THE NILE AND THE HIGH DAM
(An Analytical Study)

Prof. Hammad Y. Hammad

Faculty of Engineering, Alexandria University

1. Correction of Nile Records

ABSTRACT

The capacity of the High Aswan Dam and the regulation of its levels have been based on the Nile records of the period 1870-1954.

The accuracy of the Nile discharge records for the period 1902-1954 is rather high, whereas the accuracy of the former period 1870-1902 is doubtful. The author discovered that the records of this latter period have been affected by bed degradation behind the Low Aswan Dam built in 1902. This leads to a correction of the Nile records for the period 1870-1902 and including this period in the records of the present century raises the mean annual discharge from 84×10^9 to 86×10^9 m^3.

The extra $2 \times 10^9 m^3$ may be used to cultivate 1 million

acres of land if modern economical methods of irrigation are adopted.

The stratch of the river course receiving the furtile silt deposits lies partially in the Egyptian and partially in the Sudanese territory. This silt may be dreged to the opposite banks of the river where an "Integrity Province" may be reclaimed and supported on the extra amount of water obtained in the capacity of the High Aswan Dam.

Introduction

It is well known that the capacity of the High Dam and its regulation have been based on the Nile records of the period 1870-1954, a total of 85 years.

Although the Nile discharge records of the period 1902-1954 were directly measured in concrete basins built behind the sluices of the Low Aswan Dam built in 1902, their accuracy is thus rather high, yet the discharges of the period 1870-1902 were extracted from gauge-discharge curves constructed for the Aswan gauge much later in the thirtys.

The doubts in the records of the earlier period 1870-1902 have been increased since their average is much higher than the records of the more reliable period of direct measurement 1902-1954 Fig.(1). The yearly average discharge in the earlier period being 109×10^9 m^3, falling to $83\times10^9 m^3$ only in the latter period.[1]

One may exclaim, is it a drop in the rate of rain on the upper sources of the Nile in Central Africa, or is it an Artifcial Dam constructed on the Nile that has changed its rate of flow?

We should not forget that the aridness and famine spreading at present in Central Africa, has caused the Nile Discharge to drop in 1984 to only $40x10^9 m^3$ reaching Aswan at $34x10^9 m$ after subtracting the Reservoir losses.

This situation made me believe that a full revision of the doubtful records of the period 1870-1902 is worthwhile, since this will have a great impact on the regulation of the High Aswan Dam, particularly if more aridness is expected in Central Africa, where the sources of the Nile exist.

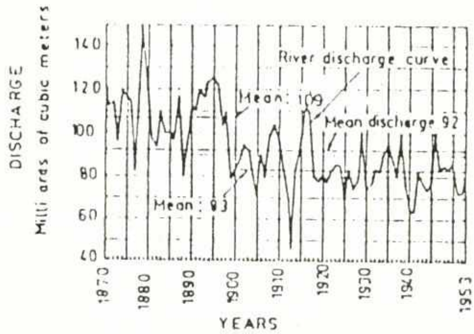

Fig. (1) Nile Discharge Records according to Vob.(10), Nile Basin (Ministry of Irrigation, Cairo) in mlds m^3 per anum.

The beginning of the 20^{th} century has seen the rise of the Low Aswan Dam built in 1902 to which the drop in the Aswan discharges may be attributed to one or both of the following two reasons:

1. Reservoir losses by evaporation, absorption and seepage.

2. Bed degradation behind the dam that affects the gauge discharge records.

1- Storage Losses in The Low Aswan Dam Reservoir

A good estimate for such losses ~~is~~ obtained by measuring the Nile discharge at Halfa, the tail of the resrvoir, and at Aswan. Current meter measurements started at Halfa, since 1921, but Aswan measurements started in 1902 in concrete basins. The accuracy of the loss figures depends on the accuracy of both measurements.

Hurst[2] concludes that the average yearly loss for the period of 24 years between 1921 and 1952 amounted to 0.5×10^9 m^3 and this is the most reliable record for the period before planning for the High Aswan Dam.

Adding the losses at Sennar Dam built in 1929 which amount to 0.28×10^9 m^3, we may conclude that both reservoir losses do not explain the drop of 24 % of the average Nile discharges between the 19^{th} and 20^{th} century records Fig. (1).

2- Effect of the Bed Degradation Behind The Low Aswan Dam

The river bed between the Low Aswan Dam and the Aswan City, (about 6-8 kms) is composed of non-erodible granit rocks, the river bed northwards is composed of erodible sand. Hurst[3] has noticed that the phenomenon of tail erosion has reached Aswan gauge after the 2nd heightening of the Low Aswan Dam in 1932. The following quotation written by Hurst appears in "The Nile Basin, Vol (4) 1933, Ministry of Irrigation, Cairo."

"Discharges of The River Nile at Aswan, About 946 Kilometers Upstream of The Delta Barrage

For the years 1869 to 1902 the discharges have been deduced from a general gauge-discharge table which has been constructed from the Aswan downstream gauge readings and the discharges measured by the sluices of the Aswan dam in the years 1903 to 1927. A comparison of the relation between Aswan and Wadi Halfa gauge readings before and after the completion of the Dam in 1902 shows that the Aswan gauge readings in the flood period are about 30 cms. lower in comparison with Wadi Halfa readings after 1902 than they were before.

This lowering of Aswan downstream gauge readings since the building of the dam is indicated also by the comparison of Delta Barrage and Roda gauge readings with those of Aswan. It is therefore probable that the discharges given for the period 1869 to 1902 are too high during the flood stage by about 8 %.

A comparison of the low stage readings is impossible owing to the regulation of the reservoir".

From this quotation we may conclude that the Nile bed at Aswan has dropped 30 cms due to the $2^{\underline{nd}}$ heightening of the Low Aswan Dam.

A similar effect in the Nile bed has happened behind the Sennar Dam on the Blue Nile, where the degradation depth reached 150 cm at only 1.760 km behind the dam and extended to about 150 kms[4].

This may show how false the discharge records, based on gauge-discharge records, may be, particularly those extracted from gauges downstream Dams and hydraulic structures in general.

Roda Gauge Records

In order to avoid the degradation effects on the gauge discharge estimates, we may resort to gauges far behind the Aswan Dams such as the Roda gauge. As a matter of fact this particular gauge has recorded readings since the $7^{\underline{th}}$ century A.D., and this, in itself, is a great help in the study of over-year storage or century storage in the High Aswan Dam reservoir.

As a matter of fact the Roda gauge registers the highest water level attained during the flood, which may be correlated to the flood discharge covering the 6 flood months, August through January. As a matter of fact the flood discharge represents 80% of the discharge of the whole year in the average. Therefore we may safely correlate the yearly Nile discharge, and the highest record of the water level attained on the Roda gauge.

Again, it will be proved in Appendix (1) of this work, that the relation between Aswan discharge and Roda discharge is a linear relationship. Therefore we may relate the Aswan discharge Q to the Roda level H directly.

On Fig. (2), a plot of Q against H is shown for the 2 periods 1870-1902 and 1902-1964. The discharge Q for the first of those 2 periods has been taken from Vol. 10 of the Nile Basin (Ministry of Irrigation, Cairo 1968)[1], and this is exagerated since it has been deduced from Aswan gauge-discharge readings after the Aswan river bed has been eroded. The discharges of the second period 1902-1964 are rather accurate since they have been directly measured in concrete tanks built behind the Low Aswan Dam (1902).

The exageration of the first period discharges (1870-1902) is manifested in Fig. (2) since their points (open dots) all lie above those of the second period (1903 - 1964) (represented by closed dots in the figure).

There is a scatter of points in both periods since this is a natural phenomenon, of course.

The Aswan discharge Q will be correlated to the Roda level H by a cubic eqn., of the form

$$Q = AH^3 + BH^2 + CH + D \qquad (1)$$

The constants A,B,C,D of this eqn. are obtained by a computer program based on the records of the rather exact period (1902-1964). This leads to

$$Q = 0.47\ H^3 - 24.19\ H^2 + 421.65\ H - 2421.83 \qquad (2)$$

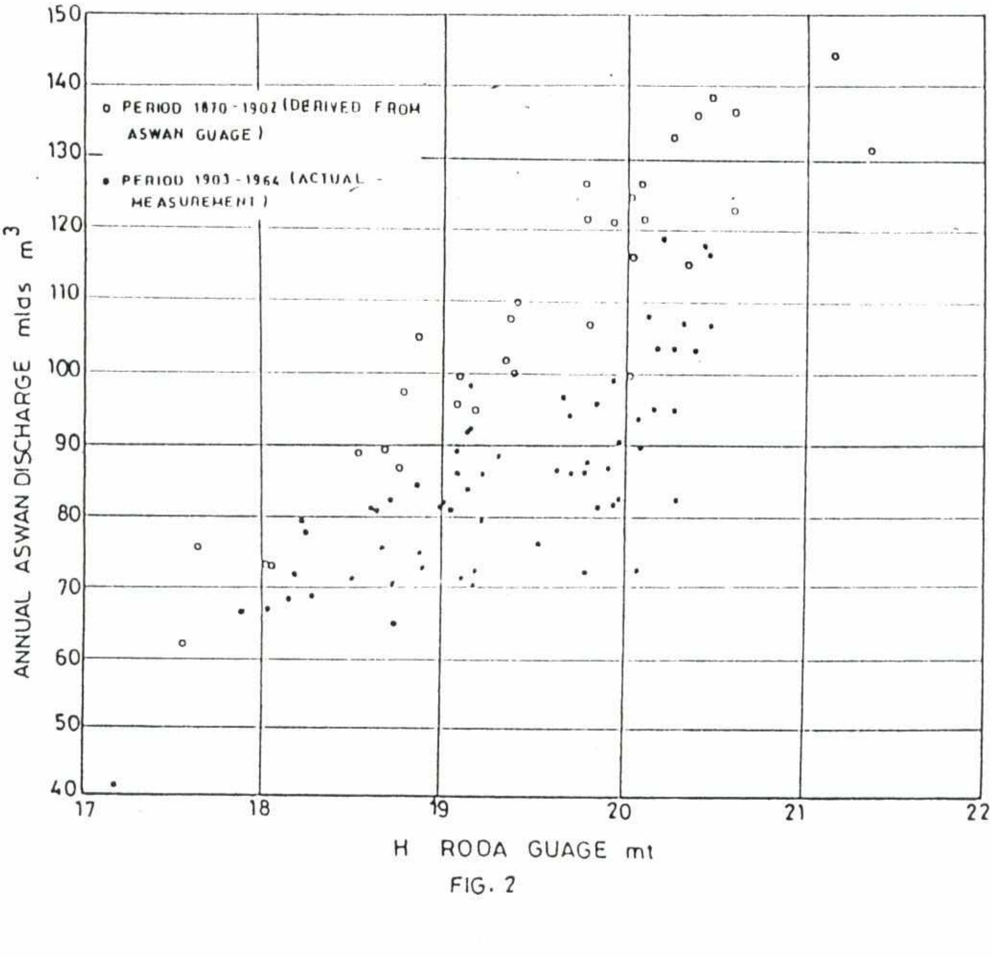

FIG. 2

Table (1) gives the records of the corrected period 1870-1902 according to Eq.(2)

Table (1): Corrected discharges of the period 1870-1902

Hyd. year	Erroneous Q mlds m /year	Corrected Q mlds m /year	Hyd.Year	Erroneous Q mlds m /year	Corrected Q mlds m /year
1870-71	131	103.71	1888-89	74	71.66
1871-72	106	92.38	1889-90	99	86.24
1872-73	121	96.08	1890-91	118	92.05
1873-74	90	76.09	1891-92	108	85.96
1874-75	125	129.95	1892-93	131	108.25
1875-76	121	97.78	1893-94	109	85.50
1876-77	111	102.63	1894-95	133	105.71
1877-78	75	68.80	1895-96	122	97.21
1878-79	150	125.22	1896-97	122	92.05
1879-80	129	100.75	1897-98	92	81.83
1880-81	99	79.32	1898-99	118	94.81
1881-82	97	96.45	1899-1900	63	68.24
1882-83	99	78.47	1900-1901	90	77.45
1883-84	111	96.45	1901-1902	4	78.26
1884-85	98	83.18	-- ---		
1885-86	97	85.27	Mean	109. 0	91.50
1886-87	102	82.07			
1887-88	115	108.25			

The corrected values of the Nile discharge for the period 1870-1902 are plotted on Fig. (3), together with the reliable period 1903-1964. It is obvious from this figure that the corrected period (open dots) lie within the reliable period (closed dots). The rather deterministic results of the corrected period according to Eqn (2)is

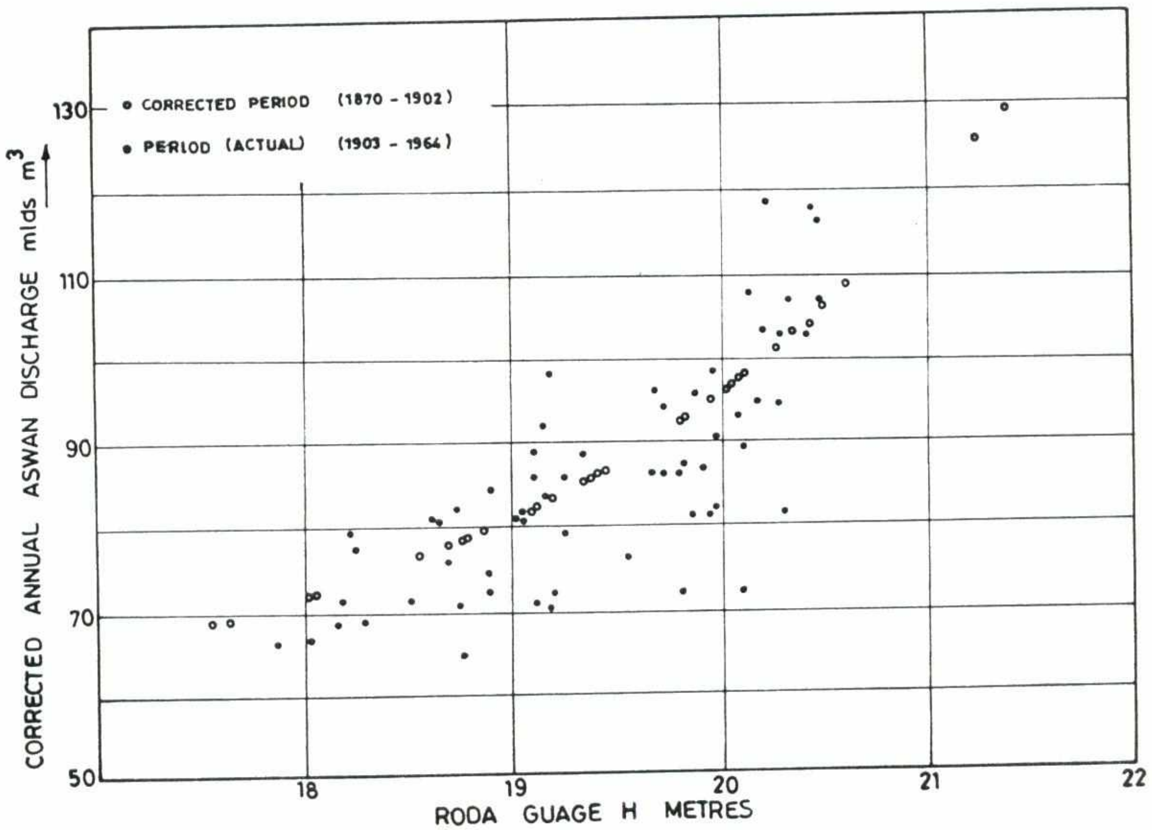

FIG. 3 - CORRECTED ANNUAL ASWAN DISCHARGE

subject to an error of $\pm$ 4.85 %, according to calculations based on the theory of probability. The open dots in Fig. (3), as well as the values of Q in Table (1) represent the average values of Q subject to an error of $\pm$ 4.85. Plotting the Nile discharges at Aswan for both periods 1870-1954 after correcting the period 1870-1902 we get the curve shown in Fig. (4), from which the mean of the first period is 91×10^9 m^3/year, while that of the second period is 83×10^9 m^3/year, the total average is 86×10^9 m^3year.

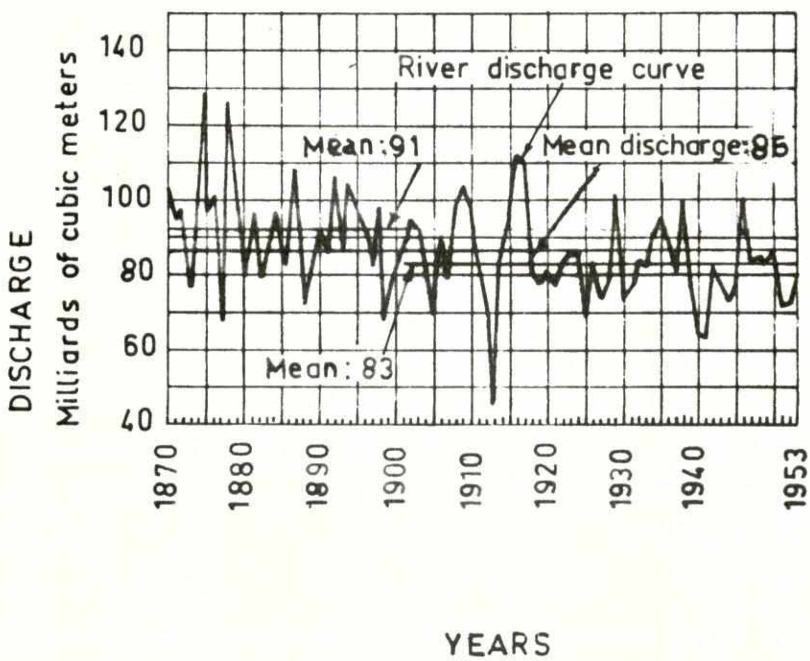

FIG. 4 - DISCHARGE AT ASWAN

Recent corrections by a UNDP program [5] for the period 1870-1902 came almost to the same conclusion as that of Hurst[3].

The 1913 Flood is a Real Fact

This year came after the completion of the first heightening of the Low Aswan Dam in 1912. The Nile discharge in the year 1913-14 droped to its lowest recorded value of only $42x10^9 m^3$/year. This drop may be attributed to the extra losses in the recently heightened dam. But the reservoir losses even in the High Dam reservoir, accurately measured at present [6], does not show that the Nile discharge may fall to almost 50 % of its average discharge as it did in 1913. So the 1913 discharge, is in the writter's opinion a real fact.

However, the exceptionally low flood of 1913 has been compensated by relatively high floods of $119x10^9 m^3$ in 1916 and $117x10^9$ in 1917.

The author, therefore believes that the aridness prevailing now on Central Africa may be well compensated by heavy rain in the next few years, as we saw in the Nile floods of 1913, 1916 and 1917.

Zones of Silt Deposition in The High Aswan Dam Reservoir

Investigations [7] show that the suspended matter in the Nile flood is composed of fine sand (30%), silt (40%) and clay (30%) of the total load. As the flood water enters the tail of the reservoir lake in the south, the heaviest of these constituents (fine sand) starts to settle followed by silt and then clay at a later place northwards. Fig. (5) shows the zones of silt deposition at places lying in the course of the river on the Egyptian Sudanese borders. The middle and northern parts of these deposits represent the most fertile soil that has made Egypt all over the ages.

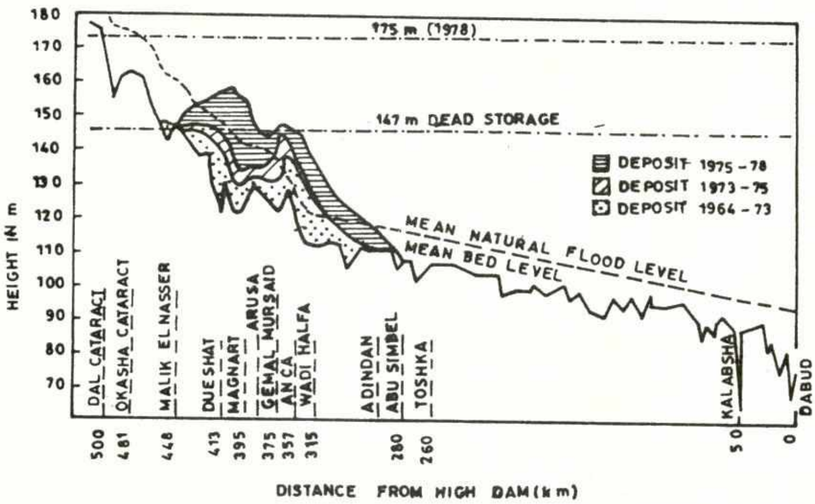

FIG. 5 - DEPOSITION OF THE NILE SEDIMENT IN THE HEADWATERS OF LAKE NASSER (AFTER MANCY AND HAFEZ, 1979)

CONCLUSIONS

The correction of the Nile discharge records for the period 1870-1902 and including this period in the records of the present century raises the mean annual discharge from $84x10^9$ to $86x10^9 m^3$.

The extra $2x10^9m^3$ may be used to cultivate 1 million acres of land if modern economical methods of irrigation are adopted.

The stretch of the river course receiving the fertile silt deposits lies between Abu-Simbel north to about a 100 km south of this site. This silt may be dredged to the banks of the river. This stretch of fertile silt deposits lies partially in the Egyptian and partially in the Sudanese teritory.

On the Egyptian-Sudanese borders lies the most fertile silt deposits that have accumulated in the tail of the High Dam Reservoir lake since the closure of the Dam in 1964. These deposits may be dredged out to the opposite banks of the lake in the same site. Here is also an extra amount of annual water storage of $2x10^9m^3$ in the reservoir lake itself, as obtained in this work.

On those two elements, soil and water, an "Integrity Province" may be reclaimed on the Egyptian Suddanese borders.

Here is a real chance for agriculturists to excercise their skills in choosing the suitable plantations (mainly fruits and vegetables) and for irrigation engineers to adopt the most economical methods of irrigation suitable for such plantations.

The products of such province may cover the present deficit in food production in both Egypt and Sudan.

More over the transportation of these agricultural products either to the north or to the south may be carried out by navigation in the Nile river itself.

By the "Integrity Province" on the Egyptian-Sudanese borders we hit two targets simultaneously:

1. Utilization of the fertile Nile silt deposits in the same site, this stratigic material that has made the soil of Egypt all over the ages.

2. Utilization of the extra Nile water, over that stated in the Nile water aggrement, for the benifit of both brother countries, Egypt and Sudan.

Appendix (1): The Relation Between Aswan Discharge and Roda Discharge is a Linear One

The discharge passing Roda is less than that passing Aswan by an amount equal to the abstraction of Upper Egypt which depends on the flood height, particularly in the period 1870-1902 during which the basin irrigation system was predominent all over Egypt. Therefore the abstraction of Upper Egypt may be taken proportional to

$$(Q_A - Q_o)$$

where Q_A is the Aswan discharge in the normal years, whereas Q_o is the minimum Aswan discharge that may not inundate Upper Egypt. Therefore we may write the following equation for the Roda discharge Q_R related to Aswan discharge Q_A.

$$Q_R = Q_A - C(Q_A - Q_o)$$

C being a constant of proportionality.

$$\therefore \quad Q_R = (1-C)\ Q_A + C\ Q_o$$

which proves the linear relationship between Aswan and Roda discharges.

Appendix (2): The Roda Discharge is a Cubic in The Water Level H

Since the water discharge crossing any section of the river is equal to the product of the cross-sectional area of the water section times the mean velocity. The mean velocity has been proved by Hurst[4] to be proportional to the mean water depth at different sections of the River Nile . Also since the area of the water section is equal to the mean depth times the surface breadth which increases linearly with the depth, therefore the discharge Q is a cubic in the water level H. The Aswan discharge Q_A may then be related to the Roda gauge H by a cubic eqn. of the form.

$$Q_A = AH^3 + BH^2 + CH + D$$

The constants A,B,C & D have been obtained by a computer program applied to the Aswan discharges Q_A and the Roda gauge level H for the period 1902-1964 to Obtain Eq. (2) appearing in the text.

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