STUDY OF ALAQI SECONDARY CHANNEL IN NASSER LAKE

GamalSallam, MohamedIhab, Waleed Emary

1Associate Professor, National water Research Center, gasallam@yahoo.com
High Dam Authority, habozha@yahoo.com
2Research Assistance, National water Research Center, waleed elemary@yahoo.com

ABSTRACT

Lake Nasser/Nubia studies have been included in many researches for national and international experts to give the required information to the decision makers about present and future status of the major water tank for both Egypt and Sudan. A key stone of all of these studies is to have sufficient information about the lake and its characteristics. Lake Nasser has hundreds of secondary channels, some of them are relatively small and shallow and some others are very wide, extended and deep. One of the largest secondary channels that have never been surveyed for a long time is Alaqi Secondary channel. Alaqi Secondary Channel is located at about 110 km upstream the High Aswan Dam on the eastern side of Nasser Lake. A field mission to Nasser Lake secondary channels was carried out in October, 2013. It was aim to collect all related data and develop bathymetric charts for Nasser Lake secondary channels in Egypt. The evaporation losses from Alaqi secondary channel is about 0.72 BCM (at W.L. 175.00 m (AMSL)), the evaporation losses from Alaqi secondary channel is about 6 % of evaporation losses from Nasser Lake. It is proposed to close this secondary channel by a dam to reduce the evaporation losses from Nasser Lake.

It could be concluded from the research that water evaporation in Nasr Lake can be reduced and controlled by closing Alaqi secondary channel.

The objectives of this study are to manage the lake storage capacity, estimate the evaporation losses, propose a closing dam, and to help in lake simulation processes.

Keywords: Lake Nasser, Alaqi secondary channel, Evaporation losses

1. INTRODUCTION

Lake Nasser/Nubia studies have been included in many researches for national and international experts to give the required information to the decision makers about present and future status of the major water tank for both Egypt and Sudan. A key stone of all of these studies is to have sufficient information about the lake and its characteristics. These characteristics include discharges, water levels, environment, meteorological data, lake topography, and other factors. The lake bed topography is one of these factors that have been surveyed since the lake formation.

Lake Nasser/Nubia Has hundreds of secondary channels, some of them are relatively small and shallow and some others are very wide, extended and deep. One of the largest secondary channels that have never been surveyed is Alaqi Secondary channels. Figure 1 shows Alaqi secondary channels.

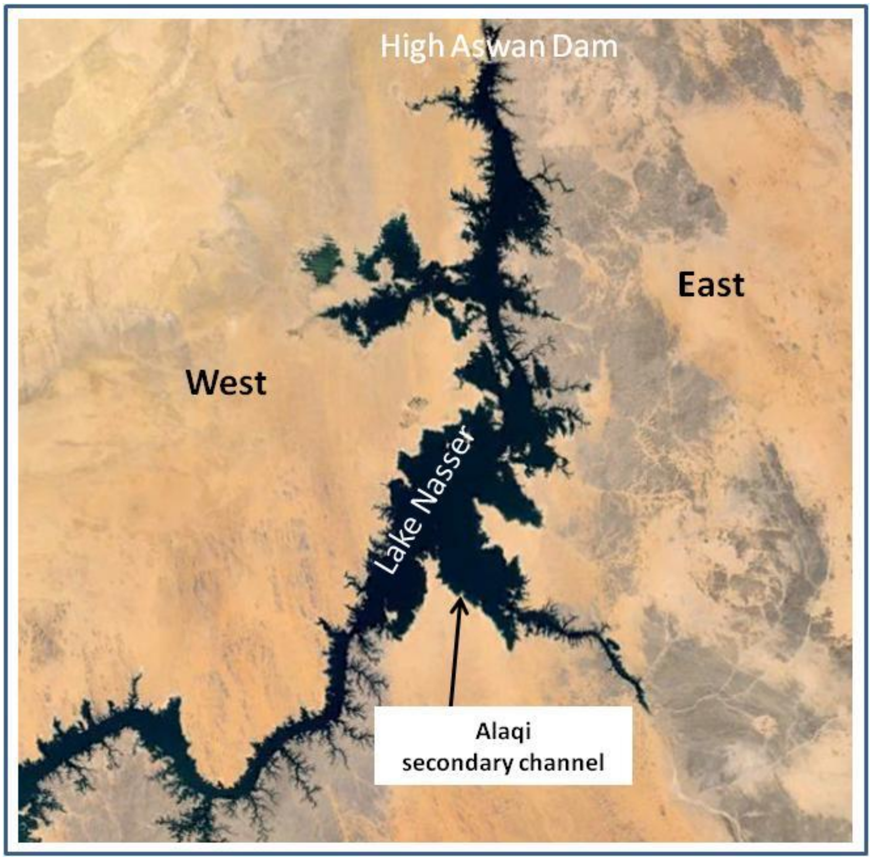


Figure 1. Alaqi secondary channel

A field mission to Nasser Lake secondary channels was carried out in October, 2013. It was aim to collect all related data and develop bathymetric charts for Nasser Lake secondary channels in Egypt. The bathymetric charts when archived will give in depth picture to the historical development in the deposition in Lake Nasser secondary channels. This was successfully carried out through the joined efforts of Nile Research Institute and Aswan High Dam Authority. Three field survey Teams using multi beam eco-sounding system, and two single beam systems were used. The teams managed to collect dense data set for Nasser Lake secondary channels. The teams surveyed cross sections at average space of 1 kilometer using three boats.

Another field team was working on a tug boat carried out flow current measurements and bed material sampling at specific locations. The data was compiled in office and contour maps were deducted. These data sets when compiled with previous historical data can be utilized when applying numerical model to predict future changes in these secondary channels. Figure 2 shows Alaqi secondary channel survived cross sections.

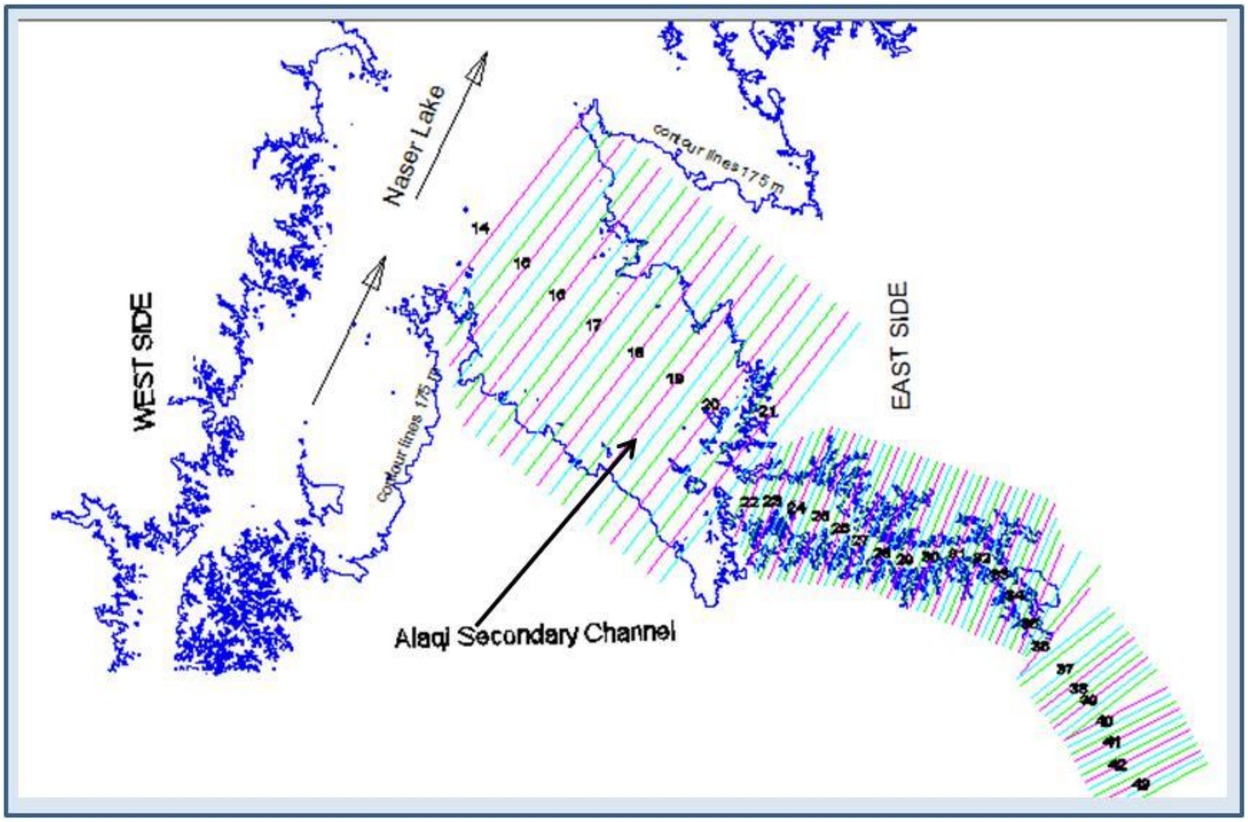


Figure 2. Alaqi secondary channel survived cross sections

2. DATA COLLECTION

2.1 Hydrographic Survey

Three Hydrographic Survey Teams were assigned to collect hydrographic data. Cross sections were planned and geo-referenced throughout Alaqi secondary channels. The space between cross sections is about 1 kilometer. The cross sections were hydrographically surveyed by the three teams. Two of the three teams used single beam echo sounder system for measuring flow depth and global positioning system for momentarily position in terms of easting and northing as Universal Transverse Mercator System (UTM). The position was corrected on the spot by the integrated Omni star system into the GPS unit. That is, corrected position was synchronized with depth from the echo-sounder through data logger by the use of Hypack software. The data logger was a normal laptops computer.

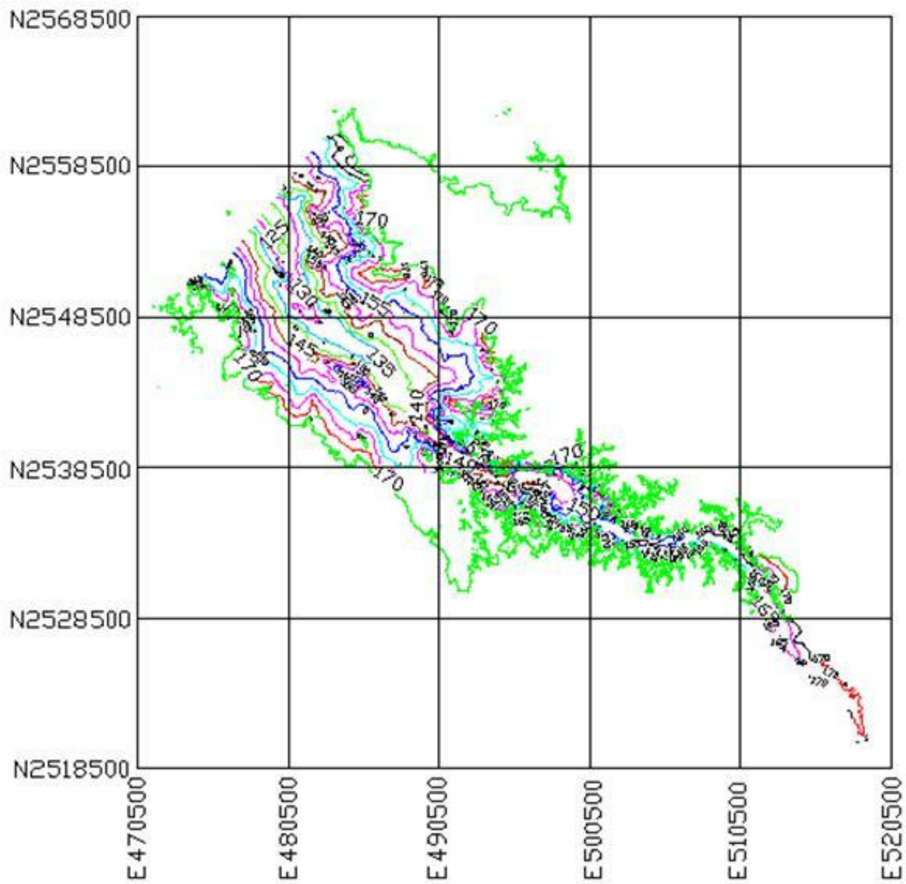


Figure 3. shows Alaqisecondary channel contour map

The third team used a multi-Beam depth sounding system for the first time. The system was integrated with real time positioning of GPS. The system was successfully installed and used in surveying cross sections. The multi-beam depth sounding system was capable on measuring flow depths along a strip of cross section has a range of width between 100 m and 200 m depending on flow depth. At the end, the system was capable on collecting huge data set for flow depth with reasonable accuracy. Data was processed in office and integrated. Then, the resulted data was used to draw the contour maps. Figure 3 shows Alaqi secondary channel contour map.

2.2 Bed Material Sampling

A bed material sampler was used to collect bed material at specific locations. The collected bed material was analyzed at Nile Research Institute laboratory. The grain size distribution was identified at each cross section. The analysis of these samples is useful in learning the process of delta formation in Lake Nasser Secondary Channels and its advancement. Table 1 shows Alaqi secondary channel bed material samples. As shown in table 1, the average size of D_{50} is about 0.17 mm, so Alaqi secondary channel bed can be classified as medium to fine sand.

Table 1. Alaqi secondary channel bed material samples

Lake Nasser Khors			October/2013											Nile Research Institute	
Khor El-Allaki															
Bed Material Samples			List for Characteristic Grain Size Parameters along the Site												
Cross Sec. Name	Cross Sec. No	Km	Location	D50 mm	D-Mean mm	% Sand				%Silt				% Clay	Classification
						Coarse	Medium	Fine	Total	Coarse	Medium	Fine	Total		
Khor El-Allaki	14	23° 06' 30.70''N & 32° 47' 57.08''E	Middle	0.2539	0.2890	11.21	52.44	27.17	90.82	4.13	2.04	1.21	7.38	1.15	Medium to fine Sand
	16	23° 02' 11.34''N & 32° 49' 30.44''E	Middle	0.2715	0.3986	15.71	46.91	28.83	91.45	2.93	0.00	0.00	2.93	0.00	Medium to Fine Sand
	21	22° 56' 24.87''N & 32° 55' 02.52''E	Middle	0.1713	0.2034	7.33	37.36	32.04	76.74	7.24	4.64	3.82	15.70	6.95	Medium to Fine Sand
	29	22° 54' 27.06''N & 33° 02' 55.77''E	Middle	0.1319	0.1634	4.91	24.01	37.80	66.71	10.20	6.17	4.46	20.83	7.67	Silty Fine to Medium Sand
	33	22° 53' 41.86''N & 33° 06' 24.08''E	Middle	0.1616	0.2069	9.82	32.35	31.47	73.65	8.97	6.17	4.84	19.99	5.64	Silty Medium to Fine Sand
	37	22° 50' 40.31''N & 33° 08' 12.22''E	Middle	0.1477	0.2160	9.80	26.37	32.47	68.64	12.22	5.42	4.30	21.95	5.64	Silty Fine to Medium Sand
	41	22° 48' 19.34''N & 33° 10' 46.35''E	Middle	0.1992	0.2821	14.44	33.85	26.43	74.72	5.04	5.65	4.45	15.15	7.45	Medium to Fine Sand

2.3 Current Velocity

Flow Velocity was measured using Vale port velocity meter. This Vale meter is capable on measuring flow velocity and its direction. So, velocity is measured in x-y coordinate. Therefore, flow velocity can be known in the main flow direction and the perpendicular direction towards the banks. The velocity is very low inside Alaqi secondary channel; it is equal about 0.10 m/s, that is related to that, Alaqi secondary channel is closed at its end.

2.4 Suspended Matters

Suspended matter in water may consist of inorganic and organic particles. Inorganic solids such as clay, silt, and other soil constituents are common in surface water. Organic material such as plant fibers and biological solids (algal cells) are also common constituents of surface waters. The suspended particles are the main source of turbidity in water, which always interfere with the penetration of light. The importance of the suspended matters in water quality assessment refers to their responsibility for pollutants transportation. They provide adsorption sites for chemical and biological agents. In addition, the type and concentration of suspended matter control the turbidity and transparency of water. In this mission water samples were collected from cross sections each cross section divided into three locations (East, Middle and West) at different depths including 0.5m from surface, 25%, 50%, 65% and 80% from total depth. Table (2) shows Alaqi secondary channel suspended matters at sec 16 and sec 19

Dissolved oxygen refers to the level of free, non-compound oxygen present in water. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. A dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality. The optimal level in an estuary for Dissolved Oxygen (DO) is higher than 6 ppm. Table (2) shows that the average level of DO is 8 ppm which mean that Alaqi secondary channel water is clear and fresh.

Generally Total dissolved solids (TDS) are normally discussed only for freshwater systems. The principal application of TDS is in the study of water quality for streams, rivers and lakes, it is used as an indication of aesthetic characteristics of drinking water. More exotic and harmful elements of TDS are pesticides arising from surface runoff. Certain naturally occurring total dissolved solids arise from the weathering and dissolution of rocks and soils. The United States has established a secondary water quality standard of 500 mg/l to provide for palatability of drinking water, Fresh water < 1,000 mg/L TDS. Table (2) shows that the average level of TDS is 150 mg/L which mean that Alaqi secondary channel water is clear and fresh.

Pure **water** has a **pH** very close to 7. The **pH** scale with a **pH** less than 7 are said to be acidic and solutions with a **pH** greater than 7 are basic or alkaline. Table (2) shows that the average level of PH is 8 which mean that Alaqi secondary channel water is clear and fresh.

Table 2. Alaqi secondary channel suspended matters at sec 16 and sec 19

Date	Location		Position	Time	Total Depth (m)	Transparent Seecchi (m)	Temperature (ç)		PH	D.O mg/l	E.Cμs/cm	TDS (mg/l)
							Air	Water				
26/9/2013	Sec. (19)	E	50 cm	3.15	11.85	4	35	29.0	8.18	8.1	237	151.6
			25%					--------	--------	--------	--------	--------
			50%					28.9	8.18	8.3	237	151.6
			65%					--------	--------	--------	--------	--------
			80%					28.8	8.18	8.3	236	151
		M	50 cm	3.45	27.5	4	35	29.5	8.13	8.4	237	151.6
			25%					29.2	8.14	8.4	236	151.0
			50%					29.2	8.12	8.4	238	152.3
			65%					29.2	8.15	8.2	236	151.0
			80%					29.3	8.14	8.3	237	151.6
		W	50 cm	4.30	14.4	4	35	29.9	8.05	8.4	237	151.6
			25%					--------	--------	--------	--------	--------
			50%					29.7	8.07	8.5	237	151.6
			65%					--------	--------	--------	--------	--------
			80%					29.8	8.05	8.4	237	151.6
27/9/2013	Sec. (16)	E	50 cm	12.45	7.60	3.5	30	29	8.06	7.8	239	152.9
			25%					--------	--------	--------	--------	--------
			50%					28.5	8.09	7.8	238	152
			65%					--------	--------	--------	--------	--------
			80%					28.4	8.08	7.9	238	152
		M	50 cm	11.50	43	3.5	30	29.1	7.98	7.8	238	152
			25%					28.4	7.95	7.9	238	152
			50%					28.3	7.94	7.6	238	152
			65%					28.3	7.95	7.6	238	152
			80%					27.3	7.56	5.5	240	157
		W	50 cm	11.10	7.10	3.5	30	28.7	7.93	7.9	239	152.9
			25%					--------	--------	--------	--------	--------
			50%					28.2	7.94	8	239	152.9
			65%					--------	--------	--------	--------	--------
			80%					28.1	7.95	7.9	238	152

3. DATA HANDLING AND ANALYSIS

3.1 Calculating Surface Area of Alaki Secondary Channel

Using Multi Beam Technique in hydrographic surveying of Alaki secondary channel, locations and water depths of Alaki secondary channel bed data (XYZ) were obtained. XYZ data were incorporated in Surfer to calculate the surface area of Alaki secondary channel at different W.L. Figure (4) shows the surface area of Alaki secondary channel of Lake Nasser. Equation (1) shows the relation between surface areas of Alaki secondary channel at different W.L.

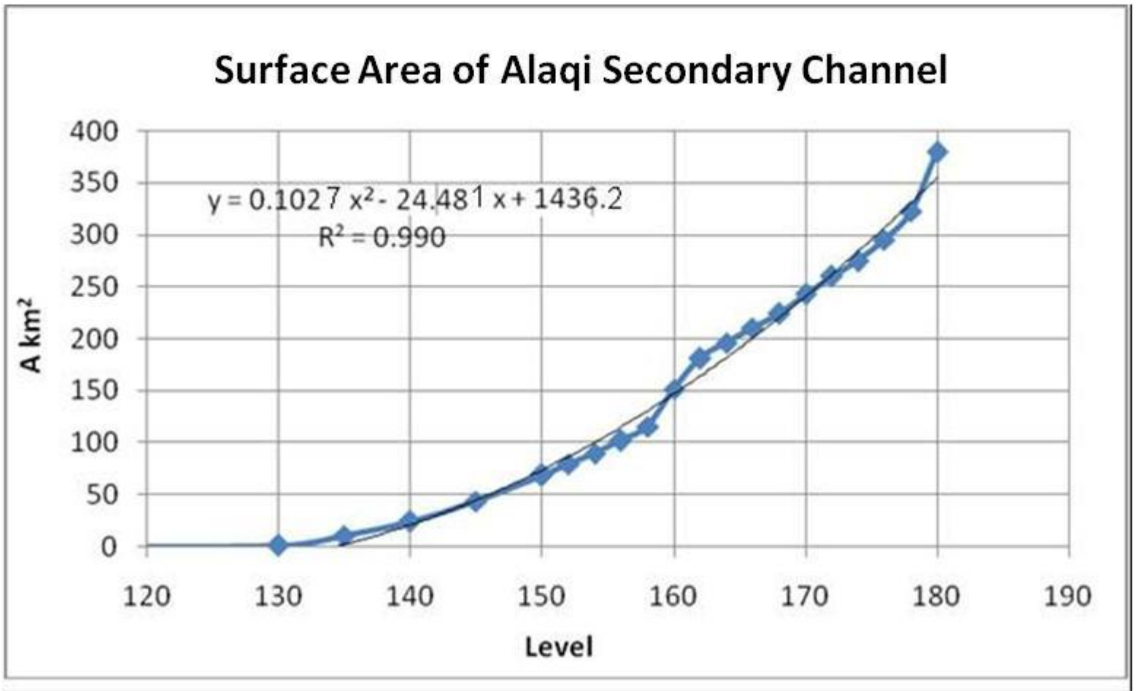


Figure 4. Surface area of Alaqisecondary channel

$$Y=-0.1027 X^2- 24.481 X+1436.2 \qquad (1)$$

Where:

Y	Surface area	(km2)
X	W.L.	(m)

3.2 Calculating the Storage Capacity of Alaki Secondary Channel

Storage capacity of the Alaki secondary channel and the relation between storage capacities at different W.L. are presented. Storage capacity of Alaki secondary channel varies between 3.38 BCM (at W.L. 165.00 m (AMSL)) and 9.25 BCM (at maximum W.L. 182.00 m (AMSL)). Figure (5), shows the relation between the storage capacity of Alaki secondary channel in (BCM) and W.L. in (M). Equation (2) shows the relation between storage capacity and water level for Alaki secondary channel.

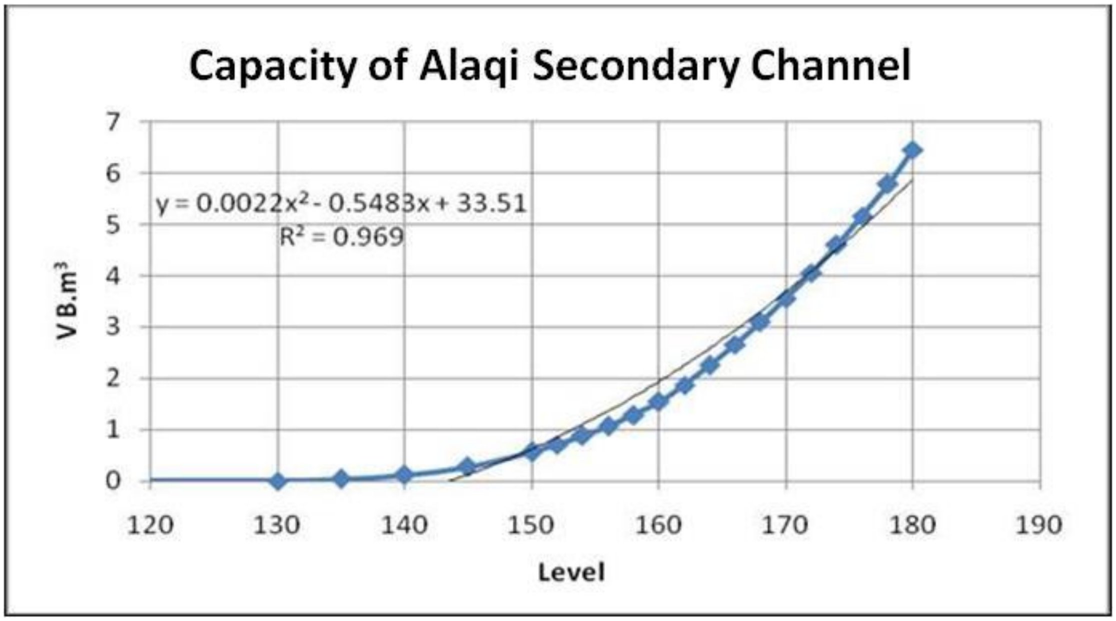


Figure 5. Storage capacity of Alaqi secondary channel

$$Y = 0.0022\ X^2 - 0.5483\ X + 33.51 \qquad (2)$$

Where:

Y	Storage capacity	(BCM)
X	W.L.	(m)

4. ESTIMATION OF EVAPORATION LOSSES

Evaporation from water surface is a continuous process affected by many meteorological parameters used in estimation of evaporation losses, the main factors effects on evaporation are temperature, humidity of the surrounding atmosphere, wind, and atmospheric pressure, all of these factors can be taken as evaporation rate. One of the most common methods used to estimate the evaporation losses based on atmospheric elements is bulk aerodynamic method, equation (3) shows the bulk aerodynamic formulae. It is found that the appropriate coefficient (N) in equation (3) equals to 0.1296 (Omar, M.H., 1981). Table (3) shows wind and evaporation rate recorded in one of metrological station in Nasser Lake.

$$E = N\ U\ (es - ed) \qquad (3)$$

E:	Evaporation (mm/day)	
N:	A constant equal to 0.1296	
U:	The wind velocity at height 2.0 m above water surface	(m/sec)
es:	A saturated vapor pressure at water temperature	(Hectopascal)
ed:	A vapor pressure of air 2.0 m above water surface	(Hectopascal)

Table 3. Evaporation rate of one metrological station in Nasser Lake

Daily Wind Conditions 2m			Daily Wind Conditions 4m			Daily
Dominant	Mean	Peak	Dominant	Mean	Peak	Evaporation
Direction	Speed	Gust	Direction	Speed	Gust	Rate
degrees	m/s	m/s	degrees	m/s	m/s	mm/day
120-150	6.320833333	10.3	120-150	6.183333	10.6	13.75688
120-150	5.354166667	10.8	120-150	5.033333	11.4	11.109311

The annual volume of the water lost by evaporation from Alaqi secondary channel was calculated based on the total yearly average of the evaporation rate from Nasser Lake, where the yearly average of the daily evaporation rate (E) reached 7.00 mm/day. The annual volume of the water lost by evaporation can be calculated using equation (4). The annual volume of evaporation losses from Alaqi secondary channel is about 0.72 billion cubic meters BCM (at W.L. 175.00 m (AMSL))

$$V = E * A \quad (4)$$

E: Yearly average of evaporation rate
A: Surface area
V: Volume

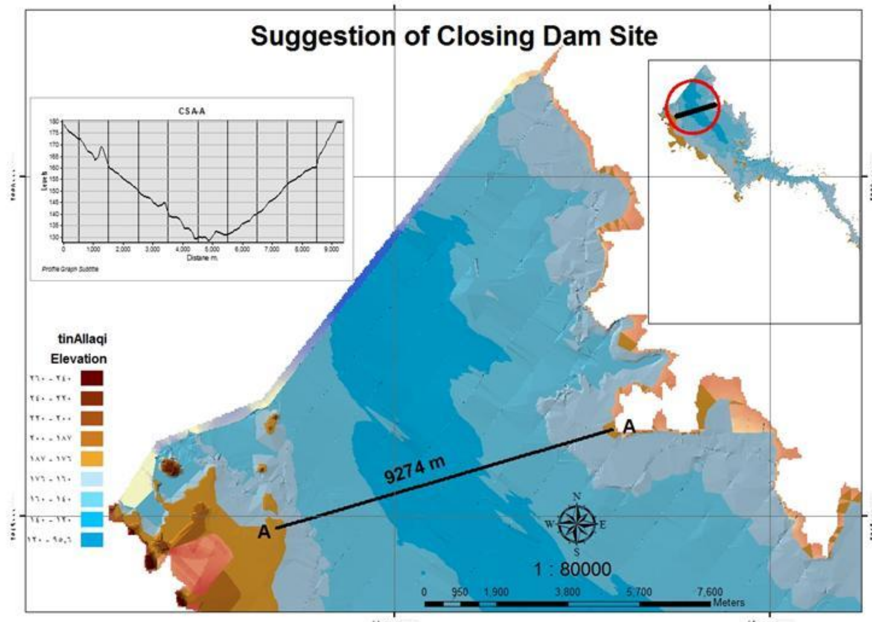
5. PROPOSED SOLUTION

The storage capacity of Alaqi secondary channel is 6.50 BCM (at W.L. 182.00 m AMSL), while the total storage capacity of High Aswan Dam Lake is 162.00 BCM (at W.L. 182.00 m (AMSL)). The storage capacity of Alaqi secondary channel is about 4 % of total storage capacity of High Aswan Dam Lake. The evaporation losses from Alaqi secondary channel is about 0.72 BCM (at W.L. 175.00 m AMSL) while the total evaporation losses from High Aswan Dam Lake is about 11.98 BCM (at W.L. 175.00 m (AMSL)).The evaporation losses from Alaqi secondary channel is about 6 % of evaporation losses from Nasser Lake. Because the evaporation losses from Alaqi secondary channel considered big, so it is proposed to close this secondary channel to reduce the evaporation losses from Nasser Lake. Also, in case of closing Alaqi secondary channel, we could consider it as a water tank.

5.1 Closing Dam Location

According to the hydro morphological studies the suitable dam site is located at the hydrographic surveyed cross section No 15, Figure (2). Using Figure (6) – and 3D bed surface Figure No (8) help us to allocate the suitable site of closing dam, as it is noticeable that, there is contraction at the entrance of the Alaki secondary channel at cross section A-A, adding to that, the selected location lies between the highest elevation topographic points. Figure (6), shows the location of dam site at cross section A – A.

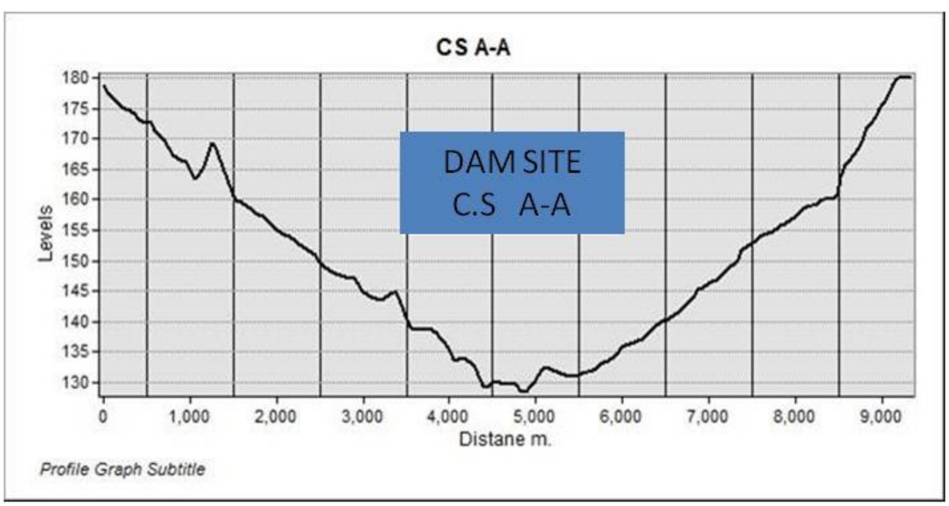
Figure 6. Location of dam site



5.2The Proposed Dam

A dam is a barrier that impounds water; the reservoirs created by dams do not only suppress floods but provide water for various needs to include irrigation, human consumption, industrial and navigation use. According to the hydro morphological studies, the base dam level is at 130 m (AMSL) and top dam level is at 183 m (AMSL), the designed dam side slope is 2: 1, the designed dam length at its top is 9247.00 m, while the designed dam width at its top is 8.00 m. Figure (7) shows the cross section at dam site location, while figure (8) shows the designed dam.

Figure 7. Cross section A – A at dam site location



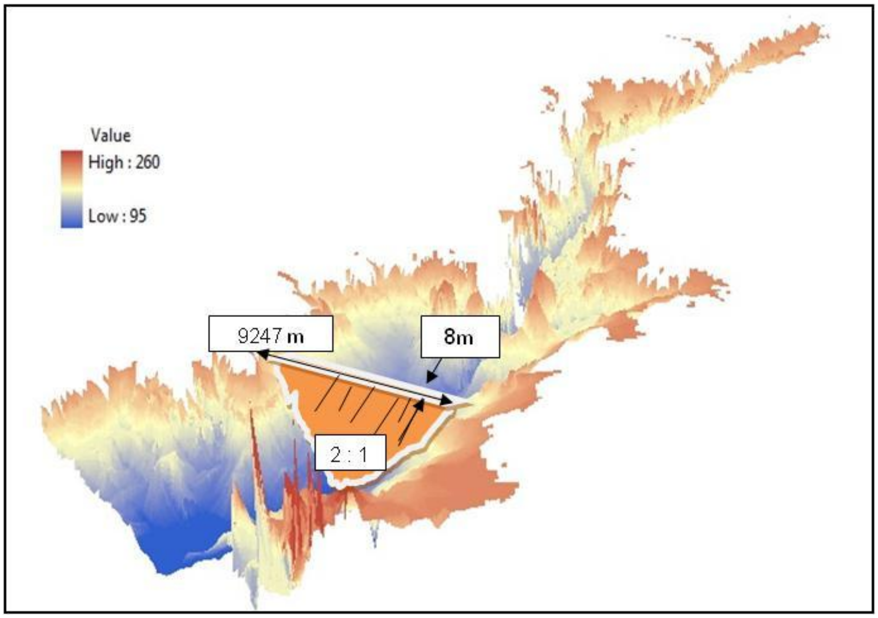


Figure 8. The designed dam

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Lake Nasser/Nubia studies have been included in many researches to give the required information to the decision makers about the major water tank for both Egypt and Sudan. Lake Nasser Has hundreds of secondary channels, one of the largest secondary channels that have never been surveyed for long time is Alaqi secondary channel. Alaqi secondary channel was surveyed recently, it is located at about 110 km upstream High Aswan Dam, on the eastern side of Nasser Lake.

The storage capacity of Alaqi secondary channel is 6.50 BCM (at W.L. 182.00 m (AMSL)), the storage capacity of Alaqi secondary channel is about 4 % of total storage capacity of Nasser Lake. The evaporation losses from Alaqi secondary channel are about 0.72 BCM (at W.L. 175.00 m (AMSL)), the evaporation losses from Alaqi secondary channel is about 6 % of evaporation losses from Nasser Lake. It is proposed to close this secondary channel to reduce the evaporation losses from Nasser Lake. Finally, it could be concluded that:

- Closing Alaqi secondary channel could reduce the evaporation losses from Nasr Lake.
- The designed dam bed level is 130 m (AMSL), its top level is 183 m (AMSL).
- The designed dam length is 9247.00 m at its top and its width is 8.00 m, while its designed side slope is 2: 1.
- Alaqi secondary channel bed material can be classified as medium to fine sand, where its D_{50} is equal to 0.17 mm.
- The velocity is very low inside Alaqi secondary channel, where the average velocity is about 0.10 m/s.

- Alaqi secondary channel water is clear and fresh because the average value of DO is 8 ppm, TDS value is 150 mg/l and the average value of PH is 7.50.

6.2 Recommendations

- Charring out at least one pore hole at dam site for define soil characteristics.
- Alaki secondary channel should be kept clear from any random development.
- Studying of Alaki secondary channel regarding to fishing, irrigation, navigation, and recreation areas.

7. NREFERENCES

Abu Atta, A., (1978), "Egypt and the Nile after the High Aswan Dam", Ministry of irrigation, Egypt.

Bob Booth, (2001), "Using Arc GIS 3D Analyst”, copyright 2001, ESRI.

Mohamed I.S. El_Azhary, (2009), "Practical Applications in GIS", Dar Elma'refa, Ain Shams, Cairo, Egypt.

Nile Research Institute, (2013), "Lake Nasser Secondary Channel Study", Nile Research Institute, National Water Research Center, Egypt.

Public Authority of High and Aswan Dams, (1973-2011), "Annual Reports of General Department of Hydrology, Egypt.

RedaM.A.Hassan, Nasr T.H. Hekal, Nader M.S. Mansor, (2007), "EvporationResuction from Lake Naser Using New Environmentally Save Techniques", IWTC11 2007 Sharm El-Sheikh, Egypt.

Waleed E. Hassan, (2015), "Impacts of Upper River Nile Projects on Lake of High Aswan Dam", Ph D, Faculty of Engineering, Al-Azhar University, Egypt.