No. 1

BASIC DESIGN STUDY REPORT
ON
THE IMMEDIATE IMPROVEMENT PROJECT
FOR
THE KHARTOUM AREA DISTRIBUTION SYSTEM
IN
THE REPUBLIC OF THE SUDAN

AUGUST 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

GRF

91--93

PREFACE

In response to a request of the Government of the Republic of the Sudan, the Government of Japan has decided to conduct a basic design study on the Immediate Improvement Project for the Khartoum Area Distribution System and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Sudan a study team headed by Mr. Akihiko Morita, Officer, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs, from April 17 to May 16, 1991.

The team held discussions with the officials concerned of the Sudan and conducted a field survey at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Sudan for their close cooperation extended to the team.

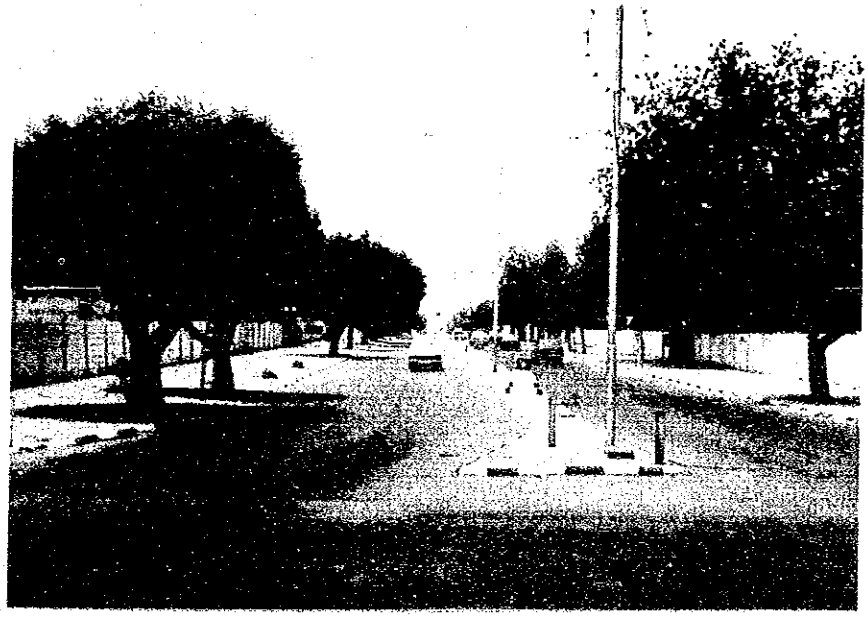
August, 1991

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

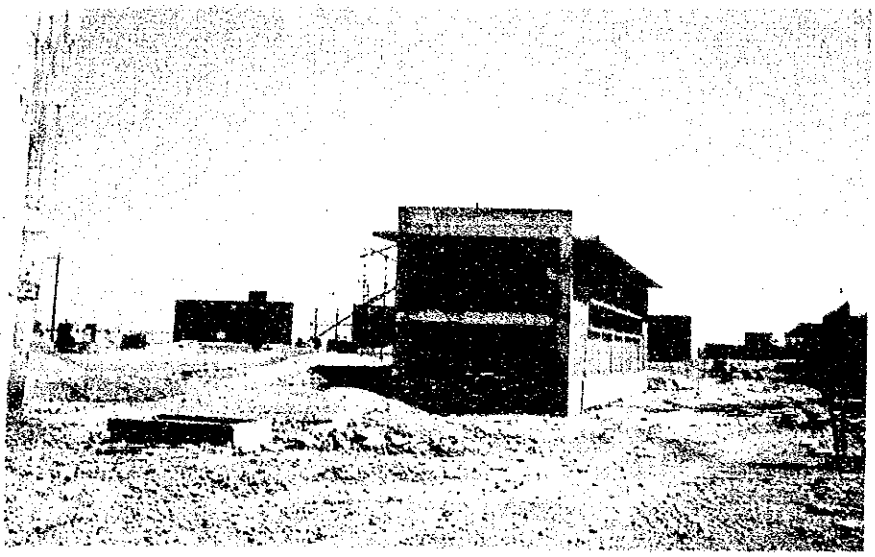
LOCATION OF THE PROJECT AREA

Scene of Road on
Pipeline Route (1)
Khartoum Area

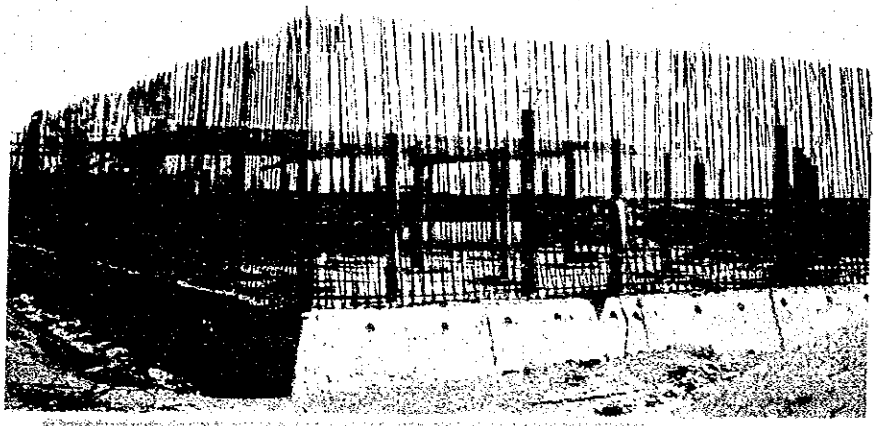


Scene of Road on
Pipeline Route (2)
Khartoum Area

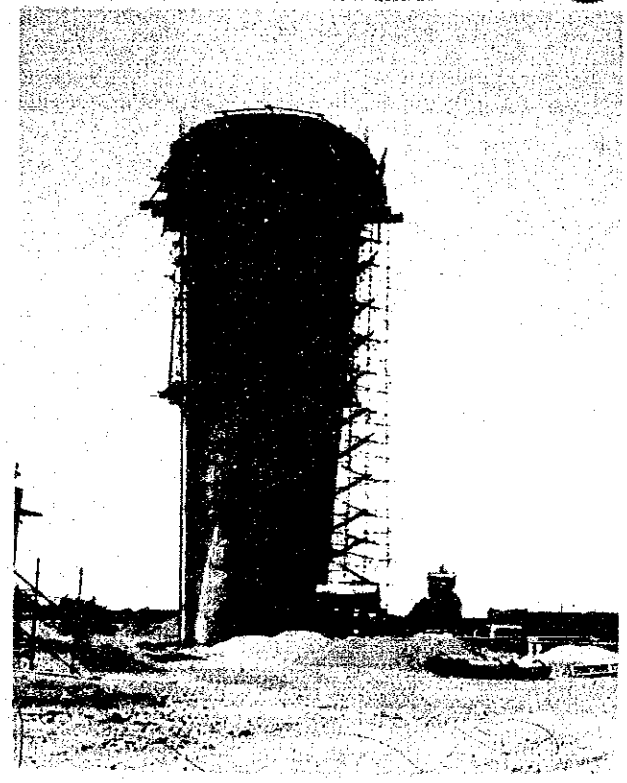
Scene of Road on
Pipeline Route (3)
Khartoum Area



Pumping Station
(Under Construction)
Khartoum South DPS



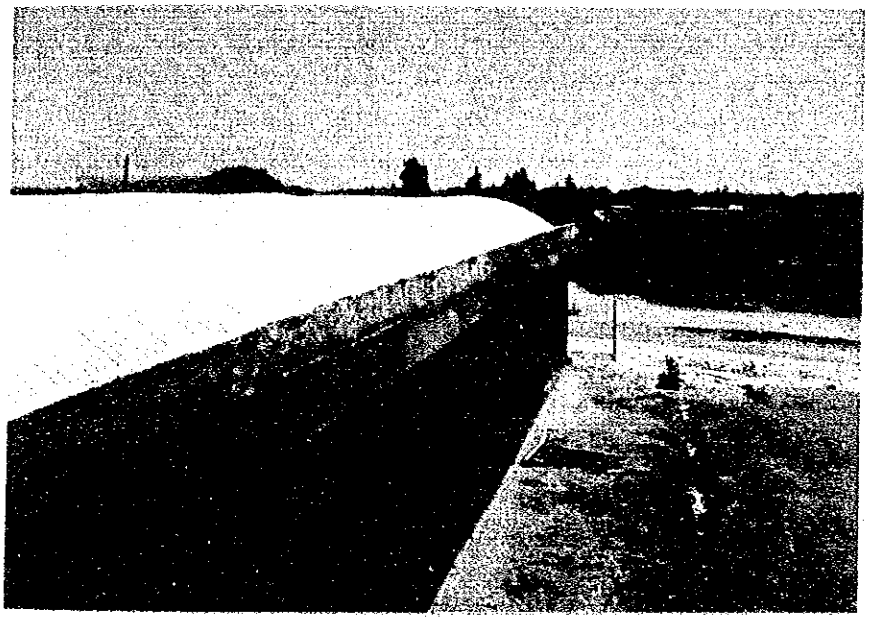
Storage Reservoir
(Under Construction)
Khartoum South DPS



Water Tower
(Under Construction)
Khartoum South DPS

NOTE : DPS : Distribution Pumping Station

Corrugated Aluminum Roof
on Storage Reservoir (1)
Mogren Water Treatment Plant



Corrugated Aluminum Roof
on Storage Reservoir (2)
Mogren Water Treatment Plant

NUWC Storage Yard
Adjacent to Khartoum South DPS

SUMMARY

The Republic of the Sudan is a typical agricultural country, bordering on the south of Egypt, and is the largest country in the African continent, holding a territory of 2,500,000 square kilometers. Of the agricultural products, cotton is outstanding, sharing beyond 50 % of total exports. The gross domestic product (GDP) has been increasing since 1984, though gradually. Along the line of "National Economy Reconstruction Program 1990 – 1993" established in 1990, the Sudanese Government is giving a top priority to development of the agricultural sector, aiming at the promotion of export of farm products and privatizing of public enterprises with heavy deficit.

The Khartoum Metropolitan Area, which consists of three areas of Khartoum, Khartoum North and Omdurman, is the center of political, economic, educational and cultural activities of the country. It is also the gate town to both domestic and foreign transportation and communication. The improved water supply facilities in the Khartoum Metropolitan Area made its start as the installation of the Burri Water Treatment Plant (WTP) in 1922. To meet the increased demand from the area, several other treatment plants, i.e., the Omdurman WTP, the Khartoum North WTP (Old), the Khartoum North WTP (New) and the Mogren WTP were established. In addition to the extensions of their facilities carried out thereafter, installation and extensions of various water distribution and supply facilities have been given one after another, and the combined total of their design capacities has reached 189,000 m^3/day.

The increase of population in the Khartoum Metropolitan Area is remarkable, reflecting a vast number of migrants such as job-seekers from rural areas and refugees from surrounding drought areas. This remarkable expansion of population is oppressing the normal functions of the urban area, and deteriorating the livelihood level of the residents, particularly in sanitary environments. The area's water demand is thus increasing rapidly and is assumed to reach 400,000 m^3/day. To make the situation worse, the deterioration in the treatment capacity due to overage facilities together with decrease in water distribution caused by obsolete transmission facilities are affecting the water shortage more vitally.

The Sudanese Government has taken various steps to improve water supply systems in the Metropolitan Area. Along the programs recommended in the "Khartoum Area Water Supply Project" prepared in 1979 under the assistance of the World Bank, construction of the Phase I and Phase II of the Khartoum North WTP (design capacity of 72,000 m^3/day) was already completed. Further, Phase III and Phase IV for the expansion of the same water treatment plant (design capacity of 108,000 m^3/day) is now under construction in continuation of the previous phases with a target year of completion in 1992. Upon completion, a part (62,400 m^3/day) of treated water will be transmitted to the Khartoum South Distribution Pumping Station (DPS) which is now under construction.

The Khartoum Area is a core of the three metropolitan areas particularly in political, economic and educational aspects. Being occupied by a number of crowded residential districts, the Khartoum Area is designated as a strategic point for improving and developing sanitary water supply systems.

As an urgent project, the construction of distribution pipeline system from the Khartoum South DPS to the Khartoum Area has been planned. Due to the shortage of funds, however, the implementation has been delayed until now. In this connection, the Government of the Republic of the Sudan has requested the Government of Japan to conduct a basic design study on the Immediate Improvement Project for the Khartoum Area Distribution System.

In response to the Sudanese Government's request, the Japanese Government decided to conduct the basic study on the Project, and the Japan International Cooperation Agency (JICA) dispatched a basic design study team from April 17 to May 16, 1991. Based on the study results, the representatives of both Governments prepared minutes of meetings describing the matters agreed upon between the two parties.

This report has been prepared after justifying the appropriateness of the program by analyses made in Japan by the members of the study team on the basis of the agreed matters with the Sudanese representatives and the field survey, and it summarizes the optimum programs in executing the current project, covering the basic design of the water supply facilities, selection of materials and equipment, and planning for operation and maintenance of the facilities.

The executing agency of the Project is National Urban Water Corporation (NUWC) under the Ministry of Energy and Mining. The NUWC is managed by six departments under Director General and staffed with about 9,500 personnel. The Project implementation will be charged by the Construction Section of the National Projects Management Department, and after the completion of the Project, jurisdiction will be taken over by the Khartoum Area Office under the National Capital Administration Department (staff members: about 950), which will maintain and administer the facilities.

The planned distribution pipeline will form a part of the networks planned along the main roads in the central and southern parts of the Khartoum Area for improving water supply conditions in these areas. A part of the planned pipeline has been revised as the site survey found a pipe network of an appropriate size formed by both old and new pipelines to be more rational than the original idea.

The ductile iron pipeline of 700 mm in diameter, 0.2 km long, is the main distribution pipeline from the Khartoum South DPS. Initially the use of ductile iron pipe for this line was not included in the Sudan's request on the ground that the work was planned to be executed with the NUWC's own budget. The site survey results reveal that, though the NUWC planned to use asbestos cement pipe for low pressure use, such materials are obviously inappropriate for the pipeline under high pressure close to the pumping station. After discussion with the NUWC, the pipe route is included in the Project.

As regards the construction machinery to be procured, the types and numbers are selected from the viewpoints of necessities in construction and maintenance of the pipeline in the area.

Corrugated aluminum is selected as the roofing materials for reservoirs, as it conforms to the Sudanese Government's standard design, and their specifications are set the same as those used for the Omdurman Area Water Supply Project, the former grant aid project offered by the Japanese Government, mainly for the sake of convenience that the same types of materials and spare parts can be used in repair works for both projects. The roofing work will be carried out with the NUWC's own budget, at the Khartoum South DPS.

Prefabricated materials will be procured for building a warehouse for storing the materials and securing space for repairing construction machines. Similarly to the case of roofing materials for reservoirs, the NUWC will make the installation works with its own budget at a neighboring site of the Khartoum South DPS.

The contents requested by the Sudanese Government and those assessed by the field survey (including revised portions) are composed as follows:

Item	Requested	Assessed
A. Distribution Pipelines (Material and Installation)		
DIP Ø 700 mm	- km	0.2 km
DIP Ø 500 mm	1.7 km	1.8 km
DIP Ø 400 mm	4.6 km	4.6 km
DIP Ø 250 mm	15.8 km	14.8 km
DIP Ø 200 mm	3.1 km	4.3 km
Total	25.2 km	25.7 km
B. Procurement of Construction Machinery and Materials		
Construction Machines and Spare Parts		
Backhoe (0.6-0.7 m^3)	1 unit	1 unit
Backhoe (0.35 m^3 with blade)	1 unit	1 unit
Pickup (double cabin)	1 unit	1 unit
Roofing Materials for Reservoirs (corrugated aluminum, with auxiliaries)	3,600 m^2	3,600 m^2
Building Materials for Warehouse (prefabricated colored steel, with installation parts and auxiliaries)	1,000 m^2	1,000 m^2
C. Detailed design and Construction Supervision	complete process	complete process

Considering the work volume of the Project under Japan's grant aid, the Project will be implemented in two phases. The contents of both phases are:

1st Phase : Distribution Pipe Works (Materials and Installation)
DIP Ø 250 mm – Ø 400 mm, 10.5 km long
Procurement of Machines and Materials
Construction Machines Backhoes : 2 units
Pickup Truck : 1 unit
Roofing Materials : 3,600 m^2
Building Materials for Warehouse : 1,000 m^2
Detailed Design and Construction Supervision

2nd Phase : Distribution Pipe Works (Materials and Installation)
DIP Ø 200 mm – Ø 700 mm, 15.2 km long
Construction Supervision

By connecting the 1st Phase pipelines (10.5 km) to existing ones, water supply will be improved to prove the effects of the 1st Phase works. The machines, as they are needed in the 1st Phase, shall be prepared in the 1st Phase. The roofing materials for the reservoirs and the building materials for the warehouse to be constructed with the NUWC's own budget will also be included in the phase as they will be required in early stages.

The whole process of the Project will consist of: (a) the 1st phase including 7-month period starting with detailed design (including survey), ending tenders for the phase construction, and 12-month period covering construction work which will include manufacturing of materials and equipment, transportation by sea and land, installation work, and final test; and (b) the 2nd phase which will include 2-month period for tenders and 12-month period for construction work.

The water shortage, the Khartoum Area is suffering, severely, will be improved by this Project, with a substantial increase in water supply in the service area. The increased water supply will improve sanitary and environmental conditions of the community. It will not only be effective to decrease epidemic diseases and fire losses, but also help make women and children released from the hard work of drawing and carrying water. In view of such contribution to improvement of the livelihood environments in the Area as a whole, the implementation of this grant aid project is sufficiently significant and justifiable.

For ensuring the full effects of the project, the NUWC in charge of maintaining and administering the completed facilities is recommended to take the following steps:

a) For operation and maintenance, piping records shall be prepared and effectively utilized.
b) Training of NUWC staff members shall be considered for sound operation of water supply facilities.
c) Allocation of necessary budgets for procurement of spare parts shall be made.
d) A Long-term Master Plan for water supply of whole metropolitan areas shall be developed reviewing the existing Water Supply Master Plan (the Khartoum Area Water Supply Project).

TABLE OF CONTENTS

ABBREVIATIONS & ACRONYMS

MOEM	:	Ministry of Energy and Mining
MFEP	:	Ministry of Finance and Economic Planning
NUWC	:	National Urban Water Corporation
JICA	:	Japan International Cooperation Agency
JWWA	:	Japan Water Works Association
IMF	:	International Monetary Fund
JIS	:	Japan Industrial Standard
BS	:	British Standard
E/N	:	Exchange of Notes
FOB	:	Free on Board
DIP	:	Ductile Iron Pipe
ACP	:	Asbestos Cement Pipe
CIP	:	Cast Iron Pipe
PVC	:	Polyvinyl Chloride
SP	:	Steel Pipe
FRP	:	Fiberglass Reinforced Plastic
WTP	:	Water Treatment Plant
DPS	:	Distribution Pumping Station
LS	:	Sudan Pound
US$	:	United States Dollars
°C	:	degrees C
Ø	:	diameter (Phi)
%	:	percent
lpcd	:	liters per capita per day
m^3/day	:	cubic meters per day
mm	:	millimeters
m	:	meters
m^2	:	square meters
m^3	:	cubic meters
km	:	kilometers
km^2	:	square kilometers

CHAPTER 1 INTRODUCTION

The Khartoum Metropolitan Area, capital of the Republic of the Sudan, is the center of political, economic, educational and cultural activities of the country, and is the gate town to domestic and foreign transportation and communication. Among the three areas (Khartoum Area, Khartoum North Area and Omdurman Area) in the Khartoum Metropolitan Area, the Khartoum Area is the town where central government offices, foreign embassies, principal bank offices, cultural institutions, hotels, etc., gather densely.

The waterworks of the Khartoum Metropolitan Area started supply of water to the area from the Burri Water Treatment Plant (WTP) in 1922 by the side of the Burri Bridge crossing the Blue Nile. To meet the increased demand of the area, new water treatment plants were introduced in Omdurman, Khartoum North (Old), Khartoum North (New) and Mogren. Extensions of these WTP's took place one after another together with the installation and improvement of water distribution and supply facilities, with their combined total design capacity elevated to 189,000 m^3/day.

The pace of increase in population resulting from the expanding number of job seekers from rural districts and recently increasing refugees from drought areas is accelerating remarkably, with the result that the functioning ability of the Area as an urban city is being oppressed. The livelihood level of the residents, particularly in sanitary aspects, is deteriorating.

Resulting from the situation mentioned above, the total water demand of the area is now estimated at around 400,000 m^3/day as against the existing capacity of the waterworks standing at about 189,000 m^3/day, with resultant chronic water deficits in the area. To make the situation worse, the deterioration in the treatment capacity due to overage facilities together with decreases in water distribution caused by obsolete transmission facilities are affecting the accounts of the waterworks adversely.

Under these circumstances, the Sudanese Government has been planning to increase water supply facilities together with the improvement of the existing facilities. In the Khartoum Area, the improvement of water supply system has been under way along the programs recommended in the "Khartoum Area Water Supply Project" prepared in 1979 under the assistance of the World Bank. The construction of the Phase I and Phase II of Khartoum North WTP (design capacity of 72,000 m^3/day) was already completed by the assistance of the Government of Czechoslovakia. Further expansion of Phase III and Phase IV of the same treatment plant (design capacity of 108,000 m^3/day) is now under construction in continuation of the previous phases with a target year of completion in 1992. The Khartoum South Distribution Pumping Station (DPS) is also planned to be constructed by October 1991 under the same assistance of the Government of Czechoslovakia.

The construction program of distribution pipeline system from Khartoum South DPS to the Khartoum Area has been planned as an urgent project. Due to the shortage of fund, however, the implementation has been delayed up until now. In this connection, the Sudanese Government has requested the Japanese Government a grant aid for the present Project, which aims at the establishment of a water supply system by installation of ductile cast iron distribution pipelines in the Khartoum Area together with related facilities and equipment.

In response to the Sudanese Government's request, the Japanese Government decided to conduct the basic design study on "the Immediate Improvement Project for the Khartoum Area Distribution System", and the Japan International Cooperation Agency dispatched a basic design study team headed by Mr. Akihiko Morita, Economic Cooperation Bureau, Ministry of Foreign Affairs, for a period of 30 days from April 17 to May 16, 1991. The team discussed with the representatives of the Sudanese Government on the details of their request and conducted site surveys and collected materials necessary for drafting the basic design. On the basis of the survey results and the matters agreed upon with the Sudanese Government representatives, the Minutes of Meetings dated April 24, 1991 were signed. Based on the agreed matters in the Minutes, the team thereafter continued surveys relating to technical matters.

This report summarizes the optimum design of the Project resulting from the analyses made by the study team members after coming back to Japan on the basis of the site survey results and the agreed matters during the meetings with the Sudanese Government representatives, and covers the basic design of the water supply facilities, selection of materials and equipment, and plans for administration of the facilities. The study team's organization, schedules, visited agencies, interviewees, minutes of meetings and the list of collected data are shown in the Appendix 1 of this report.

CHAPTER 2 BACKGROUND OF THE PROJECT

2.1 Outline of the Republic of the Sudan

2.1.1 General Features and Population

The Republic of the Sudan is located in the northern part of the African Continent, and occupies its largest area totaling 2.5 million km^2, extending about 2,250 km north to south and 1,930 km east to west. The country is bordered on Egypt in the north and on Ethiopia in the east. Khartoum, capital of the country, lies at the confluence of the Blue Nile flowing from Ethiopia and the White Nile flowing from Zaire and Central Africa. (latitude 16°N and longitude 33°E)

Geographically, the country consists mostly of plains approximately 350–500 m above the sea, with the exception of the western mountainous zone which is 3,000 m above the sea. The northern part of the country consists mainly of desert zones extending to the Nabia Desert to the east and extending to the Libya Desert to the west. The central part of the country is formed of fertile land zones centering around Khartoum. The southern part of the country consists of the Savanna zone and tropical forestry areas. The average annual precipitation in North Khartoum is 164 mm and that in South Malakal is 783 mm.

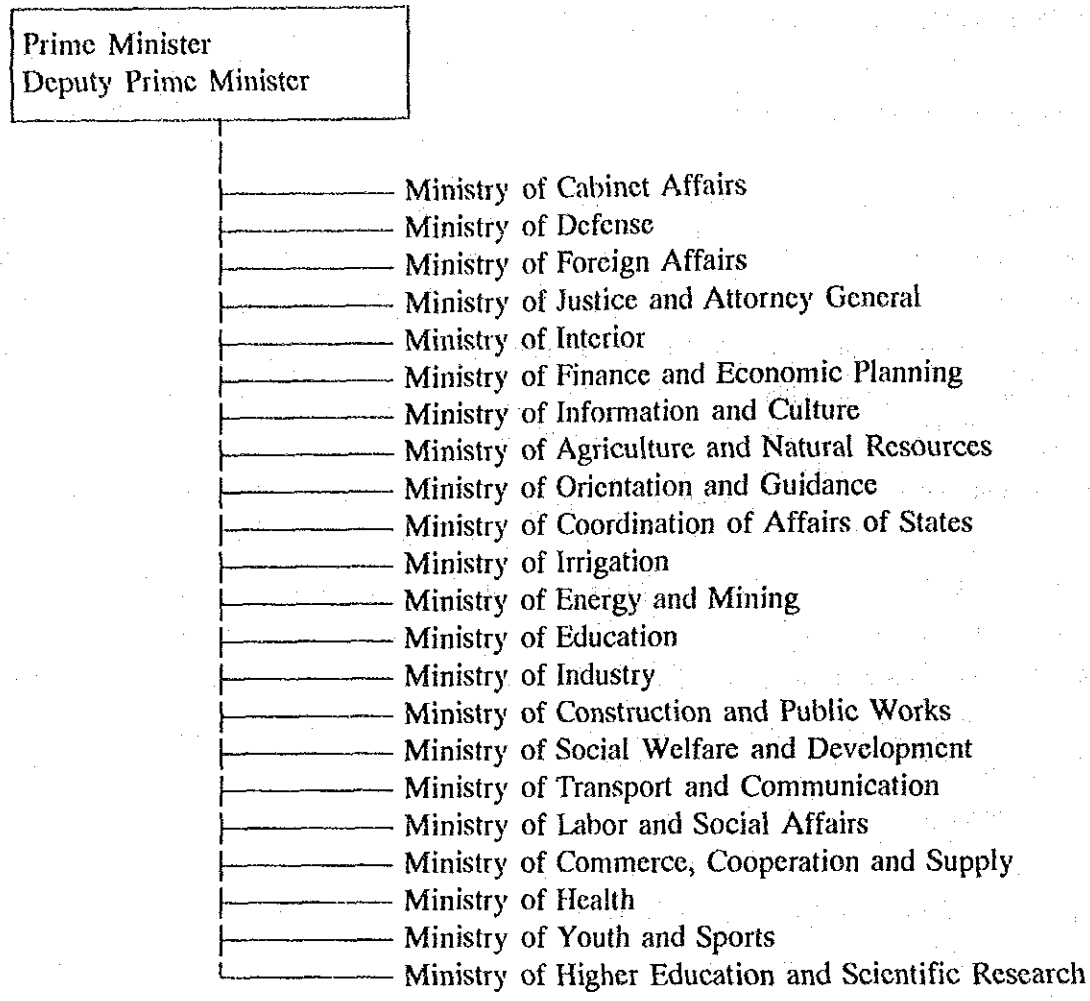
The total population of the country recorded 21.59 million in 1984 and is forecasted to reach 34 million in 2000, with an estimated average annual growth rate of 2.9 %.

2.1.2 Administrative Organization

The administrative agencies of the Sudanese Government consist of 22 ministries organized under the Office of the Prime Minister, as listed in Table 2–1.

The water supply services of the country are under the control of the Ministry of Energy and Mining. The Ministry has subordinate agencies: the National Urban Water Corporation (NUWC) and the National Rural Water Corporation (NRWC). (Refer to Section 2.3.1.)

Table 2 - 1 Organization Chart of the Government



Note: As of February, 1991.

2.1.3 National Economy and Finance

The Republic of the Sudan is a typical farming country with her products centering on cotton and gum arabic. Of the total exports in fiscal 1989/90 amounting to US$ 465 million, cotton products amounted to US$ 240 million, more than 50 % of the total as seen in Table 2-4. Labor forces classified by industry, as shown in Table 2-3, reveal that those engaged in agriculture are still rated at as high as 80 % of the total, though the rate tends to decrease as the percentages of manufacturing and service industries are gradually increasing.

Table 2-2 Gross Domestic Product

(Unit: LS million)

Sector / Fiscal	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Agriculture	1,959	2,284	2,354	2,012	2,591	2,095
Mining	4	6	6	6	6	6
Manufacturing	517	540	563	557	561	567
Electricity & Water	112	126	127	129	134	141
Construction	349	369	350	343	380	351
Government Services	695	692	651	655	738	775
Other Services	2,406	2,242	2,475	2,659	2,733	2,738
Total	6,410	6,259	6,526	6,361	7,143	6,673

Source : International Monetary Fund (IMF) Data and "Outline of the Republic of the Sudan".

Note : Values expressed at 1981/82 prices.
Figures for 1989/90 estimated.

Table 2-3 Labor Forces by Industry

(Unit: %)

Industry	1965	1981	1983	1987
Agriculture	84	78	69	63
Manufacturing	7	10	14	15
Services	9	12	17	22
Total	100	100	100	100

Source : "Present Economic and Social Conditions in the Sudan" (International Cooperation Promotion Association, Japan).
1983 figures are based on data of Department of Statistics (1983 Census).
1987 figures estimated by the Ministry of Finance and Economic Planning. (MFEP).

Table 2-4 Exports by Commodity

(Unit: US$ million)

Commodity / Fiscal	1985/86	1986/87	1987/88	1988/89	1989/90
Cotton	136.0	176.4	161.1	245.4	240.0
Peanut	8.7	5.0	26.4	25.2	16.3
Sesame	35.1	28.3	42.6	70.5	37.4
Sole Gum	0.5	31.3	53.4	33.4	10.8
Gum Arabic	27.3	100.0	59.9	49.7	55.2
Livestock	237.5	73.6	69.5	76.6	50.8
Other	54.3	67.0	73.0	47.3	54.0
Total	497.2	481.6	485.9	550.1	464.5

Source : IMF data & " Outline of the Republic of the Sudan".
1989/90 figures estimated. Values in terms of FOB.

Table 2-5 Imports by Commodity

(Unit: US$ million)

Commodity Fiscal	1985/86	1986/87	1987/88	1988/89	1989/90
Foods	190.5	135.4	165.3	232.8	141.1
Wheat, Flour	97.3	85.1	98.2	140.3	69.4
Beverage, Tobacco	4.6	4.4	7.0	12.4	8.5
Crude Oil	273.2	190.6	248.8	210.9	276.6
Chemicals	199.4	151.9	210.0	160.7	78.3
Finished Goods	163.9	145.5	247.0	282.5	140.1
Machinery, Equipment	108.1	85,6	177.0	169.0	117.4
Transport Equipment	100.1	101.6	144.0	129.8	168.8
Textile Goods	15.2	17.3	24.4	25.5	53.0
Total	1,055.2	823.3	1,223.1	1,223.5	1,053.2

Source : IMF data, and "Outline of the Republic of the Sudan".
Note : 1989/90 figures estimated. Values in terms of FOB.

Table 2-6 Balance of Payments

(Unit: US$ million)

Item Fiscal	1985/86	1986/87	1987/88	1988/89	1989/90
Exports	497	487	486	550	465
Imports	-1,055	-832	-1,223	-1,224	-984
Trade Balance	-558	-350	-737	-674	-519
Services	-634	-602	-706	-342	-823
Remittances Abroad	350	250	445	297	199
Current Transactions	-842	-702	-998	-1,219	-1,142
Capital Transactions	-65	48	138	29	-134
Short-term Capital	-145	-192	-195	-55	-39
Overall Balance	-1,052	-846	-1,054	-1,303	-1,315

Source : IMF data and "Outline of the Republic of the Sudan".
Note : 1989/90 figures estimated. Values in terms of FOB.

As seen in Table 2-5, the total imports show tendencies either of leveling off or decreasing. These tendencies are considered to be related with the chronic decreases in the total exports of Sudanese products. This relationship is clearly revealed in yearly increases in the deficit of her balance of international payments. As shown in the break-down of imported commodities for fiscal 1989/90, manufactured goods including crude oil and machinery amounted to 80 % of the total imports, with the rest 20 % of imported commodities consisting of primary products including agricultural possessed goods.

As seen in Table 2-7, the total revenue for fiscal 1990/91 shows an increase of more than 80 % over the previous year. This amount of increase, however, is considered to come from

services to be provided by public entities, and none from taxation revenue. The revenue from this kind of services rates 43 % of the total revenue. Though the total expenditures decrease by 2 %, the total budget amounts to as much as LS 700 million. The 1990/91 budget for development projects, as seen in Table 2– 8, allocates 34 % of the total expenditures to agricultural development projects, aiming at self–supply of foods, and other 26 % to transportation and communication, and services development projects. Approximately 47 % of the budget for these development projects, however, depends upon foreign aids, and the Sudan's own funds inclusive of funds from private sectors reaches only 53 %.

Table 2–7 National General Budget for Fiscal 1990/91

(Unit: LS million)

Total Revenue	15,457.8	(+ 81.2% over 89/90)
Taxation Revenue	8,750.0	(+ 32.2%)
Direct Taxes	2,500.0	(+ 52.5%)
Customs Duties	3,750.0	(+ 20.5%)
Indirect Taxes	2,500.0	(+ 33.6%)
Non–Taxation Revenues	6,707.8	(+338.1%)
Government Services, etc.	2,413.5	(+535.1%)
Public Entity Profits, etc.	4,294.3	(+273.1%)
Total Expenditure	16,163.7	(– 2.1% from 89/90)
Salaries for Public Servants	1,091.4	(– 2.2%)
Office Supplies & Services	2,005.3	(n.a.)
Land Acquisition, etc.	6,692.0	(n.a.)
National Defense	4.300.0	(n.a.)
Distribution of Local Alloc. Tax	1,910.0	(– 0.4% from 89/90)
Administration of Public Buildings	165.0	(– 0.0%)
Balance	– 705.9	(– 91.2% from 89/90)

Note : n.a.: no available previous data.
Source : IMF data & "Outline of the Republic of the Sudan".

Table 2–8 Fiscal 1990/91 Budget for Development Projects

(Unit: LS million)

Total	5,255.0
Agriculture	1,771.8
Industry	340.0
Energy and Mining	347.7
Water Supply	446.4
Transportation and Communication	641.3
Services	718.5
Rural Development	624.3
Private Sectors	365.0
Sources of Funds	5,255.0
Funds from Abroad, Commodity Aids	645.0
Project Aids from Abroad	1,845.0
Government Budget Expenditures	2,400.0
Funds from Private Sectors	365.0

Source : Data of MFEP and "Outline of the Republic of the Sudan".

2.2 Outline of National Development Programs

In 1962, the Sudanese Government drafted the "10-Year Program for Economic and Social Development," which has been taken over by the "New 5- Year Program for Economic and Social Development" published in 1969. However, a new government was established through a military revolution and the contents of the Development Program were wholly revised, with the target year extended to fiscal 1976/77.

In 1977, the "18-Year Long-term Program for Economic and Social Development," which consisted of medium-term programs for every 6 years and short-term programs for every 3 years, was established and put in effect. With another change of regime, the "4-Year Program for Salvation, Recovery and Development was drafted in fiscal 1988/89 and has since been in effect. This program targets a yearly increase of 5 % or more in GDP, by developing the agricultural sector and rehabilitating production equipment.

Table 2-9 Funds Invested for Development

(Unit: LS million)

Sector Invested	1988/89		1989/90	
	Amount	%	Amount	%
Agriculture	729	32.7	477	28.5
Manufacturing, Energy & Mining	803	36.1	430	25.7
Transportation & Communication	123	5.5	302	18.0
Services	295	13.2	278	16.6
Other(including reserves)	277	12,5	188	11.7
Total	2,227	100.0	1,675	100.0
Sources of Funds				
Foreign Sources	1,415	63.5	836	50.0
Domestic Sources	812	36.5	839	50.0

Source : "Thirtieth Annual Report 1989", Bank of Sudan.

After the birth of the El-Bashir Administration in June 1989, the "4- Year Program" mentioned above lost effect and the "National Economy Reconstruction Program 1990 – 1993" was established in June 1990. The principal policies adopted in the Program are as follows.

a) Deficits of the Treasury budget will be decreased to zero during the three years starting 1990/91.
b) Gradual liberalization of price control on consumer goods.
c) Curtailment of surplus employees of Government affiliated institutions.

d) Revision of the taxation system.
e) Stabilization of foreign exchange rates.
f) Islamization of the banking and insurance systems.
g) Other

Along the line of these policies, stress is being placed on the development of the agricultural sector, so that export of farm goods be promoted. On the other hand, efforts will be paid in lifting governmental control as much as possible, and the privatizing public enterprises with heavy deficit will be promoted. The following is the breakdown of investments by fiscal year.

Table 2-10 Program of Public Investment by Sector

(Unit: LS million)

Sector	1990/91		1991/92		Total	
	Amount	%	Amount	%	Amount	%
Agriculture	1,029.4	24.6	1,331.5	25.4	2,360.9	25.0
Manufacturing	408.2	9.7	510.9	9.8	919.1	9.7
Energy & Mining	745.8	17.8	776.8	14.8	1,522.6	16.1
Transportation & Communication	701.0	16.7	908.5	17.3	1,609.5	17.1
Services	1,305.5	31.2	1,711.3	32.7	3,016.8	32.1
Total(Nominal)	4,189.9	100.0	5,239.3	100.0	9,429.2	100.0

Source: "The Four Year Salvation, Recovery and Development Program 1988/89 - 1991/92", MFEP.

2.3 Outline of the Sector Concerned

2.3.1 Administrative Organization

The Ministry of Energy and Mining is responsible for the administration of water supply. The Ministry controls water supply through its subordinate agencies, consisting of the National Urban Water Corporation (NUWC), which administrates and manages water supply in urban districts, and the National Rural Water Corporation (NRWC), which controls water supply in rural areas. The Ministry is organized as follows.

Ministry of Energy and Mining

National Urban Water Corporation
National Rural Water Corporation
National Electric Corporation
General Petroleum Corporation
Mining Resources Corporation

Until 1983, the NUWC was organized and managed as an organization named the Public Electric and Water Corporation (PEWC), and was reorganized in the year as the Khartoum Province Water Corporation (KPWC) to make its management more efficiently and elastically. Then, in 1987, the Ministry was reorganized again as above. The NUWC administers water supply in urban areas by dividing them into the following seven regions.

National Urban Water Corporation

National Capital (Khartoum Region)
Central Region
Eastern Region
Kordfan Region
Darfour Region
Northern Region
Southern Region

2.3.2 Budget and Finance

The gist of the budget for the three years from fiscal 1988/89 to 1990/91 of the NUWC which carries out general administration of water supply in the urban areas of the Sudan is as shown below. For reference, the budget for the period is shown in Appendix 3.

According to the budget, every year will record surpluses, which are not however so-called surpluses in the real sense of the word as they will be allocated to repayment of the Government's liabilities carried from the previous fiscal year. Here the term surplus will be used as used in the *budget statement.*

The review of the budget of for fiscal 1988/89 and 1989/90, classified by the metropolitan and other local city areas (Refer to Table 2-11), reveals that expenditures for the metropolitan areas during the period exceeds income but these deficits are more than covered by surplus income of local city areas. The metropolitan areas recorded for fiscal 1988/89 a deficit amounting nearly to LS 35 million, but decreased to LS 2 million for fiscal 1989/90, thanks to the water rate revision *made in November 1989. Further, the Budget expects a surplus of about LS 164 million for fiscal* 1990/91 by another water rate revision planned in the period. The repayment of liabilities to the Government has not been completed yet. The water rate revenues from the metropolitan areas amount to almost 60 % of the NUWC's total revenue. The rate of expenditures for the metropolitan areas to the total expenditures of the NUWC is about 50 %.

Table 2-11 NUWC's Budget Allocations to Metropolitan Area and Local Cities

(unit: LS million)

Item	1988/89	1989/90	1990/91
Revenue			
Metropolitan Area	38.2	96.1	218.7
Local Cities	76.8	33.9	149.7
Total	115.0	130.0	368.4
Expenditure			
Metropolitan Area	72.6	98.3	105.4
Local Cities	10.8	23.1	99.1
Total	83.4	121.4	204.5
Balance			
Metropolitan Area	-34.4	- 2.2	113.3
Local Cities	66.0	10.8	50.6
Total	31.6	8.6	163.9

2.3.3 Outline of Water Supply System

According to the "Water Supply and Sanitation Sector Review (1988)" published by the United Nations Development Program (UNDP), the population in urban areas amounts to about 20 % of the total, and that in rural areas to 70 % and the rest of 10 % consisting of nomads. The Review also states that 47 % of urban population and 30 % of rural population in the year were served with water supply. It is assumed that this ratio of water service has not been changed largely. Of the Sudan's total population of 25 million (1989 estimate), 2 or 3 million people in urban areas and about 5 million in rural areas are considered to be served with public water supply. Classified by area, the percentage of served population in the northern districts is considered to be 53 % of urban population and to be 46 % of rural population, while those in the southern areas to be 17 % and 7 % respectively.

In 1983, of the total 174 towns in the Sudan, 62 towns were under the jurisdiction of the NUWC in regard to water supply. The number of planned schemes, water supply capacities and populations of these towns classified by region are shown in Table 2-12. As shown in the Table, the per-capita water supply in the Khartoum Metropolitan Area obtainable simply by dividing water supply capacity by population amounted to about 150 liters per capita per day. The similarly high levels of water supply could be found in northern regions, but in southern regions the per capita water supply figures thus obtainable ranged roughly from 40 to 60 liters per capita per day, indicating the undeveloped water supply conditions and low levels of water supply in these regions.

Most of the water supply facilities were constructed in the period from the early years of 1920's to the first half of 1960's, and are in great need of rehabilitation and extensions to amend their obsoleteness and to meet the growing water demand. Speaking of the water treatment facilities in the metropolitan areas, for example, the results of the survey for the Khartoum Area Water Supply Project established in 1979 reported that the treatment capacities of the facilities had fallen to levels of 70 % to 90 % of their design capacities. The Master Plan described the treatment capacities of the existing treatment plants at the time of survey and the improved capacities planned by the Master Pan, both of which are referred to in Section 2.3.5 and shown in Table 4-3 in Section 4.2.3.

Table 2-12 Urban Water Supply Capacity and Coverage

Region	No.	Capacity (m^3/day)	Population	Water Supply (lpcd)
		(A)	(B)	(A/B)
Khartoum	1	254,000	1,693,000	147
Northern	8	35,850	227,000	157
Eastern	9	60,760	706,000	86
Central	22	83,820	751,000	111
Kordfan	7	16,250	379,000	42
Darfour	4	17,500	338,000	57
Southern Region	11	19,860	365,000	54
Total	62	490,040	4,459,000	

As for a source of water supply, surface water of rivers and groundwater are generally utilized. For comparatively large-sized water supply in urban areas, surface water of rivers is used in most cases. For water supply in areas remote from urban cities or for a small-sized water supply, ground water is often used. Sedimentation and filtration is given to surface water, and the treated water is distributed after chlorination. Both coagulants and chlorine are imported. In case groundwater is used as water source, it is distributed without any treatment when water quality is good enough.

Asbestos cement pipe is widely used from the viewpoints both of economical efficiency and easiness in pipe processing. The use of steel pipe is limited to special uses such as for pipe bridges and pipes hung with road bridges. Galvanized steel pipe is generally used as service pipe. Almost all pipe materials are now imported. Service connections consist of both house connections and public standpipes. Special connections for water vendors are sometimes erected in such places as surrounding areas of the service area or remote from public standpipes. The per capita water supply ranges from 10 to 60 liters/day.

As examples of the water supply conditions of local cities, data of Khassala and Khasim Ell Gerrba, both principal cities, are referred to below.

a) Khassala

Population	:	165,000
Served Population	:	80,000
Source	:	Groundwater
Size of Well	:	Diameter 250 mm x Depth 50 m x 45 m^3/hour x 4 wells
Method of Treatment	:	none
Per Capita Water Supply	:	4,320 m^3/day /80,000 = 50 liters/day

b) Khasim Ell Gerrba

Population	:	29,800
Served Population	:	20,000
Source	:	Surface Water (the Atobara)
Method of Treatment	:	Sedimentation + Rapid Sand Filtration + Chlorination
Treatment Capacity	:	1,160 m^3/day
Distribution Pipelines	:	Diameters 200 – 50 mm x 15 km
Per Capita Water Supply	:	1,160 m^3/day /20,000 = 60 liters/day

(Source : NUWC data.)

Rural water supply schemes generally consist of systems based on (1) water yards, (2) impounded surface water (locally called "hafirs"), (3) hand pump wells and (4) use of irrigation water available in river beds or canals along the Nile and its tributaries.

(1) The water yards are the most common form of water supply in rural Sudan and they usually consist of one to three boreholes equipped with turbine pumps and diesel engines, with water being pumped into an elevated tank and distributed to the consumers through common taps or in some rare cases house connections. Generally there is no other treatment of the water except for chlorination. An average system capacity would be about 4/5 m^3/hr.

(2) The systems of impounded surface water, "hafirs", are impoundments into which surface water is diverted during the rainy season. The impounded water is used for living without treatment and is often of poor quality. Their sizes range from 5,000 to 100,000 m^3, with depth varying from 3 m to 8 m. One of the problems with hafirs is high evaporation losses of water.

(3) The irrigation water available along the river Nile and its tributaries is treated with slow sand or pressure filters but problems are caused by high turbidity which often makes filters unworkable. Sometimes, untreated water is pumped directly for consumers. Recently, Horizontal-flow Roughening Filters have been successfully introduced as pre-treatment for slow-sand filtration.

(4) Hand pump well construction started in mid 70's. Many of the open wells are more than hundred years old and may be up to 100 m deep, although normally limited to 10 – 30 m deep with a diameter of 1.2 – 1.5 m and lined with bricks. Water is lifted by ropes and

buckets, but locally made low-lift hand pumps have been used in northern Sudan.

Information on number of different kinds of water systems and estimated design capacities, by the survey of the World Bank in 1988, is shown in Table 2-13.

It could be estimated that some 30 - 40 % of the rural population is supplied with water from improved water sources but with only some 15 - 20 % having access to safe water supplies.

Table 2-13 Rural Water Supply Systems

Type	No.	Total Design Capacity
Water Yards	3,595	180,000 m^3/d
Filtration Plants	142	12,000 m^3/d
Small Roughing Filters	27	300 m^3/d
Hafirs	984	35,000,000 m^3
Dams (for Water Supply)	126	3,000,000 m^3
Hand Pump Wells	4,672	28,000 m^3/d
Deep Wells	-	4,000 m^3/d

In selecting projects for developing rural water supply systems, the following aspects have been emphasized by the World Bank.

1) a rural water supply master plan shall be prepared;
2) rehabilitation of existing systems shall have first priority;
3) appropriate technologies shall be better utilized in order to ensure economy as well as satisfactory operation and maintenance;
4) the community be more fully involved in developing, operating and maintaining water supplies;
5) ecological aspects shall be considered in the choice of technology.

The rural water supplies are designed to cater for both human and domestic animal consumption with the following criteria applied for water demand at communal water points:

- human consumption: 18 lpcd
- animal consumption: 36 liters/livestock unit/day
  (1 livestock unit = 1 cow or camel, or 5 donkeys or sheep or goats)

2.3.4 Outline of Development Projects

The Table 2-14 shows the NUWC's investment projects for the 6-year period from fiscal 1986/87 to 1991/92. These projects to be developed during the 6-year period consist of 5 projects

in the metropolitan areas, including the construction of the Khartoum North WTP, and other 8 projects in Kordfan, Darfour and other local city areas. The NUWC is thus executing 13 investment projects in all, inclusive of some improvement projects.

Table 2-14 Investment Schedule for Development Projects

(Unit : LS million)

		1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	Total
Metropolitan Region	F	-	-	28.0	28.0	18.0	8.0	82.0
	L	9.5	26.0	35.0	25.0	43.5	73.4	212.4
Local Cities	F	2.5	22.5	98.0	108.5	89.0	57.0	377.5
	L	20.3	15.4	60.0	86.0	49.0	169.7	400.4
Sub-Total	F	2.9	22.5	126.0	136.5	107.0	65.0	459.5
	L	29.8	41.4	95.0	111.0	92.5	243.1	612.8
Total of F & L		32.3	63.9	221.0	247.5	199.5	308.1	1,072.3

Note : F : Foreign Currency Portion
L : Local Currency Portion
Source : NUWC data.

2.3.5 Present Status of International Cooperation for Water Supply Projects

Repayments of external liabilities are decreasing in amount year by year, and the amount of repayment in fiscal 1989/90, for example, decreased to US$ 142 million, almost half of the repaid amount of US$ 276 million in 1985/86. The borrowing position of the Sudan is thus becoming worse yearly. Following the loan project for provision of water supply equipment, a commodity loan amounting to 2,500 million yen was given in 1982, and the Japanese Government decided in 1983 to cease to provide loan aids to the Sudan and has since been continuing aid in the form of grant.

The rehabilitation and extensions of the water supply facilities in the Metropolitan Area have almost been planned on the basis of the Khartoum Area Water Supply Project (Master Plan) prepared in 1979 under the assistance of the World Bank.

The target year of the Master Plan is set at 1993, with the populations and water demands of 1983 (Phase I), 1988 (Phase II) and 1993 (Phase III) forecast on the basis of the 1978 figures.

Regarding the Phase I, the Master Plan proposes the improvement and extensions plans in detail , emphasizing the necessity of improving and extending the existing four water treatment plants in Burri, Mogren, Khartoum North and Omdurman. The Master Plan also proposes the construction of a new treatment plant, i.e., the Khartoum North Water Treatment Plant (Phase I and Phase II)

with design capacity of 72,000 m^3/day. As regards the laying of distribution pipelines, it recommends that the areas necessitating distribution piping during Phase I must be carefully studied.

Table 2-15 below shows the volume of water supply to the Khartoum Metropolitan Area, as the total volume of design capacities of the existing and new treatment plants combined with the water supply from deep wells, in 1978 and 1983.

Table 2 - 15 Existing and New Water Treatment Plants

Facilities	Volume (m^3/day)				
	Design Capacity	1978	1983	1992*	Remarks
Mogren WTP	72,000	59,500	59,500	90,000	Rehabilitation & Extensions
Burri WTP	16,920	13,500	13,500	18,000	Rehabilitation
Khartoum North WTP (Old)	11,330	10,200	10,200	11,000	Rehabilitation
Omdurman WTP	15,750	11,100	11,100	16,000	Rehabilitation
Khartoum North WTP (New, Phases I & II)	72,000	-	36,000	72,000	36,000 m^3/d x 2 Phases
Khartoum North WTP (New, Phases III & IV)	108,000	-	-	108,000	54,000 m^3/d x 2 Phases
Deep Wells		36,400	50,000	77,000	Capacities : 110,000 m^3/d x 70 %
Total		130,700	180,500	392,000	

Note : * : Design capacities upon completion of the on-going projects.

2.4 Background and Outline of the Project

2.4.1 Background

The water deficit which has become chronic is being intensified by the expanding water demand reflecting the rapid increase of population in recent years. Further, the decreasing capacity of treatment due to inefficiency coming from the overage of equipment. The khartoum Area where the project is being requested is the political, economic and educational center of the Metropolitan Area, where population concentrates remarkably. The water deficit of the Area is therefore becoming very severe. Particularly new residential and industrial zones are being formed in the southern part of the Khartoum Area, where urgent improvement of water supply conditions is required.

As a step toward these improvements, the NUWC started in 1983 the construction of the Khartoum North WTP, financed by the Czechoslovakian Government. The construction of the 1st and 2nd phases of the project (36,000 m^3/day x 2 phases = 72,000 m^3/day) was already completed. The 3rd and 4th phases of construction now under way are planning to add another 108,000 m^3/day of treatment and are expected to be completed by the end of 1992. Upon completion, a part of treated water (62,400 m^3/day) brought about by the construction will be transmitted to the southern areas of the Khartoum Area as shown in Fig.4-3 and is planned to be distributed through the Khartoum South DPS now being constructed.

The construction scheme from the Khartoum North WTP up to the Khartoum South DPS is expected to be completed by the end of 1992. The effective distribution of the water to be brought about cannot be expected, however, if necessary distribution pipeline is not provided. The Government of the Sudan has, therefore, requested the Japanese Government a grant aid for the Project.

2.4.2 Outline of the Project

The Project requested by the Sudanese Government consist of 3 items, i.e., (a) construction of distribution pipelines, (b) procurement of construction machinery and materials and (c) detailed design and construction supervision, the details of which are:

(a) Construction of Distribution Pipelines (including materials)

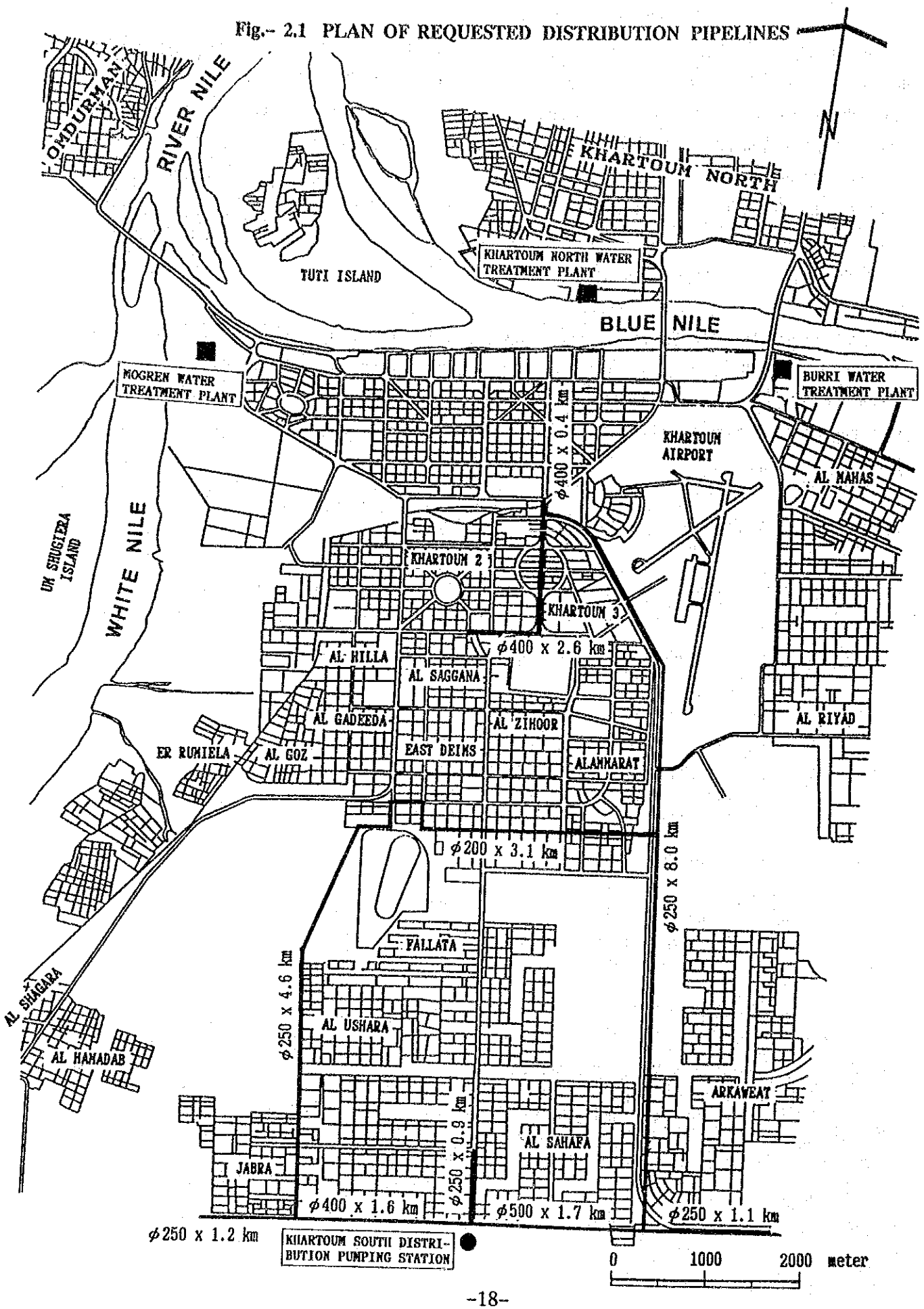
Ductile Iron Pipe	Ø 500 mm	x	1.7 km
Ductile Iron Pipe	Ø 400 mm	x	4.6 km
Ductile Iron Pipe	Ø 250 mm	x	15.8 km
Ductile Iron Pipe	Ø 200 mm	x	3.1 km

(b) Procurement of Construction Machinery and Materials

Construction Machinery and Spare Parts	
Backhoe (0.6 - 0.7 m^3)	: 1 unit
Backhoe (0.35 m^3 with blade)	: 1 unit
Pick-up Truck (double cabin)	: 1 unit
Roofing Materials for Reservoirs	
Aluminum roofing	: 3,600 m^2
Building Materials for Warehouse	: 1,000 m^2 floor space

(c) Detailed Design and Construction Supervision : complete process

Fig.- 2.1 PLAN OF REQUESTED DISTRIBUTION PIPELINES



CHAPTER 3 OUTLINE OF THE PROJECT AREA

3.1 The Project Area

Metropolitan Khartoum is located at 16 degrees north latitude, 33 degrees east longitude, and about 380 m above the sea. It lies at the confluence of the White Nile and the Blue Nile. There are three metropolitan areas named Khartoum, Khartoum North and Omdurman surrounding the confluence. The Khartoum Area, Project Area of this time, is the southern part of the metropolitan areas compassed by the White Nile and the Blue Nile. The location of the Area is shown in Fig. 3-1.

3.2 Natural Conditions

The weather of Khartoum is generally hot and dry, except during the rainy season of June – September when some precipitation is seen. During the season covering April – June, hot days recording over 50 °C are not so rare. Reference is made to Table 3-1.

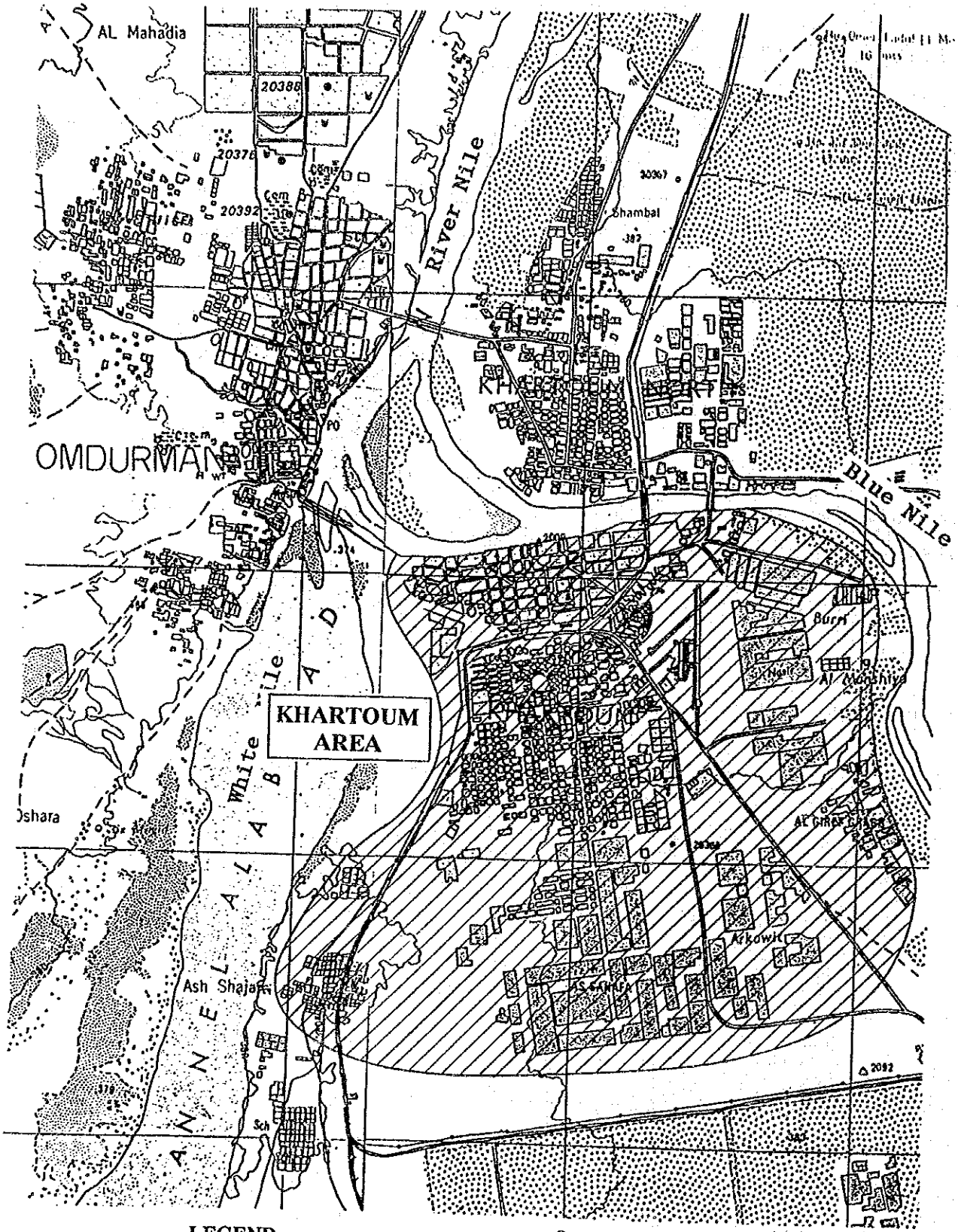
Table 3-1 Monthly Precipitation and Average Temperature

Month	Precipitation(mm)				Monthly Average Temperature (°C)			
	1975	1980	1985	1988	1975	1980	1985	1988
1	TR	0	0	0	22.5	23.0	26.1	23.3
2	0	TR	0	0	26.5	24.9	22.8	24.5
3	0	TR	0	0	28.9	29.7	30.1	29.8
4	0	0	0	0	31.5	33.0	31.4	32.5
5	0.2	0.7	0.1	TR	34.6	35.1	34.3	35.7
6	TR	0.2	3.1	TR	33.9	34.1	33.9	35.1
7	0.9	60.5	16.4	65.9	32.5	31.3	31.9	31.9
8	50.1	19.2	0.3	301.4	29.5	31.7	32.7	29.9
9	47.8	11.0	9.9	46.3	30.9	33.5	33.1	32.0
10	0	1.2	0	1.9	32.1	33.1	33.2	32.7
11	0	0	0	NA	29.2	27.9	28.1	NA
12	0	0	0	NA	23.8	24.6	24.7	NA

Note: TR: Trace, NA: Not Available
Source: Sanitary Engineering Department, National Capital Khartoum

Geographically, the Khartoum Area is a plain land accumulated between the White and the Blue Nile ranging around 380 m above the sea level, with the highest place in the southern part of the area at about 385 m.

Fig.- 3.1 GENERAL PLAN OF THE KHARTOUM METROPOLITAN AREA



The surface of land is covered by clay silt and conglomerate strata laying one upon another forming Gezila strata. The depth of these strata up to the Nabian sandstone stratum is 40–50 m in the southern part of Khartoum and 20 m in the Khartoum Area on average. Clay in the Gezila stratum has a high intensity when it is dry but loses intensity and expand its volume when wet. Careful consideration is therefore required for construction work in rainy seasons.

The water level of the both Niles changes following such cycles as beginning to rise in June, reaching the top toward the end of August and starting a downward movement from September. The bottom of the level is mostly recorded in March. The highest of the water level during the period from 1970 to 1979 was +379.86 m (bank +379.00 m) in the White Nile and +380.14 m (bank +379.00 m) in the Blue Nile. Water levels of both Niles exceeded the banks of the rivers and the areas were flooded by the heavy rainfall in August 1988.

3.3 Socioeconomic Conditions

3.3.1 Population

The rate of increase in the Sudan's national population (1973–1984) stands at around 2.9 % per annum. The rate for the Metropolitan Area now exceeds 5.0 %, reflecting the inflow of those people residing in the areas far from the Metropolitan Area and in drought areas, their number is recently expanding at an abnormal pace. Those people who have flowed from outside are residing in a number of settlements set up in the fringe areas and pose many social problems. For the purpose of grasping these problems from the viewpoint of population, national census was conducted at the beginning of 1990. The changes in the population of the Khartoum Metropolitan Area are seen in Table 3–2.

Table 3–2 Changes in Population of Khartoum Metropolitan Region

Year	Khartoum	Omdurman	Khartoum North
1955/56	97,516	116,231	46,852
1964	173,500	185,380	80.010
1973	333,906	299,399	150,989
1978*	420,000	395,000	180,000
1983	476,267	526,337	341,187
1988*	635,000	655,000	265,000
1990	1,147,669	1,417,950	1,116,822

Source : Sanitary Engineering Department, National Capital Khartoum
Department of Statistics, MFEP
* based on NUWC data
1990 figures based on National Census.

3.3.2 Status of Social Infrastructure

Electricity services to various types of consumers in Khartoum are provided by the National Electricity Corporation. The electricity voltage supplied is 415 V/240 V, 50 Hz (low-tension electricity wiring in city areas). The deterioration of equipment is also remarkable in this field. Though the frequency of blackouts varies according to area and for other reasons, blackouts usually take place three times a week per area, with the length of several hours. Hotels, shops, high class residences, offices, etc. are equipped with private generators to meet such inconveniences but procurement of fuel is another problem to solve.

Telephone circuits in Khartoum are suffering from old age deterioration and also the shortage of circuits themselves. The telephone communication in the area is therefore considerably inconvenient. Repair and extension of telephone installations are now under way, and the situation is stepping towards improvement. Telephone installations are now limited to such places as hotels, high class residences, business offices and public institutions. Extension of installations is a considerably difficult task which will take time.

Among the metropolitan areas, only the Khartoum Area has a sewerage system, but both the Omdurman and Khartoum North Areas have no sewerage system. In both areas, newly built houses are obliged to set up pit latrines to receive their daily drainage. Due to overage deterioration and insufficient supply of spare parts, the function of the Khartoum Area's sewerage system is aggravating. In this connection, urgent improvement project is being executed with a grant aid assistance by the Japanese Government.

An unprecedentedly large torrential downpour attacked the metropolitan areas in August 1988, and caused such big damages as collapse of houses and floods. Following the floods, waterborne epidemic diseases spread in these area killing many inhabitants.

In the Khartoum Area, its northern part along the Blue Nile in the north of the railroad has been developed for mostly commercial and public zones where offices, schools, hospitals, etc. are built. The area adjacent to the south of the above has embassies and high class residences. There is an international airport in the east of the commercial and high class residential zones. Other high class residences are located in the east of the airport. There has been developed an industrial zone in the west of both the area of embassies and the high class residences. Low class residences are located in the south of the embassies and high class residences. Other low class residential areas extend adjacent to the west of the low class residential area. A new high class residential area is being developed in the east of the low class residential areas.

First class residences are mostly two- or three-storied buildings equipped with enough

amenities for living. Second class residences are generally multi-storied or single storied and third class residences mostly single storied.

Average household number is 5.85 (about 6 persons/household) in 1983 according to a statistical data. Average household incomes per month are LS 7,500, LS 3,000, LS 1,000 and LS 500 for the first, second, third and lowest class household respectively.

3.4 Outline of Water Supply Sector

3.4.1 Outline of the Existing Facilities

The water supply of the Khartoum Metropolitan Area started with the Burri WTP (treatment capacity of the time: 6,800 m^3/day) built in 1922 on the left bank of the Blue Nile about 5 km up stream from the confluence of the White and the Blue Niles, and at first distributed drinking water to the district of government offices in the Khartoum Area and residential districts of foreigners. In 1928, the Omdurman WTP began to operate with a capacity of 4,600 m^3/day. Further to meet increasing demands, the Khartoum North WTP and Mogren WTP were built, and later all of these plants expanded their facilities to the existing capacities.

As shown in Table 3-5, the Khartoum Metropolitan Area have five water treatment plants. Raw water is taken from the Nile after the confluence or the Blue Nile. Location and design capacities of the plants are shown in Fig. 3-2. As seen in the figure and Table 3-5, the treated water of 11,000 m^3/day from the Khartoum North, 15,000 m^3/day from the Mogren and 16,000 m^3/day from the Omdurman WTP are supplied to the Omdurman Area. As the water level of the Nile changes as much as 8 m between dry and rainy seasons, the intake pumps of these plants are designed to cope with such water level changes. Their treatment method adopts chemical sedimentation and rapid sand filtration. The filters are cleaned with the combined use of air and water. The chemicals used by these plants are aluminum sulfate, lime and liquid chlorine, all of which are imported.

Though the water volume of the both Niles is abundant, the water of the Blue Nile contains little suspended solids and is clearer compared with the White Nile water. As the Sudan has to import all of the necessary chemicals, the water quality of the Blue Nile must be comparatively suitable to the country. The water sources of all the water treatment plants now being planned will be the Blue Nile.

As countermeasures to meet the rapidly increasing water demand, 127 pumping wells have been set up mainly in the areas surrounding the metropolitan areas for the purpose of covering the

shortage of the capacity of the existing water treatment plants and distribution facilities. The average pumping capacity of the pumping wells is around 870 m^3/day. They are on average sized diameter 300 mm with the depth of 100 m, and uses submerged pumps of diameter 150 mm. (Refer to Table 3-6.) This type of pumping wells are operating at 45 sites in the Khartoum Area, 55 sites in the Khartoum North Area and 27 sites in the Omdurman Area. Pumping wells are set up in the areas where water demand is intense. The water pumped up by pumping wells set up in the served areas is poured into the nearest distribution pipes to help increase supply to meet the expanding demand. The pumping wells in the three metropolitan areas are either set up in the suburbs of the districts or such places where distribution pipes are not yet set up and are serving people in these areas.

In the early days when the Metropolitan Area Water Supply was first introduced, cast iron pipe (CIP) was used, but at present asbestos cement pipe (ACP) is mostly used. Steel pipe (SP) is used in some limited areas such as between the Khartoum to the Mogren WTP and the place crossing the White Nile.

Table 3-5 Water Treatment Plants in Metropolitan Area

Water Treatment Plant	Year Established	Year Expanded	Design Capacity	Water Source	Served Area
Burri	1922	1948	18,000 m^3/d	Blue Nile (Left Bank)	Khartoum
Mogren	1964	1970	72,000 m^3/d	Blue Nile (Left Bank)	Khartoum
		(15,000 m^3/day is supplied to Omdurman Area.)			
Khartoum North (New)	1979	1985	72,000 m^3/d	Blue Nile (Right Bank)	Khartoum
		(11,000 m^3/day is supplied to Omdurman Area.)			
Khartoum North (Old)	1953	1957	11,000 m^3/d	Blue Nile (Right Bank)	Khartoum
Omdurman	1928	1950	16,000 m^3/d	Nile (Left Bank)	Omdurman
Total			189,000 m^3/d		

Source: NUWC

Table 3-6 Deep Wells in Metropolitan Area

Area	Number of Wells	Well Capacity (m^3/day)
Khartoum	45	39,000
Khartoum North	55	47,600
Omdurman	27	23,400
Total	127	110,000

Source: NUWC

Presently, the treated water of 189,000 m^3/day is supplied by treatment plants to the three metropolitan areas of Khartoum, Khartoum North and Omdurman. As against the supply, the present average daily demand from the areas is estimated at around 400,000 m^3/day. As indicated by these figures, the metropolitan areas are suffering from chronic severe shortage of water. Records concerning unaccounted-for water are not available, but the rate of unaccounted-for water is generally assumed at 35 %, with the rest 65 % accounted for.

3.4.2 Present Water Supply Condition in Khartoum Area

Presently, treated water of 64,000 m^3/day on average is supplied to the Khartoum Area, of which some 48,000 m^3/day from the Mogren WTP located at the left bank of the Blue Nile and about 16,000 m^3/day from the Burri WTP. In addition, about 19,000 m^3/day is supplied to the area from deep well sources. On the other hand, water demand of the area is estimated at about 150,000 m^3/day and there exists a chronic water shortage in the area.

Presently, water is distributed, from the existing Mogren WTP located at the northwestern end of the area and from the Burri WTP at the northeastern end of the area, to commercial shops, governmental offices, public facilities and residences in the Khartoum Area and further to remote residences and public facilities in the area. In the remote or southern part of the Khartoum Area, because of insufficiency of the distribution pipeline, the service level is extremely poor, as seen in the low pressure and short supply.

The pumping facilities at the Mogren and the Burri WTP's have, since originally set up, been continuously used and are deteriorating remarkably. The required rehabilitation and improvement of these facilities, under these conditions, started in 1989 with an Italian grant aid.

The water treated by the above two water treatment plants is supplied to the customers via the existing distribution pipelines (700 to 100 mm in diameter and a total of 400 km in length). Almost all of the pipes used are made of asbestos-cement and partly of steel and cast iron.

The distribution pipelines installed in the northern area occupying about one third of the Khartoum Area are mostly of the pipelines installed during the period from 1890 to 1930 and deterioration of the pipes is remarkable as seen in the results of the water pressure survey. The NUWC has a plan to install new pipelines of 250 to 600 mm in diameter, made of FRP with a total length of 21.4 km with the Italian grant aid. The project is expected to be completed by the end of 1992 in order to strengthen the pipe network at the northern half part of the area extending to the railroad.

The distribution pipelines in the central and the southern parts of the Khartoum Area were installed in the periods of 1950 to 1990 and 1960 to 1990 respectively. The water pressure survey indicates that the pipelines are partly deteriorating.

Water meters (73,000 pieces in total as of 1990) installed at service pipes are mostly malfunctioning or not calibrated. This is attributable to shortage of spare parts and insufficient facilities for repair. The flat rate system is, therefore, applied for the customers who has such damaged meters.

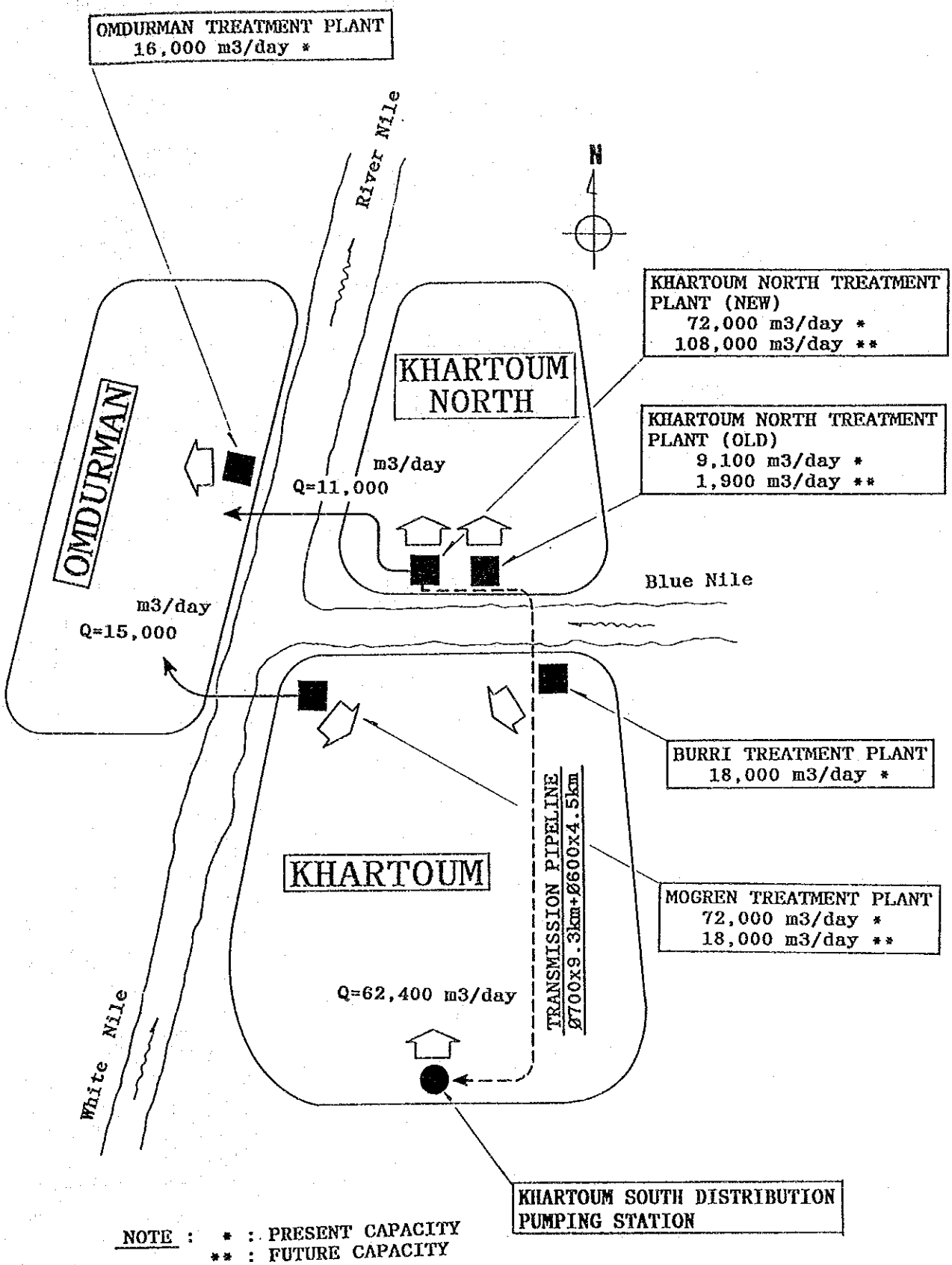
3.4.3 Relationship of the Project with the Existing Facilities

In the Khartoum Area, zones for public offices and commercial buildings have been developed along the Blue Nile. The water treated at the Burri WTP, as the first modernized water supply system in the Metropolitan Area, has been supplied to the zones since 1922. To meet the increased water demand for the area including the residential areas developed adjacent to the south of the above and their surrounding settlement areas, the Mogren WTP was newly introduced, which plant together with the Burri WTP were expanded afterward. The Khartoum North WTP was planned and its construction is under way to meet the present rapidly increasing water demand.

The treated water of the Khartoum North WTP will be transmitted to the Khartoum South DPS, which is now under construction. The Government of the Sudan requested to the Government of Japan the pipelaying work from the above pumping station to the served area as mentioned in Section 2.4.1.

Since the water demands for domestic, public, commercial and industrial use have been increasing year by year and has come to exceed the supply, the above pipelaying work is requested. Residential area has been rapidly developed in the Area and the above pipelines will be the mainstay of the Area's pipe network in the future.

Fig.- 3.2 SCHEMATIC CHART OF PRESENT WATER SUPPLY SYSTEM IN KHARTOUM METROPOLITAN AREA



NOTE : * : PRESENT CAPACITY
** : FUTURE CAPACITY

Fig.- 3.3 PRESENT WATER SUPPLY SYSTEM IN KHARTOUM AREA

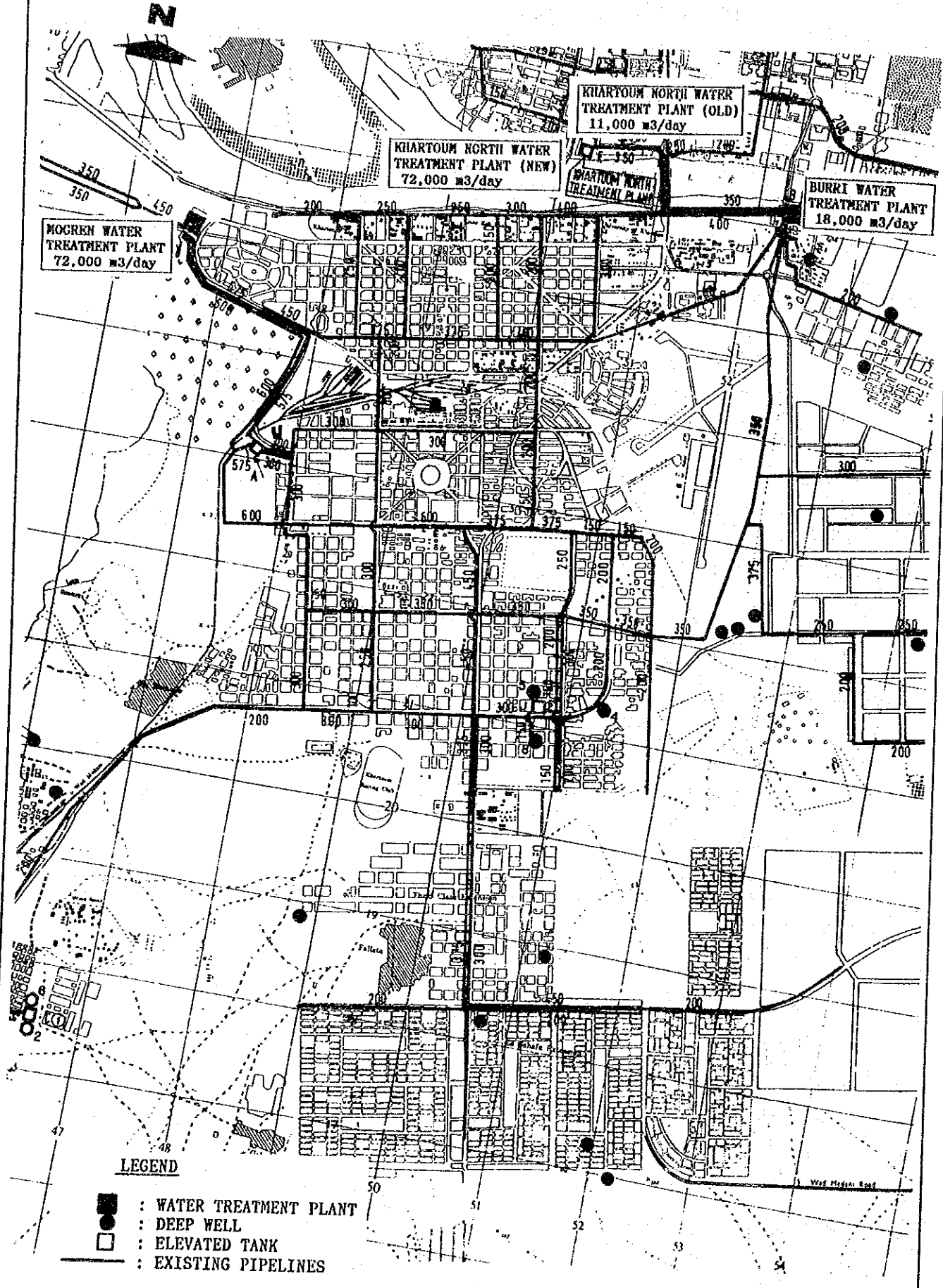
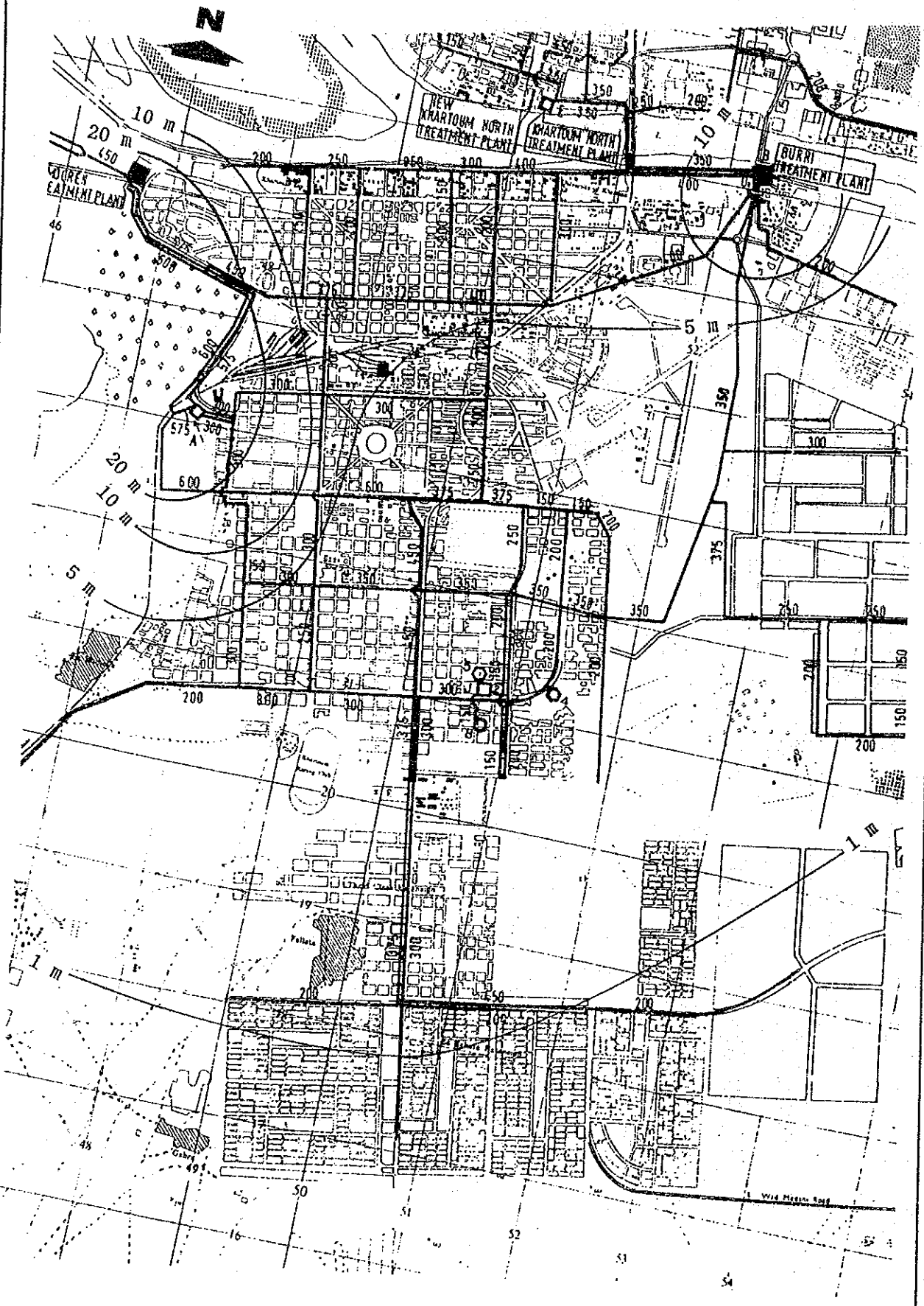


TABLE - 3.7 REHABILITATION PROGRAM OF PUMPING FACILITIES (BY ITALIAN GRANT AID)

FACILITIES	EXISTING		REHABILITATION
MOGREN WATER TREATMENT PLANT			
Raw water pump	760 m3/hr x 16.0 m x 2 Nos.	---→	1520 m3/hr x 16.0 m x 2 Nos. (NEW)
	1520 m3/hr x 16.0 m x 2 Nos.	---→	- do -
Low lift pump	760 m3/hr x 16.0 m x 2 Nos.	---→	1520 m3/hr x 16.0 m x 2 Nos. (NEW)
	1520 m3/hr x 16.0 m x 2 Nos.	---→	- do -
High lift pump	520 m3/hr x 42.0 m x 2 Nos.	---→	- do -
	520 m3/hr x 42.0 m x 1 No. (out of order)	---→	1520~760 m3/hr x 34.4~63.2 m x 1 No. (NEW)
	1520~760 m3/hr x 34.4~63.2 m x 2 Nos.	---→	- do -
	1520~760 m3/hr x 34.4~63.2 m x 1 No. (out of order)	---→	1520~760 m3/hr x 34.4~63.2 m x 1 No. (NEW)
BURRI WATER TREATMENT PLANT			
Raw water pump	500 m3/hr x 18.0 m x 1 No.	---→	- do -
	300 m3/hr x 18.0 m x 1 No.	---→	- do -
	250 m3/hr x 18.0 m x 1 No.	---→	400 m3/hr x 25.0 m x 1 No. (NEW)
Low lift pump	240 m3/hr x 10.0 m x 3 Nos.	---→	- do -
High lift pump	410 m3/hr x 41.0 m x 3 Nos.	---→	- do -
	410 m3/hr x 41.0 m x 1 No. (out of order)	---→	410 m3/hr x 41.0 m x 1 No. (under repair)
			500 m3/hr x 50.0 m x 1 No. (NEW)

Fig.- 3.4 PRESENT SERVICE PRESSURE CONTOUR LINE IN KHARTOUM AREA



CHAPTER 4 CONTENTS OF PROJECTS

4.1 Objectives of the Project

The Project is intended to strengthen the distribution facilities in the Khartoum Area, to improve the service level of water supply in the area. To achieve these, the Project involving procurement of distribution pipes and construction of distribution pipelines will be implemented under a Japanese grant aid.

4.2 Study of the Contents of the Request

4.2.1 Study of the Appropriateness of the Plan

The Khartoum Area, when roughly divided, is made up of the northern part functioning as the center of socioeconomic activities and central and southern parts of residential areas where new residential zones are being developed. Of the total 1.1 million population, the served population in the 100 km^2 area designated for water supply is estimated at 600,000.

The present water supply to the area is 83,000 m^3/day in total and it is distributed from the existing two water treatment plants, by pumping, to the whole supply area. The per capita water supply is calculated to be 140 liters/day accordingly.

Due to the remoteness from the WTP's and the insufficiency of the distribution pipelines, however, the water supply conditions in the southern part of the area have been extremely worsened.

To improve the conditions, the NUWC is planning to transmit 62,400 m^3/day of the treated water from the Khartoum North WTP, now under construction, to the Khartoum South DPS located at the southernmost end of the service area, upon the WTP's completion. The WTP and DPS, now under construction, are planned for completion in the end of 1992.

For improving the water supply conditions in the southern part of the Khartoum Area, construction of the pipelines from the DPS to the area is indispensable and needed urgently.

The implementation of the Project will greatly improve the service level in the southern area, while it equalizes the service level in the whole Khartoum Area. In addition, if accompanied by the increase of water revenue, it would help the waterworks improve its management.

4.2.2 Management Plan

a) Organization and Management

The NUWC, under the Ministry of Energy and Mining, takes charges of water supply services in all urban areas including the Metropolitan Area. The Corporation, having its head office in Khartoum, and carries out by its six departments the charges of operating and controlling of water systems, under the supervision of the Director General. It is now manned by about 9,500 staff members. The Director General is assisted by three Offices, Internal Control, Legal Department and Public Relations.

Director General

(1) Internal Control
(2) Legal Department
(3) Public Relations

The National Capital Administration Department, one of the six departments shown below, controls the Khartoum Metropolitan Area, while all other urban water supply services are managed by the Regional Administration Department.

Director General

(1) National Capital Administration Department
(2) Regional Administration Department
(3) National Projects Management Department
(4) Operation and Maintenance Department
(5) Management and Administration Department
(6) Supplies Administration Department

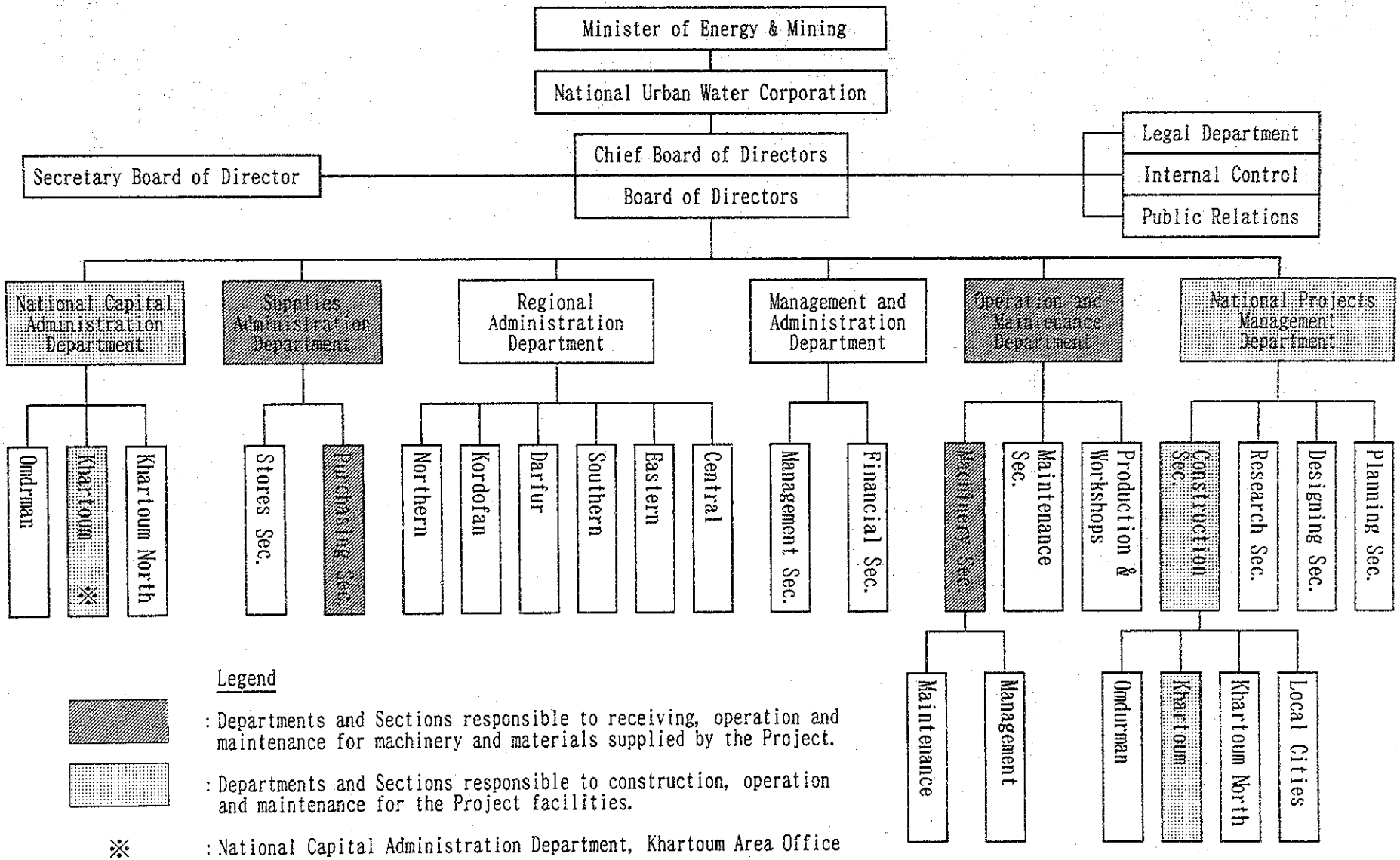
Present organization chart is shown in Fig.4–1 and the composition of the staff is shown below:

(1)	Director General	1
(2)	Engineer	173
(3)	Technical Staff	306
(4)	Clerical Staff	1,361
(5)	Laborers	7,633
	Total	9,474

The Project implementation will be managed primarily by the National Projects Management Department in coordination with the Supplies Administration Department and the Operation and Maintenance Department.

The National Projects Management Department is responsible for construction and management of water supply facilities. The Supplies Administration Department and the Operation and Maintenance Department are responsible for inspection and administration of equipment and materials procured, and management of construction machineries, respectively.

Fig.- 4.1 ORGANIZATION CHART OF NUWC

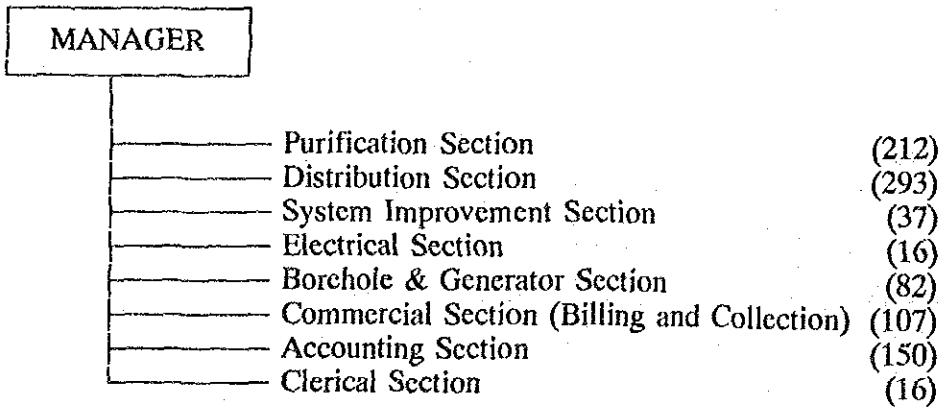


The organizational setup and the number of staff members of the National Projects Management Department are: Planning Section (7 civil engineers, 1 mechanical expert), Design Section (12 civil engineers), Construction Section (25 civil engineers, 5 mechanical engineers, 50 skilled laborers, 420 navvies and construction laborers). The Supplies Administration Department and Operation and Maintenance Department are staffed with about 100 and 80 members respectively.

The Construction Section of the National Projects Management Department, has been involved in a number of projects including the on- going Khartoum North WTP under Czechoslovakian aid, the rehabilitation and extension of the Mogren WTP under Italian grant aid, the Burri WTP rehabilitation, Central Khartoum distribution network project under Italian grant aid, the Khartoum South DPS under Czechoslovakian aid and others, and has undertaken construction of the distribution pipes (ACP) in a part of the three areas, Khartoum, Khartoum North and Omdurman. In the Omdurman Area Water Supply Project completed in 1990 under Japanese grant aid for improving the area's water supply, on-the-site guidance has been given to the NUWC. As the National Projects Management Department has thus participated and managed the implementation of projects similar to this one, the Department is therefore judged to be well capable of charging the pipeline works in this Project which will be undertaken by the Japanese Agency. The maintenance works after completion will be handled without problems by the Department and the Khartoum Area Office.

Operation and maintenance of the completed facilities will be charged by the Khartoum Area Office under the National Capital Administration Department. The office, formed by eight sections, are staffed by about 950 staff members. The organization chart is shown in Fig.4-2.

Fig. 4-2 Organization Chart of Khartoum Area Office



Note : As of May, 1991.
Figure in ( ) indicates the number of staff (Engineer, Technician and Skilled Worker) in each section.
Total number of sections is eight.
Total number of staff is 913.
Source : Khartoum Area Office

Of the total staff members, 170 take charge of office routine work (the general affairs section and accounting section), 110 meter reading and tariff collection, etc. (the business section) and 640 engineering and technical services. Percentage-wise, they are 18, 12, 70 % respectively. The percentages of technical staff, meter readers and tariff collectors, will make them sufficiently capable to charge maintenance and administration duties including meter reading and tariff collection.

The served population per staff is about 660 (estimated served population of 600,000 divided by 913 staff members). The number of staff members is judged to be sufficient.

Judging from the viewpoints of its organization, the assignments and the number of its staff members, and its financial and managerial capabilities, the NUWC is sufficiently qualified in executing functional operation of the facilities, after project completion and take-over of the facilities. This can be proved by the fact that the facilities taken over after the Omdurman Area Water Supply Project, a previous similar project which was completed in 1990, have been properly operated and maintained.

b) Operation Budget

The 1988/89 budget scale of the NUWC's metropolitan water supply service amounted to LS 40 million. Due to the revision of the water rate in November 1989, the 1990/91 budget scale increased to a level of LS 220 million. The scales of budget for the last three years are shown in Table 4-1.

Breakdown of the NUWC's 1988/89 to 1990/91 operation budget is shown in Appendix 3. Table 4-2 lists expenditures for salaries and wages, fuel and power, operating materials and others excerpted from the information.

As shown in Table 4-2, the salaries and wages increased at an annual rate of 20 to 30 % in 1988/89 to 1990/91. As the number of employees did not increase in the period, the increment is attributable to the raise of salaries and wages. The 1988/89 general price and '89/'90 consumers price indexes showed increases of 1.7 times (MFEP data) and 1.68 times (World Bank data) respectively. Taking these figures into account, the pay raise in real terms was relatively small.

The fuel and power rose two times yearly in the three years' period. The operation materials showed a remarkable rate of increase, probably due to the increase of spare parts prices. The repair and maintenance were unaffected by the spare parts price increases, as the most of them were labor cost.

Table 4-1 Budget of NUWC's Metropolitan Water Supply Service

(unit: million LS)

Item	1988/89	1989/90	1990/91
Revenues			
Water Sale	36.8	92.7	215.2
Miscellaneous	1.4	3.3	3.5
Total	38.2	96.0	218.7
Expenditures			
Production Cost	21.6	26.3	38.3
Distribution Cost	28.6	33.1	35.0
Administration Cost	12.4	27.1	21.5
Interest, etc.	10.0	11.8	10.6
Sub-total	72.6	98.3	105.4
Net Surplus*	-34.4	-2.3	113.3
Total	38.2	96.0	218.7

Source : NUWC (Management and Administration Department)

Note : Net Surplus* is a reserve for repayment of borrowings.

Table 4-2 Major Budget Items

(unit: million LS)

Item	1988/89	1989/90	1990/91
Salaries and wages (a)	24.3	31.3	36.7
Fuel and power	1.0	1.7	3.5
Operation materials (b)	0.5	4.1	35.0
Repair and Maintenance	6.5	13.1	6.7
Total (c)	32.3	50.2	81.9
Revenues (Table 4-1) (d)	38.2	96.0	218.7
(a)/(d) %	63.6	32.6	16.8
(b)/(d) %	1.3	4.3	16.0
(c)/(d) %	84.6	52.3	37.7

In the table, the ratio of total expenditures to income, (c)/(d), decreased from 85 % in 1988/89 to 50 % in 1989/90 and to 40 % in 1990/91. It is attributed to the revision of water rate in November 1989.

As seen in Table 4-1, the water supply management in the Metropolitan Area has been released from red figures and, as described in Section 2.3.2 "Budget and Finance", the NUWC could set aside a budgetary reserve for repayment of borrowings from the government.

The water tariff revision in November 1989 was a drastic raise, 2.5 - 3.0 times for the domestic use and 4.6 times for the commercial/industrial uses. As the result, the revenue from water tariff for 1990/91 will show a remarkable increase to enable repayment of the borrowings from the government. In addition to the revenue increase due to revised water tariff, increase of the revenue following the implementation of the Project is foreseeable and the budget will turn into the black in the future.

While the average monthly income of those families living in second class residences is estimated at LS 3,000, the payment of water tariff will amount to about LS 92 on the basis of an assumed average water consumption of 36 m^3/month. The payment, equivalent to 3 % of the income, is lower than 4-5 % which is thought to be well affordable for average citizens.

4.2.3 Similar Projects and Participation or Involvement with Other Donor Countries

As mentioned in Section 2.3.5, the on-going projects by the NUWC have been planned and executed on the basis of the Khartoum Area Water Supply Project (established in 1979). The projects and donor countries are listed in Table 4-3.

Among the projects listed in Table 4-3, those related with this Project will be mentioned below.

a) Khartoum North WTP (Phases III & IV) Construction Project

Following the completion of the Khartoum North WTP (Phases I & II, design capacity: 36,000 m^3/day x 2 phases = 72,000 m^3/day), for which survey started in 1982, the construction of Phases III & IV (design capacity: 54,000 m^3/day x 2 phases = 108,000 m^3/day) have been put in execution and is expected to be completed by the end of 1992. The treatment equipment and machinery are being procured with the aid (loans) by the Czechoslovakian Government and the construction works of the treatment plant are financed by local funds.

b) Transmission Pipeline Project

This project will install a transmission pipeline with SP procured under the Czechoslovakian aid (loan) mentioned above to transmit 62,400 m^3/day of the treated water from the Khartoum North WTP to the Khartoum South DPS. Of the materials for the pipeline, those of diameter 600 mm

TABLE - 4.3 NUWC ONGOING AND PLANNED PROJECT IN KHARTOUM METROPOLITAN AREA

1. Mogren WTP Extension	Capacity 18,000 m3/day including One Clariflocculator Four Rapid Sand Filters Intake Facilities (Including Burri Intake)	1992	-Equipment from Italian Grant Aid Program -Construction, Local Fund
2. Rehabilitation of WTP's (Mogren WTP, Burri WTP)	Mogren WTP Raw Water Pumps, Low Lift Pumps, High Lift Pumps Burri WTP Raw Water Pumps, Low Lift Pumps, High Lift Pumps	1992	-Equipment from Italian Grant Aid Program -Installation by local Fund
3. Khartoum North WTP (Phase III & Phase IV)	Two Clariflocculators Eight Rapid Sand Filters Two Service Reservoirs Raw Water Intake, Intake Pumping Station	1992	-Equipment from Czechoslovakian Loans -Construction by Local Fund
4. Other Extension and Improvement Projects in Khartoum			
1) Khartoum South DPS	Two Service Reservoirs Five Distribution Pumps Distribution Pumping Station One Elevated Reservoir	1992	-Equipment from Czechoslovakian Loans -Construction by Local Fund
2) Central Khartoum Network Rehabilitation	FRP (Fiberglass Reinforced Plastic Pipe) ϕ 250 - 600 mm x 21 km	1993	-FRP Italian Grant -Installation by Local Fund
3) Transmission Pipeline from Khartoum North WTP to Khartoum South DPS	SP (Steel Pipe) ϕ 700 mm x 9.3 km ϕ 600 mm x 4.5 km ϕ 500 mm x 2.5 km		-Pipe material from Czecho. Loans -Installation by Local Fund (Direct Force by NUWC)
4) Distribution Pipeline	ACP (Asbestos Cement Pipe) ϕ 100 mm x 100 km (3 areas) ϕ 150 mm x 40 km (3 areas) ϕ 200 mm x 12 km (Khartoum North, Khartoum) ϕ 300 mm x 16 km (Khartoum North) ϕ 600 mm x 8 km (Omdurman)	1991	-Local Fund
5) Deep Wells (50 Nos.)	For 3 areas (As of 1990, 24 out of 50 wells are completed)	1992	-Local Fund
6) Khartoum North DPS	Reservoir, Pumping Station, Elevated Tank	Planning	-Equipment from Czechoslovakian Loans -Construction by Local Fund
5. New Khartoum WTP	Capacity 300,000 m3/day including Intake, Treatment Plant & Distribution Facilities	Planning	-Under Request

extending 4.5 km, diameter 500 mm extending 2.5 km have already arrived and stored in the materials yards in Khartoum. The NUWC is planning to procure the rest of necessary pipe materials of 700 mm in diameter extending 9.3 km at the earliest time possible and complete the pipeline installation by the end of 1992 as the target.

c) Khartoum South DPS Project

This pumping station will receive the treated water of 62,400 m^3/day sent from the Khartoum North WTP via the above transmission pipeline. The materials and equipment including pumps for its construction will as well as the above two projects be procured by the Czechoslovakian Government aid (loan), while construction for reservoirs, elevated tanks and the pumping station will be financed with local funds. Completion is targeted at the end of 1992.

d) Central Khartoum Network Rehabilitation Project

The distribution pipe network in the northern part of the Khartoum Area facing the Blue Nile will be extended and improved with distribution pipe (FRP, 250 mm - 600 mm in diameter, total extension: 21 km) provided by the Italian Government grant aid. Construction is expected to take two years, to be finished in 1993.

e) Mogren WTP Extension and Improvement Project

This project will rehabilitate the existing pumps and install new pumping facilities by the Italian Government grant aid. The target year of completion is 1992. This Project also covers the on-going extension of the plant (design capacity: 18,000 m^3/day), for which materials and equipment are being provided by the Italian Government grant aid.

f) Burri WTP Improvement Project

As in the case of the above the Mogren WTP Extension and Improvement Project, this project aims at installation of a new intake pump and extension of distribution pumping facilities with the Italian Government grant aid. The target year of completion is 1992 as in the case of the Mogren WTP Extension and Improvement Project.

The installation of the distribution pipeline under the project will not duplicate any of the on-going or already planned project of the NUWC.

The pipeline to be installed by the current project will be connected with the main distribution pipeline (diameter 600 mm) from the Mogren WTP on one hand and, with the end of the

distribution pipeline (diameter 400 mm, connected with the gate valve) to be installed by the current project on the other hand, with the result that the connected pipelines will help formulate a distribution pipeline network in the Khartoum Area.

4.2.4 Study of the Project Components

The Project requested by the Sudanese Government is a pipeline work to be laid along the main roads in the southern part of the Khartoum Area, to improve the level of distribution in the area, especially of the southern part. Water treated at the Khartoum North WTP will be transmitted to the Khartoum South DPS, then distributed to the area by the pipelines (25.7 km long) to be constructed in the Project.

As the flow capacity of existing pipelines is very small for the required flow, water pressure in almost all locations in the southern part of the Khartoum Area is observed to be about 0 to 2 m as shown in Fig.3-4. When pipelines are laid as planned in Fig.4-3, the service level will be greatly improved.

To cope with the situation, the Project intends to supply water northward to the southern Khartoum Area, from the Khartoum South DPS, presently under construction in the area, to improve the service level and stabilize water supply for living. The water for this purpose, 62,400 m^3/day, will be produced by the increase of production capacity of the Khartoum North WTP. In planning the distribution pipeline, technical feasibility of distributing water by the existing WTP and the Khartoum South DPS has been examined. As shown by the pipeline network computation in Chapter 5, the pipeline diameter was proved to satisfy the condition.

The field survey and the assessment of the machines and materials have proved the pipelaying works requested by the Sudanese Government, as outlined in Table 4-4, to be appropriate. The difference between the amounts of some items, as requested and as assessed, is attributed to the reasons mentioned in item a) below:

Table 4-4 Comparison of the Requested and the Assessed

Item	Amounts Requested	Amounts Assessed
A. Distribution Pipe Works (Material and Installation)		
DIP Ø 700 mm	- km	0.2 km
DIP Ø 500 mm	1.7 km	1.8 km
DIP Ø 400 mm	4.6 km	4.6 km
DIP Ø 250 mm	15.8 km	14.8 km
DIP Ø 200 mm	3.1 km	4.3 km
Total	25.2 km	25.7 km
B. Procurement of Machines, Materials		
Construction Machines and Spare Parts		
Backhoe (0.6-0.7 m^3)	1 unit	1 unit
Backhoe (0.35 m^3 with blade)	1 unit	1 unit
Pickup (double cabin)	1 unit	1 unit
Roofing Materials for Reservoirs (corrugated aluminum, with auxiliaries)	3,600 m^2	3,600 m^2
Building Materials for Warehouse (prefabricated colored steel with installation parts and auxiliaries)	1,000 m^2	1,000 m^2
C. Detailed Design and Construction Supervision		
	complete process	complete process

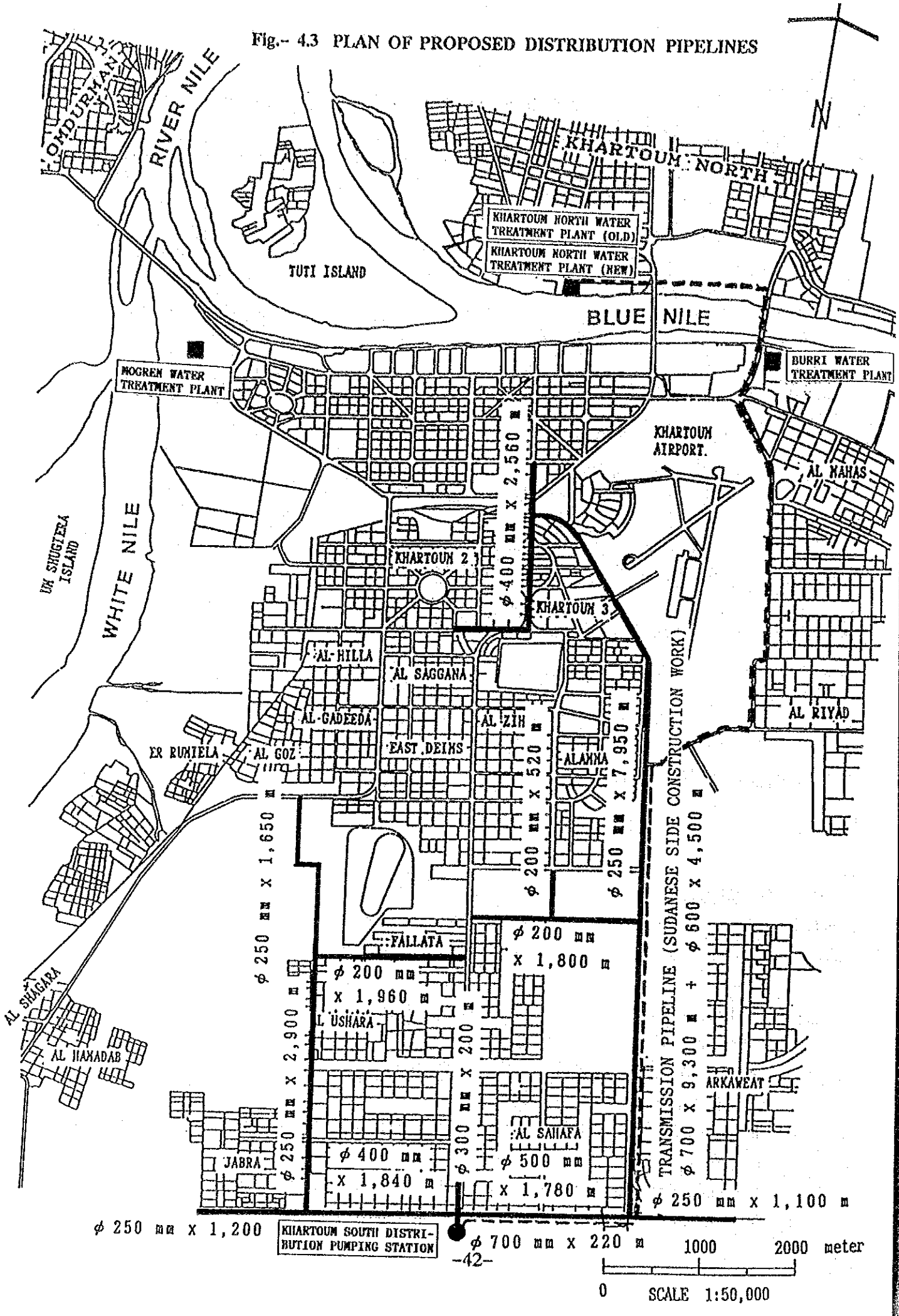
a) Distribution Pipelines

1) Pipeline Route

Based on the field survey and hydraulic analysis, the pipeline route of the Project has been selected as shown in Fig.4-3, partly modified from the requested route shown in Fig.2-1. In making the selection, the following factors have been studied:

- the distribution network composed by the existing and newly installed pipelines shall be organized rationally,
- the existing pipelines shall be utilized effectively,
- the pipelaying shall be worked easily,
- the works for joining the existing and newly installed pipelines shall be made with less difficulties,
- the pipelaying works shall cause least adverse effects on the traffic and the people's daily life.

Fig.- 4.3 PLAN OF PROPOSED DISTRIBUTION PIPELINES



2) Additional Pipeline Route

As to a pipe route of 0.2 km from the Khartoum South DPS to the pipe network in the Khartoum Area, the NUWC originally intended to install ACP (diameter 700 mm, for low pressure use). As ACP has however been found weak in its physical strength, DIP has been proposed to be utilized for this route as discussed in Item c) of Section 5.3.1. Because of the difficulty of procuring DIP by the Sudanese Government, this pipe route of 0.2 km with DIP has been included in the present Project in accordance with the discussion held with NUWC representatives during the field activity.

b) Construction Machines and Materials

1) Construction Machines

The machines procured and provided by the previous Omdurman Area Water Supply Project under the Japanese grant aid to the Sudanese Government are as follows:

Classification/Specifications/Capacity	Quantity (Nos.)
Backhoe (0.6 m^3)	2
Breaker, oil pressure driving	2
Truck Crane (16 ton)	1
Truck Crane (10 ton)	1
Tractor Shovel (1.0 m^3)	2
Dump Truck (11 ton)	2
Cargo Truck (8 ton)	1
Truck with Crane, oil pressure driving (4 ton)	2
Pickup Truck (1 ton)	4
Station Wagon	1

The construction machines listed above are being used for the pipeline extension works in the whole Metropolitan Area being executed by the NUWC's own budget, and are planned to be used for such pipelines as a transmission pipeline (600–700 mm diameter, 13.8 km long) from the Khartoum North WTP to the Khartoum South DPS and a distribution pipeline (250–600 mm diameter, 21.4 km long) of fiber reinforced plastic pipes (FRP) provided already under the Italian Government aid, in the very near future. In comparison with the volume of works, the number of construction machines is judged still insufficient.

The maintenance and operation of distribution pipelines including necessary repairs for leakage and breakage of pipes is one of the important programs for NUWC to conduct routinely. The existing pipeline system, connected with the pipeline to be newly installed under the Project, is consisted of ACP and continuous and close control of the pipeline would be required due to

physical nature of the pipe materials, as stated in Section 4.3.4. For such maintenance, machinery and equipment to be procured under the present Project will be of vital importance and be utilized fully for routine maintenance of pipelines including their repairs for leaks and breakages.

Considering future maintenance programs of distribution systems in the Khartoum Area and also construction works of this Project, construction machinery of the following items is to be procured:

Classification/Specifications/Capacity	Quantity (Nos.)
Backhoe (0.6–0.7 m^3)	1
Backhoe (0.35 m^3 with blade)	1
Pickup Truck (Double Cabin)	1

2) Construction Materials

Construction of the reservoir is under way in compliance of the Sudanese government's standard design and the roofing materials are used for protecting treated water stored in the reservoir from pollution.

Requested are two items, namely 3,600 m^2 reservoir roofing materials and 1,000 m^2 warehouse building materials. Of the reservoir under construction, the roof is planned under the Sudanese Government's standard which sets a design of roofing with corrugated aluminum member. Structurally, the materials are the same as those used for the previous Omdurman project, and considering the interchangeability for repair work, materials of the same standard were selected. They will be used at the site of the Khartoum South DPS, with installation charged by the NUWC.

At present the NUWC has storage yards but no roofed warehouses. A roofed warehouse is required to store spare parts, materials for repairing pipe, rubber rings, etc. protecting them from exposure to the sun, the rain and the air. The procured materials are to be used for building a roofed warehouse. While the warehouse will be used for storing the mentioned materials for repair and suchlikes, a part of the space may be utilized as a place for the use of repairing construction machines. Similarly to the case of the roofing materials for reservoirs, the NUWC will make the installation works on its own at a neighboring site of the Khartoum South DPS.

4.2.5 Basic Principles for Implementation

Regarding implementation of the Project, expected benefits, possibility of realization and executive capability of the counterpart have been justified, as described heretofore. Also, the benefits coincide with the objectives of grant aid projects. Accordingly, a basic design will be

made as outlined in the following section, based on the premise that the Project be implemented under Japanese Government's grant aid program. However, a part of the requested components will be modified appropriately as reasoned in Section 4.2.4.

4.3 Outline of the Project

4.3.1 Executing Agency and Implementation System

The completed distribution pipeline facilities are taken over by the Construction Section, the National Projects Management Department and maintained by the Khartoum Area Office.

Of the procured machines and materials, construction machines and vehicles are overhauled, inspected and handed over to the Operation and Maintenance Department, after completion of the Project. They are operated and maintained by the Machinery Section of the department.

The roofing materials for reservoirs and building materials for warehouse are handled by the Sudanese side, for management, installation, assemblage and construction. The administration of materials and construction works are undertaken by the National Projects Management Department.

4.3.2 Location and Conditions of the Project Site

a) Location and Conditions of the Pipeline Route

The distribution pipeline's site is a flat land at 381–382 meters elevation above the sea level. The geology is a mixture of sand and clay with dispersed weathered soft rock. Groundwater table stands lower than 10 meters below the ground surface and groundwater does not affect excavation of the pipeline trench, 2 to 3 meters deep.

Conditions of the public roads along which the pipeline route is planned are relatively good, because the northern service area is used by commercial shops and governmental and private offices. They are generally paved. Footpath is also paved mostly by wood plates. In the southern service area, the pavement gradually narrows, while on each side of the road, a certain width of land including unpaved shoulder is secured for future expansion of the road. In the northern area, 8–12 meters wide paved roads with 3–5 meters wide footpaths on both sides are generally seen, and in the southern area, some roads have 6–10 meters wide paved strips with 5– 15 meters wide footpaths or expansion zones.

b) Infrastructure at the Site (Telephone, Power, Sewer, etc.)

Telephone lines are ruled to be laid at 0.9 meters depth, 1.5 meters apart from the properties' border or buildings' walls, but depending on the conditions of roads, nearby housings, obstacles and underground structures, the rule is not always strictly observed. As another rule, telephone lines are to be buried, on the eastern side of the North to South roads and on the northern side of the East to West roads, but in the northern area where a large number of telephone lines are used by shops, government and private offices and high-class residents, telephone lines are laid on both sides of the roads.

Power lines are either overhead or underground. The underground line is ruled to be laid at 0.9 meters depth, 1.0 meter apart from the properties border. However, as in the case of telephone line, power lines are laid in positions differing from the rule according to surrounding conditions.

At some locations, brick or stone-made box culverts are laid under the footpath. Pressure sewer pipelines are laid at 4 to 6 meters depth, but except for newly laid pipelines, their route cannot be identified due to lack of information.

c) Conditions of the Site for Installation of Procured Materials

Roofing Materials for Reservoirs :

The reservoirs (design capacity 6,600 m^3 x 2 Nos.) are now under construction at the Khartoum South DPS site, to be completed by the end of this year. The materials will be roofed on the top of concrete walls. The materials are specified as 7.0 meters span corrugated aluminum plate, 3,600 m^2 in total.

Building Materials for a Warehouse :

Prefabricated materials will be assembled to form the building at a corner of a site, 140 meters by 130 meters rectangular space, adjacent to the Khartoum South DPS. The materials will cover 1,000 m^2 floor space.

4.3.3 Outline of Facilities and Materials

For the mentioned reasons, the pipeline materials, machines, roofing and building materials will be procured as follows:

Table 4-5 Materials for Pipelines, Roofing and Building

Item	Amounts
A. Distribution Pipe Works	
DIP Ø 700 mm	0.2 km
DIP Ø 500 mm	1.8 km
DIP Ø 400 mm	4.6 km
DIP Ø 250 mm	14.8 km
DIP Ø 200 mm	4.3 km
Total	25.7 km
B. Procurement of Machines, Materials	
Construction Machines and Spare Parts	
Backhoe (0.6-0.7 m^3)	1 unit
Backhoe (0.35 m^3 with blade)	1 unit
Pickup (double cabin)	1 unit
Roofing Materials for Reservoirs (corrugated aluminum, with auxiliaries)	3,600 m^2
Building Materials for Warehouse (prefabricated colored steel with installation parts and auxiliaries)	1,000 m^2

4.3.4 Maintenance Plan

The facilities will be maintained by the Khartoum Area Office, assisted by the National Capital Administration Department. The organization and the number of staff members of the Office are shown in Fig.4-2.

The distribution pipelines in the Khartoum Area will be about 770 km in total length and is made of ACP for about 680 km, 90 % of the total, and of CIP for about 90 km long, 10 %.

ACP, inferior in the physical strength and durability to CIP, will cause leakage more frequently due to land subsidence, traffic load and aging.

According to the Japanese records, leakage of distribution pipelines made of ACP are estimated to occur 250 – 300 times annually. Of the frequency, about 80 % occurs from pipes and the rest 20 % from the auxiliaries like gate valves, air release valves and hydrants.

Leakage ratio of the existing cast iron pipelines in the Khartoum Area is assumed at about 10 % of the above figure, estimating from the length of the cast iron pipelines in the area.

The maintenance and administration of the new distribution pipelines together with the existing ones will be charged chiefly by the Distribution Section and System Improvement Section. The staff members in the two Sections numbering 290 and 40 respectively, are judged sufficient in carrying out their charges.

To make the maintenance charges easier, use of DIP has been recommended for the distribution pipelines in the Project and, therefore, the frequency of breakage and consequent necessity of repair will be ignorable compared with existing asbestos cement pipelines.

The repair and maintenance expenditures in 1988/89, 1989/90 and 1990/91 for the distribution facilities in the Metropolitan Khartoum are shown in the table below. Except for 1989/90, the ratio of repair/maintenance expenditure to the total remained at about 3 %. The 1989/90 figure therefore was extraordinary, because it included a large amount of expenses for repairing distribution pumps.

Table 4-6 Repair and Maintenance Expenditures

Item	1988/89	1989/90	1990/91
(A) Repair/Maintenance Expenditure (LS 1000)	2,321	9,187	3,500
(B) Total Expenditure (LS 1000)	72,591	98,311	105,415
(C) (A)/(B) Ratio (%)	3.1	9.3	3.3

Presently, the total length of distribution pipelines in the Khartoum Area amounts to about 770 km. The pipelines' length to be constructed under the Project, about 26 km, is therefore approximately 3.3 % of their total length.

As described before, the ductile iron pipelines under the current project will cause accidents including leakage less frequently compared with asbestos cement pipelines, and the repair/maintenance expenses will therefore not exceed the present percentage level in the budget.

The warehouse will be built at an existing storage yard of materials, neighboring the Khartoum South DPS. Operation and maintenance after completion will be charged by the Khartoum Area Office staff transferred from other assignments.

CHAPTER 5 BASIC DESIGN

5.1 Principle of Design

In making the basic design, such factors as the natural and social conditions, various aspects of the Sudan's construction industry, existing water supply facilities, conditions of their status of maintenance, etc. will be taken into consideration so as to make it suitable to these factors.

5.1.1 Consideration on Natural Conditions

The climate in the Khartoum Area is generally hot and dry. Especially in the season from April to June, temperature higher than 50 °C is not rare. In the wet season from July to September, rain falls to some amount, but it would not necessitate frequent drainage for the construction works. The earth in the area is an alternate strata of clay, silt and gravel layers, about 20 meters thick. As the groundwater table is assumed at 12 to 15 meters below the surface, spring water will cause few problems to the pipeline construction.

5.1.2 Consideration on Social Conditions

In the recent years, migration of people to Khartoum from neighboring areas and drought areas has risen rapidly, causing accelerated shortage of water for living. Furthermore, due to obsolete facilities and shortage of fuel, electric power supply fails almost throughout the daytime. However, the power supply to the water supply facilities is relatively stable, because of the importance of water supply. Nevertheless, in case of electric power failure, water treatment and distribution are forced to be suspended due to the lack of standby power sources. The obsoleteness and capacity shortage of the water production and distribution facilities are worsening the water shortage.

Improvement of sanitary environments and promotion of economic activities by improving water supply through implementation of this Project is definitely urgent.

5.1.3 Utilization of Local Contractors and Locally-produced Materials

Concurrent construction of the Khartoum North (New) WTP and related pipelines is making the scarcity of contractors severer and supply of skilled laborers tighter. To remedy the situation, pipeline construction projects will be needed as for the purpose of training laborers on-the-job as well.

Of imported construction materials (cement, steel reinforcing bar, asphalt, steel and others), price hike and shortage have become noticeable since August 1990 and the procurement of materials of homogeneous quality in the general market is becoming difficult. Locally-produced

materials (sand, gravel, brick and others) on the other hand are procurable with relative easiness. In installing distribution pipelines under the Project, changes in the method of work are recommended. For example, use of mass cement must be reconsidered. In designing the structure of various valves' chamber, use of brick is recommended wherever possible.

5.1.4 Maintenance

In designing, the first consideration must be given to the easiness of repair and maintenance of facilities by the NUWC's technical staff. Public water taps will be provided in the low-income people's residential areas, for the convenience of accessibility to water and, water taps for the water vendors will be facilitated as they transport water to the people living in remote areas. In the commercial/industrial and residential areas, fire hydrants will be installed to supply water for fire-fighting. The water taps and hydrants shall comply with the NUWC standard design for the convenience of maintenance.

5.1.5 Construction Period

Considering the works volume of the Project, it is obviously difficult to carry out within a single year all the processes. The whole Project will be phased into two parts, as described later.

5.2 Conditions for Basic Design

5.2.1 Service Area and Served Population

The service area subject to the Project is about 100 km^2 wide. The served population, receiving water directly from the service facilities in the area including those people living in the neighboring area and depending on the facilities by some means (water drawn at public hydrants and transported by donkeys, etc.) is estimated at about 600,000 in total.

5.2.2 Water Supply and Water Demand

According to 1990 NUWC data, water supplied to the service area is 83,000 m^3/day on average in the total, comprising 48,000 m^3/day from the Mogren WTP, 16,000 m^3/day from the Burri WTP and 19,000 m^3/day from deep wells. When the total supply is divided by the served population, the per capita supply is calculated to be 140 liters per day.

Mogren WTP	48,000 m^3/day
Burri WTP	16,000 m^3/day
Deep Wells	19,000 m^3/day
Total	83,000 m^3/day