 and 50 m from km 132 to km 143 is considered as the optimum solution for solving all navigation bottlenecks.

5.2 Recommendations

As a result of this study the following recommendations for future studies are presented:

- The water release downstream Zefta Barrage should not be less than 9.0 Million m^3/day, if it doesn't conflict with irrigation requirements this could have a good effect on navigation operation and also will improve salinity of El-Salam canal.
- Specific type of ships with less draft can be used during the hazard periods.
- Water transport activity can be put off during one month each year when the required water depth for navigation is not available.

- Short cut of river branch meanders to decrease navigation waterway path.
- Dredging techniques should be executed in an accurate way and dredged materials should be used to compensate for the enlargement of the cross sections.

6. REFRENCES

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