Water under the sand

The Egyptians, in conjunction with Libya, the Sudan and Chad, are planning to mine the waters of the Nubian sandstone. But at what rate should this precious resource be exploited?

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"Under a good administration, the Nile gains on the desert; under a bad one, the desert gains on the Nile," noted the observant Napoleon during his brief Egyptian sojourn. The boundaries of the land which will eventually come under the command of the Nile can now be drawn with some certitude. The "Century storage" provided by the High Dam at Aswan allows the river to be tapped to its limits. But this does not mean that Egypt's struggle to bring water to the desert and feed its burgeoning population has ended. There are new horizons which urgently need to be explored.

The horizons are, in a strictly technical sense, the soils of the Nile valley and delta, the gravels underlying them and the vast beds of sandstone on which the country rests. In each exists a water regime infinitely more complex than that on the surface. And while the surface waters have been controlled, those underground still have the potential to open yet more sorely needed land—or to bring a desolation to the Egyptian fellah more destructive than that wrought by any biblical plague.

Given the politics of international aid, it is the problems caused by the High Dam that have attracted the most attention. Soviet involvement in the dam's construction neccessitated a sometimes malevolent search for its failings by Western observers. Problems have been plentiful. And among the most serious has been the waterlogging and salinisation of farmland newly converted to perennial irrigation from the traditional flood cultivation.

This has not just happened in the areas converted since the completion of the High Dam, although the process has been particularly dramatic in them. Poor drainage is a problem throughout the country's 7·5 million acres of irrigated land. A 30 year programme of drainage works has already begun.

The need for action is spelt out starkly in a World Bank drainage project document: "Without drainage," it says, "about a third of the project area is likely to become totally unproductive over the next 35 years. On the remaining productive land, average crop yields will decline 40-50 per cent." This is in a country in which agriculture contributes 31 per cent to the Gross National Product where the pressure on land is such that three-quarters of the farms are smaller than three acres, and where the problem of landlessness is growing.

The difficulties have arisen because of the change in water regime. It was hoped that the control of the Nile afforded by the High Dam—which keeps the river level only two metres above its former low water mark—would allow the sub-soil water to drain. But increased seepage losses from canals and fields into the subsoil have exceeded the rate at which the water can drain to the underlying gravels. And the rising water table has brought with it problems of salinisation, aggravated by the increased cropping intensity made possible by the provision of perennial water.

The problem is being tackled by installing "tile drains" on a massive scale. One World Bank financed project in mid-Egypt, between Beni Suef and Asyut, gives more perspective of the magnitude of the operation. An intricate buried web of concrete pipes—30 000 km in all—will form the field drains with a further 4000 km as collectors. In addition, 865 km of new canals are to be dug and 775 km of existing drainage canals deepened. Four new pumping stations will be constructed. Total cost for the 300 000 acre project area is $115·7 million.

The national drainage authority—staffed largely by the engineers who converted new lands to perennial irrigation—has already completed drainage works, over 600 000 acres of the Delta, and a further 900 000 is scheduled for completion by 1978. In the pipeline are proposals for World Bank assisted schemes to cover another 1·8 million acres.

Mining the Nubian's fossil water

While this huge drainage programme should cope with the threat posed by shallow groundwater, that in the deeper horizons raises quite different questions. Egypt is underlain by one of the world's largest artesian basins, contained in the so-called Nubian sandstone aquifers which stretch from the Sudan and Chad in the south to the Mediterranean in the north and into Libya in the west. The 6000 billion cubic metres of water stored in the aquifer represents a major natural resource. But its exploitation is problematic and controversial.

The pressure of population in Egypt is such that priority must be given to any development which expands the arable area. One futuristic proposal that has shaped official thinking is for the creation of a "New Valley" in the Libyan desert, west of the Nile. This "valley" would link a series of depressions in which artesian springs once flowed from the exposed sandstone aquifer.

In the major oases of Dakhla and Kharga, the wells no longer flow freely. They have been capped and regulated. Since 1960 more wells have been drilled as part of an intensive programme of hydrological investigation and groundwater management. The resulting fall in water table now means that many of the wells have to be pumped. By 1970, 42 000 acres of land were being irrigated to serve a population of 90 000, including about 15 000 new settlers from the Nile Valley.

The culmination of local hydrological investigation by Egypt's Desert Development Organisation has not provided simple solutions to the difficult strategic problems posed. Before military priorities supervened, proposals existed for a major programme of settlement, based on exploitation of the groundwaters. One project envisaged the settlement of 1·5 million people on 560 000 acres by 1975.

Annual water requirements for settlement of this magnitude would be perhaps five billion cubic metres—equivalent to 9 per cent of Egypt's share of the Nile's annual flow. Can the Nubian sandstone aquifers provide this much. It is a question which raises fundamental issues about the exploitation of any raw material resource.

The annual recharge of groundwater into the whole of Egypt is tentatively estimated at three to four billion cubic metres. So for development on the scale originally suggested, water would have to be drawn from storage. The sandstone strata—which range in thickness from 900 metres in the south to over 3·5 km in the north—from a reservoir with a total capacity of 6000 billion cubic metres. Palaeohydrogeological studies suggest that the bulk of this stored water was laid down during earlier pluvial periods and is not the product of slow seepage from Sudan and Chad where significant recharge occurs today. Radio dating puts the age of the water at around 25 000 years (see *New Scientist*, vol 56, p 322).

Should these fossil waters be mined? There has been con-

Left, map of the area. Right, Gemini 4 photograph showing Nile delta and Egypt

erable controversy in the past, but opinion among scien-s seems to be hardening against rapid exploitation. Dr M. El-Shazly of Egypt's National Academy of Scientific search and deputy director of the Atomic Energy ablishment, is one of the sceptics. He would rather see reserves conserved and exploited only in special cases mining or road development. He queries the sense of ablishing large settlements based on water supplies ich could be exhausted within 100 or 200 years.

The decision is one confronting the other countries derlain by the Nubian sandstones. The aquifer repre-its the only major water source in south-east Libya. In e northern Sudan, it has an essential role to play in ojects conceived to halt the southward march of the sert.

The shared interest is leading to useful collaboration. next year's UN conference to discuss international operation to combat desertification, a preliminary gional study on the management of the Nubian sandstone uifer will be presented. Apart from collating the infor-ation available from various national investigations and entifying the areas for further research, the study could lp clarify the long term strategies for exploiting the oundwaters.

Storing the Nile underground

The question is not simply one of the maximum feasible take. One possibility already raised is that Nile waters uld be stored in the Nubian sandstone; extensive seepage om Lake Nasser could also provide the basis for irriga-n development in nearby areas of both Sudan and Egypt. arious theoretical models have been made to describe the haviour of the aquifer, but they need to be checked ainst actual behaviour. In Libya, a 50 000 hectare desert igation scheme has run into serious problems with e water table falling far faster than predicted by eoretical models.

The regional study of the Nubian sandstone aquifer will elp assess the environmental impact of the proposed attara hydroelectricity project. Egypt's Ministry of Elec-icity has just commissioned a feasibility study to investi-ate the possibility of linking the depression with the editerranean by canal to generate power. The Qattara is ought to be the major natural discharge for the sand-one aquifer. Flooding it might reduce the natural losses. ut would long-term sea water infiltration pollute the emarkably pure groundwaters?

Dr El-Shazly is in charge of the geological side of a remote sensing project using the US Landsat satellite supplemented by aerial surveys. Besides providing valuable information on geology and vegetation, the project also gives data on drainage patterns, soil moisture and evaporation which will help to answer this and other questions about the aquifer.

The Nubian sandstones are by no means the only component in a national approach to groundwater management. In 1970, a consultant hydrologist proposed a complete reorientation of Egyptian irrigation strategy to take account of groundwater's potential which was "too often ignored and still by far under-exploited".

According to the persuasive argument, the 7·5 billion cubic metres of "new water" assured by the High Dam should be diverted to the New Valley rather than be used to intensify cultivation and reclaim fringe lands along the Nile. Instead, the other major aquifer in the country, the alluvial gravels in the Nile Valley and Delta, could be tapped. Tube well exploitation would recover some of the 25 per cent of the Nile's discharge lost between Aswan and the Egyptian farmer's fields. Waterlogging problems might be reduced and in dry years, the aquifer could safely be over-exploited since its recharge would be rapid.

While elegant in its simplicity, this approach would require radical reshaping of agricultural practices and a substantial reorientation of the irrigation administration. The gravel aquifers are already an important source of urban water. Their use for irrigation might give rise to further problems of salinisation—studies of the interaction between subsoil water and the groundwaters of the gravel aquifer are still in progress. Tapping the gravel aquifer also incurs a two-fold energy penalty—due to pumping requirements and the loss of power if throughput from the High Dam were to be diverted to the New Valley.

The current drainage projects and small scale investigation of the Nubian sandstone aquifers may seem rather pedestrian by comparison with this sort of visionary proposal. But with the productivity of Egypt's agriculture at stake, the decision to concentrate investment in drainage rather than dramatic but dubious desert reclamation projects will probably be justified in the long term. Studies currently in progress on the post High Dam salt balance in the Nile Valley, the hydrology of delta groundwaters, and on the sandstone aquifers will provide a sound basis for future development. The underground waters will, after all, still be there. □