STUDY OF ALAQI SECONDARY CHANNEL IN LAKE NASSER

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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 while the others are very wide, extended and deep. One of the largest secondary channels that have not been surveyed for a long time is Alaqi Secondary channel. It is located at about 110 km upstream the High Aswan Dam on the eastern side of Nasser Lake. A field mission to explore Lake Nasser secondary channels was carried out in October, 2013. The main purpose of the mission was to collect all related data and develop bathymetric charts for Nasser Lake secondary channels within the Egyptian borders. The annual evaporation losses from Alaqi secondary channel was estimated to be about 0.72 BCM (at average W.L. 175.00 m (AMSL)), which represents about 9 % of the total 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 objective of this study is to study the effect of closing Alaqi secondary channel on evaporation losses from Lake Nasser.

Keywords: Lake Nasser, Alaqi secondary channel, Evaporation losses
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1 INTRODUCTION

Lake Nasser in Upper Egypt is of a great importance for Egypt as it represents a large reservoir for the country's freshwater resources. Precise studying of all elements contributing to the water balance of Lake Nasser is very crucial for better management of Egypt's water resources. Evaporation is considered an important factor of the water balance system that causes a huge loss of the lake's waters. In this study, evaporation rate for Lake Nasser is estimated using the bulk aerodynamic formulae.

It is very important to have sufficient information about Lake Nasser secondary channels and its characteristics. These characteristics include discharges, water levels, environment, meteorological data, topography, and other factors. Bed topography is one of these factors that have not been surveyed since Lake Nasser secondary channels 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 not been surveyed is Alaqi Secondary channel. Figure 1 shows Alaqi Secondary channel.

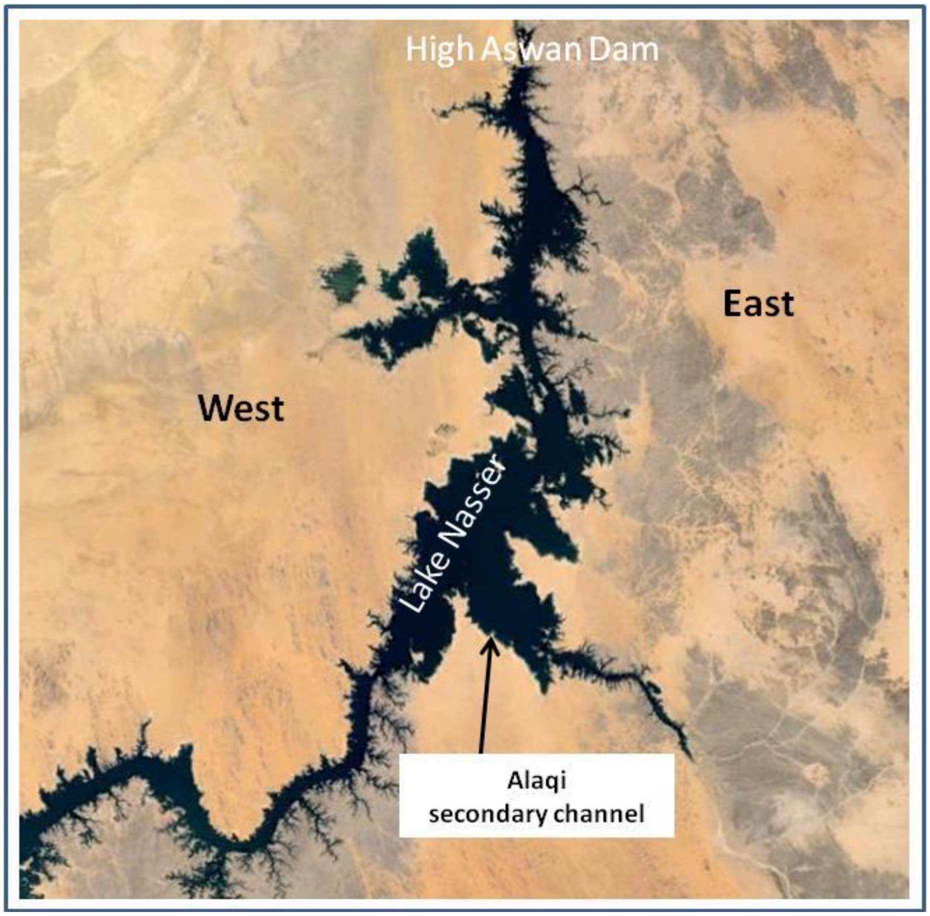

Figure 1. Alaqi secondary channel

A field mission to Lake Nasser secondary channels was carried out in October, 2013. It aimed to collect all hydrological data and to develop bathymetric charts for Lake Nasser secondary channels in Egypt. The bathymetric charts gave a complete picture about the historical development of deposition in Lake Nasser secondary channels. A field trip was done using multi beam eco-sounding system. Dense bathymetric data were collected. The surveyed cross sections were collected in an average space of one kilometer.

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 surveyed cross sections.

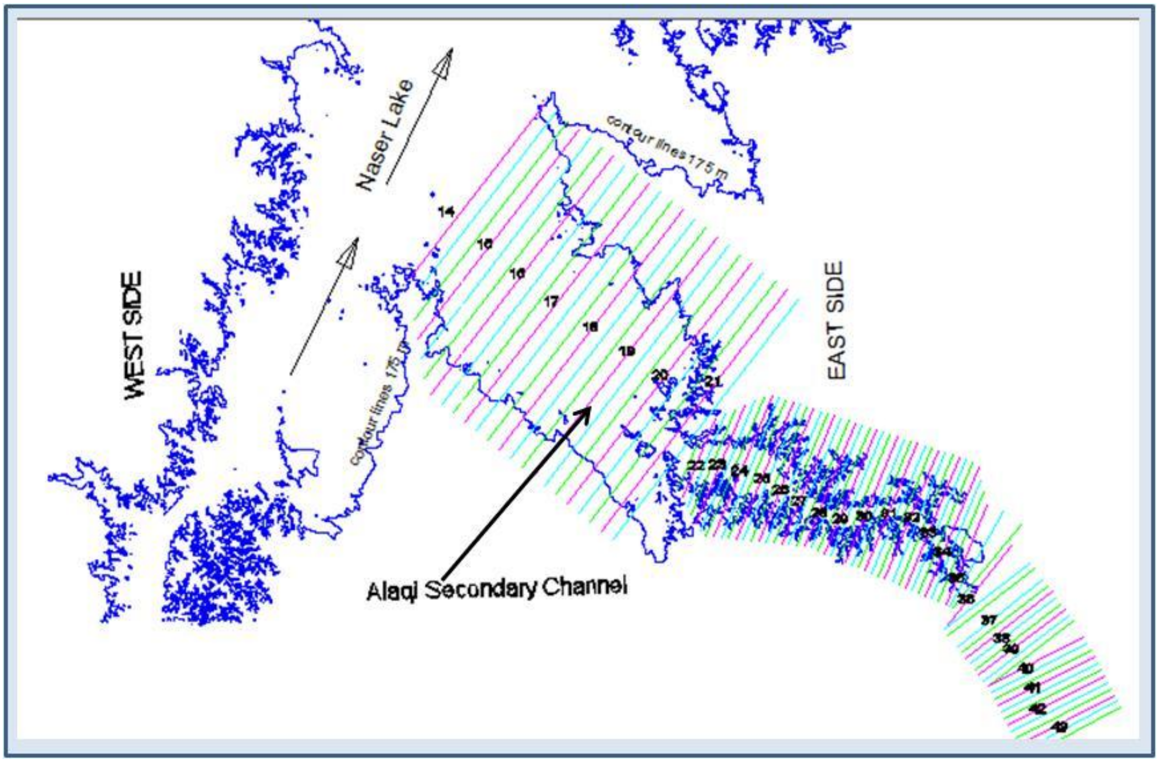

Figure 2. Alaqi secondary channel surveyed cross sections

2 DATA COLLECTION

2.1HydrographicSurvey

Three Hydrographic Survey Teams were assigned to collect hydrographic data. Cross sections were planned and geo-referenced throughout Alaqi secondary channel. 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.

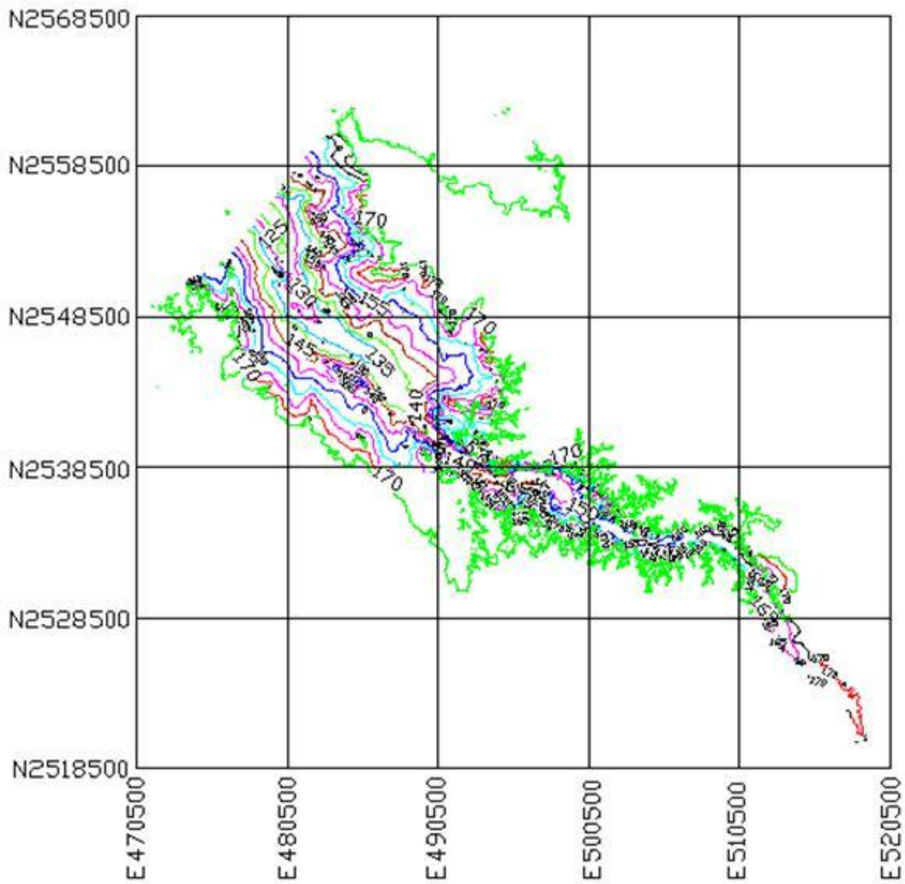

Figure 3. Shows Alaqi secondary channel contour map

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. Figure3 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 studying the process of delta formation in Lake Nasser Secondary Channels. Table 1 shows Alaqi secondary channel bed material samples. As shown in table 1, the average size of D50 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 Coarse	% Sand Medium	% Sand Fine	% Sand Total	%Silt Coarse	%Silt Medium	%Silt Fine	%Silt Total	% Clay	Classification
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 about 0.10 m/s.

2.4 Dissolved oxygen and total dissolved solids

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. Table2 Shows Alaqi secondary channel dissolved Oxygen and total dissolved solids at sec 16 and sec 19. The average level of DO is 8 ppm which means 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 150mg/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 dissolved Oxygen and total dissolved solids 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 Alaqi Secondary Channel

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

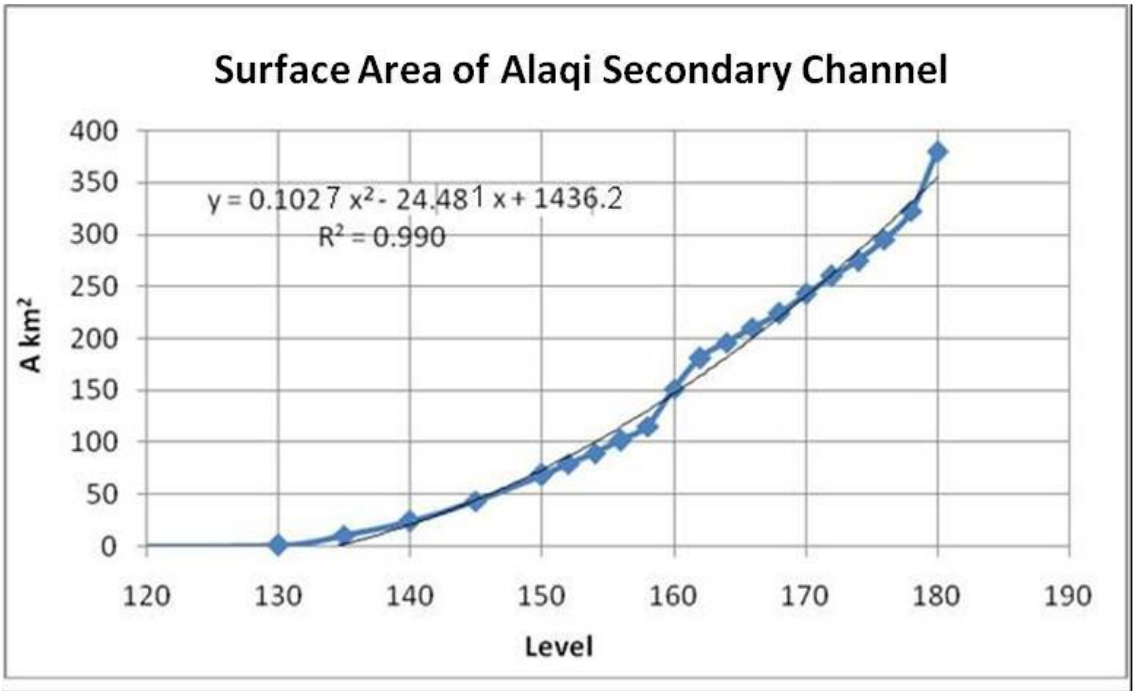

Figure 4. Surface area of Alaqi secondary channel

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

Where:

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

3.2 Calculating the Storage Capacity of Alaqi Secondary Channel

Storage capacity of the Alaqi secondary channel and the relation between storage capacities at different W.L. are presented. Storage capacity of Alaqi secondary channel varies between 3.38 BCM (at average 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 Alaqi secondary channel in (BCM) and W.L. in (M). Equation (2) shows the relation between storage capacity and water level for Alaqi secondary channel.

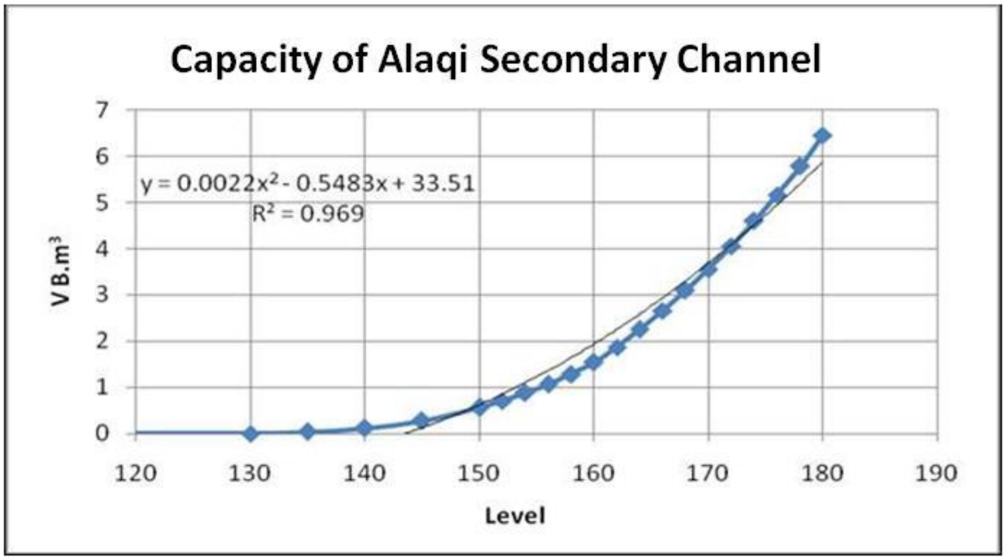

Figure 5 Storage capacity of Alaqi secondary channel

$Y = 0.0022 X^2 – 0.5483 X + 33.51$ (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 affect on evaporation are temperature, humidity of the surrounding atmosphere, wind, and atmospheric pressure. 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. Table (3) shows wind and evaporation rate recorded in one of metrological station in Lake Nasser.

$E = N U (es – ed)$ (3)

E:	Evaporation (mm/day)	
N:	A constant equal to 0.1296 (Reda M.A., 2007)	
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 Lake Nasser

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 Lake Nasser, where the yearly average of the daily evaporation rate (E) reached 7.00 mm/day (at average water level equal 175.00 m AMSL) (Waleed E. Hassan, 2015). 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 average water level equal 175.00 m AMSL).

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

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 8.06 BCM (at average water level equal 175.00 m (AMSL)), (Waleed E. Hassan, 2015). The evaporation losses from Alaqi secondary channel is about 9 % of evaporation losses from Lake Nasser. 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 Figures (6, 7 and 8) help us to allocate the suitable site of closing dam, as it is noticeable that, there is contraction at the entrance of the Alaqi 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.

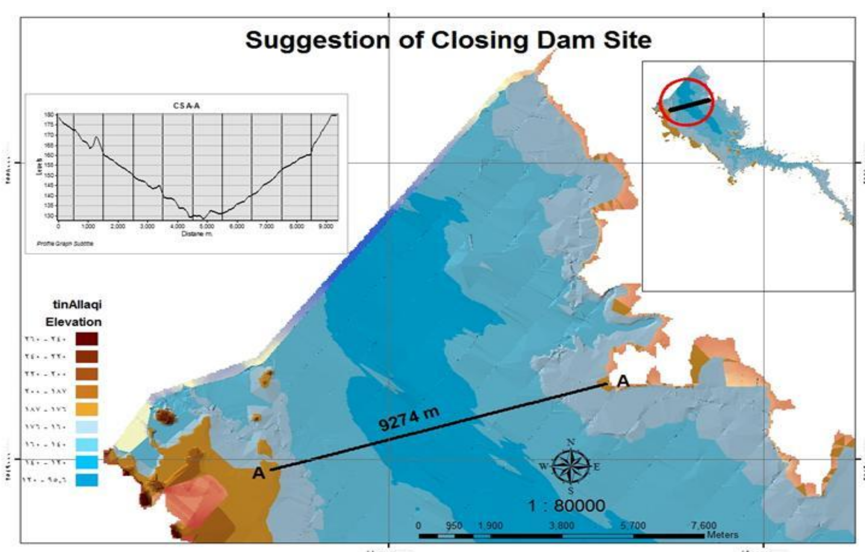

Figure 6. Location of dam site

5.2 The 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 proposed dam.

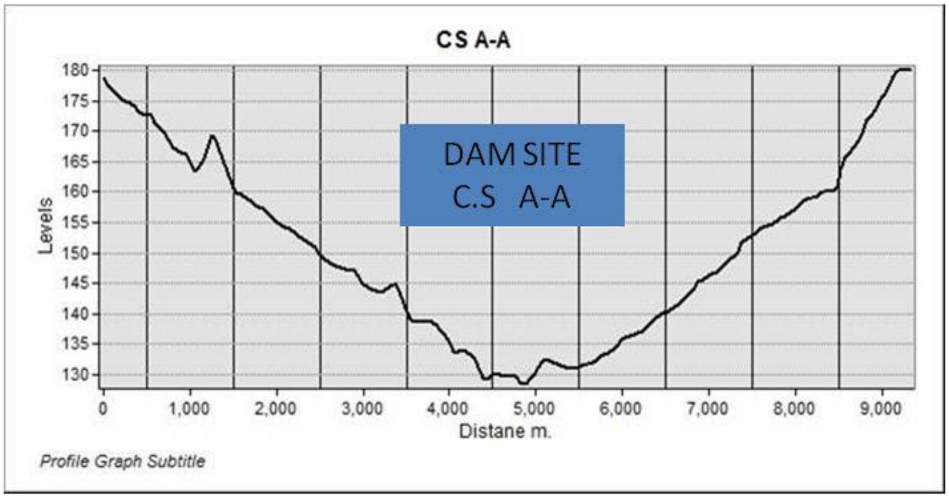

Figure 7. Cross section A – A at dam site location

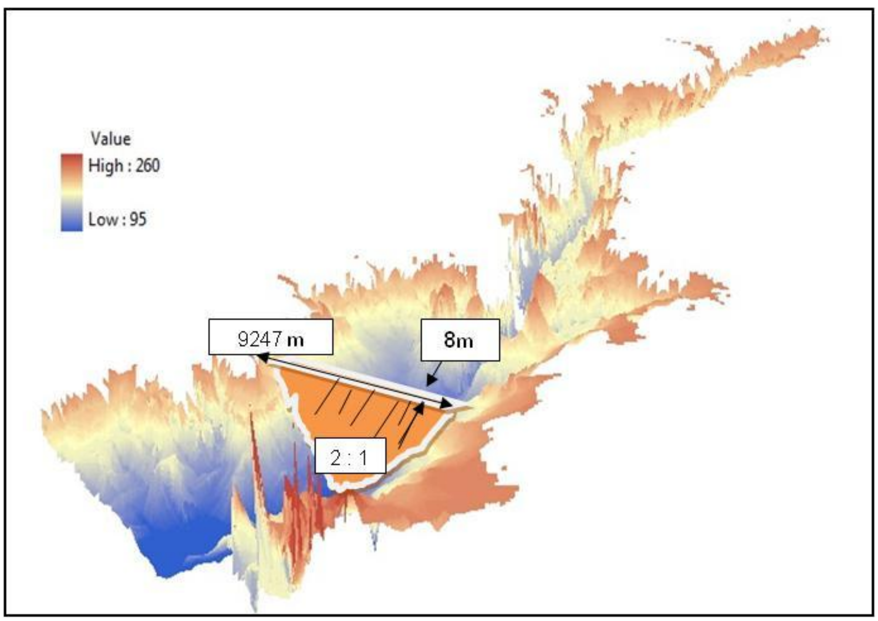

Figure 8. The proposed dam

CONCLUSIONS AND RECOMMENDATIONS

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 Lake Nasser.

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 Lake Nasser. 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 9 % of evaporation losses from Lake Nasser. It is proposed to close this secondary channel to reduce the evaporation losses from Lake Nasser. Finally, it could be concluded that:

1. Closing Alaqi secondary channel could reduce the evaporation losses from Lake Nasr.
2. The proposed dam bed level is 130 m (AMSL), its top level is 183 m (AMSL).
3. The proposed dam length is 9247.00 m at its top and its width is 8.00 m, while its side slope is 2: 1.
4. Alaqi secondary channel bed material can be classified as medium to fine sand, its D50 is equal to 0.17 mm.
5. The velocity is very low inside Alaqi secondary channel, where the average velocity is about 0.10 m/s.
6. 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.
7. The proposed dam needs more investigation about the environment impact assessment (EIA) in future research.
8. It seems that the total cost of dam construction is so high which needs deep investigation about its feasibility.

Recommendations

- Further research is needed for this subject.
- Carrying out at least one pore hole at dam site for define soil characteristics.
- Alaqi secondary channel should be kept clear from any random development.
- Studying of Alaqi secondary channel regarding to fishing, irrigation, navigation, and recreation areas.

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