5.2.4 Study of the Optimum Discharge Rate

To determine the planned water pumping rate of newly constructed wells, the past record of the water pumping rate and the proper water pumping rate should be studied.

(1) Past records of water pumping rate

Table 5.2.4-1 shows the change in the water pumping rate of five wells constructed in the Phase II Project. Table 5.2.4-2 shows the water pumping rate and the lowering of the water level measured upon construction in the Phase II Project. The water pumping rate of wells just after construction (March, 1987) was set at 63 m^3/hr, but it decreased to about 55 m^3/hr about half a year later. The probable cause is that, in about half a year, fine sand around the well has been washed away and the well has stabilized.

To determine the planned water pumping rate of a planned well, it is a general method to calculate the proper water pumping rate from the relation between the water pumping rate and the lowering of water level based on the results of the step-drawdown tests. Fig.5.2.4-1 shows the relation between the water pumping rate and the lowering of water level in the existing wells of the Balad Wellfield. In these figures, the lowering of water level is comparatively small when the water pumping rate is below 55 m^3/hr, but it becomes extremely large when the water pumping rate exceeds 55 m^3/hr. So 55 m^3/hr can be regarded as the elastic limit water pumping rate in an overall evaluation of the well group in the Balad Wellfield.

Table 5.2.4-1 Fluctuation of Discharge Rate of the Wells Constructed in Phase II Project

Well No.	Discharge Rate (m^3/hr)			
	March, 1987	Oct., 1987	Jan., 1987	Sep., 1987
10.5A	60.2	55.0	55.0	-
11.5B	62.9	55.0	54.0	-
12.0B	60.2	50.0	55.0	-
12.5A	54.3	55.0	-	55.0
14.5B	59.4	55.0	-	-
Average	59.4	54.7	-	

Table 5.2.4-2 Discharge Rate and Drawdown on the Basis of Pumping Test in the Phase II Project

Well No.	Discharge Rate $Q(m^3/hr)$	Drawdown s(m)
10.0A	50.3	4.01
11.0A	22.5	6.58
11.5A	31.7	3.22
12.0A	33.5	6.05
12.5B	33.5	10.85
13.0A	51.1	15.85
13.0B	51.1	4.92
13.5A	50.3	6.85
13.5B	29.4	9.10
14.0A	47.2	5.71
14.5A	40.0	11.67
15.0A	42.1	10.13
15.0B	25.0	13.15
10.5A	60.2	22.83
11.5B	62.9	35.43
12.0B	60.2	32.56
12.5A	54.3	23.02
14.5B	59.4	21.96

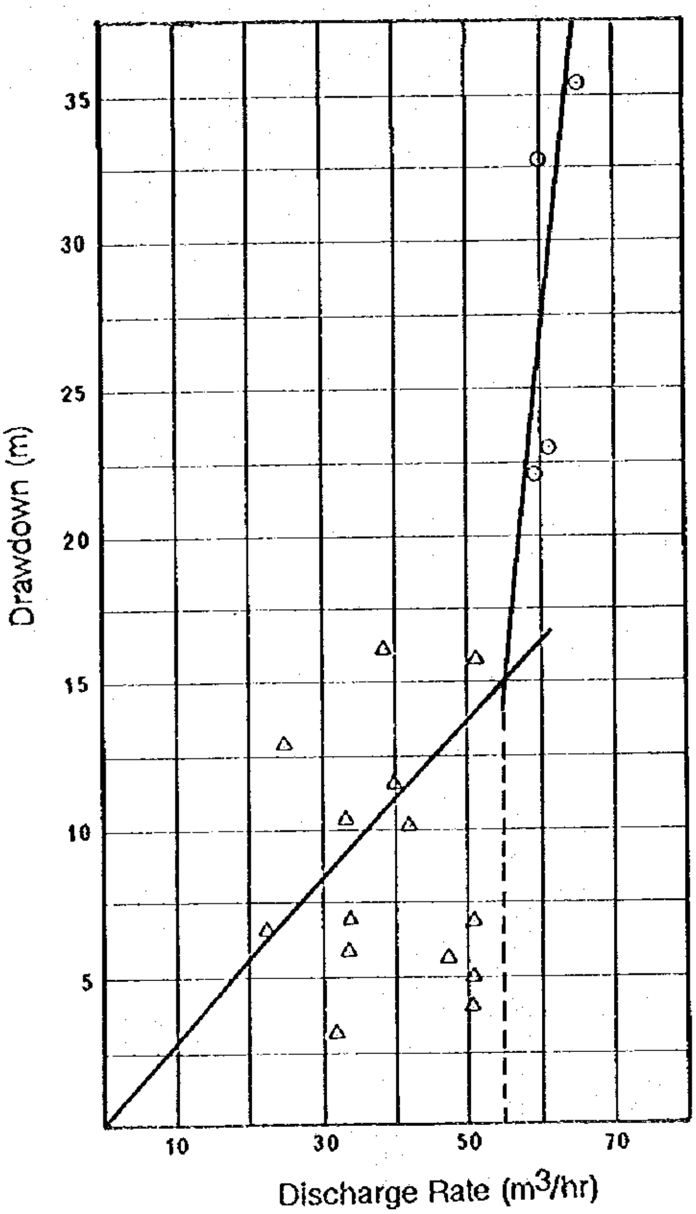


Fig. 5.2.4-1 Relation between Drawdown and Discharge Rate on the Basis of Pumping Tests in Phase II Project

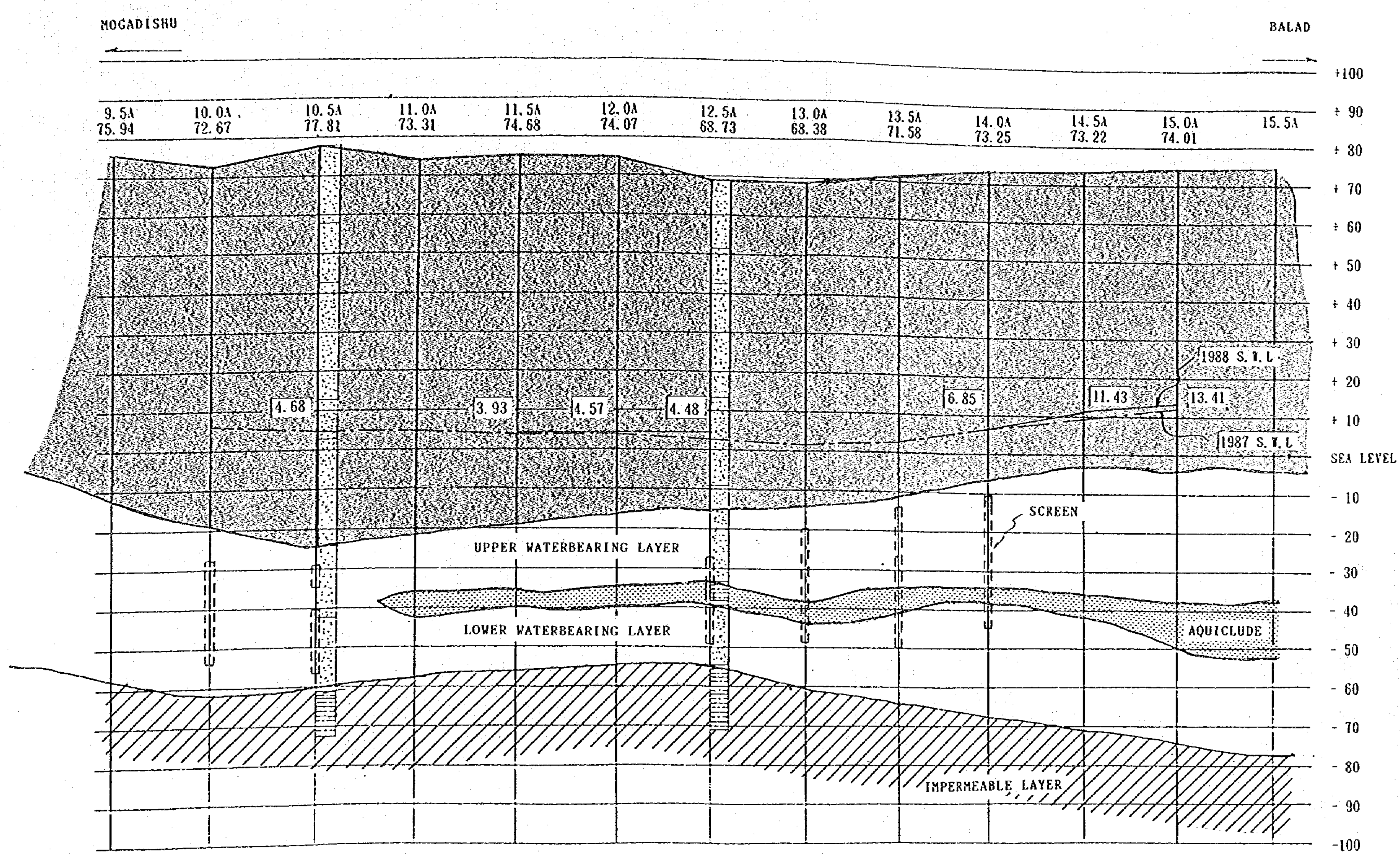


Fig. 5.2.4-2 Geological Cross-section of A line and Groundwater Level

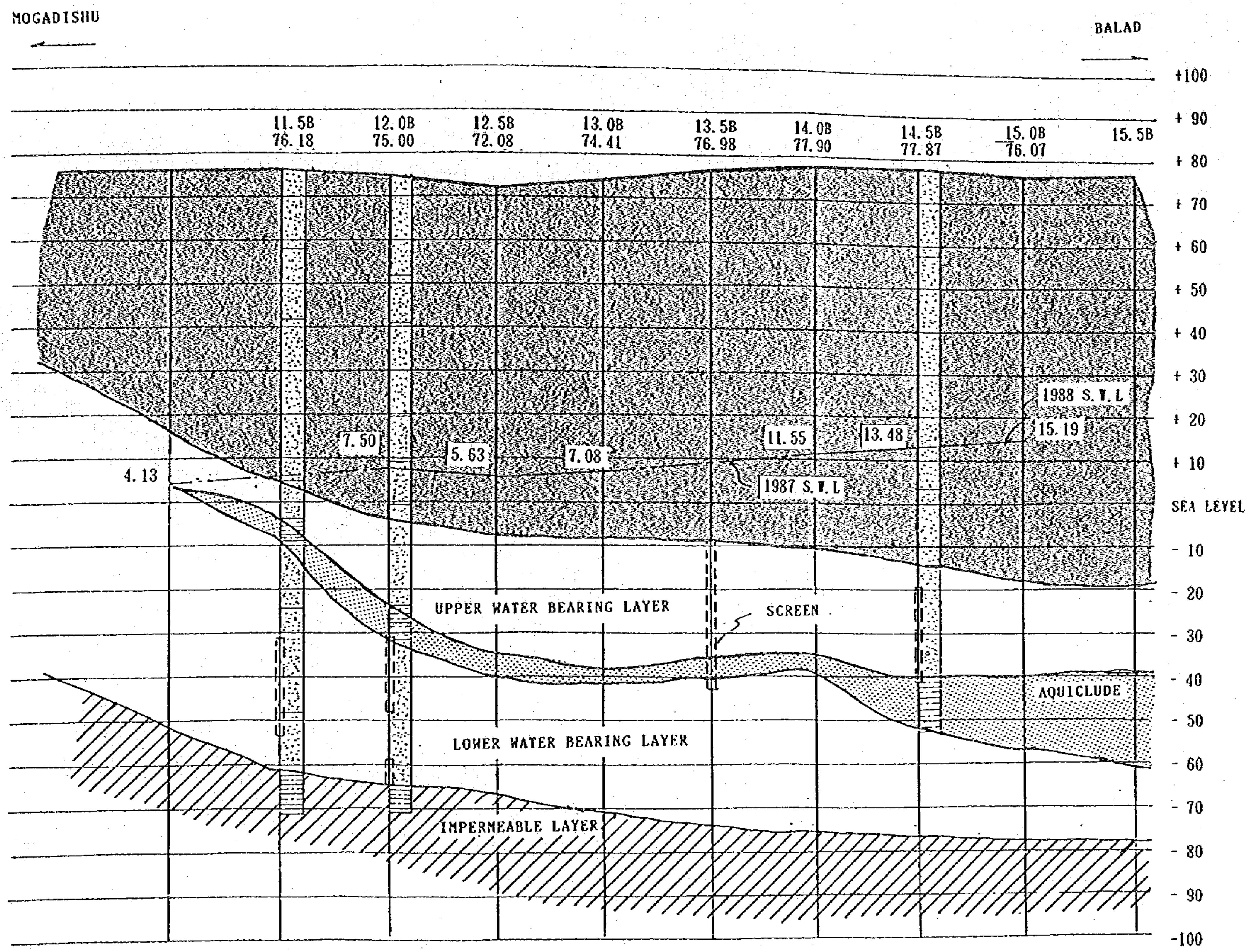


Fig. 5.2.4-3 Geological Cross-section of B line and Groundwater Level

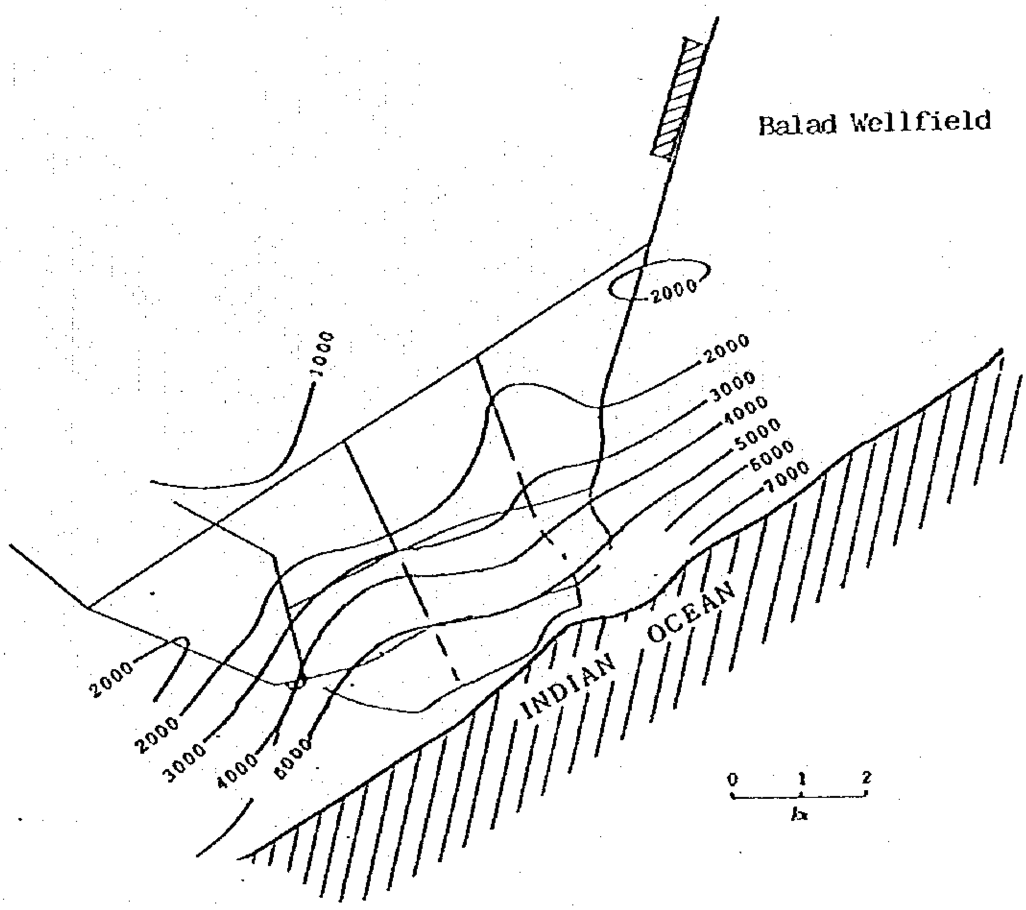


Fig. 5.2.4-4 Contour of Electrical Conductivity in Mogadishu City, 1977

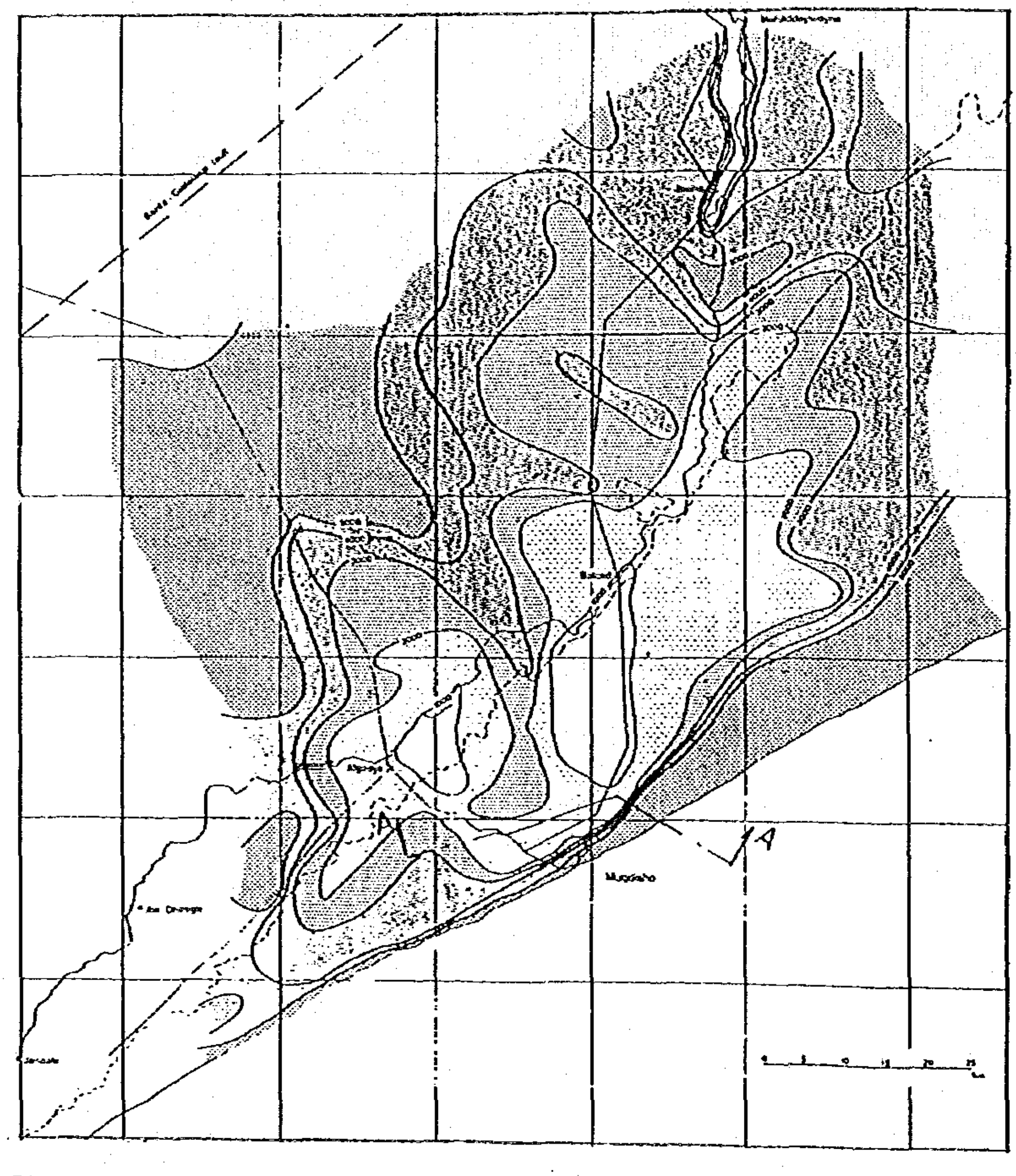


Fig. 5.2.4-5 Contour of Electrical Conductivity in Mid Benaadir District, 1983

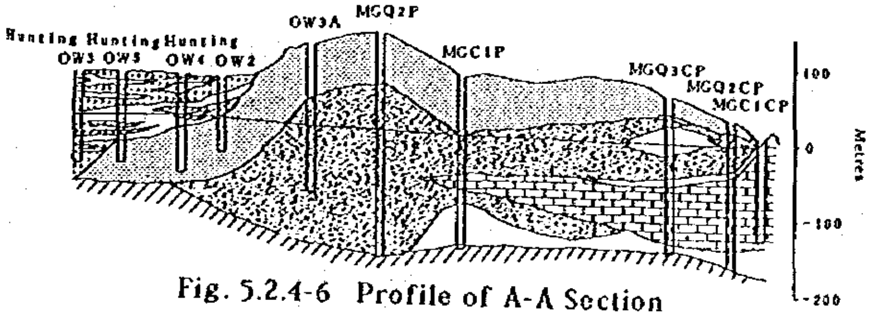


Fig. 5.2.4-6 Profile of A-A Section

(2) Study on the proper water pumping rate from the hydrogeological point of view

1) Hydrogeological circumstances

a. Aquifers

At the Balad Wellfield, an aquifer exists over a range of 0 m above sea to about -80 m, with the layer thickness varying as much as 40 m to 70 m. An aquiclude of 5 m to 15 m is interposed in the aquifer (Refer to Figs.5.2.4 -2, 3). The upper permeable layer presents a white color and consists of medium sand. This layer is the main aquifer for the existing wells. The lower permeable layer presents white and brown colors and consists of alternate shale and limestone layers of fine sand and medium sand. The interposed aquiclude presents light brown and gray colors and consists of extremely fine sand and fine sand, and is in a subconsolidated condition.

b. Water quality

Electrical conductivity in the vicinity of Mogadishu City is distributed as shown in Figs 5.2.4-4 and 5. As these figures show, the electrical conductivity is high in the portion along the coast, and it decreases gradually toward the north, being below 1,000 □s/cm in some confined portions. It is judged that in the coastal area, quality of groundwater is degraded by its being saline, and in the northern part where the electrical conductivity is low, the quality of groundwater is improved by the recharge of fresh water into groundwater from the Shabeelle River (refer to Fig.5.2.4-6). And as a result of water quality tests in the field survey, water of the Balad Wellfield is potable because the water quality is within the standard of WHO.

Table 5.2.4-3 Result of Water Analysis

Item	Unit	Value	Japanese Standard Value	WHO Standard Value
NO_3-N+NO_2-N	mg/l	0.04	under 10	-do-
Cl(chlorine)	mg/l	112	under 200	250
$KMnO_4$	mg/l	3.0	under 10	
Ca+Mg	mg/l	140	under 300	200
Evaporation Residue	mg/l	810	under 500	1000
Ignition Residue	mg/l	580	-	-

2) Coefficient of permeability

In order to obtain the coefficient of permeability in the vicinity of the Balad water source, a water pumping test was conducted on two existing wells (12.5 A, 14.0 A) in the field survey, and soil sampling was also made. The results of the water pumping test and the results of sample soil analysis are shown in Appendix. From these results and the results of the water pumping test on each well in the Phase II Project, a coefficient of permeability was obtained as follows.

a. From the results of water pumping test on 12.5 A (Theim's equation) :

$$Q=2\pi\ k\ Ds\ /\ (2.3\ \log R\ /\ r_0)$$

Where,

Q : Discharge (m^3/sec) 55/3600=0.0153

k : Coefficient of Permeability (cm/sec)

D : Thickness of Permeable layer (m) 40 m

s : Drawdown (m) 16.2 m

R : Influential radius (m) 500 m

r_0 : Well radius (m) 0.125 m

$k = (0.0153 \times 2.3 \times \log 500\ /\ 0.125)\ /\ (2 \times \pi \times 40 \times 16.2)$

$= 3.11 \times 10^{-5}$ m/sec $= 3.11 \times 10^{-3}$ cm/sec

b. From the results of soil grain size distribution analysis (Creager's equation)

3×10^{-3} cm/sec

Table 5.2.4 - 4 Relation between D_{20} and K by Creager

d_{20}	K (cm/sec)	Classification	d_{20}	K (cm/sec)	Classification
0.005	3.00×10^{-6}	Coarse Clay	0.18	6.85×10^{-3}	Fine Sand
0.01	1.05×10^{-5}	Fine Silt	0.20	8.90×10^{-3}	
0.02	4.00×10^{-5}	Coarse Silt	0.25	1.40×10^{-2}	
0.03	8.50×10^{-5}		0.30	2.20×10^{-2}	Medium sand
0.04	1.75×10^{-4}		0.35	3.20×10^{-2}	
0.05	2.80×10^{-4}		0.40	4.50×10^{-2}	
0.06	4.60×10^{-4}	Ultra Fine Sand	0.45	5.80×10^{-2}	
0.07	6.50×10^{-4}		0.50	7.50×10^{-2}	
0.08	9.00×10^{-4}		0.60	1.10×10^{-1}	Coarse Sand
0.09	1.40×10^{-3}		0.70	1.60×10^{-1}	
0.10	1.75×10^{-3}		0.80	2.15×10^{-1}	
0.12	2.60×10^{-3}	Fine Sand	0.90	2.80×10^{-1}	
0.14	3.80×10^{-3}		1.00	3.60×10^{-1}	
0.16	5.10×10^{-3}		2.00	1.80	Fine Gravel

c. From the average of the results of water pumping tests in the Phase II Project

3.57×10^{-3} cm/sec (refer to Appendix 2-1)

From the results shown above, the coefficient of permeability in the Project will be determined as 3×10^{-3} cm/sec.

3) Prediction of the lowering of water level

Judging from the geological structure, water quality contours and the change of the lowering of water level in the neighborhood, groundwater in the Balad Wellfield area is affected by the ingress of sea water. Especially the lowering of water level is predicted to be more than 5 m per year from the coefficient of permeability, transmissivity, recharge from the Shabelle River, the water pumping rate in the past, etc. in the Balad wellfield area. However, according to the past records, it is only about 0.3 m. The probable cause is that the level of groundwater is pushed up by ingress of sea water. Therefore, in order to predict the lowering of water level in the future in the Project, a water balance model considering the ingress of salt water must be set and a simulation technique must be used on this model. Simulation consists of Case 1 and Case 2. In Case 1, an overall balance of groundwater movement in a wide range from the Indian Ocean to the Shabeelle River is studied. In Case 2, the lowering of water table in a range of about 10 km X 5 km around the Balad wellfield is predicted for each of 22 years in the future. The results of this simulation are shown in Appendix 3-6. The lowering of water level in 20 years is a maximum of 5 m if water is pumped up continuously at a rate of 28,000 m^3/day.

4) Study on the length of the screen

To determine the length of the screen, the moving limit speed of sand is an important factor. This is because pump breakages due to sand ingress into the wells can cause well failures. According to the Waterworks Facility Standards, it is desirable that the influential speed of groundwater into the well should be below 15 mm/sec, and for the wells constructed in the Phase II Project, screens were installed to secure about 12 mm/sec as the target value. However, in the water pumping test conducted in the present study, an inflow of sand was noticed although in a small quantity, even at a water pumping rate of 55 m^3/hr. Then, the entrance speed of groundwater at the position of the screen must be examined.

The influential speed of groundwater at the position of the screen is expressed in accordance with the following equation.

Where; V : Influential speed

Q : water pumping rate

A : Influential area

r : radius of the screen

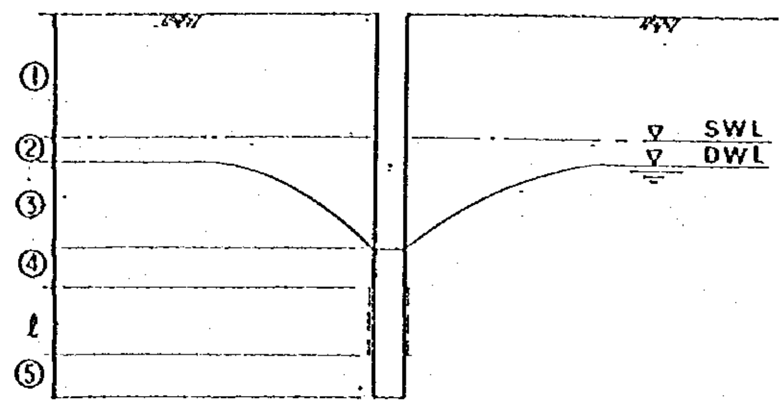
l : length of the screen

k : opening ratio of the screen

If V › Q / A, then from the above conditions, V › 8.8 mm/sec at Q=55 m^3/hr on assumption of r = 0.25 m, l = 20 m and k = 11%. Therefore, in this project, the speed of sand inflow will be set at a maximum of V=8 mm/sec by considering that extremely fine sand flows in at an influential speed of 8.8 m/sec.

5) Study on the water pumping rate

From the condition of permeable layer distributions and the condition of groundwater level (Fig.5.2.3-1, 2) in the Balad Wellfield the water pumping rate of each planned well will be studied. The average thickness from the ground surface to the bottom surface of the permeable layer is 140.7 m. The necessary well depth on an assumption of a water pumping rate of 45 to 65 m^3/hr is as follows.



where;

Q : water pumping rate, (m^3/hr)

1 : average depth from the ground surface to the static water level (1988), (m)

2 : lowering of static water level in 20 years obtained from the results of simulation, (m)

3 : lowering of water level obtained from Fig.5.2.4-1, (m)

4 : length of submerged pump, (m)

5 : sand pit, (m)

: length of the screen determined from the planned pumping rate, (m)

Table 5.2.4 - 5 Necessary Depth of Wells

$Q(m^3/hr)$	45	50	55	60	65	Remarks
①	65.5	65.5	65.5	65.5	65.5	
②	5.0	5.0	5.0	5.0	5.0	
③	13.3	14.8	16.2	29.0	36.0	
④	3.5	3.5	3.5	3.5	3.5	
⑤	10.0	10.0	10.0	10.0	10.0	
ℓ	18.1	20.1	22.1	24.2	26.2	
Σ (m)	115.4	118.9	122.3	137.2	146.2	< 140.7m
Evaluation	O	O	O	O	×	

From the results given above, it is possible to pump up water up to a rate of 60 m^3/hr. However, the permeable layer in this area is divided into two layers by an about 10 m-thick aquiclude, and a screen may be set at each of these two layers. Furthermore, a screen is set at a better position of the permeable layer for pumping, and there is no allowance of well depth in the case of 60 m^3/hr as the target. For these reasons, it is preferable that the target pumping rate is to be less than 60 m^3/hr.

(3) Determination of the planned water pumping rate per well to be newly constructed

As described above, the water pumping rate of most wells constructed in the Phase II Project has stabilized at about 55 m^3/hr, the lowering of the water level becomes extremely large when the actual water pumping rate exceeds 55 m^3/hr, and from the hydrogeological conditions, the permeable layer has no allowance in its depth for water pumping up at 60 m^3/hr. Thus, the planned water pumping rate per well to be constructed in the Project shall be set at 55 m^3/hr.

(4) Planned member of wells

The water intake rate of newly constructed wells shall be equal to the planned water intake rate less the possible water pumping rate of existing wells. Here, the relevant data are as follows.

Planned water intake rate : 28,000 m^3/day

Possible water pumping rate of existing wells : 11,340 m^3/day
(According to replacement of two submersible pumps,
8,700+(55X24X2)=11,340)

Planned water intake rate per well to be newly constructed : 55 m^3/day

The planned number of wells as given by

N = (28,000 -11,340) / (55X24) =12.6 --------- 13 wells

(5) Newly constructed well arrangement plan

Of 13 wells to be newly constructed in the Project, 11 wells shall be arranged in the vicinity of the existing wells which will not be used in the future, so that the existing piping may be utilized effectively, and other two wells shall be arranged on the north of the existing wells where the condition of the permeable layer seems to be good. The well arrangement is shown in Fig.5.2.4 -7.

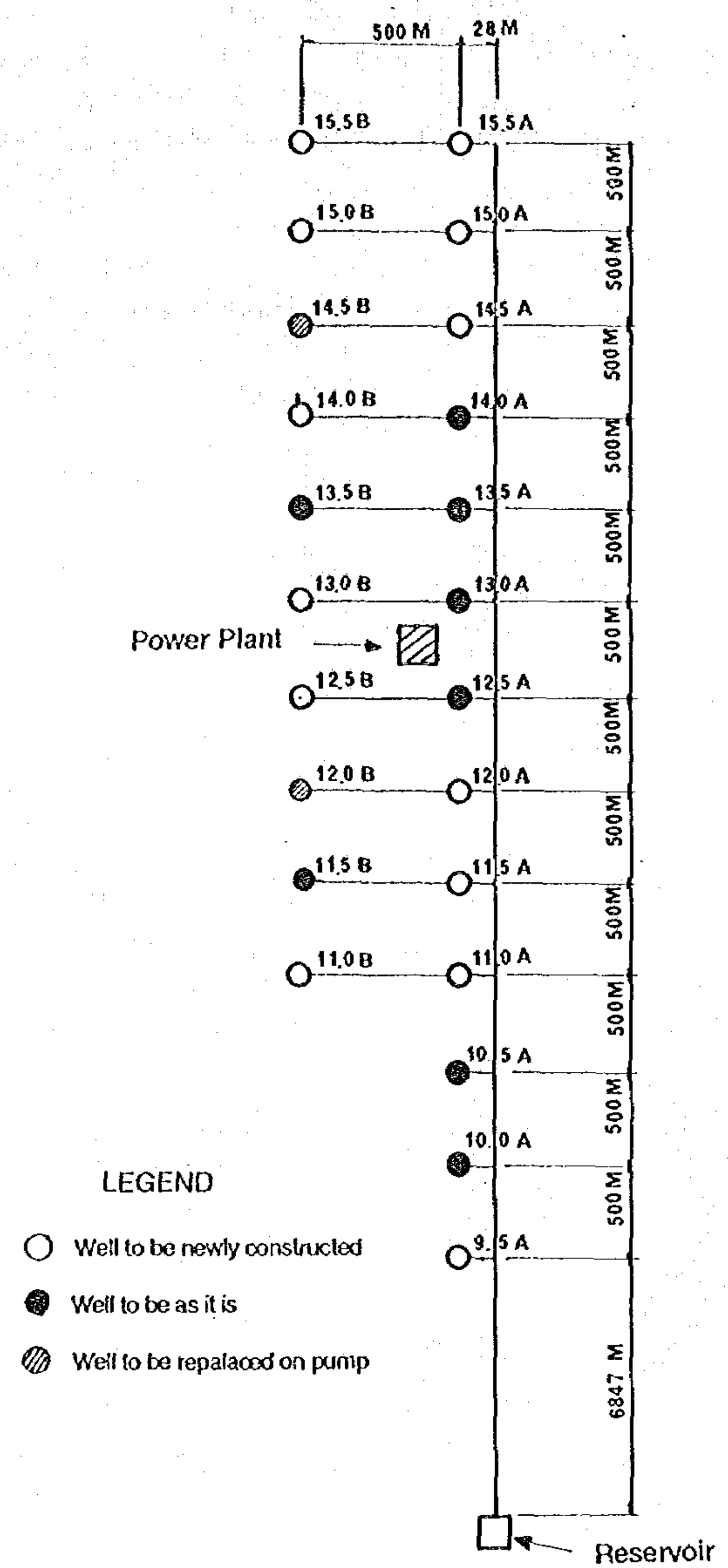


Fig. 5.2.4-7 Location Plan of Proposed Wells

5.2.5 Power Supply Facilities

Power supply facilities are classified as power generating equipment and power transmitting equipment.

(1) Power generating equipment

The Balad Wellfield has no available commercial power source. Therefore, submersible pumps for the existing wells receive power supply (15 KV) from a power plant constructed in the central part of the well group (There is no commercial power supply plan for the future). The power plant has a total of seven generators including one Japanese-made generator installed in the Phase II Project, but two American-made generators and one Japanese-made generator of these seven generators can be operated practically at present. The life of six American-made generators which are operating and disassembled seemed to expired, so that it is difficult to reuse by rehabilitation.

(2) Power transmitting equipment

The designed length of transmission lines is based on the material of line, the fluctuation of line by wind force, and the interval of pole, so that partial replacement is capable as a temporary measure. However, it is incapable as a permanent measure because of different strength between existing line and new one. In addition, the decrepitude of connection at insulator will not advance as same as entire replacement. Therefore, the existing transmission line shall be replaced entirely in the Project. Existing porcelain insulators shall be replaced with salt-proof porcelains, etc., which withstand attached salt, sand or dust.

5.2.6 Other Facilities

(1) Replacement of meters installed to wells

To each well, a pressure gauge and a flow meter are installed, but nine flow meters (50%) are defective. The probable cause is an attachment of extremely fine sand or solidification of lime contained in the well water. Therefore, flow meters to be newly installed in the Project shall be in accordance with changed specification.

(2) Consolidation of radio communication system

Radio sets to connect between the power plant, MWA headquarters and management vehicles for the purpose of maintenance and management and also repair of various facilities were installed but they were broken a half year ago, and at present personal communications using vehicles only are available. Therefore, it seems necessary to consolidate the radio communication system on the MWA side.

5.3 Basic Design of Facilities

5.3.1 Intake Facilities

(1) Design of submersible pumps

1) Loss of head

a. Loss of head of pipes

Hazen-William's formula is used.

$$h = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$$

Where, V : average flow velocity (m/sec)

Q : flow (m^2/sec)

I : dynamic water gradient (m)

L : total length of pipes (m)

C : coefficient of velocity (110)

h : frictional loss head (m)

D : pipe inside diameter (m)

b. Loss of head due to valves

The following equation is used.

$$hn = f \times v^2 / 2g$$

Where, f : loss coefficient

v : flow velocity (m/sec)

g : acceleration of gravity (9.8 m/sec^2)

c. Loss of head of straight pipe portion of well primary piping

The Darcy-Weishboch's equation is used.

$$hf = f_3 \times (l / D) \times (v^2 / 2g)$$

Where, f_3 : loss coefficient of straight pipe (m)

$$f_3 = 0.04 + (1 / 1{,}000 D)$$

D : pipe diameter of straight pipe (m)

V : flow velocity (m/sec)

g : acceleration of gravity (9.8 m^2/sec)

l : total length of straight pipe portion (m)

hf : Loss of head of straight pipe portion (m)

d. Design flow

New well	: 55 m^3/hr = 0.917 m^3/min =0.0153 m^3/sec	:13 wells
Existing well	: 55 m^3/hr =0.917 m^3/min =0.0153 m^3/sec	: 5 wells
Existing well	: 40 m^3/h r=0.067 m^3/min =0.0111 m^3/sec	: 5 wells

2) Calculation of loss of head of water conveying pipe

The loss of head (h) from 15.5 A to 15.0 A is obtained as follows.

From D=0.15 m, L=500 m, Q =55 m^3/hr X 2 = 0.0153 X 2 = 0.0306 m^3/sec.

$h = 10.666 \times 110^{-1.85} \times 0.15^{-4.87} \times 0.0306^{1.85} \times 500 = 14.48$ m

The loss of head of the main pipe up to the Shek Muhidin Reservoir is obtained similarly, and the results are shown in Tables 5.3.1-1 and 2.

3) Loss of head from each submerged pump up to main pipe

The construction of piping from the submerged pump in the well up to the water conveying pipe is shown in Basic Design Fig.5.3.5-2. Each well has a pump-up pipe, a sluice valve and a check valve, and the pipe diameter of well primary piping is 150 mm. The loss of head of the water pump-up pipe in the newly constructed well is obtained as follows.

From C =110, D = 0.1, Q = 55 m^3/hr = 0.0153 m^3/sec, l =100 m.

$h = 10.666 \times 110^{-1.85} \times 0.1^{-4.87} \times 0.0153^{1.85} \times 100 = 5.784$ m

The loss of head of valves and straight pipe portions is obtained as follows.

Check valve $f1 = 0.35$, Sluice valve $f2 = 0.145$

$V = 0.0153 / (0.152 \times \pi \times 0.25) = 0.866$ m/sec

$f_3 = 0.04 + 1/(1000 \times 0.15) = 0.0467$

$h = (0.35 + 0.145 + 0.0467 \times 4.5 / 0.15) \times 0.866^2 / (2 \times 9.8) = 0.073$ m

Therefore, the loss of head from each pump to a branch pipe is obtained as follows.

5.784 m + 0.073 m = 5.857 m

From the results shown above, the total lift is shown in Table 5.3.1-3.

Table 5.3.1-1 Loss of Head between Main Pipes

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

Section	C		D		Q			ℓ(m)	h	
	C	$C^{-1.85}$	m	$D^{-4.87}$	m^3/hr	m^3/sec	$Q^{1.85}$		Section	Total
Reservior～9.5	110	0.000167	0.6	12.034	1,190	0.331	0.129	6,840	18.914	18.914
9.5～10.0	110	0.000167	0.6	12.034	1,135	0.315	0.118	500	1.265	20.179
10.0～10.5	110	0.000167	0.6	12.034	1,095	0.304	0.110	500	1.179	21.358
10.5～11.0	110	0.000167	0.5	29.243	1,040	0.289	0.101	500	2.630	23.988
11.0～11.5	110	0.000167	0.5	29.243	930	0.258	0.0816	500	2.125	26.113
11.5～12.0	110	0.000167	0.5	29.243	820	0.228	0.0649	500	1.680	27.793
12.0～12.5	110	0.000167	0.5	29.243	710	0.197	0.0495	500	1.289	29.082
12.5～13.0	110	0.000167	0.4	86.690	600	0.167	0.0365	500	2.818	31.900
13.0～13.5	110	0.000167	0.4	86.690	505	0.140	0.0263	500	2.031	33.931
13.5～14.0	110	0.000167	0.4	86.690	425	0.118	0.0192	500	1.482	35.413
14.0～14.5	110	0.000167	0.3	351.90	330	0.0917	0.0120	500	3.761	39.178
14.5～15.0	110	0.000167	0.25	855.13	220	0.0611	0.00568	500	4.325	43.499
15.0～15.5	110	0.000167	0.15	10290.5	110	0.0306	0.00158	500	14.480	57.979

Table 5.3.1-2　Loss of Head from Lateral Pipe to Main Pipe

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

Section	C		D		Q			ℓ(m)	h(m)	Remarks
	C	$C^{-1.85}$	m	$D^{-4.87}$	m^3/hr	m^3/sec	$Q^{1.85}$			
B～A	110	0.000167	0.15	10290.5	55	0.0153	0.000438	500	4.014	
A～main pipe	110	0.000167	0.2	2535.03	55	0.0153	0.000438	28	0.055	
A～main pipe	110	0.000167	0.2	2535.03	95	0.0264	0.00120	28	0.152	
A～main pipe	110	0.000167	0.15	10290.5	110	0.0306	0.00158	28	0.811	

Table 5.3.1-3 Calculation of Respective Pump Head

Well	Discharge rate (m^3/hr)	Loss of head of pipe				Actual head			Total head
		Pump to lateral pipe	B to A	A to main pipe	Main pipe to reservoir	Resevoir water level	Design water level	Actual head	
9.5A	55	5.857	—	0.055	18.914	68.444	-15.0	83.44	108.3
10.0A	40	Intake facilities have been installed.				〃			
10.5A	55	〃				〃			
11.0A	55	5.587	—	0.20	23.988	〃	-16.5	84.94	115.0
11.0B	55	5.587	4.014	0.20	23.988	〃	-17.0	85.44	119.5
11.5A	55	5.587	—	0.20	26.113	〃	-17.5	84.94	118.1
11.5B	55	Intake facilities have been installed.				〃			
12.0A	55	5.587	—	0.20	27.793	〃	-18.0	86.44	120.3
12.0B	55	5.587	4.014	0.20	27.793	〃	-16.5	84.94	122.8
12.5A	55	Intake facilities have been installed.				〃			
12.5B	55	5.857	4.014	0.20	29,082	〃	-15.5	83.94	123.1
13.0A	40	Intake facilities have been installed.				〃			
13.0B	55	5.857	4.014	0.152	31.900	〃	-14.0	82.44	124.4
13.5A	40	Intake facilities have been installed.				〃			
13.5B	40	〃				〃			
14.0A	40	〃				〃			
14.0B	55	5.587	4.014	0.152	35.413	〃	- 9.5	77.94	123.4
14.5A	55	5.857	—	0.20	39.174	〃	-12.5	80.94	126.2
14.5B	55	5.587	4.014	0.20	39.174	〃	- 8.5	76.94	125.9
15.0A	55	5.857	—	0.20	43.499	〃	- 9.0	77.44	127.0
15.0B	55	5.857	4.014	0.20	43.499	〃	- 6.0	74.44	128.0
15.5A	55	5.857	—	0.811	57.979	〃	- 9.0	77.44	142.1
15.5B	55	5.857	4.014	0.811	57.979	〃	- 6.0	74.44	143.1

4) Pump equipment plan

The pump shaft power is calculated in accordance with the following equation.

P=0.163 X r X Q X H X (1+) / n

where,

L : pump shaft power (kw)

r : weight of liquid / unit volume (1 kg/l)

Q : discharge rate (m^3/min)

H : total head (m)

n : pump efficiency (decimal)

: allowance (15%)

From the pump discharge rate and the total lift calculated before, the pump shaft pump (kw) is calculated.

For the submersible pump in 9.5 A,

Q = 55 m^3/hr=0.917 m^3/min

H = 108.3 m

n = 0.66 (refer to Fig. 5.3.1-1)

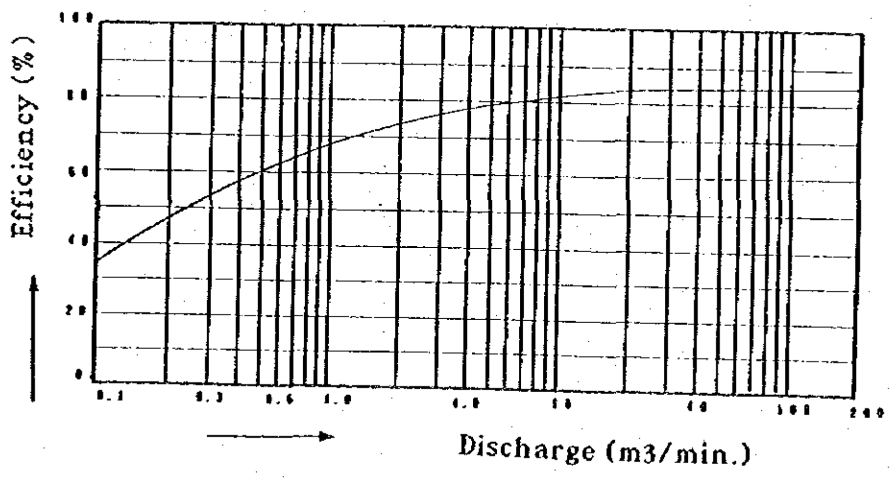


Fig. 5.3.1 - 1 Efficiency of Standard Pump

Therefore, the pump shaft power of the submersible pump from 9.5 A is :

P = 0.163 X 1 X 0.917 X 108.3 X 1.15 / 0.66 = 28.2 kw

Calculation of other pump shaft power and analysis of motor output are shown in Table 5.3.1-4,5.

Table 5.3.1-4 List of Selected Capacity of Pump for Respective Well

Well No.	Discharge Rate (m^3/hr)	Pump head (m)	Necessary pump shaft power (kw)	Selected specific motor (kw)	Remarks
9.5A	55m^3/H	108.3	28.2	30	
11.0A	55	115.0	29.9	30	
11.0B	55	119.5	31.1	37	
11.5A	55	118.1	30.8	37	
12.0A	55	120.3	31.3	37	
12.0B	55	122.8	32.0	37	
12.5B	55	123.1	32.1	37	
13.0B	55	124.4	32.4	37	
14.0B	55	123.4	32.1	37	
14.5A	55	126.2	32.9	37	
14.5B	55	125.9	32.8	37	
15.0A	55	127.0	33.1	37	
15.0B	55	128.0	33.3	37	
15.5A	55	142.1	37.0	37	
15.5B	55	143.1	37.3	37	

Table 5.3.1-5 List of Specification on Pump Facilities

Discharge Rate	Pump head	Specification of motor	Number	Applied well
55m^3/hr	115m	30kwx380vx50HZx3Phase	2	9.5A 11.0A
55m^3/hr	123m	37kwx380vx50HZx3Phase	5	11.0B 11.5B 12.0A 12.0B 12.5B 15.0A
55m^3/hr	128m	37kwx380vx50HZx3Phase	6	13.0B 14.0B 14.5A 14.5B 15.0B
55m3/hr	143m	37kwx380vx50HZx3Phase	2	15.5B 15.5A

(2) Design of intake well

The well casing diameter shall be 250 mm in accordance with the planned water pumping rate. The borehole diameter shall be 450 mm for economical reasons. The well casing material shall be steel, and the screen material shall be stainless steel. As a result of the study in 5.2.4, proposed depth for new well shall be 130 m on average in consideration of fluctuation of permeable layer's thickness and past actual result. An outline of the well body is shown in Basic Design Drawings.

5.3.2 Piping Facilities

(1) Water conveying pipes

In the Project, two wells, 15.5 A and 15.5 B, are constructed on the north of 15 A and 15 B and piping for conveying water pumped up from 15.5 A and 15.5 B (55 m^3/hr X 2) is necessary. The pipe diameter is determined on the basis of Japanese criteria for waterworks(refer to Fig. 5.3.2), and the result is shown in Table 5.3.2 .

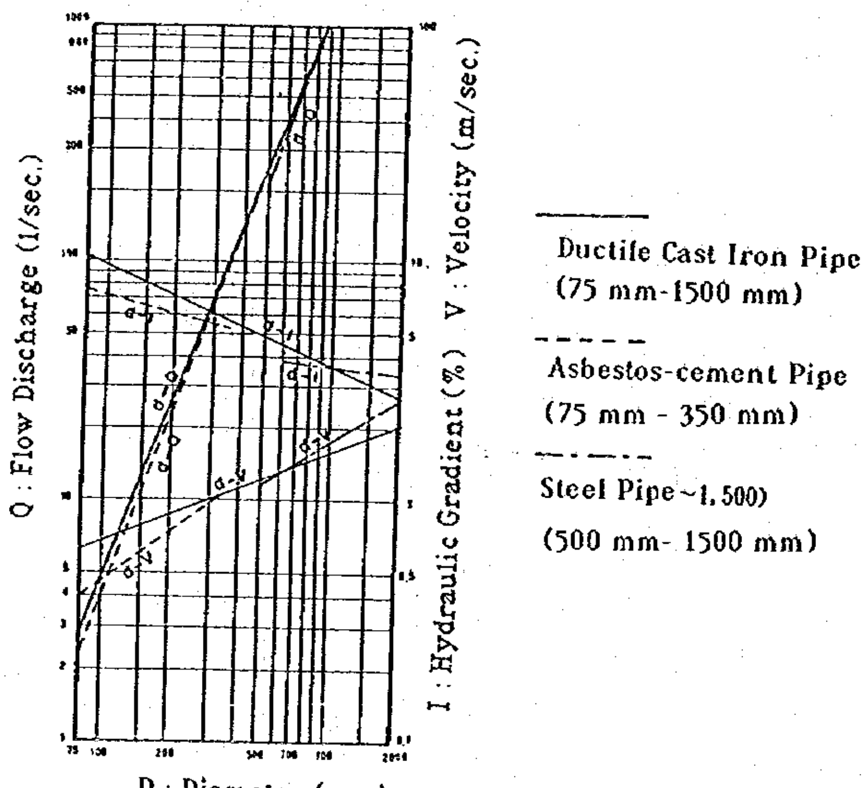


Fig. 5.3.2 Parameter of Economical Pipe Diameter

Table 5.3.2 Plan of proposed pipe

Section	Discharge Rate (m^3/hr)	Economical diameter (mm)	Diameter of existing pipe (mm)	Proposed diameter (mm)
15.5B – 15.5A	55	170	–	150 (new line)
15.5A – 15.0	110	210	–	150 (new line)
15.0 – 14.5	220	290	200	250 (replace)
14.5 – 14.0	330	340	250	300 (replace)
14.0 – 13.5	425	370	400	usable
13.5 – 13.0	505	390	400	〃
13.0 – 12.5	600	410	400	〃
12.5 – 10.5	1010	510	500	〃
10.5 – 9.5	1190	600	600	〃

Cast iron pipes, ductile cast iron pipes, steel pipes and hard PVC pipes are available and they are different from each other in material, method of manufacture, standard dimensions, strength, etc. In the Project, hard PVC pipes shall be used because such pipes are easy to handle and economical in view of the project area being in the tropics and there being shortages of skilled labor and heavy machines.

(2) Well primary piping

Around the well, a sluice valve and a check valve shall be provided for the pump. The sluice valve is used when the pump is to be disassembled or when the water pumping rate is adjusted. The valve shall be a manual-type. The check valve is used to prevent water in the discharge pipe from flowing back when the pump stops. A ductile cast iron pipe shall be used for open piping which is exposed to ultraviolet rays. In order to know the water pumping rate of each pump for management purposes, a flow meter shall be an ultrasonic-type flow meter so that the water pumping rate can be measured from outside because calcium in groundwater will be fastened in the flow meter in a long time if it is installed inside, making the measurement impossible. The measurement of the water pumping rate is not required at all times, and therefore, two portable- type flow meters shall be provided for the entire Balad Wellfield.

5.3.3 Power Supply Facilities

(1) Design conditions

The electric power generating facilities consists of electric power generating facility and electric power transmitting facility. The generation capacity shall be determined by comparison between the valve which is needed continuously and the valve which is needed at the time of motor start-up. It shall be calculated in accordance with the equation based on the "Waterworks Facility Design Guidelines, Explanatory Descriptions" compiled under the supervision by the Ministry of Health and Welfare and the value of required power to be used in this equation shall be determined from the total input of required motor shaft power for pumps and the power for lamps, which are to become the load on the generator.

The rate of operation of a high speed Diesel engine is determined as 75%, and it is assumed that the maintenance time is included in working hours and even if it exceeds eight hours, the maintenance should be continued like the generator operation.

(2) Design of generating facility

1) Capacity needed continuously (Pmi)

$$Pmi = \Sigma Pm / \Sigma nm$$

$$Qmi = (Pmi / PF) X 1 - PF^2$$

$$Pa = \sqrt{Pmi^2 + Qmi^2}$$

$$Pg \geqq PA$$

$$Pe \geqq 1.36 X Pmi / nG$$

Where, Pmi : total input of continuous loads (kw)

ΣPm : total output for continuous loads (kw)

Σnm : overall efficiency of continuous load

Qmi : total reactive power for continuous load input (KVA)

Pf : overall power factor of continuous loads

Pa : apparent power for continuous load input (KVA)

Pg : generator capacity (KVA)

Pe : engine output (Ps)

nG : generator efficiency

Motors used in the Project include three 45 kw motors and five 30 kw motors for existing well pumps, 13 37 kw motors and two 30 kw motors for new well pumps, two 1.5 kw motors for fuel pumps, and electric lamps require 5 kw, and therefore, the required power is :

$$\Sigma Pm = 45\ kw \times 3 + 30\ kw \times 7 + 37\ kw \times 13 + 1.5\ kw \times 2 + 5\ kw = 834\ kw$$

From this, the capacity needed continuously is obtained as follows.

Σnm = 0.84 (motor value for submerged pump)

Pf = 0.875 (37 kw motor)

$n G$ = 0.92 (per factor 80%)

Pmi = 834 / 0.84 = 992.9 KVA

Qmi = $(992.9 / 0.875) \times \sqrt{1-0.875^2} = 549.4$

Pa = $\sqrt{992.9^2 + 549.4^2} = 1134.8$

Pg = 1134.8 KVA

2) Capacity needed at motor start-up

$Pas = 3V \times Is \times 10^{-3}$

$Ps = Pas \times P \times fs$

$Qs = Pas \times \sqrt{1 - P \times fs^2}$

$Pa' = \sqrt{(Ps + Pm')^2 + (Qs + Qm')^2}$

$P_g \geq Pa' / (1+\alpha)$

$P_e \geq 1.36\ (Ps+Pm') / (1+\beta)$

$Is = Ps \times 10^3 \times IsL / (V \times nm \times Pfs \times 3)$

where as ;

Pas : apparent power at start-up of the load to start at the last time (KVA)

V : voltage (V)

Is : starting current of the load to start at the last time (A)

IsL : percentage of total load of starting current

Ps : input at start-up of the load to start at the last time

Pfs : power factor for above (decimal)

Qs : reactive power for above (KWA)

pa' : overall apparent power at start-up of the load to start at the last time (KVA)

Pm' : total input of loads in continuous operation before start-up of the load to start at the last time (KW)

Qm' : reactive power for above (KWA)

α : short-time overload allowance for generation, (decimal, normally about 0.5)

β : short-time overload allowance for Diesel engine, (decimal, normally about 0.1) where, V = 380 V

$Is = 45 \times 10^3 \times 1.8 / (380 \times 0.84 \times 0.85 \times 3) = 172$

$IsL = 180\ \% = 1.8$

$Pfs = 0.85$

$Pm' = (834\ kw - 45\ kw) / 0.84 = 939.3\ kw$

note: The motor for well pump to start at the last time shall be 45 KW and be star-delta started because this starting system is simple in construction and requires a comparatively small starting current.

$Qm' = (939.3 / 0.95) \times \sqrt{1 - 0.95^2} = 308.7$

$Pas = 3 \times 380 \times 172 \times 10^{-3} = 113.2\ KVA$

$Ps = 113.2 \times 0.85 = 96.2\ kw$

$Qs = 113.2 \times \sqrt{1 - 0.852^2} = 59.6\ KVAr$

$Pa' = \sqrt{(96.2 + 939.3)^2 + (59.6 + 308.7)^2} = 1099.0\ KVA$

$P_g' \geq 1099.0 / (1 + 0.5) = 732.7\ KVA < 1134.8\ KVA$

Therefore, the capacity needed continuously, 1134.8 KVA, shall be taken as the design capacity of the generator, and the total necessary capacity is calculated by adding transformer loss (380 V to 15 KV stepped up, 15 V to 380 V stepped down) of 4% at two points and a transmission loss of 2%, and assuming a generator operation rate of 75%.

Total necessary capacity

= (1134.8 X (1 + 0.02 + 0.04)) / 0.75 = 1203 * / 0.75 = 1604 KVA

*1203: necessary capacity in operation

The capacity of the Japanese-made generator installed in the Phase II Project is 250 KVA, so that the respective capacity of proposed generator in the case of three new generators and four generators is as follows;

Three generators (1604 - 250) / 3 = 452 KVA

Four generators (1604 - 250) /4 = 339 KVA

The output in lowest combination of new and existing generators is as follows;

Three generators 452 X 2 + 250 = 1154 < 1203 KVA

Four generators 393 X 2 + 250 = 1267 > 1203 KVA

It is impossible to operate whole intake facilities in the case of three generators to be installed. Therefore, three generator should be newly installed. The specifications for these generators are as follows.

Capacity	: over 339 KVA
Voltage	: 380 v/220 v
Frequency	: 50 Hz

Phase : 3

Prime mover : Diesel engine

Quantity : 4

(3) Transformer

1) Primary transformer

The power plant for the Balad wellfield is located between the wells 12.5 A and 13 A, and the power generated in this plant (380 V) is stepped up by means of two transformer sets of 500 KVA capacity to 15 KV for transmission to northern and southern well groups. Pump motors are 30 kw X 11 units and 45 kw X 1 unit on the northern side and 30 kw X 4 units and 45 kw X 4 units on the southern side. The transformer capacity is determined in accordance with the following equation.

$$T = Pm \times (1+\alpha) / (\Sigma n \times Pf)$$

where, T : transformer capacity (KVA)

α : allowance 0.15 (normally 10 to 20%)

pf : overall power factor

Σn : 0.84 (described above)

Pf : 0.85 (described above)

The necessary transformer capacity TN on the northern side:

$$T_N = (30 \times 4 + 37 \times 8) \times (1 + 0.1) / (0.84 \times 0.85) = 641 - 500 = 141 \text{ KVA}$$

The necessary transformer capacity TS on the southern side:

$$T_S = (30 \times 3 + 37 \times 5 + 45 \times 3) \times (1 + 0.1) / (0.84 \times 0.85)$$

$$= 632 - 500 = 132 \text{ KVA}$$

Therefore, there is a shortage of 141 KVA on the northern side and 132 KVA on the southern side. Then, transformers meeting the following specifications shall be added.

Transformer specifications

Capacity	: 150 KVA
Primary voltage	: 380 V (3-phase, 3-wire)
Secondary voltage	: 15 KV (3-phase, 3-wire)
Frequency	: 50 Hz
Quantity	: 2 (1 on the northern side and 1 on the southern side)

2) Secondary transformer

The transformer capacity "T " for a pump motors for water pumping rate of 55 m^3/hr to be newly constructed is:

$$T = 37 \times (1 + 0.2 *) / (0.84 \times 0.85) = 62.2 \text{ KVA}$$

* 0.2 : allowance

Therefore, transformers meeting the following specifications shall be installed in order to complement this lack.

Transformer specifications

Capacity	: 75 KVA
Primary voltage	: 15 KV (3-phase, 3-wire)
Secondary voltage	: 380 V / 222 V (3-phase, 3-wire)
Frequency	: 50 Hz
Quantity	: 11

(4) Wiring

1) High voltage lines

Electric power, stepped up to 15 KV in the power facility, is transmitted to the transformer for each pump through high voltage lines. The high voltage line used is a 22 mm^2 hand-drawn aluminum wire. In the Project, high voltage lines (about 3,000 m) with poles to transmit power to two wells shall be newly installed for constructing wells at new positions. Existing high voltage lines are nearly 20 years old and badly damaged in some portions, so that existing high voltage lines shall be entirely replaced. Moreover, porcelain insulators on the existing high voltage lines leak when it rains, and therefore, all of them shall be replaced with those capable of withstanding high voltages. Cross-arms, on which these insulators are mounted, are wooden and have been deteriorated. They shall be replaced at the time of insulator replacement.

2) Low voltage lines

The transformer (to step down 15 KV to 380 V) for pump motors shall be mounted at a high position on the pole, and this transformer shall be wired to the pump through cables. The cable to be used shall be a CV cable.

5.3.4 Ancillary Facilities

The ancillary facilities in the Project include fences and lighting apparatus to be used for management around the well. Around the well, there are a motor, a well pump operation panel, valves, etc. which are all important and should not be neglected. Moreover, 380 V and 45 KV voltages for motors are supplied. To prevent dangers, therefore, fences shall be provided. As these fences, those which were removed in the Phase II Project shall be used as a rule, and this time, fences for two wells shall be added. Lighting apparatus shall be provided for nighttime management around the well. The light projector to be used shall be a mercury-arc lamp which consumes less power and shall be installed for 13 newly installed wells.

5.3.5 Basic Design Drawings

Basic Design drawings shall be as listed below (Refer to Basic Design Drawings).

1. Construction Plan of Balad Wellfield
2. Typical Section of Intake Facilities
3. Profile of Well
4. Installation Plan of Generators
5. Plan for Fencing Work
6. Installation Plan of Electric Facilities for Well
7. Plan of Electric Wiring for Starter Panel

5.4 Specifications of Main Equipment and Materials

Specifications and quantities of facilities determined in the facility design are shown in Table 5.4-1.

Table 5.4 Outline of proposed facilities

Item	Quantity	Specification
1. Intake facilities		
(1)Well	13 wells	ϕ250 mm avg. depth130 m screen length 22 m
(2)Submersible pump	15	
New well	2	55 m³/hr× 115 m Motor30 kw
	4	55 m³/hr× 123 m Motor37 kw
	5	55 m³/hr× 128 m Motor37 kw
	2	55 m3/hr× 143 m Motor37 kw
Replacement for	1	55 m³/hr× 123 m Motor37 kw
existing well	1	55 m³/hr× 128 m Motor37 kw
(3)Piping facilities	2 Wells	ϕ150 flexible pipe, check valve, pressure gauge
(4)Flow meter	2	Supersonic wave type
2.Water Conveyance Facilities		
(1)Conveyance pipe	500 m	ϕ150 mm PVC
	28 m	ϕ150 mm PVC
(2)Transmittal pipe	500 m	ϕ150 mm PVC
	500 m	ϕ250 mm PVC
	500 m	ϕ300 mm PVC
(3)Valve	2	ϕ150 mm
3.Power supply facilities		
(1)Generator	4	339 KVA over× 380 V× 50 HZ (including operation board)
(2)Main transformer facilities	2	150 KVA× 380V/15 KV× 50 HZ
(3)Tranformer facilities for well	11	75 KVA× 1.5 KV× 380 V/222V × 3Phase× 50 HZ
(4)Lighting facilities	13	Mercury-arc light100 W (source voltage220 V)
(5)Staging for transformer	13	
(6)Electric wire	34.6 km	CV cable
(7)Electric pole	14	
4.Ancillary facilities	2 set	Wire-net fence for well

CHAPTER 6 IMPLEMENTATION OF THE PROJECT

CHAPTER 6 IMPLEMENTATION PLAN OF THE PROJECT

6.1 Project Implementing System

The implementing agency for the Project on the Somali side is the MWA (refer to Fig. 6.1). The general manager of the MWA will be responsible for contracting with the Consultant and Contractor. The Technical committee, which consist of the Project Manager, the Technical Director, the Director of Planning and Statistics, and so on, will be responsible for evaluation of technical specification and tender documents prepared by the Consultant. Prior to the commencement of construction, the Project Manager will arrange to implement the construction undertaken by the Government of Somalia and to prepare drilling rig, maintenance rig, etc. which were purchased in Phase I Project. The foreman in the Balad Wellfield will operate the generator and valve of conveyance pipe according to request of the Consultant. In addition, the operational method will be transferred to the staff stationed in the Balad Wellfield in the presence of the Project Manager and the Technical Director of MWA.

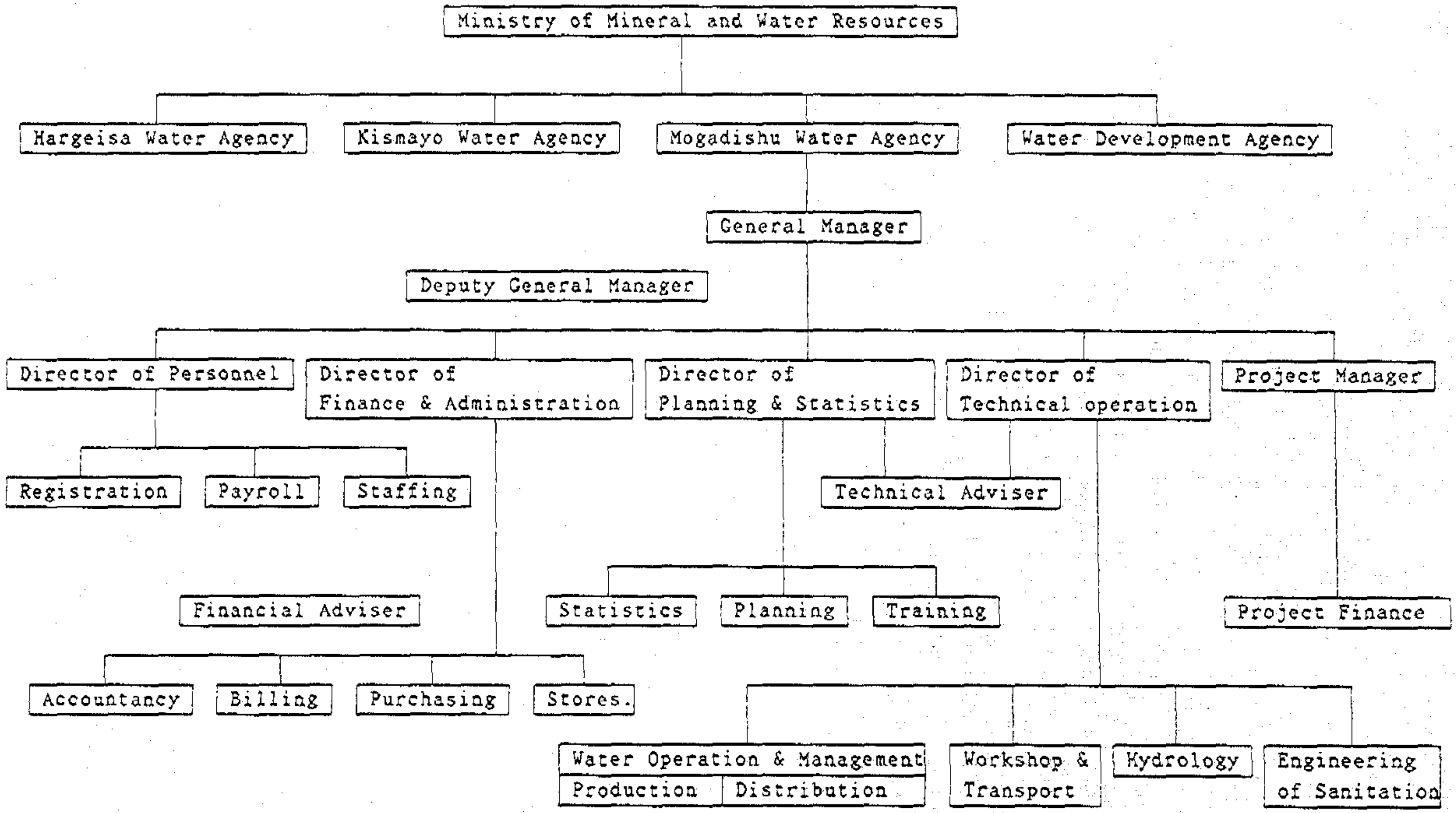


Fig. 6.1.1 Administrative Organization Chart

6.2 Division of Work

The Project is to be completed by cooperation between two governments. The division of the work is shown below.

Table 6.2 Division of Work

Item	Japanese side	Somali side
Internal transportation (From Mogadishu Port to site)	○	
Exemption from custom duties, internal taxes and other fiscal levies for products purchased for the Project and Japanese nationals concerned		○
Security of necessary land		○
Construction of roads necessary for the Project		○
Clearance of land for proposed facilities		○
Construction of wells	○	
Replacement of submersible pumps for exisitng wells	○	
Laying of conveyance and transmission pipes	○	
Replacement of generators	○	
Construction and rehabilitation of transmission facilities for power supply	○	
Construction of electric facilities	○	
Rehabilitation of power plant house	○	

6.3 Method of Work Execution

6.3.1 Execution Policies

The execution schedule from start-up to completion is executed in accordance with the execution plan prepared by the contractor and approved by the consultant. The execution plan clearly shows the work execution schedule, execution management, personal records of employees, personnel plan chart, execution method, etc.

6.3.2 Detail Design and Execution Management

The Project is divided into detail design and execution management. The contents of them are briefly as follows.

1) Detail design

a. Field survey

Complement to meteorological, hydrological, topographical and geological data, and data of construction materials, labor, work execution method, etc. obtained by the basic design and reconfirmation of the detail design at the field.

b. Detail design

Before commencement of preparation for bidding documents, design of detailed implementation calculation of detailed work costs, and set-up of work execution schedule.

c. Bidding operations

Preparation of bidding documents, assistance to bidder qualification review, witness of bidding, evaluation of bidding results, assistance to negotiation for work contracting, and assistance to conclusion of the work contract.

2) Execution management

a. Supervision

Discussion among the persons concerned before commencement, approval of design drawing, inspection of equipment and materials before shipment, control of work execution at the site, witness of equipment installation, preparation of operation reports during the work period, issuance of a work completion certificate and a payment certificate, completion inspection, etc.

b. Operations upon completion of work

Issuance of a work completion certificate, proceedings for work completion and delivery, final operation reports, proceedings for operation completion, etc.

6.3.3 Equipment and Material Procurement Plan

The equipment and materials shall be products manufactured in Japan, manufactured in Somalia, or, when specifically permitted, manufactured in third countries.

As to products manufactured in Japan and manufactured in third countries, consultant's review shall be made on successful bidder's application documents for approval of equipment and materials to see if they satisfy the conditions of performance, strength, etc. described in the bidding specification. Thereafter, as necessary, consultant's inspection as witness test shall be made during the manufacturing period of the manufacturer or after completion of the manufacture, and after consultant's approval, products shall be packaged. Completely packaged products shall be shipped on board after consultant's approval.

Products manufactured in Japan shall be transported by sea up to the Mogadishu Port, and after clearing the customs, transported to the construction site. Products manufactured in the third country shall be transported by sea from the exporting country to the Mogadishu Port, and after clearing with customs, transported to the construction site, similarly to the case of products manufactured in Japan.

6.3.4 Plan for the Work to be done by the Government of Somalia

Of the work to be done by the government of Somalia, obtainment of the construction site, site preparation and construction of work roads shall be completed with the fund of Somalia by the time the Project is commenced.

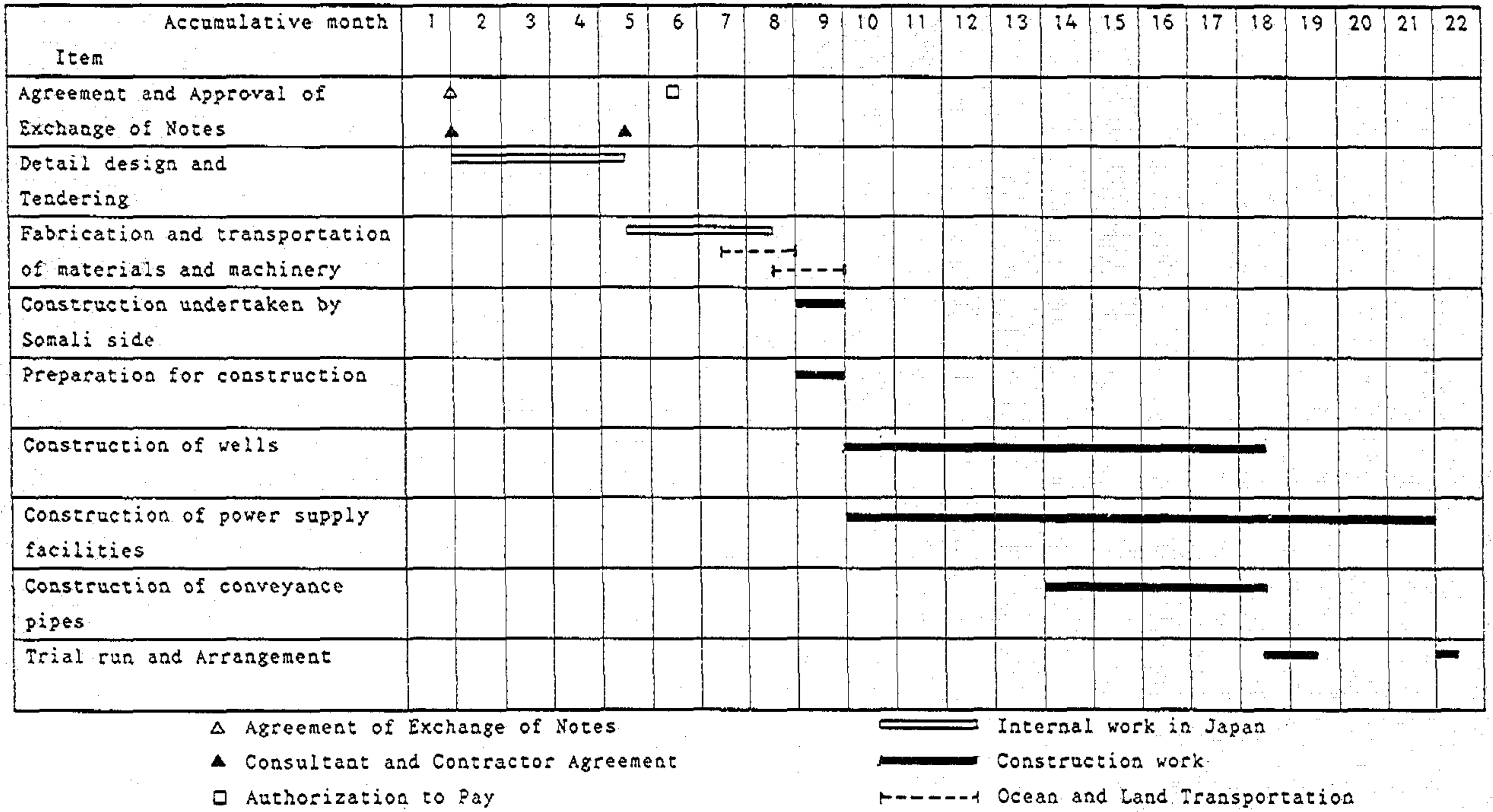
6.4 Implementation Schedule of the Project

The project implementation schedule is shown in Table 6.4 and is expected to be 20.5 months after conclusion of the Exchange of Notes.

6.5 Approximate Project Cost

It is estimated that the cost to be done by the Somali side is about ¥20,000,000 including construction of the access road and hire of the machinery.

Table 6.4 Implementation of Schedule for Mogadishu Water Supply Improvement Project (Phase III)



CHAPTER 7 OPERATION AND MAINTENANCE PLAN

CHAPTER 7 OPERATION AND MAINTENANCE PLAN

7.1 Operation and Maintenance System

At present, the MWA is responsible for maintenance and management of the existing waterworks facilities in the entire Mogadishu City area, and it is expected that all facilities to be constructed in this project shall be placed under maintenance and management by a similar system. The present maintenance and management system and personnel are as shown in Table 7.1.

Table 7.1 Organization and personnel for Maintenance

Assignment	Number	Stationing	Remarks
Head	2	1 (MWA) 1 (Balad Wellfield)	The person in MWA is also the head of Afgoi Wellfield.
Mechanics	4	Balad Wellfield	
Electrician	2	Balad Wellfield	
Well maintenance	3	Balad Wellfield	

During the work execution period, engineers and technicians of the project team will be given on-the-job training for technology transfer from engineers of the Japanese side. After completion of the facilities, the members of the project team will be responsible for maintenance and management in accordance with the maintenance and management manual to be prepared by the consultant at the time of implementation design.

As to technical capability for operation and maintenance, it is judged that there will be no specific problem from the condition of maintenance and management of the existing facilities and from the conditions observed in the Phase II Project and in the basic survey. However, in order to improve the maintenance and management capability and transfer the maintenance and management know-how, it is desired that the Japanese expert should stay and give instructions, and at the same time, Somali engineers who are to be actually engaged in operation and repair should be trained in Japan.

7.2 Operation and Maintenance Costs

In order to supply safe water for drinking purpose after completion of the Project, it is prerequisite that the facilities can be maintained and managed with the income of water charge and the MWA can operate all its facilities on a sound financial basis.

So far, the MWA has continued its operation in the red, but since the year before last when additional water meters were installed, the operating condition has been remarkably improving. The MWA has scheduled to raise the water charge of 25 shillings per cubic meter at present to a doubled rate of 50 shillings in the coming year, to reduce the continuing deficit.

CHAPTER 8 EVALUATION OF THE PROJECT

CHAPTER 8 EVALUATION OF THE PROJECT

8.1 Effects of the Project

Mogadishu City at present suffers a stringent water shortage due to the qualitative problem in the Afgoi Wellfield and the pump damage and lack of power supply in the Balad Wellfield. The implementation of the Project will effect the followings directly and indirectly: 1) increase of discharge rate, 2) increase of income , 3) improvement of of living conditions, 4) assistance for the long-term plan.

(1) Direct effect

1) Increase of discharge rate

The Discharge rate in the Balad Wellfield will be increased from 8,700 m^3/day to 28,000 m^3/day, so that the daily water consumption per capita will be from 33 liters to 70 liters.

2) Increase of income

According to the increase of water consumption, it is expected that income of about 42.7 million shillings is increased. It will remarkably contribute to maintenance and operation, because the cost for the maintenance and operation in 1986 was about seven million shillings.

(2) Indirect effect

1) Improvement of living condition

It will be incapable to supply sufficient quantity of water to the people in the highland area, so that they will not take times to secure the living water as before.

2) Assistance for long-term plan

According to the increase of discharge rate in the Balad Wellfield, it will be capable to complement the planned water supply rate in the Long-term Plan (Mogadishu Water Supply Expansion Stage IIB) and consequently reduce its construction cost.

CHAPTER 9 CONCLUSION AND RECOMMENDATIONS

CHAPTER 9 CONCLUSION AND RECOMMENDATIONS

As the results of field survey in Somalia and studies in Japan, the direct and indirect effects as described in Chapter can be expected from the implementation of the Mogadishu Water Supply Improvement (phase III). It can be said that the project will play an important and effective role not only to improve a stringent water shortage in Mogadishu City, but also to contribute the improvement of living condition.

It is confirmed that there is no organizational problem in MWA. The staff stationed in Balad Wellfield will be able to operate the facilities for maintenance by being through of the method after completion of the construction.

From the above mentioned situation, the request of the government of Somalia on the Project is judged to be reasonable, and it is concluded that the implementation of the Project under the grant aid by the Government of Japan is extremely significant.

The Project will be able to be implemented smoothly and effective under the cooperation of the Government of Somalia. Therefore, the following items are recommended to the Government of Somalia

(1) Before commencement of the work, preparations shall be made without delay within the range of undertakings of Somali side.

(2) Primarily, the Project is intended to improve the water shortage in Mogadishu City as a matter of urgency. But, since it is able to complement the planned water supply rate of the master plan (Stage 2B) being set up by the Government of Somalia at present, the MWA should review the master plan and consider an effective utilization of the Project.

(3) The planned water intake rate of 28,000 m^3/day in the Project can be continued for 20 years in the future because the groundwater level stabilizes with ingress of salt water. It is anticipated that groundwater in the Balad Wellfield will be salified in the future, so that it is necessary to check and control water quality at all times after completion of the facilities.

Furthermore, the facilities will be maintained and operated on the basis of the maintenance & operation manual prepared by Japanese side after completion of the construction, so that it is desirable to dispatch a Japanese expert in order to transfer technique of water supply for smooth maintenance & operation of the facilities. In addition, it is also desirable for Somali engineers to improve the capability of maintenance & operation and organization by means of being trained in Japan.

APPENDIX

1. ORGANIZATION OF STUDY TEAM

Basic Design Study Team

Name	Position	Home Post
Mr. Masayuki MATSUSHIMA	Team Leader	Kyoto Municipal Waterworks Bureau
Mr. Osamu KOSEGAWA	Coordinator	Japan International Cooperation Agency
Mr. Mitsuru MASHIO	Water Supply Engineer	Kyowa Engineering Consultants Co., Ltd.
Mr. Suenori ISAYAMA	Hydrogeology Engineer	Kyowa Engineering Consultants Co., Ltd.
Mr. Yoichi HARADA	Equipment Engineer	Kyowa Engineering Consultants Co., Ltd.

Draft Final Report Explanation Team

Name	Position	Home Post
Mr. Akira MITAMURA	Team Leader	Kyoto Municipal Waterworks Bureau
Mr. Mitsuru MASHIO	Water Supply Engineer	Kyowa Engineering Consultants Co., Ltd.
Mr. Suenori ISAYAMA	Hydrogeology Engineer	Kyowa Engineering Consultants Co., Ltd.

2. SCHEDULE OF FIELD SURVEY IN MOGADISHU

Basic Design Study Team

Date			Schedule	Activity
Aug.	31	Wed.	Leave Tokyo	Travel
Sep.	3	Sat.	Arrive in Mogadishu	1) Courtesy call to MWA (Mogadishu Water Agency) 2) Explanation of Inception Report
	4	Sun.	Mogadishu (Field survey)	1) Balad Wellfield (Well, Power Plant) 2) Afgai Wellfield 3) Mogadishu City, Water Supply Condition
	5	Mon.	Mogadishu (Field survey)	1) Inspection of Water Facilities 2) Discussion on Existing Water Facilities and Condition of Water Supply
	6	Tue.	Mogadishu	1) Discussion with the staff of MWA 2) Courtesy Call to M.M.W.R(Ministry of Mineral and Water Resources) and Hearing on Kismayo Water Project
	7	Wed.	Afgoi	1) Survey of the Shabelli river and Afgoi area 2) Explanation of Japan's Grant Aid to MWA 3) Discussion on Minutes of Discussions
	8	Thu.	Mogadishu	Arrangement of survey data
	9	Fri.	Mogadishu	Arrangement of survey data
	10	Sat.	Mogadishu	Meeting and Signing of the Minutes of Discussion
	11	Sun.	Balad	Survey of the Shabelli river Messrs. Matsushima and Kosegawa leave Somalia
	12	Mon.	Balad	Survey of Balad Well Field and Power Plant
	13	Tue.	Balad	Survey of Balad Well Field and existing equipment
	14	Wed.	Balad and Mogadishu	Survey of Balad well Field and Marketing
	15	Thu.	Balad	Pumping Test of Well No. 12.5A
	16	Fri.	Mogadishu	Arrangement of survey data
	17	Sat.	Balad	Pumping Test of Well No.14.0A
	18	Sun.	Mogadishu	Arrangement of Survey data
	19	Mon.	Mogadishu	1) Hearing on damaged submersible pump and condition of electric facilities 2) Data collecting at UNDP
	20	Tue.	Balad	1) Hearing on condition of existing generators 2) Measurement of static water level 3) Removal of pump casting

21	Wed.	Afgoi and Mogadishu	1) Sampling of groundwater at Afgoi well field 2) Water quality test 3) Data collecting
22	Thu.	Mogadishu	Arrangement of collected data and survey data
23	Fri.	Mogadishu	Arrangement of collected data and survey data
24	Sat.	Mogadishu	Final meeting with the staff of MWA
25	Sun.	Mogadishu Leave Mogadishu	Final meeting with the staff of MMWR
27	Tue.	Arrived inJapan	

Draft Final Report Explanation Team

Date			Schedule	Activity
Dec.	11	Sun.	Leave Tokyo	Travel
	13	Tue.	Arrive in Mogadishu	1) Courtesy call to MWA (Mogadishu Water Agency) 2) Submission of Report to MWA 3) Courtesy call to MMWR
	14	Wed.	Balad and Mogadishu	1) Field Survey of Balad Wellfield (Well, Power Plant) 2) Hearing on condition of facilities 3) Internal meeting
	15	Thu.	Mogadishu	Discussion with staff of MWA
	16	Fri.	Afgoi, Mogadishu	1) Survey of Shabelli River 2) Preparation of Minutes of Discussions
	17	Sat.	Mogadishu	Meeting and Signing of Minutes of meeting
	18	Sun.	Leave Mogadishu Arrive in Nairobi	Travel
	19	Fri.	Nairobi	1) Report to the staff of JICA Kenya office
			Leave Nairobi	2) Report to the secretary of the Embassy of Japan in Kenya
	22	Thu.	Arrive inTokyo	

3. LIST OF THE PERSONS CONTACTED

Basic Design Study

1) Ministry of Mineral and Water Resources

Mr. Abdullahi Mohamed Hersi	: Minister
Mrs. Nuro Seikh Abdulleh	: Vice Minister
Mr. Mohamed Osmar Asad	: Director General
Mr. Mohamed Yusuf Awale	: Director of Hydrology

2) Mogadishu Water Agency

Mr. Aden Farah Shirwa	: General Manager
Mr. Abdullahi Mohamed Osman	: Deputy General Manager
Mr. Mohamed Rabille Goud	: Project Manager
Mr. Osman Abdullahi Kulnie	: Technical Director
Mr. Jama Isamail	: Financial Director
Mr. Osaman Haji Ali	: Planning Director
Mr. Shek Mohamed Aweys	: Electric & Power Plant Super-intendent
Mr. Mohamed Said Musa	: Head of Balad Power Plant

3) Kismayo Water Agency

Mr. Mohamed Xassan	: Project Manager

Draft Final Report Explanation

1) Ministry of Mineral and Water Resources

Mr. Abdullahi Mohamed Hersi	: Minister
Mrs. Nuro Seikh Abdulleh	: Vice Minister

2) Mogadishu Water Agency

Mr. Aden Farah Shirwa	: General Manager
Mr. Mohamed Rabille Goud	: Project Manager
Mr. Osman Abdullahi Kulnie	: Technical Director
Mr. Mohamed Abdi Beyle	: Project Accountant

3) The Embassy of Japan in Kenya

Mr. Toshio Ishigami	: Second Secretary

4) JICA Kenya Office

Mr. Kenji Kumagishi	: Resident Representative
Mr. Ryuji Matsunaga	: Assistant Resident Representative

4. MINUTES OF DISCUSSIONS

MINUTES OF DISCUSSIONS
ON
THE MOGADISHU WATER SUPPLY IMPROVEMENT PROJECT (Phase III)
IN THE SOMALI DEMOCRATIC REPUBLIC

In response to the request made by the Government of Somali Democratic Republic for the Mogadishu Water Supply Improvement Project, Phase III (hereinafter referred to as "the Project"), the Government of Japan decided to conduct a Basic Design Study on the Project and entrusted the Japan International Cooperation Agency (JICA) to send the Basic Design Study Team (hereinafter referred to as "the Team") headed by Mr. Masayuki Matsushima, a senior engineer of Kyoto Municipal Waterworks Bureau from August 31 to September 27, 1988.

The Team had a series of discussions on the Project with the officials concerned of the Government of Somali Democratic Republic, headed by Mr. Aden Farah Shirwa, General Manager of Mogadishu Water Agency and conducted a field survey in Mogadishu City.

As a result of the study, both parties have agreed to recommend to their respective Governments that the major points of understanding reached between them, attached herewith, should be examined towards the realization of the Project.

September 10, 1988

Masayuki Matsushima
Leader
JICA Study Team

Aden Farah Shirwa
General Manager
Mogadishu Water Agency (MWA)

Attachment

1. The objective of the Project is to improve the present shortage of water supply in Mogadishu City by means of drilling new wells in Balad Well field.

2. The site of the Project is at Balad Well Field, which is located 9 to 16 km northeast from the center of Mogadishu City (Site map is attached as Annex I).

3. The content of the Project shown by the Government of Somalia is to construct new wells and to rehabilitate the existing water supply facilities in Balad Well Field(refer to Annex II).

4. Mogadishu Water Agency of the Ministry of Mineral and Water Resources is responsible for the administration & execution of the Project.

5. The Japanese Study Team will convey to the Government of Japan the desire of the Government of Somali Democratic Republic that the former takes necessary measures to cooperate by providing materials and equipment and other items within the scope of Japanese economic cooperation programme in Grant form.

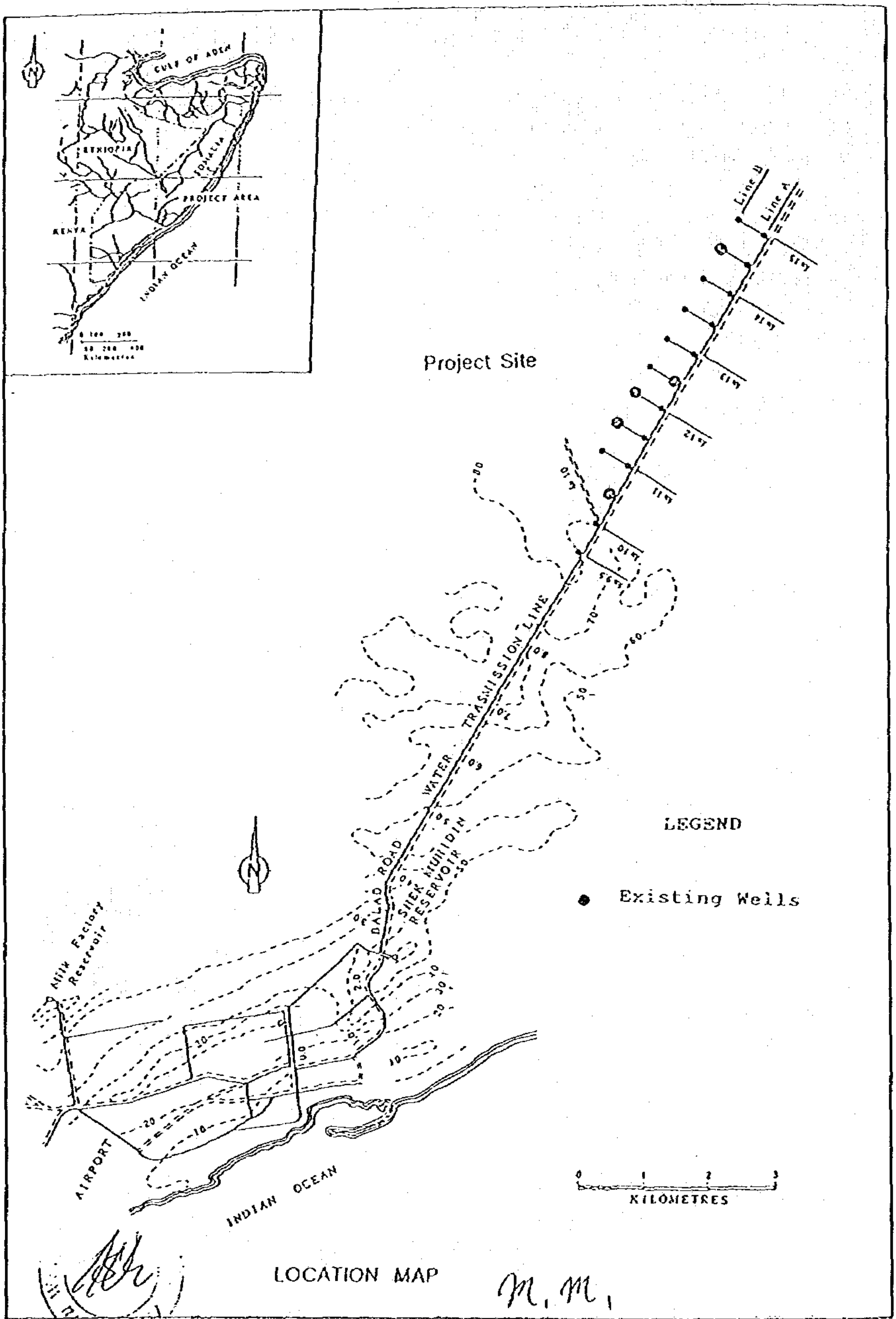
6. The Somalia side has understood Japan's Grant Aid System explained by the Team.

7. The equipment, materials, and vehicles purchased under the Grant shall be exclusively for the Project and shall not be used for other purposes.

8. The Government of Somali Democratic Republic will take necessary measures listed in Annex III on condition that the Grant Aid is extended to the Project.

M. M.

Annex 1


GULF OF ADEN
ETHIOPIA
SOMALIA
PROJECT AREA
KENYA
INDIAN OCEAN
Kilometres
Project Site
Line B
Line A
WATER TRASMISSION LINE
DALAD ROAD
SHEK MURIDIN RESERVOIR
Milk Factory Reservoir
AIRPORT
INDIAN OCEAN
LEGEND
Existing Wells
KILOMETRES
LOCATION MAP

Annex II

The main components of the Project, which will improve the present water shortage in Mogadishu City, are summarized as follows:

1) Construction of new wells:
   new wells for relieving the present water shortage in the City.

2) Provision of materials for the construction of new wells:
   submersible motor pumps, generators, transformers, pipe materials, wiring cable, consumables and etc.

3) Provision of materials for improving the existing intake facilities:
   generators, transformers, pipe materials, wiring cable, consumables and etc.

4) Provision of equipment for operation and maintenance:
   accessaries for drilling machine, equipment of workshop, tools for electric work and etc.

Annex III

Arragements to be taken 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 commencement of the construction.

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

3. To provide the space necessary for temporary offices, working areas, stock yards and others.

4. To ensure prompt unloading, tax exemption and customs clearance at port of disembarkation in Somali Democratic Republic, of the products purchased under the Grant.

5. To exempt Japanese nationals engaged in 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.

6. 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 stay therein for the performance of their work.

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

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

9. To bear commissions to the Japanese foreign exchange bank for the banking services based upon the Banking Arrangement.

10. To provide machinery free of charge that were purchased under the previous Project(rig, compressor, etc).

M. M.

Draft Final Report Explanation

Minutes Of Discussions
On The Draft Final Report Of The Basic Design Study
On The Mogadishu Water Supply Improvement Project (Phase III)
In The Somali Democratic Republic

In response to the request made by 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 (Phase III) (hereinafter referred to as "the project") and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to the Somali Democratic Republic the study team from August 31 to September 27, 1988.

As the result of the study, JICA prepared a draft final report and dispatched a mission, headed by Mr.Akira Mitamura, Senior Engineer, Water Purification Section, Technical Division, Kyoto Municipal Waterworks Bureau, to explain and discuss it from December 11 to December 22, 1988.

The Team had a series of discussions on the project with the officials concerned of the Government of Somalia, headed by the Mr.Aden Farah Shirwa, General Manager of Mogadishu Water Agency.

After Clarifying its contents, both parties had agreed to recommend to their respective governments that the major points of understanding reached between them, attached herewith, should be examined towards the realization of the project.

December 17, 1988

三田村 晃

Akira Mitamura
Leader
JICA Study Team

Aden Farah Shirwa
General Manager
Mogadishu Water Agency (MWA)

ANNEX 1

The items of the proposed facilities are summarized as follows:

1. Intake Facilities
   (1) Construction of new wells
   (2) Installation of pump for new wells
   (3) replacement of pump for existing wells
   (4) Piping Facilities
   (5) Flow meter

2. Conveyance and transmission pipes
   (1) Conveyance pipe
   (2) Transmission pipe

3. Power Supply Facilities
   (1) Generating facilities
   (2) Main Transforming facilities
   (3) Sub-transforming facilities
   (4) Staging for sub-transformer
   (5) Electric wiring
   (6) Electric pole

4. Ancillary Facilities
   (1) Net fence for well
   (2) Lightings for wells

ATTACHMENT

MAJOR POINTS OF UNDERSTANDING:

1. The Somalia side agreed in principle to the basic design proposed in the Draft Final Report. The items of proposed facilites are shown in ANNEX 1.

   But the Government of Somalia stated as follows.

   1) All of the existing generators except a generator provided by the former project should be replaced to new ones as for the generating facilities.

   2) At least 3 transportation vehicles and 1 truck are required.

   The study team promised to convey its request to the government of Japan.

2. The Somalia side understood the system of Japan's Grant Aid Program and confirmed the measures to be taken by the Somalia side towards the realization of the Project as agreed upon in the "Minutes of Discussion" signed on December 17,1988.

3. Ten copies of the Final Report on the Project will be submitted to the Government of Somalia by April,1989.

5. LIST OF COLLECTED DATA

1) Mogadishu Water Agency

(1) Feasibility study for Mogadishu Water Supply Expansion, Preliminary Report, Volume I, April 1977, Sir Alexander Gibb & Partners (Africa)

(2) Source Investigation For Mogadishu Water Supply Expansion Volume I Technical Report, June 1980, Sir Alexander Gibb & Partners (Africa)

(3) Mogadishu Water Supply Expansion, Second Water Resouces Investigation, Final Report, February 1985 Sir Alexander Gibb & Partners (Africa)

Volume I - Engineering

Volume II - Hydrogeology and Hydrology Part 1

Volume III - -do- Part 2

Volume IV - Appendices A and B

(4) Mogadishu Water Supply Expansion Stage 2B

Draft Report On Final Design, Volume 1, August 1985

Sir Alexander Gibb & Partners (Africa)

(5) Mogadishu Water Supply Expansion Stage 2A, Completion Report, December 1987, Sir Alexander Gibb & Partners (Africa)

Volume 1 - Project description and Finacial information

Volume 2 - Operational and Technical datails

Volume 3 - Wellfield development and Test pumping

Volume 4 - As made drawings

(6) Mogadishu Groundwater Investigation Projects, 1988

Eng. Abdi Farah Abdulle

(7) Hydrogeology & Well Construction Criteria Report

The Ralph H. Parsons Company

(8) Balance sheet (1985, 1986)

(9) Water charge sheet

(10) Drawings

- Mogadishu Water System

- Shek Muhidin Reservoir Plot and Grading Plan
- Water System Flow Diagram
- Milk Factory Reservoir Plot and Grading Plan
- Power Plant Plot and Grading Plans, Sections and Details
- Power Plant Piping Plan
- Mogadishu Water Supply Expansion Stage 2A
  Supplied Area
- Mogadishu Water Supply Expansion Stage 2B
  Location Map
  Location of Works and Overhead Line Routes
  Layout of Bulk Supply System
  Schematic Layout Bulk Supply Systems

2) Ministry of National Planning

(1) The Five Year National Development Plan 1987 -1991
Directorate of Planning, Ministry of National Planning, September 1988

(2) Annual Development Plan 1988
Directorate of Planning, Ministry of National Planning, January 1988

3) United Nations Development Programme Mogadishu (UNDP)

(1) Somalia Annual Development Report 1986
United Nations Development Programme Mogadishu, August 1987

4) Others

(1) Monthly Bulletin, July 1988
Somali Chamber of Commerce, Industry and Agriculture

(2) Foreign Investment Law, 1987

6. DRAWDOWN AND PERMEABILITY COEFFICIENT ON THE BASIS OF DISCHARGE RATE

Well No.	Drawdown s(m)	Discharge $Q(m^3/hr)$	Permeability Thickness M(m)	Permeability Coefficient k(cm/sec)
10.0A	4.01	50.3	42	1.09×10^{-2}
11.0A	6.58	22.5	36	3.48×10^{-3}
11.0B	7.00	34.1	67	2.66×10^{-3}
11.5A	3.22	31.7	37	9.75×10^{-2}
12.0A	6.05	33.5	38	5.34×10^{-3}
12.5B	10.85	33.5	58	1.95×10^{-3}
13.0A	15.85	51.1	46	2.56×10^{-3}
13.0B	4.92	51.1	62	6.14×10^{-2}
13.5A	6.85	50.3	53	5.12×10^{-3}
13.5B	9.10	29.4	65	1.82×10^{-3}
14.0A	5.71	47.2	60	5.05×10^{-3}
14.5A	11.67	40.0	67	1.87×10^{-3}
15.0A	10.13	42.1	70	2.17×10^{-3}
15.0B	13.15	25.0	59	1.18×10^{-3}
10.5A	22.83	60.2	35	2.76×10^{-3}
11.5B	35.43	62.9	65	1.00×10^{-3}
12.0B	32.56	60.2	60	1.13×10^{-3}
12.5A	23.02	54.3	40	2.16×10^{-3}
14.5B	21.96	59.4	62	1.60×10^{-3}
			Average	3.57×10^{-3}

7. DATA ON THE COST ESTIMATE FOR MAINTENANCE FEE

1. Fuel Fee

The quantity of fuel consumed at Balad Well Field will be caluculated on the basis of under-mentiond conditions.

Total discharge :28000 m3/day(19.44 m^3/min.)

Pump Head :125 m

Pump Efficiency :66%

Generator Efficiency:92%

Other electric power such as for light:8 Kw

Loss :6 %

Fuel percetage of diesel engine :0.20 kg/psh

Weight of fuel :0.83

Total output of diesel engine

(0.163x125x19.44+8)x1.06x1.36/(0.66x0.85x0.92)=1128.7

1kw=1.36Ps

Consumed fuel per day

1128.7x0.2/0.83x24=6527 ℓ/day

Fuel for Vehicles

170 ℓ/day

Total fuel consumption per day

6700 ℓ

Fuel fee

6700x45 shi./ℓ=301,500 Shi.

2. Salary for the staff

10,600,000 shi/(2x365)=14,520 shi.

3. Others

(5,000,000+2,600,000+1,500,000+6,400,000)/(2x365)=21,230 Shi.

8. WELL INVENTORY

Well No.	10.0A	Location	Balad Well Field	Completed	Jan.20, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.14, '88

Item			Const.	Rehab.	B/D Ⅲ	Remarks
Elevation			72.67 m			
Drilling dia.						
Well dia.			$13^3/_8$ in.			
Well Depth			140 m			
Static Water Level			67.3 m	69.73 m	–	
Dynamic Water Level				73.75 m		
Casing Material						
Screen	Location		120-140 m			
	Material		Steel($9^5/_8$ in.)			
	Opening Ratio					
Pump	style			Submersible		
	Capacity(motor)					Current 46(A)
	Discharge Rate					
Condition					Operating	
Actual Discharge Rate				44.0 m^3/hr	29.0 m^3/hr	Pressure1.6 kg/cm^2
Electric	Operation Board				Good	Voltage370(V)
	Lighting				Nil	
	Wiring				Good	
	Transformer				Good	
Piping						
Water Quality		E/C			1500	
		PH			6.6	

Others

Water Temperature 34℃

Well No.	10.5A	Location	Balad Well Field	Completed	Apr.23, '87
Owner	MWA	Contractor	Nissaku	Surveyed	Sep.14, '88

Item		Const.	B/D Ⅲ		Remarks
Elevation		77.81m			
Drilling dia.					
Well dia.		10 in.			
Well Depth		150 m			
Static Water Level		73.40 m			
Dynamic Water Level		96.23m	86.62m		
Casing Material					
Screen	Location	107.5-113.0	118.5-133.0		
	Material	Stainless Steel			
	Opening Ratio	11%			
Pump	Style	Submersible Pump			
	Capacity(motor))				Current 60(A)
	Discharge Rate				
Condition		Operationg			Pressure 1.8kg/cm²
Actual Discharge Rate		($60.2m^3/hr$)			
Electric	Operation Board	Good			Voltage 378(V)
	Lighting	Good			
	Wiring	Good			
	Transformer				
Piping		Good			
Water Quality	E/C				
	PH				

Others

Flow meter has been out of order.

Well No.	11.0A	Location	Balad Well Field	Completed	Mar.14, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.14, '88

Item		Const.	Rehab.	B/D Ⅲ	Remarks
Elevation		73.31m			
Drilling dia.					
Well dia.		$9^5/_8$ in.			
Well Depth		134.1 m			
Static Water Level		63.8 m	68.92 m	68.63m	
Dynamic Water Level			75.50 m	—	
Casing Material					
Screen	Location	83.7-109.4	127.8-134.1		
	Material	Steel($9^5/_8$	in.)		
	Opening Ratio				
Pump	Style			Removed	
	Capacity(motor)				
	Discharge Rate				
Condition				Unoperating	
Actual Discharge Rate			$40.0m^3/hr$		
Electric	Operation Board			Removed	
	Lighting			Nil	
	Wiring			Removed	
	Transformer			Removed	
Piping				Removed	
Water Quality	E/C	790μm/cm			
	cl^-	60PPm			
Others					

Well No.	11.0B	Location	Balad Well Field	Completed	
Owner	MWA	Contractor	Parsons	Surveyed	14.9,'88

Item		Const.	Rehab.	B/D III	Remarks
Elevation					
Drilling dia.					
Well dia.		$9^5/_8$ in.			
Well Depth		No data			
Static Water Level		No data	72.05m	71.87m	
Dynamic Water Level		No data	79.05m		
Casing Material		No data			
Screen	Location	No data			
	Material	No data			
	Opening Rate				
Pump	Style		Submersible	Out of Order	
	Capacity(motor)				
	Discharge Rate				
Condition				Unoperating	
Actual Discharge Rate			35.4m³/hr		Digital 453610
Electric	Operation board			Good	
	Lighting			Good	
	Wiring			Good	
	Transformer			Good	
Piping				Good	
Water Quality	E/C				
Others					

Well No.	11.5A	Location	Balad Well Field	Completed	Jul.30, '77
Owner	MWA	Contractor	Parsons	Surveyed	Sep.14, '88

Item			Const.	Rehab.	B/D Ⅲ	Ramarks
Elevation			74.7 m			
Drilling Dia.						
Well Dia			$10^3/_4$ in.			
Well Depth			118.3 m			
Static Water Level			64.9 m	71.10 m	70.75 m	
Dynamic Water Level				74.32 m		
Casing Material						
Screen	Location		85-118.3			
	Material		Stainless Steel			
	Opening Ratio					
Pump	Style			Submersible	Removed	
	Capacity(motor)					
	Discharge Rate					
Operation					Unoperating	
Actual Discharge Rate					–	
Electric	Operation Board				Removed	
	Lighting				Nil	
	Wiring				Nil	
	Transformer				usual	
Piping					Removed	
Water Quality		E/C	700 μm/cm			
		cl⁻	40 ppm			
Others						

Well No.	11.5B	Location	Balad Well Field	Completed	Jan.24, '87
Owner	MWA	Contractor	Nissaku	Surveyed	Sep.14, '88

Item		Const.	B/D Ⅲ		Remarks
Elevation					
Drilling dia.					
Well dia.		10 in.			
Well Depth		146 m			
Static Water Level		66.47 m			
Dynamic Water Level		101.90 m	82.57 m		
Casing	Material				
Screen	Location	107.5-129.5 m			
	Material	Stainless Steel			
	Opening Ratio	11%			
Pump	Style	Submersible			
	Capacity(motor)				Current 69(A)
	Discharge Rate				
Condition			Operating		Pressure 1.6kg/cm²
Actual Discharge Rate		66.6 m³/hr	-		Digital 619060
Electric	Operation Board		Good		Voltage342(V)
	Lighting		Good		
	Wiring		Good		
	Transformer		Good		
Piping					
Water Quality	E/C				
	PH				
Others					

Well No.	12.0A	Location	Balad Well Field	Completed	Jun.27, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.14, '88

Item		Const.	Rehab.	B/D III	Remarks
Elevation		74.07m			
Drilling dia.					
Well dia.		10 3/4in.			
Well Depth		121.1 m			
Static Water Level		62.80 m	70.38 m	69.50 m	
Dynamic Water Level			76.43 m		
Casing Material					
Screen	Location	84.9-121.1 m			
	Material	Steel($6^{5/8}$ in.)			
	Opening Ratio				
Pump	Style		Submersible	Out of Order	
	Capacity(motor))				
	Discharge Rate				
Condition		Operating			Pressure 1.8kg/cm^2
Actual Discharge Rate		(60.2m^3/hr)			
Electric	Operation Board			Unoperating	
	Lighting			Usual	
	Wiring			Usual	
	Transformer			Usual	
Piping					
Water Quality	E/C	760μm/cm			
	cl$^-$	40 ppm			
Others					

Well No.	12.0B	Location	Balad Well Field	Completed	Mar.19, '87
Owner	MWA	Contractor	Nissaku	Surveyed	Sep.14, '88

Item			Const.	Rehab.		Remarks
Elevation						
Drilling dia.						
Well dia.			10 in.			
Well Depth			145.0 m			
Static Water Level			68.10 m	67.50 m		
Dynamic Water Level			100.66 m	-		
Casing Material						
Screen	Location		106.5-123.0	134.9-139.5		
	Material		Stainless Steel			
	Opening Ratio		11%			
Pump	Style		Submersible	Removed		
	Capacity(motor)					
	Discharge Rate					
Condition				Unoperating		
Actual Discharge Rate			60.2 m^3/hr			Digital 729500
Electric	Operation Board			Usual		
	Lighting			Usual		
	Wiring			Usual		
	Transformer			Usual		
Piping				Usual		
Water Quality	E/C					
Others						

Well No.	12.5A	Location	Balad Well Field	Completed	Jan.1, '87
Owner	MWA	Contractor	Parsons	Surveyed	Sep.14, '88

Item		Const.	B/D Ⅲ		Remarks
Elevation		68.73 m			
Drilling dia.					
Well dia.		10 in.			
Well Depth		140.0 m			
Static Water Level		66.07 m	63.85 m		
Dynamic Water Level		89.05 m	-		
Casing Material					
Screen	Location	96.0-118.0 m			
	Material	Stainless Steel			
	Opening Rate	11 %			
Pump	Style	Submersible			
	Capacity(motor)				
	Discharge Rate				
Condition			Unoperating		
Actual Discharge Rate		66.0 m³/hr			Digital 716519
Electric	Operation board		Good		
	Lighting		Good		
	Wiring		Good		
	Transformer		Good		
Piping			Good		
Water Quality	E/C	810 μm/cm			
	cl^-	60 ppm			

Others

Pumping test was carried out in this study.

Well No.	12.5B	Location	Balad Well Field	Completed	Apr.20, '70
Owner	MWA	Contractor	Parsons	Surveyed	Aug.14, '88

Item		Const.	Rehab.	B/D III	Ramarks
Elevation		72.08 m			
Drilling Dia.					
Well Dia		$10^3/_4$ in.			
Well Depth		114.7 m			
Static Water Level		59.8 m	68.15 m	66.45 m	
Dynamic Water Level			79.00 m		
Casing Material					
Screen	Location	85.8-114.8 m			
	Material	Steel($6^5/_8$ in.)			
	Opening Ratio				
Pump	Style		Submersible	Removed	
	Capacity(motor)				
	Discharge Rate				
Operation				Unoperating	
Actual Discharge Rate			46.2 m^3/hr	—	Digital 32758
Electric	Operation Board			Removed	
	Lighting			Installed	
	Wiring			Installed	
	Transformer			Installed	
Piping				Installed	
Water Quality	E/C	875 μm/cm			
	cl^-	70 ppm			
Others					

Well No.	13.0A	Location	Balad Well Field	Completed	May 3, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.14, '88

Item			Const.	Rehab.	B/D III	Remarks
Elevation			63.38 m			
Drilling dia.						
Well dia.			10 3/4 in.			
Well Depth			117.1 m			
Static Water Level			55.7 m	67.12 m	-	
Dynamic Water Level				82.94 m	78.65 m	
Casing	Material					
Screen	Location		87.1-117.1 m			
	Material		Steel(6 5/8 in.)			
	Opening Ratio					
Pump	style			Submersible		
	Capacity(motor)					Current 52(A)
	Discharge Rate					
Condition					Operating	Pressure 1.9kg/cm²
Actual Discharge Rate				48.6 m³/hr	44.0 m³/hr	Digital 786003
Electric	Operation Board				Installed	Voltage354(V)
	Lighting				Installed	
	Wiring				Installed	
	Transformer				Installed	
Piping					Installed	
Water Quality		E/C	720 μm/cm			
		cl⁻	50 ppm			
Others						

Well No.	13.0B	Location	Balad Well Field	Completed	May 14, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.14, '88

Item		Const.	Rehab.	B/D Ⅲ	Remarks
Elevation		74.41 m			
Drilling dia.					
Well dia.		10 3/4in.			
Well Depth		126.8 m			
Static Water Level		60.5 m	69.32 m	67.33 m	
Dynamic Water Level			74.24 m		
Casing Material					
Screen	Location	87.6-123.8 m			
	Material	Stainless Steel($6^{6/8}$ in.)			
	Opening Ratio				
Pump	Style		Submersible	Removed	
	Capacity(motor))				
	Discharge Rate				
Condition				Unoperating	
Actual Discharge Rate			51.6m^3/hr		
Electric	Operation Board			Removed	
	Lighting			Nil	
	Wiring			Removed	
	Transformer			Removed	
Piping				Removed	
Water Quality	E/C	720 μm/cm			
	cl^-	50 ppm			
Others					

Well No.	13.5A	Location	Balad Well Field	Completed	May 20, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.13, '88

Item		Const.	Rehab.	B/D Ⅲ	Remarks
Elevation		71.57 m			
Drilling dia.					
Well dia.		10 4/5 in.			
Well Depth		121.6 m			
Static Water Level		57.80 m	68.73 m		
Dynamic Water Level			75.54 m		
Casing Material					
Screen	Location	84.3-121.6 m			
	Material	Stainless Steel(6 5/8 in.)			
	Opening Ratio				
Pump	Style		Submersible		
	Capacity(motor)				Current 54(A)
	Discharge Rate				
Condition				Operating	
Actual Discharge Rate			51.6 m^3/hr	47.0 m^3/hr	Digital 897937
Electric	Operation Board			Good	Voltage 355(V)
	Lighting			without hood	
	Wiring			Good	
	Transformer			Good	
Piping				Good	
Water Quality	E/C	740 μm/cm			
	cl^-	60 ppm			
Others					

Well No.	13.5B	Location	Balad Well Field	Completed	May 23, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.12, '88

Item			Const.	Rehab.	B/D Ⅲ	Remarks
Elevation						
Drilling dia.						
Well dia.			$10^{3/4}$ in.			
Well Depth			119.6 m			
Static Water Level				71.15 m		
Dynamic Water Level				80.25 m	82.28 m	
Casing Material						
Screen	Location		85.9-119.6	m		
	Material		Stainless	Steel($6^{5/8}$	in)	
	Opening Rate					
Pump	Style			Submersible		
	Capacity(motor)					Current 55(A)
	Discharge Rate					
Condition					Operating	Pressure 2.0kg/cm^2
Actual Discharge Rate				37.2 m^3/hr	37.0 m^3/hr	Digital 998296
Electric	Operation board				Good	
	Lighting				Good	
	Wiring				Good	
	Transformer				Good	
Piping					Good	
Water Quality		E/C				
		cl$^-$				
Others						

Well No.	14.0A	Location	Balad Well Field	Completed	Jun. 5, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.12, '88

Item		Const.	Rehab.	B/D Ⅲ	Ramarks
Elevation					
Drilling Dia.					
Well Dia		$10^3/_4$ in.			
Well Depth		120.0 m			
Static Water Level			67.04 m	–	
Dynamic Water Level			72.75 m	76.50 m	
Casing Material					
Screen	Location	84.9-120.0 m			
	Material	Stainless Steel($6^{5/8}$ in.)			
	Opening Ratio				
Pump	Style		Submersible		
	Capacity(motor)				Current 51(A)
	Discharge Rate				
Operation				Operating	Pressure 1.6 Kg/cm²
Actual Discharge Rate			51.6 m³/hr	42.0 m³/hr	Digital 494602
Electric	Operation Board			Good	Voltage 380(V)
	Lighting			Nil	
	Wiring			Good	
	Transformer			Good	
Piping				Good	
Water Quality	E/C				
	cl⁻				
Others					

Well No.	14.0B	Location	Balad Well Field	Completed	Mar. 3, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.14, '88

Item		Const.	Rehab.	B/D Ⅲ	Remarks
Elevation					
Drilling dia.					
Well dia.		$9^{5/8}$ in.			
Well Depth		121.9 m			
Static Water Level			67.13 m	66.35 m	
Dynamic Water Level			88.03 m		
Casing Material					
Screen	Location	82.3-119.0 m			
	Material	Stainless Steel($9^{5/8}$ in.)			
	Opening Ratio				
Pump	style		Submersible	Removed	
	Capacity(motor)				
	Discharge Rate				
Condition				Unoperating	
Actual Discharge Rate			19.3 m^3/hr		
Electric	Operation Board			Removed	
	Lighting			Nil	
	Wiring			Removed	
	Transformer				
Piping					
Water Quality	E/C				
	cl^-				

Others

No fence

Well No.	14.5A	Location	Balad Well Field	Completed	Jun.11, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.12, '88

Item			Const.	Rehab.	B/D Ⅲ	Remarks
Elevation						
Drilling dia.						
Well dia.			10 3/4 in.			
Well Depth			119.9 m			
Static Water Level				63.88 m	61.79 m	
Dynamic Water Level				75.55 m		
Casing Material						
Screen	Location		85.0-120 m			
	Material		Steel(6 5/8 in.)			
	Opening Ratio					
Pump	Style			Submersible	Out of Order	
	Capacity(motor))					
	Discharge Rate					
Condition					Unoperating	
Actual Discharge Rate				$43.8m^3/hr$		Digital 174928
Electric	Operation Board					
	Lighting				Installed	
	Wiring				Nil	
	Transformer				Installed	
Piping					Installed	
Water Quality		E/C				
		cl^-				
Others						

Well No.	14.5B	Location	Balad Well Field	Completed	Feb. 4, '87
Owner	MWA	Contractor	Nissaku	Surveyed	Sep.12, '88

Item			Const.	B/D 田		Remarks
Elevation						
Drilling dia.						
Well dia.			10 in.			
Well Depth			130.0 m			
Static Water Level			66.00 m	64.39 m		
Dynamic Water Level			87.96 m			
Casing Material						
Screen	Location		97.0-119.0 m			
	Material		Stainless Steel			
	Opening Ratio		11 %			
Pump	Style		Submersible			
	Capacity(motor)					
	Discharge Rate					
Condition				Unoperating		
Actual Discharge Rate			72.0 m^3/hr	–		
Electric	Operation Board			Good		
	Lighting			Good		
	Wiring			Good		
	Transformer			Good		
Piping				Good		
Water Quality		E/C				
		cl^-				
Others						

Well No.	15.0A	Location	Balad Well Field	Completed	Mar.19, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.12, '88

Item			Const.	Rehab.	B/D Ⅲ	Remarks
Elevation						
Drilling dia.						
Well dia.			$9^{5/8}$ in.			
Well Depth			112.8 m			
Static Water Level				62.00 m	60.60 m	
Dynamic Water Level				72.13 m	—	
Casing Material						
Screen	Location		77-110 m			
	Material		Steel($9^{5/8}$	in)		
	Opening Rate					
Pump	Style			Submersible	Removed	
	Capacity(motor)					
	Discharge Rate					
Condition					Unoperating	
Actual Discharge Rate				41.6 m^3/hr		
Electric	Operation board				Good	
	Lighting				Good	
	Wiring				Good	
	Transformer				Good	
Piping					Good	
Water Quality	E/C					
	cl^-					
Others						

Well No.	15.0B	Location	Balad Well Field	Completed	Mar.26, '70
Owner	MWA	Contractor	Parsons	Surveyed	Sep.12, '88

Item		Const.	Rehab.	B/D Ⅲ	Ramarks
Elevation					
Drilling Dia.					
Well Dia		$10^3/_4$ in.			
Well Depth		113.0 m			
Static Water Level			62.15 m	60.88 m	
Dynamic Water Level			75.30 m		
Casing Material					
Screen	Location	81-110 m			
	Material	Stainless	Steel($6^{5/8}$	in.)	
	Opening Ratio				
Pump	Style		Submersible	Out of Order	
	Capacity(motor)				
	Discharge Rate				
Condition				Unoperating	
Actual Discharge Rate			42.0 m^3/hr		
Electric	Operation board			Good	
	Lighting			Good	
	Wiring			Good	
	Transformer			Good	
Piping				Good	
Water Quality	E/C				
	cl^-				
Others					

9. RECORD OF PUMPING TESTS

RECORD OF CONTINUOUS PUMPING TEST (1/5)

Location : No.12.5A

Date : Sep.15

Discharge : 40,000 l/sec (40m/sec)

Static Water Level : G.L.- 64.76 m

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping starting (min)	Water Level G.L.- (m)	Drawdown (m)	Remarks
:		0	64.76		
:	0.5	0.5			
:	0.5	1.0	79.20	14.44	
:	0.5	1.5	79.36	14.60	
:	0.5	2.0			
:	0.5	2.5			
:	0.5	3.0			
:	0.5	3.5			
:	0.5	4.0	79.36	14.60	
:	0.5	4.5			
:	0.5	5.0			
:	1.0	6.0	79.40	14.64	
:	1.0	7.0	76.59	11.83	
:	1.0	8.0	76.21	11.45	
:	1.0	9.0	75.96	11.20	2.4(kg/cm²)
:	1.0	10.0	75.88	11.12	2.4(kg/cm²)
:	2.0	12.0	75.87	11.11	2.4(kg/cm²)
:	2.0	14.0	75.84	11.08	2.4(kg/cm²)
:	2.0	16.0	75.83	11.07	2.4(kg/cm²)
:	2.0	18.0	75.83	〃	2.4(kg/cm²)
:	2.0	20.0	75.83	〃	2.4(kg/cm²)
:	5.0	25.0	75.92	11.16	2.4(kg/cm²)
:	5.0	30.0	75.94	11.18	2.4(kg/cm²)
:30	5.0	35.0	75.95	11.19	2.4(kg/cm²)
:	5.0	40.0	75.97	11.21	2.4(kg/cm²)
:	5.0	45.0	75.962	11.20	2.4(kg/cm²)
:	5.0	50.0	75.97	11.21	2.4(kg/cm²)
:	5.0	55.0	75.98	11.22	2.4(kg/cm²)
1:00	5.0	60.0	75.98	11.22	2.4(kg/cm²)

RECORD OF CONTINUOUS PUMPING TEST (2/5)

Location : No. 12.5A

Date : Sep.15

Discharge : 50,000 l/sec (50m³/sec)

Static Water Level : G.L.- 64.76 m

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping stopping (min)	Water Level G.L.- (m)	Drawdown (m)	Remarks
:		0	75.98		
:	0.5	0.5			
:	0.5	1.0	78.08	13.32	P=0.6kg/cm²
:	0.5	1.5	79.09	13.33	
:	0.5	2.0	79.43	14.67	
:	0.5	2.5	79.71	14.95	
:	0.5	3.0	80.04	15.28	
:	0.5	3.5	80.26	15.50	
:	0.5	4.0	80.35	15.59	
:	0.5	4.5	80.41	15.65	
:	0.5	5.0	80.45	15.69	P=0.03kg/cm²
:	1.0	6.0	80.50	15.74	
:	1.0	7.0	80.51	15.75	
:	1.0	8.0	80.56	15.80	
:	1.0	9.0	80.57	15.81	
:	1.0	10.0	80.59	15.83	
:	2.0	12.0	80.60	15.84	
:	2.0	14.0	80.62	15.86	
:	2.0	16.0	80.63	15.87	
:	2.0	18.0	80.64	15.88	
:	2.0	20.0	80.66	15.90	
:	5.0	25.0	80.72	15.96	
:	5.0	30.0	80.73	15.97	
:	5.0	35.0	80.73	〃	
:	5.0	40.0	80.73	〃	
:	5.0	45.0	80.75	15.99	
:	5.0	50.0	80.76	16.90	
1:00	10.0	60.0	80.78	16.02	
:					

RECORD OF CONTINUOUS PUMPING TEST (3/5)

Location : No. 12.5A

Date : Sep.15

Static Water Level : G.L.- 64.76 m

Max Discharge : 55,000 l/sec ($55m^3/sec$)

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping stopping (min)	Water Level G.L.- (m)	Drawdown (m)	Remarks
:		0	80.78		
:	0.5	0.5			
:	0.5	1.0	80.93	16.17	
:	0.5	1.5	80.96	16.20	
:	0.5	2.0	80.98	16.22	
:	0.5	2.5	80.99	16.21	
:	0.5	3.0	80.99	〃	
:	0.5	3.5	80.99	〃	
:	0.5	4.0	80.99	〃	
:	0.5	4.5	80.99	〃	
:	0.5	5.0			
:	1.0	6.0			
:	1.0	7.0	81.00	16.22	
:	1.0	8.0	81.00	〃	
:	1.0	9.0			
:	1.0	10.0			
:	2.0	12.0			
:	2.0	14.0			
:	2.0	16.0			
:	2.0	18.0			
:	2.0	20.0			
:	5.0	25.0			
:	5.0	30.0			
:	5.0	35.0			
:	5.0	40.0			
:	5.0	45.0			
:	5.0	50.0			
:	5.0	55.0			
:	5.0	60.0			

RECORD OF RECOVERY TEST (4/5)

Location : No. 12.5A

Date : Sep.15

Discharge : ______ l/sec

Static Water Level : G.L.- 64.76 m

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping stopping (min)	Water Level G.L.- (m)	Recovery (m)	Remarks
:		0	81.00		
:	0.5	0.5	65.53	15.47	
:	0.5	1.0	62.45	18.55	
:	0.5	1.5	63.30	17.70	
:	0.5	2.0	64.65	16.35	
:	0.5	2.5	65.21	15.71	
:	0.5	3.0	65.30	15.70	
:	0.5	3.5	65.32	15.68	
:	0.5	4.0	65.28	15.72	
:	0.5	4.5	65.25	15.75	
:	0.5	5.0	65.23	15.77	
:	1.0	6.0	65.16	15.84	
:	1.0	7.0	65.11	15.89	
:	1.0	8.0	65.06	15.94	
:	1.0	9.0	65.03	15.97	
:	2.0	10.0	65.00	16.00	
:	2.0	12.0	64.98	16.02	
:	2.0	14.0	64.92	16.08	
:	2.0	16.0	64.89	16.11	
:	2.0	18.0	64.86	16.14	
:	5.0	20.0	64.85	16.15	
:	5.0	25.0	64.82	16.18	
:	5.0	30.0	64.80	16.20	
:	5.0	35.0	64.78	16.22	
:	5.0	40.0	64.76	16.24	
:	5.0	45.0			
:	5.0	50.0			
:	10.0	60.0			

RECORD OF PUMPING TEST (5/5)

Location : No. 12.5A

Date : Sep.15

Static Water Level : G.L.- 64.76 m

Discharge : 40,000 l/sec
(40m³/sec)

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping stopping (min)	Water Level G.L.- (m)	Drawdown (m)	Remarks
:		0	64.76		
:	0.5	0.5			
:	0.5	1.0	77.57	12.81	
:	0.5	1.5	74.67	9.91	
:	0.5	2.0	76.12	11.36	
:	0.5	2.5	77.06	12.30	
:	0.5	3.0	75.27	10.51	
:	0.5	3.5	75.66	10.90	
:	0.5	4.0	76.48	11.72	
:	0.5	4.5	76.76	12.00	
:	0.5	5.0	76.93	12.17	
:	1.0	6.0	77.05	12.29	
:	1.0	7.0	77.11	12.35	
:	1.0	8.0	77.16	12.40	
:	1.0	9.0	77.18	12.42	
:	1.0	10.0	77.19	12.43	
:	2.0	12.0	77.25	12.49	
:	2.0	14.0	77.28	12.52	
:	2.0	16.0	77.30	12.54	
:	2.0	18.0	77.33	12.57	
:	2.0	20.0	77.34	12.58	
:	5.0	25.0	77.35	12.59	
:	5.0	30.0	77.37	12.61	
:					
:					
:					
:					
:					
:					

RECORD OF CONTINUOUS PUMPING TEST (1/6)

Location : No. 14.0A

Date : Sep.17

Discharge : 30,000 l/sec

(30.0m³/sec)

Static Water Level : G.L.- 66.32 m

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping stopping (min)	Water Level G.L.- (m)	Drawdown (m)	Remarks
:		0	66.32		
:	0.5	0.5			
:	0.5	1.0	76.49	10.17	
:	0.5	1.5	77.24	10.92	
:	0.5	2.0	77.42	11.10	
:	0.5	2.5	77.49	11.17	
:	0.5	3.0			
:	0.5	3.5			
:	0.5	4.0			
:	0.5	4.5	75.68	9.36	
:	0.5	5.0	75.09	8.77	
:	1.0	6.0	75.01	8.69	
:	1.0	7.0	74.75	8.43	
:	1.0	8.0	73.90	7.58	
:	1.0	9.0	73.83	7.51	
:	1.0	10.0	73.75	7.43	
:	2.0	12.0	73.73	7.41	
:	2.0	14.0	73.71	7.39	
:	2.0	16.0	73.72	7.40	
:	2.0	18.0	73.73	7.41	
:	2.0	20.0	73.74	7.42	
:	5.0	25.0	73.78	7.46	P=2.0kg/cm²
:	5.0	30.0	73.78	〃	
:	5.0	35.0	73.78	〃	
:	5.0	40.0	73.78	〃	
:	5.0	45.0			
:	5.0	50.0			
:	5.0	55.0			
1:00	5.0	60.0			

RECORD OF CONTINUOUS PUMPING TEST (2/6)

Date : Sep.17

Discharge : 37,500 l/sec Static Water Level : G.L.- 66.32 m

(37.5m³/sec)

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping stopping (min)	Water Level G.L.- (m)	Recovery (m)	Remarks
:		0	73.78		
:	0.5	0.5	76.00	9.68	
:	0.5	1.0	76.60	10.28	
:	0.5	1.5	76.90	10.59	
:	0.5	2.0	77.02	10.70	
:	0.5	2.5	76.94	10.17	
:	0.5	3.0	76.90	10.58	
:	0.5	3.5	76.80	10.48	
:	0.5	4.0	76.80	〃	
:	0.5	4.5	76.80	〃	
:	0.5	5.0	76.80	〃	
:	0.5	6.0	76.82	10.50	
:	1.0	7.0	76.82	〃	
:	1.0	8.0	76.82	〃	
:	1.0	9.0	76.84	10.52	
:	1.0	10.0	76.85	10.53	
:	2.0	12.0	76.87	10.55	
:	2.0	14.0	76.89	10.57	
:	2.0	16.0	76.89	〃	
:	2.0	18.0	76.89	〃	
:	2.0	20.0	76.89	〃	
:	5.0	25.0	76.91	10.59	P=0.6kg/cm²
:30	5.0	30.0	76.87	10.55	
:	5.0	35.0	76.885	10.57	
:	5.0	40.0	76.885	〃	
:	5.0	45.0			
:	5.0	50.0			
:	5.0	55.0			
1:00	5.0	60.0			

RECORD OF CONTINUOUS PUMPING TEST (3/6)

Location : No.14.0A

Date : Sep.17

Discharge : 38,700 l/sec

(38.7m/sec)

Static Water Level : G.L.- 66.32m

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping starting (min)	Water Level G.L.- (m)	Drawdown (m)	Remarks
:		0	76.885		
:	0.5	0.5	77.04	10.72	
:	0.5	1.0	77.24	10.92	
:	0.5	1.5	77.44	11.12	
:	0.5	2.0	77.50	11.18	
:	0.5	2.5	77.63	11.31	
:	0.5	3.0	77.79	11.47	
:	0.5	3.5	77.95	11.63	
:	0.5	4.0	78.05	11.73	
:	0.5	4.5	78.09	11.77	
:	0.5	5.0	78.13	11.81	
:	1.0	6.0	78.16	11.84	
:	1.0	7.0	78.17	11.85	
:	1.0	8.0	78.18	11.86	
:	1.0	9.0	78.20	11.88	
:	1.0	10.0	78.21	11.89	
:	2.0	12.0	78.23	11.91	
:	2.0	14.0	78.25	11.93	
:	2.0	16.0	78.26	11.94	
:	2.0	18.0	78.26	〃	
:	2.0	20.0	78.28	11.96	
:	5.0	25.0	78.31	11.99	
:	5.0	30.0	78.31	〃	
:30	5.0	35.0	78.33	12.01	
:	5.0	40.0	78.35	12.03	
:	5.0	45.0	78.38	12.06	
:	5.0	50.0	78.385	〃	
:	5.0	55.0	78.41	12.09	
1:00	5.0	60.0	78.42	12.10	

RECORD OF CONTINUOUS PUMPING TEST (4/6)

Location : No.14.0A
Date : Sep.17
Static Water Level : G.L.- 66.32 m

Discharge : 38,700 l/sec
(38.7m/sec)

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping starting (min)	Water Level G.L.- (m)	Drawdown (m)	Remarks
:		65.0	78.435	12.12	
:	0.5	70.0	78.450	12.13	
:	0.5	75.0	78.465	12.15	
:	0.5	80.0	78.470	〃	
:	0.5	85.0	78.500	12.18	
:	10.0	95.0	78.520	12.20	
1:35	10.0	105.0	78.550	12.23	
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RECORD OF RECOVERY TEST (5/6)

Location : No.14.0A

Date : Sep.17

Discharge : ________ l/sec

Static Water Level : G.L.- 66.32 m

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping starting (min)	Water Level G.L.- (m)	Drawdown (m)	Remarks
:		0	78.55		
:	0.5	0.5	64.65		
:	0.5	1.0	64.17	14.38	
:	0.5	1.5	65.58	12.97	
:	0.5	2.0	66.32	12.23	
:	0.5	2.5	66.53	12.02	
:	0.5	3.0	66.55	12.00	
:	0.5	3.5	66.57	11.98	
:	0.5	4.0	66.57	〃	
:	0.5	4.5	66.58	11.97	
:	0.5	5.0	66.59	11.96	
:	1.0	6.0	66.55	12.00	
:	1.0	7.0	66.54	12.01	
:	1.0	8.0	66.53	12.02	
:	1.0	9.0	66.52	12.03	
:	1.0	10.0	66.51	12.04	
:	2.0	12.0	66.50	12.05	
:	2.0	14.0	66.50	〃	
:	2.0	16.0	66.48	12.07	
:	2.0	18.0	66.47	12.08	
:	2.0	20.0	66.47	〃	
:	5.0	25.0	66.44	12.11	
:	5.0	30.0	66.43	12.12	
:30	5.0	35.0	66.40	12.15	
:	5.0	40.0	66.40	〃	
:	5.0	45.0			
:	5.0	50.0			
:	5.0	55.0			
1:00	5.0	60.0			

RECORD OF CONTINUOUS PUMPING TEST (6/6)

Location : No.14.0A

Date : Sep.17

Discharge : 37,500 l/sec

Static Water Level : G.L.- 66.32 m

Measuring Time (hr) (min)	Time Interval (min)	Time since Pumping starting (min)	Water Level G.L.- (m)	Drawdown (m)	Remarks
:		0	66.40		
:	0.5	0.5			
:	0.5	1.0	76.36	9.96	
:	0.5	1.5	77.28	10.88	
:	0.5	2.0	77.38	10.98	
:	0.5	2.5	77.43	11.03	
:	0.5	3.0	77.47	11.07	
:	0.5	3.5	77.42	11.02	
:	0.5	4.0	77.28	9.88	
:	0.5	4.5	76.90	10.50	
:	0.5	5.0	76.82	10.42	
:	1.0	6.0	76.47	10.07	
:	1.0	7.0	76.43	10.03	
:	1.0	8.0	76.47	10.07	
:	1.0	9.0	76.45	10.05	
:	1.0	10.0	76.46	10.06	
:	2.0	12.0	76.47	10.07	
:	2.0	14.0	76.45	10.05	
:	2.0	16.0	76.47	10.07	
:	2.0	18.0	76.50	10.10	
:	2.0	20.0	76.56	10.16	
:	5.0	25.0	76.56	〃	
:	5.0	30.0	76.58	10.18	
:30	5.0	35.0			
:	5.0	40.0			
:	5.0	45.0			
:	5.0	50.0			
:	5.0	55.0			
1:00	5.0	60.0			