Modern industry such as manufactureing has not been built up, excluding cement industry developed by the Government. To improve the underdeveloped economy, the Government established the "Three-Year Development Plan" in 1973/1974, which was followed by the "First and Second Five-Year Development Plans." These developments have only just started, and are expected to have a great influence on the economy.

2.3 Outline of Development Plan

YAR registered an average growth rate of 8.1% per year from 1973 to 1984. In 1984, the GDP was 2.94 billion U.S. dollars. The economic growth depends on gross fixed capital formation due to remittance from Yemeni working in foreign countries and the economic aid of foreign countries. The capital formation is more than 40% of the GDP.

However, a signicant decrease in foreign exchange and the remittance from foreign countries has caused a recession of economic growth in recent years.

YAR established the Second Five-Year Plan (from 1982 to 1986) which follows the First Five-Year Plan (from 1977 to 1981). The Second Plan sets two targets; one is to generally level up the living standard of the nation through an increase in the gross national income and local development, and the other is to construct independent economy through an increase in the growth rate depending on industries. The Second Plan is accompanied by the investment plan in a total amount of 28.1 billion YR, as shown in Table3. The Second Plan lists the following 13 strategical items to attain the target.

1) Optional utilization of potential resources to bring up industries utilizing domestic raw materials, develop sight-seeing resources, increase agricultural production, bring up civil work industry, and strengthen mining and industry for the future export.

2) Consolidation of education, health and welfare, and social service

to moderrize and improve the education and training system, with vocational training emphasized; to offer basic services with respect to health, society, and culture.

3) Development of agriculture

to improve agricultural productivity through consolidation of various agricultural services such as harmonized local development programs, agriculture cooperatives, agricultural finance system, and agriculture popularization activities.

4) Dam construction and effective utilization of water resource

to supply potable water all over the country in addition to coping with increased water demand of agriculture through introduction of modern irrigation systems (such as sprinklers), dam construction, and development of groundwater; to supply the whole nation with potable water.

5) Research and development

to build up Sana'a University in the science and technology center and establish local laboratories; to aid enterprise for the research and development of resources. (The policy is based on cognizance that economic development involves a modern and scientific breakthrough.)

6) Increase in agricultural production and industrialization of agricultural product

to increase agricultural production and aid the private sector to industrialize agricultural products. (This policy is based on the fact that processing of agricultural products is suitable for North Yemen.)

7) Increase in production and promotion of savings to increase investment to the production sector through an increase in production by economic policies oriented to the financial policy, and through an increase in savings by supression of consumption expenditures and effective utilization of domestic savings.

8) Correction of regional differences
to increase public investment to the local district and encourage the private sector for local investment; to level up nation-wide economic activities and increase employment in industry.

9) Survey of mineral resources
to implement research and study, bring up North Yemeni experts.

10) Preservation of environment
to prevent landslides, plant trees in the mountain district, and establish the standard of water utilization.

11) Increase self-reliance
to decrease dependence of energy and industrial products on foreign countries and induce wage earners staying in foreign countries to make investment to domestic production projects.

12) Economic cooperation and combination with Arab countries
to promote economic combination with Arab countries and to try to facilitate the flow of capital among the Arab countries, and uniform education curriculums with other Arab states.

13) National participation in economic development
to familiarize the nation with economic development through mass media and have the nation participate in economic development through union activities, etc.

Table 3 Investment Plan Based on Five-Year Plan (1982-1986)

(In million rials)

Economic Activities	Public & Mixed Sector (1)	Private & Cooperative Sector (2)	Total (3)	Distribution of Gross Fixed Capital Formation: Public & Mixed Sector (4) %	Private & Cooperative Sector (5) %	Total (6) %	Structural Formation of Investments on the basis of the Sector of Ownership: Public & Mixed Sector (7) %	Private & Cooperative Sector (8) %
Agriculture, Forestry and Fisheries	2,410	1,355	3,825	8.8	4.8	13.6	13.4	14.0
Mining & Quarrying	0,677	0,228	0,905	2.4	0.8	3.2	3.7	2.4
Manufacturing	2,185	1,105	3,290	7.8	3.9	11.7	11.9	11.4
Electricity and Water	2,293	0,470	2,340	8.2	0.2	8.4	12.4	0.5
Construction	0,450	0,400	0,850	1.6	1.4	3.0	2.4	4.1
Trade, Restaurants and Hotels	0,864	1,006	2,570	3.1	7.1	10.2	4.7	20.8
Transport and Communications	3,949	0,691	4,640	14.0	2.5	16.5	21.4	7.1
Financial Institutions	0,120	0,080	0,200	0.4	0.3	0.7	0.7	0.8
Housing and Real Estate Services	0,260	3,485	3,745	0.9	12.4	13.3	1.4	36.1
Government Services	5,165	——	5,165	18.2	——	18.4	28.0	——
Other Services	——	0,270	0,270	——	1.0	1.0	——	2.8
Total	18,433	9,667	28,100	65.6	34.4	100.0	100.0	100.0

In water supply service with which the Project is associated, emphasis is placed on water supply in cities such as Sana'a and Taizz. However, the investment plan amounting to about 300 million YR per annum is established for rural water supply during the term of the Second Five-Year Plan.

The Third Five-Year Plan is now being coordinated by CPO. The plan will be started in 1987, but no announcement has been made as of December, 1986. However, informed sources reported that the plan would basically succeed the Second Plan which emphasized development of water sources and improvement of water supply facilities for villages.

Although emphasis is placed on water supply in cities, such as Sana'a and Taizz, with respect to water supply service with which this Project is associated, it is strongly recommended that rural water supply should be rapidly improved all over the country.

2.4 Present Condition of Water Utilization

2.4.1 Water Supply Condition

Most of the nation of YAR used to depend on unstable and unhealthy water sources until recent days. Main water sources were fountains, shallow hand dug wells, and cisterns (rainwater reservoirs).

After the end of the civil war, the Government established Rural Water Supply Department in the Ministry of Public Works, and started to develop stable water sources and construct modern water supply facilities for local inhabitants who account for about 90% of the nation. The Government shares the construction cost with beneficiaries. Since then, the Government project made steady progress to the point where 22.1% of local inhabitants were favored with water supply as of December, 1985 (Refer to Table 5.). However, about 75% of local inhabitants still suffer from insufficient domestic water, and this problem must be solved urgently.

Table 4 shows the population served based on recent statistics, and proves that water supply facilities have improved to a great extent. In 1986 the water supply rate was 82%. However, a significant increase in the urban population in recent years still requires further improvement of the existing water source facilities and development of new water sources. Normally, water supply in YAR depends on groundwater. Agricultural villages depend mainly on groundwater which flows out of fountains. Where groundwater is not available, cisterns are most often used to store surface runoff flowing on the ground.

Table 4 Population of Safe Water Supplied

Urban Area			Rural Area		
Year	Population (Million)	Population Surved %	Year	Population (Million)	Population Surved %
1970	0.3	45	1970	4.9	2
1976	0.5	76	1976	5.7	2
1986	1.1	82	1986	8.2	28

In this basic design study, study areas are classified into the following three categories according to present water supply conditions.

i) District where sufficient water sources are not found.
(Dimuna, Shihara, Al Rajam, and Wadi Asfan.)

ii) District where water sources are available only as point sources and requires water supply facilities.
(Al Khashna, Al Kheisen, and Al Husun.)

iii) District which requires expansion or improvement of water supply facilities.
(Ad Dahi, Al Zakiha, and Harad.)

2.4.2 Water Supply Project

1) Outline and administration system

YAR established Water Council in 1982, which reviews and coordinates overall development of water sources. The secretariat of Water Council is CPO. However, it is considered that the Water Council does not function substantially, and no development program is coordinated among Ministries and Departments. Therefore, haphazard development of water resources is made all over the country.
Water Council consists of members from the following Organization and Ministries.

. Central Planning Organization
. Ministry of Public Works, Rural Water Supply Department
. Ministry of Agriculture, Fisheries, Regional Development Office
. Ministry of Electricity, Water and Sewage
. Ministry of Health

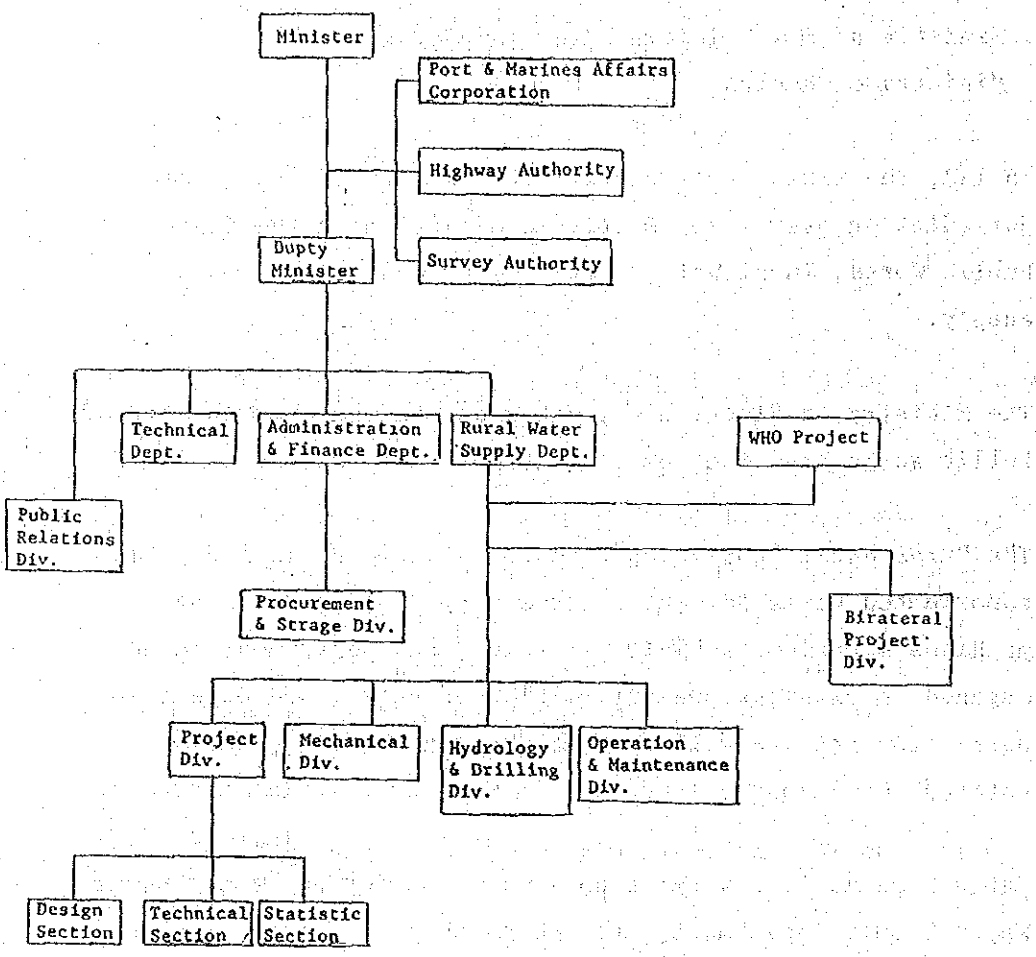
In YAR, the Ministry of Electricity, Water and Sewage has jurisdiction over water supply in cities while the Ministry of Public Works, Rural Water Supply Department over rural water supply.

The Ministry of Electricity, Water and Sewage and Ministry of Public Works have the administration system as shown Fig. 6.

The Rural Water Supply Department, established in 1972, has constructed wells for rural water supply using drilling machines supplied by USAID. However, the Department is now engaged in planning and supervision of works, and orders most works from private well contractors, who have increasingly entered the industry as demand in well contruction increased.

Table 5 summarizes water supply works performed by the Rural Water Supply Department, and proves that the First Five-Year plan places emphasis on water supply facilities utilizing the existing water source while the Second Five-Year Plan on new water sources. This suggests that the future rural water supply still requires newly developed water sources and that the Second Five-Year Plan is basically succeeded. However, the scale of the rural water supply work by far exceeds the capacity of the present Rural Water Supply Department due to the fact that such work is intended for about 90% of the total population. For this reason, other organisations frequently undertake rural water supply projects independently from the Department. Typical examples are health and hygiene projects by Confederation of Yemeni Development Association (CYDA) and the Ministry of Health, and the agricultural development project of the Ministry of Agriculture and Fisheries.

Ministry of Pubulic Works



Ministry of electricity, Water and Sewage

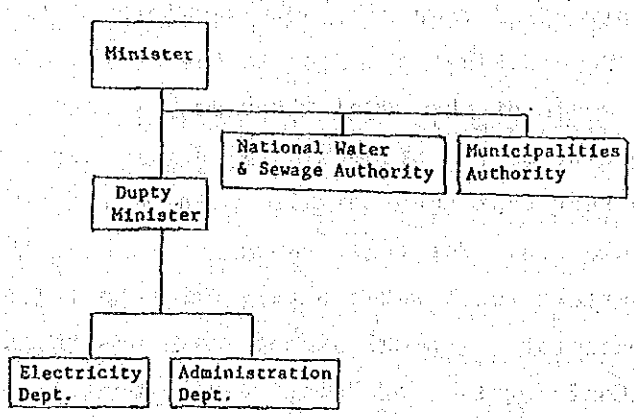


Fig. 6 Organization of the Ministries

Table 5 Rural Water Supply Schemes

Year	No. of Schemes	No. of Deepwells	No. of Pumps	Beneficiary	Cumulative Bene. Ratio of Rural Area	Investment Cost (Million Y.R.)
1976/77	38	20	38	158,096	7.0	19.0
1977/78	55	30	61	102,160	8.35	23.5
1978/79	114	77	94	151,810	10.42	71.4
1979/80	156	47	28	154,640	12.50	41.6
1980/81	453	303	290	208,870	15.35	131.3
F.F.Y.P.*	816	477	511	1,157,039	15.35	286.8
1981/82	50	129	117	120,440	16.29	83.0
1982/83	48	141	117	177,640	17.30	112.5
1983/84	40	141	362	83,000	18.24	90.0
1984/85	32	244	86	52,715	18.81	60.0
1985.July ~Dec.	17	96	69	42,200	19.50	11.0
S.F.Y.P.**	187	751	751	1,815,680	19.50	356.5
Period Total Foreign Aids (1976~1985)	143	45	50	243,892	2.60	124.4
Grand Total	1,146	1,273	1,312	2,059,572	22.10	767.7

*F.F.Y.P. : the First Five Year Plan

**S.F.Y.P. : the Second Five Year Plan

Irrespective of development devoted by the Rural Water Supply Department (RWSD), CYDA, and others, local inhabitants still suffer from insufficient water. This results from difficulty in ensuring water sources and too many small-scale villages to be developed. More particularly, most are kept comparatively dry with annual precipitation from 200-1000mm, and about 90% of the total population are local inhabitants in scattered small villages.

2) Condition of management

Management is dealt with in Chapter VII. Water supply facilities constructed by RWSD become the common property of the community, which is the unit organization under the Local Development Association's (LDA's), and are operated at the responsibility of the community.

Expenses paid by the community include wages for the operation personnel and, maintenance cost of the facilities. These expenses are borne by beneficiaries, and costs each household at 50-100YR/day. In some areas, water meters are installed in houses.

The operators are obliged to participate in the training course or water supply system performed by RWSD.

3) Water supply plan

The First Five-Year Plan gave priority to investment to water supply work. The investment growth ratio reached 20.4%/year, while 1,334 wells were dug and water sources of 27.4 million m^3 ensured for the total water supply work including urban water supply.

The core of the water supply work plan in the Second Five-Year Plan is summarised in the following 3 points.

1. To properly utilize water by confirming the volume of surface run-off water and groundwater.

2. To grant priority on development of home potable water in consideration of limited water resources.

3. To establish a long-range work implementation plan to equalize water supply works all over the country.

The plan is completed by additional potable water sources in an amount of 146 million m^3 for urban water supply and of 95 million m^3 for rural water supply.

The Second Five-Year Plan establishes the rural water supply as shown in Table 6.

4) Foreign assistance to rural water supply projects

RWSD continued activities for rural water supply construction under the technical cooperation of WHO up to recent years. At present, RWSD develops independent activities with the government budget and its own organization. RWSD depends on foreign countries for about 30% of the annual budget. The main sources include USAID, Japan, West Germany, Holland, Saudi Arabia, Arab Fund, and UNICEF.

Table 6 Existing Production Capacity and Targeted Expansion

Product Unit	Base Year 1981		Production Volume During the Five Years					Expansion Rate
	Present Production Capacity	Production to Capacity Ratio	1982	1983	1984	1985	1986	
Water cubic	7,200,000	100%	20,419,200	27,216,000	30,528,000	30,528,000	37,065,600	415%

Table 7 Rural Water Supply Projects Assisted by Foreign Aids (through Rural Water Supply Department)

Organization /Country	Period	No. of Schames	Aid Amount (Million)
USAID	1984－89	150	$ 125.0 (Grant)
Netherland	1983	13	DF 8.9 (〃)
UNICEF	－	100	$ 4.5 (〃)
West Germany	1984	Dhamar Area	DM 5.0 (〃)
Saudi Arabia	1983	50	SR 100.0 (〃)
Arab Found	1984	4	KD 0.7 (〃)
Japan	1978－83	42	¥ 3,880.0(Soft Loan)
	1982－84	12	¥ 1,600.0 (1st～3rd Grant)

2.4.3 Present Condition of Water Resources Development

1) YAR belongs to the arid and semi-arid zones with annual precipitation ranging from 200mm to 600mm during the rainy season from April to September. This results in less surface water, as a whole. Therefore, water supply used to depend on springs and shallow wells in the mountainous areas where most inhabitants live.

Under the constraints above-mentioned, the development of deep groundwater has been indispensable. In fact, most of agricultural and domestic water works depend on groundwater from deep wells, including urban areas.

Water resources necessary for the whole nation are still unknown because they are not well defined by Ministries and Departments among which water resources development plans are poorly coordinated.

2) Possibility of groundwater development
As stated above, water supply projects in YAR involves groundwater development. However, groundwater storage in aquifers greatly differs with type of strata, and groundwater development must be planned so as to meet conditions of the targeted area. In particular, groundwater along faults is difficult to estimate on the ground surface, and requires an effective groundwater utilization plan in addition to careful review of water resources.

Recent large-scale agricultural development programs plan to store surface water by means of dams. The first example is the Marib dam in Wadi Sujd. The authorities in Sana'a study the conversion of treated sewage to irrigation water. However, preservation of water supply sources requires an overall water resource development plan which restricts pumped water on the basis of calculations of safe yield by the water balance of the groundwater.

2.5 Necessity of Rural Water Supply Projects

A rural water supply rate of 4.7% in 1974 was improved to 22.1% as of 1985 through 2 Five-Year Plans. However, about 70% of local inhabitants are not yet favored with water supply even after the project in progress is completed.

In areas without proper water supply facilities, domestic water usually depends on cisterns and shallow hand dug wells. These water sources are likely to cause much trouble in the light of health, because it is so-called stored water unlnerable to contamination caused by inflow of polluted water. For this reason, local inhabitants recently tend to purchase clean water for their drinking purpose. Generally, the clean water costs them more than 50YR/m^3, or sometimes as much as 300-500YR/m^3. Evidentually, the cost is a major expense of their household economy.

In conclusion, the construction of rural water supply facilities has a great effect on (1) improvement in health, and social welfare, and (2) an saving in real daily expense of inhabitants. In particular, the construction is urgently required for inhabitants in areas where water runs short.

2.6 Prior Work by Japanese Assistance

The Japanese Government started economic assistance to YAR for rural water supply projects with the study carriedout by OECF soft loan in 1976. This study was followed by the feasibility study of rural water supply projects from 1979 to 1980 by JICA, having resulted in grant aid in 3 phases. The present basic design study corresponds to the 4th phase, and includes 5 sites that were studied the by previous feasibility study.

The design of the feasibility study was oriented to development of water sources, but the strong request of inhabitants has changed the target to the so-called improved type water system, which includes an overhead storage tank distributing water to each village. In the sites targeted by the previous feasibility study, including 9 sites built by the Japan's grant aid projects, most of water supply facilities have been changed into the said improved systems or are being planned for such systems under Saudi project, etc. The 5 sites targeted by the present basic design were included in this feasibility study. When this project is implemented, water supply works are completed for all of 26 sites targeted by the feasibility study.

The loan project by OECF (PART I) amounted to 3.9 billion Yen, and was implemented at 42 sites from 1981 to 1982, all of which employed the system improvement.

Table 8 On-going Rural Water Supply Schemes by Aids

	State	Area	Description
1	HAJJA	AL MADAN & 8 villages	Saudi Fund, Wells completed. Improved system underway.
2		ELMAN & 4 villages	ditto
3		SHIHARA	New plan. No existing facilities.
4		THARI	Saudi Fund, Wells completed. Improved system underway.
5		HARAD	JICA 1st Grant, Wells completed. Improved system under planning by this project.
6	AL MAHWEET	AL MAHWEET CITY	Improved system completed by RWSD.
7		HUFACH	Saudi Fund, same as 1.
8		AL RAJAM	- JICA 2nd & 3rd Grant at 3 sites - Wells, water transportation and a part of distribution facilities completed. - Remaining 1 site is planned under this phase of grant aid.
9	AL MAHWEET	AL KHABET	Saudi Fund, same as 1.
10	SANA'A	BANY SHAKBR & BAIT ABO SABA'A	3rd grant aid, Improved system completed.
11		BAIT ABO HASHEM	1st grant aid, Improved system completed.
12		AL SHEAB & AL-ASWAD	Improved system completed by RWSD.
13		BANY FARHAN & BANY SARIA'A	Water source unsuccessful in 1st grant aid and abandoned.
14	HUDEYDAH	GHULAYFAGA	Unfeasible site because of salt water intrusion.
15		AD DAHI	Planned to be improved at this phase of grant aid (facilities existing).
16		AL MOUNIRAH	Improved system by RWSD.
17	TAIZZ	AL MASHJAB	Point-source system completed by 1st grant aid project
18		AL MANARA & AL DUKUM	

(Continue)

	State	Area	Description
19		HADAD, QAHFA	Improved system by RWSD.
20		AL KUDAH, AL HAGL	ditto
21		SHOHAT, AL KADASH	ditto
22		AL ZAKIRA	Improved system by 2nd grant aid Extension planned at this phase of grant
23		BAB AL MANDAB	Improved system by RWSD.
24		YAHKHTOL	ditto
25		MAKBANA	ditto
26		AL MAYDAN, AL JUBAIL, SHEIBD HAMUD	Improved system by the 3rd grant aid project.

Note: Numbers circled are assumed to be completed at this phase of grant aid project.
RWSD = Rural Water Supply Department, Ministry of Public Works, the Government of YAR.

	First Grant	Second Grant	Third Grant
E/N signed in	1982/83	1983/84	1984/85
Grant Amount (Million Yen)	500	500	600
No. of Projects	5	2	5

(Some site is overlapped, therefore total scheme is counted 9.)

2.7 Content of Request

YAR promotes the rural water supply improvement work on the basis of the above scocioeconomic conditions and present water supply conditions for improvement of infrastructure in local villages.

However, YAR inevitably depends on foreign aids for about 30% of the budget of rural water supply because of imbalance of finance. The present plan is a part of the rural water supply improvement made by foreign economical aids and as such YAR requested Japan to provide a grant for sites which require urgent improvement.

The YAR requested 15 sites: (1) 5 sites which were studied by the previous Feasible Study but have not implemented, (2) 9 sites independently surveyed and planned by YAR, and (3) one site planned by OECF.

Prior to the present survey, the all these sites were reviewed for propriety of a grant, priority, etc. as a result, 10 sites were selected for the present basic design study.

The selected 10 sites comprises 6 sites (Shihara, Harad, Al Rajam, Al Dahi and Al zakira of JICA Feasibility Study sites; Al Khaskna of the remaining site of OECF loan project.) proposed by YAR in top priority and 4 other sites out of those proposed in the second priority.

Five sites have been excluded from the present study because they were regarded as those which exceed the scope of the Japan's Grant. For example, the scale of some facilities becomes large because of the water source dependent on surface water, and some sites cover too vast areas (present population: 2,500-5,000).

The content of the request is summarized for each district targeted by the Prject as shown in Table 8. Briefly, the request indicates improvement of rural water supply facilities by means of water sources to be newly installed, depending on the existing water source, groundwater, or surface water.

Table 9 Requested Sites and Contents of the Request

			Site	State	Content of Request	Remarks	
Requested Site	Selected Sites for the Basic Design Study	Selected Sites to Perform the Basic Design	1. Wadi Asfan	Sana'a	Construction of water supply facilities by means of existing water source.	Studied by MPW.	
			2. Al Khashna	Dhamar	- do -	The site of Part I.	
			3. Al Zakira	Taizz	Extension of water supply system.	System completed by JICA 2nd Grant.	
			4. Al Kheisen	Sana'a	Construction of water supply facilities by means of existing water source.	Studied by MPW.	
			5. Al Rajam	Al Mahweet	Groundwater development and Construction of water supply facilities.	JICA 2nd & 3rd Grant at 3 sites.	
			6. Shihara	Hajjah	- do -	Surveied by JICA team as Part II.	
			7. Ad Dahi	Al Hudaydah	Construction of water supply facilities by means of existing water source.	- do -	
			8. Harad	Hajjah	- do -	Well completed by JICA 1st Grant.	
		Excluded Site to Perform the Basic Design	9. Dimuna	Dhamat	- do -	Studied by MPW.	
			10. Al Husun	Marib	- do -	- do -	
	Excluded Site for the Basic Design Study		Rohan	Al Mahweel	Construction of water supply facilities on the basis of spring and ground water development.	- do -	Reason of exception: Large scale because of big population (over 5,000 persons)
			Wadi Ashoar	Sana'a	Construction of water supply facilities on the basis of river water.	- do -	Difficult scope because of surface water use.
			Ayal Ail		- do -	- do -	
			An Nashamah		Ground water development and construction of water supply facilities.	- do -	Large scale because of big population (10,000 - 40,000 persons)
			Hadan Masharah		- do -	- do -	

Note: MPW = Ministry of Public Works

III PRESENT CONDITIONS OF THE PROJECT SITES

III. PRESENT CONDITIONS OF THE PROJECT SITES

3.1 General

The 10 project sites surveyed by the basic design study are scattered in 7 administrative districts (governor) as shown in the location map. The populations of these sites range from 350 in small village to 6,000 in a mountainous village complex and a semi-urban city. The general conditions of these sites are firstly introduced below.

Natural conditions, water sources and present water use situations are separately described in detail for each site.

3.1.1 Location

The location of each site is shown in the location map. the findings during the field survey at each site together with the required range of the project, are described in the separate section, "present conditions of each site".

Access to each site from the capital city of Sana'a is as shown in Table 10.

Table 10 Distance between Sana'a and the Project Site

Site	State	Distance (km)		
		Paved Road	Unpaved Road	Total
· Wadi Asfan	Sanaa	39	2	41
· Al Khashna	Dhamar	163	4	167
· Al Zakira	Taizz	291	16	307
· Al Kheisen	Sanaa	122	19	141
· Al Rajam	Al Mahweet	57	60	117
· Shihara	Hajjah	154	38	192
· Ad Dahi	Al Hudaydah	297	3	300
· Harad	Hajjah	443	0	443
· Dimuna	Dhamar	115	14	129
· Al Husun	Marib	225	2	227

3.1.2 Social Situations

Agriculture is the main industry in all the project sites except Ad Dahi and Harad located in the coastal plain. These two sites are sprawling along the national road, and form semi-urbanized communities having more than 300 shops. Shihara, Ad Dahi and Harad are the local centers of administrative subdivision called Nahiya.

Public facilities at each site were studied in the field survey including interviews. The major findings, together with the administrative divisions of the sites, are outlined in Table 11. Generally, public facilities are not well established in middle- and small-sized villages, and social conditions greatly differ with the sites.

Public health conditions at each site are not at a good level. Table 12 shows the incidence of major diseases in each site, with the survey results concerning the relation of these diseases to water contamination. According to the interviews during the field survey, parasitic diseases are most common to each site.

Population is described in the separate section, considering its close relation to the water supply planning under this project.

Table 11 Social Infrastructure in the Project Site

	Wadi Asfan	Dimuna	Al Khashna	Al Zakira	Al Kheisen	Al Husun	Al Rajam (Block D)	Shihara	Ad Dahi	Harad
Admini-stration	Khowlan, Jihanah, Sanaa	Dawran, Dhamar	Anse, Al Salama, Dhamar	Hojaria, Turbat Ash-Shama Itayan, Taizz	Thelen, Khamer, Sanaa	Al Husun, Marib	Al Rajam, Al Mahwit	Al Markez/ Al Sharkey, Shihara, Hajjah	Addahi, Al Hudaydah	Harad, Hajjah
Hospital	—	—	—	—	—	H.1	—	C.1	C.1	C.1
School (student)	P.1 (200)	—	P.1 (100)	P.1 (400)	P.1 (50)	P.1 (—)	P.2,S.1 (2,500)	P.10 (3,000)	P.2,S.1 (1,110)	P.3,S.1,I.1 (2,000)
Post office	—	—	—	—	—	1	—	yes	yes	yes
Cars	60	5	15	16	10		40	100	150	500
Telephone	—	—	—	—	—		—	yes	yes	yes
Electric Facilities	LG 1	—	PG 1	PG 1	—	PG,LG	PG 5	PG (in evry villeges)	LG	Electric Campany
No.of Store	4	2	1	10	2		40	150	300	300

Note : H ; Hospital, C ; Clinic, P ; Primary school, S ; Secondary school, I ; Institute

LG ; Local generator, PG ; Private generator

Table 12 Major Disease in the Project Site

Diseases / Site	Schistosomiasis (Bilharziasis)	Malaria	Others	Relation To Drinking Water
Wadi Asfan	no	no		no
Al Khashna	no	no		no
Al Zakira	no	no		no
Al Kheisen	yes	no		yes
Al Rajaa	yes	no		yes
Shihara	yes	no	*	yes
Ad Dahi	no	yes	Helminthiasis	yes
Harad	no	yes		no
Dimuna	yes	no		yes
Al Husun	–	–	–	–

* The disease occured in 1985 and spreaded because of broken pipeline, closing to sewage water.

3.1.3 Population

Reliable population statistics are indispensable to establishing water supply planning and studying present water service conditions. However, since accurate population data are hardly available in YAR, population must be checked for each site. Available data include the census in 1981 (CPO), MPW research data, field survey data, and aerial photos. In estimating population, these data were compared with one another and selectively used.

The latest population data available are the quick population announcement in 1986 by CPO, which is summarized in Appendix A-2-G. These data together with those of 1981 census are employed for the determination of population growth rate of each project site, comparing the trend of population growth during these 5 years as follows:

1) Rural population of each governorate, in which the project sites are located, is compared in the two sets of data and growth rate is calculated, as shown in Table 13. Rural populations in this table are presented, excluding urban ones of governorate capitals, since this is much closer to the actual ones for the estimate of trend at the project sites which are all rural communities including two small cities.

Table 13 Rural Population Growth Rate at Each County
(Comparison of 1981 and 1986,CPO)

State	Rural Population		Growth (%)
	1981	1986	(1 Year)
SANAA	1,529,594	1,429,691	-1.342
TAIZZ	1,465,831	1,465,858	0.000
HODEIDA	989,503	1,139,249	2.859
DHAMAR	756,741	765,237	0.224
HAJJAH	867,728	881,936	0.325
HAHWIT	287,470	317,060	1.979
Total	5,896,867	5,999,031	0.344

Note : The values not included capital population

2) On the other hand, the total population of YAR was 6,490,000 in 1975, 8,540,000 in 1981 and 9,270,000 in 1986. Population increased annually by 1.7% for these 5 years from 1981 to 1986.

3) In determining design growth rate of each site for water supply planning, a ruling rate to be employed is the one of a national average by 1.7%. In case this rate is less than those by governorates in Table 13, the latter is used for the sites located in those governor. The resultant growth rates for the respective sites are shown in Table 14.

Table 14 Population Growth Rate of Each Site

Site	Governorate	Growth %	Design growth %
Wadi Asfan Al Kheisen	(SANA'A)	0.0%/year	1.7%/year
Al Zakira	(TAIZ)	0.0%/year	1.7%/year
Dimuna Al Khashna	(DHAMAR)	0.2%/year	1.7%/year
Al Rajam	(HAHWEET)	2.0%/year	2.0%/year
Shihara	(HAJJAH)	0.3%/year	1.7%/year
Ad Dahi Harad	(HUDAYDAH)	2.9%/year	2.9%/year

Present population and design population to be served are summarized in 5.8 water supply facilities for each site. The target year is 2007, 20 years after the present year 1987. Detailed population distribution at the respective villages included in the project sites is summarized in Appendix A-2-G. In addition, the population distribution of the whole area of YAR is shown in the form of population density in Appendix A-2-g.

3.2 Water Utilization

The outline of present water utilization of project sites is described below, based upon the results of the field survey.

In the areas having no deep wells, main water sources are cisterns natural fountains and/or hand-dub wells. A combination of these 2 or 3 sources is used if a single source is not sufficient.

Where a fountain is available, a simple storage tank is often installed beside it. Water is drawn into buckets, etc., and brought to each house.

Hand-dug wells are mostly 2-3 m in diameter and 10-25 m in depth depending upon the thickness of water bearing layer. Water is pumped up by a combination of a small pump with a small engine or a bore-hole pump belt-driven by an engine, both of which are considerably popular, although water is drawn by hand in some areas.

Cisterns are observed everywhere all over YAR. This is a kind of reservoir, designed to collect surface water during rain-fall. In the site of Shihara situated at the top of a high mountain, many cisterns installed there play an important role to furnish domestic water to inhabitants. The cistern is installed at such a ground level as to easily collect surface water. Accordingly contaminated water is likely to flow into it together with rain water, resulting in causing health problems to inhabitants.

Furthermore, the sites where supply is insufficient even with the above-mentioned sources purchase domestic water brought from the adjacent areas. In particular purchase of drinking water tends to increase in any of the project sites surveyed. The price of potable water widely ranges from 5 YR/m^3 to 500 YR/m^3, as shown in Table 15. In addition mineral water in PE bottle (1-1.5 ℓ) is commercially available all over YAR at a cost of 4-7 YR/bottle (=60-100 yen).

Table 15 Water Price in the Project Site (1986)

Site	Water Price(YR/m^3)
Wadi Asfan	40
Dimuna	115
Al Khashna	5
Al Zakira	free
Al Kheisen	500
Al Husun	—
Al Rajam	150
Shihara	375
Ad Dahi	15～60
Harad	100

3.3 Hydrogeology

3.3.1 General

Annual rainfall of the Yemen Arab Republic is generally less than 400 mm. Therefore, a great majority of water courses in the country remains dry in the most part of year, and the use of surface water as a water source is hardly possible in any part of the country. Consequently, the development of groundwater becomes the best way of ensuring a source for a small-scale water supply projects. This project plans to basically depend upon groundwater resources for its sources. In this section, therefore, the hydrogeological conditions of YAR is outlined by classifying the country's geology into several groups with specific hydrogeological features, with reference to the project sites.

According to YAR's hydrogeological map shown in Fig. 3, the country is divided into five areas with specific geological and hydrogeological features as follows:

i) Alluvial area (Tihama coastal plain, Rub Al Khali desert)

The two areas in the above title are representative areas of alluvial plain. In addition, alluvial areas are observed in basins of mountainous areas and along wadis. In areas where alluvium is dominant, shallow groundwater can be developed in general. Under this project, the three sites, Al Husun, Ad Dahi and Harad are included in this group; the former one in the desert and the other two in the coastal plain. Shihara is the site where groundwater is to be developed in the mountainous basins.

ii) Volcanic rocks area (Central-southern mountainous areas, northern basin of Sana'a)

Groundwater in the volcanic rocks area is principally found as fissure water. Furthermore, stratiform water exists in volcanic breccia and porous lava. Groundwater development seems possible in these volcanic rocks areas, by means of the close study of their topographical and geological conditions. This project include the sites of Dimuna and Al Khashna classified into this group.

iii) Sedimentary rocks area (North-western mountainous areas)

Groundwater is found in layers with high peameability. Generally its storage is affected by topographical and geological conditions. Therefore, it is necessary to undertake detailed study for groundwater development. This group include the sites of Shihara and Al Rajam under the project.

iv) Amran limestone area (Central and northern inter-mountain basins and its eastern slope area)

Groundwater storage is controlled by localized geological structures such as fissures and caves. Groundwater development is always difficult in this group of area, and needs detailed geological study. Al Kheisen site corresponds to this type.

v) Basement complex area (northeast and northwest fringes and southeast inter-mountain basins)

Fissure water located in weathered and faulted zones is a sole source of groundwater found in this area, and its yield is generally low. For groundwater development, detailed study on topographical and geological studies are indispensable. This type of site is not included in the project.

3.3.2 Hydrogeological Characteristics

Hydrogeological characteristics at the respective project sites are analyzed, based upon existing data and information as well as the data by the field pumping test during the survey. The results of these analyses are shown in Table 16, and details are described in Appendix A-3.

Table 16 Hydrogeological Parameter

Site	Aquifer	Transmissibility m^2/min	Permeability cm/sec	Note
Wadi Asfan	Yemen Volcanics	2.02×10^{-3}	1.87×10^{-4}	Jihana site
Al Khashna	do	2.63×10^{-3}	1.46×10^{-4}	Sanaban site
Al Zakira	do	2.14×10^{-3}		
		$\sim 1.37 \times 10^{-3}$	1.2×10^{-4}	Existing data
			$\sim 9.8 \times 10^{-5}$	
Al Kheisen	Amran Limestone	2.0×10^{-2}	2.0×10^{-3}	
		$\sim 2.7 \times 10^{-3}$	$\sim 2.5 \times 10^{-4}$	Sandstone
		(5.0×10^{-3})		
Al Rajam	Tamilah Sondstone	3.0×10^{-1}	1.6×10^{-2}	Sandstone
		$\sim 2.7 \times 10^{-3}$	$\sim 2.5 \times 10^{-4}$	
		(1.0×10^{-2})		
Shihara	Alluvium/ Sandstone	2.2×10^{-1}	4.1×10^{-2}	Field test
Ad Dahi	Alluvium	2.4×10^{-1}		
		$\sim 3.36 \times 10^{-2}$	3.02×10^{-2}	Alluvium
			$\sim 3.54 \times 10^{-3}$	
Harad	do	2.64×10^{-1}	1.62×10^{-2}	Field test
		$\sim 3.36 \times 10^{-2}$	$\sim 1.87 \times 10^{-3}$	& data

3.4 Water Quality

Information on water qualities of water resources and served water is not sufficient in the country, chiefly due to low interest in this matter. However, since water quality is an important element for rural water supply planning, sampling at each site, field testing and detailed analyses in Japan were carried out. The results are summarized in Table 17.

Electric conductivity (EC) of spring water (Al Rajam) and existing groundwater in alluvial sediments indicates a very low value of about 100 μs/cm. On the other hand, EC reaches 400 to 1,500 μs/cm in inter-mountain basins and coastal plains, with higher values experienced at Wadi Asfan, Shihara and coastal areas of Ad Dahi and Harad.

Hardness shows values of less than 500 ppm at all the sites, even less than 100 ppm at Al Khashna, Al Rajam and Harad.

A maximum fluorine value was 1.2 ppm at sampling at Al Khashna against WHO's maximum permissible range of 1.5 ppm. On the other hand, this value is less than 1.0 ppm in all the other sites, which are within the limit of WHO's Water Quality Standard.

Calcium hardness shows a higher value of 143 ppm at Wadi Asfan, 78 ppm at Al Zakira, 88 ppm at Shihara and 84 ppm at Ad Dahi. Although these values exceed WHO's standard limit of 75 ppm, they are within the maximum permissible range of 200 ppm under the same criteria.

Water temperature varies between 23° and 30°C, except 16°C measured early in the morning at the spring of Al Rajam.

pH ranges from 7.2 to 7.6, indicating no problems for this item.

Consequently, water qualities at the project areas are generally within the limit of WHO's Water Quality Standard, except with several testing items taking values between the standard limit and the maximum permissible ranges of WHO's criteria. Concerning water quality, therefore, little problem will be raised for project planning.

The results of analyses are shown in detail in Appendix A-2-i.

Table 17 Water Quality of Stady Area

Site	Temperature (℃)	pH	EC (μs/cm)	Hardness (ppm)	F (ppm)	Ca (ppm)	Mg (ppm)	Cl (ppm)	Notes
Wadi Asfan	23.0	7.4	1,350	423(685)*	0.4	143	16	39	Handdug well
Dimuna	23.0	7.2	360	— (175)	—	—	—	—	Spring
Al Khashna	25.5	7.2	450	123(205)	1.2	38	7	27	Deep well
Al Zakira	24.0	7.6	110	331(520)	0.9	78	33	12	Deep well
Al Kheisen	24.5	7.5	680	279(445)	0.8	59	32	19	Deep well
Al Husun	—	—	—	—	—	—	—	—	—
Al Rajam 1	23.0	7.0	285	138(230)	0.2	32	14	12	Deep well
Al Rajam 2	16.0	6.8	150	83(120)	0.2	25	5	9	Spring
Shihara	26.2	7.4	765	343(470)	0.5	88	30	27	Handdug well
Ad Dahi	30.0	7.2	1,450	354(480)	1.0	84	35	144	Deep well
Harad	32.5	7.6	730	21(310)	0.5	53	19	46	Deep well
WHO Standerd**	—	7.0-8.5	2,000>	500>	1.0> (1.5)	75> (200)	50 (150)	200>	

* The values in the blanket are field analyses data.

** The values in the blanket show the guideline values for drinking water of WHO

3.5 Present Conditions of the Project Sites

Basic data, such as existing facilities, pumping test data, geoelectric prospecting data, and village names are shown in Appendix A-2. The present conditions of the areas are summarized as follows:

3.5.1 Wadi Asfan Area

1) Location and natural environment

Wadi Asfan Area is situated about 2 km to the south-east of Al Asnaf on the paved road from Sana'a to Jihanah, with six villages composing this site scattered in the area. The altitude is about 2,100 m.

Precipitation is estimated at more than 300 mm/year. The meteorological condition of this area is similar to that of Sana'a City.

The villages are dotted over a slightly undulating zone along wide wadi, surrounded by small hills of 60-80 m in height. The Wadi flows towards east and joins another wadi at the eastern part of the area. Wadi has a width of 50-100 m.

Geollogically, the area is underlain by Trap volcanic series of andesite and basalt, and rhyolite dykes intrude into the series, having strike of N30-40W. Wadi deposits consist of clay to pebbles of less than 20 m in thickness. The fracture patterns are harmonically developed with dykes and another one has EW direction. Shallow groundwater is found around the surface portion of the volcanic rocks where many fractures occur.

The groundwater level is 10-20 m, standing at around the lower limit of wadi deposits or the upper horizon of volcanic rocks. Cultivated lands occur mainly along the wadi. Vineyards are widely found including other crops, such as sol and pasture, etc. In the surrounded area of the villages, wasteland are widely extended at a slightly high elevation.

2) Water supply

Several cisterns and shallow hand dug wells are found within the site as water supply facilities. Water taken from the facilities are used mainly for irrigation and livestock. None of them is used for drinking purpose.
Potable water is transported from private wells in neighbor towns and villages by truck, and stored in the steel tank of each house. The portable water cost is 100 YR/2.4 m^3 (about 40 YR/m^3).

3) Water source

Although there are eight or more hand dug wells, only four wells are found in service at present. The wells are 20 - 30 m deep, located mainly along the wadi.

The wells in use are all private and the water is used mainly for irrigation. The intake facilities include private bore-hole pumps and engines. The operation time of the pumps is 2-4 hours/day or 30 - 40 minutes/3-4 days because of the low capacity of the wells.

Groundwater of the area is geologically divided into 2 categories : one is shallow groundwater, in the alluvium and the fracture zone of upper part of volcamic rocks, and the other is deep one, mainly in fracture zones, such as faults.

It is considered that the dykes block the shallow groundwater because of the vertical dips. The shallow groundwater is considered to be insufficient in potential for water supply planning of the area, except for that existing in layers where cracks are developed such as fault pyroclastic strata.
For this reason, a water source for the project is planned to develop deep groundwater, and a drilling point is selected to the west of the area. Geologic column of the area is shown in following table, which is based on the geoelectrical logging. From the column, seasonal aquifer is estimated to occur in depths of 20-70 m, and deep groundwater, below 70 m.

Depth (m)	Geology	Electric Resisitivity (ohm-m)	Water content	Note
21	Sandy gravel with silt	21 - 42		▽ 20 m
70	Extremely weathered tuffaceous andesite	44	Seasonal aquifer	
150	Tuffaceous andesite	164	12 Aquifer (tuffaceous andesite	
170	Tuff	12	groundwater in fracture.)	
200	Tuffaceous andesite	410		

Fig. 7 Schematic Columnar Section (Wadi Asfan)

3.5.2 Al Khashna Area

1) Location and natural environment

This area consists of a single village, and is situated about 4 km to the north of a point near Sanaban on the paved road from Dhamar to Rida. The altitude is about 2,400 m. Precipitation is estimated at 400 mm per year.

This area is also one of the 1982 earthquake stricken areas and many villagers have left the village.
It is located on a small hill over the vast lava table.

Geologically, the hill is composed of porous andesite lava (on the west side) and basalt (on the east side), between which is a fault of N12E60E. The andesite lava has a flow line of N25E22W. Briefly, this area has a vast plane and a stratum composed of porous rocks. This would provide an advantageous condition in developing a groundwater source from the hydro geological viewpoint.

The village on the hill is surrounded by a large cultivated field. Main crops are barley, wheat, soybeans, and sol with several vegetables produced.

2) Water supply

There is a private well mainly used for irrigation. Well water is partly used for domestic service through supply facilities such as small tanks.

3) Water source

This area has 2 deep wells. One is the above-mentioned private well of 130 m in depth. The other is completed by MPW to a depth of 200 m. There is another deep well of 200 m in depth, which was drilled under Part I project under OECF loan but is now found dry.

The private well was pumped up (for 20 minutes at a rate of 0.3 m/min) and the MPW well 100 m away was checked for a water level drop to make sure of the water quantity of the source. No symptom of a water level drop was detected.

It may safely be said that this project has no problem with respect to the quantity of the water source.

3.5.3 Al Zakira Area

1) Location and natural environment

The surveyed area is situated about 15 km to the south of Turbah. The area targeted in the present project is Gore Area, a part of Al Zakira. The altitude is 1,500 m to 1,700 m. Precipitation is estimated at about 400 mm per year.

The surveyed area is on a table bordered by a steep cliff (specific height: about 200 m). Surrounding valleys are deeply engraved, exhibiting precipitous features.

Geologically, this area consists mainly of a sandstone stratum abounding with crystal, with pelite mudstone and rhyolite strata partly interledded. The general running slope is N30E20S and the main fault has an orientation of N30W. The wadi, where the existing deep well was drilled, consists of a deposit at least 10 m in depth which includes a lot of pebbles. On the north side of Al Zakira Area, basalt is distributed and bordered on a sandstone stratum by a fault.

Cultivated land is widely distributed in gentle recesses or on the table, producing soybeans, sol and vegetables.

2) Water supply

Agriculture in this area is rainfed agriculture using cisterns. Existing water supply facilities have been extended up to Al Kader, the center of Al Zakira Area, by the previous 2nd phase grant aid project. Inhabitants in the targeted area now come to Al Kadel over a distance of about 2 km and fetch water at taps of the public fountain.

Basically, water from the facilities is free of charges.

3) Water source

The existing water facilities depend on a deep well of 180 m in depth located the wadi to south-west of the area. This well was drilled under said Japan's Grant Aid project.

During the field survey, a pumping test after digging the well dictated the planned pumping quantity of 0.3 ml/min and proved a dynamic level of 90.9 m. The static water level was 5.4 m and therefore a water level drawdown was 85.5 m.

A pumping test was performed for the present project, and has proven that a water level drops 64 m during pumping for 51 minutes at a rate of 0.4 m^3/min, and that the level recovers to 46 m after 19 minutes. This indicates that the well has no problem in serving as water source for the planned expansion of facilities under the project.

The wadi where this well was drilled belongs to Mafadan area beyond Al Zakira area, and therefore supplies Mafadan area with a part of pumped water is being supplied to the fomer area.

3.5.4 Al Kheisen Area

1) Location and natural environment

Al Kheisen Area is situated about 20 km to the east of Al Jiraf, a village about 5 km away from Khamir, the center of Nahira, toward Sadah. The altitude is 2,100-2,300 m, and precipitation is estimated at 300 mm/year.

This area is a mountain community consisting of 5 villages, and surrounded by hills which abound with rocks and pebbles and is well developed. The stratum is of limestone. The general running direction of limestone is N40W and a slope is 10-15NW, with the structure disturbed by a lot of faults. The main fault stands straight in the direction of N20-30W, accompanied by conjugate faults in the E-W direction.

The wadi deposit is mainly composed of pebbles, and both shores stand steeply.

Cultivated land is slightly distributed around the village, with wasteland widely spread. Main crops are barley, wheat, soybeans, and sol.

2) Water supply

Agriculture in this area is typical rainfed farming by use of cisterns. Well water is bought from other villages except at Bait Al Eyani where a deep well was drilled by MPW for domestic use. The main supplier is northern Asfala, where a deep well was drilled with the CYDA fund. The well water is transported from Asfala by truck. This water is sold at 10 YR/20 ℓ (500 YR per m^3). In case of extended famine period, water is purchased even for livestock, which costs them 200 YR/m^3.

3) Water source

This area has water facilities consisting of a deep well (315m deep) and intake facilities. This well is located at a vertical fault in the direction of N40W, collecting fissure water.

Villagers of Beit Al Eyani obtain water from this well adjacent to the village. The field survey shows that water is pumped from this well at a rate of 0.43 m^3/min. The MPW data indicate that static and dynamic water levels are 100 m and 180 m respectively when water is pumped up at a rate of 0.19 m^3/min. Considering population to be served at this site, the production of this well is adequate enough for this project.

3.5.5 Al Rajam (Block-D) Area

1) Location and natural environment

This site is located about 60 km westward via the unpaved road from Shibam. The site consists of a north-south plain at an altitude of 1,940-1,960 m and mountains extended in the northeast at 2,040-2,400 m. Annual precipitation is assumed at about 400 mm.

The narrow plain zone is distributed along fault valley in the directions of N-S and NNW-SSE, and is widely used for agricultural purpose. The mountain zone is distributed as far as watershed, which shows cuesta morphology. Generally, villages are scattered at or around the top of mountains, and the gentle slopes of mountainsides are used as cultivated field for crops. The major crops are barley, wheat, soybean, and sorghum, etc.

Geological formations of this site consist of the follows:

- Rudaceous sandstone hearing conglomeratic layers in the northern area corresponding to Tawilah Group (Mesozoic) and Mejd Series (Cenozoic, Tertiary)
- Alternation of limestone and shale in the southern area corresponding to Amran Series (Upper Mesozoic, jurassic)

Both formations are bounded by faults in the NW-SE direction.

This site principally consists of sandstone mentioned above in monoclinal structure (strike: N20°-50°W, dip: 20°-30°SW). Fault and fracture system are predominant in the directions of N-S, NNW-SSE, moreover, many small fault systems are also recognized.

2) Water supply

Block-D is the remaining site for water supply project to be completed within the whole area of Al Rajam.
On the other hand, water supply systems have already been completed by the previous grant aid projects in Blocks A, B, and C located around Block-D.

Depth (m)	Geology	Electric Resistivity (ohm-m)	Water Content	Note
5	Aluvium	10-40	no-Aquifer	
40	Diluvium	110-200	Seasonal aquifer	EC=285 μS/cm T=23°C
200	Fractured Sandstone	100-650	Aquifer	

Fig. 8 Schematic Columnar Section (Al Rajam)

3.5.6 Shihara Area

1) Location and natural environment

Shihara is located in the northwest mountainous zone of the Yemen Arab Republic. Accessibility to the site is about 40 km westward via Al Atche from Huth, which is located along the paved road between Sana'a and Sadah.
Annual precipitation in the site is about 400 mm.
Geomorphology of this site can be divided into the following three zones:

Hilly zone	1,200-1,300 m m.s.l.
Mountainous zone	1,300-2,200 m m.s.l.
Top of Mountainous zone	2,200-2,500 m m.s.l.

Hilly zone is distributed on the westward of the Wadi Woar, which flows from the SSW to the NNE, and composed of terrace sediments at an altitude of 1,160-1,260 m.
Wadi Woar flows to the north along fault valley in the direction NNE-SSW and has 300-500 m of width with sandstone outcropped on the eastern side.

The mountainous zone on the western side of the wadi shows a steep topography at an altitude of 1,300-2,200 m m.s.l., made up shale, sandstone, tuff, and volcanic rocks dated Mesozoic and Tertiary.

At the top of the mountain in the main village of Shihara at 2,200-2,500 m.
A grant of gentle slopes are cultivated for cultivated fields. Some cistern systems are available for water source.
The service area of this site involves twenty-two (22) villages located on the southeastern slopes from Shihara.
Shihara is located on the mainly dacite intrusive body and bounded by steep cliff.

The cultivated fields extend on gentle concave terraces and along the wadi. The major crops are wheat, bean and vegetables.

2) Water supply

The water source was in service, existing in or near the villages, is only shallow wells at Al Qabain village (1,300 m).

Springs emerge mainly along faults, but their yields are low (100 - 1,000 ℓ/day). At the outlets of these springs are reservoirs or storage tanks installed. Existing sources, however, are far from satisfying the demand of the whole area for domestic water. Therefore, drinking water is brought from villages located along the wadi for sale at the price of 375 YR/m^3. The cistern water is also used for the domestic water in Shihara.

Productive cultivated fields are distributed in the surrounding of the wadi Woar located in the east margin of the site, where a simple type of irrigation farming is carried out by using shallow wells.

3) Water source

Existing water source for near the villages are only shallow wells located in Al Qabain.
Existing deep wells (200-300 m in depth) within the area are: two wells drilled by MPW, two by Saudi Fund, and one by CYDA. These wells are dry except one drilled by the MPW located in the wadi among the eastern hilly zone.

According to the interview with the inhabitants, all of these deep wells had or have problems in their yield.

Considering the situation of the existing deep wells, it is not practical to seek new water source for the project within mountain or hilly zones of the site. Therefore, the most provising location for water resources development for the area is judged to be along the Wadi Woar where groundwater production is so large as to make irrigation farming possible.

In the field survey the middle reach of the Wadi Woar, flowing along fault valley in the directio of NNE-SSW, is judged to be the most suitable location for the purpose, where the geoelectrical survey was carried out.
Schematic columnar section at a representative site (E-2) is shown as result of the geoelectric prospecting in Fig. 9.

Depth (m)	Geology	Electric Resistivity (ohm-m)	Water Receiving Status	Note
9.00	Clay	11-18	Non-productive aquifer	2-3 m ▽
74.0	Clayey gravel & sand	37-48		EC=765 μs/cm T=26.2°C
100.0	Sandstone	540	Aquifer in little fractured sandstone	
	Fractured sandstone	162	Aquifer in fractured sandstone	

Fig. 9 Schematic Columnar Section (Shihara)

Information on the shallow wells in this site shows that non-productive equifers consisting of clay and clayey gravel, locates to G.L-74 m, and aquifers composed of less fractured sandstone between G.L-74 and -100 m, and fractured sandstone between G.L-100 and -200 m.

3.5.7 Ad Dahi Area

1) Location and natural environment

Ad Dahi together with Harad mentioned later is located in Tihama coastal plain, which is low flat land extended east and west for about 50 km in width, and north and south for about 400 km in length between the Red Sea and the Central Highland. The altitude varies between 0 and 300 m, and ground slope is gentle (1/100 - 1/200). This plain can be divided into the desert covered by eolian sand and the alluvial fans formed by many inter-land wadis although their border is not conspicuous.

In the desert area are many sand-dunes of 10-20 m in height, located in the E-W direction at intervals of 500 m.

Ad Dahi is located at an altitude of 80 m m.s.l., about 2 km eastward from the paved road connecting Al Hudaydah to Al Hudaydah and Harad, about 45 km northward from Al Hudaydah and about 25 km eastward from the coast line.

Wadi Surdad flows to the west at about 1 km southward from the center of Ad Dahi. Annual precipitation is estimated at about 100 mm.
Geological formation of this site consists of the upper layer composed of sandy sediments coming from wadis and eolian sand, and the lower layer of fine sand and sandy soil.
Cultivated fields are widely distributed around the community, where wheat, bean, cotton, and tabacco are principally grown.

2) Water supply

The community has existing water supply facilities including water sources in operation, which were installed fifteen (15) years ago.

However, the service area is limited to only two blocks of old areas among six in total. The service hours are from 14:00 to 15:00 and one hour in the evening for each block.

These facilities include the pipeline network, an elevated tank and intake facilities.

However, these are all in deteriorated as mentioned below.

. Pipelines
  Supply is not sufficient condition in both quantity and pressure and heavy water loss by conduction is caused by pipeline leakage.

. Elevated tank
  Impossible to use because of leakage due to deterioration.

. Pump
  Pumping rate and head are very low due to deterioration of equipment.

. Engine
  Engine power is very low.

In new residential area without any pipelines, inhabitants buy and transport water at the surrounding water sources.
In the area served by the existing facilities, water fee varies between 15 and 60 YR/house/month depending upon consumption.
A pump with an engine supplied by USAID, is stored as a standby equipment at this site.

3) Water source

There are two wells: one well (60 m in depth) now in operation and the other drilled by MPW (80 m in depth) remains not yet to be in service.

Static water level varies between 20 m and 30 m.

The drawdown is estimated to be in a small range.

Taking into account the location of the project site along the large wadi and existing water sources' conditions, two wells mentioned above are expected to be given sufficient water for the project.

3.5.8 Harad Area

1) Location and natural environment

Harad also is located in the northern fringe of Tihama coastal plain, about 40 km from the coast line and near the national boundary with Saudi Arabia.

The annual precipitation is about 100 mm. Major port of this community is situated on the top of alluvial fan located in the left side of the Wadi Harad flowing to the west.

Cultivated fields with high furrous (height of 0.5-1.0 m) are widely extended around the villages. The major crops are barley, wheat, beans, sorghum, potato, millet, and vegetables.

The area is made up of a clay layer of 5-6 m in depth from ground surface, followed by sand/gravel layer around the wadi totaling 110-120 m in thickness.

Hilly zones consisting of sandstone, limestone, and andesite, etc. are located eastward of the village.

2) Water supply

The site has two (2) wells water tanks and public fountains. However, distribution pipeline are not yet installed. The well, the intake facilities and the water tank in the northern area and the other tank in the southern area are installed by the first phase Japanese grant aid project.

Domestic water is obtained from public fountain located near the tank. A part of inhabitants purchase drinking water at the price of 100 YR/m^3.
The residential area shows a rapid expansion along the road leading to Saudi Arabia after the complement of pavement and shortage of domestic water is becoming serious.

3) Water source

There are two productive wells: one well located near the center of the community and the other one in the northern area. The former well is 30 m deep and its static water level, about 20 m.

The water level recovery at this well very quickly after pumping stops, as shown in Appendix. There is no question in its production.
The present pumping rate of this well was confirmed to be 360 ℓ/min.

The latter well is 100 m deep with the static level at 20 m. This well together with the tank and intake facilities was constructed under the first phase Japanese grant aid project. The design pumping rate is 500 ℓ/min and water quality is suitable for drinking.

3.5.9 Dimuna Area

1) Location and natural environment

Dimuna area is located about 10 km south of the center of Dawran, the capital of Dawran District. The altitude of the site is 2,300-2,600 m, where 6 villages are scattered.

The annual precipitation is estimated at about 400 mm. Topographically, this area is on a part of caldera complex, where steep cliffs and slopes are widely distributed.

The area is mainly underlain by basic lava and pyroplastic material; the rocky and stony land is widely extended. Generally, the geological structure strikes N40W and dips 20SW. Massive lava is found in the lower portion.

Many valleys are of V-shape and is harmonious developed in the fracture pattern which strikes N30 to 40E or N50W.
Soil is distributed in concave land, where cultivated land is well developed. Main crops are barley, wheat, soybeans, etc.

2) Water supply

Rainfed farming is dominant in the area. Domestic water depends mainly on a small spring and cisterns. Potable water is brought from Dawran about 10 km to the north of the area or from surrounding villages.

Therefore, local inhabitants are all suffering from shortage in domestic water.

3) Water source

The present condition of the water source at the site differs largely from that the initial request from YAR, stating that the area has existing shallow wells. None of them are found. The only water source in the area is small spring at the south of Qoed Ala, which discharges only 500-700 ℓ/day.

The catchment area in the site and around is very small; massive lava occupies a greater part of the area; and steep topography is dominant. Geologically and topologically, therefore, it is considered that the groundwater development is not suitable in the area.

A dry well, 150 m deep, was once drilled in Al Hamra Area which is adjacent to the area on the south.
From the topographical and geological viewpoints, the area is not considered to be suitable for groundwater development.

4) Other information

This Area was hit by the earthquake in 1982, leaving serious damage. Interviews have shown that many people left the village on account of the earthquake. At present, the restoration project is in progress mainly in Dawran, including this area.

3.5.10 Al Husun Area

1) Location and natural environment

This site is a semi-urban densely-populated community, about 5 km to the east of a point before Marib on the paved road between Sana'a and Marib.

In the western and southern parts of the surveyed area, an irrigation project is in progress, and the main water channel is under construction at the west end of the area.
The precipitation is estimated at about 100 mm/year. The altitude is 1,000-1,100 m.

The surveyed land occupies a part of a vast plain area at the west fringe of extensive Rub Al Khali, and desert area is surrounded by several independent sandhills.

The stratum is considered to be made up of basalt, which is densely covered by wadi deposits and loss. The deposits consist of fine sand, silt, and clay. Cultivated fields surround the community.

2) Water supply and water source

Irrigation and domestic water are all pumped up from wells of 50-100 m in depth.
There are at least 6 wells, including private wells in the area.
Among these wells, an MPW well indicates that the static water level is 20 m and drops by 30 m when water is pumped up at a rate of 0.38 m^3/min.

From the topographical and geological viewpoints, these wells would cause no probelm in production when they serve as water source for the project.
Domestic water is taken out of public fountains valve beside the well. At present, any other facilities such as service pipeline have not been installed. However, the survey team has found tendering for construction of facilities was locally completed. Concerning this situation, the survey team has confirmed that the water supply project for this site is to be performed with local fund of MPW.

3.6 Water Rights and Land Acquisition

3.6.1 General

It is said that Islamic law include regulations related to water such as the establishment of water conservation areas, the priority of upper reaches in the basin, public use rights and others. Those concerning water wells are summarized below, in accordance with information obtained through interviews during the field survey.

In general the owners of water sources must share domestic water gratis to those without. However, in practical terms, this custom is applied only among the same tribe, and in most cases other tribes have to pay or are refused to use.

Basically, land tenure and water rights are individual items to be inherited or dealt with. However, since water rights are transferred together with land in most cases of actual dealings, it seems necessary to purchase land to establish a new well.

The owner of the well is considered to have an absolute right for its use. However, many complicated cases are involved in both land tenure and water rights.

LDA's local offices purchase the necessary land from the owners or get gratis or onerous the land use and water rights. However, there arise many complicated cases such as the cultivating rights belong to others. In case of such troubles, shaykh's * or a presbyter, who has jurisdiction, make necessary arrangements.

The problems mentioned above frequently tends to take a conflicting turn in case they involve other tribes.

Note: * The shaykh is a tribal leader to manage administration his tribal society. Usually he is elected by representative persons within the community such as village heads or family leaders, or is posted through the herediatry system.

3.6.2 Water Rights and Land Tenure Problems

The results of the site survey including interviews suggest that some problems on water rights and land tenure are likely to arise in relation to the implementation of the project. Furthermore it is necessary to review the problems in view of present system of tribal society in the Yemen Arab Republic. Such likely problems are described in detail in Appendix A-2-j.

In view of such a situation, the survey team asked the MPW to identify and solve those problems for the implementation of the project, and has obtained its consent to deal with them under its full responsibility. Since, this project is for public service, cooperation and understanding of the project of the owners of the water right and lands will expected (Appendix A-1-C).

However, in order to make a smooth progress of the implementation, it seems necessary to have meetings before the implementation with local authorities and land owners of the project site and obtain their agreement for the implementation of the project.

IV. THE PROJECT PLAN

IV. THE PROJECT PLAN

4.1 Objectives

In compliance with the request of the Government of YAR, the project is aimed at providing a stable supply of clean domestic water to rural inhabitants by means of constructing water supply facilities, in order to improve social environment and infrastructures of country's rural areas.

Ten sites were initially proposed for the basic design study. However, eight sites are appraised for the grant aid project, as stated in detail in the following section. Although this project is intended for the said eight sites, it is expected to make a large contribution to the improvement of social infrastructures mainly aimed in the 5-Year National Development Plan of YAR, eventually resulting in effecting a significant influence on the promotion of this sector in YAR.

4.2 Study of the Request

Based upon the field survey, the contents of the request and the project planning of the said eight sites are respectively studied as follows:

1) Wadi Asfan

The request of the Government of YAR suggested that existing shallow wells could be water sources for the project. However, it was judged through the field survey that the yields of shallow wells are not enough. Wadi Holman located in the north-east of the area was selected as the alternative location of a new water source, but it turned out the location could not be used for the project because the land tenure belonged to the other village. In this connection, geoelectric prospecting was carried out in order to probe possible water resources. As a result of this survey, a deep well is planned in the west of the site.

Since the location of the water source has completely been changed, the initially-proposed route of pipeline will have to be altered.

2) Al Khashna

Since the water supply scheme proposed by MPW was judged to be a proper one by the field survey, the basic design will follow this scheme. The site has an existing water source for the new system, as described in the request.

3) Al Zakira

The extension of existing supply facilities which was completed by the second phase of the Japan's Grant aid project was requested by the Government. The proposed scheme has no problems and the basic design will follow this scheme.

4) Al Kheisen

The field survey revealed the existing water source has an adequate production, as was confirmed through the analysis of pumping test data prepared by MPW. The basic design will follow the proposed scheme, since it is judged to be an appropriate one.

5) Al Rajam

The Government requested a new supply system with a water source should be installed for one of four blocks dividing the whole area of Al Rajam. Based upon the field survey, deep wells are proposed as possible water sources for the project, and optimum water supply scheme is planned for this site.

6) Shihara

The project area covers 22 villages scattered over the area of about 20 km^2, previously called HA-3A area in the F/S (Part II) report. Considering the results of geoelectrical survey, Wadi Woar located at the eastern fringe of the area is recommended as the candidate for the installation of a water source, and water supply scheme will be established based upon the field survey results.

7) Ad Dahi

Ad Dahi site is the center of an administrative subdivision called Nuhiya and is densely populated. Existing pipeline network has been functioning for 15 years, but has now been deteriorated resulting in as closing, leakage.

Elevated water tanks and main distribution network will be designed countermeasures in the basic design and parts of deteriorated facilities will be planned to be replaced.

8) Harad

A deep well and pumping station provided by the first phase Japan's Grant Aid and shallow wells locally installed are in service at this site. Pipelines, however, remains yet to be installed, since the site is densely populated community aimed flat plain area like Ad Dahi, an elevated tank and distribution network are planned to be installed under the project. In addition, parts of deteriorated existing facilities will be replaced.

9) Dimuna

The water supply scheme requested by the Government was previously prepared by MPW, but the overall review of this scheme is required due to its difference from the existing conditions. Particularly, since the shallow wells proposed for the project water source are not existing at the site, a new water source shall be studied.

As a result of the field survey, however, the development of a new water source seems not to prevail at the site due to the its topographic geomorphology and geologic conditions of the site. Accordingly, the proposed scheme needs to be altered.

Considering the possibility of water resources development in the adjacent areas, an extensive water supply scheme such as Dawron-Dimuna water supply scheme is recommended. In this connection, the basic design excludes Dimuna due to uncertainty in the establishment of new water sources.

10) Al Husun

MPW has agreed that Al Husun is excluded from the project since tendering for the construction of this site has been completed.

4.3 General Features of the Project

Basic design study is carried out on the basis of the site survey results. Taking into account the implementation of the project operation and maintenance plans and others, the general features of the project are outlined below: