GENERAL AUTHORITY FOR RURAL ELECTRICITY AND WATER
MINISTRY OF ELECTRICITY AND WATER
THE REPUBLIC OF YEMEN

REPORT OF THE IMPLEMENTATION REVIEW ON THE PROJECT FOR RURAL WATER SUPPLY IN THE SOUTHERN AND EASTERN GOVERNORATES OF THE REPUBLIC OF YEMEN

MAY 1997

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)
JAPAN TECHNO CO., LTD.

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PREFACE

In response to a request from the Government of the Republic of Yemen, the Government of Japan decided to conduct a study for the implementation review of the Project for Rural Water Supply in the Southern and Eastern Governorates of the Republic of Yemen and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Yemen a study team from March 12 to March 24, 1997.

The team held discussions with the officials concerned of the Government of Yemen, and conducted a field study at the study area. After the team returned to Japan, further studies were made, and as this result, the present report was finalized.

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

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

May, 1997

Kimio Fujita
President
Japan International Cooperation Agency

May, 1997

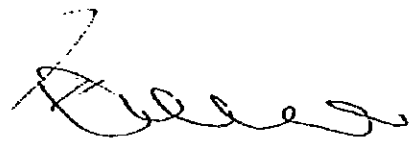
LETTER OF TRANSMITTAL

We are pleased to submit to you the report of the study for the implementation review on the Project for Rural Water Supply in the Southern and Eastern Govenorates in the Republic of Yemen.

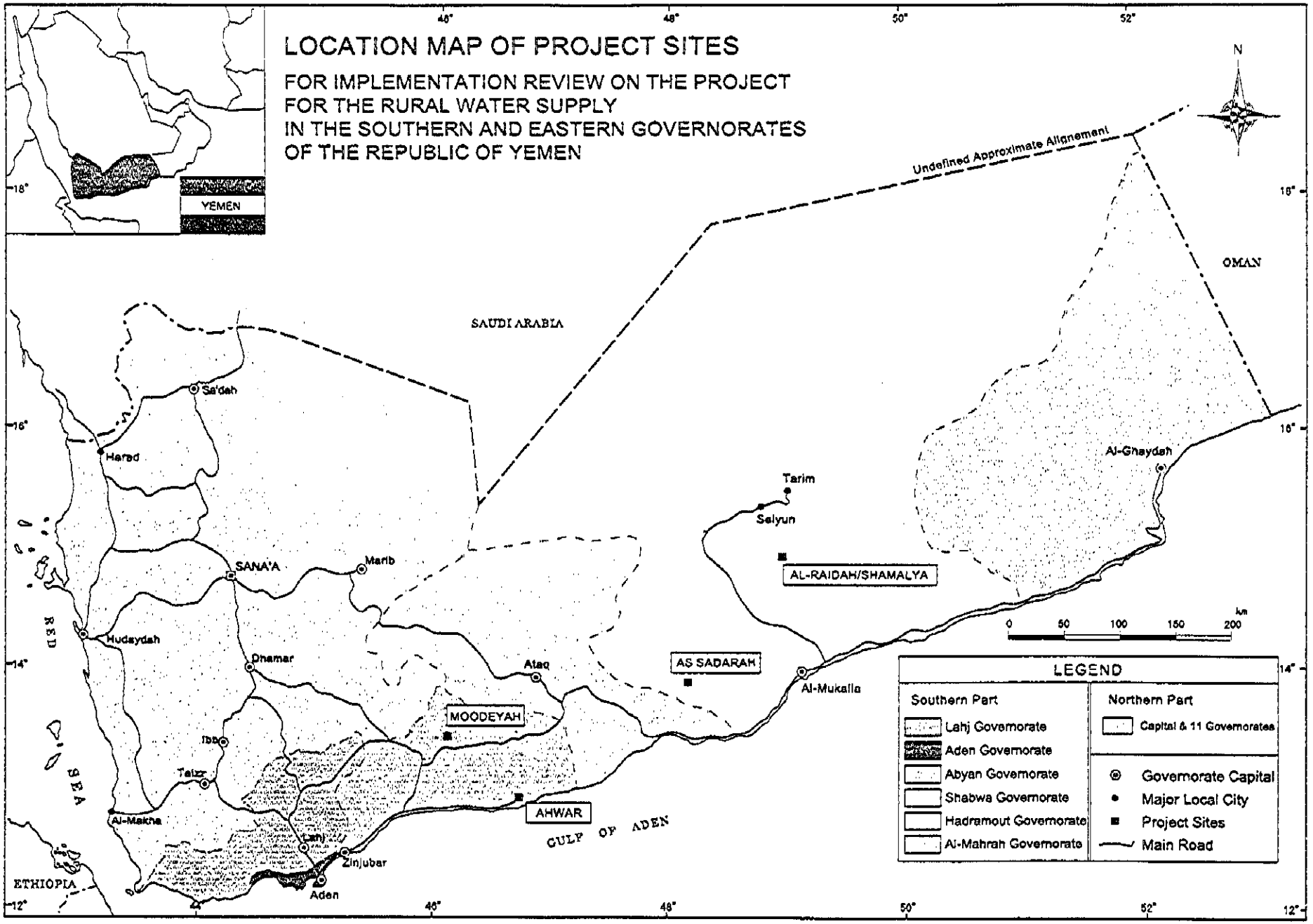
This study was conducted by Japan Techno Co., Ltd., under a contract to JICA, during the period from February 24 to June 2. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Yemen and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,



Tetsuji Niwano
Project Manager
Implementation Review Team on the Project for Rural Water Supply in Southern and Eastern Governorates
Japan Techno Co., Ltd.


LOCATION MAP OF PROJECT SITES
FOR IMPLEMENTATION REVIEW ON THE PROJECT
FOR THE RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES
OF THE REPUBLIC OF YEMEN
YEMEN
N
Undefined Approximate Alignement
SAUDI ARABIA
OMAN
Sa'dah
Harad
SANA'A
Marib
Hudaydah
Dhamar
Ataq
MOODEYAH
AS SADARAH
AHWAR
Ibb
Taizz
Al-Makha
Lahj
Zinjubar
Aden
ETHIOPIA
RED SEA
GULF OF ADEN
Tarim
Seiyun
AL-RAIDAH/SHAMALYA
Al-Mukalla
Al-Ghaydah
0 50 100 150 200 km
LEGEND
Southern Part
Lahj Governorate
Aden Governorate
Abyan Governorate
Shabwa Governorate
Hadramout Governorate
Al-Mahrah Governorate
Northern Part
Capital & 11 Governorates
Governorate Capital
Major Local City
Project Sites
Main Road

THE PROJECT FOR RURAL WATER SUPPLY IN THE SOUTHERN AND EASTERN GOVERNORATES OF THE REPUBLIC OF YEMEN

CONTENTS

Appendices

ABBREVIATIONS

GAREW	General Authority for Rural Electricity and Water
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
PWC	Public Water Corporation
UNDP	United Nations Development Programme
YR	Yemeni Riyal

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1 BACKGROUND OF THE PROJECT

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1-1 BACKGROUND OF THE REQUEST

The government of the Republic of Yemen, which was established in May 1990 through the unification of the former Yemen Arab Republic and People's Democratic Republic of Yemen (commonly called North Yemen and South Yemen respectively), announced its decision in its first economic agenda to take immediate steps for the improvement of devastated infrastructure of the country's southern part including its remotest region. In line with this policy, the united government of Yemen made a request in December 1990 to the government of Japan to extend its grant aid to a rural water supply project in 20 sites scattered in five governorates of the Southern part (hereafter called "the Project").

The population of Yemen in the land of 530,000 km^2 (about 1.4 times that of Japan) was estimated at 15.8 million through the national census conducted in 1994, with its 84% assigned as the rural population in communities of no more than 30,000 residents. The nationwide rural water supply coverage have been hovering at around 50% due to shortages of water resources all over the country, with the situation worsening in the southern part where a more barren and arid climate prevails. Under such circumstances, sanitation and health of rural areas have steadily been declining to an alarming level, as is indicated by the spread of waterborne diseases including bilharzias all over the country.

In response to the aforementioned request, the Japan International Cooperation Agency (JICA) dispatched a project formulation survey team from January 15 to February 13, 1993 to make a preliminary study of major elements of the project such as urgency and priority, reliability of water sources, accessibility, etc., in the 20 sites in 5 governorates across a distance of 1,500 km east and west. Based upon the strategies for cooperation set by that survey, the government of Japan decided to carry out the basic design study, and the JICA sent a basic design study team to Yemen from November 20 to December 26, 1993. The team held discussions with the Yemeni authorities concerned with the project along with the

collection of related data and information, and carried out the field survey of sites about natural environment, water use practice, water sources as well as topographic survey. After returning home, the team made analysis of the survey results, based upon which a plan was worked out to take 4 sites among 9 surveyed as the candidates for the implementation of the Project. A draft final report for the Project was presented to and accepted by the Yemeni side during the period from March 30 to April 7, 1994.

Yemen at that time had been suffering a hard blow on the socio-economy inflicted by the 1990 – 1991 Gulf crisis/war, although on the eve of unity the economy had steadily been upturning, thanks to the oil development commenced from the middle to the end of 1980s in both North and South Yemens. Triggering the expulsion of nearly 800,000 of Yemeni expatriate laborers chiefly from Saudi Arabia, it produced hard effects such as the radical slide of foreign remittances that had been a major source of earning hard currency, abrupt halt of aid from oil-rich Gulf countries and spiraling rate of unemployment. Then political tensions that had been straining between the former North and South Yemens culminated to the outbreak of civil war between both sides in May 1994, immediately after the explanation of the draft final report for the Project was concluded.

The conflict between the same ethnic Arabs wound up in about one month with the fall of the southern capital of Aden. The multinational oil conglomerates immediately resumed their operations. The Dutch and Germany were quick to return to their assistance once again, while Japan sent a mission in December that year to investigate pertinent strategies for economic cooperation and to examine local security after the war. It led to the resumption of its assistance in March 1995 in the restricted groups of projects such as material/equipment procurement and food production increase. The projects for construction of facilities including this one, however, was suspended for the reasons that social instability in rural areas had not yet been subdued and that there remained local risks of land mines reportedly buried during the war time. In March 1996, the Yemeni government renewed its request for this Project to the government of Japan, asking for urgent commencement of its implementation, assuring all the risks had been removed by that time.

By then, the socio-economic base of Yemen had nearly been crushed by the devastating effects of Gulf war followed by the latest civil war. According to the World Bank, the per-capita GDP plummeted to US$280 in 1995 from the pre-war US$530 for the year 1990 of unification. Such a situation of the country urged the government to embark on the economic reform program advised by the World Bank and the IMF in early 1995, and as a complementary step to this program, the government prepared the First Five-Year Plan in 1996, in which its major tasks were assigned first to regulate the national economy by controlling macro-economic policies in a market economy and secondly to continue to promote reinforcement of social infrastructure, particularly the water sector, for the purpose of renovating and stabilizing people's living conditions. Reflecting such a policy, first comes "the drinking water projects in rural areas (all governorates)" in the list of government development projects contained in the Five-Year Plan, with an assignment of the investment of approximately YR 50 billion. In response, the General Authority for Rural Electricity and Water under the Ministry of Electricity and Water formulated its own first five-year program for the rural water supply scheme, which aims to boost the rural water coverage in the year 2000 to 64% from the present 45% by implementing 3,000 projects in total for the population of about 2.5 million. However, the achievement of such a seemingly high target would need a dramatic improvement of the finance of the government, even if the rural population might make due contribution to their projects, as has been proposed by a new rule of the said GAREW's program for ensuring the required investment.

This study intends to make a review of the Project for its implementation in response to the request thus renewed by the government of Yemen. It is to re-examine the current conditions, the organization, the cost estimate for its implementation after a lapse of nearly three years, taking into account the adjustment and modification, if necessary and possible, of initial planning and designing relevant to the present conditions of the project sites. In addition, the situation of local security will be examined as an essential condition for proceeding to the implementation of the Project.

1-2 CONTENTS OF THE REQUEST

The outline of the request confirmed by this study is described as follows:

(1) Project Sites

1) Ahwar (Abyan governorate)
2) Moodeyah (Abyan governorate)
3) Al-Raidah/Shamalya (Hadramout governorate)
4) As-Sadarah (Hadramout governorate)

(2) Contents of the Request

Construction of relevant water supply facilities in the above-listed four sites, based upon the basic design study conducted in 1993 (For the alterations of designs necessary to adapt to the current conditions of these sites, refer to the review of the request detailed in Chapter 2 of this report.)

CHAPTER 2 CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 OBJECTIVES OF THE PROJECT

On the occasion of its unification in 1990 overwhelmingly supported by the great majority of the people, the government of the united Yemen pledged to promote its efforts for the construction of water supply facilities in the Southern part of the country where basic infrastructure had long been devastated. In line with this policy, a rural water supply project for that region (hereafter called "the Project") was requested to the government of Japan for grant aid that year. Nearly a decade has passed for the residents of the sites in the Project since its planning had been taken up by the former Public Water Corporation that had been in charge of the water sector all over the former South Yemen. Since then the country's socio-economic conditions have been aggravated by the adverse effects of the Gulf war and the subsequent civil war between the former North and South Yemens. Such a situation has urged the government to put the highest priority on the improvement of the water sector as well as electricity of the country in its First Five-Year Plan in 1996, as it aims to reform the country's social infrastructure, particularly that in the hardest-hit rural areas, and the General Authority for Rural Electricity and Water (hereafter called the "GAREW"), which is to assume the role of the executing agency for this Project, complemented the government's policy in the same year through the formulation of its own first five-year program for the rural water sector, in which the rural water coverage was targeted to be boosted to 64% from the current 45%.

In support of such a distinguished policy of the Yemeni government, the Project is aimed at constructing relevant water facilities composed of water sources, pumping facilities and distribution systems in the 4 sites in the country's southern and eastern governorates that have acutely been suffering from lack of safe and stable water.

2-2 BASIC CONCEPT OF THE PROJECT

2-2-1 Basic Policy for Cooperation

The survey for the implementation review was carried out in March 1997 in order to examine the current conditions of various elements of the Project in preparation for its implementation in the four sites located in the southern and eastern governorates, which had been determined to be the feasible sites for grant aid as a result of the basic design study conducted by JICA from November to 1993 to April 1994. The strategy of the study was to make review of initial planning and designing of the basic design study, and to finalize them with any revision, if necessary and possible, to adapt to the current conditions, in light of the survey results. Local security in the aftermath of civil war was examined as well to assure safety of those to be engaged in the implementation of the Project.

The results of the survey are outlined as follows: In Ahwar and Moodeyah, existing water services have reached a critical stage due to the occurrence of breakdowns and shutdowns of the facilities and equipment. On the other hand Al-Raidah/Shamalya has installed a locally funded water supply system for a part of the communities that was planned to be covered in the foregoing basic design study. Nevertheless all the remaining communities composing the administrative division of Al-Raidah/Shamalya have been left without water, depending solely upon costly and unsanitary water vending. The residents in the site, therefore, are anxious that the initial planning and designing be altered to cover these communities without facilities. As-Sadarah has seen little change since the basic design study, although the residents are now desirous of an extension of distribution to three additional villages.

As a policy of cooperation, these current conditions including the contents of the renewed request for the respective sites will be reviewed in the following section, based upon the criteria to justify the feasibility of the sites such as (1) urgent necessity of facilities construction, (2) possibility to secure the relevant water sources, (3) cost-effect benefit, and (4) capability of operation and maintenance.

(1) Contents of the Renewed Request

The major points of the renewed request for the 4 sites are described in Table 2-1, comparing the conditions at present with those during the basic design study.

Table 2-1 Outline of the Renewed Request in Comparison with the Results of the Basic Design Study

Site Name	Basic Design Study(1993-1994)	This Survey (1997)
1. Ahwar (Abyan Governorate)	(1)The Ahawar city, center of the site, operates an existing water service, but citizens are suffering from extremely inferior water quality containing a high rate of chloride.	(1)The existing facilities has thoroughly been deteriorated with the elevated water tank destroyed due to corrosion. Still no significant renovation of facilities could be made due to financial reasons. Urgent improvement is required.
	(2)The basic design plans to employ 2 unused deepwells. However, due to the limit of available quantity, the planned area for new service is restricted to 6 communities including the Awhar city	(2)Existing distribution network has been highly corroded. This situation requires to increase the extent of pipeline installation by the Japanese side as well as the quantity of piping materials to be supplied.
2. Moodeyah	(1)The site is comprised of 4 independent water service zones with their own facilities. Each of them has longstanding troubles particularly in its water source (s), in respect of quantity or quality, or both.	(1)The basic design study planned to employ 3 existing deepwells remaining unused and 1 new well to be constructed by the Japanese side. Up to now, however, the GAREW newly constructed two (2) additional wells. This situation allows to exclude the construction of a new well by the Japanese side in the Project.

Site Name	Basic Design Study(1993–1994)	This Survey (1997)
Moodeyah	(2)The basic design covers 2 service areas of "Moodeyah" and "Al-Qurath" out of 4 ones due to the limit of available quantity of planned sources. The planned facilities consist of new water sources and feeder lines connecting these sources to the existing network of these 2 zones.	(2)The water services of 2 zones have lately worsened. Moreover, a third one, "Al-Jowal" has halted its service due to the collapse of a deep well that has been a sole source for the area. The remaining one has also been suffering from the existing source producing highly saline groundwater. Under such circumstances, the Yemeni side has requested the team to re-design a system to cover all the four service zones.
3. Al-Raidah/ Shamalya (Hadramout Govenorate)	(1) The site consists of 25 villages scattered on the highland plateau. Due to the apparent difficulty in new groundwater development, a planned service area is restricted to an area of 7 villages where a deepwell source has successfully been installed.	(1) The GAREW has successfully constructed 4 new wells with its own fund in the site since the basic design study.
		(2) Part of formerly planned service area has completed its own water facilities covering 4 villages, which has been operated and maintained by a local committee.
		(3) The Yemeni side has requested an alteration of the initial design to cover all the villages of 21 remaining without pertinent facilities except for the completed sources.
4.As-Sadarah	(1)The site has no public water facilities and residents are in the habit of taking water from springs and hand-dug wells. A new system is planned to cover 7 communities including the As-Sadarah city, center of the region.	(1)The site has basically had no change in water practice. Urgent implementation is required. (2)A new request has been presented to extend the initial plan to 3 additional villages.

The comparison in the above table shows the worsening water environment in the respective sites, necessitating urgent implementation of the Project. The examination of essential elements in details is as follows:

1) Urgency of Facilities Construction

The preceding basic design study selected the 4 sites under this study out of 20 candidates as the ones necessitating the most urgent step for the construction of facilities. Urgency has further increased in Moodeyah and Ahawar, both the centers of the respective regions, since the major existing facilities in these sites have recently been broken down, leading to growingly worsening water service. When the study team had a conference on the survey for the review with the authorities in Abyan governorate in charge of both communities, the governor stressed urgent necessity for swiftly proceeding to the implementation of the Project to relieve citizens of current hardships. The situations of the two sites are as follows:

a. Ahwar

Corrosion and deterioration of facilities has lately been accelerated due to high contents of salt in served water. Such deterioration culminated in January 1997, when the elevated steel panel tank burst at the panel joints immediately after the tank was filled with water. Since the collapsed tank got unusable, water is directly pumped into distribution network, resulting in the breakout of intensive leakage calling for frequent shutdowns of pumping due to higher pressure.

b. Moodeyah

All the four water service areas in this site shows degraded performance. Particularly Al-Jowal service area suffered the collapse of existing deepwell and the resultant shutdown of the operation late in 1996. As result, all the served population of 5,100 have been forced to switch to costly vending water.

Meanwhile Al-Raidah/Shamalya lately acquired deepwell water sources.

Nevertheless most of the area still lacks facilities for water service, with nearly 20,000 residents left in the habit of purchasing expensive water. On the other hand, As-Sadarah residents have easily accessible water sources. However, artificial contamination has steadily been in progress there, aggravating uneasiness of most residents.

These situations in the four sites clearly shows they are badly in need of relevant water facilities, demanding the immediate implementation of the Project.

2) Securing Water Sources

Located on the highland plateau, Al-Raidah/Shamalya looked a waterless site during the survey for the basic design study, where up to now four new wells have successfully been installed by the GAREW, assuring reliable water sources to its residents. This new situation rules out a plan of the basic design study to drill a new well for the site. Moreover the GAREW has so far made efforts to add two new wells to 3 wells existing in Moodeyah. Although the former basic design study planned to construct an additional well for Moodeyah beside 3 existing ones in view of a larger population there, it is now judged needless as well, as the site has secured 5 feasible water sources.

Ahwar holds secure two deepwells that were planned by the basic design study to be employed for the Project. In As-Sadarah, the stream flow rising in a nearby spring is found stable for the planned intake facility of the Project.

The survey has witnessed that the water sources for the 4 sites have become more secure and adequate than they were at the time of the basic design study.

3) Evaluation of Benefits

The rural water project in Yemen generally entails great difficulties; a technical one in developing and securing water sources and a financial one requiring a higher

amount of investment for a relatively sparse population of beneficiaries in a widely scattered service area. These conditions often make the major donors keep a distance from projects in this sector. On the other hand, all the 4 sites in this Project selected among 20 candidates involve their respective administrative and financial centers, with a total planned served population reaching 94,000, as shown in the following table:

Table 2-2 Administrative Division, Numbers of Planned Communities and Populations

Site Name	Administrative division	Number of planned communities	Number of Planned Population
Ahwar	Markaz (*)	6	21,420
Moodeyah	Mudirya (**)	23	37,800
Al-Raidah/ Shamalya	Markaz	21	19,620
As-Sadarah	Markaz	10	15,200
Total		60	94,040

Note: * A *markaz* means a center that is a lower administrative division next to a mudirya.

** A *mudirya* means a district as a division subsequent to a governorate.

The preceding basic design study made an evaluation of cost effectiveness of the candidate sites. Compared to the other sites, these four sites registered a far higher level of cost effectiveness. In this study, the cost effectiveness of these sites remains intact, keeping a similar level to the one in the basic design study.

4) Capability of Operation and Maintenance

Rural water facilities in the country are run by local water committees, based upon the provision of the President's decree issued in 1992. As a matter of fact, in Ahwar and Moodeyah exist the local committees which are now operating their own water service. On the other hand there are no specialized committees for Al-Raidah/Shamalya and As-Sadarah because they have no facilities yet. However, the

residents will find no difficulty in setting them up because they already have similar organizations for local development works.

As a result of the aforementioned examination, the four sites are judged to meet the essential conditions for the implementation of the Project with grant aid previously required by the basic design study. As for the site of Al-Raidah/Shamalya, the wide extent of alteration in planning and designing may be justified on the following reasoning:

a. Initially the site was not considered to fit for extensive development of groundwater resource, and the basic design study formulated a plan to install a system for part of this site where a feasible deepwell had been completed. As a result of successful development of groundwater in the area by the GAREW since then, that plan needs close reviewing by this study to adapt to the situation at present. Since the modified plan includes the most important communities in the site represented by Al-Aulieb and Al-Sufila, it is expected to produce a larger impact on the regional society. The cost-effect benefit will become higher as well.

b. The modified plan, already prepared by the GAREW's Hadramout Branch in Al-Mukalla, is one of the highest priority project of that office. Since this Project aims to assist the GAREW's current water supply program, the cooperation for this site is considered to follow that objective.

c. The site remains yet to have water facilities since its settlement, with its residents long suffering from hardship in obtaining safe and stable water. In view of basic human needs for the residents, the Project is worthy of implementing with grant aid.

In a renewed planning for this site, however, the available fund must be taken into close account, since it is the largest in scale among the 4 sites under study. A feasible plan should be worked out, with due consideration to the contents and scale of the Project.

(2) Examination of Contents and Scale of Facilities

The request by the Yemeni side for re-planning and re-designing facilities for the respective sites features the expansion of the planned water service areas, entailing longer extensions of distribution pipelines. In view of a similar trend encountered, the previous basic design study ruled that trunk mains for distribution be installed by the Japanese side, while branches and house connections, by the Yemenis, with assistance of supply of piping materials under the Project. This policy is considered to be effective in formulating a renewed plan for the Project, although the increase of quantities in plumbing works is inevitable. However, the decision for the supply of materials needs careful examination of the capabilities and characteristics of the respective sites. The following table shows the outline of the contents and scale of facilities thus determined:

Table 2-3 Comparison of Facilities Planning of the Basic Design Study and that of the Implementation Review Study

Site	Water Source		Machinery House/ Pumps		Water Tanks		Pipelines (Supply of Materials)	
	B/D (*)	I/R(**)	B/D	I/R	B/D	I/R	B/D	I/R
Ahwar	Existing well x 2 Nos	Same as B/D	M.House x 3 Nos.	Same as B/D	250 m³ x 1 No.	Same as B/D	φ80~ 200 mm 12,100m	φ80~ 200 mm 17,500m
			Deepwell pump x2 Nos.	Same as B/D	100 m³ x 1 No.	Same as B/D	(φ50~ 100 mm x 6,600m)	(φ50~ 80 mm x 10,000m)
			Booster pump x 2 Nos.	Same as B/D				
Moodeyah	NewWell x 1 Nos	Can-celled	M.House x 4 Nos	M.House x 5 Nos.	300 m³ x 1 No.	Same as B/D	φ80~ 200 mm x 15,300m	φ80~ 200 mm 19,600m
	Existing well x 3 Nos.	Existing well x 5 Nos.	Deepwell pump x4 Nos.	Deepwell pump x5 Nos.	100 m³ x 1 No.	Same as B/D	No supply	(φ50 mm only x 6,000m)
			Booster pump x 2 Nos.	Same as B/D				

Site	Water Source		Machinery House/ Pumps		Water Tanks		Pipelines (Supply of Materials)	
	B/D (*)	I/R(**)	B/D	I/R	B/D	I/R	B/D	I/R
Al-Raidah Shamalya	New Well x 1 No.	Cancelled	M.House x 3 Nos.	M.House x 3 Nos.	200 m^3 x 1 No.	200 m^3 x 2 Nos.	φ50~ 150 mm x 20,690m	φ80~ 200 mm 36,700m
	Existing well x 1 No.	Existing well x 3 Nos	Deepwell pump x1 No.	Deepwell pump x3 Nos.	100 m^3 x 1 No.	150 m^3 x 1 No.	(φ50~ 80 mm x 2,680m)	(φ50~ 80 mm x 20,880m)
			Booster pump x 4 Nos.	Cancelled				
As-Sadarah	Infiltration gallery x 1 No.	Same as B/D	M.House x 3 Nos.	Same as B/D	300 m^3 x 1 No.	Same as B/D	φ80~ 200 mm x 21,800m	Same as B/D
			Booster pump x 6 Nos.	Same as B/D	50 m^3 x 2 Nos.	Same as B/D	(φ50~ 80 mm x 2,200m)	(φ50~ 80 mm 6,460m)

Note: * = Basic Design Study / ** = This Study for Implementation Review

As indicated in the above table, the increase of pipeline extension is remarkable in the 4 sites. The following conditions have been taken into account for the decision of the scope:

The Ahwar and Moodeyah water committees respectively have four plumbing technicians engaging in operation and maintenance of existing facilities. Since they have no machinery or equipment for pipe threading and welding, such kind of works is done by specialists at shops within the cities. Normally the sizes of pipes they can readily deal with are 3" and less. Taking such local capability into account, the Japanese side is to undertake lines of 4" and larger, while those of 3" and less will be done by the Yemeni side, with the supply of piping materials under the Project. In Ahwar, the trunk mains to be installed by the Japanese are 4" and 6" in size, while in Moodeyah mainly 8" lines are to be installed for feeder lines, although some sections of 3", particularly connecting lines between trunk mains are planned to be handled by the Japanese side.

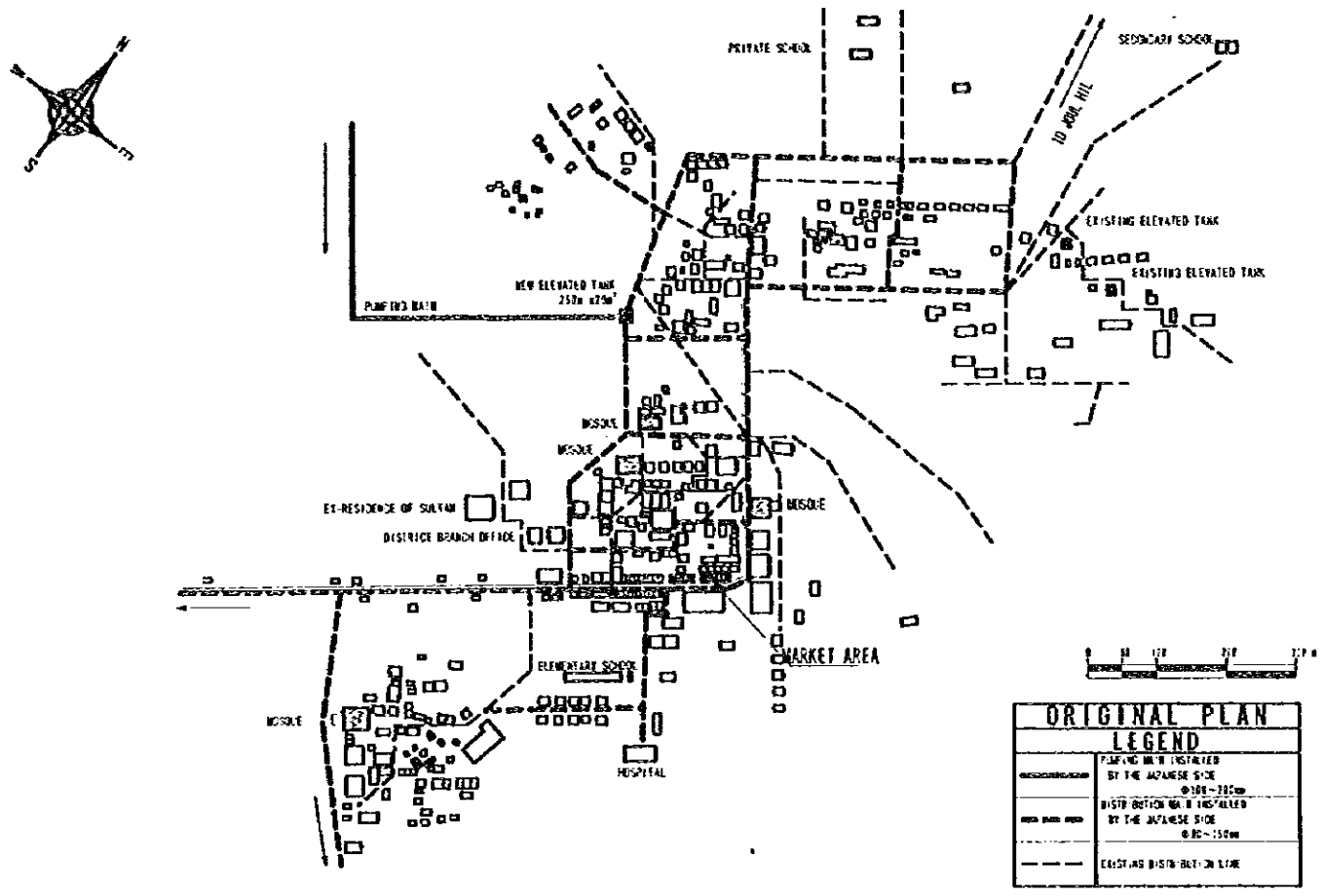
Al-Raidah/Shamalya and As-Sadarah will ask major part of pipelines to be installed by contractors based upon nearby cities, probably in the governorate capital of Al-Mukalla, since they have no committees or technicians to deal with such works within the site.

The suitable sizes of pipes to be locally handled will also be 3" and less. For a particularly broad site of Al-Raidah/Shamalya covering 21 villages, however, the total extension of distribution lines reaches a quite long distance with the length of 3" pipelines only totaling about 12,000 m. In order to relieve the residents of financial burden, pipes of less than 3", namely 2-1/2" and 2", are planned to be supplied to this site, with the Japanese undertaking the works for 3" and larger pipes.

During the previous basic design study, the GAREW agreed to provide necessary funding and dispatch of specialists for pipeline installation by the Yemeni side, and has confirmed the same policy for this study once again. Its budget for the year 1996 was reportedly about YR 13 million, one third of which was earmarked for civil works. Since the estimated cost for plumbing works by the Yemenis for this Project corresponds to about 2 % yearly of the said budget for civil works, the GAREW will find no difficulty with securing such a level of the budget for this Project.

For reference, the comparison of the plans and designs in both the basic design and this study is illustrated in Figs. 2-1 to 2-4 for the respective sites.

As the conclusion of the foregoing examinations, the four sites under study are truly in need of the implementation of the Project without a moment's delay, with enough justification to receive assistance under Japan's grant aid program. Although the scale of the Project needs to be expanded to a considerable extent, the required budged could be limited to a range formerly assigned for the Project by the basic design study, owing to a measure to ask for the self-efforts of the Yemeni side in the construction of extended distribution networks.



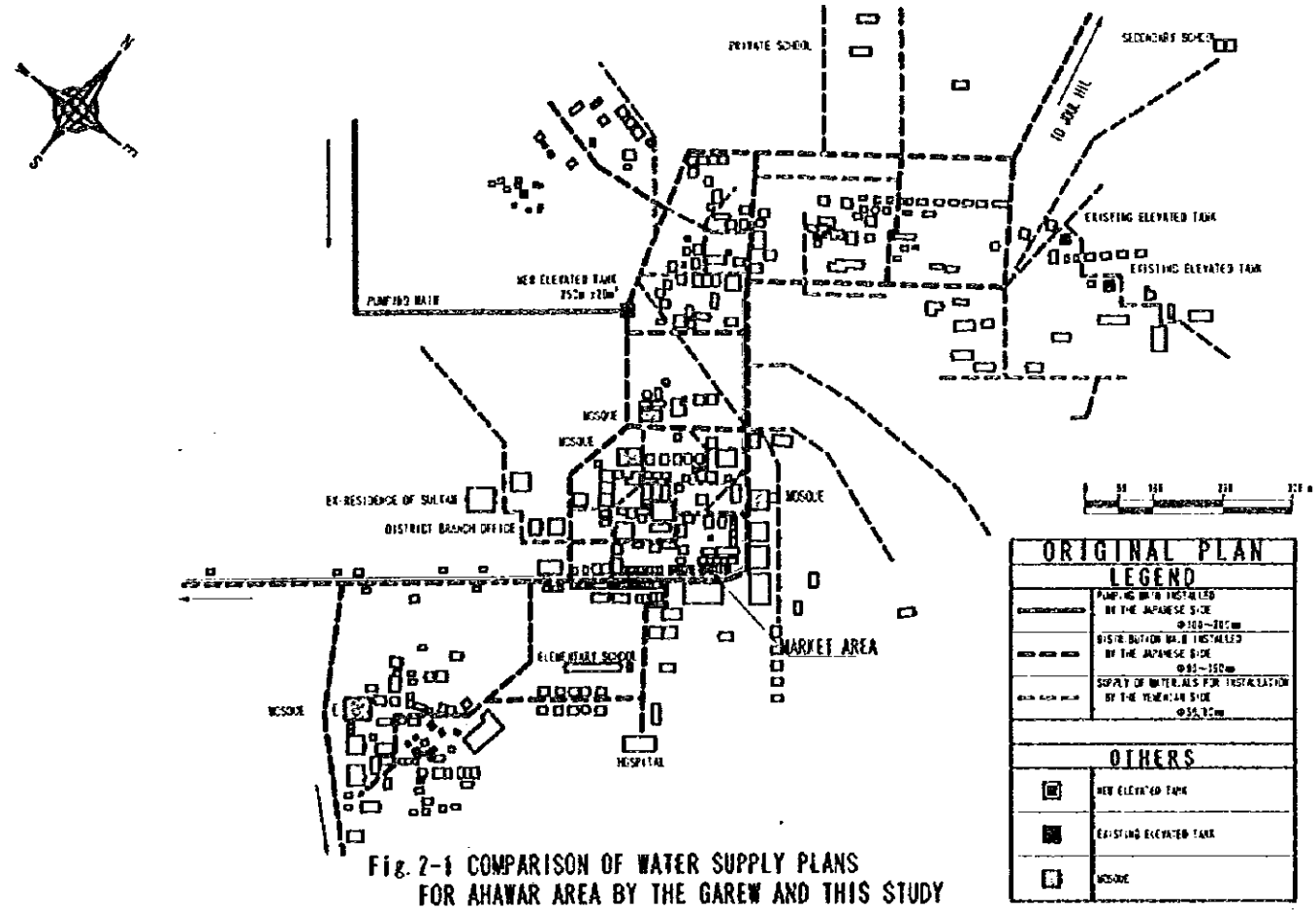


Fig. 2-1 COMPARISON OF WATER SUPPLY PLANS FOR AHAWAR AREA BY THE GAREW AND THIS STUDY

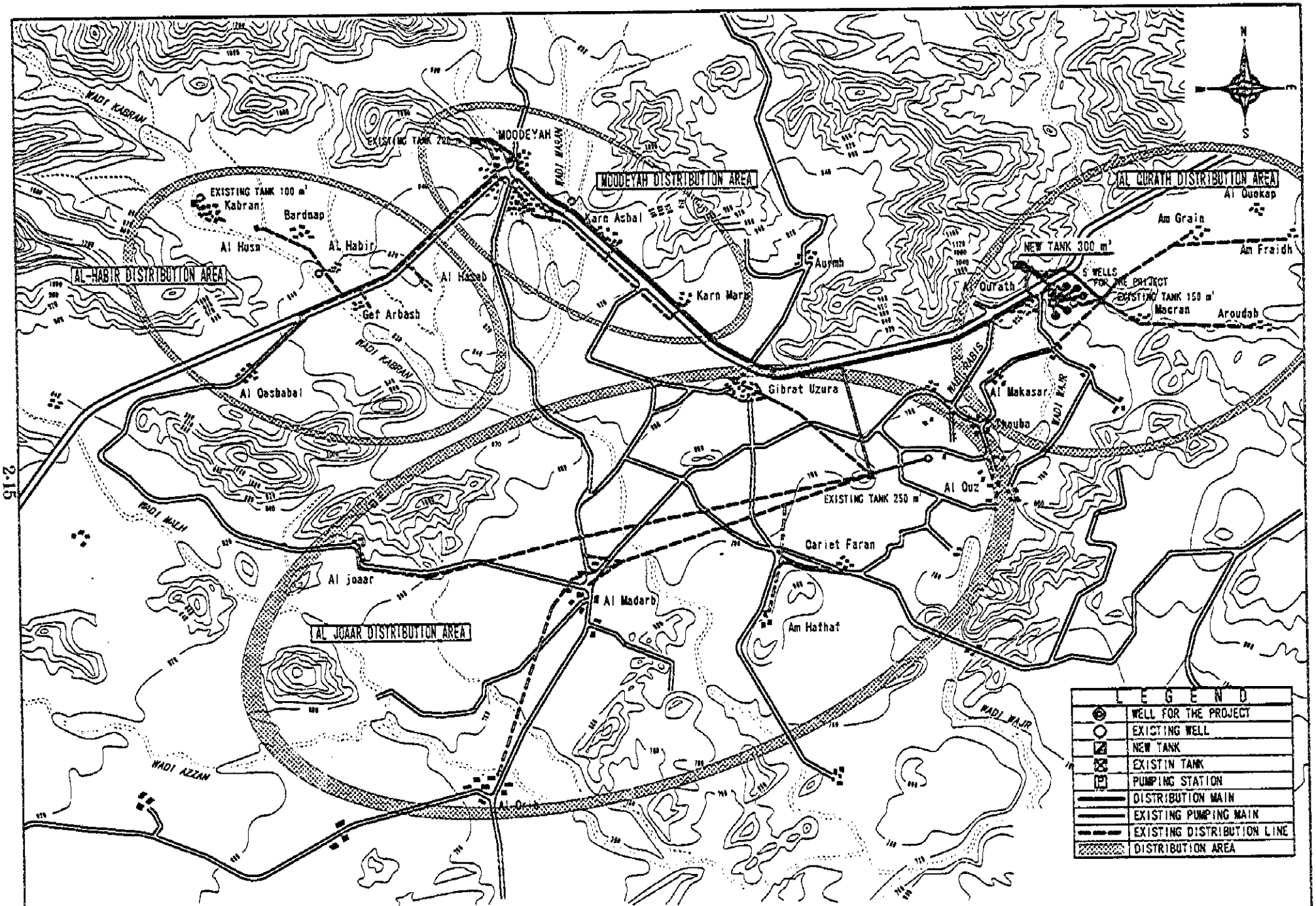
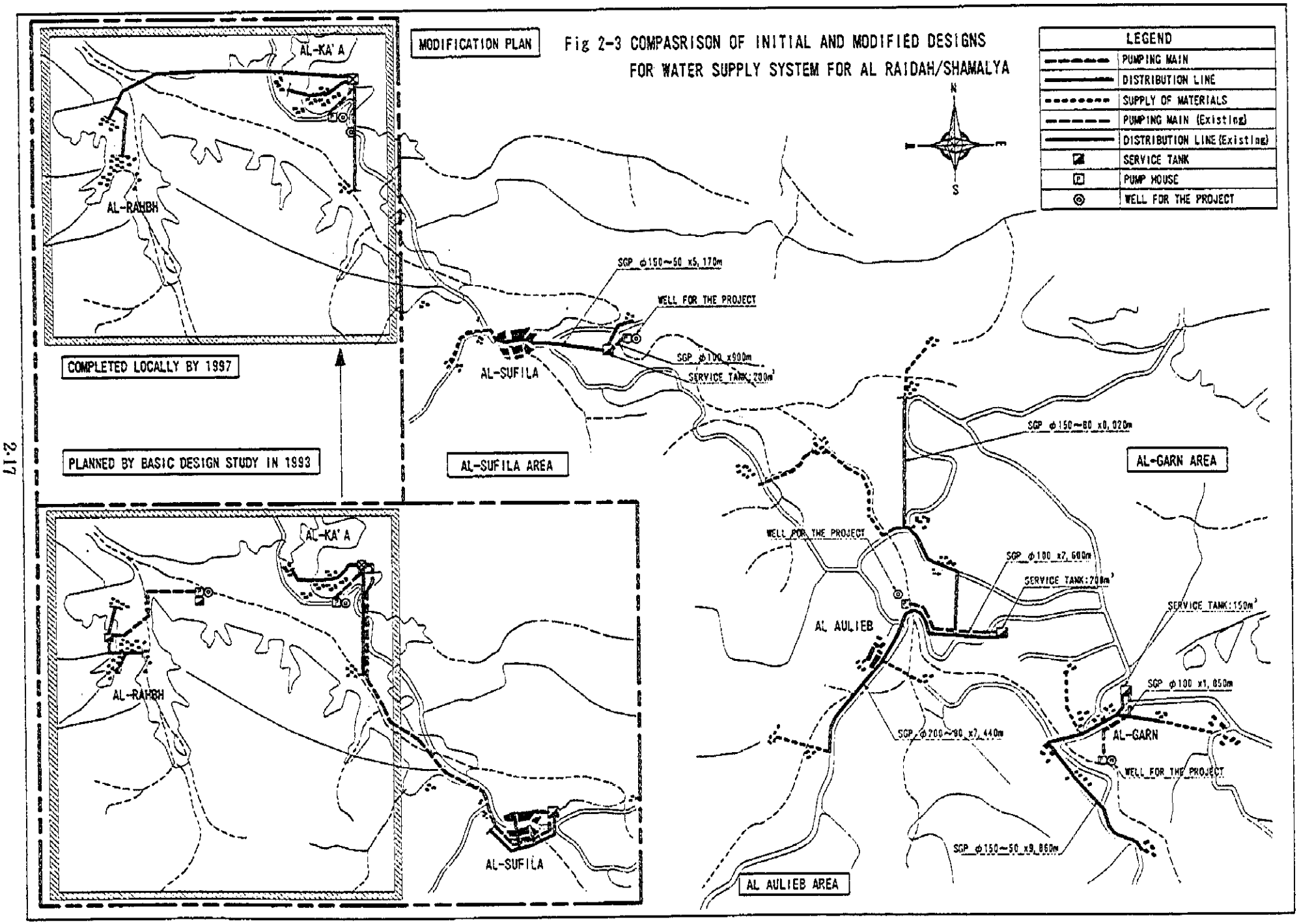


Fig. 2-2 COMPARISON OF SUPPLY PLANS FOR MOODEYAH AREA


MODIFICATION PLAN
Fig 2-3 COMPASRISON OF INITIAL AND MODIFIED DESIGNS
FOR WATER SUPPLY SYSTEM FOR AL RAIDAH/SHAMALYA
LEGEND
PUMPING MAIN
DISTRIBUTION LINE
SUPPLY OF MATERIALS
PUMPING MAIN (Existing)
DISTRIBUTION LINE (Existing)
SERVICE TANK
PUMP HOUSE
WELL FOR THE PROJECT
N
S
AL-KA' A
AL-RAHBH
COMPLETED LOCALLY BY 1997
PLANNED BY BASIC DESIGN STUDY IN 1993
AL-SUFILA
AL-SUFILA AREA
SGP φ150~50 x5,170m
WELL FOR THE PROJECT
SGP φ100 x900m
SERVICE TANK:200m³
SGP φ150~80 x0,020m
AL-GARN AREA
WELL FOR THE PROJECT
SGP φ100 x7,600m
SERVICE TANK:700m³
SERVICE TANK:150m³
AL AULIEB
SGP φ100 x1,050m
SGP φ200~80 x7,440m
AL-GARN
WELL FOR THE PROJECT
SGP φ150~50 x9,860m
AL AULIEB AREA

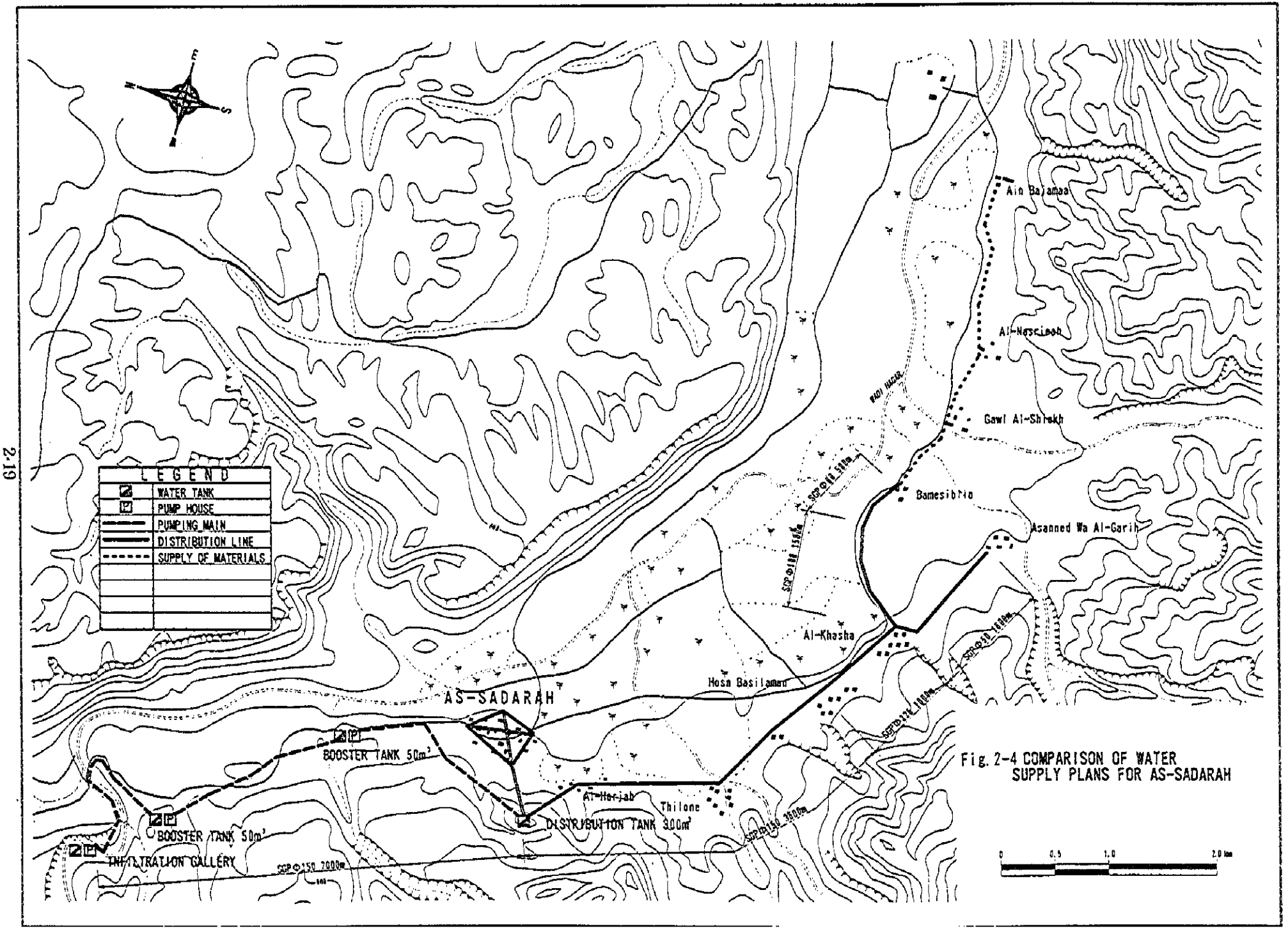


Fig. 2-4 COMPARISON OF WATER SUPPLY PLANS FOR AS-SADARAH

2-3 BASIC DESIGN

2-3-1 Design Concept

(1) Policy for natural and social conditions

The southern and eastern govornorates of Yemen are dominated by the searing heat throughout the year except for a short period of December to February under a relatively mild weather. The annual mean temperature there is reportedly 27°C against 18°C in much of the northern part where the climate is rather cool throughout the year. Worse than that, the rainfall is a scanty 100 mm to 200 mm annually throughout the region due to a smaller scale of ranges forming the region's watershed than that of the northern part. Such rigorous natural environment makes the situation of water resources acutely worse than in its northern counterpart, not only quantitatively but qualitatively. The water crises in the project sites of Moodeyah and Ahwar suffering from lack of safe and stable water sources typically demonstrate the severe natural conditions common in the Southern part. Located 10 km inland from the coast of the Bay of Gulf, the Ahwar water service has only saline water to serve its population. Moodeyah is another area featuring a broad distribution of highly saline groundwater despite its inland location, with much of its area suffering from scarce production at the same time. In the midst of such adverse conditions, the preceding basic design study made efforts to spot relevant water sources for the public service, especially concentrating on water quality. These efforts resulted in locating the zones of narrow belts in the respective sites in which groundwater is comparatively far better than the one currently in use. The existing deepwells remaining unused in these belts are planned to be employed both in Ahwar and Moodeyah. One shortfall in this plan is their quantities stemming from the small scales of basins. Overpumping from many wells in such small patches of basins to satisfy large populations of both sites is feared to invite intrusion of degraded groundwater in the surrounding areas. To solve this problem, it has been planned to employ solely the existing wells, two in Ahwar and five in Moodeyah, that were already confirmed in respect of quantity and quality, while ruling out a program of extra drilling in the basins. The accurate capacities of the basins in both sites remain yet

to be examined through a detailed process of aquifer testing before starting the operation of the wells. This testing is preferred to be carried out by the consultant, aiming at a technology transfer to the GAREW's counterparts. In case the test reveals a possibility of further development of the basins, it is proposed the subsequent works of further development be done by the Yemeni side to extend served areas to the communities that have been left out in this plan due to the limited productions of the existing wells.

In fact, besides being limited in production, most of the water sources earmarked for the Project hardly have any alternatives in and around the respective sites. The use of such precious sources should be intended to meet the BHN of the residents in the first place. Under such circumstances, the needs for livestock should come second to those for human beings, even though livestock breeding is one of the economic essentials for the latter. The survey results indicate that the three project sites among four have so great a difficulty with the water sources, particularly in their productions, that planned facilities could serve only part of the entire population. The remaining site of As-Sadarah has affluent running water in the wadi, which has been and will be used by herds of livestock within the site. There is no need to give costly piped water to livestock at this site. In view of these specific water source conditions in the respective sites, this Project is deemed in no position to plan sharing water with livestock.

The most difficult element to tackle in the planning of the Project has been the water source, even though the Yemeni efforts in Al-Raidah/Shamalya and Moodeyah have cleared previous uncertainty about securing water sources, particularly in the former site. The available water sources for the 4 sites, therefore, should be treated with much attention and care of all the concerned with the Project. The basic policy of this study is to plan and construct water facilities for helping improve living standards of the residents as well as their health and sanitation, which are believed to enhance their interests in preservation of natural and social environment, leading to a gradual improvement of their current practice in water use.

(2) Policy for Local Participation in Construction Works and Procurement of Local Materials

Local participation in construction works and procurement of local materials are highly

recommended for the implementation of the Project. Nevertheless the local construction sector in the country remains yet to be firmly established and organized as one class of modern industries. For the water sector, private companies are seen to be growing, although most of them are still in a smaller size, with a fragile technical and financial base. Under such circumstance, the implementation of the Project is considered to be undertaken directly by management of a Japanese contractor(s) for fulfilling required control of quality and progress of the works. The reasons the Yemeni construction sector hovers in an antiquated level are that most of buildings have been employing the traditional method of construction. Multinational contractors based upon the western and Gulf countries frequently join in the construction works of a large scale of project, but they have not been able to settle in the Yemeni soil except several joint companies of the Chinese and the Yemeni mainly doing the job in the road construction.

Despite the aforementioned situation of local contractors, this Project intends to positively employ the conventional methods of construction, specifically suited to the climate of the Southern part. One example is a "masonry tank", a reservoir made of stone material prevailing in the Southern part. It has a structure with its walls filled with stones and concrete, materials that can easily be got in any part of the country, and finished with stone tiles all over its outside surface. These stone walls act as insulators against the scorching heat of this part of the country as well as reinforcement of the tank structure. (The width of walls of a 300 m^3 tank employed in the Project is as large as 2.2 m at the bottom.) This design has spread over the southern area as a standard specification of the former Public Water Corporation, presenting an appearance in harmony with the surrounding scenery. This type of construction can be done by locally specialized contractors who have acquired expertise and experience through the contracts with the said organization. The employment of locally designed construction will encourage active participation of the regional communities and residents.

Meanwhile local materials are reportedly abundant on the local market, thanks to active participation of private sectors trading with the European and Asian countries. The supply of home-made cement is constant on the market through vigorous production of two plants that were completed with assistance from Japan. Steel products are being imported

mainly from Korea and Russia. Although the Yemeni market at present can provide any material for civil works, fine aggregates are normally inferior in quality due to a rich content of silt material affecting concrete structures. Concrete works, therefore, needs much care in the choice of materials and quality control in construction.

The final design for the Project rules out technology and methods unfamiliar to the local people as much as practicable, to allow their maximum participation in construction as well as operation and maintenance. Experts from the Japanese contractor(s) are anticipated to lead and inspire such local activities.

(3) Policies Related to Operation and Maintenance

The water facilities completed under the Project are to be operated and maintained by the water committees in the respective sites. To cope with this situation, facilities and equipment to be turned over to them are planned to be types hardly requiring special technology in their daily operation and maintenance. This policy is particularly focused on (1) deepwells (2) pumps and (3) pipelines. One example is a type of pumps. Although the previous design selected electric motor driven pumps, this study plans to switch to diesel-engine driven pumps to which the local people have been accustomed, based upon the request raised by the residents during the survey for this study.

When it comes to deepwells, maximum pumping is a common practice all over Yemen despite the fact water is absolutely in short supply. This routine practice has often caused the depletion of water resources in various parts of the country. To prevent this habit of overpumping, this Project plans to attach a simple type of water level meter to each deepwell so that the operator can properly judge its condition. The meter is a battery-powered type, consisting of a potable meter body with a calibrated wire having an electrode at one end. It is manually operated by lowering the cable with the electrode into the well, and a lamp on the meter lights up or a signal sounds when the electrode reaches the water level.

For pumps and power units, special types will not be adopted, and those commonly in use in Yemen will be provided, together with a supply of necessary meters, gauges and protective switches as standard accessories, which help the daily operation by the water committees.

The facilities and equipment under the Project would not break down, if they are properly operated and maintained. Their sustained operation could be guaranteed by constant attention and care of the staff at the water committees. Technology transfer to the local staff is planned at the time of test operation of completed facilities. Spare parts and standby materials/equipment that are hard to get on the local market are planned to be supplied to them, since the water committees have no financial resources to procure them during the kick-off period of new water service.

(4) Policies for Scopes and Scales of Facilities

Each of the four sites in the Project needs a planning for an extensive water supply system, requiring an expanded scale of facilities. To avoid an excessive investment in the planning, one of the policies in the basic design was to call for the self-efforts by the Yemeni side, including drilling work (testing and/or construction of new wells) and plumbing works (installation of branch distribution lines and house connections). So far the drilling work has been completed by the hand of the Yemeni side including 4 new wells in Al-Raidah/Shamalya that was previously considered to be the most difficult site for the development of groundwater. Concerning the plumbing work, piping materials are planned to be supplied to the Yemeni side under the Project to assist its smooth undertaking of necessary installation works, as was proposed in the previous basic design.

The extent of plumbing work to be undertaken by the Japanese side has been decided, taking into account the specific conditions of the respective sites as well as their social and economic conditions. (The policies for its decision are described in Section 1 - 2 of this Chapter). In case of Ahwar, all the pipelines are to be buried underground, and the installation work of branch lines by the Yemeni side is expected to be undertaken simultaneously with the progress of installation of trunk mains by the Japanese side. On that occasion, experts of the Japanese contractor present in the site are requested to

cooperate in the work by the Yemeni side, offering relevant information and advice from time to time. This measure is necessary, since the supplied materials are of Japanese make. Even if the works do not progress simultaneously in the other sites, they are required to offer expertise in the installation work to the understanding of representatives of the sites in charge of the Project.

2-3-2 Basic Design

(1) Examination of Capacities of Water Sources

In view of the importance of the water sources for the formulation of the Project, their capacities are examined to justify the design bases of the respective plans of the sites as follows:

1) Ahwar (Abyan Governorate)

a. Hydrogeological Characteristics of the Site

As Ahwar is located in the basin of the Wadi Ahwar, groundwater generally abounds through the entire area, and significant amounts of groundwater can be expected. However, because the area is close to the coastline, the chloride contents of groundwater are normally in a very high level. Despite such general trend, the survey has spotted an area along the narrow belt on both banks of the Wadi Ahwar containing groundwater with a relatively good quality, probably the underflow of the wadi.

b. Planned Water Source

There are two unused deepwells in the left bank of the Wadi Ahwar drilled by the regional agricultural development plan by the former Soviet Union in 19802. The water analysis at these wells revealed quality was far better than those of the surrounding area, and these two wells are planned to be used for this Project. They are some 70 m deep, tapping shallow alluvial aquifers at approximately 20 m to 50 m.

c. Planned Production Rate and Water Level

According to information available from the pumping tests performed by the former Soviet Union at the time of drilling in 1988, the maximum pumping rate was 13.2 lit/sec (800 lit/min) with a drawdown of 7.4 m, although duration of pumping is unknown. As the production from the wells depends on the underflow through shallow formations, pumping at a rate less than 80% of the maximum is desirable as a safe yield. To secure a production rate as much as possible in view of a large planned population of this site, a ratio of 75% is recommended as a safe yield. The pumping plan at this rate of safe yield will be calculated as follows:

* Pumping rate: 13.2 lit/sec (800 lit/min) x 0.75= 10 lit/sec (600 lit/min)
* Static water level: 10.9 m (actual measured value at the time of the survey, December 1993).
* Pumping water level: 15.9 m (predicted value from an analysis of the Soviet test results)

As a result of the calculations, a supply rate of 20 lit/sec (1,200 lit/min) is possible for the Ahwar service area, operating two wells simultaneously.

d. Special Remarks

Detailed pumping tests are necessary in order to obtain conclusive evidence of the exact rate of production, since the records of the former testing are not new and the pumping duration is unknown. The main reason for the requirement of testing is that the fall of water level due to overpumping at the wells is feared to lead to inevitable invasion of saline water from the surroundings of the wadi reaches through which rather fresh underflow is suspected to pass. The details of the Hydrogeological characteristics of the basin remain yet to be seen, and the plan to develop additional wells downstream to increase the production for meeting the total demand of the population must be postponed. In case this Project could shed some light on the possibility of further groundwater development in the wadi basin, increasing the production by drilling an additional well(s) may become possible.

2) Moodeyah (Abyan Governorate)

a. Hydrogeological Characteristics of the Site

Although Moodeyah is located inland on a plain and hilly area, major part of groundwater in the region contains high salinity except for the one occurring along the reaches of the Wadi Wajar approximately 10 km east of the central area of Moodeyah town. This basin is a zone of belt running along the ancient river channel. The shallow sedimentary formation underlain by the Precambrian bedrock form the aquifer in this wadi belt.

b. Planned Water Source

There existed five deepwells in the reaches of the Wadi Wajar, two of which were in operation during the basic design study in 1993. The other three unused deepwells was earmarked for this Project. During the field survey for the basic design study, water analysis was carried out by opening the welded covers of the unused wells, and the results indicated groundwater in this basin would raise no question in quality, at least for the moment. The five wells are closely located to each other with their depths reaching about 76 m. A new additional well was planned with a similar structure as there was a possible development point downstream the wadi.

After three years since then, this survey has found that the GAREW drilled another two wells close to the existing ones. There are now five deepwells available to the Project, ruling out the necessity of additional drilling by the Japanese side.

c. Planned Production Rate

A data from the previous pumping test is available from the one well among 7 existing ones, which is in service as the public water source for the Al-Qurath service area. when it was constructed by a Chinese project. However, the test pump seems to have been of small capacity, and the data can be used only as reference. Instead, the observation during the field survey can provide enough information for making judgements. At the time of survey for the basic design study, the two wells in the Wadi Wajar basin were working, and the rates of 7.5 - 8.3 lit/sec (400-500 lit/m) were

continuously being pumped. During the survey for this study, however, these wells have been witnessed to discharge less yields than before. In fact, the Al-Qurath area depending on one well has been short of water for its service, and compelled to enforce water rationing on the day basis.

The static water levels of the unused three wells in the basin were also measured when the welded caps were opened for water sampling. The drilling depth was 76 m with the static water level standing at an unexpectedly deep level of some 45 m. At present only two wells are still working among seven existing in the Wadi Wajar basin. If all these seven wells are simultaneously operated in the future upon completion of the Project, the interference between the wells are suspected to grow large due to their close distance between each other, possibly causing the further decline of the water levels in the wells. Furthermore, it might result in a possible reduction in flow rates due to the falls of water levels and worst of all, the invasion of brackish water from the surrounding area. To protect against such a fatal damage, it is of vital importance to control the pumping rates of these wells by limiting them to a safe yield in order to secure sustained operation of the water sources. An average flow rate of currently working wells is 6.7 lit/sec (400 lit/min), and the maximum production for this Project is proposed to be 75% of this rate, as shown in the following calculation:

* Pumping rate: 6.7 lit/sec (400 lit/min) x 0.75 = 5.0 lit/sec (30 lit/min)
* Static water level: 45 m (measured at the three unused wells at the time of the basic design study)
* No information available on the pumping water level

The basin for the Project needs detailed aquifer testing, using 5 wells to confirm the capacity of water production in a similar manner to that for Ahawar. The most effective and efficient method to operate 5 wells will be decided, based upon this testing. As a basic plan for this study, one well among five is proposed to be left aside as a standby source or to remain alternately unoperated while the other 4 wells are in operation. This measure will contribute to preserving this precious basin as a sole source for the Project. This proposal leads to 1,200 lit/min as the available rate of

water productions from 4 wells.

d. Special remarks

An accurate pumping test is necessary for the existing wells in the Wadi Wajar, as is the case with the site of Ahwar. In order to conserve the water basin producing good groundwater solely in this area, overall control and monitoring of the basin is critically important. It is most desirable, therefore, that a single agency, which means the Moodeyah water committee, undertake to operate and maintain all the wells in the basin, including the two wells which are now in operation. As the planned pumping tests have not yet been conducted, only limited information related to the characteristics of hydrogeology of the basin is available. However, since further development is judged to be difficult in view of the size of the Wadi Wajar basin, the offices concerned with the Project are required to pay special attention and care to protect it.

3) Al-Raidah/Shamalya (Hadramout Governorate)

a. Hydrogeological Characteristics of the Site

This area is located on a corner of a limestone platform of highlands called the South Hadramout Arch, south of the east-to-west anticline, which is intersected by the Wadi Hadramout. The Wadi Hadramout is the largest basin in the southern area. Securing a stable water source on this high plateau had been considered to be extremely difficult, although one deepwell over 400m in depth was successfully installed as a by-product of the oil exploration in this area in the early 1990s. This well was assumed to tap groundwater in a sandstone formation deeply seated under a thick limestone layer, but the assumption could not be confirmed at that time due to lack of detailed information. In recent years, the GAREW launched on the groundwater development in the area in response to the earnest request of the residents in the area, and has succeeded in installing 4 deepwells capable of producing yields of a similar level to that of the preceding one.

b. Planned Water Source

The first deepwell constructed in the early 1990s is located close to the Al-Ka'a village

belonging to this site. After the basic design study, the residents of that village started to construct their own water service facilities, involving other 3 villages among 7, which were included in the plan of the basic design. Their facilities were completed in 1996, and are now in operation for the service to the said 4 villages. According to a simple flow rate measurement during the basic design study, the Al-Ka'a well was confirmed to yield a rate of about 5 lit/sec (300 lit/min) . One problem, however, was that the water level was extremely deep, as it reached as deep as 350 m, requiring a special pumping capacity. The village now uses an Italian-made deepwell pump with a successful result.

The 4 deepwells recently constructed by the GAREW are scattered within the site; the first one near the previously installed well at Al-Ka'a village (410 m deep) ; the second one near Al-Sufila village (260 m deep); the third near Al-Aulieb village (266 m deep) and the fourth near Al-Garn village (310 m deep). The wells of 260 m to 310 m in depth tap a fractured zone of upper limestone bed, while the wells around Al-Ga'a area has been confirmed to tap a lower sandstone aquifer. The yields of these new wells are reportedly 400 lit/min to 500 lit/min, enough to serve the region's population.

c. Planned Production Rate and Water Level

The Project plans to separate the site into 3 independent service areas, employing three new wells located near Al-Sufila, Al-Aulieb and Al-Garn. The capacities of these wells are reportedly stable, and distances between them are long enough to eliminate any interference. The production rate of each well can be 400 lit/min, taking a lower rate of testing rate.

* Pumping rate: 6.7 lit/sec/well (400 lit/min)
* Static water level: 100 to 180 m
* Pumping water level: Unknown yet

4) As Sadarah (Hadramout Governorate)

a.. Hydrogeological Characteristics of the Site

As-Sadarah is located at the upper stream of the Wadi Hagar, approximately 140 km

north of Myfa City where the wadi flows into the Gulf of Aden. Surface water flows throughout the year in all channels until the wadi reaches the Gulf of Aden. The origin of the stream flow is a spring occurring approximately 10 km upstream As-Sadarah. Other than this water source, a hot spring zone are distributed in a shallow part of the underground within this site. Hot springs are encountered everywhere when one digs the earth only several meters.

b. Planned Water Source

Currently the residents use hot springs, which can be collected easily anywhere in the site, as the source for domestic water. As a water source for the overall water supply plan of the site, however, they desire to draw unpolluted running water from the upper stream of the Wadi Hagar. As the Wadi Hagar flows down near As-Sadarah, the water quality deteriorates as its salinity increases by mixing with discharges of hot springs. Moreover, since the communities are located over the hot spring zone along the reaches of the wadi, artificial contamination of the hot spring source by waste water from the community has grown much of concern among the residents. In view of such a situation, the running water from the Wadi Hagar, which is approximately 5 km from As-Sadarah, is proposed to be collected in a infiltration gallery for the supply to the communities.

c. Planned Water Intake Rate

The wadi flow rate of the intake point for this plan, which is located in the upper stream of Wadi Hagar, is 50 lit/sec (3,000 lit/min) or greater, even during the dry season at the time of the survey for the basic design study (December 1993). The survey this time (March 1997, small rainy season) witnessed a rate of about 80 lit/sec. (4,800 lit/min). The wadi flows becomes richer downstream within the site, collecting hot spring flows. The water intake rate is proposed to be 16.5 lit/sec (1,000 lit/min) based on the planned water supply rate.

(2) Examination of Parameters for Planning

1) Planning Target Year

The basic design study set the target year of the Project planning for a period of 15 years, which is to be basically followed by this study. However, for Moodeyah a shorter period of ten years are proposed for the following reason:

Moodeyah has now a far larger population than the one planned under the basic design study because of necessity of including two additional service areas which were left out in the basic design study. One of them suffered collapsing of the deepwell source late last year, and the residents have all been forced to switch to water vending. The other has long been enduring highly saline water service. The quantity of water from the new sources, however, is not considered sufficient enough to satisfy thus increased demand for a long period of 15 years, although there may be a possibility to increase the total production, thanks to two additional wells so far installed by the GAREW. Testing of the water sources expected in the near future will confirm the exact range of supply. However, since the basin itself is of small size, extensive groundwater development there does not seem possible, and some measure will have to be taken to cope with demand of these additional areas within the site of Moodeyah. Under such unstable situation, a target of 15 years is judged to be excessive.

The following table shows the planning periods of the Project for the respective sites.

Table 2 - 4 Project Planning Period for the 4 Sites

Site Name	Administrative Division	Planning Target Year
1. Moodeyah	District	10 years(the year 2007)
2. Ahwar	Sub-district	15 years(the year 2012)
3. Al-Raidah/ Shamalya	Sub-district	15 years(the year 2012)
4. As-Sadarah	Sub-district	15 year (the year 2012)

2) Planned Served Areas

The planned served areas in the respective sites are determined, based upon the following policies:

a. The extent of the planned served area in the site is based upon the quantity of production of water sources analyzed in Section 2-3-2 and the planned served population in the planning target year. For Moodeyah and Al-Raidah/Shamalya where the population to be served has increased through the renewed request, the following policy is applied:

* Moodeyah

The two service areas requested to be added to the initial plan have acutely been suffering from lack of safe water, and need to be included in the Project. All the population in the 4 service areas is planned to receive a fair share of the available quantity of water.

* Al-Raidah/Shamalya

The GAREW has already drawn up its own plan for water supply to this site as follows:

- Al-Sufila service area

Al-Sufila has the largest population within the site. It was one of the 7 villages to be supplied by the Project in the basic design. Although 4 villages among 7 have already installed water facilities depending upon the deepwell previously constructed, it has been left with no connections to those facilities due to a long distance from them. The GAREW drilled one well near to this villages, and planned an independent system including two other villages.

- Al-Aulieb service area

Al-Aulieb is the main village of Al-Raidah/Shamalya sub-district, functioning

as a center of the regional administration. Scattered around it are 18 villages, with all the population depending upon vending water. In recent years the GAREW drilled two wells for these villages and planned to distribute water to them from a single reservoir of large size located on a surrounding hilltop.

This study carried out the field survey of all the area of the site, including the Al-Ka'a service area with the existing facilities, and examined the plan by the GAREW. As a result, the following plan is proposed.

- For Al-Sufila service area, the GAREW's plan is acceptable. The three villages will be covered by the system in this area.
- The Al-Aulieb area shall be devided into two service areas, based upon the locations of two wells recently drilled by the GAREW. Compared with the plan of the GAREW with a single reservoir, this proposal with two reservoirs is technically and economically feasible, since the length of pipelines can be cut back considerably, enabling to reduce the size of pumping equipment with a power unit. (For reference, the comparison of both plans are shown in Fig. 2-5.)

b. The daily water production rate increases if the operation is continued for a longer period. However, a suspension of pumping is regularly necessary in order to preserve the stable groundwater level and maintain the water source facilities. From a realistic point of view, the daily maximum operation should be confined to approximately 20 hours in the project target year.

c. The water service to the central area of the site has the first priority. The priority of other villages within the site comes next, through the detailed examination of the survey results.

Table 2-5 shows the list of the communities thus decided to be covered by the Project, together with their present and planned populations.

Fig. 2-5 COMPARISON OF WATER SUPPLY PLANS FOR AL-RAIDAH/SHAMALYA BY THE GAREW AND THIS STUDY

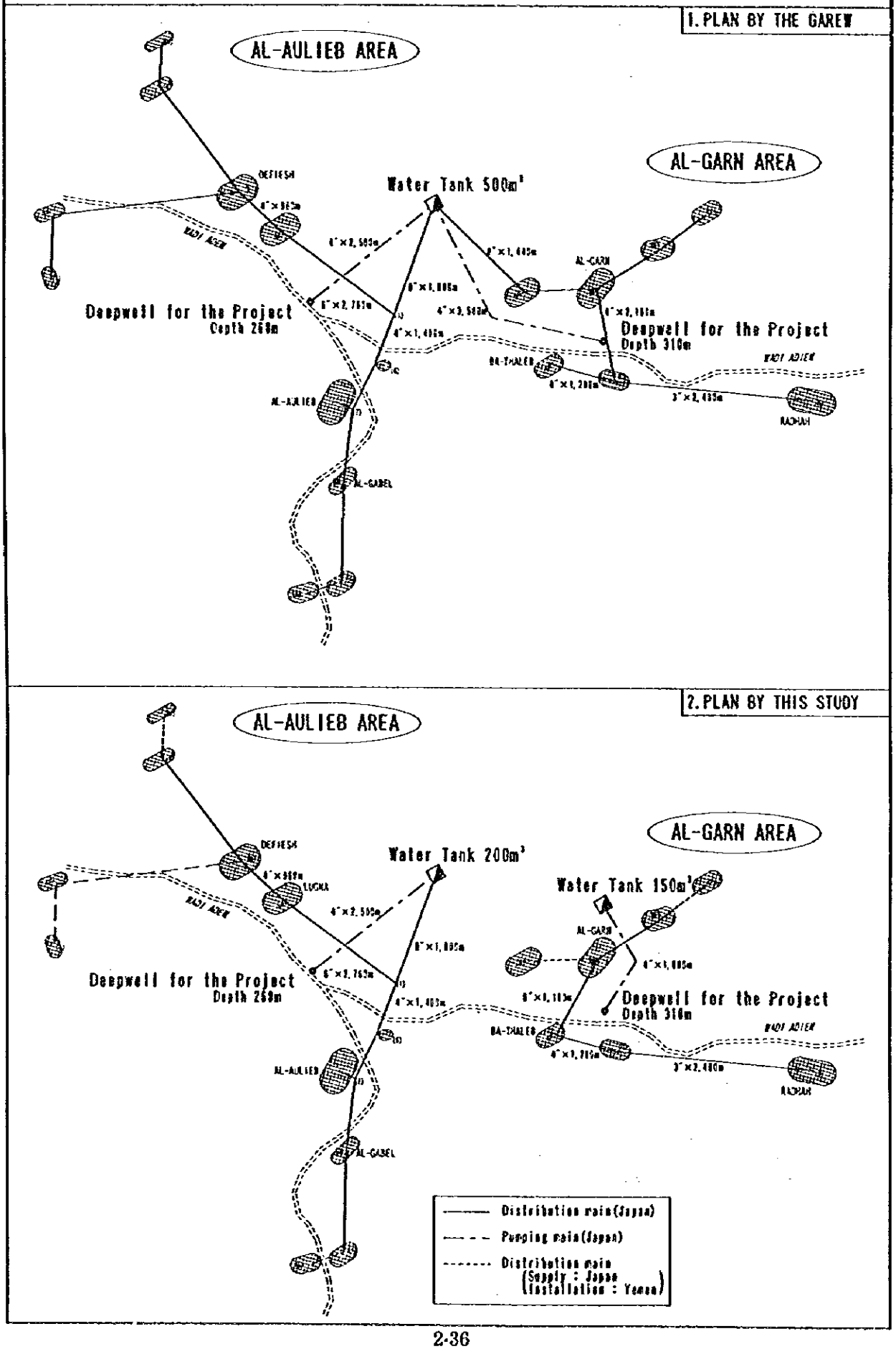


Table 2-5 Project Service Area and Served Population

Project site	Water service area	Villages	Present population (1997)	Planned served population (2012)	Project site	Water service area	Villages	Present population (1997)	Planned served population (2012)
Ahwar	Ahwar water service area	Ahwar	8,000	11,350	Al-Raidah /Shamalya	Al-Aulieb water service area	Al-Aulieb	1,180	1,590
		Hay badeed	4,120	5,540			Al-Gabel	200	270
		Joul Hil	1,390	1,880			Aal Magis	120	160
		Al-Garieb	860	1,160			Al-Salabieh	210	280
		Al-Sharwa	730	1,010			Dulben	200	270
		Al-Subel	330	480			Rugna	1,225	1,650
	Total		15,430	21,420			Defiesh	1,000	1,350
Moodeyah (Project target year of Moodeyah is 2007)	Moodeyah water service area	Moodeyah (Karn Achal, Karn Marm, Gezt Hageh)	12,000 (including Moodeyah)	15,410			Al-Huthy Al-Asfal	588	790
							Al-Huthy Al-Alieya	266	360
		Al-Magbabh	4,770	5,820			Al-Hadbah	200	270
		Sub-Total	16,770	21,230			Saboha	200	270
	Al-Qurath water service area (As this service area has one existing well, project plans to serve 1/2 population of this area for reinforcement of the existing facilities.)	Al-Qurath Macran Aroudah Am-Grain Al-Gocap Am-Fraidh other 4 villages	(8,250/2) = 4,130	5,050			Sub-Total	5,390	7,260
						Al-Garn water service area	Al-Garn	1,021	1,370
							Radhab	1,145	1,540
							Al-Gazah	610	830
							Ba Thaleb	120	160
							Garah	200	270
							Ba Balheig	550	740
							Al-Omoun	250	340
		Sub-Total	4,130	5,050			Sub-Total	3,905	5,250
	Al-Zyoar water service area	Gibrat Uzura Qariet Faran Am Hafhaf Zyoar Al-Qrih	5,100	6,240		Al-Sufilah water service area	Al-Sufilah	4,860	6,540
							Wadi Aal Dodo	200	270
							Wadi Al Sudif	220	290
							Sub-total	5,280	7,100
						Total		14,575	19,610
		Sub-Total	5,100	6,240	As-Sadarah	As-Sadarah water service area	As-Sadarah	4,850	6,530
	Al-Habir water service area	Al-Habir Bardnap Gef Arbash A-Qashabal Kabran Al-Husn Al-Hasab	4,300	5,270		Surrounding water service area	Hosn Basilaman	2,450	3,300
							Al-Kasha	2,340	3,150
							Al-harjah	260	350
							Thilone	150	200
							Asanned Wa Al-Garib	200	270
							Bamesiblin	360	480
							Gawl Al-Shiekh	220	300
							Al-Nasrieah	120	160
		Sub-Total	4,300	5,270			Ain Bajamaa	360	480
	Total		30,300	37,790		Total		11,310	15,220
					Grand Total			73,685	94,040

3) Planned Served Population

The populations planned to be served by the Project in the respective sites have been determined, based upon the results of the preceding basic design study and this survey. Those of new villages added to the plan by this survey comply with the data collected during the survey.

According to the latest census carried out in the country in 1994, the average growth rate of the national population was estimated at a record 3.5% from the late 1980s when the national censuses were conducted respectively in the former North and South Yemens. On the other hand, the First Five Year Plan for the rural water sector by the GAREW in 1996 uses 2.8% as an annual average rate for the rural population until the year 1999 and 2.7% thereafter, based upon the results of the national census. Although the rates widely vary with the regions, this Project employs the previous estimation by the former Public Water Corporation, as it was difficult to collect the accurate data and information on the trend in the respective sites; 2.6% for Moodeyah and Ahwar which are located along the national highway and are absorbing the population from nearby villages and 2% for Al-Raidah/Shamalya and As-Sadarah situated in the mountainous areas.

The present and planned populations to be served by the Project are listed in the foregoing table 2-5.

4) Unit Supply Rate

For an average rate to be served to the rural population, the Five Year Plan for the rural water supply in 1996 anticipates 30 to 35 lit/capita/day. This Project is based upon the requirement of the design criteria of the former Public Water Corporation; 40 lit/capita/day for the public fountains and 60 lit/capita/day for the house connections. The request by the Yemeni Side to plan basically the system with house connections has also been taken into due consideration. The unit supply rates for the respective sites

are listed in the following table:

Table 2-6 Planned Unit Supply Rates for the 4 Sites

Site Name	Current Consumption (lit/capita/day)	Method of supplying		Planned unit supply rate (lit/capita/day)
		Present	This Project	
Ahwar	25	House connections	House connections	50
Moodeyah	10 – 30	House connections	House connections	40
Al-Raidah Shamalya	20	Water vending	Public fountains	50
As-Sadarah	30 – 40	Springs/dug wells	Public fountains	50

As shown in the above list, the unit rate for Moodeyah is less than that for the other sites because the estimated available water production is not sufficient for a large number of population added to the initial plan. For Al-Raidah/Shamalya and As-Sadarah that have no facilities yet, public fountains are planned to be installed for the initial service system in these sites. Since a majority of the residents in both sites are willing to install their own house connections in both sites, the unit has been set at a higher rate.

5) Planned Supply Rates

In Yemen where water supplies have been restricted all over the country chiefly due to severe water shortages, such factors as the daily average, daily maximum and hourly maximum supply rates is hard to apply to planning. Nevertheless, as house connections increasingly expand in a vast majority of rural communities, these parameters appear more important. In order to fix the planning of facilities for the Project, including the selection of the pipe diameters, the following criteria will be based upon:

a. Planned Daily Average Supply Rate

This rate is the planned supply rate in the Project target year for each site, and is calculated as follows.

* (Planned served population in the target year) x
(Average daily per capita supply rate)

However, the basic daily planned supply rates for the project sites, including Ahwar and Moodeyah, depend on the available daily production rates from the planned water sources.

b. Planned Daily Maximum Supply Rate

This rate is given by multiplying the average daily supply rate by 1.3 . This calculation was a standard adopted for the water supply criteria of the former Public Water Corporation.

* (Planned daily average supply rate x 1.3)

c. Hourly Maximum Supply Rate

This rate indicates a maximum consumption rate per hour in a day in the site, when the maximum number of taps in the villages is assumed to be open. The rate is used to determine the sizes of distribution pipelines. In Yemen, two hours during the lunch time correspond to the period of maximum water use. The calculation of this rate uses a flow ratio index based upon the village population, which is a criterion of the small-scale water facilities standard of Japan, and is assumed to be effectively applied to this Project as well. (An example of the calculation is shown in Appendix 7)

* (Daily maximum supply rate) x
(Hourly maximum rate based on village population) / 24 hours

(3) Planning of Facilities

1) Water Sources

The major water sources in the Project are the existing deepwells except one case of As-Sadarah where an infiltration gallery of the stream flow is designed. The respective water sources in the sites are listed in the following table:

Table 2-7 Water Sources for Project Sites

	Site Name	Conditions	Type	Depth	Number
1.	Ahwar	Existing	Deepwell	70 m	2
2.	Moodeyah	Existing	Deepwell	76 m	5
3.	Al-Raidah/ Shamalya	Existing	Deepwell	260 m-- 310 m	3
4.	As Sadarah	New	Infiltration gallery	-	1

The characteristics of the above facilities are as follows:

a. Existing deepwells

The existing deepwells in Moodeyah and Ahwar were drilled in 1988 to 1990, and have since been remaining closed. If a drilled well is left unused for a long period, water passage is likely to be clogged by hardening of mud left in the borehole during drilling. For the unused wells, therefore, it is considered necessary to conduct cleaning work with a high pressure compressor, together with brushing work to take off hardened materials clogging screen slot openings. If necessary, chemicals to dissolve deposits may be used in order to secure planned productions.

b. Infiltration Gallery

A water source facility is planned in As-Sadarah which will collect running water from the upper stream of the Wadi Hagar. The facility is built of reinforced concrete, consisting of an intake section with filtering materials and wire-wound continuous slot-type screens and a water transmission/storage section. The facility is also equipped with water overflow structure in case of river flooding. The basic design drawings for the above facilities are presented in the flow diagrams of site plans and details of water supply facilities.

2) Pumping Facilities

This section discusses pumps and related auxiliary equipment for the water source.

a. Selection of Pumping Equipment

The two types of pumps most frequently used in Yemen are the diesel engine-driven borehole vertical pumps and the diesel generator-driven submersible motor pumps. The following is a comparison of the characteristics of both pumps.

Table 2-8 Types of Deepwell Pumps

	Submersible motor pump	Borehole pump
Structure	One assembly of a pump and a motor, both installed in the well, driven by a power source (generator) on the ground surface through an electric cable.	A pump installed in the well and a drive unit on the ground surface, connected with a string of shafts for power transmission.
Power source	Electric power (generator)	Mechanical power transmission with an engine or electricity.
Capacity and Performance	High-speed rotation and high -pressure types are available	Due to the structure of the vertical axis, high-speed rotation is impossible, and a high head is difficult.
Characteristics	Overloading may be caused if excessive sand or other foreign material intrude inside the pumps, likely to cause damage with motor.	Due to its mechanical structure, relatively durable against foreign materials.

Engine-driven borehole pumps have widely been used in Yemen due partly to the power supply conditions, and partly to long experience in operation and maintenance. Except for the areas that require large total heads, engine-driven borehole pumps are generally recommended. This type is usually used at deepwell stations with a pump head less than 150 m. However, at the stations where a deepwell pump and a booster

pump are installed in one room, a diesel generator is used for the combined use of both pumps. In Al-Raidah/Shamalya where the static water level is deep, there is no choice but for a submersible motor pump.

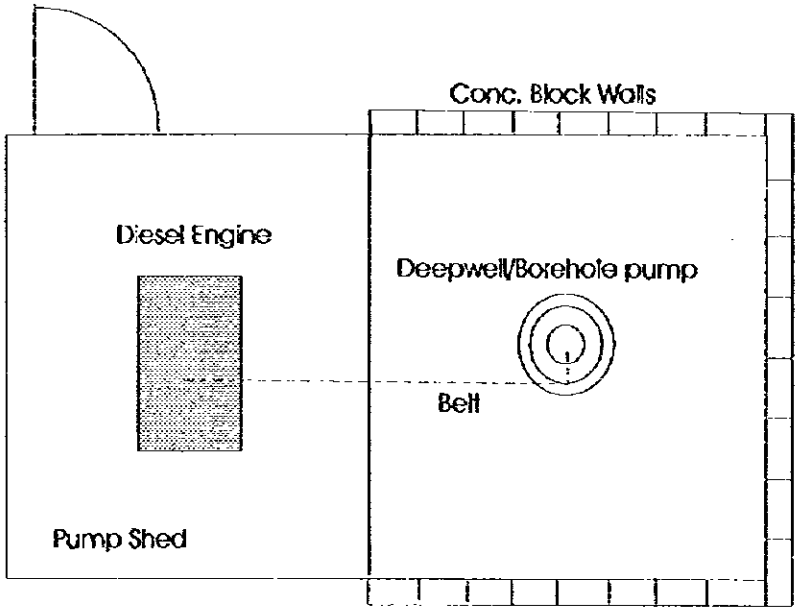
b. Control of Deepwell Pumps

In view of the current conventional practice of operation and maintenance in the country's rural water projects, a minimum control system is adequate for the Project to avoid troubles due to malfunctioning of a complex control system. One of such controls provided in the Project is an automatic shutoff of pump running at a low water level in the deepwell to prevent an abrupt drop of water levels due to excessive pumping, which may result in motor burnout, pump failure and in the worst case eventual drying up of the deepwell itself. Nevertheless an automatic re-starting system triggered by a water level recovery is not necessary, since it is likely to make a complex control system. Even though a low level automatic stop is to be provided, water level measurements must routinely be carried out by the operator as a basic requirement for maintenance.

c. Deepwell Pump Stations

The pump station for housing a deepwell pump and the well itself needs a special measure different from that for a booster pump. In case any trouble happens to the well or pump, a crane truck or sometimes a drilling machine is called for operation at the base of the well. Therefore it is not advisable to enclose the deepwell facility entirely in a pump house. In many local pump houses in Yemen, the well is left in the open outside, while the shed houses only a power unit.

Fig. 2-6 Typical Deepwell Pump Shed in Rural Yemen



The deepwell facility left in the open is not a wise way in terms of facilities protection and contamination prevention. The design for the Project proposes a detachable structure of housing for the deepwell facilities, made of steel sheet and fastened with bolts to the walls and floor of the pump station so that it can be removed when an operation is necessary at the base of the well. (Refer to the attached basic drawings.)

3) Booster Pump Facilities

a. Types of Booster Pumps

In contrast to vertical pumps for deepwells, booster pumps are horizontal pumps directly coupled to drive units. In this Project, boosting facilities are planned for (1) Ahwar and Moodeyah, where numbers of water wells are simultaneously operated to send water to the distribution tank, and the service rate must be adjusted; (2) As-Sadarah, where the pumping mains from the well to the final distribution tank runs for a long distance over the rugged terrain. In case of Al-Raidah/Shamalya, water is directly pumped up to the distribution tank without an intermediate facility

so that operation and maintenance of the system could economically be carried out without much difficulty.

Two power sources to drive the booster pump are available: engine or diesel generator. The engine direct coupling drive is simple and economical, but electrical power is necessary when using the control system for booster pump protection. Therefore, the pump will basically be of an electric motor direct coupling-type and operated by a generator. For As-Sadarah, all the booster pumps are of diesel engine driven type, according to the request of the residents.

b. Controls for Booster Pumps

Controlling of booster pump operation is based upon a similar principle to the one for the well pump, as follows:

* Reservoir Low Water Level Control

A booster pump shall be installed with a control panel including a system to automatically stop its running when the water level of the reservoir has dropped to its low. However, the automatic recovery of operation is not considered to be necessary.

* Reservoir High Water Level Alarm

The open structure of water tanks in Yemen allows excess water to discharge through overflow pipes and the pump continues to deliver water even after the tank is full. A control system which automatically stops the pumping when the tank gets full has not been used for the rural water supply in Yemen. The operators learn from experience to stop the pump after a certain period when the water tank becomes full. Operators keep watching pump running not to waste precious water.

As one of measures to improve this traditional operation, a simple control equipment is proposed for the Project which can signal the operator when the tank got full. This control uses the occurrence of dynamic water pressure rises in the

pumping line when the destination water tank becomes full and overflows. When pressure changes are detected in the pipes, a control panel in the pump station catch the signal and an alarm goes off. This system consists simply of a meter and a control panel, both to be installed in the pump station.

* Booster Pump Station

The main structure and finish of the booster pump station is the same as those of the well station except a well shed attached to the latter. In Moodeyah and Ahwar, the booster pump station is designed to house a deepwell pump facility as well as a booster pump in one room. Therefore, the pump station is slightly larger than the ones in As-Sadarah.

4) Water Tanks

a. Function of Water Tanks

The Project includes the following types of water tanks:

* Booster Tanks

– Where a distance of water transportation is quite long over the rugged terrain, water is delivered via a booster station consisting of a booster pump and a water tank. The Project designs this type of facility for As-Sadarah.

– Where the water source consists of more than one deepwells, and the distance from these wells to the distribution tank is very long, discharges from the wells had better be collected into an intermediate reservoir near the water sources and then transported through a pumping main to the tank by a booster pump, in order to transmit a stable quantity of planned supply rate. This system applies to the sites of Ahwar and Moodeyah.

* Distribution Tanks

The distribution tank acts as a reservoir for water distribution to villages comprising a service area. Since water is distributed by gravity, the tank is to be constructed at

nearly the highest location in the site. The elevated water tank is planned for Ahwar situated on flat land of the coastal area.

b. Structure of Tanks

The standard water tank structure for rural water projects in the southern part is a masonry tank, featuring side walls built of stone material. Its upper and lower slabs are normal reinforced concrete structure, but only stones fixed with concrete form the four side walls to reinforce the tank strength. The side walls of this tank are so thick that they can have an effect to alleviate the influence of the outside heat on the stored water. This is a relevant structure for the country's southern area where intense heat lasts for much of the year. The stone tank also has an appearance harmonizing with the surrounding environment. As this structure was the standard specification of the former Public Water Corporation, this type of tanks has been built in various locations all over the southern part. Their capacities range from 10,000 gal (approximately 50 m^3) to 60,000 gal (approximately 300 m^3), increasing in units of 10,000 gal. Their standard specifications and drawings are available. When the capacity becomes extremely large, it is difficult for the tank to have sufficient strength in its stone wall, and normal reinforced concrete or panel tanks are used. (the 750 m^3 existing tank in Al-Raidah/Shamalya is concrete-made, and the water tanks in the Crater Area of Aden are steel panel tanks.)

The British-made prefabricated steel plate panel tanks have often been employed for elevated water tanks. A similar type of tanks was used in the previous Japanese project, for both elevated and ground tanks. The water tank of this type installed for the first time in North Yemen under the loan project is more than 15 years old, and the tank is still in use without any problem. Corrosion resistant and rust resistant coatings applied on the surface of panels provide strong protection even under the tropical coastal climate such as in the Tihama lower pressure zone in North Yemen.

As a result of an examination of the situation related to water tank facilities in South Yemen, together with the evaluation of the preceding Japanese projects, the following water tank structure is appropriate for this Project

– Ground water tank: Masonry tanks

– Elevated water tank: Steel panel tanks

The existing masonry tanks have no level indicator, but this Project plans to provide an appropriate indicating instrument.

e. Tank Volume

* Booster Tanks

Since the booster tank acts as an intermediate reservoir on the way of water transportation, its volume is based on the retention period of the booster pump discharge rate. The retention period for the sites in the Project is 60 minutes. The type of the tank is of masonry make, and the volumes of tanks for the respective sites are as follows:

- Ahwar 100 m^3
- Moodeyah 100 m^3
- As-Sadarah 50 m^3

* Distribution Tanks

The distribution tank volume is based upon the house connection system, where the required water storage volume is decided, based upon an analysis of the pumping rate from the water source and the water consumption rate. The following table shows the water tank volumes for each project site:

Table 2-9 List of Water Tanks in the Project Sites

	Site Name	Service Area	Type	Capacity
1	Ahwar	Ahwar	Elevated tank of steel panels	250 m^3
2	Moodeyah	4 areas	Ground tank, masonry	300 m^3
3	Al-Raidah/ Shamalya	Al-Aulieb	Ground tank, masonry	200 m^3
		Al-Sufila	Ground tank, masonry	200 m^3
		Al-Garn	Ground tank, masonry	150 m^3
4	As Sadarah	New	Ground tank, masonry	300 m^3

5) Pipelines

a. Classification of Pipelines

Pipelines for the water facilities are classified depending on their functions. All the pipelines to convey water by pressure directly to the distribution tank from the water source or via a booster station are called "pumping main" lines. The pipelines installed for supply to the villages from the water tank are classified as "distribution" pipelines and "service" pipelines. Furthermore, the distribution lines can be divided into the "distribution mains" (distribution lines without service or house connections) and the "distribution branch" lines (distribution lines connected with house connections). Nevertheless, the pipelines in the rural villages are different from those in cities, where the mains and branch pipelines cannot be clearly distinguished. The basic principle for distribution lines of this Project is to install all the major distribution lines under the Project except for house connections. However, pipelines connecting distribution lines with public fountains, which are grouped as service lines, are included in the Project.

b. Pipe Materials

The types of pipe materials used in Yemen for water supply are as follows.

* Ductile cast-iron pipes (only for water supply in large cities, such as the capital of Sana'a)
* Galvanized steel pipes for water supply (covering over 90% of existing pipelines in the country)
* Asbestos cement pipes for water supply (not in use in the North, but still common for larger sizes of lines in the South. Strength is low compared with other pipes.)

Among the above-listed pipes, the majority in use throughout the country are galvanized steel pipes. Although inexpensive, vinyl pipes are not in use since most of the land is made up of hardrock outcroppings where pipelines are usually laid exposed. Exposed vinyl pipes are vulnerable to extreme temperature changes.

Only galvanized steel pipes have so far been used in the Japanese projects in North Yemen. Further in the North, which is dominated by mountains and rugged terrain, high-pressure pipes with thick walls (conforming to JIS G-3443) are frequently required for pumping mains.

Strong and flexible pipes must be used for this Project. As a result of the examination of the water transportation and distribution plan, the following pipes are selected.

* Ductile cast-iron pipes

  In this Project, the pumping and distribution lines with a diameters of 200 mm must be used in the two sites of Ahwar and Moodeyah. Part of 200 mm line in Moodeyah needs to be laid exposed in a rugged mountainous area, and such working condition requires a firmly welded and supported line of 200 mm galvanized steel pipe on the rock bed. Major part of 200 mm lines to be used both in Ahwar and Moodeyah are ductile cast iron pipe of Type-T with slip-on joint, which is excellent in workability. These lines are designed to be buried in the field along the roads. Although the cast iron pipe has rarely been used in the rural water projects in Yemen, the project plans to employ this type of pipe because of difficulty in locally recruiting a lot of welding technicians for completing long welded lines of 200 mm steel pipes.

* Galvanized steel pipe for water supply

  For the pipelines with diameters less than 200 mm, threaded galvanized steel pipe is used, as has been the case with the foregoing projects. For the steel pipelines, a flange or union coupling is designed to be installed every 10 sections of pipe (5.5 m/pc), which is the standard construction method in Yemen. Whenever local maintenance, inspection or repair is necessary, this measure enables the easy removal of pipe sections. The diameters of pipes range from 25 mm to 150 mm. This Project does not need high-pressure pipe except for some extension of pump connections in As-Sadarah since the pump discharge pressure at the booster pump stations there exceeds well over 100 m.

c. Pipe Sizes

Pumping main, distribution and service lines in this Project require pipe sizes ranging from 25 mm to 250 mm. For the calculation of sizes, the following formulas have been employed, based upon the unit quantity of flow through the pipe:

– Pipe diameter 50 mm or less : Empirical formula of Tokyo Metropolitan Water Works

– 65 mm or more : Hazen-Williams formula

The calculation also must take the velocity of flow at a given quantity into account. A higher velocity can make a pipe size smaller, but results in a larger capacity of a power unit for a pump due to the increase of pressure head. Experience has determined an "economic velocity" which can balances the relations of a pipeline to equipment in terms of the cost including both their construction as well as operation and maintenance. According to this standard, the economic velocity for the pipe sizes up to 150 mm used for this Project is recommended to be 0.7 to 1.0 m/sec.

This Project has further taken the following factors into consideration.

* Pumping main

  A smaller velocity is effective for protecting pipelines against water hammering. In this view, the lower range of economic velocity has been reduced to 0.5 m/sec to overcome the complicated changes in mountainous slopes through which pumping main is installed.

* Distribution Lines

  The service pressure at each village has to be considered when determining distribution pipe size. In this Project, the standards of the former PWC are also referred to and consideration is made to ensure a terminal service pressure of 10 m or greater.

d. Other Plumbing Materials

Various plumbing devices including valves are necessary along the pumping main and distribution pipelines, as follows:

* Air vent valves : to be installed at the highest points of prominently elevated sections along the course of pipeline

* Drain valves : to be installed at depressed sections along the pipeline courses where such arrangements are considered necessary, using gate valves

e. Measures to Protect Pipelines against Damages

* Expansion and Contraction of Pipelines

Pipelines in the country's mountainous regions are mostly exposed on rocky ground surface. Directly affected by the typical highlands climate intensely differing in temperature during day and night, in some cases reaching 20℃, the exposed lines follow a cycle of expansion and contraction. In an extreme case, this movement results in breakage in pipe connections. A rough estimate of such expansion and contraction range is about 1 cm for every 100 m of pipeline.

To absorb this expansion, several types of special fittings are effective, but most of them have difficulties in the installation on long pipelines over the rugged terranes. In particular, the fittings for high-pressure service are limited and costly, and their use in quantities is not considered practical. Local pipelines have no such fittings, but manage to avoid possible damage through an arrangement of pipes during installation. The pipelines do not run straight, having many bends, artificial or natural due to the weight of a pipeline, which function to absorb the expansion; lots of elbow-to-elbow connections along steep slopes are another arrangement for evading contortion. Pipelines in previous Japanese projects successfully employed such arrangements, and this experience will be utilized for the pipeline design for exposed pipes.

* Water Hammering

The transmission lines in this Project involve a high risk of causing water hammering due to their long distances over intensively varying rugged terranes of the sites. Water hammering may result in damages to pipelines and pumps. To safeguard against such accidents, the following measures are judged to exert practical effects.

- Check valves for pumps shall be of slow-closing type.
- Transmission lines shall be of large diameters and their velocities kept to a minimum.

These measures have already been taken in the previous projects, and water hammering countermeasures using special auxiliary devices have been taken for the areas where topographical changes are intense. Although the respective countermeasures involve cost increase, they are judged to be indispensable, and necessary measures will be taken mainly using the above two items after sufficient examination.

6) Service Facilities

In order to increase the effectiveness of the Project, public fountains will be installed in proper locations within the villages of both Al-Raidah/Shamalya and As-Sadarah, where new distribution networks will be installed. House connections in a portion of the villages will be made in the future, but some residential groups are predicted to continue the effective use of public stands. This ratio cannot be determined because of regional differences. According to the former PWC planning standards, the maximum ratio for house connections is 70% in the rural villages.

Three types of public water stands, in accordance with the number of taps, will be used for this Project. (Refer to the attached basic design drawing for details.)

In regard to the taps to be installed on these stands, since the water tank will be installed

at an elevated location, part of the villages near the tank tends to have high-pressure water supply. An ordinary type of 5 kg/m^3 tap, therefore, is weak, and a ball valve pressure-tight water tap which has been used in the foregoing projects will be used.

(4) Details of Planning for the Project Sites

The planning of facilities at four project sites based upon the basic design is formulated in the following table.

Table 2-10 List of Water Supply Facilities for the Project Sites

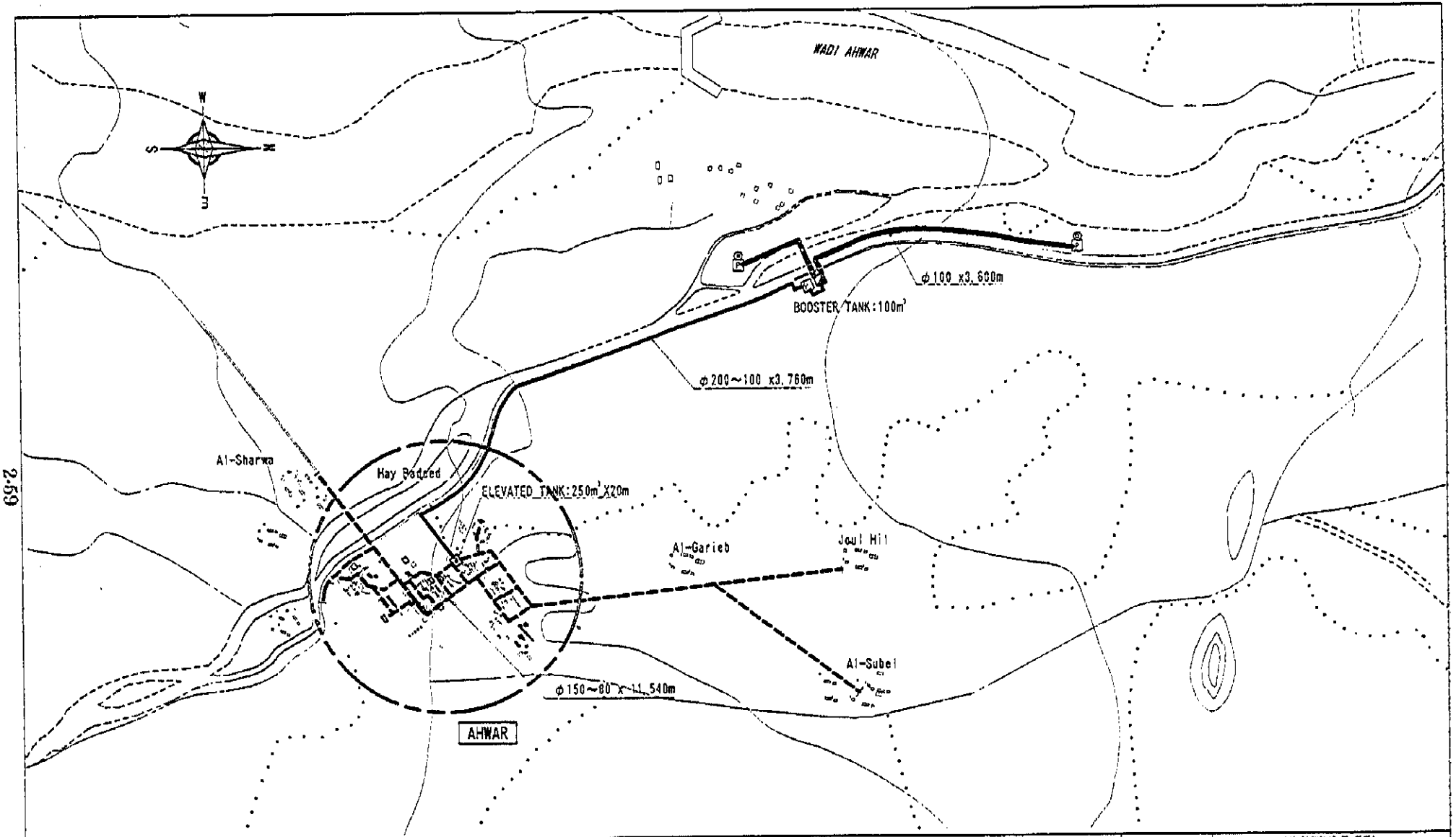
Project Sites	Category	Facilities	Specifications	Q'ty
Ahwar	Water Source	(* Existing Deepwell)	(Depth 70m) Rehabilitation works	2 Nos.
	Intake Facilitie	Deepwell Pump	Borehole pump 600 lit/m x 110 m x 31kw	2 Nos.
		Deepwell Pump Station	Reinforced concrete construction with concrete block wall	2 Nos.
		Pumping Main	SGP ϕ 100mm	3,600 m
	Transmission Facilities	Booster Pump	Horizontal type volute pump 1,200 lit/m x 77m x 37 kw	2 Nos.
		Booster Pump Station	Reinforced concrete construction with concrete block wall	1 No.
		Booster Tank	100 m^3, Reinforced concrete construction with masonry wall	1 No.
		Pumping Main	DIP ϕ 200mm	1,610 m
			SGP ϕ 150mm	2,100 m
			SGP ϕ 100mm	50 m
	Distribution Facilities	Distribution Tank	Elevated panel tank 250 m3 x 20 m	1 No.
		Distribution Line	SGP ϕ 150 mm	2,880 m
			100 mm	3,050 m
			80 mm	4,260 m
Moodeyah	Water Source	(* Existing Deepwell)	(Depth 75m) Rehabilitation works	5 Nos.
	Intake & Transmission Facilities	Deepwell Pump	Borehole pump: 340lit/mx 100 m x 27kw	4 Nos.
			Submersible pump: 340lit/m x 100 m x11kw	1 No.
		Booster Pump	Horizontal type volute pump 1,200 lit/m x 100m x 45kw	2 Nos.
		Diesel generator	130 KVA, 400 V	1 No.

Project Sites	Category	Facilities	Specifications	Q'ty
Moodeyah		Deepwell Pump Station	Reinforced concrete construction with concrete block wall	4 Nos.
		Deepwell Pump & Booster Station	Reinforced concrete construction with concrete block wall	1 No.
		Booster Tank	100 m^3, Reinforced concrete construction with masonry wall	1 No.
		Pumping Main	SGP ϕ 100 mm	2,200 m
			SGP ϕ 200 mm	1,245 m
	Distribution Facilities	Distribution Tank	300 m^3, Reinforced concrete construction with masonry wall	1 No.
		Distribution Line	DIP ϕ 200 mm	10,270 m
			SGP ϕ 200 mm	815 m
			ϕ 100 mm	2,530 m
			ϕ 80 mm	2,565 m
Al-Raidah /Shamalya	Water Source	(* Existing Deepwell)	(Depth 270-310m) Rehabilitation works	3 Nos.
	Intake & Transmission Facilities	Deepwell Pump	Submersible pump: 400lit/m x 380 m x45kw	3 Nos.
		Diesel generator	130 KVA, 400 V	3 Nos.
		Deepwell Pump Station	Reinforced concrete construction with concrete block wall	3 Nos.
		Pumping Main	SGP ϕ 100	5,350 m
	Distribution Facilities	Distribution Tank	200 m^3, Reinforced concrete construction with masonry wall	2 Nos.
			150 m^3,Reinforced concrete construction with masonry wall	1 No.
		Distribution Line	DIP ϕ 200 mm	350 m
			SGP ϕ 200 mm	1,450 m
			ϕ 150 mm	8,260 m
			ϕ 100 mm	6,560 m
			ϕ 80 mm	11,910 m
			ϕ 50 mm	1,960 m
	Service Faciliti	Public Fountain	4-Tap	9 Nos.
			2-Tap	6 Nos.
As Sadarah	Water Source	Infiltration Gallery	Reinforced concrete construction, Infiltration screen	1 No.

Project Sites	Category	Facilities	Specifications	Q'ty
As Sadarah	Intake Facilitie	Intake Pump	Diesel driven horizontal volute pump 1,000 lit/m x 50 m x 40ps	2 Nos.
	Transmission Facilities	Booster Pump (1)	Diesel driven horizontal volute pump 1,000 lit/m x 50 m x 40ps	2 Nos.
		Booster Pump (2)	Diesel driven horizontal volute pump 1,000 lit/m x 140 m x 37kw	2 Nos.
		Intake Pump Station	Reinforced concrete construction with concrete block wall	1 No.
		Booster Pump Station	Reinforced concrete construction with concrete block wall	2 Nos.
		Booster Tank	50 m^3, Reinforced concrete construction with masonry wall	2 No.
		Pump Main	SGP ϕ 150 mm	7,000 m
	Distribution Facilities	Distribution Tank	300 m^3, Reinforced concrete construction with masonry wall	1 No.
		Distribution Line	SGP ϕ 150 mm	3,640 m
			ϕ 125 mm	1,030 m
			ϕ 100 mm	4,020 m
			ϕ 80 mm	1,660 m
			ϕ 50 mm	1,550 m
	Service Faciliti	Public Fountain	4-Tap	9 Nos.
			2-Tap	4 Nos.

Flow Diagrams of Site Plans
And
Details of Water Supply Facilities

1. Site plan : AHWAR
2. Details of Distribution Network in Ahwar City
3. Site plan : MOODEYAH
4. Site plan : AL-RAIDAH/SHAMALYA
5. Site plan : AS-SADARAH
6. Typical Structure of Installation of Deepwell Pumps
7. Layout Plan for Infiltration Gallery
8. Layout Plan for Elevation Tank : 250m^3
9. Layout Plan for Masonry Reservoir : 300m^3
10. Layout Plan for Masonry Reservoir : 100m^3
11. Typical Pump House construction Type-A / Elevation
12. Typical Pump House construction Type-C / Elevation
13. Public Fountain 4-Tap
14. Details of Pipeline-1
15. Details of Pipeline-2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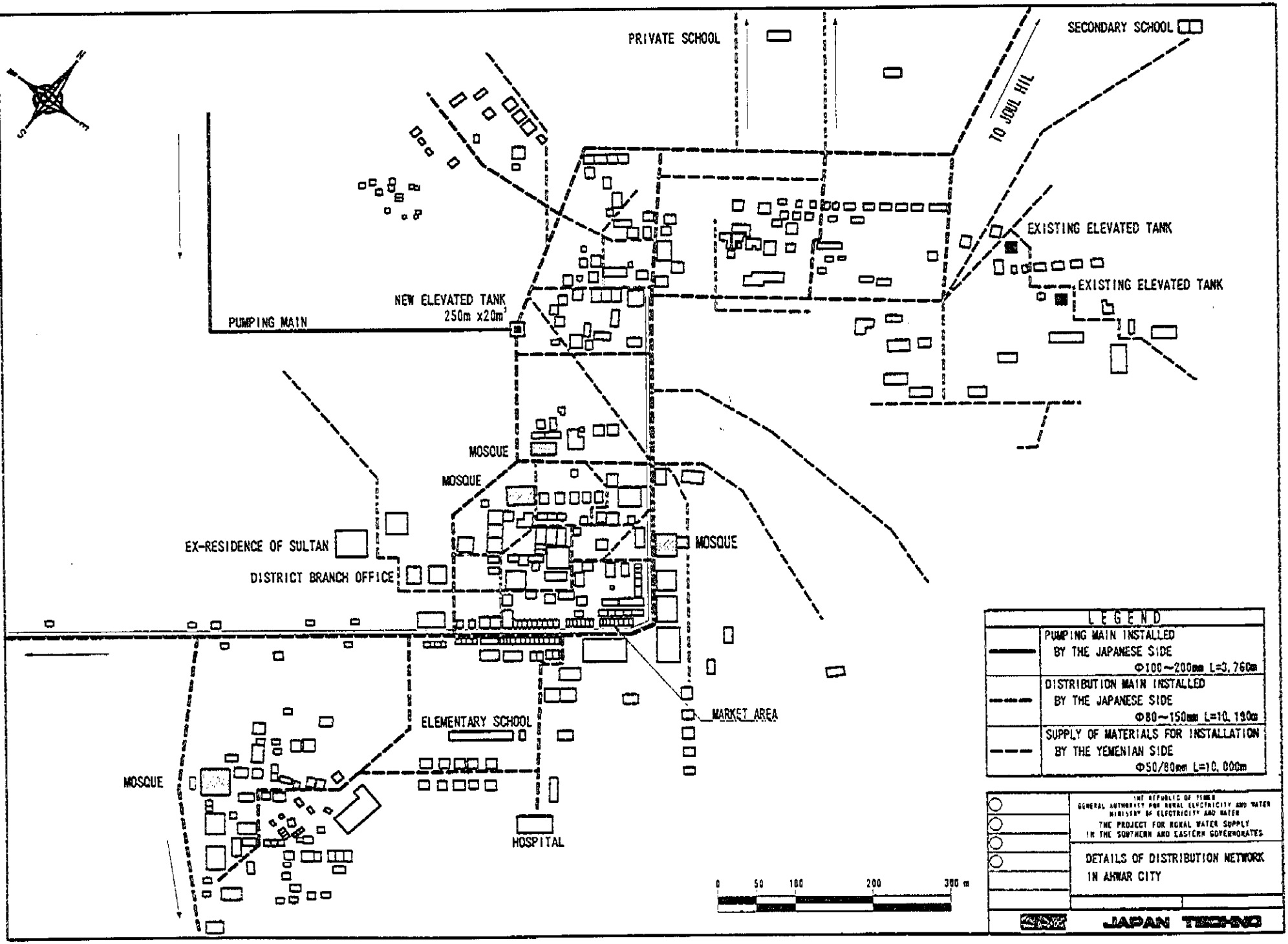
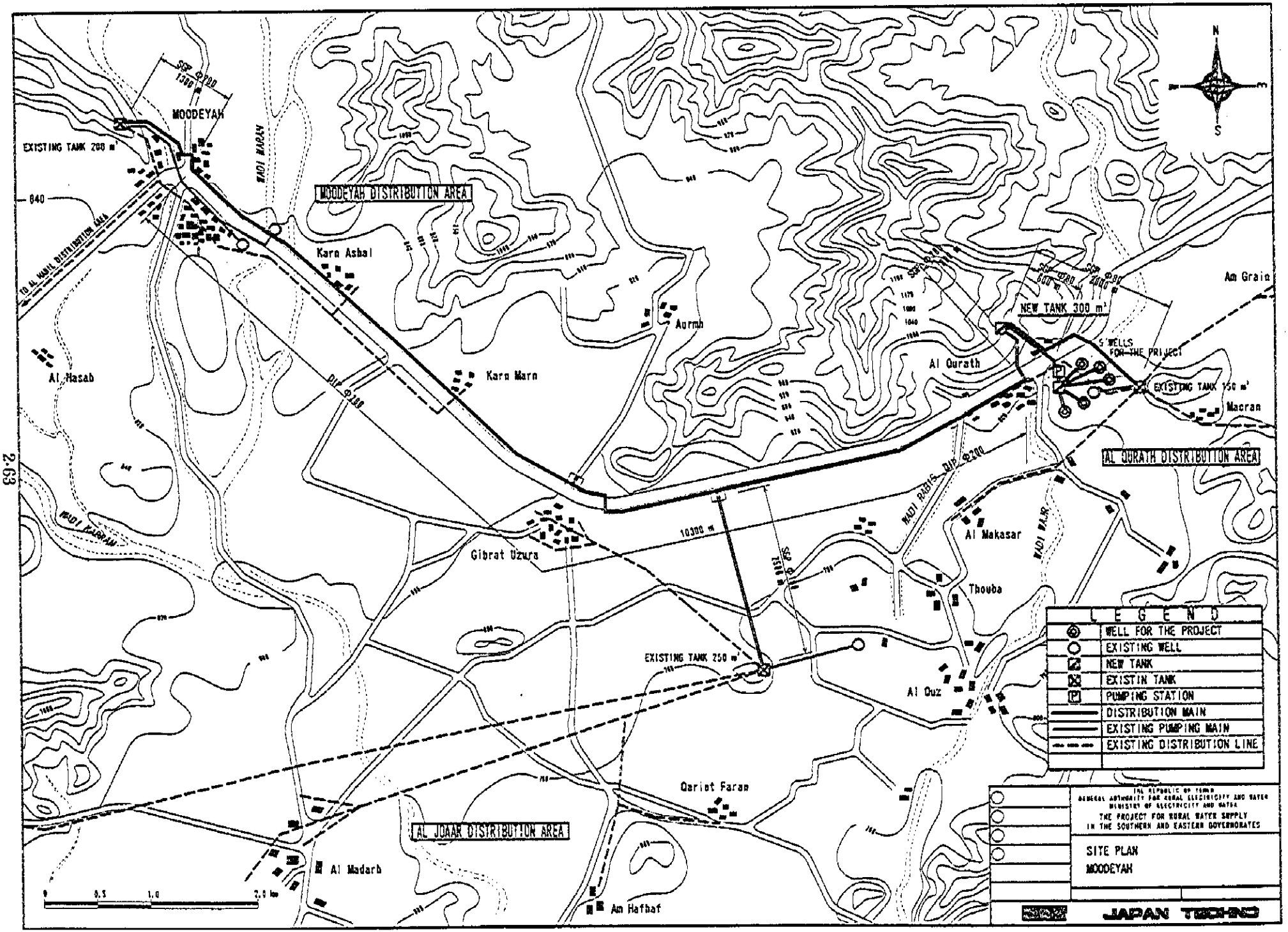
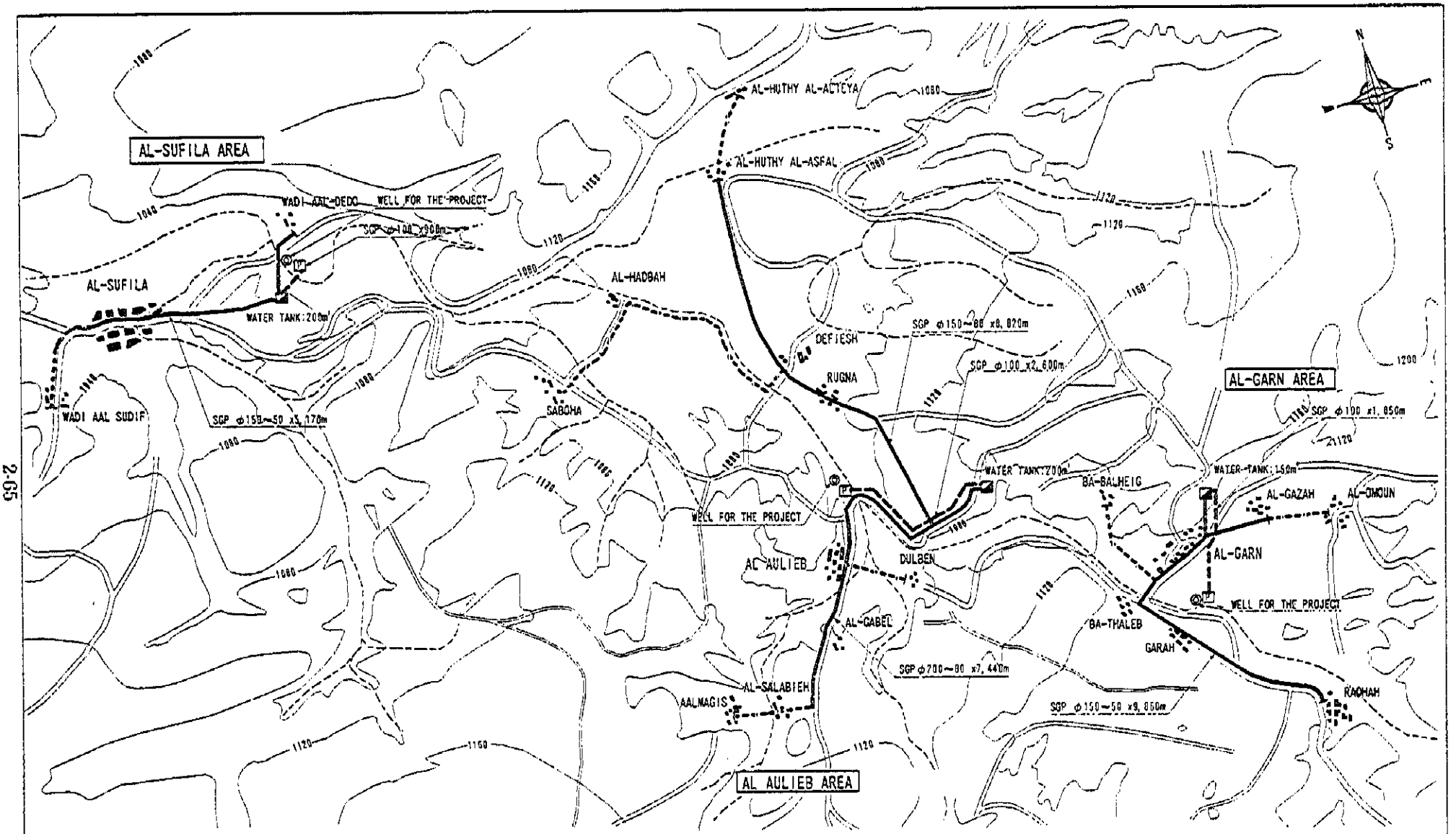
W
S
N
E
φ100 x3,600m
BOOSTER TANK:100m³
φ200~100 x3,760m
Al-Sharwa
Hay Padeed
ELEVATED TANK:250m³ X20m
Al-Garieb
Joul Hil
Al-Subei
φ150~80 x11,540m
AHWAR
PUMPING MAIN-1
PUMPING MAIN-2
DISTRIBUTION LINE
ELEVATED TANK
BOOSTER TANK
PUMP HOUSE
WELL FOR THE PROJECT
0
0.5
1.0
2.0 km
THE REPUBLIC OF YEMEN
GENERAL AUTHORITY FOR RURAL ELECTRICITY AND WATER
MINISTRY OF ELECTRICITY AND WATER
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES
SITE PLAN
AHWAR
JAPAN TECHNO


PRIVATE SCHOOL
SECONDARY SCHOOL
TO SOUL HIL
EXISTING ELEVATED TANK
EXISTING ELEVATED TANK
NEW ELEVATED TANK
250m x20m³
PUMPING MAIN
MOSQUE
MOSQUE
MOSQUE
EX-RESIDENCE OF SULTAN
DISTRICT BRANCH OFFICE
MARKET AREA
ELEMENTARY SCHOOL
MOSQUE
HOSPITAL
0 50 100 200 300 m
LEGEND
PUMPING MAIN INSTALLED BY THE JAPANESE SIDE Φ100~200mm L=3,760m
DISTRIBUTION MAIN INSTALLED BY THE JAPANESE SIDE Φ80~150mm L=10,190m
SUPPLY OF MATERIALS FOR INSTALLATION BY THE YEMENIAN SIDE Φ50/80mm L=10,000m
THE REPUBLIC OF YEMEN
GENERAL AUTHORITY FOR RURAL ELECTRICITY AND WATER
MINISTRY OF ELECTRICITY AND WATER
THE PROJECT FOR RURAL WATER SUPPLY IN THE SOUTHERN AND EASTERN GOVERNORATES
DETAILS OF DISTRIBUTION NETWORK IN AHWAR CITY
JAPAN TECHNO


MOODEYAH
EXISTING TANK 200 m³
WADI MAQAN
MOODEYAH DISTRIBUTION AREA
Karn Ashal
Aurmh
Karn Marn
Al Hasab
Al Qurath
NEW TANK 300 m³
5 WELLS FOR THE PROJECT
EXISTING TANK 150 m³
Am Grain
Masran
AL QURATH DISTRIBUTION AREA
Gibrat Uzura
Al Makasar
Thouba
Al Quz
EXISTING TANK 250 m³
Qariat Faran
AL JOAAR DISTRIBUTION AREA
Al Madarb
Am Hafhaf
LEGEND
WELL FOR THE PROJECT
EXISTING WELL
NEW TANK
EXISTIN TANK
PUMPING STATION
DISTRIBUTION MAIN
EXISTING PUMPING MAIN
EXISTING DISTRIBUTION LINE
THE REPUBLIC OF YEMEN
GENERAL AUTHORITY FOR RURAL ELECTRICITY AND WATER
MINISTRY OF ELECTRICITY AND WATER
THE PROJECT FOR RURAL WATER SUPPLY IN THE SOUTHERN AND EASTERN GOVERNORATES
SITE PLAN
MOODEYAH
JAPAN TECHNO


AL-SUFILA AREA
AL-HUTHY AL-ACTEYA
AL-HUTHY AL-ASFAL
WADI AAL-DEDO WELL FOR THE PROJECT
SGP φ100 x900m
AL-SUFILA
WATER TANK:200m
AL-HADBAH
DEFIESH
RUGNA
SGP φ150~80 x8,820m
SGP φ100 x2,600m
AL-GARN AREA
SGP φ100 x1,850m
WADI AAL SUDIF
SGP φ150~50 x5,170m
SABOHA
WATER TANK:200m
WATER TANK:150m
BA-BALHEIG
AL-GAZAH
AL-OMOUN
WELL FOR THE PROJECT
AC AULIEB
DULBEN
AL-GARN
WELL FOR THE PROJECT
AL-GABEL
BA-THALEB
GARAH
SGP φ700~80 x7,440m
AL-SALABIEH
AALMAGIS
SGP φ150~50 x9,850m
RAOHAH
AL AULIEB AREA
N
S
PUMPING MAIN
DISTRIBUTION LINE
SUPPLY OF MATERIALS
WATER TANK
PUMP HOUSE
WELL FOR THE PROJECT
0 0.5 1.0 2.0 4.0 km
THE REPUBLIC OF YEMEN
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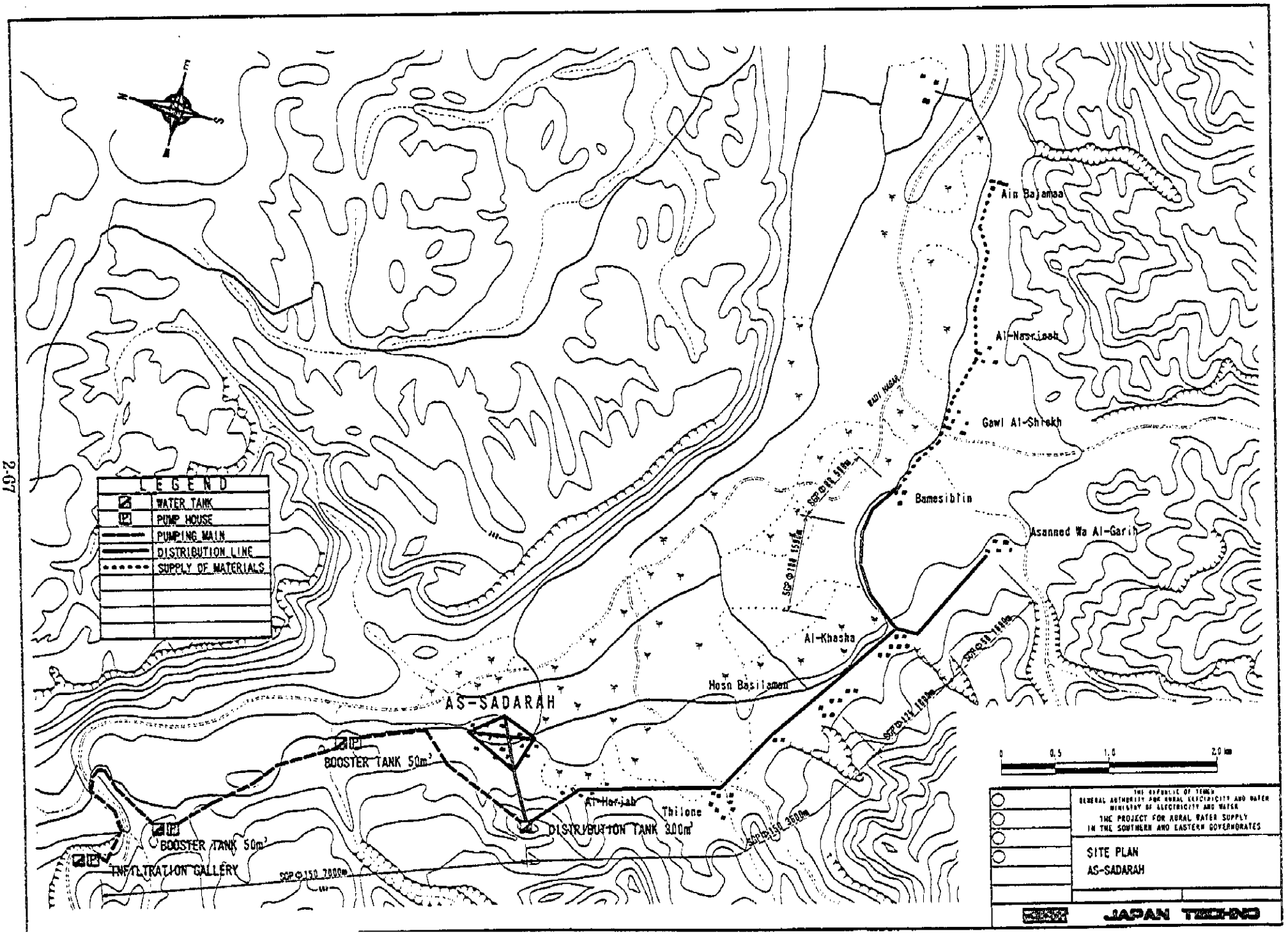
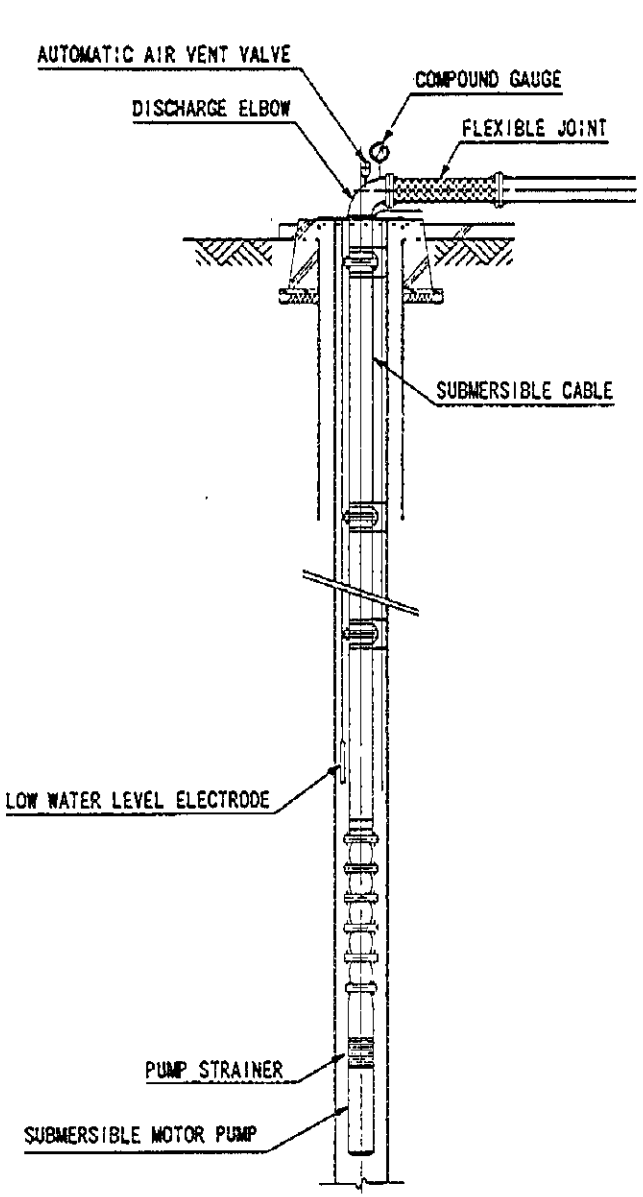
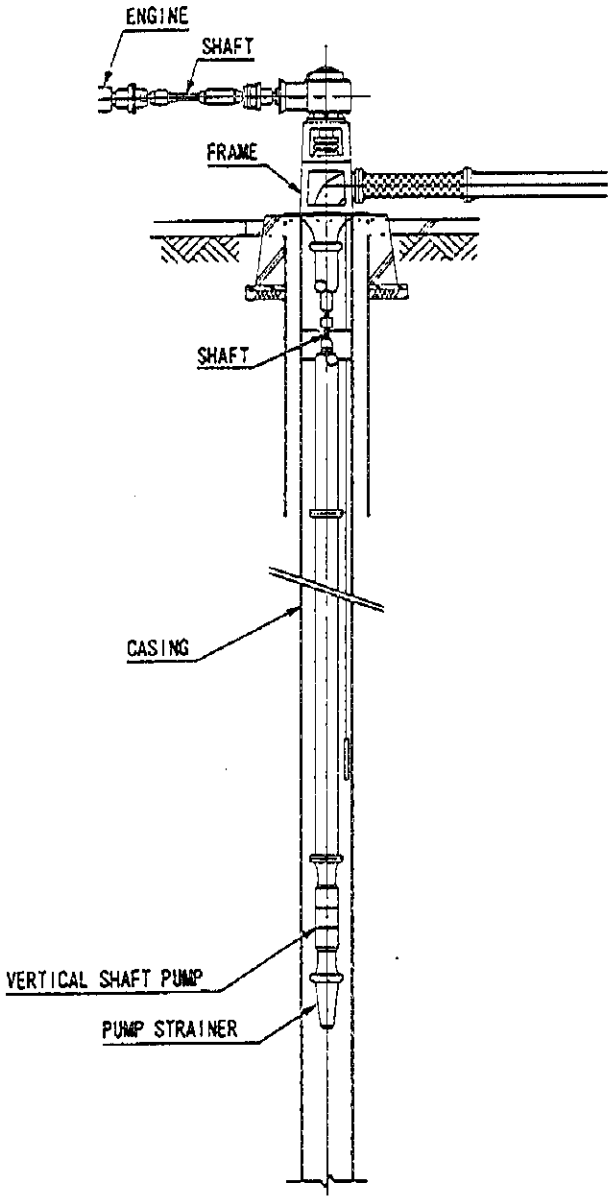
MINISTRY OF ELECTRICITY AND WATER
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES
SITE PLAN
AL-RAIDAH / SHIMALYA
JAPAN TECHNO


LEGEND
WATER TANK
PUMP HOUSE
PUMPING MAIN
DISTRIBUTION LINE
SUPPLY OF MATERIALS
AS-SADARAH
BOOSTER TANK 50m³
BOOSTER TANK 50m³
INFILTRATION GALLERY
DISTRIBUTION TANK 300m³
Ain Bajamaa
Al-Nasrjash
Gawl Al-Shiekh
Bamesibtin
Asanned Wa Al-Garih
Al-Khasha
Hosn Basilamen
At-Horjah
Thilone
0 0.5 1.0 2.0 km
THE REPUBLIC OF YEMEN
GENERAL AUTHORITY FOR RURAL ELECTRICITY AND WATER
MINISTRY OF ELECTRICITY AND WATER
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES
SITE PLAN
AS-SADARAH
JAPAN TECHNO



SUBMERSIBLE MOTOR PUMP



VERTICAL SHAFT PUMP

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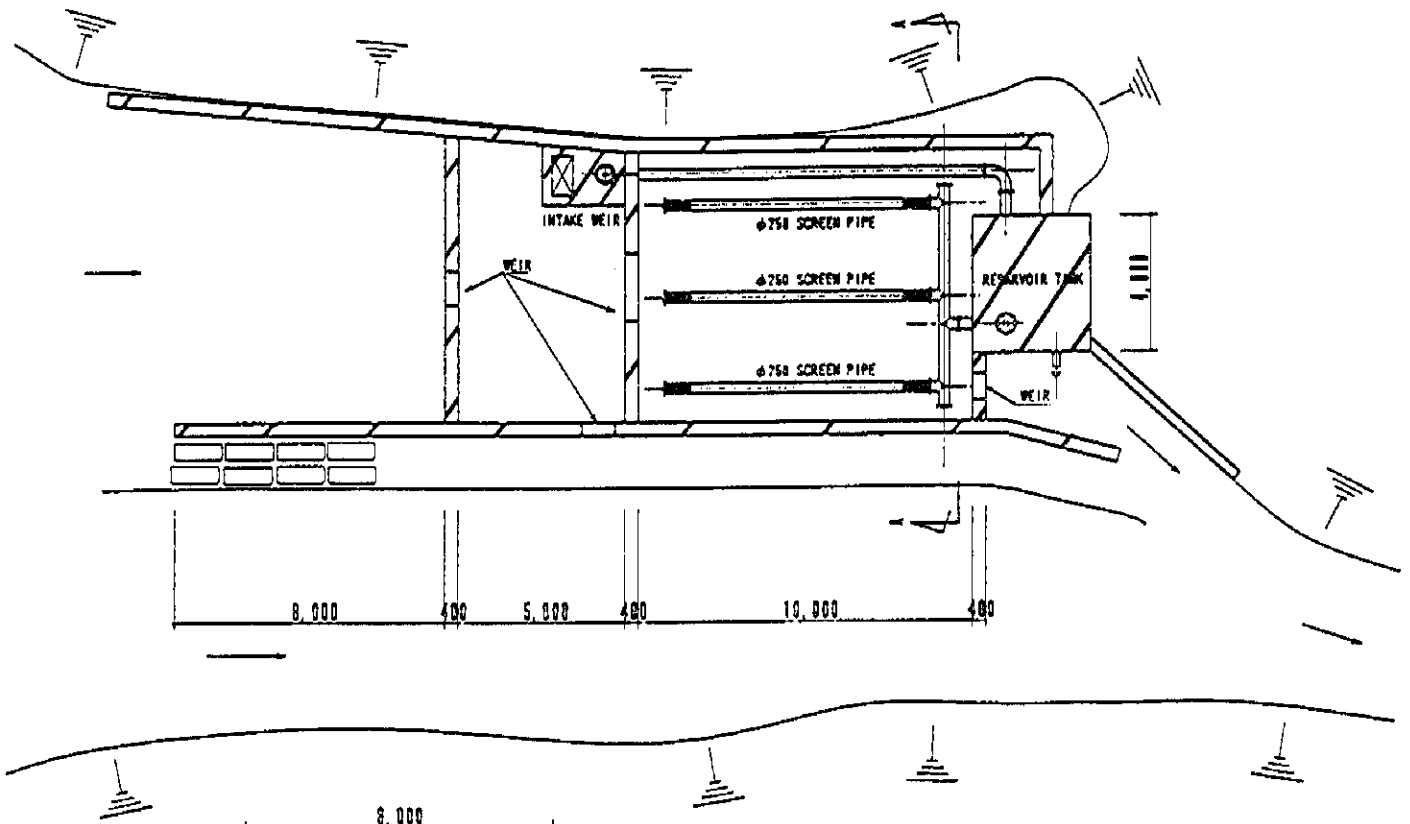
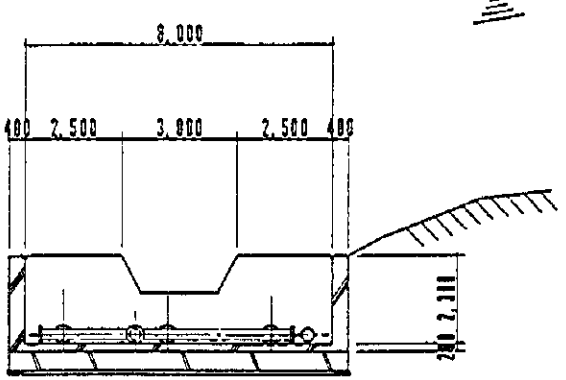
MINISTRY OF ELECTRICITY AND WATER

THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES

TYPICAL STRUCTURE OF INSTALLATION
OF DEEPWELL PUMPS

JAPAN TECHNO





A - A

THE REPUBLIC OF YEMEN
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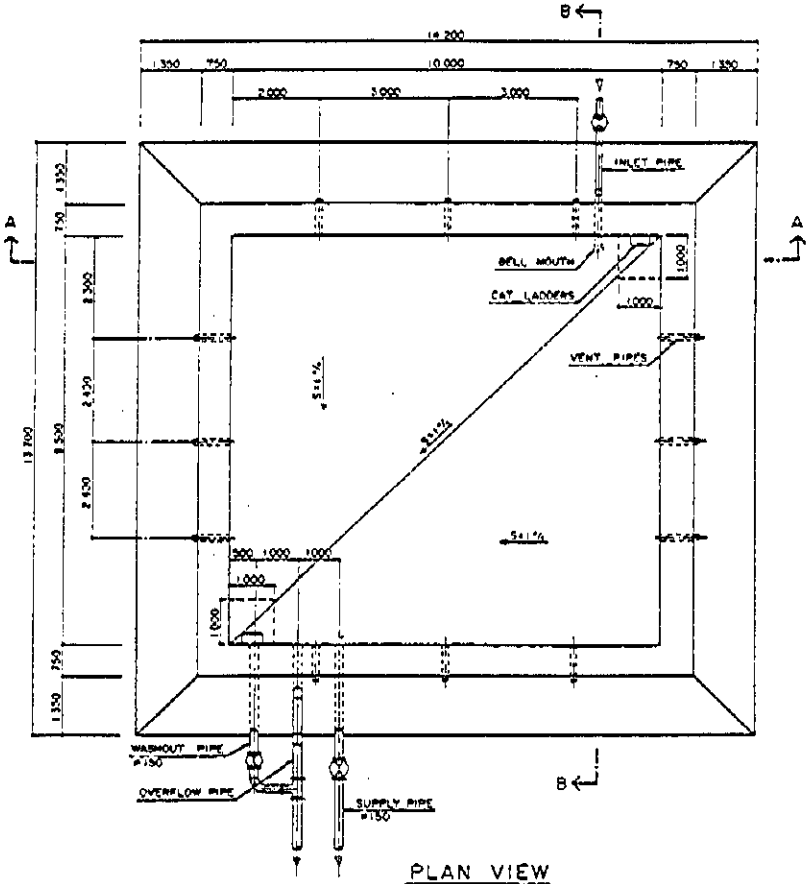
MINISTRY OF ELECTRICITY AND WATER
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES

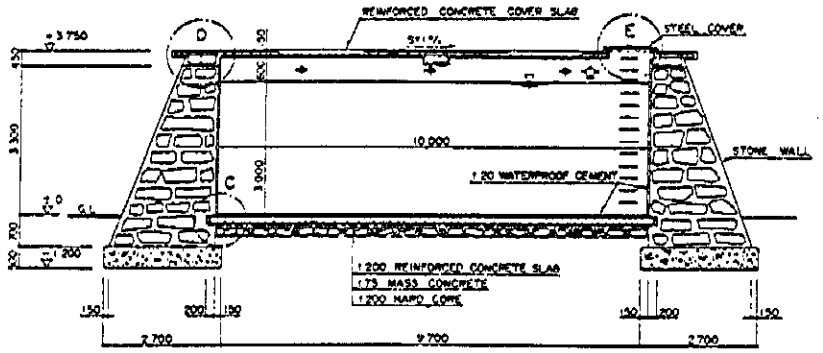
LAYOUT PLAN
INFILTRATION GALLERY

JAPAN TECHNO

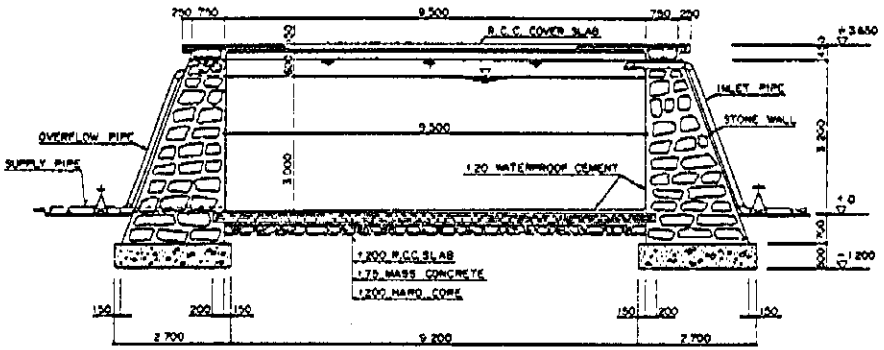
A-A
B-B
ELEVATED TANK : 250m³
JAPAN TECHNO



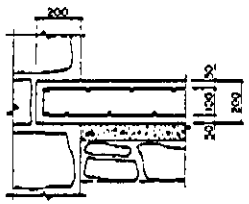
PLAN VIEW



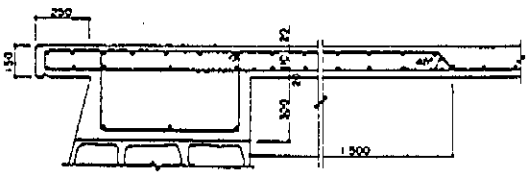
SECTION A-A



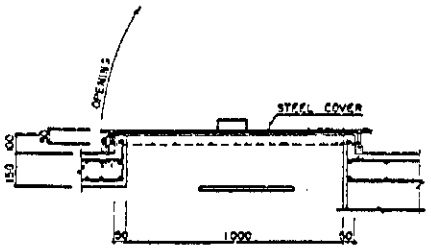
SECTION B-B



DETAIL C
R.C.C. SLAB



DETAIL D
R.C.C. COVER SLAB



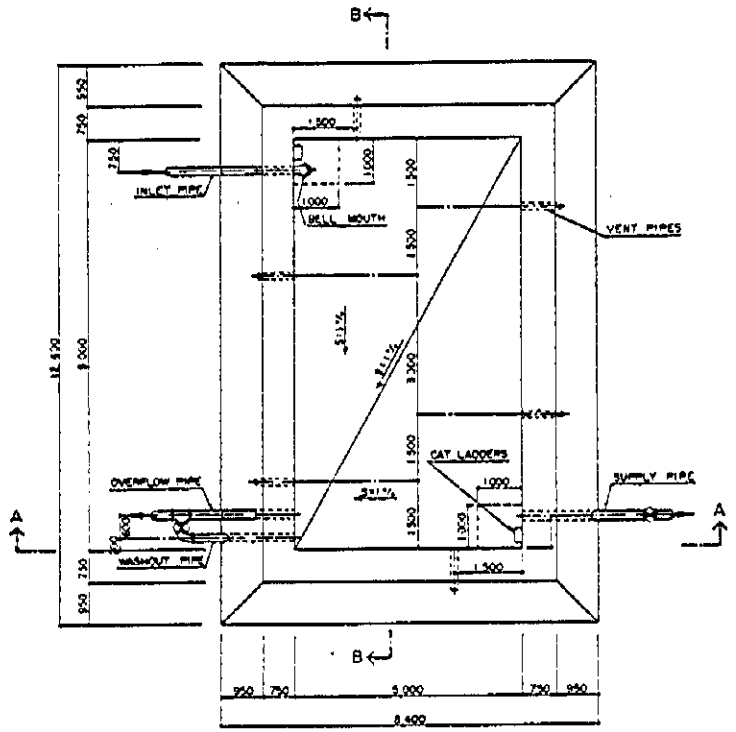
DETAIL E
MANHOLE COVER

THE REPUBLIC OF YEMEN
GENERAL AUTHORITY FOR RURAL ELECTRICITY AND WATER
MINISTRY OF ELECTRICITY AND WATER

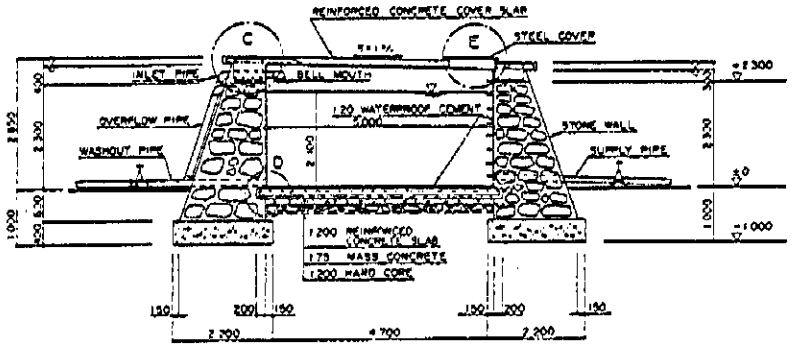
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES

MASONRY RESERVOIR :300m³

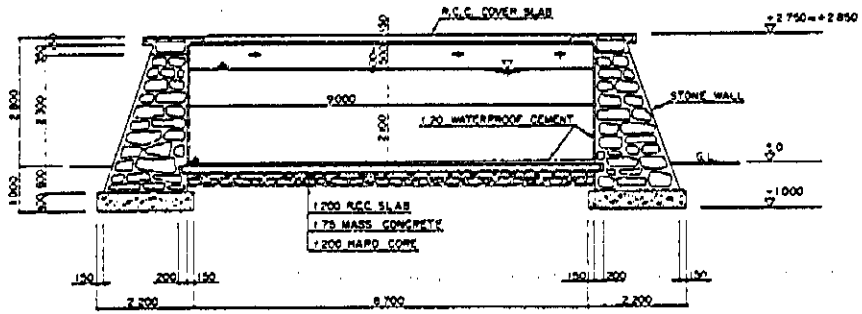
JAPAN TECHNO



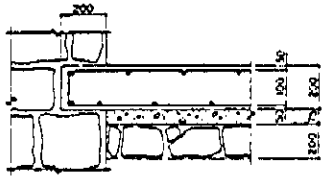
PLAN VIEW



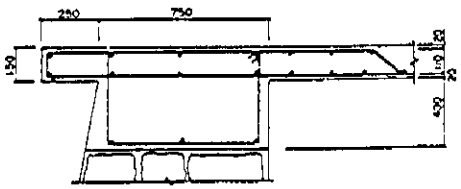
SECTION A-A



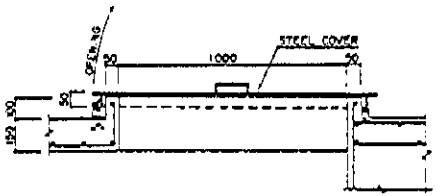
SECTION B-B



DETAIL D
R.C.C. SLAB



DETAIL C
R.C.C COVER SLAB



DETAIL E
MANHOLE COVER

THE REPUBLIC OF YEMEN
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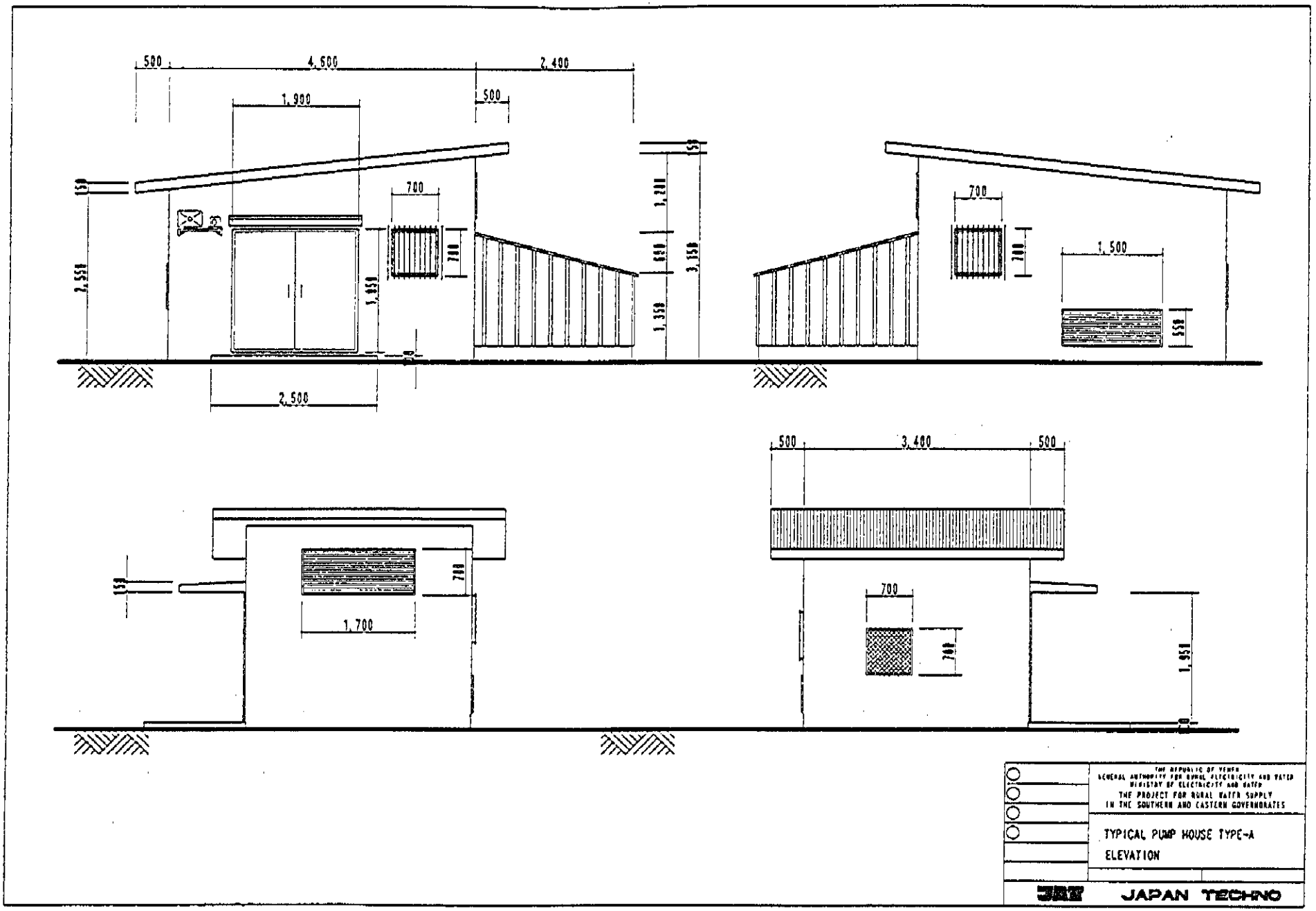
MINISTRY OF ELECTRICITY AND WATER
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES

MASONRY RESERVOIR : 100m³

JAPAN TECHNO


500
4,600
2,400
500
1,900
700
700
2,550
1,850
2,500
1,200
850
1,350
3,350
700
700
1,500
500
3,400
500
700
700
1,700
700
700
1,950
THE REPUBLIC OF YEMEN
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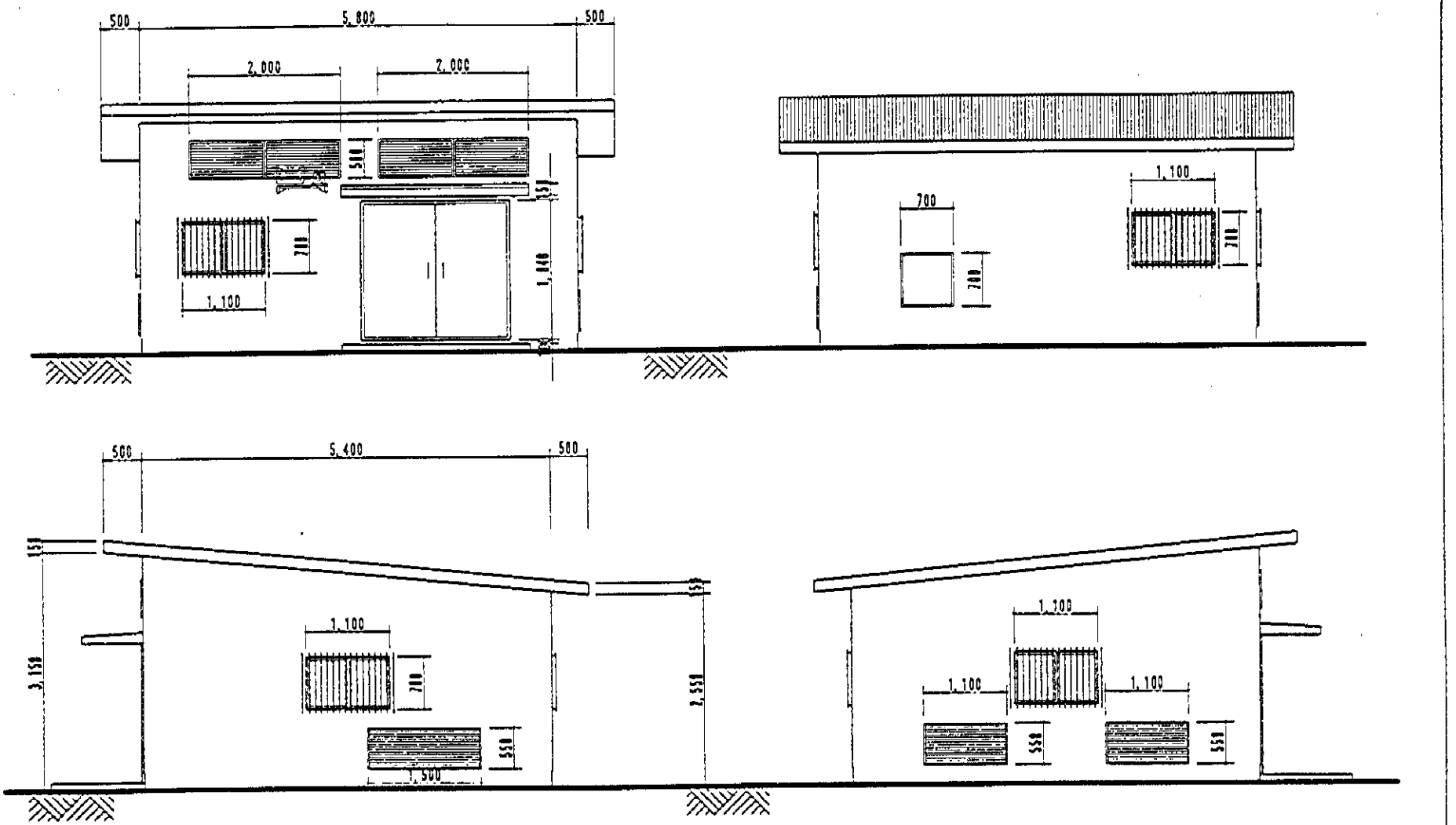
MINISTRY OF ELECTRICITY AND WATER
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES
TYPICAL PUMP HOUSE TYPE-A
ELEVATION
JAPAN TECHNO



THE REPUBLIC OF YEMEN
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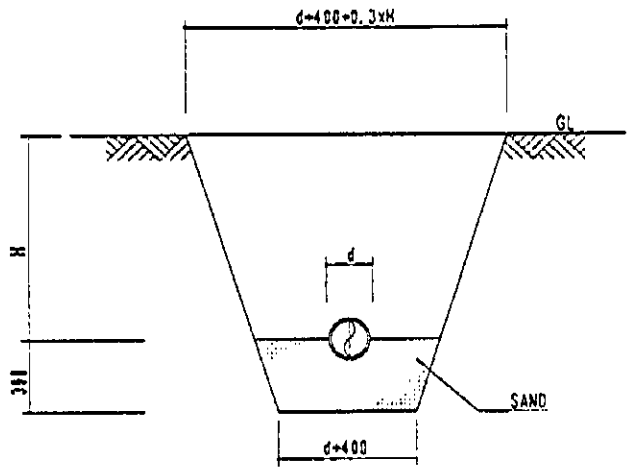
MINISTRY OF ELECTRICITY AND WATER
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES

TYPICAL PUMP HOUSE TYPE-C
ELEVATION

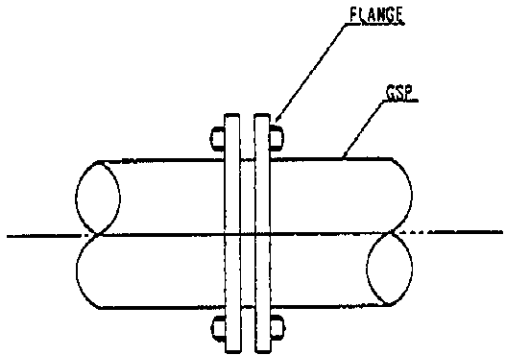
JAPAN TECHNO

B-B
C-C
A-A
PUBLIC FOUNTAIN 4-TAP
JAPAN TECHNO

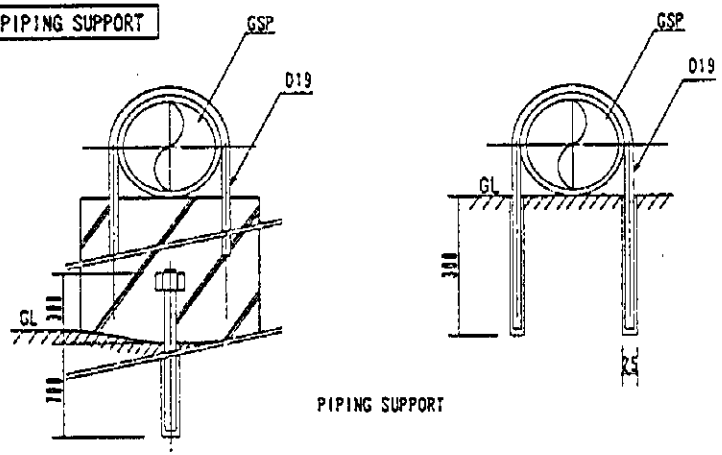
SECTION OF UNDERGROUND PIPING



REFERENCE DETAIL OF JOINTS

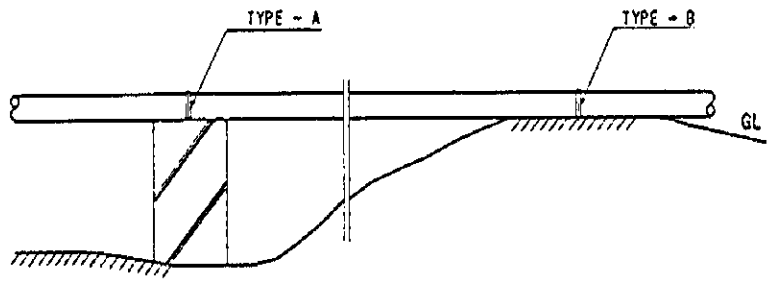


DETAILS OF PIPING SUPPORT



TYPE - A

TYPE - B



ROCKY GROUND

THE REPUBLIC OF YEMEN
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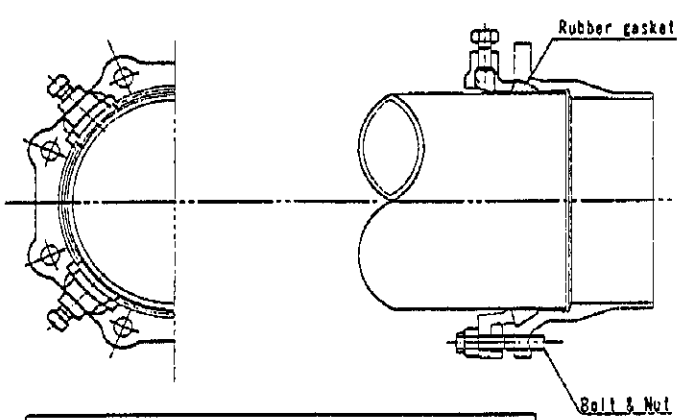
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES

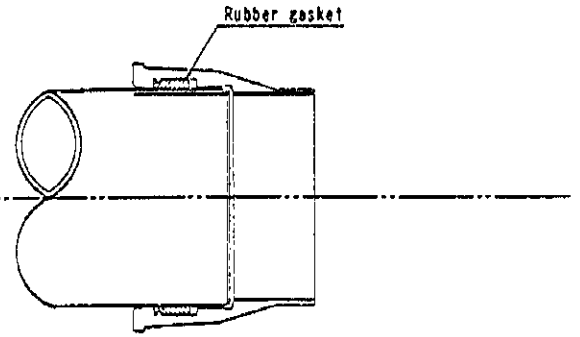
DETAILS OF PIPELINE -1

JAPAN TECHNO

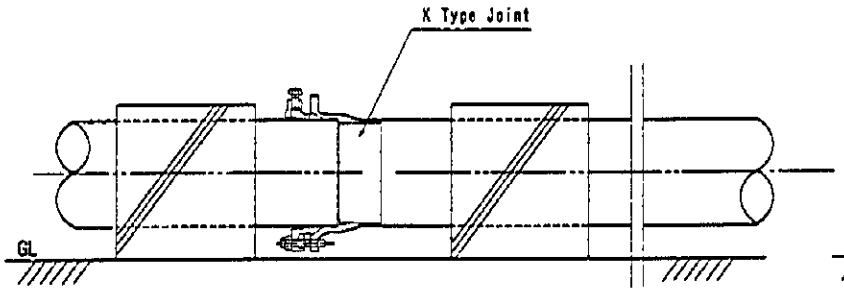
DETAILS OF DUCTILE IRON PIPE CONNECTION

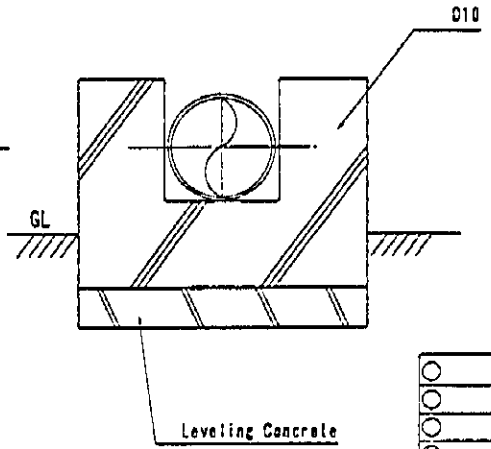


FLANGED CONNECTION (TYPE"K") FOR EXPOSED SECTIONS



SLIP-ON JOINT (TYPE"T")FOR BURIED SECTIONS





RCC PIPING SUPPORT FOR DIP LINES

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DETAILS OF PIPELINE -2

JAPAN TECHNO