EFFECT OF WATER SURFACE RECESSION ON BRIDGE-TYPE INTAKES PROPOSED ALONG THE RIVER NILE

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ABSTRACT

Water Surface Recession (WSR) along the River Nile within Egypt always governs the construction of the bridge-type water intake. The distance with which such an intake is extended offshore mainly depends on the WSR distance. The intake extension length should be longer than the maximum WSR occurring during the period of min water levels so that the pipes carried on the bridge can reach the stream water. The aim of this study is to determine the max WSR distances expected along the two banks of the River Nile so that they can be used as a preliminary estimation of the required min offshore extension length of a proposed bridge type water intake. Reach (1) of the River Nile was chosen as a case study to determine the WSR distances on both sides. A number of 158 cross sections along the study reach with an in-between spacing of 1.00 km (km 760 – km 917) were taken out from the most recent available hydro-topographic survey maps of 2006. Also, the records of the max and min water levels of year 2004 measured at all the staff gauges along the reach were used to compute the highest and lowest water levels at the different cross sections by linear interpolation. Using the computed water levels and the cross sections, the points of intersection where the water surface meets the riversides were computed at the lowest and highest discharge releases through the reach. The horizontal distances between the highest and lowest points (at all sections, west and east) were computed to get the max WSR distances expected along the reach. Analyzing the obtained results, it could be concluded that the longest WSR distances on one riverside of the study reach is almost encountered by the shortest recession distances on the opposite side. This means that a state of equilibrium has been reached regarding riverbed morphology and the corresponding water recession. Also, the shortest WSR distances could be determined. They were considered the best places for the construction of the bridge-type intake as far as the economy is concerned. Moreover, knowledge of the values of the recession distances could provide the decision maker with preliminary information, and clear conception of how long a bridge type intake at a certain place within the study reach could be extended and if the project is feasible or not.

Received 14 July 2015.Accepted 8, November 2015

1 INTRODUCTION

Water intakes are structures that are used to carry water conveying pipes offshore open channels to get water (whether under gravity or by pumping) and supply it to the water plant premises for treatment and purification before pumping to its final destination. There are different types of water intakes. The bridge-type intake is the most common along the River Nile within Egypt. Its extension into water is basically governed by water recession distances that depend on water level fluctuations. The longer this distance is the longer the expected extension will be. This long intake always causes problems overtime such as detaining floating debris, weeds, trash, dead animals, straw which, in turn, cause continuous sediment deposition that finally accumulates around the pipe inlets preventing water from flowing into the water plant.

The intake is usually designed to carry water supply pipes to reach channel water specifically during periods of minimum water stages such that it can ensure permanent water abstraction and supply. It is known that the water stage fluctuates up and down all the year round due to the released different discharges that are based on the essential water requirements of the country. There are two critical periods of water levels along the Nile. The minimum water level (WL) period occurs during the release of minimum discharges downstream Aswan High Dam and the maximum WL one that takes place during the release of maximum discharges. When the water level fluctuates down to the minimum, the water is said to be receding offshore leaving large areas of floodplains uncovered. This offshore recession distance differs along the bank sides according to the irregular nature of the channel water bed and banks. This distance is essential to determine the length of the intake structure into water.

Since its very beginning, the Nile Research Institute (NRI) has been assigned to give its scientific opinion on the different types of intakes proposed along the Nile and its two branches within Egypt. So, many research reports on studying the best possible places for water intakes have been issued with relevant recommendations. Each report is an individual study on the intake place proposed by the demanding client examining if it is suitable or not. Suitability basically depends on how far and deep river water is offshore during minimum water levels and discharges. Obviously, if the water is deep and close to the river bank all the year round, it is considered the best place for a bridge-type intake structure as its extension will be as short as possible. This means its construction will be most economic. Also, there will be very little chance for sediments to deposit and accumulate, and the water abstraction will be ensured round the year.

Therefore, this research study basically aims to evaluate and determine the maximum water recession distances expected along the two banks of the River Nile so that they can be used as a preliminary estimation of the required minimum offshore extension length of a bridge-type water intake. Generally, knowledge of the recession distance value along the river helps the decision maker to recognize the different places where water intake construction is feasible or not. It also helps estimate and spare the funds necessary for construction.

2 DEFINITIONS

2.1 Water Recession Distance

During the maximum water discharge release through a river, the water surface meets the bank at a certain point. Also, when the water surface declines to its minimum level due to the release of minimum discharges, it meets the bank at another lower point. The horizontal distance between these two points as shown in "Fig.1" is defined as the maximum water recession distance. This distance has to be computed at the river cross section where it is required to extend a bridge type intake offshore carrying pipes to abstract water for irrigation or drinking or any other purpose.

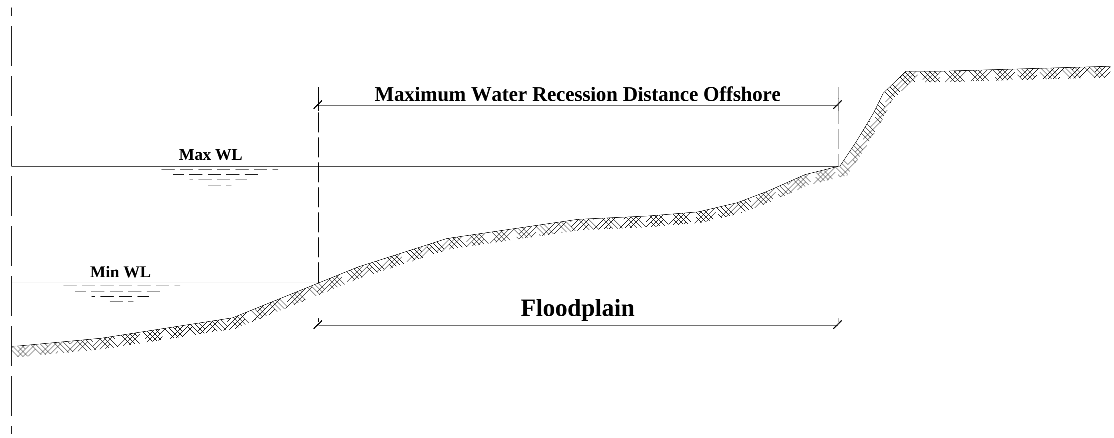

Figure 1. Maximum water recession distance offshore (after the author)

2.2 Bridge-type Water Intake

It is a bridge built of steel (truss-like) or concrete that starts at the bank of the channel and extends for some distance offshore to reach water particularly during the period of minimum water stage. It is constructed on piers resting on pile caps. The bridge main task is to carry pipes and pumps on the deck to abstract water from the open channel as shown in "Fig. 2". The inlet of the suction pipe is submerged into the channel to abstract water. It is covered with a strainer to prevent sediment inflow. Sometimes, the pipes are carried on a bridge deck submerged under the minimum water surface to convey water under gravity to a turbid water sump on the land side.

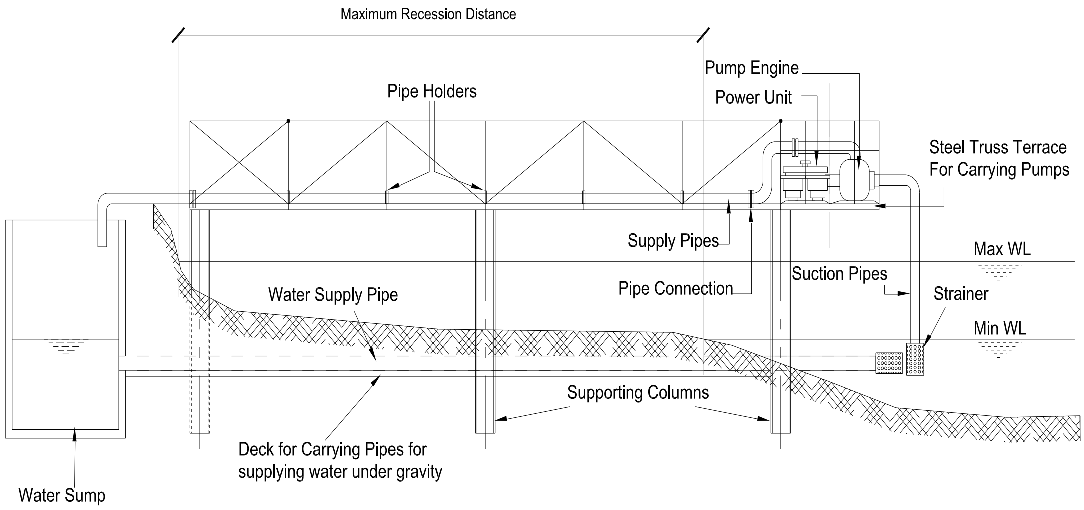

Figure 2. Bridge type Intake - side view (after the author)

It is clear from "Fig. 2" that the bridge extension offshore depends basically on the recession distance. The extension should always be greater than this distance so that the pipe inlets are completely submerged under water surface for ensuring permanent water supply in case of gravity pipes or for avoiding the occurrence of vortexing and cavitation phenomena in case of suction pipes. It is worth mentioning that cavitation produces adverse effects on the suction pump. When the submergence of the intake pipe is not sufficient, air enters the intake by means of an air entraining free vortex, states Fi˙Kret Kocabas (2000). Isbasoiu (2005) states that vortexes (vortices) and water surface turbulence may produce adverse effects on the suction pump. According to Randall W. Whitesides (2008), the entrained air causes flow reductions, vibrations, structural damage and loss of efficiency in turbines or pumps and in water conveying structures.

3 CASE STUDY

Reach (1) of the River Nile as shown in "Fig. 3" was chosen as a case study to determine the water recession distances on both sides. It starts at km (927) upstream “Roda” gauge in Cairo and ends down at the new Esna Barrages, km (760) upstream “Roda”. It is known that Roda gauge is taken as the start point of kilometrage along the River Nile within Egypt.

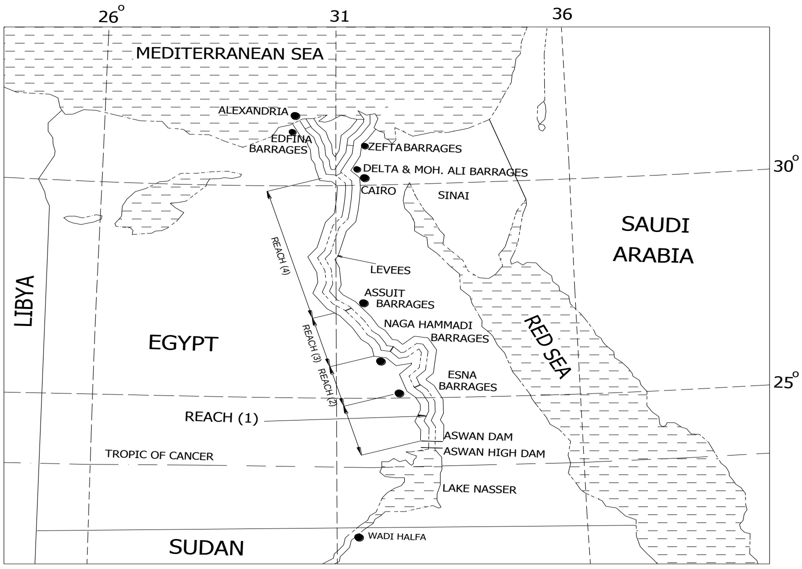

Figure 3. Reach (1) of the River Nile.

4 DATA COLLECTION & PROCESSING

4.1 Topographic & Hydrographic Data

A number of 158 cross sections along Reach (1) with an in-between spacing of 1.00 km (km 760 – km 917) as shown in "Fig. 4" were taken out from the most recent available topo-hydrographic survey maps of 2006 that were produced for the River Nile by the Nile Research Institute (NRI), the Survey Authority (SA), and the Remote Sensing Authority (RSA). Each cross section was obtained in the form of a set of points of three coordinates (Easting, Northing, and Elevation). The Easting and Northing coordinates are based on the Survey Reference System (Datum) of Egypt 1907, Map Projection Type (Egyptian Transverse Mercator "ETM"), Red belt zone, with which the maps were developed. In this way, the water cross section could be drawn in three dimensions representing the real nature.

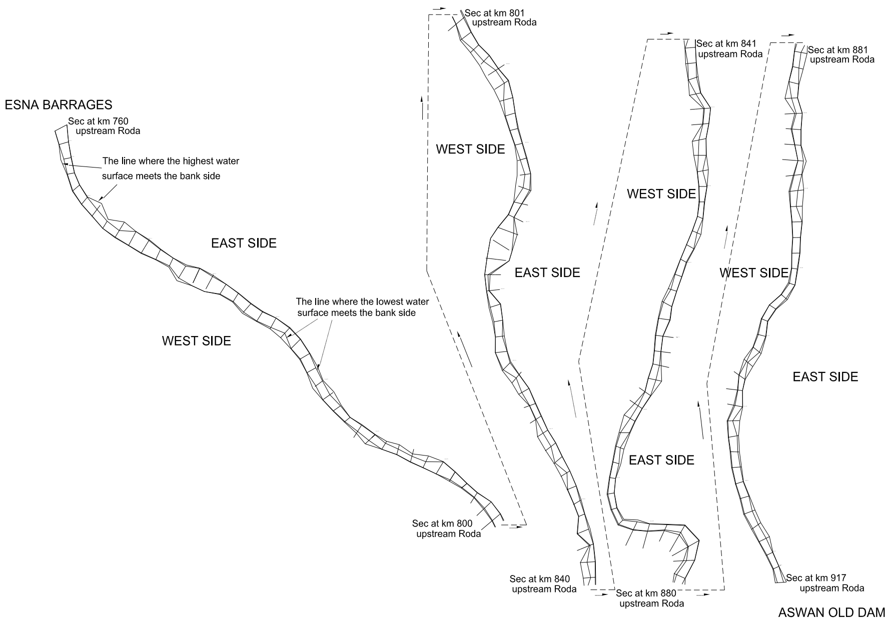

Figure 4. Reach (1) showing the 158 x-sections and the water surface intersection lines with both banks at lowest and highest discharges

4.2 Hydrologic Data

In order to get the maximum and minimum water levels at the 158 cross sections selected along the study reach, the historical records of the measured levels at the marble staff gauges spread along the two banks of the reach were collected from the NRI database system. Only 15 years of the records between 1990 and 2004 were available complete with no missing data as shown in "Table 1". As for the records of the following years, some were missing as some staff gauges were out of order and decommissioned. After checking all the records, it was decided to use those of the year 2004 as it was nearest the year 2006 on which the topo-hydrographic maps were finally produced. It was believed this would result in good representation of reality and nature. This is because the hydro-topographic data of the maps (which took long time under revision and scrutiny before final map release) were collected in year 2005 which was nearest to 2004. This one year difference is too short for tangible morphological changes to occur along the river. Thus, the reality could be represented very closely. It is worth mentioning that the work of data acquisition of a 158-km reach takes several months of field survey to collect the details of practice and another more several months of office work to produce the final maps.

The measured records of year 2004 were used to compute the highest and lowest water levels at the different cross sections by mathematical interpolation. Every two consecutive staff gauge records were used to compute the water levels at the cross sections lying between them. For facilitating this process, the author developed a spreadsheet macro that computes such water levels quickly and accurately (Hekal, N.T.H., 2003).

The Macro is designed to compute the water level knowing the kilometer. In this Macro, the minimum and maximum water levels recorded over a number of past years at different staff gauge stations along the study reach are stored together with the station kilometers in a certain format. Then, the min & max water levels are computed by linear interpolation along the reach for each year using the kilometer of each control cross section and the nearest upstream and downstream staff gauge stations. Finally, the water levels over the number of years considered are selected. The macro uses two "DO LOOPS" to do the job. One for computing the min/max water level over the considered years at a certain kilometer and the other repeats the computation for the other kilometers required. These water levels are finally plotted against their kilometer as shown in "Fig. 5" below. Looking at the curve of the min water levels, it is found that the water surface profile along the distance between km 760 and km 786 goes down as you go upstream which is not logical at the first sight then it starts to go up again at a certain point. It is usually known that the water level upstream must be higher than that downstream. But in our case here, this is what actually happens in reality during gradual discharge reduction downstream the upstream structure. This can be explained as that during the gradual reduction of discharges downstream the upstream hydraulic structure of Reach (1) (which is Aswan High Dam in our case), the detention water level directly upstream the downstream hydraulic structure (which is Esna Barrages in our case) keeps the same value due to the lag time the water takes to reach the barrages. In case the coming discharges become lower than the previous ones, the water surface profile starts to reduce gradually upstream the downstream structure for a certain distance until the new lower discharges have arrived. Overtime, the water surface profile starts to adjust itself until reaching a steady state. Here, in our case, the water levels plotted on the chart represent the water surface profile at a certain time when the water levels recorded at the staff gauges along the study reach were lowest. This is very important to determine the minimum water level that can be reached at a certain cross section so that the recession distance can be computed accurately as it affects the bridge-type water intake extension offshore.

Table 1. Records of Max & Min water levels at the staff gauges along Reach 1

Staff Gauge/km Upstream Roda	Year/WL	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Aswan	Max. WL	85.27	85.35	85.27	85.27	85.27	85.42	85.42	85.70	85.42	85.63	85.77	85.77	85.83	85.63	85.27
920	Min. WL	82.19	81.84	81.84	82.07	81.71	81.71	81.71	81.71	81.71	82.89	82.78	83.28	82.20	81.97	82.20
Gaafra	Max. WL	83.95	84.04	84.07	84.20	84.25	84.25	84.45	84.50	84.33	84.54	84.71	84.71	84.38	84.53	84.25
893.25	Min. WL	80.70	80.60	80.80	80.80	80.65	80.63	80.40	80.75	80.57	81.75	81.63	82.13	81.40	80.85	81.08
Daraw	Max. WL	83.65	83.70	83.80	83.90	83.90	84.05	84.15	84.25	84.27	84.37	84.54	84.54	84.13	84.28	83.82
887	Min. WL	80.90	80.30	80.50	80.50	80.70	80.70	80.10	80.85	80.81	81.25	81.13	81.63	81.11	80.60	80.83
Benban	Max. WL	83.55	83.60	83.70	83.80	83.85	83.95	84.05	84.20	84.14	84.29	84.46	84.46	84.02	84.23	83.66
883	Min. WL	80.80	80.20	80.40	80.40	80.60	80.00	80.00	80.80	80.76	81.20	81.08	81.58	80.00	80.55	80.78
Kom Ombo	Max. WL	83.25	83.30	83.15	83.25	83.45	83.50	83.60	83.72	83.55	83.70	83.80	83.80	83.90	83.80	83.80
877.5	Min. WL	80.30	79.80	80.00	80.15	79.80	79.70	79.80	80.40	80.05	80.49	81.00	81.50	80.55	80.30	80.50
Ekleet	Max. WL	82.80	82.55	82.56	82.58	82.60	82.77	82.82	82.83	82.91	83.06	83.16	83.16	83.26	83.16	83.11
864.55	Min. WL	79.80	79.40	79.70	79.77	79.35	79.35	79.92	80.00	79.60	80.04	80.55	81.05	80.05	79.80	79.95
Selwa Kebli	Max. WL	81.63	81.68	82.05	81.70	81.68	81.77	81.78	81.85	82.23	82.38	82.48	82.48	82.58	82.48	82.40
851	Min. WL	79.00	78.66	78.76	78.93	78.10	78.58	78.57	78.67	79.13	79.57	80.08	80.58	79.58	79.23	79.17
Selwa Bahri	Max. WL	81.33	81.43	81.55	81.55	81.66	81.75	81.76	81.68	81.76	81.91	81.90	81.90	82.00	81.90	82.05
841.55	Min. WL	78.60	78.36	78.40	78.62	78.53	78.56	78.55	78.74	78.80	79.24	79.85	80.35	79.35	79.12	79.20
El Ramadi	Max. WL	80.36	80.53	80.61	80.60	80.76	80.86	80.82	80.91	80.93	81.08	81.07	81.07	81.20	81.15	81.10
824.5	Min. WL	77.50	77.40	77.55	77.52	77.75	77.85	77.18	78.09	78.27	78.71	79.32	79.82	78.15	78.10	78.00
Edfu ElMahata	Max. WL	80.16	80.33	80.32	80.48	80.55	80.66	80.62	80.79	80.74	80.84	80.90	80.90	81.01	80.90	80.90
811.9	Min. WL	77.30	77.20	77.30	77.32	77.55	77.65	77.61	77.89	78.07	78.68	78.80	79.30	78.27	78.20	77.80
Edfu ElBald	Max. WL	80.10	80.28	80.35	80.44	80.49	80.60	80.59	80.73	80.67	80.77	80.83	80.83	80.94	80.84	80.84
808.58	Min. WL	77.24	77.14	77.24	77.26	77.49	77.60	77.55	77.83	77.99	78.60	78.72	79.22	78.19	78.14	77.74
Edfu Sarf	Max. WL	79.71	79.94	80.12	80.05	80.15	80.51	80.52	80.59	80.62	80.72	80.78	80.78	80.89	80.79	80.79
807.4	Min. WL	76.89	76.76	76.95	77.03	77.25	77.31	77.49	77.77	77.96	78.57	78.69	79.19	78.69	78.09	77.69
El Bosilia	Max. WL	78.91	79.26	79.26	79.46	79.54	79.56	79.51	79.51	79.56	79.66	79.65	79.65	79.61	79.81	79.86
796	Min. WL	76.06	76.06	76.36	76.21	77.11	77.11	77.11	77.46	77.86	78.47	78.20	78.70	78.26	77.96	77.46
El Sebaeia	Max. WL	78.85	79.20	79.20	79.10	79.48	79.50	79.45	79.45	79.50	79.60	79.59	79.59	79.55	79.60	79.50
785.8	Min. WL	76.00	76.00	76.30	76.15	77.05	77.05	77.05	77.40	77.75	78.36	78.09	78.59	78.00	77.60	77.10
Old Kalabia	Max. WL	78.50	78.93	78.95	79.15	79.25	79.15	79.05	79.05	79.05	79.05	79.05	79.05	78.95	79.07	79.05
761.3	Min. WL	76.53	75.51	76.45	76.52	77.02	77.02	77.02	77.02	77.70	77.70	78.05	78.55	77.65	77.15	77.65
US Esna Barr.	Max. WL	78.30	78.60	78.60	79.00	79.01	79.00	79.00	79.00	79.01	79.03	79.04	79.00	78.90	79.10	79.00
759.25	Min. WL	76.10	75.70	75.90	75.65	76.97	77.00	77.00	77.00	77.40	77.64	77.64	78.00	77.65	77.59	77.60

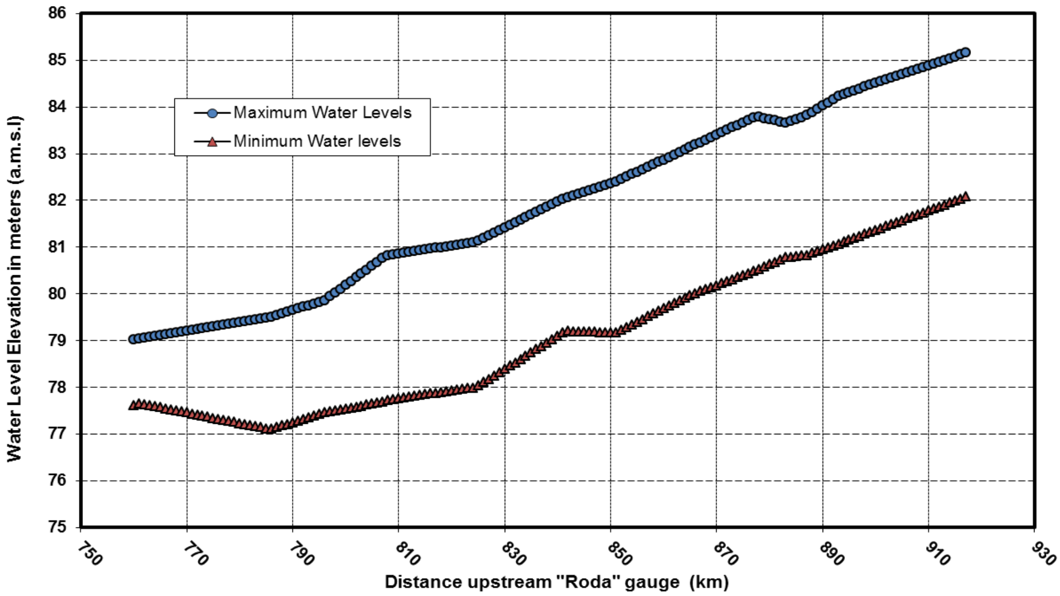

Figure 5. Computed Maximum and Minimum Water Levels along Reach (1) - Year 2004

5 ANALYSIS & RESULTS

A spreadsheet macro was developed based on the equation of the intersection of two straight lines to compute the 2 coordinates (Easting & Northing) of the points where the water surface meets the cross section on both river sides during low and high water stages (Nasr Hekal, 2005). "Fig. 6" below shows these points of intersections at a model cross section. Also, the lines connecting the computed points along the whole reach on both sides during the lowest and highest water levels are shown on "Fig. 4" above.

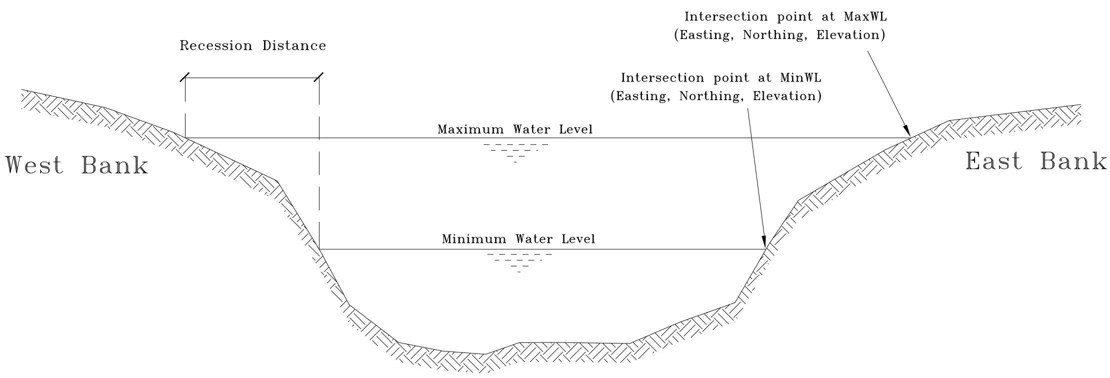

Figure 6. Points of intersection where the water surface meets the river banks at the lowest and highest discharge releases

Using the square root equation, the horizontal distance between the intersection point at the minimum water level and that at the maximum water level at each cross section, on both of the east and west riversides, could be computed. This horizontal distance is the maximum water recession. The value of this distance at each cross section is plotted in "Fig. 7 & 8" and shown in "Table 2" below.

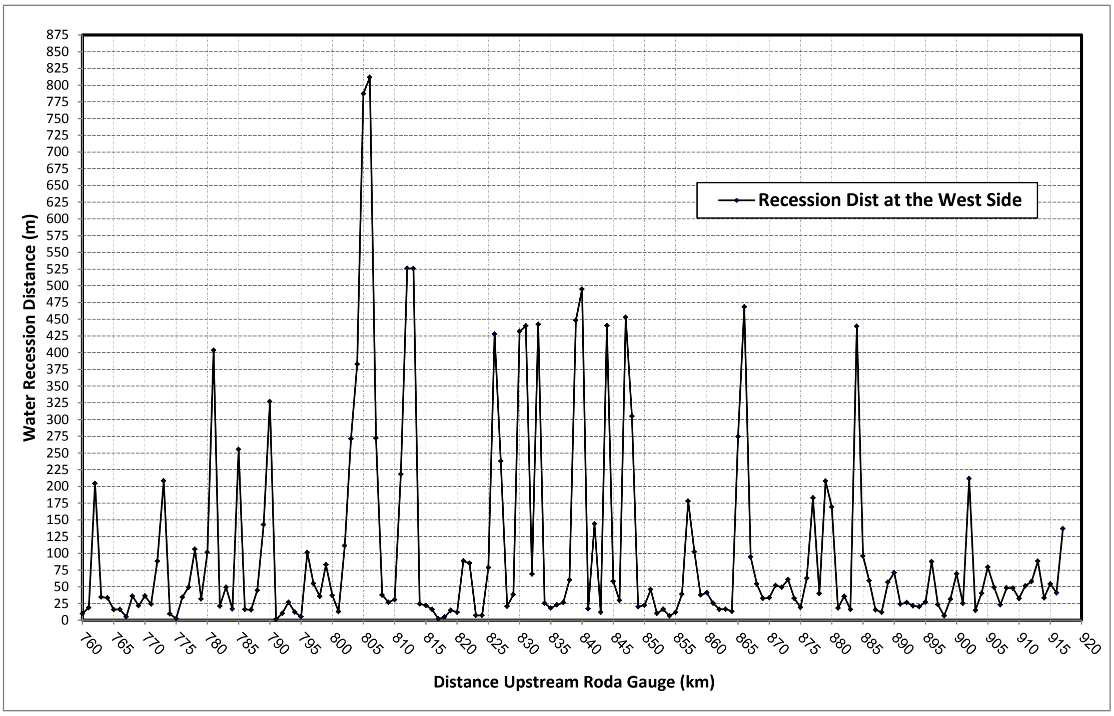

Figure 7. Water Recession Distance along Reach (1) - West Side

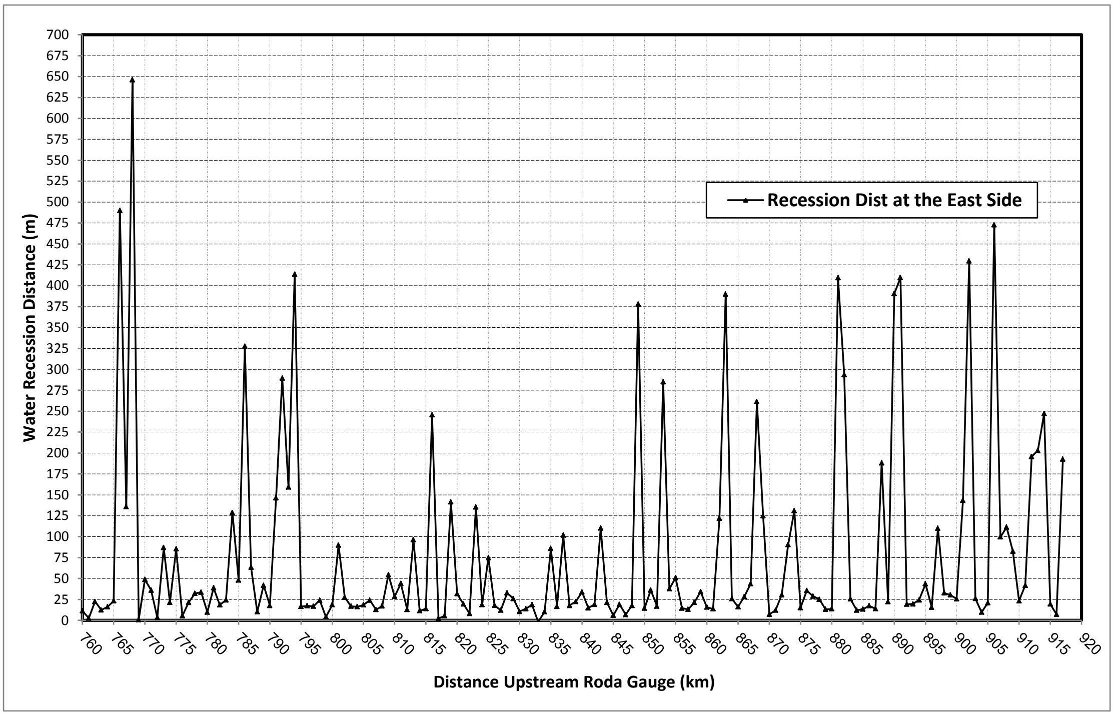

Figure 8. Water Recession Distance along Reach (1) - East Side

Table 2. Water Recession Distances along Reach (1) at Both Bank Sides

(Km) Upstream Roda Gauge	Min WL a.m.s.l	Max WL a.m.s.l	Water Recession Dist (m) West Side	Water Recession Dist (m) East Side
760	77.62	79.02	9.96	11.23
761	77.64	79.04	18.89	2.63
762	77.63	79.06	204.54	22.46
763	77.61	79.08	34.49	12.46
764	77.59	79.10	33.45	16.04
765	77.57	79.12	15.80	23.17
766	77.54	79.14	16.21	490.00
767	77.52	79.15	5.02	135.81
768	77.50	79.17	36.12	646.14
769	77.48	79.19	21.65	0.67
770	77.45	79.21	36.20	48.81
771	77.43	79.23	24.11	35.96
772	77.41	79.25	88.08	3.22
773	77.39	79.26	208.33	86.98
774	77.36	79.28	9.39	21.34
775	77.34	79.30	2.34	85.31
776	77.32	79.32	34.47	5.45
777	77.30	79.34	49.32	21.34
778	77.28	79.36	106.09	32.13
779	77.25	79.38	31.72	33.66
780	77.23	79.39	101.46	9.75
781	77.21	79.41	403.46	38.74
782	77.19	79.43	21.11	18.43
783	77.16	79.45	49.23	24.37
784	77.14	79.47	16.75	128.89
785	77.12	79.49	255.35	48.15
786	77.11	79.51	16.19	327.82
787	77.14	79.54	15.32	63.49
788	77.18	79.58	44.72	10.20
789	77.21	79.61	142.82	41.86
790	77.25	79.65	326.70	17.78
791	77.28	79.68	1.12	146.32
792	77.32	79.72	10.28	289.48
793	77.35	79.75	26.82	159.27
794	77.39	79.79	12.15	413.63
795	77.42	79.82	5.17	16.56
796	77.46	79.86	101.30	17.37
797	77.48	79.94	54.69	16.81
798	77.50	80.02	35.77	24.09
799	77.52	80.10	82.85	4.03
800	77.54	80.19	36.96	18.65

(Km) Upstream Roda Gauge	Min WL a.m.s.l	Max WL a.m.s.l	Water Recession Dist (m) West Side	Water Recession Dist (m) East Side
801	77.56	80.27	12.84	89.88
802	77.58	80.35	111.30	27.48
803	77.60	80.43	271.34	16.81
804	77.62	80.51	382.90	16.25
805	77.64	80.59	787.17	18.35
806	77.66	80.68	811.57	24.08
807	77.68	80.76	272.15	12.86
808	77.72	80.82	37.69	16.99
809	77.75	80.85	26.84	54.51
810	77.77	80.87	30.79	28.38
811	77.78	80.88	218.40	44.02
812	77.80	80.90	526.02	12.82
813	77.82	80.92	525.80	96.33
814	77.83	80.93	24.28	11.48
815	77.85	80.95	22.19	13.84
816	77.87	80.97	15.99	245.54
817	77.88	80.98	1.76	2.13
818	77.90	81.00	4.69	5.41
819	77.91	81.01	14.80	141.49
820	77.93	81.03	11.90	31.78
821	77.94	81.04	88.47	19.62
822	77.96	81.06	85.19	8.22
823	77.98	81.08	7.24	135.38
824	77.99	81.09	7.02	18.62
825	78.04	81.13	78.49	74.85
826	78.11	81.18	427.79	17.84
827	78.18	81.24	237.85	11.97
828	78.25	81.30	20.63	32.72
829	78.32	81.35	38.40	25.96
830	78.39	81.41	431.69	10.58
831	78.46	81.46	439.98	13.69
832	78.53	81.52	69.02	18.63
833	78.60	81.57	442.18	1.73
834	78.67	81.63	25.33	10.35
835	78.74	81.69	18.11	85.92
836	78.81	81.74	22.91	16.67
837	78.88	81.80	26.22	101.94
838	78.95	81.85	60.02	17.70
839	79.02	81.91	448.12	22.51
840	79.09	81.96	494.97	33.85
841	79.16	82.02	17.14	14.83

(Km) Upstream Roda Gauge	Min WL a.m.s.l	Max WL a.m.s.l	Water Recession Dist (m) West Side	Water Recession Dist (m) East Side
842	79.20	82.07	144.04	18.95
843	79.20	82.10	11.91	110.30
844	79.19	82.14	440.20	21.40
845	79.19	82.18	58.00	5.95
846	79.19	82.21	29.57	19.07
847	79.18	82.25	453.05	6.90
848	79.18	82.29	304.99	17.67
849	79.18	82.33	20.19	377.87
850	79.17	82.36	22.32	14.43
851	79.17	82.40	45.88	36.20
852	79.23	82.45	9.99	16.89
853	79.29	82.50	16.33	285.16
854	79.34	82.56	6.47	37.74
855	79.40	82.61	11.75	50.98
856	79.46	82.66	38.83	14.56
857	79.52	82.71	178.00	13.12
858	79.57	82.77	102.16	21.38
859	79.63	82.82	37.57	34.23
860	79.69	82.87	41.18	15.67
861	79.75	82.92	25.40	13.66
862	79.80	82.98	16.17	121.85
863	79.86	83.03	16.47	389.81
864	79.92	83.08	13.29	25.82
865	79.97	83.13	274.45	16.17
866	80.01	83.19	468.33	28.34
867	80.05	83.24	94.46	43.60
868	80.10	83.29	54.15	261.39
869	80.14	83.35	32.65	124.82
870	80.18	83.40	33.48	7.11
871	80.22	83.45	51.98	11.98
872	80.27	83.51	49.25	30.38
873	80.31	83.56	60.69	90.41
874	80.35	83.61	32.52	131.08
875	80.39	83.67	19.16	15.11
876	80.44	83.72	62.67	35.58
877	80.48	83.77	182.96	28.81
878	80.53	83.79	39.81	25.15
879	80.58	83.76	207.99	13.12
880	80.63	83.74	169.47	13.60
881	80.68	83.71	17.93	409.54
882	80.73	83.69	35.72	293.55

(Km) Upstream Roda Gauge	Min WL a.m.s.l	Max WL a.m.s.l	Water Recession Dist (m) West Side	Water Recession Dist (m) East Side
883	80.78	83.66	16.23	25.55
884	80.79	83.70	439.40	11.98
885	80.81	83.74	95.91	13.42
886	80.82	83.78	59.07	17.26
887	80.83	83.82	15.59	13.83
888	80.87	83.89	11.95	188.24
889	80.91	83.96	56.70	22.24
890	80.95	84.03	71.10	390.54
891	80.99	84.10	23.88	409.69
892	81.03	84.16	26.52	19.14
893	81.07	84.23	21.54	19.59
894	81.11	84.28	20.19	24.30
895	81.15	84.32	27.18	43.51
896	81.20	84.35	87.68	15.59
897	81.24	84.39	23.32	110.13
898	81.28	84.43	6.52	32.72
899	81.32	84.47	31.17	30.33
900	81.36	84.51	69.22	25.65
901	81.40	84.55	24.87	143.42
902	81.45	84.58	211.66	429.50
903	81.49	84.62	14.73	26.11
904	81.53	84.66	40.36	9.61
905	81.57	84.70	79.41	20.95
906	81.61	84.74	49.12	472.89
907	81.66	84.77	23.06	99.64
908	81.70	84.81	48.15	111.30
909	81.74	84.85	47.94	82.52
910	81.78	84.89	32.32	23.28
911	81.82	84.93	51.20	41.77
912	81.87	84.96	57.89	195.71
913	81.91	85.00	88.19	203.02
914	81.95	85.04	33.34	247.07
915	81.99	85.08	54.22	19.37
916	82.03	85.12	41.07	7.12
917	82.07	85.16	136.80	192.78

In general, the two figures and table show the values of the distances with which the water surface recedes offshore along reach (1) on both riversides. Comparing the two figures 7 and 8, it is obvious that the places undergoing bigger recession distances on one side of the river are corresponding to smaller recession distances on the opposite side. It is worth mentioning that the big recession distance could be attributed to changes in riverbed morphology due to navigation and human interventions in the river. Sometimes, the navigation movement of watercrafts causes morphological changes in the bed (aggradation and degradation). Also, people encroachments on the riverside floodplains especially during the periods of minimum discharges may cause changes in the floodplains. During such periods, large areas of river floodplains get uncovered, a matter which offers a chance for the nearby residents to advance and occupy the floodplains. Then, the occupants start to raise the land level by earth filling to use it in cultivation or pasturing. Even worse, they are sometimes tempted to build houses on the floodplains. In this way, the river water recedes long away offshore (from the original river bank) even during the periods of maximum discharges. Generally, the river morphology is responsive and susceptible to any human intervention.

Doing more statistical analysis of the recession distances could categorize them according to length as shown in "Table 3". From the table, it is clear that the most economic places for construction of a bridge-type intake are available at only 13 and 15 cross sections on the west and east riversides respectively, where the water recession distances are the shortest. They are shorter than or equal to 10 m. On the contrary, the costliest places are available at about 39 and 35 cross sections on the west and east riversides respectively, where the water recession distances are equal to or longer than 100 m. It was also noticed that the recession distances ranging from 10 to 100 m are available at about 106 and 108 cross sections on the west and east riversides respectively. This means that the two banks are almost similar when speaking of the equality of the number of cross sections where the recession distances are shorter than 10 m or longer than 100 m. It further means that reach (1) is almost experiencing a state of equilibrium regarding water recession. This may be attributed to the annual routine cycle of releases of almost same discharges downstream the High Dam.

Table 3. The number of x-sections with their percentages at different recession distances

	Recession Distance (m)	≤ 10	>10 & <20	>20 < & < 30	>30 & <40	>40 & <50	>50 & <60	>60 & <70	>70 & <80	>80 & <90	>90 & <100	≥ 100
West Side	No of X-Secs	13	26	23	21	11	9	5	3	6	2	39
	% of Secs	8.23	16.46	14.56	13.29	6.96	5.70	3.16	1.90	3.80	1.27	24.68
	Cumultive No of Secs	13	39	62	83	94	103	108	111	117	119	158
East Side	No of X-Secs	15	51	24	14	7	2	1	1	5	3	35
	% of Secs	9.49	32.28	15.19	8.86	4.43	1.27	0.63	0.63	3.16	1.90	22.15
	Cumultive No of Secs	15	66	90	104	111	113	114	115	120	123	158

6 CONCLUSION

From the above analysis and results, a general management for the feasibility of the bridge-type water intake with respect to position and economics along reach (1) of the River Nile could be done. Moreover, the following points could be concluded:

1. Identifying and classifying water recession distances at riversides are essential to provide decision makers with preliminary information, good background, and clear vision which eventually enable him/ her to properly select a relevant place for a proposed bridge-type intake;

2. Human encroachments on the river floodplains may result in negative impacts on the river water recession which, in turn, may affect the implementation of bridge-type water intakes alongside the river Nile;

3. Determination of water recession distances provides multiple alternative places that may be relevant to a proposed intake;

4. The shortest recession distance places were determined exactly along the study reach on both sides. They are considered the most suitable places for construction of bridge-type intakes as far as the economics of the project is concerned; and

5. It is found that the longest water recession distances on one riverside of the study reach is almost encountered (along the whole reach) by the shortest recession distances on the opposite side. This means that a state of equilibrium has been reached regarding riverbed morphology and the respective water recession. This may be attributed to the annual routine cycle of releases of similar or same discharges downstream the High Dam.

RECOMMENDATIONS

1. The output of this study could be used as a preliminary selection of the most economic places available for construction of bridge-type water intakes along Reach (1);

2. The number of cross sections along the study reach should be doubled or increased as many as possible to get a better representation of reality and accurate water recession distances;

3. This study can be further applied to the other reaches of the Nile to ensure the selection of the most economic places along the whole river where a bridge-type water intake is to be constructed. In this way, the bank sides could be better managed.

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