WATER QUALITY ANALYSIS OF WATER STRUCTURES PROJECTS CASE STUDY: NEW NAGA HAMMADI BARRAGE IN EGYPT

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ABSTRACT

In the frame of the Environmental Impact Assessment for the New Naga Hammadi Barrage project, a number of adverse impacts have been identified and relevant mitigation measures have been defined, evaluated and proposed. The water quality program has included initial review of environmental studies and essential data on water quality of the Nile River in the study area. Possible nuisances to quality of the water resources related to the construction and operation of the New Naga Hammadi Barrage are studied. The water quality program presented in this paper extends over the pre-construction and construction periods and includes also the long term operational phase of the new barrage. This paper includes four sections concerned with the status of water quality within the project affected area; environmental issues related to water quality; monitoring program; and recommendations. The paper concludes that none of the physical and chemical parameters monitored in the Nile River exceed national and international standard values for raw water to be used for drinking water, or drinking water itself.

INTRODUCTION

The New Naga Hammadi Barrage Barrage *NNHB* will be located some 3,500 m downstream of the existing structure in a confined reach of the river and where geologic conditions enable the establishment of a large construction pit in the river with a depth of 25 m below river water level. The New Barrage consists of a navigation lock, a sluiceway with 7 vents and a run-of-river hydropower plant with bulb turbines and an installed capacity of 64 MW. A full Environmental Impact Assessment was performed, comprising detailed surveys in the fields of agriculture, irrigation and drainage, wildlife and fisheries, land tenure, groundwater, upstream infrastructure, public health, sanitation and water supply.

After studying various alternatives, Egypt has decided to construct a multipurpose barrage to guarantee the supply of irrigation, to generate hydropower, and to increase the navigation capacity for river traffic (**Figure 1**). New Naga Hammadi Barrage *NNHB* will consist of a sluiceway to evacuate emergency flood release, a double navigation lock and a road bridge.

The existing Naga Hammadi Barrage is located on the River Nile in Upper Egypt 360 km downstream of Aswan Dam and 135 km north of the city of Luxor. The existing barrage (**Figure 2**) was constructed from 1927 to 1930 to provide water for irrigation, and also to facilitate navigation in the reach in the reach of Naga Hammadi.

Figure 1. Water levels will be raised by 4m

Since water quality issues are related in logical sequence to both water supply and health, one task of the activities related in the Environmental Impact Assessment EIA is to determine needs for necessary investigations which would help to minimize any possible negative effect. To simplify implementation, it is organized according to the following six fields of activity or "Programs" based on the impacts and mitigation measures identified in the EIA: communication & coordination, land acquisition & compensation, engineering & hydrology, fisheries, agriculture and health. The paper has been set up with the intent of providing a record of data for further comparison. This would allow a better understanding of biochemical processes taking place in the Nile upstream and downstream from the NNHB.

ENGINEERING AND HYDROLOGY

The New Naga Hammadi Barrage and Hydropower Plant Location, in the context of Upper Egypt are shown in the Map 1. The EIA identified a number of potentially significant environmental impacts during both construction and operation. A work Plan for Implementation of the Environmental Management Plan during Pre-

Construction has been implemented to define the activities, which must be carried out during pre-construction and assist in making decision on staffing and financial resources.

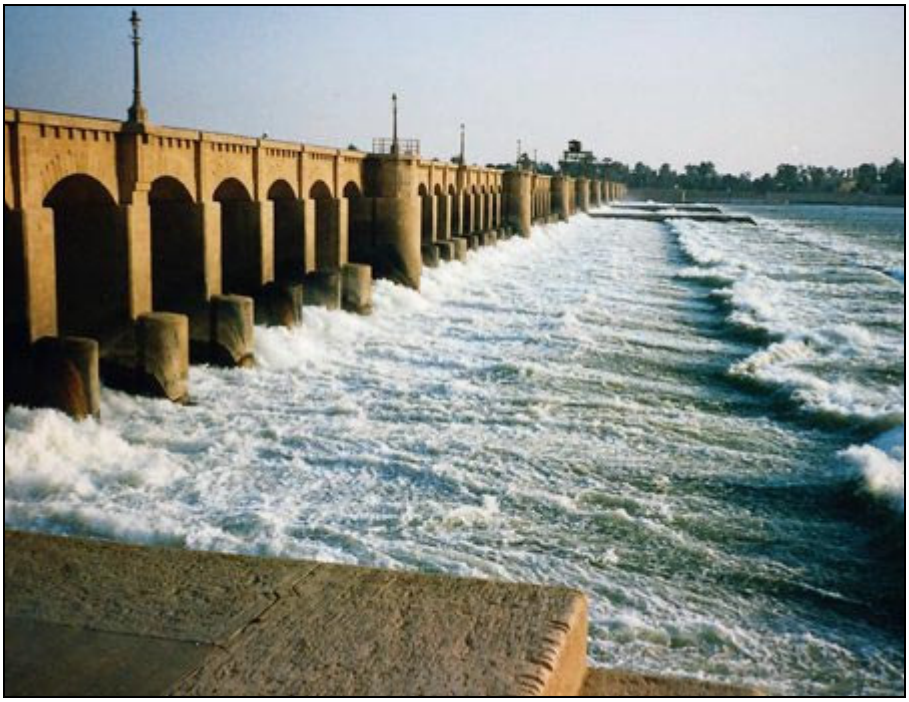


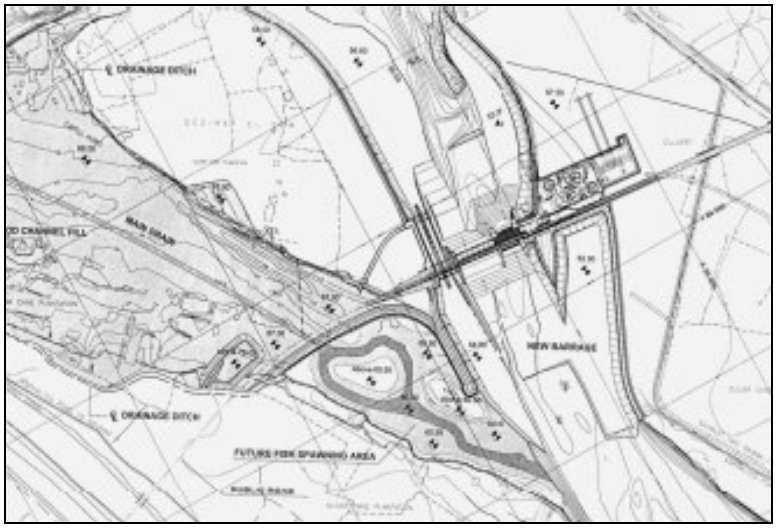
Figure 2. The old Naga Hammadi Barrage

WATER QUALITY COMPONENT

During pre-construction, the Engineering and Hydrology Program will have six main components: Engineering Services, Mapping, Groundwater, Drainage, Sanitation and Water Quality. The Program's Water Quality component finally will follow up water Quality issues identified in the EIA, which are:

- Quality issues directly related to and with a most likely or possible influence from project implementation (e.g. cumulative changes in river water quality especially in relation to pollution during construction and reduced oxygenation after construction);
- Quality issues for which it will be necessary to have long term monitoring data for understanding the reasons for impacts being observed after project implementation (e.g. reduction in fish catch), and to better assess the effective influence of the new barrage on these impacts compared with other pollution sources (e.g. change in drainage water quality due to agricultural production or increased human pollution); and

- Quality issues with no or unlikely direct influence from project, but of general interest (e.g. groundwater total dissolved solids content drinking water quality, suitability of water used for cements, etc.).



Map 1. The New Naga Hammadi Barrage Location

WATER QUALITY MONITORING PROGRAM

1. Selected Sites

A number of potential sites for surface and groundwater sampling were identified and recognized at the occasion of the fieldwork of the water specialists in the project area during the period 6 to 11 November, 1999. The selected monitoring sites for surface water are summarized in Table 1.

Table 1: Selected sites for surface water quality monitoring

Sample Identification	Location
NW-1	Upstream from the existing Naga Hammadi Barrage, before the left bank irrigation canal head regulator
NW-2	Downstream from the existing Naga Hammadi Barrage
NW-3	1 km downstream from the existing Naga Hammadi Barrage
NW-4	Upstream from the axis of the Naga Hammadi Barrage
NW-5	1 km downstream from the New Naga Hammadi Barrage
NW-6	2 km downstream from the New Naga Hammadi Barrage
NW-7	3.6 km downstream from the New Naga Hammadi Barrage
NW-8	11 km downstream from the New Naga Hammadi Barrage

2. Monitoring during the Pre-construction and construction Periods

With regard to the monitoring the following resolutions have been considered as necessary and appropriate:

Time Intervals

It is assumed that bimonthly monitoring of essential parameters as indicated in Table 2 are sufficient to provide a picture of annual changes of Oxygen, nutrient and trophic status, particularly at periods typically characterized by respectively low and high water flows. A monthly time resolution is sought for the parameters of changes in physical status of the water, Viz. the turbidity and TSS.

Spatial Distribution

For the period of time encompassing both pre-construction and construction periods,it is opportune to take advantage of the existing barrage , to design a monitoring program with the purpose of providing information on transformation of oxidizable compounds at various distances downstream of the site, including the site of the new barrage . All monitoring points are in the centerline of the river, upstream of the existing barrage and at various sites downstream.

The pre-construction and construction monitoring program for stations NW-1and NW-4, which are essential for further comparisons, include the determination of major cations and anions, which typically characterize the chemical composition of water on a BI-annual base. The site NW-4 will be maintained for the long term monitoring after commissioning of the barrage. During the construction period, monitoring of the turbidity and TSS at the site NW-3 shall be continued with monthly frequency in order to provide reference monitoring of turbidity from an upstream site, non-influenced by construction work. A site 11 Km downstream from the new barrage (NW-8) shall be monitored only for turbidity and TSS before and during the construction of the barrage so to provide indications of possible extension of plumes of suspended matters during excavation work.

3. Monitoring related to the Long Term Operation of the Barrage

For the long term monitoring, the sampling points NW-4 (at the location of the new barrage) and NW-5 (5Km downstream from it) will be maintained. The sampling point NW-4 will be particularly significant in providing long term trending information on the evolution of the trophic state, Oxygen and untrient balance before and after impounding. All indicators given in Table 2 shall be included in the long term monitoring program.

On November 11, 1999, four samples of water were taken from four stations in the river Nile at Naga Hammadi. From results of these analyses displayed in Table 1, the following remarks can be formulated at this stage:

Table 2: Results of Analyses of water samples from the River Nile

	Sample Identification			
	NW-1	**NW-3**	**NW-4**	**NW-7**
Sampling time	12:00	09:00	09:10	09:20
EC	371	335	343	341
NO_3 (mg/l)	‹ 0.2	‹ 0.2	‹ 0.2	‹ 0.2
P total (mg/l)	‹ 0.2	‹ 0.2		‹ 0.2
Na (mg/l)	21.4	21.6	21.5	19.8
K (mg/l)	5.01	5.03	4.97	4.70
Ca (mg/l)	26	25.6	25.6	24.6
Mg (mg/l)	5.01	5.03	4.97	4.70
SO_4 (mg/l)	17.4	18.6	19.1	17.4
Cl (mg/l)	9.5	10.5	10.4	9.29
HCO_3 (mg/l)	98	95	96	94
Turbidity NTU	54.1	45.1	37.5	51.5
TSS (mg/l)	30	15	20	18
TDS (mg/l)	225	210	217	215
TS (mg/l)	255	225	237	233

Mitigation measures related to incumbent groundwater quality deterioration include chiefly renovation and construction of septic tanks, or other suitable sanitation systems, allowing neutralizing risks of contamination of the shallow groundwater by leaching the existing pit sanitation infrastructures.

The monitoring can be subsequently use as a feedback to improve or to adjust this management plan as well the monitoring system within the project affected area, and if necessary, also outside. Activities undertaken in connection with this paper are summarized as follows:

- Review existing information in both surface and groundwater quality within the project affected area;
- Identification of appropriate and suitable links with relevant national local institution involved in water quality and related issues such as health; water supply institutions, sanitary drainage, laboratories as well as dissemination of information on the scope of the water quality monitoring activities;
- Preparation of a comprehensive, project-related water quality-monitoring program to be implemented before (baseline surveys) as will as during and after the construction of the new barrage, including also.
    - Identification of indicators of water quality which would provide early warning on any decline of the quality of the water resources for most immediate identified users, taking into consideration existing national and international standards for water quality,
    - Identification of needs for procurement of laboratory and portable instruments for water quality determination and

definition of the relevant technical specification for the provision of the equipment and spare parts,
- Evaluation the analytical capacity of laboratories in Cairo and near the project site for the realization of specific water quality and bacteriological analyses,

- Collection and analysis of samples of water quality of the Nile at sampling points included in the surface water-monitoring plan.

Possible nuisances to quality of the water resources related to the construction and operation of the New Naga Hammadi Barrage are:

- Pollution of the downstream of the barrage during construction works namely by temporary increase of turbidity in the river downstream the construction site during excavation works; or/and temporary risks of contamination of the river water by accidental spills of chemicals or combustible and lubricant oils;
- Possible bacteriological contamination of the shallow groundwater in areas affected by permanent upraise of the groundwater during the operation of the new barrage.

Since water quality issues are related in logical sequence to both water supply and health, one task of the activities related in the working paper was to determine needs for accessory investigations which would help to minimize any possible negative effect. On both water quality and waterborne diseases that might be related to the project. This has included some rapid assessments about the present status and quality of the water supply in the project area.

ENVIRONMENTAL ISSUES RELATED TO WATER QUALITY

1. Environmental Concerns Related to Surface Water Quality

Some construction works for the New Naga Hammadi Barrage are expected to increase temporarily the solid loag and consequently the turbidity of the Nile downstream to the construction site. These essentially: The diversion canal, the foundation of the powerhouse and of the sluiceway, the navigation lock, and the removal of the cofferdams at the end of the construction.

The construction of the foundation of the powerhouse, the sluiceway and the navigation lock will require excavation in the riverbed, the constion of two cofferdams respectively upstream and downstream from the new barrage, the establishment of an approximately 1 m wide and 60 m deep bentonite cutoff wall included with the cofferdams and the riverbanks. Excavation works and final removal of some temporary structures such as the cofferdams will be pursued more or less continuously, throughout the duration of the construction period and are expected to generate temporary increase of concentration in Total Suspended Solids (TSS) in the river downstream the construction site. Al though it is anticipated that the sand and silt

fraction composing the suspended load will be settled again within short distance from the working site, the finest clay-sized particles may remain in suspension for several Km downstream the new barrage site. Similarly, the use of bentonite, substantially a clay material could possibly slightly contribute to increase the turbidity of the Nile downstream during the construction of the cutoff wall.

The incidence of temporary increase of the suspended solids, and consequently of the turbidity of the river on photosynthesis enhanced processes taking place during the day light, are rated as negligible. In a similar way, temporary increase of turbidity in water is not expected to affect to significant levels the few pump deriving water for irrigation as well as fishing activities in the reaches of the river downstream from the working site. However, the temporary occurrence of a plume of turbidity and suspended matters in water deserves opportune monitoring during and before starting construction work. It is important to create a reference baseline of the present situation of contamination (oils, organic surfactants) for further comparison.

Water extracted from pit dewatering the construction of the building foundations is expected to be free of turbidity and will be discharged into the river downstream the work site. No consequences to the Nile water are expected to occur in connection with this specific activity. It is advisable to carry out a mortising of the TSS and of other related parameters such as the turbidity in the river before and the construction period at sites along the centerline of the main river channel according to a program further detailed in Section 4. Such measurements would be superseded after commissioning of the new barrage.

For the long term, namely during the operation of the barrage, there are no foreseeable consequences to the water quality of the river. However, as stated under section 2.1 above, the occurrence in the next years of moderate but progressive deterioration of the trophic status of the Nile water due to activities external to the barrage operation, yet affecting the aquatic activities taking place around it, particularly fisheries and water supply, cannot be ruled out at this stage. Therefore, it is justified to implement, within water quality monitoring activities, a program aimed at providseasonal information about the status of nutrients and oxygen balance at selected sites in the river.

2. Environmental Concerns Related to Groundwater Quality

In determining the extent of the study region and hence boundaries to be adopted for groundwater observation, cognizance was taken of the magnitude of changes in river levels resulting from the new barrage and likely impact on the groundwater regime by generating local permanent uprising of the groundwater level to depths less than 1m from the ground.

The adverse influence of the localized rise of the groundwater level on sanitation and drainage systems, has set a concern over the possible contamination of groundwater

from latrine pits, which will be mitigated by the implementation, among other, of a program of improvement of sewage system for houses in affected areas as detailed in the Environmental Impact Assessment. Beside this indirect nuisance on groundwater quality, which can be fully controlled by the implementation of the mitigation measures, a further marginal concern is seen in a possible increase of bacterial contamination in the shallow groundwater and its repercussion on water.

A large number of households even in the rural agglomeration within the project area, benefit of piped water supply. The raw water originates from either boreholes (groundwater) or from the Nile and some irrigation canals. The water supply systems include disinfection of the treated water by chlorination. However, a number of hand pumps deriving water from the shallower parts of the aquifer remains still in service along public streets and in private houses. Some rural agglomerations rely still entire upon hand pumps systems for their domestic water supply. In this connection, it is advisable to carry out monitoring of bacterial indicators in groundwater at selected sites.

RECOMMENDATIONS

A water quality monitoring program has been set up with the intent of providing not only a mean of setting a record of data for further comparison, but also an useful bank of information. This would allow a better understanding of biochemical processes taking place in the Nile upstream and downstream from the NNHB. The surface water quality program is aimed at providing a record of information on main indication of trophic state of the water, essential indicators concerning toxicity, oxygen need and balances as well as general water quality status. The groundwater quality program will focus on the determination of long term trends of bacteriological contaminant, particularly in shallow groundwater still largely used as occasional or emergency source of potable water, particularly in rural communities. It is anticipated that the content of TSS in the Nile water temporary increase during some excavation works, namely for the realization construction pit. It is therefore suggested to consider the realization of specific surveys of water pumps and other river intakes for water supply currently operated along the riverbanks downstream to at least 11 Km from the NNHB.

CONCLUSION

In general terms, none of the physical and chemical parameters monitored in the Nile exceed national and international standard values for raw water to be used for drinking water, or drinking water itself. There was little variation in results between the 10 monitoring stations over a 28 km stretch of the Nile. For each indicator, differences in measurements performed on a given data between stations were significantly smaller than the seasonal changes over the year. The main indicators of water status such as dissolved oxygen (DO), temperature and electrical conductivity (EC) follow normal

seasonal trends. The global content of dissolved cations and anions, represented by the EC (280 µS/cm on average), is rather high for river water. However, it follows normal seasonal trends: it is highest during the coolest months of December and January when discharge of the river is low, and lowest during the summer months when the flow released from Lake Nasser is highest. The status of oxygen saturation in the water of river Nile was almost always above 80% and in most cases near saturation. This represents (a) optimum conditions for fish at all times, and availability of oxygen for the degradation of chemically and biologically active substances in water. Average concentration of indicators of toxicity for fish such as NO2, turbidity and pH, also indicate good conditions for fish at all times. In spite of a rather high content for river water, the trophic status of the Nile can be assessed as oligotrophic (low to moderate levels of nutrients).

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