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DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D.C. 20523

CAPITAL ASSISTANCE PAPER

Proposal and Recommendations
For the Review of the
Development Loan Committee

SUDAN - GROUNDWATER DEVELOPMENT (PHASE I)

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AGENCY FOR INTERNATIONAL DEVELOPMENT
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AID-DLC/P-512
February 24, 1967

MEMORANDUM FOR THE DEVELOPMENT LOAN COMMITTEE

SUBJECT: Sudan - Groundwater Development (Phase I)

Attached for your review are the recommendations for authorization of a loan in an amount not to exceed \$1,200,000 to the Government of the Republic of the Sudan ("Borrower") to assist in financing the foreign exchange costs of engineering and management consulting services for Phase I of the Groundwater Development Project.

This loan proposal is scheduled for consideration by the Development Loan Staff Committee at a meeting on Wednesday, March 8, 1967.

Rachel C. Rogers
Assistant Secretary
Development Loan Committee

Attachments:

Summary and Recommendations
Project Analysis
ANNEXES A-G

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SUDAN - GROUNDWATER DEVELOPMENT (PHASE I)

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SUMMARY AND RECOMMENDATIONS

SUDAN

GROUNDWATER DEVELOPMENT LOAN

1. APPLICANT: The Government of the Republic of the Sudan (GOS) for the Rural Water and Development Corporation (RWDC), an independent GOS agency under the Ministry of Mineral Resources.
2. AMOUNT: \$1.2 million
3. TOTAL COST OF ACTIVITY:

\$1,200,000	Foreign Exchange (A.I.D. Loan)
141,360	Local Currency (GOS Contribution)
<u>\$1,341,360</u>	Total
4. DESCRIPTION OF ACTIVITY: Under the newly-established Rural Water and Development Corporation, the GOS plans to increase the tempo of its top-priority groundwater development program. From a present level of 60 deep wells per year, the GOS hopes to increase well production to 200 per year within the next few years with U.S. and other assistance.
5. PURPOSE OF LOAN: To finance Phase I of a two-phased program. Under Phase I, it is proposed to finance the foreign exchange costs of providing the services of: (1) a rural water management consultant (two years) to advise the RWDC with respect to its efficient organization and with respect to planning, implementation and execution of its groundwater development programs; and (2) an engineering consultant (ten months) to locate drilling sites, to provide training to Sudanese in drilling methods and operations, and to prepare bid documents and specifications for a two-year drilling program to be undertaken in Phase II by a drilling firm. Total foreign exchange costs under Phase II are estimated at \$5,125,000.
6. JUSTIFICATION FOR THE PROJECT: In the central and coastal regions of the Sudan, where most of the population and agricultural and livestock wealth are found, the 3-4 month rainy season provides sufficient water for crops and grasslands to support livestock, but during the remaining 8-9 month dry season serious drinking water shortages occur. By increasing the availability of drinking water supplies through wateryards, the completion of Phases I and II should result in marked increases in livestock production and agricultural output of rural farmers. Total foreign exchange costs under Phases I and II are estimated at \$6.3 million. The overall cost benefit ratio is expected to be 4.90 to 1.

7. BACKGROUND OF ACTIVITY: Due to rising demand from local communities and rural councils for adequate drinking supplies, the GOS has created a new Rural Water and Development Corporation to administer the functions of hydrogeological investigations and productive drilling and construction of wateryards which previously had been performed by separate agencies. Although the GOS drills about 60 new deep wells every year, it does not have the resources, in terms of skilled technical personnel, to operate additional rigs at the present time.
8. EXIMBANK INTEREST: The Export-Import Bank on December 14, 1965 said it considered the project to be more suitable for financing by A.I.D.
9. COUNTRY TEAM VIEWS: The Country Team strongly endorses the proposal.
10. STATUTORY CRITERIA: Satisfied; see Annex F.
11. ISSUES: None.
12. RECOMMENDATION: Authorization of a loan to the Government of the Republic of the Sudan in an amount not to exceed \$1,200,000 under the following terms:
 - a. Interest: 1% per annum during the first ten years and $2\frac{1}{2}\%$ per annum thereafter.
 - b. Maturity: 40 years, including a grace period of 10 years on principal repayments.
 - c. Currency: Interest and principal payable in U.S. dollars.

CAPITAL ASSISTANCE COMMITTEE MEMBERS:

Capital Development Officer: Richard S. Greene, AFR/CDF
Counsel: Willis Jourdin, GC/AFR
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SUDAN

GROUNDWATER DEVELOPMENT

SECTION I - BACKGROUND

A. History of the Loan Proposal

In October, 1965, the Geological Survey Department (GSD), Ministry of Mineral Resources, submitted to A.I.D. a loan application in the amount of \$3,500,000 to finance the cost of eight complete exploratory drilling rigs and related equipment in order to enlarge the capacity of the GSD to undertake hydrogeological investigations and prepare groundwater availability maps. At the time of the loan request, actual drilling of productive wells in rural areas of the Sudan was the responsibility of the Land Use and Rural Water Development Department (LURWD) of the Ministry of Agriculture, after obtaining advice from GSD on location and hydrology.

Shortly after the loan request was submitted, the Government of the Sudan, in response to considerable pressures from communities and rural councils where lack of drinking water has been a serious problem, decided to create an integrated water development agency which would combine the investigatory and productive drilling functions theretofore exercised independently by GSD and LURWD under separate ministerial jurisdictions. In January and March, 1966, the Sudanese Council of Ministers passed resolutions creating the new Rural Water and Development Corporation (RWDC). See Annex A for additional information on the establishment and proposed operation of the RWDC.

In order to consider the economic and technical feasibility of the loan application, A.I.D. hired the firm of Henningson, Durham, and Richardson (HDR) to conduct a field investigation in February, 1966. The HDR final report of May, 1966 concluded that:

1. the thirst problem is one of the most serious domestic problems facing the GOS;
2. A.I.D. should consider financing the cost of productive well drilling by an American contractor using five drilling rigs during a two-year drilling program, in order to assist the GOS in meeting the need for drinking water in the "thirst areas";
3. there are not enough trained technical personnel in the Sudan at the present time to execute an accelerated drilling program;
4. in view of the establishment of the RWDC, A.I.D. should not consider financing the purchase of drill rigs for the use by the GOS for exploration or investigation only, as requested by the GSD in its loan application.

In June, 1966, in response to a GOS request for a statement concerning possible A.I.D. assistance in groundwater development, the Mission was authorized to inform the GOS that A.I.D. was considering a loan proposal on a priority basis and expected to discuss with the GOS methods of project implementation.

Shortly thereafter, when the new Sudanese Government was installed, there was some doubt as what form the new Sudanese water authority was to take and what kind of assistance in groundwater development the GOS desired. In September, 1966, the Sudanese Council of Ministers reaffirmed the decision of the previous government to establish the RWDC (see Annex A). The Finance Minister visited Washington in September, 1966 and informed AID/W that the GOS continued to give top priority to groundwater development, and requested that A.I.D. consider on an urgent basis assistance of the following types:

1. equipment for use by the RWDC,
2. technical assistance in locating promising sites for deep wells,
3. well drilling by an American contractor to supplement the drilling activities of the RWDC, and
4. technical advisory services related to training of Sudanese, assisting in setting up the RWDC and planning the long-range groundwater development program.

Pursuant to the appeal by the Finance Minister, a team from AID/W visited the Sudan in November to review the equipment and personnel capabilities of the GOS drilling departments and to make recommendations concerning the scope of proposed assistance. As indicated in Section F, below, the AID/W team recommended that technical assistance be provided to strengthen the GOS personnel resources before any equipment for use by the RWDC is provided. A well drilling program is proposed for a later date.

B. Country Team Position

The Country Team strongly endorses the development loan proposal.

C. Export-Import Bank Clearance

Received December 14, 1965.

D. A.I.D. Objectives in the Sudan

The general objective of A.I.D. in the Sudan has been the encouragement of an independent, stable, and unified nation, able to respond to its development needs. A.I.D. has placed heavy emphasis upon the development of institutions and infrastructure in the Sudan, with particular attention to improvement and diversification of agriculture, improved road and air transportation, and technical education.

Under the revised U.S. aid policy for Africa, agreed in November, 1966, Sudan is identified as one of the "development emphasis" countries scheduled to receive continuing substantial U.S. development support on a country basis as part of a multilaterally coordinated country program.

Past A.I.D. assistance, in the form of drill rigs, technical instruments and participant training for the Geological Survey Department, has been of substantial benefit in the search for underground water supplies. An A.I.D.-financed study of rural water resources in the Sudan, completed in January, 1965, resulted directly in the loan provided by Sweden as discussed in Section F, below. In 1966 A.I.D. agreed to provide P.L. 480, 104(e) grant funds to assist in financing the costs of constructing about 300 shallow wells under the current campaign of the GOS to provide adequate drinking water supplies in areas where thirst is a serious problem. The present proposal is fully consistent with the major aims of the A.I.D. program in the Sudan because it is expected to result in expansion and diversification of agricultural output and livestock production.

E. Borrower

The borrower will be the Government of the Sudan. The proposed project will be administered by the newly-created Rural Water and Development Corporation. See Section II.C. and Annex A for discussion of personnel capabilities of the RWDC and its proposed organizational structure. It is proposed that the loan be conditioned on the implementation of the organization plan for the RWDC as proposed by the GOS.

F. Relationship of Loan Proposal to GOS Water Programs

In September, 1965, prior to the creation of the RWDC, the GOS promulgated a three-year, LS 15 million (\$43 million) "Thirst-Fighting" program in response to public demand for an accelerated rural water supply program. It was estimated that the LS 15 million program, including construction of 1,000 deep wells and 350 surface water stations, would satisfy 75% of the water shortage problem. The program called for loans and grants from the following sources:

Millions
of LS

2.5	Swedish loan
2.5	U.S. aid (grant and loan)
3.0	British, Czechoslovakian and Yugoslavian loans
1.0	From general development loans of foreign currencies
6.0	Internal loans and aid from Provincial Councils

The Swedish loan, announced in September, 1965, calls for the expenditure of \$5.8 million during three years for water surveys and studies, rectification of about 35 hafirs (earthen catchment basins) and dams, preliminary study for construction of about 45 hafirs and three dams, drilling of about 110 boreholes, erection of 40 wateryards, construction of buildings, purchase of transport and spare parts for GOS use, and other expenditures. The loan followed the program of assistance proposed in the HDR rural water survey of January, 1965. Since all GOS groundwater development activity will now be undertaken by one agency, the RWDC, Swedish and U.S. assistance is expected to be closely coordinated.

The ultimate goal of the Sudanese Government under its Thirst-Fighting Program is to make available to all in the project area sufficient supplies of water for basic human needs, i.e., four gallons per person per day as established by WHO as the world minimum standard. In terms of achievement over the next ten years, two gallons per person per day is considered by the GOS to be a realistic goal. Present human water consumption in some sections of the project area averages as low as 1/2 gallon per person daily.

Within the project area of roughly one million square kilometers (see pages 6-8, below), it is estimated that 400,000 square kilometers are non-productive areas. This includes the estimated area which will not prove to contain water-bearing formations, urban or community areas already supplied with adequate water, river basins, and irrigated croplands such as the Gezira Scheme, Roseires, Gash and Tokar. Within the remaining 600,000 square kilometers, the development area supplied or to be supplied by shallow wells is estimated at 25%, or 150,000 square kilometers. The development areas supplied or to be supplied by hafirs and dams is estimated at 20%, or 120,000 square kilometers. About 330,000 square kilometers, then, are estimated to be in need of deep well water supplies.

Presently, one wateryard serves about 400 square kilometers (Km^2). (A wateryard typically consists of two deep wells and well pumps plus water storage and distribution facilities.) This area should be reduced, ultimately, to one wateryard to every 100 Km^2 , which is considered the most economic agricultural area to be served by a watering point on the basis of time required to travel to and from the wateryard and average population density. However, in view of the limited resources of the GOS, a more realistic goal for the next ten years would be the reduction of the area served by each wateryard from 400 to 200 Km^2 . At two deep wells per wateryard, a total of 3,300 wells would be required to reach this goal. An estimated 1,080 productive deep wells have been drilled in the project area through 1965. An additional 60 wells were drilled by the GOS in 1965-66 and another 60 should be drilled in the 1966-67 season with existing equipment. A total of 2,100 wells, therefore, would be required to achieve the 200 square kilometer goal.

The present annual production capacity of the GOS is about 60 deep wells. When the three light rotary drill rigs are provided under the Swedish loan, the GOS production capacity should reach about 105 deep wells annually. On the basis of GOS personnel availabilities and requirements as discussed in Section II.C, it is believed that, with training and other forms of technical assistance, the GOS can further increase its production of deep wells over the next few years to about 200 annually. Thus the total of 2,100 wells required to serve 200 Km^2 can be produced over a 10-year period at 200 wells per year.

In addition, analysis of projected water demand in the project area (see Annex B) indicates that the proposed production rate of 200 deep wells annually should make it possible in ten years to reach the level of two gallons of water

per person daily in the project area as well as meet the water needs of a projected 31.1 million head of livestock.

In terms of equipment requirements, six additional light rotary rigs, capable of drilling 15 wells per year each, would be needed to close the gap between 105 wells annually and the goal of 200. This level of production cannot be achieved, however, with equipment alone. The present GOS personnel resources and capabilities are not sufficient to manage and undertake a successful 200-well-per-year program without technical assistance. Under the conditions which exist in the Sudan, technical assistance is an essential element of the proposed deep well program.

In order to assist the GOS in closing the gap between present deep-well production capabilities and goal requirements, it is proposed that assistance be provided in two separate phases. The present loan proposal would cover the foreign exchange costs of Phase I (technical assistance) only. A second loan, covering the foreign exchange costs of Phase II (drilling contract), would be considered at a later date.

SECTION II - PROJECT ANALYSIS

A. Summary Description of the Loan Proposal

The proposed \$1.2 million loan would cover the estimated foreign exchange costs of:

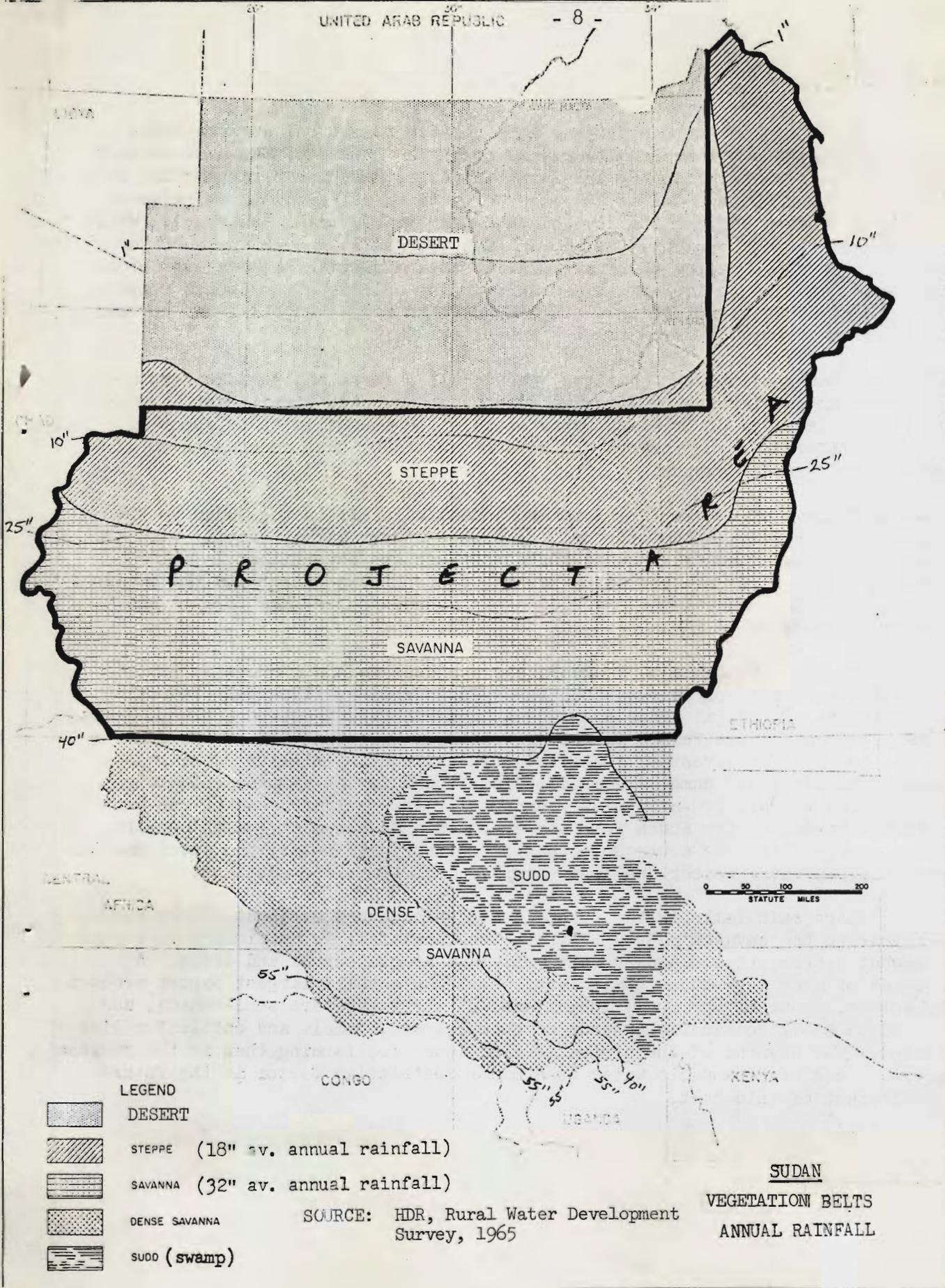
1. procurement of management consultant services for a period of two years to (a) advise and assist in the organization of the newly-established Rural Water and Development Corporation, (b) make recommendations concerning land use, soils conservation, livestock development and nomadic settlement, and (c) assist in the preparation of a comprehensive and long-range groundwater development program for the RWDC; and
2. procurement of consulting engineering services for a period of about ten months to (a) undertake a limited hydrogeological investigation in sufficient detail to provide site locations for a subsequent drilling program under Phase II, (b) prepare a drilling program and specifications for the design of wells and wateryards to be constructed under Phase II, (c) prepare bid documents and specifications suitable for competitive bidding on the Phase II drilling program and prepare specifications for equipment procurement, and (d) provide a training program in hydrogeological investigation and drilling for the benefit of Sudanese counterparts.

B. Economic Analysis

1. Introduction

The broad central and coastal belt of the Sudan (see map following) has been chosen by the GOS as the "project area" for groundwater development because of the concentration there of most of the country's population, livestock and productive land. Nearly all the people in the project area are engaged in agricultural activities of one kind or another, and agricultural commodities comprise more than 90% of the Sudan's export volume. The proposed A.I.D. assistance will be restricted to the project area (about one million square kilometers out of the total land area in the Sudan of about 2.6 million square kilometers).

A striking ecological feature of the project area is that while sufficient rain falls annually to support vegetation for livestock grazing and to permit the cultivation of farm crops, drinking water for humans and animals is in serious short supply during most of the year. Virtually all the annual rainfall occurs during a period of about three months, and during the rest of the year life depends partly upon the availability of natural and man-made water supplies and partly upon the ability of humans and animals to adapt themselves to reduced levels of water consumption.



LEGEND

-  DESERT
-  STEPPE (18" av. annual rainfall)
-  SAVANNA (32" av. annual rainfall)
-  DENSE SAVANNA
-  SUDD (swamp)

SOURCE: HDR, Rural Water Development Survey, 1965

SUDAN
VEGETATION BELTS
ANNUAL RAINFALL

8

Vast portions of the project area contain no natural surface-water supplies except rainy-season streams; although the number of man-made sources of supply has increased during the last ten years, many inhabitants still must drive livestock herds 20 miles and more daily to watering points and migrate in search of water during the dry season as far as 750 miles southward. Where such travel is not feasible, the people have learned to reduce the need for drinking water by keeping physical activity to a minimum. Farmers and herdsment are compelled to lie still in shaded areas; children, who do not comprehend the consequences of thirst, are tied down to keep them still and covered to restrict evaporation from the surface of the skin.

Because of these conditions, many small farmers and nomadic herdsmen are found in subsistence or survival circumstances. Any significant increase in the availability of drinking water would allow more time to be spent in gainful activities, and farmers and herdsmen would be thus encouraged to expand agricultural output.

The map of vegetation belts and annual rainfall in the Sudan on the following page reveals that the project area conforms almost exactly with the steppe and savanna zones where living conditions are better than in other areas. To the north are the sandy wastes of the Libyan Desert and the Nubian Desert. To the remote south one encounters dense, jungle-like forests and the vast impenetrable marshes called the Sudd.

In the savanna belt, however, where annual rainfall averages 32", a composite population is sustained on dryland farming, livestock production and hunting. Principal crops are sesame, groundnuts and cotton. Sheep, goats, camels and cattle are raised in the grasslands. More than 90% of the Sudan's 26 million head of livestock (cattle and sheep, about 9 million each; goats, about 7 million; and camels, 2 million) are found in the savanna and steppe belts. The roughly 200-mile-wide savanna belt is considered one of the best potential areas of the Sudan for future economic development. Although the water shortage is less acute here than in the northern belts, the developmental potential appears greater due to geographic and climatic conditions.

Less rain falls in the steppe belt, which averages about 18" of rain per year to the savanna's 32". Nevertheless, rainfall is sufficient to sustain somewhat sparse grasses and drought-resistant acacia scrubs and trees. A species of acacia produces gum arabic, the Sudan's third largest export product by volume. Most of the rural inhabitants of the steppe are semi-nomadic and depend on their considerable herds of sheep, goats, camels and cattle for livelihood. The dryness of the steppe permits less crop farming than in the savanna areas. Lack of consumable water is a major restricting factor in the future development of this belt.

In both the steppe and savanna belts it is believed that a much higher level of economic activity can be supported as the drinking water problem is solved. Most of the western part of the Sudan, for example, is reported to be capable of supporting many more than the present number of livestock in areas without an adequate supply of drinking water. The same is true of crop production, where lack of or uncertainty of drinking water supplies reduces the area tilled by one family to considerably less than the area tilled by a similar family in areas of adequate drinking water supplies, even with existing farming techniques.

The economic feasibility of the proposed program is therefore evaluated in terms of anticipated economic benefits.

2. Increased Livestock Production

The proposed program (Phases I and II) should increase substantially the net value of livestock production in the project area by (a) encouraging farmers to raise more cattle and (b) improving the quality of cattle marketed and dairy products.

a. Increased Utilization of Cattle-Grazing Area. The GOS Land Use and Rural Water Development Department of the Ministry of Agriculture has attempted to relate the extent of land use to the availability of drinking water. In a review of twelve land inventory reports (5,100 square miles total) from villages which have submitted requests for drinking water facilities, the GOS found that the number of livestock on the lands in question was only 65% of the optimum number of livestock which could be supported on the same land if adequate drinking water were available. The median annual net value of livestock output in the areas studied was found to be £S 45 (\$130) per square mile. It can be validly assumed that as a result of a significant improvement in the adequacy, reliability and accessibility of the drinking water supply, the grazing potential of such locations in the project areas would be more fully utilized.

Based upon the facts given above, it is assumed that as a result of adequate water supply the utilization of land for grazing will increase from the present estimated 65% to a projected 83% utilization over a 15-year period, resulting in an increase in median annual net value of livestock production from £S 45 (\$130) to £S 57.6 (\$166) per square mile by the fifteenth year.

b. Improved Quality of Cattle and Dairy Products. The second important livestock benefit which can be derived from greater accessibility of watering points is the reduction of the cattle-maturing period and the increase of the average daily milk yield. A 1962 Range Reconnaissance Survey of the Babanousa area in southwest Kordofan Province (within the project area) by the Ministry of Animal Resources showed that the age of physical maturity of "nomadic" cattle was four years compared with 2.5-3 years for cattle in the settled areas

in the same region. In other words, cattle which must be driven long distances in search of watering points require a period before maturity of from 33% to 60% longer than that for cattle which are raised near reliable and adequate sources of drinking water in the test area.

Similarly, the average daily milk yield for nomadic cattle was 8.4 pounds per cow in the rainy season and only 3.6 pounds in the dry season, compared with 18 pounds and 16 pounds, respectively, for cows in the permanently settled areas with an adequate water supply. The lower quality of nomadic cattle is further illustrated by the fact that the per head market price of cattle raised by nomads is only one-fourth the price of cattle raised commercially for export purposes, according to the Ministry of Local Government. A recent survey of livestock resources development in the Sudan, financed by AID, concluded that conditions are favorable for increasing quantity of supply and improving quality, and that long-range market growth potential is excellent. In view of the above it can be conservatively assumed that the proposed ground-water development project would gradually increase the net value received by farmers per head of cattle by at least 50% over a period of ten years and remain constant thereafter.

On the basis of these assumptions stated in 2.a. and 2.b. above, the total net value of benefits due to increased livestock production would exceed £S 390 (\$1,123) per square mile during the next 15 years. Since the optimum grazing area served by one watering point is believed to be between 100-150 square miles, total benefits over the useful life of the well equipment would be about £S 50,000 (\$144,000) per one watering point. For livestock benefit calculations, see Annex C, Table 1.

3. Agricultural Benefits

While a wide variety of benefits may accrue to a community by the establishment of an adequate drinking water supply, it is not possible, for purposes of the present analysis, to develop a quantum of agricultural benefits attributable to the availability of water supply which would be both comprehensive and typical of all the regions of the project area. Some of the presumed benefits are common to all parts of the project area, but others vary depending on soil characteristics, climate, availability of marketing and transport facilities, etc.

In view of such limitations, it is appropriate to adopt a more conservative approach which attempts to quantify only those benefits which appear to be common to the predominantly agricultural sections of the project area. It is believed that common benefits which would accrue from the proposed improvements in water supply are (a) increased acreage of cultivated land, (b) diversification of crops in order to increase earnings, and (c) probable savings in water distribution costs in the predominantly agricultural parts of the project area.

a. Increased Acreage Cultivated. Analysis by Henningson, Durham, and Richardson of land inventory reports for villages and village clusters in predominantly agricultural areas without adequate water supply revealed that the average area cultivated by a family is less than 20 feddans (roughly 20 acres). According to the Ministry of Agriculture, an average farm family can cultivate up to 40 feddans of land using existing farming techniques, provided adequate drinking water is available. The average annual net value of output per feddan in areas without adequate water supply was found to be slightly over LS 5 (\$14), for an average net value of total output for the typical farm family in the project area of LS 95 (\$274) per annum.

There have been no controlled experiments measuring the effect on agricultural output of establishing a permanent watering point in an area which had previously lacked an adequate supply of water in the Sudan. However, where responsible estimates have been made the value of benefits attributable to the availability of drinking water supply has been impressive. According to J. H. K. Jefferson, Soil Conservation in the Sudan, 1955, construction of watering points in the Paloich region (within the project area) in 1949 increased grain output from 15,000 sacks (1948) to 50,000 (1951). Similarly, in the Nuba Mountains region (also within the project area), annual cotton production by small farmers rose from 9,000 tons to 31,000 tons within three years after construction of drinking water facilities in the area, according to a 1963 GOS report to the IBRD.

Such large increases are attributable to several factors. To begin with, in areas where sufficient drinking water is absent the production base is very low. A large portion of the working day is devoted to the search for water or to travel to and from known watering points. Too, the inadequacy of the water supply reduces efficiency of both the farmer and his work animals, and often reduces the number of hours which can be worked during the day. Consequently, a crop plot tends to be small and the crops are not tended as much as they should be for maximum output. Field crops sometimes must be abandoned when migration is required to obtain drinking water. On the whole, in the absence of adequate drinking water for humans and animals the agricultural output of small farmers in the project area is reduced to a fairly marginal level.

Once this serious economic impediment is removed, production often reaches 2, 3 or 4 times the previous levels, depending on various local conditions. In general, the new higher levels of agricultural output resulting from adequate drinking water supplies will tend to reflect the "normal" or optimum outputs under the conditions imposed by existing farming techniques and the climate pattern.

Under the conservative approach to projected agricultural benefits utilized herein, it can be assumed that following the establishment of a permanent adequate and accessible drinking water supply the farmers would gradually increase cultivated feddanage to close to the estimates limits imposed by currently-used farming techniques. For this purpose, it is assumed that the average area cultivated by a family will rise gradually from 20 to 36 feddans out of an assumed potential of 40, as discussed above.

b. Crop Diversification to Increase Earnings. The table below shows that dura is by far the most commonly grown crop in the project area. Of all major crops in the Sudan, dura has the lowest commercial value, but it also has the shortest growth cycle, which means that farmers are more certain to harvest the crop before lack of drinking water forces them to leave the area in search of water supplies.

Agricultural Output and Prices in the Project Area*

<u>Major Crops</u>	<u>Volume (metric tons)</u>	<u>Price (£S per ton)</u>
<u>Food Crops</u>		
Dura (sorghum)	714,000	12-24
Dukhin (millet)	279,000	23-30
<u>Cash Crops</u>		
Sesame	144,000	66
Groundnuts	330,000	55

Since most subsistence needs are now met from the presently cultivated crops (basically dura and dukhin), it is assumed that practically all additional output would be in cash crops such as sesame and groundnuts, and that the per feddan value of such valuable crops will be about twice as high as that of subsistence crops.

On the basis of the assumption stated in 3.a. and 3.b. above, the average net value of output for a typical farm family can be expected to rise from £S 95 (\$274) to £S 275 (\$792) in the 15th or last year of the assumed useful life of the wells and well pumps. At present there are approximately 1.5 families per square kilometer of the agricultural sections of the project area, and the population growth over the next 15 years should raise the density to two families per square kilometer. As the most economical agricultural area

*Source: Ministry of Agriculture

to be served by a watering point is about 100 square kilometers, one watering point will eventually serve 200 families, with a total net benefit over the assumed useful life of wells of £S 285,500 (\$822,240) per watering yard. For benefit calculations, see Annex C, Table 2.

c. Savings in Water Distribution Costs. Water distribution costs in the project area vary depending primarily on the method of distribution but also on distances from the bulk supplies. Where farming activity is market-oriented -- as in areas of cotton, gum arabic, sesame and groundnut cultivation -- farmers pay for water brought to them by lorries. Elsewhere, where subsistence farming predominates, people carry the water themselves with donkeys or camels, using both time and effort which could otherwise be employed more productively. The use of camels or donkeys is the least expensive and most common way of obtaining drinking water. According to recent studies, the average distribution cost of water based on this method is about 15 mills per 4-gallon tin. The average distance traveled to obtain water is about 20 km. (round trip), although trips of up to 30 km. (one way) are reportedly made to get water. The need for trips of such length is illustrated in the table on the following page.

If, under the proposed program (Phases I and II), new wells are drilled in optimum locations, distances between existing permanent water sources could be halved, reducing water distribution costs to 8 mills per tin. It is assumed, however, more realistically, that new well locations will not always be optimal and that distribution savings will be closer to 6 mills per tin.

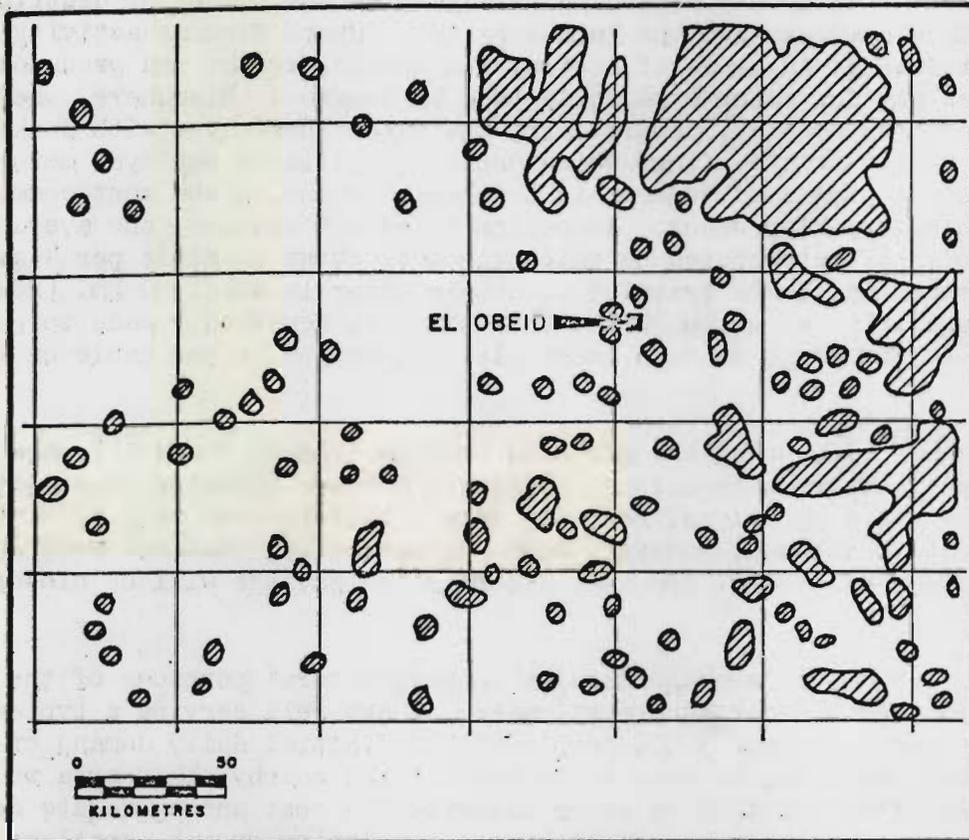
Given average density in agricultural portions of the project area of eight persons per square kilometer, a new well serving a typical area would supply water to over 3,000 people with an initial daily demand of about 10,000 gallons. In time, as more wells are drilled nearby, this area would decrease but the effect of this on water distribution cost and aggregate demand for water would probably be offset by the population growth, settlement of nomads, and growing per capita consumption of water. Hence, it is assumed that the aggregate daily demand for water and water distribution cost from one watering point will remain constant over the useful life of the watering point.

An annual savings in distribution cost per watering point would be about £S 5,500 (\$15,840) annually, or £S 82,000 (\$236,160) for the period under review.

4. Cost-Benefits Ratio

As discussed in Section I.F., the proposed program (Phases I and II) is designed to assist in developing the resources of the GOS to the extent that the GOS will have the capacity to increase annual deep well production from 60 to 200 wells per year. As part of this effort, it is proposed that A.I.D.

DISTANCES TRAVELED TO OBTAIN WATER
IN A CENTRAL SECTION OF THE PROJECT AREA



THE SHADED AREAS COVER THE LANDS WHICH ARE WITHIN 5KM. OF AN ALL-SEASON WATER SOURCE IN THE EL OBEID SECTION OF KORDOFAN PROVINCE. ANY PLACE IN THE BLANK AREAS IS MORE THAN 5KM. FROM AN ALL-SEASON WATER SOURCE. ONE SQUARE REPRESENTS 2,500 SQ. KM.

finance the costs of drilling 90 wells per year for two years. With the equipment and training provided, the GOS is expected to continue producing 90 wells (45 wateryards) per year for 15 years, the assumed useful economic life of the drilling equipment. The wells and well pumps also have an estimated life of 15 years. Accordingly, benefits for purposes of this paper are calculated on the basis of livestock and agricultural benefits, and water distribution savings arising during the 15-year drilling period and continuously throughout the useful life of the wells drilled.

On this basis, about 675 new wateryards will be established, yielding total benefits during the collective economic life of the wells of about \$437 million. See Annex C, Tables 4 and 5.

Costs during the first two years of drilling under the project will be high, reflecting the total estimated foreign exchange and local currency costs of the project of about \$8 million, including costs of maintenance during the second year. For the remaining 13 years, the GOS will drill and construct 45 wateryards per year at a cost of about \$1,701,900 annually. This is based on HDR's January, 1965, report which calculated total costs of \$47,820 per wateryard in the Sudan.

In addition to the costs of drilling and wateryard construction, the GOS must bear maintenance expenditures. On the basis of field investigations conducted by HDR, the following maintenance costs per wateryard can be anticipated:

Labor (3 men)	\$1,296
Fuel and lubricants	1,440
Maintenance and parts	288
Total	<u>\$3,024</u>

At this rate, the yearly production of 45 wateryards will result each year in an additional \$136,080 in net maintenance costs.

In sum, total costs will reach \$60.6 million during the useful collective life of the wateryards constructed under the program initiated by the proposed A.I.D. drilling and training program.

The overall benefit-cost ratio for the proposed investment, including all costs and benefits during the useful economic life of the wells, is as follows:

$$\frac{\text{Present Worth of Benefits (6\%)}}{\text{Present Worth of Costs (6\%)}} = \frac{\$174.0 \text{ million}}{\$35.5 \text{ million}} = 4.90:1$$

5. Internal Rate of Return

The above cost-benefit ratio indicates the economic feasibility of the proposed investment. However, the rate of return on the investment should also be indicated for purposes of comparison with alternate investments or ranking proposed projects in order of priority of highest rate of return. Although the GOS does not typically utilize such an approach in ranking development priorities, the internal rate of return does provide an additional and useful index of priority from a purely economic point of view.

As a standard of comparison, private investors do not usually consider undertaking projects in developing countries unless they are expected to yield 20% or more. As indicated in Annex C, Table 6, the internal rate of return on the proposed investment should be about 34%.

C. Technical Analysis

1. Phase I

As discussed in Section I.A. and Annex A, the new Rural Water and Development Corporation (RWDC) will undertake the duties previously exercised by the Land Use and Rural Water Development Department (LURWD) related to the production of deep wells and related land use problems. The RWDC will also assume the functions of the Geological Survey Department (GSD) related to exploratory drilling and hydrological investigations.

The RWDC expects to utilize the services of the following personnel when transfer from LURWD and the GSD is completed:

Hydrogeologists and Geologists	7
Qualified Drillers	6
Assistant Drillers	23
Head Rigmen	40

One of the proposed functions of the engineering consultant (Phase I), as discussed in Section II.A., above, is to provide a training program in drilling so that the number of qualified RWDC drillers will be adequate for the proposed expanded program. It is estimated that a total of about 60 qualified drillers would be required to man the 21 rigs (three-shift basis) which would produce a total of 200 deep wells annually. The skills of the 23 assistant drillers should be developed under the training program so that the assistant drillers would be fully qualified as drillers. About 30 more drillers would have to be trained under the program. The RWDC plans to recruit trainees from local technical schools. Training would be initiated in Phase I and continue throughout Phase II by the engineer with the cooperation of the drilling contractor.

About 20 head rigmen would be required in addition to the 40 now available. The RWDC should have no difficulty in recruiting such personnel from graduates of technical schools.

It is expected that about nine geologists would be needed in addition to the seven hydrogeologists and geologists now available. The engineering consultant will establish a training program in techniques of hydrogeological investigation to further acquaint the RWDC hydrogeologists and geologists in U.S. water exploration methods. It will be the function of the management consultant to review the requirements for additional geologists and/or hydrogeologists and make recommendations to the RWDC concerning sources for recruitment.

Apart from the technical training which the engineering consultant will provide, the services of a consulting management firm are required to review the organizational, planning, and rural development problems which face the RWDC. The RWDC is a newly-established organization which will combine and greatly expand the groundwater development functions previously performed by separate GOS agencies. Assistance is needed in planning and setting up the operations of the RWDC's fiscal, budgeting, personnel, procurement, and management departments.

In addition, the RWDC will need professional advice in the operation of its Rural Development Department. This section will be responsible for carrying out range management, soil conservation, nomadic settlement and land use programs to help assure that each new wateryard and the area around it is effectively utilized.

Finally, the management consultant is needed to assist in the planning and preparation of a long-range groundwater development program for the RWDC. Such a program is needed to help assure that the various rural water development programs such as construction of shallow wells, hafirs and dams, are coordinated with the deep well drilling activities, and that development assistance provided by Sweden and possibly other governments or development agencies is coordinated with A.I.D. assistance.

As mentioned in Section II.A., other technical assistance proposed under Phase I relates to engineering work in preparation for drilling activities proposed under Phase II. Such preliminary engineering work includes, first, undertaking a limited hydrogeological investigation in sufficient detail to provide site locations for the Phase II drilling. As discussed in Annex D, the GOS does not now have the personnel and equipment resources to undertake the necessary hydrogeological investigations for the proposed drilling program under Phase II in addition to the hydrogeological work required for the existing GOS drilling program. Annex D also contains a discussion of hydrogeology in the Sudan and the potential for groundwater availability.

Second, the engineer, under Phase I, would be responsible for the preparation of a drilling program and specifications for the design of wells and wateryards to be constructed under Phase II. The engineer would, in addition, prepare bid documents and specifications for competitive bidding on the Phase II drilling program and prepare specifications for equipment procurement. Finally, the engineer would assist the GOS in bid analysis and contractor selection for Phase II.

On the basis of the above discussion and the engineering analysis found in Annex D, the loan proposal is considered to be technically sound.

2. Phase II (not included in present loan proposal)

Pursuant to the necessary preliminary engineering work performed under Phase I, it is proposed that a drilling contractor undertake a two-year drilling program for the construction of about 90 deep wells annually and necessary wateryards. This would serve the important purpose of providing on-job training and demonstrating U.S. drilling techniques, as well as providing the supplemental deep-well drilling required to reach the GOS goal of 200 wells per year as previously discussed. The GOS, with the advice of the management consultant, would consider the most practical ways of continuing annual production at the 200-well level after the two-year U.S. drilling program is completed. Total foreign exchange costs under Phase II, including costs of supervision of construction, contract costs and costs of necessary equipment and materials, are estimated at \$5,125,000. A.I.D. would consider a second loan, to cover the reasonable foreign exchange costs under Phase II, at the appropriate time.

3. Implementation Schedule

- | | |
|-----------------------|---|
| a. February 28, 1967 | Loan authorization |
| b. 1 month subsequent | Execute loan agreement |
| c. 2-1/2 months | Approve selection management consultant and engineer |
| d. 4-1/2 months | Approve management and engineering contracts |
| e. 5-1/2 months | Engineer begins limited hydrogeological study; management consultant arrives in Sudan |
| f. 11 months | Engineer completes bid documents and specifications for drilling program |
| g. 12 months | AID review of bid docs and specs completed |
| h. 15 months | Receipt of bids for drilling program |
| i. 16 months | Award Drilling Contract |

D. Financial Considerations

1. Financial Plan

Based upon the cost details provided in Annex E, the following financial plan indicates the financial requirements for the proposed loan:

	<u>U.S.</u>	<u>Local</u>	<u>Total</u>
Rural Water Management Consultants	\$ 725,000	\$ 80,000	\$ 805,000
Engineering Consultants	475,000	61,360	536,360
	<u>\$1,200,000</u>	<u>\$141,360</u>	<u>\$1,341,360</u>

U.S. costs include an 8% contingency allowance for management costs and a 6% contingency reserve under the engineering costs. Also included in the total U.S. cost is about \$100,000 for necessary supporting equipment to be used by the engineer and management consultants.

Local costs, including housing, vehicle operation and maintenance and other supporting costs, will be borne by the GOS.

The proposed loan would be repayable in dollars over a 40-year period, including a 10-year period of grace on principal payments, with interest at 1% per annum during the grace period and 2 $\frac{1}{2}$ % per annum thereafter.

2. Estimated Financial Requirements for Phase II

Cost estimates for Phase II are set forth in detail in Annex E. They are summarized as follows:

	<u>Foreign Exchange Costs</u>	<u>Local Currency Costs</u>	<u>Totals</u>
Engineer (Construction Supervision)	\$ 375,000	\$ 61,360	\$ 436,360
Drilling Contractor	4,750,000	1,361,680	6,111,680
Totals	<u>\$5,125,000</u>	<u>\$1,423,040</u>	<u>\$6,548,040</u>

On the basis of the bids received for the drilling contract, A.I.D. would consider a second loan to cover the foreign exchange costs. The GOS would be expected to bear all local currency costs.

3. Other Sources of Financing

In the past, the GOS has obtained development financing from a variety of countries, including West Germany, the United Kingdom, Kuwait, Yugoslavia, Italy, the Netherlands and Sweden. Major support has also come from the IERD and the IDA. Such development financing has provided assistance for such major projects as the Khashim El Girba agricultural development, the Roseires Dam, extension of the Gezira irrigation scheme, and Sudan railroad equipment. In the past ten years, other free world loans and credits to the GOS have exceeded \$300 million. There is no reason to believe that other free world assistance will not continue to be available to the GOS.

U.S. assistance programs have been coordinated with those of other donors in the past. It is hoped that such coordination will be strengthened in the future through the reactivation of the IERD Consultative Group.

As discussed in Section I.F., the Government of Sweden agreed in 1965 to finance a \$5.8 million water development project related to the present proposal. In addition to Sweden and the U.S., the GOS expects to obtain assistance in the future from the United Kingdom, Czechoslovakia, and Yugoslavia under the broad outlines of the "Thirst-Fighting" program.

In view of the assistance being provided by Sweden and possibly by other donors in groundwater development, and in view of high level of technical skill available in the U.S. in the fields of hydrogeology and well-drilling, plus the interest of the U.S. in agricultural development, the project is considered appropriate for A.I.D. financing.

E. Other Considerations

1. Repayment Prospects

Analysis of GOS balance of payments projections indicates that prospects for loan repayment are good provided export earnings rise in accordance with present projections. Even if export earnings do not closely conform to the rates projected by the GOS, the Sudan's debt service ratio (amount of principal and interest due on foreign loans in relation to the amount of export earnings) will be within reasonable limits.

With export earnings estimated at \$186.55 million for 1964/65 and external debt servicing totaling approximately \$14.07 million for the same period, the Sudan's present debt servicing ratio is 7.5%. (Refer to the table on the following page.) Export earnings of \$267.48 million are projected for 1970/71, the terminal year of the Ten-Year Plan. A debt service ratio of 12.5% would result under an estimated annual loan service payment in 1970/71 of \$33.58 million.

Debt service ratios in other countries, by contrast, range as high as 22% (Brazil) and 30% (Turkey). Colombia, Argentina and Mexico each presently maintain a ratio of about 17%, while the current rate for Iran and Peru is about 10%.

BALANCE OF PAYMENTS, PROJECTIONS, 1964/65 - 1970/71
(\$ Millions)

	(9 mos Actual) 1964/65	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	
I. Current Account								
1. Exports ^{1/}	186.6	229.6	237.0	244.5	252.0	259.4	267.5 ^{2/}	
2. Imports	<u>215.2</u>	<u>252.6</u>	<u>261.7</u>	<u>270.9</u>	<u>280.1</u>	<u>289.3</u>	<u>298.5</u>	
Balance of Trade	-28.6	-23.0	-24.7	-26.4	-28.1	-29.8	-31.0	-191.7
3. Net Invisibles	<u>-34.4</u>	<u>-34.4</u>	<u>-34.4</u>	<u>-34.4</u>	<u>-34.4</u>	<u>-37.3</u>	<u>-37.3</u>	
Total Deficit on Current Account	-63.1	-57.4	-59.1	-60.8	-62.6	-67.2	-68.3	-438.5
II. Capital Account								
4. Official Capital								
a. Inflow	33.0 ^{3/}	51.7 ^{4/}	51.7	53.1	54.5	57.4	60.3	
b. Repayment foreign loans (incl. interest)	<u>14.0</u>	<u>16.6</u>	<u>19.2</u>	<u>21.8</u>	<u>24.4</u>	<u>27.6</u>	<u>33.6</u>	
Official Capital (net)	19.0	35.0	32.4	31.3	30.1	29.8	26.7	
5. Private Capital (net)	<u>4.3</u>	<u>4.3</u>	<u>4.3</u>	<u>5.7</u>	<u>7.2</u>	<u>8.6</u>	<u>10.0</u>	
Total Net Capital Inflow	23.2	39.3	36.7	37.0	37.3	38.4	36.7	248.8
6. Additional Foreign Exchange	+39.9	+18.1	+22.4	+23.8	+25.2	+28.7	+31.6	+189.7

^{1/} Based on straight line average; does not take into account fluctuations caused by great variations in cotton crops.

^{2/} IBRD Report, Extra Long Staple Cotton, Demand and Price Prospects, April 10, 1964, p. 76: Expected production, 1970, 1,050,000 acres x 500 lb. yield per acre (optimistic) x \$.28 per pound (Liverpool price, 1970) = \$146.6 million.

Cotton exports	\$146.6 million
Other exports	<u>120.8 million</u>
Total	<u>\$267.5 million</u>

^{3/} Excludes all IMF drawdowns.

^{4/} Includes \$14.17 million in stabilization loans from Kuwait and possibly other donor nations.

Since it is not now possible to accurately project GOS foreign exchange income and expenditures beyond the Ten-Year Plan, resort also must be made to other indicators to estimate long-term GOS debt servicing capabilities. The clear record of prompt foreign loan repayments which the Sudan has enjoyed since independence may be considered relevant insofar as a habit of sound fiscal policy has been firmly established. The substantial development program (1961-1971) upon which the GOS is now embarked is intended, in part, to relieve the dependence of the country upon a single major commodity for foreign exchange earnings and thus provide increased dependability of foreign exchange reserves with which foreign loan principal and interest payments may be made. Significant progress has been made in this effort, and the process of diversification of agricultural production for export is expected to continue indefinitely.

2. Impact on U.S. Economy

There should be no adverse impact on the U.S. economy as a result of the proposed loan since all services and equipment to be financed under the proposed loan will be procured in the U.S. Under Phase II, i.e., contract drilling and construction of wateryards, all necessary equipment and services which A.I.D. agrees to finance would also be procured in the U.S.

3. Effect on Private Enterprise

The proposed loan should have a beneficial effect on U.S. private enterprise since only U.S. firms would be considered to provide the necessary engineering and management services. Sudanese private enterprise would be encouraged under the loan proposal since the chief beneficiaries of the drilling program would be rural farmers and herdsman who will be stimulated to produce cash crops and to develop livestock production.

4. Conditions

As discussed in Annex A, the GOS implementing agency was recently created and has not yet been fully organized. The proposed loan is conditioned upon completion of the transfer of personnel and equipment to the jurisdiction of the RWDC as described in Annex A.

GOS GROUNDWATER DEVELOPMENT ORGANIZATIONS

Within the Government of the Sudan, responsibility for development of rural water supplies has been divided heretofore between (i) the Geological Survey Department of the Ministry of Mineral Resources, which among other duties undertook hydrogeological investigations to help locate potential well sites, and (ii) the Land Use and Rural Water Development Department (LURWD) of the Ministry of Agriculture, which was responsible for the drilling of productive water wells and their maintenance. Under a recent series of governmental reorganizations, these separate groundwater development responsibilities have been combined into one independent agency, the Rural Water and Development Corporation (RWDC).

The Ministry of Mineral Resources, now abolished, used to have primary responsibility for geophysical studies and geographics related to development of mineral and groundwater resources. These functions were divided within the Ministry between the Survey Department, which has been chiefly concerned with geographic mapping, and the Geological Survey Department (GSD), which was concerned with scientific studies of mineral and water resources. The recent governmental reorganizations transferred the Survey Department to a newly-created Ministry of Industry and Mining. Those functions of the GSD relating to minerals studies were also transferred to the Ministry of Industry and Mining, while the hydrogeological functions of the GSD were invested in the new RWDC.

The creation of the RWDC was undertaken pursuant to a series of decisions of the Sudanese Council of Ministers, commencing with Resolution No. 635 of January 12, 1966, which provided the initial structure for an independent water authority to plan and execute rural water and related social development programs. Council of Ministers Resolution No. 737 of March 23, 1966, provided a more detailed outline of the structure and duties of the independent water agency. Provision was made therein for two main departments under a managing director: (i) the land use department, which would be concerned with soil conservation, development of agricultural land, and nomadic settlement, and (ii) the rural water department, subdivided into "deep water" and "surface water" divisions.

With regard to rural water development, Resolution 737 specifically stated that the "deep water survey unit" of the GSD would be assimilated within the "deep water" division of the new water corporation. By putting "all the necessary units within one frame", Resolution 737 stated, "conflicting responsibilities between different departments, which cause a lot of delay for the progress

of projects, will be avoided." It was pointed out in Resolution 737 that the functions of hydrogeological surveys and groundwater drilling are closely related and would be combined under the "deep water" division. It was also mentioned that the functions of deep water and surface water development are interrelated and, moreover, closely connected with the functions of the land use department. Resolution 737 clearly was intended to consolidate and coordinate water development activities and related land use programs.

A copy of Resolution 737 of March 23, 1966, provided by officials of the RWDC, is found on the following pages. Also attached is a chart prepared by the RWDC pursuant to Resolution 737, providing a preliminary detailed outline of the staffing pattern for the Water Corporation.

Resolution 737 was formally reconfirmed under the new Sudanese government of September 26, 1966, when Council of Ministers Resolution 985 was passed. The only significant change was the decision to place the RWDC under the jurisdiction of the Ministry of Animal Resources. The previous resolutions had directed that the new corporation should be responsible to the Ministry of Mineral Resources (now abolished).

SUDANESE COUNCIL OF MINISTERS
RESOLUTION NO. 737 OF MARCH 23, 1966

ESTABLISHMENT OF THE RURAL WATER AND DEVELOPMENT CORPORATION

(The following is a translation from the Arabic provided by the Corporation.)

After studying H.E. the Minister of Local Government's memorandum No. MLG/11-L-4 dated 15th January 1966.

The Council of Ministers establishes an independent corporation of a recognizable corporate body - to be known as "the Rural Water Supply and Social Development Corporation"¹ from:

- 1 - Representative of the Ministry of Local Government
- 2 - Representative of the Ministry of Health
- 3 - Representative of the Ministry of Works
- 4 - Representative of the Ministry of Animal Resources
- 5 - Representative of the Ministry of Agriculture, Forests and Land Use
- 6 - Representative of the Ministry of Mineral Resources
- 7 - Representative of the Ministry of Finance and Economics
- 8 - Representative of the Ministry of Education
- 9 - Representative of Darfur Province
- 10 - Representative of Kordofan Province
- 11 - Representative of Blue Nile Province
- 12 - Representative of Kassala Province

These representatives will be appointed by their names. The object of the Corporation shall be:

- a - Water supply to men and animals
- b - Location of grazing and agricultural land
- c - Soil conservation
- d - Coordination of various activities with the object of developing rural areas in all aspects, for the settlement of nomads and raising the standard of living of the citizen.

THE EXECUTIVE BODY

1 - The Corporation in the execution of its responsibilities shall be responsible to the Council of Ministers through H.E. the Minister of Mineral Resources,² who will work with a Ministerial Committee appointed by the

¹ Changed to Rural Water and Development Corporation by subsequent action of the Council of Ministers.

² Changed to Minister of Animal Resources by C.M. Resolution 985 of September 26, 1966.

Council of Ministers with the Minister of Local Government as secretary. The Minister and the Ministerial Committee will have the right to give directions of a general nature to the Corporation in connection with the Government plans towards the desirable rural development and in connection with the execution of its duties in matters which the Minister regards as having a national effect, and the Corporation shall follow those directions.

2 - The Corporation shall inform the Minister of details of its projects before execution and of the progress in execution from time to time so as to inform the Council of Ministers. The Minister has the right to express his point of view to the Corporation regarding the proposed projects and their execution and in case of difference of opinion between the Minister and the Corporation in connection with any of the projects or with execution, the matter will be brought before the Council of Ministers whose decision will be final and obligatory upon the Corporation.

3 - Without impinging on section (2) above, the Corporation will submit to the Minister - for the information of the Council of Ministers - in the shortest possible time after the closure of each financial year, a report showing the achievements of the last year, future projects and policy. The annual report with the report of the auditors will be placed on the table of the General Assembly.

4 - In light of the Corporation's proposals and on agreement between the concerned Minister and the Ministerial Committee, the budget of the Corporation will be decided and put forward to the Council of Ministers for approval.

5 - The Corporation shall have a free hand in the budget which the Government allots for the execution of its duties without impinging on sections (1) and (2) above and will not be bound with routine administrative and financial regulations which rule ordinary Government departments. The Managing Director of the Corporation shall have a free hand in the budget after its approval and under the supervision of the Corporation.

6 - DUTIES OF THE CORPORATION:

- a) The Corporation shall determine for the Council of Ministers the policy, ways of rain - land use and development of rural waters, in a plan which includes the exploitation of those resources on the best technical, economic and social basis applicable in the country. The Corporation, through its full executive body, shall undertake geological and hydrological research necessary for water projects and will coordinate such projects in different ways according to the availability of deep or surface water.
- b) The Corporation will decide the priorities for execution of all land use projects in rural areas and rural water supply programs and will approve

such programs according to its approved budget. The Corporation will look after and encourage Rural Councils and Provinces to fulfill such duties insofar as their financial and technical resources permit, and will have the right to coordinate such programs with its central program and give technical and financial aid to Councils when their resources run short.

c) The Corporation shall follow up the standard execution, improvement and maintenance of natural-resource development projects, which will stem from the execution of land use and rural water supply projects, and will guard against the deterioration of resources such as pastures and agricultural lands, and will also guard against soil destruction and devastation of the country's tree wealth.

d) The Corporation whenever possible will carry out the necessary research and surveys.

e) The Corporation shall attend to the formulation of the legislation necessary for the execution of its responsibilities and shall draw the necessary by-laws for the organization of its meetings and the running of its works. It will also establish provincial and central sub-committees whenever necessary.

f) The Corporation will supervise the production of its executive body and ensure competence of the progress of the work.

7 - The Corporation will have a President appointed by the concerned Minister.

8 - The Corporation will have an Executive Body under the control of a Managing Director appointed by the Council of Ministers according to the recommendations of the Minister. The Director will be directly responsible to the Corporation. The Executive Body shall be established in accordance with the attached illustrated diagram.

9 - The Managing Director - by virtue of his position - shall be the Secretary of the Corporation and the link between it and the Minister.

10 - The Corporation will appoint all its staff by assimilating the existing concerned units in the different Ministries and departments named in the enclosed structure; staff will be recruited on secondment whenever necessary.

THE MINISTERIAL COMMITTEE

The Ministerial Committee is formed of:

- H.E. the Minister of Local Government
- H.E. the Minister of Mineral Resources
- H.E. the Minister of Health
- H.E. the Minister of Finance and Economics
- H.E. the Minister of Agriculture and Forests
- H.E. the Minister of Education

This Committee will be responsible for planning, laying the general policy and securing the necessary funds to the independent Corporation, besides the necessary coordination between the concerned Ministries.

* * * * *

S U P P L E M E N T

THE EXECUTIVE BODY

On the top of the Executive Body shall be a Managing Director and a Deputy Managing Director. The work will then be divided into the following different departments:

I. DEPARTMENT OF RURAL WATER

This is the Department which H.E. the Minister of Agriculture and Forests called for in his memorandum on this matter:

This Department will be divided into two divisions as follows:

A. DEEP WATER DIVISION

1. Deep waters surveys
2. Drilling section
3. Construction of deep water stations
4. Maintenance of deep water stations
5. Transport
6. Work shops
7. Stores

Since the establishment of this Division will mean the assimilation of the existing deep water survey unit from the Department of Geological Survey there will be the following justifications:

1 - This new Executive Body will be complete, having all the necessary units within one frame and by so doing conflicting responsibilities between different departments - which cause a lot of delay for the progress of such projects - will be avoided.

2 - As can be observed from the previously mentioned units which constitute the Deep Water Division - the units are closely related to each other and cannot be cleaved - they will also be linked to the surface water section of the Department of Rural Water and both are closely related to the agricultural survey unit of the Department of Land Use. It will not be logical to transfer these units to the one unit in the Department of Geology (i.e., the GSD).

3 - The transfer of this specialized unit connected with deep waters from the Department of Geology will allow the Department to be more highly devoted to other mineral resource work.

B. SURFACE WATER DIVISION

1. Surface water surveys
2. Haffir digging and dam machinery
3. Haffir and dam construction
4. Maintenance of haffirs and dams
5. Alternative projects

II. DEPARTMENT OF LAND USE

Formed of the following divisions:

1. Agricultural surveys and soil conservation section.
2. A new section for soil surveys which does not mean assimilating the existing soil survey unit in the Ministry of Agriculture and their duties will neither interfere nor conflict with each other.
3. Improvement and conservation of pastures section - which means the transfer of this section from the Ministry of Animal Resources to the Corporation.

The illustrated drawing enclosed gives the complete body of the Corporation for ease of reference.

PLANNING COMMITTEE FROM THE GENERAL AND PRIVATE SECTOR
LAND USE AND RURAL WATER CORPORATION

MANAGING DIRECTOR
DEPUTY MANAGING DIRECTOR

RURAL WATER DEPARTMENT

LAND USE DEPARTMENT

DEEP WATER DIVISION

1. Deep Water Surveys
2. Drilling Section
3. Construction of Deep Water Stations
4. Maintenance of Deep Water Stations
5. Transport
6. Work Shops
7. Stores

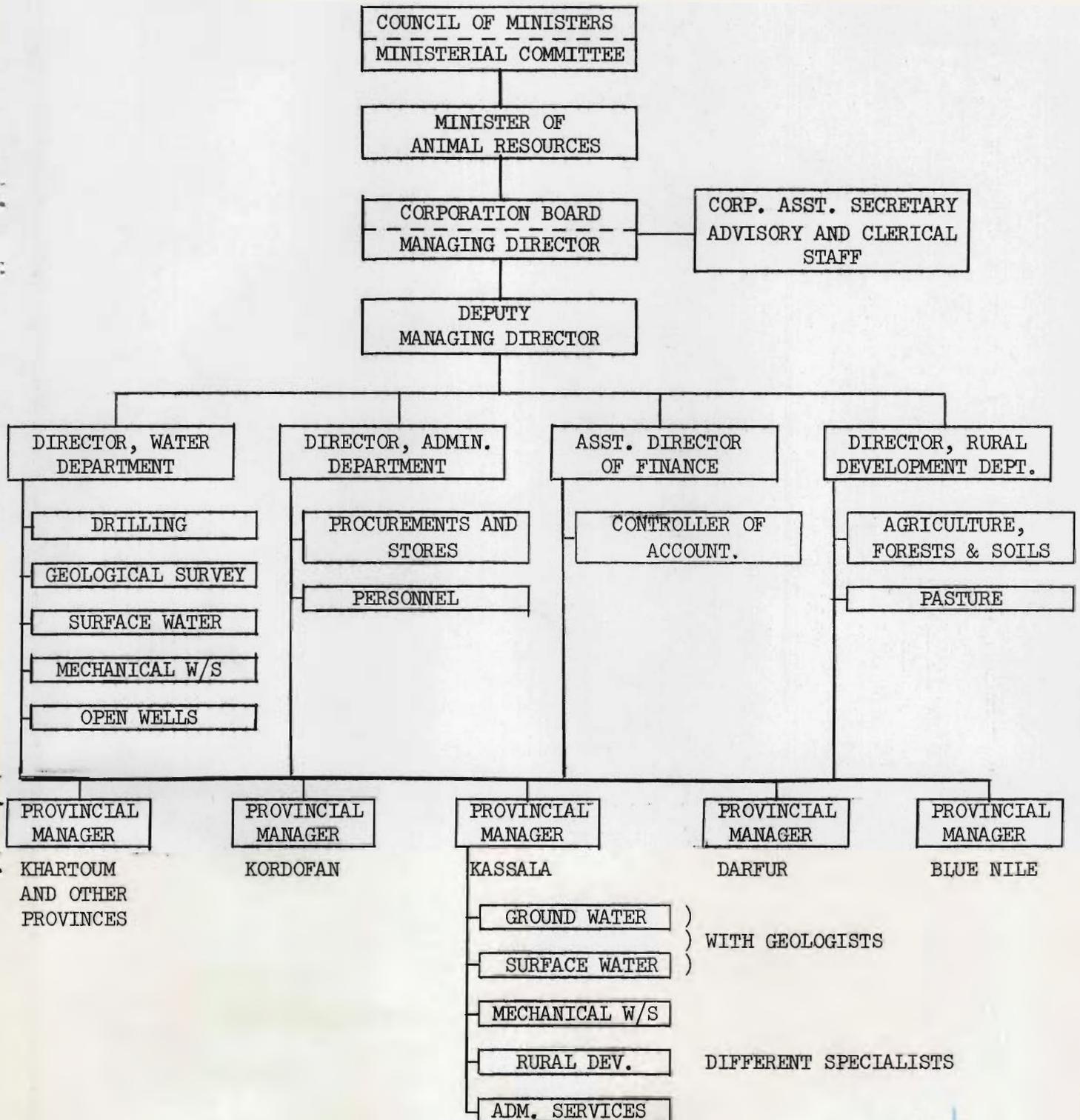
SURFACE WATER DIVISION

1. Surface Water Surveys
2. Haffir Digging and Dam Machinery
3. Haffir and Dam Construction
4. Maintenance of Haffirs and Dams
5. Alternative Projects

1. Agricultural Surveys and Soil Conservation Section
2. A new Section for Soil Surveysation
3. Improvement and Conservation of Pastures Section

PROPOSED ORGANIZATION OF
RURAL WATER AND DEVELOPMENT CORPORATION

(Preliminary Organization Chart Prepared by Water Corporation Officials Pursuant to C.M. Resolution 737)



31

PROJECTED GROUNDWATER SUPPLY AND DEMAND
IN THE PROJECT AREA

The total estimated project area demand for water in 1970, the tenth year of drilling operations under the 200 wells per year program, is about 50.92 billion gallons per year (BGY). This includes present rural population projected at an annual increase rate of 2.8% and present estimated livestock levels projected at an overall net increase of 1% annually. At these rates, about 42.81 BGY will be required for livestock (based on actual field trials in the project area, as reported by HDR) and about 8.12 BGY for humans, based upon per capita consumption of two gallons per day.

With deep well production at 200 wells per year and production of shallow wells, hafirs and dams at planned rates of increase, the supply of water in the project area in 1979, including natural supplies, should amount to 50.74 BGY -- just about enough to meet the projected demand of animals and humans at two gallons per person per day. The projected deep well production in 1979 is 17.16 BGY, about 34% of the total rural water supply, compared with 5.08 BGY in 1965 (20% of available supply).

If the proposed levels of supply can be reached, an important advance in rural water supply will be achieved. Present human water consumption in the project area averages well below two gallons per person per day -- as low as 1/2 gallon per person daily in certain of the project areas. In contrast, the World Health Organization has established four gallons per person daily as the world minimum standard to meet basic human needs. The present proposal should make it possible to reach the level of two full gallons per person daily in the project areas by 1979, as well as meet the water needs of an estimated 31.1 million head of livestock.

By the end of 1984, the 15th year of drilling, it is estimated that supply will reach 61.30 BGY and meet for the first time combined human and animal drinking water demand, with human demand calculated on the basis of four gallons per person per day.

The tables on the following pages provide statistical data on projected groundwater supplies and demand, and human and livestock population projections.

RURAL WATER AVAILABILITY (Billions of Gallons)

Year	Dry Season			Rainy Season	Total
	Hafirs, Dams	Shallow Wells	Deep Wells	(Natural Sources)	
1965	1.734*	1.600*	5.078*	16.110	24.522
1966	1.936	2.320	5.378	16.340	25.974
1967	2.044	2.555	5.678	16.570	26.847
1968	2.234	2.794	6.208	16.810	28.046
1969	2.586	3.232	7.183	17.050	30.051
1970	2.937	3.671	8.158	17.270	32.036
1971	3.297	4.121	9.158	17.520	34.086
1972	3.657	4.571	10.158	17.770	36.156
1973	4.017	5.021	11.158	18.020	38.216
1974	4.377	5.471	12.158	18.290	40.296
1975	4.737	5.921	13.158	18.560	42.376
1976	5.097	6.371	14.158	18.830	44.456
1977	5.457	6.821	15.158	19.110	46.546
1978	5.817	7.271	16.158	19.390	48.636
1979	6.177	7.721	17.158	19.680	50.736

*Based on Henningson, Durham and Richardson, Evaluation of Water Development Loan Application, May, 1966, pp. II-2, II-3.

NOTE: Deep wells provide 55% of Dry Season Availability.
Hafirs, dams provide 20% of Dry Season Availability.
Shallow wells provide 25% of Dry Season Availability.

RURAL WATER DEMAND (Billions of Gallons)

Year	Animal	Humans	Total*	Total**
1963	36.59	10.43	47.02	41.80
1964	36.96	10.72	47.68	42.32
1965	37.33	11.00	48.33	42.83
1966	37.70	11.33	49.03	43.36
1967	38.08	11.64	49.72	43.90
1968	38.46	11.97	50.43	44.45
1969	38.85	12.30	51.15	45.00
1970	39.15	12.65	51.80	45.48
1971	39.54	13.01	52.55	46.05
1972	39.94	13.37	53.31	46.63
1973	40.33	13.73	54.06	47.20
1974	40.74	14.13	54.87	47.80
1975	41.14	14.53	55.67	48.40
1976	41.55	14.93	56.48	49.02
1977	41.97	15.35	57.32	49.65
1978	42.39	15.78	58.17	50.28
1979	42.81	16.23	59.04	50.92

* Based on 4 gallons per person daily.
** Based on 2 gallons per person daily.

HUMAN WATER DEMAND - PRESENT AND PROJECTED

<u>Year</u>	<u>Rural Population (Project Area) (Thousands)</u>	<u>At 2 Gallons Per Person Daily (Billions of Gallons)</u>	<u>At 4 Gallons Per Person Daily (Billions of Gallons)</u>
1963	7,144	5.22	10.43
1964	7,343	5.36	10.72
1965	7,549	5.50	11.00
1966	7,760	5.62	11.33
1967	7,977	5.82	11.64
1968	8,199	5.98	11.97
1969	8,429	6.15	12.30
1970	8,665	6.32	12.65
1971	8,909	6.50	13.01
1972	9,160	6.68	13.37
1973	9,417	6.87	13.73
1974	9,680	7.07	14.13
1975	9,951	7.26	14.53
1976	10,229	7.46	14.93
1977	10,516	7.67	15.35
1978	10,810	7.89	15.78
1979	11,114	8.12	16.23

NOTE: Population projection at 2.8% estimated annual increase.

ANIMAL WATER DEMAND - PRESENT AND PROJECTED
(Billions of Gallons)

<u>Year</u>	<u>Camels*</u>	<u>Cattle*</u>	<u>Sheep*</u>	<u>Goats*</u>	<u>Total</u>
1963	3.120	24.940	4.760	3.770	36.590
1964	3.151	25.192	4.811	3.808	36.962
1965	3.182	25.444	4.859	3.846	37.331
1966	3.215	25.698	4.907	3.884	37.704
1967	3.246	25.956	4.956	3.923	38.081
1968	3.279	26.216	5.005	3.962	38.462
1969	3.312	26.477	5.056	4.002	38.847
1970	3.345	26.657	5.106	4.042	39.150
1971	3.377	26.923	5.157	4.082	39.539
1972	3.412	27.192	5.209	4.123	39.936
1973	3.446	27.463	5.261	4.164	40.334
1974	3.480	27.737	5.314	4.206	40.737
1975	3.515	28.014	5.367	4.248	41.144
1976	3.550	28.293	5.421	4.290	41.554
1977	3.586	28.575	5.476	4.333	41.970
1978	3.622	28.860	5.531	4.376	42.389
1979	3.658	29.148	5.586	4.420	42.812

* Average Annual Consumption:

Camels	- 1,560 gallons/year
Cattle	- 2,740 gallons/year
Sheep and Goats	- 550 gallons/year

ANIMAL POPULATION (PROJECT AREA) (Thousands)

<u>Year</u>	<u>Camels</u>	<u>Cattle</u>	<u>Sheep</u>	<u>Goats</u>
1964	2,020	9,194	8,747	6,923
1965	2,040	9,286	8,834	6,992
1966	2,061	9,379	8,922	7,062
1967	2,081	9,473	9,011	7,133
1968	2,102	9,568	9,101	7,204
1969	2,123	9,663	9,192	7,276
1970	2,144	9,729	9,284	7,349
1971	2,165	9,826	9,377	7,422
1972	2,187	9,924	9,471	7,496
1973	2,209	10,023	9,566	7,571
1974	2,231	10,123	9,662	7,647
1975	2,253	10,224	9,759	7,723
1976	2,276	10,326	9,857	7,800
1977	2,299	10,429	9,956	7,878
1978	2,322	10,533	10,056	7,957
1979	2,345	10,638	10,157	8,037

NOTE: Average annual net livestock increase of 1% assumed.

TABLE 1, PART I

SUDAN - GROUNDWATER DEVELOPMENT

Calculation of Livestock Benefits
 (Prepared by HDR)

Year	VALUE OF GRAZING BENEFITS DUE TO BETTER AREA UTILIZATION															(£)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	TOTAL
1	.7															.7
2	.7	2.1														2.8
3	.7	2.1	1.4													4.2
4	.7	2.1	1.4	.7												4.9
5	.7	2.1	1.4	.7	.7											5.6
6	.7	2.1	1.4	.7	.7	.7										6.3
7	.7	2.1	1.4	.7	.7	.7	.7									7.0
8	.7	2.1	1.4	.7	.7	.7	.7	.7								7.7
9	.7	2.1	1.4	.7	.7	.7	.7	.7	.7							8.4
10	.7	2.1	1.4	.7	.7	.7	.7	.7	.7	.7						9.1
11	.7	2.1	1.4	.7	.7	.7	.7	.7	.7	.7	.7					9.8
12	.7	2.1	1.4	.7	.7	.7	.7	.7	.7	.7	.7	.7				10.5
13	.7	2.1	1.4	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7			11.2
14	.7	2.1	1.4	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7		11.9
15	.7	2.1	1.4	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	.7	12.6
TOTAL	10.5	29.4	18.2	8.4	7.7	7.0	6.3	5.6	4.9	4.2	3.5	2.8	2.1	1.4	0.7	112.7

NOTE: As discussed on page 9 of the loan paper, one square mile of grazing area utilized to only 65% of its potential yields £S 45 annually in net benefits from animal grazing, or £S 0.7 for each percentage point. It is assumed that as a result of adequate water supply the utilization of the area will increase over the 15-year period as follows:

Year 1 - 66%	4 - 72	7 - 75	10 - 78	13 - 81
2 - 69	5 - 73	8 - 76	11 - 79	14 - 82
3 - 71	6 - 74	9 - 77	12 - 80	15 - 83

The more rapid rate of increase initially is based on the belief that herdsmen will take greatest advantage of opportunities afforded in the early years.

TABLE I, PART 2

SUDAN - GROUNDWATER DEVELOPMENT

Calculation of Livestock Benefits - Cont'd
(Prepared by HDR)

Year	Value of Benefits Due to Better Area Utilization			Value of Benefits Due to Higher Mkt. Prices for Better Quality Cattle		Combined Grazing Benefits	
	Per Sq Mile Value Existing	Without Quality Improvements Added By Better Area Utilization	Total	Percent Increase in Value Due to Better Quality	Value of Benefits Due to Better Quality	Per Sq Mile	Per Water Yard
	LS	LS	LS	%	LS	LS	
1	45.00	0.70	45.70	5	2.49	3.19	399
2	45.00	2.80	47.80	10	4.78	7.58	948
3	45.00	4.20	49.20	15	7.68	11.88	1485
4	45.00	4.90	49.90	20	9.98	14.88	1860
5	45.00	5.60	50.60	25	12.65	18.25	2281
6	45.00	6.30	51.30	30	15.39	21.69	2711
7	45.00	7.00	52.00	35	18.20	25.20	3190
8	45.00	7.70	52.70	40	21.08	28.78	3597
9	45.00	8.40	53.40	45	24.03	32.43	3934
10	45.00	9.10	54.10	50	27.05	36.15	4519
11	45.00	9.80	54.80	50	27.40	37.20	4650
12	45.00	10.50	55.50	50	27.78	38.28	4785
13	45.00	11.20	56.20	50	28.10	39.10	4888
14	45.00	11.90	56.90	50	28.45	40.35	5044
15	45.00	12.60	57.60	50	28.80	41.40	5175
					LS 283.86	LS 396.56	LS 49,400

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TABLE 2

SUDAN - GROUNDWATER DEVELOPMENT
Calculation of Agricultural Benefits
 (prepared by HDR)

ANNEX C
 Page 3 of 7

LAND UTILIZATION AND NET VALUE OF OUTPUT
IN PREDOMINANTLY AGRICULTURAL AREAS WITHOUT
ADEQUATE POTABLE WATER SUPPLY IN THE SUDAN

<u>LOCATION</u>		<u>AREA</u>		<u>POPULATION</u>		<u>NET VALUE OF OUTPUT (L)</u>	
<u>Area</u>	<u>Province</u>	<u>Total Sq. Miles</u>	<u>Sown Feddans</u>	<u>Number of Families</u>	<u>Feddans Sown by Family</u>	<u>Total</u>	<u>Per Feddan</u>
Ghibeisha	Darfur	100	2,800	160	19	11,040	3.9
Tamad Debeish	Darfur	100	3,400	200	17	20,050	5.9
Abu Reida	Kordofan	300	79,000	875	85	423,500	5.4
El Ganenna	Kordofan	700	26,200	340	85	154,680	5.9
Al Gellerig	Kordofan	500	77,000	700	110	622,000	8.1
Kradis	Kassala	N.A.	7,200	100	72	39,380	5.5
Qoz Beima	Darfur	100	1,100	60	18	5,680	5.2
Daein	Darfur	2,500	7,000	900	8	36,300	5.2
Lunia	Darfur	100	1,800	160	12	9,540	5.3
Karingu	Darfur	100	2,800	200	14	12,400	4.4
Umm Khashnein	Kordofan	500	70,000 ^{1/}	1,100	63	420,000 ^{1/}	6.0
Urgud Mararit	Darfur	200	3,200	160	20	24,700	7.7
Hagila	Darfur	100	500	100	5	2,350	4.7
Arayis	Darfur	100	900	100	9	3,470	3.9
Katonto	Darfur	100	900	200	5	4,800	5.3
					<u>18 Median</u>	<u>LS 5.3 Median</u>	

^{1/}Includes income from 11,000 feddans of gum arabic

Source: Land Inventory Reports on File on the Department of Land Use and Rural Water Development, Khartoum.

TABLE 3

SUDAN - GROUNDWATER DEVELOPMENT
Calculation of Agricultural Benefits
(prepared by HDR)

Year	FEDDANS CULTIVATED PER FAMILY			NET VALUE OF ADDED OUTPUT (LS)			
	Total	Subsistence	Market	Value Added Per Family	Families Per Sq. Km.	Value Added Per Sq. Km.	Value Added Per Wateryard
1	19	18	1	10.0	1.5	15.0	1500
2	21	18	3	30.0	1.5	45.0	4500
3	23	18	5	50.0	1.5	75.0	7500
4	25	18	7	70.0	1.6	112.0	11,200
5	26	18	8	80.0	1.6	128.0	12,800
6	27	18	9	90.0	1.6	144.0	14,400
7	28	18	10	100.0	1.7	170.0	17,000
8	29	18	11	110.0	1.7	187.0	18,700
9	30	18	12	120.0	1.7	204.0	20,400
10	31	18	13	130.0	1.8	234.0	23,400
11	32	18	14	140.0	1.8	252.0	25,200
12	33	18	15	150.0	1.9	285.0	28,500
13	34	18	16	160.0	1.9	304.0	30,400
14	35	18	17	170.0	2.0	340.0	34,000
15	36	18	18	180.0	2.0	360.0	36,000
TOTAL						LS 285,500	

TABLE 4

SUDAN - GROUNDWATER DEVELOPMENT
Calculation of Combined Benefits

IN LS

Year	Grazing Benefits		Agricultural Benefits		Distribution Savings		Total B+D+F G	Benefits for all (45) water yards built in one year H
	Total	"Composite" Factor Value*	Total	"Composite" Factor Value*	Total	"Composite" Factor Value*		
	A	B	C	D	E	F		
1	399	180	1,500	825	5,475	3,011	4,016	180,720
2	948	427	4,500	2,475	5,475	3,011	5,913	266,085
3	1,485	668	7,500	4,125	5,475	3,011	7,804	351,180
4	1,860	837	11,200	6,160	5,475	3,011	10,008	450,360
5	2,281	1,026	12,800	7,040	5,475	3,011	11,077	498,465
6	2,711	1,220	14,400	7,920	5,475	3,011	12,151	546,795
7	3,190	1,436	17,000	9,350	5,475	3,011	13,797	620,865
8	3,597	1,619	18,700	10,825	5,475	3,011	15,455	695,475
9	3,934	1,770	20,400	11,220	5,475	3,011	16,001	720,045
10	4,519	2,034	23,400	12,870	5,475	3,011	17,905	805,725
11	4,650	2,093	25,200	13,860	5,475	3,011	18,964	853,380
12	4,785	2,153	28,500	15,675	5,475	3,011	20,839	937,755
13	4,888	2,200	30,400	16,720	5,475	3,011	21,931	986,895
14	5,044	2,270	34,000	18,700	5,475	3,011	23,981	1,079,145
15	5,175	2,329	36,000	19,800	5,475	3,011	25,140	1,131,300
	LS 49,466	LS 23,500			LS 82,125		LS 224,982	LS 10,124,190
							(\$647,950)	(\$29,157,700)

* 45 percent of all water yards with boreholes drilled with contract equipment will be in a primarily grazing area and 55 percent in a primarily agricultural area. Since distribution savings will occur only in agricultural areas, "composite" factor of 55 percent is used

Table 5

SUDAN - GROUNDWATER DEVELOPMENT

Present Worth of Project Benefits and Costs

<u>Year</u>	<u>Cumulative Number of Wateryards</u>	<u>Total Benefits (LS)</u>	<u>Present Worth of Benefits Discounted 6% (LS)</u>	<u>Total Costs Including Maintenance (\$)</u>	<u>Present Worth of Costs Discounted 6% (\$)</u>
0	-	-	-	4,590,380	4,590,380
1	45	180,720	170,491	3,410,100	3,217,075
2	90	446,805	397,655	1,974,060	1,756,897
3	135	797,985	670,003	2,110,140	1,771,714
4	180	1,248,345	988,805	2,246,210	1,779,207
5	225	1,746,810	1,305,318	2,382,300	1,780,193
6	270	2,293,605	1,616,900	2,518,380	1,775,357
7	315	2,914,470	1,938,289	2,654,460	1,765,367
8	360	3,609,945	2,264,923	2,790,540	1,750,818
9	415	4,329,990	2,562,912	2,926,620	1,732,261
10	450	5,135,715	2,867,752	3,062,700	1,710,193
11	495	5,989,095	3,154,977	3,198,780	1,685,076
12	540	6,926,850	3,442,430	3,334,860	1,657,322
13	585	7,913,745	3,710,272	3,470,940	1,627,312
14	630	8,992,890	3,977,555	3,607,020	1,595,385
15	675	10,124,190	4,224,470	2,041,928	852,025
16	630	9,943,470	3,914,313	1,905,120	749,943
17	585	9,677,385	3,593,832	1,769,040	656,958
18	540	9,326,205	3,267,371	1,632,960	572,096
19	495	8,875,845	2,933,582	1,496,880	494,738
20	450	8,377,380	2,612,101	1,360,800	424,303
21	415	7,830,585	2,303,406	1,224,720	360,258
22	360	7,209,720	2,000,733	1,088,640	302,103
23	315	6,514,245	1,705,410	952,560	249,377
24	270	5,794,200	1,431,040	816,480	201,652
25	225	4,988,475	1,162,305	680,400	158,532
26	180	4,135,095	908,935	544,320	119,647
27	135	3,197,340	663,023	408,240	84,656
28	90	2,210,445	432,429	272,160	53,243
29	45	1,131,300	208,788	136,080	25,114
ALS		LS 151,862,850	LS 60,430,020		
		<u>\$437,365,008</u>	<u>\$174,038,457</u>	<u>\$60,607,818</u>	<u>\$35,499,202</u>

TABLE 6
SUDAN - GROUNDWATER DEVELOPMENT

Present Worth at 35%

<u>Year</u>	<u>35% Discount Factor</u>	<u>Total Benefits (LS)</u>	<u>Present Worth of Benefits (LS)</u>	<u>Total Costs (\$)</u>	<u>Present Worth of Costs (\$)</u>
0				4,590,380	4,590,380
1	.740740	180,720	133,866	3,410,100	2,525,997
2	.548696	446,805	245,160	1,974,060	1,083,159
3	.406442	797,985	324,335	2,110,140	857,650
4	.301068	1,248,345	375,837	2,246,210	676,261
5	.223013	1,746,810	389,561	2,382,300	531,284
6	.165195	2,293,605	378,892	2,518,380	416,024
7	.122366	2,914,470	356,632	2,654,460	324,816
8	.090642	3,609,945	327,213	2,790,540	252,940
9	.067142	4,329,990	290,724	2,926,620	196,499
10	.049735	5,135,715	255,424	3,062,700	152,323
11	.036841	5,989,095	220,644	3,198,780	117,846
12	.027289	6,926,850	189,027	3,334,860	91,005
13	.020214	7,913,745	159,968	3,470,940	70,162
14	.014973	8,992,890	134,651	3,607,020	54,008
15	.011091	10,124,190	112,287	2,041,928	22,647
16	.008216	9,943,470	81,696	1,905,120	15,652
17	.006086	9,677,385	58,896	1,769,040	10,766
18	.004508	9,326,205	42,043	1,632,960	7,361
19	.003339	8,875,845	29,636	1,496,880	4,998
20	.002473	8,377,380	20,717	1,360,800	3,365
			<u>LS 4,127,209</u>		<u>\$12,005,143</u>
			(\$11,886,361)		

ENGINEERING ANALYSIS

Rural Water Development Project in Sudan

Project Objectives: The objectives of the project are to improve the general welfare of the main concentration of human and animal population of Sudan by providing: (a) sufficient water to meet the basic needs for the development of rural communities; (b) stabilization of nomadic tribes; and (c) improvement of health and education, all of which should result in producing economic benefits through its effect on output and costs.

Project Description: The overall project area is the central belt of Sudan lying generally between latitudes 10 degrees and 16 degrees north, and between 22 degrees and 36 degrees west of the Greenwich meridian plus the Red Sea hills area. More specifically, the areas to be covered under the loan shall be limited to sections, agreed to by the GOT and consulting engineer, which shall meet the objectives of the project and provide the greatest economic returns for Sudan.

The work to be accomplished under Phases I and II within the above described area sections and the regional headquarters shall consist of: (1) conducting a limited hydrogeological study in sufficient detail to lay out a program for the siting of wells; (2) designing and drilling approximately 180 production wells at 90 water yard locations; (3) providing technical assistance to the GOS in the establishment and management of the newly formed Rural Water and Development Corporation; (4) providing on-the-job and classroom training for Sudanese drilling crews; (5) procuring drill rigs and supporting equipment needed to carry out the drilling of wells for this program and future water development requirements; and (6) procuring pumps, tanks, pipes, fencing, etc. needed to equip and construct 90 water yards.

Studies: Groundwater studies of local problems have been carried out since 1905. However, most of the groundwater data concerning the Sudan appeared in short unpublished reports by members of the Sudan Geological Survey. It was not until the 1930's that the first reports describing occurrence of groundwater in Western Sudan were published by Grabham (1934). Since then many published and unpublished reports were written. However, one of the first published reports on a proposed program of groundwater studies was prepared by H.A. Waite (USGS) in 1955. Most of the recommendations of this report have been carried out and published by the Sudan Geological Survey in July 1964 entitled "Groundwater Geology of Kordofan Province" (Bulletin #14). This report includes a compilation of data on selected drilled and dug wells in the province of Kordofan.

The firm of Henningson, Durham and Richardson of Omaha, Nebraska, were employed by AID/W to conduct an evaluation of the water development program in the Sudan as a basis of a loan application. This report was submitted in May, 1966, and has been, to some extent, used as the basis of this loan paper, supplemented by a physical investigation of the condition of the drilling equipment establishment of the operating corporation, availability of personnel, etc., made in November 1966 by an AID/W team.

Technical Analysis: Although the overall project covers an area of about one million square kilometers, only about six hundred thousand square kilometers can be considered as present or possible area for development. Studies on these areas were made with special consideration based upon availability of groundwater, general thirst of the area, human and animal population density, agricultural potential, geological information available, and availability of surface water supply. It has been stated in the HDR report that dams and hafirs will provide water to about 20% and shallow wells to about 25% of the area for development exclusive of the rainy season supplies. This leaves about one-third of the overall project area to be served by deep wells at water yards (See Exhibit 1). It is estimated that it will require a drilling program for about 10 years to provide water yards to serve the selected areas, provided the technical assistance, training and procurement of drilling rigs is made available under this loan to upgrade the GOT ability to develop 200 wells per year. The drilling of wells under the loan, over a two-season period, will effectively serve about one-tenth of the area to be assigned to deep wells.

Geological studies in the Sudan indicate the presence of both water-bearing and non-water bearing formations. The perennial ground water supplies are found chiefly in the hydrologic units in the Nubian and Umm Ruwaba strata of which the sandstone and conglomerate beds form the principal aquifers and has been withdrawn at about 1250 U.S. gallons per hour per well. Generally water from the Nubian aquifers is satisfactory for most uses and of better quality than that obtained from the Umm Ruwaba aquifers. Only sparse well data information is available for the water bearing properties of the basement rocks throughout the central part (North to South) of Kordofan province, Kassala province and the eastern portion of Darfur province. These areas are considered as of major concern in the present program of "Water for Thirst." Of the numerous wells in Kordofan that penetrate basement rocks, relatively few provide water in sufficient quantity for the minimum requirements of domestic and stock use. Many wells are either dry part of the year or provide so little water that they are eventually abandoned. Although the basement rocks are virtually impermeable, water occurs locally in the weathered and creviced zones. Where the weathered and creviced rocks underlie areas having low average

annual precipitation, the seasonal replenishment is not always sufficient to sustain wells yielding perennial supplies. On the other hand, in topographic lows where withdrawals have remained moderate, dug wells continue to yield amply from weathered basement rocks. In areas having comparatively high average annual rainfall, the weathered rocks yield moderate supplies of water to wells throughout the year.

Subsurface investigations for water are still in the early stages of development in the Sudan because of the vast areas which have not been significantly explored as well as the lack of sufficiently trained personnel and equipment needed to perform such investigations. However a well drilling program will yield profitable geological and hydrogeological information. Such information coupled with collecting and compiling of all available geological and hydrogeological information should be of assistance in expediting the discovery of some additional productive aquifers. Due to the absence of sufficient qualified personnel, limited equipment and the lack of a coordinated program, it is imperative that the new corporation set-up and maintain a system of adequate and complete records properly cross referenced and categorized. These records should not be limited to only hydrogeological information but should also contain data relative to drilling, equipment, costs, personnel, transportation difficulties and other related items. Because of the sparsity of subsurface information, the available geological and hydrogeological maps can serve only as a general guide in exploration and drilling for new or additional ground water supplies.

The mean annual rainfall ranges from less than four inches in the north to more than 31 inches in the south. Rain generally falls in high intensity storms of short duration between July and September in the north and between April and October in the south. The mean annual air temperature is 80 degrees F with temperature extremes of 50 degrees F to 115 degrees F common to most areas. The mean relative humidity ranges from a low of about 21 per cent in the dry season to an average of 75 per cent during the rainy season. The prevailing winds in the winter are from the north while during the rainy season they are from the southwest.

The Sudanese Government lacks the managerial, administrative and technical personnel necessary to launch and carry out a water development program of any large magnitude. All technical and administrative resources of the GOS are utilized in carrying out their responsibilities in connection with the present program of water exploration and development. The GOS lacks qualified drillers, mechanics and supervisory personnel as well as an adequate number of hydrogeologists to make full use of all available equipment plus the equipment being procured under the Swedish loan. In spite of these handicaps, it is better that the GOS continue with their drilling program (about 60 wells per year) to help

alleviate some of the pressing demands for water until a training program for management, operation and up-to-date drilling methods can be carried out, at which time the personnel would be capable of using lighter mobile rotary equipment to produce efficient production wells.

The programming for the execution of the deep well drilling operations has been hampered by lack of timely decisions, limited budgets and technical know-how, in carrying out an efficient program. Much time is lost in moving, rigging up, maintenance and repair and other down-time activities, such as limiting rotary drilling to the two eight-hour shifts and the percussion drilling to one twelve-hour shift. Transport of the materials, drilling equipment and supplies from the working bases to the drilling sites and from site to site constitutes a loss of up to 65 per cent of the working season. Managerial and technical assistance to the GOS is considered of prime importance to the proper scheduling as well as to reducing the overall time and cost in carrying out a drilling program.

The headquarters personnel in Khartoum determine the location of the well sites including the drilling depths of the wells and the determination of the aquifers. The drillers follow the headquarters' pre-determined instructions in drilling the wells because of their lack of know-how in design. These instructions do not always conform to actual field conditions; hence, some slotted pipe screens are not installed in the well to obtain the maximum advantage of the aquifers. The development of the wells consist of cleaning them out by pumping for 72 hours using a 1200 gph piston type pump. Although the wells can produce a quantity of water to the limit of the pump, such wells are not properly designed, developed or tested to determine the capacity of the well. It is a rare occasion if a hydrogeologist visits the drilling operations and the regional supervisory personnel only visit each drill unit about once a season due to lack of adequate transportation and communication facilities. Hence, it is necessary to provide training in the proper design and latest methods of drilling and developing wells and to provide training for the supervision and maintenance of such wells.

Attached as Exhibit 2 is a complete list of all the presently available rigs being assigned to the Corporation to carry out the GOS drilling program. Although the equipment is operable and maintained in fair to good condition, the drilling program is delayed due to the late delivery of replacement parts. In most instances the parts are received at the close of the rainy season instead of at the beginning thus causing delays in the program operation. The Ballerini rotary rigs, although good drilling rigs, are too cumbersome to rig up and down and to transport from site to site. The percussion rigs, the majority of which are twenty years old, are about one-third as effective as the rotary rigs. The Swedish loan has provided for the procurement of three new rotary

drill rigs and the necessary support equipment (trucks, etc.) needed to support the additional three rigs. Additional support equipment is also being procured to provide for the replacement of the worn out transport equipment. It is intended that the A.I.D. proposed loan will provide for the procurement of six additional light mobile rotary rigs plus the supporting equipment to permit a U.S. contractor to drill wells for the two seasons and then relinquish custody of the equipment to the Corporation to continue the program.

In purchasing these additional rigs from the U.S., the difficult transport problem must be borne in mind so that the design and selection can be geared to an overall speed-up in transporting from site to site as well as being capable of drilling to depths (300' to 1250') that will be normally encountered. The same consideration must be employed in the procurement of all the support equipment to achieve the maximum mobility and communication in carrying out the drilling program.

The Corporation states that they have six qualified Sudanese drillers, 23 assistant drillers and about 40 head rigmen who direct and operate four rotary rigs and twelve percussion rigs which are under their jurisdiction. During the 66-67 season, they are assigning 12 of the assistant percussion drillers to the rotary rigs for training in rotary drilling so they will have some competence to operate the three rotary rigs being procured under the Swedish loan. The above personnel have operated the rotary rigs on a two eight-hour shift basis and the percussion rigs on one twelve hour shift basis. To obtain efficiency from their drilling equipment and the resultant wells, it is necessary to establish a well drilling training program to update the knowledge of their present crews and to provide an adequate number of drilling personnel to obtain the maximum efficiency from their existing equipment as well as providing qualified drilling crews to operate any newly acquired equipment.

The Corporation states that they presently have two hydrogeologists assigned to them and anticipate the transfer of two additional hydrogeologist and two geologists from the Geological Survey Department. One hydrogeologist is studying in the U.S. and should be assigned in March 1967 to the Corporation. Although these geologists will be adequate to meet the present program needs, the Corporation must provide now for additional geologists for the future expanded water development program.

The Corporation will undertake all the duties of the Land Use and Rural Water Department which are related to the development of rural water and its affect on land, cattle and humans. The personnel presently assigned to LURWD will be assigned to the new Corporation to carry out the water related assignments. An on-the-job training program in land use, range management and social problems should be fostered in conjunction with the water development program in order to reap the maximum economic benefits.

The present LURWD has been erecting water yards at producing well sites. After the wells are proven, the yards are programmed for erection the following year. Each yard consists of two interconnected producing wells about 1000 feet apart. Each well is enclosed in a 50 meter by 50 meter fenced compound. One compound contains three houses for the guard, clerk and pump attendant while the other contains the 10,000 gallon water tank animal troughs, dispensing taps for humans and the guard house. The water yards are located where the greatest need is determined based upon such factors as availability of ground water, animal and human population, land use, etc. At present a water yard services an area of about 400 square kilometers. The present program will reduce this area to 200 square kilometers. Meters are installed at these yards and water is sold in the provinces of Kardofan and Khartoum and the northern parts of Darfur and Kassala. Water at present is free in the Blue Nile Province and southern parts of Darfur and Kassala. The present water rates are 2 millimes per 4 gallons for humans, 8 millimes per camel, 4 millimes per cattle and 2 millimes per sheep or goat.

The estimates of costs for U.S. Management Services, U.S. Engineering Services and the services of a U.S. construction firm to procure commodities, drill wells and erect water yards is found in Annex D.

Proposed Implementation of the Project: This project is needed to intensify the development of ground water sources in the Central Belt (Savannah and Steppe) of the Sudan to increase the availability of water to the rural population in sufficient quantity to approach the minimum WHO world standard of four gallons per capita as a goal. The availability of water sources is also needed to assist the GOS in settling the nomadic tribes on economically permanent agricultural or cattle raising farms and to provide them with educational and health facilities in the rural areas. There is danger that an accelerated rural water development program of large magnitude unrelated to land capabilities and proper method of land utilization could adversely affect natural resources by overstocking of grasslands and overcropping of arable land with resultant erosion, soil depletion and sand movement. Sound planning must be employed to assure that short-term expediency is not permitted to take precedence over long-term development needs.

In order to carry out sound planning for the objectives of the project, the loan funds should be made available to the GOS to employ the following U.S. services:

Phase I

1. Provide financing for a Management Consulting firm to advise in the establishment of the organizational structure of the Rural Water Development Corporation. This firm will advise on the management, fiscal, personnel, budgeting, program planning, warehousing, mechanical shops and other procedural matters. This firm shall also possess competence in developing a long range program in hydrogeology and geophysics, all of which is related to water resources development. Competence will also be required to assist the Corporation in the supporting fields of activity such as land use, soils studies, range management and sociology to the extent that it is required to carry out the long range water development program. In addition, long range training programs should be established.

2. Provide financing for a Consulting Engineering firm to make a limited hydrogeological investigation in conjunction with the fields of activity covering land use, soils, range management, and social problems to locate the most economical water points to be developed. Prepare a drilling program and specifications for the design of the wells and water yards. Also prepare the bid documents for the drilling construction contract and assist the Corporation in the analysis and award of the drilling contract. Performance specifications for the procurement of drilling rigs and supporting equipment will be included as a part of the drilling contract. In addition the Engineering firm shall also procure electric logging, geophysical and laboratory equipment and possibly the services of aerial photo interpreters or other necessary consulting services. A driller training program should be established shortly after the arrival of the Engineering firm. Basic facilities are available for the training of 30 to 50 trainees at the Wad El Magboul training center near Khartoum North.

Phase II

After bids are received under Phase I, A.I.D. would consider a separate loan to assist in financing (1) the engineering supervision of the drilling contractor and installation of pumps and water yards; (2) the procurement of drilling rigs and supporting equipment, and for the drilling and development of the wells and construction of water yards, over a two-year period. The drilling contractor shall also be required to train Sudanese in the proper operation and maintenance of all equipment and the latest methods in drilling and developing wells.

Exhibit 1

SUDAN RURAL WATER DEVELOPMENT PROJECT

Project Area	about	1,000,000	Sq. Km.
Estimated Non-Productive Area (Fig 1-HDR)	about	-400,000	" "
Estimated Development Area (Fig 1-HDR)		600,000	" "
Development Area to be Supplied by Shallow Wells (25%)		-150,000	" "
Development Area to be Supplied by Hafirs & Dams (20%)		-120,000	" "
Development Area to be Supplied by Deep Wells		330,000	" "

Presently One Water Yard Services 400 Square Km.
Ultimately One Water Yard to Service 100 Square Km.
Present Recommendation - One Water Yard to Service
200 Square Km.

Hence Number of Water Yards Required (330,000÷200)	1,650	Yards
Hence Total Number of Wells (2 per yard) required	3,300	Wells
Number Drilled Through 1965	-1,080	"
Number Wells Drilled by GOS (1965-1966)	-60	"
Estimated Number Being Drilled by GOS (1966-1967)	-60	"
Remaining Wells to be Drilled	2,100	

Estimated Number Wells to be Drilled by GOS during
1967/1968 - 1968/1969 and 1969/1970 seasons Using
Additional 3 Rigs From Swedish Loan (105 per Year)

-315

Estimated Number Wells to be Drilled by an American
Contractor During 1968/1969 and 1969/1970 seasons
using 6 Rotary Rigs (Drilling 15 Bores per Rig per Year
of 240 days)

-180

Remaining Wells for Continuation of Program

1,605

Extended Program by GOS

After training in U.S. methods, the GOS can continue the program at the rate of 199 wells per year by using 9 rotary rigs (6 U.S. and 3 Swedish) each producing 15 wells per rig. The 4 Ballerini rigs can produce 10 wells per rig and percussion rigs can produce 3 wells per rig. The two Mayhew rotary rigs can be used for exploration and 4 of the percussion rigs can be used for rectification of existing wells.

Exhibit 2

EXISTING GOS DRILL RIGS

<u>Rig No.</u>	<u>Type</u>	<u>Present Location</u>	<u>Programmed for</u>	<u>Condition</u>	<u>Remarks</u>
1	Rotary Ballerini No. 2	El Obeid	Kordofan	Very good	The Ballerini Drilling Rigs are too cumbersome to move from one location to the other due to need for transportation of supporting mud tanks, platforms, water tanks, rotary table, drilling pipe, etc. It requires approximately five trucks exclusive of supply requirements. These Rigs procured in 1961 (New)
2	Rotary Ballerini No. 3	Wad El Magbool	Kassala	Very good except for cables & hoses	
3	Rotary Ballerini No. 4	El Fasher	Darfur	Very good except for cables, two tires, lubrication and cleanup	
4	Percussion Woodfield	Khartoum	Darfur	Good - Tire treads torn	This Rig procured in 1958 (New)
5	Percussion Woodfield	El Obeid	Darfur	Good	The engine for the draw works being overhauled
6.	Percussion Woodfield	El Fasher	Khartoum for overhaul	Needs new draw works engine & possibly new truck. Also new cables	The truck for this Rig has received harsh treatment. It is understood that the truck engine is capable of making the trip to Khartoum
7	Rotary Mayhew	El Obeid	Darfur	Good except for engine	This Rig has been broken down for the past six months because of broken engine block. Presently being overhauled
8	Percussion Rustin Bucyrus 22/W	El Obeid	Kordofan	Fair-installing new draw works engine	Needs cleaning & replacement of cables
9	Percussion Rustin Bucyrus	El Obeid	Kordofan	Fair-installing new draw works engine	Truck engine fair - needs replacement of cables - cleaning and greasing

EXISTING GOS DRILL RIGS (cont'd)

10	Percussion Rustin Bucyrus	El Fasher	Darfur	Good - two tires need replacement, also cables	Installed new draw works engine. Believe truck engine should be replaced
11	Percussion Rustin Bucyrus	El Fasher	Darfur	Down for repair	Installed new draw works engine. Truck motor was removed - except new motor in two weeks
12	Percussion Rustin Bucyrus	El Obeid	Kordofan	Fair - truck good - needs new cables	To be used for rectification and cleaning boreholes
13	Percussion Rustin Bucyrus	El Dindir	Local Government	Fair but poorly maintained	Needs new belt-battery-shock absorbers-new cables. Shocks rusted. Appearance of truck poor.
14	Percussion Rustin #RB 13559	Khartoum	Khartoum	Good - tire treads torn. Cables need replacement	Procured in 1946 from British Army surplus. Fordson Motor replaced by International on draw works
15	Percussion Rustin #10345	Khartoum	Khartoum	Good - appearance of truck poor	Procured in 1946 from British Army surplus. Draw works engine replaced by new Rustin engine
16	Percussion Rustin Unnumbered	Khartoum	Khartoum	Fair-appearance of truck poor. Truck & draw works motors near end of life	Procured in 1946 from British Army surplus. Although Rig frame are good - This should be retired after one year
17	Combination Ballerini	GSD Khartoum	Blue Nile	Very good	Same comment as above Ballerini Rigs. This Rig was still under the jurisdiction of the Geological Survey
18	Rotary Mayhew	GSD (not inspected)	Kordofan	Understood it is in good condition	This Rig was still under jurisdiction of the Geological Survey

PROJECT COST SUMMARY

	<u>U.S.</u>	<u>Local</u>	<u>Total</u>
<u>PHASE I</u>			
Rural Water Management Consultant	\$ 725,000	\$ 80,000	\$ 805,000
Engineer	475,000	61,360	536,360
Total Phase I	<u>\$1,200,000</u>	<u>\$ 141,360</u>	<u>\$1,341,360</u>
<u>PHASE II</u>			
Engineer	\$ 375,000	\$ 61,360	\$ 436,360
Drilling Contractor	4,750,000	1,361,680	6,111,680
Total Phase II	<u>\$5,125,000</u>	<u>\$1,423,040</u>	<u>\$6,548,040</u>
GRAND TOTALS	<u><u>\$6,325,000</u></u>	<u><u>\$1,564,400</u></u>	<u><u>\$7,889,400</u></u>

ESTIMATE OF COST

RURAL WATER MANAGEMENT CONSULTANT

1 Project Manager (Management).....	@ \$2,400/mo. x 24	\$ 57,600
1 Fiscal & Budget Accountant.....	@ \$1,600/mo. x 24	38,400
1 Operations Engineer.....	@ \$1,500/mo. x 18	27,000
1 Stores Officer.....	@ \$1,300/mo. x 12	15,600
1 Hydrogeologist-Geophysicist.....	@ \$1,500/mo. x 18	27,000
1 Land-Use Expert (Agri. Economist).....	@ \$1,800/mo. x 24	43,200
1 Sociologist.....	@ \$1,500/mo. x 24	36,000
1 Civil Engineer (Water Development & Soils).....	@ \$1,300/mo. x 18	23,400
Differential - 25% x \$268,200.....		67,050
Short-term Consultants - 20 days @ \$150/day.....		3,000
Travel: 8 men x 2 - one way @ \$600.....		9,600
16 dependents x 2 - one way @ \$600.....		18,800
3 consultants - round trip @ \$980.....		2,940
4 principal - round trips @ \$980.....		3,920
Per Diem - 150 days @ \$6.....		900
- 50 days @ \$23.....		1,150
Air Freight - 24 x 100 x 2 x \$4.....		19,200
Household Furnishings - 8 x \$3,000.....		24,000*
Housing Allowance - 8 x \$3,000 x 2.....		48,000*
Payroll Taxes - 20% x \$268,200.....		53,640
Miscellaneous (Telephone, Cables, Visas, Etc.).....		8,400
Overhead - 60% x \$268,200.....		160,920
Profit - \$250/MM x 162.....		40,500
Equipment - 4 Jeeps @ \$3,500.....		14,000
Operation & Maintenance Costs - 4 x \$1,000 x 2.....		8,000*
		<u>\$752,220</u>

Dollar Costs.....	\$672,220	
Contingencies (8%).....	52,780	
	<u>\$725,000</u>	(90%)
Local Costs (GOS).....	80,000	(10%)
TOTAL.....	<u>\$805,000</u>	(100%)

* Local Currency Items

ESTIMATE OF COST

ENGINEERING CONSULTANT

1 Project Drilling Engineer Manager.....@ \$1,500/mo. x 34	\$ 60,000
1 Office Manager.....@ \$ 900/mo. x 34	30,600
2 Hydrogeologists-Geophysicists.....@ \$1,200/mo. x 24	57,600
1 Driller Supervisor (Training).....@ \$1,100/mo. x 26	28,600
3 Drilling Engineers.....@ \$1,000/mo. x 20	60,000
1 Airplane Pilot.....@ \$1,350/mo. x 24	32,400
Differential - 25% x \$269,200.....	67,300
Consultants 2 x 7 x \$150/day.....	32,400
Travel: 9 men x 2 one ways @ \$600.....	10,800
18 dependents x 2 one ways @ \$600.....	21,600
2 consultants @ \$980 round trip.....	1,960
2 principal - round trips @ \$980.....	1,960
Per Diem - 160 days @ \$6.....	960
- 30 days @ \$23.....	690
Air Freight - 27 x 100 x 2 x \$4.....	21,600
Household Furnishings - 9 @ \$3,000.....	27,000*
Housing Allowance - 9 @ \$3,000 x 2.....	54,000*
Payroll Taxes - 20% x \$269,200.....	53,840
Miscellaneous (Telephone, Cables, Visas, Etc.).....	10,800
Home Office Backstopping.....	20,000
Home Office Overhead - 80% x \$20,000.....	16,000
Overhead (Field) - 60% x \$269,200.....	161,520
Profit - 226 man months x \$250.....	56,500
Commodities - Airplane (Cessna 185).....	25,000
Equipment (Electric logging, testing, geophysical).....	16,000
8 Jeeps @ \$3,500.....	28,000
2 Field Port-O-Camps @ \$8,000.....	16,000
Operation & Maintenance Costs - Airplane, 180,000 miles @ \$.10/mile.....	18,000*
Jeeps, 8 x \$1,000 x 2.....	16,000*
Field Office Expenses, Rent, Etc.....	7,720*
	<u>\$924,550</u>

Dollar Costs	
(Freight to Sudan included).....	\$801,830
Contingencies (6%).....	48,170
	<u>\$850,000 (87%)</u>
Local Costs (GOS).....	122,720 (13%)
TOTAL.....	<u>\$972,720 (100%)</u>

* Local Currency Items

ESTIMATE OF COST

DRILLING CONTRACTOR

1 Project Manager.....	@ \$1,800/mo. x 24	\$ 43,200
12 Drillers.....	@ \$1,250/mo. x 20	260,000
1 Office Manager.....	@ \$1,000/mo. x 24	24,000
2 Tool Pushers.....	@ \$1,200/mo. x 20	48,000
1 Warehouseman.....	@ \$1,100/mo. x 22	24,200
1 Airplane Pilot.....	@ \$1,350/mo. x 20	27,000
Differential - 25% x \$446,400.....		111,600
Travel: 18 men x 2 one way @ \$600.....		21,600
18 dependents x 2 one way @ \$600.....		21,600
2 principal - round trips @ \$980.....		1,960
Per Diem - 200 days @ \$6.....		1,200
- 20 days @ \$23.....		460
Air Freight - 36 x 100 x 2 x \$4.....		28,800
Household Furnishings, 9 @ \$3,000 (Assume Half).....		27,000*
Housing Allowance, 18 @ \$3,000 x 2.....		108,000*
Payroll Taxes - 20% x \$446,400.....		89,280
Miscellaneous (Telephone, Cables, Visas, Etc.).....		10,000
Overhead - 30% x \$446,400.....		133,920
Profit - 25% x \$446,400.....		111,600
 <u>EQUIPMENT</u> (+ = specifications as indicated HDR Report)		
1 Airplane (Cessna 185).....		25,000
+ 6 Drilling Units (Truck-Mud Pumps-Drill Strings) @ \$85,000....		510,000
+ 6 Water Tanks (1000 gal.), on truck @ \$25,000.....		150,000
+ 12 Trucks 646 (Flat Bed) @ \$12,000.....		144,000
18 Pickups-Passenger Carriers, 4-wheel Drive @.....		52,500
+ 6 Additional Support Equipment @ \$17,000.....		102,000
24 Port-O-Camp Trailers @ \$8,000.....		192,000
+ Radio Equipment.....		185,000
6 Generators, 25 kw, @ \$4,000.....		24,000
 <u>COMMODITIES</u>		
Bits & Bentonite 5250' x 2 x 6 x \$1.00/ft.....		63,000
Casing 6-5/8" & Slotted Pipe 5250' x 2 x 6 x \$3.00/ft.....		189,000
 <u>OPERATION & MAINTENANCE</u>		
Diesel, (6 Rigs & Trucks x 72,000 gal. @ \$.23.....		99,360*
Gasoline, (Pickups, Generators, Etc.) 80,000 gal. @ \$.51.....		40,800*
Oil & Grease, 6 Rig Units @ \$1,000.....		6,000*
Cost for Airplane 180,000 @ \$.10/mi.....		18,000*
Spare Parts.....		10,000

ESTIMATE OF COST - DRILLING CONTRACTOR (Continued)

LOCAL LABOR FOR 6 RIG UNITS

36 Driller Assistants.....@ \$1,600/yr x 2	\$ 115,200*
6 Mechanics.....@ \$1,200/yr x 2	14,400*
36 Cooks & Servants.....@ \$ 600/yr x 2	43,200*
30 Drivers.....@ \$ 800/yr x 2	48,000*
60 Helpers.....@ \$ 520/yr x 2	62,400*

WATERYARD ERECTION (90 YARDS)

3 Construction Foremen.....@ \$1,200/mo. x 20	78,000
Differential - 25% x \$78,000.....	19,500
Travel: 3 x 2 one ways @ \$600.....	3,600
Per Diem - 20 days @ \$6.....	120
Air Freight - 3 x 100 x 2 x \$4.....	2,400
Housing Allowance - 3 x \$3,000 x 2.....	18,000*
Payroll Taxes - 20% x \$78,000.....	15,600
Miscellaneous (Visas, Health, Etc.).....	600
Overhead - 30% x \$78,000.....	23,400
Profit - 25% x \$78,000.....	19,500

LOCAL LABOR

3 Assistant Foremen.....@ \$1,600	4,800*
27 Artesians.....@ \$1,200	32,400*
54 Assistant Artesians.....@ \$ 800	43,200*
54 Unskilled Laborers.....@ \$ 520	28,080*

EQUIPMENT

3 Pickups @ \$3,500.....	10,500
6 Dump Trucks, 5-ton @ \$7,000.....	42,000
3 Flatbed Trucks, 12-ton @ \$12,000.....	36,000
3 Water Tank Trucks, 500-gal. @ \$6,000.....	18,000
3 Concrete Block-making Machines @ \$3,000.....	9,000
3 Well Service & Pump Unit.....	17,500
180 Pumps & Engines @ \$3,100.....	558,000
180 Riser Pipes, Pump Rods, Cylinders @ \$1,500.....	270,000
90 Water Tanks, Meters, Derricks, Troughs, Etc. @ \$5,100.....	459,000
90 Buildings, Tank Supports, Etc. @ \$3,500.....	315,000
90 Miscellaneous Local Materials @ \$7,000.....	630,000*

MAINTENANCE & OPERATIONS ABOVE EQUIPMENT

Gasoline - 40,000 gal. @ \$.51.....	20,400*
Oil & Grease.....	600*
Diesel Fuel - 8,000 gal. @ \$.23.....	1,840*
Spare Parts.....	3,600

\$5,887,920

Dollar Costs

(Freight to Sudan included) \$4,526,240

Contingencies (5%) 223,760

\$4,750,000 (78%)

Local Costs (GOS) 1,361,680 (22%)

TOTAL \$6,111,680 (100%)

*Local Currency Items

CHECK LIST OF STATUTORY CRITERIA

(Development Loan Fund)

1. FAA §.102. Precautions that have been or are being taken to assure that loan proceeds are not diverted to short-term emergency purposes (such as budgetary, balance of payments, or military purposes) or any other purpose not essential to the country's long-range economic development. Will be covered in loan agreement by limiting use of loan funds to this project.
2. FAA §.102. Information on measures taken to utilize U.S. Government excess personal property in lieu of procurement of new items. Loan agreement will require purchase of U.S. excess property to extend suitable items available.
3. FAA §.102. Information whether the country permits or fails to take adequate measures to prevent the damage or destruction by mob action of U.S. property. No such situation is known to exist.
4. FAA §.201(b). Manner in which loan will promote country's economic development, emphasizing help for long-range plans and programs designed to develop economic resources and increase productive capacities. Sections I-F and II-B.
5. FAA §.201(b)(1). Information and conclusion on availability of financing from other free-world sources, including private sources within the United States. Sections I-C and II-D
6. FAA §.201(b)(2). Information and conclusion on activity's economic and technical soundness, including the capacity of the recipient country to repay the loan at a reasonable rate of interest. Sections II-B, II-C and II-E.
7. FAA §.201(b)(3). Information and conclusion on existence of reasonable promise activity will contribute to development of economic resources or increase of productive capacities. Section II-B.
8. FAA §.201(b)(4). Information and conclusion on activity's relationship to other development activities, and its contribution to realizable long-range objectives. Sections I-D and I-F.

The following abbreviations are used:

FAA - Foreign Assistance Act of 1961, as amended by the Foreign Assistance Act of 1966.

App. - Foreign Assistance and Related Agencies Appropriations Act, 1967.

9. FAA §.201(b)(5). Country's self-help measures, including institution of Foreign Assistance Act investment guaranty programs. Sections I-F and II-D. An investment guaranty agreement with the Sudan has been executed.
10. FAA §.201(b)(6). Information and conclusion on possible effects on U.S. economy, with special reference to areas of substantial labor surplus. Section II-E
11. FAA §.201(b)(7). Information and conclusion on the degree to which the country is making progress toward respect for the rule of law, freedom of expression and of the press, and recognition of the importance of individual freedom, initiative, and private enterprise. 1/
12. FAA §.201(b)(8). Information and conclusion on the degree to which the country is taking steps to improve its climate for private investment. 1/
13. FAA §.201(b)(9). Information and conclusion on whether or not the activity to be financed will contribute to the achievement of self-sustaining growth. Sections II-B and II-C.
14. FAA §.201(b). Information and conclusion on reasonable prospects of repayment. Section II-E.
15. FAA §.201(b). Information on applicability of the ten country ceiling. Section I-D. Sudan has been included in Presidential Determination 67-14 (Jan. 5, 1967)
16. FAA §.201(d). Information and conclusion on legality (under laws of the country and the U.S.) and reasonableness of lending and relending terms. Terms softest available under AID financing.
17. FAA §.201(e). Information and conclusion on availability of an application together with sufficient information and assurances to indicate reasonably that funds will be used in an economically and technically sound manner. Sections I-A, II-B and II-C.
18. FAA §.201(f). If a project, information and conclusion whether it will promote the economic development of the requesting country, taking into account the country's human and material resource requirements and the relationship between the ultimate objectives of the project and the country's overall economic development. Sections I-D, I-F, II-B.
19. FAA §.201(f). If a project, information and conclusion whether it specifically provides for appropriate participation by private enterprise. Section II-E.
20. FAA §.202(a). Total amount of money under loan which is going directly to private enterprise, is going to intermediate credit institutions or other borrowers for use by private enterprise, is being used to finance imports

from private sources, or is otherwise being used to finance procurements from private sources. Section II-E.

21. FAA §.281. Extent to which the loan will contribute to the objective of assuring maximum participation in the task of economic development on the part of the people of the developing countries, through the encouragement of democratic private and local governmental institutions. Section II-B
22. FAA §.601(a). Information and conclusions whether loan will encourage efforts of the country to: (a) increase the flow of international trade; (b) foster private initiative and competition; (c) encourage development and use of cooperatives, credit unions, and savings and loan associations; (d) discourage monopolistic practices; (e) improve technical efficiency of industry, agriculture, and commerce; (f) strengthen free labor unions. (a), (b) and (c): Sections II-B, II-C and II-D.
23. FAA §.601(b). Information and conclusion on how the loan will encourage U.S. private trade and investment abroad, and how it will encourage private U.S. participation in foreign assistance programs (including use of private trade channels and the services of U.S. private enterprise). Section II-E.
24. FAA §.601(d). Conclusion and supporting information on compliance with the Congressional policy that engineering and professional services of U.S. firms and their affiliates are to be used in connection with capital projects to the maximum extent consistent with the national interest. Section II-E-2.
25. FAA §.602. Information and conclusions whether loan will permit American small business to participate equitably in the furnishing of goods and services financed by it. Section II-E-3. To be covered in Loan Agreement.
26. FAA §.604(a); App. §.108. Compliance with restriction of commodity procurement to U.S. except as otherwise determined by the President and subject to statutory reporting requirements. Section II-E-2. Will be covered in loan agreement.
27. FAA §.604(b). Compliance with bulk commodity procurement restriction to prices no higher than the market price prevailing in the U.S. at time of purchase. Not applicable.
28. FAA §.604(d). Compliance with requirement that marine insurance be purchased on commodities if the participating country discriminates, and that insurance be placed in the U.S. Will be covered in loan agreement.

29. FAA §.611(a)(1). Information and conclusion on availability of engineering, financial, and other plans necessary to carry out the assistance and of a reasonably firm estimate of the cost of the assistance to the United States. Section II-C, II-D. The purposes of this loan is to develop such plans and cost estimate.
30. FAA §.611(a)(2). Necessary legislative action required within recipient country and basis for reasonable anticipation such action will be completed in time to permit orderly accomplishment of purposes of loan. No legislative action is believed to be required.
31. FAA §.611(b); App. §.101. If water or water-related land resource construction project or program, information and conclusion on a benefit-cost computation. Section II-B.
32. FAA §.611(c). Compliance with requirement that contracts for construction be let on competitive basis to maximum extent practicable. Not applicable.
33. FAA §.612(b); §636(h). Appropriate steps that have been taken to assure that, to the maximum extent possible, the country is contributing local currencies to meet the cost of contractual and other services and foreign currencies owned by the U.S. are utilized to meet the cost of contractual and other services. Section II-D. Will be covered in loan agreement and implementing documents.
34. FAA §.619. Compliance with requirement that assistance to newly independent countries be furnished through multilateral organizations or plans to maximum extent appropriate. Section II-D.
35. FAA §.620(a); App. §.107(a); App. §.107(b). Compliance with prohibitions against assistance to Cuba and any country (a) which furnishes assistance to Cuba or failed to take appropriate steps by February 14, 1964, to prevent ships or aircraft under its registry from carrying equipment, materials, or supplies from or to Cuba; or (b) which sells, furnishes, or permits any ships under its registry from carrying items of primary strategic significance, or items of economic assistance. The Sudan is not believed to be in violation of these provisions.
36. FAA §.620(b). If assistance to the government of a country, existence of determination it is not controlled by the international Communist movement. Such a determination was made by the Secretary of State on October 11, 1961.
37. FAA §.620(c). If assistance to the government of a country, existence of indebtedness to a U.S. citizen for goods or services furnished or ordered where such citizen has exhausted available legal remedies or where the debt

is not denied or contested by such government or the indebtedness arises under an unconditional guaranty of payment given by such government. No such situation is known to exist.

38. FAA §.620(d). If assistance for any productive enterprise which will compete with U.S. enterprise, existence of agreement by the recipient country to prevent export to the U.S. of more than 20% of the enterprise's annual production during the life of the loan. Not applicable.
39. FAA §.620(e)(1). If assistance to the government of a country, extent to which it (including government agencies or subdivisions) has, after January 1, 1962, taken steps to repudiate or nullify contracts or taken any action which has the effect of nationalizing, expropriating, or otherwise seizing ownership or control of property of U.S. citizens or entities beneficially owned by them without taking appropriate steps to discharge its obligations. No such situation is known to exist.
40. FAA §.620(f); App. §.109. Compliance with prohibitions against assistance to any Communist country. Sudan is not considered to be a Communist country.
41. FAA §.620(g). Compliance with prohibition against use of assistance to compensate owners for expropriated or nationalized property. Loan agreement will limit use of funds to this project.
42. FAA §.620(h). Compliance with regulations and procedures adopted to insure against use of assistance in a manner which, contrary to the best interests of the U.S., promotes or assists the foreign aid projects or activities of the Communist-bloc countries. Will be covered in loan agreement and implementing documents.
43. FAA §.620(i). Existence of determination that the country is engaging in or preparing for aggressive military efforts. No such determination is in existence.
44. FAA §.620(i). Information on representation of the country at any international conference when that representation includes the planning of activities involving insurrection or subversion against the U.S. or countries receiving U.S. assistance. Sudan is not known to have been so represented.
45. FAA §.620(j). Indonesia restriction. Not applicable.
46. FAA §.620(k). If construction of productive enterprise where aggregate value of assistance to be furnished by U.S. will exceed \$100 million, identification of statutory authority. Not applicable

47. FAA §.620(l). Consideration which has been given to denying assistance to the government of a country which after December 31, 1966, has failed to institute the investment guaranty program for the specific risks of convertibility and expropriation or confiscation. Not applicable since an investment guaranty program was previously instituted in the Sudan.
48. FAA §.620(n); App. §.107(b); App. §.116. Compliance with prohibitions against assistance to countries which traffic or permit trafficking with North Vietnam. Sudan is not believed to be in violation of these provisions.
49. FAA §.620(o). If country has seized, or imposed any penalty or sanction against, any U.S. fishing vessel on account of its fishing activities in international waters, information on the consideration which has been given to excluding the country from assistance. No such situation is known to exist.
50. FAA §.620(p); App. §.117. U.A.R. restriction. Not applicable.
51. FAA §.620(q). Existence of default under any Foreign Assistance Act loan to the country. Sudan is not now in default under any FAA loan.
52. App. §.102. Compliance with requirement that payments in excess of \$25,000 for architectural and engineering services on any one project be reported to Congress. Such reports will be made.
53. App. §.104. Compliance with bar against funds to pay pensions, etc., for military personnel. Loan agreement will limit use of loan proceeds to this project.
54. App. §.106. If country attempts to create distinctions because of their race or religion among Americans in granting personal or commercial access or other rights otherwise available to U.S. citizens generally, application which will be made in negotiations of contrary principles as expressed by Congress. No such distinctions are known to be made.
55. App. §.111. Compliance with existing requirements for security clearance of personnel. Will be covered in loan agreement and implementing documents.
56. App. §.112. Compliance with requirement for approval of contractors and contract terms for capital projects. Will be covered in loan agreement and implementing documents.
57. App. §.114. Compliance with bar against use of funds to pay assessments, etc., of U.N. member. Loan agreement will limit use of proceeds to this project.

58. App. S.115. Compliance with regulations on employment of U.S. and local personnel for funds obligated after April 30, 1964, (Regulation 7).
Not applicable.
59. App. S.118. Vietnam iron and steel restrictions. Not applicable.
60. App. S.401. Compliance with bar against use of funds for publicity or propaganda purposes within U.S. not heretofore authorized by Congress. Loan Agreement will limit use of proceeds to this project.

1/ The Sudan is a parliamentary democracy. The change of government of July, 1966, was accomplished by majority vote in the Constituent Assembly.

The new government has recently made serious efforts to end the southern insurrection and restore the rights of southerners. The government has indicated strong desire to initiate development projects in the south for the benefit of the inhabitants.

Individual freedom is traditional in the Sudan. There are several active daily newspapers in Khartoum which appear to operate without censorship.

Private enterprise is officially encouraged under the Approved Enterprises Act, which provides incentives and concessions to approved businesses.

CAPITAL ASSISTANCE LOAN AUTHORIZATION

Provided from: Development Loan Funds
Sudan: Groundwater Development, Phase I

Pursuant to the authority vested in the Assistant Administrator for Africa of the Agency for International Development ("A.I.D.") by the Foreign Assistance Act of 1961, as amended, and the delegations of authority issued thereunder, I hereby authorize the establishment of a loan pursuant to Part I, Chapter 2, Title I, the Development Loan Fund, to the Government of the Republic of the Sudan ("Borrower") of not to exceed \$1,200,000 to assist in financing the foreign exchange costs of engineering and management consulting services for Phase I of the Groundwater Development Project subject to the following terms and conditions:

1. Interest Rate and Terms of Repayment. Borrower shall repay the loan to A.I.D. in forty (40) years, including a grace period not to exceed ten (10) years. Borrower shall pay interest on the unrepaid principal and any interest accrued thereon at the rate of (a) one percent (1%) per annum during the grace period and (b) two and one-half percent (2-1/2%) per annum thereafter.
2. Currency of Repayment. Repayment of the loan and payment of interest shall be made in United States dollars.
3. Other Terms and Conditions:
 - (a) Goods and services financed under this loan shall be of United States source and origin.
 - (b) Such other terms and conditions as A.I.D. may deem advisable.

Assistant Administrator for Africa

Date