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EASTERN NILE POWER TRADE PROGRAM STUDY

AfDB

PRE-FEASIBILITY STUDY OF DAL HYDROPOWER PROJECT, SUDAN

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with participation of :

- EPS (Egypt)
- Tropics (Ethiopia)
- YAM (Sudan)

FINAL
INITIAL
ENVIRONMENTAL IMPACT ASSESSMENT

November 2007

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List of Acronyms and Abbreviations

AfDB	African Development Bank
AHD	Aswan High Dam
AHDA	Aswan High Dam Authority
AIDS	Acquired Immune Deficiency Syndrome
ARPA	Aswan Regional Planning Authority
BCM	billion cubic metres
CO_2	carbon dioxide
CRA	Cooperative Regional Assessment
DRC	Desert Research Centre (Egypt)
EEAA	Egyptian Environmental Affairs Agency
EEHC	Egyptian Electricity Holding Company
EIA	Environmental Impact Assessment
El.	Elevation
EMP	Environmental Management Plan
ENSAP	Eastern Nile Subsidiary Action Programme
ENTRO	Eastern Nile Technical Regional Office
FAO	Food and Agriculture Organization of the United Nations
FRA	Forest Resources Assessment (FAO)
FSL	full supply level
GWh	gegawatt hour
ha	hectare
HAD	High Aswan Dam
HCENR	Higher Council for Environment and Natural Resources (Sudan)
HPP	hydropower project
IDEN	Integrated Development of the Eastern Nile
IPCC	Intergovernmental Panel for Climatic Change
IUCN	International Union for the Conservation of Nature
JMP	Joint Multi-purpose Program
kg	kilogram
km	kilometre
m	metre
MALR	Ministry of Agriculture and Land Reclamation (Egypt)
masl	metres above sea level
MIWR	Ministry of Irrigation and Water Resources (Sudan)
mm	millimetre
MOHP	Ministry of Health and Population (Egypt)
MOL	Minimum operating level
MW	Megawatt
MWRI	Ministry of Water Resources and Irrigation (Egypt)
NBI	Nile Basin Initiative
NEC	National Electricity Corporation (Sudan)
NGO	Non-government Organization
PAP	Project Affected People
SCENR	State Council for Environment and Natural Resources (Sudan)
STDs	sexually transmitted diseases
UNHCR	United Nations Higher Commission for Refugees
USD	United States Dollar

E.1 EXECUTIVE SUMMARY

E.1.1 INTRODUCTION

The Dal hydropower project is located on the northern reach of the Main Nile in the Nubian Desert and Northern State of Sudan, immediately upstream of where the Nile enters Lake Nasser/Nubia created by High Aswan Dam in Egypt (Figure E.1).

The energy produced by the 400 MW Dal project (2,160 GWh/year) will make a considerable contribution to economic development in Sudan, being valued at close to USD 86 million per year. Energy generation at Dal is expected to be sustainable for many years but its long-term sustainability requires implementation of watershed management measures in the Blue Nile and Atbara catchment areas. Plans for these are under development.

Engineering of the project has been studied at pre-feasibility level and without the usual benefit of having contour mapping for the flattish reservoir basin. None of the key engineering parameters of the Dal project have been optimised. Optimisation awaits detailed mapping and a feasibility study. Initial examination of the engineering project as currently presented indicates that the project will have some potential secondary benefits, the main ones being employment during construction and development of new skills for the future, upgrading and extension of roads promoting some local area development, extension of rural electrification and reservoir fisheries development.

The project has a number of major adverse impacts relating to the impacts of reservoir impoundment on a large rural population and on physical cultural heritage.

E.1.2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

There appears to be no policy, legal or administrative obstacles to the development. The policy and legal instruments in Sudan are conducive to development of more energy projects in the interests of national development goals, and in general provide the safeguards required for environmental and social protection and mitigation of adverse impacts. However, Northern State has not yet established its State Council for Environment and Natural Resources (SCENR).

The Dal project will trigger several World Bank safeguard policies, namely Environmental Assessment, Projects on International Waterways, Involuntary Resettlement, Indigenous Peoples, Physical Cultural Resources and Dam Safety. It may also trigger the safeguard policy on Natural Habitat but will not invoke policies on Forestry, Pest Management or Projects in Disputed Areas.

Figure E.1 : Location of Dal, Border and Mandaya Sites

E.1.3 EXISTING ENVIRONMENT

E.1.3.1 Physical environment

The Dal project is located in the Nubian Desert. The physiography comprises a flat plain of Basement rocks and Nubian sandstone interspersed with ranges of hills and isolated inselbergs. Rainfall is erratic, many years receiving none. Extreme temperatures range from 52.5 to a minimum of 2°C. Sand, silt and rock temperature range between 65 and 84°C, the maximum being equal to world records.

Through this hyper-arid wilderness flows the Nile (mean annual flow 2,280 m^3/s). The river brings water from the East African Lakes region and the Ethiopian Highlands and conveys large quantities of suspended sediment mainly from the Blue Nile catchment area in Ethiopia. Outcrops of rocks resistant to erosion in the river's channel have created a number of cataracts. All of the cataracts are potential dam sites for hydropower projects. Dal cataract is one of these, located between the Second and Third Cataracts. The First Cataract, downstream in Egypt, is the site of High Aswan Dam and hydropower station (2,100 MW) constructed in the 1960s. The reservoir impounded by High Aswan Dam, Lake Nasser/Nubia, drowned the Second Cataract and stretches 488 km upstream to near the toe of Dal cataract. The Fourth Cataract, between Dongola and Khartoum, is the site of Merowe hydropower project (1,250 MW) now under construction and nearing completion.

Annual flooding, in August/September, causes deposition of silt in a relatively narrow and very fertile floodplain along the length of the Main Nile. These alluvial soils give rise to a linear pattern of village settlements which are wholly dependent on the river for their water supplies, date palms, agricultural and other production.

The bulk of the Nile's sediment transport passes through the Dal dam site into Lake Nasser/Nubia. The quantity has been estimated at 142 million tons per year. It is believed to be increasing owing principally to increasing population pressure and degradation of the Abbay/Blue Nile catchment area in Ethiopia.

E.1.3.2 Biological environment

Immediately away from the river's narrow floodplain, desert conditions prevail where vegetation is rare or non-existent. In the floodplain at Dal, millennia of settlement have removed most of the natural riverine vegetation (*Hyphaene thebaica*, *Tamarix* sp. and *Acacias* - usually *A. nilotica* and *A. tortilis*) in favour of date palms, citrus fruit and shade trees and agricultural production. Thus, the riverine area exhibits a biodiversity dichotomy – one that is rich relative to the surrounding desert but poor because of its fragmentary nature following long settlement and conversion to date palms and cultivation. Wildlife habitat and wildlife are therefore not very remarkable. Following brief site visits, literature reviews and consultations with other professional ecologists and local people, ecologists report that among the reported species of plants, mammals, birds and aquatic life, none are recorded to be endemic to the project area and none are critically threatened. There is therefore, at this stage, no known impediment with regard to terrestrial or aquatic ecology to proceeding to more studies of the project. Nevertheless, because the database is incomplete and rare species, with restricted range distributions, are not easily sampled and brief surveys can easily miss these species, future studies should make provision for detailed ecological surveys.

The Dal dam site and reservoir area (300 km^2) does not encroach on any protected area.

E.1.3.3 Cultural and socio-economic environment

Administration

The project-affected area is in the administrative units of Ferka, Abri and Delgo within Wadi Halfa locality (Figure E.2) in the far north of the Northern State of Sudan.

The people - Mahas Nubians

The majority of the population in the project area comprises an indigenous ethnic minority, the Mahas Nubians, which has a social and cultural identity distinct from the dominant society of Sudan, making them vulnerable to being disadvantaged in the development process. The Mahas speak the Nubian language and maintain their linguistic and cultural differences with great pride. Apart from their distinct language, the Mahas have their own style of house construction and a very long history. To be Mahasi means to be a true Nubian, to speak a pure Nubian language and to live in the Nubian heartland. This is the best description for the area between Dal cataract to Kajbar as far south as Kerma. Of course many Mahas speak Arabic, being the lingua franca of the country, but in their day-to-day conversations at home, on the farm, and in the market they speak Nubian.

Population

The Dal project area is occupied by the Mahas Nubians. The area is too arid to be visited by nomadic pastoralists from other parts of the country. However, due to the civil strife in other parts of the Sudan, the project area has recently attracted war-displaced families from Southern Sudan, Nuba Mountains and Darfur. About 760 internally displaced persons (IDPs) are currently living in Abri town alone.

The last population census was in 1993. This indicated a total population of some 64,300 and some 12,600 households in the Wadi Halfa locality which gives an average household size of 5.1. For this study, populations of the census base year of 1993 have been projected to 2006 at the rate of 1.7%, which is the annual rate of population growth reported for the Northern State. The project area is believed to be completely within Abri and Delgo administrative units, and extends slightly into Ferka in north.

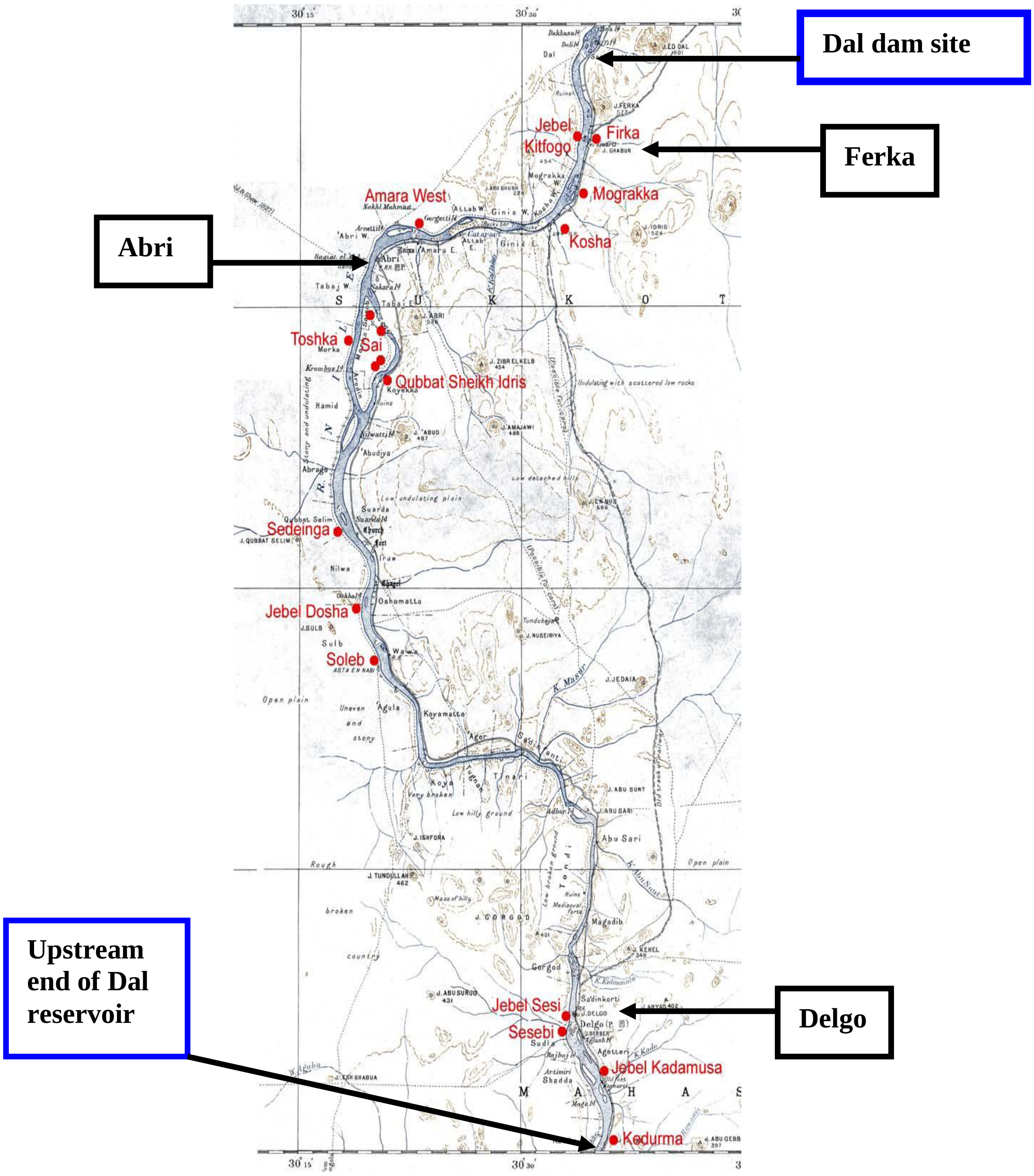


Figure E.2 : Administrative Unit Headquarters and major archaeological sites in Dal reservoir reach

Maps showing the boundaries of former and new administrative units are not available. Indeed, the only detailed map showing place names and islands is a map from the Sudan Survey Department's series based on the Nile Valley Triangulation (Talbot 1897) and cadastral surveys, partially revised in 1951 with provincial boundaries and railways revised in 1976[1]. The lack of up-to-date mapping contributes to the uncertainty in estimating the population that would be affected by the Dal project.

The population that would be directly affected by the Dal project (from the dam site at Dal cataract to Kagbar cataract) is considered to be the whole population of Abri, 80% of Delgo and 25% of Ferka administrative units. The projected population for 2006 is estimated at 42,000 people.

The population that would or might be influenced by downstream impacts of the Dal project is the balance of the projected population of Ferka (those downstream of the dam site) and Wadi Halfa. This rural population and most of the urban population of Wadi Halfa are directly engaged in or have interest in farming along the river.

Emigration appears to occur due to land scarcity and population pressure. Men leave their villages to find work elsewhere. Women are left behind to take care of farmland in addition to their domestic chores. Emigrants regularly send remittances back to the villages in accordance with the needs of their dependents and the obligations they may have. However, many of the emigrants still own land and date palm trees in their home villages. Relatives often work these with the emigrants entitled to a share in the harvest.

Land use and economy

The riverbanks are often steep and are commonly between 8 and 12 metres high. They are inundated by the annual floods and cultivated utilising the residual moisture made available as the flood recedes. These are known as gerouf lands.

The parts of the lower terraces that can be cultivated are commonly between 50 and 200 metres wide (140 metres on average) and are irrigated using small diesel pumps. At some locations, the lower terraces may also be inundated by annual floods and in such cases, flood recession cultivation is undertaken followed by a second crop under irrigation.

Upper terraces, which are a transition between the cultivated area and the desert, are found at a number of places along the river. In former times floodwaters of the river reached these terraces. The soils are generally a mixture of sandy silt and gravel and are marginally suitable for irrigated agriculture due to their irregular topography, salinity, wind erosion hazards or wind-blown sand intrusion.

The population is principally engaged in cultivation of riverbanks and the narrow floodplain. The prevailing agricultural system is small-scale subsistence and commercial crop production, using simple irrigation technology as well as flood recession cultivation (gerouf). The farmers have to cope with scarcity of land and the seasonal flow regime changes of the Nile. The agricultural cycle involves two

[1] The map sheet is named KOSHA and designated NF-36-M at a scale of 1:250,000.

irrigation seasons and the gerouf season. Cultivation is of *seluka* type (local name for digging stick). The main crops beside date palm are *Vicia faba* (broad beans), *Triticum* sp. (wheat), *Lupinus termis* (turmus), Medicago sativa (bersim), *Allium cepa* (onion) and a variety of vegetables. Water for irrigation is raised from the Nile by pumps and is led along irrigation canals to the fields. Other activities relate to harvesting dates, attending to livestock and many and various off-farm income generating activities.

Dates are the main cash crop. They are the most cherished possession, an invaluable item of livelihood security, a basic source of cash and an essential symbol of wealth. A date palm may live 75 -100 years. For elderly people the ownership of date palms is considered as insurance for the days when they retire from seasonal farming. Other fruits produced include citrus, mangos, guava and bananas. On average a family owns 30 date palms. Ownership of palms does not necessarily correspond with ownership of land. The harvest is distributed according to customary law with one third each for the landowner, the owner of the irrigation pump and the cultivator. Annual production of one date palm tree is 30 - 40 kg. When trees are inherited they may remain commonly owned by the heirs who distribute the harvest among themselves.

Animal husbandry plays an important role in the local economy. Donkeys are an important means of transport. Sheep and goats supply milk and meat and provide a vital source of household cash income. Animal droppings are widely used as manure. As there are no rangelands in the area, animals are fed with cultivated fodder and crop residues.

Farmers usually have certified rights to their irrigated land. This is recorded in land register documents which certify land location and size for an owner who may be an individual or the head of an extended family consisting of several individuals. In the latter case, the individual shares are certified in girats (1/24th of the total size). In cases where land has not been registered, ownership is determined by a combination of Sudanese legislation and customary law. Land is divided among heirs according to the Islamic laws of inheritance. When a plot reaches the minimum productive size, i.e. 1 girat, its owners divide its produce rather than the plot itself. Sale of land rarely exists.

Household income is mainly based on commercial crop production and animal husbandry. Due to the prevailing economic conditions the farmers tend to diversify their income sources by combining subsistence and commercial crop production, animal husbandry, and off-farm income generating activities. For each household the top priority is to produce enough staple food needed for one year. The cash obtained from the sale of commercial crops and livestock covers any deficit in the staple grain produced. Remittances from emigrants play an important role in augmenting the cash needs of the household

Off-farm income generating activities include rope making, pottery, petty trading, shop keeping, construction, woodworking and handicraft. Lorry owners often work as traders. Small shops are found in every village. Teachers, health workers and other government officials usually have a second source of income, such as from farming or petty trading, since their salaries are undermined by the chronic high inflation rates and their payment is often delayed up to a few months.

Health and education status

The Dal project area is endemic with the main waterborne diseases of the country i.e. schistosomiasis (bilharzia) and malaria, together with other diseases which have exerted a heavy toll on the health of the human population. Trachoma, non-blinding onchocerciasis, filariasis, dermal leishmaniasis, and other viral infections (e.g. Rift Valley, dengue fever) have been documented to occur. The nuisance caused by Chironomidae midges swarms (*Nimiti)*, Culex spp. mosquitoes and house flies is extensive.

The health service infrastructure across the project area consists of two hospitals at Delgo and Abri and dispensaries and dressing stations in some villages. Health facilities, although adequate by Sudanese standards, are extremely poor in terms of effective service provision by minimum international standards recommended by WHO. All medical institutions are poorly equipped in terms of medical equipment as well as medicines. Most of the rural population cannot afford paying for medical treatment or medicines and resort to medicinal plants and traditional healers. Buildings of medical services seldom receive maintenance and are in poor condition.

Sanitation is not a very serious problem due to access to relatively adequate and safe water supply, hygienic conditions at available sources and use of latrine services at households, public places or schools. The situation is consequently not conducive to the spread of endemic diseases (e.g. diarrhoea). Epidemic diseases (e.g. eye and skin infections) are not very common. However, malaria is a major health problem that attacks 30% of the population and is responsible for 5% of the total mortality rates.

Education and health indicators are generally better than in other peripheral regions of Sudan. The basic health infrastructure is generally good and, like education, statistical health indicators look much better than other peripheral parts of Sudan in terms of population ratios to institutions. However, some extenuating circumstances are given in the main report.

Other services

Northern State government’s provision of other services in the area in terms of road communications, water supply, sanitation, in addition to education and health mentioned above, are variable but again in some cases much better than in other peripheral parts of Sudan. Services are handicapped to a large extent by the immense geographical area.

E.1.3.4 Physical cultural heritage

The Dal area is very rich in physical cultural resources. Many sites have been identified. A few of these have been studied in detail but many have not and await resources to conduct detailed studies. Many more sites may be expected to be found and require detailed study.

The Honorary Secretary of the Sudan Archaeological Research Society (SARS) has prepared a summary of the archaeology and heritage of the Dal reservoir area, illustrated with photographs and maps. His summary account is included as an Annex of this initial environmental impact assessment report.

Archaeological surveys and research have revealed the existence of human settlements in the Dal area for 200,000 years. This testifies to the immense value of the Nile valley's fertility in an otherwise climatically hostile environment. The riverbanks and islands through the Dal reservoir area exhibit a complete sequence of occupation as follows:

- Palaeolithic and Neolithic (200,000 – 3500 BC) - Sai
- Kerma period (c. 2500 – 1500 BC) - Sai
- Pharaonic (c. 1550 – 1070 BC) – Amara West, Sai, Sedeinga, Jebel Dosha, Soleb, Sesebi
- Kushite (c. 950 BC – AD 350) – Sai, Sedeinga, Soleb, Kedurma
- Post-Meroitic (c. AD 350 – 550) – Firka, Kosha, Sai
- Christian (c. AD 550 – 1500) – Jebel Kitfogo, Mograkka, Sai, Toshka
- Post Christian (c. 1500 – present) – Sai, Qubbat Sheik Idris

The monument of the Temple of Amenhotep III at Soleb is regarded as having World Heritage status.

E.1.4 PRINCIPAL IMPACTS, MITIGATION AND ENHANCEMENT MEASURES

E.1.4.1 Construction phase – bio-physical impacts in Sudan

Construction of the project is expected to take six years. Mitigation of the bio-physical impacts of the project, following detailed assessment of these in a future EIA study, will require conscientious attention by contractors to planning and implementing environmental protection measures for every aspect of construction. There is no reason currently to believe that the construction mitigation measures cannot be successfully implemented.

The downstream release rates during river diversion and during first filling of the reservoir, which is expected to be achieved very rapidly, may be expected to be arranged and agreed by the Permanent Joint Technical Committee of Sudan and Egypt and cause relatively small impacts downstream and at High Aswan Dam.

Following first filling, Dal reservoir itself (300 km^2) would be a very large wetland resource, supporting fisheries development and being habitat for many local and migratory water birds. With a visitors' centre established by the project, it would become a focal point for studies of natural history for residents of Wadi Halfa locality and from more distant regions.

No known commercial mineral deposits would be adversely affected by the project. Ancient mining sites of the "gold of Kush" may be inundated but they and more recent mining have long since been abandoned.

E.1.4.2 Construction phase – socio-economic impacts in Sudan

Construction of the Low Dal project will cause inundation and loss of most of the gerouf cultivation along 160 km of riverbanks, the irrigated alluvial flood plain soils and the settlements supported by the river and this cultivation. The principal affected settlements are listed in Table E.1.

Table E.1 : Main settlements impacted by Dal reservoir inundation

Administrative Units HQ	West (Left) Bank Settlements	East (Right) Bank Settlements	Island Settlements
Ferka, Abri and	Dal village	Sakamatto	Jerjatti
Delgo	Dal Cataract	**Ferka**	Arnatti
	Hai Al-Arab	Mofrakka	Sai
	Mofrakka West	Kosha	Nolti
	Kosha West/Selam	Ginis	Swarda
	Ginis West	Atab	Oshba
	Abri West/Sagyat Al-Abid	Amara	Wawa
	Tabaj West	**Abri**	
	Morku	Tabaj East	
	Toshki	Koyeka	
	Hamid	Abboud	
	Abraqa/Qubbat Salim	Swarda	
	Nilwa	Irau	
	Dosha	Oshimatto	
	Solib	Wawa	
	Agula	Kimatto	
	Tobba	Agger	
	Koya	Saad Fadali	
	Tinari	Abu Sari	
	Magadib	Khor abu Sunt	
	Hadika	**Delgo**	
	Sudla	Agetteri	
	Shaddah	Khor Kado	
	Koka	Kedurma	
		Kudayn	

Mitigation of these socio-economic impacts of the project, following detailed assessment of these in future EIA and RAP studies, will require conscientious attention to land and property acquisition, compensation for loss of property, natural resources and livelihoods, and an all embracing resettlement and development program, following national and international safeguard procedures for involuntary resettlement. The affected population is very large, estimated at 42,000 people.

E.1.4.3 Construction phase - physical cultural heritage impacts in Sudan

The locations of principal archaeological and historical sites that will or may be adversely affected by the project are shown in Figure E.2. The temple at Soleb and sites north and downstream of Soleb will be inundated by the reservoir.

The fate of archaeological sites in the south towards the upper end of Dal reservoir is uncertain because of lack of data on their elevations and lack of contoured mapping. If not inundated, they will survive but some may be adversely affected by the humidity from raised groundwater levels and by the impacts of sedimentation of the reservoir in this upper reach. Some may therefore require salvage.

E.1.4.4 Operational Phase – bio-physical Impacts in Sudan

Hydrological impacts

It is proposed to operate the Dal project as a run-of-river project with the reservoir typically operated at or near Full Supply Level and making use of the maximum head possible (Table E.2).

Table E.2 : Dal Reservoir – Levels, surface area and storage volumes

Reservoir Level Characteristic	Level masl	Surface Area km^2	Volume $m^3 \times 10^9$
Full Supply Level (FSL)	201	300	2.47
Minimum Operating Level (MOL)	199	250	2.12
Difference between FSL and MOL	2	50	0.35

A 10-day inflow database has been used for Dal power station and reservoir simulations for the 50-year period January 1954 – December 2003. Components of the 50-year reservoir water balance generated by simulation of the project are presented in Table E.3.

Table E.3 : Dal reservoir 50-year water balance

Water balance component	Quantity m^3/s	Proportion of mean annual inflow %
Mean Annual Inflow	2,280	100
Turbined flow Spillway flow Total Downstream Flow	1,409 844 2,253	62 37 99
Evaporation losses	27	1
Mean of all outflows	2,280	100

Under the proposed run-of-river operating regime, downstream flood flows will be as received at Dal reservoir except for some minor attenuation and minor evaporation losses. Annual floods for three years are illustrated in Figure E.3 where about 2,000 m^3/s is passing through Dal's turbines and the remaining through the spillway gates. In this simulation run, the scheme was operated at FSL throughout (without any reservoir drawdown of 2 m) and the constant reservoir level at 201 masl may be seen at the top of the diagram.

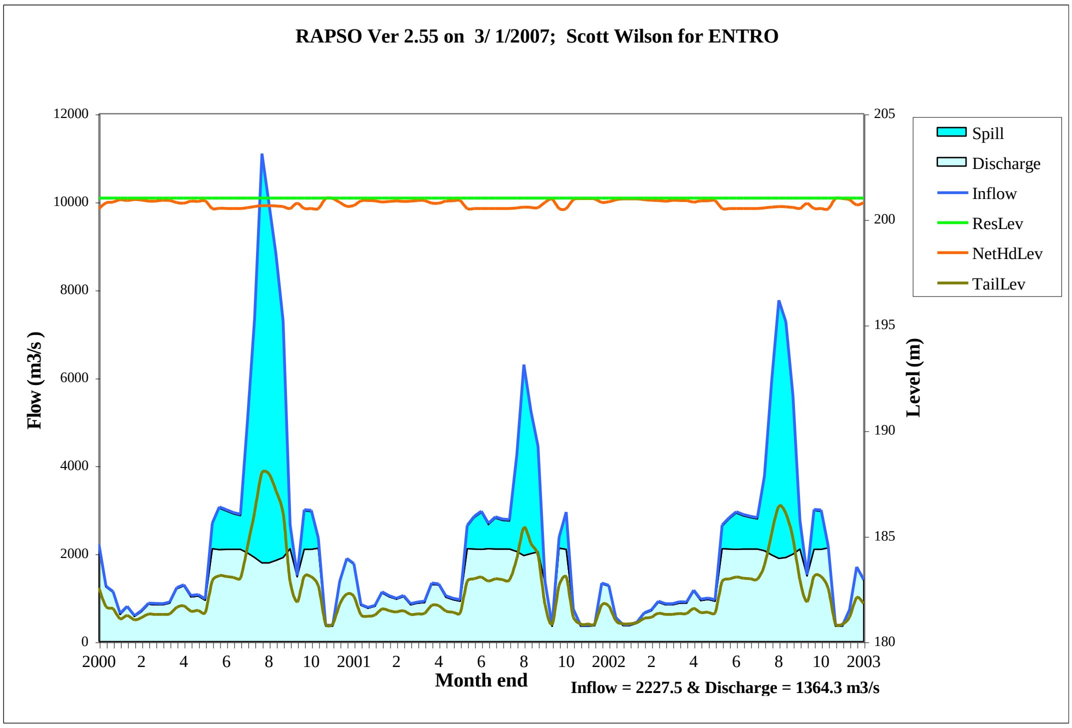


Figure E.3: Operation of Low Dal with 8x50 MW

In the dry season, downstream flows will be as received at Dal reservoir except for evaporation losses. In this case, all downstream releases pass through the turbines.

Thus operational impacts on downstream riparian users (mainly gerouf cultivation, ferry boats and fishermen) are considered likely to be insignificant. However, some cautionary points are made in the main report. In particular, the turning on and turning off of turbines, and the opening and closing of spillway gates, may cause rapid changes in flow conditions downstream. Secondly, if the operating regime at Merowe and/or Dal changes, i.e. from run-of river to some diurnal peaking (using the available storage capacity of the reservoir for this), changes from the normal flow regime will be noticeable. This may happen in future and this would require a special study of impacts. A flow forecasting and warning system will be required.

Reservoir sedimentation

Reservoir sedimentation will begin during first filling and continue thereafter. Although the overall balance of sediment along the Nile downstream of Merowe is uncertain, the average annual sediment discharge at the Dal site following construction of the Merowe project can probably be expected to lie within the range 75 Mt to 100 Mt, depending on the effectiveness of the sediment flushing regime at Merowe. Much of this sediment will be very fine grained and will have a lower trapping efficiency in Dal than would be the case without Merowe upstream. A trapping efficiency of 55 % has been estimated for Dal based on Brune's relationship for primarily fine grained and colloidal particles and assuming that sediment flushing at Dal would not take place. Under these circumstances it is anticipated that sediment deposition in the Dal reservoir will be some 40 - 55 Mt/year, or some 30 – 40 Mm^3/year. Thus, even with some protection provided by Merowe, Dal is vulnerable to loss of storage capacity in the medium to long term, emphasising the need for effective implementation of watershed management measures in the Blue Nile and Atbara catchment areas.

Groundwater

Groundwater levels will rise significantly around the reservoir in areas where rock types are not impermeable and geological structures are favourable. Such areas are not thought to be extensive but there are likely to be some. Once groundwater levels are established after first filling, they will remain constant if the Dal project is operated at FSL continuously. If reservoir levels fluctuate by one or two metres from the FSL, groundwater levels may adjust accordingly but probably not rapidly.

Whilst seepage losses from the reservoir are not expected to be significant from a project point of view, the availability of groundwater nearer to the land surface may be valuable as a new resource for water supply for existing communities and for any resettlement communities in the area.

On the other hand, any local increases in ground water levels approaching the land surface in flat terrain around the reservoir margins could have an impact on foundations of structures and artefacts of historical and archaeological interest. Water may be expected to rise by capillary action by at least one metre. This new source of moisture may have a rapid and disastrous effect on organic material in particular, but also on skeletal material that tends to explode on contact with water. Thus the rise in water table may affect sites of archaeological and other interests some considerable distance from the reservoir depending on geology and geomorphology of the area. Specialist advice on this should be sought during future studies.

Monitoring of any observation boreholes established in the construction period should continue in the operational period. Favourable areas should be considered for development of water supplies for local communities.

Wetlands Ecology

In the operational period, it is anticipated that environmental management will require wildlife habitat and wildlife surveys to be conducted around the reservoir margins, and for waterfowl surveys to be conducted and results submitted to Sudanese and international agencies that coordinate waterfowl monitoring and reporting in Africa (African Waterbird Census, International Waterbird Census, BirdLife International, Wetlands International).

Aquatic life and fisheries development

In the operational period, it is anticipated that reservoir management will require aquatic surveys to be conducted in Dal reservoir and adjacent tributary khors, and that these may be coordinated with aquatic surveys in Merowe reservoir upstream and Lake Nubia downstream. Fish surveys should include information on fisheries development and management at Dal reservoir and the results used to inform and improve fisheries management of the reservoir.

Water quality, hydrological and aquatic surveys should contribute to a post-construction impact assessment of Dal reservoir, similar to the work of the Hydro-biological Research Unit for Roseires in the 1960s and subsequently, and as may be carried out for Merowe after some years of operation.

An opportunity to sample fish for research purposes may become available below Dal's spillway after spilling, and rarely at the Dal tailrace. Typically, numerous fish may be netted when spillway gates close and fish become stranded. To arrange for fish biologists to obtain these samples (for species identification, length, weight, sex, development of gonads, etc), good awareness and coordination is required between the project owner (who anticipates the closing of one or more gates), EMU and research agencies. These opportunities are frequently unrecognised and not used. Fish in this sampling, as has been done occasionally below Roseires reservoir, may or may not be distinct from fish in the reservoir and much additional information may be learned about the Main Nile's fish population and migratory habits from this. This may contribute to exploitation and conservation practices, and assist planning of other water resources developments in future.

E.1.4.5 Operational Phase – socio-economic impacts in Sudan

Electricity supplies

As stated in the introduction, the energy produced by the 400 MW Dal project (2,160 GWh/year) will make a considerable contribution to economic development in Sudan, being valued at close to USD 86 million per year. Energy generation at Dal is expected to be sustainable for many years but its long-term sustainability requires implementation of watershed management measures in the Blue Nile and Atbara catchment areas. Plans for these are under development.

The generated energy will be transmitted to the Sudan grid at Dongola, outside of the direct impact zone. A local low voltage supply will be provided from the Dal power station to the project and project facilities (with diesel generator backup facilities). Extensions of this local distribution are not planned at pre-feasibility stages of planning but cases for negotiating greater rural electrification provisions in the future planning process have been made in the report.

Resettlement, development and monitoring

The geographical spread of Dal project's resettlement locations is now unknown. Wherever resettlement takes place, the Dal project owner and financiers will wish to see and know that improvements have been achieved in living conditions in resettlement communities, and are continuing to improve in the project operation phase. With these and other points in mind, the Resettlement Monitoring Unit will have already sought to ensure, and will continue to monitor, that resettlement conditions are satisfactory, or developing inexorably to a foreseeable satisfactory condition, for all people without exception. The principal items to be surveyed and monitored relate to new houses, availability and use of mosquito nets, water supplies, sanitation provisions, drainage arrangements, clinics, and qualified health care staff numbers, schools and qualified teaching staff, community buildings and facilities including market places, energy sources and shade trees.

The RMU will also have already sought to ensure that livelihoods have been re-established and improved, including carrying out monitoring of family incomes, agricultural production, tree production, livestock production and grazing/crop residue resources and other activities depending on location and resources.

The RMU and the resettlement's agricultural research centre will also be responsible for ensuring on-going provision of satisfactory veterinary, agricultural, horticultural and other specialist advisory and treatment services.

In addition, RMU monitoring should cover households in the villages which were impacted by the Dal project and remained in place. These may be households alongside upper reaches of Dal reservoir in Delgo administrative unit. These will have been compensated earlier for loss of livelihood resources, including some or all of their cultivated areas in the reservoir basin. Alternative sources of income generation are required to replace their losses, separately from the compensation. The RAP plan and its updates will cover these also.

E.1.4.6 Construction and Operational Impacts in Egypt

First filling of Dal reservoir should occur rapidly because the average flow of the Nile in each of the 10 months from March to December is greater than Dal's gross storage capacity (2.47 billion m^3) and less than one week's average flow in August is capable of filling Dal reservoir to capacity. The first filling of Dal reservoir storage will deplete Lake Nasser/Nubia's storage by the same amount and therefore have the impact of reducing Lake Nasser/Nubia's level and surface area compared to what they would have been. Assuming first filling occurs when Lake Nasser/Nubia has a level of 175 masl, the reductions in level and surface area would be in the order of 0.5 m and 170 km^2 respectively. If first filling occurs when Lake Nasser/Nubia has a much lower level, say 165 masl, the reductions in level and surface area would be in the order of 0.75 m and 95 km^2 respectively.

The impact will be less than that caused by first filling of Merowe, which has a larger storage capacity than Dal. These changes are not expected to have very significant adverse impacts on fisheries, agriculture and settlements and navigation at Lake Nasser/Nubia but in this harsh desert environment any small adverse impact on family income or expenditure can make livelihoods more difficult. The changes in lake level will also impact on power generation at Aswan. These relatively small impacts will necessarily be cumulative impacts following first filling of Merowe and any other upstream storage schemes constructed before Dal.

Future studies will need to consider the need for physical, biological and socio-economic or other compensation mitigation measures around Lake Nasser/Nubia, and compensation for reduced power output at Aswan. Some additional fish stocking may be required but the principal local compensations appear likely to be related to increased irrigation and water supply pumping costs for farmers and small settlements at a number of sites around the lake, and additional pumping costs at the Mubarak pumping station for its large irrigation and settlement project if it is operational when the Dal project is constructed.

On the positive side, reservoir sedimentation at Dal will reduce sedimentation in Lake Nasser/Nubia to some extent, thereby prolonging the life of the High Aswan Dam project and extending the years of reliable water supplies in Egypt for public water supply, for irrigated food and cash crop production and for industry.

Furthermore, the reduction in Lake Nasser/Nubia's level and surface area will reduce evaporation losses from the lake. This feature may be expected to provide some self-compensation for evaporation losses at Dal reservoir for a while. Thus the balancing of the mitigation costs in the short term and the longer-term benefits at Lake Nasser/Nubia is complex and may be expected to be the subject of negotiations when more details are known from additional studies.

E.1.4.7 Summary of Dal's principal impacts

The principal impacts of the Dal project are summarised in Table E.4.

Table E.4 : Summary of principal project impacts of Dal project

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
Sudan			
Dal project	Dal power generation, a substantial national energy benefit	Major involuntary resettlement (42,000) of Nubian people, with cumulative impact following involuntary resettlement for High Aswan Dam (53,274)	Major resettlement and development program
Dal project	Construction employment, new skills for the future	Major loss of Nubian cultural heritage	Major archaeological surveys, excavations and dismantling of Temple of Amenhotep III and rebuilding it on new site
Dal project	New roads, Nile crossing at new bridge or across dam, promoting local area development	Loss of wildlife habitat and wildlife	New reservoir wetland and development of fisheries industry

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
Dal project	Extension of rural electrification	Loss of date palm and agricultural production	Development of irrigated date palm and agricultural production at resettlement sites
Dal project		Additional evaporation loss from Sudan's water allocation	No physical mitigation other than improving water use efficiency elsewhere
Egypt			
Dal project	Reduction in sedimentation in High Aswan Dam. Long term benefits for sustaining power generation and water supplies downstream of Aswan	Reduced level of Lake Nasser	Increase fish stocking Navigation works at jetties and pontoons Compensation for additional pumping costs for irrigation and water supplies Compensation for reduced power generation at Aswan
Regional			
Dal project	Carbon emissions savings of some 68 million tonnes compared with equivalent thermal generation		

E.1.5 ALTERNATIVES

There are alternative hydropower sites upstream of Dal at other cataracts on the Main Nile. The Dams Implementation Unit is currently investigating these at feasibility level. Because of the low topography associated with each cataract site, impoundments may be expected to have large reservoir surface areas exposed to evaporation and therefore high evaporation losses. Development of any of these will reduce the amount of usable water for other purposes: irrigation, public water supply and industrial use.

There are alternative hydropower sites on the Abbay river in Ethiopia: Border, Mandaya, Mabil, Beko Abo and Karadobi. Their locations provide relatively low evaporation rates and their topographies provide greater head for power generation. Any one of these would require much less involuntary resettlement and, subject to further investigation, no known great loss of physical cultural resources. Additionally, development of one or more of these would provide major uplifts in energy generation in Sudan's existing hydropower cascade at Roseires, Sennar and Merowe. In the case of Mandaya, the estimated uplift in the Sudan cascade (2,211 GWh/year) would be greater than the energy generated at Dal (2,160 GWh/year) and this could be achieved without additional capital expenditure.

E.1.6 PUBLIC CONSULTATIONS

Consultations with local people indicate that owing to the recent history of dams causing major resettlement of Nubian peoples to the north (High Aswan Dam) and resettlement of others to the south (Merowe, under construction), very few people would welcome the Low Dal project. No-one, other than some government officers who would welcome the benefits brought by more energy generation, wishes to contemplate resettlement and no suggestions were received for potential resettlement sites.

E.1.7 ENVIRONMENTAL MANAGEMENT AND MONITORING

Environmental management of the Dal project is concerned with implementation of the measures necessary to minimize or offset adverse impacts and to enhance beneficial impacts. In order to be effective, environmental management must be fully integrated with the overall project management effort at all levels, which itself should be aimed at providing a high level of quality control, leading to a project which has been properly designed, constructed and functions efficiently throughout its life.

The main report presents a draft Environmental Management Plan for the project and introduces the probable overall institutional arrangement for project ownership and management, including execution of the Environmental Management Plan as one component of the project. The report also introduces the requirements and components of a Resettlement Action Plan, associated with a broader development plan, which will be needed for people displaced by the project – mainly in the reservoir and dam works areas but possibly along a short length of the transmission line in the Dongola area. A description of a grievances handling procedure is given.

Overall management will be carried out by the project Owner[2], supported by a project Environmental Monitoring Unit and a project Resettlement Management Unit. The project Owner will be responsible, following feasibility studies, for submitting the EIA and RAP to the Higher Council for Environment and Natural Resources for evaluation according to internal procedures in Sudan. The EIA report, with its overall management and monitoring plans, will also be submitted to the Permanent Joint Technical Committee, the authorities in Egypt and to funding agencies.

The project Owner will compile “the Owner’s requirements” in consultation with stakeholders including the Higher Council for Environment and Natural Resources and lenders of finance for the project. These will cover, *inter alia*, environmental protection, monitoring and management expected of the contractors from the outset. The Owner’s requirements are made known in tender documents and contractors are

[2] At Merowe, the Dams Implementation Unit (DIU) is an upgrading of the Merowe Dam Project Implementation Unit (MDPIU), which was headed by the State Minister for Irrigation and Water Resources. DIU is an autonomous body directly under the Office of the President of the Republic with a status of full Federal Ministry. The responsibility for the formulation and execution of Merowe resettlement and compensation policies is assigned to the Commission for Environmental and Social Affairs of the DIU. It is unknown whether this arrangement would be used for implementing the Dal project. If it is, then readers should interpret the project Owner as being DIU, and the EMU and RMU functions being carried out by the Commission for Environmental and Social Affairs of the DIU.

required in their bids to demonstrate their social and environmental awareness and capability in meeting the Owner's requirements. Contractors for the dam and associated engineering works will carry responsibility for environmental protection measures.

Staff of the project Owner, Environmental Monitoring Unit and Resettlement Management Unit will be appointed and newly equipped for the job. The contractors will provide staff and equipment according to contract documents.

The Owner will be responsible for developing and implementing public relations procedures and communications for the project to ensure transparency and build up trust and confidence about the project. Regarding environment, the Owner will use his public relations procedures and communications to make known details of the project and its time schedule, impacts and mitigation measures, and grievance procedures for host and resettled communities, especially those measures relating to compensation and resettlement. Care will be taken to present information in languages that are understood by all Nubian and other stakeholders, and by all conceivable means in order to reach all stakeholders effectively.

Opportunities for misinformation and misunderstanding are many during the pre-construction activities and the period of construction activities. The project Owner will make every effort to avoid these by establishing and using vigorously a first class public relations and communications system.

In terms of participation and additional monitoring by the local administration, relevant government departments of Northern State and Wadi Halfa locality and administrative units at Ferka, Abri and Delgo will be engaged. The Northern State's Ministry of Agriculture, Animal Resources and Irrigation, Ministry of Engineering Affairs and Public Utilities, and the Ministry of Health are the principal state ministries that will be involved in the Dal project. They are represented at Dongola but may be not in all of the administrative units of Wadi Halfa locality. Very considerable institutional strengthening is expected to be required.

Like most other states in Sudan, the Northern State is yet to promulgate an act for the establishment of the State Council for Environment and Natural Resources (SCENR). This report makes the assumption that the Northern State will have established its State Council prior to the implementation of the Dal project, equivalent in other countries to a regional environmental protection agency. Clearly, as the SCENR does not yet exist, considerable institutional strengthening measures may be anticipated. It will be important that SCENR functions at Dongola and plays an active role in the many environmental protection measures and the major resettlement component of the Dal project.

This report makes the assumption that because the Dal project is so rich in physical cultural resources which require specialist attention, the project Owner will engage the Antiquities and Museums National Corporation and the Sudan Archaeological Research Society (SARS) to carry out all surveys, excavations and mitigation measures relating to physical cultural heritage over a distance of 320 km of Nile riverbanks and about seven islands. This assignment is estimated to take at least 10 years and would involve dismantling and reconstruction of the temple at Soleb and possibly other monuments. This requirement for 10 years or more of excavations therefore has a bearing on the earliest date when construction of the Dal project may begin.

The main report envisages that the project Owner will wish to ensure not only that habitat loss, large-scale involuntary resettlement and major archaeological excavations and salvage in the Dal reservoir area have been competently and generously addressed but also that riparian users along the Nile downstream are similarly satisfied by mitigation measures which may be required. For these important objectives to be realized, it is expected that an independent Panel of Experts for the Environment and Community Protection will be appointed and be pro-actively involved in reviewing all mitigation measures from the outset. This panel will be in addition to the Panel of Experts on Dam Safety.

At intervals, independent auditing and monitoring will be required. Targets set in the mitigation and development plans, especially those concerning resettlement, must be capable of being monitored realistically, and provide no possibility of political or other interference. Results of auditing and monitoring require to be made known to the Owner, the independent Panel of Experts for the Environment and Community Protection, local communities and local administrations, government, CSOs, NGOs and project financiers. Failures to achieve targets should result in immediate measures to improve conditions.

In Egypt, support is expected to be necessary for the Ministry of Water Resources and Irrigation, Ministry of Agriculture and Land Reclamation and the Egyptian Environmental Affairs Agency for their extended management and monitoring roles around Lake Nasser. The report identifies some NGOs active in research and development works around the lake which may also be candidates for support.

E.1.8 PROJECT COMPENSATION, MITIGATION, MANAGEMENT AND MONITORING COSTS

For this initial environmental examination of the project, estimates have been made of the principal compensation/socio-economic costs (USD 360 million) and cultural heritage mitigation costs (USD 10 million). The former have been based on assumptions made concerning compensation and resettlements costs at Merowe; the latter have been based on the cost of works of the Sudan Archaeological Research Society and British Museum at Merowe. Cost estimates of environmental management and monitoring and institutional capacity building have also been made.

A total provisional sum of USD 429.6 million is included for mitigation and monitoring in the direct impact zone and for downstream monitoring. This represents some 32% of the estimated overall project cost (USD 1,322.8 million)[3].

[3] It is noted that the estimated overall project cost in Table 3.11 provided for a lower figure of environmental mitigation, USD 220 million, and that this was included in the project model for investment planning and modelling (Module 6). This subsequent revision by an additional USD 209.6 million is based on a higher estimate of resettlement population, greater archaeological mitigations and greater institutional strengthening needs.

E.1.9 CONCLUSIONS

The primary energy benefits of the Dal project (2,160 GWh/year) are substantial. According to parallel coordinated investment planning studies, the economic cost of power generation at Dal is favourable in comparison to other power sources in Sudan when Sudan's power resources are considered in isolation. The Dal project is a relatively high cost source of energy when compared to major projects on the Abbay (Blue Nile) river in Ethiopia, such as the Mandaya, Border and Karadobi projects. As such, the Dal project does not form part of the regional power trade development plan.

However, in advance of the implementation of the regional inter-connector, Dal project may be considered as part of a national power development strategy within Sudan since it offers a lower cost source of energy than the thermal power alternatives within Sudan.

This initial environmental assessment has scoped and considered many issues. Six World Bank safeguard policies are triggered by the Dal project. Thus, for the project to be considered further and in line with Dal having a Category "A" status, a comprehensive environmental impact assessment study is required.

The Dams Implementation Unit has already commissioned a feasibility and EIA study of the Dal project, along with feasibility and EIA studies of other Nile cataract sites. These studies will permit informed comparisons to be made about the costs and benefits of individual dam projects in the Main Nile's potential hydropower cascade and their environmental and social impacts.

These studies will also permit Dal and other potential Main Nile sites to be considered in the context of Blue Nile flows being partially regulated by additional storage proposed at Roseires dam on the Blue Nile, and by future regulatory storage works on the Abbay/Blue Nile in Ethiopia. Thus, when the DIU feasibility studies are completed, the short and medium term strategies for future hydropower development and environmental protection on the Main Nile in Sudan should become clear.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

The Nile River system is shared by 10 riparian countries: Burundi, Democratic Republic of the Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania and Uganda. Under the Nile Basin Initiative, all countries agreed and established a basin-wide framework to fight poverty and promote economic development in the region. Action oriented sub-basin programs (NELSAP, ENSAP) were formulated that are intended to shift focus from planning to action on the ground through investment in development projects. For this purpose, ENCOM was established and Ethiopia, Egypt and Sudan have jointly adopted a strategy to develop, utilize and manage water resources of the Eastern Nile Basin in an integrated, equitable and sustainable manner. In doing so, they are guided by a shared vision "to achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources".

Over the past 30 years, various sub-groups of the Nile countries have engaged in cooperative activities. However, the inclusion of all countries in a joint dialogue opens up new opportunities for realizing win-win solutions. It also holds the promise for potential greater regional integration, both economic and political, with benefits far exceeding those derived from the Nile river itself. The NBI comprises a Council of Ministers of Water Affairs of the Nile Basin (Nile-COM), a Technical Advisory Committee (Nile-TAC), and a Secretariat (Nile-SEC) located in Entebbe, Uganda.

It is with this background that ENTRO commissioned pre-feasibility studies of three hydropower projects in connection with development of power trading in the eastern Nile region. By investigating three project candidates (Mandaya and Border in Ethiopia, and Dal in Sudan) in much more detail than in earlier identification studies but without the substantial expenses of detailed feasibility level studies, it is expected that one of these will emerge as a favoured project for much more detailed examination.

This report presents the results of scoping social and environmental issues of the Dal project, consistent with pre-feasibility level of engineering studies and the budget. The report is based on investigations carried out by YAM Consultants and Scott Wilson between November 2006 and April 2007 (Appendices 1.1 and 1.2).

Dal dam site and reservoir basin is located on the Main Nile river in the Nubian Desert in Wadi Halfa Locality of the Northern State.

1.2 APPROACH AND METHODOLOGY ADOPTED FOR THE STUDY

The approach and methodology for the initial environmental examination study follows the established pattern for hydropower projects, as follows:

- Review of Documents. An extensive review of relevant documents has been undertaken, including environmental protection regulations and guidelines, policy papers, census reports, Northern State documentation, Cooperative Regional Assessment (CRA) watershed management reports, Flood Preparedness and Early Warning reports and many other technical publications. Documents and information were collected from ENTRO, regional offices and elsewhere.

- Maps and images. There is no detailed topographical mapping for the project area; this is a handicap for hydropower and environmental assessment studies. Various road maps are available and an old and detailed but un-scaled map covering the Nile area from Dongola to a point north of Dal was found to be very useful. Satellite images obtained via the Internet have been consulted. Black and white 1:40,000 scale air photos flown in January 1985 are available for the whole of the project area.

- Field surveys and public participation. A reconnaissance survey to Dal was made in November 2006 (Appendices 1.3 and 1.4). Geological survey was carried out in February 2007 and the YAM consulting team carried out environmental and socio-economic surveys in April 2007. Visits were made to Dal dam site and accessible surrounding areas. Fieldwork included water quality sampling, observations of physical, biological and socio-cultural environments, consultations with communities at Sai Island, Solib, Abri, Akasha and Kerma, and with displaced persons from other regions. Data was collected from local offices and Dongola. Discussions with representatives of local administration offices focused on demographic data, land management and agricultural activities, and infrastructure. These investigations and consultations have resulted in first hand knowledge of the existing social and environmental conditions, sufficient for scoping the major issues of the Dal project and outlining mitigation measures.

- Downstream Impacts. Fieldwork was conducted along the Main Nile as far north as Akasha where the river level is potentially influenced by Lake Nasser/Nubia when at a high level. Downstream impact assessment along this reach is based on field observations, discussions held with staff at Akasha, examination of satellite images and results of a river and reservoir behaviour simulation model calibrated for Dal using 50 years river flow data with a 10-day time step.

- Workshops. Preliminary results of scoping investigations at Dal (and Border and Mandaya) were presented at ENTRO workshops in Khartoum in January 2007, at Cairo in March 2007, at Khartoum in June 2007 and at Cairo in July 2007. Formal and informal feedbacks from participants at these meetings assisted the subsequent preparation of this report.

1.3 AREAS OF STUDY

The principal social and environmental impacts of the Dal project occur in three principal zones. In addition, a fourth area of interest is relevant.

1.3.1 Direct Impact Zone

The most direct impacts are associated with land use changes for access roads, the principal construction areas at and near the dam site and for towers along transmission line routes, and for reservoir inundation. The latter involves flooding a large area, some 300 km^2 for the Full Supply Level of 201 masl adopted in the pre-feasibility engineering study. It is these construction and reservoir impoundment areas, and their local administrative units, that have been the principal areas of focus for fieldwork and data collection.

1.3.2 Secondary Impact Zone

Secondary impact areas in Sudan extend downstream of Dal dam site and construction works area along the Main Nile river channel into Lake Nubia, and then Lake Nasser in Egypt.

1.3.3 National Energy Benefits

The third principal area of project impacts relates to the national benefits of the new and additional energy supplies that Dal project would bring to the economy of Sudan, typically some 2,160 GWh/year for an installed capacity of 400 MW. The future demands for additional energy supplies are presented in related power trade reports in this ENTRO assignment. Here, these national energy benefits are taken as being understood from the outset and are not therefore the subject of any original work in this scoping report.

1.3.4 Blue Nile, White Nile and Atbara Catchment Areas

In practice, there is a fourth area of interest which is not directly impacted by the project but which impacts the Dal project’s medium-term and long-term viability. This is the large Nile river catchment area to the Dal dam site that yields the water for the project’s energy generation and the sediment load. A summary of these matters, particularly watershed management issues, is integrated with the description of the existing environment of the direct impact zone.

1.4 CONTENTS AND ORGANIZATION OF THE REPORT

This report of an initial social and environmental assessment of the Dal hydropower project follows the report contents suggested in the Terms of Reference and is organized as follows:

- Following the Executive Summary, the background and methodology of the study, and its principal study areas, are presented in Chapter 1.

- Chapter 2 summarizes relevant environmental policy, legal and institutional frameworks in Sudan and Egypt. It proceeds to introduce the African Development Bank’s environmental policy and the World Bank safeguard policies that are considered for the project. It concludes by presenting the provisions of the Nile Waters Treaty (1959).

- Chapter 3 provides a description of the engineering project as studied at pre-feasibility level in parallel with this report.

- Chapter 4 presents the existing environmental and social conditions of the project area in Northern State, Sudan, and includes an Annex covering the rich cultural heritage of Dal’s potential reservoir area.

- Chapter 5 presents the existing environmental and social conditions downstream of Dal in Sudan and in Egypt as far north as High Aswan Dam and Lake Nasser. In Chapters 4 and 5, baseline environmental conditions are presented, where usefully separable, in three categories: physical, biological and socio-economic environments.

- Chapter 6 describes the Dal project's principal potential impacts and mitigation measures during construction over a period of six years. It anticipates management and monitoring plans for these and considers aspects of river diversion and then reservoir impoundment before presenting principal impacts on the physical, biological and socio-economic environments in the Dal region respectively – the direct impact zone. The final sections consider downstream impacts of construction and impoundment in Sudan and Egypt – the secondary impact zone.

- Chapter 7 describes the Dal project's principal potential impacts and mitigation during the operation phase, following first filling. It first introduces the principal hydrological impacts of the operation of Dal reservoir. The chapter continues with a description of the overall situation expected in the Dal area at the beginning of the operations phase before considering principal impacts on the bio-physical and socio-economic environments in the Dal region – the direct impact zone. The final sections consider operational impacts and mitigation measures along the river downstream of Dal in Sudan and Egypt – the secondary impact zone.

- Chapter 8 considers project alternatives.

- Chapter 9 presents a draft environmental management plan for the project and describes the institutional strengthening which is expected for managing and monitoring the project in Sudan and Egypt. It then outlines a resettlement action plan and presents a suggested format for handling and resolving grievances.

- Chapter 10 presents a consolidated environmental monitoring plan for the project and concludes with indicating some of the principal items to be monitored at resettlement sites.

- Chapter 11 presents an indicative summary of costs of mitigation and enhancement measures.

- Chapter 12 presents conclusions drawn from screening the project in a global and regional context and lists the conclusions reached about main impact areas.

Appendices at the back of the report include:

- Contributors to Initial Environmental Impact Assessment studies
- Itinerary of reconnaissance and field surveys
- Consultations during the Inception Mission in Sudan in November 2006

- Notes on a reconnaissance visit to Dal Cataract in November 2006
- Consultations during Field Visits in April 2007
- Dal Hydropower project – CO_2 Emissions

2. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

This chapter presents relevant environmental policies, legislative and administrative frameworks in Sudan and Egypt at regional, national and international level, including summaries of the African Development Bank's environmental policy and the World Bank's safeguard policies that will or may be triggered by the project. Focus has been given to regional level organizations that are responsible for preparation of environmental policy, technical guidelines, review and close follow-up of implementation of environmental safeguard measures.

2.1 SUDAN - NATIONAL POLICY AND STRATEGY

In the Sudan federal system there are three levels of authority: national level, state level and locality level. The powers over land and other natural resources are divided among the various levels as follows:

- At the national level, the federal organs exercise the power of planning, legislation and execution on federal lands, natural resources, mineral and subterranean wealth, inter – state waters, national electricity projects, epidemics and disasters.

- The state organs within the boundaries of the state exercise power on state lands, natural resources, animal resources, wildlife, non-Nile waters and electric power.

- There are concurrent powers where both federal (national) and state organs exercise power on education, health, environment, tourism, industry and meteorology.

This section presents relevant environmental policies, legislative and administrative frameworks at state, federal and international level. Focus has been given to state level organizations that are responsible for preparation of environmental policy, technical guidelines, review and follow-up of implementation of environmental safeguard measures.

2.1.1 National Policy and Strategies

The 2005 Interim National Constitution (INC) of the Republic of the Sudan, which came shortly after the signing of the Comprehensive Peace Agreement (CPA) between the ruling National Congress Party (NCP) and the Sudan People's Liberation Movement (SPLM), was the first in the history of Sudan to formally recognise the subject of "Environmental Pollution and Ecology" and placed the subject on the Concurrent Legislative List. Environment and social justice enjoy the protection of the INC wherein Chapter II: Guiding Principles and Directives, Section 11 on Environment and Natural Resources:

- guarantees the right of the Sudanese's people to clean and diverse environment while imposing a duty on the citizens to preserve and promote the country's biodiversity;

- precludes the State from pursuing any policy, or taking or permitting any action, which may adversely affect the existence of any special animals or vegetative life or their natural or adopted habitat; and

- guarantees that the State shall promote, through legislation, sustainable utilisation of natural resources and best practices with respect to their management.

The Interim Constitution provides for the creation of commissions, particularly on land to assume among others planning and division of lands and forests between federal and state authorities. Section 12 requires the State:

- to develop policies and strategies to ensure social justice through ensuring means of livelihood and opportunities of employment.

- to encourage mutual assistance, self-help, cooperation and charity.

Section 24 describes the Sudan as the decentralised State with three levels of government:

- the national level of government with the power to protect national sovereignty, and territorial integrity of the entire Sudan and to promote the welfare of its people,

- the State level of government with the power to exercise authority at the State level throughout the Sudan, and render public services through the level closest to the people, and

- the local level of government, which shall be throughout the Sudan.

The Interim Constitution has five Schedules (Schedules A-F), which more specifically state the powers of the various level of government in respect of, among others, environment, land acquisition and conservation of cultural heritage. Such powers include:

1) Exclusive legislative and executive powers of the national level as stated under Schedule A:

    - Natural lands and national natural resources (item no. 15),
    - Meteorology (item no. 19),
    - Signing of International Treaties on behalf of the Republic of Sudan (item no. 25),
    - National Public Utilities (item no. 30),
    - National Museums and National heritage Sites (item no. 31),
    - National Economic Policy and Planning (item no. 32), and
    - Nile Water Commission, the management of the Nile Waters and transboundary waters and disputes arising from the management of interstate waters (item no. 31).

2) Exclusive legislative and executive powers of a State of the Sudan as stated under Schedule C:

- State Land and State Natural Resources (item no. 8),
- Cultural matters within the state (item no. 9),
- Enforcement of state laws (item no. 19),
- The development, conservation and management of state natural resources and state natural resources and state forestry resources (item no. 21),
- Laws relating to Agriculture within the state (item no. 23),
- Pollution control (item no. 27),
- Quarrying regulations (item no. 31),
- Town and rural planning (item no. 32),
- State cultural and heritage sites… and other historical sites (item no. 33),
- Traditional and customary law (item no. 34),
- State irrigation and embankments (item no. 36),
- State archives, antiquities and monuments (item no. 38), and
- State public utilities (item no. 40).

Schedule E provides for residual powers exercised by the relevant level of government depending on the nature to which they relate. Schedule F deals with the resolution of disputes in relation to concurrent powers at various levels of government. New legislations expounding the broad principles of the Interim Constitution may be enacted while revision or repeal of some of the existing laws might be considered in order to conform to the provisions of the Constitution.

Article 43 (2) of the Interim Constitution gives the federal government the right to expropriate land for development purposes and to compensate owners. There are a number of articles related to natural resource management, protection of cultural heritage sites and respect of traditional and customary regulations related to land ownership.

The Interim Constitution also specifies land issues which are under national powers (federal level) and those under the control of states as well as joint powers (concurrent powers) shared by federal and states. The States manage issues related to State lands which are not under national control. These include: management, lease and utilization of lands belonging to States, town and rural planning and agricultural lands within the State boundaries. The concurrent powers include matters related to urban development, planning and housing, electricity generation, waste management, consumer safety and protection, water resources other than inter-state waters and regulation of land tenure and the rights on land.

2.2 SUDAN - LEGAL FRAMEWORK

Environment as a direct concern of the Government of Sudan dates back to the British colonial government. Until that time, environmental protection was the concern of weakly enforced indirect provisions in local, provincial, and federal laws. These provisions were mainly designed to improve civic and factory conditions and the management of canals, forests, and wildlife.

The national legal framework for protection of the environment in Sudan is acknowledged by all concerned to be weak. A study carried out with the help of UNEP in 1994 discovered over 120 references to environmental legislation over a wide range of topics (e.g. soils, pesticides, wildlife, etc.) and with authority spread among over 30 government bodies. Furthermore, there was no national coordination of environmental policy.

In an effort to remedy this situation, particularly in the light of obligations taken at the1992 Rio Conference, the Higher Council of Environment and Natural Resources (HCENR) has taken the lead in drafting a new framework law for the environment. This is an “umbrella” law that clarifies the role of the Ministry of Environment and Physical Development as the competent Ministry responsible for coordinating all matters concerning the environment. However, the new law also acknowledges that other Government Ministries with particular competence in certain fields are responsible for developing environmental measures within their areas of competence, e.g. the Ministry of Transport as the appropriate Ministry to implement measures to prevent pollution from ships.

In 2000 the federal cabinet directed the drafting of “an overall legislation for environmental protection”. In the same year, the Ministry of Environment and Physical Planning was established. The role of the Ministry or the concept of environment however, continued to be restricted to the living conditions and planning and housing sector. The most notable achievement in the 2001 was the enactment of the Sudan Environmental Protection Act (EPA). The EPA envisaged the HCENR as a policy making body and the environmental protection agency for implementation of the Ordinance. Although without executive powers and scantily staffed, the HCENR enjoyed considerable international exposure. The HCENR met irregularly, the establishment of state environment and natural resources councils was very slow, federal and state environmental conservation strategies and standards are yet to be developed.

Currently, Sudan has drafted a National Environmental Action Plan (NEAP) comprising strategies for management of natural resources and the environment.

2.2.1 Environment Related Laws in Sudan

The Sudan Environmental Protection Act, 2001 is the basic environmental law in Sudan. The act is first in the history of Sudan and meant to overcome the deficiencies in existing laws, which were considered narrow in scope, conflicting and fragmentary. Various regulations relating to the environment have been promulgated since the colonial time and to date some are still under review. Various other laws cover different facets of environmental protection, biodiversity, cultural heritage, and natural resources.

a. Environmental Protection Act of 2001

The Environmental Protection Act of 2001 provides an umbrella law and general principles to be considered in carrying out EIA studies. This law provides definitions and several clarifications regarding natural resources management, sources of pollution and pollutants and endorses the principal of the "polluter pays". The act also make it the responsibility of the project proponents, before embarking on any development activity, to carry out an EIA study, to identify the positive and negative environmental impacts with suggestions to mitigate adverse impacts According to the Act, such studies must contain the following:

- Description of the existing environmental conditions as a baseline.
- Description of the project.
- Assessment of potential environmental impacts, both positive and negative throughout the project phases.
- Provision of recommendations to mitigate the negative environmental effects.

According to this Act all development projects outside environmentally protected areas and in environmentally sensitive areas require an EIA. Proponents of all projects are required to monitor their projects and submit reports to the HCENR.

b. Environmental Health Act 1975, the Public Health Act 1975

These Acts ensure the correct calculation, reporting and payment of pollution charges by polluting/industrial units. They require the owners, tenants or occupiers of commercial and industrial concerns to have at their own cost prepared and implement a scheme for the safe drainage and disposal of their wastes and effluents of the quality permitted under the rules or the bye-laws. Pollution units per unit of production are the basis for calculation of the pollution charge by the industrial unit.

c. Industrial Relations Act 1976, Minimum Wage Act 1974

These acts deal with employment terms and conditions including such issues as minimum wage, health insurance and redundancy payment.

d. Electricity Act 2001

The Act of 2001 relates to the generation, transmission, supply, and use of electricity in the Sudan.

e. Weapons, Ammunition and Explosive Act 1986 (WAEA)

The WAEA 1986 gives the central government the power to make rules as to licensing of the manufacture, possession, use, sale, transport and importation of explosives. The Act also gives the authority to grant licenses, the fees to be charged for licenses, and the other sums (if any) to be paid for expenses by applicants for licenses; the manner in which application for licenses must be and the matters to be specified in such applications; the form in which, and the conditions on and subject to which, licenses must be granted; and the period for which licenses are to remain in force

f. Land Acquisition Ordinance 1930

This act is the legal umbrella under which the government or private parties, subject to certain conditions and procedures, may in the interest of the public undertake compulsory acquisition of land. The land may be acquired for use in development activities or projects, which directly or indirectly promote the general welfare of the public.

g. Unregistered Land Act 1970

The 1970 Unregistered Land Act declared all unregistered land as government land. The declaration was made without recognition of the long established and existing usufruct rights communally enjoyed village or pastoral communities. The Act is an amendment to the Land Settlement and Registration Ordinance 1925, which recognized usufruct customary rights with respect to unregistered land.

h. Wildlife Protection and National Parks Act 1986

This Act was issued to provide protection, preservation, conservation and management of wildlife and setting up of a National Park. This Act is applicable to all areas for protection, conservation and preservation and management of wildlife.

i. Forestry Act 1989, Forests and Renewable Natural Resources Act 2002

These Acts empower provincial governments to prohibit the clearing of forest for cultivation, grazing, hunting, removing forest produce; quarrying and felling, lopping and topping of trees, branches in reserved or protected areas. Penalties for breach of regulation and payment of cash compensation are provided in these Acts.

2.2.2 Legislation on Land Acquisition and Compensation

Specific details and procedures on land are found in sectoral laws including:

- Land Settlement and Registration Ordinance 1925 provides rules to determine rights on land and other rights attached to it and ensure land registration.
- Land Acquisition Act 1930 gives the government the power to appropriate lands for development purposes. It also states detail formalities of acquisition and rules governing assessment and payment of compensation. The Act outlines detailed procedures to be followed in the acquisition of land and rules governing payment of compensation for land for public purposes. The procedures for land acquisition in any locality are initiated with a notification by the People's Executive Council in a Gazette stating that it appeared to the President of the Republic to authorize the acquisition of land for public purposes (Section 4). It is only after such notification that it shall be lawful to enter into, bore, set out boundaries, mark or survey the land. An appropriation officer appointed by the People's Executive Council would notify the occupant of land the declaration that a designated area of land is to be appropriated for public purposes; call upon persons claiming compensation to appear before him at a place and time (not earlier than fourteen days) and to state the particulars of their claims for compensation (Section 10). He must attempt to agree on the amount of compensation for the land. The Act provides for

further steps to be taken with regard to assessment of compensation if agreement is not reached.

- Unregistered Land Act 1970 deems any unregistered land, before the enactment of this law, as being registered in the name of the government.
- The Civil Transactions Act 1984 regulates the different matters related to civil transactions with respect to titles on land, means of land acquisition, easement rights and conditions to be observed by land users.
- Urban Planning and Land Disposal Act 1994 regulates designation of lands for different purposes and urban planning. With respect to land expropriation for public purposes Section13 of the Act recognizes the application of its predecessor – Land Acquisition Act, 1930
- Central Forest Act, 1932 empowers the Minister of Agriculture, Food and Natural Resources to declare to be a central forest reserve an area of land, which is registered under the Land and Settlement and Registration Act, 1925 as a Government land (Section 5). Unless with special license or a permit has been first obtained from the Director of Forest any act, including entry upon or remaining in such forests would be an offence (Sections 9 & 10 of Central Forest Act, 1932).
- Provincial Forest Act, 1932 protects an area in Gezira province as provincial forest reserve from being interfered with on the same principle as applied to the central forest reserve.
- The Environmental Health Act, 1975 contains detailed provisions for the protection of water and air from pollution and assigns defined administrative responsibilities to District Councils with respect to preservation of environmental health in general.

Generally, these Acts provide procedures for land expropriation for development purposes and ways to specify rights in order to compensate the owner. The Urban Planning Act sets specific rules for the separation of industrial areas from residential areas.

2.2.3 Legislation on Preservation of Cultural Heritage

The Antiquities Ordinance of 1905, 1952 and the Antiquities Protection Act 1999 are the principal national legislations that deal with the protection and preservation of Sudan's archaeological heritage. These acts empower the Government to preserve and protect any premises or objects of archaeological, architectural, historical, cultural, or national interest in Sudan by declaring them protected; compulsorily purchasing them; or making arrangements to restore and maintain the object or premises.

2.3 SUDAN - INSTITUTIONAL ARRANGEMENTS FOR ENVIRONMENTAL PROTECTION

2.3.1 Higher Council for Environment and Natural Resources

The Higher Council for Environment and Natural Resources was founded in 1992, as part of the Sudan's follow-up to the Rio Conference, with the task of coordinating national plans and policies on the environment. Headed by a federal minister, the Ministry of Environment and Physical Development is the main government organization responsible for the protection of environment and resource conservation. The Ministry works with the Higher Council for Environment and Natural Resources (HCENR). The HCENR is a high-level committee comprising the Minister of Environment and Physical Development as the Chairperson; the Khartoum State Governor; federal ministers; environmentalists and community representatives. The functions of the Council include policy formulation and approval of standards. The state governors chair the SCENR.

The HCENR's objectives are the sustainable utilisation, rational development and conservation of natural resources, undertaken through line Ministries and public bodies. Apart from steering through the new environment law, the HCENR has coordinated major projects on Strategic Planning (funded by UNDP, 1996-1999), on Climate Change (funded by GEF, 1998-2001) and on a Biodiversity Action Plan (funded by GEF, 1999-2003).

2.3.2 State Council for Environment and Natural Resources

The Environmental Protection Act 2001 empowers each state to establish its own independent State Council for Environment and Natural Resources (SCENR) with the responsibilities to coordinate and follow-up the state effort to ensure public participation in the decision making process, to play an active role in coordinating the formulation and implementation of conservation policies as well as to foster environmental monitoring, protection and regulation.

However, like most other states in Sudan, the Northern State is yet to promulgate an act for the establishment of the State Council Environment and Natural Resources (SCENR)

2.3.3 Wildlife Conservation General Administration

The Wildlife Conservation General Administration (WCGA) is responsible for formulation of national wildlife policies; co-ordination with provincial wildlife departments on the implementation of these policies; and co-ordination with international organisations on matters related to international treaties. The WCGA works under the Ministry of Interior.

2.3.4 Antiquities and Museums National Corporation

The Antiquities and Museums National Corporation (AMNC) under the Federal Ministry of Culture is the custodian of the nation's cultural heritage. The main functions of the Department are as follows:

- Preservation and conservation of historical and archaeological monuments
- Exploration and excavation
- Collaboration with foreign archaeological missions working at various sites in Sudan
- Control of movement of cultural property
- Establishment and maintenance of museums
- Treatment and restoration of antiquities
- Administration of the Antiquities and Museums National Corporation Act, 1991
- Research on epigraphy, numismatics, and other relevant fields of archaeology
- Organisation of seminars, symposia, and workshops at the national and international level

The State governments have not yet enacted laws governing archaeological and historical sites.

2.3.5 Dams Implementation Unit

The Dams Implementation Unit (DIU) is an upgrading of the Merowe Dam Project Implementation Unit (MDPIU), which was headed by the State Minister for Irrigation and Water Resources. DIU is an autonomous body directly under the Office of the President of the Republic with a status of full Federal Ministry. The responsibility for the formulation and execution of resettlement and compensation policies is assigned to the Commission for Environmental and Social Affairs of the DIU.

2.3.6 Other Government Institutions

Other government institutions with designated responsibility for natural resource management are sectorally organised, in line with the general arrangements for administration and development between the federal, state and local governments.

2.3.7 Civil Society

Numerous national and local NGOs are active in the social sector in the Northern State: emergency support, rehabilitation, health, and education. Other areas include environmental conservation, income generation, poverty reduction, vocational training, nutrition and food security, and maternal, child health and family planning. The most important NGO in the Northern State is the Sudanese Red Crescent working in disaster (mainly flood) management.

The Sudanese Environment Conservation Society (SECS) is the most popular in terms of its composition and size of membership, regional coverage, and the range of environmental issues tackled. However, in the Northern State SECS branches are among the most inactive in the country.

2.4 SUDAN - INTERNATIONAL CONVENTIONS

Sudan is a signatory to a number of international and regional treaties addressing environmental conservation. The implications of these treaties for the hydropower projects are discussed below. Global and regional treaties are, in principle, binding in the first instance on national governments, which are obliged to implement such arrangements through national legislation. In the Sudan speed and timing of implementation of international have been slow and not all international treaties have a local legislation to support their implementation. However, it is prudent and environmentally desirable for the proponents of hydropower projects to ensure that the intent of such treaties is respected. A summary of the international conventions is provided below.

2.4.1 The Convention on Conservation of Migratory Species of Wild Animals, 1979

The Convention requires countries to take action to avoid endangering migratory species. Species covered in the Convention should be given special attention during EIA and monitoring of hydropower projects, and any impacts identified should be mitigated to acceptable levels.

Mitigation measures should be allowed in projects to ensure that for all species in Appendix I of the Convention their habitats are conserved; there is prohibition on the hunting, fishing, capturing, harassing and deliberate killing of the species; and the projects activities do not seriously hinder migration of the species.

2.4.2 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973

The convention requires the signatories to impose strict regulation (including penalisation, confiscation of the specimen etc.) regarding trade of all species threatened with extinction or that may become so, in order not to endanger further their survival. In view of the threats to the species covered in the Convention, all hydropower projects should evaluate impacts on the species and adopt mitigation measures necessary to bring the impacts to acceptable levels

2.4.3 Climate Change Convention 1992

The convention aims at stabilizing greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. To achieve the objective of the convention, all parties are generally required to develop national inventories of emission and formulate and implement national and regional programmes of mitigation measures.

2.4.4 Biodiversity Convention 1992

The Convention on Biological Diversity was negotiated under the auspices of the United Nations Environment Programme (UNEP). Article 25 of the CBD establishes a Subsidiary Body on Scientific, Technical and Technological Advice to provide all parties with "timely advice" relating to implementation of the Convention. The CBD deals with issues such as the monitoring and assessment of biodiversity, practical approaches to taxonomy, economic valuation of biodiversity, access to genetic resources, agricultural biodiversity, terrestrial biodiversity, marine and coastal biodiversity and bio-safety.

The relevance of this convention to hydropower projects becomes apparent since they will always introduce interference with biological sources such as land, vegetation and forests, and dam construction and operations may contribute directly or indirectly to various environmental problems ranging from air pollution to climate change.

2.4.5 The Rio Declaration

The Rio Declaration comprises twenty seven principles which address such important issues as: sustainable development to integrate environmental protection into the development process; common but differentiated responsibilities to conserve, protect and restore the earth's ecosystems; public participation and information access at the national level, reduce and eliminate unsustainable patterns of production and consumption.

2.4.6 Agenda 21

Agenda 21 is a blueprint and action plan for international cooperation towards sustainable development. It is important to note that Agenda 21 makes particular reference to dam operations, which encourages states to assess the need for additional measures to protect the riparian environments against pollution arising from hydropower projects.

2.4.7 Conventions on Wetlands (Ramsar Convention)

The broad aim of the Convention on Wetlands (Ramsar, Iran, 1971) is to halt the worldwide loss of wetlands and to conserve those that remain through wise use and management. This requires international cooperation, policymaking, capacity building and technology transfer. Contracting Parties have made commitments to:

- Designate at least one site that meets the Ramsar criteria for inclusion in the List of Wetlands of International Importance
- Protect the ecological character of listed sites
- Include wetland conservation within their national land-use planning
- Establish nature reserves on wetlands and promote wetland training.

2.4.8 Convention to Combat Desertification and Drought (CCD)

The stated objective of the Convention is to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa. Most of the endangered dryland regions lie near the world's five main desert areas of which the Sahara Desert extending from the Atlantic shore to the Red Sea coast. High Aswan Dam, Merowe and Low Dal and sites at other cataracts are in this zone.

2.5 EGYPT - LEGAL AND INSTITUTIONAL FRAMEWORK

2.5.1 Institutions with Responsibilities for Water Quality

The institutions involved with water quality management in Egypt are generally line-management ministries with responsibilities in areas that are related to, but not necessarily coincident with environmental protection. The Ministry of Health and the Ministry of Industry have many other functions, many of which conflict with water quality management. Egypt lacks such a relatively strong central coordinating or managing body, although the Egyptian Environmental Affairs Agency (EEAA) has some of the appropriate rules (coordination, studies and evaluation). The following outlines institutions with major roles in water quality management.

2.5.2 Ministry of Water Resources and Irrigation (MWRI)

The MWRI is formulating the national water policy to face the problem of water scarcity and water quality deterioration. The overall policy's objective is to utilize the available conventional and non-conventional water resources to meet the socio-economic and environmental needs of the country. Under law No. 12 of 1984, MWRI retains the overall responsibility for the management of all water resources, including available surface water resources of the Nile system, irrigation water, drainage water and groundwater.

The MWRI is the central institution for water quality management. The main instrument for water quality management is Law 48. The MWRI is responsible to provide suitable water to all users but emphasis is put on irrigation. It has been given authority to issue licenses for domestic and industrial discharges. The responsibility to monitor compliance to these licenses through the analyses of discharges has been delegated to MOHP.

The National Water Research Centre (NWRC) supports the MWRI in its management. Within the NWRC, three institutes are focusing on the Nile, the irrigation and drainage canals and groundwater (NRI, DRI, RIGW). NWRC maintains a national water quality monitoring network and contracts portions of the monitoring activity to these institutes. NWRC also operates a database where all MWRI water quality data is consolidated. NWRC also operates a modern, well equipped water quality laboratory.

2.5.3 Egyptian Environmental Affairs Agency (EEAA)

The central organization for environmental protection is the EEAA. This agency has an advisory task to the Prime Minister and has prepared the National Environmental Action Plan of Egypt 2002/17 (2002). The Minister of State for Environment heads the agency. According to Law 4, it has the enforcing authority with respect to environmental pollution except for fresh water resources. Through Law 48, the MWRI remains the enforcing authority for inland waterways.

The EEAA is establishing an Egyptian environmental information system (EEIS) to give shape to its role as coordinator of environmental monitoring. Moreover, staff is being prepared to enforce environmental impact assessment (EIA). Major industries have been visited in view of their non-compliance with respect to wastewater treatment. Compliance Action Plans (CAP's) are being agreed upon to obtain a grace period for compliance. Additionally EEAA is monitoring waste from Nile ships and is responsible for coastal water monitoring. In cooperation with the MWRI, an action plan was implemented to reduce industrial pollution of the Nile.

2.5.4 Ministry of Health and Population (MOHP)

The MOHP is the main organization charged with safeguarding drinking water quality and is responsible for public health in general. Within the framework of Law 48/1982, this Ministry is involved in standard setting and compliance monitoring of wastewater discharges. The Environmental Health Department (EHD) is responsible for monitoring with respect to potable water resources (Nile River and canals). The MOHP samples and analyses all intakes and treated outflows of drinking water treatment plants. Also water from drinking water production wells is monitored. In case of non-compliance of drinking water quality, especially with respect to bacterial contamination, MOHP takes action.

Within the framework of Law 48 MOHP samples and analyses drain waters to be mixed with irrigation waters, industrial and domestic wastewater treatment plant effluents and wastes discharged from river vessels. In case of non-compliance of discharges, the MWRI generally takes action upon notification from the MOHP.

2.5.5 Ministry of Housing, Utilities and New Communities (MHUNC)

Within the Ministry of Housing, Utilities and New Communities, the National Organization for Potable Water and Sanitary Drainage (NOPWASD) has the responsibility for planning, design and construction of municipal drinking water purification plants, distribution systems, sewage collection systems, and municipal wastewater treatment plants. Once the facilities have been installed, NOPWASD organizes training and then transfers the responsibilities for operation and maintenance to the regional or local authorities.

2.5.6 Ministry of Agriculture and Land Reclamation (MALR)

MALR develops policies related to cropping patterns and farm production. Moreover they are in charge of water distribution at field level and reclamation of new agricultural land. With respect to water quality management issues, their policies on the use and subsidy reduction of fertilizers and pesticides is important. In addition, MALR is responsible for fisheries and fish farms (aquaculture).

The Soil, Water and Environment Research Institute is part of the MALR and is responsible for research on many subjects such as water and soil quality studies on pollution, bioconversion of agricultural wastes, reuse of sewage wastewater for irrigation, saline and saline-alkaline soils, fertilizer and pesticide use and effects.

2.6 EGYPT - POLICY FRAMEWORK

2.6.1 Egypt’s Agricultural policy up to 2017

A Land Master Plan of Egypt was prepared in 1986. It concluded that the construction of AHD not only made the intensification of agriculture feasible in the old lands but also extended it to new “reclaimed” areas. Some 650 000 fedddans out of 805 000 feddans of land reclaimed during 1960-70 was made possible due to the increased supply of water from AHD. The total land that could be reclaimed is subject to water availability. The arable area per person declined by 75% from

0.51 feddan/person to 0.13 feddan/person during 1887-1990 (Abu Zeid and Rady 1991).

The strategy for agricultural development up to 2017 has a number of aims.

(i) To increase the annual rate growth in the agricultural production from 3.4% to 3.8% during the remaining period of the Fourth 5-Year Plan, and to 4.1% annually up to 2017. This goal is attainable only through vertical and horizontal expansion of plant and animal production, which will have a positive bearing on job creation, income to producers and the overall standard of living of the rural population.

(ii) To reclaim no less than 150,000 feddans annually, within the Master Plan of Egypt's Land and water resources which assesses the reclaimable and cultivable lands in the Delta, Southern Valley, East Owaynat, the area of and round Lake Nasser and East and West of Suez Canal by the year 2017 at about 3.4 million feddans. The inhabited area would reach 25% of the total area of Egypt.

(iii) To increase the agricultural production horizontally and vertically through the efficient allocation and use of soil and water resources. Maintenance and development of the natural resource base is an integral part of Egypt's sustainable agricultural development program.

(iv) To form a national strategic stock of the basis food commodities by focusing on the efficient use of the available resources and redirecting investments to such areas that help fulfill the increasing food needs of the population. This shall be accompanied with rationalization of food consumption levels, reduction of post-harvest losses.

2.6.2 Water Policy

The Ministry of Water Resources and Irrigation (MWRI) has prepared a National Water Policy till the year 2017 including three main themes:

- optimal use of available water resources;
- development of water resources; and
- protection of water quality and pollution abatement.

At present, Egypt is addressing the issue of limited water quantity by managing the demand side. MWRI formulated a water master plan in 1981. This plan is currently updated. The process of updating the water master plan aims to allocate available water resources according to various needs and demands that are feasible from the economic perspective. It also aims to gain social acceptance and political support. The Water Master Plan is updated through the National Water Resources Plan (NWRP) project.

The NWRP has been operated since 1998 and jointly funded between MWRI and the Netherlands Government. This project is directed towards developing a National

Water Resources Plan that describes how Egypt will safeguard its water resources both quantity and quality and how it will optimize the use these resources in response to the socio-economic and environmental conditions.

2.7 EGYPT - NON-GOVERNMENT ORGANISATIONS WORKING IN THE AREA OF LAKE NASSER

2.7.1 Centre for Development Services (CDS)/Desert Development Centre (DDC) – American University in Cairo

The CDS is a Cairo based NGO established in 1990 and together with the DDC of the American University in Cairo are the implementing agencies for the "Agro-Ecology West of Lake Nasser - Towards a Sustainable Livelihoods Strategy" Project. The High Dam Lake Development Authority (HDLDA) is a strategic partner. The Canadian International Development Research Centre (IDRC) is the main funding agency.

The NGO is working in three of the settlement communities on the western shores of Lake Nasser: Khor Galal, Kalabsha, and Garf Hussein: numbered 4, 5 and 6 respectively of Map 8. The project is an Action Research project using a trans-disciplinary and multi-stakeholder approach to encourage sustainable improvements to household incomes and positive environmental actions that will enhance human health and community welfare. The project is being implemented over three years. It commenced in July 2004 and is due for completion in July 2007. Total funding is CAD$ 478,760.

They project is focusing on (i) action research into environmentally safe methods of pest control and fertilization, (ii) marketing and (iii) human and animal health.

The project is also working with the University of the South Valley and Suez Canal University.

2.7.2 Egyptian Swiss Development Fund (ESDF)

The ESDF is also working in other Settlement communities west of the Lake. It also covers agricultural extension and research and health aspects. It also supports capacity building for the Community Development Associations (CDA's) – the elected bodies that are involved with the day-to-day management of the Schemes.

2.7.3 World Food Programme (WFP)

WFP's Food Aid project directly supports the establishment of the Settlement Schemes from a physical perspective. It has its own field staff in the same areas as CDS and ESDF. As with CDS and ESDF they also provide capacity building support to the CDA's.

2.7.4 Wadi Allaqi Project: Universities of the South Valley in Aswan and Glasgow, U.K.

This project has been running since the late 1980's and is collaborative research link between the University of the South Valley in Aswan and the University of Glasgow in the UK. It is funded by UK DiFID's Academic Links and the Gender and Development programmes.

It focuses on the peoples' livelihoods in the Wadi Allaqi and studies the changes in their livelihood strategies under changing environmental conditions due to the formation of Lake Nasser. It has studied in depth indigenous knowledge of both men and women, livelihood strategies of women headed households and the natural resource management systems in the Wadi.

2.8 AFRICAN DEVELOPMENT BANK'S ENVIRONMENTAL POLICY

The African Development Bank's (AfDB) environmental policy was approved in 1990 and its environmental assessment guideline followed in 1992. The Bank has continually updated its environmental policy and its social and environmental study guidelines. AfDB's updated policy on environment was issued 2004, incorporating and redefining environmentally sustainable development. The Bank's development plan seeks to ensure that environmental management tools like strategic impact assessment and project level environmental and social assessment will be used systematically to monitor environmental performance and encourage community involvement. With regard to sustainable energy development, the Bank has identified the need to refocus its instruments and policy to deliver sustainable, reliable and environmentally friendly energy resource development. The proposed hydropower project under study is in line with the Bank's policy in relation to sustainable and environmentally friendly energy resource development.

In line with the updated policy, two relevant guidelines, namely the Strategic Impact Assessment Guideline and the Integrated Environmental and Social Assessment Guideline that were produced in 2004, were used for guiding the present pre-feasibility study and preparation of TOR for a future feasibility study. Based on the nature, scale and identified impacts the project can be categorized as Category 1. According to the AfDB, Category 1 projects that proceed to full feasibility study and implementation require a full Environmental and Social Impact Assessment, including the preparation of an Environmental and Social Management Plan. The Environmental and Social Impact Assessment examines the project's potential beneficial and adverse impacts in detail and recommends any measures needed to prevent, minimise, mitigate or compensate for adverse impacts and to enhance environmental and social project benefits. The Bank provides special attention to public participation in the environmental study process through conducting meaningful consultations with relevant stakeholders, including potential beneficiaries, affected groups, Civil Society Organisations (CSOs) and local authorities, about the project's environmental and social aspects and take their views into account.

2.9 WORLD BANK'S SAFEGUARD POLICIES

The World Bank has developed a series of safeguard policies to help promote socially and environmentally sustainable approaches to development as well as to ensure that Bank operations do not harm people and the environment. These safeguard policies include the Bank's policy on Environmental Assessment (EA) and those policies that fall within the scope of EA. These have been considered in relation to the Dal project and their applicability is summarized as follows:

Safeguard policies on Environmental Assessment, International Waterways, Involuntary Resettlement, Indigenous Peoples, Physical Cultural Resources and Safety of Dams apply to the Dal project.

Safeguard policies on Natural Habitat may be applicable to the Dal project.

Safeguard policies on Forestry, Pest Management and Disputed Areas are considered not applicable to the Dal project.

For future funding purposes, it is intended that the present scoping/IEA report should reflect the current policies, requirements and guidelines of the World Bank. The 10 safeguard policies are outlined below. By examining these in relation to the Dal project in this initial environmental assessment report, it is also intended to build up confidence and trust in all stakeholders that these important issues will be addressed in detail in any future phases of study.

2.9.1 Environmental Assessment (OP 4.01)

Environmental Assessment is one of the 10 environmental, social, and legal safeguard policies of the World Bank. Environmental Assessment is used in the World Bank to identify, avoid, and mitigate the potential negative environmental impacts associated with Bank lending operations. This policy is considered to be the umbrella policy for the Bank's environmental 'safeguard policies'.

The Operational Policy (OP) and Bank Procedure (BP) 4.01 on Environmental Assessment (EA) published in January 1999, applies to the Dal project. The Dal project is determined as Category ‘A’, requiring a full EIA in future.

Annexes of the OP define the required structure of the EIA report and the structure of the Environmental Management Plan (EMP) with which the future EIA report must comply.

OP 4.01 states that for Category ‘A’ projects that are highly risky or contentious or that involve serious and multidimensional environmental concerns, the developer should normally engage an advisory panel of independent, internationally recognized environmental specialists to advise on all aspects of the project relevant to the EA.

In relation to public consultation, OP 4.01 requires a two-stage process:

a) shortly after environmental screening and before the terms of reference for the full EIA are finalised, and

b) once a draft EIA report is prepared.

In addition, the borrower is required to consult with stakeholder groups throughout project implementation as necessary to address EIA-related issues that affect them.

2.9.2 Projects on International Waterways (OP 7.50)

This policy applies to the Dal hydropower project because the Main Nile flows through two or more states.

The Bank recognizes that the cooperation and goodwill of riparians is essential for the efficient use and protection of international waterways. Therefore, it attaches great importance to riparians' making appropriate agreements or arrangements for these purposes for the entire waterway or any part thereof. The Bank stands ready to assist riparians in achieving this end. In cases where differences remain unresolved between the state proposing the project (beneficiary state) and the other riparians, prior to financing the project the Bank normally urges the beneficiary state to offer to negotiate in good faith with the other riparians to reach appropriate agreements or arrangements.

It is noted that this process began along time ago in the form of the Nile Waters Agreement between Egypt and Sudan, and continues to be recognised by World Bank already being a stakeholder in promoting NBI and ENTRO's pursuit of viable projects including these relating to power trading.

2.9.3 Involuntary Resettlement (OP 4.12)

This policy applies to the Dal hydropower project because substantial involuntary resettlement will be required.

Any requirement for involuntary resettlement is considered to be one of the most important environmental impacts of a proposed project, and Bank guidance on resettlement and compensation is now very comprehensive and specific, particularly in relation to the identification, participation and support of project-affected persons (PAPs). The policy objectives stated in OP 4.12 are as follows:

- Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs;
- Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs;
- Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.

The "Involuntary Resettlement Sourcebook: Planning and Implementation in Development Projects", comprising some 468 pages published in 2004, is the authoritative document which clarifies many policy and technical issues that confront resettlement policymakers and practitioners. It provides guidance on resettlement design, implementation, and monitoring, recognizing that construction of road and dam infrastructure (considered a pre-requisite for sustained socioeconomic growth in ENTRO's power trade projects) requires acquisition of land and, therefore, physical relocation and economic displacement of people.

2.9.4 Indigenous Peoples (OP 4.20)

This Operational Policy provides policy guidance to ensure that indigenous people benefit from development projects, and to avoid or mitigate potentially adverse effects on indigenous people caused by Bank-assisted activities. Special action is required where Bank investments affect indigenous peoples, tribes, ethnic minorities, or other groups whose social and economic status restricts their capacity to assert their interests and rights in land and other productive resources. The Bank defines "indigenous peoples," "indigenous ethnic minorities," "tribal groups," and "scheduled tribes" as social groups with a social and cultural identity distinct from the dominant society that makes them vulnerable to being disadvantaged in the development process.

The people living in the Dal area are Mahas Nubians, all speaking the Nubian language. Along the Nile in Upper Nubia, from north of the Third Cataract, where the Mahas district begins to Akasha, Nubian villagers maintain their linguistic and cultural differences with great pride. To be Mahasi means to be a true Nubian, to speak a pure Nubian language and to live in the Nubian heartland. This is the best description for the area between Dal cataract to Kajbar as far south as Kerma.

Thus, the Mahas are an indigenous minority with their distinct language, style of house construction and history. Of course many Mahas speak Arabic, being the lingua franca of the country but in their day-to-day conversations at home, on the farm, and in the market they speak Nubian. Currently, therefore, this policy is expected to be triggered by the project.

2.9.5 Physical Cultural Resources OP/BP 4.11

This policy will be triggered by the Dal project. Cultural resources are important as sources of valuable historical and scientific information, as assets for economic and social development, and as integral parts of a people's cultural identity and practices. The loss of such resources is irreversible, but fortunately, it is often avoidable. The objective of OP/BP 4.11 on Physical Cultural Resources is to avoid, or mitigate, adverse impacts on cultural resources from development projects that the World Bank finances.

The United Nations term "cultural property" includes sites having archaeological (prehistoric), palaeological, historical, religious, and unique natural values. Cultural property, therefore, encompasses both remains left by previous human inhabitants (including middens, shrines, and battlegrounds), and unique natural environmental features such as canyons and waterfalls. The World Bank requires that, before proceeding with a project that may risk damaging cultural property (e.g., any project that includes large scale excavations, movement of earth, superficial environmental changes or demolition), the cultural property aspects of the project site must be determined. If there is any question of cultural property in the area, a reconnaissance survey should be undertaken in the field by specialists.

2.9.6 Dam Safety (OP 4.37)

This policy will be triggered by the Dal project. For the life of any dam, the owner is responsible for ensuring that appropriate measures are taken and sufficient resources provided for the safety of the dam, irrespective of its funding sources or construction status. Because there are serious consequences if a dam does not function properly or fails, the Bank is concerned about the safety of new dams it finances and existing dams on which a Bank-financed project is directly dependent.

When the Bank finances a project that includes the construction of a new dam, it requires that the dam be designed and its construction supervised by experienced and competent professionals. It also requires that the borrower adopt and implement certain dam safety measures for the design, bid tendering, construction, operation, and maintenance of the dam and associated works.

The Bank distinguishes between small and large dams. The proposed Dal dam is a large dam being “15 metres or more in height”. For large dams, the Bank requires

a) reviews by an independent panel of experts (the Panel) of the investigation, design, and construction of the dam and the start of operations;

b) preparation and implementation of detailed plans: a plan for construction supervision and quality assurance, an instrumentation plan, an operation and maintenance plan, and an emergency preparedness plan;

c) pre-qualification of bidders during procurement and bid tendering, and

d) periodic safety inspections of the dam after completion.

The Panel consists of three or more experts, appointed by the borrower and acceptable to the Bank, with expertise in the various technical fields relevant to the safety aspects of the particular dam. The primary purpose of the Panel is to review and advise the borrower on matters relative to dam safety and other critical aspects of the dam, its appurtenant structures, the catchment area, the area surrounding the reservoir, and downstream areas. However, the borrower normally extends the Panel’s composition and terms of reference beyond dam safety to cover such areas as project formulation; technical design; construction procedures; and, for water storage dams, associated works such as power facilities and river diversion during construction.

The borrower contracts the services of the Panel and provides administrative support for the Panel’s activities. Beginning as early in project preparation as possible, the borrower arranges for periodic Panel meetings and reviews, which continue through the investigation, design, construction, and initial filling and start-up phases of the dam. The borrower informs the Bank in advance of the Panel meetings, and the Bank normally sends an observer to these meetings. After each meeting, the Panel provides the borrower a written report of its conclusions and recommendations, signed by each participating member; the borrower provides a copy of that report to the Bank. Following the filling of the reservoir and start-up of the dam, the Bank reviews the Panel’s findings and recommendations. If no significant difficulties are encountered in the filling and start-up of the dam, the borrower may disband the Panel.

2.9.7 Natural Habitat (OP 4.04)

This policy may be triggered by the Dal project. It states that wherever feasible, Bank-financed projects are sited on lands already converted (excluding any lands that in the Bank's opinion were converted in anticipation of the project). The Bank does not support projects involving the significant conversion of natural habitats unless there are no feasible alternatives for the project and its siting, and comprehensive analysis demonstrates that overall benefits from the project substantially outweigh the environmental costs. If the environmental assessment indicates that a project would significantly convert or degrade natural habitats, the project should include mitigation measures acceptable to the Bank. Such mitigation measures include, as appropriate, minimizing habitat loss (e.g., strategic habitat retention and post-development restoration) and establishing and maintaining an ecologically similar protected area. The Bank accepts other forms of mitigation measures only when they are technically justified.

The Bank encourages borrowers to incorporate into their development and environmental strategies, analyses of any major natural habitat issues, including the identification of important natural habitat sites, the ecological functions they perform, the degree of threat to the sites, priorities for conservation, and associated recurrent-funding.

Inundation of the Dal reservoir basin will clearly ‘convert or degrade’ its natural habitat. The question is whether that can be considered ‘critical’ natural habitat. The World Bank definition of critical natural habitat is as follows:

Existing protected areas and areas officially proposed by governments as protected areas (e.g., reserves that meet the criteria of IUCN classifications), areas initially recognized as protected by traditional local communities (e.g., sacred groves), and sites that maintain conditions vital for the viability of these protected areas (as determined by the environmental assessment process);or sites identified on supplementary lists prepared by the Bank or other authoritative sources. Such sites may include areas recognized by traditional local communities (e.g. sacred groves); areas with known high suitability for biodiversity conservation; and sites that are critical for rare, vulnerable, migratory, or endangered species. Listings are based on systematic evaluations of such factors as species richness; the degree of endemism, rarity, and vulnerability of component species; representativeness; and integrity of ecosystem processes.

If an EIA indicates that a project would significantly convert or degrade natural habitats, the project must include mitigation measures acceptable to the Bank. Such mitigation measures may include, as appropriate, minimizing habitat loss (e.g., strategic habitat retention and post-development restoration) and the establishment and maintenance of an ecologically similar protected area. The Bank accepts other forms of mitigation measures only when they are technically justified.

The Bank takes into account the borrower's ability to implement the appropriate conservation and mitigation measures. If there are potential institutional capacity problems, the project must include components that develop the capacity of national and local institutions for effective environmental planning and management.

2.9.8 Forests (OP 4.36)

This policy appears unlikely to be triggered by the Dal project. Whilst this policy is principally related to World Bank activities in the forestry sector, it includes policies on the conservation of forest biodiversity, the sustainable management of forest areas, and the participation of local people particularly in the management of the surrounding forests. The policy emphasizes that the management, conservation, and sustainable development of forest ecosystems and their associated resources are essential for lasting poverty reduction and sustainable development.

The policy states that:

- The Bank does not finance projects that, in its opinion, would involve significant conversion or degradation of critical forest areas or related critical natural habitats;
- If a project involves the significant conversion or degradation of natural forests or related natural habitats that the Bank determines are not critical, and the Bank determines that there are no feasible alternatives to the project and its siting, and comprehensive analysis demonstrates that the overall benefits from the project substantially outweigh the environmental costs, the Bank may finance the project provided that it incorporates appropriate mitigation measures.

This policy overlaps with that on Natural Habitat (OP 4.04) to a great extent. In Dal's case, if woodland issues are not considered covered by Natural Habitat (OP 4.04), it would cover roads, reservoir basin clearance/inundation and transmission lines through woodlands, if any.

2.9.9 Pest Management (OP 4.09)

Rural development and health sector projects have to avoid using harmful pesticides. A preferred solution is to use Integrated Pest Management techniques and encourage their use in the whole of the sectors concerned.

If pesticides are considered necessary at full EIA stage, either for crop protection at resettlement sites or in the fight against water-related vector-borne diseases, a Bank-funded project should include a Pest Management Plan (PMP), prepared by the borrower, either as a stand-alone document or as part of the Environmental Assessment. Currently, this policy is not expected to be triggered by the project.

2.9.10 Projects in Disputed Areas (OP 7.60)

The Dal project area is not in a disputed area and the Bank's policy on disputed areas will not be triggered by the project.

2.10 THE NILE WATERS TREATY

The Nile Waters Treaty (1959) had the following provisions:

- The average flow of the river is considered to be 84 BCM/yr. Evaporation and seepage were considered to be 10 BCM/yr., leaving 74 BCM/yr. to be divided.

- Of this total, acquired rights have precedence, and are described as being 48 BCM for Egypt and 4 BCM for Sudan. The remaining benefits of approximately 22 BCM are divided by a ratio of 7 1/2 for Egypt (approx. 7.5 BCM/yr.) and 14 1/2 for Sudan (approx. 14.5 BCM/yr.). These allocations total 55.5 BCM/yr. for Egypt and 18.5 BCM/yr. for Sudan.

- If the average yield increases from these average figures, the increase would be divided equally. Significant decreases would be taken up by a technical committee, described below.

- Since Sudan could not absorb that much water at the time, the treaty also provided for a Sudanese water "loan" to Egypt of up to 1,500 MCM/yr. through 1977.

- Funding for any project which increases Nile flow (after the High Dam) would be provided evenly, and the resulting additional water would be split evenly.

- A Permanent Joint Technical Committee to resolve disputes and jointly review claims by any other riparian would be established. The Committee would also determine allocations in the event of exceptional low flows.

- Egypt agreed to pay Sudan £E 15 million in compensation for flooding and relocations.

3. PROJECT DESCRIPTION

3.1 PROJECT AREA

The Dal project site is located on the Nile some 280 km downstream of Dongola and immediately upstream of Lake Nubia / Lake Nasser formed by the Aswan High Dam. (Figure 3.1, and Drawing No.D1 at the end of the report). The catchment area for the Dal project comprises the entire Blue Nile and White Nile river basins together with the Main Nile downstream of Khartoum.

3.2 DEVELOPMENT OPTIONS FOR THE NILE IN SUDAN

The Nile Waters Study was completed in 1979 and identified potential hydropower development sites on the main stream of the Nile in Sudan as well as on each of the tributary valleys of the Blue and White Nile as listed in Table 3.1. These projects have subsequently been re-evaluated in successive power system planning studies carried out for the National Electricity Corporation in 1993 and 2006.

Table 3.1 : Characteristics of Hydropower Projects on the Nile

Site	Gross Head (m)	Full Supply Level (m)	Reservoir Area (km^2)	Installed Capacity (MW)	Average Energy Output (GWh/year)
Dal (Low)	20.5	201	300	340	
Dal (High)	37.5	218	990	780	3150
Kagbar	17	218	300	108	
Merowe	55	300	700	1250	5500
Dagash	16	323	250	285	1520
Shereik	20	343	250	315	2000
Sabaloka	11.5	374	140	120	520

The Merowe project commenced construction in 2003 and is now nearing completion.

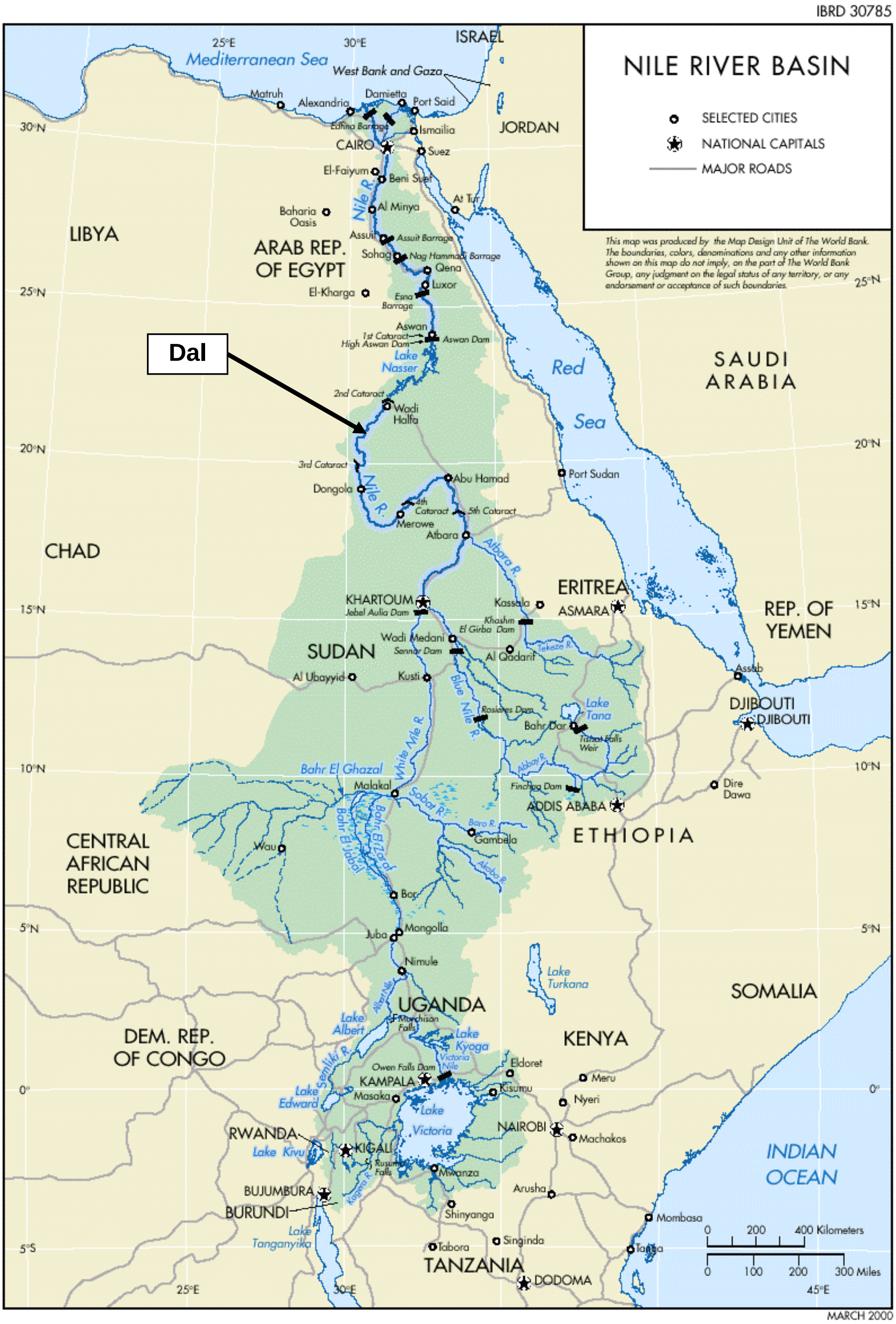


Figure 3.1 : Location of Hydropower Project Sites

The characteristics of the Dal project as proposed in the Nile Waters Study are shown in Table 3.2. The Dal project was planned as a 600 MW development with 6 turbine-generator units each of 100 MW. A 400 kV transmission line was planned to evacuate the power over the 670 km distance to Khartoum.

Table 3.2 : Characteristics of Dal Hydropower Project (Nile Waters Study, 1979)

Length of Dam (m)	5,200
Maximum Height (m)	74
Retention Level (m)	218
Reservoir Area (km^2)	1,000
Installed Capacity (MW)	600
Rated Head (m)	38
Average Annual Energy (GWh/Yr)	3,500

3.3 INITIAL REVIEW OF PROJECT

At the outset of this study an initial review of the Dal project was undertaken based on information from available mapping and field reconnaissance. The primary objective of the review was to assess the previous studies and to identify constraints to development of the Dal site.

The principal constraints to the development of the Dal site comprise low topography on the west bank of the river, the number of affected persons living and depending on the river and in particular on its annual flood regime in an area which does not benefit from rainfall, and an immense wealth of Nubian physical cultural resources.

The review concluded that the site was potentially suitable for development of a dam up to some 20 m in height with a full supply level of up to El. 201 m. This development has been characterised in previous studies as the “Low Dal” option. In contrast, the “High Dal” option with a dam some 40 m in height and with full supply level of El. 218 m was considered to have very high and much greater social and cultural impacts.

As a result of this initial review the study of the Dal project described in this report has been confined to the “Low Dal” option. The development of the Low Dal project is compatible with development of the Kagbar project upstream and does not have any impact on other developments upstream along the Nile.

3.4 RESERVOIR CHARACTERISTICS

The reservoir characteristics of the Dal reservoir have been determined from existing reports based on cross-sections that have been surveyed at 5 km intervals along the Nile and are presented in Table 3.3 and Figs. 3.2 and 3.3.

Table 3.3 : Dal Reservoir Elevation Area Volume Relationship

Elevation (m)	Area (km^2)	Volume ($m^3 \times 10^6$)
180	14	45
183	24	100
187	52	246
190	87	456
193	133	780
197	195	1,420
200	277	2,120
205	421	3,876
210	614	6,436
215	836	10,031
220	1,117	14,842
230	3,177	39,172

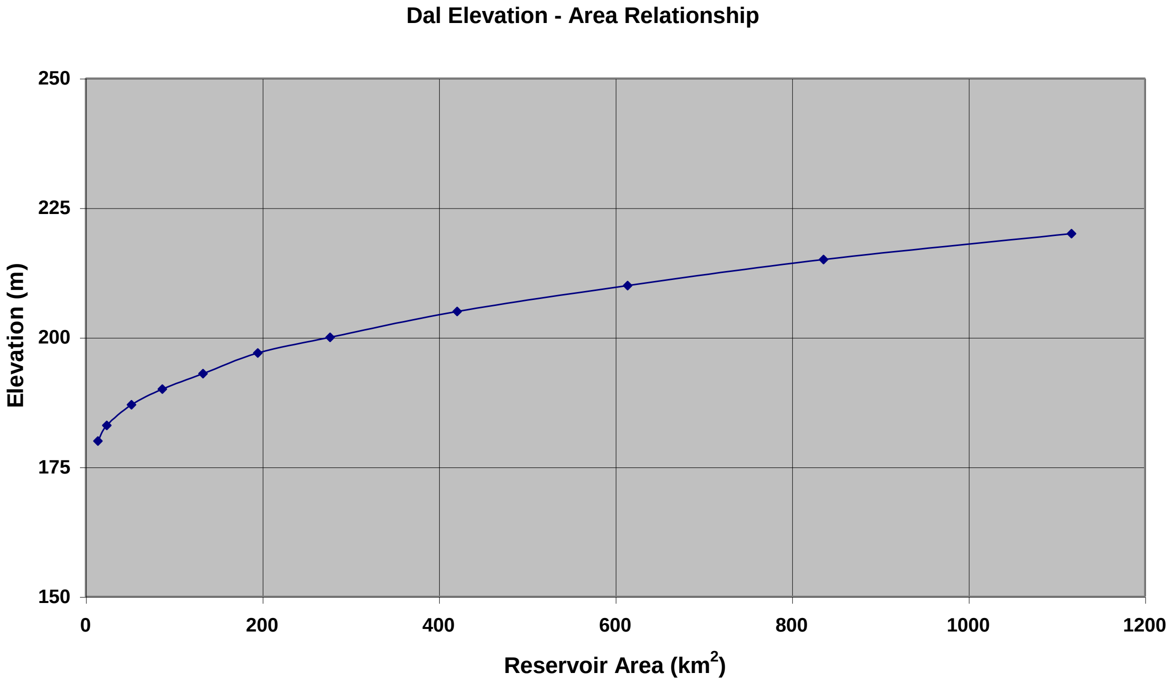


Figure 3.2 : Dal Reservoir Elevation Area Relationship

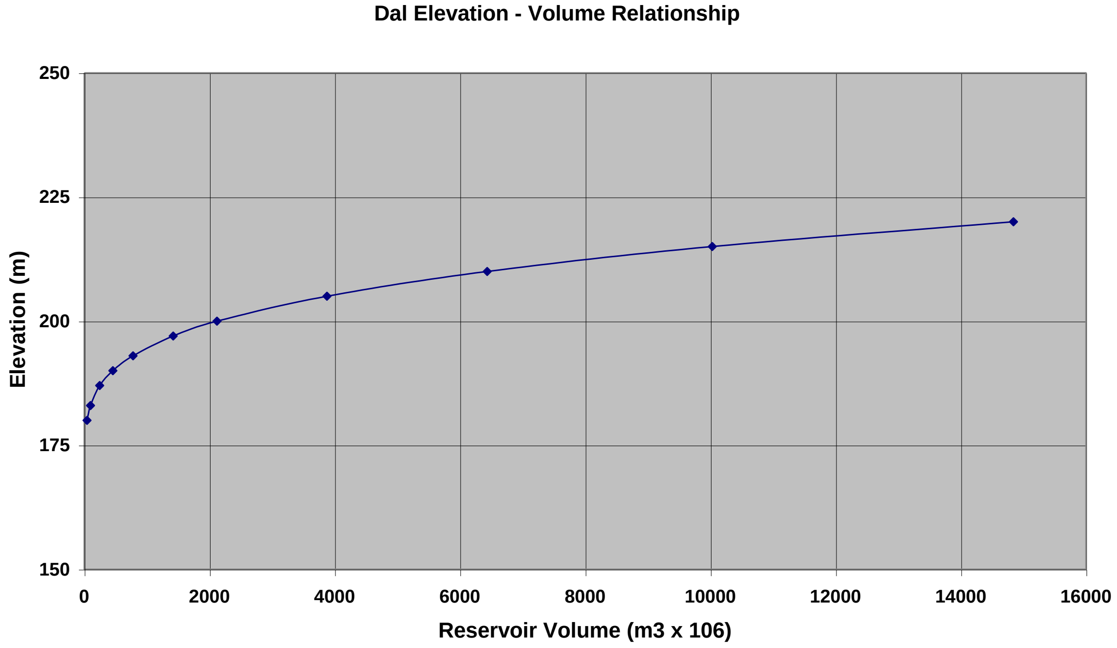


Figure 3.3 : Dal Reservoir Elevation Volume Relationship

3.5 HYDROLOGY

The Dal site is located some 280 km downstream of the Dongola hydrometric station and some 120 km upstream of the former Wadi Halfa hydrometric station. There are no intervening catchments. Accordingly the time series for flow at Dongola has been adopted directly for the Dal site. Recorded average monthly flows for Dongola are given in Table 3.4.

Table 3.4 : Summary of Average Discharge for Dongola (1890-1995) (m^3/s)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1,335	1,053	847	864	812	837	1,967	6,982	7,930	4,979	2,611	1,694	2,668

The flow sequence for the period 1954 – 2003 has been adopted for reservoir simulation studies in common with the other projects, Mandaya and Border, in Ethiopia.

3.6 FLOOD STUDIES

Flood estimates for design of the Dal spillway to ensure safe passage of flood flows and design of river diversion works are shown in Table 3.5, below.

Table 3.5 : Frequency Analysis of Flood Flows (m^3/s) for Nile at Dongola

Return Period (Years)	Method	
	LP3	Gumbel
10000		21,670
1000		18,240
500		17,200
100	13,790	14,800
50	13,080	13,760
20	12,100	12,370
10	11,260	11,300
5	10,340	10,190

The construction of the Merowe project upstream of Dal will alter the flood regime in the Nile at Dongola and further downstream at Dal. Depending on the exact mode of operation a significant attenuation of flood magnitude in the Nile at Dongola and Dal can be anticipated associated with the routing of floods through the Merowe reservoir, particularly with the lower return period events. A design capacity of 10,000 m^3/s has been adopted for the river diversion works during construction approximately equivalent to the 1 in 20 year flood.

For reasons of dam safety, it will be necessary to ensure that flood releases from Merowe can pass the Dal dam safely under all foreseeable circumstances. Accordingly, a spillway capacity of 20,000 m^3/s has been adopted for the Dal site, similar to the design capacity of the Merowe spillway.

3.7 SEDIMENT

Recent measurements over the period 2001 to 2003 suggest that the mean annual suspended sediment discharge in the Main Nile at Dongola amounts to some 140 Mt/yr.

It is noted that this figure is significantly lower than recent estimates for average sediment discharge in the Abbay (Blue Nile) at Kessie in Ethiopia of 220 Mt/yr produced as part of the present study, based on sediment concentration measurements carried out at the Kessie hydrometric station in 2004.

A sediment balance for the Nile River was prepared as part of the Cooperative Regional Assessment (CRA). In this analysis the sediment discharge entering Karadobi has been assumed as 92 Mt/yr compared to a current estimate for sediment discharge at Kessie (slightly upstream of Karadobi), based on 2004 data of 220 Mt/yr in this study.

There is a high level of uncertainty regarding many of the estimates involved in deriving a sediment balance for the Nile given that many of the individual components of the balance are highly variable from year to year and that measurements are infrequent and imprecise. Some data is now more than 40 years old whilst it is anticipated that sediment discharge will have increased over this period due to pressures of population, agriculture and deforestation.

Although the overall balance of sediment along the Nile downstream of Merowe is therefore uncertain, the average annual sediment discharge at the Dal site following construction of the Merowe project can probably be expected to lie within the range 75Mt to 100 Mt, depending on the effectiveness of the sediment flushing regime at Merowe. Much of this sediment will be very fine grained and will have a lower trapping efficiency in Dal than would be the case without Merowe upstream. A trapping efficiency of 55 % has been estimated for Dal based on Brune's relationship for primarily fine grained and colloidal particles and assuming that sediment flushing at Dal would not take place. Under these circumstances it is anticipated that sediment deposition in the Dal reservoir will be some 40 - 55 Mt/year, or some 30 – 40 Mm^3/year.

3.8 RESERVOIR AND POWER SIMULATION

Computer simulations have been carried out to estimate the energy characteristics of the potential alternative scheme configurations of the Dal project. The simulations have been performed employing a program named RAPSO that has been developed over a long period of years to represent seasonal and annual operation of any combination of hydroelectric schemes. The RAPSO model was set up and calibrated for the recent National Electricity Corporation (NEC) long-term power system planning study to represent all existing and potential schemes in the Sudanese Nile system. Results are summarised in tabular and graphical forms below.

The average energy outputs together with some other key indicators that have been calculated for the alternative installations of the Low Dal scheme, both without and with the Mandaya project upstream, are presented in Table 3.6. Operation without Mandaya over the three years 2001 - 2003 is illustrated graphically in Figure 3.4.

The flow commanded by Mandaya, which that scheme could regulate to a considerable extent, is some 44 % of the inflow to Dal. Operation with Mandaya over the same three years is illustrated graphically in Figure 3.5. The reductions in the spillway flows with Mandaya upstream can be seen by comparing Figure 3.4 with Figure 3.5.

Table 3.6 : Energy Outputs for Dal Project

Option	Full Supply Level (m)	Installed Capacity (MW)	Energy Output (GWh/year)
Low Dal	201	340	1,944
Low Dal	201	400	2,160
Low Dal with Mandaya	201	340	2,088
Low Dal with Mandaya	201	400	2,304

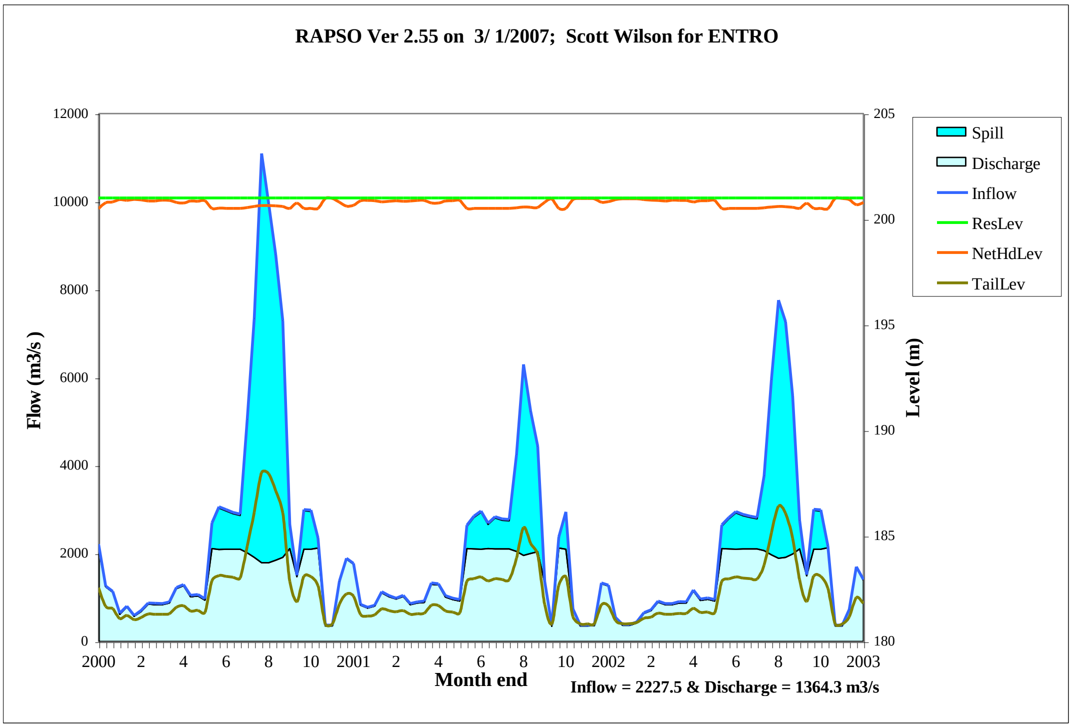


Figure 3.4 : Operation of Low Dal with 8x50 MW

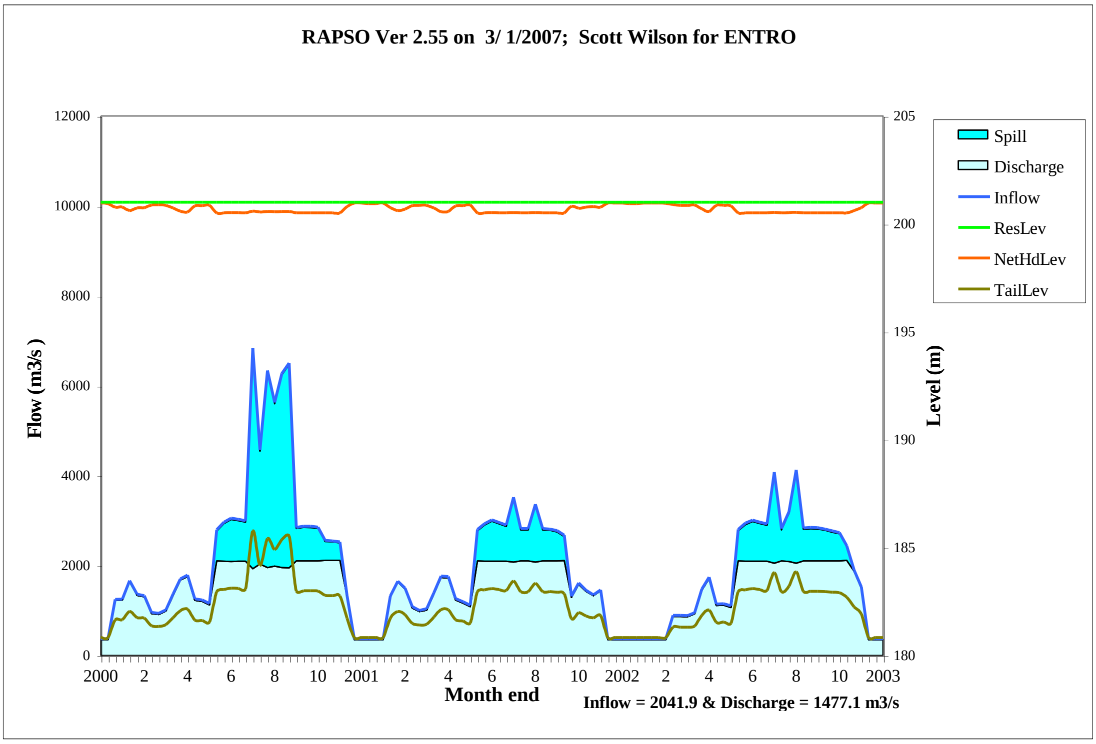


Figure 3.5 : Operation of Low Dal with 8x50 MW and Mandaya 800 m FSL

3.8.1 Downstream Impacts in Egypt

The Low Dal and Kajbar projects are essentially run-of-river projects with very small storage reservoirs. As such there are no significant impacts associated with reservoir filling or operation. There will be a reduction in sediment loads into Lake Nasser/Nubia and an additional evaporative loss of Nile water resources.

3.9 GEOLOGY

Dal dam site is situated at the northern end of a south/north stretch of the Nile. In the Dal stretch the river is following a north striking foliation trend and possibly a geological contact parallel to the foliation. The Dal cataract is carved out of resistant granite and gneissic granite rock.

The Nile appears to have migrated from west to east at Dal. The slopes to the west of the river are relatively flat and planed-off, with sparse hills of granite protruding from out of desert sands. An old elevated terrace of the Nile is found on the west side of the river. Elevated levees and scatters of alluvial pebbles on top of windblown sand indicate that the alluvial terrace is at least 1 km wide.

The landscape to the east of the Nile is very rocky, and steeper than that seen on the west side. This side of the Nile has only a narrow recent alluvial terrace, and it appears that the rocky outcrops are being undercut and steepened by gradual eastward migration of the river. Wadis on the east bank correspond to geological weaknesses that have been eroded away (dykes and faults) during “geological time”.

Geological mapping at the site confirmed the existence of four broad geological formations; namely the Massive Grey Granite, Sheared Granitoid Gneiss, Pink Sheared Syenite/Diorite Granitoid Gneiss, and Biotite Schist / Amphibolite Gneiss. All these rocks are Precambrian in age, and they are all intruded by pegmatite, felsite, and basic dykes of indeterminate age. Fault zones were not seen in the field. Pegmatite and acidic dykes are ubiquitous across the entire mapped area.

A striking feature of both potential centre lines for the Dal dam is the rock slope that forms each right flank, and the very narrow alluvial terrace at the base of each rock slope, but the depth of these narrow terraces is unknown. Both centrelines have a single deep active river channel on the eastern side of the river section. The depth of alluvium below this channel is unknown. Both centrelines have rocky islands in the centre and west side of the active channel, and outcrops are quite frequent, this gives the favourable impression of shallow alluvium and good foundation conditions. However it is possible that the outcrops and islands are buried pinnacles separated by deep trenches filled with alluvium. The depth of alluvium at the dam site is crucial to the cost effectiveness of the Dal dam site and this will need to be investigated in detail during feasibility studies.

The Dal Site falls on the stable intra-cratonic plate. The nearest earthquake hot-spot to the Dal site, is the Red Sea rift trench, but this is 800 km from Dal. Clearly the Dal site lies in a zone of low to very low risk of seismic hazard.

3.10 PROPOSED DESIGN OF DAL DAM AND POWER STATION

The valley profile at the Dal site allows development of the dam, diversion works and power station as surface structures within the river channel (Drawing No.s D5 and D11). The site is suitable for dams up to some 20 - 40 metres in height but appears to be limited by the elevation of the left bank where an extensive embankment may be required as well as saddle dams in the reservoir rim and by a low saddle on the East bank at an elevation of approximately El. 224 m.

The Dal dam at the selected site will have a crest length of some 1,400 m and will have a maximum height of some 30 metres. Having regard to the site topography, geology and availability of materials at the Dal site, together with the substantial flows which must be accommodated both during construction and in the spillway facilities it is considered that a concrete-faced rockfill (CFR) dam is the most appropriate choice of dam type and offers advantages over alternative dam types such as clay-core rockfill or concrete dams.

The width of the valley at the river level allows development of a river diversion arrangement based passing flow through the western channel while construction of the spillway and power station structures is carried out within the Eastern channel protected by temporary cofferdams.

The spillway will comprise 12 radial gates each 10 m wide by 12.5 m high, with a total discharge capacity of 20,000 m^3/s with the reservoir at full supply level. The spillway gates have been sized to be capable of discharging the 1 in 10,000 year flood released from the Merowe dam upstream.

The power waterway system will comprise a reinforced concrete intake structure incorporating unitised intake gates and associated control equipment for each of the eight turbine-generator units. The intake structure will also be equipped with trash screens and trash raking mechanism, and slots to allow bulkhead gates to be deployed for gate, waterway and unit maintenance. The intakes will be integral with the powerhouse substructure and the concrete semi-spiral arrangement of the Kaplan turbine units.

The powerhouse will be a surface type structure of reinforced concrete and structural steel, construction, integral with the dam structure and located in the Eastern river channel. The powerhouse accommodates a loading/service bay, one bay for each of the 8 Kaplan turbine units, control block and offices. The tailrace of the Dal scheme will discharge directly into the existing river channel.

Each turbine will be directly connected to a vertical shaft synchronous generator. The rated output of each turbine will be 50 MW assuming a design net head of 18 m. The synchronous speed of the unit has been selected at 100 rpm.

3.11 TRANSMISSION SYSTEM

It is envisaged that the transmission system would connect the Dal power station to the existing Sudan grid at Dongola (Figure 3.6).

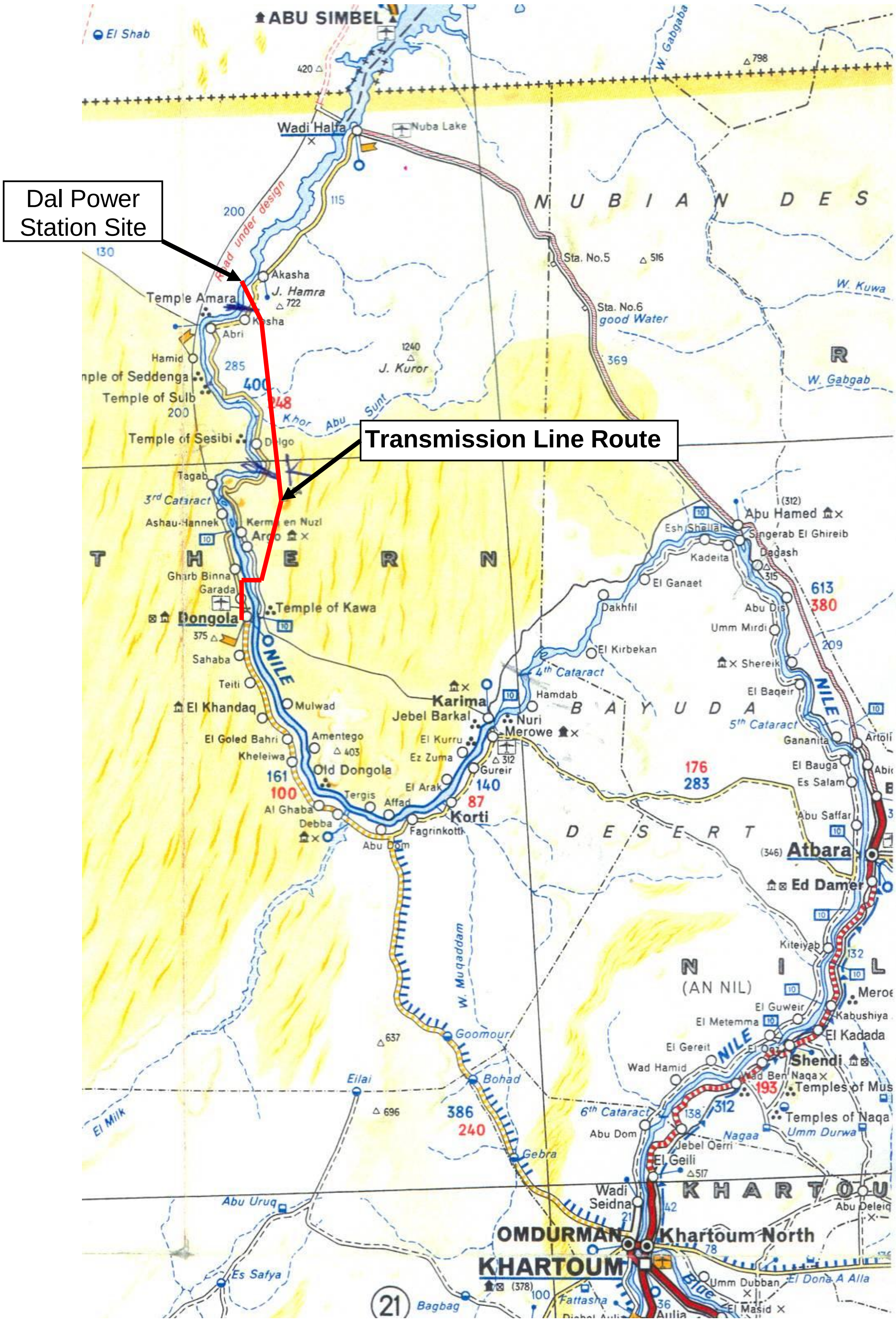


Figure 3.6 : Transmission Line Route Dal to Dongola

3.12 ACCESS ROADS AND BRIDGES

Improvement of the existing road on the East bank from Dongola to the Dal site will be required to accommodate construction traffic and heavy loads. A temporary crossing will be required across the Nile to permit construction access to the West bank.

3.13 COST ESTIMATE

The cost of the Dal project has been estimated as USD 1,113.2 million inclusive of environmental mitigation measures. A breakdown of the project cost is given in Table 3.7.

Table 3.7 : Dal Project Cost Estimate

Item	Cost (Million USD)
Environmental Mitigation	220.0*
Access Roads and Infrastructure	48.5
Reservoir Clearance	16.5
Civil Works	
Diversion works	17.2
CFR Dam	98.6
Spillway	53.6
Powerhouse and tailrace	125.9
Switchyard and Buildings	5.7
Civil contingencies	45.1
Mechanical and Electrical Plant	345.5
Sub-total	976.6
Engineering and Construction Management	97.6
Owners Administration	39.1
OVERAL TOTAL	1,113.2*

* Mitigation cost and overall project cost subsequently revised. See Chapter 11

Source : Pre-feasibility Engineering Report

3.14 CONSTRUCTION PROGRAMME

The Dal project will take some 6 years to construct. Final installation and commissioning of all 8 turbine-generator is anticipated to require 7.5 years from commencement of construction (Drawing No. D12).

Assuming that feasibility studies are carried out over the period 2007 – 2008, it is considered that the project could be completed by the end of year 2016.

3.15 CO_2 EMISSION SAVINGS

The Dal project will provide carbon emission savings of some 68 million tonnes of CO_2 over the assumed 50 year project life compared to equivalent thermal generation based on a 50/50 gas-fired CCGT / coal fired thermal generation mix.

3.16 GENERATION PLANNING AND ECONOMIC APPRAISAL

The Dal hydropower project is a relatively high cost source of energy when compared to the major projects on the Abbay (Blue Nile) river in Ethiopia such as the Mandaya, Border and Karadobi projects. As such, the Dal project does not form part of the regional development plan.

However, in advance of the implementation of the regional interconnector, Dal project may be considered as part of a national power development strategy within Sudan since it offers a lower cost source of energy than the thermal power alternatives within Sudan.

3.17 KEY PROJECT CHARACTERISTICS

Power and Energy			
	Installed Capacity	400 MW	
	Annual energy generation	Average	2,160 GWh/yr
	Plant factor	62%	
Hydrological data			
	Mean annual flow	2668 m^3/s	
Reservoir data			
	Full supply level	201 m	
	Minimum operating level	199 m	
	Operating range	2 m	
	Gross storage	2.47×10^9 m^3	
	Live storage	0.35×10^9 m^3	
	Surface area at FSL	300 km^2	
	Length of reservoir at FSL	160 km	
Dam			
	Type	Concrete faced rockfill (CFR)	
	Maximum height	30 m	
	Crest elevation	204 m	
	Crest length	1400 m	
	Dam volume	2,300,000 m^3	
Spillway			
	Type	Gated barrage	
	Design capacity	20,000 m^3/s	
	Elevation of spillway invert	172 m	
	No.of gate bays	12	
	Size of gates (W x H)	10 m x 12 m	

Power Intake		
	Sill elevation	170.5 m
	No. of intakes	8
Powerhouse		
	Type	Surface
	Overall length	211 m
	Overall width	20 m
	Generator floor level	180 m
	Access / loading bay level	190 m
Turbines		
	Type	Kaplan, vertical axis
	No.	8
	Speed	100 rpm
	Design net head	18 m
	Setting	170.5 m
Generator		
	Type	Vertical synchronous
	Size	62 MVA
Transmission		
	Route	Dal to Dongola
	Length	240 km
	Voltage	220 kV ac
	Type	Double circuit

4. EXISTING ENVIRONMENT OF PROJECT AREA

The Dal project is located in the far north of the Northern State of Sudan, administratively in the southern part of Wadi Halfa locality. The dam site and potential reservoir areas are located in three administrative units of Wadi Halfa, namely Ferka, Abri and Delgo. The unit of local administration at village level is the sheikhship of which there are 45 in the project area.

This chapter describes the existing physical, biological and social environments in the region and in the project area.

An annex at the end of Chapter 4 provides an illustrated summary of the rich cultural heritage of the project area.

Appendices 1.3 and 1.4 at the end of the report present notes on a reconnaissance visit made to Khartoum, Dongola and the Dal area during the inception mission in November 2006. These notes include photograph identification (date, time, number) for many and valuable photographs taken by the NEC member of the reconnaissance team – for future reference, as may be required.

4.1 PHYSICAL ENVIRONMENT

4.1.1 Regional Physiography and Drainage

The project area lies within the Main Nile sub-basin which comprises a broad gently sloping basin extending some 582,368km^2 or 49 percent of the Eastern Nile Basin within the Sudan (Figure 4.1).

The perennial Blue Nile and perennial White Nile join at Khartoum to form the Main Nile. The seasonal flows of the Atbara join the Main Nile north of Khartoum from the east. To the northeast are the Red Sea Hills with a number of khories whose ephemeral discharges rarely reach the Nile. A large wadi – the Wadi el Milk – drains North Kardofan in the southwest but its ephemeral flows rarely reach the Nile.

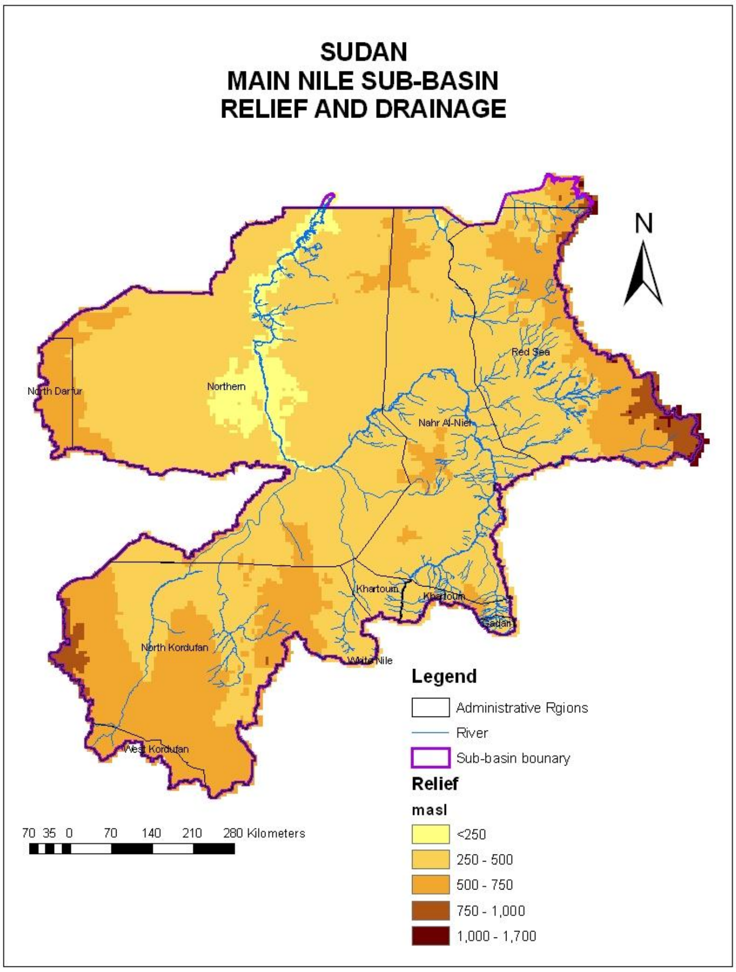


Figure 4.1 : Main Nile - Relief and Drainage

4.1.2 Dal Dam Site and Mapping

Dal village and Dal dam site are at the upstream end of the 5 km long Dal Cataract.

Dal village is on the left bank of the Nile. Sarkamatto is the nearest village to Dal located on the right bank. A motor boat service connects Sarkamatto to Dal village. The dam centreline is about 80 m downstream of the boat moorage and crosses an unnamed island through an ancient Assyrian ruin. The coordinates of the dam alignment are approximately as follows:

Easting 30 deg 34 minutes, 14.76 seconds: Northing 20 degrees, 58 minutes 21.76 seconds.

No detailed topographic maps exist of the Dal dam site. An antiquated, untitled map of the Nile between Dongola and the Egyptian border is available, and this gives a sense of topography, but without any reliable contour information (Figures 4.2 and 4.3).

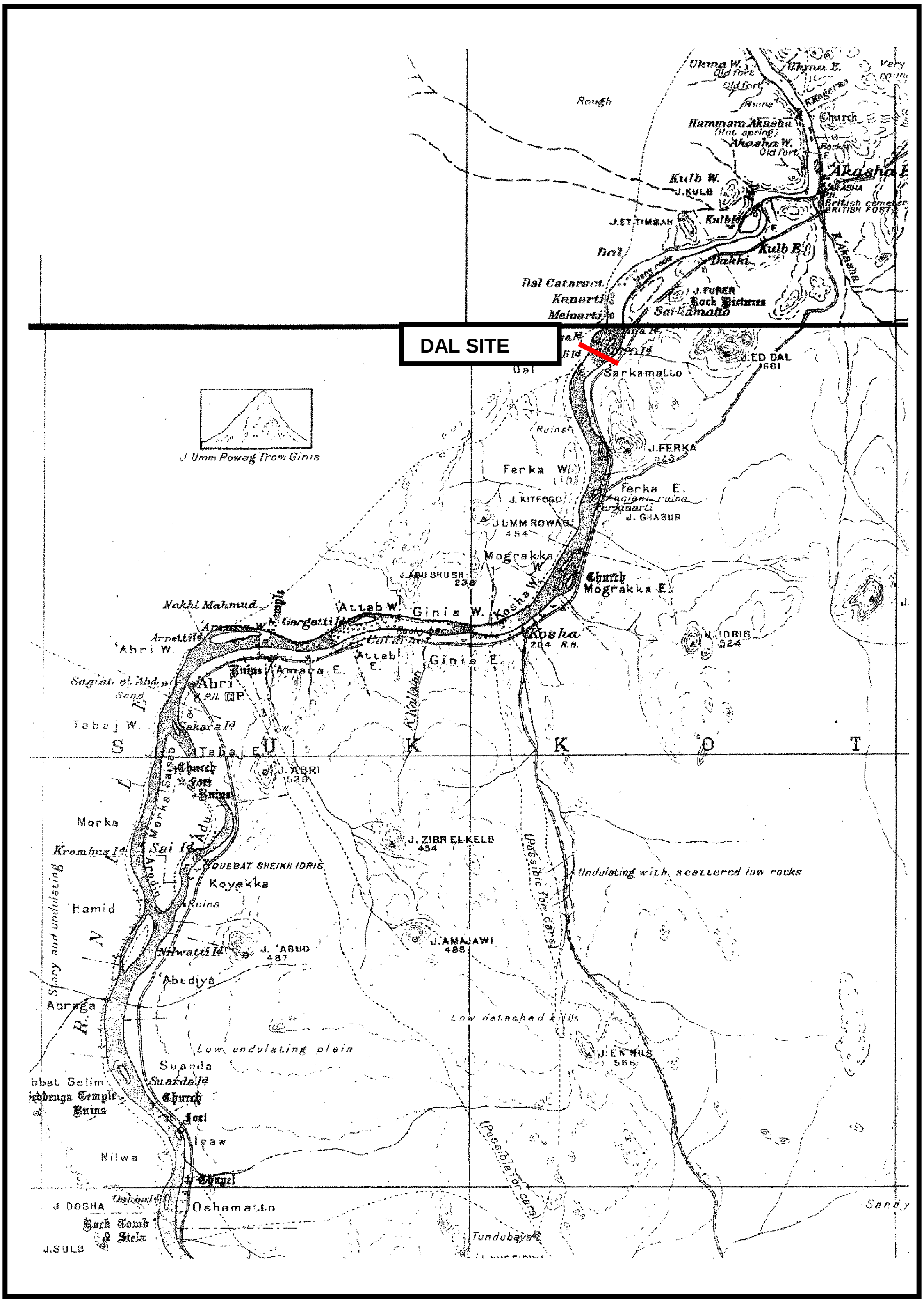


Figure 4.2 : Dal Dam Site, Nile River and Northern Part of Dal Reservoir

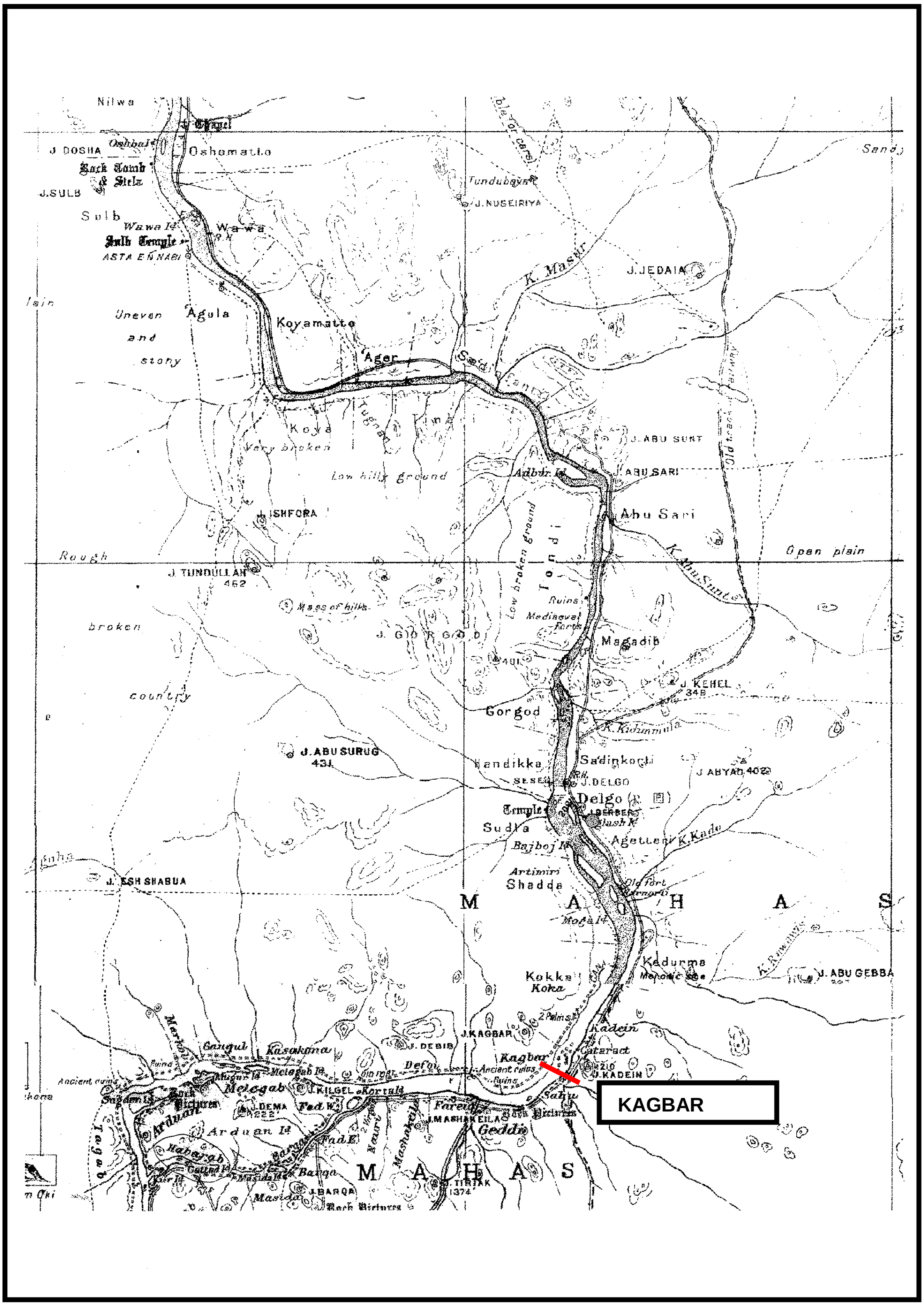


Figure 4.3 : Nile River, Southern Reaches of Dal Reservoir to Kagbar Cataract

In 1947, cross sections were produced at systematic intervals for the entire Nile river downstream of Khartoum. One section at km1342.750 coincides approximately with the centreline. In 1985 a hydrographic survey of the Nile was carried out between Dongola and Wadi Halfa. Sheets 9 and 10 of a sequence of 19 sheets give valuable information on the river bed morphology for various centre lines.

Modern, 1: 40,000 scale air photos of the Nile river through the Dal area are available. They were produced by the BKS and flown in January 1985. The key photos that cover the dam area and nearby basin are Run 19, nos. 159 to 170. This is a north to south run, with north at the bottom of each photograph. The stereographic trio of photos that cover the dam sites are nos. 165 to 167.

4.1.3 Regional Geology

The main underlying geological formations within the Main Nile Sub-basin include the older Basement Complex rocks, the Nubian Sandstones, Tertiary unconsolidated sediments and Recent superficial wind blown sands as shown in Figure 4.4. The Basement Complex comprises gneisses, schists, marbles and intrusive granites and basic rocks. The Nubian Sandstones overly unconformably the Basement Complex rocks and comprise mainly sandstones, siltstones and conglomerates. The Recent deposits include the Nile alluvium, sand dunes and the black clays of the flood plains.

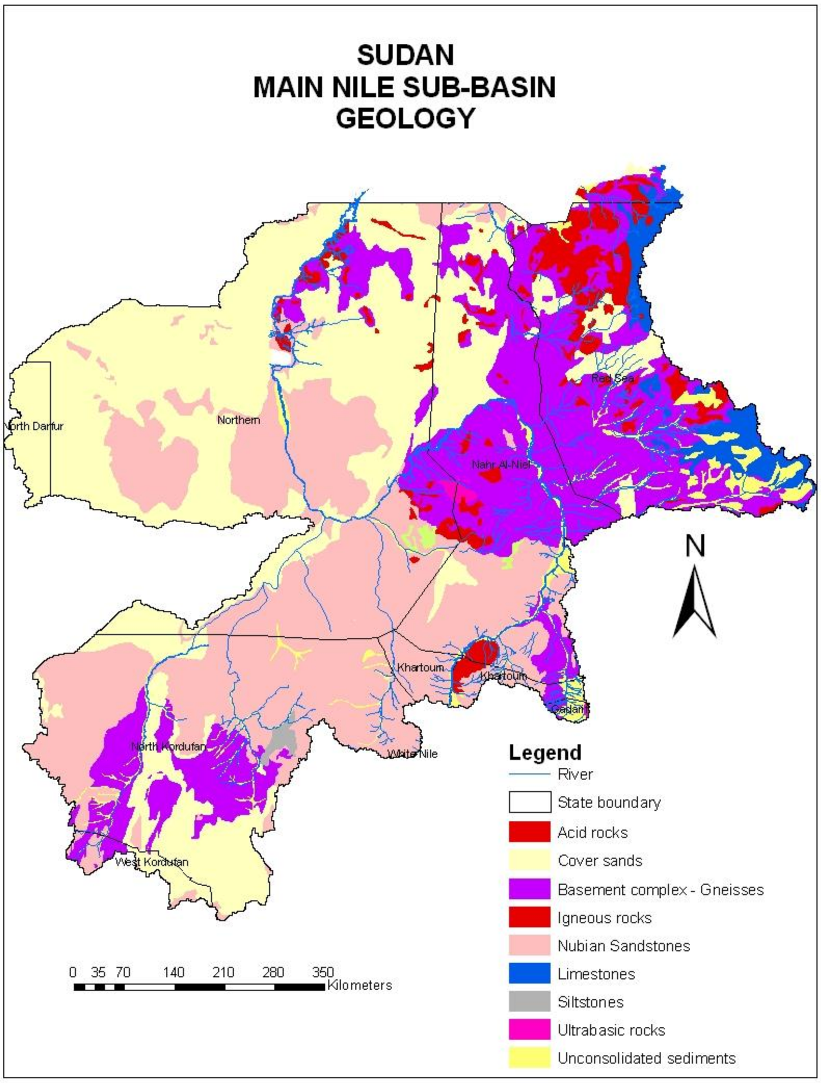


Figure 4.4 : Main Nile - Geology

4.1.4 Dal Dam Site Regional Geology and Geomorphology

The Dal site falls entirely within the Precambrian outcrop area. On the left side of the river these rocks are mainly covered by windblown sand, but on the right side there are large tracts of solid outcrop, separated by sand filled wadis.

A fragment of the published 1 to 1,000,000 scale geological map, which is centred on Dal site, is reproduced here as Figure 4.5 The map suggests that Dal site is underlain by three Precambrian rock Formations.

The left flank is shown as underlain by poorly exposed, undifferentiated metamorphic rocks of gneissic and migmatite varieties. This is vague nomenclature and suggests mapping by remote sensing method only.

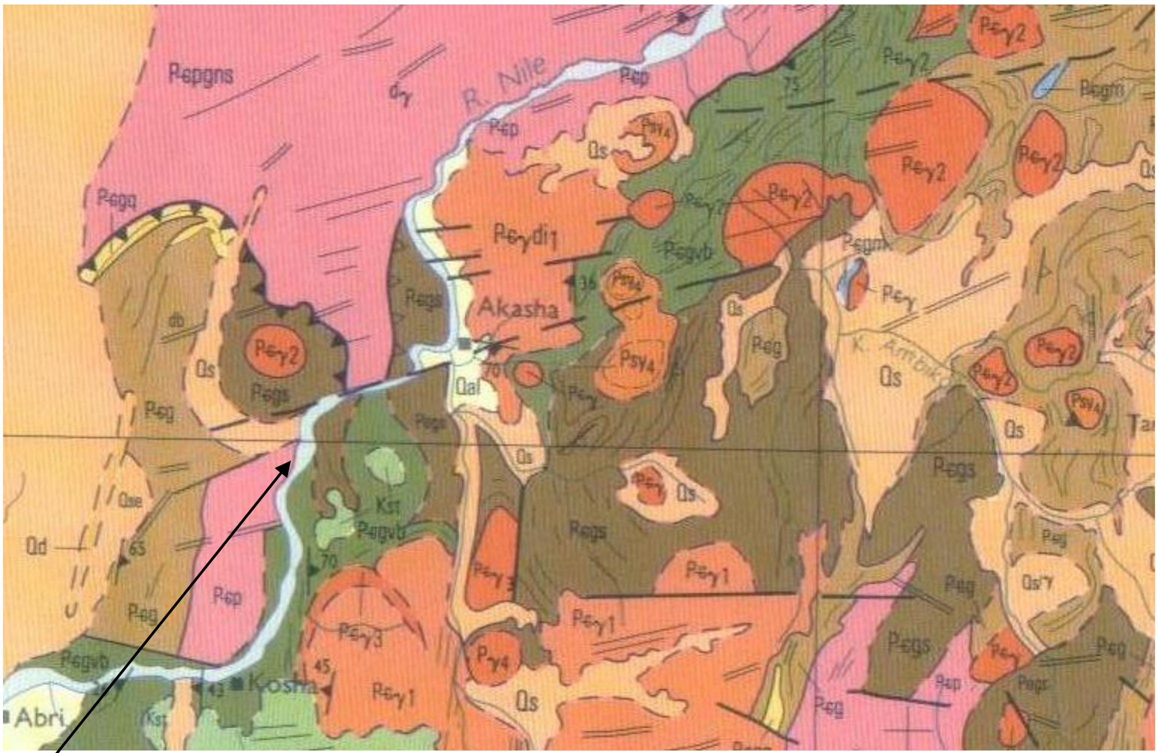
The south part of the right flank is shown as underlain meta-sediment and meta-andesite of green schist facies, meaning low grade basic rock. This appears to be an interpretation by remote sensing, of a belt of well-exposed, and macro foliated, black rock.

The northern part of the right flank is shown as being underlain by schist and phylites. Again this appears to be an interpretation of macro lineated pale rocks visible on remote images.

The regional foliation trend is suggested as north south. No lineaments or faults are shown within 3 km of the dam site. However a very large regional fault is shown 6 km north of the site, having vertical orientation and striking ENE-WSW.

From Khartoum to Dal, the landscape consists of a vast, almost flat pedeplain. Cataracts are present at infrequent intervals; they represent resistant rock formations that have been graded almost flat by the river. Grades are slightly steeper in the cataracts, creating rapids and shoals.

The monotony of the pedeplain landscape is broken by inselbergs, and table-top mountains of more resistant geological formations. In the absence of rain, weathering is achieved by mechanical disintegration and ablation. The landscape can be divided into floodplain, rocky desert, stony desert, and sand desert. The floodplain consists of modern low terraces, and ancient high terraces of alluvium. The distribution of different types of desert is haphazard.



Dal Dam Site (height of photo is approximately 50 km)

Qs — Active or recently active sand sheets and amalgamated dunes.

Kst — Undifferentiated fluviatile sandstones, siltstones and minor conglomerates of presumed Cretaceous age. Analysis of palaeoflora indicates Late Cretaceous age and unit may include Lower Tertiary sediments.

Pєgvb — Andesitic-basaltic volcanic rocks.

N.B. Pєgva, Pєgvt and Pєgvb have been subjected to varying degrees of greenschist facies metamorphism and are associated with derived volcano-clastic sediments.

Pєp, Pєpgns, Pєpmg — Pєp : Undifferentiated Proterozoic metamorphic rocks. Pєpgns: gneissic areas; Pepmg: migmatites.

Pєgs, Pєgst — Pєgs : metasedimentary units differentiated within Pєg: slates, phyllites and low grade schists. Pєgst: metasedimentary units differentiated within Pєg: sandstones and conglomerates.

NB Os is recent, Kst is Cretaceous, and the other units are of Precambrian age.

Figure 4.5 : Regional Geological Map

Dal dam site is situated at the northern end of a south/north stretch of the Nile. The Dal cataract is carved out of resistant granite and gneissic granite rock.

The Nile appears to have migrated from west to east at Dal. The slopes to the west of the river are relatively flat and planed-off, with sparse hills of granite protruding from out of desert sands. On old elevated terrace of the Nile is found on the west side of the river, elevated levees and scatters of alluvial pebbles on top of windblown sand, indicate that the alluvial terrace is at least 1 km wide.

On the left bank near Dal village, distinctively yellow sand dunes are present (Plate 4.1). In Dal village itself, near the mobile phone mast, a house is partially buried in sand. Sand grains appear to be moved by winds from a predominantly northerly direction.

Plate 4.1 : Sand dunes on left bank of Nile at Dal dam site

The landscape to the east of the Nile is very rocky, and steeper than that seen on the west side. This side of the Nile has only a narrow recent alluvial terrace, and it appears that the rocky outcrops are being undercut and steepened by gradual eastward migration of the river. Slopes rise steeply to 220 masl from the river-bed level of 173 masl, but then fall away into a system of sandy wadis. The wadis correspond to geological weaknesses that have been eroded away (dykes and faults) during "geological time". The wadi network situated on the east side of the centre lines seems to extend south east, and then south west back to the river. They could define escape routes for the impounded water, and if they do, saddle dams will have to be constructed. This is all conjecture, as there are no topographic maps available.

Geological mapping at the site for this study confirmed the existence of four broad geological formations; namely the Massive Grey Granite, Sheared Granitoid Gneiss, Pink Sheared Syenite/Diorite Granitoid Gneiss, and Biotite Schist / Amphibolite

Gneiss. All these rocks are Precambrian in age, and pegmatite, felsite, and basic dykes of indeterminate age intrude them all. Fault zones were not seen in the field. The regional geological map was correct in demarcating three out of the four formations by remote sensing only, but incorrect in the generic description given to each division. Pegmatite and acidic dykes are ubiquitous across the entire mapped area.

An epicentre map from the US Geological Survey, National Earthquake Information Centre, for the time span 1850 to 1991, illustrates two epicentres at distances of 200 km north of Dal dam site and 180 km south of the site respectively. The northern epicentre is at Lake Nasser and is interpreted as induced by the reservoir. Its magnitude was 4 on the Richter scale. The southerly epicentre was at Dongola and also measured only 4 on the scale. These are isolated minor events therefore. The nearest earthquake hot-spot to Dal is the Red Sea rift trench, but this is 800 km from Dal. It is therefore concluded that the Dal site lies in a zone of low to very low risk of seismic hazard.

4.1.5 Minerals

The Gold of Kush was mined in the Dal area and districts between the 2nd and 3rd Cataracts in ancient times (Vercoutter, 1959). Gold used to be mined in this area in the early 19th Century, but there are no existing mining operations.

4.1.6 Groundwater

The Nubian Sandstones overly unconformably the Basement Complex rocks and comprise mainly sandstones, siltstones and conglomerates and form the main groundwater basins in Sudan.

Relationships between Nile river levels and groundwater levels in alluvium and the mataras on the desert edge, adjacent to and up to some kilometres away from the alluvium, are well known and understood by local people with many years of experience and a deep vital interest. However, so far as is known, these relationships have not been surveyed and quantified by fieldwork in the Delgo, Abri and Dal areas. It is known that overbank floods of the Nile recharge groundwater, including the mataras, but no quantitative information appears to be available on the groundwater levels in the alluvial strip and mataras and how these relate to Nile river levels, including those years when the Nile does not flood out of its banks (e.g. 1972, 1984, 1986).

4.1.7 Regional Soils

In the northeast on the hills and ridges of the Basement Complex rocks are shallow, stony and light textured Regosols, Leptosols and Phaeozems of low fertility. These soils are highly erodible. Across the northern part of the Sub-basin Arenosols are widespread and are derived from unconsolidated sediments and textures are very sandy. Soils are deep but excessively well drained. These soils are extremely susceptible to wind erosion. Where rock is near the surface these grade into shallow and stony Leptosols. Along the Nile River is a narrow band of Vertisols and Fluvisols. The distribution of the main soil types is shown in Figure 4.6.

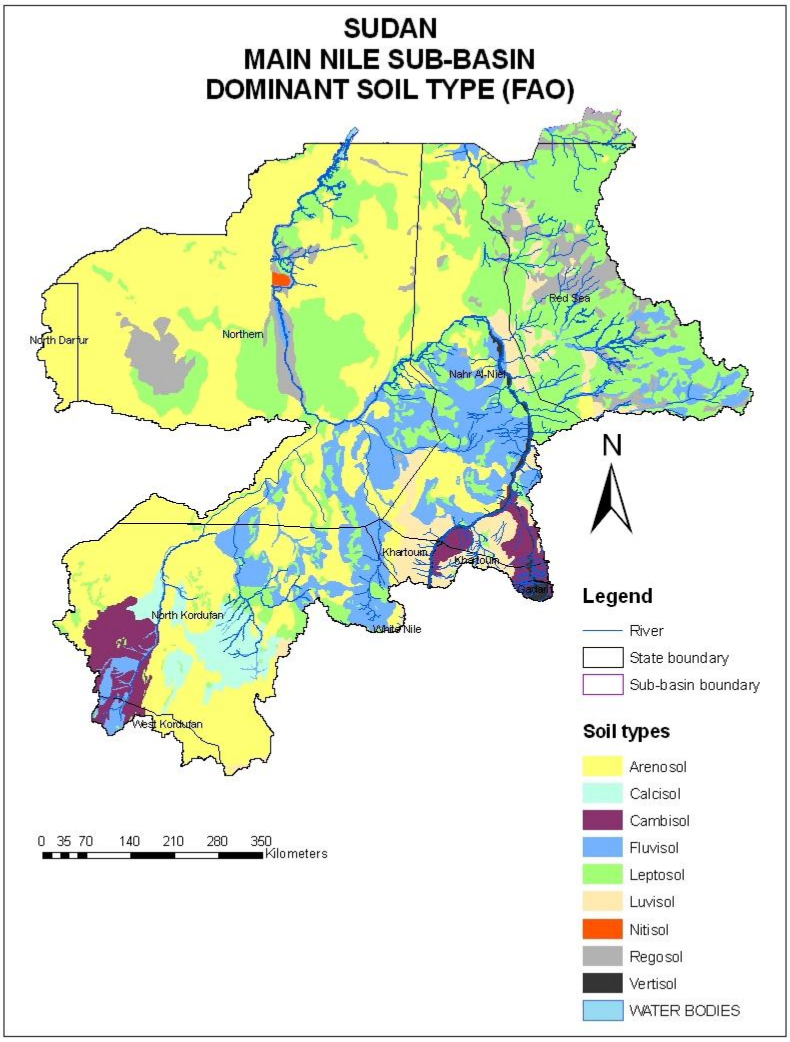


Figure 4.6 : Main Nile – Soil Type

4.1.8 Regional Rainfall

Annual rainfall isohyets generally run southwest to northeast, ranging from less than 25mm in the north to 400mm in the south (Figure 4.7). Rain falls mainly between July and September in a single season. Two broad rainfall belts are recognized:

- from < 25mm near the border with Egypt to 150mm near Khartoum, rains are erratic with a coefficient of variation (CV) as high as 100 percent;
- from 150mm to 400mm, rains are variable with CV's as high as 30 percent;

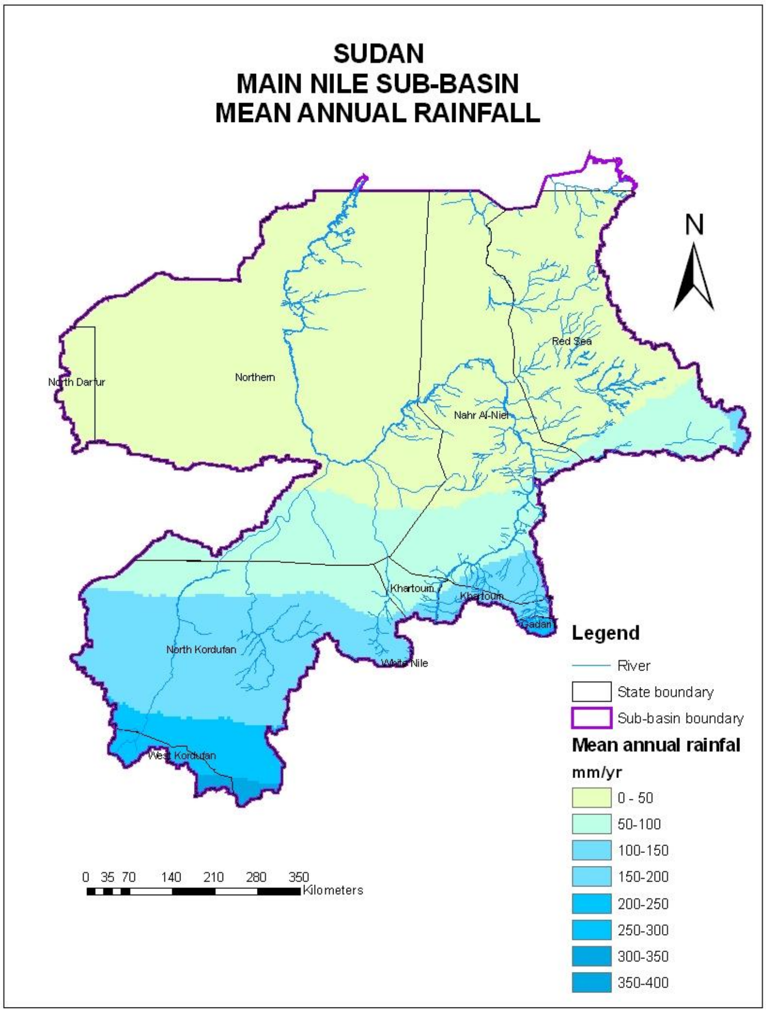


Figure 4.7 : Main Nile - Mean Annual Rainfall (mm)

4.1.9 Regional Temperatures

Highest mean annual temperatures (27 – 28 °C) occur along the Main Nile river course from Khartoum to the centre of the long reach between Merowe and Dongola (Figure 4.8). Mean annual temperature around Dal and Lake Nubia is slightly lower owing to the more northerly latitude with a slightly stronger winter effect (24 – 26 °C).

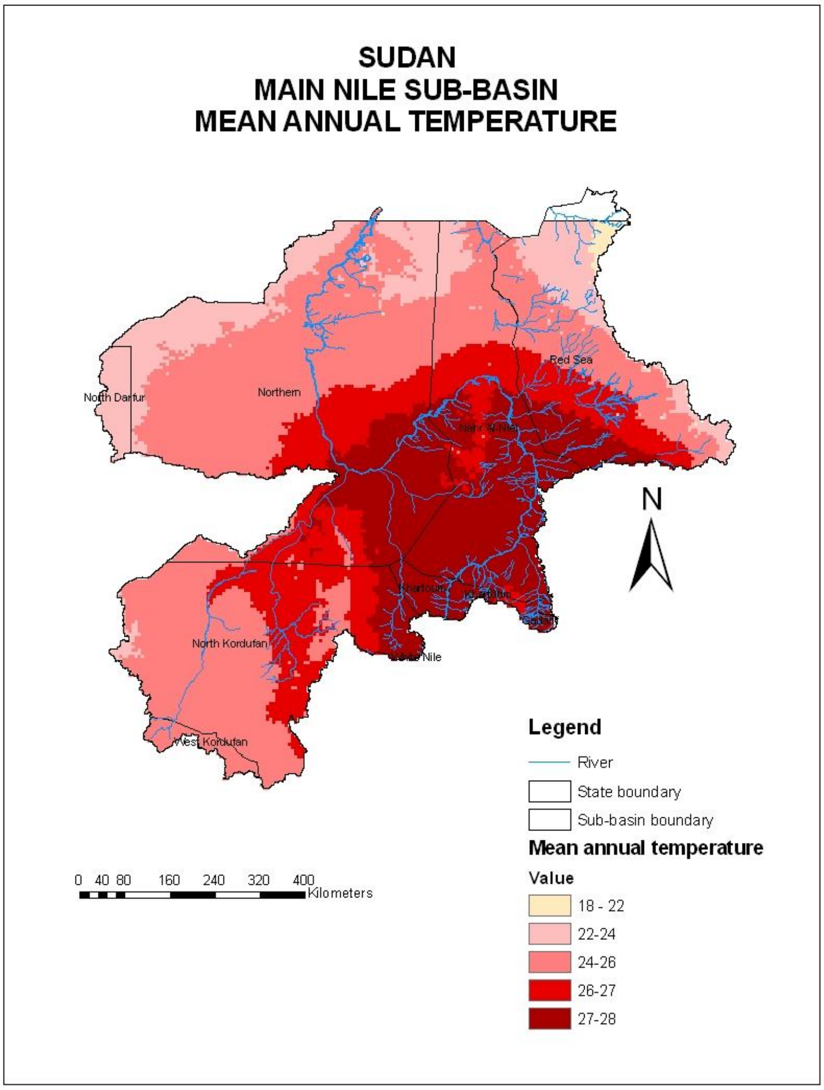


Figure 4.8 : Main Nile - Mean Annual Temperatures

4.1.10 Evaporation

Evaporation rates are high, the mean annual open water evaporation rate being estimated at 2,886 mm.

Estimates of evaporation are not adjusted for rainfall in the RAPSO model for simulation of the Dal project because rainfall is negligible. Average open water evaporation rates adopted for Dal are shown in Table 4.1.

Table 4.1 : Monthly Mean Net Evaporation Rates at Dal Reservoir

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
174	179	233	255	295	291	288	285	270	251	198	167	2,886

Source: This study, reservoir simulation modeling, pre-feasibility engineering report.

4.1.11 Climate of Dal Area

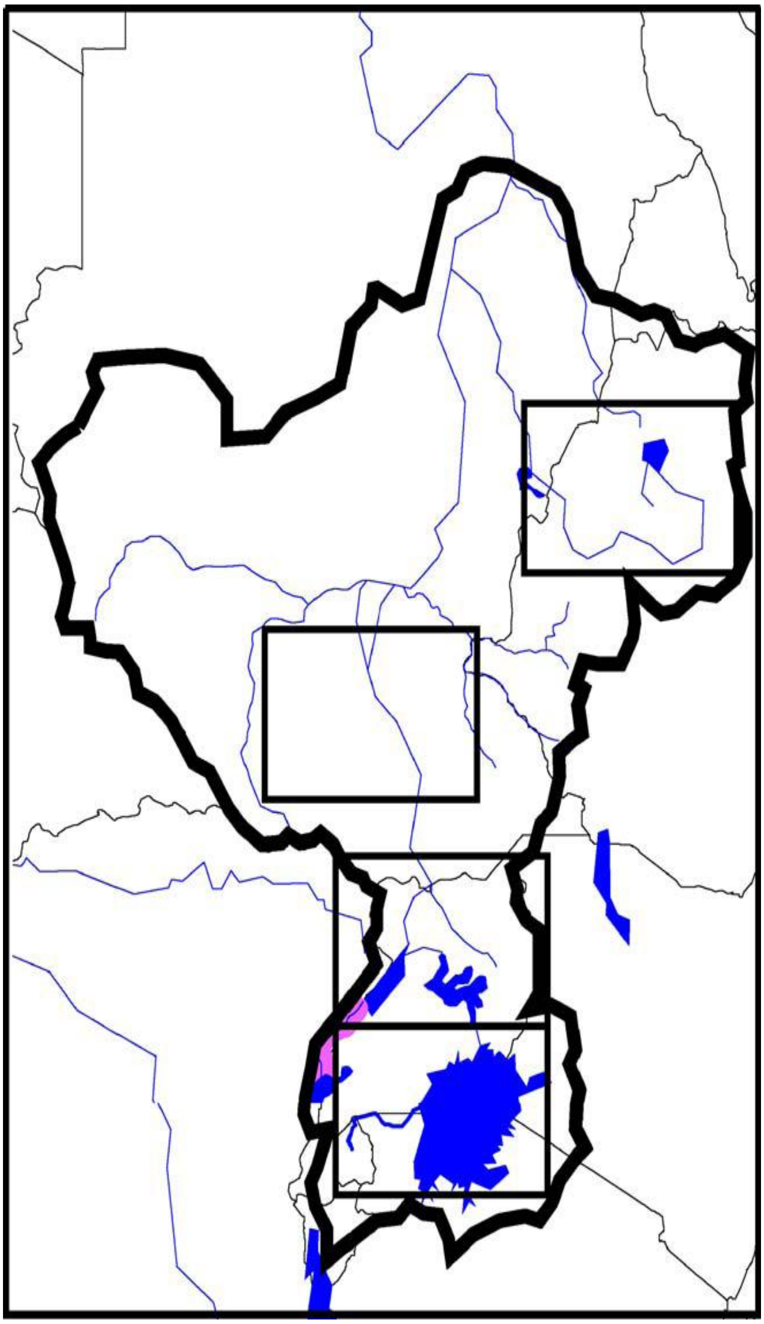
There is no climatological station at Dal. Based on records for Dongola further south, the Dal project area is characterised by one of the most extreme desert climates in the world. The most prominent features are:

- Rainfall is erratic and negligible. Most years have no rainfall at all. When questioned in Dal village in November 2006, a resident recalled a shower on one day only in the previous two years.
- Maximum temperature 52.5°C, minimum 2°C.
- Wind speed 0-67 m/min, normally from the north.
- Relative humidity: mean average 20-50%, range 0-60%.
- Sand, silt and rock temperature 65-84°C, the maximum equal to world records.

4.1.12 Climate Change

A number of climate and climate change studies of the Nile basin upstream of Aswan High Dam have been conducted. Conway (2005) concludes from a review of many of these that there is high confidence that temperatures will rise, leading to greater losses to evaporation. However, there is much less certainty about future rainfall because of the low convergence in climate model rainfall projections in the key headwater regions of the Nile. He states, for example, that Hulme et al (2001) found large inter-model differences in the detail of rainfall changes over Ethiopia using results from seven recent climate model experiments. Inter-model disparities in future rainfall change over much of the basin are also presented in reports of the Intergovernmental Panel on Climate Change (IPCC, 2001). When rainfall changes are considered for four key regions in the Nile basin for summer (June to August) and winter (December to February) from nine recent climate model experiments using IPCC's special report on emissions scenarios (outlined in Hulme et al, 2003), the Blue Nile region shows large divergence in rainfall changes in summer which is the crucial monsoon rainfall season. In the White Nile system (Lakes Victoria and Kyoga and the Sudd), winter shows inter-model convergence towards a small to large increase in rainfall but there is divergence in summer (Figure 4.9).

This large divergence in model results for the source areas of the Nile basin means that there is currently no confident basis for concluding annual rainfalls will be generally higher or lower. Consequently, estimation of power generation at existing and proposed projects investigated by the RAPSO model for the Dal, Mandaya and Border studies is based on historical flow records.



Boxes show four regions used to calculate area averages of temperature and rainfall projections from climate models. Blue Nile region; Sudd wetlands in Southern Sudan; Lake Kyoga central Uganda; Lake Victoria, Kenya, Tanzania and Uganda.

Source: After Conway (2005)

Figure 4.9 : Climate Change Model Areas: Nile Basin Upstream of Egypt and the Aswan High Dam reservoir.

4.2 HYDROLOGY AND WATER QUALITY

4.2.1 Surface Water Resources

The Main Nile flows 1,500 km from Khartoum to Lake Nubia. The river flows through a series of cataracts with a total drop of 250m. The seasonal flow pattern exhibits the combined characteristics of the two main tributaries with the seasonal pattern of the Blue Nile superimposed on the regular pattern of the White Nile.

There are a number of ephemeral streams (wadis and khors) that flow during the rainy season. The more important of these include the Atbara on the east bank and the Wadi El Milk on the west bank.

The total annual flow at the border with Egypt has historically been taken (before any significant abstraction) as 84 billion m^3 (1905-1959). However, there are considerable year-on-year as well as periodic variations (Figure 4.10).

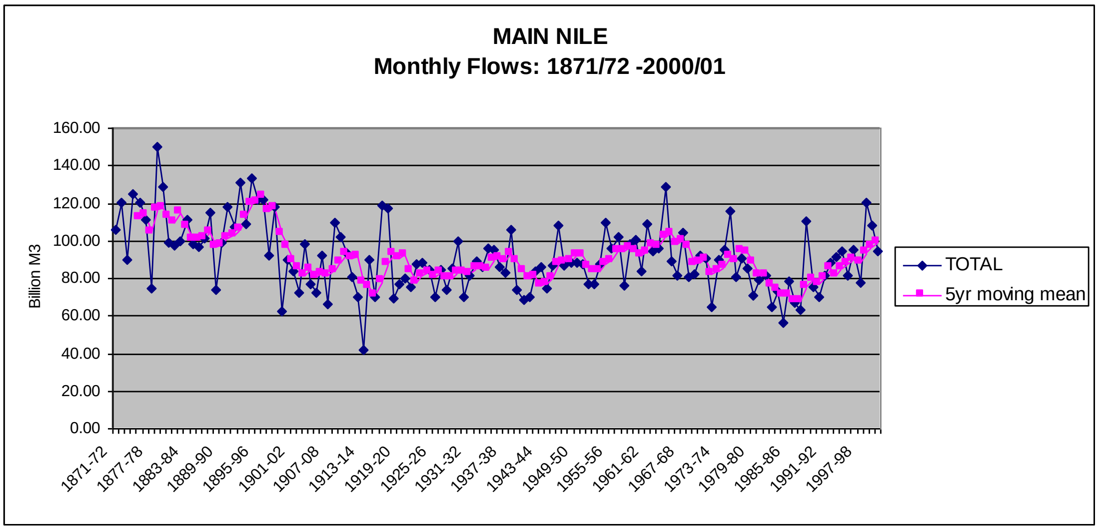


Figure 4.10 : Main Nile: Monthly Discharges and 5 year Moving Mean (1871/72 -2000/01)

From 1871 to 1896 saw a period of high flows, a period that saw high lake levels across East Africa. Between 1901 and 1975 annual discharges averaged around 87 billion m^3. The decade from 1976 to 1987 saw a series of very low flows – average annual flow about 76 billion m^3, since when flows have increased again.

There is no river gauging station at Dal. Records at Dongola are adopted as representative of flows at Dal. The monthly mean and annual flows adopted in the RAPSO simulation model for investigation energy generation are shown in Table 4.2.

Table 4.2 : Average Monthly and Annual Nile Flows at Dal, 1954 - 2003

Month	Nile flow at Dal m^3/s
January	786
February	784
March	951
April	1,065
May	1,030
June	1,281
July	2,721
August	6,068
September	5,653
October	2,496
November	1,331
December	1,581
Year	
Mean	2,280
Maximum	3,328
Minimum	1,366
Standard Deviation	431

Source: RAPSO simulation model output, pre-feasibility engineering report, 2007.

4.2.2 Water Levels

Argo gauge (235 km upstream the dam) has been taken as the reference. The normal difference of water level between the gauge in Agro, downstream of Dongola, and the Dal site is about 30 m. Table 4.3 shows the main features of the water level at the dam site.

Table 4.3 : Estimated Water Levels at Dal Dam Site

Site	Normal flood level (masl)	High flood level (masl)	Mean level (masl)
Argo	220.9	221.73	216.56
Dal	190.9	191.73	186.56

Source: Government of Egypt (1992) Nile Basin, Vol. III.

4.2.3 Water Quality

The Water Quality Monitoring Baseline Report for Sudan, a Transboundary Environmental Action Project, has presented summary water quality sampling for monitoring stations at Dongola on the Main Nile, Soba on the Blue Nile and Malakal on the White Nile (Table 4.4). Ground Water and Wadis Directorate (GW & W) of the Ministry of Irrigation and Water Resources carried out the sampling and laboratory analysis. All results are within WHO guidelines for drinking water.

Table 4.4 : Nile Water Quality - Maximum and Minimum Concentrations in 2003-2004

Location	NILE (Dongola)		BLUE NILE (Soba)		WHITE NILE (Malkal)	
	x	y	x	y	x	y
coordinate	30.6E	19.02N	32.61E	15.5N	31.6E	9.57N
Water level (m)	13.5	9.26	16.25	8	12.45	12.7
Discharge(m3/day)	680.64	49	552.6	8.3	97	12.08
PARAMETER	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.
Appearance	muddy	turbid	muddy	clear	muddy	turbid
TURBIDITY NTU	6575	5	7275	4	115	6
PH	8.4	7.3	8.4	7.5	7.6	7.3
CONDUCT. Us/cm	278	183	295	194	180	121
Hardness	116	50	132	80	86	26
Alkalinity	178	122	183	79.2	109	73
Calcium	40	14	37.6	24.8	5.6	
Magnesium	17	3	13.61	2.43	13	2.9
Chloride	34	7.1	22.72	4.6	9.9	5.7
Sulfate	39	1	42	8	5	1
Nitrate	12.3	0	3.96	0	5.7	0.3
Nitrite	0.99	0	0.52	0	0	0
TSS	8400	8	8875	3	126	84
TDS	194	126	189	125	18	2
Fluoride	0.85	0.2	0.7	0.2	0.9	0.6

Source: Ground Water and Wadis Directorate, in NBI (2005)

Five parameters were chosen as indicators of pollution status: conductivity, chloride concentration, nitrate, nitrite and ammonia. Maximum and minimum values for the Main Nile at Dongola over the period 2001 to 2004 are presented in Table 4.5. All results are within WHO guidelines for drinking water.

Table 4.5 : Main Nile Water Quality at Dongola: Annual Minimum and Maximum Values of Pollution Indices

Year	Minimum and Maximum Values									
	E.C. µS/cm		Chloride mg/l		Nitrate (NO_3) mg/l		Nitrite (NO_2 mg/l		Ammonia (NH_3) mg/l	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
2001	238	442.2	9.2	17	0.0	13.6	0.0	0.019	0.0	0.44
2002	184	318	7.1	12.8	0.0	13.2	0.0	0.102	0.0	0.38
2003	133	278	4.3	23.4	0.0	12.3	0.0	0.08	0.0	0.80
2004	183	309	7.8	34	0.0	9.24	0.003	0.99	0.0	0.98
W.H.O. Guidelines	-	-	250		50		3.0		1.5	

Source: Ground Water and Wadis Directorate, in NBI (2005)

Water quality characteristics of a water sample at Dal cataract taken during field work for this study in April 2007 are listed in Table 4.6. These results are similarly within the WHO guidelines for drinking water.

Table 4.6 : Nile Water Quality at Dal Cataract, 7th April 2007

Parameter	Concentration	Parameter	Concentration
Ca	24.6 mg/l	NH_3	0.03 mg/l
Mg	10.7 mg/l	SO_2-Si	16 mg/l
Na	4.8 mg/l	Alkalinity(mg/$CaCO_3$)	110 mg/l
K	2.3 mg/l	Cu	0.08 mg/l
Cl	8.8 mg/l	Zn	0.56 mg/l
SO_4	6. 7 mg/l	Fe	0.18 mg/l
PO_4	0.38 mg/l	Pb	0.02 mg/l
NO_3-N	1.13 mg/l	Oil and grease	Nil
pH	7.6	Conductivity	201 μS/cm

Source: YAM Consultants: sampling about 10 m from right bank. Laboratory: Hydro-biological Research Unit, Institute of Environmental Studies, University of Khartoum

4.2.4 Sediment Transport

Measurements of suspended sediment concentration have been carried out regularly at hydrometric stations in Sudan and Egypt since 1929. Measurements were carried out between Halfa (or Kajnarty) and Gaafra since 1929 and more recently at Dongola since 1971.

Average values of suspended sediment at Halfa and Kajnarty for the period 1929 to 1963 are presented in the Nile Waters Study and reproduced in Table 4.7. It can be seen that the average sediment discharge over the period 1929 to 1963 was some 134 million tons per year. Some 98% was transported in four months only, between 21 July and 20 November.

Table 4.7 : Sediment Measurements at Halfa / Kajnarty, 1929 - 1963

Period		Concentration (ppm)	Total Suspended Sediment (Mt)
July	1 – 10	70	0.07
	11 - 20	128	0.21
	21 – 31	418	1.52
August	1 – 10	1450	7.66
	11 – 20	2861	19.61
	21 – 31	3425	28.95
September	1 – 10	3260	26.20
	11 - 20	2449	18.35
	21 - 30	1827	12.12

Period		Concentration (ppm)	Total Suspended Sediment (Mt)
October	1 - 10	1371	8.14
	11 - 20	971	4.80
	21 - 31	671	2.60
November	1 - 10	397	1.23
	11 – 20	267	0.59
	21 - 30	187	0.34
December	1 – 10	136	0.21
	11 – 20	118	0.17
	21 – 31	108	0.15
January	1 – 10	93	0.11
	11 – 20	82	0.09
	21 – 31	74	0.08
February	1 – 10	64	0.06
	11 – 20	59	0.05
	21 - 28	57	0.04
March	1 - 10	53	0.03
	11 - 20	51	0.03
	21 - 31	52	0.04
April	1 - 10	50	0.04
	11 - 20	49	0.04
	21 - 30	48	0.04
May	1 – 10	41	0.03
	11 - 20	39	0.02
	21 - 31	39	0.02
June	1 - 10	39	0.02
	11 - 20	43	0.03
	21 - 30	49	0.04
TOTAL			**133.73**

Source: Nile Waters Study, 1979

Measurements at Dongola in 1971 are reported in the Nile Waters Study (Coyne et Bellier et al, 1979). The results of the measurements are summarised in Table 4.8.

Table 4.8 : Sediment Measurements at Dongola, 1971

Period		Mean Discharge (m^3/s)	Concentration (ppm)	Total Suspended Sediment (Mt)
July	11 – 20	1,817	300	0.47
	21 – 31	3,183	1,800	4.95
August	1 – 10	4,676	2,750	11.1
	11 – 20	7,199	3,200	19.9
	21 – 31	9,282	3,600	32.5
September	1 – 10	9,502	3,000	24.6
	11 - 20	8,218	2,050	14.5
	21 - 30	5,602	1,250	6.05
October	1 - 10	4,201	700	2.54
	11 - 20	3,403	500	1.50
	21 - 31	2,859	350	0.86
November	1 - 10	2,222	300	0.58
	11 - 20	2,338	250	0.50
TOTAL				**120.00**

Source: Nile Waters Study, 1979

Measurements for a single year do not accurately reflect the long-term average sediment discharge. However, it can be seen that the figures for sediment discharge at Dongola for 1971 are somewhat lower than the long term mean presented in Table 4.7. This is likely to be due, in part, to the completion of the Roseires dam and the consequent deposition of a proportion of the sediment load in Roseires reservoir.

Sediment concentrations and flows for the Main Nile at El Koro, upstream of Dongola, have been provided by the Ministry of Irrigation and Water Resources for the years 2001 to 2003. The data is summarised in Table 4.9 and Table 4.10.

Table 4.9 : Sediment Concentrations at El Koror (u/s of Dongola)

Period	2001	2002	2003
July III	n.a.	n.a.	n.a.
Aug. I	2898	6300	n.a.
Aug. II	3328	7163	5943
Aug. III	1639	5362	4004
Sept. I	2526	2969	3571
Sept. II	1841	1465	4095
Sept. III	1032	801	1273
Oct. I	545	499	911
Oct. II	n.a.	352	537
Oct. III	n.a.	320	155
Nov. I	n.a.	n.a.	139

Source: Ministry of Irrigation and Water Resources

Table 4.10 : Sediment Discharges at El Koror (u/s of Dongola)

Period	2001	2002	2003
July III	n.a.	n.a.	n.a.
Aug. I	21.9	22.2	n.a.
Aug. II	30.6	42.5	37.4
Aug. III	18.1	33.1	30.4
Sept. I	21.2	13.8	26.2
Sept. II	13.5	4.7	22.5
Sept. III	5.3	2.3	4.7
Oct. I	1.7	1.1	3.3
Oct. II	n.a.	0.7	1.7
Oct. III	n.a.	0.5	0.3
Nov. I	n.a.	n.a.	0.2
Sub-total	112.3	120.8	126.7
Adjustment for remainder of year	11.7	5.0	12.2
Estimated Total	124	125.8	138.9

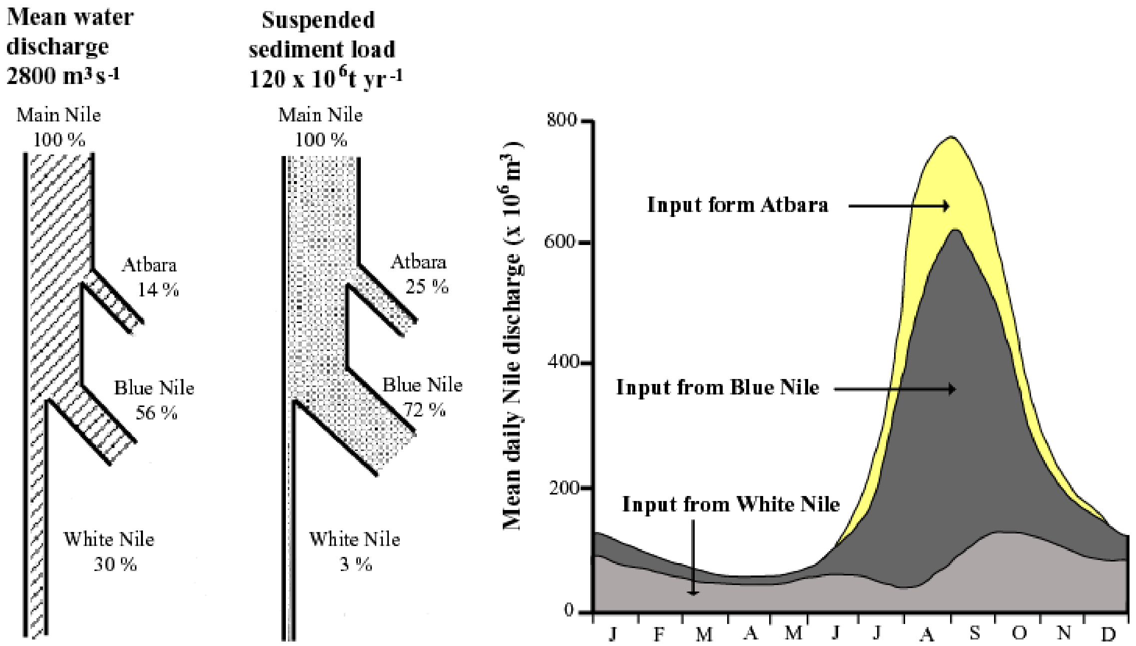
Source: Ministry of Irrigation and Water Resources

It can be seen that average sediment concentrations for the flood season range from some 500 ppm to over 7,000 ppm.

It can be seen that the suspended sediment discharge for the period August to October ranged from 112.3 Mt to 126.7 Mt over the period 2001 to 2003. When account is taken of sediment discharge for the remainder of the year (data for which has not been received) it is estimated that the annual suspended sediment discharge would probably range from some 124 Mt to 140 Mt.

4.2.5 Sediment Deposition in High Aswan Dam Reservoir

The suspended sediment load entering Lake Nasser/Nubia originates almost entirely from the Ethiopian Highlands (Figure 4.11). Some 72% is derived from the Blue Nile and most of the remainder from the Atbara (25%). The mean water discharge differs considerably with the White Nile contributing 30 % and the Blue Nile and the Atbara 56 and 14 % respectively.



Source: Cooperative Regional Assessment for Watershed Management, Transboundary Analysis, Country Report, Egypt, July 2006.

Figure 4.11 : Mean Discharge and Suspended Sediment Load for Nile Basin

The concentration of suspended sediment entering Aswan High Dam Reservoir, via Dal dam site, has a seasonal variation similar to the flow hydrograph. However, the peak discharge and peak suspended sediment concentration do not occur simultaneously. The suspended sediment concentration rises to a maximum (5,000 ppm) many days before the peak of water discharge. The lag time between the peak of the water discharge and the suspended sediment concentration varies from year to year, and on average is approximately 10 days.

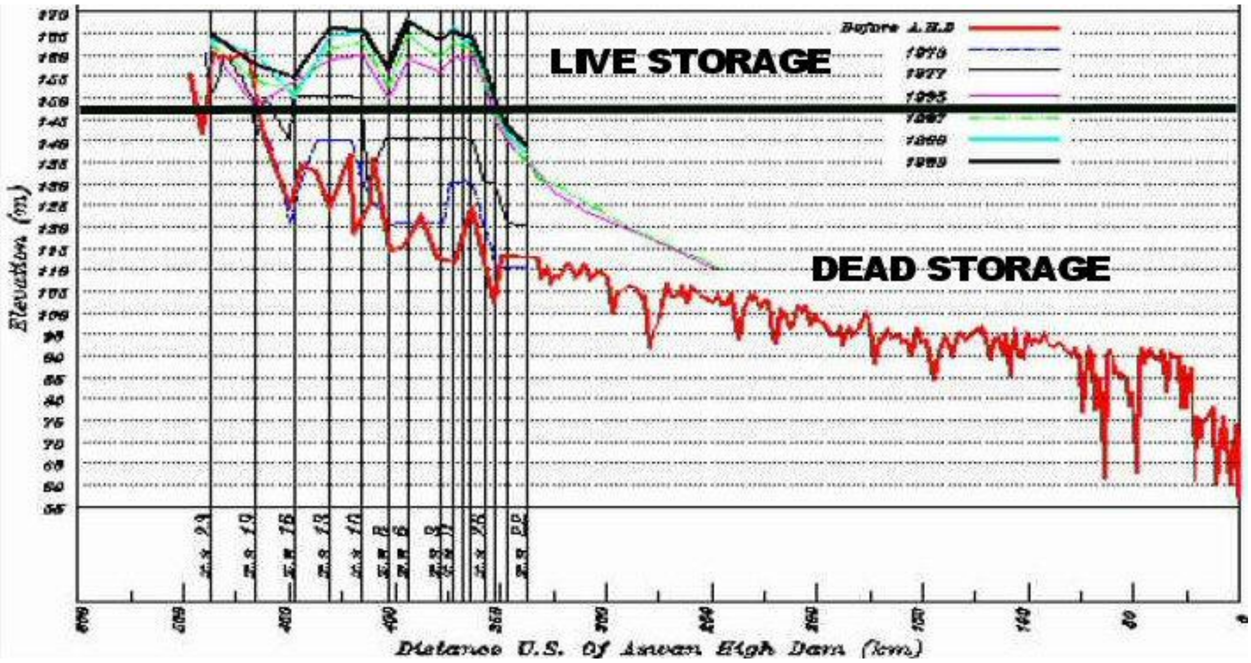
Shalash (1982) estimated the total annual inflow as 142 million tons, the average rate of outflow as 6 million tons with a net sedimentation within the Lake of 136 million tons. Using an average sediment density of 1.56 g cm^{-3} and corrected for compaction (dry weight density of 2.6 g cm^{-3} and a porosity of 40 %), the amount of annually retained sediment of 136 million tons of suspended sediment corresponds to an accumulated volume of 87 million m^3 per yr (Shalash, 1982). However, it is important to note that there is considerable annual variation in sediment load, ranging from 50 and 228 million tons.

Since 1973 cross-section measurements have been taken at selected points in order to monitor changes in the lake bed. By 1973 about 20 meters of sediment had been deposited near the Second Cataract (345-370 km upstream from the Aswan High Dam). From km 345 to km 285 the deposits decreased to less than 1 meter forming an inland delta some 85 km long. By 2000 the maximum deposits had reached

60 metres near the Second Cataract and deposition of sediment now reached 120 km from the dam. Thus, the inland delta had extended some 165 km and now stretched 250 km.

The extent of the sediment has been measured by Mohamed El-Moattassem et al, 2005). The sediment deposition is concentrated at the head of the Lake mainly in the Sudan. Figure 4.12 illustrates the longitudinal section of the lowest bed elevation of Aswan High Dam Reservoir from year 1964 to 2003 using bathymetric data collected by the Nile Research Institute. The reservoir was designed with 31.6 billion m^3 of dead storage to accommodate the sediment being retained in the reservoir. In 1982 the Research Institute to Study Effects of the High Dam estimated that the reservoir would function unimpeded by sediment for approximately 362 years (Smith, 1990).

However, it can be seen in Figure 4.12 that 360 km from the dam to 500 km from the dam the sediment is filling up the live storage as well as the dead storage. This is having an immediate impact on the useful storage capacity of the reservoir and thus is reducing the amount of water available for hydro power generation and for irrigation.



(Source: Mohamed El-Moattassem et al, 2005)

Figure 4.12 : Longitudinal bed elevation profiles for Aswan High Dam Reservoir

Continuing deposition of sediment in the High Aswan reservoir would result in gradually rising levels in the Nile immediately upstream as the delta formation progresses. In the long term this might begin to affect tailwater levels at the Dal site. However, the construction of the Merowe dam, described in the following section, will reduce the sediment discharge into High Aswan reservoir and slow the rate of deposition in the delta region.

4.2.6 Impact of Merowe Project

The Government of Sudan is currently constructing the 60 metre high Merowe Dam some 400 km north of Khartoum. The reservoir will submerge the fourth cataract of the Nile and form a 200 km long reservoir. With a surface area of 800 km^2, the lake will have a gross storage of 12.45 billion m^3 and an active storage capacity of 8.3 billion m^3. The dam will be fitted with deep sluices that can be used to operate the dam at a relatively low level during the period of highest sediment concentration thereby reducing sedimentation within the reservoir. Exactly how much sediment will be retained by the dam is a matter of some discussion. Three studies are available: (i) by Lahmeyer International, (ii) a study by MIT (Paris, A, T.Yamana and S.Young, 2004) and (iii) by the EAWAG, Switzerland.

The Lahmeyer study estimates that some 30 % of the annual mean sediment load of 120 million tons will be retained within the reservoir behind the dam.

The EAWAG study disputes this and claims some 90 % of the annual sediment load will be retained behind the dam. This study also uses an estimated mean annual sediment load of 143 million tons. The study estimated that the reservoir would fill completely in approximately 150 years.

The MIT study estimates a trapping percent of 84 % of which 65 % will rest in the dead storage and 35 % in the live storage. It used a mean annual sediment load of 128 million tons but notes that this can vary from 50 to 228 million tons. The MIT study looked at the changes in trapping efficiency as the reservoir capacity decreased. It also assumed that the dam would be operated to allow at least 40 % of the sediment to pass through the sluices in July-August with a net retention rate of 60%. It looked at six scenarios of varying flow rates and sediment loads to determine the economic life. Assuming 60 % retention and a suspended load of 128 millions tons it estimated the economic life of the dam as 105 years.

Brune’s relationship suggests a trapping efficiency of some 86% for Merowe assuming that the sediment is primarily fine-grained and colloidal particles. This is broadly in line with the MIT estimate referred to above. However, this analysis does not take account of sediment flushing activities and it could be expected that regular flushing at the start of each flood season would result in a significant reduction in trap efficiency and that some 30-50% of sediment could reasonably be anticipated to pass through the dam into the Main Nile downstream and thereafter into Dal reservoir.

4.2.7 Sediment Balance and Inflow to Dal Reservoir

Recent measurements over the period 2001 to 2003 suggest that the mean annual suspended sediment discharge in the Main Nile amounts to some 140 Mt/yr.

It is noted that this figure is significantly lower than recent estimates for average sediment discharge in the Abbay (Blue Nile) at Kessie gauging station in Ethiopia of 220 Mt/yr produced as part of the present study, based on sediment concentration measurements carried out in 2004.

A sediment balance for the Nile river was prepared as part of the Cooperative Regional Assessment (CRA) as shown in Table 4.11. It can be seen in this analysis that sediment discharge entering Karadobi has been assumed as 92 Mt/yr compared to a current estimate for sediment discharge at Kessie (slightly upstream of Karadobi), based on 2004 data of 220 Mt/yr in this study.

There is a high level of uncertainty regarding many of the estimates involved in deriving a sediment balance for the Nile given that many of the individual components of the balance are highly variable from year to year and that measurements are infrequent and imprecise. Some data is now more than 40 years old whilst it is anticipated that sediment discharge will have increased over this period due to pressures of population, agriculture and deforestation.

Table 4.11 : Eastern Nile Basin: Estimated Current Sediment Budget: No Watershed Management Programme and only Existing Dams

LOCATION	NO WSM OR DAMS
SEDIMENT ENTERING KARADOBI	92.00
SEDIMENT RETAINED IN KARADOBI	0.00
SEDIMENT THRU' KARADOBI	**92.00**
SEDIMENT ENTERING ABBAY RIVER BELOW KARADOBI (EXCLUDING BELES)	46.81
SEDIMENT ABOVE BELES-ABBAY CONFLUENCE (M t/yr)	138.81
SEDIMENT ENTERING BELES	1.56
SEDIMENT RETAINED IN BELES RESERVOIR	0.00
SEDIMENT THRU' BELES	1.56
SEDIMENT IN ABBAY AT BORDER	**140.37**
SEDIMENT ENTERING ROSIERES	140.37
SEDIMENT RETAINED IN ROSIERES (%)	15%
SEDIMENT RETAINED IN ROSIERES M t/yr	21.06
SEDIMENT THRU' ROSIERES	119.31
SEDIMENT ENTERING RAHAD + PUMP SCHEMES	119.31
SEDIMENT RETAINED IN RAHAD + PUMP SCHEMES (%)	1.88%
SEDIMENT RETAINED IN RHAD = PUMP SCHEMES PUMP (M t/yr)	2.24
SEDIMENT AFTER RAHAD = PUMP SCHEMES	117.07
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	1.25%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	1.46
SEDIMENT ENTERING SENNER RESERVOIR	115.61
SEDIMENT RETAINED IN SENNER (%)	10%
SEDIMENT RETAINED IN SENNER	11.56
SEDIMENT THRU' SENNER	104.05
SEDIMENT AT GEZIRA/MANAGIL INTAKE	104.05
SEDIMENT RETAINED IN GEZIRA/MANAGIL (%)	7.5%
SEDIMENT RETAINED IN GEZIRA/MANAGIL M t/yr	7.88
SEDIMENT AFTER GEZIRA	96.17
SEDIMENT FROM RAHAD-DINDER	9.19
SEDIMENT BELOW RAHAD-DINDER CONFLUENCE	105.36

LOCATION	NO WSM OR DAMS
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	2.5%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	6.32
BLUE NILE SEDIMENT AT KHARTOUM	99.04
SEDIMENT FROM WHITE NILE (3% OF 142mT/YR)	4.26
SEDIMENT MAIN NILE AT KHARTOUM (Mt/yr)	**103.30**
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	4%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	4.13
SEDIMENT MAIN NILE ABOVE ATBARA	**99.16**
SEDIMENT FROM ATABARA	58.43
SEDIMENT MAIN NILE BELOW ATBARA CONFLUENCE	**157.60**
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	4%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	6.30
SEDIMENT ENTERING MEROE RESERVOIR (M t/yr)	**151.29**
SEDIMENT RETAINED IN MEROE RESERVOIR (%)	0%
SEDIMENT RETAINED IN MEROE RESERVOIR (M t/yr)	0.00
SEDIMENT BELOW MEROE DAM (M t/yr)	151.29
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (%)	6%
NET LOSS TO PERMANENT STORAGE IN RIVER BED/ALLUVIAL PLAINS (Mt/yr)	9.08
SEDIMENT ENTERING LAKE NASSER/NUBIA (M t/yr) (passing through Dal dam site)	**142.22**
SEDIMENT ENTERING LAKE NASSER/NUBIA (M M3/yr)	133.85
SEDIMENT RETAINED IN LAKE NASSER/NUBIA (%)	96%
SEDIMENT RETAINED IN LAKE NASSER/NUBIA (M t/yr)	136.53
SEDIMENT RETAINED IN LAKE NASSER/NUBIA (M m3/yr)	128.50
SEDIMENT THRU' LAKE NASSER	5.69

Source: Draft CRA report on Distributive Analysis (January 2007)

Techniques adopted for many of the measurements have changed over the years – for example, sediment sampling at El Deim, upstream of Roseires was at one time carried out in a precise manner using 25 point samples on 5 verticals across the river but for the last 20 years has been based on a single bottle sample taken at the water surface adjacent to the river bank.

Other elements in the sediment balance such as deposition in irrigation systems are not regularly measured, whilst deposition on flood plain areas is extremely imprecise, but probably accounts for a large quantity of sediment especially in high flood years when sediment discharge and flooding is at its highest.

With significantly higher estimates of sediment transport at Kessie on the Abbay (Blue Nile) River in Ethiopia for current conditions, the sediment budget given in Table 4.11 would necessarily be disturbed. However, there appears to be no reason why the budget could not be adjusted to reflect greater sediment inflows at Kessie. It would require greater depositions along the Nile and the possibility of adopting a different trap efficiency and density factor for converting surveyed volume of sedimentation (m^3) in Roseires reservoir and Lake Nubia/Nasser to equivalent tons.

Experience on other projects is that sediment reductions downstream of new dams such as Merowe are often less than estimated. This is thought to be because the erosion of the riverbed and banks downstream of the new dam provides a continuing source of sediment until a new regime becomes established. The alluvial material comprising the riverbed and banks of the Nile between Merowe and Dal are thus likely to provide a source of substantial quantities of sediment entering Dal reservoir for many years to come.

Although the overall balance of sediment along the Nile downstream of Merowe is therefore uncertain, the average sediment discharge at the Dal site following construction of the Merowe project can probably be expected to lie within the range 75Mt to 100 Mt, depending on the effectiveness of the sediment flushing regime at Merowe. Much of this sediment will be very fine grained and will have a lower trapping efficiency in Dal than would be the case without Merowe upstream. A trapping efficiency of 55 % has been estimated based on Brune's relationship for primarily fine grained and colloidal particles and assuming that sediment flushing at Dal would not take place. Under these circumstances it is anticipated that sediment deposition in the Dal reservoir will be some 40 - 55 Mt/year, or some 30 – 40 Mm^3/year.

4.2.8 Future Water Resources Developments

Based on master planning in 1979, it was envisaged that all the reaches of the Main Nile, including Merowe dam and Dal, would experience variations in river flows as a result of proposed upstream sequential works, as follows:

- completion of the Jonglei canal
- construction of Machar conservation project
- construction of Bahr El Ghazal conservation project

The construction of water conservation works in Jonglei and Machar were expected to increase flows in the Main Nile by reducing evaporation losses in the Sudd swamp. Table 4.12 shows the expected flows in the Main Nile. These plans remain but are not implemented.

Table 4.12 : Mean Monthly Nile Flows Representative of Dal

Month	Natural flow (m^3/s)	Flow after Projects (m^3/s)		
		Jonglei canal project	Machar project	Bahr El Ghazal project
January	1,084	1,221	1,334	1,425
February	875	1,024	1,112	1,201
March	734	879	960	1,059
April	1,160	1,101	1,187	1,292
May	1,292	1,195	1,234	1,325
June	1,192	1,122	1,166	1,230
July	1,852	1,949	2,031	2,113
August	5,503	5,678	5,551	5,537
September	4,765	4,940	4,764	4,726
October	2,633	2,800	2,890	2,961
November	1,802	1,951	2,065	2,152
December	1,256	1,417	1,512	1,605
Year	**2,019**	**2,113**	**2,157**	**2,226**
Year Billion m^3	**63.7**	**66.6**	**68.0**	**70.2**

Source: Nile Waters Study, 1979

4.3 ANNUAL FLOODS

4.3.1 Mixed blessings of annual floods

The annual flood of the Nile is of inestimable importance to the Dal area and all riverside settlements, agriculture and all activities along the Main Nile in the desert. Although flow is perennial and water is always physically available in the Nile river channel in all seasons, it is the annual rise and fall of water level which is critical for delivering water to the riverine strip of alluvial soils for cultivation, grazing, date palms, citrus, other tree crops and shade trees, and for recharging groundwater resources. However, the highest floods are a mixed blessing because they cause major public health problems, damage to properties in settlements and to flood defence dykes, irrigation schemes and equipment.

Dongola is the capital of Northern State and the town itself is an important agricultural and trading centre. Dongola town and surrounding areas have experienced some severe flooding from time to time but particularly in 1988 and more recently. The Eastern Nile Flood Preparedness and Early Warning study (SMEC, 2006) has considered this in its reports which note that a large proportion of Dongola would be subject to inundation in large Nile floods except for the protection afforded by a number of levees. The main town levee is over 12 km long, but has not resisted floods in the years of highest floods, and is therefore not performing its intended function. The SMEC report notes that failures are not always due to overtopping, and may occur because of structural failure.

As shown earlier in Table 4.2, the flood season is July, August and September. Floods peak in late August. High floods always occur at this time, although they have also been known to occur in early September. The dry season is from October to June, with Nile floods subside after about October 15.

4.3.2 Flood Warning System

The Ministry of Irrigation and Water Resources has established a flood warning system along the Nile and an agricultural interpretation of floods and control levels is helpful for understanding the existing biological and socio-economic environments described later.

Control Levels (CLs) are established and divided into four categories: "Normal", "Alert", "Critical" and "Flooding". These are determined according to the morphology of the river, riverbank conditions and topography. As a result, the CLs have both flooding and agricultural significance as follows:

- "Normal" - the flood is considered as "Normal" if the flow during the flood is confined within the banks of the river;
- "Alert" – the flood is determined as "Alert" if the flow tops over the banks of the river and floods part of the farm lands and agricultural areas adjacent to the river;
- "Critical" – the flood is considered as "Critical" if all the flood plain and cultivated areas are flooded;
- "Flooding" – the flood is considered as "Flooding" if permanent residential areas near the river are affected.

Table 4.13 shows the Control Levels adopted along the Blue and the Main Nile, using the colour coding adopted by the Ministry.

Table 4.13 : Flood Control Levels along Blue and Main Nile

Control Level	El Deim	Wad Medani	Khartoum	Shendi	Atbara	Dongola
Normal	<10.8	<18.4	<15.0	<16.1	<14.18	<13.47
Alert	10.8 – 11.8	18.4 – 19.4	15.0 –16.0	16.1 – 17.1	14.18 – 15.18	13.47 – 14.72
Critical	11.8 – 12.3	19.4 – 19.9	16.0 – 16.5	17.1 – 17.6	15.18 – 15.75	14.72 – 15.22
Flooding	>12.3	>19.9	>16.5	>17.6	>15.75	>15.22

Source: Ministry of Irrigation and Water Resources, Khartoum

At Dongola, the range of the Alert control levels is 1.3 m. This means that the water levels are up to 1.3 m higher than the bankfull discharge and benefit part of the farmlands and agricultural areas adjacent to the river. This may be interpreted as many agricultural areas benefiting from water and silt deposits but some farming communities will be disappointed that floodwater and silt does not reach them.

At Dongola, the range in Critical levels is 0.5 m. This means that the water levels are up to 0.5 m higher than the Alert level and benefit all farmlands in the flood plain. In this case, all agricultural areas benefit from water and silt deposits and, generally speaking, no farming communities will be disappointed that flood water and silt does not reach them.

At "Flooding" levels, permanent residential areas near the river are affected. These are the levels at which damage to property is caused, and when flood protection dykes may be overtopped or breached incurring additional maintenance costs compared to less severe flood years. The flood duration is longest in this case, delaying the time of planting and beginning of plant growth on the flood's recession.

4.3.3 Interpretation of Flood Experience in Dongola and Dal areas

Figure 4.13 shows the historical occurrence of annual flood Control Levels at Dongola for the 42-year period 1965 – 2006 and summarises the frequency of occurrence. The situation in the Delgo, Abri and Dal areas is expected to be similar to Dongola.

YEAR	Control levels			
	NORMAL < 13.47	ALERT 13.47-14.72	CRITICAL 14.72-15.22	FLOODING > 15.22
1965		■		
1966		■		
1967		■		
1968		■		
1969			■	
1970			■	
1971		■		
1972	■			
1973		■		
1974			■	
1975			■	
1976		■		
1977			■	
1978		■		
1979		■		
1980			■	
1981		■		
1982	■			
1983		■		
1984	■			
1985			■	
1986		■		
1987		■		
1988				■
1989		■		
1990		■		
1991			■	
1992		■		
1993				
1994				■
1995			■	
1996			■	
1997		■		
1998				■
1999				■
2000				■
2001				■
2002		■		
2003				■
2004			■	
2005			■	
2006				■
FREQUENCY	3	19	12	8
	NORMAL	ALERT	CRITICAL	FLOODING
%	7	45	29	19

Source: Ministry of Irrigation and Water Resources, Khartoum

Figure 4.13 : Flood Control Levels at Dongola in 42-year period 1965 – 2006

From farming and livelihoods points of view along the Main Nile from Dongola to Dal, the various situations may be summarised as follows:

"Normal" flood years present crisis conditions (food shortage) because the river does not flow out of its banks, unless an area enjoys pumping facilities for irrigation. 1972, 1982 and 1984 were the only years in the 42-year record with "Normal" floods at Dongola.

"Alert" years are the most common, occurring in a little under half of all years, are good for many but not for all (for whom there may be food shortage);

"Critical" years, occurring in about one year in four, are good for all – all the flood plain is flooded and receiving a dressing of silt as a fertilizer; (the word "critical" here refers to potential imminent flooding of properties and overtopping or breaching of dykes in the flood warning sense of critical levels; for future agricultural production on the flood recession and for future water supplies from recharged groundwater and mataras, the situation is not critical but welcome and perhaps almost "ideal");

"Flooding" years are a mixed blessing – they support recession agriculture in the following months, fully recharging groundwater and mataras adjacent to the floodplain and encouraging spawning and fish recruitment, but cause major public health problems, delay cultivation, seriously spoil communications and cause damage to properties, equipment and flood protection dykes – all incurring heavy costs. In the 42-year record, eight years have experienced flooding conditions, all concentrated in the period 1988 to 2006.

With regard to "Flooding" conditions, the situation at Delgo, Abro and Dal is not only influenced by local flooding conditions but also by how the floods are affecting Dongola, the state capital, and roads, bridges and culverts on the road to Dongola because a lot of trade and services are provided to the northern areas from Dongola.

4.4 BIOLOGICAL ENVIRONMENT

4.4.1 Regional Land Cover

Dal is located in the far north of the Main Nile sub-basin, an area which apart from the fertile alluvial strip is dominated by desert conditions. This may be seen in the land cover of the Main Nile region in Figure 4.14.

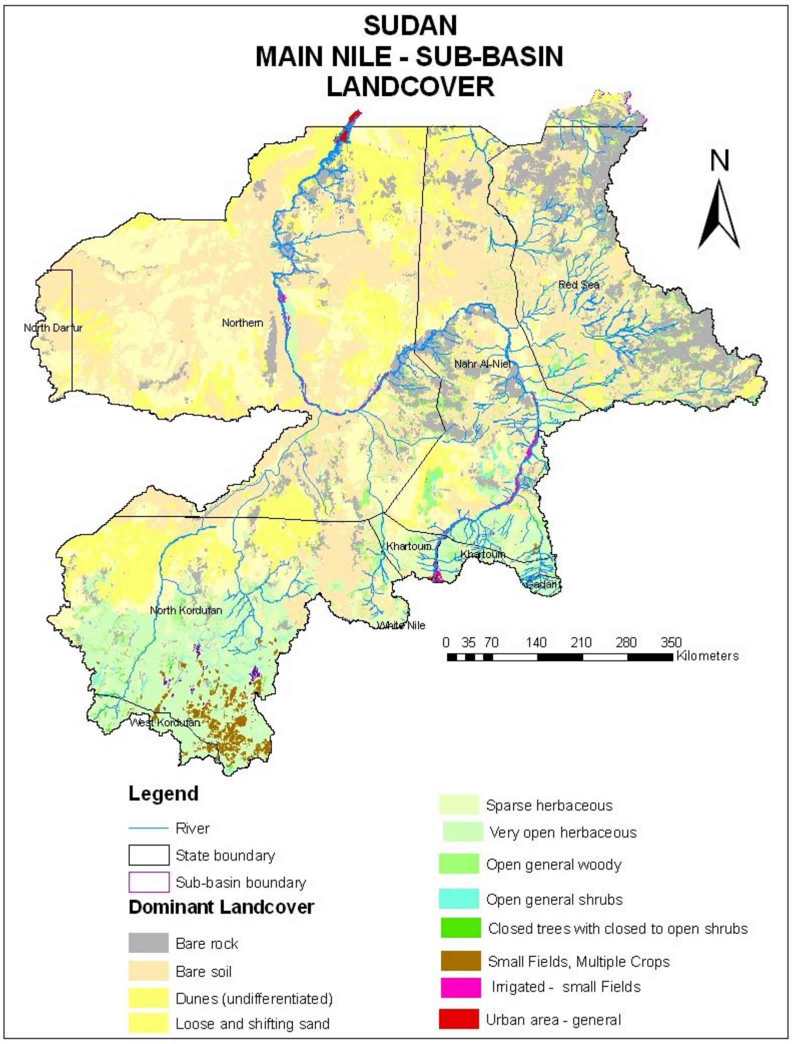


Figure 4.14 : Main Nile Sub-basin - Landcover
Source: Africover, 2002

4.4.2 Biological Environment of Dal Area

The Dal project area lies in the Nubian Desert. The project area is of special biological interest for two reasons:

- It is one of the most extreme deserts in the world.
- It will be partly flooded by a 160 km long lake when the dam is completed.

Terrestrial Fauna

The Nubian Desert is very arid with very little vegetation confined to khors and depressions. The fauna is extremely sparse comprising:

- *Arthropods*: Flightless or have weak powers of flight like ant-lions, termites beetles. These are less easily dispersed by wind.
- *Arachnids*: Scorpions, spiders, ticks.
- *Insecta*: House fly and nimitti are most prevalent.
- *Vertebrates*: Lizards, gecko, bats, *Buffo regularis,* insectivores (hedgehogs), rabbits, mice and rats as well as bats; foxes and mongoose; commonly seen along the Nile banks.
- *Birds*: Nearly 50 species were observed in the project area in April 2007, with their identification confirmed by reference to field guides (Cave and MacDonald, 1955; Stevenson, Terry and Fanshawe, 2000). They included: Grey heron, Buff-backed heron, Squacco heron, Night heron, Egyptian vulture frequently seen throughout the length of the Nile Valley; Nubian vulture; Short toed eagle; Pallid harrier; quail stone curlew; Spur winged plover; Black headed Plover; Greenshank; Egyptian plover; Rock dove; Turtle dove; Laughing dove; Red eyed pigeon; crow; kite; Sand Martin; Barn Swallow; sedge warbler; Sand grouse; Raven; Palm swift; Hoopoe; Egrets; Starlings; Pied Wagtail; Crested Lark; Night Jar .

Wildlife is scarce and there are no protected areas in the vicinity. Some species reported from the area include: the Dorcas Gazelle, Red fronted Gazelle, Spotted Hyena. The desert fox has not been seen for some time.

None of the mentioned species is endemic to the area. Generally speaking, the area is poor in the way of biodiversity, both qualitatively and quantitatively.

Fish and Fisheries

No endangered fish species have been reported and there is no evidence of fish migration other than local movements in the main river.

A survey of the fish markets along the stretch of the river demonstrated that the catch is mainly composed of *Synadontis*, *Labeo spp, Bagarus bayad, Claris spp., Alestes spp. , Lates niloticus, Tilapia spp., Mormyrus spp., Dystacodus spp.*

Gill-nets used are of twine numbers 6 to 7; 5 to 6 during the flood season. The total number of boats in the Dongola area is 40 (two fishermen per boat). Nets are set in bays and around river bends. The average catch for the largest market at Dongola is around 100 kg per day. Maximum catches are landed during periods of rise and fall of floodwaters. The maximum price per kilogram is in the periods of low flow for favoured fish, e.g. the Nile perch fetch around S£ 6,000 per kg (USD 3/kg). Labeo sells at S£ 4, 000 per kg (USD 2/kg). In seasons of abundance, prices drop to 500 ls per kg. (For comparison, beef sells at S£12,000 per kg (USD 6/kg).

Terrestrial Flora

It was evident from field visits that plant cover is not evenly distributed along the banks of the river. The plant impact/patches/density varied between Delgo town and Dal village.

The vegetation is very limited in distribution. The micro-topography of the Nile and the extreme climate of the Nubian Desert cause the permanent vegetation to be restricted to a narrow strip on each side of the river, and in khors, wadis and depressions. In the Delgo - Dal stretch, the river is variable in width rarely exceeding 1 km.

The overall picture is that the riverine flora of the study area, though narrow in certain stretches, is rich and diverse, often characterized by patchiness and fragmentation of habitats.

The site visits showed that for convenience of description, the vegetation may be divided into two main zones: riverine vegetation immediately on the banks, and vegetation in wadis, khors and desert hollows.

Riverine Vegetation

The riverine vegetation may be considered to occupy the banks of the Nile and the land in front of the cultivated ground. The riverine vegetation is predominantly trees and large grasses whose presence is directly dependent on the Nile (Plate 4.2).

Plate 4.2 : Riverine vegetation at Dal dam site and islands in Nile

The date palms (*Phoenix dactylifera*) and acacias of this zone are undoubtedly the most conspicuous vegetation feature of the Delgo - Dal stretch. They form a more or less conspicuous strip along both the eastern and western banks.

Of the Acacias, the most abundant is *Acacia nilotica*. *A. tortilis* and *A. ehrenbergiana* and sometimes *A. seyal* var *fistula* as well as *Mimosa tementosa* occur at some higher levels on the banks. Where trees have been cleared, *A. nilotica* is often regenerating passing through a shrub phase. A few specimens of *A. tortilis* and *A. ehrenbergiana* are also found on rocky and sand banks.

Patches of *Tamarix* sp., *Salix* sp. and *Phragmites* sp. occur at some lower levels on the silt banks of the Nile particularly where there are gaps in the tree cover just outside the *Acacia nilotica*.

Generally the date palms (*Phoenix dactylifera*) tend to occur at higher levels on the banks and thus formed an indistinct zone inside the Acacias, although at times they are found at the water edge.

Much of the ground under the trees is bare or has a sparse herb layer in which *Cynodon dactylon* predominates. However, under the Acacias there are usually small numbers of rather stunted plants or seedlings of weeds typical of cultivated or disturbed ground (e.g. *Solanum incanum, Calotropis procera, Rhyncosia minima, Tephrosia apollinea* and *Desmostachya* sp).

Vegetation in Wadis, Khors and Desert Hollows

The only signs of life away from the riverbanks occur in wadis and khors. A number of wadis and khors lead into the Nile. These contain a number of shrubby perennials near the river where the sediment in the khors is thickly deposited. Since rain is too infrequent and very scanty to produce any permanent or semi-permanent run-off and since these plants are no great distance from the river, it seems reasonable to assume that the roots of these plants reach the water table of the Nile.

The khors and wadis contain: Acacia ehrenbergiana, A. tortilis, Calotropis procera Desmostachya bipinnata, Leptadenia pyrotechnica, Tamarix spp., Colocynthis vulgaris, Aerva sp., Cassia spp., Euphorbia granulata, Fagonia sp., Pulicaria crispa, and Tribulus terrestris. The plant species represented in these areas are variable. Differences may be due to differences in soil composition.

4.5 INFRASTRUCTURE

Over much of the Basin road network is very poor given the vast expanse of desert. Within the Main Nile Sub-basin there are two primary (asphalt) and some all-weather secondary roads (Figure 4.15).

- Khartoum - Atbara (312km) and Atbara - Haiya (under construction)
- Khartoum - Abu Dom (386 km) and Abu Dom - Dongola (under construction)
- Atbara - Wadi Halfa (613 km) (secondary)

Other roads are generally in poor condition and on the clay plains often impassable during the rains. There is one rail line: Wadi Halfa-Khartoum.

4.5.1 Communications in Dal Project Area

Communication infrastructure within the project area is poor. There are no paved roads but only tracks linking villages with each other, with the headquarters of the administrative units of Abri and Delgo, with the locality headquarters at Wadi Halfa town near the Egyptian border, and with Dongola, the capital of the Northern State.

Despite the poor state of the roads, lorries and buses do manage to reach even the most remote places on both banks of the Nile. Vehicles are able to cross the river by ferries, the major crossing being the Dongola ferries. Other ferries downstream link towns, villages and islands. Small boats are also used for crossing the river or accessing the islands (Plate 4.3).

Generally transportation between villages is by means of donkeys. Each family has at least one donkey. A few families have small Toyota pickups which they operate on a commercial basis for local transport.

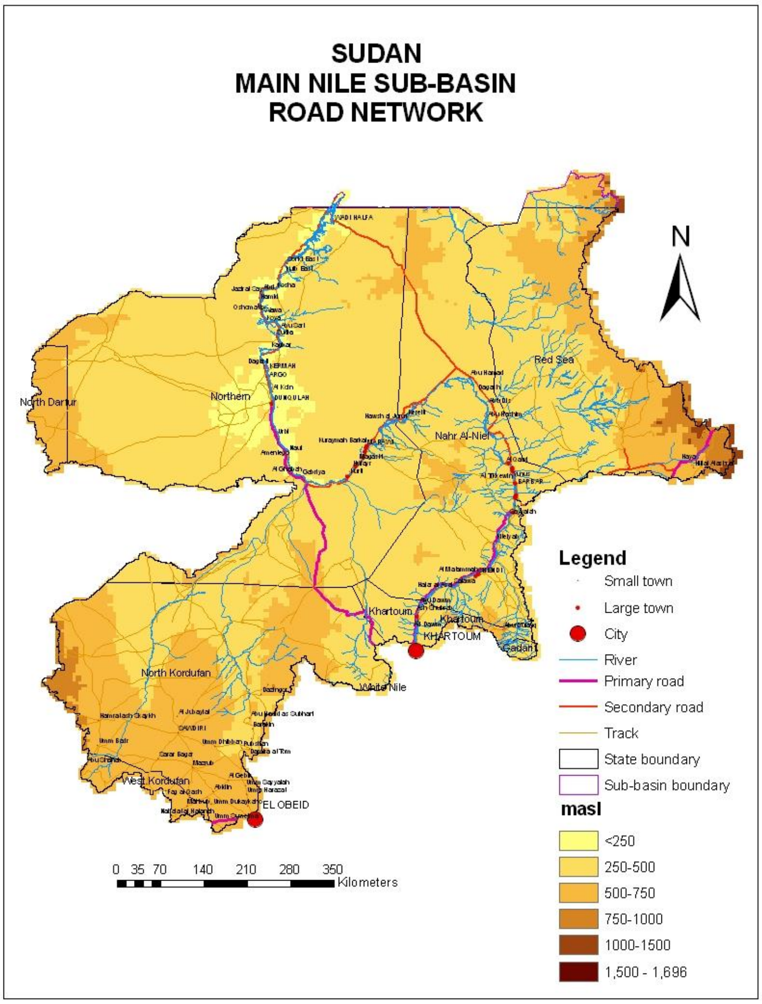


Figure 4.15 : Main Nile - Road Network

Plate 4.3 : Ferry boat serving Sarkamatto and Dal villages

4.5.2 Settlements in Dal Project Area

The Dal project area has a rural character with larger settlements being the towns of Abri and Delgo. The settlement pattern along the Nile river is closely related to the physical characteristics of the river banks and has resulted in a very large number of small hamlets or groups of houses, these being elements of the 55 villages of the project area. Of these villages, seven comprise large islands.

Houses typically have two to five rooms, a veranda and a yard of 30m X 20 m. The rooms of women and men are separate. Houses are built of mud, the inside walls plastered with smooth mud or white lime, while the floors are of hard packed mud. Strong wood poles are used to support the roof which is made from the stems and fronds of date palm trees that are then covered with mud. Women usually do house decoration and plastering using white lime and colours extracted from local rocks. Every village has at least one mosque (Plates 4.4, 4.5 and 4.6)

Plate 4.4 : Dal village housing

Plate 4.5 : Dal village street

Plate 4.6 : Dal village mosque

4.5.3 Markets and Trade

There are marketplaces in Abri and Delgo towns on the eastern bank of the Nile. Several other small markets are scattered throughout the area but a great deal of trade transactions takes place in the villages outside the marketplaces. Village merchants who own lorries are able to operate on a greater scale and to trade with Dongola and Khartoum.

4.5.4 Energy

There is a small power station providing electricity to part of Abri town. Electricity is not provided to the area of the future reservoir although a number of generators are operated on a cooperative basis with most villages currently being supplied with electrical energy in this way from sunset around 7pm until 10pm. Families unable to afford the use of a generator generally use kerosene lamps. Most households use open fire for cooking and burn charcoal and the branches of date palm and other trees. More recently, some families started using gas for cooking. Grain mills are driven by diesel engines.

4.6 REGIONAL ADMINISTRATION AND POPULATION

4.6.1 Administration

The Main Nile Sub-basin encompasses eight Administrative Regions (Table 4.14).

Table 4.14 : Administrative Regions within Main Nile Sub-basin

Region	Area (km^2)	% of Sub-basin
North Darfur	9,788	1
North Kordafan	139,636	21
West Kordafan	7,220	1
Northern	259,180	39
Khartoum	13,663	2
Nile	118,500	18
Al Gadarif	1,654	0.3
Red Sea	111,236	17
SUB-BASIN	660,877	100

Dal is in the Northern State, the second largest (Figure 4.16).

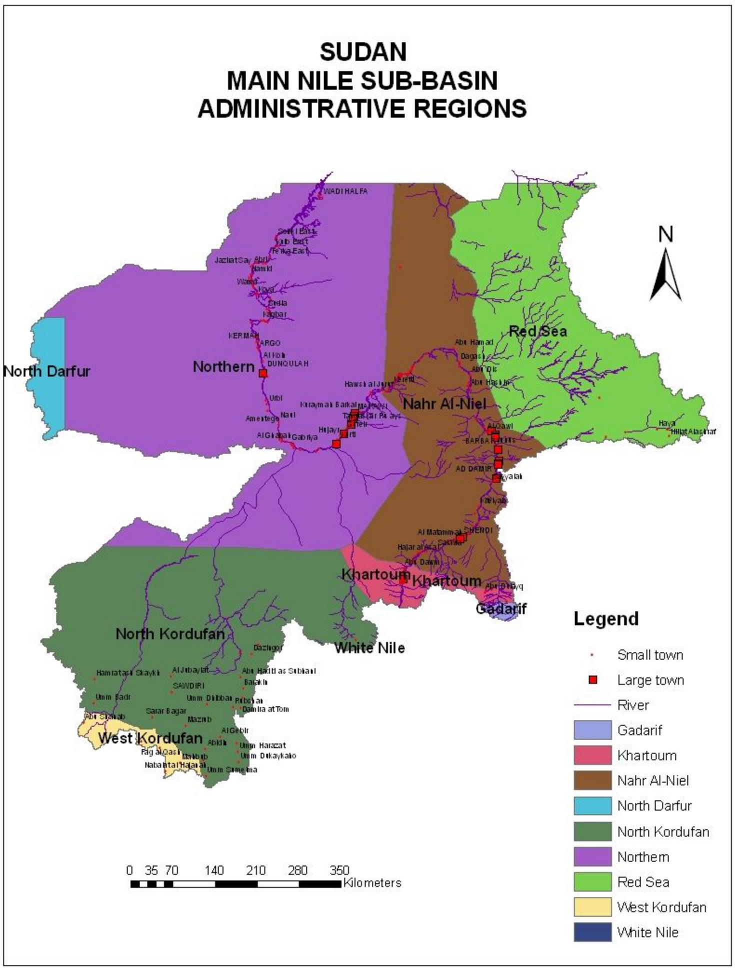


Figure 4.16 : Main Nile: Administrative States

4.6.2 Population

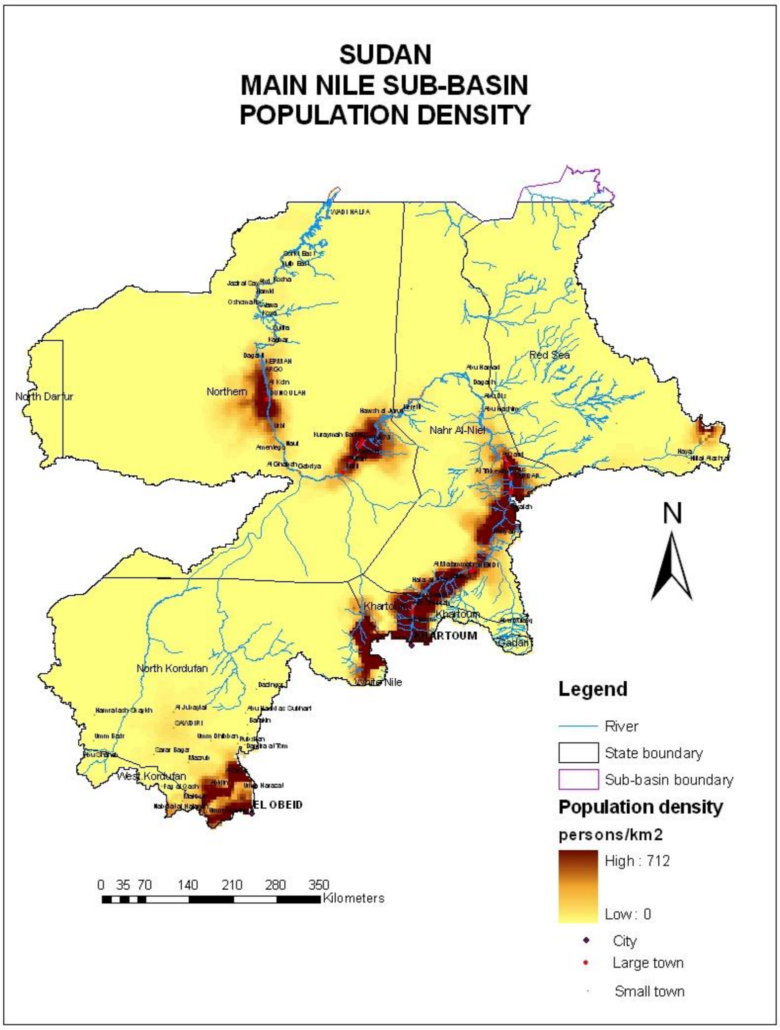
The population of the States contained mainly within the north of the Main Nile Basin are shown in Table 4.15. About half of this population is in Northern and Nile regions and may be considered to be totally dependent on the Nile for both water and food supplies where flood recession agriculture and irrigation schemes use Nile water.

Table 4.15 : Population of States within Main Nile Sub-basin

Northern	1,179,399
Nile	701,256
Red Sea	2,048,041
TOTAL	**3,928,696**

Source: CRA Sudan Report (2006)

The main areas of high population density along the Main Nile are north of Khartoum and in the areas around Atbara, Karima/Merowe and Dongola. Away from villages and towns along the Nile's fertile alluvial strip, with few exceptions, densities are typically zero. Population density for the Main Nile in Sudan is shown in Figure 4.17.



Source: CRA Sudan Report (2006)

Figure 4.17 : Main Nile Sub-basin - Population Density (persons/km^2)

4.6.3 Demographic and Livelihood Characteristics

Regional population growth rates are low, between 0.52 and 1.9 % per annum (Table 4.16). There is high youth emigration, particularly to Khartoum and the Gulf countries.

Table 4.16 : Main Nile Sub-basin: Demographic Characteristics

State	Growth rate %	Urban %	% <15yrs	% >60yrs	Sex ratio M/F	Crude birth rate	Crude death rate	Infant mort. male*	Infant mort. female *
Northern	1.70	15.2	39.7	5.9	94.7	37.8	11	116	98
Nile	1.90	33.7	41.0	5.3	97.6	34.0	10.8	108	90
Red Sea	0.52	60.5	38.5	4.3	116.1	34.7	9.7	95	88
North Kordofan	1.60	31.1	47.4	4.3	91.8	40.1	12.2	125	106
NORTH SUDAN	2.8	37.3	42.8	4.1	100.4	37.8	11.0	116	98

* per 1000 live births

4.6.4 Socio-cultural Aspects of population

There is considerable socio-cultural diversity among the population of the Main Nile sub-basin mirroring that of the whole of Sudan. The following description is a brief summary of a complex picture and lists only the larger socio-cultural groups.

The main groups are Nubians, Danagla, Bedirya and Rekabia. Along both banks of the Nile itself are the Gaa'lian people who have inherited the rights to use their land and being closest to water were able to survive the devastating drought of 1983/84. Also living both sides of the river are the Shaigia, Kawahla, Kababish and Hassaniya peoples, mainly pastoralists but who also cultivate sorghum along the wadis. As with all the pastoral/agro-pastoral groups wage labour is a major feature of livelihood strategies. Living mainly along the Wadi Muqadam and more recently along the Nile below Korti are the Hawaweer people. Their livelihoods too were devastated by the 1983/84 drought but many have returned and rebuilt their livelihoods.

4.6.5 Nubian Culture and Population

The region between the Nile's Second Cataract near the Egyptian border (inundated by Lake Nubia 40 years ago) and some 550 km to the south is known as Upper Nubia. It is a land that has a very long and distinctive history and where the Nubian language is spoken (Kirwan, 1963). The Nubians are divided into three groups:

1. Halfawyin in the Wadi Halfa area, those remaining in the north after High Aswan Dam caused involuntary resettlement of 100,000 people. 53,274 persons were evacuated from Halfa district; 372,749 productive date palms were destroyed in Sudanese Nubia (Sudan Government, 1963);

2. Mahas/Sekot along the Nile from from Akasha, north of Dal, to Kerma, south of Delgo, and including the potential Dal reservoir area;

3. Donglawi along the Nile from Argo, near Kerma, to Old Dongola, south of Dongola.

These groups all speak the Nubian language but Arabic becomes more common the further south one goes. However, within Upper Nubia, north of the Third Cataract near Kerma, where the Mahas district begins and the asphalt and electricity end, Nubian villagers maintain their linguistic and cultural differences with great pride. To be Mahasi means to be a true Nubian, to speak a pure Nubian language and to live in the Nubian heartland. This is the best description for the area between Dal and south of Kajbar as far south as Kerma.

Plate 4.7 : Residents of Dal village

It is therefore legitimate to speak of Mahas as an indigenous minority with their distinct language, style of house construction and history. Of course, many Mahas speak Arabic, being the lingua franca of the country but in their day-to-day conversations at home, on the farm, and in the market they speak Nubian.

4.7 DEMOGRAPHIC CHARACTERISTICS OF DAL PROJECT AREA

The Dal project area is occupied by the Mahas Nubians. The area is too arid to be visited by nomadic pastoralists from other parts of the country. However, due to the civil strife in other parts of the Sudan, the project area has recently attracted war-displaced families from Southern Sudan, Nuba Mountains and Darfur. About 760 internally displaced persons (IDPs) are currently living in Abri town alone.

The 1993 population census indicated a total population of some 64,300 and some 12,600 households in the Wadi Halfa locality which indicates an average household size of 5.1 (Table 4.17).

Table 4.17 : Population of Wadi Halfa Province, 1993 Census

Council	Households	Population	Males	Females
Wadi Halfa Rural	721	3,082	1,590	1,492
Wadi Halfa Town	2,159	12,032	6,511	5,521
Abri Rural	2,530	12,096	5,571	6,525
Abri Town	418	2,644	1,440	1,204
Delgo Rural	3,540	17,914	8,207	9,707
Delgo Town	199	1,611	593	1,018
Al-Turaah Rural	3,047	14,942	6,630	8,312
Total	**12,614**	**64,321**	**30,542**	**33,779**

Source: 1993 National Population Census: Northern State Volume. Khartoum: Central Bureau of Statistics

Subsequently, new administrative divisions were established for which the 1993 population is re-arranged in Table 4.18.

Table 4.18 : Population of Wadi Halfa (1993) for New Administrative Divisions

Administrative Unit	Households	Population	Males	Females
Wadi Halfa	2,880	15,114	8,101	7,013
Ferka	3,047	14,942	6,630	8,312
Abri	2,948	14,740	7,011	7,729
Delgo	3,739	19,525	8,800	10,725
Total	**12,614**	**64,321**	**30,542**	**33,779**

In Table 4.19, populations of the census base year of 1993 are projected to 2006 at the rate of 1.7%, which is the annual rate of population growth for the Northern State. The project area is completely within Abri and Delgo administrative units, and extends slightly into Ferka in north and slightly into Kerma further south.

Table 4.19 : Population Projections of Wadi Halfa's New Administrative Divisions

Year	Wadi Halfa	Ferka	Abri	Delgo	Total
1993 (census year)	15,114	14,942	14,740	19,525	64,321
1994	15,371	15,196	14,990	19,857	65,414
1995	15,632	15,454	15,245	20,194	66,525
1996	15,899	15,717	15,504	20,537	67,657
1997	16,169	15,984	15,767	20,886	68,806
1998	16,444	16,256	16,035	21,241	69,976
1999	16,723	16,532	16,307	21,602	71,164
2001	17,007	16,813	16,584	21,969	72,373
2002	17,296	17,099	16,866	22,342	73,603
2003	17,590	17,390	17,153	22,722	74,855
2004	17,889	17,686	17,445	23,108	76,128
2005	18,193	17,987	17,741	23,501	77,422
2006	18,502	18,293	18,042	23,900	78,737

Maps showing the boundaries of former and new administrative units are not available. Indeed, the only detailed map showing place names and islands is undated but thought to be more than 50 years old. This is an important defect because this limits the reliability in estimating the population that would be affected by the Dal project.

For current purposes, the population which would be directly affected by the Dal project (from upstream end of Dal cataract to Kagbar cataract) is considered to be the whole populations of Abri and Delgo, some of Ferka administrative unit (with Ferka itself and one or two villages being upstream of Dal dam site) and some northern villages of Kerma administrative unit (for which the projected administrative unit population is 33,174 for year 2006).

The population that would or might be influenced by downstream impacts of the Dal project is the balance of the projected population of Ferka (those downstream of the dam site) and Wadi Halfa. It may be noted that the rural population and most of the urban population of Wadi Halfa are directly engaged in farming.

Emigration appears to occur due to land scarcity and population pressure. Men leave their villages to find work elsewhere. Women are left behind to take care of farmland in addition to their domestic chores. Emigrants regularly send remittances back to the villages in accordance with the needs of their dependents and the obligations they may have. However, many of the emigrants still own land and date palm trees in their home villages. Relatives often work these with the emigrants entitled to a share in the harvest.

4.7.1 Gender Roles

The contrast between men and women is sharply emphasised in every way. To a large extent men and women are segregated in both work and leisure. The division of labour is clear and strictly observed and only partially relaxed in female-headed households.

Men undertake irrigation, feed livestock, control transport and conduct all relations with the outside world, including almost all the buying and selling transactions. They make all decisions, at least ostensibly, and defend the family and its honour. The major resources are in the hands of the household head and he controls cash income and expenditure. He has authority over land and other assets, such as the house and animals, until his death.

Women carry out domestic tasks, prepare food, manure fields and feed and milk goats and sheep. Many of these domestic chores take place without much attention or interference from men, thus providing women with some autonomy over their own affairs. Women do have generally acknowledged rights to minor domestic products (e.g. poultry products, handicrafts, etc). Women do not trade outside the village.

Women development indicators have been derived for Northern State which show that the proportion of women that are heads of household, participate in the formal labour force and have parliamentary seats are 13%, 8% and 14% respectively. (States Encyclopaedia: Northern State, 2000, published by the Federal Government Chamber, Khartoum, 2000).

4.8 LAND USE OF DAL PROJECT AREA

Soils of the riverbanks and lower terraces (also called Recent terraces) are deep alluvial deposits of different compositions of sand, silt and clay. They are subjected to annual flooding which replenishes their fertility through the yearly deposition of new silt. Farm sizes along the reach of the river between Dal and Kajbar differ considerably and range between 0.5 ha and 1.0 ha.

The riverbanks are often steep and are commonly between 8 and 12 metres high. They are inundated by the annual floods and are cultivated utilising the residual moisture made available as the flood recedes. These are known as gerouf lands.

The parts of the lower terraces that can be cultivated are commonly between 50 and 200 metres wide (140 metres on average) and are irrigated using small diesel pumps. At some locations, the lower terraces may also be inundated by annual floods and in such cases, flood recession cultivation is undertaken followed by a second crop under irrigation.

Upper terraces (also known as older terraces), which are a transition between the cultivated area and the desert, are found at a number of places along the river. In former times floodwaters of the river reached these terraces. The soils are generally a mixture of sandy silt and gravel and are marginally suitable for irrigated agriculture due to their irregular topography, salinity, wind erosion hazards or wind-blown sand intrusion.

Desert covers the rest of the area. Wadis, huge rocks and hilly areas often intersect it. The upland soils are stony or sandy and are unsuitable for irrigated agriculture.

4.9 LOCAL ECONOMY OF DAL PROJECT AREA

4.9.1 Farming

The Delgo town - Dal village reach has features common with other reaches of Nubian region, i.e. the narrow alluvial strip being confined to the banks; usually to one bank only while the opposite bank is buried in blown sand which reaches down to the river. However, this rocky reach is characterized by narrowness and often discontinuity of the alluvial strips. The areas suitable for cultivation in this reach do not extend outwards for a long distance on one or the other side of the Nile. The alluvial cultivated strips are bordered like elsewhere in Nubia by vast sterile rocky-sandy desert on both sides of the Nile. In contrast, between Kerma and Dongola, further south and upstream of the proposed Dal reservoir, cultivated land is the largest and most fertile in the Nubian region. The land suitable for cultivation in this reach may extend outward to more than 3 or 4 km.

The permanent cultivations tend to be situated on the silt between the riverine vegetation and the houses at the desert edge. Irrigable land occurs on both banks or on the east bank and in few places on the west bank. Outcropping of Basement rocks limit cultivable land in certain stretches. Cultivation is of *seluka* type (local name for digging stick). The main crops beside date-palm are *Vicia faba* (broad beans), *Triticum* sp. (wheat), *Lupinus termis* (turmus), Medicago sativa (bersim), *Allium cepa* (onion) and a variety of vegetables. Water for irrigation is raised from the Nile by pumps and is led along irrigation canals to the fields.

Virtually all the original or natural vegetation is cleared for cultivation although a few trees of *Hyphaene thebaica*, *Tamarix* sp. and *Acacias* (usually *A. nilotica* and *A. tortilis*) could be seen within this zone. The natural vegetation in cultivated areas is almost entirely composed of weeds widespread in irrigated areas in Sudan.

The permanent irrigation ditches usually carry well-developed and probably permanent vegetation on the silt embankments. They are normally covered by the common typical weeds, e.g. *Euphorbia hirta*, and by grasses, e.g. *Cynodon dactylon*, *Desmostachya* sp. and *Echinochloa colonum*.

Prior to cultivation the ground is hoed or broken so that it starts clear of weeds. Once irrigation starts, the weed seeds germinate and before harvest a dense covering of weeds develops e.g. *Cynodon dactylon, Cyperus rotundus, Euphorbia granulata, Pulicaria* sp., and *Tribulus terrestris.*

The prevailing agricultural system is small-scale subsistence and commercial crop production, using simple irrigation technology as well as flood recession cultivation (gerouf). The farmers have to cope with scarcity of land and the seasonal flow regime changes of the Nile. The agricultural cycle involves two irrigation seasons and the gerouf season. Irrigation crop intensity is 120%, the major part attributable to the winter season (November to March).

Farmers usually have certified rights to their irrigated land. This is recorded in land register documents which certify land location and size for an owner who may be an individual or the head of an extended family consisting of several individuals. In the latter case, the individual shares are certified in girats (1/24th of the total size). In cases where land has not been registered, ownership is determined by a combination of Sudanese legislation and customary law. Land is divided among heirs according to the Islamic laws of inheritance. When a plot reaches the minimum productive size, i.e. 1 girat, its owners divide its produce rather than the plot itself. Sale of land rarely exists.

The winter season (November-March) is the main irrigation season for major subsistence and commercial crops, which include wheat, vegetables, legumes and spices. The success of the winter grown crop depends on the length and coolness of the season – high temperatures at the end of the growing season can negatively affect productivity. The summer season (April - July) is characterised by high temperatures that suit only a limited number of crops, i.e. cropping intensity is very low compared to winter. Sorghum and maize are the main crops grown. The flood (damira) season extends from August to October. This is the time when gerouf are cultivated. The main crops grown are fodder crops.

4.9.2 Date Palms

Dates are the main cash crop. They are the most cherished possession, an invaluable item of livelihood security, a basic source of cash and an essential symbol of wealth. A date palm may live 75 -100 years. For elderly people the ownership of date palms is considered as insurance for the days when they retire from seasonal farming. Other fruits produced include citrus, mangos, guava and bananas.

On average a family owns 30 date palms. Ownership of palms does not necessarily correspond with ownership of land. The harvest is distributed according to customary law with 1/3 each for the landowner, the owner of the irrigation pump and the cultivator. Annual production of one date palm tree is 30 - 40 kg. When trees are inherited they may remain commonly owned by the heirs who distribute the harvest among themselves.

4.9.3 Livestock

Animal husbandry plays an important role in the local economy. Donkeys are an important means of transport. Sheep and goats supply milk and meat and provide a vital source of household cash income. Animal droppings are widely used as manure. As there are no rangelands in the area, animals are fed with cultivated fodder and crop residues.

4.9.4 Off-Farm Income Generating Activities

Off-farm income generating activities include rope making, pottery, petty trading, shop keeping, construction, woodworking and handicraft. Lorry owners often work as traders. Small shops are found in every village. Teachers, health workers and other government officials usually have a second source of income, such as from farming or petty trading, since their salaries are undermined by the chronic high inflation rates and their payment is often delayed up to a few months.

4.9.5 Household Income

Household income is mainly based on commercial crop production and animal husbandry. Due to the prevailing economic conditions the farmers tend to diversify their income sources by combining subsistence and commercial crop production, animal husbandry, and off-farm income generating activities. For each household the top priority is to produce enough staple food needed for one year. The cash obtained from the sale of commercial crops and livestock covers any deficit in the staple grain produced. Remittances from emigrants play an important role in augmenting the cash needs of the household.

4.10 PUBLIC HEALTH IN DAL PROJECT AREA

The area proposed for the establishment of the Dal project is endemic with the main waterborne diseases of the country i.e. schistosomiasis (bilharzia) and malaria, together with other diseases which have exerted a heavy toll on the health of the human population. Trachoma, non-blinding onchocerciasis, filariasis, dermal leishmaniasis, and other viral infections (e.g. Rift Valley, dengue fever) have been documented to occur.

The nuisance caused by Chironomidae midges swarms (*Nimiti)*, Culex spp. mosquitoes and house flies is extensive.

The health service infrastructure across the project area consists of two hospitals at Delgo and Abri. There are also some dispensaries and dressing stations in some villages. Health facilities, although adequate by Sudanese standards, are extremely poor in terms of effective service provision by minimum international standards recommended by WHO. All medical institutions are poorly equipped in terms of medical equipment as well as medicines. Most of the rural population cannot afford paying for medical treatment or medicines and resort to medicinal plants and traditional healers. Buildings of medical services seldom receive maintenance are in poor condition particularly in rural areas.

Sanitation is not a very serious problem due to access to relatively adequate and safe water supply, hygienic conditions at available sources and use of latrine services at households, public places or schools. The situation is consequently not conducive to the spread of endemic diseases (e.g. diarrhoea). Epidemic diseases (e.g. eye and skin infections) are not very common. However, malaria is a major health problem that attacks 30% of the population and is responsible for 5% of the total mortality rates.

Education and health indicators are generally better than in other peripheral regions of Sudan. The basic health infrastructure is generally good and, like education, statistical health indicators look much better than other peripheral parts of Sudan in terms of population ratios to institutions. However, it may be noted that:

- The statistics might conceal the issue of accessibility as the longitudinal expansion of the northern region along the Nile and poor transport make access to institutions very difficult for the rural population.

- The local population, with the help of expatriates from the region, has built many of these institutions. Local authorities estimate that 65% of service institutions in the state, including education, have been funded through self-help schemes.

- Most of the health institutions, especially in rural areas, suffer the problems of scarcity of drugs and shortages of essential equipment as well as the shortage of specialized personnel. While in terms of facilities, the population ratios are much lower in the state compared to Khartoum, for example, when it comes to specialists and service providers, the picture is reversed.

Public health data are not published for the Wadi Halfa locality or Dal area specifically. Tables 4.20, 4.21 and 4.22 provide summary statistics for Northern State.

Table 4.20 : Demographic and Health Indicators - Northern State

Indicator	No / %	Indicator	No / %
Total population	603,000	Mothers Mortality per 100,000	300
Urban population	15.40	Infant mortality per 1000	56
Nomadic population	1.74	*Infant mortality per 1000 - Female	90
Population Under 15 years	39.50	*Infant mortality per 1000 - Male	108
Population 15-59	54.60	Under 5 Mortality per 1000	78
Population 60 years & over	5.90	*Life expectancy at birth	56.7
Population growth rate	1.75	*Male life expectancy at birth	54.7
Male/Female Ratio	95.2	*Female life expectancy at birth	58.7
Fertility Rate	4.8	Population over 60 years	5.9%
Crude birth rate (1998-2003)	3.4	**Population per hospital bed	275

Sources: Taha (2004), * States Encyclopaedia 2000, ** State Min. of Health, Dongola, 2005

Table 4.21 : Health Institutions - Northern State (2005)

Facility	Hospitals	Rural hospital	Health Centre	PHCU	Dressing station
Number	25	19	65	16	16

Source: State Min. of Health, Dongola, 2005

Table 4.22 : Health Facilities in Northern and Khartoum States (2000)

Health Facility	Population per each health facility		
	Northern State	**Khartoum State**	**Northern compared to Khartoum**
Health Care unit	31,904	66,738	Better
Health centre	56,718	44,968	Worse
Hospital	20,419	172,623	Better
Specialized doctor	36,467	15,377	Worse
Physician	16,467	7,453	Worse
Dentist	102,093	41,164	Worse
Medical Assistant	4,442	3,364	Worse
Nurse	19,633	1,357	Worse
Midwife	2,331	4,155	Worse

Source: Adapted from States Encyclopaedia, 2000

Egypt Sudan Health Cooperation Agreement

In 1970, after the construction of High Aswan Dam, a health agreement was signed between Egypt and Sudan aimed at making the area between the two countries free from both malaria vectors and parasites. Since then, two joint expeditions have carried annual inspections covering an area of 850 km alongside the Lakes Nasser/Nubia (350 km in Egypt and 500 km in Sudan) for both vectors of transmission: Anopheles gambiae and Plasmodium falciparum. Insecticides were sprayed where larval and adult mosquitoes were found and anti-malarial treatment was administered to people found positive.

4.11 EDUCATION AND LITERACY

School enrolment and literacy data are not published for the Wadi Halfa locality or Dal area specifically. Tables 4.23 and 4.24 provide summary statistics for Northern State.

Table 4.23 : Northern State – Enrolments in Pre-, Basic and Secondary Schools (2000)

State	Enrolment Rates %				
	Pre-schools	Basic Schools			Secondary*
		M	F	Both	
Northern	36.9	89.1	69.9	79.4	10.4
Khartoum	12.6	43.1	48.4	45.7	13.0
Sudan	9.2	42.9	37.8	40.4	Not available

* Note: females constitute 44% of secondary schools students

Source: SMOE, Khartoum, 2000.

Table 4.24 : Northern State – Literacy

Literacy and Primary School Enrolment Rates	
Literacy >15yrs % Average	65.2(54.5)
Literacy >15yrs % Male	75.0(66.6)
Literacy > 15yrs % Female	56.6(42.4)
Population 6-13yrs	114,040
Total primary school enrolment	100,336
% enrolment	88.0(51.0)

4.12 WATER SUPPLY AND SANITATION

Information on access to water and sanitation facilities are not published for the Wadi Halfa locality or Dal area specifically. Table 4.25 provides summary statistics for Northern State.

Table 4.25 : Northern State – access to water and sanitation facilities

Drinking Water by Source	Access % of population
Piped into dwelling	50.8
Public tap	4.3
Deep well/pump	15.8
Dug well/bucket	9.8
River/canal	12.8
Others	6.5
Sanitation Facility by Type	**Access % of population**
Flush to sewage system	0.0
Flush to septic tank	7.7
Traditional pit latrine	69.2
Soak away pit	1.6
Others	1.6
No facility	19.9

4.13 ARCHAEOLOGY AND CULTURAL PROPERTY

4.13.1 Rich Cultural Heritage

The Dal area is very rich in physical cultural resources. Many sites have been identified; a few of these have been studied in detail but many have not and await resources to conduct detailed studies. Many more sites may be expected to be found and require detailed study.

The Honorary Secretary of the Sudan Archaeological Research Society (SARS) has prepared a summary of the archaeology and heritage of the region, illustrated with photographs and two maps, for this report. His summary account is in the Annex following this section.

Archaeological surveys and research have revealed the existence of human settlements in the Dal area for 200,000 years. This itself testifies to the immense value of the Nile valley's fertility in an otherwise climatically hostile environment.

It is notable that the riverbanks and islands through the Dal reservoir area exhibit a complete sequence of occupation as follows:

- Palaeolithic and Neolithic (200,000 – 3500 BC) - Sai
- Kerma period (c. 2500 – 1500 BC) - Sai
- Pharaonic (c. 1550 – 1070 BC) – Amara West, Sai, Sedeinga, Jebel Dosha, Soleb, Sesebi
- Kushite (c. 950 BC – AD 350) – Sai, Sedeinga, Soleb, Kedurma
- Post-Meroitic (c. AD 350 – 550) – Firka, Kosha, Sai
- Christian (c. AD 550 – 1500) – Jebel Kitfogo, Mograkka, Sai, Toshka
- Post Christian (c. 1500 – present) – Sai, Qubbat Sheik Idris

It may be noted that the monument of the Temple of Amenhotep III at Soleb is regarded as having World Heritage status.

4.13.2 Reconnaissance Survey

Literature review by the Consultant noted, *inter alia*, that an intensive archaeological survey was conducted during the 1970s between Dal village (21 02 N 30 35 E) and Nilwati Island, upstream of Sai Island. Along this stretch, a total of 544 sites were identified on both banks of the Nile (Vila, 1978).

A reconnaissance of both banks of the river was carried out between 3rd and 9th April 2007. Observations were made while travelling by car, thus only some monument sites and sites with highly visible surface remains could be identified, close to the track followed while travelling. An inventory of these sites is provided in Table 4.26. It may be noted that positions and elevations were given by a GPS instrument and are not considered precise. However, the Temple at Soleb at 192 masl appears to be firmly within the proposed inundation area.

Table 4.26 : Small Sample of Archaeological Sites in the Project Area

Location Moving from Dal dam site in upstream direction	Description
20 49 15 N – 30 28 27 E. 195 masl	Extensive mounds and plain with thick scatter of Christian pottery sherds. The site is apparently undisturbed
Soleb Temple. 20 26 17 N – 192 masl	Well-known New Kingdom temple.
Close to Koya village. 20 20 29 N – 30 24 20 E.	Mounds and plain with heavy scatter of sherds. ?Christian.
Tenneri. 20 21 00 n – 30 28 20 E. 204 masl	Mud-brick structure, possibly church
Tenneri. 20 21 14 N – 30 29 00 E. 217 masl	Mud-brick fortress. Abundant scatter of painted and plain Christian pottery.
South of Gargud village. 20 10 59 N – 30 32 40 E. 204 masl	Mud-brick and granite stone fortress. Painted Christian sherds were observed inside structure
North of Hendeka. 20 09 44 N – 30 32 57 E. 205 masl.	Kurfa or fortified house. Possibly Islamic. Modern metal door on east side.
South of Hendeka. 20 08 10 N – 30 32 59 E. 227 masl.	Mud-brick castle.
Near Sudla. 20 07 28 N - 30 32 52 E. 229 masl.	Large castle.
South of Sudla. 20 06 10 N – 30 32 40 E. 215 masl.	Mud-brick castle or fortified house. Possibly Late Medieval.
20 00 43 N – 30 34 09. 212 masl.	Stone structure seen at a distance.

4.14 EXISTING INSTITUTIONAL CAPACITY

In 2003, the administrative federal states in Sudan were divided into localities (Mahaliat), which in turn were divided into administrative units and then to small councils at village levels. The Governor (Wali) is overall head of the state, while the Mayor (Muatamed) is the head of the locality (the former province) with wide administrative and legal powers, and then the Executive Director is responsible for the administrative unit. The official administrative institutions (state and localities), which are run by elected and appointed members, are responsible for economic, security, social and political affairs. The Northern State consists of four localities, namely, Wadi Halfa, Dongola, Ed Dabba, and Merowe. Wadi Halfa locality, where the proposed Dal dam is located, is divided into four administrative units, namely Wadi Halfa, Ferka, Abri and Delgo.

The state ministries relevant to a hydropower project are the Ministry of Agriculture, Animal Resources and Irrigation, the Ministry of Engineering Affairs and Public Utilities, and the Ministry of Health. However, the representation of these ministries at the locality and administrative levels is very weak, if it exists at all.

Parallel to the official administration, the traditional (native) administration, which was created during colonial times, is very effective among rural communities to deal with local affairs and in conflict resolution. It is known by various hierarchical titles (Nazir, Amir, Omda, Mek, and Sheikh) and it is regarded as a system operating with a certain socio-cultural nature. For example, there are 26 sheikhships in Abri Administrative Unit. The Sheikh is granted some legal authority to maintain law and order and to collect taxes; he is used also for political mobilization.

There are no modern civil society organisations (CSOs) currently in the project area. Private sector roles in providing services are not significant (health and water supply in limited situations). Federal, state and locality level technical and political units represent other stakeholders. Some political parties are represented at locality and state level political structures. In some places, previous informal experience of voluntary work exists and there is interest among communities to re-establish those CSOs. However, most of the newly established CSOs are a reaction to the proposed hydropower projects in the area, at Kajbar and Dal.

It is very clear that there is a lack of technical capacity below the state level (i.e. at the locality and administrative unit levels) to provide services or to monitor environmental management plans. In fact, such capacity is lacking even at the Khartoum level. Even the HCENR lacks such capacity.

A major program of capacity building for Wadi Halfa locality and its administrative units will be required to support implementation of the Dal project and its resettlement and development program.

4.15 PUBLIC PERCEPTIONS OF THE DAL PROJECT

Consultations with a variety of stakeholders (Appendix 4.1) showed a range of public perceptions about the Dal project. Local people in Kajbar and Dal areas are totally against both dams, recalling the fate of their own Wadi Halfa people (53,274) who were displaced by High Aswan Dam nearly 50 years ago. They expressed lack of trust in the authorities, as they are well aware of continuing grievances concerning Merowe. While most are totally against Dal dam, others are worried about not getting fair compensation. Some say they might accept Dal dam if compensation is houses in Garden City - one of the most expensive and exclusive housing areas in Khartoum along the Blue Nile.

As stated earlier, most of the newly established civil society organisations (CSOs) are a reaction to the proposed hydropower projects at Dal and Kajbar.

Positive perceptions come from some government officials, both Nubian and non-Nubian. These groups refer to the positive impacts expected in terms of electricity generation and distribution.

Annex : Dal Cataract Dam, Impact on the Archaeology and Heritage of the Region

(Five page annex follows here)

Dal Cataract Dam

Impact on the archaeology and heritage of the region

Major sites which would be totally destroyed (see Figure 1)

Palaeolithic and Neolithic (200,000 – 3500 BC)

Sai - very important remains of some of the earliest evidence for human activity in the Middle Nile Valley dating to around 200,000 years ago

Kerma period (*c.* 2500-1500 BC)

Sai – very large Kerma cemetery, some massive well-preserved tumuli

Pharaonic (*c.* 1550-1070 BC)

Amara West, large, extremely well preserved town dating from the early 13th century BC, abandoned *c*. 1070 BC

Sai – large town founded about 1550BC with associated cemetery

Sedeinga, ruined Temple of Queen Tiye, one column still upright

Jebel Dosha – rock-cut shrine and many fine inscriptions

Soleb. Temple of Amenhotep III.

Soleb. Temple of Amenhotep III. Columns in the forecourt.

Soleb, very well preserved temple, the finest ancient Egyptian monument surviving in Sudan. Contemporary cemetery close by. This monument is of World Heritage status; to allow its flooding would seem unimaginable. If the dam were to go ahead a strong case could be made for dismantling the temple and removing it to a new site.

Sesebi, large town founded by Akhenaten, associated cemetery

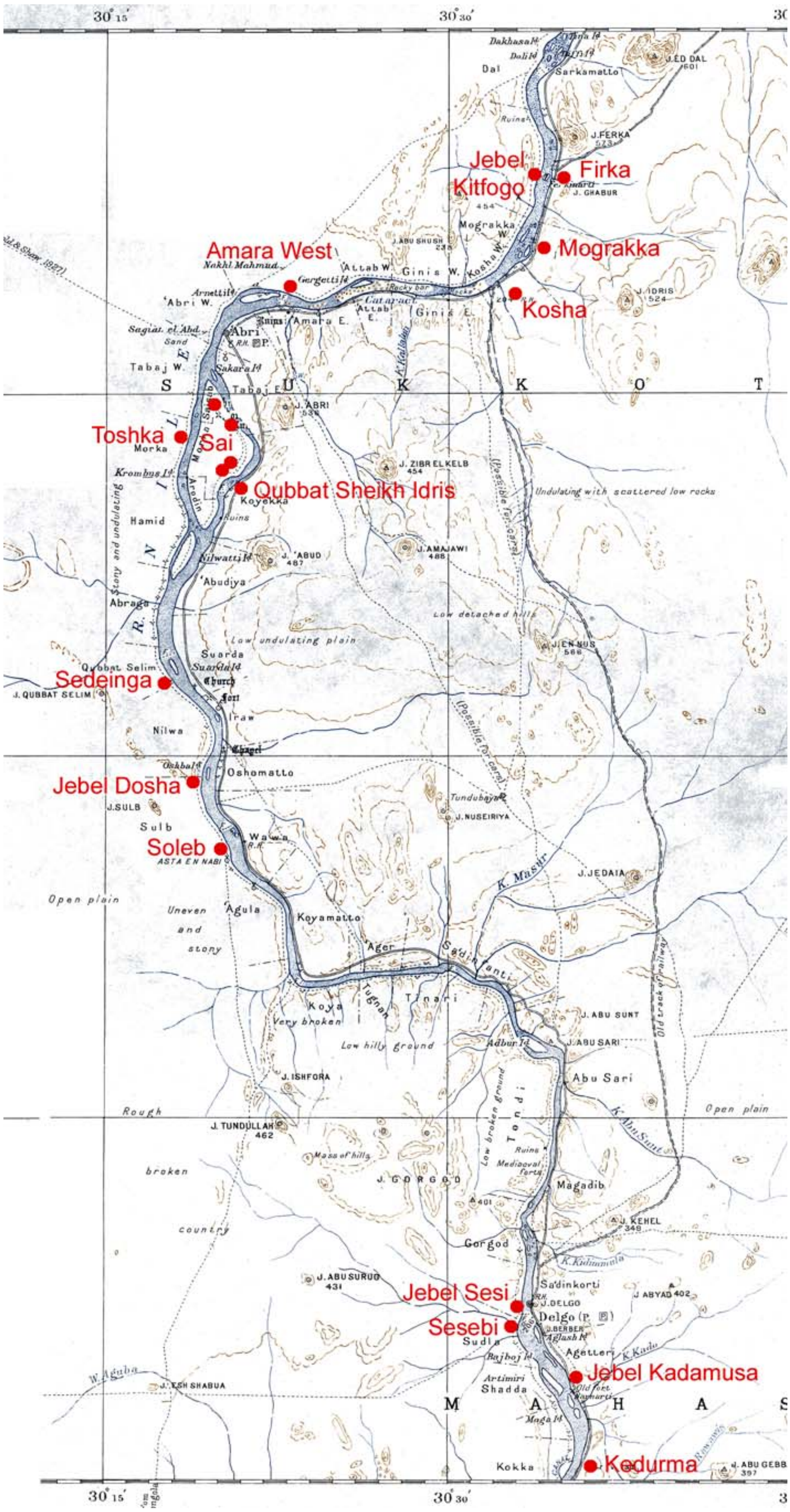


Figure 1. Map of the area to be inundated by the proposed dam at Dal. Major archaeologocal sites marked. Scale 1:500,000.

Sesebi. The main temple within the town founded by Akhenaten in the 14th century BC.

Kushite (*c.* 950 BC – AD 350)

Sai – extensive cemetery, large town

Sedeinga – extensive cemetery

Soleb – extensive cemetery

Kedurma – small settlement

Sedeinga. Pyramids in the Kushite cemetery

Post-Meroitic (*c.* AD 350-550)

Firka – massive tumuli, burials of regional elite group.

Kosha – massive tumuli

Sai – extensive cemetery, large town

Christian (*c.* AD 550-1500)

Jebel Kitfogo – granite quarry

Mograkka – well-preserved mud-brick church

Sai – granite columns of a large cathedral, extensive cemeteries, large town

Toshka – settlement with two(?) well-preserved churches

Sai. The granite columns and capitals of the cathedral.

Post Christian (*c.* 1500-present)

Sai – Ottoman fortress, the southernmost on the Nile

Qubbat Sheikh Idris – large polygonal *qubba*

In addition the lower-lying parts of the large fortified settlements at **Jebel Sesi** and **Jebel Kadamusa** may be affected by the reservoir.

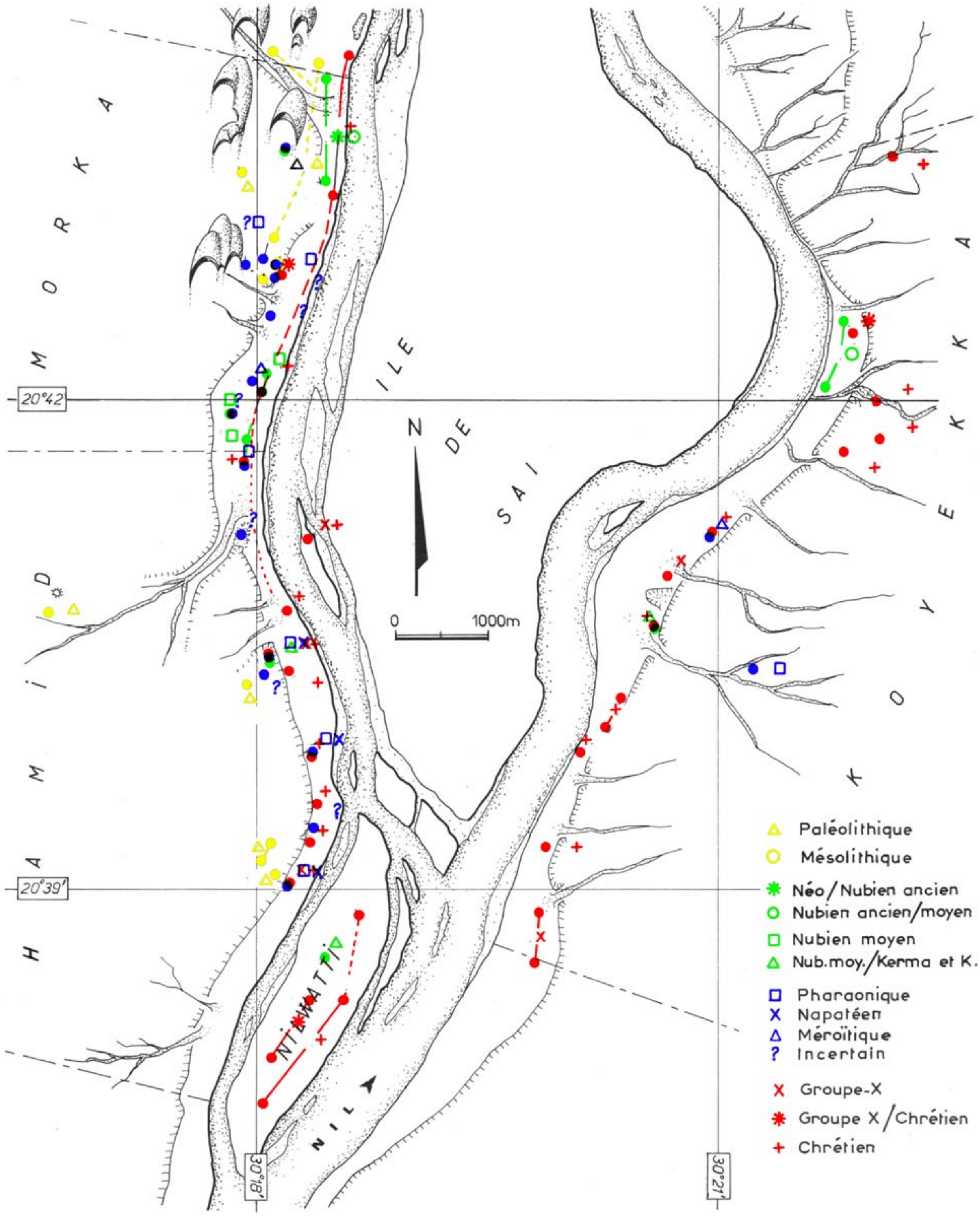


Figure 2. Detailed map of the Nile at Sai Island. Sites of all periods recorded by the survey conducted by Vila marked (after Vila, A. 1978. *La prospection archéologique de la vallée du nil au sud de la cataracte de dal 10. Le district de Koyekka (rive droite). Les districts de Morka et de Hamid (rive gauche). L'ile de Nilwatti*. Paris). Note that no sites on Sai were surveyed.

To these must be added innumerable smaller archaeological sites, the data from which have an important contribution to make to our understanding of the human settlement in the region over the last 200,000 years. Figure 2 illustrates the richness of the area archaeologically, A similar concentration of sites was found by Vila over the whole area surveyed from Dal to a little upstream of Sai and can be expected over the rest of the area to be inundated by the dam.

Sai. The Ottoman fortress built on the remains of the Pharaonic, Kushite, post-Meroitic and Christian town.

The proposed reservoir, at 160km in length along the Nile, is directly comparable in size to that which will be impounded by the Merowe Dam currently under construction. Many archaeological missions are working in that area undertaking survey and excavations. To date several thousands of sites have been located although many others will disappear beneath the water before they are even found.

Qubbat Sheikh Idris.

The financial cost of mounting these expeditions is immense. As an example, the Sudan Archaeological Research Society in conjunction with the British Museum has spent over a quarter of a million pounds sterling on the fieldwork to date and vastly more work still remains. The estimate for the post-excavation project, an essential prerequisite before publication of the results, is somewhere in the order of £300,000. This expenditure was incurred only within the 40km concession granted to SARS on the left bank of the river and on the adjacent islands, the total cost of the rescue project is much greater. A similar major rescue project, with similar levels of funding, would be essential in advance of the construction of a dam at Dal. A total duration of the project of not less than 10 years should be allowed.

Complied by Derek A. Welsby PhD, FSA 18th July 2007

Assistant Keeper, Department of Ancient Egypt and Sudan
Honorary Secretary, Sudan Archaeological Research Society
President, International Society for Nubian Studies

5. EXISTING ENVIRONMENTAL CONDITIONS DOWNSTREAM OF DAL PROJECT

5.1 INTRODUCTION

This chapter describes existing environmental conditions downstream of Dal dam site, along the Main Nile in Sudan and Egypt. For fuller accounts of biophysical and social conditions of the Main Nile in Sudan and Egypt, readers are referred to the principal sources of the text - reports entitled: "Cooperative Regional Assessment (CRA) for Watershed Management – Transboundary Analysis, Country Report, Sudan and Egypt", produced for the Nile Basin Initiative/ENTRO for its Eastern Nile Watershed Management Project (Hydrosult *et al*, September 2006).

The Dal dam site lies some 120 km upstream of Wadi Halfa on the eastern shore of Lake Nubia. The region downstream of the Dal project within Egypt comprises Lake Nasser, retained by the High Aswan Dam, and the Nile river downstream of Aswan.

5.2 EXISTING ENVIRONMENTAL CONDITIONS WITHIN SUDAN

Conditions downstream of the Dal project are broadly similar to the area immediately upstream as already described in Chapter 4. The region comprises desert with a riverine strip of vegetation along the Nile (Plate 5.1) and isolated settlements. The principal settlement is Akasha (Plate 5.2) some 15 km downstream of the Dal site.

Plate 5.1 : Nile River at Akasha

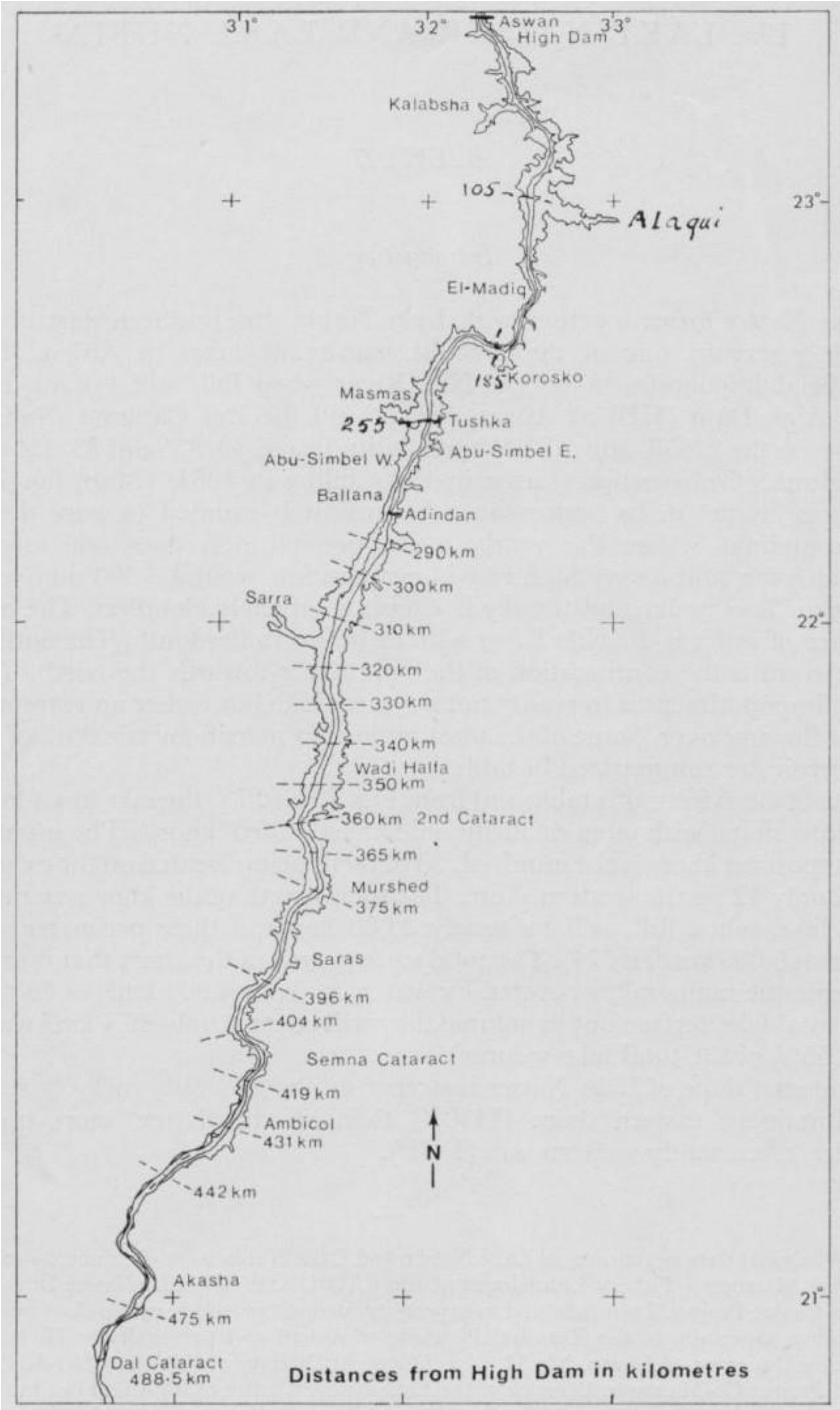
Plate 5.2 : Akasha Town

Most of the length of the Nile's river channel downstream of Dal cataract is below the Full Supply Level of High Aswan Dam. On one or more rare occasions in the history of High Aswan Dam when Lakes Nasser/Nubia were at a very high level (eg. 1998, 1999), the Nile river reach below Dal cataract to Akasha, and further north, has been in the backwater effects of Lake Nubia. On these rare occasions, sediment is deposited in these upper reaches.

But most of the time, year after year, Lake Nubia levels operate at lower levels and the Nile river discharges through the upper reaches and past Akasha as a normal flowing river.

Wadi Halfa, headquarters of the Wadi Halfa locality which comprises the administrative units of Wadi Halfa, Ferka, Abri and Delgo, is an important town and route centre for road, railway and lake navigation. The town has important lake fisheries development facilities that may provide insights into fisheries developments at Merowe and Dal reservoirs.

Surveyed distances between Dal Cataract, various villages, cataracts, Wadi Halfa and High Aswan Dam are shown in Figure 5.1 and Table 5.1.



Source: Entz, 1976. Note: this figure shows one contour only at 160 masl.

Figure 5.1 : River Distances (along the former Nile channel) in Lakes Nasser/Nubia

Table 5.1: River distances (along the former Nile channel) in Lakes Nasser/Nubia

Location	Lake	River distance from High Aswan Dam km	River distance from Dal Cataract to High Aswan Dam km
At High Aswan Dam	Nasser	0	488.5
Near Wadi Halfa	Nasser/Nubia	350	138.5
2^{nd} cataract	Nubia	360	128.5
Near Murshed	Nubia	375	113.5
Near Saras	Nubia	396	92.5
Near Semna cataract	Nubia	404	84.5
Near Ambicol	Nubia	431	57.5
Near Akasha	Nubia	475	13.5
At Dal cataract	Nubia	488.5	0

Source: Entz, 1976 (Figure 5.1 above)

These river distances are believed to be the same as shown in Professor El-Moattassem's diagram of longitudinal bed profile and sediment survey results reproduced earlier from the CRA report and shown in Chapter 4 as Figure 4.12.

5.3 EXISTING ENVIRONMENTAL CONDITIONS WITHIN EGYPT

5.3.1 Relief and Drainage

Higher relief is found on the eastern side of the Lake Nasser drainage area (Figure 5.2). In the southwest, the watershed has lower relief with the Toshka Depression lying to the west. A number of wadis with catchments of considerable size are found in the east.

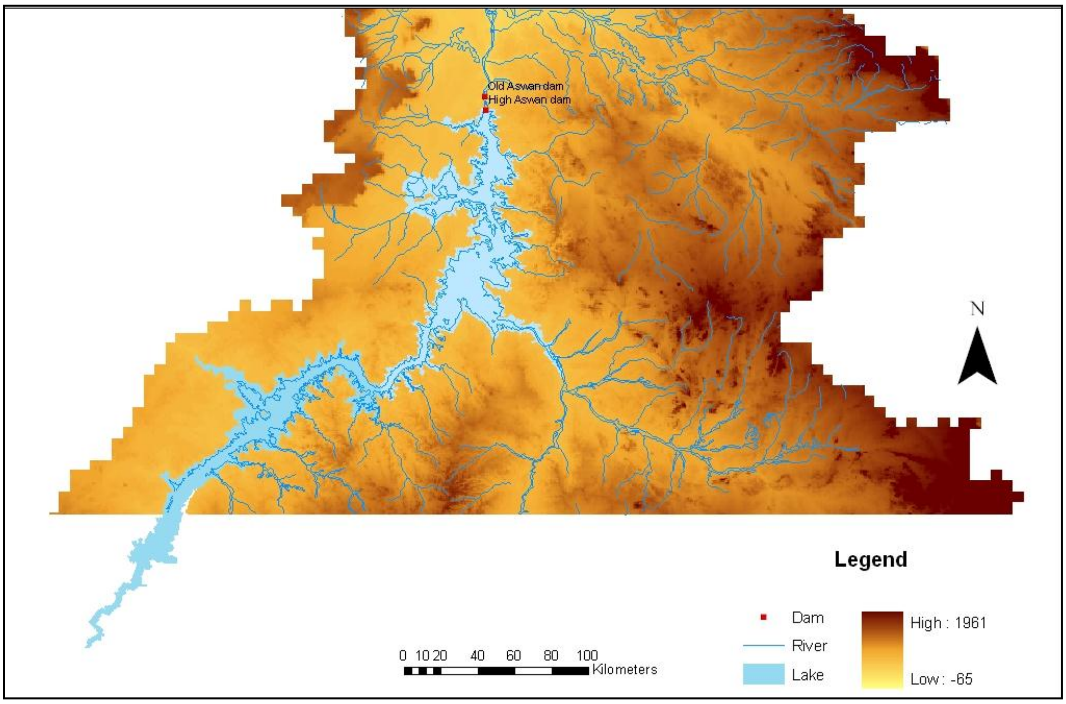


Figure 5.2 : Lake Nasser - Relief and Drainage

5.3.2 Geology and Landscape

The main underlying geological formations within the Lake Nasser basin include the older Basement Complex rocks, the Nubian Sandstones, Tertiary unconsolidated sediments and Recent superficial wind blown sands (Figure 5.3). The Basement Complex comprises gneisses, schists, marbles and intrusive granites and basic rocks. The Nubian Sandstones overly unconformably the Basement Complex rocks and comprise mainly sandstones, siltstones and conglomerates. The Recent deposits include the Nile alluvium, sand dunes and the black clays of the flood plains.

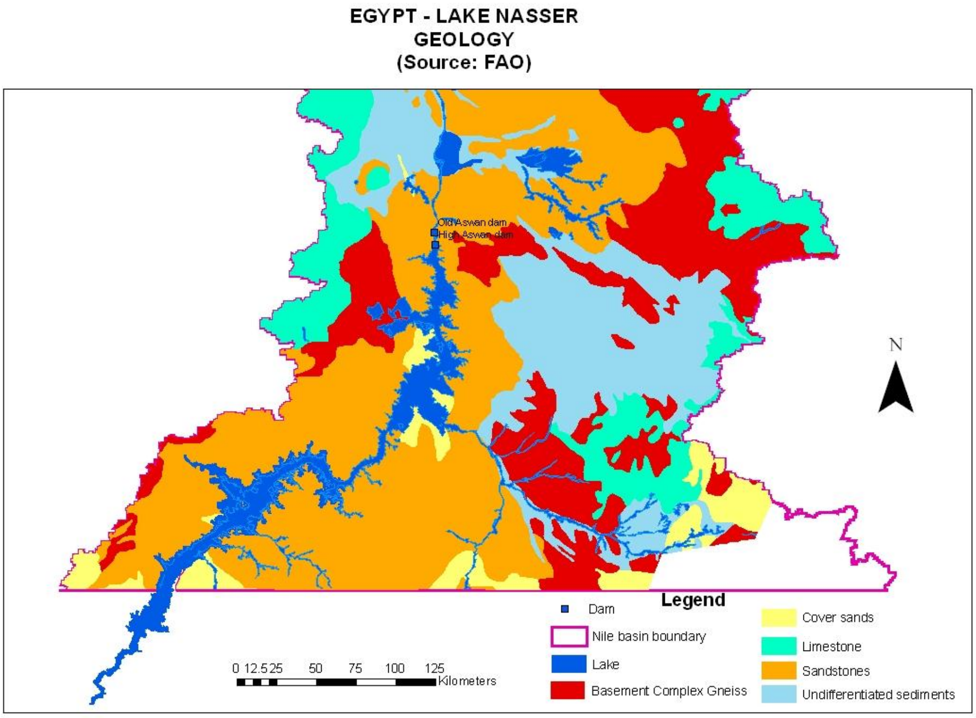


Figure 5.3 : Lake Nasser: Geology (Source: FAO/IGADD)

5.3.3 Land Cover

The landcover around Lake Nasser is mainly bare rock and sand. The distribution of the sand is an important factor in determining the potential sources of drifting sand. Generally the most extensive areas of sand are to the west with most bare rock to the east. The prevailing winds are from the northwest, adding to the problem of sand drifting into the Lake (Figure 5.4).

The resolution of the satellite imagery is not sufficient to detect the lines of Tamerix around the lake shores.

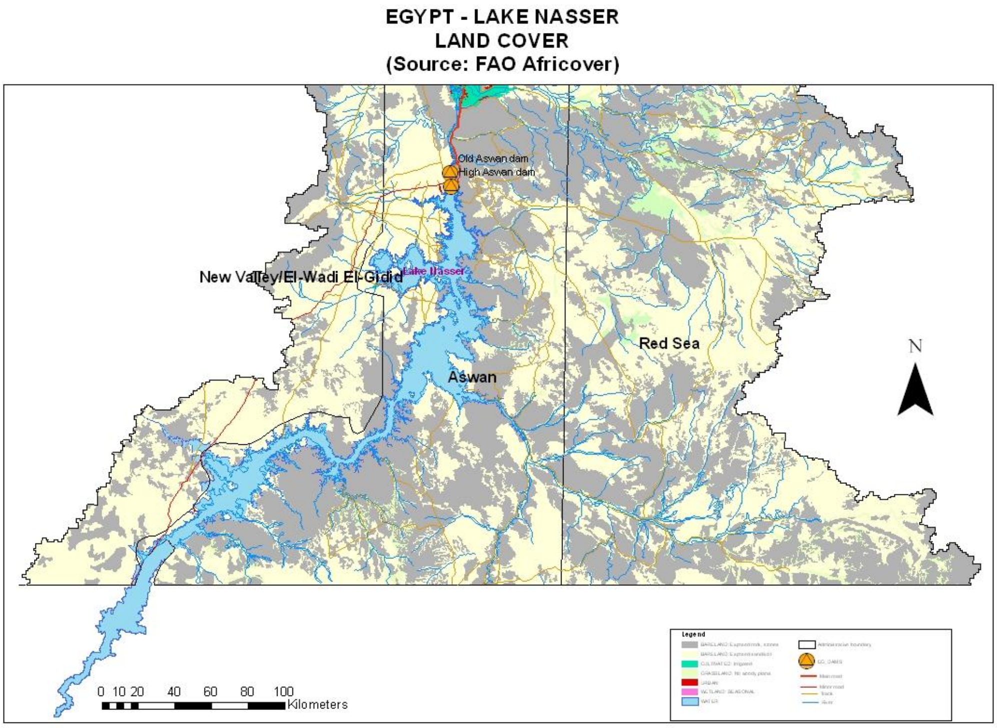


Figure 5.4 : Lake Nasser: Land Cover (Source: FAO Africover)

5.3.4 Water Resources

The main source of surface water and sediment loads is the Nile. Inflows are as described for Dongola and Dal in Chapter 4.

5.3.5 Ground Water Resources

Four categories of ground water basins have been recognized based on the geological formations:

- fractured/weathered basement complex aquifers
- Nubian sandstone basins
- Detrital Quaternary-Tertiary Basins
- Recent Alluvium Basins.

Basement complex rocks only have a limited ground water yield but are especially important in the rainfed farming areas where reliable water supplies are a major constraint to agricultural development.

The Nubian sedimentary formation forms the most extensive and largest ground water basin in Egypt. Although recharge from rainfall is very limited a substantial annual amount is received from the Nile river system. The quality is good to excellent with salinity values rarely exceeding 600mg per litre.

5.3.6 Soil Types

The dominant soil types around Lake Nasser are shown in Figure 5.5. The most extensive soils are Leptosols on rock and Arenosols derived from the cover sands. In valley bottoms Fluvisols are very important, as they comprise the main soils for irrigation along the Nile below High Aswan Dam. Locally Calcisols are found derived from crystalline limestone.

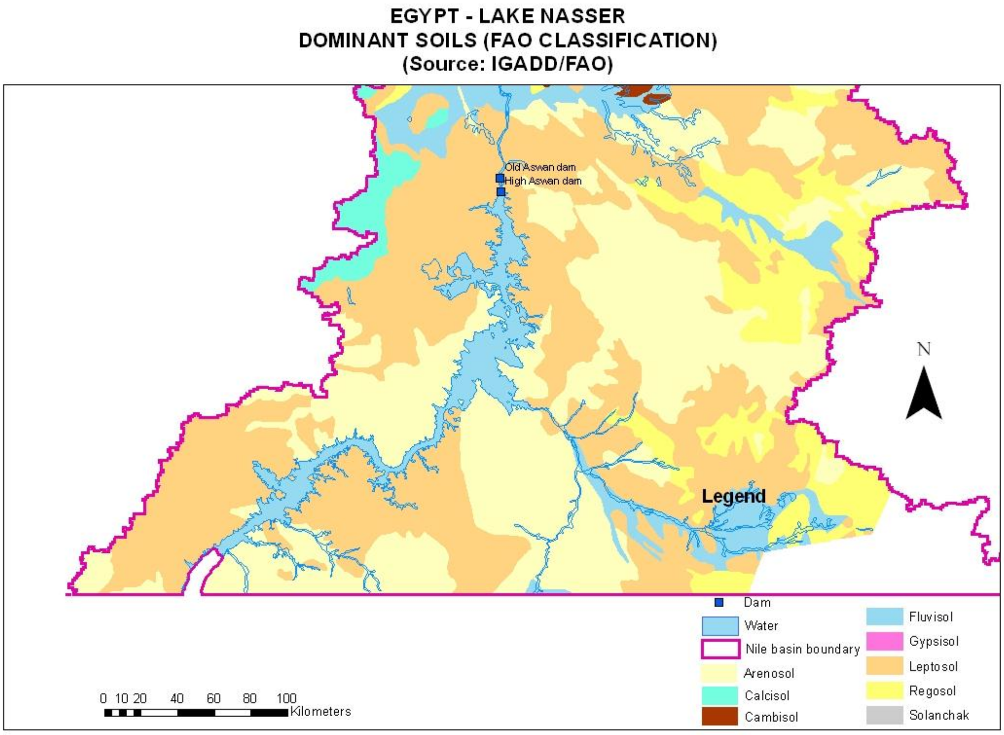


Figure 5.5 : Lake Nasser - Dominant Soil Types

5.3.7 Socio-economic Setting

Administrative Structure and Population

The Lake Nasser basin encompasses three Governorates: Aswan, New valley and Red Sea (Figure 5.6). The key Governorate for the Lake itself is Aswan with its capital in the town of Aswan. Populations are given in Table 5.2.

Table 5.2 : Total Population by Governorate (2005)

GOVERNORATE	2005 Population
Aswan	169,647
Red Sea	1,120,275
New Valley	186,375

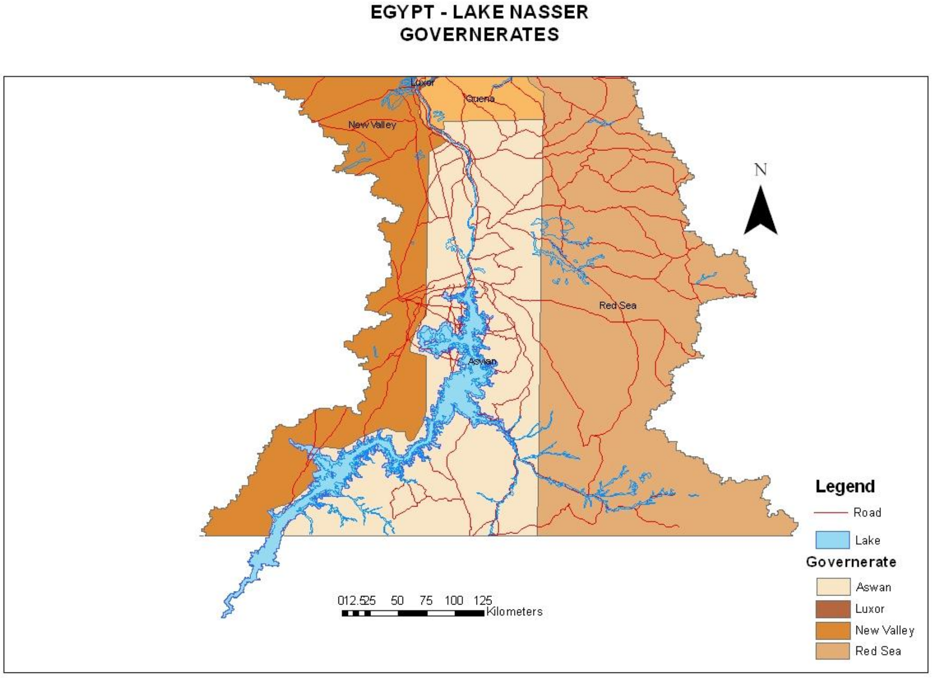


Figure 5.6 : Lake Nasser - Administrative Structure

The population in concentrated along the Nile Valley. The desert is almost totally un-inhabited (Figure 5.7).

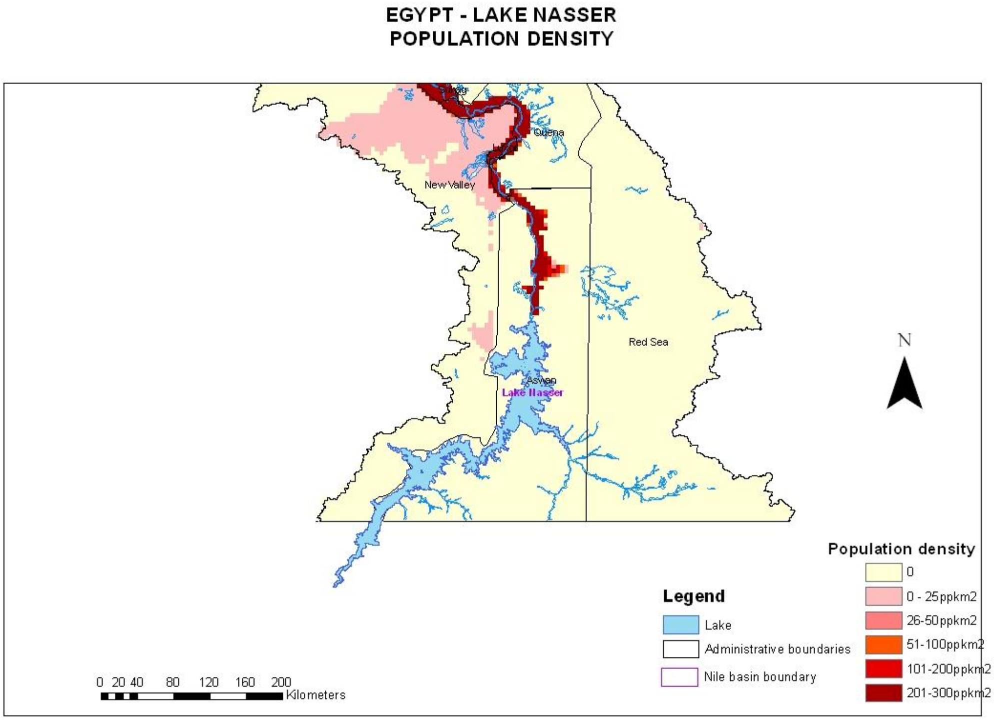


Figure 5.7 : Lake Nasser - Population density

5.4 HIGH ASWAN DAM

"Egypt is the gift of the Nile", wrote the Greek historian Herodotus in the fifth century B.C. No other country owes its very existence to a single lifeline" (El-Sayed and van Dijken, 1995). The runoff from the rainfall in East Africa caused the annual summer flood of the Nile that the Egyptians depended on for water to irrigate their crops, and deposit fertile topsoil. This annual flood was the major reason that the areas surrounding the Nile became habitable. But at the turn of the 20th century the growth of population had well exceeded agricultural production. The Nile had to be controlled if there was going to be agricultural stability along its banks.

The first of the dams was the Aswan Dam. This was completed in 1902, constructed 5 km upstream of the city of Aswan. It was the chief means of storing irrigation water for the Nile valley. The Aswan Dam's height was raised in subsequent building campaigns of 1907-12 and 1929-34. Even after these campaigns, it was necessary to open the sluices to release flood inflows. This caused tremendous amounts of damage downstream, flooding the areas that were supposedly protected. It was then decided that a second, larger and more effective dam was necessary. In the early 1950s, designs began to be drawn for what was to become the High Aswan Dam. The construction of the Aswan High Dam had many effects on Egyptian life, agriculture, and the environment (Schall, 2001).

The High Aswan Dam supported a very high population growth rate because it expanded agriculture, energy, and manufacturing production. Lake Nasser became an important fishing site, supplying food and providing livelihoods for the population around it (Dubowski, 1997). Also, the agriculture and farming industry of Egypt was also directly impacted by construction of the Dam. There were positive and negative impacts.

One of the positive impacts on agriculture was that crops could be grown year round. The High Dam created a 30% increase in the cultivable land in Egypt.

The formation of the artificial lake known as Lake Nasser/Nubia extended nearly 500 km to Dal cataract, with a width in places of 10 to 25 km. The area surrounding the lake provides another potential for land resource use. It consists of two types of deposits. The first resulted from fragmentation of limestone mixed with clay or fragments of the Nubian sandy stone. The second originated from the alluvial deposits of the ancient valleys that had been connecting eastern and western Egypt before the formation of the Nile Valley. The potentially cultivable area around the lake is almost one million feddan. Generally speaking, most of the new lands are calcareous or sandy, or both (Hanna and Osman, 1993).

Egypt’s strategy for agricultural development aims at reclaiming about 3.4 million feddan by the year 2017. The land Master Plan of Egypt indicates that there are about 2.88 million feddan reclaimable by Nile water and 0.55 million feddan reclaimable by ground water. The main reclaimable areas around Lake Nasser are located on the east bank of the lake in Wadi El-Alaki and Wadi El-Targi (Figure 5.8). Those on the west bank are found in Wadi Kurker, Kalabsha, Dekka, Marwa, Toshka, Abo-simble, Khor sara, Tomas and Affia (Desert Research Centre, 2005).

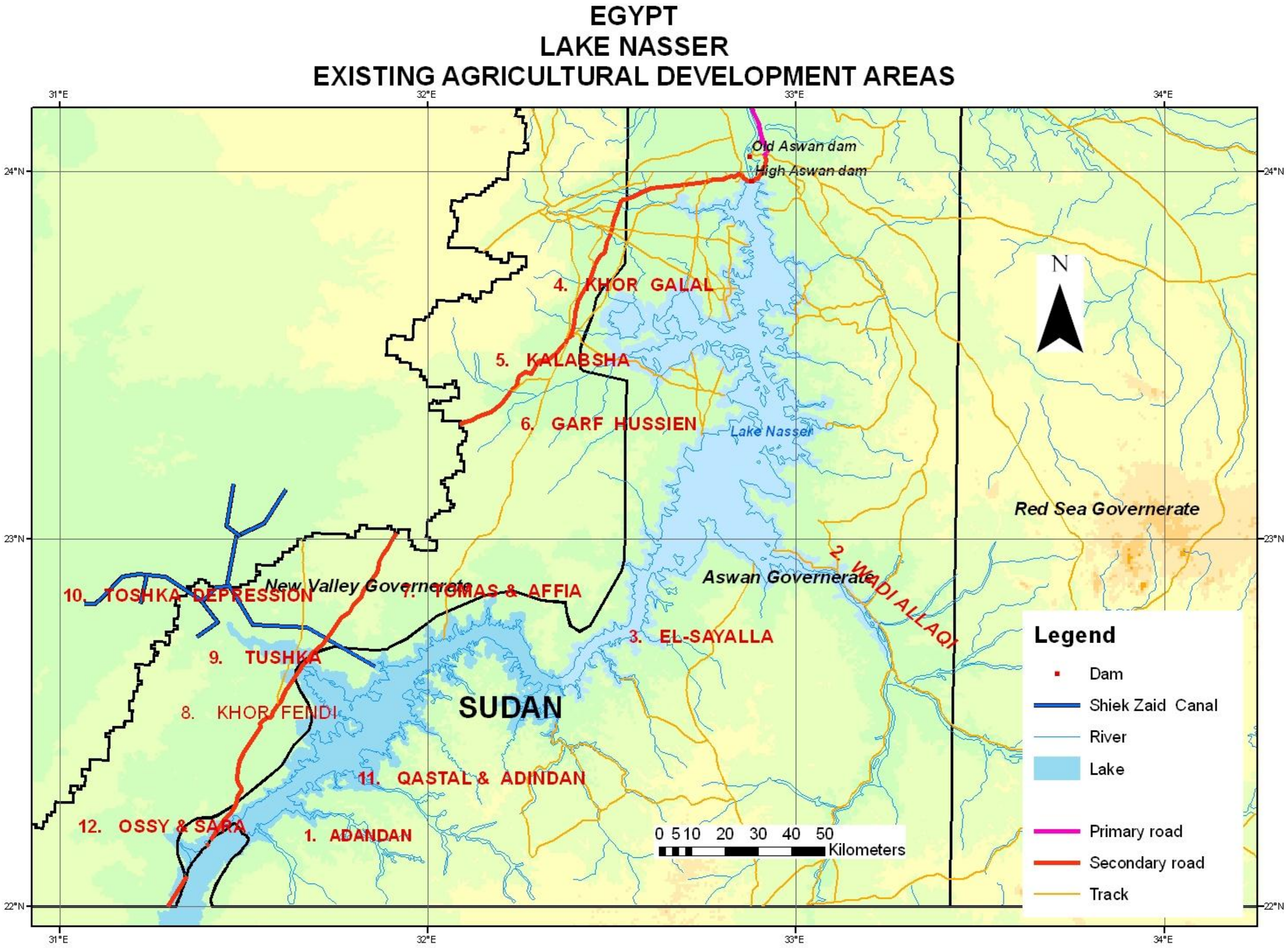


Figure 5.8 : Lake Nasser: agricultural development schemes

As part of the national strategy to combat poverty, the Government of Egypt plans to settle approximately one million people on reclaimed desert in the area around Lake Nasser by the year 2017. Despite widespread support for this goal, experience shows that new settlers are highly vulnerable to hardship and that the impact of new settlements on the environment can be adverse. Research projects aim to develop sustainable strategies for improving the socio-economic conditions, health and livelihoods of poor and marginalized settlers living in fragile ecosystems. Researchers work closely with members of the community (men and women) and decision-makers to encourage agro-ecology as an alternative farming system, increase incomes through value-added production and niche marketing, and to mitigate environmental threats to human health (El-Fattal, 2005).

5.5 LAKE NASSER AREA

Lake Nasser has a gross capacity of 168,900 million m^3. Regulated discharges from Lake Nasser have brought 324,000 ha of additional land under irrigation and have converted 283,000 ha from flood to perennial irrigation. The lake has been stocked with food fish. In the early 1980s land reclamation projects began in the desert around the lake. The northern two-thirds of the lake, lying in Egypt, is named for Gamal Abdel Nasser, president (1956-70), and the southern third, in Sudan, is called Lake Nubia. About 14 % of the water contained in Lake Nasser evaporates, reducing the amount of Nile water downstream. Before Lake Nasser was formed, the area was the site of the temples of Abu Simbel, which were built by Egyptian pharaoh Ramses II in the 1200s BC. During the construction of the Aswan High Dam in the 1960s these temples were moved, but many other historic monuments were submerged. Also submerged is a portion of the historic lands of the Nubians, who lived along the Nile between Aswan and Khartoum, Sudan, for thousands of years.

Due to the reservoir’s large storage capacity which approximates the flow of the Lower Nile over a two year period, the project’s three major goals of hydropower generation, flood management, and completing a shift from flood-based or basin to perennial irrigation have been realized. According to financial data collected by Biswas (2002), the costs of the project were paid off within two years, while Shenouda (1999) estimates that increases in agricultural productivity alone paid for the financial costs of the dam within several year period. Even if such estimates exaggerate returns, when one adds the income from agriculture, generation of hydropower and benefits of flood management, the financial success of the project is clear.

5.5.1 Historical development of area around Lake Nasser (Aswan Province)

In 1963, the Government of Egypt established the Aswan Regional Planning Authority (ARPA) to plan and implement the development of Aswan Governorate following the completion of the High Dam. A research function was added in the mid-1960s based on recommendations from the United Nations Development Program (UNDP). In collaboration with the Food and Agriculture Organization of the United Nations (FAO), UNDP was assisting several African governments to establish research organizations on new man-made lakes. In 1966, UNDP’s Governing Council approved a similar request from Egypt to establish a “Lake Nasser Development Centre” which became operational in July 1968 for a six year period.

Development-relevant research activities included agriculture, fisheries, public health, settlement planning, tourism and transportation. A final report was issued in 1975 on project findings and recommendations. Subsequently a High Dam Development Authority (HDDA) was established to develop the lake region. Planning has continued into the present century, with socio-economic plans for the Aswan area and the reservoir being prepared with UNDP assistance during the 2000-2004 period (Scudder, 2003).

Agriculture and Settlement

Under the UNDP/FAO project, a 60 feddan research station was built near Abu Simbel and several kilometres inland from the reservoir to experiment with different crops in the reservoir drawdown and inland areas. Results suggested that it might even be possible to restore the lucrative cultivation of date palms that provided the principal cash crop before the construction of the original Aswan Dam. Between 1968 and 1974 government staff using aerial photography carried out extensive soil surveys. Though requiring use of fertilizers, large areas - especially around reservoir inlets were identified with agricultural potential. These included areas requiring lift irrigation up to 30 m above full storage level. It was estimated that 10 % could be added to Egypt’s total arable land.

Below full storage level, approximately 200,000 feddan could be cultivated during the winter months in short maturing crops “using mainly subsoil moisture” though supplementary irrigation would increase reliability of yields (UNDP/FAO 1975). The most economic crops to grow without irrigation would be fodder crops and vegetables along with a wide variety of fruit trees along the reservoir margin. Further inland in the Toshka depression, 500,000 feddan were identified for pump irrigation. Granted the escalating costs of pump irrigation at higher elevations and the extensive reservoir drawdown during drought years, these figures may be significant over-estimate Nonetheless, the potential appears to be considerable. In response, a majority of Saiidi fishers from overcrowded rural communities have stated a desire to farm such lands with their families if government facilitated their settlement in viable communities in terms of housing, social services and transport.

After 1988 reservoir levels began to rise, with full storage levels again reached during the 1990s. In 1989, the World Food Program (WFP) agreed to launch a joint program with the High Dam Lake Development Authority whereby WFP would provide food for work to reclaim land along the lake shore for agriculture as well as for the eventual construction of 33,000 houses (Poeschke 1996). By the mid-1990s, 10,000 feddan had been reclaimed in three upper reservoir areas that Nubians had first attempted to pioneer in the late 1970s. Nubians, however, are only one of the people involved; others included non-Nubian fisher/farmers from Upper Egypt as well as Beja pastoralists from the eastern desert and the Red Sea coast who have begun to graze and water their stock around the edges of the reservoir. Whether or not the Nubians, as the former residents of the area, will be able to compete successfully against these other pioneers remains to be seen.

The most recent data (2006) regarding agriculture and farming around Lake Nasser show that the total agricultural area is 12,970 feddans, of which about half is cultivated and half is uncultivated. These areas are located around the lake as shown in Table 5.3 and Figure 5.8.

Table 5.3 : Zones, Group Locations and Cultivated Areas on Lake Nasser Shores

Location on Zone	Groups	Persons*	Agriculture area feddan		Total area feddan
			Cultivated	Uncultivated	
A. East	**53**	**159**	**1,073**	**900**	**1,973**
Dahmeet	1	3	40	-	40
El-Alaki	23	79	485	260	745
El-Sayalla	29	77	548	640	1,188
B. North	**166**	**471**	**3,357**	**835**	**4,192**
Khor Galal	15	54	335	37	382
Kalabsha	67	211	1,417	68	1,486
Garf Hussien	51	145	843	620	1,473
Tomas &Affia	33	70	742	110	852
C. South	**95**	**379**	**2,338**	**4,467**	**6,805**
Khor Fendi	32	134	577	1,070	1,647
Tushka	34	114	1,291	1,042	2,334
Tushka	10	43	429	2,100	2,529
Depression	19	88	41	254	295
Qastal & Adindan	-	-	-	-	-
Ossy & Sara					
Total	314	1,009	6,768	6,203	12,970

* Number of settlers

Source: CRA Report, Egypt (2007), from General Authority for Development of AHD Lake (GAD-AHD-Lake), 2006 (High Dam Development Authority), Agricultural Sector

It may be noted in the Table that the total number of farmers currently engaged in cultivation around the lake and in its annual drawdown zone is about 1,000 persons.

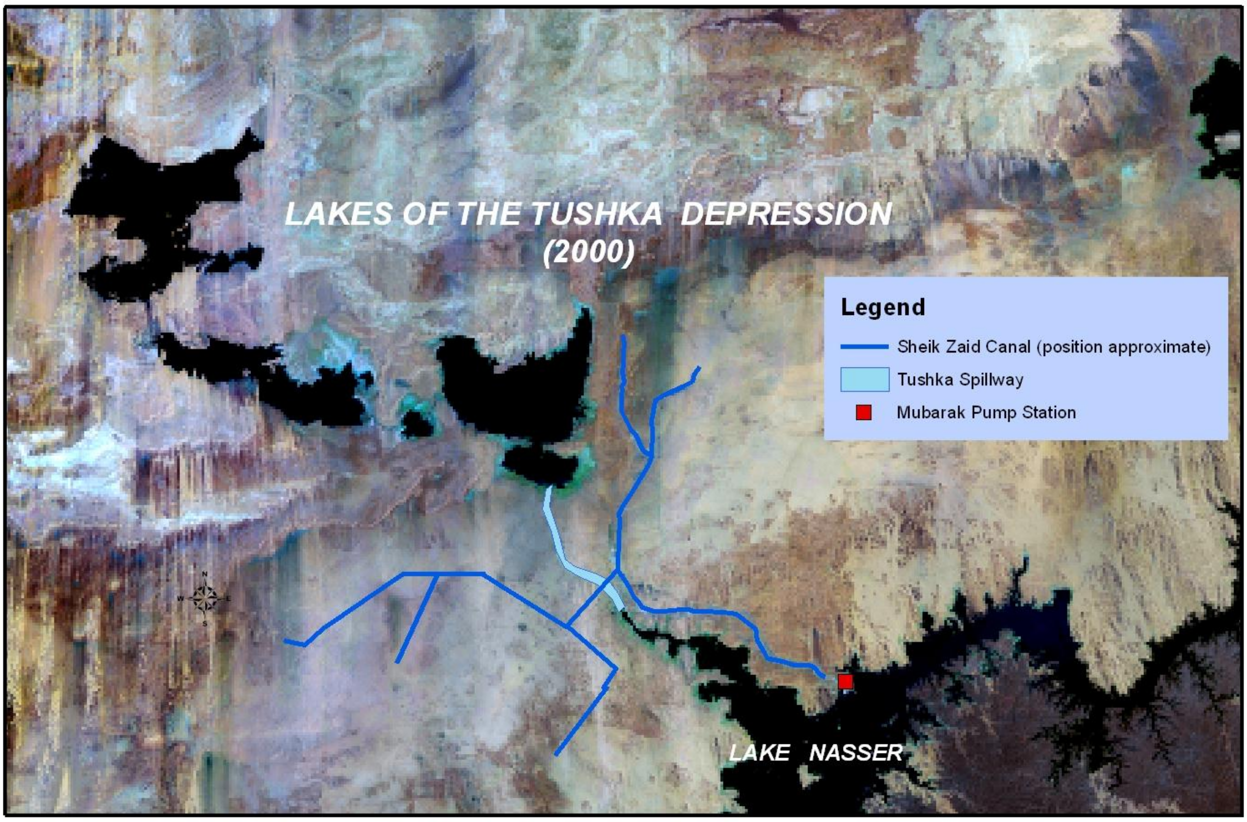
In addition, plans exist for additional large-scale irrigation and associated settlement. These relate to the Mubarak pumping station and the Sheik Zayed Canal (Figure 5.9). The Mubarak Pumping Station is constructed and equipped but not operating. The first phase of Sheikh Zayed Canal is constructed. This major project may be operating before the Dal project is constructed.

The pumping station will draw water from Lake Nasser and release it into the Sheikh Zayed Canal through a discharge basin. The 21 pumping units within the station can lift 5,000 million m^3/year. (This is equivalent to a river's mean annual flow of 159 m^3/s). These units can be increased by another three. Aswan's power station will supply the 250 megawatts of electricity required for operation.

A 50 m deep intake channel, the deepest inland channel ever constructed, will feed water to the pumping station. The differences between the elevation of the canal (201 masl) and the water levels of Lake Nasser, which vary between 147 masl and 182 masl, are 54 m and 19 m. The maximum static lift is 52.5 m.

The anticipated impact of water projects upstream causing reduction in Lake Nasser levels is that increased energy costs for pumping will be incurred, assuming the Mubarak Pumping Station / Sheikh Zayed Canal project is operational.

EGYPT
LAKE NASSER
THE TUSHKA SPILLWAY AND LAND RECLAIMATION PROJECT



Source: CRA Egypt Report, 2007

Figure 5.9 : The Tushka Depression, Spillway, Sheik Zaid Canal and Ephemeral Lakes after the 1999 Spill (Landsat TM Image 2000)

Fishing

Several hundred fishers were already fishing Lake Nubia at the time that the Development Centre was established. To reduce conflicts among them, that same year the Egyptian portion of the reservoir was divided into five sections based on fishers' areas of origin (Sorbo 1977). During the next six years numbers increased. By the end of the project fishers numbered approximately 5,000. They were Saiydis, (an upper Egyptian peasant population) from two governorates with a long history of fishing immediately north of Aswan. Though more transport boats had been added along with refrigerated railway cars to continue to Lower Egypt, the state of the fishery remained greatly undeveloped with fisher people living either in their boats or in temporary shelters in 150 fish camps. Estimated landings were 10,000 tons per annum. Potential of the inshore fishery at the then reservoir level of 160 masl was estimated at 12,000 tons, rising to 23,000 tons at full storage level.

Tourism

Adding Lake Nubia to tourist destinations around Aswan has considerable potential, especially during the winter months. Already the rebuilt Abu Simbel temple complex is a major tourist attraction by both boat and plane. In 1989, the Government began cooperating with UNESCO in making other archaeological sites available to local and international tourists. During the salvage operations of the 1960s these had been grouped in three locations, the first being close to the western end of the dam and the other two also on the west bank-approximately 100 and 200 km up the reservoir from Aswan. The first site is already accessible as the other two will be when connecting roads are built from the now tarred Aswan-Abu Simbel highway. As for the town of Abu Simbel, by the mid1990s it had a total population of approximately 5,000 people.

5.5.2 Toshka spillway

The Toshka spillway played an important part in flood control and management during 1998 and 1999 high floods (Figure 5.10). In 1998, the total discharge passed through it was 12.4 billion m^3. During the 1999 flood, it was expected to pass about 16 billion m^3.

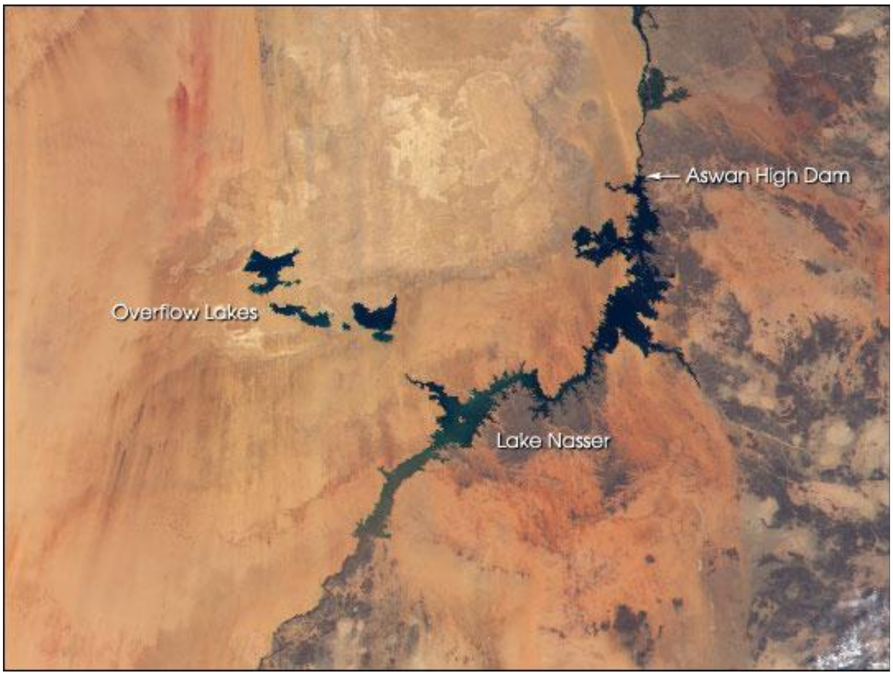


Figure 5.10 : Toshka Depression and ephemeral lakes during 1999 floods

5.6 NATURAL VEGETATION, ENVIRONMENT AND BIODIVERSITY

5.6.1 Natural Vegetation

The area around Lake Nasser is typically desert characterized by its very dry and hot climate. Temperature is very high in summer and moderately low in winter. Rainfall is very rare and erratic and absent for long periods exceeding ten years in some cases. Heavy showers causing sizeable damages are sometimes experienced. The soil is gravely sand and sandy clay at the edges of the lake.

Natural vegetation cover is almost absent because of the climatic and soil characteristics of the area except for the very narrow strip parallel to the lake banks and its extensions which narrow and widen according to the topography and the seasonal flood height.

According to a study carried out by the Public Corporation for the Development of the High Dam Lake of the Ministry of Agriculture and Land Reclamation the woody vegetation in the area is mainly desert scrub including; *Tamarix mannifera* (Tarfa or Abal) which grows very densely and to very appreciable sizes in seasonally inundated areas or in areas which are not regularly inundated to a distance of three kilometers from the lake, *Salsola javanica (G*hazal Tree), *Salsola baryosma* (Khirait), *Acacia ehrenbergiana* (Salam), *Acacia nilotica ,A.nubica, A.seyal, A.radiana, Fedherbia albida, A.laeta, A.tortlis, Silvadora persica, Leptadenia pyrotechnica, Capparis deciduas, Cadaba glandulosa , Maerua crassifolia and Balanites* aegyptiaca. From the aero plane and from the Tarfa seems to grow in a form of a belt along the lake shores.

The Food and Agriculture Organization of the United Nations (FAO) in its Global Forest Resources Assessment for the year 2000 (FAO, 2000) estimated the forest area of Egypt to be nil, or 0% in other words. FRA (2005) estimated the extent of plantation forests in Egypt to be 67,000 ha representing 0.1% of the land area with 50% of this area as protection forests and 48% has a multiple function (i.e. protection and production function). This is of course quite natural when considering the fact that the whole country lies within the Great Sahara Region in Africa.

5.6.2 Assessment of the Extent, Trends and Impact of Deforestation and Desertification

In Egypt and specifically around the High Dam Lake there is nothing like deforestation or desertification process taking place because the area is already deforested and desertified. No actual records of fuel wood are kept but the field staff estimates that it constitutes only 20% of the population's energy needs. For the remaining 80% they depend on kerosene. The concern is only about the improvement of the harsh and hard desert conditions in the area for better agricultural production, health condition of the population and protection of housing and infrastructural constructions including the High Dam and its lake.

It was reported that sand has encroached on the old farm and the Dam Authority farm in Abu Simbel area. On the Egyptian side of the lake there is no serious sand dunes movement problem but drifting sand is blown into the lake. The Dam Authority in collaboration with the Environment Research Institute is undertaking some research studies on wind speed, sand dunes movements, types and quantities of sand, estimates of sand volumes which are deposited into the lake using sand traps in 12 stations on the western side of the lake where there are active sand movements. The purpose of this research is to find the most effective ways of solving the problem.

It has been estimated that the moving sand is $700m^3$/km annually and that 125 million tons are blown into the lake annually. The impact of this is reduced storage capacity of the lake and barrages downstream.

It is well known and proved that the hot desiccating winds which are experienced in similar areas have direct negative effects on agricultural production because of their physiological and mechanical effects on the crops. Forests and agriculture are strongly inter-related for the many effects of each on the other. In fact they must be looked upon as complementing each other rather than competing on land. Many research results have shown that trees and shelter belts have positive impact on crop plants both physiologically and mechanically leading to increased crop yield. Forests also have a great role in water and soil conservation. Shelterbelts increase relative humidity and hence decrease evaporation from leaves surfaces and irrigation canals. They also reduce wind and water erosion of soil, siltation and burial of valuable agricultural land with sand as in River Nile and Northern states.

Research has shown the effective role of trees in soil fertility replenishment. Acacia trees were shown to increase levels of nitrogen, phosphorus and organic matter. Data for *Fedherbia albida* in the Sahel showed that shed leaves added the equivalent of 50 t/ha/yr of farmyard manure in stand of 50 trees/ha. This is equivalent to 75 kg nitrogen, 12 kg phosphorus, 13 kg potassium, 20 kg sulphur, 25 kg magnesium and

120 kg of calcium. It was also proved that leguminous trees could fix up to 600 kg of nitrogen/ha/yr.

5.6.3 Biodiversity and Natural Flora, Plant Cover and Genetic Resources:

The natural flora and botanic cover of the areas of and around Lake Nasser encompasses a vast range of genetic resources both natural and improved by careful man-selection. Natural genetic resources include within species genetic differences in certain characteristics (i.e. sub-species) and the germplasm of selected species of considerable economic importance. For example medicine and aromatic plants are of major importance. Lake Nasser Nubia, the AHD and the main Nile river between Khartoum and Aswan provide important habitat for aquatic flora and fauna. In the desert areas the climate is hypothermic and torrid most of the year.

The Encyclopaedia of Southern Valley and Toshka (Egypt, 1999) records about 390 plant species. They belong to different plant families as follows: 50 species belong to the legume family, 65 species of grasses, and about 275 species belongs to 55 different plant families.

It is important to conserve the Main Nile around Lake Nasser/ Lake Nubia species biodiversity. The conservation of species biodiversity is mainly dependent on the conservation and protection of habitats and the maintenance of ecosystems integrity. It is necessary to consider in-situ and ex-situ conservation. It is important to further study current ecosystems of natural resource base, use and management (formal and informal) and the role of the natural ecosystem in relation to agriculture. Pastoral systems of production should be studied in order to better manage the natural recourses in an effective sustainable way.

5.7 LIVESTOCK WEALTH:

Table 5.4 shows that the total number of livestock is about 24,500.

Table 5.4 : Livestock wealth around Lake Nasser (2006).

Type	Number	%
Sheep	15,279	62
Goats	6,146	20
Camels	2,583	11
Cow	20	
Buffalo	9	
Donkey	197	<1
Total	24,544	

Source: General Authority of High Dam Lake Development (March 2006), Agricultural Sector.

5.8 FISHERIES IN LAKE NASSER

The fisheries sector and activities in Lake Nasser is under the control of the General Authority of High Dam Development (GA-HDD). There are four major Fishermen Associations comprise about 5,000 fishermen.

Measuring 1.25 million feddan, with some 32 species of fish to its name, Lake Nasser was providing adequate supplies until the early 1980s, when production started to plummet. Over the last two decades, fishermen have proceeded with their work despite the steady decrease in the quantity of fish they produce - from 34,000 tons in 1981 to a mere 8,000 in 2000. Recorded total fish catch during 2004 was 12,434 tons, and 15,285 tons during 2005 (Table 5.5).

Table 5.5 : Lake Nasser Fish Production (Ton), 1966-2005

Year	Total	Year	Total
1966	751	1986	16,315
1967	1,415	1987	16,815
1968	2,662	1988	15,888
1969	4,670	1989	15,650
1970	5,676	1990	21,882
1971	6,819	1991	30,838
1972	8,343	1992	26,219
1973	10,587	1993	17,931
1974	12,255	1994	22,074
1975	14,635	1995	22,058
1976	15,791	1996	20,540
1977	18,471	1997	20,503
1978	22,725	1998	19,203
1979	27,021	1999	13,983
1980	30,216	2000	8281
1981	34,206	2001	12,164
1982	28,667	2002	22,093
1983	31,282	2003	17,029
1984	24,534	2004	12,434
1985	26,450	2005	15,285

Source: **GALD, Fisheries Department**.

Because of plummeting production figures, in 2000 Law 324 was issued. It re-allocated fishing space, giving the fishermen's associations only 60%, with 40% handed over to six private sector companies - a move that generated unrest among fishermen, resulting in conflict between the associations and the governorate. The companies promised to increase production to over 40,000 tons per year by fishing at lower depths and developing breeding farms, thereby exploiting the full potential of the lake (Dena Rashed, 2005).

Lake Nasser is characterized by the existence of many khors and lagoons on its banks. The number of the important khors is 85: 48 are on the east bank and 37 are on the west bank. Khors are considered suitable habitat for fish rearing due to slow water current and phytoplankton growing in them.

According to 1985 studies, there were 1,683 boats used for fishing in the lake with an average catch of about 10 tons per boat per year. Fisheries studies record 57 different fish species in Lake Nasser. The most dominant species are tilapia spp, mainly Nile Tilapia (HD Development Authority, 1981).

The fishing surface of the lake is divided into two fishing areas (zones). Fishing in shallow water khors around the shores, which represents about 20% of the lake surface (about 250,000 feddan). The formation of flood khors and lagoons on and around the lake shores provides natural habitat for Nile Tilapia breeding. Tilapia does not tend to migrate from these habitats, therefore, restocking the lake with Tilapia fingerlings is one way to increase production and to introduce aquaculture technology to the lake.

Fishing in deep water represents 80% of the lake surface (around one million feddan). Despite presence of phytoplankton in deep water, there are very few fish living in deep water. There may be need to introduce adapted deep-water fish species to develop fisheries in these areas of deep water.

A Japanese study stated that the lake potential is estimated at 80 000 tons per year. The governorate of Aswan information states that 60,000 - 70,000 tons of fish are yearly smuggled out of the lake. To reach the potential of 80,000 tons, some infrastructures are essential. These include: establishing 3 new fish hatcheries, 3 docks for boats, ice factories and fish processing and canning factory.

The GALD aims to promote fish production in Lake Nasser. During year 2005, the Authority released and restocked 17.35 million Tilapia fingerlings in the lake - from Sahra Hatchery (7.7 million), Garf Hussein Hatchery (5.65 million) and Abo-Simbel Hatchery (4.0 million).

6. CONSTRUCTION IMPACTS, IMPOUNDMENT AND MITIGATION MEASURES

This chapter considers the impacts of construction activities until the time when first filling of Dal reservoir occurs. Most project impacts are therefore already observed or occurring by the end of this period.

Section 6.1 covers the principal engineering construction impacts over a period of six years and Co_2 emissions associated with the project's construction and operation.

Section 6.2 introduces the physical aspects of river diversion and then reservoir impoundment.

Sections 6.3, 6.4 and 6.5 consider principal construction impacts on the physical, biological and socio-economic environment and mitigation measures in the Dal region respectively – the direct impact zone.

Section 6.5.25 considers construction and impoundment impacts in the downstream area in Sudan. Section 6.6 considers these downstream impacts in Egypt – the secondary impact zone.

The principal impacts and mitigation measures of the project are consolidated in a draft environmental management plan (EMP) in Chapter 9.

6.1 CONTRUCTION ACTIVITIES AND MITIGATION MEASURES DURING PROJECT CONSTRUCTION

6.1.1 Access Roads – Impacts and Mitigation

The road network and its condition are poor in the dam site project area. Most of the network is in desert without any vegetation. Some roads will be upgraded and new roads will be constructed for the project; some will be along the river's fertile alluvial banks. Alignments through any sensitive ecological habitat, productive agricultural land and in locations where there are settlements and potential natural hazards should be avoided where practicable. The major impacts and their mitigation associated with construction of roads by the contractor are summarized in Table 6.1. These generally also apply to access roads for transmission line construction.

6.1.2 Dam site and Quarries- Impacts and Mitigation

Excavated rock and dumped material may lead to unacceptable terrestrial, aquatic and socio-economic impacts if disposal is not carefully planned. Some spoil may be dumped in the reservoir inundation area where its visual and ecological impact will be later minimized. Other spoil will have to be integrated into the landscape so as to form acceptable conditions with minimum impacts.

Quarries and borrow pits may be hazardous to people and livestock. Furthermore, some may be developed in materials which may contribute to enhanced erosion of sensitive landscapes. The exact location and extent of these quarry sites will be determined during Site Investigations of the feasibility study. The project contractor should prepare detailed site environmental management and monitoring plans in accordance with conditions stipulated in the project's environmental management plan (Chapter 9). These should address all matters relevant to environmental protection and minimization of impacts due to excavations, quarry development and other activities, including those of the workforce (Table 6.1). These generally also apply to transmission line construction.

Table 6.1 : Principal Impacts and Mitigation Measures during Construction Activities

Impacts during construction by contractor's works/workforce	Proposed mitigation measures - examples
Erosion and sediment – all sites	• Preserve top soil stripped from road edges and construction sites for re-use
Spoil disposal – all sites	• Minimise numbers of spoil heaps; stabilize them; consider dumping in the reservoir inundation area where practicable
Quarry development	• Rehabilitate and landscape borrow pits and quarries; ensure safety measures are implemented and sustainable indefinitely
Water quality	• Take measures to protect wells and the Nile river from contamination from all potential polluting sources
Chemical waste/spillage	• Ensure toxic compounds are not located near rivers and water points. Provide interception and control measures for chemical wastes and potential spillage • Provide all vehicles and machinery with drip-pans for catching oil; maintain regularly
Hazardous materials	• Provide safe systems for hazardous waste disposal
Dust and emissions	• Suppress dust along project roads, especially at and near settlements • Maintain construction equipments to minimize air pollution • Check and clean injectors of diesel engines regularly
Noise and visual disturbance	• Minimize the use of explosives and utilise a systematic blasting schedule • Limit working hours in environmentally sensitive areas
Physical/cultural resources	• Report immediately to client any archaeological or historical resources (e.g. rock art, artefacts) previously not identified • Avoid settlements and agricultural areas wherever practicable – all works areas
Landscaping and vegetation	• Minimize vegetation clearing for project infrastructure works • Remove potential "eyesores" of woody material from reservoir area which would otherwise protrude after filling in vicinity of public viewing points

Impacts during construction by contractor's works/workforce	Proposed mitigation measures - examples
Vegetation clearing	• Remove woody material from reservoir area according to recommendations
Waste management	• Treat/remove/dispose waste oil, lubricants and other chemicals, and domestic waste (rubbish and sewage) to approved facilities
Coffer dam and reservoir impoundment	• Follow agreed procedures for coffer dam and first filling • Provide timely warnings to upstream and downstream vulnerable communities using agreed procedures • Liase with RAP officers
Environmental training for construction workers	• Provide training on environmental protection measures for flora and fauna
On-site traffic and access management	• Provide road warning signage (e.g. severe slopes, blind bends, speed limits) for all access roads and project works areas; reinforce these on public roads used as haulage routes for cement and other materials
Construction work camps	• Provide appropriate facilities for accommodation of workforce
Project staff health	• Provide safe water supply to workers • Establish on-site health facilities and strengthen health services of communities adjacent to dam site • Provide health education for workforce, including education on STDs and HIV/AIDS

6.1.3 CO_2 Emissions during Construction and Operation

The Dal hydropower project offers potential for generating reliable energy to support regional economic growth. In the following sections the CO_2 emissions resulting from the project's construction activities and the decomposition of biomass in the project reservoir are quantified and compared with the potential CO_2 emissions from generating the same electrical energy through burning fossil fuels. Further details are given in Appendix 6.1.

CO_2 associated with the construction of the Dal hydropower project

The energy requirement for the excavation, transport and placing of soil and rock material is covered under the diesel fuel requirements of 23,000 tons. The burning of 23,000 tons diesel fuel will result in a CO_2 emission of about 74,000 tons.

If it is assumed that the energy required to produce the cement and steel is generated by a thermal mix as described below (coal/gas = 50/50 per cent) then some 47,000 tons of coal and 31,000 tons of gas would be needed. The burning of these fossil fuels would ultimately lead to a CO_2 emission of approximately 215,000 tons.

The total emission of CO_2 associated with the construction of the Dal hydropower project will thus be approximately 290,000 tons.

CO_2 associated with decomposition of biomass in Dal reservoir

The Dal hydropower project will inundate a gross area of about 300 km^2, which, after exclusion of the existing river channel, will result in a net area of about 250 km^2 of land. The biomass is limited to the immediate area of the riverbanks as the remaining area is desert and a total biomass of about 35,000 tons (dry weight) is estimated. Decomposition of biomass in the Dal reservoir area could lead to a maximum CO_2 emission of about 52,000 tons.

Thus, the estimate of the total quantity of CO_2 released into the atmosphere during construction and operation of Dal will be some 342,000 tons.

CO_2 associated with emissions from equivalent thermal power plants

The annual average energy to be generated by the Dal hydropower project would amount to 1,944 GWh/yr. If the same quantity of energy was to be generated by a thermal mix consisting of 50 per cent coal-fired and 50 per cent gas-fired combined cycle power plants, some 1.36 million tons of CO_2 would be discharged to the atmosphere annually. It is noted that the CO_2 emission of 1.36 million tons annually is related purely to the fuel consumption (equal proportions of coal and gas) and does not include the CO_2 emission related to the construction of the thermal power plants. Over a period of 50 years, the assumed commercial life of Dal, this annual CO_2 emission would result in a total of 68 million tons of CO_2.

Consequently the generation of hydro-electric energy at Dal will result in CO_2 emissions 200 times less than if the same energy were generated by burning fossil fuels.

6.2 HYDROLOGICAL IMPACTS ON SITE DURING CONSTRUCTION

6.2.1 River Diversion

The width of the valley at river level allows development of a river diversion arrangement based on passing Nile flows through the western channel while construction of the spillway and power station structures is carried out within the eastern channel protected by temporary cofferdams. River diversion during construction is expected to take place in a number of stages (Table 6.2).

Table 6.2: Stages of River Diversion

Diversion Stage	River Diversion and Construction Works
1	Excavation to enhance capacity of western diversion channel and construction of cofferdams to protect works area in eastern channel.
2	Construct power station substructure and spillway structures in eastern channel works area. Construct rockfill embankment to form east abutment section of dam and install concrete facing.
3	Remove upstream and downstream cofferdams from eastern channel. Open spillway gates to pass river flows downstream. Continue construction of power station and installation of generating plant.
4	Construction of cofferdams to protect works area in western channel.
5	Construct rockfill embankment to form west abutment section of dam and install concrete facing.
6	Remove downstream cofferdam in western channel. Control release of flow through spillway gates and commence impounding.
7	Complete impounding and commence generation.

The impacts of these works will be to lower upstream water levels slightly when the first river excavation works take place to increase the capacity of the western diversion channel, and then to raise levels when the spillway width and sill elevation become the controlling factors on flow levels. At all times, flows will pass downstream more or less as normal. No mitigation works are considered necessary at this stage other than resettlement.

6.2.2 First filling

When dam construction is completed, cofferdams removed and the spillway gates closed, reservoir impoundment will raise water levels until the reservoir attains full capacity. The gross storage capacity is 2.47 billion m^3 (Table 6.3) and should be filled rapidly. This is illustrated by the fact that the average flow of each of the 10 months from March to December is greater than this volume, and that less than one week's average flow in August is capable of filling Dal reservoir to capacity.

Table 6.3 : Dal Reservoir – Levels, Surface Area and Storage Volumes

Reservoir Level Characteristic	Level masl	Surface Area km^2	Volume $m^3 \times 10^9$
Full Supply Level (FSL)	201	300	2.47
Minimum Operating Level (MOL)	199	250	2.12
Difference between FSL and MOL	2	50	0.35

First filling requires the reservoir level to attain MOL in order to test and commission each turbine (8 No.). As may be seen, it is clear from flow records that the duration of the first filling period will be rapid. The rates of downstream releases during first filling will need to maintain in situ water requirements for aquatic life downstream and public/domestic water supply and irrigation demands. As a general rule, the minimum release should not be less than the historical minimum flow. In this case, a flow in the order of 400 to 500 m^3/s may be adequate for the very short filling time but detailed assessment will be required during further studies.

Under provisions of the Nile Waters Agreement, all aspects of the Dal project's construction and operations, including flows during diversion and first filling, will be subject to agreement of Sudan and Egypt.

6.3 PHYSICAL ENVIRONMENT: CONSTRUCTION IMPACTS AND MITIGATION

6.3.1 Soil Erosion, Water Quality and Air Quality at Construction Sites

Environmental protection and remedial measures during construction against soil erosion, and for water quality and air quality at construction sites, are foreshadowed in the above section relating to the activities of the project construction contractors.

6.3.2 Water Resources Impacts

The physical impacts of reservoir first filling are described in Section 6.2 and Table 6.3.

Mitigation

There is no alternative to diverting the river for dam construction and no mitigation for dessicating the river channel at the dam site.

The backwater effects of the upstream cofferdam will have varying impacts on upstream water levels. Biological and socio-economic impacts arising from these require mitigation measures before river diversion; in principle, but not in geographical extent, these impacts will mirror the impacts which will occur during reservoir impoundment.

Mitigation measures will be required to be carried out by the contractor for river diversion and reservoir impoundment according to the project's EMP. Various biological and socio-economic impact mitigations are discussed later.

6.3.3 Water Quality Impacts

Available and additional data on river water quality, soils and residual biomass in the Dal reservoir area (300 km^2) is required to fully assess impacts on water quality from the time of river diversion until after first filling. However, the small capacity of the impounded water relative to the daily flows through the reservoir suggests no water quality problems will arise from river diversions and first filling.

Mitigation

Measures to remove woody vegetation from the reservoir basin are discussed under biological impacts below.

A water quality simulation model may be required to assess seasonal changes in reservoir water quality and project design and management strategies to minimize adverse changes. For this model, if required, data from future water quality sampling, soil sampling and biomass studies would be required. Currently, it is not considered that such modeling will be necessary but the experience gained during the first filling and operation of Merowe upstream should be taken into account.

6.3.4 Sedimentation Impacts

Reservoir sedimentation will begin during first filling in the construction period and continue throughout the life of the project. The mode of operation of Merowe hydropower project upstream (with or without flushing) will influence the sediment transport rates at Dal. Similarly, any development of storage projects in Ethiopia will influence sediment transport rates at Merowe and Dal, and Merowe’s mode of operation.

The distinctly yellow sand noted in dunes upstream of Dal village on the left bank will be within the future reservoir. The northerly source of these sands, and the northerly source of sand burying a house in Dal village, may be expected to continue. The quantities involved may be small and insignificant but this should be investigated in future work.

Mitigation

There is no known economical and practical mitigation measure for removing silt from large reservoirs to recover significant quantities of their original storage capacity.

Great efforts are needed to reduce sediment transports rates of the Blue Nile and Tekezi river basins in Ethiopia and Sudan. Implementation of a watershed management program is required for this, as being prepared by relevant regional governments and ENTRO. This is one of the most challenging areas of work in the Nile river basin.

If investigations conclude that the northerly source of wind blown sand is incapable of control, and if the quantities involved are not small but significant, measures (shelter belt) may needed to arrest blowing sand north of the dam’s left bank abutment. Investigations should also cover the whole reservoir length, including the north side (left bank) west-east river reach between Abri and Mograkka in order to rule out wind blown sand problems elsewhere or to consider mitigation measures.

6.3.5 Reservoir Slope Stability

The Dal dam reservoir basin is so flat there appears to be no risk of side slope instability. No mitigation measures are expected to be required.

6.3.6 Groundwater and Reservoir Seepage

There is considered to be low risk of reservoir leakage at Dal.

The dam site is extremely flat compared to normal dam sites. The topography of both flanks is broken due to differential weathering along weakness planes like dykes and fault zones. The flanks rise very gradually and then fall away into wadis or low flat areas of windblown sand. There is no topographic mapping available. The foundations rocks on the west side of the centre line are quite massive and in all likelihood systematic grouting of rock foundations to prevent seepage through the dam would not be needed. Contrarily, the rocks on the east side of the river are highly sheared and intersected by numerous dykes and fault zones. These rock masses are prone to mechanical disintegration.

Groundwater levels in areas that favour groundwater may be expected to rise with reservoir impoundment. However, generally, as discussed above, areas adjacent to Dal reservoir have rock types and structure unfavorable for seepage and groundwater supplies.

Mitigation and Enhancement

The rocks on the east side of the river are highly sheared and intersected by numerous dykes and fault zones and prone to mechanical disintegration. Systematic grouting of these rocks is expected to prevent seepage through rock below the right flank of the dam.

Advantage should be taken of groundwater resources around the reservoir margins that may be augmented by Dal reservoir storage with an operating range close to 201 masl. New sites of water supply, and augmented old ones, including mataras, may become available according to local geological conditions.

6.3.7 Reservoir-induced Seismicity

The Dal dam project area is located in a relatively low seismic hazard zone. No analysis of reservoir-induced seismicity has been made in this study. The need for this will be assessed during feasibility studies. No mitigation measures are currently expected, other than is normal in dam design.

6.3.8 Impacts on Minerals

On first impoundment in the construction period, Dal reservoir will inundate an area of 300 km^2. The inundation area in general may have old “Gold of Kush” mining sites and the main river and tributary khors may have reaches containing alluvial gold. It is thought that no sites have been worked for gold for a very long time and therefore that no compensatory mitigation measures will be required. No other known valuable minerals are reported.

Mitigation

If future assessment and surveys indicate that old “Gold of Kush” mining sites, having historical and cultural interest, will be lost, mitigation measures should be incorporated with others for archaeological salvage.

6.4 BIOLOGICAL ENVIRONMENT: CONSTRUCTION IMPACTS AND MITIGATION

6.4.1 Clearing Vegetation (small scale)

Environmental protection and remedial measures relating to clearing vegetation on each construction site (mainly roads, dam, quarries, borrow areas, power house and switchyard sites) have been foreshadowed in Table 6.1.

6.4.2 Clearing Vegetation (reservoir basin)

Clearing of woody vegetation from the reservoir basin will be required in the construction period before first filling the reservoir. Clearing of some or all areas will avoid or minimize water quality problems and trash problems during the operational period and should benefit future reservoir based activities: fishing with nets, boat operators. Furthermore, standing dead trees are very unsightly and clearance will improve the new landscape aesthetically.

The area to be cleared is relatively small because most of the reservoir basin is barren desert.

Experience elsewhere has shown that total clearance of woody vegetation in the live volume areas of reservoirs is unnecessary and that some advantages accrue to aquatic life from residual woody habitat in this zone, including its provision of breeding places and hiding places for small fauna including juvenile fish.

As local demands for timber are heavy for construction purposes, fuelwood and charcoal, there is expected to be a ready market for the cleared timber (mainly date palms and acacia).

Mitigation

One or more specialist or local community contractors may develop Dal reservoir clearance plans. Nothing should be decided without seeking the views and having full consultations with contractors and local communities. Having made this point, the project’s EMP concerning reservoir basin clearance will ensure that whatever mechanisms are decided for clearance, a realistic timeframe is declared, understood and agreed, taking into account seasonal ground conditions for operations, local labour availability and its other seasonal commitments, and other factors.

Emergency contingency measures should also be formulated, especially for clearing the dead storage zone (if recommended). This is because once filled with water on first impoundment, the opportunity to clear this area does not occur again. Various reservoir projects have suffered in this regard, where project management or professional or community contractors failed to mobilize effectively before it was too late.

The project's EMP will require careful preparation following detailed surveys and following reservoir water quality modelling, if required. It needs to be developed and implemented in consultation with the Owner, EMU, Northern State Council for Environment and Natural Resources and Wadi Halfa administrative units. The realities of how timber (or community) contractors work, and may work, should be reflected in the time-schedule of the EMP for reservoir basin clearance.

6.4.3 Residual Vegetation and Reservoir Impoundment

During first filling, loose residual woody material, and other floating materials, will cover parts of the reservoir. Depending on wind directions (mainly northerly), these will accumulate in bays and may be redirected according to seasons. None of this material can escape from the reservoir until the spillway operates, when water currents will direct materials to the dam, power station intake and spillway. Booms will control and divert floating materials and trash racks will remove materials at the Dal intake. Trees, shrubs, dead animals and other materials that pass through the spillway will eventually be received in Lake Nasser/Nubia.

Potentially, such quantities of floating and semi-submerged materials (in addition to the normal trash load carried by the Nile) could be troublesome at Dal dam in the early years. Costs of remedying these problems are not insignificant.

Mitigation

Dal reservoir basin clearance needs to be effective. This aspect relating to dealing with additional trash at Dal, caused by reservoir basin clearance and first impoundment, requires to be fully considered in future studies with mitigation measures being included in the EMP.

6.4.4 Terrestrial Fauna

During clearance of the reservoir basin, most of the tree habitat, and shaded habitats in lower layers of shrubs and grasses, will be destroyed. This loss of terrestrial habitat is unavoidable with such a project. In due course, some of the area (the dead storage zone) will be permanently under water. Finally, the live storage zone will be inundated. Terrestrial fauna that cannot escape will therefore be decimated.

Mitigation

Directives for construction workers concerning wildlife conservation and protection are foreshadowed in Table 6.1.

The EMP for fauna will be required for the reservoir and surrounding areas. Information on wildlife is currently too scanty and inadequate to anticipate remedial measures in specific terms. The plan will be drawn up in consultation with local communities, relevant wildlife departments and NGOs following detailed vegetation and fauna surveys.

The EMP will, *inter alia*, need to take into account, through consultations, all wildlife matters which local communities may fear. When reservoirs are filling for the first time, local residents typically fear an influx of snakes.

6.4.5 Aquatic Fauna

When the various stages of river diversion take place, an area of river channel, riverbanks and adjacent desert will be flooded in the high flow season. Flows will be diverted, to permit dam site construction works, and be released in the Nile channel downstream of the downstream cofferdam. Changes in aquatic life are expected during this time as the habitat changes temporarily, from a running river to a lacustrine environment, then back to running river as levels fall.

During the first impoundment of Dal reservoir, major changes may be expected to begin and continue until species suited to a reservoir aquatic environment are established.

No endangered fish species have been reported and there is no evidence of fish migration other than local movements on the main river. Therefore the impact of the dam on fish will be mainly limited to changes in the future reservoir.

Populations of fish which are especially adapted to water with currents and riverine habitats will decrease while those which can adapt to the lake environment will increase.

The future composition of fish species in the Dal reservoir, the development of which would certainly need several years, is anticipated to be similar to that in Lake Nubia. The total fish population will increase with the formation of the lake. 19 of the principal fish species expected in Dal reservoir are listed in Table 6.4.

The impacts on fish could be considered as insignificant. This conclusion is made on the basis of three factors: first, relative low sensitivity of present fish (no migration); second, the impacts are only transitional until establishment of the new conditions which will be different but basically not adverse; third, the final conditions in the lake are beneficial with respect to the population of different fish species.

Table 6.4: Fish Species Expected in Dal Reservoir

Family	Scientific Name	Local Name
Bagridae	*Bagrus byad*	Byad
	Bagrus docmac	Kabarose
Characidae	*Alestes baremose*	Kawara
	Bryeinus nurse	
	Hydrocynus brevis	Kas
Clariidae	*Clarias anguillaris*	Garmut
	Clarias lazera	Garmut
Mormyridae	*Mormyrops anguilloides*	Taraza
	Mormyrus caschive	Khashm el-Banat
	Mormyrus kannume	Khashm el-Banat
	Petrocephalus bane	Ras el-Hagar
Schilbeidae	*Schilbe niloticus*	Shilba
	Schilbe uranoscopus	Um Katif
Cyprinidae	*Barbus bynni*	Binnie
	Labeo coubie	Tutkum
	Labeo niloticus	Dabs
Mochocidae	*Synodontis batensoda*	Galaby
	Synodontis schall	Gargur
Centropomidae	*Lates niloticus*	Lgl

Mitigation - Fisheries Development

The EMP regarding aquatic life and fisheries development will be required during future studies. This should benefit from experience of Lake Nubia downstream and fisheries developments at the new Merowe reservoir upstream.

6.4.6 Disease Vectors

Reservoir impoundment will increase the surface water area and create a larger conducive environment for disease vectors, especially mosquito breeding.

Mitigation

Mitigation measures are required in terms of health education, making available mosquito nets and provision of health care clinics with adequate staff and materials for screening and treatment. The EMP and the contactor’s response to it should cover the workforce and camp followers. The project will need to boost these services in any settled areas surrounding the reservoir and for host and resettlement communities (described later).

6.5 SOCIAL ENVIRONMENT: CONSTRUCTION IMPACTS AND MITIGATION

6.5.1 Summary

Our assessment indicates that there will be major loss of resources and income generation opportunities in the direct impact zone of the Dal hydropower project.

There will also be temporary negative effects for local people caused by increased turbidity and possibly chemical pollution of local water sources during construction of project roads, the dam and ancillary works.

All of the above will require mitigation actions in the form of compensation, resettlement and environmental protection measures. In addition, an extensive livelihood safeguard program should be developed to maintain and preferably improve the well being of affected people and any related host communities. The project will require a Resettlement Action Plan (RAP) on a very large scale.

Some few impacts are foreseen between Dal dam site works area and Lake Nubia owing to construction activities, assuming satisfactory water releases will be made to the Nile during river diversion and the short period of reservoir first-filling.

Some socio-economic impacts of the Dal construction activities are foreseen in Egypt, mainly related to first filling.

6.5.2 Principles of Compensation and Procedures

The general principles of compensation that apply are summarized as follows.

1. Compensation for lost property will be paid.
2. Compensation and entitlement provided to the project affected people (legal and illegal) should ensure that the lives of the people and host communities are improved or at least the pre-project living standards are maintained;
3. Temporary displacement shall be kept to the minimum;
4. Land replacement (allocation) should be sufficient to maintain the livelihood of project affected people (PAP);
5. PAP should be fully consulted about the project including impacts of the project, eligibility, compensation rates and income restoration, etc;
6. All public property affected will be paid in cash to the owner of the property and replacement shall be made to the communities in their new setting;
7. Special attention will be given to vulnerable groups such as female household heads, the sick, aged, extremely poor and other disadvantaged groups.

Environment and social justice enjoy the protection of the 2005 Interim National Constitution of the Republic of the Sudan wherein Article 43 (2) gives the national government the right to expropriate land for development purposes and to compensate owners (Chapter 2).

Specific details and procedures to be followed in the acquisition of land and rules governing payment of compensation for land for public purposes are found in the Land Acquisition Act,1930 (Chapter 2).

The procedures for land acquisition in any locality are initiated with a notification by the People's Executive Council in a Gazette stating that it appeared to the President of the Republic to authorize the acquisition of land for public purposes (Section 4). It is only after such notification that it shall be lawful to enter into, bore, set out boundaries, mark or survey the land.

An appropriation officer appointed by the People's Executive Council would notify the occupant of land about the declaration that a designated area of land is to be appropriated for public purposes; call upon persons claiming compensation to appear before him at a place and time (not earlier than fourteen days) and to state the particulars of their claims for compensation (Section 10). He must attempt to agree on the amount of compensation for the land.

The Land Acquisition Act, 1930, also provides for further steps to be taken with regard to assessment of compensation if agreement is not reached.

Claims for compensation may be forwarded either directly to the State Director of the Ministry of Agriculture, Animal Resources and Irrigation or indirectly via the Commissioner of the Locality where the land is affected. The precise mechanisms, and the grievance procedure (Section 9.5), will require to be determined as a result of further consultations during feasibility studies.

6.5.3 Principal Settlements Impacted by Dal Reservoir Project

A list of settlements in the river reach from Dal cataract to Kagbar cataract (the length of Low Dal reservoir) was complied with the assistance of residents of Abri (Table 6.5). It should be noted that listed settlements are in order from north to south, moving from Dal going upstream to Kagbar cataract. Several important islands are included.

Table 6.5 : Main settlements Impacted by Dal Reservoir Inundation

Administrative Units HQ	West (Left) Bank Settlements	East (Right) Bank Settlements	Island Settlements
Ferka, Abri and	Dal village	Sakamatto	Jerjatti
Delgo	Dal Cataract	Ferka	Arnatti
	Hai Al-Arab	Mofrakka	Sai
	Mofrakka West	Kosha	Nolti
	Kosha West/Selam	Ginis	Swarda
	Ginis West	Atab	Oshba
	Abri West/Sagyat Al-Abid	Amara	Wawa
	Tabaj West	Abri	
	Morku	Tabaj East	
	Toshki	Koyeka	
	Hamid	Abboud	
	Abraqa/Qubbat Salim	Swarda	
	Nilwa	Irau	
	Dosha	Oshimatto	
	Solib	Wawa	
	Agula	Kimatto	
	Tobba	Agger	
	Koya	Saad Fadali	
	Tinari	Abu Sari	
	Magadib	Khor abu Sunt	
	Hadika	Agetteri	
	Sudla	Khor Kado	
	Shaddah	Kedurma	
	Koka	Kudayn	

6.5.4 Uncertainties in Baseline Information

Population density in the project area is high along the river and on river islands but negligible or zero in the desert beyond the fertile riverine strips.

Owing to the lack of any contoured mapping whatsoever, and the lack of maps showing the boundaries of administrative units of Wadi Halfa locality, it is very difficult to estimate the numbers of households and population that would be directly impacted by the Dal project with FSL at 201 masl. By the same token, until detailed topographic mapping becomes available, engineers are uncertain about the reservoir's elevation/capacity/area relationship and the dimensions of some elements of the project.

Another difficulty relates to the last census (1993) taking place some 14 years ago, and surrounding issues about the reliability of the original census data. Because there is no recent census data, projections of populations have to be made over a relatively long period and at an assumed but unconfirmed growth rate for the area (Chapter 4).

Furthermore, owing to the extreme sensitivity among Nubian people to hydropower dams and resettlement, for whom the concept of satisfactory resettlement cannot be imagined, there has been no possibility at this pre-feasibility level of study of conducting formal focus group discussions or formal sampling of the population to ascertain numbers and views on compensation and potential resettlement sites.

6.5.5 Estimate of Involuntary Resettlement

Given the uncertainties in baseline information, the population directly affected by the project (Table 6.6) has been assessed with assumptions as follows:

- Some of Delgo town and nearby settlements will or may be above the FSL of 201 masl and remain as viable settlements. 80% of the Delgo administrative unit population is assumed to be unviable and resettlement will be necessary;
- All settlements of Abri administrative unit will be inundated or otherwise unviable;
- One quarter of Ferka's population will be directly affected and will require resettlement.

Table 6.6 : Estimate of Population Requiring Resettlement

Administrative Unit	Projected population in 2006	Proportion to be resettled %	Population to be resettled	Households to be resettled
Delgo	23,900	80	19,120	3,749
Abri	18,042	100	18,042	3,538
Ferka	18,293	25	4,573	897
Total			**41,735**	**8,184**

Thus, the estimate of involuntary resettlement is for say, 42,000 people comprising say, some 8,200 households. The unreliability of these estimates is unfortunate but inevitable in the circumstances of there being no contoured maps available, no administrative boundary maps and populations being projected over 14 years from census data in 1993. Nevertheless, the estimate indicates that a major program of resettlement will be necessary for the Low Dal hydropower project.

6.5.6 Cost Estimates of Involuntary Resettlement

For estimating compensation and resettlement costs for such a very large population at Dal, it was considered prudent to review some of the resettlement arrangements of the on-going Merowe project and seek to obtain up-to-date estimates of total resettlement numbers and costs of resettlement.

For this purpose, one of Merowe's resettlement areas, New Hamdab, was visited on two occasions in November 2006. The new settlement is in the desert near Abu Dom and Ed Debba on the left bank of the Nile and comprises well-constructed houses with walled gardens, roads, schools, health centre, community facilities, mosques and water supplies. Cultivated land continues to be prepared, all facilitated by a very large irrigation canal (Plate 6.1). Horticultural crops, alfalfa, date palms and other crops and trees appeared to be thriving, including shade trees. An agricultural research station is carrying out crop trials, recording all growth, nutrient and weight gain parameters for selected plant species, with and without different levels of fertilizer applications. The research station conducts regular demonstrations for farmers, and is flexible about introducing and experimenting with new crop varieties, especially those which may provide greater incomes for farmers.

New Hamdab provides an example of modern resettlement being seriously executed in desert conditions. The irrigable land available for farmers appears to be much greater than areas farmed in their original setting; the potential allocations of land for willing farmers appeared to exceed areas they could comfortably manage if they so wished to cultivate more land.

Plate 6.1 : Canal Supplying Water for Irrigation And Power Line at New Hamdab Resettlement Scheme

In November 2006, the only curious features observed at New Hamdab were the apparent low occupancy of new homes and the apparent slow uptake of cultivable land. These may reflect the relative newness of the resettlement project and possibly the fact that full resettlement was not scheduled until impoundment at Merowe was more imminent – advantage being taken of final cultivations and harvesting at former village sites. However, these features may imply that many have received compensation and temporarily or permanently rejected the resettlement site, preferring to begin or continue with a new way of life elsewhere.

Whilst some excellent resettlement descriptions accompanied by some cost estimates appear on the Merowe project's website, these are not complete and comprehensive for the total resettlement involved.

Other formal means of obtaining authoritative estimates of total resettlement numbers and mitigation costs for Merowe failed to produce the numbers required for providing a guide for Dal resettlement costs. It has therefore been necessary to use referenced and unsubstantiated data as follows:

- total resettlement: approximately 70,000 persons; (Failer, Mutaz & El Tayeb, 2006)
- total compensation, resettlement and all resettlement development costs, approximately USD 600 million. It is not known whether this unsubstantiated figure includes archaeological surveys and salvage costs.

These figures give a resettlement cost estimate of USD 8,600 per person.

There is no known unit cost data for other comparable desert resettlement schemes with which to compare this estimate. The estimated resettlement cost estimate of USD 8,600 per person, or USD 43,700 per household (adopting an average size of 5.1 persons per household) is understood to include all compensation, new house construction, health facilities, community buildings, road infrastructure, electricity supplies, water supply systems, land preparation, agricultural research facilities, crop trial plots, farmers' demonstrations and other works. Adopting this rate for current purposes, the estimated costs of resettlement for Dal are given in Table 6.7.

Table 6.7 : Estimated Costs of Resettlement Program for Dal

Dal resettlement population No.	Resettlement program cost per person USD	Resettlement program cost USD million
42,000	8,600	360

6.5.7 Transmission Line

The preliminarily selected transmission line route (Dal to Dongola, 240 km) is the shortest route between Dal switchyard and Dongola to provide connection with the national grid. The route follows the road route in the desert, more or less parallel with the river and avoids all settlements and cultivated areas, except for a very short distance approaching Dongola where it is necessary to cross the river to the interconnection point on the left bank.

Compensation is not expected to be required along 98% of the route because the Right of Way would be in desert and should therefore avoid all settlements and cultivated land. In the area where it is necessary to cross the flood plain and river near Dongola, it may also be possible for detailed line routing and tower siting to avoid properties and cultivated land. If this is not possible, compensation for any properties and crops produced from cultivated land, date palms and any other impacted resources will be required. In view of the small fraction of the total line length which may or may not require compensation payments, no estimate of compensation has been made. This will need to be addressed during any future detailed studies.

6.5.8 Irrigation and Irrigation Potential

There are irrigated lands in the Dal reservoir area. Most of these will be inundated. Irrigated land at the upstream end of the reservoir, downstream of Kagbar cataract, will probably be unaffected and continue to be productive. The point, or the transition zone, at which irrigated land, date palms and other resources will be and will not be impacted cannot be determined because there are no contoured maps available.

During first filling of Dal reservoir, there is potential for short-term water shortages to be created at existing irrigation schemes downstream of Dal dam construction area.

Mitigation

Compensation is required for impacted irrigated lands and all production from them. This has not been estimated. It is here assumed to be included in the overall resettlement program costs described above.

The release rates during river diversion and first filling need to take account of downstream irrigation and water supply demands, and *in situ* ecological demands. With regard to downstream pumped abstractions, it is not only the flow rate itself which is important (and there should be no problem at all in providing this) but the water depth at the abstraction sites. In other words, there can be plenty of water in the river but it may not be accessible with the lengths of suction hoses available to farmers and others. Care needs to be taken that the short term reductions in flow rates provide river water levels that reach abstraction points. If this is not practicable, then assistance with pumping equipment should be provided to abstractors by the project to ensure that sufficient water abstractions take place as needed.

6.5.9 Infrastructure

Roads, water supply abstraction points with pipelines, water towers and distribution systems, telephone lines and electricity distribution systems from diesel generators will be impacted by the project. It was noted that a mobile phone mast has been constructed in Dal village. There are likely to be other social infrastructures also.

Compensation is required for publicly and privately owned infrastructure.

During construction, the project will need to improve standards of existing roads and construct access roads. The access arrangements will need to be capable of carrying all envisaged construction traffic including transport of construction plant, materials and equipment to the site, together with normal construction traffic around the site. In particular, the roads and bridges will need to be capable of carrying the heavy loads associated with the main items of the permanent mechanical and electrical equipment for incorporation in the project, specifically the turbine components, generator components and transformers. Construction plant, materials and the major items of permanent equipment for the project will be transported to the site over the existing national road network to Dongola where a major river crossing is under construction. Beyond Dongola existing roads and tracks extending to Dal will require upgrading.

A temporary crossing of the Nile will be required during construction. This may be by bridge or ferry. It is envisaged that the dam itself would be used as a future road crossing following completion of the project.

In addition, the following infrastructure will be required:

- Construction camp.
- Construction works areas (e.g. crusher, concrete batching plant, etc.).
- Quarry locations.
- Site access roads

Mitigation and Enhancement

Compensation is required for publicly and privately owned infrastructure. This has not been estimated. It is here assumed to be included in the overall resettlement program costs described above.

Environmental protection measures concerning construction, including dust suppression on roads (which will be very important) and control of traffic (very important through settlements and especially near schools), has been covered in Table 6.1.

Donors expect projects to internalise all costs. In this regard, care will be needed in future studies and contract documents (Owner’s requirements) to ensure not only that main roads are upgraded for the project but are left in good shape for local use after the project.

The project roads will be beneficial after project completion, replacing those drowned by the reservoir. The bridge downstream of the project, if constructed, and/or use of the dam crest for crossing the river will be assets to the region for local use.

6.5.10 Patterns of Mobility and Navigation (roads and river crossing)

There are small ferry services operating along the Nile, maintaining community and trading connections. Some ferrymen will become redundant when resettlement is completed.

Mitigation

Compensation will be required for ferrymen, along with all other livelihoods affected. This has not been estimated. It is here assumed to be included in the overall resettlement program costs described above.

The bridge downstream of the project, if constructed, and/or use of the dam crest for crossing the river will be assets to the region for local use, replacing the ferry services at Dal village.

New ferry services for the 160 km long reservoir will be required. These may be incorporated in a reservoir fisheries development program for Dal reservoir.

6.5.11 Access to Natural Resources

Agriculture practices are supplemented by uses of natural resources in the project area. These mainly include collection of honey, fish and possibly hunting wild animals. These activities are mainly meant for family consumption and generate income in some cases.

Compensation has not been estimated. It is here assumed to be included in the overall resettlement program costs described above.

6.5.12 Water Supply for Domestic and Other Purposes

Construction activities, particularly channel excavation and river diversion works, may increases turbidity of the Nile. Oil and other chemicals from construction machinery and activities may pollute water sources and adversely affect water supplies for human and livestock populations.

Mitigation

Mitigation measures include environmental protection measures by the contractor and construction workers to avoid or minimize construction activities that cause adverse impacts such as oil pollution and increased turbidity (Table 6.1). The contractor's plan, in response to the Owner's EMP, should cover avoiding soil erosion and construction activities causing contaminated surface runoff, ensuring proper handling and use of toxic compounds during construction, preventing cleaning of trucks and other vehicles near or in water bodies to avoid chemical contamination, proper siting of construction camps with provision for safe disposal of solid and liquid wastes, and ensure construction of water schemes for the surrounding residual settlement areas.

6.5.13 Aesthetic Landscape

Aesthetic appreciation, or dismay, at the sight of dams, reservoirs and transmission lines is in the eye of the beholder and little or nothing can be done about this.

However, there are two aspects of the Dal project about which something can and should be done. These relate to post-construction rehabilitation and landscaping of works areas and to clearing the reservoir basin to avoid dead trees standing up through the reservoir water surface later.

Mitigation

Mitigation measures include environmental enhancement measures by the contractor, as will be stated in the project EMP.

Similarly, measures for enhancing landscape values should be included in the EMP for clearing woody vegetation from the reservoir basin.

6.5.14 Archaeological and Historical Locations

Review of literature and study documents by the archaeologist in the consultant's team indicated numerous sites of archaeological and historical importance in the proposed reservoir and surrounding area (Chapter 4). The submission of an illustrated summary document on the heritage of the region by the Honorary Secretary of the Sudan Archaeological Research Society and President of the International Society for Nubian Studies (Annex, at end of Chapter 4) anticipates the seriousness with which many specialists in Sudan and the international community would view loss of these sites.

Mitigation

Extensive surveys, excavations and salvage will be required, beginning long before construction begins. It is suggested that a period of not less than 10 years would be required.

The cost of survey, salvage, reporting and mitigation works is difficult to estimate. At Merowe, more than USD 500,000 has been spent on a SARS/British Museum expedition at the 4th cataract, without completing what is truly needed, and the post-excavation project, an essential prerequisite before publication of the results, is estimated to be in the order of USD 600,000. Both expenditures are for a 40 km concession on the left bank of the river and adjacent islands. Thus, as a guide, more than USD 1.1 million is required for 40 km along one riverbank, giving a unit cost of greater than USD 27,500 per km. The whole length of the reach between Dal and Kagbar cataracts (estimated at 160 km) is considered rich in archaeological treasures. A first estimate of costs at Dal is given in Table 6.8.

Table 6.8 : Estimate of Costs of Dal Archaeological Surveys, Excavations and Documentation

Guideline Unit cost of survey and excavations and reporting USD / km	Length of both river banks between Dal and Kagbar km	Cost of Dal project survey, excavations, reporting USD	Notes
>27,500	320	>8,800,000	Excludes mitigation works to dismantle and re-erect the Temple at Soleb, and other mitigation works

Specialists will be required to conduct these surveys, excavations and mitigation works.

Apart from these in the reservoir basin, there will be the possibility that the contractor will disturb valuable artefacts during his works that have not been recorded or otherwise mitigated. Adequate procedures for protecting/recording and conserving artefacts that may be found at the dam construction site and associated works areas during the construction period will be necessary. These will be included in the EMP and Owner's requirements so that the contractor has a responsibility for such finds. The continuing service of an archaeological team attached to the contractor is foreseen for the construction period.

6.5.15 Health Status of Old and New Communities

The present low-level public health status in the project area is related to the inadequate health facilities. During the project construction, increased health problems may be expected relating to accidents, use of chemicals, dust, noise, waste disposal, traffic and STDs, HIV, etc. resulting from the influx of construction workers and camp followers. For resettlement communities, upgraded health services are required in new locations.

Mitigation

Mitigation measures include those of the contractor in Table 6.1 (to avoid health problems) and specifically for health education, screening, protection and care as will be required in the contractor's health care plan. These will include:

- Continuous health education to employees, camp followers and local people that are participating in the project construction activities (Sub Plan Code 17)
- Conducting and encouraging tests for diseases, including HIV, for employees, camp followers and local people that are participating in the project construction activities

- Provision of treated mosquito nets to construction employees, camp followers and local people that are participating in the project construction activities
- Ensuring proper sanitation and waste disposal
- Appropriate camp siting.

Future studies will need to make some provision for health measures beyond health services provided by the contractor.

6.5.16 Access to Social Services

Availability of social services in the project construction and surrounding areas is very limited. Among others, major social services that require consideration in the project area include health, safe water supply and education. Influx of a large number of workers will create further pressure on the existing facilities such as health services and the contractor must provide these for them in response to requirements of the project's EMP. With respect to public health services, increases in transmittable diseases that include STDs, HIV and other cases is inevitable.

Disease cases relating to the absence of safe water supply may be common in the project area.

Construction workers usually arrive at sites with their families and increase pressure on existing education facilities. It is possible that some of the local labour force will remain in the project area even after the completion of construction activities.

Thus, resettlement planning should include high standard provisions for all resettled families. Where there are host communities, planning should make provision for improvements for them.

Mitigation

The contractor must look after (plan, provide, manage, monitor and pay for) health, water supply and sanitation, and any education requirements of construction workers and camp followers, as will be included in the project EMP.

The RAP must make provisions for all resettlers requirements and host communities where applicable. Compensation has not been estimated. It is here assumed to be included in the overall resettlement program costs described above.

6.5.17 Graveyards

There are graveyards in almost every settlement between Dal and Kagbar cataracts. In most cases, but not all, graveyards are located away from the river and on high ground. High ground is a relative term here in generally flat terrain apart from the major rock outcrops and inselbergs; high ground so far as burial grounds are concerned usually means "safely above historical river flood levels". Thus, many graveyards associated with settlements along the 160 km of the river upstream of the 30 m high Dal dam are expected to be affected, with a greater proportion in the Abri and Ferka reaches than in the Kagbar to Delgo reach.

Disturbance of old and recent burial grounds is among the hottest issues regarding dams and reservoir impoundment, worldwide. Nobody likes it.

Mitigation

Community religious leaders would need to be advised of project proposals and impacts and their advice sought on ceremonial procedures for de-consecrating burial grounds and various mitigation measures. In the cases of burial sites containing recent remains, procedures are likely to be different than for ancient ones. Recent and on-going experience concerning Merowe should be sought during any EIA and RAP studies. All costs should be allocated to the project.

The required measures should be included in the project's EMP.

6.5.18 Social Structure of Existing Communities

There may be changes in social structure due to cultural interaction between construction workers and camp followers and local resettlers and residents who are not involved with the project. Some changes may be negative but exposure to new influences can also bring better life styles. Residents are already familiar with different types of visitors so no immediate cultural shock is expected.

Mitigation

Changes are considered generally positive. Mitigation is needed with regard to public health awareness and education and health facilities and services.

6.5.19 Employment Opportunities

The project will create temporary and permanent employment opportunities due to construction and other support activities (sale of food and consumables, barbers, shoe makers, etc). Many skilled and semi-skilled workers are expected to arrive from previous construction sites in other regions. When construction finishes, workers will be laid off.

Mitigation

Measures are required to maximize local employment during construction, and for training/apprenticeship courses to be provided to enable this whenever possible. This requirement, for preferential employment of residents of Wadi Halfa locality and Northern State where practicable, should be reflected in contractors' tenders and seriously pursued.

6.5.20 Commercial and Trade Opportunities

It is normal for major construction sites, with many workers, to increase trading activities in the area and for local people to supply foodstuffs to the workforce. Also, manufactured goods and fuel need to be imported from elsewhere to the construction site. However, at some development sites, this may give rise to shortages locally and to price inflation, causing local people to suffer as a result of shortages and price increases. Careful consideration will be required to protect the local community whilst not denying them opportunities to increase trading activities.

Mitigation

In project planning, care is needed to establish what foodstuffs may be provided locally from the region without causing local price inflation. This should determine policy on whether food supplies of some or all commodities for the contractor's workforce should be sourced locally (incidentally, with minor carbon footprint) or whether the contractor should be totally self-sufficient by bringing in foodstuffs from elsewhere.

6.5.21 Energy Use

There is currently no formal electricity supply in the Dal area. It is probable that the contractor will install diesel generators for all electricity requirements during construction. These requirements include electricity for hot water and cooking food for the large workforce. If this is the case, there should be no cutting of trees and shrubs by the contractor or workforce for charcoal or fuel wood.

The transmission line route, described earlier, will pass through a large area without NEC electricity supplies. This high voltage double circuit line (220 kV) is not suited to providing local supplies along the route but some areas in the north could be supplied from the switchyard at Dal.

Because new supplies will be provided to Dongola substation from the Merowe project (the transmission line towers were already constructed during the November 2006 field visit), it may be assumed that much of Northern State will be provided with supplies within the next few years.

Thus, provisions of rural electricity supplies from Dongola and to a limited local extent from Dal in the north (if not supplied from extension of rural supplies from Dongola) may be expected to benefit the whole region within the foreseeable future.

These supplies appear likely to occur with or without the Low Dal hydropower project. The provision of electricity supplies is likely to be welcomed by all consumers (providing they can pay the tariff) and transform many sectors of the economy of the region. In particular, the ability to have electrical energy for pumping Nile river water, and Nile-related groundwater supplies, for more water supplies and irrigation should be very beneficial for public health a well as land productivity. These supplies would support development in

- the agricultural sector (irrigation pumps, poultry, animal husbandry, preservation of products);
- the commercial sector (shops, restaurants);
- small and medium industries (flour mills, rural water supply installations, tanneries, and processing plants);
- the residential sector (lighting, heating, and cooking);

- the education sector (pre-schools, basic schools, secondary schools and technical colleges); and

- the health sector (pharmacies, clinics, health centres and hospitals).

In brief, Merowe's and possibly Low Dal's electricity supplies will assist in the facilitation of economic growth in the region and in Dal project affected areas, and create long-term employment opportunities for the poor, including women, thereby increasing income levels and reducing poverty.

In the Low Dal project context, with its enormous burden of resettlement, this new phase of economic growth, facilitated and stimulated by NEC's rural electricity supplies, may be the catalyst for developing resettlement programs within close or reasonable proximity to the original home areas of the people to be resettled.

We have not studied or estimated costs of provision of rural electrification as a development activity along the floodplain from Dongola to Dal, or indeed further north. This is an area for further consideration in future and the planning needs to be incorporated in any future studies of the Low Dal project and its resettlement program.

Mitigation

The project EMP on vegetation clearing and construction work camps should make clear what use may be made of local timber, if any (Table 6.1). Depending on the timing and extent of the reservoir clearance program, it is conceivable that the EMP, after consulting local people, may permit some cleared timber to be used for energy purposes.

To contribute to mitigation of lost resources and the need for major involuntary resettlement with income generating opportunities, rural electrification plans should be drawn up and made known. This would relieve the frustration of local people observing a new high voltage double circuit line (220 kV) being constructed and operated between Dal and Dongola without local benefits along the way.

Consideration should be given to providing local supplies in the north which could be supplied from the switchyard at Dal. This would benefit local people in downstream areas and bind them into the Dal project as stakeholders.

6.5.22 Migration

A large number of people are expected to migrate to the project area for employment and trading. Employment levels will change as construction continues, reaching a peak of about 2,000 to 3,000 and falling to a low number during the operational period. Most workers are expected to leave the area when laid off.

Mitigation

Health, food, water supplies, sanitation and cultural exchanges have been considered earlier. There will be need for contractors and local administrations dealing with RAP to make sure that supplies and services will be sufficient for construction workers and camp followers and for resettlement and host communities.

6.5.23 Tourism

There is little or no tourism in the project area. No impacts are expected. However, if archaeological salvage works create a series of accessible sites which might be coupled with water-based recreation, new wetland habitats, Dal cataract and sand dune viewing, and indeed water sports in a restricted area of the reservoir, interesting tourism possibilities and packages may develop – all supported by Dal reservoir fish on the menu.

6.5.24 Living Standards and Poverty Level

Living standards of employed persons at the construction site may be expected to rise. It is the duty of the RAP to ensure the existing conditions of all resettlers and host communities are at least maintained and preferably improved.

Mitigation

A comprehensive RAP is required to be professionally prepared, implemented and independently monitored.

6.5.25 Construction Impacts Downstream of Dal in Sudan

There are expected to be few potential impacts along the Nile downstream of the Dal construction works areas. Most of these should be avoided or minimized by implementation of the protection measures in the EMP already described. There are four particular impacts for which special attention will be required.

Sedimentation and Morphological Impacts

Reservoir sedimentation will begin when first filling begins in the construction period and continue throughout the life of the project. Impacts on High Aswan Dam and Lake Nasser/Nubia will be positive because sediment stored in Dal reservoir will reduce reservoir sedimentation downstream.

From first filling, the reduction in downstream sediment loads will reduce the annual dressing of silt given to cultivated alluvial areas (as a free fertilizer) along the Nile during the annual flood. This is covered under Recession Agriculture below.

Once turbines are commissioned, and full generation begins, downstream flows will be more or less at the inflow rates to Dal reservoir, minus evaporation losses. Thus the annual flood will pass through turbines and the spillway without noticeable change in flow rates downstream. Because the annual flood passing from the dam downstream and other flows will be similar to inflows but convey less sediment, some morphological changes may be expected in the river channel downstream. These are unlikely to occur and be noticeable in the several kilometers of hard rocks in the Dal downstream cataract but after the cataract reach.

Mitigation

With regard to changes in river channel morphology, resulting from reduced sediment loads in turbine and spillway releases at Dal, there may be need for some river training works, bank protection and other measures. Much greater field study is required of this before the potential needs can be assessed.

Trash Loads

During first filling, loose residual woody material, and other floating materials, will cover parts of the reservoir. None of this material can escape from the reservoir until such time as the spillway operates, when water currents may direct materials to the dam, power station intake and spillway. Booms will control and divert floating materials and trash racks will remove materials at the Dal intake. Trees, shrubs, dead animals and other materials that pass through the spillway will be received downstream and in Lakes Nasser/Nubia. The duration of the impact is expected to be short because the amount of material is relatively small. The impacts may be insignificant but some fishermen's nets may be troubled by additional floating and semi-submerged materials. Some aquatic species will benefit from this moving woody habitat.

Mitigation

Dal reservoir basin clearance needs to be effective. This aspect requires to be fully considered in future studies with mitigation measures being included in the project EMP regarding reservoir basin clearance.

River Crossings and Safety Issues

Significant changes in water releases in connection with cofferdam operations and river diversion works are not expected. Normally, discharges downstream will be received "as usual" in the construction period until first filling begins. At this time, there is expected to be changes in seasonal release patterns as prescribed in the Owner's requirements. As mentioned earlier, the determination of the downstream release regime during cofferdam operations and during first filling of the reservoir (and during operations) requires thorough consideration and agreement with authorities in Sudan and Egypt (Permanent Joint Technical Committee).

It is expected that river crossings of the Nile by small boats (ferries, fishermen) will be generally undisturbed by construction activities upstream. However, the potential will exist for rapid changes in water levels when changing downstream releases at the dam site, when commissioning turbines and in the operational period. Some of these may be directly due to construction and project works; some may be due to operations of the new Merowe project.

Mitigation

Precautionary downstream warning measures may be required in advance of changes in releases. These measures should be included in the Owner's requirements.

Recession Agriculture

When the short period of reservoir impoundment begins, flows will be reduced downstream – for a short time. After filling to MOL, turbine testing and commissioning will take place, with variable downstream releases if the dam is not spilling during commissioning. During operations, spillway discharges at Dal will be frequent (as described in Chapter 7).

The amount of flood recession agriculture (gerouf) in this downstream reach has not been assessed but it may extend through Akasha to near Wadi Halfa and to “islands” of sediments in Lake Nubia. Relatively small variations in flow appear unlikely to adversely affect these areas during the construction period. If future assessment suggests otherwise, compensation or other mitigation will be required.

Mitigation

If required, mitigation measures could be in the form of monetary compensation for loss of production. Alternatively, pumps could be supplied by the project for irrigation of the land in anticipation or following any damage to gerouf cultivation caused by the project. In future studies, the pumping option should be fully explored. If viable, this could not only produce a crop instead of flood recession but another crop each year also.

With regard to mitigation for reductions in valued silt deposits downstream, as has occurred on the Main Nile in Egypt following construction of High Aswan Dam, some use of artificial fertilizers may be expected downstream of Dal. However, most of the clay fraction and fine silt components of the suspended sediment loads of the annual flood will continue to be conveyed by turbines and the spillway. Future studies should consider the need for artificial fertilizers to substitute and compensate for reduced alluvial depositions in the downstream reach.

Downstream construction impacts in Egypt are considered in Section 6.6.

6.5.26 Public Relations, Communications and Grievances

When major dams are constructed, creating large reservoirs with the need for a resettlement program, and causing a large workforce to concentrate in camps, there are limitless opportunities for grievances to occur. Whilst the contractors will take responsibility for their workforce and establish a grievance procedure, there is need to establish good public relations between the project owners and the local communities, regional government and other agencies. This requires transparency about the project, its impacts and mitigation measures, including grievance procedures for host and resettled communities, especially those measures relating to compensation and resettlement but also to many other stakeholders. Care has to be taken to present information in languages that are understood by stakeholders, and by all conceivable means in order to reach all concerned effectively.

Among the earliest common grievances are those relating to acquisition of land (how much?, where? and when?) for the project construction activities.

Further studies will be required to define the project more closely so that EIA and RAP reports may be as precise as possible. These are then typically followed by revisions to engineering design before and even after construction begins. Some 2,000 or 3,000 or more engineering drawings will be produced during final design; some will be amended long after final EIA and RAP reports are produced and made public. Only perhaps two or three project staff may know these amendments, some of which may have a direct bearing on the extent and magnitude of impacts. These may or may not be significant. The point is made that opportunities for misinformation and misunderstanding are many during the construction period and every effort has to be made to avoid these by establishing a first class public relations and communications system, and then using it vigorously.

The public is also keenly interested in dam safety. In Dal's case, this means people downstream of the dam in Sudan and along the shores of Lake Nasser/Nubia and at High Aswan Dam.

Mitigation

The project will need to develop a first class public relations and communications system for all aspects of the project, including grievance procedures and dam safety related matters.

6.5.27 Dam and Public Safety

The 30 m high concrete faced rockfill dam proposed for Dal is considered by many to be among the safest types of dams. However, the consequences of dam failure, failure of other structures and mechanical equipment or mal operation (e.g. spillway gates) and failure of warning systems could be catastrophic, not only for the Dal project itself but also at all places along the Nile downstream. This is one of the reasons that owners of a new major dam employ an independent Panel of Experts (POE) to review design and design changes and inspect the construction works closely. The POE also, importantly, reviews the engineering operation and maintenance plans for the project and insists on failsafe systems being adopted. The POE also includes in its brief oversight of hazards plans including those for flood forecasting and flood warning.

Mitigation

A dam safety Panel of Experts is required, and for its findings to be made known to the public at all times.

6.5.28 Environmental and Community Protection

It is believed that the magnitude and extent of environmental and social impacts that have been considered in this report are large and serious enough to require the Owner to appoint an independent Panel of Experts for the Environment and Community Protection. The composition of this panel is a matter for the future but this report indicates that special expertise in environmental offset planning and management, resettlement and archaeology will be required as a minimum. Consideration should be given to appointing a female specialist for work on resettlement, as half of the resettled communities are female and most are Muslim.

Mitigation

An Environmental and Community Protection Panel of Experts is required, and for its findings to be made known to the public at all times.

6.6 CONSTRUCTION AND IMPOUNDMENT IMPACTS IN EGYPT

6.6.1 Introduction

The assumption is made here that the future planning stages of this project will continue to fully involve Sudan and Egypt, as occurs through the Permanent Joint Technical Committee established by the Nile Waters Agreement. The logical sequence of this is that all parties will have contributed to planning, and agreement will have been reached on the downstream release requirements and downstream mitigation measures.

6.6.2 Water Resources Impacts and Socio-Economic Impacts

The physical impacts and timing of river diversion and reservoir first filling are described in Section 6.2 and Table 6.2.

The determination of the downstream release regime during river diversion and during first filling of the reservoir (and during operations) requires thorough consideration and agreement with authorities in Sudan and Egypt. The agreed release rates will be incorporated in the project EMP.

As stated earlier, Dal's gross storage capacity of 2.47 billion m^3 (Table 6.3) is relatively small and Dal reservoir should be filled rapidly. This was illustrated by the fact that the average flow of each of the 10 months from March to December is greater than this volume, and that less than one week's average flow in August is capable of filling Dal reservoir to capacity. Thus first filling will have the impact of reducing Lake Nasser/Nubia's level and surface area.

Assuming first filling occurs when Lake Nasser/Nubia has a level of 175 masl, the reduction in level and surface area would be in the order of 0.5 m and 170 km^2 respectively. If first filling occurs when Lake Nasser/Nubia has a much lower level, say 165 masl, the reduction in level and surface area would be in the order of 0.75 m and 95 km^2 respectively. These ranges are illustrated in Table 6.9.

Table 6.9 : Indicative Changes in Lake Nasser/Nubia with Dal First Filling

Lake Nasser/Nubia				
Level range **masl**	**Capacity range** **Billion m^3/m**	**Surface area** **km^2/m**	**Change in level with Dal first filling with 2.47 billion m^3**	**Change in surface area with Dal first filling with 2.47 billion m^3**
175 - 170	4.74	172	-0.52	-171
165 - 160	3.28	126	-0.75	-95

The impact will be less than that caused by first filling of Merowe, which has larger storage capacity.

These changes are not expected to have significant adverse impacts on fisheries, agriculture and settlements and navigation at Lake Nasser/Nubia (Chapter 5) but in this harsh desert environment any small adverse impact on family income or expenditure can make livelihoods more difficult. The changes in lake level will also impact on power generation at Aswan. These relatively small impacts will necessarily be cumulative impacts following first filling of Merowe and any other upstream storage schemes constructed before Dal.

Mitigation

Mitigation measures regarding downstream releases will be required to be presented in the project EMP regarding river diversion and reservoir impoundment.

Future studies will need to consider the need for physical, biological and socio-economic or other compensation mitigation measures around Lake Nasser/Nubia, and compensation for reduced power output at Aswan.

Some additional fish stocking may be required but the principal compensations appear likely to be related to increased pumping costs for farmers around the lake, and at Mubarak pumping station if it is operational, and to reduced power output at Aswan.

It is noted that precedents for compensation in Egypt as a result of river-based developments in Sudan are currently occurring as a result of the on-going construction of Merowe hydropower project which has greater impacts than Dal on inflows to Lake Nasser and Lake Nasser water levels.

The mechanisms for assessing compensation, and a grievance procedure, will require to be determined as a result of further consultations during feasibility studies of Dal. Future studies should assess the legal framework, all types of compensation and alternative mitigation measures and should elaborate the negotiation and grievance procedures by concerned parties.

6.6.3 Water quality impacts

These have been discussed above. Impacts are likely to be negligible and unnoticeable in Egypt.

6.6.4 Sedimentation and Morphological Impacts

Dal reservoir sedimentation will begin when first filling begins in the construction period and continue throughout the life of the project. Impacts on High Aswan Dam and Lake Nasser/Nubia will be positive because sediment stored in Dal reservoir will reduce sedimentation downstream.

6.6.5 Trash Loads

As mentioned for the downstream Nile reach in Sudan, some temporary additional trash loads may be expected. The duration of the impact is expected to be short because the amount of material is relatively small. The impacts may be insignificant but some fishermen’s nets may be troubled by additional floating and semi-submerged materials in Lake Nasser. Some aquatic species will benefit from this moving woody habitat.

Mitigation

Dal reservoir basin clearance needs to be effective. This aspect requires to be fully considered in future studies with mitigation measures being included in the EMP with regard to reservoir basin clearance.

6.6.6 Dam and Public Safety

The 30 m high concrete faced rockfill dam proposed for Dal is considered by many to be among the safest types of dams. However, the consequences of dam failure, failure of other structures and mechanical equipment or mal operation (e.g. spillway gates) and failure of warning systems could be catastrophic, not only for the Dal project itself but also at all places along the Nile downstream. Impacts of catastrophic failure would be felt in Lake Nasser, along shorelines and, although with huge attenuation, at High Aswan Dam. This is one of the reasons that owners of a new major dam employ an independent Panel of Experts (POE) to review design and design changes and inspect the construction works closely. The POE also, importantly, reviews the engineering operation and maintenance plans for the project and insists on failsafe systems being adopted. The POE also includes in its brief oversight of hazards plans including those for flood forecasting and flood warning.

Mitigation

A dam safety Panel of Experts is required, and for its findings to be made known to the public at all times, including stakeholders in Egypt.

7. OPERATIONAL IMPACTS AND MITIGATION MEASURES

This chapter considers impacts and mitigation measures from the time of reservoir first filling.

Section 7.1 describes the overall situation expected in the Dal area at the beginning of the operations phase.

Section 7.2 introduces the principal hydrological impacts of the operation of Dal reservoir, and the alteration of downstream flows.

Sections 7.3 and 7.4 consider principal impacts on the biophysical and socio-economic environments in the Dal region respectively – the direct impact zone.

Section 7.5 summarises operational phase impacts downstream of Dal – the secondary impact zone in Sudan.

Section 7.6 considers operational phase impacts in Egypt – the remaining part of the secondary impact zone.

Section 7.7 summarises the principal benefits of the project and adverse impacts with expected mitigation measures.

7.1 SITUATION AT BEGINNING OF OPERATION PHASE

Major impacts and mitigation measures for the construction period have been scoped in Chapter 6. This has included the time when turbines are tested and the power station is commissioned. At this time, Dal reservoir's storage contents are somewhere between MOL and FSL (the 2 m range is very small) and some power is being dispatched to consumers.

By this time, most of the construction workforce has long since disappeared from the camps, and (almost) all of the mitigation and enhancement works relating to contractors have been implemented and completed. Also, the resettled communities will have been living at their new village sites for some years.

A small settlement will have become established at Dal, with former senior staff houses built for the construction period now being occupied by operational staff. Some shops, a restaurant or two, a police post, sports grounds, a school, clinic or small hospital, gardens and recreational facilities will exist, with treated reticulated water supplies and sanitation provisions. An airstrip for small aircraft, if developed for the construction period, will continue to provide services, as may be needed. Modern communication facilities will exist, providing telephone, Internet and TV services in this formerly remote area.

Importantly, a new bridge across the Nile may exist downstream of the dam, linking west and east banks, or the dam itself may be used for pedestrian and vehicle crossings.

By taking the time when Dal is commissioned as the cut-off point between construction and operation phases, and acknowledging that this is in practice a transitional phase extending over a few or many months, the majority of environmental and social impacts of the project have already been felt, as described in Chapter 6. Some of these impacts continue occurring in the operation phase and this has been already foreseen and introduced in the impacts and mitigations described for the construction phase. It is not the purpose to scope all these issues again here. This section therefore limits itself to mentioning important impacts in the operational phase, including some begun during construction, which will require continuing emphasis and follow up in EIA and RAP studies.

The major issues that will require overriding emphasis in the operational phase relate to the following: Environmental management and monitoring; Resettlement, development activities and monitoring; Dam Safety; Watershed management; Reservoir management; and Public Relations, Communications and Environmental Awareness. The need for these is apparent in this chapter.

7.2 HYDROLOGICAL IMPACTS

The primary operational impacts on environment of the Dal hydropower project are hydrological and extremely small. This is because the scheme is operated as a run-of-river project, using the net head available from the Full Supply Level (average 18.3 m). The storage is effectively unused. Most other impacts are secondary or tertiary, and very small. Before considering operational impacts in this chapter, summary results of simulation of reservoir behaviour and downstream flows are described. These simulations have been carried out to estimate the energy characteristics of the potential alternative scheme configurations of the Dal project.

The simulations have been performed employing a program named RAPSO that has been developed over a long period of years to represent seasonal and annual operation of any combination of hydroelectric schemes. The RAPSO model was set up and calibrated for the recent National Electricity Corporation (NEC) long-term power system planning study to represent all existing and potential schemes in the Sudanese Nile system. The RAPSO model network is shown in Figure 7.1 and is fully described in the Pre-feasibility engineering report.

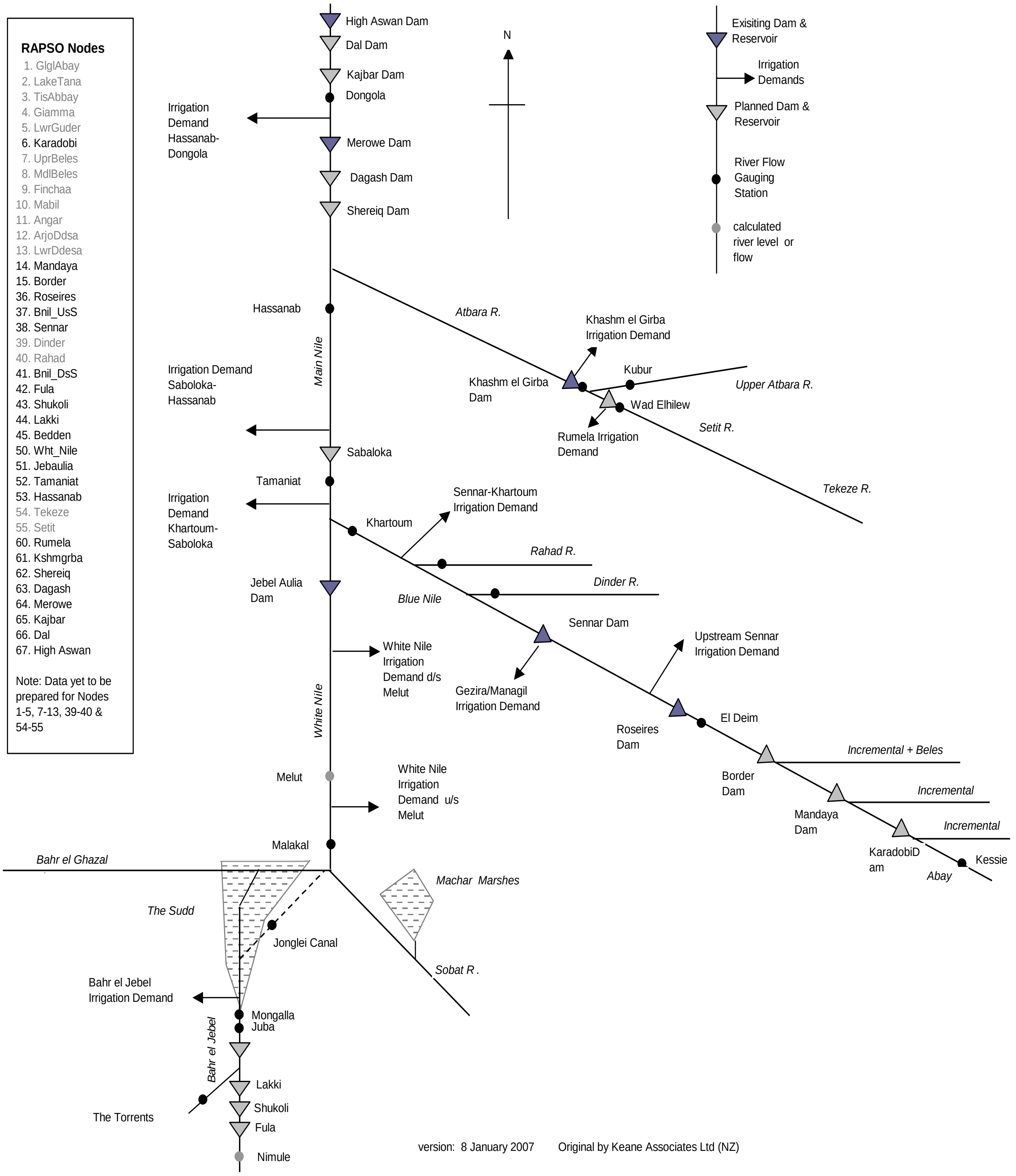


Figure 7.1: Abbay and Nile system as modelled with program RAPSO

It is repeated here that dimensions of the Dal hydropower project (described in Chapter 3 and summarized in Table 7.1) are adopted for pre-feasibility study purposes. However, they are not optimized. The reservoir elevation/capacity/area relationship adopted in this study is considered reasonable but not precise because no contour maps are available. Similarly, dam height, Full Supply Level, Minimum Operating Level, reservoir surface area, installed capacity, and regulation release patterns are not optimized and may change in any detailed feasibility studies that follow.

Table 7.1: Dal Reservoir – Levels, surface area and storage volumes

Reservoir Level Characteristic	Level masl	Surface Area km^2	Volume $m^3 \times 10^9$
Full Supply Level (FSL)	201	300	2.47
Minimum Operating Level (MOL)	199	250	2.12
Difference between FSL and MOL	2	50	0.35

7.2.1 Summary of simulations of reservoir and power plant operation

It may be seen that reservoir level vertical range is very small, only 2 metres. The reservoir surface area at FSL is 300 km^2. At MOL (the area permanently inundated) the surface area is 250 km^2. The operational surface area, which is variously inundated and exposed to air, is 50 km^2. Therefore, in Dal's case, the water surface area will always be large and normally close to 300 km^2.

A 10-day inflow database was used for Dal reservoir simulations for the 50-year period January 1954 – December 2003. Components of the 50-year reservoir water balance generated by simulation of the project are presented in Table 7.2 where it is noted that 62% of flows are used in power generation and 37% discharge through the spillway. A relatively small quantity of water, in terms of mean annual flow, is lost to evaporation (1%).

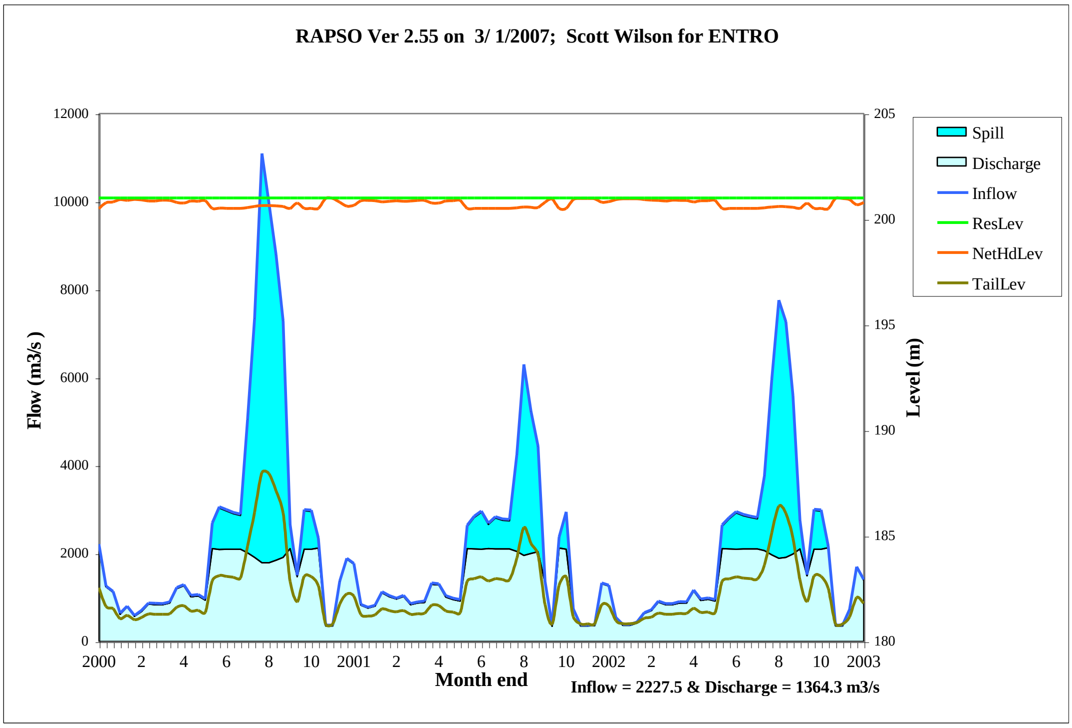
Table 7.2 : Dal reservoir 50-year water balance

Water balance component	Quantity m^3/s	Proportion of mean annual inflow %
Mean Annual Inflow	2,280	100
Turbined flow Spillway flow Total Downstream Flow	1,409 844 2,253	62 37 99
Evaporation losses	27	1
Mean of all outflows	2,280	100

Source: reservoir behaviour simulations, this study

7.2.2 Flood Flows

Under the proposed run-of-river operating regime, the downstream flood flows will be as received at Dal reservoir except for some minor attenuation and minor evaporation losses. Three year's annual floods are illustrated in Figure 7.2 where about 2,000 m^3/s is passing through Dal's turbines and the remaining through the spillway gates. In this simulation run, the scheme was operated at FSL throughout (without any reservoir drawndown of 2 m) and the constant reservoir level at 201 masl may be seen at the top of the diagram. Because of high tailwater levels during large flood flows, the net head varies and can fall to just over 14 m.



Source: RAPSO model output, this study

Figure 7.2 : Operation of Low Dal with 8 x 50 MW

7.2.3 Dry Season Flows

Again, under the proposed run-of-river operating regime, the downstream flows in the dry season will be as received at Dal reservoir except for evaporation losses. In this case, all downstream releases pass through the turbines.

7.2.4 Downstream Flows and Dangers

Thus, under the proposed operation as a run-of-river scheme, riparian settlements downstream will receive high and low flows more or less as normal. The losses in flows caused by additional evaporation and by flood attenuation of the reservoir will barely be noticeable.

However, whilst this is generally true with regard to flows over several days and over the seasons, flows will not be same on a short-term basis as if the Dal project does not exist.

Firstly, the turning on and turning off of turbines, and the opening and closing of spillway gates, can cause rapid changes in flow conditions downstream. Many lives are lost because of this.

Secondly, if the operating regime at Merowe and/or Dal changes, i.e. from run-of river to some diurnal peaking (using the available storage capacity of the reservoir for this), changes from the normal flow regime will be noticeable. This may happen in future and this would require a special study of impacts.

7.3 PHYSICAL AND BIOLOGICAL IMPACTS – DIRECT IMPACT ZONE

The project's Environmental Monitoring Unit (and Resettlement Monitoring Unit) is expected to continue with its monitoring roles for some years, involving continuing close relationships with Dal project's management, local administration units of Wadi Halfa and Northern State's headquarters in Dongola.

Having developed experience of impact monitoring during the construction phase, the EMU will be well placed to develop a management and monitoring plan for its work for say, a five year program, and for individual years within that program. In collaboration with Dal's project management, the Northern State Council for Environment and Natural Resources and relevant government and research departments, and environmental agencies in Egypt, the EMU's important roles are likely to relate to the following aspects.

7.3.1 Water levels, flows and sediment concentrations

Dal's engineering managers will obtain reservoir water level and tailrace level records as a routine. A system is required to produce an ongoing water balance for the reservoir which will give outflows (turbined flows produced from megawatts generated, and spillway flows), net evaporation (losses from reservoir surface areas, rainfall, if it occurs, and adjusted evaporation pan measurements) and any changes in storage and derived inflows. Engineering hydrologists require this data. It is envisaged that the EMU will contribute to this, and ensure all necessary monitoring continues competently.

Not only are hydrological records required as good practice, they are needed with regard to compliance with the Permanent Joint Committee of Sudan and Egypt and any other institutional/legal arrangement which may apply to the Dal project. Thus records of downstream discharges and evaporation losses will be required as evidence of Agreement conditions being met, including any prescribed minimum flows to maintain acceptable conditions in the event of scheduled or unscheduled maintenance and plant shutdown. These conditions may change as years pass and experience is gained. The earlier records will be essential for reviewing releases and considering or proposing new ones.

It is not expected that a river gauging station will be installed downstream of Dal dam site during feasibility studies because the long cataract reach is unsuitable for calibration and after it finished the Nile is potentially within the backwater effects of Lake Nubia when at a high level. The reservoir water balance method is therefore expected to be used for reconstituting a flow record, as described. This would supplement records at Dongola and confirm the water resources at Dal as being nearly identical to Dal, or otherwise. This work will inevitably be facilitated by good accommodation for Ministry or NEC hydrologists being available at Dal.

At intervals of say five years, reservoir sedimentation surveys may be required for operational purposes, in particular to revise the elevation/storage curve and revise assessment of live and dead storage. This could become more important if the mode of operation changes in future from run-of-river operation to include some diurnal and/or seasonal peaking. A boat with specialised equipment will be required for this. Arrangements for these surveys will be made by the project Owner.

The results of these surveys, and the monitoring results of sediment transport downstream of Dal dam will also be required by agencies implementing the Blue Nile and Atbara watershed management programs and by authorities in Egypt concerning sedimentation surveys and estimates in Lake Nasser/Nubia.

The need for laboratory facilities at Dal in the operation phase should be considered before project construction commences. The contractor will establish a materials testing laboratory for the construction phase and the Owner, EMU and others may require this facility in the operations phase (for analysis of suspended sediment samples, river and reservoir water quality samples, well and borehole water samples, etc).

7.3.2 Reservoir Yield - Sedimentation

Dal's gross storage volume (2.47 BCM) is subject to siltation.

There is a high level of uncertainty regarding many of the estimates involved in deriving a sediment balance for the Nile given that many of the individual components of the balance are highly variable from year to year and that measurements are infrequent and imprecise. Some data is now more than 40 years old whilst it is anticipated that sediment discharge will have increased over this period due to pressures of population, agriculture and deforestation.

Although the overall balance of sediment along the Nile downstream of Merowe is uncertain, the average sediment discharge at the Dal site following construction of the Merowe project can probably be expected to lie within the range 75Mt to 100 Mt, depending on the effectiveness of the sediment flushing regime at Merowe. Much of this sediment will be very fine grained and will have a lower trapping efficiency in Dal than would be the case without Merowe upstream. A trapping efficiency of 55 % has been estimated for Dal based on Brune's relationship for primarily fine grained and colloidal particles and assuming that sediment flushing at Dal would not take place. Under these circumstances it is anticipated that sediment deposition in the Dal reservoir will be some 40 - 55 Mt/year, or some 30 – 40 Mm^3/year.

The impact of reservoir sedimentation on Dal's yield for power generation has not been studied, it being largely irrelevant for the run-of-river mode of operation. Over the course of time, the mode of operation may change and the loss of storage capacity in the live storage zone will become increasingly important and consequential.

Mitigation measures have been discussed in Chapter 6.

7.3.3 Reservoir Yield – Climate Change

Dal's future inflows have been assumed to be similar to past records. No adjustment for climate change is currently justified because there is no agreement among scientists on the impact of global warming on annual rainfalls in the Blue and White Nile catchment areas.

7.3.4 Reservoir Yield – Water supplies, Irrigation and Water Transfers

The known major consumptive use abstractions in the White, Blue and Main Nile sub-basins have been deducted from Dal's reservoir inflows in RAPSO model simulations in order to be as realistic as possible about power generation at Dal.

In future studies, the flow record will need to be worked up and documented thoroughly, and naturalised for historical consumptive use abstractions. It is then that future projections of consumptive use abstractions will be required, and deducted from the naturalised inflow record. Apart from allowing for growth in existing consumptive use, account can then be taken of proposals for new irrigation schemes and any water transfers out of the Nile watershed area.

Power generation may be expected to reduce as upstream consumptive abstractions increase. There are two features that may counterbalance this. Firstly, any measures taken in the White Nile basin to reduce evaporation losses, as mentioned in Chapter 4, would increase flows at Merowe and Dal. Secondly, any upstream regulatory storage developments on the Blue Nile (e.g. Karadobi, Mandaya and/or Border) would increase power generation at Dal by converting some of the spillway discharges into turbined discharges. This is illustrated for Dal "with Mandaya" in Chapter 3.

7.3.5 Reservoir and Downstream River Water Quality

Impacts on water quality in the operational period are expected to be insignificant. They may be estimated, as stated earlier, by use of a water quality model during feasibility studies.

The EMU with the project Owner will need to prepare and implement a water quality monitoring program for Dal reservoir and its releases downstream (both turbined discharges and spillway discharges). A boat will be required for reservoir surveys. Samples should be taken from a network of locations at different depths and the results archived and plotted. As the record continues, it will assist understanding of any algae blooms, weed growth, changes in primary productivity, etc. Apart from usual physical and chemical parameters, consideration should be given to monitoring suspended sediment in turbined and spillway discharges – monitoring which is often overlooked. Concentrations will change according to seasons, and according to the changing trap efficiency of the reservoir.

7.3.6 Climate

The EMU should continue climatological records begun at Dal during the construction phase. Micro-climate impacts of the reservoir are not expected to be significant but records should be collected for general purposes. The project climate station will be satisfactorily sited and these stations should therefore meet requirements of the state and national meteorological agency and be formally registered.

It could be argued that humidity levels will increase in the reservoir area because the mean annual evaporation estimated at 2,886 mm, equivalent to a constant loss of 27 m^3/s in river flow terms, must go somewhere. The atmosphere is so vast, and hyper-arid in the Nubian Desert, and the north winds fairly constant, that such quantities of added water content are miniscule. Nevertheless, there may be occasions when calms occur and relative humidity is raised very considerably. This could have an impact on surface surviving artefacts of historical and archaeological interest. Specialist advice on this should be sought during future studies.

7.3.7 Groundwater, Water Supplies and Archaeological Sites

As noted earlier, groundwater levels will rise significantly around the reservoir in areas where rock types are not impermeable and geological structures are favourable. Such areas are not thought to be extensive but there are likely to be some. Once groundwater levels are established after first filling, they will remain constant if the Dal project is operated at FSL continuously. If reservoir levels fluctuate by one or two metres from the FSL, groundwater levels may adjust accordingly but probably not rapidly.

Whilst seepage losses from the reservoir are not expected to be significant from a project point of view, the availability of groundwater nearer to the land surface may be valuable as a new resource for water supply for existing communities and for any resettlement communities in the area.

On the other hand, any local increases in ground water levels approaching the land surface in flat terrain around the reservoir margins could have an impact on foundations of structures and artefacts of historical and archaeological interest. Water may be expected to rise by capillary action by at least one metre. This new source of moisture may have a rapid and disastrous effect on organic material in particular, but also on skeletal material that tends to explode on contact with water. Thus the rise in water table may affect sites of archaeological and other interests some considerable distance from the reservoir depending on geology and geomorphology of the area. Specialist advice on this should be sought during future studies.

Monitoring of any observation boreholes established in the construction period should continue in the operational period. Favourable areas should be considered for development of water supplies for local communities.

7.3.8 Wetlands Ecology

In the operational period, it is anticipated that environmental management will require wildlife habitat and wildlife surveys to be conducted around the reservoir margins, and for waterfowl surveys to be conducted and results submitted to Sudanese and international agencies that coordinate waterfowl monitoring and reporting in Africa (African Waterbird Census, International Waterbird Census, BirdLife International, Wetlands International).

7.3.9 Aquatic Life and Fisheries Development

In the operational period, it is anticipated that reservoir management will require aquatic surveys to be conducted in Dal reservoir and adjacent tributary khors, and that these may be coordinated with aquatic surveys in Merowe reservoir upstream and Lake Nubia downstream. Surveys will include phyto-plankton, zoo-plankton, benthic fauna and fish. Such surveys should also be coordinated with water quality surveys if possible, or at least utilise the results of water quality monitoring.

Fish surveys should include information on fisheries development and management at Dal reservoir and the results used to inform and improve fisheries management of the reservoir.

The water quality, hydrological and aquatic surveys should contribute to a post-construction impact assessment of Dal reservoir, similar to the work of the Hydro-biological Research Unit for Roseires in the 1960s and subsequently, and as may be carried out for Merowe after some years of operation.

An opportunity to sample fish for research purposes may become available below Dal's spillway after spilling, and rarely at the Dal tailrace. Typically, numerous fish may be netted when spillway gates close and fish become stranded. To arrange for fish biologists to obtain these samples (for species identification, length, weight, sex, development of gonads, etc), good awareness and coordination is required between the project owner (who anticipates the closing of one or more gates), EMU and research agencies. These opportunities are frequently unrecognised and not used. Fish in this sampling, as has been done occasionally below Roseires reservoir, may or may not be distinct from fish in the reservoir and much additional information may be learned about the Main Nile's fish population and migratory habits from this. This may contribute to exploitation and conservation practices, and assist planning of other water resources developments in future.

In keeping with the bi-national aspects of Dal's development, continuing close liaison with Egyptian authorities is expected to continue in the operational phase. It is clear from CRA reports (mentioned in Chapter 5) that the need for exploiting Lake Nasser/Nubia fisheries at a high sustainable level is increasingly important, and there can be great value in future cooperation and sharing information about aquatic life and fisheries developments of lakes Merowe, Dal, Nubia and Nasser.

7.4 SOCIO-ECONOMIC IMPACTS IN OPERATION PHASE

As stated earlier, by taking the time when Dal reservoir first fills as the cut-off point between construction and operation phases, the majority of environmental and social impacts of the project, described in Chapter 6, have occurred by the beginning of the project operation phase. The major initial social impacts are over, such as the arrival and presence of a large construction workforce (now gone) and house and property moving of the resettled communities (now living at their new village sites for some years). A small town will have become established at Dal and, as anticipated earlier, rural electrification may have been extended, or still be in the process of extension, to rural areas between Dongola and Dal, and further north. The road network should also be improved by the project and be in good condition for everyone's use.

These new developments and improved regional communications should facilitate services required for the on-going care and development of the project's host and resettlement communities. It may be anticipated that the RAP and development plan will now have been updated by the RMU and local administration and provide for detailed monitoring of the mitigation measures implemented during the construction phase. Project funds, from Dal's income stream from energy sales, should be available for addressing residual liabilities of the project, in line with recommendations of the World Commission on Dams report in year 2000.

7.4.1 Electricity Supplies

Power generation from the project has been estimated by simulation of Dal reservoir behaviour with two installed capacities, 340 MW and 400 MW, over a 50-year period, giving average annual energy of 1,944 GWh/year for an installed capacity of 340 MW. The output increases by some 11% when the installed capacity is raised to 400 MW in order to capture more of the annual flood flows. Summary simulation results are presented in Table 7.3 for the Dal base case (as a stand-alone project), and for other cases as stated.

Table 7.3 : Summary Energy Simulation Results

Option	Full Supply Level (m)	Installed Capacity (MW)	Energy Output (GWh/year)
Low Dal	201	340	1,944
Low Dal	201	400	2,160
Low Dal with Mandaya	201	340	2,088
Low Dal with Mandaya	201	400	2,304

Some 10% or more of generated energy may be expected to not reach consumers owing to unavoidable transmission losses. The benefits of these additional supplies are legion, stimulating industrial developments and employment and improving civic and domestic living conditions in areas supplied.

Some idea of the potential sale value of the electricity generated at Dal may be gained by considering that the annual sale of energy (2,160 GWh/year) at US cents 4 per KWh implies sales worth some USD 86 million/year.

The generated energy will be transmitted to the Sudan grid at Dongola, outside of the direct impact zone. A local low voltage supply will be provided from the Dal power station to the project and project facilities (with diesel generator backup facilities). Extensions of this local distribution are not planned at pre-feasibility stages of planning but cases for negotiating greater rural electrification provisions in the future planning process have been made in Chapter 6, Section 6.5.21.

7.4.2 Resettlement, Development and Monitoring

The geographical spread of Dal project's resettlement locations is now unknown. Wherever resettlement takes place, the Dal project owner and financiers will wish to see and know that improvements have been achieved in living conditions in resettlement communities, and are continuing to improve in the project operation phase. With these and other points in mind, the RMU will have already sought to ensure, and will continue to monitor, that the following are satisfactory, or developing inexorably to a foreseeable satisfactory condition, for all people without exception:

- New houses
- Mosquito nets
- Water supplies
- Sanitation provisions
- Drainage arrangements
- Clinics, and qualified health care staff numbers
- Schools, and qualified teaching staff
- Community buildings and facilities, including market places
- Energy sources
- Shade trees

The RMU will also have already sought to ensure that livelihoods have been re-established and improved, including carrying out monitoring of the following:

- family incomes
- agricultural production
- tree production
- livestock production and grazing/crop residue resources
- other activities depending on location and resources

The RMU and the resettlement's agricultural research centre will also be responsible for ensuring on-going provision of satisfactory veterinary, agricultural, horticultural and other specialist advisory and treatment services.

In addition, RMU monitoring should cover households in the villages which were impacted by the Dal projected and remained in place. These may be households alongside upper reaches of Dal reservoir in Delgo administrative unit. These will have been compensated earlier for loss of livelihood resources, including some or all of their cultivated areas in the reservoir basin. Alternative sources of income generation are required to replace their losses (separately from the compensation). The RAP plan (and its updates) will cover these also.

7.4.3 Independent Auditing

At intervals, independent auditing and monitoring will be required for all host and resettled communities, and those remaining in the project area. Any targets set in the RAP and development plan, and in later editions (original targets, or otherwise subsequently revised) must be capable of being monitored realistically, and provide no possibility of political or other interference. Results of auditing and monitoring require to be made known to local communities and local administrations, Northern State government, civil society organisations (CSOs), NGOs and project financiers.

Failures to achieve targets should result in immediate measures to improve conditions. Financial provision for such contingencies to mitigate and improve conditions should be made available from Dal project's income stream, over and above annual allocations of funds. The mechanism for this needs to be established early in the project, and contractually agreed. The proposed independent Panel of Experts for the Environment and Community Protection during the construction phase should advise on this. The annual allocation of funds, and provision for contingencies, needs to be available through project management at Dal, with well-devised procedures involving stakeholders (possibly through a Trust Fund) to support a range of maintenance and development measures.

All of this needs to be on the agenda early in project preparation, and clarity sought about the roles of the regional government and the project. All provisions should be tabled and clarity sought on such things as who will pay for salaries of teachers, nurses, technicians and others in resettlement areas, maintenance of infrastructure, supply of drugs at clinics, replacement of mosquito nets, etc, and for how many years before any changeover from Dal project to State and local administrations. All of these things require to be worked out, declared and known by all.

7.4.4 Miscellaneous Important Matters

Scoping of principal social issues relating to the operational period has been outlined above. These need to be taken up in future RAP and development studies. There remain some related important issues about which brief comments are made in subsequent sub-sections.

7.4.5 Access across Dal reservoir

Large quantities of sediment will be deposited in Dal reservoir each year. Small ferry boats and footbridges across the narrowest sections of the reservoir are expected to be required in future. Ferries will have to operate over a small annual range of levels of about 2 metres. Because the topography is so flat, this small range may be associated with rather long muddy and slippery banks. The same applies to fishing boats. Ramps may therefore be required. As experience is gained, communities (supported by the RMU) may require improvements and more of these facilities. Budgets will need to make provision for these.

In terms of total expenditure, these are very minor; but in terms of local people's perceptions of the project, and fostering an attitude of care and goodwill, these small things matter.

7.4.6 Fisheries

Dal reservoir should offer sustainable employment and fish-related commercial opportunities. It is expected that fishing will be modernized and systematically developed for markets in the project and surrounding areas. Local capacities should be developed through training and adoption of appropriate technologies. With rural electrification in the area, as time passes, the conservation of fresh fish meat by chilling or freezing for marketing could offer an addition or alternative to sun dried fish. Budgets will need to make provision for the enlightened fisheries management and marketing.

7.4.7 Pollution

Although local pollution sources for Dal reservoir are not expected to be large, it is conceivable that portions of the reservoir may require special measures to prevent transmission of water-related diseases, local reservoir sedimentation and pollution by livestock and human populations. Any necessary restrictions will need to be explained to local communities and their support sought for them.

7.4.8 Archaeological and Historical Sites

Numerous archaeological and historical sites have been identified in the Dal project area. A major survey, excavation and salvage project will have been mounted in the pre-construction and construction period, possibly lasting more than 10 years. These will have attended especially to sites that would be directly affected by construction activities and reservoir impoundment. Sites above full supply level are also considered to be numerous. Some of these may be affected by increases in air humidity (though in the hyper-arid atmosphere at Dal, even with a reservoir, this may be most unlikely) and/or raised groundwater levels particularly, as already described above. Monitoring will be required. Any required remedial or additional salvage works should be supported by the project.

7.4.9 Employment

Relatively few employment opportunities will be created by the project itself in the operation phase. Most jobs available relate to very skilled, skilled and semi-skilled work. It may be hoped that some of these may go to local persons trained and apprenticed during the construction period. (The need for this training in the pre-construction and construction period was mentioned earlier in Chapter 6).

7.4.10 Commercial and Trade Opportunities

Commercial and trade activities may be expected to develop substantially in and around the project area because of new demands for goods and services at Dal New Town, resettlement areas and improved communications. However, these may grow further or stagnate according to the policy adopted on provision of rural electricity supplies.

7.4.11 Rural Electricity Supplies

It is often thought that new hydropower projects will provide electricity to surrounding areas, and at a “reasonable” tariff. Furthermore, it is argued that this provision will reduce dependence on traditional energy sources, and that this will contribute favourably to reducing erosion and maintaining wildlife habitat.

Unfortunately, this has rarely been the case in the past. High voltage transmission lines passing overhead are technically not suited to local distribution where low voltage lines are needed. These low voltage lines can be provided to the area from the project’s switchyard, and/or by extensions from the nearest areas currently supplied.

In the case of Dal, where a lot of land will be sacrificed for developments in faraway places, it may be very reasonably argued that the project should look after and pro-actively promote development of surrounding areas. The potential for this in the Dongola area will exist when power generation at Merowe begins. NEC plans for rural electrification in the Delgo, Abri and Ferka areas have not been seen for this study and they may be well advanced. This is scoped here as a major issue for the project promoters and Northern State government.

7.4.12 Public Relations, Communications and Grievances

As foreshadowed in the construction phase, opportunities for misinformation and misunderstanding are many and every effort has to be made to avoid these. In the operations phase of the project, the public relations and communications system will need to continue. The principal operational impacts are mentioned in this section but the residual population around the reservoir and in downstream areas will be keenly interested in how operational impacts will affect them.

The project will need to continue with a first class public relations and communications system for all aspects of the project and care taken that it reaches all relevant stakeholders effectively.

7.4.13 Dam and Public Safety

Reports of the Panel of Experts on dam safety will have been made available to the public during the construction phase. In the operation phase, there will be keen public interest in engineering operations at Dal, including releases of water according to the agreed program, maintenance of failsafe systems for flood forecasting and warning, and the operation of spillway gates.

7.4.14 Project Induced Developments

Project induced developments are commonly overlooked in project design and implementation. They are related to secondary growth that could arrive or pre requisite the project implementation. These induced impacts cannot be predicted on a reliable basis, rather suggested based on experience of implementation of similar projects in the region and elsewhere.

The scale of the proposed project development requires a large skilled and unskilled labour force brought mainly for the six year project construction period. This is a long period during which there will be impacts on traditional communities. The present poor infrastructure, economic opportunities and other services will be improved spontaneously due to the project implementation; this may later attract people from the surrounding areas and from further a field. In-migration could be temporary or permanent. The experience of hydropower development construction sites elsewhere shows that small construction sites can be transformed into large towns and commercial centres. The major impacts associated with project induced developments include: -

- Pressure on existing public services and institutions including water supply, health and education
- Increased pressure on health and sanitary facilities
- Breakdown of traditional methods of social control

Mitigation measures for these can include:

- Training local people beforehand, especially for the less skilled jobs, making special efforts to provide training for local people; improving transport facilities to and from the site to enable local people to work at the sites.
- Planning new infrastructure and services adequately for the voluntary immigrants as well as the unknown numbers of construction workers coming to the project area.
- Promoting investment in local resources such as fisheries, poultry and others to improve the local resource base and capacity to produce food or services for sale to the migrants.
- Locally, strengthening existing institutions or developing new ones to undertake long-term development and regional planning that addresses changes, to handle an increased number of disputes and social problems, and to accommodate a much more diversified population.
- Planning adequate health, drinking water and sanitary facilities to deal with the unexpected rise in the incidence of disease and pest problems.

With these points in mind, attention has been drawn earlier in this report to implementing health education/awareness and improving health services to vulnerable communities (for those not specifically included in RAP and associated development plan); implementing plans for preferential employment of local people, with training; making salvaged timber from construction sites, including reservoir basin clearance, available to local communities; and accelerating plans for rural electrification in the region. These are specifically mentioned in the draft EMP in Chapter 9 where the plan also includes a requirement to anticipate, plan for and implement measures for non-specified project induced developments.

7.5 OPERATIONAL PHASE IMPACTS DOWNSTREAM OF DAL IN SUDAN

Some of the impacts on the lower reaches of the Nile experienced in the construction phase will continue in the operational phase. Mitigation measures carried out earlier will apply (Section 6.5.25).

7.5.1 Sedimentation and Morphological Impacts

Reservoir sedimentation will continue throughout the life of the project. Impacts on High Aswan Dam and Lake Nasser/Nubia will be positive because sediment stored in Dal reservoir will reduce reservoir sedimentation downstream.

The reduction in downstream sediment loads will reduce the annual dressing of silt given to cultivated alluvial areas (as a free fertilizer) along the Nile during the annual flood. This is covered under Recession Agriculture below.

Downstream flows will be more or less at the inflow rates to Dal reservoir, minus evaporation losses. Thus the annual flood will pass through turbines and the spillway without noticeable change in flow rates downstream. Because the annual flood passing from the dam downstream and other flows will be similar to inflows but convey less sediment, some morphological changes may be expected in the river channel downstream. These are unlikely to occur and be noticeable in the several kilometers of hard rocks in the Dal downstream cataract but begin after the cataract reach.

Mitigation

Monitoring of this by the project Owner and EMU will be required. Some river training works, bank protection and other measures, additional to measures already taken in the construction period, may be required.

7.5.2 River Crossings and Safety Issues

Safety issues should always have top priority. There are always, without exception, possibilities of injuries and fatalities downstream of dams. Downstream families become accustomed to routine flow releases, and the years pass without mishap. But a change in operations at Merowe causing a change at Dal, or a change in operations at Dal (e.g. to provide diurnal peaking), could cause greater turbined flows or spillway gate(s) to be opened unexpectedly, even out of season, with people downstream completely unaware and oblivious to the Dal Owner's change in operations.

Mitigation

Warning measures will be required in advance of changes in releases. These measures should be included in the Owner's requirements and made known to all potentially affected stakeholders along the river downstream. These include farmers, fishermen and boat operators, indeed all persons who may have close contact with the river and riverbanks. The warning systems adopted should be tested regularly.

7.5.3 Recession Agriculture

During the operational period, spillway discharges at Dal will be frequent. In the three years shown in Figure 7.2, one or more spillway gates are operating for six periods of time.

The amount of flood recession agriculture (gerouf) in this downstream reach has not been assessed but it may extend to and through Akasha to near Wadi Halfa and to “islands” of sediments in Lake Nubia. Relatively small variations in river flow caused by the Dal project appear unlikely to adversely affect these areas, and in the lower reaches they may be more influenced by Lake Nubia’s changing levels related to operations at High Aswan Dam rather than Nile flow releases from Dal. However, if productivity is reduced and ascribable to Dal’s operations, compensation claims may be expected and justified.

Mitigation

In the operational period, mitigation measures, if required, could be in the form of monetary compensation for loss of production. Alternatively, pumps could be supplied by the project for irrigation of the land in anticipation or following any damage to gerouf cultivation caused by the project.

With regard to mitigation for reductions in silt deposits downstream, some use of artificial fertilizers may be expected. However, most of the clay fraction and fine silt components of the suspended sediment loads of the annual will continue to be conveyed by turbines and the spillway. Future studies should consider the need for artificial fertilizers to substitute and compensate for reduced alluvial depositions in the downstream reach.

7.5.4 Evaporation and Water Allocation

Mean annual evaporation at Dal reservoir is estimated at 866 Mm^3/year (2,886 mm on 300 km^2, or equivalent to a constant loss of 27 m^3/s in river flow terms). The additional evaporation loss compared to normal evaporation from the natural river surface area (320 Mm^3/year) may be estimated at 546 Mm^3/year. According to the Nile Waters Agreement, this additional consumptive use of water, whatever the average figure is agreed and adopted, will become a part of Sudan’s allocation of 18,500 Mm^3/year. The amount given above is about 3% of the allocation. It is an undesirable loss but one which is inevitable when a large water surface is created in the hyper-arid environment of the Nubian Desert.

7.6 OPERATIONAL PHASE IMPACTS IN EGYPT

7.6.1 Reduction in Sediment Loads

As mentioned earlier, reservoir sedimentation will continue at Merowe and Dal throughout the life of the projects. Impacts on High Aswan Dam and Lake Nasser/Nubia will be positive because sediment stored in Merowe and Dal reservoirs will reduce sedimentation in Lake Nasser/Nubia.

7.6.2 Reduction in Lake Nasser/Nubia Level

Once first filling is achieved, Dal will release Nile flows just as received from Merowe upstream because it is proposed to operate Dal as a run-of-river power station. At any time, releases will be turbined flows only, or turbined flows plus spillway flows (Figure 7.2). Thus, in the operational period, Lake Nasser/Nubia will receive inflows more or less as before.

There are two exceptions. The total flow released will be reduced by Dal reservoir evaporation, estimated at 546 Mm^3/year, as described above. Secondly, if some of Dal's storage capacity is utlised for peaking, there will be some diurnal variations in outflows.

The general impacts of Dal's operations on Lake Nasser/Nubia's levels are therefore expected to be small. However, they will be cumulative because of Merowe's first filling, Merowe's operational evaporation losses, Dal's first filling and Dal's evaporation losses. Thus, care needs to be taken in feasibility studies to assess the potential cumulative impacts on Lake Nasser/Nubia levels of the first filling and evaporation losses of Merowe and Dal, and to consider the impacts and mitigation measures taken in Dal's construction period for the operational period also. These relate to the lake fisheries, agriculture (and additional pumping costs), settlements and navigation and power generation at Aswan.

Mitigation

In the operational period, some mitigation measures, if required, could be in the form of monetary compensation for loss of fisheries and agricultural production. Also, for additional pumping costs and reduced power generation at Aswan. Where physical or biological measures are available, these should be considered. For fisheries, additional stocking with fingerlings may be required. For navigation, some works at moorings, jetties and pontoons may be required.

The resolution of mitigation measures and compensation may not be straightforward. The relatively small lowering of Lake Nasser/Nubia levels caused by first filling and by evaporation losses at Dal (and Merowe) may to some extent be compensated by Lake Nasser/Nubia's surface area being smaller and reducing evaporation losses from the lake. Also, the reduction in sediment deposition in Lake Nasser/Nubia has some value in the long term, causing the Nile's water yield to Egypt and Aswan's power generation to be sustained for longer than otherwise.

7.7 SUMMARY OF DAL'S PRINCIPAL IMPACTS AND MITIGATIONS

The major impacts of the Dal project described in Chapters 6 and 7 are summarised in Table 7.4

Table 7.4 : Summary of Principal Project Impacts of Dal Project

Positive Impacts	Principal Benefits	Negative Impacts	Mitigation measures
Sudan			
Dal project	Dal power generation, a substantial national energy benefit	Major involuntary resettlement (42,000) of Nubian people, with cumulative impact following involuntary resettlement for High Aswan Dam (53,274)	Resettlement and development program
Dal project	Construction employment, new skills for the future	Major loss of Nubian cultural heritage	Major archaeological surveys, excavations and dismantling of Temple of Amenhotep III and rebuilding it on new site
Dal project	New roads, Nile crossing at new bridge or across dam, promoting local area development	Loss of wildlife habitat and wildlife	New reservoir wetland and development of fisheries industry
Dal project	Extension of rural electrification	Loss of date palm and agricultural production	Development of irrigated date palm and agricultural production at resettlement sites
Dal project		Additional evaporation loss from Sudan's water allocation	No physical mitigation other than improving water use efficiency elsewhere
Egypt			
Dal project	Reduction in sedimentation in High Aswan Dam. Long term benefits for sustaining power generation and water supplies downstream of Aswan	Reduced level of Lake Nasser	Increase fish stocking Navigation works at jetties and pontoons Compensation for additional pumping costs for irrigation and water supplies Compensation for reduced power generation at Aswan
Regional			
Dal project	Carbon emissions savings of some 68 million tonnes compared with equivalent thermal generation		

8. PROJECT ALTERNATIVES

8.1 PROJECT LOCATION

There are alternative hydropower sites upstream of Dal at other cataracts on the Main Nile. It is understood that the Dams Implementation Unit is currently investigating these at feasibility level. Because of the low topography associated with each cataract site, impoundments may be expected to have large reservoir surface areas exposed to evaporation and therefore high evaporation losses. Development of any of these will reduce the amount of usable water for other purposes: irrigation, public water supply and industrial use.

There are alternative hydropower sites on the Abbay river in Ethiopia: Border, Mandaya, Mabil, Beko Abo and Karadobi. Their locations provide relatively low evaporation rates and their topographies provide greater head for power generation. Any one of these would require much less involuntary resettlement and, subject to further investigation, no known loss of physical cultural resources. Additionally, development of one or more of these would provide major uplifts in energy generation in Sudan’s existing hydropower cascade at Roseires, Sennar and Merowe. In the case of Mandaya, the estimated uplift in the Sudan cascade (2,211 GWh/year) would be greater than the energy generated at Dal (2,160 GWh/year) and this could be achieved without additional capital expenditure.

8.2 DAM ALIGNMENT

Within the Dal dam site area, the topography and geology offer several alternative alignments. There is currently no detailed topographical mapping to assist optimisation of the dam alignment.

8.3 FULL SUPPLY LEVEL

The Full Supply Level (FSL at 201 masl) is for “Low Dal”. It is at or close to the maximum possible for the site without adversely affecting the Kagbar cataract upstream. In this pre-feasibility study, the project is operated as a run-of-river scheme with more or less constant head, and is therefore not for flow regulation.

Higher levels are possible (as for the High Dal scheme) but this would cause much greater involuntary resettlement and a greater permanent loss of physical cultural resources.

A lower FSL is possible. It would provide a smaller head and less firm energy generation, less involuntary resettlement and smaller permanent loss of physical cultural resources.

The elevation/capacity/area relationship adopted is based on cross sections taken at 5 km intervals, not on detailed topographic mapping. The accuracy in estimates of reservoir storage capacity and surface areas is unknown.

8.4 MINIMUM OPERATING LEVEL

In this pre-feasibility study, the project is operated as a run-of-river scheme with more or less constant head. Adoption of a Minimum Operating Level (MOL at 199 masl) some 2 m lower than FSL provides some flexibility in operations but essentially FSL and MOL are one and the same. As mentioned above, FSL/MOL could be higher or lower but would have to be within a sensible range for power generation for technical reasons. Optimisation studies would be required in a feasibility study, making use of new topographic mapping.

8.5 PRESCRIBED FLOWS

The mode of operation of the Dal project is run-of-river. Flows received are released through turbines up to their capacity; any surplus inflows are released as spillway flows. In the RAPSO modelling, no prescribed monthly flows for Dal releases were required for this mode of operation - the river downstream receives flows as usual, excepting losses from evaporation. These losses average 27 m^3/s over the 50-year simulation, and vary between a minimum of 19 m^3/s in December and 34 m^3/s in May.

If alternative modes of operation – utilising storage for diurnal/seasonal peaking – are investigated in future, prescribed flows may be required.

8.6 INVOLUNTARY RESETTLEMENT

Resettlement, estimated at about 42,000 people in the reservoir area, is an important aspect of the project. Our adopted estimate is unreliable because of the unreliability of original census data in 1993, projections made from it over many years, and the unavailability of contoured mapping and administrative boundary maps. The numbers take no account of population growth in future. Detailed surveys are required, associated with new topographic mapping. The significance of a change in FSL, by say 1 to 5 m, cannot currently be assessed.

The overriding impression of the consulting team was that resettlement would be strongly resisted. This is mainly a result of some 100,000 Nubians being resettled for the High Aswan Dam project 40 to 50 years ago, of which 53,274 were from Nubia in Sudan downstream of Dal cataract, and an estimated 70,000 people currently being resettled for the Merowe project upstream. Nubians in the Dal and Kagbar areas suffer from uncertainties about their future and fear that a compensation and resettlement program in another place cannot maintain their way of life or compensate for family and cultural losses.

8.7 ENVIRONMENTAL OFFSETS

No environmental offsets have been suggested for the Low Dal project. Most of the 300 km^2 of land inundated by the project is desert and there is no shortage of it in the north of Sudan. The highly valued riverine alluvial strip is not rich in wildlife habitat, having been heavily modified over millennia by settlements and cultivation for survival in desert conditions. There is not considered to be any possibility of replicating this elsewhere.

8.8 TRANSMISSION LINE ROUTE

The preliminarily selected route (Dal to Dongola, 240 km) is the shortest route between Dal switchyard and Dongola to provide connection with the national grid. The route follows the road route in the desert, more or less parallel with the river and impacts on no settlements or cultivated areas, except for a very short distance approaching Dongola where it will cross the river and some arable land to the interconnection point on the left bank. The alternative route of crossing the river at Dal and following an alignment on the left bank to Dongola would have no significant socio-environmental advantages.

8.9 CONSTRUCTION ROADS

Reliable access to the project site will be required for efficient and timely construction and subsequent operation and maintenance of the Dal hydropower project.

The access arrangements will need to be capable of carrying all envisaged construction traffic including transport of construction plant, materials and equipment to the site, together with normal construction traffic around the site. In particular, the roads and bridges will need to be capable of carrying the heavy loads associated with the main items of the permanent mechanical and electrical equipment for incorporation in the project, specifically the turbine components, generator components and transformers.

Construction plant, materials and the major items of permanent equipment for the project will be transported to the site over the existing national road network to Dongola where a bridge is under construction replacing the vehicular ferry. North of Dongola, existing roads and tracks to Dal will require upgrading.

A temporary crossing of the Nile will be required during construction. This may be by bridge or ferry. It is envisaged that the dam itself would be used as a future road crossing following completion of the project. Some local benefits of this crossing are foreseen but no major regional advantage is foreseen.

No alternative road routes are considered possible or necessary.

8.10 WATERSHED MANAGEMENT

The Dal project is conceived as a run-of-river scheme utilising a net head ranging between 16 m and 19 m throughout the year. It is not dependent on regulatory storage at Dal but on releases made from the Blue and White Nile, Atbara and especially releases made at Merowe. As with other structures upstream, Dal will be vulnerable to sedimentation (about 140 million tons per year currently, but to be reduced by sedimentation in Merowe reservoir shortly) but, when the time comes, it can be operated to permit flushing of high sediment loads through the reservoir, as currently happens at Roseires and Sennar. This will probably be necessary if Merowe operates this way.

In order to permit Dal to operate at its capacity for all flows received, without the seasonal flushing mode which reduces power generation, implementation of the developing watershed management proposals for the Abbay, Blue Nile and Atbara sub-basins will be essential.

8.11 CUMULATIVE IMPACTS

The principal cumulative impacts of the Dal project are considered to be fourfold.

1. As a run-of-river hydropower project its downstream impacts will be relatively minor excepting it causing additional net evaporation losses estimated at 546 Mm^3/year from its reservoir surface area of 300 km^2. This water loss to the Nile system is additional to relatively small evaporation losses at reservoirs on the Blue and White Nile and the very large losses at Merowe and at Lakes Nasser/Nubia (10 billion m^3/year).

2. The required involuntary resettlement for Dal is not known in absolute terms but is estimated at 42,000 people. This is in addition to 100,000 resettled for the High Aswan Dam project in the 1960s and in addition to the estimated 70,000 being resettled as part of the Merowe scheme. If these estimates for Dal are confirmed, the aggregate resettlement of the three projects on the Nile (say, 212,000) would be the greatest in the world from a desert environment for hydropower and irrigation schemes, and the third greatest for all types of environments – being exceeded only by Three Gorges project in China (18,200 MW, 1,300,000 people) and Cabora Bassa in Mozambique (2,075 MW, 250,000 people).

3. The inundation of 300 km^2 of land at Dal would cause the loss of innumerable historical and physical cultural resources. This would be in addition to those lost in Lakes Nasser/Nubia and at Merowe. This would be a major cumulative impact.

4. The inundation of 300 km^2 of land at Dal would cause the loss of fertile alluvial strips along one or other, or both, banks of the Nile. This would be in addition to fertile cultivated areas lost in Lakes Nasser/Nubia and at Merowe. This would again be a major cumulative impact of the project.

Regarding energy generation, some relatively small reduction in power generation at Aswan will occur because of reduced levels of Lake Nasser/Nubia during first filling of Dal reservoir, and subsequently during the operational period. On the positive side, power generation at Dal will benefit in future from any upstream flow regulation works which will be provided by raising Roseires, and may be provided by hydropower projects in Ethiopia.

8.12 "DO NOTHING" SCENARIO

In the context of ENTRO promoting power trade between Ethiopia, Sudan and Egypt, Dal's capacity and energy characteristics are too limited for it to be of interest for regional power trading. The "do nothing" scenario at Dal would reinforce the need for power generation and river regulation to take place in Ethiopia. Alternatives are available, as discussed above under project location.

9. ENVIRONMENTAL MANAGEMENT

9.1 INTRODUCTION

Environmental management of a project is concerned with implementation of the measures necessary to minimize or offset adverse impacts and to enhance beneficial impacts. In order to be effective, environmental management must be fully integrated with the overall project management effort at all levels, which itself should be aimed at providing a high level of quality control, leading to a project which has been properly designed, constructed and functions efficiently throughout its life.

This chapter therefore introduces the role of Environmental Management Plans (EMPs) in project development and implementation and introduces the probable overall institutional arrangement for project ownership and management, including management of the EMP as one component of the project. The draft, or pro-type, EMP for the project is then introduced with comments on the institutional strengthening which will be required.

After introducing the need for and role of an Independent Panel of Experts for the Environment and Community Protection, the requirements and components of a Resettlement Action Plan (RAP) are introduced. The section on RAP concludes with a description of grievance handling procedures.

9.2 ENVIRONMENTAL MANAGEMENT PLAN

9.2.1 General

Proponents develop environment management plans during a project's planning and design phases in order to promote self-regulation and integration of environmental management issues. The project owner takes primary responsibility for protection of the environment that may be affected by the project and this responsibility may be expressed as commitments set out in the prepared EMP. The EMP may specify all affected environmental values, all potential impacts on environmental values, mitigation strategies and relevant monitoring together with appropriate indicators and performance criteria, reporting requirements and, if an undesirable impact or unforeseen level of impact occurs, the appropriate corrective actions available.

The EMP relates to the various stages of planning for a proposal including development assessment in the pre-construction phase, and in construction and operational phases. It provides a summary of likely environmental impacts, how they will be managed and the responsible implementing and supervisory agencies.

A detailed EMP will be prepared during the project feasibility study. At that time, Site Investigations and engineering studies will firm up proposals and give much clearer definition of the project's impact areas. The future detailed EMP should include the following components: -

- Establishment of agreed **performance criteria and objectives** in relation to environmental and social impacts. These should include measurable indicators and standards;

- Detailed **prevention, minimization and mitigation strategies or action programs (including design standards)** for controlling environmental impacts at specific sites;
- Details of the proposed **monitoring** of the effectiveness of remedial measures against the agreed performance criteria in consultation with relevant government agencies and the community;
- Details of implementation **responsibilities** for environmental management;
- **Timing** (milestones) of environmental management initiatives;
- Reporting requirements and auditing **responsibilities** for meeting environmental performance objectives;
- **Corrective action** (as options) to rectify any deviation from performance standards.

9.2.2 Draft EMP for Dal

This initial assessment of the pre-feasibility engineering proposals has indicated many impacts of project implementation and various mitigation measures in Chapters 6 and 7. These are brought together in the draft consolidated EMP in Table 9.1.

The EMP tables proceed through pre-construction, construction and operational phases.

As the EMP table footnotes state, columns to indicate impact and mitigation locations, timing and costs should be added to this table for the project EMP at feasibility stage.

Table 9.1 : Consolidated EMP for Mitigation and Enhancement Works

Project activities / Environmental issues/impacts in Sudan (unless stated otherwise)	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	Supervision
P r e – c o n s t r u c t I o n P h a s e			
Project feasibility study Full environmental study	Review and submission of EIA documentation to Higher Council for Environment and Natural Resources (HCENR), Egyptian Environmental Affairs Agency (EEAA) and the Permanent Joint Technical Committee for evaluation. Detailed drawing showing land acquisition requirements Preparation and subsequent evaluation and approval of RAP Land and property expropriation survey Assessment and payment of compensation and implementation of RAP.	Project Owner/consultant National and state government departments, as appropriate	
Training	Training and capacity building of relevant organizations Training for environmental management and safety	Project Owner/consultant	
Project study and contract documents	Ensure that all government and funding agency requirements and procedures relating to EIA are pursued Ensuring that environmental protection measures are stipulated in contract documents, including occupational health and safety plan. Implementation of land and property acquisition procedures including payment of compensation Complete preparation for and implementation of RAP Complete the surveys, documentation and salvage of physical cultural heritage, allowing at least 10 years before construction begins	Project Owner/consultant National and regional government departments, as appropriate	HCENR and Northern State CENR

- [1] Columns to indicate location, timing and costs should be added to this table for the project EMP at feasibility stage

Project activities / Environmental issues/impacts in Sudan (unless stated otherwise)	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	Supervision
Construction Phase			
1. principal engineering construction impacts from construction of access road, dam excavation, quarries, civil works, etc			
Erosion and sediment control – all construction sites	• Preserve top soil stripped from road edges and construction sites for re-use	Contractor	Project Owner and EMU and NEC' EMU concerning transmission line
Spoil disposal	• Minimise numbers of spoil heaps; stabilize them; consider dumping in the reservoir inundation area where practicable	Contractor	Project Owner and EMU And NEC's EMU concerning transmission line
Quarry rehabilitation	• Rehabilitate and landscape borrow pits and quarries; ensure safety measures are implemented and sustainable indefinitely	Contractor	Project Owner and EMU
Water quality	• Protect wells and Nile from all pollution sources, including particulate matter from all works sites.	Contractor	Project Owner and EMU
Chemical waste/spillage	• Ensure toxic compounds are not located near river, wells and water points. Provide interception and control measures for chemical wastes and potential spillage • Provide all vehicles and machinery with drip-pans for catching oil; maintain regularly	Contractor	Project Owner and EMU and NEC's EMU concerning transmission line
Emergency plan for hazardous materials	• Provide safe systems for hazardous waste disposal	Contractor	Project Owner and EMU and NEC's EMU concerning transmission line

Project activities / Environmental issues/impacts in Sudan (unless stated otherwise)	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	Supervision
Dust and emissions control	• Suppress dust along project roads, especially at and near settlements • Maintain construction equipments to minimize air pollution • Check and clean injectors of diesel engines regularly	Contractor	Project Owner and EMU and NEC's EMU concerning transmission line
Noise control	• Minimize the use of explosives and utilise a systematic blasting schedule • Limit working hours in environmentally sensitive areas	Contractor	Project Owner and EMU and NEC's EMU concerning transmission line
Physical/cultural resources	• Report immediately to client any archaeological or historical resources (e.g. rock art, artefacts) previously not identified and salvaged • Avoid settlements and agricultural areas wherever practicable – all works areas	Contractor	Project Owner and EMU and NEC's EMU concerning transmission lines
Vegetation clearing	• Remove woody material from reservoir area according to recommendations	Contractors	Project Owner and EMU
Landscaping and re-vegetation	• Minimize vegetation clearing for project infrastructure works and rehabilitate sites • Remove potential "eyesores" of woody material from reservoir area which would otherwise protrude after filling in vicinity of public viewing and fishing points	Contractor	Project Owner and EMU and NEC's EMU concerning clearing and rehabilitation along transmission line
Waste management	• Treat/remove/dispose waste oil, lubricants and other chemicals, and domestic waste (rubbish and sewage) to approved facilities	Contractor	Project Owner and EMU and NEC's EMU concerning transmission line
Coffer dam and reservoir impoundment	• Follow agreed procedures for coffer dam and first filling • Provide timely warnings to upstream and downstream vulnerable communities using agreed procedures • Liaise with RAP officers	Contractor	Project Owner and EMU

Project activities / Environmental issues/impacts in Sudan (unless stated otherwise)	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	Supervision
Environmental training for construction workers	• Provide training on environmental protection measures for flora and fauna	Contractor	Project Owner and EMU And NEC's EMU concerning transmission line
On-site traffic and access management	• Provide road warning signage (e.g. severe slopes, blind bends, speed limits) for all access roads and project works areas; reinforce these on public roads used as haulage routes for cement and other materials	Contractor	Project Owner and EMU and NEC's EMU concerning transmission line
Construction work camps	• Provide appropriate facilities for accommodation and recreation of workforce at dam site camps • Provide appropriate facilities for accommodation at transmission line fly camps	Contractor Contractor	Project Owner and EMU NEC's EMU
Project staff health	• Provide safe water supply to workers • Establish on-site health facilities and strengthen health services of communities adjacent to dam site • Provide health and safety education for workforce, including education on STDs and HIV/AIDS	Contractor	Project Owner and EMU and NEC's EMU concerning transmission lines
2. Reservoir sedimentation	• Maintain mitigation measures (if required) to stabilise blown sand from the north and avoid or minimise sand accumulation in Dal reservoir • Support implementation of upstream watershed management programs	To be determined To be determined	To be determined To be determined
3. Reservoir slope stability and reservoir induced seismicity	• Implement precautionary measures as may be recommended	Contractor	Project Owner and EMU
4. Groundwater	• Utilise raised groundwater if and where significant for beneficial use • Provide drainage for raised groundwater levels if and where impacts are adverse	State government health and water departments	Project Owner and EMU, regional EPA

Project activities / Environmental issues/impacts in Sudan (unless stated otherwise)	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	Supervision
5. Disease vectors	• Provide health care education, clinics and mosquito nets	Contractor for workforce Government Health Department for others	Project Owner and EMU
6. Aquatic environment and fishing	• Avoid where possible, otherwise minimise adverse impacts on water quality by implementation of above mitigation measures for project construction • Implement a reservoir fisheries development program	Contractor State Fisheries Department	Project Owner and EMU Project Owner, EMU & Northern State CENR
7. Natural terrestrial habitats and wildlife	• Avoid where possible, otherwise minimise adverse impacts on habitats by implementation of above mitigation measures for project construction • Avoid damage to any notified habitat sites of special scientific, historical or cultural interest • Implement conservation management measures in reservoir perimeter buffer zone	Contractor Contractor Wildlife Department	Project Owner, EMU & Northern State CENR Project Owner, EMU & Northern State CENR Project Owner, EMU & Northern State CENR
8. Socio economic impacts due to the various construction activities including the filling of the reservoir			
Loss of arable land due to project construction, including along transmission line route	Early notification and consultation with the affected farmers; consider alternative routes locally as a result of consultations. Provide just compensation expeditiously	Project Owner, EMU, RMU & state government departments. NEC's EMU concerning transmission lines	Northern State CENR
Houses and fixed assets lost due to construction, including along transmission line route	Early notification and consultation with the affected communities. Provide just compensation expeditiously	Project Owner, EMU, RMU & state government departments. NEC's EMU concerning transmission line	Northern State CENR

Project activities / Environmental issues/impacts in Sudan (unless stated otherwise)	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	Supervision
Grazing and natural resources lost due to construction, including along transmission line route	Early notification and consultation with the affected communities. Provide just compensation expeditiously	Project Owner, EMU, RMU & state government departments. NEC's EMU concerning transmission line	Northern State CENR
Infrastructure lost due to construction, including along transmission line route	Early notification and consultation with the affected communities and regional government. Provide mitigation measures	Contractor	Project Owner, EMU, RMU & Northern State CENR. NEC's EMU concerning transmission line
Local communications, including ferries.	Provide alternative river crossing facilities and compensate for ferrymen's incomes	Contractor	Project Owner, EMU, RMU & Northern State CENR
Resettlement, including any along transmission line route	Implement a comprehensive resettlement action plan (RAP), including a development program for host areas, host communities and PAPs; support viable income generating schemes	Project Owner, RMU, EMU and regional government departments. NEC's EMU concerning transmission line	Northern State CENR
Physical/cultural resources	Implement recommendations, if any, for detailed survey, documentation and/or salvage (anything outstanding after major works in pre-construction phase)	Project Owner, EMU, national and state museums. NEC's EMU concerning transmission line	Antiquities and Museums National Corporation
Public health	Implement health education/awareness and improve health services to vulnerable communities (for those not specifically included in RAP and associated development plan)	Project Owner, EMU, RMU, regional government health department	Northern State CENR
Graveyards	Implement recommendations of religious leaders, as may be required	To be determined	Northern State CENR
Employment	Implement plans for preferential employment of local people, with training	Contractors	Project Owner, EMU. NEC's EMU concerning transmission line
Local commerce and trade	Avoid causing price inflation of local produce	Contractor	Project Owner, EMU

Project activities / Environmental issues/impacts in Sudan (unless stated otherwise)	**Proposed mitigation/enhancement Measures[1]**	**Responsible agents**	
		Implementation	**Supervision**
Energy use	Make salvaged timber from construction sites, including reservoir basin clearance, available to local communities Accelerate plans for rural electrification	Contractor NEC	Project Owner, EMU
Downstream river crossings and safety	Implement recommended warning systems	Contractor, then Project Owner	Wadi Halfa government departments, EMU and Northern State CENR
Downstream recession agriculture	Provide just compensation expeditiously and/or provide pumps and fuel costs	Project Owner, EMU	Wadi Halfa government departments, Northern State CENR
Navigation on Lake Nubia – reduced levels during first filling	Provide any required physical mitigation measures at Wadi Halfa port	Contractor	Project Owner's Engineer
Public relations	Implement first class communication system and procedures for keeping the public informed about project's progress	Project Owner	Wadi Halfa government departments, Northern State CENR
Project induced developments	Anticipate, plan and develop infrastructure and other responses for probable induced developments	Project Owner, EMU, RMU, Northern State government departments	Northern State CENR
9. Egypt - Lake Nasser/Nubia, concerning reduced lake levels during Dal first filling			
Fisheries	Additional stocking with fingerlings and/or compensation	Ministry of Agriculture and Land Reclamation on behalf of Project Owner	Egyptian Environmental Affairs Agency
Small-scale irrigated farming around lake	New or additional pumping equipment and/or compensation for additional pumping costs	Ministry of Agriculture and Land Reclamation on behalf of Project Owner	Egyptian Environmental Affairs Agency
Pumped water supplies	New or additional pumping equipment and/or compensation for additional pumping costs	Ministry of Agriculture and Land Reclamation on behalf of Project Owner	Egyptian Environmental Affairs Agency
Navigation	Provide any required physical mitigation measures at Lake Nasser's ports and harbours	Contractor	Project Owner's Engineer Egyptian Environmental Affairs Agency

Project activities / Environmental issues/impacts in Sudan (unless stated otherwise)	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	Supervision
Mubarak pumping station (if operational)	Compensation for additional pumping costs	Project Owner	Egyptian Environmental Affairs Agency
Aswan power station	Compensation for reduced power generation	Project Owner	Egyptian Environmental Affairs Agency
Operational Phase			
Dam and river safety	Ensure all dam safety measures and warning systems are functional/updated	Project Owner, EMU	Northern State CENR
Resettlement	Ensure proper implementation of resettlement and development program	Project Owner, RMU, EMU	Northern State CENR
Reservoir sedimentation	Locally, ensure project area's rehabilitated areas are maintained. Maintain vigilance on mitigation measures, if any, for blown sand from north. Maintain financial contributions to upstream watershed management. Insist on receiving reports on areas conserved and verify these.	Project Owner, EMU	Northern State CENR HCENR
Reservoir fisheries development and water based recreation	Ensure facilities, stocking, training, and commerce are maintained/improved. Support multiple uses of reservoir consistent with good environmental practice.	Fisheries Department	Project Owner, EMU. Northern State CENR, Sudanese Environment Conservation Society
Environmental buffer zones at reservoir	Continue support for management of buffer zones. Facilitate waterbird and other surveys by NGOs.	Wildlife Department, Project Owner	Sudanese Environment Conservation Society and Northern State CENR
Transmission Lines Right of Way - encroachment	Maintain vigilance on adopted restrictions of land use along transmission lines, including houses with respect to electro-magnetic fields	NEC and NEC's EMU	Northern State CENR
Completed project mitigation and enhancement measures - general	Meet any residual liabilities helpfully and maintain interest in good practices	Project Owner, EMU, RMU, state government departments	Northern State CENR
Project induced developments	Continue to anticipate, plan and develop infrastructure and other responses for probable induced developments	Project Owner, EMU, RMU, state government departments	Northern State CENR

Project activities / Environmental issues/impacts in Sudan (unless stated otherwise)	Proposed mitigation/enhancement Measures[1]	Responsible agents	
		Implementation	Supervision
Public relations	Continue to maintain first class communication system about the project. Employ local people wherever possible. Develop educational and environmental tours for visitors/groups.	Project Owner	
In Egypt, navigation, small scale irrigation around Lake Nasser, pumped water supplies, navigation, Mubarak pumping and Aswan power station generation	Continue to compensate for items, if necessary, according to agreements made	Project Owner	

Footnote:

At the full feasibility study stage, when Site Investigations are completed, engineering is advanced and a full EIA report is prepared, the EIA will have an Environmental Management Plan. The above table is a proto-type of the EMP; it cannot now be completed with respect to location, timing and costs for each and every issue. Many of these are unknown at pre-feasibility stage.

9.3 INSTITUTIONAL RESPONSIBILITIES FOR ENVIRONMENTAL MANAGEMENT

Effective environmental management will be achieved only if it is undertaken as a fully integrated part of the overall project management. In order to effectively implement a comprehensive environmental management plan, coordination of efforts of various agencies is necessary.

9.3.1 Project Owner's Responsibilities

The overall responsibility for the day-to-day coordination and administration of the implementation of the environmental and social management and monitoring plans set out in the EIA and RAP for Dal activities, when developed at feasibility level, will lie with the project Owner[2]. It is envisaged that an Environmental Management Unit (EMU) and a Resettlement Management Unit (RMU) will be established by the project to assist the project Owner.

The project Owner will be responsible, following feasibility studies, for submitting the EIA report, with its EMP and RAP plans, to the HCENR in Khartoum and other competent authorities for evaluation according to internal procedures in Sudan. The EIA report, with its overall management and monitoring plans, will also be submitted to competent authorities in Egypt and the Permanent Joint Technical Committee.

The project Owner will compile “the Owner's requirements” in consultation with stakeholders including the HCENR and lenders of finance for the project. These will cover, *inter alia*, environmental protection measures presented in the project's EMP. The Owner's requirements are made known in tender documents and contractors are required in their bids to demonstrate their social and environmental awareness and capability in meeting the Owner's requirements. Once contracts are awarded, environmental management (protection) and monitoring plans will be prepared by contractors, in accordance with the project's EMP, for approval of the Owner. These contractors' plans, responding to the Owner's EMP, will be site specific, updated and reported on regularly by contractors.

It is envisaged that NEC, by arrangement with the project Owner, will compile “the Owner's requirements” for the transmission line component of the project in consultation with stakeholders and lenders of finance.

The Owner will ensure procedures are instituted to maintain a flow of information to Egypt.

The Owner will be responsible for developing and implementing public relations procedures and communications for the project to ensure transparency and build up

[2] At Merowe, the Dams Implementation Unit (DIU) is an upgrading of the Merowe Dam Project Implementation Unit (MDPIU), which was headed by the State Minister for Irrigation and Water Resources. DIU is an autonomous body directly under the Office of the President of the Republic with a status of full Federal Ministry. The responsibility for the formulation and execution of Merowe resettlement and compensation policies is assigned to the Commission for Environmental and Social Affairs of the DIU. It is unknown whether this arrangement would be used for implementing the Dal project. If it is, then readers should interpret the project Owner as being DIU, and the EMU and RMU functions being carried out by the Commission for Environmental and Social Affairs of the DIU.

trust and confidence about the project. Regarding environment, the Owner will use his public relations procedures and communications to make known details of the project and its time schedule, impacts and mitigation measures, and grievance procedures for host and resettled communities, especially those measures relating to compensation and resettlement. Care will be taken to present information in languages that are understood by stakeholders, and by all conceivable means in order to reach all concerned effectively.

Opportunities for misinformation and misunderstanding are many during the pre-construction and construction period activities. The project Owner will make every effort to avoid these by establishing and using vigorously a first class public relations and communications system.

Among the many issues to be made widely known are those relating to compensation and mitigation measures, the schedule of phased movements required in the RAP plan, dam safety and the downstream flow release regime during the early years of construction, during first-filling of the reservoir and during the project operational phase. It is noted here that all of these and other matters will have been sorted out and agreed in pre-financial closure stages of planning. The RAP plan for the project's reservoir and works areas is outlined in Section 9.5.

The EMU will assist the project Owner in monitoring progress of the contractor's works and environmental protection measures but also in coordinating implementation of the project's EMP for other activities outside of the contractor's responsibilities. In addition to the EMU, it is anticipated that the project's RMU will assist the project Owner in managing and monitoring RAP, along with state government officers, and ensuring that (phased) resettlement will be achieved according to dates in the program prescribed in the RAP.

With regard to construction of the project transmission line and related works, it is expected that contractors will carry out these works for NEC, by arrangement with and on behalf of the project Owner, with arrangements for compensation and any resettlement (as may be needed in the Dongola area) and for monitoring being made by NEC.

9.3.2 Occupational Health and Safety

General

Health and safety are paramount issues for dam owners and construction contractors. The Owner's requirements, among other requirements, will therefore require the contractor and his subcontractors to ensure that the workplace is a healthy and safe working environment and that public safety is safeguarded within the construction areas with respect to the works. The contractor shall provide all necessary staff, resources and materials to provide for health and safety in accordance with a Health and Safety Plan of the Conditions of Contract and other provisions of the Contract and all applicable laws.

Without in any way limiting the generality of the foregoing, the contractor shall, in respect of all activities in connection with execution of the Works:

a) develop all appropriate measures to be taken to control dangerous goods and prevent industrial accidents;

b) provide medical services adequate to deal with the medical needs of the contractor's and Owner's personnel, including accompanying families, at all times on the construction areas ;

c) install and develop appropriate fire protection, monitoring and prevention services;

d) ensure that any temporary works comply with the Environmental Management Plan and all applicable laws;

e) implement health and safety measures in respect of the buildings and adjacent areas, including offices, workshops, factories, security posts, workers' shelters, schools, accommodation blocks and houses, canteens, messes and restaurants, recreation facilities, markets and retail stores;

f) construct and maintain facilities for water supply treatment and reticulation, and sewage collection and treatment that comply with applicable laws and applicable WHO requirements;

g) provide for the collection and disposal of household commercial and industrial garbage and by-products, including used oils and hydrocarbons, that complies with the applicable laws and the Environmental Management Plan;

h) provide effective storm water collection and disposal systems for all work and accommodation sites, with open areas sufficiently well graded and drained to prevent ponding.

Health and Safety Plan

The contractor shall provide a comprehensive Health and Safety Plan to be submitted to the Owner for non-objection at a prescribed time (e.g. 3 months before construction begins).

The primary purpose of the Health and Safety Plan is to establish a process to preserve the health of all personnel and prevent any accidents that may injure personnel or damage property within the construction areas. The Health and Safety Plan shall be based on a recognized International Standard, such as those issued by the International Labour Organisation

(http://www.ilo.org/public/english/protection/safework/standard.htm).

The Health and Safety Plan shall include:

- guidelines to be followed by the Owner, contractor, sub-contractors and other contractors and their personnel working at the construction areas;
- guidelines and safety rules to be followed by authorized visitors to the construction areas;

- the organization structure and reporting lines in respect of health and safety involving the Owner, the contractor, sub-contractors and other contractors;
- detailed description of the responsibilities, roles, authorities and functions of the Site Safety Officer and the Safety Committee;
- emergency procedures and plans for responding to health and safety emergencies;
- training requirements and implementation plan and programme;
- a plan and timetable for implementing the Health and Safety Plan;
- proposed method of implementing the contractor's Health and Safety Plan;
- proposed reporting format and health and safety information to be provided in monthly and quarterly progress reports.

The contractor shall, as may be required by the Owner, translate into local languages parts of the final version of the contractor's Health and Safety Plan.

The contractor shall report on the implementation, monitoring and performance of the plan in each Progress Report.

Safety Officer

The contractor shall appoint a Site Safety Officer to undertake the general responsibilities specified in relevant clauses of the Conditions of Contract. The specific responsibilities, roles, authorities and functions of the Site Safety Officer shall be set out in the Health and Safety Plan.

Safety Committee

Within a prescribed time (e.g. 60 days from beginning of works), a Safety Committee shall be established with representatives of the Owner and the contractor. The Safety Committee shall review general safety policy at the construction areas and its specific responsibilities, roles, authorities and functions shall be set out in the Health and Safety Plan. The responsibilities of the Safety Committee shall include:

- setting the procedures for safety meetings;
- defining the requirements for safety monitoring and reporting;
- defining the role and responsibilities of all relevant health and safety personnel;
- reviewing emergency procedures for responding to a health or safety emergency;
- reviewing the implementation of the Plan, including safety education, safety clothing, extent of worker awareness and prominence of safety signs and reporting.

The Safety Committee shall meet at prescribed intervals (e.g. quarterly) or after particular circumstances at the request of the Owner or the contractor.

Safety of Personnel

The contractor shall ensure that safe work practices are developed and adopted by all personnel. Such safe working practices shall be developed in respect of safety equipment, barriers and signals for dangerous areas, noise protection, lighting, equipment management, order and tidiness, signs, fire prevention and fighting, smoking, fire extinguishers, house-keeping, heating and/or cooling devices, paint and painting, emergency procedures, instructions, electrical activities, working at heights, safe transport and lifting, forklift trucks, hoisting, welding/burning, storage and handling of gas, work inside confined spaces, work in tunnels and underground works, dangerous/flammable products, hand tools, radiographic inspections, storage and handling of radio-elements, issue of work permits, explosives, rock drillings, rock bolting, shotcreting, concrete placement, crane operations, earth moving and excavation plant and equipment, and vehicle driving.

Emergency Procedures

Emergency procedures shall be prepared as part of the Health and Safety Plan and issued separately. The contractor shall update all emergency procedures each time there is a material change to working conditions. These emergency procedures, among other things, shall anticipate health and safety aspects of reservoir impoundment and variable downstream flow releases during cofferdam operations, first filling and project operations.

9.3.3 Institutional Strengthening for Environmental Management in Sudan

Institutional strengthening will be required in relation to environmental management and monitoring capacities for access roads, dam construction and associated works, and for transmission line works. Apart from the Owner's organisation, NEC and the contractors getting staff up to strength with regard to implementing good environmental engineering practices, there will be need to strengthen Northern State's government departments in Dongola, Wadi Halfa at locality level and Ferka, Abri and Delgo administrative units.

Northern State Ministries

The State's Ministry of Agriculture, Animal Resources and Irrigation, Ministry of Engineering Affairs and Public Utilities, and the Ministry of Health are the principal state ministries that will be involved in the Dal project. As stated in Chapter 4, they are represented at Dongola but may be not in all of the administrative units of Wadi Halfa locality.

State Council for Environment and Natural Resources

The Environmental Protection Act 2001 empowers each state to establish its own independent State Council for Environment and Natural Resources (SCENR) with the responsibilities to coordinate and follow-up the state effort to ensure public participation in the decision making process, to play an active role in coordinating the formulation and implementation of conservation policies as well as to foster environmental monitoring, protection and regulation.

However, as mentioned in Chapter 2, like most other states in Sudan, the Northern State is yet to promulgate an act for the establishment of the State Council of Environment and Natural Resources (SCENR). This report makes the assumption that the Northern State will have established its State Council prior to the implementation of the Dal project, equivalent in other countries to a regional environmental protection agency. Clearly, as the SCENR does not yet exist, considerable institutional strengthening measures may be anticipated. It will be important that SCENR functions at Dongola and plays an active role in the many environmental protection and enhancement measures and the major resettlement component of the Dal project.

The Antiquities and Museums National Corporation and Sudan Archaeological Research Society

The Antiquities and Museums National Corporation (AMNC) is under the Federal Ministry of Culture and is the custodian of the Sudan's cultural heritage. The main functions of the Department are: preservation and conservation of historical and archaeological monuments; exploration and excavation; collaboration with foreign archaeological missions working at various sites in Sudan; control of movement of cultural property; establishment and maintenance of museums; treatment and restoration of antiquities; administration of the Antiquities and Museums National Corporation Act, 1991; research on epigraphy, numismatics, and other relevant fields of archaeology.

As mentioned in Chapter 2, the State governments have not yet enacted laws governing archaeological and historical sites.

This report makes the assumption that because the Dal project is so rich in physical cultural resources which require specialist attention, the project Owner will engage the Antiquities and Museums National Corporation and the Sudan Archaeological Research Society (SARS) to carry out all surveys, excavations and mitigation measures relating to physical cultural heritage over a distance of 320 km of Nile riverbanks and about seven islands. Apart from fees for this work, it may be anticipated that the Antiquities and Museums National Corporation and SARS will need to employ and train staff for various aspects of this work. It has been noted earlier that this assignment is estimated to take at least 10 years and would therefore need to be commissioned and funded at least 10 years before the main dam construction starts. It is expected, *inter alia*, to involve dismantling and reconstruction of the temple at Soleb and possibly other monuments.

Plate 9.1 : Soleb. Temple of Amenhotep III, and Columns in the Forecourt

Other support

The principal non-government organisation appears likely to be the Sudanese Environmental Conservation Society. Participation of the Society could be in commenting and advising on components of the project's EMP and later contributing to various aspects of it and the monitoring plan.

9.3.4 Environmental Management in Egypt

The responsibility for coordination and administration of the implementation of mitigation measures for the Dal project around Lake Nasser/Nubia will be determined by Egypt. As seen in Table 9.1, several agencies are expected to be involved.

The project Owner in Sudan, in close liaison with one or more of the delegated agents in Aswan and New Valley Governorates, will be responsible for developing and implementing public relations procedures and communications for the project to ensure transparency and build up trust and confidence about the project. Among the issues to be made widely known in Egypt are those relating to compensation and mitigation measures, dam safety and the estimated range of changes in Lake Nasser/Nubia levels during first-filling of Dal reservoir and during the project operational phase. To these must be added all relevant aspects of the EMP in relation to any expected changes in fisheries, navigation and irrigated agriculture and proposals to mitigate them in Aswan and New Valley Governorates.

9.3.5 Institutional Strengthening for Environmental Management in Egypt

Institutional strengthening may be required in relation to environmental management and monitoring capacities for implementation of any mitigation works associated with fisheries, navigation and irrigated agriculture at and around Lake Nasser/Nubia (MWRI and MALR).

In addition, the Egyptian Environmental Affairs Agency (EEAA) will be involved and may require to strengthen its operations in the Lake Nasser area. The principal non-government organisations appear likely to include one or more of the following: Centre for Development Services/Desert Development Centre – American University in Cairo, the Egyptian Swiss Development Fund, World Food Programme, and the Wadi Allaqi Projec (Universities of the South Valley in Aswan and Glasgow, U.K). Their roles are summarised in Chapter 2 and their experience and presence in the Lake Nasser area is relevant to contributing to the design, management and monitoring of mitigation measures. Thus support from the project is expected to be necessary.

9.4 INDEPENDENT PANEL OF EXPERTS FOR THE ENVIRONMENT AND COMMUNITY PROTECTION

The proposed project is a national project but also an international project with environmental impacts in Egypt. As the magnitude and extent of environmental and social impacts are large and wide-ranging, including those downstream, it is envisaged that the project Owner will appoint an independent Panel of Experts for the Environment and Community Protection. (This is in addition to another panel – the Panel of Experts on Dam Safety). The composition of this environmental and social panel is a matter for the future but this report indicates that special expertise in desert resettlement, antiquities, and irrigation and reservoir fisheries development will be required as a minimum.

Management includes building trust and confidence in the project. In order to build up confidence in the project’s implementation of the EMP and RAP, it will be essential that the project Owner makes full use of all means to inform stakeholders about the project and that the Environmental and Community Protection Panel of Experts make its findings known to the public at all times.

This Panel of Experts will therefore not only provide critical guidance to the project Owner (who directs contractors) but also issue candid advice on implementation of the EMP and RAP, public relations, liaison, and practical matters concerning all environmental and social aspects of the developing project.

The Panel will review the EMP to ensure that the document is an adequate reflection of the environmental impacts that may result from the development and that the document provides sufficient information on which decisions may be taken.

9.5 RESETTLEMENT ACTION PLAN

This section outlines the general provisions for a Resettlement Action Plan (RAP) suitable for the Dal hydropower project reservoir and construction works area.

The RAP should be developed to meet the policy and regulation requirements of the Government of Sudan and the AfDB/the World Bank for the project in relation to compensation and resettlement. It identifies people affected by the project, the nature and degree of the impacts on them, measures taken to minimize the effects and compensation and other assistance to be delivered to affected people for inevitable negative impacts.

The RAP has been made in line with the assessment of potential losses that were investigated during the pre-feasibility study of the hydropower project and the actions defined to minimize damage or loss to project affected people and the environment. This RAP also considers loss of access to resources (domestic dwellings, crops, vegetation, grazing lands, infrastructures, businesses and services) or displacement and relocation due to construction and operation of the project.

Its objectives are to evaluate all physical or economic impacts, displacement, or temporary or permanent loss of assets or facilities that may be experienced by project-affected communities.

The World Bank's Involuntary Resettlement documentation (World Bank, 2004) states the principles of resettlement as:

People should be at least as well off, preferably better off, after resettlement. Fairness and equity are major issues in the resettlement.

The factors to consider in resettlement plans are:

- Institutional and organization capacity needed for resettlement including all responsible bodies and need of training.
- Participation of affected people in decision-making, implementation, operation, and evaluation and monitoring of the resettlement of both settlers and host populations.
- Base line data on affected population; census of population, property and common area inventory, map of receiving area and environmental constraints in the host community.
- Resettlement policy and legal framework. This encompasses definition of affected lands, structure, compensation and entitlement criteria and grievance procedures.
- Development plan for new sites which includes detailed engineering plans and layouts, agricultural development packages, non-agricultural employment packages, monitoring arrangements and environmental protection.
- Transfer arrangements including information campaign, transition monitoring, and maintenance and mobilization schedule.
- Cost estimate, financing plan, implementation schedule and disbursement schedule.

9.5.1 Resettlement Principles

The RAP is prepared in accordance with international best practices on resettlement. These may be summarised as:

- Involuntary resettlement should be avoided, or minimised where unavoidable.
- Where resettlement is unavoidable, resettlement plans and activities should be seen and executed as development programs.
- Resettled persons should be provided with sufficient investment resources (livelihood safeguard projects) in order to restore their livelihoods.
- Displaced persons should be meaningfully consulted, and participate in planning and implementation of resettlement programs.
- Displaced persons should be compensated for their losses at full replacement cost, prior to the move.
- Resettled persons should be assisted with the move and provided with support during the transition period.
- Resettled persons should be assisted with their efforts to improve, or at least restore, their former living standards, income earning capacity and production levels whichever is higher.

9.5.2 Eligibilty

This section of the RAP spells out the categories of people who qualify for resettlement assistance, and the associated eligibility criteria. They are the following:

- People who will be displaced by having to move their place of residence, agricultural production, or business to allow for the construction of the project, or any other associated infrastructure. People who were recorded as project affected people will be regarded as eligible for qualification.
- People who will lose land over which they have established ownership or rights of usufruct (either in a permanent or temporary fashion) to allow for the construction of the project, or any other associated infrastructure. People who are recorded as project affected people (PAP) in the full EIA and RAP study are regarded as eligible for qualification.
- Members of communities who will lose access to their communal resource base. People who are recorded as PAPs during the full EIA and RAP study will be regarded as eligible for qualification.
- Public and private businesses and property that may have to relocate as a result of the project.
- Worshipers who may be affected through their place of worship having to be relocated.

- Host communities who will receive those displaced are eligible for Livelihood safeguard programs and other benefits that would improve the community in general.

9.5.3 Potential Scale of Resettlement

The estimated scale of resettlement for Dal dam and reservoir, but not including any PAPs relating to transmission line towers and ROW near Dongola, is 42,000 people. The environmental, socio-economic and cultural background of the project area is given in Chapter 4, and details of potential socio-economic impacts and mitigation measures are given in Chapters 6 and 7.

9.5.4 Organizational Responsibility

The responsibilities for compensation and resettlement rest with the project Owner. Regional and sectoral government regulatory and supervisory organs have the responsibility of implementing as well as ensuring mitigation measures are taken properly and timely.

The project Owner should provide both the financial and technical input into the compensation process, as well as significant additional managerial and technical expertise in supporting the resettlement.

The organisations responsible for the resettlement process have the following collective responsibilities in general:

- Oversee the generation of the RAP.
- Ensure maximum participation of the affected people in the planning of their own resettlement and post resettlement circumstances.
- Accept financial responsibility for payment of compensation and other designated resettlement related costs.
- Pay the affected farmers’ compensation to the amounts agreed.
- Construct infrastructure in the host resettlement areas, including schools, dispensaries, health centers, water supplies, sanitation facilities, places of worship (mosques and churches) and other infrastructure as per the RAP developed during the feasibility study phase.
- Ensure monitoring and evaluation of the PAPs and the undertaking of appropriate remedial action to deal with grievances and to ensure that income restoration is satisfactorily implemented.

9.5.5 Community participation

Relocating or compensating people requires dialogue with all stakeholders.

9.5.6 Relocation Areas

No potential relocation areas have been proposed to-date. The majority local view about resettlement for the Dal project has been described in Chapter 4.

9.5.7 Grievance Handling Procedures

Grievance philosophy

In order to ensure that PAP grievances and complaints on any aspect of land acquisition, compensation, and resettlement are addressed in a timely and satisfactory manner, and that all possible means of filing complaints are available to PAPs to air their grievances, a well defined grievance redress mechanism will need to be established by the project.

Grievance Redress Mechanisms and Institutional Framework

Grievance redress mechanisms are essential tools for allowing affected people to voice concerns about the resettlement and compensation process as they arise and, if necessary, for corrective action to be taken on time. Such mechanisms are fundamental to achieving transparency in the resettlement process. The suggested dispute or grievance mechanisms are as follows:

Grievance should be clearly stated, orally or written, by a settler or settlers, of any resettlement- and relocation-related problem, concern or complaint.

Grievance handling procedure has three steps described below.

1. **Grievance receiver:** Grievance Receivers shall be established in the administrative office of relocated or host communities. The local administration shall appoint one or more grievance receiving officers.

   The Grievance Receiver's role is to listen to the concern of the settlers or host communities and gather information and explore alternatives. If the problem is minor the grievance receiver will give the solution. This will be the end of that particular grievance if agreed by the person who filed the grievance. Otherwise the case will be forwarded with advice to the Arbitration Committee.

   If required, the Grievance Receiver will investigate all aspects of grievances, including the interviewing of witnesses, and prepare a formal report for the Arbitration Committee, together with recommendations for resolution.

2. **Arbitration Committee:** The Arbitration Committee is next to the Grievance Receiver in the hierarchy to examine the grievance case. The committee members constitute the following.

   - Local Administrator
   - Representative of State Lands Administration

- Local community leaders in affected villages
- Representatives of PAPs
- Local NGOs and CSOs

Disputes are referred to the committee. If deemed necessary by the committee, the case will be re-investigated. The committee shall resolve the problem with fairness. If the person who filed the case is not satisfied the committee will forward the file to a higher level or organ with a recommendation as to how it is to be addressed.

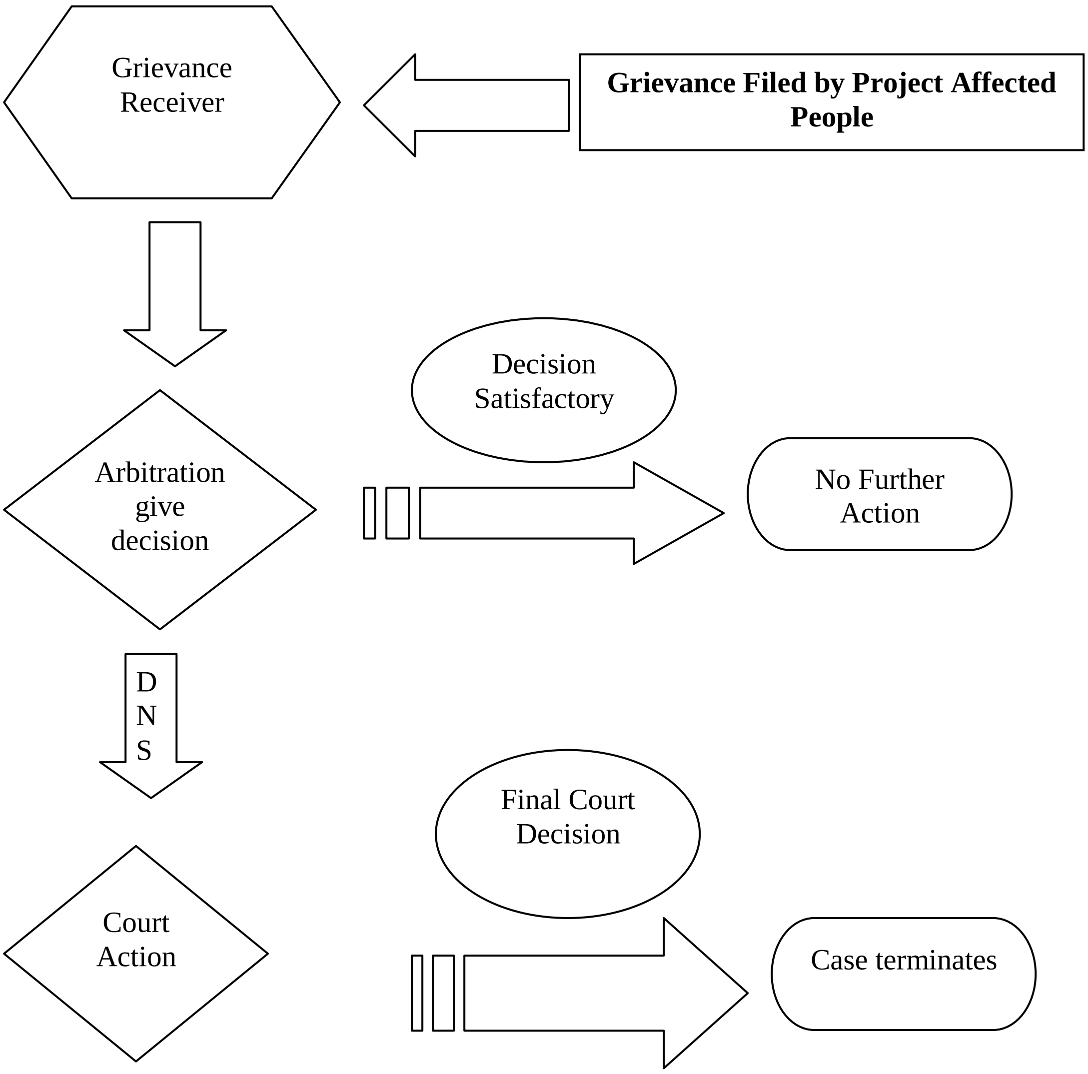
3. **Court:** Any one who is not satisfied with the decisions given by Arbitration Committee may try to get solution in Court. A Court decision shall be final and the person in regard to that particular case shall make no further attempt thereafter.

Figure 9.1 below summarizes the suggested grievances handling mechanism.

However, there are reports on involuntary resettlement in Sudan that state that most resettlement cases brought to the courts are initiated by the authorities seeking eviction orders, rather than by individuals and groups in pursuit of addressing grievances.

In preparing grievance procedures for the Dal project, the benefits and shortcomings of the particular grievances procedures and practices adopted for the Merowe dam project and its resettlement require to be thoroughly examined.

The PAPs of Dal will expect nothing less. These procedures and practices require examination, and re-examination, from all sides but especially for the PAPs – those who will be resettled against their will. It is the interests of everyone, especially the project Owner, that lessons are learned from the past and that perceived or real malpractices are avoided and put right for future projects. The Dal project's feasibility RAP study will need to address this and put forward a grievances procedure for discussion in the public participation procedures that attend the EIA and RAP processes. Necessarily, scholars and advocates of Sudan's legislation on land acquisition and compensation should contribute their expertise and provide guidance so that a workable grievances procedure may be formulated, adopted and then practised transparently.



DNS-Decision not satisfactory

Figure 9.1 : Grievance Redress Procedure

10. ENVIRONMENTAL MONITORING PLAN

10.1 GENERAL

The purpose of the environmental monitoring program is to ensure that the envisaged outcome of the project is achieved and results in the desired benefits. To ensure the effective implementation of the EMP it is essential that an effective monitoring program be designed and carried out. The environmental monitoring program provides such information on which management decisions may be taken during construction and operational phases. It provides the basis for evaluating the efficiency of mitigation and enhancement measures and suggests further actions that need to be taken to achieve the desired project outcomes. A draft consolidated environmental monitoring plan for the project is presented which shows the major items to be monitored.

A detailed monitoring plan will be developed alongside a detailed EMP as part of the project's full EIA study and engineering feasibility study in future. The draft monitoring plan, a pro-type of the future final plan, is expected to meet the following objectives for the Dal project:

- to monitor the environmental conditions of the Main Nile in Sudan and Lake Nasser in Egypt
- to check whether mitigation and benefit enhancement measures are being adopted, and proving to be effective in practice
- to provide a means whereby any impacts which were subject to uncertainty at the time of preparation of the EIA, or which were unforeseen, can be identified, and to provide a basis for formulating appropriate additional impact control measures
- to provide factual information on the nature and extent of key impacts and the effectiveness of mitigation and benefit enhancement measures which, through a feedback mechanism, can improve the planning and execution of future, similar projects.

10.2 INSTITUTIONAL ARRANGEMENTS FOR ENVIRONMENTAL MONITORING

The principal agencies concerned with both environmental management and monitoring have been introduced in Chapter 9. In brief, they include

- the Project Owner assisted by the project's environment management/monitoring unit (EMU), resettlement management/monitoring unit (RMU) and the Project Owner's Engineer in respect of dam engineering technicalities relating to operations, safety, telemetry and warning systems
- NEC, on behalf of the project, responsible for construction of transmission lines and associated works, and NEC's environment management/monitoring unit (EMU)

- those agencies, on behalf of the project, responsible for implementing any construction or other mitigation works around Lake Nasser in relation to fisheries, agriculture and navigation
- national and state environmental protection agencies (HCENR/SCENR, EEAA)
- all contractors
- Panel of Experts on Dam Safety
- Panel of Experts on Environment and Community Protection

The need to strengthen existing institutions for environmental management, which includes the monitoring function, and to create and support new institutions or units where necessary, has been described in Chapter 9.

10.3 ENVIRONMENTAL MONITORING PLAN FOR DAL

A draft environmental monitoring plan for the whole project is presented in Table 10.1.

The plan is structured according to pre-construction, construction and operational phases.

Monitoring activities in the construction period are classified into monitoring of

- the construction sites and activities and contractor's workforce,
- the bio-physical environment, and
- the socio-economic environment

Thus, in this draft plan, the monitoring of impacts during the construction period is generically covered for the main construction works in Sudan and for any mitigation works in Egypt.

Monitoring activities in the operational period are classified into monitoring of

- the bio-physical environment, and
- the socio-economic environment

At the full feasibility study stage, when Site Investigations are completed, engineering is advanced and a full EIA report is prepared, the EIA will have a detailed Environmental Management Plan, a detailed Resettlement Action Plan and a detailed Environmental Monitoring Plan. The draft Environmental Monitoring Plan here cannot now be completed with respect to details of every impact to be monitored, all locations, frequency of monitoring, responsibilities and costs for each mitigation measure to be monitored. The draft plan (Table 10.1) is restricted to

- mitigation measures to be monitored,
- parameters to be monitored,
- location (all sites, as required, or named particular locations), and
- the kind of monitoring/measurement required.

The draft monitoring plan consolidates all monitoring works into one table. This has a practical advantage, for present purposes, of preventing repetition of, for example, monitoring the preserving of top soil, spoil heaps and rehabilitation of works areas at the Dal dam site, and at access roads, quarries, borrow areas in relation to Dal, transmission line towers and related works, and in relation to any required construction activities around Lake Nasser/Nubia.

Similarly, where individuals or a community require compensation for loss of assets and livelihood resources, the need for monitoring disbursement of compensation is described in one row only, recognising that this element is required at one or more sites of project impact, including sites where mitigation works themselves have socio-economic impacts requiring compensation. In such cases, the location for this universal monitoring requirement is given as “all, as applicable”.

The majority of monitoring will comprise visual observations, carried out at the same time as the engineering monitoring activities. Water quality, noise and air emissions may be monitored qualitatively and quantitatively. Site inspections will take place with emphasis on early identification of any environmental problems and the initiation of suitable remedial action. Where remedial actions have been required on the part of the contractor, further checks will need to be made to ensure that these are being implemented to the agreed schedule and in the required form. Each part of the site where construction is taking place needs to be formally inspected from an environmental viewpoint on a regular basis. The frequencies of monitoring should be indicated during following studies.

In relation to basic physical and biological monitoring, it is important that those responsible for environmental monitoring seek the views of local people and community leaders who live near to the project component since they may be aware of matters which are unsatisfactory, but which may not be readily apparent or recognized during normal site inspections and monitoring visits. There is an obvious overlap here between environmental and socio-economic monitoring and need for regular liaison between those responsible.

10.3.1 Monitoring of construction labour health and accidents

In addition to items listed in the table, parameters that should be monitored include:-

- effective warning procedures and signage for minimizing risks such as visible signs on towers, works areas, and all other hazardous features;
- use of protective clothing, eye goggles, helmets, etc, where appropriate;
- sanitary facilities at campsites;

- awareness of communities about dangers/risks associated with power lines;
- water supply quantities and quality; sanitation condition
- reporting of diseases and accident cases

10.3.2 Monitoring of downstream releases

Regular monitoring of discharge downstream of the tailrace outfall to confirm releases are in line with prescribed conditions in the EMP.

10.3.3 Water quality monitoring

Major water quality parameters to be monitored include but will not be limited to major cation and anions, pH, EC, turbidity, colour, NO_3, DO, BOD, COD, grease and oil. Measurement of these parameters should reflect standards set by relevant national government authorities.

10.3.4 Noise monitoring

In addition to blasting operation and permitted times for blasting, there is need to monitor sound levels during construction activities relating to use of heavy machinery and also haulage vehicles for protection of workforce and villagers.

Table 10.1 : Consolidated Environmental Monitoring Plan for Dal

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
Pre-Construction Phase			
• In project feasibility and EIA study/ tender documents phase	• Project designs and specifications - incorporate appropriate mitigation and enhancement measures • Appropriate environmental protection clauses specified in contract documents, including non-exceedance thresholds, e.g. for solids in site runoff, air quality, noise; and contractor's monitoring frequency	• For all project sites	
• Upstream watershed management	• The soil conservation program itself, as prepared and led by program manager • River sediment loads	• Blue Nile and Atbara watersheds • Blue and Main Nile river gauging stations	• Observe reported progress of implementation of measures; inspect sites and report • Levels, flows and suspended sediment concentrations

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
Construction Phase **Contractor's works areas including access roads, quarries, borrow areas, dam, bridges, transmission line towers, stringing, and other construction sites for mitigation works which will disturb the environment in Sudan and Egypt**			
• Preserve top soil stripped from road edges and construction sites for re-use	• Stockpiles and their stability	• All, as applicable	• Observations
• Minimise numbers of spoil heaps; stabilize them; consider dumping in the reservoir inundation area where practicable	• Spoil disposal; spoil heap stability	• All, as applicable	• Observations
• Rehabilitate and landscape borrow pits and quarries; ensure safety measures are implemented and sustainable indefinitely	• Rehabilitation, restoration and landscaping of used sites; slope stability; access, safety measures	• All, as applicable	• Observations
• Avoid or minimise water pollution	• Water quality parameters	• All, as applicable	• Observations and sampling concentrations of treated, non-treated discharges and receiving watercourses
• Ensure toxic compounds are not located near rivers and water points. • Provide interception and control measures for chemical wastes and potential spillage • Provide all vehicles and machinery with drip-pans for catching oil; maintain regularly	• Location of sites • Interception and control measures • Drip-pans	• All, as applicable	• Observations • Observations • Observations

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Provide safe systems for hazardous waste disposal	• Storage and transport of hazardous materials including explosive etc • effluents	• All, as applicable	• Observations • Sampling of effluents
• Suppress dust along project roads, especially at and near settlements • Maintain construction equipments to minimize air pollution • Check and clean injectors of diesel engines regularly	• dust • construction equipment and emissions level • diesel engines	• All, as applicable	• Observations and reports of communities
• Minimize the use of explosives and utilise a systematic blasting schedule • Limit working hours in environmentally sensitive areas	• Blasting schedule and noise • Working hours	• All, as applicable	• Observations and reports of communities • Observations and reports of communities
• Report immediately to client any archaeological or historical resources (e.g. rock art, artefacts) previously not identified and salvaged • Avoid settlements and agricultural areas wherever practicable – all works areas	• Physical and cultural resources • Works areas	• All, as applicable	• Observations and reports of communities • Observations and reports of communities
• Remove woody material from reservoir area according to recommendations	• EMP recommendations	• Reservoir area	• As per EMP recommendations
• Minimize vegetation clearing for project infrastructure works and rehabilitate sites • Remove potential “eyesores” of woody material from reservoir area which would otherwise protrude after filling in vicinity of public viewing and fishing points	• Vegetation clearing at infrastructure works • Remove of potential “eyesores”	• All, as applicable • Reservoir area	• As per EMP recommendations • Observations

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Treat/remove/dispose waste oil, lubricants and other chemicals, and domestic waste (rubbish and sewage) to approved facilities	• Treatment, removal and disposal of wastes	• All, as applicable	• Keen observations of contractor's practices
• Follow agreed procedures for coffer dam and first filling • Provide timely warnings to upstream and downstream vulnerable communities using agreed procedures • Liase with RAP officers	• Agreed procedures • Timely warnings • Liaison taking place	• Dam site • Upstream and downstream vulnerable communities • Resettlement office and resettler locations	• Water levels and discharges • Observations and reports of communities • Liaison
• Provide training on environmental protection measures for flora and fauna	• Training for workforce	• Dam site offices	• Compliance with requirements
• Provide road warning signage (e.g. severe slopes, blind bends, speed limits) for all access roads and project works areas; reinforce these on public roads used as haulage routes for cement and other materials	• Signage on access roads and project works areas; public roads used as haulage routes	• All, as applicable	• Observations
• Provide appropriate facilities for accommodation and recreation of workforce at dam site camps • Provide appropriate facilities for accommodation at transmission line fly camps	• Accommodation and recreation facilities at dam site camps • Appropriate facilities for accommodation at transmission line fly camps	• Dam site • Transmission line fly camps	• Observations and reports of workforce • Observations and reports of workforce

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Provide safe water supply to workers • Establish on-site health facilities and strengthen health services of communities adjacent to dam site • Provide health and occupational safety education for workforce, including education on STDs and HIV/AIDS	• Water supply • On-site health facilities • health and occupational safety education/training courses; screening	• All, as applicable • Dam site • All, as applicable	• Water quality testing • Observations and reports of workforce • Records of training; records of health screening; records of health and safety status and site accidents; records of diseases including STDs and HIV/AIDS
• Implement plans for preferential employment of local people, with training	• Staff and labour recruitment procedures • Training/apprenticeships	• All, as applicable	• Records of staff and labour recruitment according to origin • Records of training and apprenticeships provided
• Implement first class communication system and procedures for keeping the public informed about project's progress	• Project communication system	• All, as applicable	• Records of communicated information by different means
• Anticipate, plan and develop infrastructure and other responses for probable induced developments	• Induced developments	• All, as applicable	• Observations, in liaison with state government and NGOs
Construction Phase **Bio-physical environment in Sudan and Egypt**			
• Upstream watershed management	• The soil conservation program itself, as prepared and led by program manager • River sediment loads	• Blue Nile and Atbara watersheds • Blue and Main Nile river gauging stations	• Observe reported progress of implementation of measures; inspect sites and report • Levels, flows and suspended sediment concentrations

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Reservoir slope stability - precautionary measures by contractor (only if in EMP)	• Reservoir slope stability measures	• Reservoir basin flanks/cliffs	• Observations, followed by SI if required
• Reservoir induced seismicity - precautionary measures by contractor (only if in EMP)	• Seismicity before and during first filling • Precautionary measures	• Around reservoir	• Seismograph network records • Observations on vulnerable structures
• Blown sand stabilisation measures (only if in EMP)	• Blown sand stabilisation measures	• North banks of Dal reservoir	• Observations on adequacy of measures
• Utilise raised groundwater if and where significant for beneficial use • Provide drainage for raised groundwater levels if and where impacts are adverse	• raised groundwater during and after first filling • new springs, or improved flow of existing springs • poor drainage	• Around reservoir	• Borehole and well records • Spring discharges • Observation of poor drainage
• Disease vectors - provide health care education, clinics and mosquito nets	• Water-related disease vectors • Adequacy of provision of health care education, clinics and mosquito nets	• Around Reservoir • Communities around reservoir	• Observations of vectors • Records of health care education • Records of diseases treated • Adequacy of clinics • Records of issued mosquito nets
• Aquatic environment – minimise adverse construction impacts on watercourses by implementation of mitigation measures by contractor during project construction • Implement a reservoir fisheries development program	• All erosion and pollution aspects mentioned above • EMP program recommendations	• All, as applicable • Reservoir and hatchery (in conjunction with surveys and monitoring at Merowe if practicable)	• All observations and measurements relating to erosion and pollution mentioned above • As per EMP, including water quality parameters, phyto- and zooplankton, benthic fauna, fish species, catch per unit effort

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Natural terrestrial habitats and wildlife - minimise adverse construction impacts on habitats by implementation of mitigation measures by contractor during project construction • Avoid damage to any notified habitat sites of special scientific, historical or cultural interest • Implement conservation management measures in reservoir perimeter buffer zone	• All erosion, pollution, noise aspects mentioned above • Notified habitats • Conservation management measures	• All, as applicable • Reservoir perimeter buffer zone	• All observations and measurements relating to erosion and pollution mentioned above • Observations and reports of workforce • As per EMP recommendations, including surveys/census of water birds and terrestrial wildlife, and surveys of habitats
Construction Phase **Socio-economic environment in Sudan and Egypt**			
• Provide compensation to affected communities	• Disbursement of compensation	• All, as applicable	• Correct procedures, amounts according to schedules
• Arrange for relocation and settlement of affected people	• Relocation arrangements, and physical and social infrastructure for resettled communities in place	• All, as applicable	• As per RAP recommendations
• Ensure provision of all the necessary facilities in the new settlement area	• Provisions for improved livelihoods for resettled communities in place • Development plan	• All, as applicable	• As per RAP recommendations • As per development plan

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
▪ Measures to compensate for lower reservoir levels – power generation	▪ Power generation	▪ In Egypt, High Aswan Dam	▪ Power generation, according to agreed formulae for compensation ▪ Compensation payments
▪ Measures to compensate for lower reservoir levels - fisheries	▪ All measures (e.g. greater stocking with fingerlings, compensation)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ Measures to compensate for lower reservoir levels – agriculture/ pumped irrigation	▪ new pumps, ▪ compensation for additional fuel costs)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ Measures to compensate for lower reservoir levels – navigation	▪ All measures (e.g. moorings, jetties, pontoons, boats)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ Project induced developments, as anticipated, or as they occur spontaneously	▪ Unknown	▪ All, as applicable	▪ Observations and measurements, as required
Operational Phase **Bio-physical environment in Sudan and Egypt**			
• Upstream watershed management	• The soil conservation program itself, as prepared and led by program manager • River sediment loads	• Blue Nile and Atbara watersheds • Blue and Main Nile river gauging stations	• Observe reported progress of implementation of measures; inspect sites and report • Levels, flows and suspended sediment concentrations

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
• Maintenance of rehabilitated surface works areas, including roads, spoil heaps, quarries and borrow areas. Arranging for re-grading, re-planting as required.	• Rehabilitated areas, and public safety	• Rehabilitated former works areas	• Surveys
▪ Safe transport and storage of all hazardous materials	▪ EMP for hazardous materials storage and transport	▪ All, as applicable	▪ As per EMP recommendations
▪ Waste management for each type of industrial, domestic and sewage waste. ▪ Sanitary engineering at permanent works areas and compounds	▪ All wastes	▪ All, as applicable	▪ Observation on waste storage, treatment and disposal ▪ Monitor effluents and water quality of receiving watercourses and groundwater
▪ Project climatological station	▪ Sites and instruments ▪ Climate parameters	▪ All, as applicable	▪ Observe and Inspect sites, instruments and records for quality and continuity
▪ Safety of reservoir banks	▪ Reservoir banks/slopes	▪ Around reservoir	▪ Observations, made by boat and land access
• Blown sand stabilisation measures (only if in EMP)	• Blown sand stabilisation measures	• North banks of Dal reservoir	• Observations on adequacy of measures
▪ New and existing springs, boreholes and shallow	▪ Levels and flows	▪ Around reservoir	▪ Observe sites and inspect instruments and records for quality and continuity
▪ Release of water downstream in line with Owner's requirements	▪ Downstream releases	▪ Dal Dam	▪ Turbined and spillway flows
▪ Flood forecasting and flood warning scheme	▪ The scheme	▪ Dal Dam and downstream	▪ Checking records of past operations; checking equipments and schemes are operational
▪ Dal, Merowe and Nubia reservoirs	▪ Full aquatic/limnological surveys – all hydro-biological aspects	▪ Dal, Merowe and Nubia reservoirs	▪ Surveys, synchronised if possible
▪ Reservoir buffer zone	▪ Wildlife habitat and wildlife, including contribution to African Water Bird Survey	▪ Dal, Merowe and Nubia reservoirs	▪ Surveys, synchronised if possible
▪ Reservoir sedimentation	▪ Hydrographic survey	▪ Dal, Merowe, Nasser/Nubia reservoirs	▪ Surveys, synchronised if possible

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
▪ Environmental protection measures for new roads, housing and industrial developments, etc.	▪ Environmental protection measures	▪ All, as applicable	▪ Surveys
Operational Phase **Socio-economic environment in Sudan and Egypt**			
▪ Resettlement Action Plan and development program(s)	▪ RAP and development plans, and their targets	▪ All, as applicable	▪ Surveys, auditing
▪ Burial grounds, historical or other cultural sites	▪ . Burial grounds, historical or other cultural sites	▪ All, as applicable	▪ Surveys, auditing
▪ Vigilance concerning encroachment of settlements and activities along transmission line Right of Way	▪ Encroachment along transmission line Right of Way	▪ Project high voltage transmission lines	▪ Surveys of any encroachment along ROW
▪ Rural electrification in project areas, as part of development plans	▪ Level of individual and community connections; tariffs; affordability; energy consumption; energy uses, income improvements. Regional development parameters.	▪ All, as applicable	▪ Surveys, auditing
▪ Road communications	▪ Vehicle types, numbers, purposes of travel. Regional development parameters	▪ Dal dam crest road or bridge, new project roads	▪ Traffic surveys

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
▪ Reservoir communications	▪ Condition and uses made of new or improved crossing places of the reservoir (ferries). Determine areas where needs are not being met.	▪ Dal reservoir crossing places	▪ Condition and use surveys
▪ Reservoir and river fishery development	▪ CPUE, fishermen numbers, boats, nets, catches, fish consumption, market prices, fishermen's incomes	▪ Dal reservoir, Merowe, Lake Nasser/Nubia	▪ Surveys
▪ Measures to compensate for lower reservoir levels – power generation	▪ Power generation	▪ In Egypt, High Aswan Dam	▪ Power generation, according to agreed formulae for compensation ▪ Compensation payments
▪ Measures to compensate for lower reservoir levels - fisheries	▪ All measures (e.g. greater stocking with fingerlings, compensation)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ Measures to compensate for lower reservoir levels – agriculture/ pumped irrigation	▪ new pumps, compensation for additional fuel costs	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees
▪ Measures to compensate for lower reservoir levels – navigation	▪ All measures (e.g. moorings, jetties, pontoons, boats)	▪ In Sudan, Lake Nubia ▪ In Egypt, Lake Nasser	▪ Surveys of measures, satisfaction of affectees

Proposed Mitigation	EMP parameter to be monitored	Location	Observation/Measurement
▪ Project induced developments, as anticipated, or as they occur spontaneously	▪ Unknown now	▪ All, as applicable	▪ Observations and measurements, as required

Footnote:

At the full feasibility study stage, when Site Investigations are completed, engineering is advanced and a full EIA report is prepared, the EIA will have an Environmental Monitoring Plan. The above table is a proto-type of the future Environmental Monitoring Plan; it cannot now be completed with respect to location, frequency, responsibilities and costs for each mitigation measure to be monitored. Many of these are unknown at pre-feasibility stage.

10.4 RESETTLEMENT ACTION PLAN AND DEVELOPMENT

The draft consolidated monitoring plan purports to cover project monitoring generically, and is necessarily light concerning RAP. Resettlement and associated development is a very important component of the project and a few additional points are made here.

When construction contracts are awarded, the contractors will require all land acquisition to be completed and to have freedom to get on with construction works. Schedules for moving out of works areas, including provisions for vulnerable groups, will be incorporated in RAP plans produced during feasibility studies for the Dal dam area and, as may be required, for the transmission line. The RAP plans for these will also cover items concerning compensation, compensation disbursement, restoring and improving livelihoods, training, infrastructure and social services.

Implementation of RAP plans requires monitoring by agencies described earlier.

The items to be monitored in the construction phase will be scheduled in detail in RAP plans. Some are anticipated and summarised in Table 10.2. In consultations with local people and community leaders, those monitoring will ensure that these are satisfactory, or developing to a foreseeable satisfactory condition, for all PAPs without exception.

Table 10.2 : Socio-economic Monitoring for Resettlement

Items to be monitored before resettlement	
(1)	Disbursement of compensation which should take place promptly and according to agreed rates
Items to be monitored at resettlement sites	
(2)	New houses
(3)	New housing suitable for all kinds of livestock
(4)	Universal availability and use of mosquito nets
(5)	Water supplies, quantity and quality
(6)	Sanitation provisions
(7)	Waste drainage arrangements
(8)	Roads and footpath networks
(9)	Clinics, and qualified health care staff numbers
(10)	Schools, and qualified teaching staff
(11)	Community buildings and facilities, including market places
(12)	Energy sources
(13)	Shade trees

Livelihood conditions to be monitored at resettlement sites	
(14)	Provision of health care facilities, and monitoring numbers of diseases cases, especially STD and HIV
(15)	Family incomes, and their meeting targets
(16)	Vulnerable groups
(17)	Agricultural production
(18)	Tree production
(19)	Livestock production (chickens, goats, sheep, cattle, donkeys) and grazing resources
(20)	Fish, honeybee, and non-timber forest products and related activities.

Those monitoring (regional government departments and RMU) will seek to ensure that livelihoods of resettled PAPs are re-established rapidly, and improving. The RMU will also be responsible for ensuring on-going provision of satisfactory veterinary, agricultural, horticultural and other specialist advisory and treatment services in host/resettlement villages.

At intervals, independent auditing and monitoring will be required for all host and resettled communities. Targets set in the RAP and development plans, and as may be subsequently revised, must be capable of being monitored realistically, and provide no possibility of political or other interference. Results of auditing and monitoring require to be made known to the independent Panel of Experts for the Environment and Community Protection, local communities and local administrations, government, NGOs and project financiers.

Where such monitoring reveals failures to achieve targets, measures should be taken to improve conditions immediately. It is suggested that financial provision for such contingencies to mitigate and improve conditions should be made available from Dal project's income stream, over and above annual allocations of project funds, unless other arrangements are in place.

11. PRELIMINARY ENVIRONMENTAL COST ESTIMATES

11.1 COST ESTIMATES

The environmental cost estimates address unavoidable negative impacts that will take place during the project's construction and operation. These impacts are generally categorized into physical, biological and socio-economic as described in Chapter 6.

Table 11.1 provides preliminary cost estimates. The following notes refer to row numbers in this table.

1) ***Reservoir Clearing:*** Cost of removing most biomass (vegetation) from the reservoir inundation area. The estimated cost is shown here but included in civil engineering cost estimates.

2) ***Technical Environmental Optimization:*** Additional cost that may be necessary to cater for environmental concerns during the detailed design

3) ***Compensation and Resettlement:*** The total is based on unsubstantiated costs and resettlement numbers at Merowe, giving USD 8,600 per resettled person. This rate is applied to 42,000 people at Dal. The total provides for

   - Compensation for all houses, assets, structures, date palm trees, other trees, cultivated irrigated land and flood recession agriculture (gerouf), crops, grazing areas, production from natural resources (honey, hunting, fish) and any other items;
   - Resettlement construction costs for new houses, community buildings, schools, health facilities, water supplies, sanitation, preparing land for cultivation, irrigation systems, agricultural research centre and any other facilities and services;
   - All necessary income generation projects for ensuring that directly affected people and communities are not disadvantaged by the project and have access to viable income generating opportunities in the resettlement areas.

   The estimate for compensation and resettlement at Dal is considered to be a minimum estimate.

4) ***Archaeological surveys, excavations and documentation***: The estimate provided in Table 6.8, greater than USD 8.8 million, is based on similar work at Merowe but is here rounded up to USD 10 million in recognition of the very rich cultural heritage between Dal, Abri, Delgo and Kagbar and archaeological interests on the dam centre line and possibly in quarry and access roads areas. The sum does not provide for dismantling and reconstructing the temple at Soleb and possibly other monuments. This would be additional.

5) ***Fisheries study/outreach program:*** Dal reservoir fisheries development support, taking into account present and future fishery potential through study, training and capacity building.

6) ***Conservation Initiatives:*** An allowance provided for promoting a protected area of the reservoir for conservation purposes.

7) ***Water Quality Monitoring:*** Cost of checking water quality in the reservoir and downstream of the tailrace outlet, over and above the contractor's obligations.

8) ***Monitoring of Construction Work:*** Monitoring and auditing of environmental protection works during construction and adherence to the EMP. EMU.

9) ***Socio-Economic Monitoring:*** Cost of ensuring effective implementation of the resettlement's livelihood safeguard program and providing services to redress grievances; cost of monitoring disbursements under the compensation/mitigation program and the health status of the local community, etc. RMU.

10) ***Institutional Capacity Building Program:*** Institutional capacity building for local institutions to cope with the modalities of a large construction project in their locality and support to state agencies responsible for advising on and inspecting aspects of implementation including land acquisition, compensation and environmental mitigation. Special attention to strengthening the State Council for Environment and Natural Resources, State Ministry of Agriculture, Animal Resources and Irrigation, State Ministry of Engineering Affairs and Public Utilities, and the State Ministry of Health; also relevant offices of Wadi Halfa locality and its administrative units at Ferka, Abri and Delgo. Includes some allocations for strengthening CSOs and NGOs which may contribute positively to supporting the needs of resettlement communities and environmental management.

11) ***Post Construction Environmental Audit*****:** One time cost of checking the construction site remediation after the contractor has left (final payment of contractor will be tied to a successful audit inspection).

Because the pre-feasibility engineering report proposes a run-of-river mode of operation for Dal hydropower project, as opposed to one which would have a diurnal or seasonal peaking regime, the environmental assessment has concluded that downstream impacts on river morphology and recession agriculture will be negligible. No budget allowance has therefore been made for downstream mitigation for these. If the mode of operation changes to peaking, then some mitigation costs may be involved.

Table 11.1 : Dal Environmental Cost Estimate – USD

No.	Item	Text Reference	Units	Quantity	Unit Cost USD	Capital Cost USD	Recurrent Cost Lump Sums USD	
							Construction Phase	Operational Phase
1	Reservoir clearing (costed as Civil Work)	See Note	ha	30,000	550	16,500,000		
2	Technical Environmental Optimisation	See Note	LS			200,000		
3	Compensation and Resettlement	Table 6.7	LS			360,000,000		
4	Archaeological surveys, excavation, documentation	Table 6.8	LS			10,000,000		
5	Fisheries outreach program	See Note	LS			200,000		20,000
6	Conservation initiatives	See Note	LS			150,000		
7	Water quality monitoring	See Note	LS				10,000	10,000
8	Monitoring of construction works	See Note	LS			200,000	80,000	40,000
9	Socio-economic monitoring	See Note	LS			300,000	200,000	50,000
10	Institutional capacity strengthening program	See Note	LS			2,000,000	100,000	
11	Post construction environment audit	See Note	LS			50,000		
Sub-totals (excluding reservoir clearance)						373,100,000	390,000	120,000
Grand Total, including 15% contingencies								**429,651,500**

The estimated provisional sum of USD 429.6 million is for mitigation and monitoring in the direct impact zone and for downstream monitoring. This represents some 32% of the estimated overall project cost (USD 1,322.8 million)[1].

11.2 COSTS AND BENEFITS IN EGYPT

Some environmental mitigation, management or monitoring costs are foreseen for Egypt as a result of implementing the run-of-river Dal hydropower project. As described in Chapters 6, 7, 9 and 11, mitigation costs relate, or may relate, to fisheries, agriculture, settlements and navigation around Lake Nasser/Nubia, additional pumping costs at Mubarak pumping station (if operational), and to reduced power generation at Aswan.

Management costs, including institutional strengthening and monitoring costs, relate to agencies described in Chapter 9.

These costs will require assessment during feasibility and EIA studies of the Dal project, when all preliminary costs in Table 11.1 should be examined in detail.

11.3 WATERSHED MANAGEMENT

Minimisation of reservoir siltation at Dal is in the medium and long term interests of the project. During full EIA studies, consideration should be given to including an operational annual project cost as a contribution towards watershed management upstream.

[1] It is noted that the estimated overall project cost in Table 3.11 provided for a lower figure of environmental mitigation, USD 220 million, and that this was included in the project model for investment planning and modelling (Module 6). This subsequent revision by an additional USD 209.6 million is based on a higher estimate of resettlement population, greater archaeological mitigations and greater institutional strengthening needs.

12. CONCLUSIONS

12.1 PRELIMINARY SCREENING

12.1.1 Power, Land and Population Displacement

The energy produced by the run-of-river 400 MW Dal project (2,160 GWh/year) is substantial. Screening the project by considering the land area flooded (300 km^2) and the numbers of people displaced (42,000) by the reservoir for each installed MW suggests that Dal is not favourable in comparison to many of the major hydropower developments in the world. Plots of these two indices are shown together with those for other major dams listed by IUCN/World Bank (1997) in Figure 12.1.

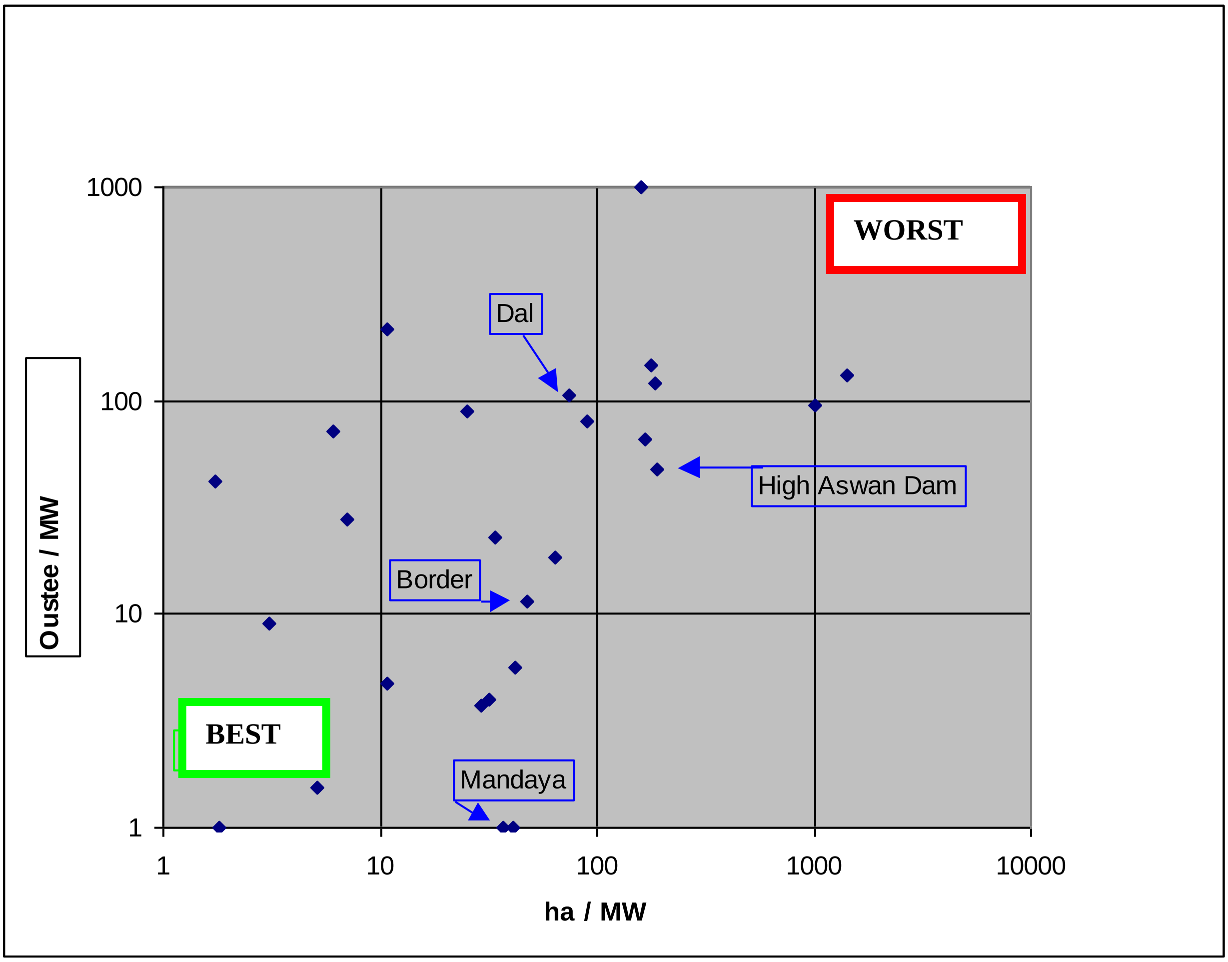


Figure 12.1 : Hydropower Efficiency Ratios

Taking a global view, with an index of greater than one hundred people per installed MW, it has to be concluded that Dal must be one of the few remaining potential hydropower project sites in the world where a modest run-of-river power development would disturb so many people directly.

12.1.2 Physical Cultural Resources

The Dal area is extraordinarily rich in physical cultural resources. Many sites have been identified. A few of these have been studied in detail but many have not and await resources to conduct detailed studies. The Honorary Secretary of the Sudan Archaeological Research Society (SARS) has prepared a summary of the archaeology and heritage of the Dal reservoir area. Archaeological surveys and research have revealed the existence of human settlements in the Dal area for 200,000 years. This testifies to the immense value of the Nile valley's fertility in an otherwise climatically hostile environment. The riverbanks and islands through the Dal reservoir area exhibit a complete sequence of occupation. The monument of the Temple of Amenhotep III at Soleb, regarded as having World Heritage status, is one that will require dismantling and re-construction. It is estimated that surveys, documentation and salvage, will require at least 10 years of sustained work.

12.1.3 Water Conservation

Ten riparian countries share the Nile river system and demands on the river are high and increasing. The population in the desert in the north of Sudan and almost the whole population of Egypt are totally dependent on the river for water supplies and irrigated food production, not to mention the river's importance to these countries for power generation. Whilst all reservoirs in the region cause loss of precious water resources through evaporation, reservoirs in the wetter and cooler highlands of Ethiopia offer least evaporation losses. Figure 12.2 shows the amount of annual evaporation losses per installed MW and per GWh/year for Dal in the Nubian desert in Sudan and for Mandaya and Border in Ethiopia. Dal's evaporation losses for each unit of electrical energy are nine times greater than at Mandaya.

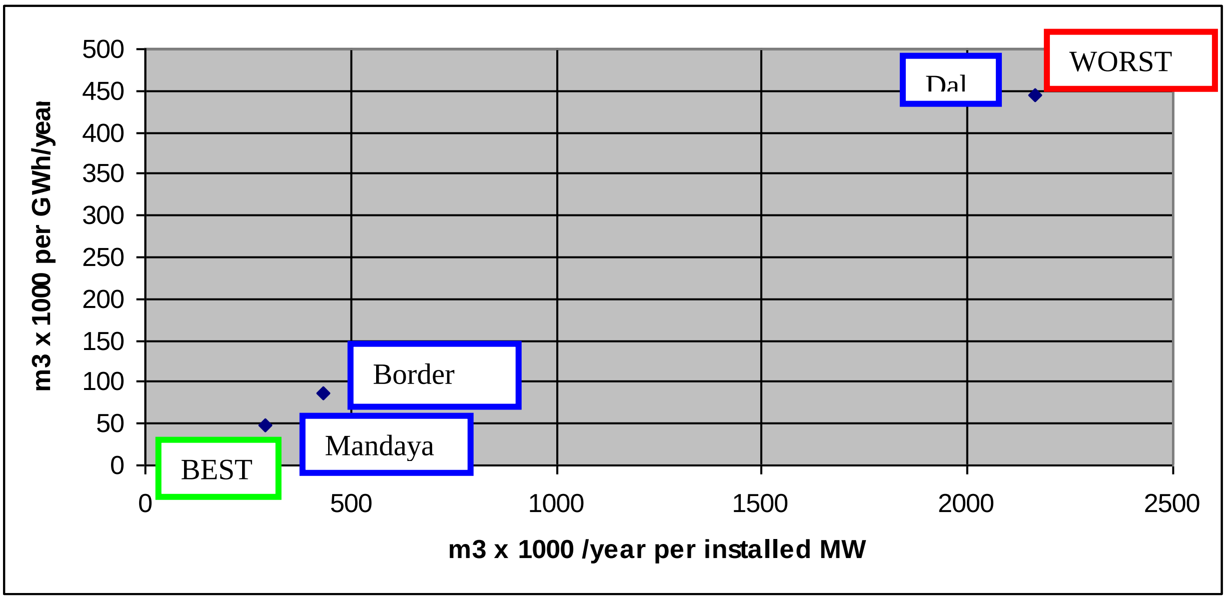


Figure 12.2 : Hydropower Efficiency Ratios of Annual Evaporation Losses for Installed Capacity and Annual Energy

12.1.4 Conclusions on Preliminary Screening

It is concluded that development of Dal on the Main Nile in Sudan is unfavourable from the points of view of minimising population displacement and loss and disturbance of physical cultural heritage. Dal is also unfavourable with regard to conserving water resources in the water constrained Nile system where demands continue to increase.

12.2 PRINCIPAL ENVIRONMENTAL IMPACTS AND MITIGATION

The primary energy benefits of the Dal project (2,160 GWh/year) are substantial. According to parallel coordinated investment planning studies, the economic cost of power generation at Dal is favourable in comparison to other power sources in Sudan when Sudan's power resources are considered in isolation. The Dal project is a relatively high cost source of energy when compared to the major projects on the Abbay (Blue Nile) river in Ethiopia, such as the Mandaya, Border and Karadobi projects. As such, the Dal project does not form part of the regional development plan.

However, in advance of the implementation of the regional inter-connector, Dal project may be considered as part of a national power development strategy within Sudan since it offers a lower cost source of energy than the thermal power alternatives within Sudan.

This pre-feasibility has scoped and considered many issues but all of these require more detailed studies in line with Dal having a Category “A” status and therefore in need of a comprehensive environmental impact assessment study. Conclusions about the principal impacts are described below.

12.2.1 Resettlement

The anticipated resettlement associated with the Dal project (42,000 people) may be regarded as very large for the size of project and resettlement will be a very important component of it. Land resources and socio-economic surveys will be required in order to propose a Resettlement Action Plan associated with a development plan for host and resettled communities. This will be a very challenging assignment because of the scale of the involuntary resettlement required, the declared resistance of the Nubian people to move and the difficulties of establishing livelihoods and a new way of life, away from the river's fertile alluvial strip, in harsh desert conditions in the area. Resettlement at Dal invokes the World Bank's safeguard policies on involuntary resettlement and on indigenous peoples. Because of the complexities and wide-ranging nature of impacts and mitigation measures, it is concluded that the project will require an international Panel of Experts for Environment and Community Protection.

12.2.2 Physical Cultural Resources

The physical cultural heritage along both banks of the Nile and on the river islands in the potential Dal reservoir basin is extraordinarily rich. It is observed that at least 10 years surveys and salvage would be required before the basin could be flooded.

This archaeological and historical richness invokes the World Bank's safeguard policy on physical cultural resources.

12.2.3 Terrestrial Ecology

The 300 km^2 reservoir area is dominated by desert habitats within which the river and its narrow fertile alluvial strip is located. Preliminary field surveys and documentation have indicated no terrestrial plant or animal species endemic to the area. However, because the fertile riverine area has been occupied and cultivated for millennia, the area appears to offer no intact terrestrial habitats which may be considered essential to conserve.

12.2.4 Aquatic Ecology

Similarly, preliminary field surveys and documentation have indicated no aquatic plant or animal species endemic to the area. Fish migration is considered to be local and to not have regional significance. Dal reservoir is expected to be a haven for migratory water birds and attention to managing conservation of parts of the lake may more than offset the loss of some aquatic resources in this reach.

12.2.5 Mineral Deposits

Assessment of the geology of the reservoir basin by the project geologist did not reveal the known occurrence of existing, or potentially, commercially valuable mineral deposits. Gold mining occurred in the past but has long since been abandoned.

12.2.6 Reservoir First Filling and Operation

The proposed storage capacity of Dal reservoir is very small (2.47 billion m^3). First filling will occur rapidly and necessarily cause reduced flows for a short period downstream. Owing to the very large storage capacity at High Aswan Dam, which in all but the most severe hydrological sequences provides a buffer against water shortages in Egypt, Dal may be filled without causing water supply shortages for public water supply and irrigation. Once filled, the proposed run-of-river operations of Dal will release water downstream as received upstream with only minor modifications due to evaporation, slight attenuation and possibly some diurnal peaking.

12.2.7 River Morphology

With retention of only some of the sediment load in Dal reservoir, the released turbined and spillway water will have slightly greater energy. However, significant changes in river morphology are not expected as the flow rates will remain essentially unchanged and the river passes over several kilometres of hard bedrocks in the Dal cataract downstream of the dam and immediately enters the upper end of Lake Nasser/Nubia.

12.2.8 Flooding and Recession Agriculture

The annual flood supports life along the river through the desert to Lake Nasser/Nubia, providing overbank water supplies for flood recession agriculture (gerouf) and other vegetation, and re-charging groundwater. It also deposits silt regarded by farmers as an annual dressing of fertilizer. The proposed run-of-river operations at Dal will not alter this flooding regime, apart from some reductions in deposited silt. Precautionary mitigation measures have been outlined in the report.

12.2.9 Reservoir Fisheries, Communications and Recreation Development

The principal secondary benefits of the Dal project relate to the creation of a permanent wetland which will give opportunities for fisheries development and related processing, trade and employment. The new wetland, with surface area constantly within a certain range, is expected to be a safe means of communication by boat and to potentially offer development opportunities for recreation. These potential benefits require greater study.

12.2.10 Lake Nasser/Nubia

Several thousand people depend on fisheries, lake recession and irrigated agriculture, and navigation in the Lake Nasser/Nubia area. Development proposals indicate that greater settlement will take place in future to exploit the available resources in the region. The first filling reduction in Lake Nasser/Nubia levels caused by Dal (some 0.52 to 0.75 m are indicated) may have some adverse impact on livelihoods and the local economy, and will reduce power generation at Aswan. These impacts will be cumulative to those caused by first filling of Merowe. Some mitigation and compensation measures are expected to be required, and these may continue into the operational period. It is concluded that more detailed studies will be required to assess impacts and make proposals to address them with cost estimates. The construction of the Dal project on the Nile river invokes the World Bank's safeguard policy on international waterways.

12.2.11 Watershed Management

The long-term sustainability of power generation at Dal will be impaired by reservoir siltation. It is concluded that proposals for watershed management in the large Abbay river basin in Ethiopia, and for the Blue Nile and Atbara sub-basins, need to be completed and implemented as soon as practicable and that it will be in the interests of the Dal project that some portion of the watershed management program is boosted by addition funding from the income stream of the Dal project when it becomes operational.

12.2.12 Dam Safety

It is proposed that the concrete faced rockfill dam at Dal will be 30 m high. There will be need for every precaution to be taken in its design, operation and maintenance and for all relevant information to be known to the public. For this it is concluded that the project will require an international Panel of Dam Safety Experts. The construction of the Dal dam invokes the World Bank's safeguard policy on dams.

12.2.13 Public Relations, Communications and Grievances

The construction of the Dal project is expected to take six years. Works to mitigate adverse impacts are many, including a major resettlement and development program, archaeological surveys, documentation and salvage, and possibly some works at Lake Nasser/Nubia. Thus the opportunities for grievances will be many. Because of the project being developed and having impacts on two countries, it is concluded that a first class communications system will be required to inform stakeholders of plans, changes in plans and progress, and that procedures for dealing with grievances will be required to be developed and made widely known. This aspect requires attention and priority in future project studies.

12.3 THE WAY FORWARD

The Dams Implementation Unit commissioned a feasibility study of Dal hydropower development, along with an EIA study, before this initial environmental impact assessment was completed. Hydropower feasibility studies of other Nile cataracts were similarly commissioned in 2007. These studies will permit informed comparisons to be made about the costs and benefits of individual dams in the Main Nile's potential hydropower cascade and their environmental and social impacts.

These studies will also permit Dal and other potential Main Nile sites to be considered in the context of raising Roseires dam on the Blue Nile and future regulatory storage works on the Abbay in Ethiopia.

It is hoped that this initial environmental impact assessment report on Dal will contribute to the planning of future hydropower developments in Sudan and the Eastern Nile region.

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APPENDICES

Appendix 1.1	**Contributors to Initial Environmental Impact Assessment of Dal Hydropower Project**
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Appendix 1.1

Contributors to Initial Environmental Impact Assessment of Dal Hydropower Project

YAM Consultants, Khartoum

Professor Asim I. el Moghraby	Team Leader, Aquatic ecology
Dr. Faysal A. Sinada	Terrestrial ecology and land use
Eng Issam Mustafa	Climate/flows/sediment loads and Water demands
Professor Souad Suliman	Public Health profiling
Dr Mustafa Babikir	Demography/socioeconomic profiling and Compensation and Resettlement.
Dr Khidir A Kharim	Archaeologist/cultural property

Scott Wilson Contributors

Andrew Wain	Co-ordinator and editor; river regulation; downstream assessment
Edda Ivan-Smith	Resettlement
Alan Bates	Engineering, carbon assessment
Terry Page	Geology, minerals, seismology, slope failures

Appendix 1.2

Itinerary

Reconnaissance fieldwork was carried out in November 2006, and more detailed investigations in February 2007 (geological) and April 2007 (social and environmental)

Month	Locality	Arrival Date	Departure date
November 2006	New Hamdab/Dongola/Bayuda	2	2
	Bayuda/Dongola/Abri	3	3
	Dal/Abri/Bayuda	4	4
	Bayuda/Dongola/New Hamdab	5	5
	High Aswan Dam, Lakes Nasser/Nubia (overview during scheduled flight)	8	8
March 2007	Dal dam site and environs		
April 2007	Dongola	3	4
	Abri	5	5
	Dal/Akasha	7	7
	Abri /Solib	8	8
	Solib/Dongola	8	9
	Dongola/Khartoum	10	10

Appendix 1.3

Consultations during Inception Mission in Sudan in November 2006

Meeting Date	Person/Agency	Environmental issues raised and discussed in Khartoum and Dongola/Dal
1/11/06	**Eng. Ibrahim Salih Adam** Ministry of Irrigation and Water Resources – focal point for study	On arrival in Khartoum from Addis Ababa, advise on ENTRO study inception stage and proposed safari to Dal.
1/11/06	**Yahia Abdel Mageed** YAM Consultants	Khartoum. Discussion on Abbay water resources development scenarios.
3/11/06	**Kamal** Irrigation Department at Dongola	Dongola. Visited river gauging station at Dongola, downstream of ferry on right bank. Kamal then attended two-day visit to Dal and other cataracts. Discussed hydrometric issues relating to other Nile stations, observers, gauging by Egyptian team, etc.
4/11/06	**Residents at Dal**	Dal. Discussions on possible project and resettlement concepts; fish (caught and eaten daily), bird flyway, sand dune encroachment, water supply. A left bank village - no vehicles here. Note. Dal is 278 km from Dongola, and 825 km from Khartoum.
5/11/06	**Commissioner at Dongola**	Dongola. Courtesy call to inform him about ENTRO project and future field studies relating to Dal.
5/11/06	**Elfatih Elajib**, New Hamdab Research Station, Ministry of Science and Technology, Agricultural Research and Technology Corporation	New Hamdab Research Station. Watched promotional video of Merowe project. Discussions on establishment of research centre, crop trials and responses to organic and inorganic fertilizers. All relevant to any future resettlement.
6/11/06	**Tageldin Faragalla Dalil** NEC	Khartoum. Report on 4-day safari to Kajbar and Dal cataracts. Inspected one volume of Russian feasibility report on Kajbar – but no contours. There had been significant protests about resettlement to President by local people; some claim manipulation of local people (to protest).
6/11/06	**Bushra Abdalla Gadalla**, NEC	Khartoum. Description of pre-feasibility studies to Acting General Manager. Emphasis on sediment transport problems.
6/11/06	**Eng. Ibrahim Salih Adam** Ministry of Irrigation and Water Resources	Khartoum. Report on 4-day safari to Kajbar and Dal cataracts. Chasing reports by Coyne/Gibb; Russian Kajbar volumes; and recession agriculture by FAO Africover – National Forest Corporation or Remote Sensing. Discussion of UNESCO work on sand encroachment of Lake Nasser/Nubia – only TORs, not a report.
7/11/06	**Bader El Din Ali Mohamed,** Mierag Space Technologies Company	Khartoum. 1:100,000 mapping unknown of Dongola – Dal - Akasha area. Only available mapping is at 1:250,000. Copy printed from Akasha in north to Dongola in south - many old features recorded on this map (probably dated 1930s).
7/11/06	**Eng. Ibrahim Salih Adam** Ministry of Irrigation and Water Resources	Khartoum. Discussion of 1988 and 2006 floods. 1998 was normal flood from upstream, augmented by local intense runoff along main Nile. No early warning system in place then; much damage. Thus flooded area and recession agriculture potential near maximum this year. What is return period? National Defence early warning system in place; much damage was avoided and assistance was provided. NBI Flood Project now moving to 2nd phase with national flood forecasting centres in Ethiopia and Sudan, and reaching out to communities.

Meeting Date	Person/Agency	Environmental issues raised and discussed in Khartoum and Dongola/Dal
7/11/06	**Dr. Amna Ahmed Hamid**, Remote Sensing Authority	Khartoum. On-screen demonstration of mapping of Africover – project led by National Forest Corporation. Amna participated in the project. Potential for abstracting gross areas (in hectares) of recession agriculture and other Nile water dependent vegetation along main Nile; RSA is now working on year 2001/02 imagery.

Appendix 1.4

Notes on Safari to Dal Cataract, 2-5 November 2006

Thur 2nd Nov Time	Vehicle kilometre reading km	Event/comments Khartoum/Dongola/Bayuda Idris' digital photos – time and photo number (fitted into comments according to time sequence)
0730		Depart Khartoum.
		See Merowe transmission line, substation and two more transmission lines along the route to Abu Dom.
0838	48501	Abu Dulua Toll station
0910	48531	Begin tarmac; Merowe Transmission Line (T/L) visible
0940		Merowe T/L visible
1012	48632	TamTam camp Merowe T/L works
1112	48743	Cross T/L. After desert drive, some "green" ahead.
1114		Stop. Villagers resettled 130 km from Merowe. Driver of vehicle is a resettler but living and working in Khartoum.
1210		Wadi Halfa. Lunch.
1236	48752	At resettlement – **New Hamdab**
1210	42558 **change vehicle**	Drive into **resettlement village**. Neem trees. Graves, health centre, 1000 homes x 5 persons. Visit driver's (unoccupied) house compound – young palms, lemon, squash planted in garden.
1237	42564	Depart village centre. (Idris' photos below: time of photo, number of photo, headline description) 1239 3 at canal bridge. **New Hamdab resettlement**. 1240 4 at canal bridge 1240 5 canal, desert and transmission line 1240 6 at canal bridge 1241 7 canal stop logs controls 1241 8 canal stop logs controls 1242 9 canal, silt deposit and two offtakes, local power line 1242 10 settlement buildings, transmission line 1242 11 canal, silt deposit and two offtakes, dredged silt on banks, local power line.
1244	42565	See **canal and irrigated fields**. 6 feddan per family. Additional area provided for irrigation but not taken up. See pumping station downstream of canal. Walk in basin-irrigated fields. Young date palms growing in alfalfa – providing shade later. Goats in pen. Re-sale prices mentioned of USD 20,000 for 6 feddan, and USD 7,500 for house. Neem and Australian plant along canal banks. Canal flowing full but little used. What is occupancy ? 5% ? Many resettlers went to Saudi – strong connections from Merowe area and Saudi. Cost of resettlement programme not declared but could be USD 600 million of the USD 2 billion project - i.e. implying resettlement mitigation is 30% of project cost – an exceptionally high proportion. 1249 12 irrigated alfalfa crop with young palms. 1249 13 irrigated alfalfa crop with young palms. 1251 14 sheep and goats in compound 1251 15 sheep and goats in compound 1251 16 group at sheep/goat pen 1255 17 Mohammed Hieba and local men 1255 18 Mohammed Hieba, drivers and local men 1310 19 Mosque 1310 20 Mosque 1310 21 resettlement housing and school 1310 22 Mosque, resettlement housing and school 1311 23 resettlement housing and school
		See transmission line substation.

Thur 2nd Nov Time	Vehicle kilometre reading km	Event/comments Khartoum/Dongola/Bayuda Idris' digital photos – time and photo number (fitted into comments according to time sequence)
1428	42659	Stop for food.
1637	42739	
1649		Dongola
1654	42757	Dongola. Visit tombs. Failed to meet Kamal of Department of Irrigation. Arrange to meet tomorrow.
1715		At Dongola ferry, left bank. Use vehicle/pedestrian ferry.
2030	42808	Arrive in dark at Sheik's house in Bayuda. 2027 24 Sheik, Mohammed, Sheik's son 2028 25 Sheik, Mohammed, Sheik's son

Friday 3rd Nov Time	**Vehicle kilometre reading km**	**Event/comments Bayuda/Dongola/Abri Idris' digital photos – time and photo number (fitted into comments according to time sequence)**
		0834 26 Breakfast table at Sheik's house 0834 27 Breakfast table at Sheik's house 0828 28 Group with Sheik
0935	42808	**Bayuda**. **Elevation 243 m. GPS 19 31; 30 27.25**. Compare "Big Dal" FSL at 218 m. Fertile area, yet apparently far from the river. Depart Sheik's house 0935 at Bayuda. Go back to Dongola to collect Kamal, Department of Irrigation.
		Babiker Ibrahim describing severe droughts of 1984/86 and 1994, causing migrations from many areas. Decision support systems now assisted by FAO, simulating flows from rainfall. Nile Waters Agreement provides for yield at Aswan of 84 billion m^3 (though annual yield is variable and may be 110 billion) with 55.5 to Egypt and 18.5 to Sudan. 10 billion balance is losses. With Merowe, Sudan may utilise about 15 billion – i.e. not her full allocation. ASW referred to adverse impacts of large Ethiopian storage and high degree of flow regulation, not entirely a win-win situation. Recession agriculture in Sudan would be reduced and require mitigation. Query Karadobi report figure of 18,000 ha – much more, may be 200,000 ha. See FAO work on AfriCover. Follow up.
		Need to see and benefit from Merowe EIA and RAP – but they are not released.
	42851	**Dongola river gauging station**. Visit with Kamal. On RB, a few hundred metres downstream of ferry crossing. Lower concrete posts partly or completely buried in silt. Upper posts seen, on top of bank. **Bench mark 233.12** **Gauge zero 212.03** **GH 10.93** (yesterday, Thursday 2/11/06) Maximum GH 15.93 in 2006 (Thus, Dal FSL at 218 would be GH 5.97; about 5 m lower than yesterday's level. No impact of Big Dal reservoir on Dongola housing, but possible impact of sedimentation/delta in reservoir on existing ferry. NB. Dongola Bridge beginning construction next week).
1225	**42852**	**Depart Dongola**, with Kamal.
1313	42885	Residual open water and wetland area remaining on east side of road, 30 km north of Dongola. Only open water seen, apart from Nile. Is this residual water from last flood or from a canal?
1329	42894	Passing Bayuda, where we started last night. Dongola to Bayuda 42 km in 1 hour 4 minutes. Average 39km/hour.
1337		Bridge. Road under construction (big job, going to Wadi Halfa by Lake Nubia)
1341		**Bridge. Irrigation scheme**. (7000 feddan **=** 3,167 ha) 2.21 feddan = 1 ha. In 1998 flood, all houses reported flooded.
1354		**Argo** village.
1404	42910	Stop in linear village. Neem trees. Nile river. Traders, etc, not farmers. Everybody is dependent on Nile flooding/irrigation.
1417		Kerma 1421 29 Nile, palms, fallow fields 1422 30 Nile, palms, fallow fields 1422 31 Desert and bare hill 1422 32 Palms, minaret, small patch of river 1423 33 Desert, buildings, palms 1424 34 at tomb/temple, fort 1426 35 Group

Friday 3rd Nov Time	**Vehicle kilometre reading km**	**Event/comments Bayuda/Dongola/Abri Idris' digital photos – time and photo number (fitted into comments according to time sequence)**
1430		Stop at **rock outcrop/3rd cataract**. Irrigation scheme. 1440 37 Nile, rock bar, riverside garden 1440 38 Nile, rock bar, boat, across river 1440 39 Nile, minaret, water tower, sailing boat, rocks 1441 40 Nile, sailing boat, rocks 1441 41 Nile, rock bar. 1442 42 Group 1446 43 Group on rocks 1447 44 Group on rocks
1455		Depart from **3rd cataract**.
1506		In desert plain.
1514	42929	Desert. 1529 45 Desert scene 1529 46 Desert scene
1532	42941	**Maseda (Masida**), rocks. Barrage sign. Palm trees.
1537		Village, palm trees, cemetery, hills on LB.
1541		Near river, **Noori (Nauri)**
1550		**Furiag (Fareig**). Large village is district headquarters.
1555		Still in village, housing continues
1156		Rocks/river; village continuing
1601	42955	103 km, 3.5 hours from Dongola, average 29 km/h, with stopping.
1605		Palm trees continuous. In Merowe compensation, valued at USD 250/mature tree (including value of 20 years of fruiting). Cemetery.
1609		Village continuing.
1612	42962	Stop. **Sabow** (**Sabu**) El 209 m; GPS 19 57 N, 30 33.219E **Note. Elevation 209 masl is 8 m higher than FSL of Low Dal reservoir (201 masl).**
1630		Walk to RB through fields. 500 m width of palm trees and vegetables to river. Noise (roar) of cataract heard d/s. Islands in river at falls. 1706 47 Group with children after lunch 1706 48 Group with children after lunch
1710		Depart (from late lunch)
1711	**42963**	At **Kagbar Cataract.** 111 km from Dongola. 1714 49 Nile scene at sunset (very dark photo) 1714 50 Nile scene at sunset (very dark photo) 1714 51 Nile scene at sunset (very dark photo) 1716 52 Nile scene at sunset (very dark photo) 1717 53 Nile, (Sabow) village, minaret at sunset 1717 54 Nile and (Sabow) village (clearer photo) 1717 55 Nile (dark photo) 1719 56 across Nile to rocks, palms and isolated hillocks 1720 57 Nile, looking downstream to big left bend (towards Delgo and uppermost end of Low Dal reservoir), cultivated banks, palms, 4 minarets in distant settlements. 1720 58 Nile (dark photo) 1727 59 Nile 1727 60 Nile 1728 61 Nile and Idris (These are Idris' photos). 1728 62 Nile and Idris 1729 63 Nile, rock bar, village, minaret 1729 64 Nile (dark photo) 1729 65 Across Nile

Friday 3rd Nov Time	Vehicle kilometre reading km	Event/comments Bayuda/Dongola/Abri Idris' digital photos – time and photo number (fitted into comments according to time sequence)
		1730 66 Across Nile 1730 67 families on rocks by river 1730 68 driver 1731 69 Nile (looking u/s), Idris 1735 70 Riverbank cultivation, Kamal, Idris 1735 71 Riverbank cultivation, Kamal, driver 1737 72 Nile (dark photo) 1737 73 Nile (dark photo) 1738 74 Mohammed, Alan Bates, driver, in Toyota 1739 75 rocks and fort 1739 76 Nile (looking u/s) 1741 77 Desert hill
1735		Return from **Kagbar Cataract.** My notes confirm photos:- Upstream – Sabow on RB, and big village on LB. Fortress on RB outcrop. Close jointing of Nubian sst. Sun setting. Downstream, LB, tractor working, pump. Downstream. River bends in far distance to left and along this length see 4 minarets implying a long settlement. "Big Dal" would inundate all.
1742	42964	Depart **Kagbar Cataract**.
1800	42975	Cross bridge. (Now in impact area of Low Dal reservoir)
1802		**Kade** village (**Kadurma or Kado**??)
1808		Village by river 1810 78 rocks/jointing 1815 79 compound wall (blurred)
1815	42984	Delgo 1820 80 desert, building (blurred) 1820 81 desert, building (blurred)
1824		Village. Getting late, getting dark, no records
2105	43089	Arrive at **Abri**. Stay at Elfagr Hotel. Tel. 22384. 237 km from Dongola; 105 km from Delgo. 127 km from Sabow.

Sat 4th Nov Time	Vehicle kilometre reading km	Event/comments Abri/Dal/Bayuda Idris' digital photos – time and photo number (fitted into comments according to time sequence)
		0743 82 Group – breakfast at Elfagr Hotel, Abri. 0745 83 Group – breakfast at Elfagr Hotel, Abri. 0745 84 Drivers at Elfagr Hotel, Abri.
	43089	**Depart Abri**. Elfagr Hotel. El. 187 GPS 20 48 N, 30 21.858E (Continue in impact area of Low Dal reservoir)
0918	43130	Arrive RB **opposite Dal**. 41 km from Abri. Across river, see a chequered black and white water tower on LB, and minaret, and distinctive yellow sand dunes on LB upstream of Dal village – a special feature, very scenic. On RB, walk around vegetable gardens, old water tanks, water tower with platform, palms, old pump – disused, old and very deep well with wheel. Much basin irrigation behind palm trees. **El. 182, at say 8m above river level.** **GPS 20 58.447N, 30 34.245E**. Islands in river. 0922 85 Group by rocks/hill opposite Dal village 0922 86 Group by rocks/hill opposite Dal village 0924 87Group, palms, opposite Dal village
		14 km excursion in desert, on RB side, looking for access to Dal cataract further downstream. Some photos taken before turning round, as follows: 0959 88 Two vehicles in desert. 1002 89 Idris in desert 1003 90 in desert
1024	43139	Turn round – from excursion in desert, on RB side, looking for Dal cataract further downstream. Lost time. Returned to river opposite Dal. 1044 91 Nile looking to Left Bank at Dal Cataract 1044 92 Nile looking to Left Bank at Dal Cataract 1045 93 Nile looking to Left Bank at Dal Cataract 1045 94 Nile looking to Left Bank at Dal Cataract 1045 95 Nile looking to Left Bank at Dal Cataract 1045 96 Nile looking to Left Bank at Dal Cataract 1045 97 Nile looking to Left Bank at Dal Cataract 1045 98 Nile looking to Left Bank at Dal Cataract 1059 99 Group at Dal Cataract 1059 100 Group at Dal Cataract 1059 101 Group at Dal Cataract 1100 102 Group at Dal Cataract
1102	43146	At **Dal Cataract**, say 1.5 km d/s on RB – a continuous rapids reach, not a single rock bar and fall. (No need for 14 km excursion away from river). 1110 103 Nile looking to Dal village water tower and sand dunes on Left Bank 1111 104 Nile looking to Dal village minaret on Left Bank 1111 105 Group and cultivation/palms on Right Bank 1112 106 Ferry boat and Group, RB. 1112 107 Nile looking to Dal village water tower and sand dunes on Left Bank 1112 108 Nile looking to Left Bank upstream of Dal village.

Sat 4th Nov Time	Vehicle kilometre reading km	Event/comments Abri/Dal/Bayuda Idris' digital photos – time and photo number (fitted into comments according to time sequence)
1126	**River boat**	Depart RB (7 No. in boat). 5 minute crossing of Nile. 2 No. camera video clips by Idris. 1126 111 Nile, on ferry boat crossing river to Dal 1126 112 Nile, on ferry boat crossing, two forts 1126 113 Nile, on ferry boat crossing, two forts 1131 114 Nile, from Left Bank on arrival of ferry boat.
1131		Arrive LB, **Dal village** side. Deposits of "Muger" silt/alluvium here. Walk to mosque and 4-street village. 1135 115 Dal village mosque 1136 116 Dal village mosque 1139 117 Group outside family home, Dal 1153 118 Family group outside family home, Dal 1215 119 Group, tea in family home, Dal 1215 120 Group, tea in family home, Dal 1216 121 Discussing bird shooting, Dal 1216 122 Idris and host at Dal 1222 123 Ladies and son, Dal 1222 124 Young boy, Dal 1222 125 Young boy, Dal Tea in family house. EA team will be welcome. Only one day with rainfall here in 2006; no rainfall at all remembered in 2005. Water supply good, fish eaten daily, migratory birds in Nile flyway seen, not much shooting, mobile phone mast. Sand encroachment on house. Query sand encroachment in Dal reservoir. No vehicles and no litter in Dal village. 1232 126 Ferry boat and skipper Zohereldean, before departing Dal village.
1235	**River boat**	Depart LB for RB Arrive at 1241.
1245	43148	Depart Dal 1253 127 Group at Abri with Sheik's friend 1253 128 Group at Abri with Sheik's friend
1345	43190	**Abri** (42 km from Dal). Lunch.
1455	43190	Depart Abri. Discussion with Kamal. Gauge readers paid SD 7500 per month. Read at 6am in dry season. Read at 6, 2 and 6pm in floods. C/m gaugings by Egyptian team at Dongola 3 x week, every week. Maximum in 2006, 15.58 m on 10/9/06 – noted different from 15.93 quoted two days ago, or 9.6 m greater than Dal FSL at 218m.
1547	43235	Sand dunes. At **Wawa**, new dunes by the river. 45 km south of Abri. Air photo Run 11, Photo No. 88
1622		New irrigation. Discussion of de-merits of taxes on rural people.
1733		Bridge.
1745		**Kitene (or Kadein?) irrigation**, near to Kajbar.
1748	43315	**Sabow.** 125 km from Abri.
1835		In desert. Sand, rock. Are we lost?
1902		**Tomus (Tumbus?)**
1940	43376	**Bergeig**. Arbo ahead. 1 hour to Dongola?
		Pass Bayuda by about 6km. Retrace route back to Bayuda.

Sat 4th Nov Time	Vehicle kilometre reading km	Event/comments Abri/Dal/Bayuda Idris' digital photos – time and photo number (fitted into comments according to time sequence)
2020	43396	**Bayuda**. Stay night at Sheik's house. Excellent hospitality and food again. 307 km today, including two unexpected excursions – say 14 km return at Dal, and say 12 km return when overshooting at Bayuda. Dal to Bayuda is 43396 minus 43148 minus 12 overshoot, say 236 km. Compare with Bayuda to Dal on outward journey yesterday 236 km (43130 minus 42894). Good agreement. 2240 129 Sheik and Mohammed 2241 130 Group with Sheik 2242 131 Group with Sheik 2242 132 Group with Sheik 2243 133 Sheik and Mohammed 2243 134 Sheik and Mohammed

Sun 5th Nov Time	**Event/comments** **Bayuda/Dongola/New Hamdab/Khartoum** **Idris' digital photos – time and photo number (fitted into comments according to time sequence)**
	No record of vehicle kilometre readings today - distances already known. 0916 135 Sheik and son, and Mohammed 0917 136 Sheik and Group 0918 137 Sheik and Group **Depart Bayuda** with Sheik's son for Arbo ferry crossing.
1000	**Ferry** on RB of Nile at Arbo. Tight squeeze for vehicles. Proceeded upstream along RB (reeds, bushes, trees) before cutting across river through a number of silt-deposit islands. Some bird life along river but not outstanding. Some pumps on river banks.
1020	Ferry arrived on LB. Proceed to Dongola via dirt road, crossing a number of canals.
	Dongola. Courtesy call on Commissioner. Return Kamal to Irrigation office.
1212	**Depart Dongola**. Not keeping record of distances today.
1453	At canal main road bridge. Canal leading to New Hamdab resettlement.
1500	**New Hamdab Research Station**. Meet officer.
1545	New Hamdab. Meet Elfatih Elajib, Director of Research**.** **Began in March 2005. Establishment: 4 professionals, 2 technicians, 7 labourers, 1 clerk, 2 accounts.** Similar research stations may be needed for other Merowe resettlement areas. **Situation is completely new for everyone**. 30,000 feddan. Half is surveyed. 13,000 is suitable for farming, rest not suitable. Purposes 1) to assist farmers, 2) research crops and performance in order to demonstrate and advise. 15 to 20 Field days per year for farmers, 10 demonstration plots. Soil examination, organic and inorganic fertilisers, efficiency, crop agronomy, seed heads, sugar beet – new crop doing well, introduce some new crops to area – ground nuts, sunflower, sesame, legumes, date palm, oil crops, etc. wheat, barley, sugar beet. Soil – 1995 surveyed, non-saline but might be problem in future, fertility poor. 0.5 to 1 m depth, all trees but exclude mango. Wheat sown in November, harvested in March. From 1619 to 1631; Photo numbers 138 to 149. All photos of Elfatih Elajib, research staff, offices and groups at New Hamdab Research Station.
1635	Depart New Hamdab Agricultural Research Station.
	Driver's aunty received Merowe compensation. USD 100,000 for date palms. Must have been 400 trees. But did 5 suckers count as 5 trees at USD 250 per tree? Alleged that claims/allocations not carefully supervised. Bridge to be constructed at Dongola soon. **Compensation - Resettlement family gets 6 feddan, serviced by compensation package. Plus 3 feddan for each feddan previously farmed. So total of 9 new feddan for 1 old feddan previously farmed where 6 are serviced by the resettlement project and 3 are on self-help basis, if required**. Were target incomes for resettlers established for say 5 and 10 years ahead? Are they monitored? Not known. Need social facilitators from Dongola, and female sociologist for assessing women's perspectives because men cannot do this. If not possible in this pre-feasibility study by YAM, a must for full EIA later if Dal is selected. Include this point in TORs if Dal selected.
2330	Arrive Meridian Hotel, Khartoum.

Notes compiled by Andrew Wain, 20th November 2006

Summary of GPS readings (above)

Location	Elevation reading	Northing	Easting
Bayud – Sheik's house	243	19 31	30 27.25
Sabu by Kagbar	209	19 57	30 33.219
Abri at hotel	187	20 48	30 21.858
Dal, opposite village	182	20 58.44	30 34.245

These readings confirm that the gridlines on the un-named, un-scaled map we received from Eng. Bader El Din Ali Mohamed (Mierag Space Technologies Company on 7/11/06) are longitude and latitude at 15 minute intervals. See notes below.

Notes on Map

We obtained the map from Eng. Bader El Din Ali Mohamed (Mierag Space Technologies Company) on 7/11/06, after we returned from the field.

We have since assessed the scale of this map to be 1:200,000, or 1 cm = 2 km. The 1:250 000 scale series began around the end of the Nineteenth century; the last major revision was just after the Second World War, according to the Map Librarian, Information Services & Resources Division, Royal Geographical Society in London.

Notes on map compiled by Andrew Wain, 16th January 2007

Appendix 4.1

Consultations[1] during Field Visits in April 2007

At Dongola
Ms Mawahib Mahdi Nawar, Ministry of Health
Forestry Department (Director, Assistant/Director and Supervisor)
Fish Trader, Fish Market
Survey Department
Water Development Corporation
Ministry of Agriculture
Ministry of Irrigation and Water Resources
Dr. Tong Chor Malek, Onchocerciasis Control Programme
Dr Awad Hassan, Trachoma Control Programme
Mr Osama Mekki, Malaria Control Programme, Entomologist
Dr El Fateh Malik, Malaria Control Programme
Director, Filaria Control Programme

At Abri
Executive Officer, Abri Administrative Unit
Director of Education, Abri Administrative Unit
Health Supervisor, Mustafa Murad Taha
Malaria Supervisor, Amir Hussein
Abri-Sai Island Ferry Operator
Sameer Elhadi, local youth leader
Abdelmageed Elamin Yousif, Elder
Khalid Sadabi, Trader
Egyptian Health Campaign

With Communities
Solib
North Abri
Displaced Southern Sudanese, Darfurians, and Nubians
Akasha
Kerma
Sai Island

[1] Because of recent incidents surrounding dams in Sudan many people requested us not to mention their names.

Appendix 6.1

DAL HYDROPOWER PROJECT – CO_2 EMISSION

1. DAL HYDROPOWER PROJECT – CO_2 EMISSION

1.1 INTRODUCTION

The proposed Dal hydropower project on the River Nile in Sudan offers potential for generating energy to support regional economic growth. In the following sections the CO_2 emissions resulting from the project's construction activities and the decomposition of biomass in the project reservoir are quantified and compared with the potential CO_2 emissions from generating the same electrical energy through burning fossil fuels.

1.2 CO_2 EMISSION BY THE DAL HYDROPOWER PROJECT

The CO_2 emission associated with a hydroelectric power project are those produced during the manufacture and construction of the project structures and equipment and those produced by slowly decomposing biomass in the reservoir during the project's lifetime.

1.2.1 CO_2 Emission related to Construction

It is well known that the implementation of a hydroelectric power plant involves considerable construction activities and large quantities of construction materials which, in turn, require a large energy input. For the construction of the Dal project the required quantities of major construction materials and consumables are summarized in Table 1.

Table 1 : Quantities of Major Construction Materials and Consumables

MATERIALS / CONSTRUCTION	QUANTITIES
Civil Works	
- Soil excavation	4,638,000 m^3
- Rock excavation	4,308,000 m^3
- Conventional concrete	522,600 m^3
- Reinforcement steel	42,400 tons
- Diesel fuel	23,000 tons
Electro-mechanical equipment	
- Steel	7,500 tons

Based on the volume of concrete and other construction activities such as grouting, shotcreting, etc. a cement requirement of about 183,000 tons is calculated. The production of one ton of cement requires approximately 4 GJ of energy. Hence the energy input for all concrete works results in approximately 732,000 GJ.

The weight of reinforcement steel, hydraulic steel structures and steel for the electro-mechanical equipment totals about 50,000 tons. It takes approximately 40 GJ of energy to produce one ton of steel. Therefore, the energy input into steel and equipment is about 2 million GJ.

The energy requirement for the excavation, transport and placing of soil and rock material is covered under the diesel fuel requirements of 23,000 tons.

If it is assumed that the energy required to produce the cement and steel is generated by a thermal mix as described below (coal/gas = 50/50 per cent) then some 47,000 tons of coal and 31,000 tons of gas would be needed. The burning of these fossil fuels would ultimately lead to a CO_2 emission of approximately 215,000 tons.

The burning of 23,000 tons diesel fuel will result in a CO_2 emission of about 74,000 tons. The total emission of CO_2 associated with the construction of the Dal hydropower project will thus be approximately 290,000 tons.

1.2.2 CO_2 Emission caused by the Biomass with the future reservoir

The Dal hydropower project will inundate a gross area of about 300 km^2, which, after exclusion of the existing river channel, will result in a net area of about 250 km^2 of land. The biomass is limited to the immediate area of the river banks as the remaining area is desert and a total biomass of about 35,000 tons (dry weight) is estimated.

All living plants grow by absorbing water and carbon dioxide to form reserves of carbohydrate, known as biomass. This process is fuelled by sunlight and is termed photosynthesis. In simple terms the process is as follows:

$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2\uparrow$$

When plants die, decomposition by oxidation takes places which is the photosynthesis process in reverse:

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

The same amount of CO_2 absorbed during photosynthesis is released during complete oxidation of the biomass.

By considering molar weights, one ton of carbohydrate produces 1.47 tons of carbon dioxide during complete decomposition as follows:

$$180\ g\ C_6H_{12}O_6 + 192\ g\ O_2 = 264\ g\ CO_2\uparrow + 108\ g\ H_2O$$

$$1\ t\ C_6H_{12}O_6 + 1.07\ t\ O_2 = 1.47\ CO_2\uparrow + 0.6\ H_2O$$

Using the same relationship on the total estimated quantity of biomass affected by the Dal hydropower project the decomposition of the biomass in the reservoir area could lead to a maximum CO_2 emission of about 52,000 tons.

1.2.3 The Total CO_2 Emission of the Dal Hydropower Project

Approximately 290,000 tons of CO_2 will be produced with the construction of the Dal hydropower project. The maximum potential CO_2 emission associated with the aerobic decomposition of the biomass located in the reservoir is estimated to be approximately 52,000 tons. Thus the implementation of Dal hydropower project will lead to a total CO_2 emission of about 342,000 tons.

1.3 CO_2 EMISSION BY equivalent THERMAL POWERPLANTS

This section quantifies the CO_2 emissions resulting from generating the same average energy as Dal but by burning fossil fuels. Present thermal plant technology does not include the recovery of carbon dioxide from flue gases. Hence the carbon content of the fuel and the efficiency characteristics of the thermal plant are the governing parameters in calculating CO_2 emission levels. The following formula may be used to compute the CO_2 emission from fossil fuels:

$$CO_2 = A \times (B + C \times HV)$$

where:

CO_2 = emission of CO_2 in metric tons per ton of fuel;

A = multiplier for indirect emissions (exploration, mining);

B, C = regression constants for the particular type of fuel;

HV = lower calorific value of fuel in GJ/ton.

Typical CO_2 emissions for various type of fossil fuel are shown in Table 2. Approximate CO_2 values per MWh delivered to the grid would be as shown in Table 3 for various types of powerplant.

Table 2 : Typical CO_2 Emissions for various Type of Fuel

Fuel Type	A	B	C	HV (GJ/ton fuel)	CO_2 (ton/ton fuel)
Lignite	1.08	0.20090	0.08693	7	0.87
Coal	1.06	0.20090	0.08693	29	2.90
Oil	1.04	2.50291	0.01494	41	3.24
Gas	1.01	0.55159	0.04463	44	2.53

Table 3 : Approximate CO_2 Emission per MWh for various Types of Thermal Powerplants

Plant Type	HV (GJ/ton fuel)	CO_2 (tons/ton fuel)	Efficiency (per cent)	CO_2 (ton/MWh)
Lignite-fired steam	7	0.87	36	1.24
Coal-fired steam	29	2.90	37 - 39	0.97
Oil-fired steam	41	3.24	38 - 40	0.75
Gas-fired combined cycle	44	2.53	48 - 52	0.43

Note:Efficiencies shown include station consumption.

The annual average energy to be generated by the Dal hydropower project would amount to 1,944 GWh/yr. If the same quantity of energy was to be generated by a thermal mix consisting of 50 per cent coal-fired and 50 per cent gas-fired combined cycle power plants, some 1.36 million tons of CO_2 would be discharged to the atmosphere annually.

Table 4 : Approximate CO_2 Emission of equivalent Thermal Power Mix

Plant Type	Annual Energy GWh	CO_2 Million tons
Coal-fired steam	972	0.94
Gas-fired combined cycle	972	0.42
Total	**1,944**	**1.36**

It is noted that the CO_2 emission of 1.36 million tons annually is related purely to the fuel consumption (equal proportions of coal and gas) and does not include the CO_2 emission related to the construction of the thermal power plants.

Assuming that the annual average energy generated by the Dal hydropower project would be generated by an "environmentally friendly" gas-fired combined cycle power plant only, which is a most optimistic scenario, then the annual CO_2 emission into the atmosphere would be approximately 0.8 million tons.

1.4 CONCLUSION

The energy sector is the greatest single source of CO_2 emissions into the atmosphere and within that sector the burning of fossil fuels to generate electricity accounts for some 25 per cent of global warming. The Dal hydropower project will produce an average of 1,944 GWh of electrical energy annually. During construction of the project, energy is required to manufacture cement and steel and to excavate and construct the project structures. The generation of this energy will result in the release of CO_2 into the atmosphere. During operation of the project, the residual biomass submerged within the reservoir will slowly decompose also releasing CO_2 into the atmosphere. The estimate of the total quantity of CO_2 released into the atmosphere during construction and operation of Dal will be some 342,000 tons.

Generating the same energy by burning fossil fuels (equal proportions of lignite, coal, oil and gas) would release into the atmosphere some 1.36 million tons of CO_2 every year. Over a period of 50 years, the assumed commercial life of Dal, this annual CO_2 emission would result in a total of 68 million tons of CO_2. Consequently the generation of hydro-electric energy at Dal will result in CO_2 emissions 200 times less than if the same energy were generated by burning fossil fuels.