BASIC DESIGN STUDY REPORT
ON
THE MOGADISHU WATER SUPPLY IMPROVEMENT PROJECT
IN
SOMALI DEMOCRATIC REPUBLIC

JUNE 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Somali Democratic Republic, the Government of Japan decided to conduct a Basic Design Study on the Mogadishu Water Supply Improvement Project and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Somalia a study team headed by Mr. Sadao Aihara, Sub-Chief, Construction Section, Water Works Bureau, City of Sapporo from February 14 to March 8, 1985.

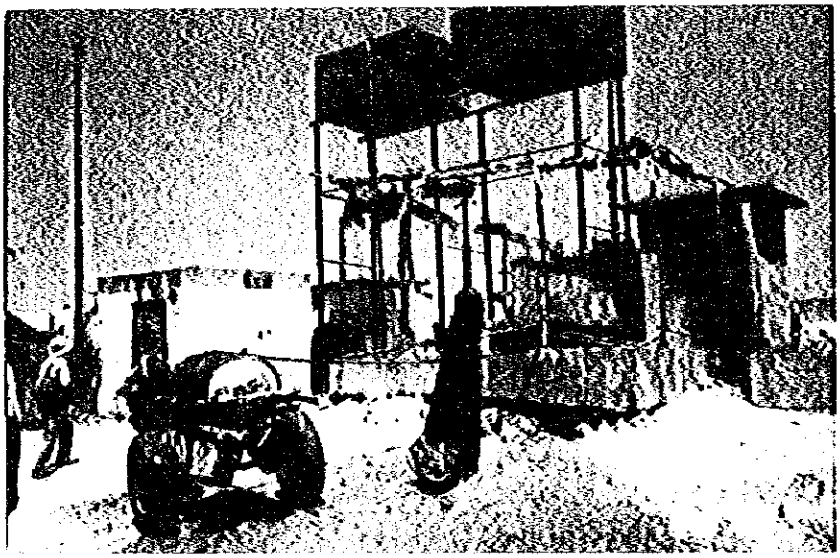
The team had discussions on the project with the officials concerned of the Government of Somali Democratic Republic and conducted a field survey in Mogadishu area in Somalia. After the team returned to Japan, further studies were made and the present report has been prepared.

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

I wish to express my deep appreciation to the officials concerned of the Government of the Somali Democratic Republic for their close cooperation extended to the team.

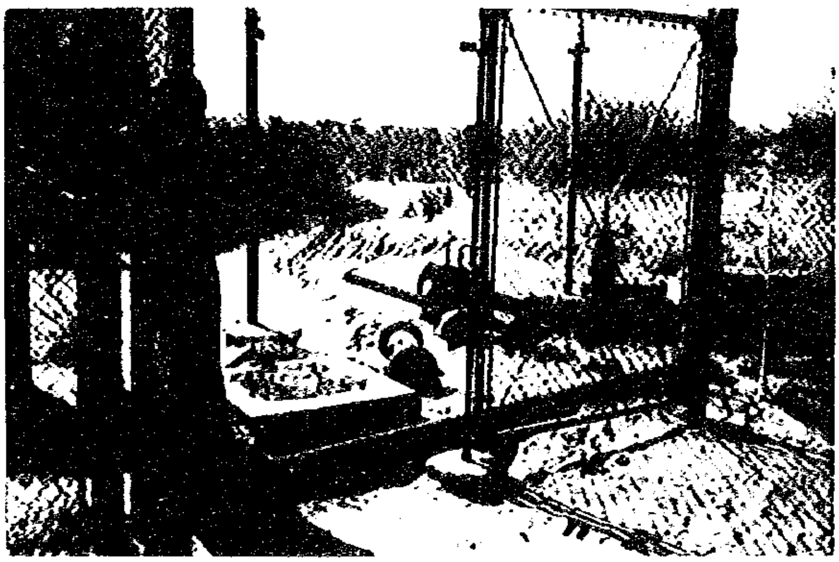
June, 1985

Keisuke Arita
President
Japan International Cooperation Agency



An ass-cart receiving water supply from a common water faucet and going out for selling the water

Water level measurement of a well (15B)



A well becoming unserviceable for water intake and left alone

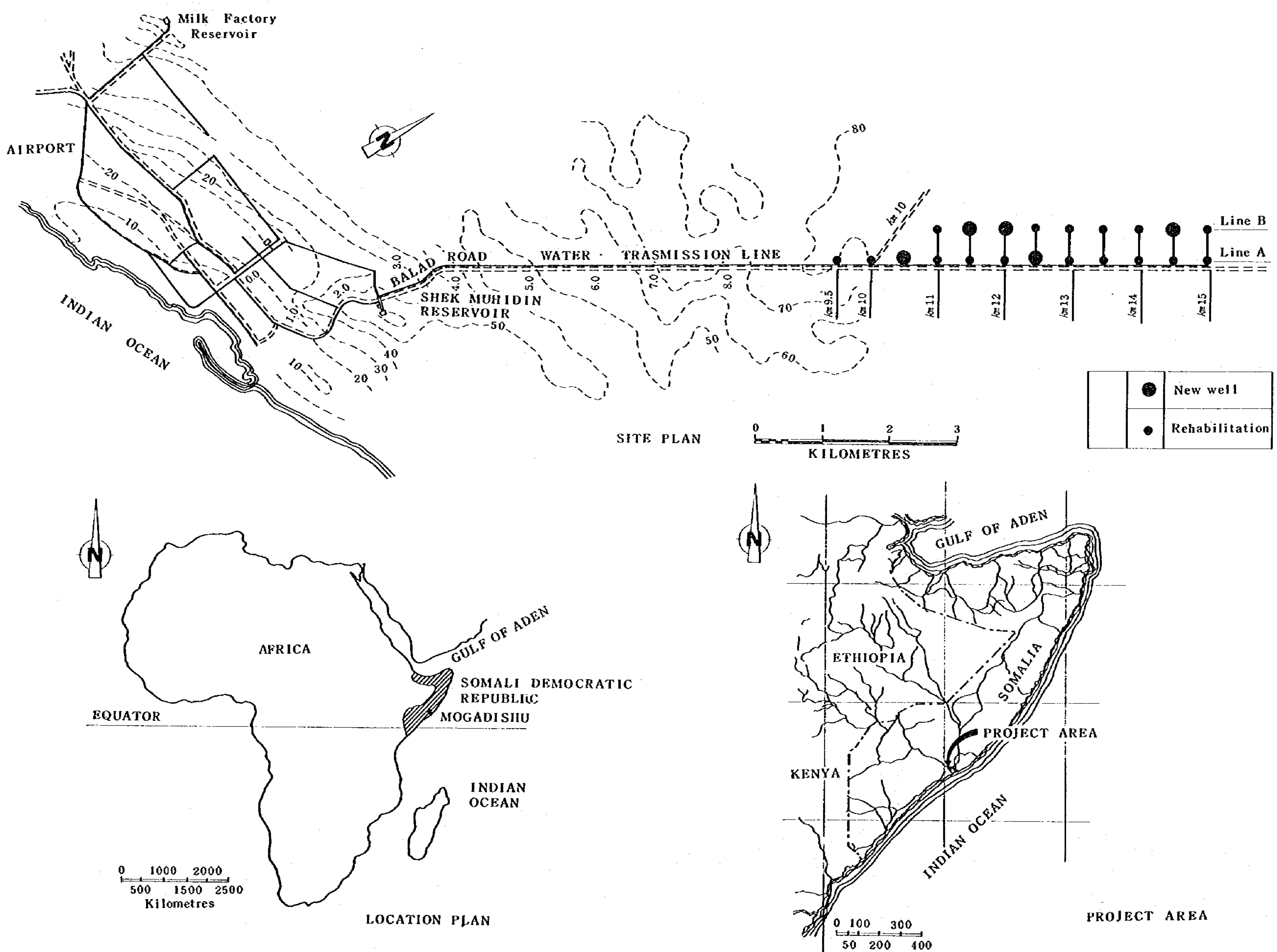


Fig.1 LOCATION MAP

Summary

Mogadishu City, the capital of the Somali Democratic Republic, has shown rapid population increases in recent years. The population, which was 440,000 in 1976, is estimated to reach 1,000,000 in 1987, and it has become an urgent problem to consolidate the infrastructures of the same city. The Government of Somali has planned and is implementing the living water development plan as the top priority project, and regarding the rehabilitation of the existing wells, which is to be undertaken as a matter of special urgency, the same government submitted a request to the Government of Japan for economic cooperation in grant form.

In response to this request, the Government of Japan carried out the basic design study through the Japan International Cooperation Agency (JICA).

At present, the living water in Mogadishu is supplied from three places, the water source in the city, Balad water source and Afgoi water source. The water source in the city is just before it is to be discussed owing to the deterioration of the facilities and the degradation of the water quality. The Balad water source has been decreased in its water production rate year by year as compared with the planned value at the beginning owing to the deterioration of the facilities and the low capabilities of maintenance, and at present, it produces water only at below a half of the planned capacity. The Afgoi water source is now under construction and its water supply was partially started. In 1986, all works will be completed and full operation is expected to be started. However, even if the Afgoi water source is completed, it will be impossible to supply the entire living water necessary for Mogadishu unless the Balad water source is rehabilitated to produce the planned water volume at the beginning of construction, and it will still be impossible to resolve away the chronic water shortage in Mogadishu. Therefore, it is necessary to promptly execute the rehabilitation work for boosting the pumping rate of the Balad water source up to the planned value.

The objective of this study is to clarify the causes for the decreased water production rate of the Balad water source by conducting field surveys, and then to plan the rehabilitation project, and consider how to carry out the aid by the Japanese Government for implementing the project. The overall scheme for setting up the rehabilitation project is as follows.

① Planned target year	1987
② Planned water supply population	1,000,000 persons
③ Planned water supply rate	70ℓ/day/person
④ Planned pumping rate	70,000 m^3/day
Afgoi water source	42,000 m^3/day
Balad water source	28,000 m^3/day

The rehabilitation works necessary for securing the Balad water source's pumping rate of 28,000 m^3/day are as follows.

① To execute the rehabilitation works on the 16 existing wells at the Balad Wellfield, of which the pumping rate can be expected to be recovered.

② To construct five new wells for making up the pumping rate shortage after completion of the rehabilitation works.

③ To secure maintenance equipment and materials necessary for continued production, without lowering, of the pumping rate intended, by the execution of the rehabilitation works of the existing wells and installation works of new wells at the Balad water source.

5. The contents of the works are as follows.

Name of work	Contents of work	Necessary equipment and materials	
Rehabilitation works of the existing wells	For the 16 existing wells, the well bodies will be cleaned by sand removal, acid treatment, etc. and then, the component parts of the deteriorated pumps, pipings, etc., which have caused the pumping	Materials	
		Turbine pumps	16 sets
		Pipings around pumps	16 sets
		Fences	16 sets
		Well refreshing solution	4.6t
		Other consumables	1 set

Name of work	Contents of work	Necessary equipment and materials
	rate to be decreased, must be replaced to secure the pumping rate of 19,200 m^3/d.	Machines Well rehabilitation machine 1 unit Pump-out test equipment 1 set
Installation works of new wells	Wells with an outside diameter of 450 mm and depth 150m will be dug, the water intake position will be determined by electric prospecting, and casing strainers will be installed, then well cleaning and pump-out test will be conducted, production pumps will be set, and the pumping rate will be checked. By five wells constructed, the pumping rate of 8,800 m^3/day will be ensured.	Materials Well body (ϕ250, ℓ=150m) 5 wells Submerged pump (45 kW) 5 sets Pipings around pumps 5 sets Generator (250 kVA) 1 unit Transformer (75 kVA) 5 units High-voltage wiring 22 mm^2 1,590m Low-voltage wiring 32 mm^2 300m Electric pole ℓ=12.5m 1 set Mercury lamp (100W) 5 sets Fence 5 sets Bentonite, etc. consumables 1 set Machines Well digger 1 unit muddy water machine, tooling
Arrangement of the machines for maintenance and management	All the machines used for well rehabilitation work and installation works of new wells can also be used for maintenance purpose. In addition, it is judged that some work shop machines, electeical tooling and working vehicles will be necessary.	Machines Work shop machine 1 set Electrical tooling 1 set Vehicle 6 units

By the implementation of this project, it will become possible to supply safe potable water stably to the people in Mogadishu.

CONTENTS

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

Mogadishu City, the capital of the Somali Democratic Republic, has shown rapid population increases in recent years. The population, which was 440,000 in 1976, is estimated to reach 1,000,000 in 1987, and it has become an urgent problem to consolidate the infrastructures of the same city. The Somali Government has planned and is implementing the living water development plan as the top priority project, and regarding the rehabilitation of the existing wells which is to be undertaken as a matter of special urgency, the same Government submitted a request to the Government of Japan for economic cooperation in grant form.

In response to this request, the Government of Japan decided to carry out a basic design study and sent the basic design study team headed by Mr. Sadao Aihara (Sub-Chief, Construction Section, Water Works Bureau, City of Sapporo) from February 14 to March 8, 1985.

The study team, after discussions with the relevant authorities of Somalia, conducted the following field survey for establishing the water supply facility improvement project by ① actual state grasping and future prediction of water demand and supply volume and ② surveys and diagnoses on the deteriorated degree of the existing facilities.

① Field survey
- * Survey of water supply conditions in Mogadishu City
- * Survey of work progress conditions at the Afgoi Wellfield
- * Survey of the condition of the existing water supply facilities at the Balad Wellfield

② Field test
- * Water quality test
- * Exploration of ground water level
- * Pump-out test
- * Study on the deteriorated degree of each facility

③ Collection of data necessary for the preparation of the basic design study report

④ Discussions with the relevant authorities of Somalia on the project formulating policies

CHAPTER 2

BACKGROUND OF THE PROJECT

2.1 Outlines of Somalia

2.1.1 General Features

Name of the country:	Somali Democratic Republic
Capital :	Mogadishu
Location :	The Somali Democratic Republic is located in the north-eastern part of the African Continent ranging from 2° south latitude to 12° north latitude and facing the Gulf of Aden and the Indian Ocean. The country is bound on the north by Jibudi, on the west by Ethiopia and Kenya and on the south by Kenya.
Area :	637,664 km^2 (about 1.8 times the area of Japan) (Farm lands 82,000 km^2 and pasture lands 288,000 km^2)
Population :	About 5,100,000 (1982 estimate) The rate of population growth is 3.1% per year (from 1972 to 1981). The population of Mogadishu, the capital, is about 900,000 (Mogadishu Water Agency estimate).
Racial composition :	Somali (Cushitic)
Language :	Official ... Somali language Others ..... Arabic and English (The Somali language as the mother tongue was Romanized in 1972, and legal, official documents, etc. are prepared in this style, but its written language has not yet been completed.)
Religion :	Islamite (mainly Sunnite) --- over 95%
Government system :	Republic (One-party government of the Somali Revolutionary Socialist Party (SRSP))

Member country of : United Nations (UN), Organization of African Unity (OAU), Islam Countries' Conference, Arab league, etc.

2.1.2 General Conditions of Industry and Economy

Since 80% of the population depend, in their living, on the traditional stock farming and agriculture, the economy of Somalia is liable to be affected by the meteorological phenomena such as repeated droughts and floods and is basically of weak constitution. It is also featured by shortage of skilled laborers, shortage of raw materials and component parts, unconsolidated infrastructures, shortage of development funds, etc., which are all common to the non-petroleum producing developing countries.

The Government of Somalia, in order to cope with the 4.8% yearly average growth rate of GDP in accordance with the new five-year project (1982 to 1986) started in 1982, has set up the development strategy and public investment programs (1984 to 1986). The same program aims at stabilizing the economy, improving a standard of living, creating the opportunity of employment and constructing the fair and free society.

The Government of Somalia is now performing the economic stabilization program through currency cut-down, price policy, alleviation of importation control, tightening of finance, etc., and recently, the economic condition has been improved to some extent, such as rising of the growth rate, lowering of the inflation rate, etc.

* Currency
  Somali shilling sh. 1 = c. 100
  US $1 = Somali shs. 77.5 (March, 1985)

* Gross national income
  $1,240 million (1981, estimated data of the World Bank)

* Foreign currency reserve
  $14 million (1982, IMF data 1983)

* Trade
  Import : $407 million
  Export : $101 million
  Balance : Minus $306 million

Major imports:

Crude oil, construction materials, foods, etc.

Major exports:

Live stock, banana, leather, etc. (IMF data 1984)

* National budget

Total revenue : Somali shs. 4,393 million
(including grants of Somali shs. 1,106 million)

Total expenditure :

Somali shs. 5,576 million (including development expenditures of Somali shs. 2,097 million)

Balance : Minus Somali shs. 1,283 million
(IMF data 1984)

* Major industries

Stock farming: Cow, sheep, goat, camel, etc.
(Livestock export is 80% of the amount of total exports)

Agriculture : Banana, sugar cane, grape fruit, sesame, etc.

Mining : Limestone, meerschaum, sea salt, etc.

2.1.3 Japan-Somalia Relation

Japan recognized Somalia upon its independence in 1960, and at present, the Embassy of Japan in Sudan is also in charge of Somalia. On the other hand, Somalia established its Embassy in Japan in October, 1982.

Beginning with the food assistance in the fiscal year of 1980, the Japan's relation with Somalia for economic and technical cooperation has been in satisfactory progress achieving records of a yen loan of ¥5,200,000,000 (1983) and a grant aid of about ¥3,800,000,000 (up to March, 1984), contributing to the development of Somalia in various fields, such as food assistance, consolidation of electric communication networks as the infrastructure improvement for development purpose, improvement of hospital facilities for improving the sanitary conditions, etc.

2.2 Location and Socio-Economic Conditions of Project Area

The Somali Democratic Republic is located in the north-eastern part of the African Continent ranging from 2° south latitude to 12° north latitude. Facing the Red Sea and the Indian Ocean, it forms coastlines of 3,200 km. Since the north-eastern part of this country protrudes like a horn of a rhinoceros into these two seas, the north-eastern part of this continent around Somalia is called usually "Horn of Africa". This country is bound by Jibudi, Ethiopia and Kenya. (Fig. 1)

The northern part of the country facing the Gulf of Aden consists of coastal areas, high lands with an altitude of 2,153m and sloping areas spreading between both. The north-eastern part consists of dry plateaus with the maximum altitude of 2,215m. The central part consists of sterile areas with an altitude about 584m.

The southern part, in which the Shabeelle River and the Giuba River flow, form the central areas of Somalia where the soil is most fertile, and the farm lands are concentrated there.

The City of Mogadishu in the project area is situated directly under the equator, downstream of the Shabeelle River, at about 3° north latitude and 45° east longitude. As the capital of the Somali Democratic Republic, this city is the social, economic, educational, traffic center of the same country. Its population at present is about 900,000 (MWA data) corresponding to 15% of the total population. The people are Somali for the most part, and speak Arabic and English in addition to the Somali language which is spoken by the majority of the habitants as their mother tongue.

International traffic means available is the international airport (having runways of 2,750m) and the international sea-port (having design depths of 10m). Local traffic means used is cars, and partially asses and camels. All the main roads in the city have been paved, and all the main key roads, Afgoi Road, Balad Road, etc. running out of the city are also paved ones. The roads leading to the Balad Wellfield, where this project is to be implemented, from the airport, the sea-port and the main town areas are in the well paved condition.

Communication media are telephone, telex, radio, etc., and at present, color TV is broadcast for several hours every day. However, the condition of communication is not always good, and it takes considerable labor and time for the liaison to Japan whether by telephone or telex. Between the inside of the city and the Balad Wellfield, as the objective area of this project, telephone service is not available, and an only liaison means is the radio communication with the MWA head office.

2.3 Natural Condition

2.3.1 Climate

The project area is situated in the dry zone. The coastal area is of the high temperature and high humidity type showing average temperature of 27°C and average humidity of 80%, while the inland area is of the high temperaturedry type with decreased humidity.

2.3.2 Precipitation

Mogadishu in the objective study area has the dry season showing no precipitation at all from January to March, the first rainy season showing monthly precipitation about 50 mm, the semi-dry season showing monthly precipitation about 10 mm, and the second rainy season from November to December. (Fig. 2)

According to the precipitation record of Mogadishu, the yearly precipitation for the past 20 years (1964 to 1984) largely varies between 1,138 mm (maximum) and 243 mm (minimum), and in the recent 5 years (1979 to 1984), it is 620.4 mm, 629.7 mm, 520.6 mm, 296.5 mm and 346.5 mm, indicating that the precipitation particularly in these years has decreased likewise in the adjacent countries.

On the other hand, the potential evapotranspiration in the same area is 200 to 400 mm per year, and it can not be expected that the above-mentioned precipitation is enough for recharging the ground water in this area.

2.3.3 Rivers

The Somali Democratic Republic has two large rivers, Shabeelle and Giuba, originating from the Badda mountain of Ethiopia. The two rivers combine with each other downstream of Afgoi and flow into the Indian Ocean.

The area being studied is located on the sea side of the Shabeelle River which goes south along the coastline. The water source for the ground water is the infiltration water of the Shabeelle River. Although the area of this water source in Ethiopia has a yearly precipitation of more than 1,000 mm, the precipitation in the dry season from November to March is small. In the inland of Somalia, the river dries up in January to March, the surface water disappears, and the infiltration water only remains. In March, the water depth begins with about 2m, and in August, September and October, it reaches 4m, and in December, about 2m.

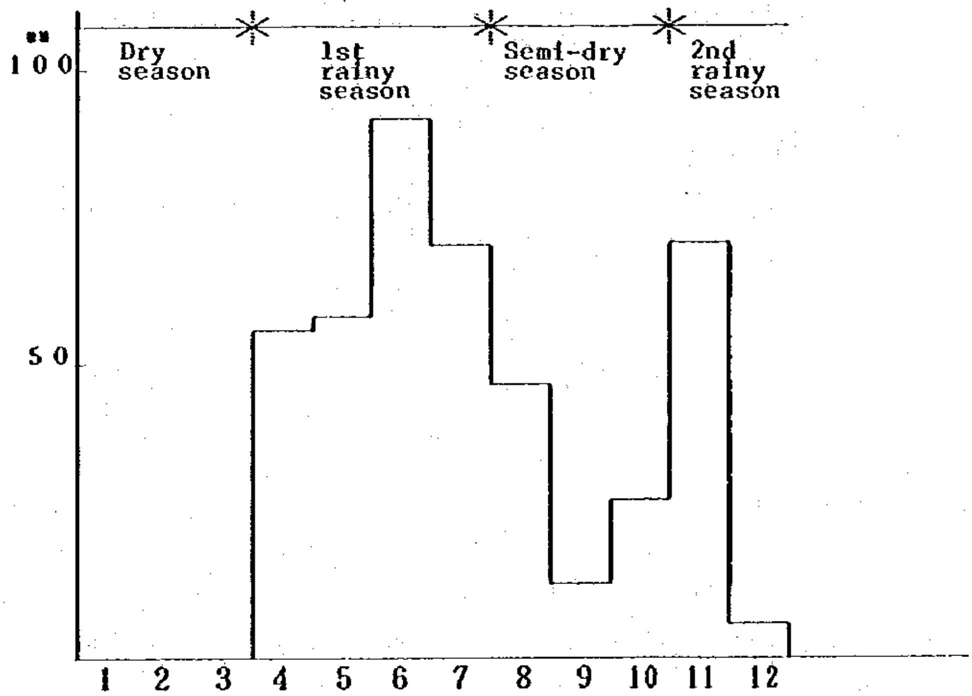


Fig.2 Monthly Mean Precipitation in Mogadishu City for 6 Years from 1979 to 1984

(prepared from the Mogadishu City precipitation record of the Ministry of Agriculture, Early Warning System Development)

2.3.4 General Geological Features

The southern part of Somalia is divided geologically into two provinces, coastal and inland, as shown in Fig. 3.

The coastal province and the inland province are separated by the Banta Gialalassi fault from each other.

The geological structure of the coastal province is as follows.

- Cenozoic
  - Tertiary ------- Tertiary sedimentary rocks (sandstone, clay rock, limestone)
  - Quaternary
    - Diluvial ------ Diluvium (sand, gravel, clay, limestone)
    - Alluvial ------ Alluvium (sand, clay) Aeolian deposits

The geological structure of the inland province is as follows.

Pre-Cambrian --- Old bed rocks such as granites, geniss

Mesozoic {
- Jurassi ------ Sandstone, limestone, doromite
- Cretaceous --- Sandstone, limestone, doromite

Cenozoic Tertiary --- Tertiary sedimentary rocks
(sandstone, limestone, doromite)

The two major rivers Giuba and Shabeelle, originate in Ethiopia and flow southeast in the inland province. In the coastal province, the Giuba River flows in the same direction until it drains into the Indian Ocean at Kismaayo. The Shabeelle River turns to the southeastern direction at about 20 km northeast of Balad. It produces a wet land between Brava and Kismaayo before it combines with the Giuba River.

The Banta Gialalassi fault falls along 4,250m to the coastal side.

The coastal province southwest of Mogadishu is divided into three topographical zones, each of which runs parallel to the coastline.

Coastal belt: An active sand dune zone having maximum altitude 50m and width 2 km.

Banadir coastal plain: A stable zone consisting of reddish brown dune sand having altitude between 30 and 70m and width about 20 km. The highest points of these sand dunes form the part of 12 to 17 km on the inland side.

Shabeelle basin: A flat alluvial flooded plain consisting of blackish clay and silt having width 50 km. On this plain, the Shabeelle River repeats meandering into the wet land.

The alluvial plain around the Shabeelle River spreads 50 km wide between Jowhan and Aw Dheegle in the present meandering zone which is blocked as the south-eastern side boundary of the alluvium, as shown in Fig. 3.

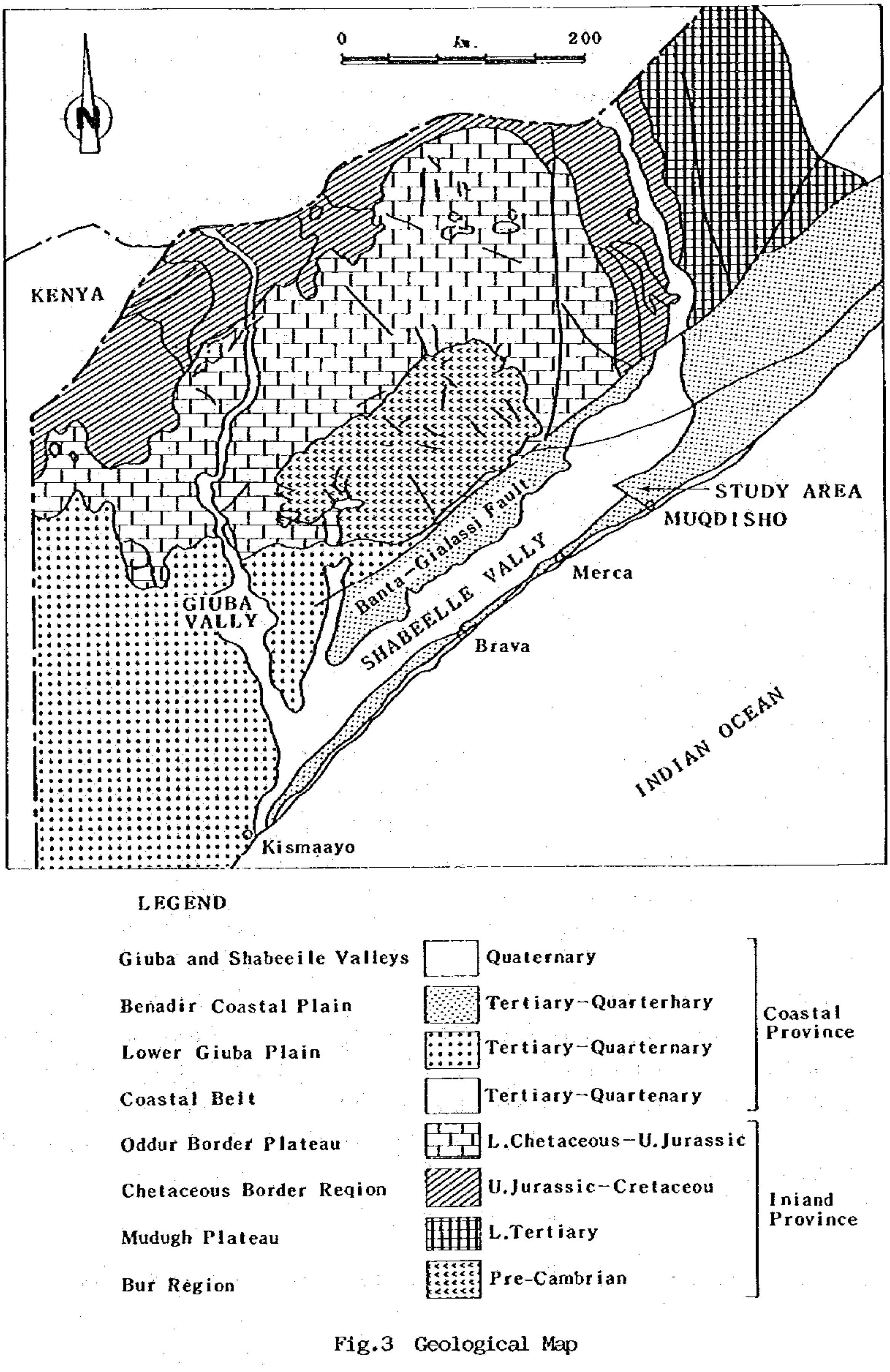


Fig.3 Geological Map

It is reported in the Hunting Technical Service*1) that the alluvium is extremely varied, and consists sometimes of gravel, sand, silt and clay. However, in accordance with the 1980 study, no gravel layer could be found in the alluvium.

It is reported that, at 20 km north of Afgoi, the alluvium has the maximum thickness of 150m. However, there is a possibility that the maximum thickness may be larger.

The strata spreading under the alluvium consist of sedimentary deposits which can not be distinguished to be either tertiary or quaternary, and the maximum thickness of both is in excess of 900m.

It is known that, in this area, good aquifers exist in the alluvium. However, at some places, the major ground water aquifers are distributed deep in the quaternary sedimentary deposits. The ground water level contour maps around the study area, prepared by Hunting, are shown in Fig. 4. The ground water level rises just below the river suggesting that the ground water is recharged by the leaking river water. In general, the ground water flows to the northwest or southeast from the rising water level in the recharging part existing just below the river.

On the northern side of Aw Dheegle or Afgoi, the ground water flows southwest at a slow slope.

The hydrological slope from the river to the sea is uniform. However, the ground water flow, supplying to the aquifers, shows rapid slopes. This seems to be related with the uniformity of the strata.

The results of the ground water quality in the study area obtained by Hunting are shown in Fig. 4.

The water quality becomes good as the water level in the recharging part rises. This confirms that the river is the major supply source for recharging the aquifers.

Areas where the electric conductivity is high or the water quality is bad are associated with the area of low ground water levels such as the ground water basin to the north of Aw Dheegle. The study area, except for a narrow coastal vicinity, has electric conductivity contour lines of 2,500 μmho (Fig.4).

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*1 Inter Riverine Agricultural Study: Technical Service, Nov. 1977

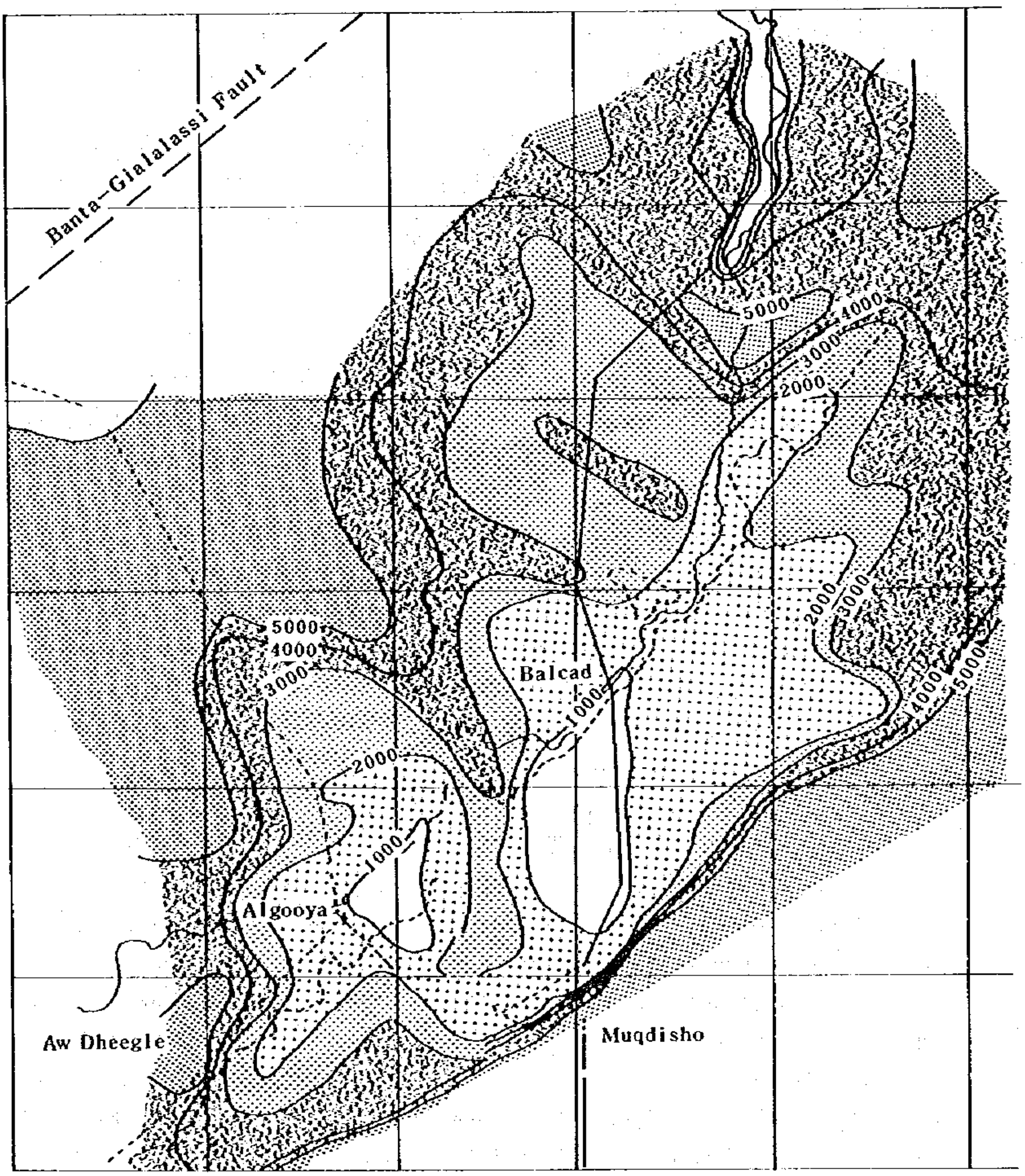


Fig.4 Electric Conductivity Contour Map

The electric conductivity at the Balad Road north of Mogadishu indicates that salt is contained in the aquifers. In general, it is accepted that the water is fresh where the ground water level countour lines are dense (or the flow velocity is high), and is bad where they are coarse.

In the case of this area, the water quality is not constant in spite of uniform ground water level contour lines, and it may be asid that the uniformity of the ground water level contour lines does not reflect the chemical composition.

2.3.5 Hydrogeological Features

1) Topography and Geology

The vicinity of Mogadishu is located in the Shabeelle basin. Its town district facing the Indian Ocean presents a rolling condition since hills of sand dunes extending from northeast to southwest are distributed there in three or four lines approximately in parallel to the coastline. In the town district, generally, the trees cultured by artificial water supply are grown, but grasses are less, and the sands are seen frequently. Outside the town district, the trees are extremely decreased and the soil is left as semi-desert.

The Balad Wellfield looks, at a glance, like in a flat condition, but it slopes slowly rolling toward the coastside. This part is in a semi-desert condition with scattered trees. There, plants of the rose family are grown generally at equal intervals.

Grasses are hardly grown and the sands are left.

The geology of the vicinity of Mogadishu is shown in Fig. 5 and Fig. 6. As seen in the geological sectional views in these figures, alluvial layers are rarely distributed, and in the highest part, red aeolian soil deposits are thickly distributed. In the middle part, reddish brown marine sands are distributed, but on the coastside, white and gray limestones are distributed in the condition interposed like a lens. At the Balad Well-field, these limestones are distributed as the non-water bearing layer in the lowest part. The lower layer consists of brown and green silt or clay in the subconsolidated and consolidated condition.

The good aquifers in the vicinity of Mogadishu are marine sand layers in the middle part, but their distributed conditions and properties are different from place to place.

2) Aquifers

At the Balad Wellfield, two permeable layers (water intake can be obtained) and two aquicludes (water intake can not be obtained) are distributed. Their depths and thicknesses are shown in the geological sectional views of Fig. 5 and Fig. 6.

These layers have the following features.

(1) Upper aquiclude

In the relevant area, the upper surface of the upper aquiclude is at depths of altitude 23m to 16m. The thickness is 20m to 36m in many cases. These layers slope slowly at an average slope of 3m per 1 km toward the coastside.

The aquiclude consists of light brown and brownish-gray fine sand and extremely fine sand. The sand shows a moderate degree of compactness. The upper aquiclude bears the ground water which affects the upper aquifer.

(2) Upper permeable layer

The upper permeable layer is the main water intake layer in the relevant area. The upper surface of this layer is at depths of altitude -3m to -16m. The thickness is 20m to 36m in most parts. This layer slopes slowly at about 2m per 1 km.

The upper permeable layer consists of white and light brown extremely fine sand to medium sand. The sand is combined by calcium carbonates and shows a moderate degree of compactness.

The wells in the appropriate area have been constructed to pump up mainly from the upper permeable layer which is in a better condition and permits larger pumping rates than the lower permeable layer.

(3) Lower aquiclude

The lower aquiclude is interposed between upper and lower permeable layers. It is a stratum having a low porosity that is obvious with the electrical prospecting. The upper surface of the lower aquiclude is at depths of altitute -34m to -40m. This layer is distributed in every place of the appropriate area. The thickness is generally small, but is varied from 4m to 11m.

The lower aquiclude has a hydrological continuity with the upper and lower permeable layers and can be regarded as a permeable layer. This layer consists of light brown and gray extremely fine sand and fine sand, and is slightly in the subconsolidated condition.

(4) Lower permeable layer

In the relevant area, the upper surface of the lower permeable layer is at depths of altitude -38m to -18m. The thickness is 45m to 70m.

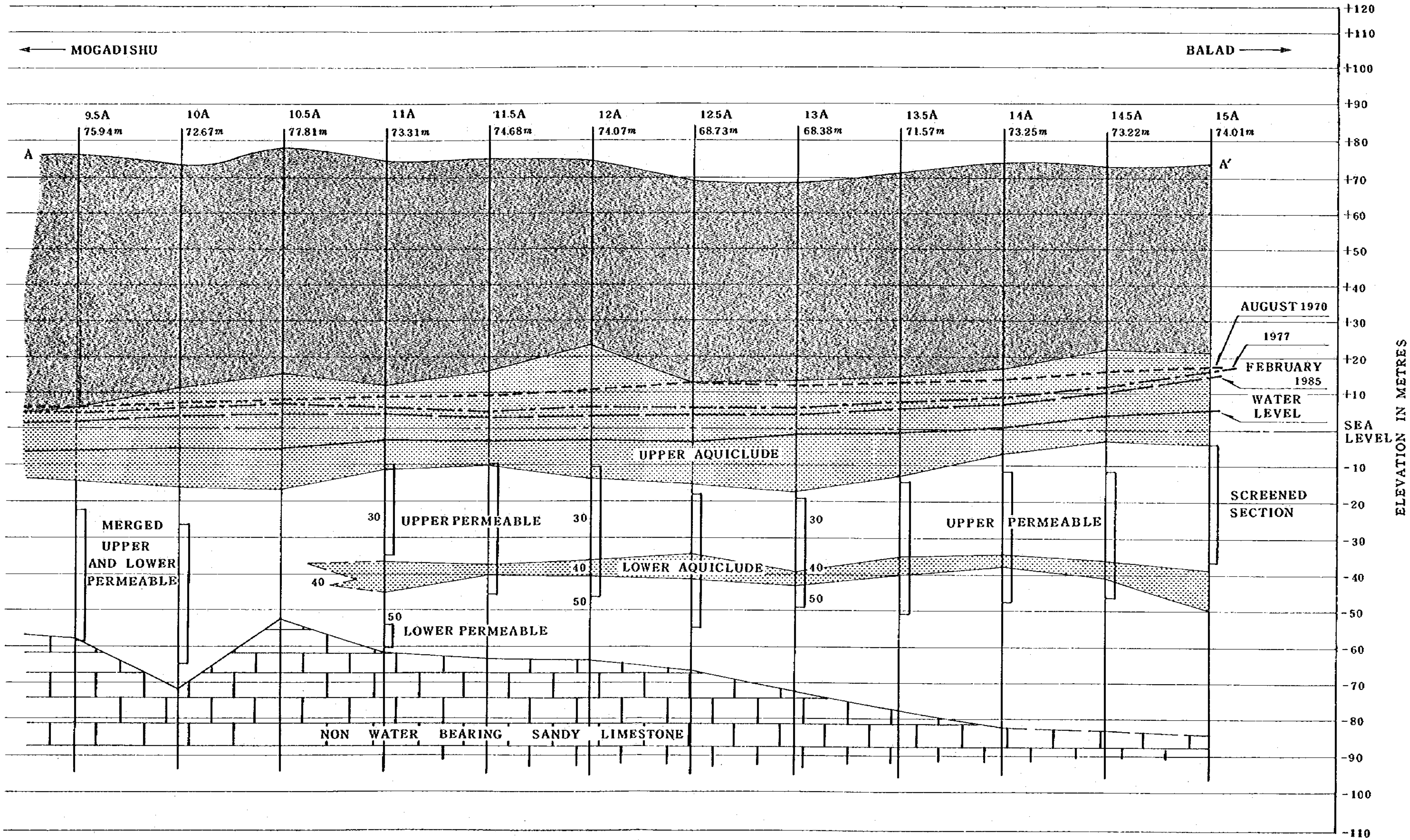


Fig.5 Water Level (A-Line)

WATER LEVEL (B-Line)

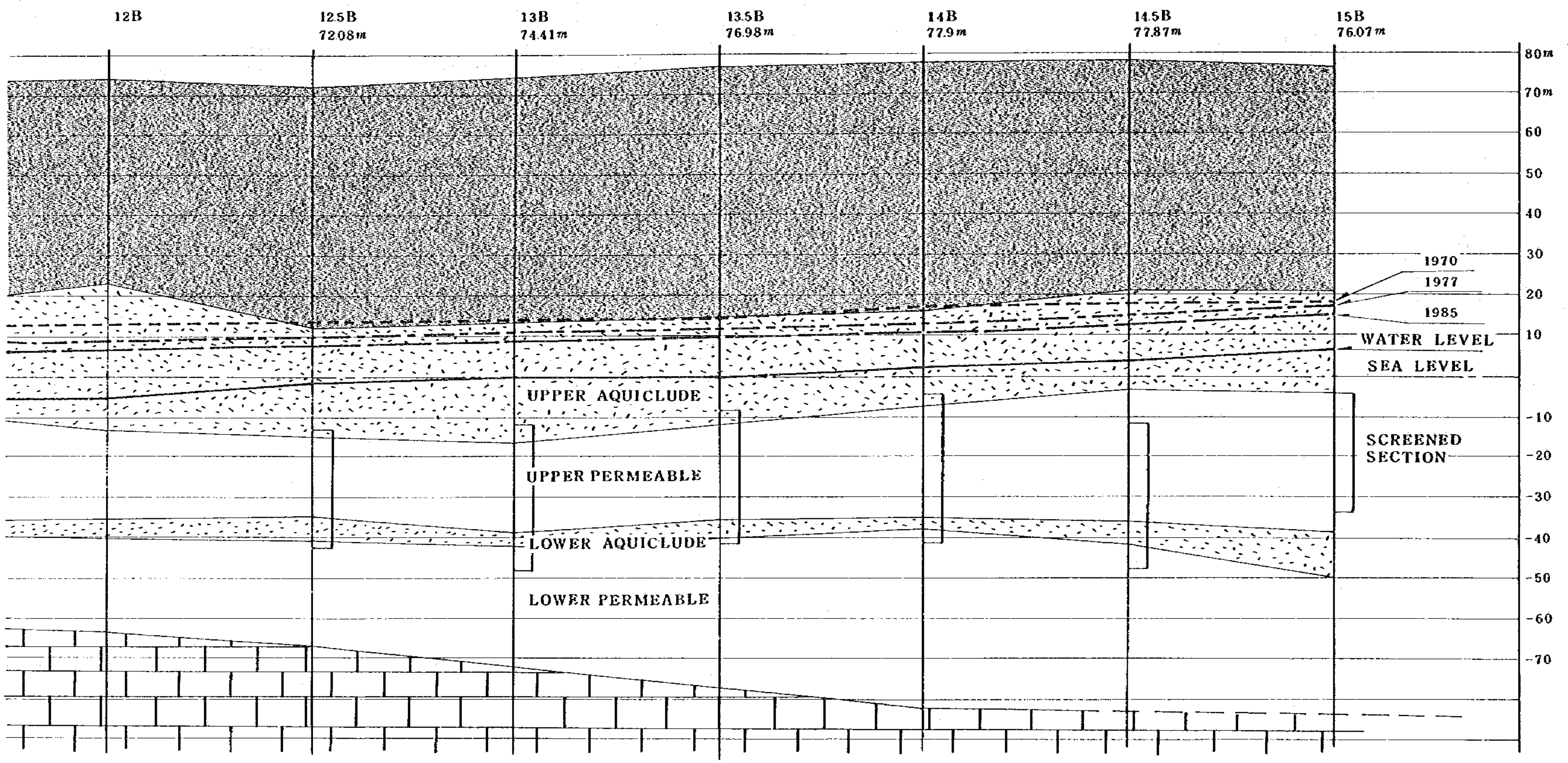


Fig.6 Water Level (B-Line)

This layer is distributed over the sediments corresponding to the basin bottom and forms the base layer.

The lower permeable layer is in the subconsolidated condition, and consists of alternate shale and limestone layers of fine sand and medium sand combined by carbonates.

(5) Non-water bearing layer

In the relevant area, the upper surface of the non-water bearing layer is at depths of altitude -53m to -82m and slopes slowly toward the coastside. This layer consists of limestones containing sand and no ground water is stored in it.

Of the various layers mentioned above, the major aquifers of the Balad Wellfield are the upper and lower permeable layers, and strainers are installed in these layers.

3) Water Quality

The distribution of the electrical conductivity*1 representing the water quality in the vicinity of Mogadishu is shown in Fig. 7. As this figure, the electrical conductivity is very high in the portion along the coast, and it increases gradually toward the north from the Shabeelle River, suggesting that the water quality becomes worse.

Around the Shabeelle River, the electrical conductivity is below 2,000 μS/cm, and in some confined portions, it is below 1,000 μS/cm. The low electrical conductivity around the Shabeelle River indicates that the water quality is improved by the storage of ground water from the Shabeelle River. Along the coast, the electrical conductivity is high, and the reason for this is the ingress of sea water. Fig. 7 shows the change of the electrical conductivity with the elevation in the town district of Mogadishu.

The electrical conductivity in 1977 is significantly higher than that in 1970. Moreover, the portions having the same order of electrical conductivity has moved toward the inland owing to the remarkable salination of ground water.

Also, Fig. 9 shows the change of electrical conductivity of well water in the vertical direction. The value in 1983 is higher than in 1979, and especially, the value shown at MG3CP is about 2.5 times.

In this way, the well water in the town district of Mogadishu has been remarkably salinated as a result of water pumping and is no more suitable as the potable water. All the wells distributed in this town district are just before they are to be disused. Thus, supplying water through waterworks to the town district is necessary.

The results of the electric conductivity measurement at the Balad Wellfield indicate that the electric conductivity is 1,200 μS/cm which corresponds approximately to the value in the 1970's and no salination and water quality change are noticed.

The Balad Wellfield is 9.5 to 15 km away from the coastline. Considering the depth of water levels lowered by pumping and the geological conditions (the inclusion of impermeable limestones has made ingress from the coastal portions toward the inland), it can not be expected that the salt water wedge makes into ingress up to the Balad Wellfield and salination occurs.

*1) The general value of electric conductivity (EC) is as follows.

Sea water

Cl ≒ 19% : EC = 40,000 μS/cm

Cl ≒ 5% : EC = 10,000 μS/cm

Salt water EC = 1,000 μS/cm

Fresh water EC = 100 μS/cm

Natural water having a small salt content

EC = 10 μS/cm

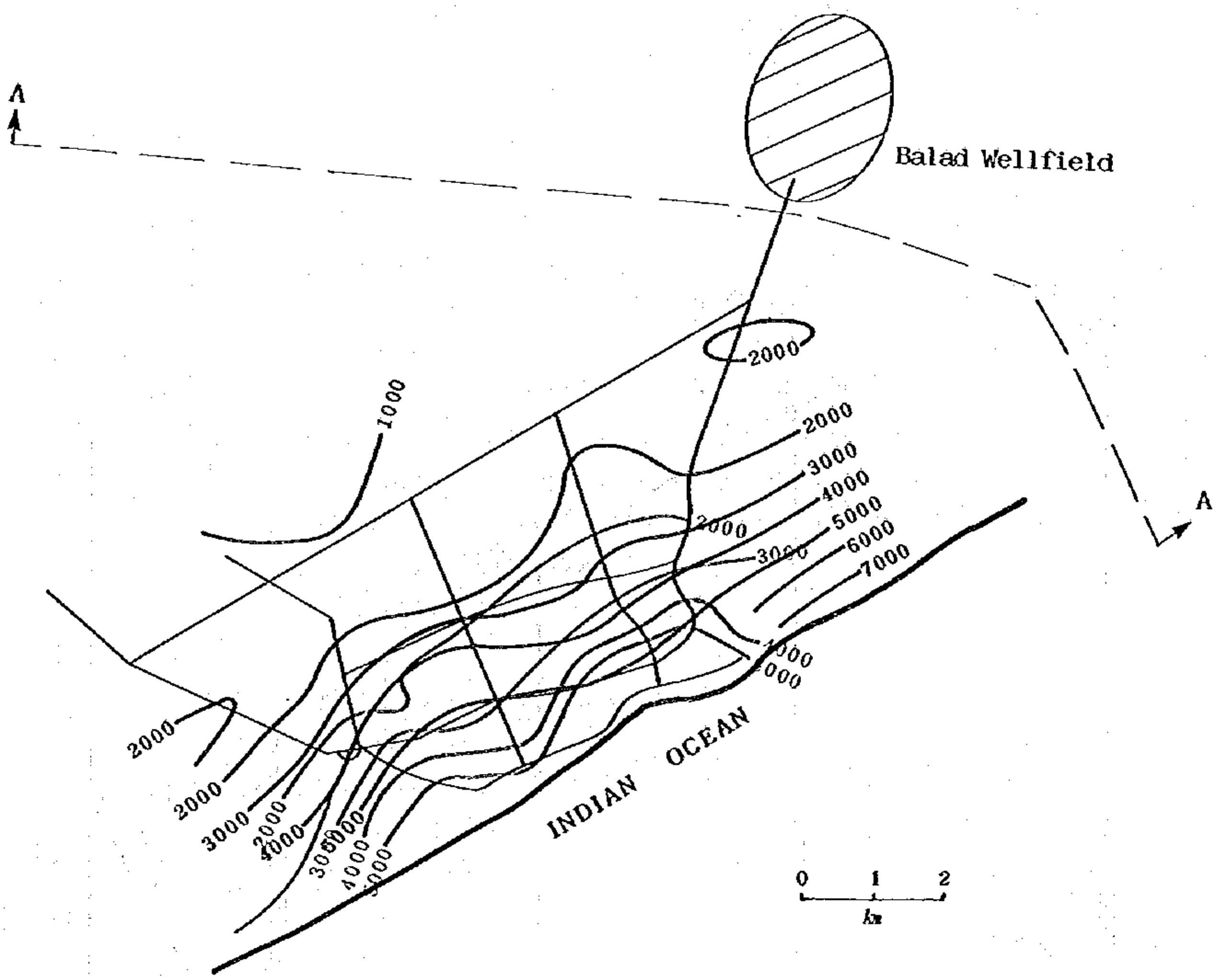


Fig.7 The Change of the Electrical Conductivity Plan

NOTES		
		1970
		1977

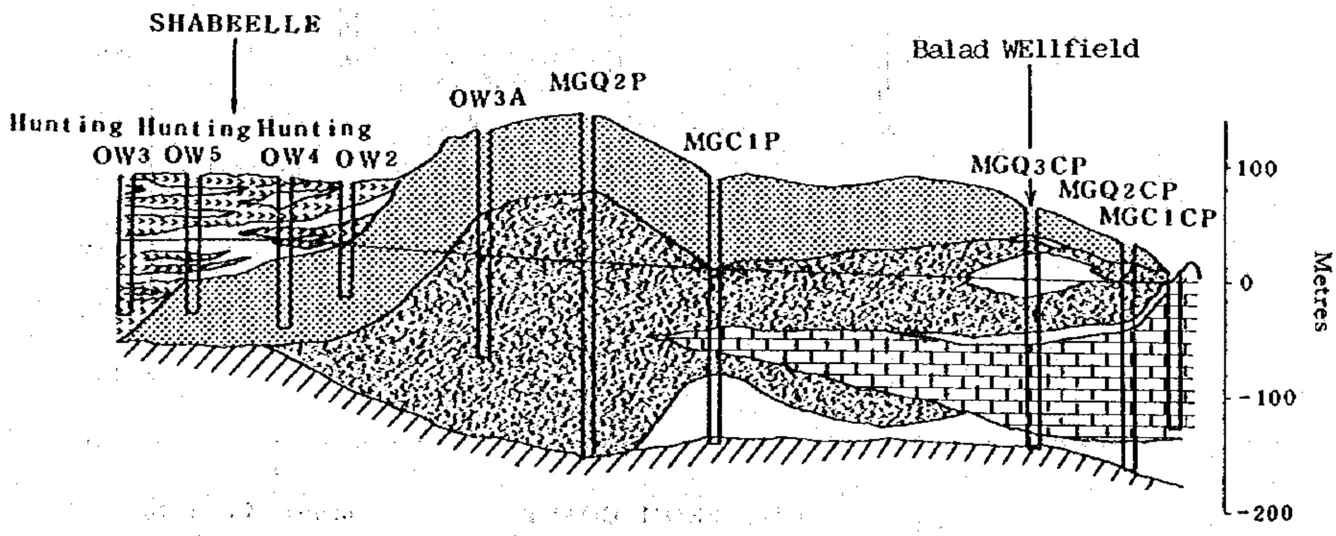


Fig.8 Section A-A

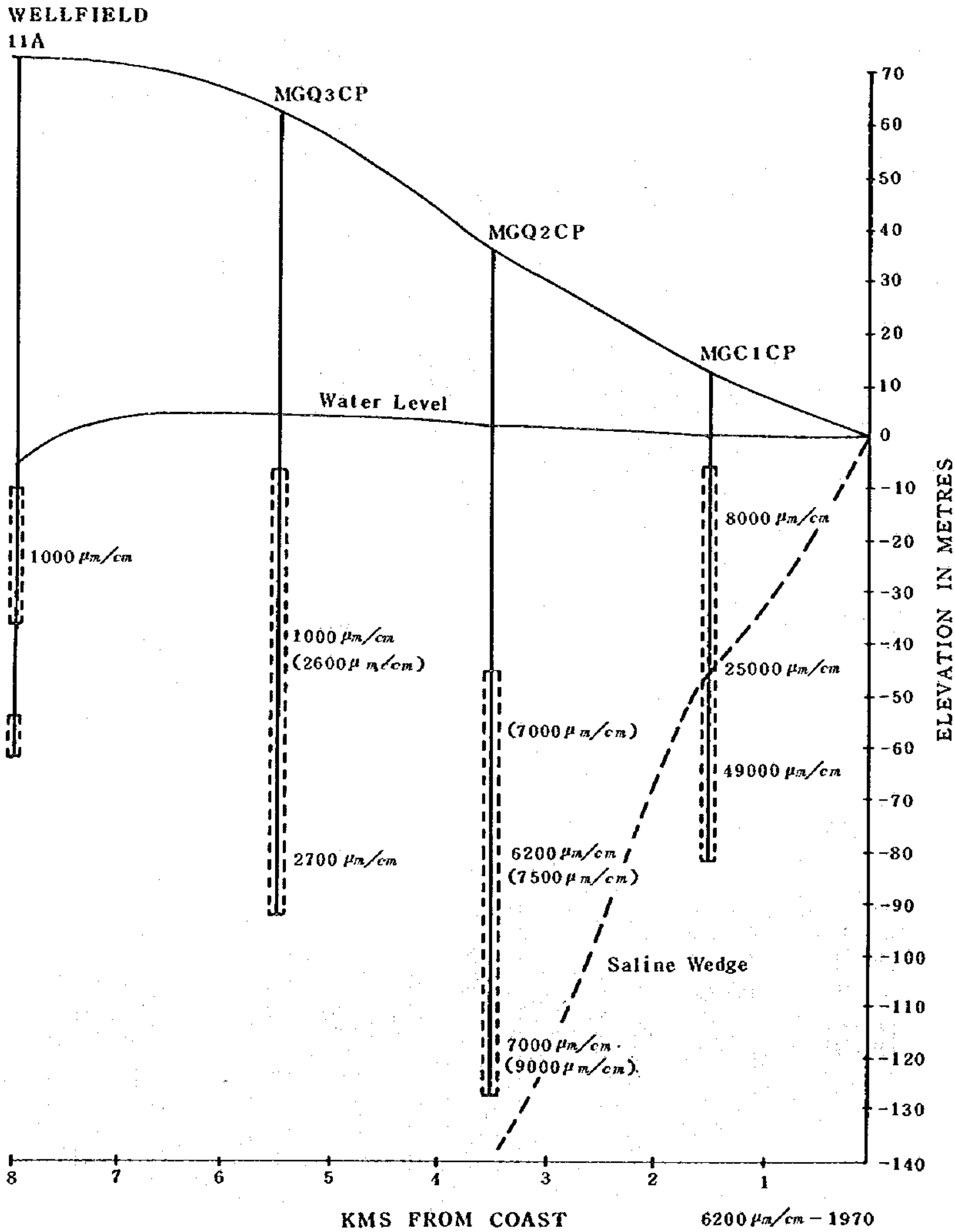


Fig.9 The Change of the Electrical Conductivity Section

2.4 Waterworks

2.4.1 Waterworks Administration

The waterworks administration is under supervision and management of the Ministry of Mineral and Water Resources (MMWR), and the nation-wide waterworks development is governed by the Water Development Agency (WDA). In each city, the water works public authority of the city undertakes construction, operation and management. In Mogadishu as the city for this study, the Mogadishu Water Agency (MWA) is the competent organization. It is judged that this agency is well-established to clarify where the responsibility lies. The administrative organization chart is shown in Fig. 10.

2.4.2 Waterworks and Environmental Sanitation

The average life expectancy of the people in Somalia is 40 years in the local areas and 43 years in the city areas. The death rate of 1000 people before one year from their birth is 170 persons (below 1 person in Japan). This high death rate of infants is due mainly to unsanitary potable water, and the government gives the top priority to supplying sanitary potable water.

At present, 80% of the population live in the local areas. The water supply pervasion is 20% in the local areas and 60% in the city areas. But, in the city areas, the water supply is below 50% of the water demand.

However, year by year, the city water supply facilities have been degraded in the water supply capability because of their deterioration and the low capabilities of maintenance and management. On the other hand, the urbanization, a common tendency in all developing countries, and a large immigration of refugees from the neighboring country of Ethiopia (the number of refugees amounting to 70×10^4, 1980 UN HCR survey) have accelerated the shortage of potable water supply, and made it urgent to rehabilitate the existing facilities and construct new facilities although these can not be accomplished for the economical reasons.

2.4.3 Water Supply Circumstances

1) Change of The Water Supply Circumstances

In the past, Mogadishu was supplied with water from the wells existing in the city. However, owing to the increased population, lowered water levels of the water source in the city, and deteriorated wells, the water

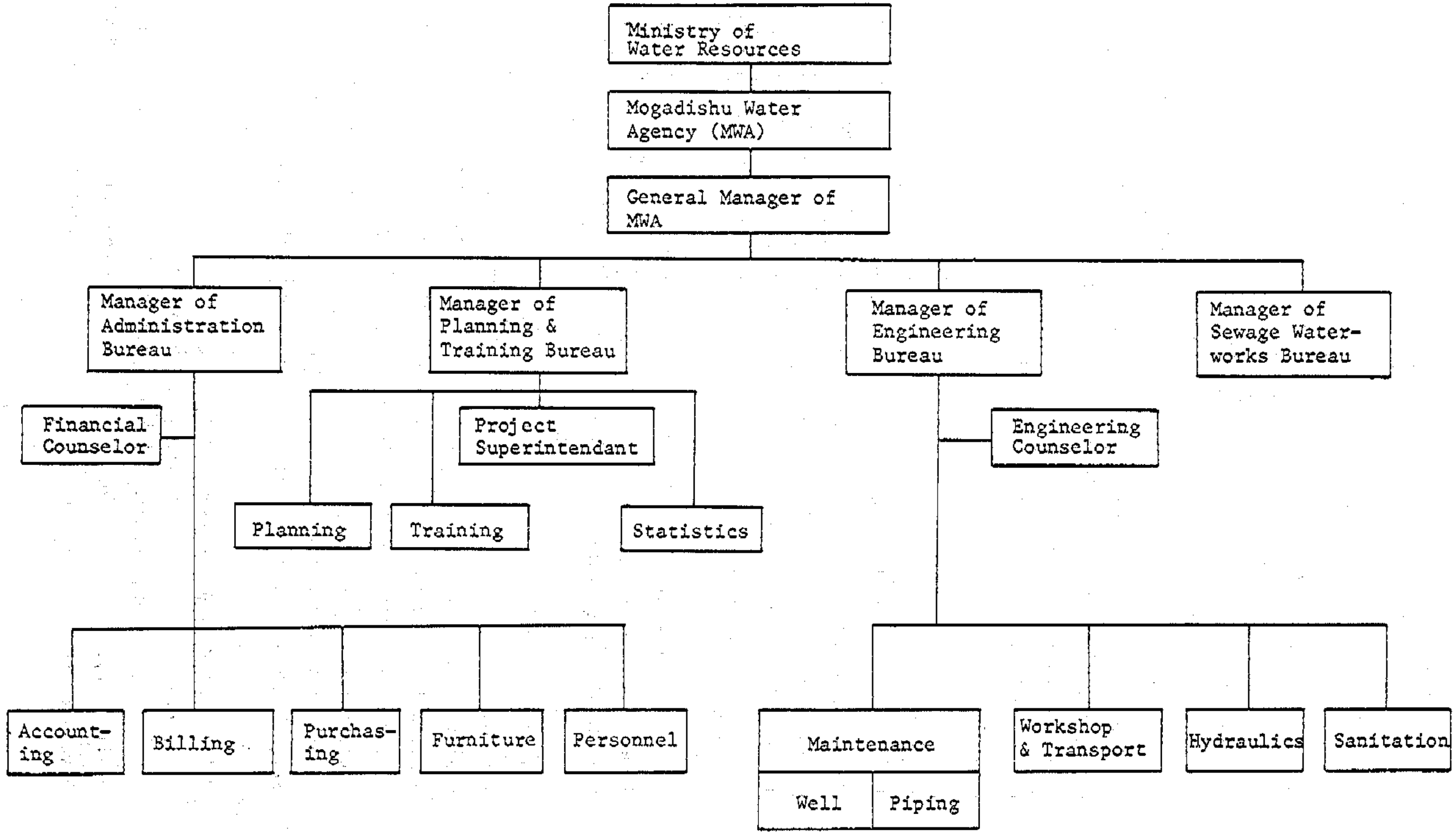


Fig.10 The Administrative Organization Chart

supply became short, and owing to the increased salt concentration and the contamination with sewage, etc., the water quality was degraded. In order to assure the water volume and improve the water quality, a long-term water supply project was set up in the later 1960's to move the water source from the coastline toward the inland and also toward the Shabeelle River which is a ground water recharging source.

In accordance with this project, in a district called "Balad Wellfield" along the Balad Road between 9.5 km and 15.0 km from the city, 20 wells were begun to be constructed in 1970 to supply water at 28,000 m^3 per day.

In 1973, 19 wells of them were completed, and as of that point of time, a record of water supply of 24,000 m^3 per day was achieved. Furthermore, in order to cope with the growing water demand, in a district called Afgoi Wellfield (II, IIA) in a range of about 15 km from the city, 32 wells are now being constructed under cooperative financing of the World Bank, the Arab Fund and the EEC, for water supply of 42,000 m^3 per day. All these wells and almost all the water supply facilities have already been completed, and water supply of 16,000 m^3 per day matching the installed generator capacity has been started.

2) Long-term water supply project

Subsequent to the Afgoi Wellfield to be completed in 1986, the Expansion IIB project using as the water source the groundwater in the district further inland from the Balad Wellfield and near the Shabeelle River, and thereafter, the Expansion III project for taking water directly from the Shabeelle River and supplying the purified water to Mogadish, are being made up. As to the Exapnsion IIB project to be implemented for the time being, the detail design has been completed and the bid documentation has been prepared completely. However, there is still no hope for raising the funds and its completion can not be expected at the present time. (Fig. 11)

3) Urgent Water Supply Improvement Project

At present, it is economically difficult to realize the long-term project intended to cope with the rapidly growing population of Mogadishu. In addition, due to the decreased water volume and degraded water quality of the water source in the city in recent years, and also due to the decreased water volume at the Balad Wellfield (Fig. 12), the stringent water shortage can not be resolved away even if the water supply from the Afgoi Wellfield to be completed in 1986 is added up. Therefore, the MWA

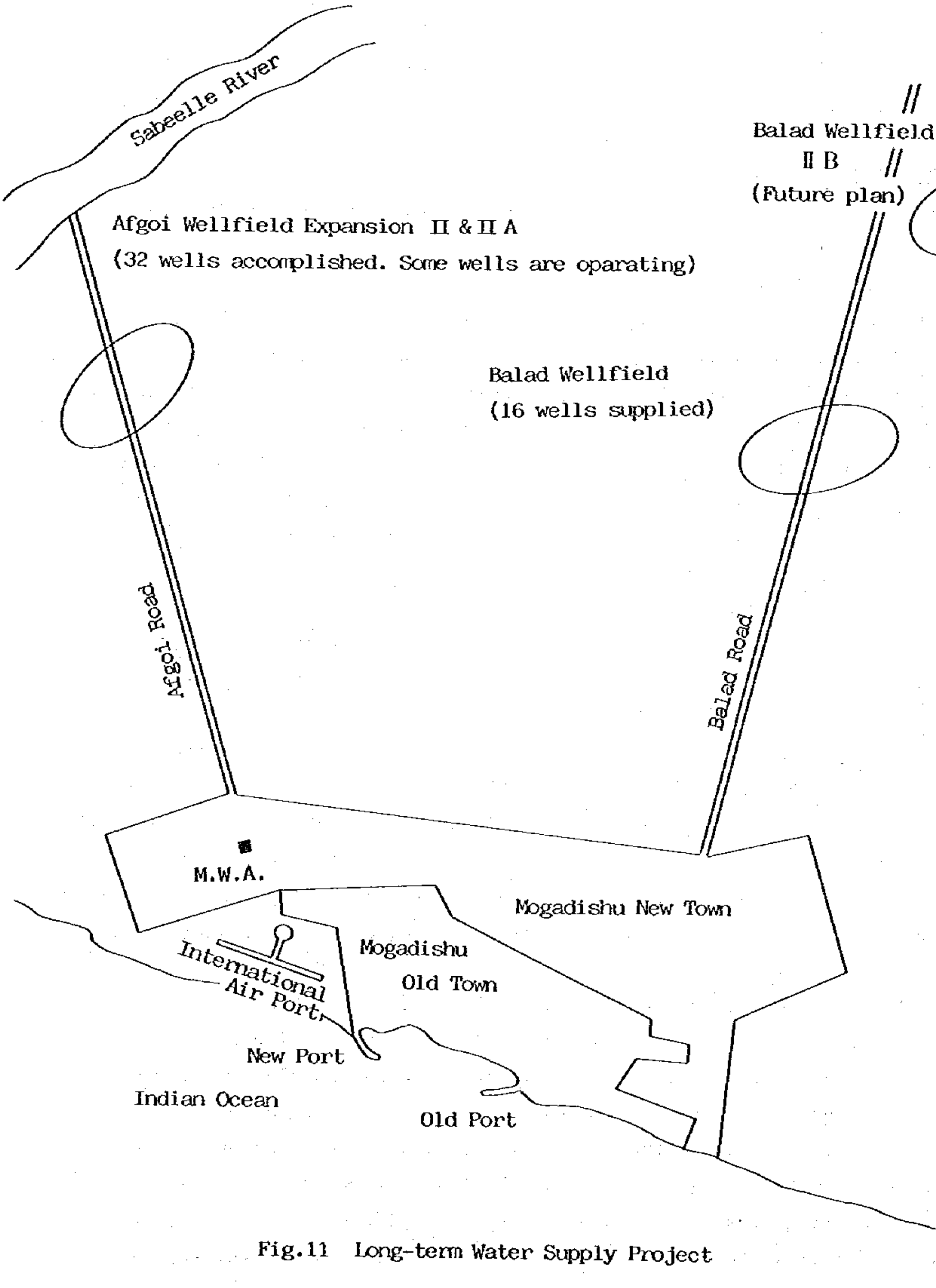
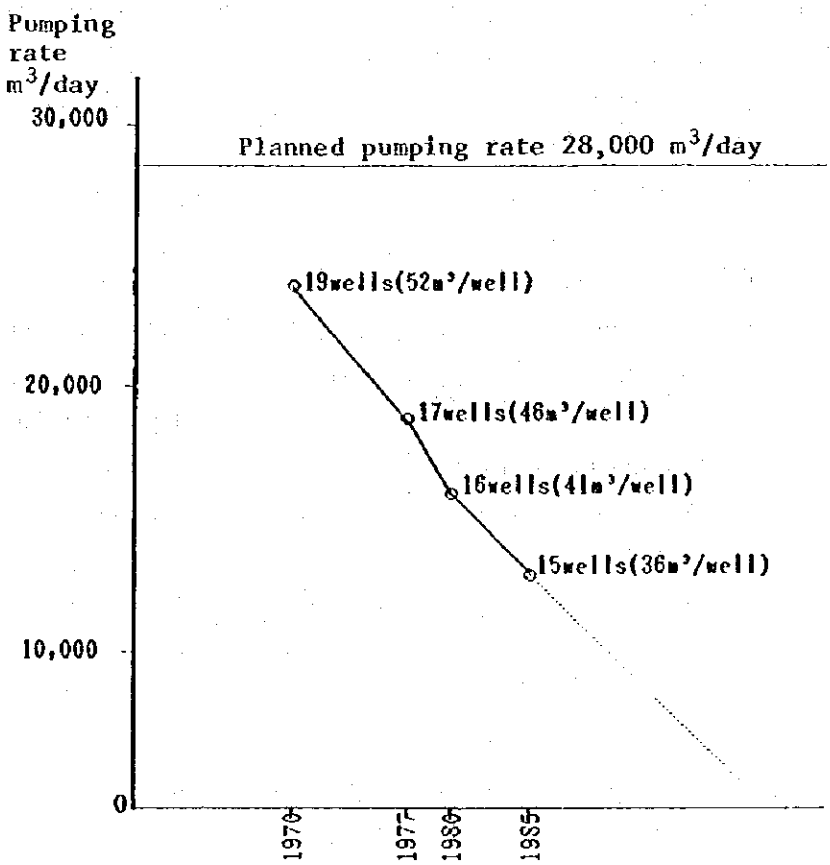


Fig.11 Long-term Water Supply Project

has established the urgent water supply improvement project, consisting mainly of water volume recovery at the Balad Wellfield, with the year of 1987 as the target, and has requested an aid for this project to be implemented by the Japanese Government.



NOTES (1) Planned pumping rate

20 wells x 60 m^3/h x 24h = 28,800 m^3/day

(2) Pumping rate

According to the MWA data.

(3) Average pumping rate per well within parenthese

Fig.12 Change of Pumping Rate at Balad Wellfield

2.5 Circumstances and Contents of The Request

The urgent water supply improvement project of Mogadishu City consists of surveys and diagnoses of the existing facilities, and carrying out of rehabilitation works and security of necessary maintenance materials as required by the results thereof, so as to insure stably in the future the initially planned water supply rate of 28,000 m^3/day.

The contents of the request are as follows.

① Removal and replacement of pumps
② Pumping-out test of wells
③ Installation of new pumps and motors, and storage of enough spare parts for the former
④ Treatment of wells with acids or others
⑤ Storage of enough spare parts for the maintenance and repair of the water supply system
⑥ Development, maintenance and repair of wells using well maintenance rigs
⑦ Washing of overhead electric cables using fire-fighting trucks
⑧ Securing of equipment and worker transporting vehicles

For the contents shown above, the works, equipment and materials requested as necessary by the Somali Government are as follows.

① Well maintenance rigs	1 unit
② Well rehabilitation equipments and materials including air-lifts	1 unit
③ Turbine-pumps	
1) Q = 60 m^3/h, TDH = 130m	25 units
2) Q = 60 m^3/h, TDH = 200m	15 units
④ Generators for above maintenance	1 unit
⑤ Submerged motor pumps	20 sets
⑥ Generators	10 units
⑦ Wheel loader	1 unit
⑧ Excavator	1 unit
⑨ Pump truck	1 unit
⑩ Vehicles	
1) Small car	10 units
2) 8-ton dump truck	2 units
3) 6-ton dump truck	2 units

	4) 2-ton crane truck	1 unit
	5) Station wagons	5 units
	6) Pick-up vans	10 units
11	Spare parts for above for 3 years	1 lot
12	Galvanized steel pipe (for domestic water supply)	
	1) 2-inch	3000m
	2) 3-inch	3000m

2.6 Present Conditions and Problems of Existing Facilities

2.6.1 Existing Water Supply Facilities

1) Water Supply Area

The existing inhabited district of Mogadishu extends 16.5 km in parallel to the Indian Ocean and 4.5 km in the direction perpendicular thereto, and has gross area of about 60 km^2. At present its population is estimated to be about 900,000. This city is similar in scale to Setagaya-ku, Tokyo, Japan which has area 59 km^2 and population 800,000. The individual house water supply area, corresponding to the old town, is about 17 km^2, the area which has water supply pipes installed and uses the individual house water supply system and the public water faucet system, corresponding to the current town, is about 26 km^2, and the area which depends almost on the sold water although the public water faucet system exists, corresponding to the new town, is about 15 km^2.

2) Method of Water Supply

The raw water from two major water sources, Balad Wellfield and Agoi Wellfield, is delivered under pressure to the distributing reservoir provided on a hill overlooking the town and, thence, it is distributed to the city.

Before the water supply facilities of the Agoi Wellfield have been completed, the raw water from the Balad Wellfield was received in the Shek Muhidin distributing reservoir, and thence, it was distributed to the low-area distributing district and the high-area water distributing district, by gravity and by boosting with the booster pump, respectively, but after completion of the Agoi Wellfield water distributing reservoir, water distribution by gravity to the whole city including the high-area water distributing district has become possible. (Fig. 12)
However, at present since the water volume available is insufficient, this booster pump station is operated for the time limited water supply in accordance with the pumping rate at each water source and the water consumption rate. The distributing reservoir is provided with a sterilization equipment, which has failed and is left unused.

3) Water Supply Rate

At present, the average water supply rate per day is 13,000 m^3 from the Balad Wellfield and 16,000 m^3 from the Afgoi Wellfield, 29,000 m^3 in total. Considering the living conditions, water supply facilities, etc. of Mogadishu, the MWA requires 63,000 m^3/day for the present population of 900,000 on assumption of an average water demand per person of 70ℓ. This water supply rate is below a half of the water demand. Water supply interruption and water pressure dropping occur frequently, and complaints or petitions to the MWA are every day occurrences. Now, water shortage is stringent.

4) Water Supply Facilities

The water supply facilities for the Afgoi Wellfield water source, now near completion, are new facilities and involve no problems. While, the old water supply facilities for the Balad Wellfield water source involve various problems. The details are as follows.

(1) Water Source

The initially planned water intake rate is 28,000 m^3/day, and just after the construction, the pumping rate was 24,000 m^3, but inspite of the various efforts for maintaining the pumping rate, such as extended well installation, pump replacement, etc., the present value is only 13,000 m^3.

(2) Electrical Equipments

Six generators of 250 kVA are installed in the power plant exclusively for the Balad Wellfield. However, one of them has failed, and one or two often being in check or repair. Since no stand-by generator is available under these circumstances, electric power supply is insufficient and, even with a trifle accident, the pump must be unavoidably shut-down. Indeed, during our survey, a total shut-down of the power plant was experienced two times.

Moreover owing to the unavailability of maintenance machines and materials for power transmission lines, short-circuit troubles with sand accumulation, salt damage, etc. of porcelains occurred and made electric power supply impossible in some cases.

Besides the mentioned electrical equipments, transformers, indoor panels and field panels are judged as normal.

(3) Water Transmission Pipe

The water transmission pipes from the wells to the distributing reservoir consist of cast iron pipes in the exposed pipings on the ground around wells, and asbestos pipes in the buried pipings. On the buried pipes under the ground, no water leakage is found, and ancillary equipments such as sand discharge, air valves, etc. are judged as normal. On the other hand, all flow meters and air valves, ancillary to the cast iron pipes in the exposed pipings around wells, are broken. For each well, the pumping rate was measured by installing a sound flow meter only where replacing the pump, and otherwise, no pump rate measurement was done. Therefore, well management can not be done. In case the pump was automatically tripped due to motor overheating or over-current, the pump can not be restarted after the cause is removed, without adjustment, etc. of air valve operation, make-up tank, etc. since the air valve has been broken.

(4) Distributing Reservoir

The distributing reservoir is a rectangular water tank made of reinforced concrete. It is judged as good because the concrete is not cracking. Using flow meters installed just in front of the inlet to the distributing reservoir, the total pumping rate from all wells is measured every day. Through common faucets provided at four places between the Balad Wellfield and the distributing reservoir, potable water is supplied to the nearby inhabitants and livestock although only at small flow rates.

(5) Water Supply Facilities

At present, the total length of water supply pipes in the city is about 120 km, and no water leakage on the ground from damaged pipes is noticed. Generally, pipes are judged as good, although leaking water at small flow rates may penetrate into the ground which consists of sand layers. The water charge is determined by reading the integrating flow meter, as a rule, and is sh. $10/m^3$. If meters were correctly installed at all destinations of water supply, it would be possible to estimate the water leaking rate. However, actually, meter impellers are covered with scale and give significantly small readings in some cases, or meters are not installed and enough data for estimating the water leakage can not be obtained. In the case of the public water faucets, the manager sells water at sh. $10/m^3$ to the water seller who has an ass-cart carrying water drums. Of sh. 10, sh. 5 is sent to the MWA and sh. 5 is given as the maintenance cost and expenses to the manager.

For the water production rate of 29,000 m^3/day in the last year, the total water sales amount is sh. 60,870,000 and the revenue is sh. $5.7/m^3$.

From the foregoing, it seems that flow meters capable of accurate integration, if installed for large consumers, will increase the revenue of the MWA and thereby contribute to improving the condition of operation.

2.6.2 Studies and Diagnoses of the Existing Water Sources

1) Results of Studies

The studies at the field for diagnosing the existing facilities, and the results thereof are as shown in Table 1.

By these studies, it was found that the causes for the secular decrease were as follows.

(1) Destruction of wells

At 11.5B, 12.5A and 14.5B, gravel was accumulated around the screen and was sucked up. (At the time of cleaning of the well, replacement of parts, etc., the turbine pump should be lifted up and again inserted. When lifting the pump, the pump was dropped and the screen was destroyed, or when inserting the pump, the centralizer was inadequately installed and the resulting rotating vibrations caused the pump to break the casing strainer. Thus, the well body was destroyed and the well rehabilitation is impossible.

(2) Worn-out of Impeller

By measuring the worn-out dimensions of the impeller, and by checking the change in the pumping rate at the time of impeller replacement, it was found that the pumping rate was decreased.

(As sand flows into the pump, the impeller of the pump is worn-out, and thereby the pumping rate is decreased. Normally, the influent speed at the strainer should be 3 cm/sec (upper limit). At the Balad Wellfield, the influent speed is between minimum 4.4 cm/sec and maximum 6.0 cm/sec.

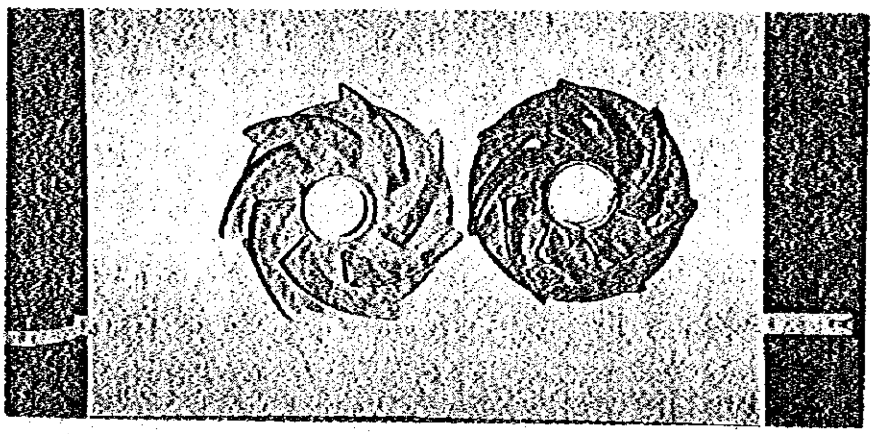
On 12.5B and 13A which are in operation at this maximum 6.0 cm/sec, the impeller was replaced (April 1982), and as a result, the pump rate was increased largely from 21^3/h to 54 m^3/h and from 27 m^3/h to 72 m^3/h. However, at present, it is 32 m^3/h and 65 m^3/h, respectively. This indicates that the impeller is worn-out with the influent sand and this is a large cause for the decreased pumping rate.)

Table 1 Outlines of Field Study Results

Item		Purpose	Method	Result
Ground water measurement		To determine the design underground static water level.	Using water level gauges (100m), water level in all possible wells was measured.	Water level variations with year could be grasped, and the design underground static water level necessary for the rehabilitation plan could be set for each well.
Pumping-out test		To estimate the design underground running water level to obtain the data for determining the design water pumping rate.	The water pumping rate and water level of existing well 10A and its observation well were observed.	Estimated data of water level and water pumping rate after rehabilitation, and data for planning of new wells could be obtained.
Water test	pH	To understand pH change	Using pH meters.	Well groups, distributing reservoirs, and water faucets were good, pH 7.0 to 7.3.
	Water temperature	To understand water temperature change.	Using the water temperature meter.	All data were 34° to 35°C.
	EC	To understand EC change.	All data are 1,100 to 1,150 μS/c and show	No differences from the past data, and there

Item		Purpose	Method	Result
Water test	EC		no changes.	is no tendency toward salination.
	Bacteria	To understand the degree of contamination.	Outlines of bacteria (coliform) could be grasped.	Well groups, distributing reservoirs and water faucets contain miscellaneous bacteria, but no coliform contamination.
Existing facilities survey	Well, pump, motor, electric equipment, piping, distributing reservoir, distributing pipe	To determine the degree of deterioration to obtain the data for determining the method of rehabilitation.	The circumstances necessary for this determination were actually surveyed at the field.	Data for distinguishing between those suited and not suited for rehabilitation, and determining the method and degree of rehabilitation, could be obtained.

Fig.13 Worn-out Condition of an Impeller



The photo at left shows the condition before use and the photo at right shows the condition after use. The blade area is reduced to half.

(3) Clogging of strainers

It was confirmed that owing to air mixture, the running water level was lowered.

(The change in the overall water level at The Balad Wellfield shows the same tendency in 1970 and 1977, and in 1985 of this study, but the pump rate is decreased year by year. At present, wells 12A and 14B can hardly be used for water intake, but their strainers are clogged and there is a high possibility that, by the rehabilitation work, their pumping rate can be recovered.

(4) Reduced Operation Time

Owing to the failure of generators, short-circuit of transmission lines, motor overheating and shut-down, shortage of Diesel oil for power generation, etc., the operation time is reduced and thereby the pumping rate is decreased.

(5) Interference between Wells

At the Balad Wellfield, wells are installed at 500m intervals. Generally, in the case of sand layers at this field, it is accepted that the influencial radius of the well is about 500 to 750m. Since the well interval is less than this influencial radius, wells interfere with each other and the well water level is that which results from the interference. The pumping rate is decreased by this interference. It is necessary to estimate the decrease when setting up the rehabilitation project.

(6) Secular Lowering of Static Water Level

1970 to 1977	Max. lowering 6m	Min. lowering 2m
1977 to 1985	Max. lowering 3m	Min. lowering 0m

The yearly average lowering of the water level is about 60 cm. Since the surface of the aquifer is at about 50m depths from the bottom, it is judged that the required pumping rate can not be insured unless the pump capacity is adjusted to the estimated decreased water level.

The causes for the decreased pumping rate are as described above. Except for (1), it is judged that the pumping rate can be recovered.

From the results of topographical, geological and EC measurements, it is judged that there is no fear for salination.

Therefore, the rehabilitation project can be set up by considering the conditions of (2) through (6) given above.

2) Operating Conditions of Wells

There are 20 existing wells. The operating conditions of these wells are as shown in Table 2.

As shown above, 20 wells have 15 pumps, and the motor for one of these pumps is heated. Thus, 14 wells are in good operation. The pumps used are vertical-shaft type multi-stage turbine pumps manufactured by Jonsoon Company in USA. The impellers of these pumps are both open and semi-closed types.

Two of 20 wells have no transformers, the other one has no emergency transformer. Thus, 17 transformers are available.

One pump has no electrical wirings and the other wells have high-voltage wirings.

3) Results of Dignoses

A total of 21 wells were dug and lifting pumps were installed there. The record and results of diagnoses of all wells excepting the 12.0B well are shown in Table 3. These wells can be classified into two groups.

(1) Wells which can not be Rehabilitated (4 wells)

In general, as a result of broken screens, gravel accumulated around the screen, fine sand around the gravel, etc. enter the well and cause the pump to be damaged to make water pumping impossible. Only when the accumulation consists of gravel and sand-gravel layers, the well can be rehabilitated by removing the accumulation and installing new small opening screens inside the existing casing. However, when the surrounding soil consists of fine sand and the accumulating gravel has been destroyed as in the present case, it is impossible to stop ingress of the fine sand. Thus, it is judged that these wells can not be rehabilitated.

(2) Wells which can be Rehabilitated (16 wells)

The wells which are judged as rehabilitative of the pumping rate in any way include 15 wells now in operation and one well, 14B, which sucked air as a result of clogging or the like and was left as its

Table 2 Operating Conditions of Mogadishu Water Supply Pumps

Well dia.	Motor	Condition	Remarks
9.5A	40 HP 380V 50 Hz 1470 RPM	Good	Flow meter, air valve defective
10 A	40 HP 380V 50 Hz 1470 RPM	Good	Flow meter defective
11 A	40 HP 380V 50 Hz 1470 RPM	Good	Flow meter defective
11 B	40 HP 380V 50 Hz 1470 RPM	Good	Flow meter defective
11.5A	40 HP 380V 50 Hz 1470 RPM	Good	In operation with an emergency transformer
11.5B	None	Without pump	Without wire, with pole, without transformer
12 A	40 HP 380V 50 Hz 1470 RPM	Motor heated and sometimes automatically stopped	Flow meter defective
12 B	None	Without pump	With wire and transformer
12.5A	None	Without pump	Without transformer
12.5B	40 HP 380V 50 Hz 1470 RPM	Good	Flow meter indication inaccurate
13 A	40 HP 380V 50 Hz 1470 RPM	Good	Without flow meter
13 B	40 HP 380V 50 Hz 1470 RPM	Good	Without flow meter
13.5A	40 HP 380V 50 Hz 1470 RPM	Good	Flow meter defective
13.5B	40 HP 380V 50 Hz 1470 RPM	Good	Flow meter defective
14 A	40 HP 380V 50 Hz 1450 RPM	Good	Flow meter, air valve difective
14 B	None	Pump removed	With wire and transformer
14.5A	40 HP 380V 50 Hz 1450 RPM	Good	
14.5B	None	Pump defective	With wire and transformer
15 A	40 HP 380V 50 Hz 1450 RPM	Good	
15 B	40 HP 380V 50 Hz 1450 RPM	Good	

pumping rate was decreased. These 16 wells were classified into the following three groups taking into account the present pumping rate and the degree of deterioration in order to secure the average pumping rate of the rehabilitation project mentioned later.

◎ Wells having the pumping rate of above 50 m^3/h at the present time
6 wells

o Wells having the pumping rate of from 50 m^3/h to 40 m^3/h at the present time
6 wells

Δ Wells having the pumping rate of below 40 m^3/h at the present time
4 wells

Table 3 Changes of Water Pumping Rate and Results of Diagnoses

Well No.	Water pumping rate 1973	1977	1982	1982	1985	Diagnosis	Remarks
	m^3/h		Before impeller replacement	After impeller replacement			
9.5A	38.6				41.0	o	
10 old A	61.8		Damaged			x	Well damaged
10 A new					47.0	o	Recovered up to 68.4 by swapping.
11 A	68.1	49.5	27.0	48.0	40.0	o	
11 B	34.1	41.4			50.0	◎	
11.5A	68.1	41.1	24.0	60.0	54.0	◎	
11.5B	36.3	36.0	24.0	54.0	Screen damaged	x	
12.0A	45.4	48.5	39.0	54.0	7.0	Δ	Seriously clogged
12.0B	—	—	—	—	—	—	USA. WDA. works Without water
12.5A	56.8	40.0	21.0	55.8	Screen damaged	x	Well damaged
12.5B	56.8	39.4	21.0	54.0	32.0	Δ	
13 A	68.1	61.5	30.0	72.0	65.0	◎	
13 B	68.1	61.2	30.0	60.0	45.0	o	Pump checked on Feb. 1985, no abnormal symptom
13.5A	56.8	47.8	27.0	60.0	50.0	◎	
13.5B	40.9	46.2		—	27.0	Δ	
14 A	56.8	47.3	30.0	60.0	54.0	◎	
14 B	45.4	19.5		Air mixture	—	Δ	Seriously clogged
14.5A	40.9	50.0	46.8	50.4	40.0	o	
14.5B	45.4	56.7		Screen damaged	—	x	Well damaged
15 A	68.1	49.7	28.5	60.0	47.0	o	
15 B	40.9	50.6	24.0	48.0	52.0	◎	
Total	24091 m^3/day	18376	9247	17669	15624		
Number	19	17	13	13	15	◎ 6 O 6 Δ 4 x 4	

CHAPTER 3

CONTENTS OF THE PROJECT

3.1 Objective

Among the existing water supply facilities in Mogadishu City, the water pumping rate of the Balad Wellfield is decreased year by year, and if these facilities are left as they are, it is predicted that this water pumping rate will further be decreased. (Refer to Fig. 11.)
As a result, there is no prospect that the stringent water shortage can be resolved even if the Algoi Wellfield (II, IIA) facilities, expected to be accomplished in the coming year, are put into full operation. Therefore, the objective of this project is to carry out the rehabilitation work for securing the initially planed water pumping rate of the Balad Wellfield urgently, and also to make necessary provisions to secure this pumping rate continuously in the future. The details of the project are as follows.

1) Design Standard

The Somalia design standards are based on WHO or the other standards. In implementing the programs of this project, however, it is judged as necessary to consider the localism and peculiarity (distinctiveness) of the object city, and after discussions with the technical staff of Somalia, the following design standards have been established and based on them, the waterworks plan was set up.

2) Planned Year

The planned year will conform to the year of 1990 as the last year of the IDWSSD, and the target year of this urgent project will be the year of 1987.

3) Planned Population Supplied

In 1976 census, the population in 14 wards of Mogadish was 444,816. Thereafter, no census has been carried out, but various population estimates have been made taking into account the expansion of city districts, increase of houses, immigration of refugees, etc. According to these estimates, the population in the planned last year of 1990 is various between maximum 1,320,000 (July 1980 Population Estimate by Sir Alexander Gibb and Partners -- Feasibility study for Mogadishu Water Supply Expansion -- Stage 2 Final Report -- Volume 3 Demand Forecasts) and minimum 1,050,000 (June 1982 Population Estimate by Dr. M.M. NUR and Associates -- Tariff Study -- Final Report). The Mogadishu Water Agency (MWA) has made a planned population estimate by adding unique data to the estimates given above.

According to the MWA's estimate, based on the 1976 population of about 445,000, the planned population is 1,000,000 (increasing rate per year 8.4%) in the target year of 1987 of the urgent project, and 1,200,000 (increasing rate per year 4.7%) in the planned year of 1990. Considering the speciality of Mogadishu against the nation-wide population increasing rate of 3.1% per year (1972 to 1981, IMF data), the MWA's estimate is judged as reasonable and it has been decided to use it as the basis for calculating the planned population supplied.

4) Planned Water Supply Rate

The water supply rate/person/day as the basis for setting up the planned water supply rate is determined by the scale of the city, meteorological conditions and the available water resource. The MWA has determined 30ℓ/person/day for public water faucets and 130ℓ/person/day for indivisual house water supply systems. (Plan for the Drinking Water Supply and Sanitation in Somalia for the Decade 1981-1990)

At present, the Mogadishu expansion works II and IIA are just near completion, the main pipes of water works in the whole city have been installed, and water supply from public water faucets has been started. After this, installing water supply pipes for individual house water supply can be started. After all the works have been completed, it is expected that the individual house water supply will be 70% and the public water faucets 30%, and the water supply rate/person/day will be 100ℓ. However, it is not considered that the individual house supply will pervade as planned, since it is based on the personal request and the expenses for the work should be born by the requesting person. After discussions with the technical staff of Somalia taking into account these circumstances, it was decided that the water supply rate in this urgent project should be 70ℓ/person/day.

Planned water supply rate

$= 0.070\ m^3/person/day \times 1,000,000$

$= 70,000\ m^3/day.$

5) Planned Water Intake Rate

At present, Mogadishu has three water sources, the water source at the Balad Wellfield, the water source at the Afgoi Wellfield and the water source in the city.

The wells in the city are old facilities constructed by the aid of the United States of America from 1968 to 1969. Owing to the decreased intake rate caused by deterioration of facilities, increased salt concentration, degreaded water quality under the influence of sewage, etc., changes of connections to the main pipes of water supply from the Balad Wellfield and the Afgoi Wellfield are being made in succession. Moreover, the water volume is small. Therefore, the wells in the city are excluded from the water intake source of this project.

The expansion works II and IIA of the Afgoi Wellfield are now under construction with funds of US$42,000,000 from the World Bank, Arab Fund, EEC and Somali Government. Most of the works have been accomplished and started to supply water partially.

According to the MWA's plan, four generators will be installed in 1986 so that the whole works will be accomplished and the facilities will be put into full operation. From the progress of the works at the site, it was judged by this study team that the works will be accomplished as scheduled. The Afgoi project is outlined in Table 4.

Table 4 Outlines of Afgoi Project

Name of project	Well	Generator
Expansion II	8	250 kW x 4
Expansion II A	24	480 kW x 2

Water intake rate per well

$60\ m^3/h = 1,440\ m^3/day$

Number of wells operated (spare parts 3 wells)

29 wells

Planned water intake

$1,440 \times 29 \doteqdot 42,000\ m^3/day$

At present, maximum 13 wells are operated by four generators already installed to supply water at 16,000 m^3/day.

Therefore, the plan of facilities will be set up to intake a volume of water 28,000 m^3 from the Balad Wellfield, which is equal to the difference between the planned water supply rate 70,000 m^3 and the amount of 42,000 m^3 which already can be supplied with certainty.

3.2 Studies on The Contents of The Request

The objective of the project mentioned above was confirmed and agreed on between the study team and the technical staff of Somalia. Then, with this objective, the contents of the request were studied again, and it was agreed on by both parties that the measures necessary for fulfilling the objective are described in "Minutes of Discussion". shown as follows.

① To execute the rehabilitation works for the 16 wells of the existing wells which are promising to be rehabilitated at the Balad Wellfield

② To construct new wells necessary for securing planned water intake rate of 28,000 m^3/day.

③ To provide equipment and materials necessary for maintaining the rehabilitated facilities at the Balad Wellfield.

According to the above items, summaries of the request objective of the Somali Democratic Republic are shown in Table 5.

Judgements on necessary works and equipment and materials as the contents of the request described in the written request, in terms of the above objective, are shown in Table 5'.

Based on the above study, taking into account the results of studies in the basic design, necessary works and equipment and materials will be determined.

Table 5 Objectives of The Request, and Study Results

No.	Objectives	Results	Remarks
①	Removal and replacement of pumps	Execute for 16 wells	
②	Pump-up test of wells	Execute for 16 wells	
③	Installation of new pumps and motors, and supply of their spare parts	Construct new necessary wells, and supply their spare parts.	
④	Treatment of wells with acids or other materials.	Execute for 16 wells	Technology transfer also has been executed
⑤	Supply of spare parts enough for the maintenance of water supply system	Supply spare parts necessary for the whole system at Balad Wellfield	
⑥	Development, maintenance and repair of wells with well maintenance rigs	Execute with new well digging rigs and rehabilitation rigs	
⑦	Cleaning of power transmission lines using a fire-fighting car	Furnish pressure pumps and execute cleaning.	
⑧	Securing of machine and worker transport vehicles	Furnish minimum required vehicles only.	

Table 5' Objectives of The Request, and Study Results

No.	Objective	Results	Remarks
①	Well maintenane rigs	Recognized as necessary.	
②	Well rehabilitation machines and materials including air-lift	Recognized as necessary.	
③	Turbine pumps 40 units	Recognized as necessary for 16 rehabilitatable wells.	
④	Generator 1 unit	Judge based on the power requirement.	Judge from the results of basic design.
⑤	Submerged pump 20 sets	Not to be furnished, because it is for town areas and considered to be out of scope of this project	
⑥	Generator	Not to be furnished for the same reason as above.	
⑦	Wheel loader	Not recognized as urgent and not to be furnished.	
⑧	Excavator	Not recognized as urgent and not to be furnished.	
⑨	Fire-fighting car	Recognized as necessary, but the furnished equipment is serviceable for the purpose.	
⑩	Vehicles Small car 10 units 8-ton dump 2 units 6-ton dump 2 units 2-ton crane 1 unit Station wagon 5 units Pick-up van 10 units	 Not recognized as urgent. Not recognized as urgent Not recognized as urgent Recognized as necessary. Minimum 2 units are recognized as necessary. Minimum 2 units are recognized as necessary.	 For rehabilitation work and maintenance.
⑪	Spare parts for above, for 3 years	For work period plus 1 year	
⑫	Galvanized steel pipe	Out of scope of urgent objective	

3.3 Outline of The Project

3.3.1 Implementing Agency and Operating System

The implementing agency for this project is the MWA. Since this project comprises mainly of rehabilitation works, it is judged that the operating system by the existing organization and personnel may be sufficient for the operation.

3.3.2 Basic Plans

This project is an urgent measure project. The target year is 1987, the population supplied is 1,000,000, and the water supply rate is 70ℓ/person/day. Considering the other water supply circumstances, the water pumping rate improving work at the Balad Wellfield will be executed.

The details are calculated in Chapter 4. The basic plans are shown in Table 6.

Table 6 Basic Plans

Existing facilities water pumping rate (15 wells in full operation)	13,000 m^3/day
Planned water pumping rate after rehabilitation	28,000 m^3/day
Rehabilitation of existing wells (16 wells)	19,200 m^3/day
Construction of new wells (5 wells)	8,800 m^3/day

3.3.3 Planned Position and Circumstances

The planned position is the Balad Wellfield. It is in a range of 9 km to 16 km from the center of Mogadishu City. From town to the site, the road conditions are good, but traffic conditions for vehicle and fuel procurement are bad. At the field, facilities excepting power plant for waterworks are not available.

3.3.4 Outline of Facilities and Equipment and Material

For supplying water at 28,000 m^3/day of the basic plan, the existing facilities should be rehabilitated and, any facilities which are badly damaged or have insufficient capacity, should be replaced with new ones. Outlines of the facilities, equipment and materials are as follows.

1) Well

The existing wells will be rehabilitated to make it possible to supply water at average 50 m^3/day for each well, and new wells will be dug to make up for the water supply shortage.

2) Pump

The existing pumps are badly damaged. All pumps for the existing and new wells should be new ones.

3) Generator

The existing generators are not enough for operating the pumps for pumping rate 28,000 m^3/day. One generator will be newly installed.

4) Electrical Equipment

Where there are no transmission lines or transformers, these will be newly installed.

5) Fence

Fences are installed at all pump stations. If they are badly damaged, new ones will be installed.

6) Excavator

Excavators and associated machines will be furnished for constructing new wells, and after the construction, they will be used for maintenance purpose.

7) Vehicle

Required minimum vehicles for work and maintenance will be furnished.

8) Equipment and materials for maintenance

The existing maintenance equipment and materials are not sufficient, and new ones will be furnished.

3.3.5 Administration Plan and Personnel Arrangement

Considering the stringent water shortage in Mogadishu at the present time, it is not permitted to stop water pumping for a long time even if the work is being done. On this condition, in order to cope with occurrence of unexpected events, the persons concerned with the work should stay at all times in the field office in the following arrangement.

Japanese side person responsible for works	1 person
Somali side person responsible for works	1 person
Native car driver	1 person
Native laborer	2 persons
Total	5 persons

3.4 Technical Aids

This project has been requested for the reasons of the economical affairs and the technical capabilities in Somalia. One of the reasons on the background for which the rehabilitation work has become necessary is the low technical capability for maintenance.

During the execution of this project, technology must be transferred to the personnel and laborers of the MWA. In order to maintain the planned water pumping rate even after accomplishment of the work, it is desired to provide technical aids such as guidance of the competent engineers who stay there and have skills in taking measures based on the long time of experiences regarding deep wells, and also to train and educute the Somali engineers for carrying out actual repairs.

CHAPTER 4

BASIC DESIGN

4.1 Design Policy

For the design, the technical capability, existing machines, and other circumstances at the field should be taken into consideration, and if possible the method of execution, materials, equipment, etc. which are without hindrance in the operation and maintenance should be selected.

4.2 Design Condition

As a rule, the design condition should be in accordance with the Japan Waterworks Association's "Design Guidelines for Waterworks Facilities", and in addition, the circumstances at the site shall be taken into consideration in determining the particular design condition.

4.3 Design of the Facilities

4.3.1 Water Source Design

1) Existing facilities Rehabilitation Plan

(1) Determination of The Water Pumping Rate at the Existing Wells

The data on the strainer were obtained for the wells shown in Table 7.

Table 7 List of Strainers

Well No.	Strainer material	Diameter	Length	Opening ratio	Influx speed
9.5A	SS	9 5/8 in.	37.7 m	1.32 %	4.39cm/sec
11 A	SS	9 5/8	32.0	1.32	5.18
12.5B	SUS	6 5/8	27.9	1.92	5.97
13 A	SUS	6 5/8	29.0	1.92	5.74
13 B	SUS	6 5/8	36.2	1.92	4.57
13.5A	SUS	6 5/8	36.3	1.92	4.57
13.5B	SUS	6 5/8	33.7	1.92	4.95
14 A	SUS	6 5/8	35.1	1.92	4.72
14 B	SS	9 5/8	36.7	1.32	4.50
14.5A	SUS	6 5/8	35.2	1.92	4.72
15 A	SS	9 5/8	33.0	1.32	5.03
15 B	SUS	6 5/8	29.0	1.92	5.74

These strainers are used by slit type so that the opening ratio is small and the influx speed is very rapid.

As was found in the attached impeller worn-out study, at this so rapid influx speed, fine sands around the filling gravel inflow into the pump and cause the pump to be worn-out and result in the decreased water pumping rate.

The influx speed is determined by the conditions of the surrounding soil and sand, and the pump speed of revolution. In general, its guide value is 30 mm/sec. In the Japan Waterworks Association's "Design Guidelines for Waterworks Facilities", it is recommended that the opening ratio should generally be 15 to 30% and the influx speed of ground water should be below 1.5 mm/sec. This recommendation is based on the circumstances in Japan that the submerged motor pumps are used, and for the purpose of reducing the construction cost, the speed of revolution is taken high (3,000 rpm), and the ingress of sand should be avoided strictly.

On the other hand, the existing pumps are the vertical shaft type turbine pumps which are relatively strong to the ingress of sand, and the speed of revolution is 1,500 rpm which is half of the general values. Therefore, it is not always necessary to adjust to the Japanese standards.

According to "Ground Water Manual" (written by Toshio Murashita), the relation between the sand grain size and the efflux critical velocity is shown in Table 8.

Table 8 Efflux Critical Velocity

	Very fine sand	Fine sand	Medium sand	Coarse sand
Grain size (mm)	0.05 - 0.1	0.1 - 0.25	0.25 - 0.5	0.5 - 1.0
Critical velocity (mm/sec)	2.8 - 9.6	9.6 - 27	27 - 52	52 - 97

As to the water intake layers in the project area, the upper aquifer consists of extremely fine to medium sand, and the lower aquifer consists of alternate shale and limestone layers of fine sand and medium sand. From the above table, therefore, it is necessary to select the influx speed at least less than the speed of the medium sand. Taking into account the past conditions of water pumping the influx speed for the existing facilities rehabilitation plan was decided to be 40 mm/sec.

The corresponding planned water pumping rate after rehabilitation is shown in Table 9.

Table 9 Planned Water Pumping Rate after Rehabilitation

Well No.	Water pumping rate (m^3/h)	Well No.	Water pumping rate (m^3/h)
9.5A	54.0	13.5B	48.5
11.0A	46.3	14.0A	50.8
12.0A	50.8	14.0B	53.3
12.5B	40.2	14.5A	50.8
13.0A	41.8	15.0A	47.7
13.0B	52.5	15.0B	41.8
13.5A	52.5	Total (13 wells)	631.7

Thus, the average water pumping rate after rehabilitation for 13 wells shown above, of which the details of strainers are known, will be taken at 50 m^3/h and for 4 wells 10A, 11B, 11.5A and 12.0A, of which the details of strainers are not known, it will be taken also at 50 m^3/h.

However, in executing the work, it is necessary to measure the sand influx rate and the water pumping rate and thereby determine the water pumping rate again.

(2) Method of Rehabilitation

Table 10 shows the causes and remedies for the decreased water pumping rate of wells, and the effects for each well.

Table 10 Causes for lowered Water Pumping Rate, and Remedies

Cause		Remedy	Effect
Clogging	Sticking of scale Much bicarbonates such as calcium, magnesium, etc. are dissolved in ground water (total dissolved solids 600 ppm), and therefore, with the lowering of running water level, they become difficult to dissolve and stick to screens causing clogging of screens.	Remove stickings by phosphate treatment, and reduce pumping rate so as to reduce lowering of running water level.	Remarkable effects in the case of 12.0A, 12.5B, 13.5B and 14.0B wells
	Corrosion products Corrosion products such as iron hydroxides cause clogging of screens.	Can be removed by phosphate treatment.	Fe is about 0.21 ppm. Therefore, it causes little drop of pumping rate
	Slimes with bacteria Ferrobacteria and other micro-organisms grow in the well, and resulting slimes cause clogging of screens.	Clean or slerilize.	Water test indicates few bacteria and hence, little drop of pumping rate.

	Cause	Remedy	Effect
Clogging	Physical causes due to soil particles Soil particles of sand, silt, clay, etc. fill in the filling material and interfere with water flow.	Apply swapping to improve water flow through the filling material.	Effective in 12.0A, 12.5B, 13.5B, 14.0B, 9.5A, 10.0A, 11.0A, 13.0B, 14.5A and 15.0A wells where pumping rate was lowered
Deterioration of water intake facilities	Worn-out of impeller Impeller worn out with influent sand to reduce pumping rate.	Replace impeller and increase pumping rate.	Effects can be expected for the whole wells.
	Reduced power supply Reduced power transmission time or transmitted power reduces pumping rate.	Rehabilitate power generation equipments and improve transmission facilities.	Whole pump operation time is increased and effects can be expected.
	Deteriorated motor Deteriorated motor causes over-currents resulting in operation shut-down, or slipping resulting in reduced rotation speed.	Replace motor.	The MWA recognizes no problem, but effects can be expected in 12.0A well. Details are unknown. Judged as requiring a study.

Taking into consideration the above-listed circumstances and the present water pumping rate, the wells to be rehabilitated will be classified into three groups as shown in Table 11, to secure the average water pumping rate after rehabilitation of 50 m^3/h.

Table 11 Rehabilitation Work

Present water pumping rate		Below 40 m^3	50 ∼ 40 m^3	Above 50 m^3
Well		12.0A, 12.5B 13.5B, 14.0B	9.5A, 10.0A, 11.0A 13.0B, 14.5A, 15.0A	11.0B, 11.5A, 13.0A 13.5A. 14.0A, 15.0B
Rehabilitation work	Confirmation of flow	o	o	o
	Sand ramoval	o	o	o
	Acid treatment	o	o	
	Well cleaning	o	o	
	Brushing	o		
	Pump-out test	o		
	Pump setting	o	o	o
	Piping (including meter)	o	o	o
	Test running	o	o	o

2) Plan for New Wells

Planned water intake rate

28,000 m^3/day

Existing well water pumping rate after rehabilitation

16 x 50 m^3/h x 24h = 19,200 m^3

New well water pumping rate

28,000 - 19,200 = 8,800 m^3/day

The existing facilities were planned for the water pumping rate of 60 m^3/h, and after rehabilitation, they are capable of continuous water pumping at 50 m^3/h. The number of wells to be newly installed to make up for the shortage is determined by their water pumping rate. The existing facilities are of old type and their water pumping rate per well is taken at a low value. For the new wells, therefore, a higher water pumping rate can be well expected, but in connection with the water level in the other wells, it can not be increased unlimitedly.

If the water pumping rate per well is assumed as 70 m^3/h to 80 m^3/h, then the number of wells, n, will be

$$n = \frac{8,800}{(70 \sim 80) \times 24} = 5.2 \sim 4.5 \text{ units}$$

Therefore, n = 5 and the water pumping rate per well is determined as follows.

$$Q = \frac{8,800}{5 \times 24} = 74 \ m^3/h$$

The pump layout plan is shown in Fig. 14.

3) Prediction of The Lowering of Static Water Level

At the Balad Wellfield, for past 15 years, the water level was lowered by maximum 7.8m and minimum 2.5m. It suggests that the water recharge is less than the water pumping rate. The major cause may be that many wells were installed in a narrow range and these wells interfered with each other.

At this point, the lowering of water level at the Balad Wellfield will be estimated.

In the present plan, 21 wells at the Balad Wellfield is expected to provide water pumping at 28,000 m^3/day. The lowering of water level with this water pumping at 28,000 m^3/day will be calculated.

Assumptions:

1. All 21 wells form a single large well.
2. The lowering of water level is calculated in accordance with the Theim's equation.

$$Q = \frac{2\pi D \cdot k \ (H - h)}{2.3 \log R/\gamma_0}$$

where D: thickness of aquifer (m)

k: permeability coefficient

T: = D.k, water permeation coefficient

H-h: lowering of water level

R: influencial radius

γ_0: well radius

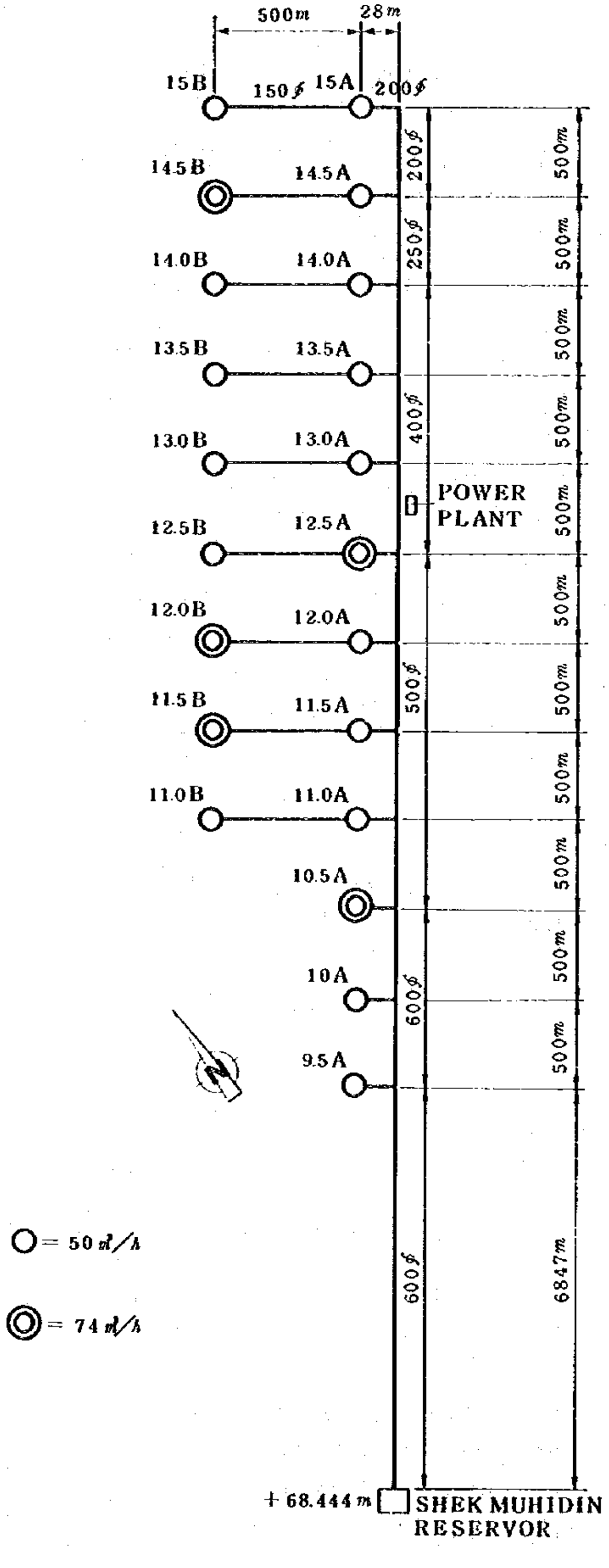


Fig.14 The Pump Layout Plan after Rehabilitation

By rewriting the above equation,

$$H - h = \frac{Q \times 2.3 \log R/\gamma_0}{2\pi D \cdot k}$$

As the numerical values at the Balad Wellfield, the average values in the pump-out test will be used.

As the water permeation coefficient (T), the results of the pump-out test in 1980 (493 m^3/day, 317 m^3/day) will be used.

$$T = \frac{(493 + 317) \times 1/2}{24 \times 60} = 0.281\ m^2/min$$

Well group radius:

The Balad Wellfield spreads from 9.5 km to 15 km in 500m width. Its area is

$$A = (15 - 9.5) \times 0.5 = 2.7\ km^2$$

The radius of a circle corresponding to this area, γ_0, is

$$\gamma_0 = 2.75/\pi = 0.94\ km = 940m$$

Influencial radius:

$$R = \gamma_0 + R' = 940 + 500 = 1{,}440m$$

where R' = influencial range (500m)

Water pumping rate $Q = 28{,}000\ m^3/day$
$= 19.4\ m^3/min$

From these conditions,

$$S = H - h = \frac{19.4 \times 2.3 \log 1{,}440/940}{2\pi \times 0.281}$$
$$= 4.68m$$

Therefore, it is planned that the design water level will be set minus 4.7m beneath the present groundwater level.

Therefore, the lowering of the static water level will be taken as 4.7m.

4) Prediction of The Lowering of Running Water Level

(1) By water pumping in the existing wells at 50 m^3/h = 0.833 m^3/min, the running water level is lowered as follows.

$$S = H - h = \frac{Q \times 2.3 \log R/\gamma_0}{2\pi \cdot D \cdot k}$$

where $Q = 0.833\ m^3/min$

$R = 500m$

$\gamma_0 = 0.122m$

$D \cdot k = T = 0.281\ m^2/min$

$$S = H - h = \frac{0.833 \times 2.3 \log 500/0.122}{2\pi \times 0.281}$$

$$= 3.92m$$

(2) By water pumping in the new wells at 74 m^3/h = 1.23 m^3/min, the running water level is lowered as follows.

$$S = H - h = \frac{1.23 \times 2.3 \times \log 500/0.122}{2\pi \times 0.281}$$

$$= 5.79m$$

In this way, the lowering of the running water level is different from the water pumping rate. Therefore, the lowering of the running water level will be taken as 4.0m for the existing wells and as 5.8m for the new wells.

5) Design Water Level

In order to determine the pump lift, the water level (design water level) in the water source wells used at the water pumping rate of 28,000 m^3/day in this project will be calculated.

The water level in the water source wells was examined in this study in the following wells. The results of the examination are shown in Table 12.

Table 12 Well Water Level (surveyed in Feb., 1985)

Well	Well height above sea level	Water level below ground	Water level above sea level
10A	72.67	-70.20	+ 2.47
14P2	73.47	-66.55	+ 6.92
14B	77.90	-67.51	+10.39
14BP	77.94	-67.44	+10.50
15CP	78.81	-62.67	+16.14

At the field, about 9 observation wells were dug, but all these wells except three wells which were used in this examination were covered with sand and could not be used.

Moreover, in two wells 10A and 14B, the water level was examined because the pumps of them were removed and it became possible to examine the water level in them.

From these results and the data in 1970, the lowering of the water level in the wells was calculated. For any wells which could not be examined in this study, it was calculated from the lowering of the water level in the wells which could be examined. That is, wells 9.5A through 14.0B were allocated equally with the value in wells 10.0A and 14.0B. For wells 14.5A through 15.0B, it was estimated from that of well 15CP.

To these values, the design value 4.7m around the Balad wells, and appropriate value 4.0m or 5.8m at the water pumping rate 50 m^3/h or 74 m^3/h, were added. (Table 13)

The changes of water levels in wells and the design water level from 1970 to 1985 are shown in Fig. 5 and Fig. 6.

4.3.2 Design of Pump Equipments

As to the existing pump equipments, pump casings, impellers, etc. were badly worn-out due to sand ingress and they require replacement or repair. Moreover, from the circumstances at the site, it is impossible to shut down the pumps for a long time.

Table 13 Static Water Level Variations of Wells

(above sea level, m)

Well	Year			Lowering of water level 1970 → 1985	Estimated design lowering value				Design water level
	1970	1977	1985		1970 → 1985	Around Balad wells	Individual value	Total	
9.5A	+ 6.7				4.35m	4.7m	4.0m	13.1m	-6.4
10.0A	+ 7.0		+ 2.47	4.53	4.53	4.7	4.0	13.2	-6.2
B10P2	+ 8.67	+ 6.66							
10.5A	+ 8.5				4.72	4.7	5.8	15.2	-6.7
10.5CP		+ 9.06							
11.0A	+ 9.5	+ 5.37			4.90	4.7	4.0	13.6	-4.1
11.0B					4.90	4.7	4.0	13.6	-4.1
11.5A	+ 9.8				5.09	4.7	4.0	13.8	-4.0
11.5B					5.09	4.7	5.8	15.6	-5.8
12.0A	+10.9				5.27	4.7	4.0	14.0	-3.1
12.0B					5.27	4.7	5.8	15.8	-4.9
12.5A	+12.2				5.46	4.7	5.8	16.0	-3.8
12.5B	+13.1				5.46	4.7	4.0	14.2	-1.1
K13H		+ 5.72							
13.0A	+12.5				5.64	4.7	4.0	14.3	-1.8
13.0B	+14.3				5.64	4.7	4.0	14.3	±0.0
13.5A	+13.3				5.83	4.7	4.0	14.5	-1.2
13.5B	+14.6				5.83	4.7	4.0	14.5	+0.1
B14P1	+14.92	+ 8.85							
B14P2	+14.71	+ 8.56	+ 6.92	7.79					
14.0A	+14.6				6.01	4.7	4.0	14.7	-0.1
14.0B	+16.4		+10.39	6.01	6.01	4.7	4.0	14.7	+1.7
14BP	+17.24	+11.96	+10.5	6.74					
14.5A	+16.1				4.0	4.7	4.0	12.7	+3.4
14.5B	+17.3				4.0	4.7	5.8	14.5	+2.8
15.0A	+16.8				3.0	4.7	4.0	11.7	+5.1
15.0B	+18.6				3.0	4.7	4.0	11.7	+6.9
15CP	(+18.6)	+17.50	+16.14	(2.46)					
K15H2		+12.71							
K15H4		+12.75							

At the site, equipments and materials and technical personnel for repair are not adquately available. If it were attempted to purchase parts (pumps are old American made and it is unknown that their parts are available or not) and repair by the engineers dispatched from Japan by spending a long time would require vast cost, and yet, complete rehabilitation would be impossible. Therefore, the pump equipments will be entirely replaced with new ones.

For the existing wells where much sand will enter the pumps, the vertical shaft type turbine pumps will be adopted since sand can easily be removed from these pumps, and for the new wells where sand ingress will be small owing to the construction of the strainers, submerged motor pumps will be installed.

The pump capacity will be selected at 50 m^3/h for 16 pumps to match the capacity of the existing wells after rehabilitation, and at 74 m^3/h for 5 pumps in the new wells.

1) Design Condition

Flow

Existing wells: $50\ m^3/h = 0.833\ m^3/min$
$= 0.0139\ m^3/sec$

New wells : $74\ m^3/h = 1.233\ m^3/min$
$= 0.0206\ m^3/sec$

Pipes

Asbestos cement pipe

Flow equation

Hazen-William's Formula

$$h = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot \ell$$

where C = 110 (including the bending loss)
(according to the Japan Waterworks Association's Water works Facilities Standards)

D = pipe diameter (m)

Q = flow (m^3/sec)

ℓ = total length of pipes (m)

2) Calculation of Loss Heads of Pipes

(1) From 15B to 14.5 main pipe Tee

From 15B to 15A:

Pipe diameter D = 0.15m

Total length ℓ = 500m

Flow Q = 0.0139 m^3/sec

(h = loss head)

$$h = 10.666 \cdot 110^{-1.85} \cdot 0.15^{-4.87} \cdot 0.0139^{1.85} \cdot 500$$

$$= 10.666 \times 0.000167 \times 10290.5 \times 0.000367 \times 0.000674 \times 500$$

$$= 3.368\text{m}$$

From 15A to 14.5 Tee

D = 0.2m, ℓ = 28m + 500m = 528m

Q = 0.0139 x 2 = 0.0278 m^3/sec

$$h = 10.666 \times 110^{-1.85} \times 0.2^{-4.87} \times 0.0278^{1.85} \times (28 + 500)$$

$$= 0.167\text{m} + 2.980\text{m}$$

$$= 3.147\text{m}$$

The head losses of various pipes are summarized in Table 14, 15 and 16.

(2) Summary of Head Losses of Pipes

Table 14 Loss Head of Pipes in Various Main Pipe Sections

$(h=10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot \ell)$

Section (Km)	C		D		Q			ℓ(m)	h(m)	
	C	$C^{-1.85}$	m	$D^{-4.87}$	m^3/h	m^3/sec	$Q^{1.85}$		Section	Total
Water Storage tank 9.5	110	0.000167	0.6	12.034	1,170	0.325	0.125	6,840	18.346	18.346
9.5 ~ 10.0	110	0.000167	0.6	12.034	1,120	0.311	0.115	500	1.233	19.579
10.0 ~ 10.5	110	0.000167	0.6	12.034	1,070	0.297	0.106	500	1.136	20.710
10.5 ~ 11.0	110	0.000167	0.5	29.243	996	0.277	0.0930	500	2.422	23.132
11.0 ~ 11.5	110	0.000167	0.5	29.243	896	0.249	0.0764	500	1.990	25.122
11.5 ~ 12.0	110	0.000167	0.5	29.243	772	0.214	0.0577	500	1.503	26.625
12.0 ~ 12.5	110	0.000167	0.5	29.243	648	0.180	0.0419	500	1.091	27.716
12.5 ~ 13.0	110	0.000167	0.4	86.690	524	0.146	0.0284	500	2.193	29.909
13.0 ~ 13.5	110	0.000167	0.4	86.690	424	0.118	0.0192	500	1.482	31.391
13.5 ~ 14.0	110	0.000167	0.4	86.690	324	0.0900	0.0116	500	0.896	32.287
14.0 ~ 14.5	110	0.000167	0.25	855.13	224	0.0622	0.00587	500	4.471	36.758
14.5 ~ 15.0	110	0.000167	0.2	2535.03	100	0.0278	0.00132	500	2.980	39.738

(3) Summary of Head Losses around Pumps

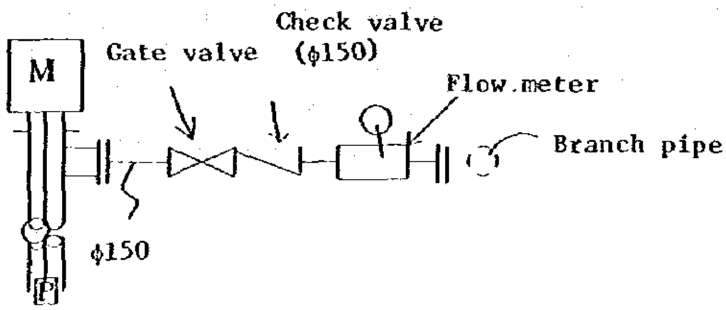
Table 15 Loss Head of Pipes between

Pump and Main Pipe Tee

(According to the equation $h = 10.666 . C^{-1.85} . D^{-4.87} . Q^{1.85} . \ell$)

Section	Q			C		D		ℓ(m)	h(m)	Remarks
	m^3/h	m /sec	$Q^{1.85}$	C	$C^{-1.85}$	m	$D^{-4.87}$			
B A	50	0.0139	0.000367	110	0.000167	0.15	1029.5	500	3.368	
B A	74	0.0206	0.000760	110	0.000167	0.15	1029.5	500	6.965	
A Tee	50	0.0139	0.000367	110	0.000167	0.2	2535.03	28	0.046	
A Tee	74	0.0206	0.000760	110	0.000167	0.2	2535.03	28	0.096	
A Tee	100	0.0278	0.00132	110	0.000167	0.2	2535.03	28	0.167	
A Tee	124	0.0344	0.00196	110	0.000167	0.2	2535.03	28	0.247	
A Tee	148	0.0411	0.00273	110	0.000167	0.2	2535.03	28	0.345	

3) Head Losses from Pump to Branch Pipe



Valve head loss equation

$$f \cdot v^2/2g$$

where f: loss coefficient 1.0 for check valve and 0.145 for sluice valve

v = flow velocity (m/sec)

$$\frac{0.0139}{0.15^2 \times \pi/4} = 0.787 \quad \frac{0.0206}{0.15^2 \times \pi/4} = 1.166$$

$g = 9.8 \ m/sec^2$

Table 16 Loss Head between Pump and Branch Pipe

Pumping rate	Valve, etc.	V (m/sec)	$V^2/2g$	f	h (m)	Remarks
50 m^3/h	Check	0.787	0.0316	1.0	0.0316	
	Sluice	0.787	0.0316	0.145	0.0046	
	Other				1.0	Flow meter, piping, well pump-up pipe, etc.
	Total				1.036	
74 m^3/h	Check	1.166	0.0694	1.0	0.0694	
	Sluice	1.166	0.0694	0.145	0.0101	
	Other				1.5	Flow meter, piping, well pump-up pipe, etc.
	Total				1.580	

4) Calculation of Total Lift of Each Pump

The total lift of each pump will be calculated by adding the actual lift which is the difference between the water storage tank and well design water levels to the piping head loss shown above.

Table 17 Total Head Calculation Table for Pumps

Pump	Pumping rate (m³/h)	Loss head of pipes				Actual lift			Total head	Allowance 50% added
		Pump to branch pipe	B A	A to main pipe tee	Main pipe tee to water storage tank	Storage tank water level	Well design water level	Actual lift water level difference		
9.5A	50	1.04		0.046	18.346	68.444m	-6.4m	74.84m	94.27	99.0
10.0A	50	1.04		0.046	19.579	68.444	-6.2	62.24	82.91	87.1
10.5A	74	1.58		0.096	20.710	68.444	-6.7	75.14	97.53	102.4
11.0A	50	1.04		0.167	23.132	68.444	-4.1	72.54	96.88	101.7
11.0B	50	1.04	3.368	0.167	23.132	68.444	-4.1	72.54	100.28	105.3
11.5A	50	1.04		0.247	25.122	68.444	-4.0	72.44	98.85	103.8
11.5B	74	1.58	6.965	0.247	25.122	68.444	-5.8	74.24	108.15	113.6
12.0A	50	1.04		0.247	26.625	68.444	-3.1	71.54	99.45	104.4
12.0B	74	1.58	6.965	0.247	26.625	68.444	-4.9	73.34	108.76	114.2
12.5A	74	1.58		0.247	27.716	68.444	-3.8	72.24	101.78	106.9
12.5B	50	1.04	3.368	0.247	27.716	68.444	-1.1	69.54	101.91	107.0
13.0A	50	1.04		0.167	29.909	68.444	-1.8	70.24	100.36	106.4
13.0B	50	1.04	3.368	0.167	29.909	68.444	±0	68.44	102.92	108.1
13.5A	50	1.04		0.167	31.391	68.444	-1.2	69.64	102.24	107.4
13.5B	50	1.04	3.368	0.167	31.391	68.444	+0.1	68.34	104.31	109.5
14.0A	50	1.04		0.167	32.287	68.444	-0.1	68.54	102.03	107.1
14.0B	50	1.04	3.368	0.167	32.287	68.444	+1.7	66.74	103.60	108.8
14.5A	50	1.04		0.247	36.758	68.444	+3.4	65.04	103.09	108.2
14.5B	74	1.58	6.965	0.247	36.758	68.444	+2.8	65.64	111.19	116.7
15.0A	50	1.04		0.167	39.738	68.444	+5.1	63.34	104.29	109.5
15.0B	50	1.04	3.368	0.167	39.738	68.444	+6.9	61.54	105.9	111.1

5) Pump Equipment Plan

From the pump heads calculated above, the pump equipment will be planned.

The pump equipment will consist of two kinds of 50 m^3/h capacity pumps and one kind of 74 m^3/h capacity pumps, respectively, for interchangeability in the event of failure.

The planned pump equipment is as shown in Table 18.

The shaft power of the pump will be calculated.

The following calculation formula in JIS B-8301 (1976) will be used.

$$P = 0.163 \gamma Q H / \eta$$

where P: pump shaft power (kW)

γ: weight of liquid/unit volume (kg/ℓ)

Q: discharge rate (m^3/min)

H: total head (m)

η: pump efficiency (decimal)

Calculations

1. $P = 0.163 \times 1 \times 0.83 \times 107 \times 1 / 0.6$ $\quad \eta = 0.6$ (vertical shaft type turbine)
   $= 24.13kW$
2. $P = 0.163 \times 1 \times 0.83 \times 112 \times 1 / 0.6$ $\quad \eta = 0.6$ (vertical shaft type turbine)
   $= 25.25kW$
3. $P = 0.163 \times 1 \times 1.23 \times 117 \times 1 / 0.67$ $\quad \eta = 0.67$ (submerged motor)
   $= 35.01kW$

Table 18 Pump Equipmemt Specifications

No.	Water pumping rate	Head	Unit	Type
1	50 m^3/h (0.83 m^3/min)	107m	8	Vertical shaft turbine
2	50 m^3/h (0.83 m^3/min)	112m	8	Vertical shaft turbine
3	74 m^3/h (1.23 m^3/min)	117m	5	Submerged motor pump
	Total		21	

The driving force output of the pump will be calculated.

The driving force output will consist of the shaft power plus an allowance.

The allowance will be taken as 10 to 15% because the prime mover is the motor and head variations are small at high lifts.

The following calculation formula will be used.

$P_m = (1 + \alpha)$

where P_m = prime mover output (kW)

α = allowance (decimal)

Calculations

1. 24.13×(1+0.15) = 27.7kW $\alpha = 0.15$
2. 25.25×(1+0.15) = 29.0kW "
3. 35.01×(1+0.10) = 38.5kW $\alpha = 0.1$ (for submerged pump)

At this pump, the motor output will be taken as follows.

1. and 2.: 30 kW

3. : 45 kW

In the case of existing wells, much sand flows out and the impeller of the pump may thereby be worn-out. In order to minimize worn-out of the impeller, the revolution number of the pump for these wells should be decreased. Thus, the 4-p (1,500 rpm) motor will be used for the vertical shaft type turbine pump.

Table 19 Specification of The Pumps at The Balad Wellfield

No.	Type	Pumping rate	Head	Motor	Unit
1	Vertical shaft turbine	50 m^3/h	107m	30 kW, 380V, 50 Hz 4p	8
2	Vertical shaft turbine	50 m^3/h	112m	30 kW, 380V, 50 Hz, 4p	8
3	Submerged motor pump	74 m^3/h	117m	45 kW, 380V, 50 Hz, 2p	5
	Total				21

4.3.3 Design of Piping Equipments

The piping equipments around the pumps will be replaced. Branch pipes to be connected to 21 pumps are 150ϕ pipes, and the specifications for them will be determined as shown in Table 20.

Table 20 Piping Equipment

Name	Flexible joint	Flow meter	Check Valve	Valve	Pressure gauge
Type	Flange type	Turbine	Swing type	Sluice type	Bourdon tube
Pipe dia.	150ϕ	150ϕ	150ϕ	150ϕ	150ϕ
Material	Rubber, FC	FC	FC, SUS	FC, SUS	BC, SUS
Quantity	21	21	21	21	21

The existing main pipings of diameter 150ϕ to 600ϕ asbestos cement pipes are not damaged. They can still be used and replacement is not needed.

4.3.4 Design of Electrical Equipments

1) Generator

Among the existing generator equipments, five 250 kVA generators are usable. But, if one of them is taken as stand-by, the remaining four generators can be used regularly.

At this point, the generator capacity will be examined on assumption that 16 motors of 30 kW and 5 motors of 45 kW are operated. Additional loads other than the pumps include 100 kVA for repair shops and 10 kVA for illumination, 110 kVA in total.

The generator capacity to be required will be determined by the necessary capacity for operating all pumps or the necessary capacity in terms of the voltage drop whichever is larger.

(1) Necessary Capacity for Operating All Pumps

$$P_{G1} = \frac{\Sigma P_0}{\eta_L \times \psi_L} \times \alpha$$

where P_{G1}: generator capacity kVA

ΣP_0: sum of driving force (kW)

η_L: overall efficiency of loads, 0.85

ψ_L: overall power factor of loads, 0.8

α: demand factor, 0.8

Calculations:

$$\Sigma P_0 = 30 \times 16 + 45 \times 5 = 705 \text{ kW}$$

$$P_{G1} = \frac{705}{0.85 \times 0.8} \times 0.8 = 829.4 \text{ kVA}$$

(2) Necessary Capacity in Terms of Voltage Drop

If the motor of maximum capacity is to be started at the last, then the following formula will be used.

$$P_{G2} = \frac{\left(\frac{\Sigma P_0 \times \alpha}{\eta_L} - \frac{P_m}{\eta_m} \right) + P_m \times \beta \times C \times \psi_s}{\gamma \times \psi_g}$$

where P_{G2}: generator capacity (kVA)

P_m : maximum capacity motor output (kW)

β : starting kVA per kW of maximum capacity, 7.2 kVA

c : constant determined by the starting system, 1.0 (direct-starting will be used in provision for failure of the operation panel)

ψ_s : maximum capacity motor power factor, 0.8

γ : prime mover momentary load capacity, 1.1

ψ_g : generator power factor, 0.8

η_m : maximum capacity motor efficiency, 0.85

$$P_{G2} = \frac{\left(\frac{705 \times 0.8}{0.85} - \frac{45}{0.85}\right) + 45 \times 7.2 \times 1.0 \times 0.8}{1.1 \times 0.8}$$

$$= 988.4 \text{ kVA}$$

Therefore, the generator capacity required by motors is 988.4 kVA.

The distance from the generator to the farthest pump is about 3.0 km. Taking into account the voltage drop, 4.0% will be added to the above capacity, and moreover, repair shop and illumination loads of 110 kVA in total will be added.

$$988.4 \times (1 + 0.04) = 1.027.9\text{kVA} = 1.028\text{kVA}$$

$$1.028\text{kVA} + 110\text{kVA} = 1.138\text{kVA}$$

Thus, the four existing generators of 250 kVA each, 1,000 kVA in total, are not sufficient, and one more generator is necessary.

The generator to be installed will have the same specifications as the existing generators for interchangeability in the event of failure of the existing equipments.

One generator of the following specification will be newly installed.

Capacity	:	250 kVA
Voltage	:	380V/220V
Frequency	:	50 Hz
Prime mover	:	Diesel engine

2) Transformer

The existing plant equipments include two 500 kVA capacity transformers which are to supply power to the north and the south, respectively.

The transformer capacity will be examined.

On the northern side, there are 9 pump motors of 30 kW and one of 45 kW on the southern side, there are 7 pump motors of 30 kW and 4 of 45 kW.

The transformer capacity will be calculated in accordance with the following formula.

$$T = \Sigma P_0 \times \frac{\beta \times \alpha}{\eta \times \psi}$$

where α: allowance, 1.1

T: transformer capacity (kVA)

β: demand factor

For the pumps on the northern side which have high head, β will be taken as 0.83, and for the pumps on the southern side, β will be taken as 0.77.

For the transformers on the northern side, the capacity T_n is to be:

$$T_n = (30 \times 9 + 45) \times \frac{0.83 \times 1.1}{0.85 \times 0.8} = 422.9 \text{ kVA}$$

For the transformers on the southern side, the capacity T_s is to be:

$$T_S = (30 \times 7 + 45 \times 4) \times \frac{0.77 \times 1.1}{0.85 \times 0.8} = 485.8 \text{ kVA}$$

Therefore, the existing transformers on both sides have sufficient capacities.

As the voltage dropping transformers for 45 kW pumps to be installed in the new wells, the existing transformers are not sufficient. New transformers have to have the following capacity.

$$T = 45 \times \frac{0.8 \times 1.1}{0.85 \times 0.8} = 58.2 \text{ kVA}$$

Five transformers of the following specifications will be installed.

Capacity :	75 kVA
Primary voltage :	15 kV, 3-phase 3-wire
Secondary voltage:	380V/220V, 3-phase, 4-wire
Frequency :	50 Hz

3) Wiring

On the high voltage transmission poles of the existing equipments, 22 m^2 hard-drawn aluminum stranded wires are strectched for power transmission.

These transmission wires will be examined if the sectional area is proper or not.

The maximum current to flow through these wires is given by the following formula.

$$I = \frac{\Sigma P_0 \times \beta}{\eta \times \psi \times \sqrt{3} \times E \times \alpha}$$

where I: current (A)

E: transmission voltage (kV)

α: current reduction ratio, 1.0

ΣP_0 means summation of 9 unit 30 kW and 1 unit 45 kW pumps on the northern side and 7 unit 30 kW and 4 unit 45 kW pumps on the southern side.

For the pumps on the northern side which have high heads, β will be taken as 0.83 and for the pumps on the southern side, β will be taken as 0.77.

Because of 3-phase AC 15 kV, the current I_n on the northern side is

$$I_n = \frac{(30 \times 9 + 45) \times 0.83}{0.85 \times 0.8 \times \sqrt{3} \times 15 \times 1} = 15.2$$

and the current I_s on the southern side is

$$I_s = \frac{(30 \times 7 + 45 \times 4) \times 0.77}{0.85 \times 0.8 \times \sqrt{3} \times 15 \times 1} = 17.4$$

Thus, the existing 22 mm^2 hard-drawn aluminum bare stranded wires (allowable current about 50A) are suitable.

At 11.5B, there are poles, but wires have been removed.

Therefore, for 500m between 11.5A and 11.5B, high-voltage wirings will newly be installed.

At 10.5A, there are no electrical wire equipments at the present time. Therefore, entrance high-voltage wirings and transformer mounting poles from the Balad Road to 10.5A will be installed.

Entrance wirings from the transformer to the pump motor will be newly installed only for 45 kW motors for 74 m^3/h pumps which are to be newly installed. Vinyl wires of 38 mm^2 will be used.

4) Generator fuel consumption

The generator is driven by a Diesel engine. The generated power will be enough for 24-hour continuous operation of all pumps and in addition, illumination and repair shop operation for 8 hours/day.

The Diesel-engine output will be calculated as follows.

$$P = \frac{P_g \times \psi_g}{\eta_g} \times 1.36$$

where P : Diesel-engine output (PS)

P_g: generator output (kVA)

ψ_g: generator power factor 0.8

η_g: generator efficiency 0.9

The electric power to be used for pumps will be 829.4 kVA. An allowance for loss of 4% will be added to this, and the Diesel-engine output for the total will be calculated.

$$P = \frac{829.4 \times (1+0.04) \times 0.8}{0.9} \times 1.36 = 1.042.8 \text{ Ps}$$

The operation power PS·h is 1,042.8 x 24 = 25,026.2 PS·h/day, and the illumination and repair shop power is 110 kVA. Then,

$$P = \frac{110 \times 0.8}{0.9} \times 1.36 = 133.0 \text{ Ps}$$

The operation power PS·h is

$$133.0 \times 8 = 1.064 \text{ Ps·h/day}$$

The fuel consumption will be calculated in accordance with the following formula.

$$Q = \frac{PH \times be}{d}$$

where Q : fuel consumption (ℓ)

PH: Diesel-engine operation power (PS·h)

be: fuel consumption rate (kg/PS·h)

d : fuel density (0.83 kg/ℓ)

$$Q = \frac{(25.026.2 + 1.064) \times 0.2}{0.83}$$

$$= 6.287 \text{ ℓ/day}$$

The existing fuel tanks are two tanks of 100 m^3 intalled underground. Thus, the fuel storage duration is

$$\frac{100\ m^3 \times 2}{6.287\ m^3/day} = 31.8\ days$$

that is, maximum one month.

The new equipments and machines are summarized in table 21.

Table 21 List of Equipments and Machines to be Newly Installed

Name	Specifications	Q'ty
Pump	Vertical shaft turbine 50 m^3/h, 107m Motor 30 kW, 380V, 3ϕ, 50 Hz, 4p	8 units
	Vertical shaft turbine 50 m^3/h, 112m Motor 30 kW, 380V, 3ϕ, 50 Hz, 4p	8 units
	Submerged motor pump 74 m^3/h, 117m Motor 45 kW, 380V, 50 Hz, 2p	5 units
Piping	150A flexible joint, check valve, flow meter, sluice valve with pressure gauge	21 sets
Generator	250 kVA (200 kW), 380V, 50 Hz, Diesel engine	1 unit
Transformer	75 kVA, 15 kV, 380V, 3ϕ (4-wire), 50 Hz	5 units
Wiring	Hard-drawn aluminum bare stranded wire 22 mm^2, overhead 500m, 3ϕ, 15,000V with cabling material	1 set
	Hard-drawn aluminum bare stranded wire 22 mm^2, overhead 30m, 3ϕ, 15,000V with cabling material	1 set
	38 mm^2 vinyl wire, outdoor 15m, 3ϕ (4-wire), 380V with cabling material	5 sets
Illumination	Mercury-arc light 100V (source voltage 220V) mounted on pole	5 sets
Pole	Concrete pole (fabricated at the field)	1
Wire-net Fence	4m x 6m, 2.0m high gate door width 2.0m, double side opening (1,0m x 2) with spike	21 sets

4.4 Process for Implementation

4.4.1 Circumstances of Construction, and Work Execution Policies

In order to grasp the circumstances of construction in the Somali Democratic Republic, we have studied the construction work now being in progress at the Afgoi Wellfield as the largest one of the waterworks related programms in the same country. This work comprises 32 deep wells at depths down to 180m, power generating equipments for operating these wells, overhead water tank more than 30m high, and other waterworks facilities, which are being constructed using the same degree of advanced civil engineering techniques as in the country of Japan.

These works are undertaken by the construction companies in the developed countries including West Germany, England, etc. All the construction machines used, with exception of very few ones owned by the private companies at the site, are owned by these foreign construction companies, and as the Works are completed, they are being removed in succession from Somalia.

On the other hand, we have examined two construction companies in Somalia. They have only simple machines such as concrete mixer, excavator, etc. It has not been judged that these companies are capable of undertaking the works with their own responsibility and achieving the expected results in implementing this project.

For implementing this project, therefore, it will be programmed that all the works except for employment of unskilled laborers should be undertaken by the Japanese side.

By the way, the above program is a request from the officials concerned of Somalia.

4.4.2 Division of Works

The project consists mainly of rehabilitation works and is executed at the same district. By its urgent nature, it should be implemented as one project, and division of works will not be done.

4.4.3 Control of Work Execution

At the same time as the Japanese contractors start the on-site works, the consultants will start control of work execution, and thereafter, will stay there for 6 months until the rehabilitation works and the new well digging works are half completed and the working methods are established. Further for two months, the consultants will stay and control work execution for electrical machine installation, test running, etc. just after most works have been accomplished.

4.4.4 Equipment and Materials Procurment Plan

The equipment and materials from Japan will be transported collectively to the site after the lapse of a 6-month fabrication period in Japan from receipt of the order.

Water, sand and gravel, as the domestic product, will be procured in the city of Mogadishu. Gravel wall to be used for filling into the well will be procured in a proportion which will be determined after "Sieving Test" is carried out on the aggregate available at the site in the implementation design.

4.4.5 Implementation Schedule

Implementation may be scheduled as either simultaneously undertaking the rehabilitation work and the new well construction work, or successively executing two works one after the other.

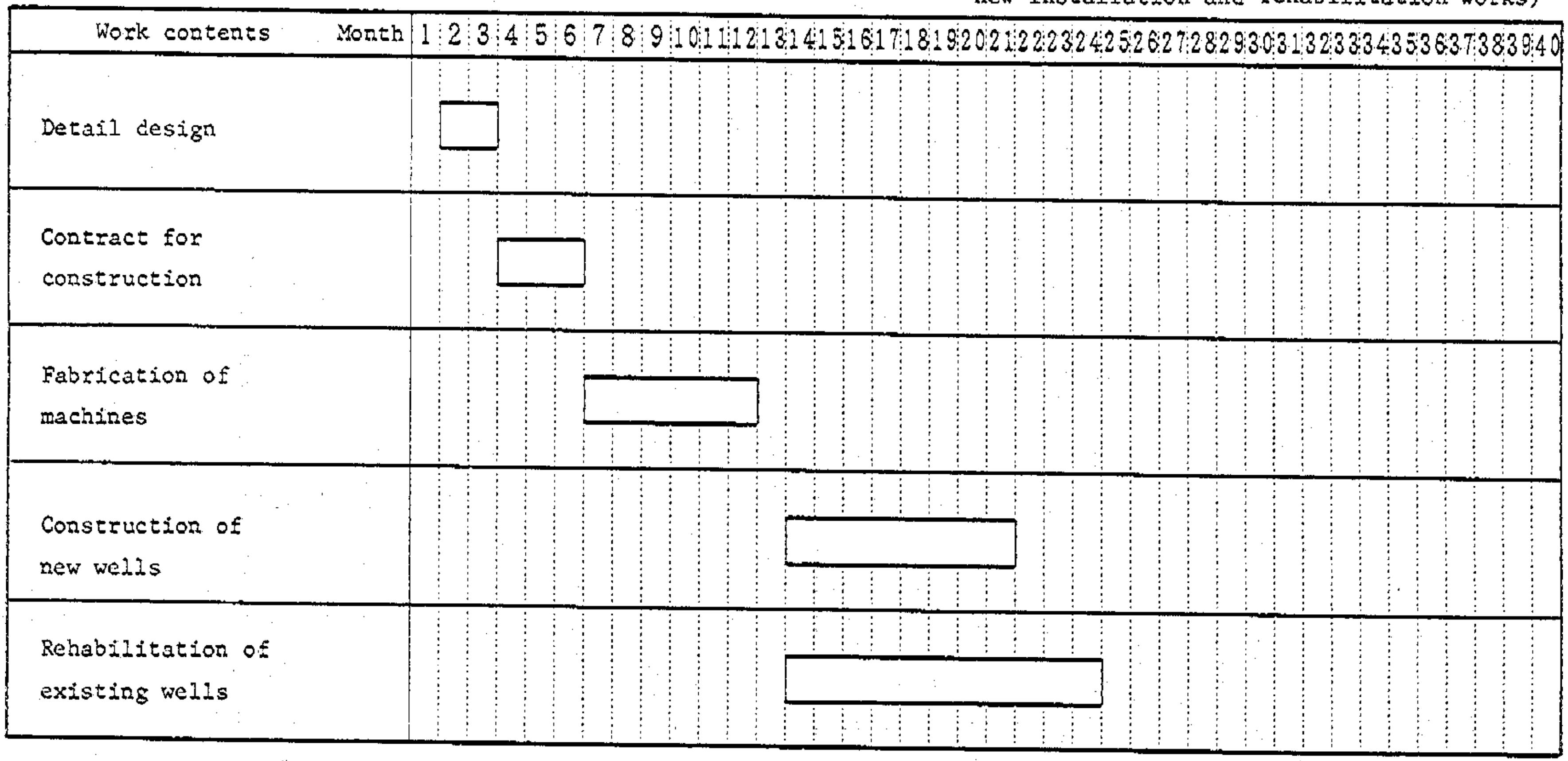
In the case of successive execution, the equipment and materials to be furnished are lessened, but the required period is prolonged such as to 32 months after E/N as compared with the 24-month period in the case of simultaneous execution, and therefore, taking into account the supervision and administration cost, the total cost will be almost the same. Thus, considering the urgent nature of this project, it is scheduled to execute two works simultaneously in accordance with the construction schedule shown in Fig. 15.

4.4.6 Approximate Project Cost

It is estimated that the cost to be born by the Somali side is about ¥5,000,000 including access road (27,000 m^2, about ¥2,200,000) and drainage equipments (21 points, about ¥2,800,000).

Fig.15 Construction Work Schedule

(Simultaneous execution of new installation and rehabilitation works)



CHAPTER 5

EVALUATION OF THE PROJECT

CHAPTER 5 EVALUATION OF THE PROJECT

The evaluation of the project of the potable water supply facilities can occur in various aspects. The one of them, which can be calculated as a profit, is the water charge to be collected from the inhabitants.

At present, potable water is sold at shs. 10 per m . Of this money, shs. 5 per m^3 after subtraction of the manager's expenses in the case of public water faucets, or shs. 10 per m^3 in the case of the individual domestic water supply, is the revenue to the MWA which runs the water supply system on the self-supporting accounting basis on this revenue.

According to the 1983 MWA statement of the accounts, the total revenue is shs. 49,000,000, while the personnel cost is shs. 9,000,000, fuel cost is shs. 17,000,000, construction cost is shs. 10,000,000, and clerical cost shs. 5,000,000, and surplus money is shs. 8,000,000 in the black. However, most of the cost are fixed cost, and the maintenance cost is only shs. 3,200,000 of the construction cost shs. 10,000,000 less the pipe installation cost and vehicle cost, and it is not judged that repairs necessary on the wells, pumps, power plants, equipments, etc. can be fully done.

Upon completion of this project, the water production at the Balad Wellfield will be improved from 13,000 m^3/day to 28,000 m^3/day. A yearly water supply increase of 55,000,000 ton is expected, corresponding to a revenue increase of about shs. 27,000,000 on the 1 m^3 shs. 5 basis. The fuel cost for this increased water supply is 3,400ℓ/day or shs. 16,000,000/year, an estimated revenue increase of shs. 13,000,000.

For the scale of the facilities of this project at the Balad Wellfield, the repair cost per year is about shs. 1,500,000 per year on assumption of 5% of the facilities cost and can be paid well by the revenue increase. Therefore, based on the normal maintenance, it is possible to assure stable water supply for a long time.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Owing to a rapid propulation growth including the acceptance of refugees in recent years, the population of Mogadishu, the capital of the Somali Democratic Republic, is estimated to reach 1,000,000 in 1987.

However, the potable water supply, which is most required by the inhabitants, is badly short as a result of delayed waterworks facilities construction and also of deteriorated existing water supply facilities.

This shortage of potable water supply requires the water supply facilities to be improved urgently. Especially, the rehabilitation of the existing facilities is expected to be immediately effective, and it is considered that implementing this rehabilitation work in the grant form by the Government of Japan will contribute to the stabilization of the inhabitants' living conditions and lead to further development of the friendly relationship between both countries.

6.2 Recommendations

As was described above, this project is expected to be significantly effective for the stabilization and improvement of the inhabitants' living conditions. The target year of this project is 1987, and it is desired that the construction should be put into execution immediately.

For this purpose, it is necessary for the Government of Somalia to undertake arrangements for the following items beforehand.

① To secure land necessary for the construction of the facilities and necessary for temporary installations for works and to clear, fill and level the site

② To construct and repair the access road for works

③ To proceed with necessary legal procedures for construction works

④ To make allowances for customs clearance, etc. regarding the equipment and materials required to be imported from Japan

⑤ To make arrangements for fuels as necessary with the progress of works

It is also considered that it should be of the most importance for the MWA to be, upon accomplishment of this project, able to secure the necessary potable water supply and to maintain the water supply rate in the future. However, considering the MWA's present maintenance capabilities, technical capabilities, etc., it is desired that technical aids should be provided subsequently, such that Japanese experts should stay and give guidance, and on the other hand, Somali engineers who are to be engaged actually in operation and repair should be given training in the country of Japan.

APPENDIX

APPENDIX

Minutes of Discussion

List of Members of JICA Mission

List of Somali Staffs Concerned

Study Schedule

MINUTES OF DISCUSSION

ON

THE MOGADISHU WATER SUPPLY IMPROVEMENT PROJECT,

SOMALI DEMOCRATIC REPUBLIC

In response to the request by the Government of Somali Democratic Republic for assistance in improving the Mogadishu Water Supply (hereinafter refferred to as "the Project"), the Government of Japan has sent through the Japan International Cooperation Agency (JICA) a study team headed by Mr.Sadao Aihara,Sub Chief,Construction Section,Water Works Bureau, City of Sapporo, to conduct the Basic Design Study on the Project from February 17 to March 5,1985.

The team held a series of discussions and exchanged views with the relevant Authorities of Somali Democratic Republic.

As a result of the study and discussions,both parties have agreed to recommend to their respective Governments to examine the result of the survey attached herewith towards the realisation of the Project.

February 24,1985

Sadao Aihara
Sadao Aihara
Leader
JICA Study Team

Mohamed Abdulle Hersi
General Manager
Mogadishu Water Agency

Attachments

1. The objective of the Project is to improve urgent problems of Mogadishu Water Supply System.

2. The main role of the Project is as follows;

   It is understood that the urgent problems of Mogadishu Water Supply System are connected with the water shortage due to deterioration of facilities of wells in the Balad Well Field.

   Therefore, the main role of the Project is to Resolve those problems.

3. The Japanese Study Team will convey the desires of the Government of Somali Democratic Republic to the Government of Japan that the latter will improve the Mogadishu Water Supply as listed in Annex I within the scope of Japanese economic cooperation in grant form.

4. The Government of Somali Democratic Republic will take the necessary measures listed in Annex II.

5. Both sides confirmed that the Japanese Study Team explained Japan's Grant Aid Programme and that the Somalian side understood it.

ANNEX I.

Main project feature is as follows;

1. To rehabilitate the sixteen possible wells in the Balad Well Field.

2. To drill the appropriate number of wells.

3. To provide the necessary equipments for the rehabilitation of wells in the Balad Well Field.

ANNEX II.

Required Arrangements to be undertaken by the Government of Somali Democratic Republic.

1. To secure land necessary for the construction of the facilities and to clear,fill and level the site as needed before the start of the construction.

2. To construct and prepare the access road to the Project site.

3. To ensure prompt unloading, tax exemption and customs clearance at ports of disembarkation in Somali Democratic Republic and prompt internal transportation therein of the products purchased under the grant.

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ANNEX II.

4. To exempt Japanese nationals engaged on the Project from customs duties, internal taxes and other fiscal levies which may be imposed in Somali Democratic Republic with respect to the supply of the products and the services under the verified contracts.

5. To accord without delay to Japanese nationals whose services may be required in connection with the supply of the products and services under the verified contract such facilities as may be necessary for their entry into Somali Democratic Republic and their stay therein for the performance of their work.

6. To maintain and use properly and effectively the facilities constructed under the grant.

7. To bear all the expenses, other than those to be borne by the grant, necessary for the construction of the facilities.

8. To provide the space necessary for such construction as temporary offices, working areas, stock yards and others.

List of Members of JICA Mission

Mr. Sadao Aihara : Leader

Sub-Chief, Construction Section, Water Works Bureau,
City of Sapporo

Mr. Yasuyuki Uehara: Planning adminstration

Third Training Section, Training Division,
Japan International Cooperation Agency (JICA)

Mr. Tsuyoshi Komori: Planning administration (also ICARA II)

Basic Design Section, Grant Aid Division
Japan International Cooperation Agency (JICA)

Mr. Masaaki Shindo: Planning of ground water development

Kyowa Engineering Consultants Co., Ltd. (KEC)

Mr. Sadayuki Kamide: Excavation machines

Kyowa Engineering Consultants Co., Ltd. (KEC)

List of Somali Staffs Concerned

I. Ministry of Foreign Affairs

(1) Mr. Abdul Kadir Ali Ahmed
Director. Economic Cooperation Department.

(2) Mr. Ahmed Abdul Gules
Protocol Officer

II. Ministry of Mineral & Water Resources

(1) Mr. Moxmuud Sheekh Mursal
Vice Minister

(2) Mr. Mahamud Omar Ased
Permanent Secretary

(3) Mr. Mohamed Awoale
Director. Hydrology Department

III. Mogadishu Water Agency

(1) Mr. Mohamed Abudulle Hersi. General Manager

(2) Mr. Mohamed Rabile Goud. Project Superintendant

(3) Mr. T. Albano. Electrical Engineer

(4) Dr. Osman Hagi Ali. Director of Planning

(5) Mr. A. M. Handulle. Planning Department

(6) Mr. B. J. B. Ross. World Bank Advisor. Technician

(7) Mr. D. J. Thomas. World Bank Advisor. Finance

Study Schedule

Date	Place	Details
Feb. 14 (Thur.)	Tokyo	JL433 21:30 departed
15 (Fri.)	~Frankfurt	
16 (Sat.)		
17 (Sun.)	Mogadishu	HH503 5:30 arrived, visiting government officials concerned
18 (Mon.)	Mogadishu	Study of water works facitities in Mogadishu
19 (Tue.)	Balad Wellfield	Study of Balad Wellfield facilities
20 (Wed.)	Mogadishu	Discussions with government officials
21 (Thur.)	Mogadishu	Arrangements with the MWA and inspection of Afgoi Wellfield
22 (Fri.)	Balad Wellfield	Balad Wellfiels pump-out test
23 (Sat.)	Mogadishu	Arrangements with the MWA
24 (Sun.)	Mogadishu	Minutes of discussion signed
25 (Mon.)	Mogadishu	Discussions with the MWA
26 (Tue.)	Mogadishu	Collection of financial and well data
27 (Wed.)	Mogadishu	Study of standards on well piping, etc.
28 (Thur.)	Mogadishu	Study of data concerning construction
Mar. 1 (Fri.)	Mogadishu	Processing and analysis of obtained data
2 (Sat.)	Balad Wellfield	Detail study of Balad Wellfield
3 (Sun.)	Mogadishu	Discussions with the MWA (government data obtained)

Date	Place	Details
4 (Mon.)	Mogadishu	Confirmation of MWA's technical basic policy
5 (Tue.)	Mogadishu ~ Khartoum	AZ821 6:00 departed
6 (Wed.)	Khartoum ~ London	Report of the study results to the ambassy
7 (Thur.)	London	
8 (Fri.)	~ Tokyo	

JICA