4.2.3 Evaluation of the Request

As examined in Section 4.2.2, it was considered appropriate for the Project (Phase II) to be implemented with grant aid cooperation from the Government of Japan as a part of the Groundwater Development Project in the Southern Province that calls for the construction of 880 new deep wells.

The examination of the requested construction of new deep wells at 120 sites and rehabilitation of malfunctioning wells at 100 sites, the amount of the Japanese side's cooperation construction work, the need for drilling equipment and other pertinent equipment and materials necessary for Project construction was made as follows:

(1) Outline of Phase I and Phase II projects:

The procedure used for selecting the new well construction sites requested by the Zambian Government was described in detail in Section 3.4.2. An outline of the details is set forth below:

- The construction of wells having the highest priority at 120 sites of the Groundwater Development Project in the Southern Province was submitted as a request to the Japanese Government as the Phase I project. 102 wells were constructed under this project.

- Due to the lack of funds to construct all of the wells, the Government of Zambia selected the wells that are in most urgent need of either being constructed or rehabilitated at 220 sites -- there are 100 malfunctioning wells that need to be rehabilitated -- and submitted a request to the Japanese Government to undertake the work as the Phase II project (this Project).

The requested well sites are widely distributed throughout the seven districts of the Southern Province. The distance between well sites is quite far.

Residents in the well site areas are in urgent need of domestic water.

(2) Examination of the Water Supply Plan

The number of necessary wells in the requested 220 widely scattered site areas was examined based on the following water supply criteria:

- Water supply rate: 30 liters/day/person (design standard).
- Pumping rate of hand pumps: 750 liters/hr (well capacity).
- Hand pump operating time: 10 hrs/day (standard operation).

Thus, the planned daily pumping rate for hand pumps will be 7,500 liters/day (750 liters/hr X 10 hrs/day), and the number of beneficiaries per well will be 7,500 liters/day ÷ 30 liters/day/person = 250 persons.

However, it would be uneconomical to construct two wells in a site having a population of 270. Since the maximum daily hand pump operating rate is about 12 hours, in general, the maximum number of beneficiaries per well was calculated as being 300 persons: the maximum daily pumping rate per hand pump will be 750 liters/hr X 12 hours/day = 9,000 liters/day. The maximum number of beneficiaries will be 9,000 liters/day ÷ liters/day/person = 300 persons.

It would be uneconomical to construct a well for a small number of residents. Thus, the minimum number of beneficiaries was examined. The

standard operating time of a hand pump is defined as being 10 hours a day. It was considered that a site requiring less than 5 hours of hand pump operation cannot be considered as having a peiority for well construction. Therefore, the minimum daily pumping rate for a hand pump will be 750 liters/hr X 5 hours/day = 3,750 liters/day. The minimum number of beneficiaries per well will be 125 persons (3,750 liters/day ÷ 30 liters/day/person), and this figure will be used for Project well evaluation.

Based on the number of beneficiaries per well, as cited above, the desirable number of wells in well site areas was examined as shown in Table 4-2-2.

Table 4-2-2 The Number of Wells Desired and the Population in Well Site Areas

Range of A*	Area Population	Desired Number of Wells
A < 0.5	Less than 124	0
0.5≦ A < 1.2	125 - 300	1
1.2≦ A < 2.4	301 - 600	2
2.4≦ A < 3.5	601 - 874	3
3.5≦ A < 4.5	875 - 1,124	4
4.5≦ A < 5.5	1,125 - 1,374	5
5.5≦ A < 6.5	1,375 - 1,624	6
Continues with same rate	Continues with similar rate	Continues with same rate

*NOTE: $A = \frac{\text{Popultion in Project Site Area}}{250 \text{ (persons)}}$

- The population growth rate in the Southern Province was 2.8% per year (1969-1980 period). However, the population growth rate in the rural areas of the Southern Province was

estimated as 0.4% per year during the 1980-1990 period and 0.3% per year during the 1990-2000 period. The future rural population will be 2% more than the present one five years from now, and 4% more than 10 years from now. Thus, the population increases of a 250 resident community will be 5 persons five years from now (250 X 0.02) and 10 persons ten years from now (250 X 0.04). The increases are not significant; therefore, it was decided to use the present population figure in the Project site area and the total area population (158,974) for the Project well evaluation.

- Based on the above, the desirable number of wells in each requested Project site area was analyzed and the results, together with the requested number of wells, are tabulated in Table 4-2-3 (see Appendix Table B-9-1 for details).

Table 4-2-3 NUMBER OF WELLS DESIRED IN PROJECT SITE AREAS

	Number of Requested Sites	Number of Requested Wells	Population in the Site Areas	Desirable Number of Wells		
				To be Constructed	To be Regabilitated	Total
Requested New Well Construction	120	120	86,499	353	-	353
Requested Wells to be Rehabilitated	100	100	72,475	196	100	296
TOTAL	220	220	158,974	549	100	649

As shown in Table 4-2-3, the desirable number of wells in the Project site areas was calculated as 649 -- 549 new wells to be constructed; 100 wells to be rehabilitated.

Since the total population in the Project site areas is 158,974, the desirable number of wells can be simply estimated as follows: 158,874 persons ÷ 250 persons/well = 635 wells. Thus, the desirable number of wells in each requested Project site area that were calculated based on area population is considered to be reasonable.

(3) Examination of the Basic Design Policies

649 wells will be required in the 220 Project site areas to supply water that will staisfy the design standards of the Zambian water supply facilities.

In view of the recent frequent droughts, Project implementation is urgent. However, it will require a great deal of funds and a long period of time to construct and rehabilitate the 649 wells.

In order to alleviate the present domestic water shortages under the "scarce fund" situation, Project implementation will be a significant contribution in supplying drinking water to the residents.

(4) Examination of the Basic Conditions

The following four requirements had to be satisfied in order for a site to be evaluated as being eligible for either new deep well construction or malfunctioning well rehabilitation:

① Safe drinking water was not available from existing water sources, such shallow wells, rivers, and ponds that dried up during dry seasons (September through November).

② An area must have more than 125 residents (the minimum number of beneficieries per well).

③ As most of the existing water sources become depleted during dry season, the following conditions must be satisfied to obtain a Project well for providing safe drinking water;

Zambian water supply standards specify the minimum drinking water supply rate as 5.0 liters/day/person (the water supply rate is 30 liters/day/person).
In general, a human's daily water intake is from 2 to 3 liters. The standard of emergency water supply is set as 3 liters/day/person. The maximum daily hand pump operation time is approximately 12 hours. Thus, the maximum daily water supply rate per well is 750/liters/hr x 12 hr/day = 9,000 liters/day.

By applying the Zambian minimum drinking water supply rate -- 5 liters/day/person -- the maximum number of beneficiaries per well is 9,000 liters/day ÷ 5 liters/day/person = 1,800 persons. The above figure indicates that one well will be able to, at least, sustain the residents during drought seasons in areas having population of less than 1,800. Therefore,

an area whose population relies on one deep well must be less than 1,800.

④ Well location in the requested site must be planned so that it is easily accessible to by the residents.
The wells should be located in such places as a schoolyard, hospital complex, village center, market area, or field.
The conditions of the requested site areas are described in Section 3.4.2 and outlined in Tables 3-4-5 and 3-4-7.

The conditions of the requested site areas were examined based on the above four requirements. From this the necessity of new deep well construction or malfunctioning well rehabilitation was evaluated. The evaluation results are described below:

(5) Evaluation of New Deep Well Construction

The construction of 120 deep wells was requested. All of the requested sites, except two, satisfied the aforementioned four requirements. The two sites did not satisfy requirement ③ , ie., an area population must be less than 1,800 to secure the minimum amount of water (5 liters/day/person) during drought seasons. The two site areas have populations of 2,335 and 3,100 respectively. However, each of the areas has one existing deep well. Therefore, the number of residents who will rely on the new Project wells will be less than 1,800 persons per well and the Project wells will be able to provide more than 5 liters/day/person of drinking water during drought seasons.

As a result of the above evaluations, it was considered necessary to construct a total of 120 new deep wells at 120 requested sites -- one well per one site.

(6) Rehabilitation of Malfunctioning Hand Pump Wells

The rehabilitation of 100 malfunctioning hand pump wells at 100 sites was requested. All the requested well sites, except for six, satisfied the proviously mentioned four requirements. Five of the six sites did not satisfy requirement ③, ie., an area's population must be less than 1,800. The most populated area among the five site areas had 2,050 people. If a Project well is operated 12 hours a day, it will provide 4.39 liters/day/person (750 liters/hr x 12 hrs/day ÷ 2,050 persons) of drinking water during drought seasons; this is slightly less than the standard rate of 5 liters/day/person.

However, as described in requirement ③, a human's daily water intake is from 2 to 3 liters. 4.39 liters/day/person is more than the emergency water supply standard of 3 liters/day/person. In order to supply 5 liters/day/person of drinking water from a Project well, the required pump operation time X hours will be:

5 liters/day/person x 2,050 person = 750 liters/hr x X hrs/day.

Thus, X = 13.67 hours/day

This hand pump operating time exceeds the maximum hand pump operating hours of 12 hr/day. However, this hand pump operating time of 13.67 hrs/day will be limited only during drought seasons. It is a realistic figure.

For this reason, it was considered that these five requested sites satisfied the basic requirement ③.

The remaining one site did not satisfy basic requirement ②; ie., an area must have more than 125 residents. The work in this requested site for the rehabilitation of a malfunctioning hand pump well; the hand pump requires replacement. The cost for replacing the pump would be small compared to that for constructing a new deep well. For this reason, and because there is an urgent need from the humanitarian viewpoint, it was considered appropriate that the requested malfunctioning well should be rehabilitated.

(7) Examination of the Amount of Cooperation Construction Work to be Performed by the Japanese Side

The amount of cooperation construction work requested of the Japanese side takes in the construction of new deep wells at 80 of the 120 sites and the rehabilitation of the malfunctioning wells at all 100 sites. The requested amount was examined as follows:

The results of the analyses of Phase I project construction made it clear that improper drilling technique application, unfamiliarity with the drilling machines, improper equipment operations, and improper problem handling were encountered during the Phase I construction period. Thus, it is evident that the transfer of techniques needs to be provided under the Project (Phase II).

As the above happenings and equipment overuse occurred frequently, the equipment broke down often. For this reason, it is necessary to provide not only drilling techniques, but also there is the need to transfer equipment repair, maintenance, and management techniques from the Japanese engineers to the Zambia team. DWA

strongly requested the transfer of the above mentioned techniques.

To efficiently and smoothly carry out Project implementation it will be necessary not only to provide equipment and materials required for construction, but also to make a sufficient transfer of techniques. This can be accomplished by an on-the-job training program conducted by the Japanese side during the cooperation construction period. Japanese cooperation also includes providing the necessary technical advise, consultation, and construction supervision.

It is assumed that by providing the sufficient transfer of techniques, the Zambian team will be able to complete -- as initially planned -- the Groundwater Development Project that calls for the construction of 880 new deep wells after the completion of the Japanese side's cooperation construction work. Thus, the transfer of techniques will greatly contribute to the rural water supply projects in Zambia.

In light of the above reason, the Study Team considers that the Japanese side's cooperation construction work is necessary.

The amount of the Japanese side's cooperation construction work is to be decided upon by taking into account the allowable construction period under the rules of the Japanese grant aid system, the total length of the required construction period, the amount of construction equipment, the methods for transferring techniques, etc. Details concerning these amounts and times are described in the next chapter.

It was considered appropriate to undertake the construction of 32 new deep wells at 32 sites and the rehabilitation of 40 malfunctioning wells at 40 sites under the Japanese side's cooperation construction program.

(8) Evaluation of the Requested Drilling Machine

The Government of Zambia initially made a plan to construct 120 hand pump operated deep wells of the Project (Phase II) within a one year period by using the two drilling machines provided with grant aid under the Phase I project and the one drilling machine to be provided under the Project.

It took approximately one year to construct 102 deep wells under the Phase I project.

The Project (Phase ii) includes the construction of 120 new deep wells. Based on the drilling rate of the Phase I project, it will be possible to complete these 120 new deep wells within a one and a half year period. For this reason, for the time being, it is not considered necessary to provide one more new drilling machine under the Project.

(9) Other Related Equipment and Materials

In order to construct 120 deep wells and to rehabilitate 100 malfunctioning wells under the Project, it was considered appropriate to provide ① other pertinent materials necessary for the well rehabilitation work; ② spare parts for the equipment that was provided by grant aid from the Japanese Government for the Phase I project; ③ repair tools, wireless communications equipment,

testing equipments, and their spare parts; ④ Supporting vehicles.

The necessity for the above items -- the amounts, types, and specifications -- is described in Chapter 5.

4.3 Project Description

4.3.1 Project Agency

The responsible agency for the Project is the Ministry of Agriculture and Water Development (MAWD). Project implementation and management will be undertaken by the Department of Water Affairs (DWA). The contact point of DWA for the Project is the Data Planning Department.

The Project will actually be implemented, managed, operated, and maintained by the Southern Provincial Office and the District Offices as it was during the Phase I project. These offices will be responsible for providing a sufficient number of personnel to carry out the Project.

DWA will procure the equipment and materials necessary for the Project -- other than that which is to be provided by grant aid from the Government of Japan -- and will bear the costs of procurement.

4.3.2 The Project

The outline of the Project follows:

① The Project is a part of the Groundwater Development Project in the Southern Province (a rural water supply project) to construct 880 deep wells; it is a continuation of the Phase I project.

② The main objective of the Project is to supply reliable, safe drinking water throughout the year in the rural areas of the seven districts of the Southern Province.

It includes the following two items:

- Construction of hand pump operated deep wells: 120 sites
  Cooperation construction by Japanese side: 32 sites
  construction by Zambian side: 88 sites
- Rehabilitation of malfunctioning hand pump operated wells: 100 sites

Cooperation construction by Japanese side: 32 sites
construction by Zambian side: 88 sites

TOTAL 220 sites

③ The number of deep wells to be constructed, and the population in the well construction site areas in each district are as shown in Table 4-3-1.

Table 4-3-1 NUMBER OF NEWLY PROPOSED BOREHOLES AND POPULATION

Items \ District	GWEMBE	MAZABUKA	CHOMA	NAMWALA	MONZE	KALOHO	LIVING-STONE	TOTAL
Number of the newly proposed boreholes	14	20	29	9	28	17	3	120
Total population around the newly proposed boreholes	11,266	8,986	18,302	12,221	25,028	9,359	1,337	86,499
Average population around one newly proposed boreholes	805	437	632	1,358	894	551	446	719

④ The number of malfunctioning wells to be rehabilitated and the population in the well rehabilitation site areas in each district are listed in Table 4-3-2. The details of the each site are shown in Table 3-4-7.

Table 4-3-2 NUMBER OF PROPOSED BOREHOLES FOR REHABILITATION AND POPULATION

Items \ District	GWEMBE	MAZABUKA	CHOMA	NAMWALA	MONZE	KALOHO	LIVING-STONE	TOTAL
Number of the newly proposed boreholes	15	15	20	10	20	18	2	100
Total population around the newly proposed boreholes	20,450	7,350	11,990	12,000	8,440	11,745	500	72,475
Average population around one newly proposed boreholes	1,364	490	600	1,200	422	653	250	725

⑤ The water supply rate in rural areas of Zambian design criteria is 30 liters/day/person. By using this rate and by setting the Project well's design water yield as 750 liters/hr and the well operation time as 10 hours/day, one Project well will be able to provide a sufficient amount of water to 250 residents.

The population in the well construction site areas is more than can be supplied water by the above rated Project wells. Judging from the urgency of the Project, however, the Project wells will be able to provide precious drinking water to all of the people in the well construction site areas during drought seasons.

⑥ Project wells shall be the "borehole" type that will not become exhausted during the year. The average depth of the boreholes shall be about 50 m. Borehole water intake facilities shall be hand pumps.

Incidental facilities, such as concrete bases, drainage ditches, and drain pits are to be installed around the wells. Wooden fences, if necessary, shall be constructed around the concrete bases to prevent animal intrusions.

⑦ Project construction will be carried out by using the equipment provided by grant aid from the Japanese Government under the Phase I project and for the Project.

⑧ For project implementation, the Japanese side will undertake the detailed design, procurement and transportation of equipment and materials, the

construction of deep wells, the rehabilitation of malfunctioning hand pump wells, and the dispatching of engineers to supervise and give advise concerning the construction work and provide the technical guidance necessary for the operation and maintenance of the equipment and well facilities.

The Japanese side will also provide sufficient technique transfer to their Zambian counterparts so that it will be possible for them to continue on with the rural water supply project in the Southern Province after the completion of the Project.

⑨ Considering the urgency and importance of the Project, the system of Japanese grant aid cooperation, the Project scale, the nine month period of time for equipment and material procurement and transportation, and the actual construction period, two years and half will be necessary to complete the Project after signing the Exchange of Notes. The cooperation terms of the Japanese team's technical guidance, advice, and construction management work shall be within the limits of the Japanese grant aid system.

4.3.3 Equipment and Materials

The equipment and materials necessary for Project implementation are listed as follows (specifications and equipment and material quantities shall be studied during the basic design period):

I For Well Construction

1 - Equipment

A) New Equipment and Spare Parts:

1. Supporting Vehicles
2. Testing equipment
3. Repair tools
4. Other related equipment

5. Spare parts for items 1 through 4.

B) Spare Parts for Previously Donated Equipment

1. For two drilling rigs and their appurtenances
2. For vehicles
3. For other related equipment

2 - Other equipment and Materials

1. Guide pipe
2. Casing pipe
3. Screen pipe
4. Hand pumps and their appurtenances
5. Chemical agents
6. Other related materials

II For Malfunctioning Well Rehabilitation

1 - Equipment

1. Vehicles
2. Air compressor
3. Spare parts for air compressor

2 - Other Equipment and Materials

1. Hand pumps and their appurtenances
2. Guide pipe
3. Casing pipe
4. Screen pipe
5. Chemical agents

CHAPTER 5. BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5.1 BASIC DESIGN POLICIES

The Project is a part of the Groundwater Development Project in the Southern Province and is a continuation of the Phase I project. Its purpose is to construct hand pump operated deep wells and to rehabilitate malfunctioning hand pump wells in order to provide safe drinking water in rural areas throughout the year.

As it was planned to implement the Project with grant aid cooperation from the Japanese Government, the rules of the grant aid system was taken into consideration for the basic design of the Project. Additionally, various Zambian situations, Project Area conditions, compatibility to the Phase I project, and other related conditions were also considered as prerequisites for the basic design. As a result, the following design policies were established for the basic design:

(1) To conform to the Zambian water supply policies, rules and standards.

(2) To design economical facilities that will suit the standards of each Project site.

(3) To make Project planning by taking into account the Project Area's climatic conditions, and the situations and usual practices of DWA's Drilling Section.

(4) To select such economical equipment and materials that are suitable not only for use in the Project Area, but in all natural conditions of Zambia.

(5) To make a Project implementation plan that will utilize the equipment already provided by the

Phase I project and the equipment to be provided by the Project.

(6) To select such equipment that meets the specifications of the equipment that was provided under the Phase I project by considering the standardization of DWA's equipment, provision of spare parts, management and maintainability, ease of operation, and the efficiency of grant aid.

(7) To exclude such requested equipment, if any, that will not be necessary for Project implementation. To examine such equipment, even if not requested, that will be indispensable for Project implementation and suitable for grant aid in order to include it in the Project's equipment supply programme.

5.2 DESIGN CRITERIA

The Project and Phase I project have certain similarities in their scales, items, and area. Based on Phase I project experience, the items for Project (Phase II) were specified in the request. Since the conditions necessary for the basic design were already evaluated in Chapter 4, section 4.2.3., summaries of basic design conditions are given below:

5.2.1 Deep Well Construction

(1) Construction Sites:

There are 120 construction sites in the seven districts of the Southern Province as shown in Fig. 2-3-1. 36.7% of the sites are located in schoolyards, 4.2% in hospital complexes, 55% in village centers, and 4.2% in market and field areas. All locations are easily accessible to by the residents.

Residents in these site areas are presently taking their drinking water from dug wells or streams that become exhausted during dry and drought seasons.

(2) Water Sources and Intake Facilities:
The water sources for the Project wells are to be "boreholes" that will not run dry at any time throughout the year. The water intake from the boreholes shall be made by hand pumps.

(3) Water Supply Rate:
The water supply rate in the residential areas of the Zambian design criteria is 30 liters/day/person. This rate is also used for the rural water supply projects. Thus, this rate was adopted for the basic design.

(4) Beneficiaries and Population in the Well Construction Site Areas:

The design water intake rate by a hand pump was set at 750 liters/hour and 7,500 liters/day for a 10-hour operation.

The number of beneficiaries per one well is 250 persons based on the water use rate of 30 liters/day/person. Thus, the 120 Project wells will provide water to: 120 wells x 250 persons/well = 30,000 persons. However, the actual number of people living in the Project well site areas is 86,499. Therefore, the number of people who will use one Project well in each district will be from 446 to 1,358 for an average of 721 persons/well.
The present standard for well construction projects is 250 to 300 persons per well. Most of the wells, however, are planned based on 200 to

600 persons per well. Some are planned as having more than 1,000 persons per well.

In the Project well construction site areas, the shallow wells and streams dry up during drought seasons. Therefore, it is considered that the entire population in the areas (86,499 residents) will use the Project wells during drought seasons. The minimum amount of drinking 5 liters/day/person will be obtainable during drought seasons.

(5) Drilling Depth

The minimum depth of the 102 boreholes drilled under the Phase I project was 26 m, the maximum was 79 m, and the average was 49.2 m. According to the DWA Drilling Section's data, the average depth of the 214 boreholes drilled during the past 3 years is in the range of 49 to 57 m.

Taking into account the above figures, and from the viewpoint of possible water contamination from the ground surface and the capacities of the hand pumps, it was determined that the depths of the Project's boreholes were to be in the range of 30 to 70 m having an average depth of 50 m.

(6) Selection of Drilling Sites

As described in the previous chapter, the borehole drilling sites were selected based on present water source conditions and the number of beneficiaries in each district. In order to determine the best well locations in each site area it is necessary to further examine the geological features by conducting electrical prospecting and well loggings as well as to investigate the area topography, hydrogeology,

the distribution of houses and population, the distances between the well and the houses, etc.

(7) Hand Pump Installation

The judgement made as to whether the hand pump installation should be made was based on the same standards used in the Phase I project, they are as follows:

- The borehole must be judged as a "dry hole" if groundwater is not found within a depth of 50 meters.
- If the static water level of a well was more than 50m below the ground surface, it would be impossible to draw water using a hand pump. In this case, no hand pump installation is to be made.
- If a pumping test reveals a pumping rate of more than the design criteris 750 liters.hr, ie., 12.5 liters/min., a hand pump must be installed without question.
- If a pumping test indicates a pumping rate of less than the design criteria, whether to install a hand pump will be a matter decided upon after discussions are held with the Zambian side. The discussions will take into account the existing wells in the vicinity, as was done when the Phase I project wells were being constructed. Case example, if a well yields 7 liters/min., the hourly yield will be 420 liters; the daily yield will be 5,040 liters per 12 hour period. It would be possible for this well to supply 20 liters/day/person of water to 250 residents. Thus, to install a hand pump in a well having a yield rate less than the design criteria will be a matter decided upon only after holding discussions with the Zambian side with

consideration given to area conditions and without abandoning the constructed borehole.

5.2.2 Rehabilitation of Malfunctioning Deep Wells:

(1) Rehabilitation Well Sites

In the seven districts of the Southern Province there are 100 wells sites to be rehabilited. These sites are shown in Fig. 2-3-1. 49% of the sites are in schoolyards, 3% are in hospital complexes, 44% are in village centers, and 4% are in market or field areas. These sites can be reached easily by the residents.

The wells in these sites have been malfunctioning for an average of nine years. Presently, the residents in these site areas rely on shallow wells or streams that become exhausted during dry and drought seasons.

(2) Water Supply Rate:

The water supply rate in Zambian residential areas is 30 liters/day/person. This rate is applied to the rural water supply projects. Therefore, this rate was adopted for the basic design.

(3) Beneficiaries and Population in the Rehabilitation Well Site Areas:

The design water intake rate by a hand pump was set at 750 liters/hr and 7,500 liters/day for 10-hour use. The number of beneficiaries per one well is 250 persons based on the water use rate of 30 liters/day/person. Therefore, the 100 wells that are presently malfunctioning will be able to provide water to: 100 wells x 250 persons/well = 25,000 persons. However, there are 72,475 people living in the site areas; therefore, from 250 to 1,200 people in each

district -- an average of 725 persons/well -- will use one rehabilitated well. The present standard for well construction projects is 250 to 300 persons; however, most wells are planned based on 200 to 600 persons per well. Some are planned for use by more than 1,000 persons per well.

In the rehabilitation well site areas, the shallow wells and streams become exhausted during drought seasons. Therefore, most of the 72,475 people may use the newly constructed deep wells. Even if in this case, the minimum amount of drinking 5 liters/day/person will be obtainable.

(4) Well Rehabilitation:

The purpose of well rehabilitation work is to make well facilities usable by replacing malfunctioning hand pumps with new ones. However, there are some wells that are beyond repair due to deterioration or the collapse of boreholes, or because of groundwater conditions.

It was estimated that about 20% of the rehabilitation wells would be beyond repair. These wells will have to be replaced by new ones. The design criteria for the construction of these new wells shall be the same as previously described.

5.3 DESIGN OF WELLS

5.3.1 Borehole Structure

Project boreholes are to be drilled to the depth of from 30 to 70 m. The average well depth will be 50 m. The water intake rate by a hand pump is to be 750 liters/hr. To allow for this water intake rate, the diameter of the pump cylinder should be from 50 to 90

mm. Thus, the required minimum diameter of the well's permanent casing should be 100 mm.

Some of the 102 wells drilled under the Phase I project have casing diameters of 150 mm. Taking into account the possibilities of installing electric power operated submersible pumps in the future, some wells' permanent casings should have diameters of 150 mm (minimum).

In view of the above, it was decided upon to design two types of well structures: those having 100 mm (4 inch) casings, and those having 150 mm (6 inch) casings.

The borehole drilling method and the drill hole diameter must be changed depending upon the geological conditions, such as hard rock, weathered soft rock in shallow strata, unsolidified deposits, etc., and their depths.

Four types of the basic design's borehole structure are shown in Fig. 5-3-1 and 5-3-2.

The design of the borehole structure was made based on the following conditions:

① The borehole depths shall be in the range of 30 to 70 m with the average being 50 m.

② Gravel pack shall be placed between the permanent casing and the drilled hole from the borehole bottom up to 6 m from the ground surface. Then, cement motar shall be filled in up to the ground surface.

③ The drill bit diameter for the final drilling shall be selected to make a minimum clearance of 25 mm

between the screen pipe and the borehole wall in order to allow space for effective gravel packing.

④ Center risers shall be installed at the joints of the screen pipe (4 m intervals). This will keep the screen pipe at the center of the borehole, and will allow uniform gravel packing around each screen pipe section.

⑤ A 270 mm (10 5/8 inch) diameter tricorne bit was used for the surface drilling of boreholes under the Phase I project. The clearance between the borehole and the surface temporary casing, that was used to prevent dirt from falling, was only 8 mm, and it was reported that the extraction of the surface temporary casing was extremely hard. For this reason, plans were made to use 311.2 mm (12 1/4 inch) diameter tricorne bits for the surface drilling of Project boreholes. The surface temporary casing shall be equipped with metal shoe to prevent air leakage during air-percussion drilling.

5.3.2 Appurtenant Facilities

The appurtenant facilities for the hand pump operated wells, such as concrete slabs, drainage ditches, and infiltration pits, are to be installed around the wells to prevent well pollution.

The slabs shall be made of reinforced concrete, having 9mm round steel bars at 300 mm intervals to prevent cracking.

Fences were not designed for the wells in the Phase I project. However, DWA installed wooden fences around the wells to prevent animal intrusions, thereby keeping the well area safe and sanitary.

The Study Team found that the fences were beneficial for the well users. Also, fences would make the residents aware of the importance of the wells. For these reasons, the installation of fences around the wells was included in the basic design.

The details of the appurtenant facilities are shown in Figs. 5-3-3, 5-3-4, 5-3-5, and 5-3-6.

Fig. 5-3-1 STRUCTURE OF THE BOREHOLE WITH 4" DIAMETER

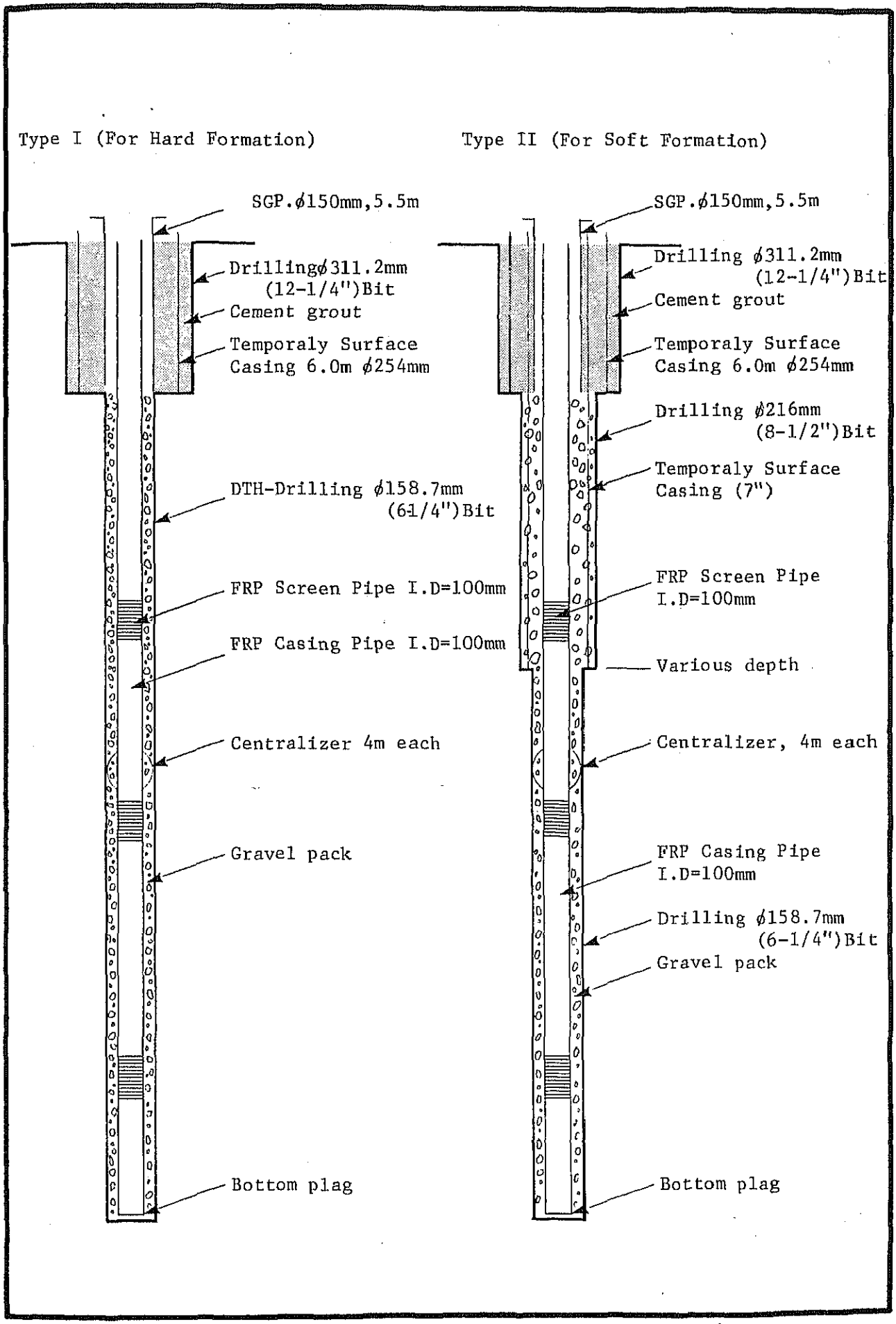


Fig. 5-3-2 STRUCTURE OF THE BOREHOLE WITH 6" DIAMETER

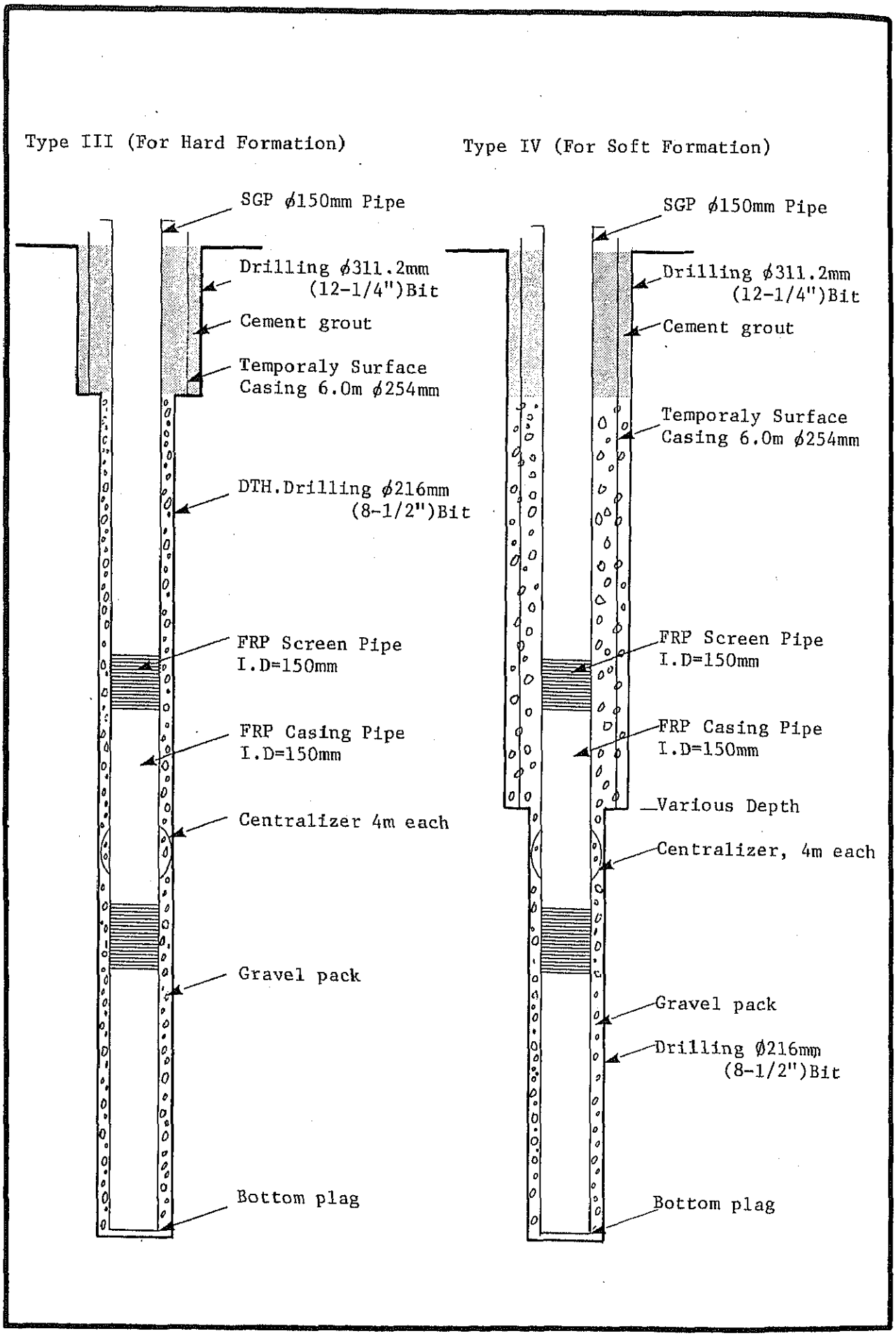


Fig. 5-3-3 GENERAL PLAN OF CONCRETE SLAB AND APPURTENANCE

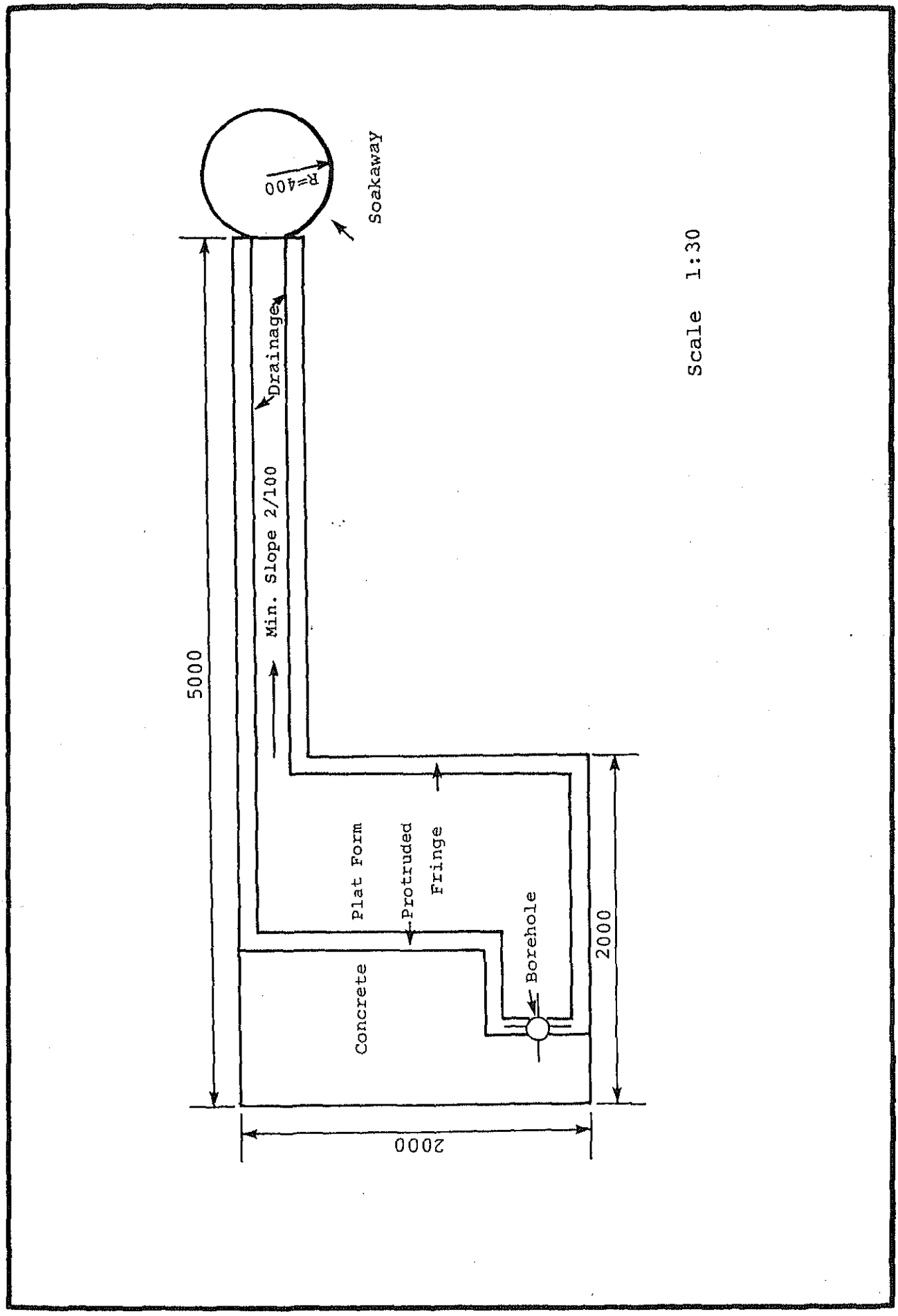
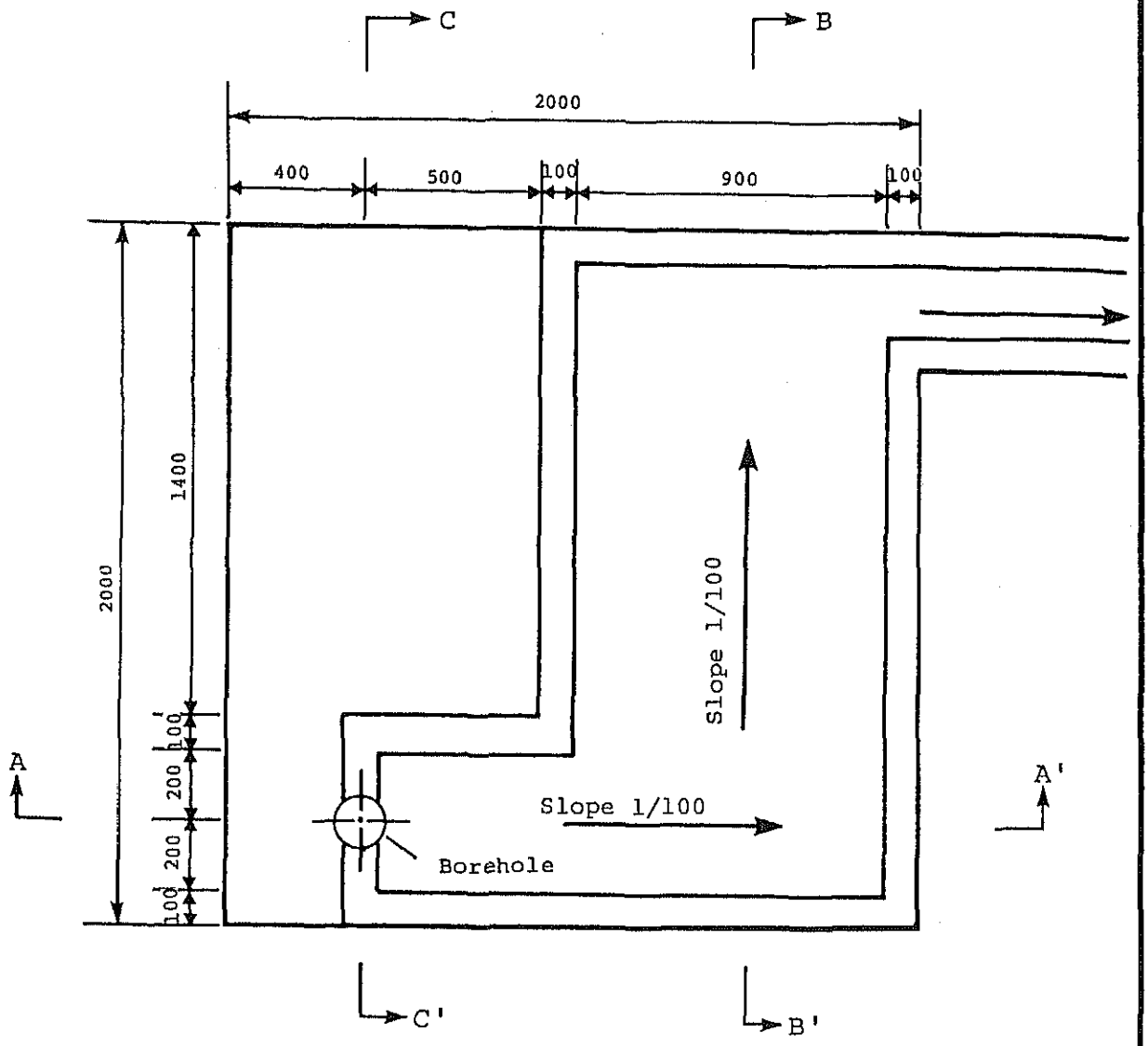


Fig. 5-3-4 DETAIL PLAN OF PLAT FORM



(Scale 1:20)

Fig. 5-3-5 SECTION OF PLAT FORM

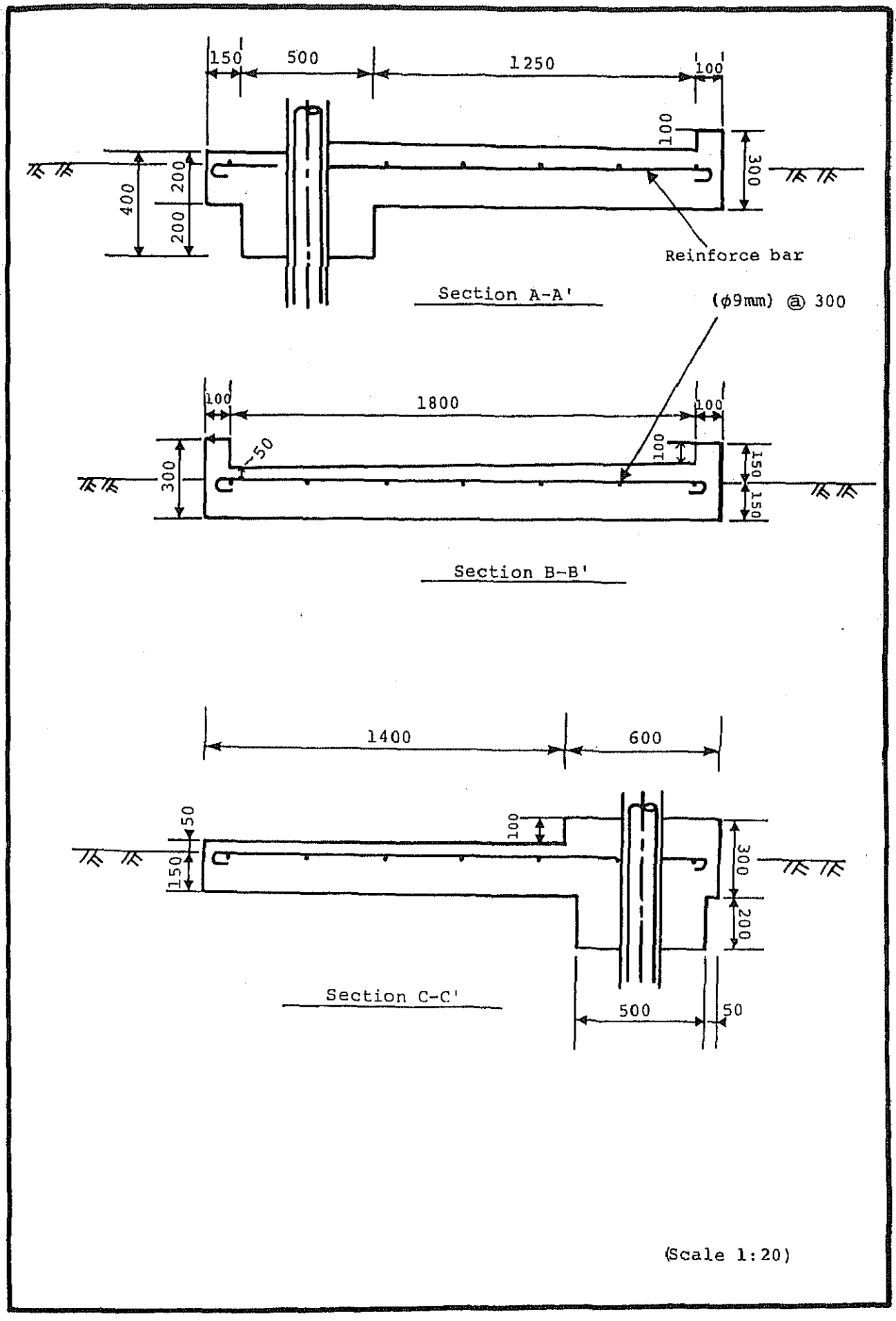
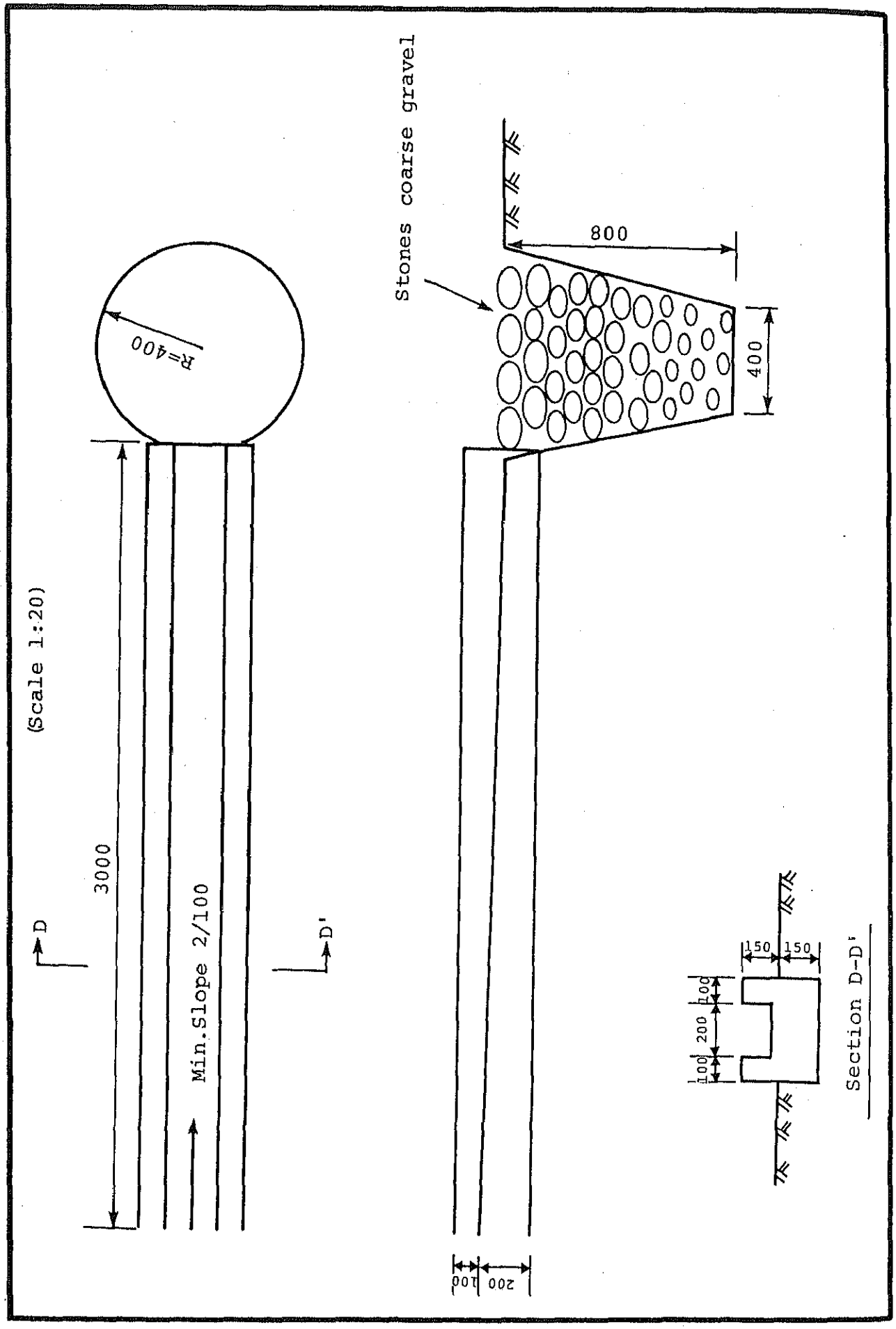


Fig. 5-3-6 DETAILS OF APPURTENANT STRUCTURE



5.4 EQUIPMENT AND MATERIAL PLAN

5.4.1 Selection of major Equipment and Materials:

Major equipment and materials necessary for the Project were selected based on the previously described basic design and the Project construction plan outlined in Chapter 6.

The equipment and materials necessary for the Project are as follows:

I For Well Construction

(1) Equipment

A) New Equipment and Spare Parts:

1. Vehicles

2. Testing equipment

3. Repair tools

4. Other related equipment

5. Spare parts for items 1 through 4.

B) Spare Parts for Previously Donated Equipment

1. For two drilling rigs and their appurtenances

2. For vehicles

3. For other related equipment

(2) Other Equipment and Materials

1. Guide pipe

2. Casing pipe

3. Screen pipe

4. Hand pumps and their appurtenances

5. Chemical agents
6. Spare parts for item 4.

II For Malfunctioning Well Rehabilitation

(1) Equipment

1. Vehicles and tools for hand pump maintenance service

2. Air compressor

3. Spare parts for item 1 and 2

(2) Other Equipment and materials

1. Hand pumps and their appurtenances

2. Guide pipe

3. Casing pipe

4. Screen pipe

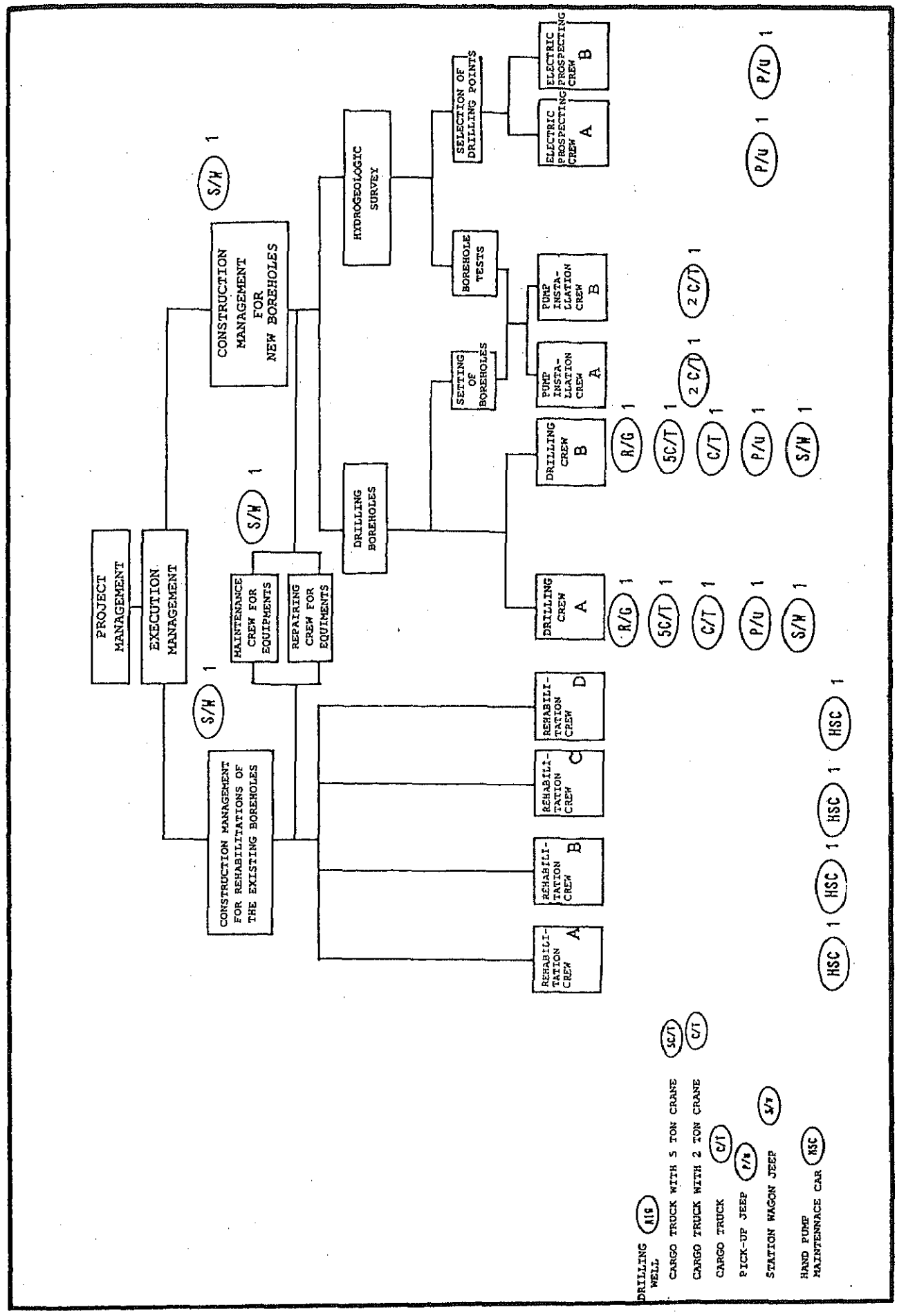
5. Chemical agents.

The equipment and material selections were made based on the following considerations:

(1) Vehicles

For the selection of vehicles necessary for Project implementation, the vehicle arrangement structure necessary for each work group was made as shown in Fig. 5-4-1.

Fig. 5-4-1 VEHICLES ARRANGEMENT



From Fig. 5-4-1, the number and types of vehicles to be arranged for each work group can be tabulated as shown in Table 5-4-2.

Table 5-4-1 VEHICLE ARRANGEMENT FOR THE DIFFERENT TYPES OF WORK

Vehicle / Work	Number of Work Groups	Cargo Truck			Light Vehicle		Total	Drilling Machine	Hand pump service vehicle
		With 5ton Crane	With 2ton Crane	Without Crane	Pickup Truck	Station Wagon			
Supervision (construction and rehabilitation)	2					2	[0] 2		
Site Investigation and Electrical Prospecting	2				[1] 2		[1] 2		
Borehole Drilling	2	[1] 2		[2] 2	[2] 2	[2] 2	[7] 8	[2] 2	
Pumping Test, Pump Installation, and well Logging	2		[1] 2				[1] 2		
Equipment Repair and Maintenance	2					1	[0] 1		
Well Rehabilitation	4								[0] 4
Total	14	2	2	2	4	5	15	2	4
Numbers provided under Phase I		[1]	[1] *	[2]	[3] ** (2)	[2] *** (1)	[9] (7)	2	0
Number to be provided under Phase II		1	1	0	2	4	8	0	4

Notes: * The trucks provided under Phase I were with 3ton Cranes.

** Three pickup trucks were provided under Phase I, but the one was heavily damaged, beyond repair.

*** Two station wagon were provided under Phase I, but the one is inoperable after an accident.

[ ] : Units provided under Phase I.
( ) : Presently operating units.

Based on the number and types of vehicles shown in Fig. 5-4-1 and Table 5-4-1, the vehicle selection was made as follows:

a) Cargo Truck with 5-ton Crane

By taking into account the poor road conditions in the Southern Province, heavy equipment, such as high-pressure air compressors, welding machines, etc., must be transported by truck. The truck must be equipped with a 5-ton crane for loading and unloading equipment as well as for transporting casing pipe, gravel, etc.

Because of the nature of borehole drilling work, one truck must be assigned to each drilling machine. In the Phase I project, only one truck was assigned to the two drilling machines. Thus, for the Project, one more cargo trucks with 5-ton cranes must be provided.

b) Cargo Truck with 2-ton Crane

Cargo trucks equipped with 2-ton cranes will be required for borehole loggings, pumping tests, and hand pump installation work after the borehole drillings.

Since only one cargo truck equipped with a 3-ton crane was provided under the Phase I project, the hand pump installation work, after borehole drilling, was delayed. For this reason, two cargo trucks having small turning radiuses, that are equipped with 2-ton cranes, shall be provided for under the Project. One cargo truck will be assigned to each of the two drilling teams.

c) Light Vehicles

Light vehicles will be required for use when making field surveys related to borehole drillings and for transporting drilling personnel, equipment, and materials.

Station wagons will be suitable for personnel transportation. Pickup trucks will be convenient for equipment and material transportation.

The wagons and trucks shall be long-body types.

For Project implemention, a total of two pickup trucks and four station wagons will be required (see Table 5-4-2).

(2) Testing Equipment

For the selection of borehole drilling locations, hydrogeological tests, pumping tests, and water quality examinations after the borehole drillings, the following equipment shall be provided:

a) Electrical Prospecting Equipment (two sets):
Electrical prospecting must be conducted to examine the hydrogeological condition in order to select proper borehole drilling locations. The electrical prospecting shall be carried out by two teams. Thus, two sets of electrical prospecting equipment shall be provided.

b) Electric Conductivity Meter (one unit):
One electric conductivity meter shall be provided to measure the conductivity of pumped up groundwater.

c) PH Meter (one unit):
One PH meter is to be provided to measure groundwater quality.

(3) Repair and Maintenance Tools

DWA requested the provision of repair and maintenance tools for use at the repair shops of DWA's Monze and Choma offices. The tools are

essential for repairing and maintaining the provided equipment.

DWA submitted the list for vehicle repair and maintenance tools. However, a suitable number of repair and maintenance tools shall be provided for the vehicles and equipment presently in DWA's possession, as well as for those to be provided under the Project.

(4) Other Related Equipment

The following equipment related to borehole drilling work are to be provided:

a) Wireless Communications Equipment:

During the Project implementation period, communications between DWA's Drilling Section Office in Monze and the field survey camps, and the drilling and rehabilitation well sites is essential for periodically reporting work progress of for making notification of accidents.

As there is no telephone network to cover the villages in the rural areas, a wireless communications system is to be provided.

One fixed communication station shall be installed at Monze, and a total of four mobile stations shall be provided to the drilling teams, and construction and management personnel vehicles. The fixed station's output power of 100 W should be sufficient for communicating with the mobile stations.

(5) Spare Parts for Previously Donated Equipment

For the Phase I project, two drilling machines and other equipment required were provided for the construction of 102 wells.

As described in Section 5.1, Project construction will be carried out by two drilling teams using the previously provided equipment and the equipment to be provided under this Project. Thus, it will be necessary to maintain the capabilities of the previously provided equipment at the same level as the new equipment to be provided under the Project.

The wear and tear of tools and consumable spare parts for the previously provided equipment were examined. The selection of tools and spare parts were made based on the degree of the wear and tear of the tools and spare parts of equipment, the inventory list (dated October 1987, at the time when the drilling of the 102 boreholes was completed) of the DWA Monze Office's warehouse, and the results of the Study Team's investigation.

a) Drilling Tools:
   Drilling tools, such as drill pipes, bits, and hammers, are, after the drilling machines, the most important items for borehole drilling.

   These tools can be roughly classified as follows:

   1. Standard accessories for the drilling rig

   2. DTH drilling tools

   3. Operating tools for rotary mud circulation drilling

   4. Other work tools

The above listed types of tools required for drilling boreholes were provided under the Phase I project.

The inventory rate for each tool (obtained from the inventory list of October 1987, and the results of the Study Team's investigation) that indicates its consumption rate was tabulated as shown in Figs. 5-4-2, 5-4-3, 5-4-4, and 5-4-5. From these Figures, the consumption rate for each tool was obtained as follows:

Standard accessories for drilling rig:	55.3%
DTH drilling tools:	90.6%
Operating tools for rotary mud circulation drilling:	59.4%
Other work tools:	72.3%

Fig. 5-4-2 STOCK PERCENT OF STANDARD ACCESSORIES FOR DRILLING RIG

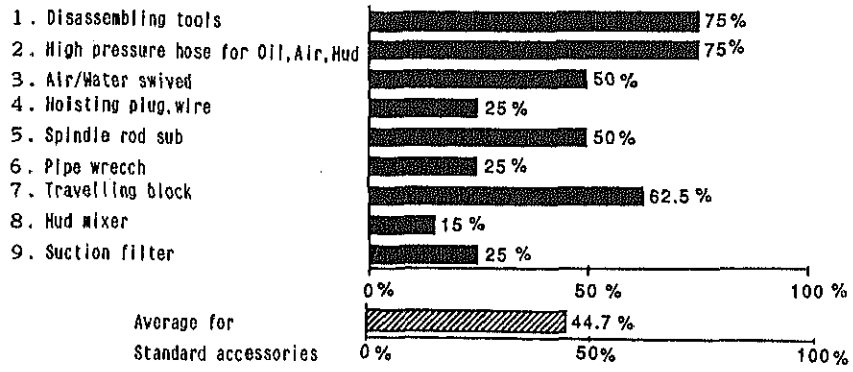


Fig. 5-4-3 STOCK PERCENT OF DTH DRILLING TOOLS

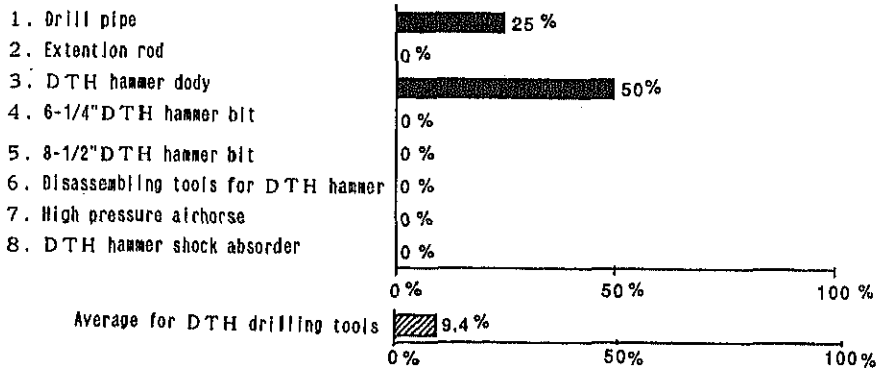


Fig. 5-4-4 STOCK PERCENT OF OPERATING TOOLS FOR ROTARY MUD-CIRCULATION DRILLING

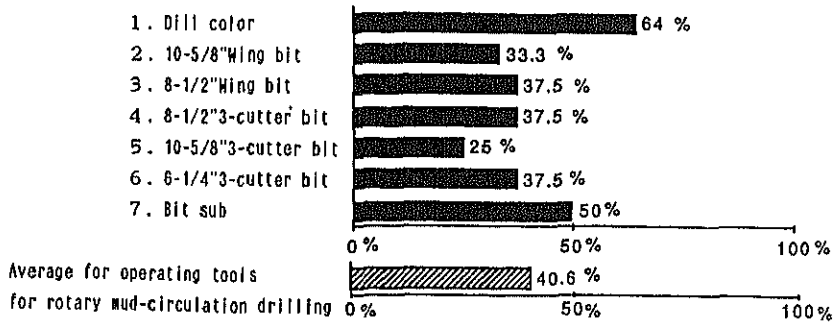
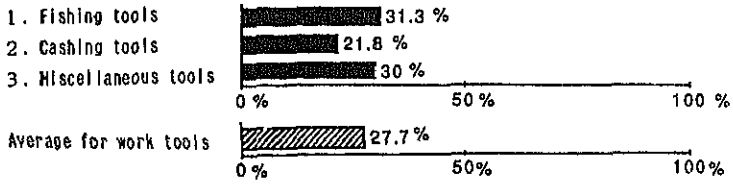


Fig. 5-4-5 STOCK PERCENT OF WORK TOOLS



From the above Figures, it is clear that the provision of DTH drilling tools is extremely insufficient because of their high consumption rate. In particular, the supplies of 6 1/4 and 8 1/2 inch DTH hammer bits, extension rods, DTH hammer assembling/disassembling tools, high-pressure hose, and DTH hammer shock absorbers were depleted (see Fig. 5-4-3). This fact was also recorded in the drilling work diary of the Phase I project. The use rate employing the DTH hammer method was estimated as being 80% of the borehole drilling. In reality, however, this method was used for 91% of the drilling (93 out of 102 boreholes employed this method). In order to provide for well-balanced tool consumption, the selection of proper quantities and types of tools must be made by taking into account the above figures.

The inventory rate of the rotary mud circulation drilling tools was 40.6%. DWA will have to drill boreholes only by the rotary mud circulation method using these tools for a 14 month period prior to the commencement of the project. The consumption rates of these tools depend upon the number of boreholes to be drilled. However, it is assumed that these tools will be completely used up prior to starting the Project as will most of the DTH drilling tools.

In view of the above, a sufficient number of each type of tool must be provided based on past consumption rates.

b) Equipment Spare Parts:
The previously provided equipment must be thoroughly repaired in order to reduce the

differences in the capabilities and levels of wear and tear between the previously provided equipment and the new equipment to be provided by the Project. Further, the prolonging of the equipments' period of serviceability is one of the basic policies of the Project.

Based on the above concept, spare parts for the following equipment were selected (by taking into account the spare part consumption rates based on the inventory lists of DWA's Monze Office, the number of spare parts for each piece of equipment that will be sufficient for two-years' use -- that will be in balance with the Project's construction schedule and costs -- shall be provided):

	Spare Parts
1. Drilling machine, FSW-7T (made by KOKEN Co.), including mounting truck NZ 227:	For two units
2. Cargo truck with 5-ton crane, ZC141EC (Made by Hino Co.):	For one unit
3. Cargo truck with 3-ton crane, NZ227KA (Made by Hino Co.):	For one unit
4. Cargo truck, NZ227KA (Made by Hino Co.):	For two units
5. Pickup truck, BJ75RP-KR (Made by Toyota Co.):	For two units
6. Station Wagon, BJ75RV-KR (Made by Toyota Co.):	For one unit

7. High-pressure aircompressor, XRH350DD (Made by Atlas Copco Co.): For two units

8. Submersible motor operated pump for pumping tests 40BHS 22-53.7 (Made by Ebara Co.): For two units

9. Generator for the submersible pumps DCA14AM (Made by Denyo Co.): For two units

10. Electric welding machine, DCX-270SSI (Made by Denyo Co.): For two units

11. Pipe splitter, PRIMAC370 (Made by Daido Co.): For one unit

12. Motor operated grinder, GBK-2 (Made by Hitachi Co.): For one unit

13. Motor operated drill, BUI-SH3 (Made by Hitachi Co.): For one unit

14. Pipe cutter, H-12C (Made by Hitachi Co.): For one unit

(6) Guide Pipe:

The installation of temporary guide pipe is required to prevent dirt from falling into the borehole near the ground surface. A metal shoe must be installed at the top of each temporary guide pipe to prevent air leakage during the air-percussion drilling period.

(7) Casing Pipe / Screen Pipe

The following three types of material are being used at present for casing/screen pipes of wells:

-SGP (Steel Galvanized Pipe)
-ERP (Fibre glass Reinforced Plastic)
-PVC (Poly Vinyl Chloride)

The type of pipe to be used is selected according to the type of well and its location. Each has its merits, however in order to choose the appropriate material for this project, the following characteristics of each material have been considered:

		S G P	F R P	P V C
	Bending Load	- *	650 kg	160 kg
	Eccentric Breaking Load	- *	1,065 kg	355 kg
	Tensile Strength	30kg/mm	10,400 kg	2,850 kg
	Tensile Strength of Joints	- *	6,400 kg	3,350 kg
	Strength against impact	Very Strong	Fair	Weak
Chemical Resistance		Easily erroded by salts and acids	Strong	Strong
Bending due to High Temberature		Very Small Change	Minor change: Maximum deflecton was 7mm after heating to 60°C for 10 min.	Significant change: Maximum deflection was 35mm after heating to 60°C for 10 min.
Price		High	Medium	Low
Joining Method		Welding or bolting	Bonding or bolting	Bonding or bolting

*Notes: In case of physical Strength of SGP there are no concrete Indicate range except tensile strength.
However, each strength are especially stronger than other pipes.

Taking into account the characteristics of each materialmentioned above, the following conditions should be considered:

① The transportation facilities in Zambia are such that the physical strength of the material needs to be considered in order to decrease damage at the time of transportation and setting up.

② In order to secure safe drinking water, which is the purpose of this project, the material has to be resistant to any chemical change.

③ Considering the high temperature of the country, it has to be resistant to direct sunlight.

④ It needs to be economical

Taking into account the above points, SGP can resist bending due to high temperature or physical strength, however it is weak with regard to chemical resistance. Moreover, the cost of the slitting process when used as a screen pipe is expensive.

On the other hand, PVC is very economical and is resistant to chemical change, however it is physically weak and bending will occur under the high temperature conditions of Zambia, therefore its use cannot be possible. Taking into consideration the various conditions of this project, we have selected the use of FRP, although its cost is slightly higher than PVC.

As regards the joining method, bonding was used, however as the work is done outside under high temperature conditions, the bonding cannot efficiently stand up to it and in one case it

actually dropped into the well itself. As the joining process took a long time i this case, the bolting method will be used in this project.

Based on Section 5.3 of the original plan a 4 inch (100mm) and 6 inch (150mm) diameter pipe will be used. Based on the original plan of average depth 50m, the pipe extension will be 52m (4m x 13) taking into account pipe loss. Therefore the number of pipes needed for the 120 new wells (6 inch x 24, 4 inch x 96) at 16m screen distance is estimated as follows:

6 inch (150mm) CASING PIPE: 864m =216pcs (1=4.0m)
4 inch (100mm) CASING PIPE: 3,456m =864pcs (1=4.0m)
6 inch (150mm) SCREEN PIPE: 383m = 96pcs (1=4.0m)
4 inch (100mm) SCREEN PIPE: 1,536m =384pcs (1=4.0m)

Furthermore, the following amount of casing/screen pipes will be necessary for 20 wells to be used for the rehabilitation of defective wells (examined in section 6.3)

4 inch (100mm) CASING PIPE: 720m =180pcs (1=4.0m)
4 inch (100mm) SCREEN PIPE: 320m = 80pcs (1=4.0m)
BOTTOM PLUG 4 inch diameter: 20
CENTRALIZER 4 inch diameter: 120

(8) Chemical Agents:

For the application of the rotary mud circulation drilling method, bentonite and CMC will be required for use as the active agent and filler of the mud.

When the air-percussion (DTH) method is used, a foaming agent is required to make drill chip removal easier, and for preventing drill chips from scattering on the ground.

Considering the remaining amount of chemical agents supplied under the Phase I project, the amounts necessary for drilling the 120 boreholes are: 8.5 tons of bentonite; 0.85 ton of CMC agent; 0.43 ton of foaming agent.

The amounts of chemical agents needed for drilling the additional 20 boreholes that are to replace the malfunctioning wells that are beyond repair are: 1.5 tons of bentonite; 0.15 ton of CMC agent; 0.07 ton of foaming agent.

(9) Hand Pumps

As was done for the Phase I project, deep well hand pumps to be installed in the Project's boreholes were selected from the viewpoint of their prime costs, operation and maintenance costs, ease of management and maintenance, and their water supply capacity.

In Zambia, Indian Mark II (plunger type) and Mono (rotary type) model hand pumps are widely used.

The capabilities of the hand pumps vary largely depending upon the companies manufacturing them. The hand pumps can be roughly classified in three groups: plunger type; bellows type; diaphragm type. A comparison of these types are shown in Table 5-4-2.

Table 5-4-2 COMPARISON OF PUMP TYPES

	Plunger Pump	Bellows Pump	Diaphragm Pump
I. Specifications:			
(1) Pumping Method:	Plunger	Bellows	Diaphragm
(2) Power Transmission method:	Rod	Cable	Hydraulic
(3) Operation:	Hand	Hand	Hand or foot
(4) Cylinder diameter:	75 mm	89 mm	92 mm
(5) Minimum borehole diameter	100 mm	100 mm	100 mm
(6) Cylinder pipe:	50 mm steel	32 mm steel	Two - 26mm hose
(7) Pumping rate (lift):	15 liters/min (25m)	18 liters/min (30m)	20 liters/min (30m)
II. Price:			
(1) Price Comparison:	100	170	291
(2) Annual cost comparison:	100	90	164
III. Operation and Maintenance:			
(1) Operation:	Relatively heavy	Light	Light
(2) Maintenance requirement:	High	Small	Small
IV. Manufacturing contries	India, Japan, South Africa	Japan	France, Japan Ivory Coast

Each of the above three pump types has merits and demerits. Bellows pumps are superior for their high operability under high lift.

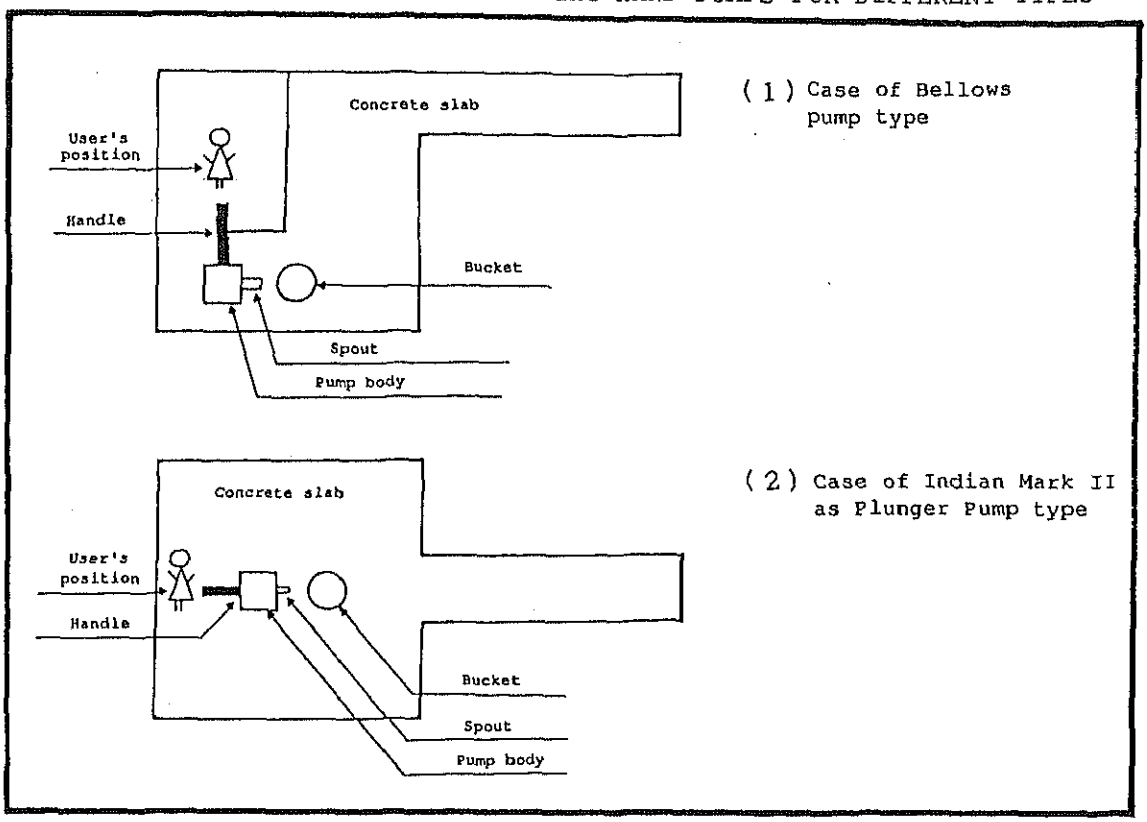
Under the Phase I project, 59 units of West German made Indian Mark II model (plunger type) pumps, and 43 units of Japanese made NS-B model (bellows type) pumps were provided. Presently, these two types of pumps are efficiently used; no problems have been encountered concerning their capabilities and operability.

DWA desires to receive Indian Mark II model (plunger type) pumps that are the most widely used in Zambia in order to standardize the water supply planning for the sake of the management and maintenance of spare parts.

Presently, the Indian Mark II model pumps are widely adopted for multipurpose use not only in Zambia, but in many other countries. The maintainability of this pump is better than for other types.

From the viewpoint of the effective water and pump use by the villagers, the Study Team believes that the bellows type pump is superior to the plunger type for the following reason: the handle of the bellows type pump is installed 90° to the pump outlet; thus, the pump operator can see the pump discharge conditions as well as the water receiving bucket conditions while he is operating the pump. On the other hand, the handle of the Indian Mark II model (plunger type) is installed on the opposite side of the pump outlet. The pump operator can hardly see the pump discharge and receiving bucket conditions while he is pumping the water (see Fig. 5-4-6).

Fig. 5-4-6 LAYOUT OF SETTING HAND PUMPS FOR DIFFERENT TYPES



As described above, each pump type has merits and demerits. From the view point of the high lift and the easy operation, however, it was decided to install bellows type pumps.

(10) Service Vehicles for Hand Pumps

Service vehicles are required for the rehabilitation work of malfunctioning hand pump wells. The well rehabilitation work can be roughly classified into the following categories:

① Function tests of existing pumps and removal of pumps from wells.

② Well cleaning with air lift.

③ Assembling and installation of new wells.

④ Form making and concrete work.

Service vehicles shall be small-sized cars sufficiently equipped for work categories

1 , 3 , and 4 above. Work category 2 , because of the nature of the work, requires a different type of equipment.

In view of the above, the service vehicles shall be 4-wheel drive jeep trucks equipped with 500 kg capacity cranes for the removal of existing pumps and for the installation of new pumps, and with hydraulic jacks, chain blocks, sets of small tools for pipe handling, pipe cutter wrenches, etc.

From the standpoint of the Project's construction schedule and the number of work groups, four service vehicles are required (see Fig. 5-4-1 and 5-4-2, and Table 5-4-2).

(11) Air Compressors for Well Cleaning

Air compressors shall be provided for well cleaning work described as work category 2 in the above section.

Most of the malfunctioning wells were constructed around 1970. In these wells, casing pipes were not installed in the lower section of the boreholes -- the wells are half-casing types. A number of these wells, because of malfunctioning hand pumps, have not been used for many years. The gravel and dirt that might have fallen into these wells must be cleaned out.

Each well rehabilitation work team will have one service vehicle and one air compressor. Thus, four air compressor units are required. Because the work teams will travel by means of the service vehicles, the air compressors must be trailer-mounted types.

(12) Spare Parts

The number of spare parts required for the vehicles and compressors to be provided for under the Project shall be in sufficient quantities to cover the two year period that will meet the Project's construction schedule and the amount of Project construction work.

5.4.2 Specifications of the Major Equipment and Materials

Based on the above evaluations, the specifications of the major equipment were established as follows:

(1) Vehicles:

① Cargo Truck with Crane (one unit)

Truck:	Water cooled diesel engine, right-side handle, 4 x 4-wheel drive
Loading Capacity:	12.5 tons
Crane Capacity:	5 tons

② Cargo Truck with Crane (one unit):

Truck:	Water cooled diesel engine, right-side handle, 4 x 4-wheel drive
Loading Capacity:	3.5 tons
Crane Capacity:	2.0 tons

③ Pickup Truck (two units):

Water cooled gasoline engine, right-side handle, 4 x 4-wheel drive, long-body type.
Loading Capacity: More than 1 ton

④ Station Wagon (four units):

Water cooled gasoline engine, right-side handle, 4 x 4-wheel drive, long-body type, more than 6 passengers

(2) Testing Equipment

① Electric Prospecting Equipment (two units)
Relative resistivity, direct current
Prospecting depth: More than 100 m
To include standard appurtenances and cables

② Electric Conductivity Meter (one unit)
Simple field measuring type
Measuring range: UP to 20,000 MS/cm

③ PH Meter (one unit)
Simple field measuring type
Type: Digital indication system
Measuring range: 0 to 14 PH

(3) Repair and Maintenance Tools (one set):

1.	Engine tune-up tools:	11 types
2.	Tire repair tools:	5 types
3.	Battery maintenance tools:	9 types
4.	Hand tools:	12 types
5.	Oil & grease application tools:	13 types
6.	Electrical and mechanical tools:	4 types
7.	General repair tools:	53 types
8.	Measuring tools:	33 types
9.	Vehicle repair tools:	11 types
10.	Welding tools:	9 types
11.	Air tools:	6 types
12.	3-ton crane for garage:	1 unit

(4) Other Related Equipment

Communications Equipment (one set)

Base Station	Out put:	150W (one unit)
	Frequency range:	2.0 MHz - 18.0 MHz
	Number of channels:	6 channels

	Power supply:	DC 24V
Mobile Station	Out put:	50W (four units)
	Frequency range:	2.0 MHz - 12.0 MHz
	Number of channels:	6 channels
	Power supply:	DC 12V

(5) Spare parts for Previously Provided Equipment

① Drilling tools for two FSW-7T drilling machine (for a total drilling length of 5,250 m)

a) Standard appurtenances (one set):
Disassembling tools, swivels, suction hose, valves, high-pressure hose, hoists, plugs, spindles, etc.

b) DTH drilling tools (one set):
Drills, pipes, various subs, DTH hammers, DTH bits, air hose, etc.

c) Slurry circulation drilling tools (one set)
Drill collars, various subs, wing bits, tricorne bits, etc.

d) Work tools (one set):
Pump removal tools, casing tools, pipe wrenches, hammers, etc.

② Spare Parts

a) Spare parts for FSW-7T (made by KOKEN Co.)
drilling machines including NZ227 mounting trucks:
For two units

b) Cargo truck with 5-ton crane, ZC141EC (made by Hino Co.):

For one unit

c) Cargo truck with 3-ton crane, NZ227KA
(made by Hino Co.)

For one unit

d) Cargo truck, NZ227KA
(made by Hino Co.):

For two units

e) Pickup truck, BJ75RP-KR
(Made by Toyota Co.):

For two units

f) Station Wagon, BJ75RV-KR
(Made by Toyota Co.):

For one unit

g) High-pressure air compressor, XRH 350DD
(made by Atlas Copco Co.):

For two units

h) Submersible motor operated pump for pumping tests, 40BHS22-53.7
(made by Ebara Co.):

For two units

i) Generator for item h),DCA/4AM
(made by Denyo Co.):

For two units

j) Electric welding machine, DCX-270SSI
(made by Denyo Co.):

For two units

k) Pipe splitter, PRIMAC 370
(made by Daido Co.):

For one unit

l) Motor driven grinder, GBK-2
(made by Hitachi Co.):
For one unit

m) Electric drill, BUL-SH3
(made by Hitachi Co.):
For one unit

n) Pipe cutter, H-12C
(made by Hitachi Co.):
For one unit

(6) Guide Pipe
SGP 200 mm X 5.5 m with shoe: 24 each
SGP 150 mm X 5.5 m with shoe: 116 each

(7) Casing Pipe and Screen Pipes
Casing and screen pipes For 140 boreholes

① Material: Strengthened vinyl chloride (FRP)

② Diameters:
4 inch (106 mm OD and 100 mm IPS)
6 inch (159 mm OD and 150 mm IPS)

③ Joints:
Flush-pad joints

④ Unit length: 4.0 (for both 4 inch and 6 inch pipes)

⑤ Screen:
Hole opening rate: 5%
Type: Slit type, slit width of 1.0 mm

⑥ Quantity:
6 inch casing pipe: 216 each
4 inch casing Pipe: 1,044 each

6 inch screen pipe: 96 each
4 inch screen pipe: 464 each
Bottom plug:
For 6 inch casing pipe: 24 each
For 4 inch casing pipe: 116 each
Center riser:
For 6 inch screen pipe: 114 each
For 4 inch screen pipe: 696 each

(8) Chemical Agents

① Bentonite: 10 tons
② CMC 1 ton
③ Foaming agent 0.5 ton

(9) Hand Pump (220 units):

① Type: Manual type
② Discharge rate and lift: 15 liters/min, 40 m
③ Inside diameter of well casing: 100 mm
④ Standard appurtenances: Pump head, cylinder, installation tools, etc.

(10) Service Vehicles for Hand Pump Repair/Installation (4 units):

① Type: 4 X 4 pickup truck, ling body
② Crane capacity: 500 kg, 3 m long
③ Standard equipment:
Chain block: 1 unit
5-ton hydraulic jack: 1 unit
Thread cutter: 1 unit
Pipe cutter: 1 unit
Vise: 1 unit
Welding machine: 1 unit
④ Standard appurtenances: One set of work tools.

(11) Air Compressor for Well Rehabilitation (4 units):

① Type: Trailer-mounted portable type
② Capacity: 2.0 m^3/min with 7 kg/cm^2 pressure
③ Appurtenances: High-pressure air hose

(12) Spare Parts

Sufficient provision for two-years' use of the above new equipment (1), (2), (3), (4), (5), (6), (11), (12), and (13)

CHAPTER 6. PROJECT IMPLEMENTATION PLAN

CHAPTER 6 PROJECT IMPLEMENTATION PLAN

6.1 PROJECT IMPLEMENTATION SCHEDULE

(1) Ministry of Agriculture and Water Development:

The implementation agency of the Project is the Ministry of Agriculture and Water Development (MAWD) of the Government of Zambia. The actual Project construction will be undertaken directly by the Department of Water Affairs (DWA) of MAWD.

After the Government of Zambia and the Government of Japan sign the Exchange of Notes, DWA will secure the personnel necessary for Project construction, procure the equipment and materials necessary for the Project (equipment and materials other than those provided by the Japanese side) at its own expense, and will conduct the construction of the hand pump operated deep wells and the rehabilitation of malfunctioning hand pump wells by using the equipment and materials provided under the Phase I project and the Project.

With the cooperation of other Zambian agencies concerned, MAWD will sign the Exchange of Notes together with the Government of Japan, and will smoothly carry out various procedures, such as banking arrangements, tax exemption and customs clearance for imported equipment and materials for the Project, site procurement, tax exemption and customs clearance for Japanese engineers required for Project implementation, etc.

(2) Consultant

Immediately after the Exchange of Notes for the Project is signed by the Japanese and Zambian governments, the consultant will make a contract with MAWD to proceed with the following consulting services:

a) Assisting with the equipment and material procurement, in the preparation of the detailed design and tender documents.

b) Assisting with the tendering and evaluation of tender documents.

c) Witnessing the contract agreement and assisting the Zambian Government and the contractor in its preparation.

d) Supervision of procuring and transporting equipment and materials, and of the Japanese engineers dispatched for Project implementation.

e) Site selection and technique transfer.

f) Other related services

(3) Contractor

The contractor shall procure the equipment and materials specified in the contract and transport them to the location specified by DWA. The contractor shall dispatch engineers to Zambia for the set period of the contract. The contract will effect the transfer of techniques related to the construction of hand pump operated wells and the rehabilitation of malfunctioning hand pump wells, and will supply the materials that shall be procured from local markets.

6.2 THE BOUNDARY OF RESPONSIBILITY FOR THE PROJECT

Project work will include the construction of new boreholes at 120 sites, the rehabilitation of malfunctioning hand pump wells at 100 sites, and the provision of necessary equipment and materials.

The Project that is so necessary for Zambia will be possible to implement within the limitations of the Japanese grant aid programme. The responsibilities of the Zambian and Japanese government in relation to the Project are as follows:

(1) Items to be covered by grant aid from the Japanese Government:

a) Procurement, transportation, and delivery of the major equipment and materials described in Section 5.4 "Specifications of Equipment and Materials."

b) The following necessary measures related to the construction of hand pump operated boreholes at 32 sites and the rehabilitation of malfunctioning hand pump wells at 40 sites:

i) Dispatch construction cooperative engineers for a period of seven months, and transfer techniques to the Zambian team.

ii) Procurement of locally available materials.

c) Design management services related to the above Project items including the dispatch of design management engineers.

(2) Items to be borne by the Government of Zambia

a) Promotion of the Project until its completion.

b) At its own expense, secure a sufficient number of personnel for implementing the Project.

c) Procurement of equipment and materials that will not be provided by grant aid from the Government of Japan.

d) Procurement of materials required for the construction of hand pump operated boreholes at 88 sites and the rehabilitation of malfunctioning hand pump wells at 60 sites.

e) Securing land and passage necessary for Project implementation.

f) Ensuring that customs clearance and tax exemption for equipment and materials related to the Project is taken care of at the port of entry.

g) Ensuring that customs clearances and tax exemptions are obtained for the Japanese engineers and their possessions.

h) Providing for the security of the Japanese engineers

i) Securing the smooth entry and re-entry of Japanese engineers working on the Project.

j) Payment of bank commissions.

k) Management and maintenance of completed Project facilities.

6.3 CONSTRUCTION PLAN

The Project covers the following works in the seven districts of the Southern Province:

① To construct hand pump operated deep wells at 120 sites.

② To rehabilitate malfunctioning hand pump wells at 100 sites.

These site locations were previously described.

The above works are to be carried out by using the two drilling machines and related equipment that was previously provided under the Phase I project and the related equipment to be provided under the Project.

6.3.1 Construction Plan

(1) Basic Policies:

① The Project implementation shall be under the direct management of DWA. An efficient construction plan shall be made based on the rules of the Japanese grant aid cooperation programme.

② Practical, efficient construction schedules and construction implementation systems must be made by taking into account the Project's urgency and importance, the Japanese grant aid cooperation programme's system, the amount of Project work, the 9 month equipment and material procurement and transportation period, the actual construction period of approximately one and half year, the estimated two and half years it will take to complete the Project after the signing of the Exchange of Notes, the transfer of techniques, etc.

③ The Japanese side shall dispatch engineers to provide technical guidance, advice, construction cooperation, and construction supervision for the construction of some of the 120 hand pump operated deep wells and the rehabilitation of some of the 100

malfunctioning hand pump wells during the limited period of time that is within the scope of the Japanese grant aid cooperation programme.

The remaining wells must be constructed or rehabilited by the Zambian team utilizing the provided equipment and materials and by applying the transferred techniques.

④ As described above, the major duties of the dispatched Japanese engineers will be to advise and transfer techniques to the Zambian team who will carry out the Project.

The staffing plan shall be made based on the above premises.

(2) Quantity of Project Work

The quantity of Project work is listed in Table 6-3-1.

Table 6-3-1 QUANTITY OF CONSTRUCTION WORK

District / Items	GWEMBE	MAZABUKA	CHOMA	NAMWALA	MONZE	KALOHO	LIVING-STONE	TOTAL
Number of New Boreholes	14	20	29	9	28	17	3	120
Number of existing boreholes to be rehabilitated	15	15	20	10	20	18	2	100
Total drilling length	700	1,000	1,450	450	1,400	850	150	6,000
Number of hand pumps to be installed	29	35	49	19	48	35	5	220

(3) Construction Implementation System

As shown in Fig. 6-3-1, the construction implementation system can be classified into the ten sections necessary for the construction of new wells and the rehabilitation of the malfunctioning wells. For efficient work, each section shall be specialized to suit the type of work to be performed. Each section can possess its own independent work groups, if required.

The responsibilities of each section and group are described in the Staffing Plan.

The ten sections are as follows:

① Project Management Section
② Construction Management Section
③ New Well Construction Management Section
④ Hydrogeology and Site Selection Section
⑤ Drilling Section --- (Drilling Group)
⑥ Borehole Tests and Hand Pump Installation Section --- (Pump installation group)
⑦ Malfunctioning Well Rehabilitation Section -- (Repair work group)
⑧ Warehouse Management
⑨ Equipment Repair, Maintenance, and Management
⑩ Administration

(4) Work Procedures

The Project is to drill new boreholes at 120 sites and rehabilitate malfunctioning hand pump wells at 100 sites. It is necessary to understand the work procedures and the contents of each type of work in order to examine the construction schedule. Table 6-3-2 and 6-3-3 summarize the work procedures and work contents.

Fig. 6-3-1 IMPLEMENTATION SYSTEM FOR THE PROJECT

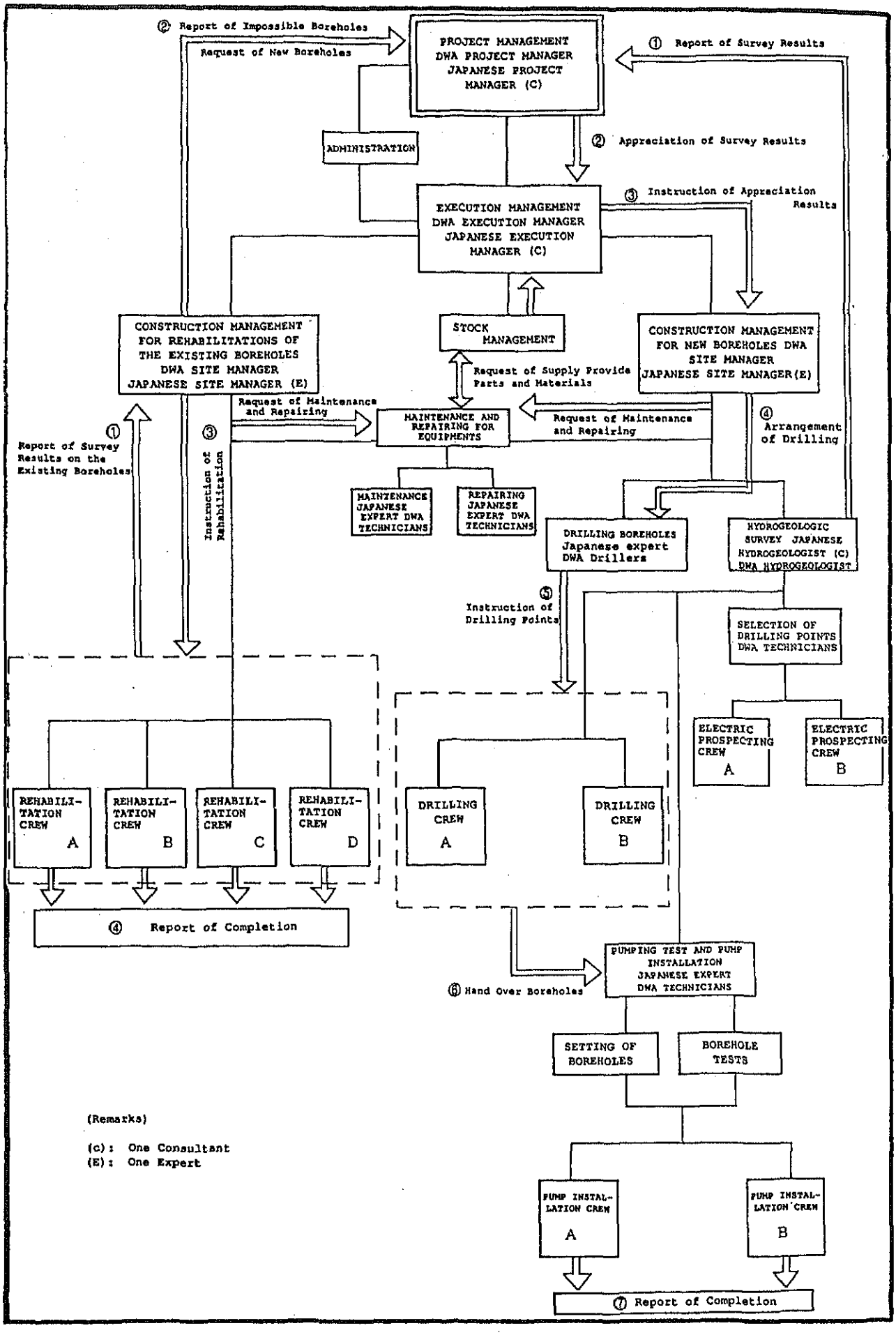


Table 6-3-2 WORKING ORDERS AND CONTENTS FOR CONSTRUCTION OF NEW BOREHOLES

Order	Working Items	Working Contents	Working Division			
			Project Management	Hydrogeologic Survey and Electrical Prospecting	Drilling Boreholes	Pumping Test and Pump Installation
1	Selection of Drilling Points	Examination of Population Distribution in the Proposed Site	**********			
		Examination of Topography	**********	**********		
		Electric Prospecting	----------	**********		
2	Drilling Boreholes	Drilling			**********	
		BoreholeLogging		**********	----------	
		Appreciation of Aquifer	**********	----------		
		Dicision of Depth for Screen	**********	----------		
		Installation of Casing and Screen			**********	
3	Pumping Test and Pump Installation	Pumping test	----------			**********
		Water Quality Test	----------			**********
		Foundation of Hand Pump				**********
		Concrete Slab				**********
		Installation of Hand Pump				**********

********** : Direct responsibility for implementation
---------- : Indirect responsibility for implementation by technical support and advice.

Table 6-3-3 WORKING ORDERS AND CONTENTS FOR REHABILITATION OF THE EXISTING BOREHOLES

Order	Working Items	Working Contents	Working Division			
			Project Management	Hydrogeologic Survey and Electrical Prospecting	Drilling Boreholes	Pumping Test and Pump Installation
1	Survey of the Existing Boreholes	Survey of the Existing Hand Pump	----------	**********		
		Survey of the Existing Borehole Structure	----------	**********		
		Decision of Possible or Impossible Borehole for Rehabilitation (Drilling New Boreholes)	**********			**********
2	Withdrawal and Cleaning	Withdrawal of the Existing Broken Hand Pump		**********		
		Cleaning of Boreholes		**********		
3	Pumping Test and Pump Installation	Pumping Test	----------		**********	
		Water Quality Test	----------		**********	
		Foundation of Hand Pump			**********	
		Concrete Slab			**********	
		Installation of Hand Pump			**********	

********** : Direct responsibility for implementation
---------- : Indirect responsibility for implementation by technical support and advice.

(5) Construction Schedule Plan

The construction schedule plan was made based on the previously mentioned Project work quantity, construction implementation system, and work procedures. As specified in the construction plan's basic policies, the construction schedule was examined by aiming to complete Project implementation within two years after the ratification of the Exchange of Notes. This includes the actual construction period of one year, the tendering period, and the equipment and materials procurement and transportation periods.

Under the rules of the Japanese grant aid cooperation system, the Japanese cooperation construction and construction supervising period is set as 6 months out of the actual construction period of one year. Thus, remaining Project construction work must be carried out by the Zambian team within 11.5 months after the departure of the Japanese team. For this reason, it is necessary to determine the possible number of new wells and malfunctioning wells to be constructed or rehabilitated by Japanese cooperation construction within the limits of the Japanese grant aid cooperation system as well as to examine the construction schedule. Therefore, the number of workdays and the duration of each work assignment were calculated after which the construction schedule and the possible amount of Project work that is to be undertaken by the Japanese team were analyzed.

① Number of Workdays:

The number of workdays for Project construction was calculated based on Zambian labor conditions.

a) Labor Conditions:

Working hours: From 8:00 to 17:00 (8 hours a day)
Non-working days: Saturdays, Sundays, and National holidays

b) Number of Workdays:
By assuming the construction period to be from October 1989 to March 1990, based on Japanese grant aid cooperation rules, the number of workdays will be as follows:

30 days X 6 months -48 days (weekends) -4 days (holidays) -10 days (for assembling prior to its delivery) =
118 days
Total: 118 days

② Each Required Workdays for Each Type of Work:
The average number of required workdays, obtained by analyzing DWA's Phase I project's construction work diary, were adopted for the Project's drilling work, pump installation work, and concrete work. The standard required workdays were adopted for the rehabilitation work of the malfunctioning hand pump wells.

a) Required Workdays for Borehole Drilling (figures based on the actual work performed during the Phase I project):
The workdays include rainy days, the Japanese cooperation construction period, the time taken for providing technical guidance, and transportation.

Transporting, assembling, and preparation work:	1.02 days
Drilling:	2.53

Borehole logging and casing installation:	0.72
Casing finishing work:	0.59
Disassembling rig and cleaning work:	0.33
Repair and drilling trouble times:	0.83
Total	6.02 days

It was determined to use 6 days/borehole.

b) Required Workdays for Borehole Drilling (figures based on the actual work conducted by the Zambian Team during dry seasons):

Transporting, assembling, and preparation work:	0.78 day
Drilling:	1.92
Borehole logging and casing installation:	0.55
Casing finishing work:	0.49
Disassembling rig and cleaning work:	0.25
Repair and drilling trouble times:	0.65
Total	4.62 days

0.62 of an 8-hour workday is approximately 5 hours. By rounding out the 5 hours into 1 day, it was determined to use 5 days/borehole.

c) Required Workdays for Pump Installation and Concrete Work (figures based on the actual work of the Phase I project):

Bringing in materials:	0.37 day

Foundation work, and form and steel bar setup:	0.85
Concrete work:	0.65
Pump installation:	0.61
Removal and land cleaning:	0.24
Total	2.72 days

Thus, the required workdays for well installation and concrete work will be three days/well.

d) Standard Required Workdays for Malfunctioning Hand Pump Well Rehabilitation Work:

Bringing in materials:	0.4 day
Function tests of existing hand pump and removal time:	1.0
Well cleaning with air lift:	2.0
Assembling and installing hand pump:	1.5
Form setup and concrete work:	1.6
Removal and land cleaning:	0.5
Total	7.0 days

The well cleaning work by air lifting means is to flush out the dirt that has falling from the well walls into the wells.

Some wells require cleaning while others do not, depending upon the degree of well deterioration and on geological conditions. It was assumed that 50% of the malfunctioning hand pump wells would require cleaning. Thus, it was determined to use 7 days/well for the

wells to be cleaned and 5 days/well for the 50% of the wells requiring cleaning. The average workdays for well cleaning work will be 6 days/well.

③ Examination of the Construction Schedule and the Possible Number of New Wells and Malfunctioning Wells to be Constructed or Rehabilited by the Japanese Team:
The possible number of new wells and malfunctioning wells to be constructed or rehabilited by the Japanese Team within the examined construction period was calculated based on the required workdays that were analyzed in 1 and 2 above.

a) Construction of New Boreholes:
   i) 118 days ÷ 6 days (required workdays to drill one borehole) X 2 drilling teams = 39 boreholes

Within the 118 workdays, a total of 39 new boreholes are estimated by actual record of work performed during the Phase I Project.

However,in this Phase-II project, Training work should be give priority for technical transfer to the Zambian project team. Thus, the number of borehole to be drilled for this project construction was calculated based on training program are as follows.

- Technical guidance
  As mentioned in Section 3.4.3 of the Project Phase I concerning groundwater development, and examining the actual

results of this Phase I, Zambia seems to have mastered the basic use of the drilling process and is capable of continuing on her own, however the following problems are still present in their drilling technique:

- Application of technical skills according to the various geological conditions
- Dealing with trouble
- Proper use of the machinery (excessive use of the machine)
- Prevention of accidents
- Maintenance, management, repair

In order to improve these skills, the following guidance will be necessary:

- Examination of basic operations
- Thorough instructions in drilling
- Daily and weekly inspection of all machinery
- Proper judgement and action during drilling
- Dealing with trouble and prevention of errors
- Maintenance and repair of machinery

• Technical guidance method

The following conditions should be observed:

- One Japanese engineer to be dispatched
- Drilling team to be split into two groups, 3 trainee drillers and 3 trainee driller assistants
- Two test boreholes to be set up at the start of drilling and training to be

conducted on all 3 drillers and driller assistants at the same time.

- After training on the 2 test boreholes are completed, the trainees are to be separated into the 2 groups. The Japanese engineer will conduct training on each group. The course of training will be as follows:

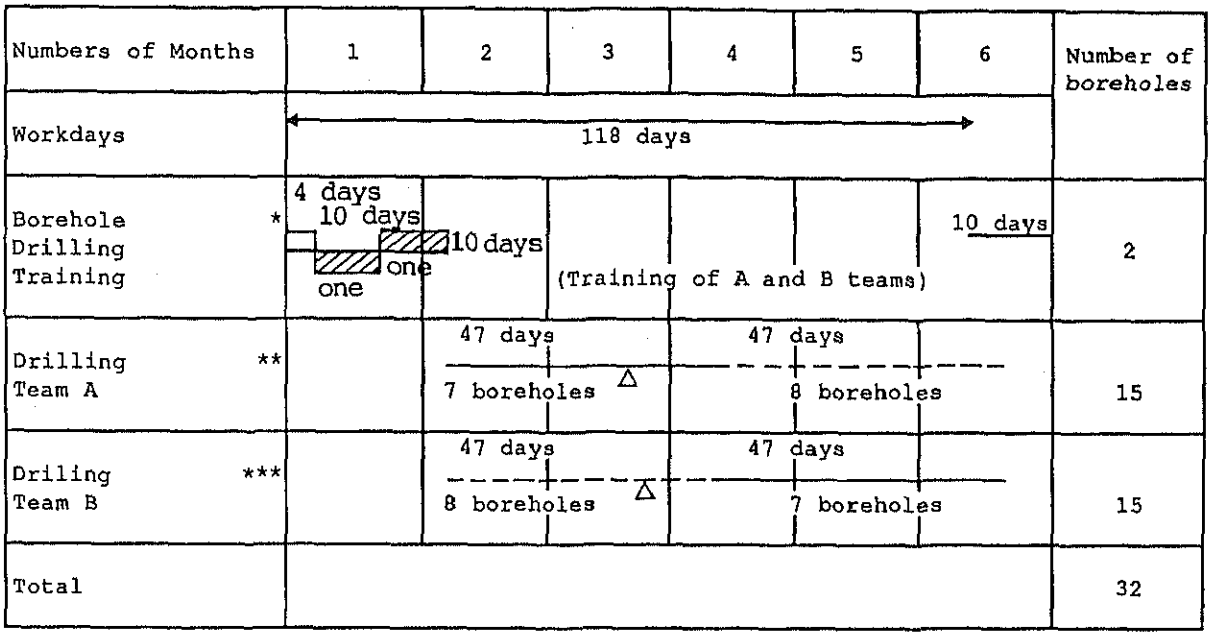
a) Lecture on the previously mentioned subjects, plus talks on actual experiences.
b) Actual training of drilling technique (based on a)
c) Direction on the actual drilling process
d) Have the trainees list up any problems, and provide them with a logical and technical explanation (repetition of c)
e) Have the trainees drill on their own with the Japanese engineer noting down any problems.
f) The problems will be pointed out together with logical and technical explanations and through actual 'on-the-spot' training, there will be a repetition of (e).

Although Zambia has become capable of drilling on her own through the Phase I Project, the Phase II Project will center upon the improvement of technical skills and the transfer of technical guidance. Therefore, our main purpose is to carry out the necessary training mentioned in the previous paragraphs, starting with the test drilling of the 2 boreholes and the training of the separate drilling groups. The drilling schedule, together with the training program will be carried out according to plan Fig.6-3-2. The total

number of wells to be drilled under the cooperation of Japan will be 32.

Taking into account the number of days necessary for the actual work, transportation and drilling, the number of wells to be drilling works out to be 39, however we would like to place importance on the transfer of technical training, therefore the actual number of wells under the cooperation of Japan will actually be 32.

Fig. 6-3-2 SCHEDULE OF DRILLING WORK INCLUDING THE TRAINING WORK



Lecture day, total 4 days (obtained by training plan analysis)

Observtaion study and test drilling: 10 days/borehole
(obtaimed by training plan analysis)

Drilling under the guidance of Japanese engineers:
7 days/borehole (Phase I project drilling rate plus one boehole)

△ Trouble handing

Notes: * The borehole drilling training shall be conducted as follows:
- Three machine operators and three assestants shall be trained.
- Item of training are consist of:
  (1) To teach basic operating methods.
  (2) To teach drilling procedures.
  (3) To teach daily and weekly inspection procedures.

** *The two drilling groups shall drill boreholes as follows:*
- Japanese engineers will give technical guidances to the each group.
- The trainees shall be one operator and one assistant at a time.
- Item of training are consist of:
  (1) Evaluate the drilling progress and make trouble shooting.
  (2) Take a sufficient accident prevention measures.
  (3) Prevent miss operation and conduct proper trouble handing.
  (4) Make equipment repair and maintenance.

The pump installation and concrete work will be as follows:

42 days ÷ 3 days (required workdays for one well) X 1 pump installation team = 14 wells

76 days ÷ 3 days (required workdays for one well) X 2 pump installation teams = 50 wells

Total 64 wells

From the above figures, the pump installation teams will be able to install hand pumps and engage in concrete work without delaying the drilling teams.

The remaining 88 boreholes must be drilled only by the Zambian Team after receiving the equipment and materials from the Japanese Team. The required number of workdays for this work will be:

88 boreholes X 5 days (required workdays to drill one borehole) ÷ 2 drilling teams = 220 days

Thus, the Zambian team will be able to complete the drilling of 88 boreholes within approximately 10 months after receiving the equipment and materials.

b) Rehabilitation of Malfunctioning Hand Pump Wells:

The rehabilitation work shall commence after receiving the rehabilitation equipment and materials from Japan. Thus, it was assumed that the rehabilitation work would be conducted during the 76 days from December 1989 through March 1990. Thus,

76 days ÷ 6 days (average required workdays to rehabilitate one well) X 4 rehabilitation work teams = 50.6 wells

However, it is assumed that there are some malfunctioning wells that are beyond repair. The number of these wells is estimated as being 20% of all malfunctioning wells. Therefore, the number of malfunctioning hand pump wells to be rehabilitated by the Japanese Team will be:

50.6 wells X 0.8 = 40 wells.

The remaining malfunctioning hand pump wells must be rehabilitated by the Zambian Team after receiving the equipment and materials from the Japanese Team.

The number of required workdays for the rehabilitation work be:

50 wells X 6 days (average required workdays to rehabilitate one well) ÷ 4 rehabilitation work teams = 75 days/

This is about a 4 month period after receiving the equipment and material.

The malfunctioning wells that are beyond repair must be replaced by new wells. The number of new wells replacing malfunctioning wells will be: 100 wells X 0.2 = 20 wells.

The number of workdays required to drill the 20 new boreholes will be:

20 boreholes X 5 days (required workdays to drill one borehole) ÷ 3 drilling teams = 33 days.

This is approximately a 1.5 month period.

The drilling of these 20 boreholes must be conducted after completing the drillings of 120 boreholes.

Thus, the estimated completion day of the drilling work for these 20 boreholes will at the middle of May 1991 (see Fig. 6-4-1).

6.3.2 Staffing Plan

(1) Zambian Side Staffing Plan

In accordance with the construction schedule, construction implementation system, and the work procedure planning shown in Table 6-3-1, the major duties of each work section and group required for Project implementation were established as follows:

a) Project Management (one work group):

- Coordination with related administrative agencies concerned
- Coordination with related rural offices concerned
- Management of the Project's overall implementation schedule
- Overall supervision of construction sections
- Selection of borehole drilling sites
- Evaluation of successful boreholes
- Recording of the Project's implementation work
- Management of Project personnel
- Management of unused equipment and materials and the inventory management of spare parts
- Accounting management
- Other pertinent work

b) Construction Management (one work group):

- Management of base camps
- Management of borehole sites

- Coordination with construction sections
- Inventory management of construction equipment and materials.
- Procurement of construction materials at local markets and material supply to construction sites
- Management of construction section personnel
- Management of well construction
- Preparing work schedules for electrical prospecting teams, pump installation teams, and drilling teams
- Inspection of completed wells.

c) Hydrogeology (one work group):
- Evaluation of selected borehole sites
- Analysis of geophysical exploration
- Evaluation of proposed well sites and the reporting of evaluated results to the project manager
- Analysis of borehole loggings
- Evaluation of screen pipe locations and the reporting the results to the well manager

d) Site Selection (one work group):
- Assisting hydrogeologists
- Management of electrical prospecting

e) Electrical Prospecting (one work group):
- Conducting electrical prospecting at proposed well sites
- Reporting prospecting data to hydrogeologists

f) Drilling (two work groups)
- Conducting drilling work
- Installation of well casings

g) Pumping Test and Pump Installation (two work groups)
   - Installation of hand pumps after borehole logging
   - Installation of screen and casing pipes
   - Conducting pumping tests
   - Installation of hand pumps
   - Installation of appurtenant concrete facilities
   - Removal and land cleaning work after well completion

h) Management of Malfunctioning Wells' Rehabilitation Work (one work group):
   - Preparing work schedules for rehabilitation work groups
   - Evaluation of the malfunctioning wells that are beyond repair
   - Evaluation of new replacement well drilling
   - Inspection of completed wells

i) Rehabilitation Work (four work groups):
   - Surveys of existing hand pump conditions
   - Surveys of existing well conditions
   - Collection of Damaged pumps
   - Well Cleaning
   - Installation of new hand pumps
   - Construction of appurtenant structures
   - Removal and land cleaning after the completion of the water supply facilities

j) Administration (one work group):
   - Clarification of construction work diaries
   - Preparation of reports
   - Preparation of related documents concerned with the Project

- Accounting and administrative work

k) Warehouse Inventory (one work group):
   - Inventory management of unused equipment and spare parts at DWA's Monze Office's warehouse
   - Preparation of monthly inventory reports

l) Equipment Repair, Maintenance, and Management (one work group):
   - Daily management and maintenance of drilling machines and supporting equipment, and vehicles
   - Repair of damaged drilling machines and supporting equipment, and vehicles

A minimum of 88 Zambian personnel (81 to be assigned to construction sites) will be required to cover all of the above work sections for Project implementation (see Table 6-3-4). All expenditures for personnel must be borne by DWA.

Table 6-3-4 ZAMBIAN PERSONNEL FOR THE PROJECT

	Project Management	Adminis-tration	Stock Management	Maintenance and Repair-ing for Equipment	Construction Management for New Boreholes	Hydro-geologic Survey	Selection of Drill-ing Points	Electric Prospect-ing Crew A.B	Driling Crane	Pump In-stallation Crew A.B.C	Construction Management for the Rehabilitation of Existing Boreholes	Rehabili-tation Crew	Total
Project Manager	1												1
Execution Manager					1								1
Site Manager											1		1
Accountant		1											1
Typist	1	1											2
Store Manager			1										1
Hydrogeologist						1							1
Sub-Hydrogeologist							1						1
Electric Prospect-ing Technician								2					2
Driller									2				2
Assistant Driller									2				2
Plumber										2		4	6
Borehole Logging Technician										2			2
Rehabilitation Technician												4	4
Machinist				2									2
Laborer								8	8	4		8	28
Driver	1			1	1	1		2	10	2	1	4	23
Watchman			1						3			4	8
Total	3	2	2	3	2	2	1	12	25	10	2	24	88

(2) Engineers' Dispatch Plan

Japanese engineers shall be dispatched to assist the Zambian personnel in the implementation of the Project within the limits of the Japanese grant aid cooperation system.

The dispatched Japanese engineers will provide technical advice to the Zambian personnel. They will cooperate with the Zambian team to effect smooth Project implementation. During Project implementation they will also conduct the transfer of techniques, particularly in the following fields:

a) Project management
b) Selection of new borehole drilling sites
c) Design of deep wells
d) Construction management
e) Borehole drilling
f) Borehole tests
g) Management of malfunctioning wells' rehabilitation work
h) Repair, maintenance, and management of drilling machines and supporting equipment, and vehicles
i) Inventory management of equipment and materials
j) Assembling of hand pumps and their maintenance and management.

The Japanese side shall dispatch the following engineers to accomplish the above objectives (see Table 6-3-5):

Table 6-3-5 JAPANESE PERSONNEL DISPATCHED FOR THE PROJECT

Items	Designation	Assignment	Numbers
Consulting Section	Project Manager	Project Management	1
	Hydrogeologist	Site Selection, and evaluation of Hydrologic Conditions	1
	Execution Manager	Execution Management	1
Subtotal			3
On-The-Job Technology Transfer Section	Drilling Expert	Drilling Technology	1
	Hand Pump Expert	Borehole Tests, Pump Installation	1
	Rehabilitation Expert	Construction Management for the Rehabilitation of the Existing Boreholes	1
	Mechanic Expert (A)	Equipment Maintenance	1
	Mechanic Expert (B)	Equipment Repair	1
Subtotal			5
Total			8

The responsibilities of the Japanese to be dispatched to Zambia are as follows:

A. Design Management Section (consultant):

a) Project Manager (leader of Japanese Team):

- Conferring with, and reporting to DWA and JICA
- Supervision of management of Japanese team members.
- Supervision and management of Project work that is to be borne by the Japanese side
- Overall management of the transfer of techniques
- Technical advice, cooperation, and the transfer of techniques to the Zambian project manager as related to the following work:
  - Coordination with related administrative agencies and rural communities concerned with the Project
  - Management of the Project's implementation schedule
  - Supervision of construction sections
  - Selection of borehole drilling sites
  - Evaluation of successful boreholes
  - Preparing Project records
  - Management of Project personnel
  - Other pertinent matters

b) Hydrogeologist:

- Technical advice, cooperation and transfer of techniques related to the borehole drilling site selections to the Zambian personnel:
  - Evaluation of borehole drilling site areas
  - Conducting geophysical exploration and analysis of exploration data

- Evaluation of proposed borehole drilling sites and preparation of the evaluation report

c) Construction Supervising Engineer:

- Technical advice, cooperation, and the transfer of techniques related to the following work to the Zambian construction supervisor as well as supervising the Project work to be borne by the Japanese side:
  - Designing boreholes
  - Supervision of borehole tests
  - Supervision of boreholes' appurtenant facility construction and hand pump installation work
- Control and management of Japanese construction section's engineers
- Control accounting, management, record keeping, and the preparation of reports related to the construction work to be borne by the Japanese side.
- Providing technical advice, cooperation, and the transfer of techniques to the Zambian construction supervisor that are related to the following work:
  - Management of base camp
  - Management of borehole sites
  - Coordination with and management of construction sections
  - Inventory management of construction materials
  - Procurement of construction materials at the local markets and their supply to borehole drilling sites
  - Management of construction sections' personnel

- Preparation of construction records and report presentation

B. Construction Cooperation Section

a) Borehole Drilling Engineer

- Providing technical advice, cooperation, and the transfer of techniques to Zambian personnel related to the following work:
  - Operation of drilling machines and supporting equipment
  - Borehole drilling techniques
  - Casing installation and gravel placing
  - Borehole cleaning

b) Pumping Test and Pump Engineer

- Providing technical advice, cooperation, and the transfer of techniques related to the following work to Zambian personnel:
  - Pumping tests and their analysis
  - Hand pump installation techniques
  - Construction techniques of appurtenant concrete facilities

c) Well Rehabilitation Engineer

- Providing technical advice, cooperation, and the transfer of techniques related to the following rehabilitation work to Zambian personnel:
  - Survey of the conditions of existing hand pumps
  - Survey of existing well conditions
  - Evaluation of malfunctioning wells that are beyond repair
  - Repair of damaged pumps
  - Borehole cleaning

d) Mechanical Engineer (A) (Maintenance and operation)

- Providing technical advice, cooperation, and the transfer of techniques related to the management and maintenance of the following equipment and the inventory management of equipment and spare parts:
  - Daily management and maintenance of drilling machines and supporting equipment, and vehicles
  - Inventory management of unused equipment and spare parts
  - Management and maintenance of hand pumps

e) Mechanical Engineer (B): (Repair)

- Providing technical advice, cooperation, and the transfer of techniques related to the repair work of the following equipment to Zambian personnel:
  - Drilling machines and supporting equipment, and vehicles
  - Adjustment of the above
  - Repair and tune-up of the engines and hydraulic systems of the equipment provided under the Phase I Project.

6.4 PROJECT IMPLEMENTATION SCHEDULE

Commencement of the Project will be at a time when the Government of Japan and the Government of Zambia sign the Exchange of Notes of the Project's grant aid cooperation agreement.

After the signing of the Exchange of Notes, DWA of the Ministry of Agriculture and Water Development and a Japanese consultant company will make a contract concerned with the Project's design management services. After making the contract agreement, the Consultant will prepare the detailed design and

tender documents. After the approval of the detailed design and tender documents by the Japanese and Zambian governments, the Consultant will conduct the tendering of the Project to Japanese contractors for the Government of Zambia, and will evaluate the tender documents.

The Consultant will witness the contract agreement between the prospective Japanese contractor and the Government of Zambia.

It will take approximately four months to reach contract agreement after the signing of the Exchange of Notes.

After the contract agreement, the Japanese contractor will procure equipment and materials necessary for the Project. It may take from two to five months to manufacture, procure, and pack the new drilling machine. Further, it will take approximately four months for the land and sea transportation of the equipment and materials.

Thus, it will take from ten to thirteen months before commencement of Project construction and technical guidance will be possible.

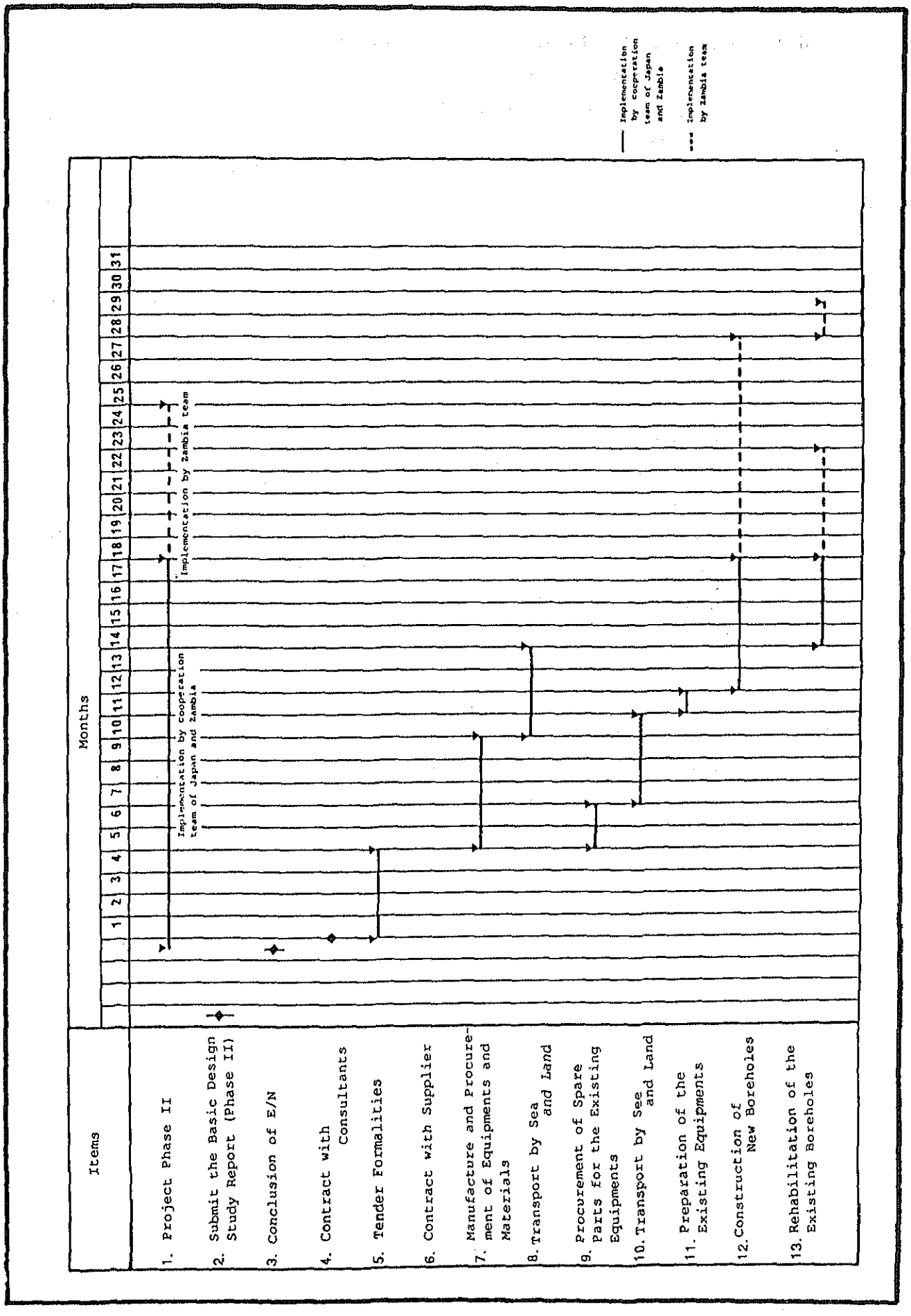
The Japanese fiscal year ends in March as does the time of limit of the Exchange of Notes. The rules of the Japanese grant aid system allows for extending the Exchange of notes for one additional year. Even with a one year extension, the maximum allowable borehole drilling for new boreholes will be six months, and four months for rehabilitation work on malfunctioning wells.

Thus, after the signing of the Exchange of Notes, it will require seventeen months to complete the

equipment and material delivery to the Zambian team after the completion of the Project work borne by the Japanese side. Furthermore, it will take twelve months for the Zambian team to complete the construction and rehabilitation of the remaining wells. Therefore, the expected Project completion date will be at the end of May 1991.

The implementation schedule is shown in Fig. 6-4-1.

Fig. 6-4-1 IMPLEMENTATION SCHEDULE FOR THE PROJECT



6.5 EQUIPMENT AND MATERIAL PROCUREMENT

The equipment and material procurement, within the rules of the Japanese grant aid system, is limited to either Japanese or Zambian products. The equipment and materials that are unobtainable in Zambia must therefore be procured in Japan and exported to Zambia.

Bentonite and steel bars can be made in Zambia with the use of imported raw materials. However, the supply of raw materials is unstable due to the Zambian foreign currency reserve situation and the business situations of importers. Thus, the bentonite and steel bars will be shipped from Japan.

DWA desires to install Indian Mark II model hand pumps that are manufactured in West Germany. If this type of hand pump is to be selected at the final stage, an exemption to the rules of the Japanese grant aid system shall be made.

Upon the expiration of the Exchange of Notes, additional materials required to complete Project construction are to be procured by the Zambian side at its won expense.

6.6 COST ESTIMATE

The following major scope of Project work will be financed by grant aid from the Government of Japan.

(1) Supply of supporting vehicles, and related equipment and materials necessary for the construction of new deep wells at 220 sites.

(2) Drillings of new boreholes at 32 sites, cooperation construction of water supply facilities, and providing construction management.

(3) Cooperation construction for rehabilitating malfunctioning hand pump wells at 40 sites and providing construction management.

The estimated cost to be borme by the Government of Zambia is approximately 2,310,355 kwachas (40,385,000 yen).

The estimated costs are March 1988 prices.
The foreign exchange rate at that time was as follows:

1 U.S. dollar = 137.41 yen
1 U.S. dollar = 7.86 kwachas
Thus, 1 kwacha = 17.48 yen

Project costs to be borne by the Zambian side are construction costs (including personnel expenditures) of the remaining Project work after the Japanese side completes its work, and the costs necessary for Project implementation.

These costs are estimated as follows:

Personnel expenditures:		
	1,002,097 kwachas	17,516,000 yen
Material costs:		
	755,274 kwachas	13,202,000 yen
Contingencies:		
	553,087 kwachas	9,667,000 yen
Total:		
	2,310,355 kwachas	40,385,000 yen

CHAPTER 7. MAINTENANCE AND MANAGEMENT PLAN

CHAPTER 7 MAINTENANCE AND MANAGEMENT PLAN

7.1 MAINTENANCE AND MANAGEMENT PLAN

The subjects concerned with the maintenance and management of the Project are well facilities, drilling machines, and supporting equipment. Maintenance and management for the above will be DWA's responsibility and will be undertaken in the same manner as it presently is.

(1) Maintenance and Management of the Well Facilities

The maintenance and management of the existing well facilities are undertaken by each DWA's District Officer that is under the supervision of the manager of DWA's Provincial Office in each Province of the country.

Each District Office maintains the "Borehole Follow-up Data Sheet," and entries of the well-use conditions, qualities of well water, water level and pump conditions, and any problem relating to the well are supposed to be made three months after the well completion date and at 3-month intervals thereafter. However, the District Offices do not have any maintenance and management vehicles, and, so far, only the entries made three months after the well completion date were recorded. Some data sheets have, as yet, not been collected.

In view of the above background, the Study Team recommends that a "Management and Maintenance Center" be established as a test case at the Monze District Office of the DWA (the Project's implementation office) in order to maintain and manage a total of 322 wells -- 220 Project wells (120 new wells to be drilled and 100 wells to be rehabilitated) and the 102 Phase I project wells that were previously constructed.

DWA's Monze District Office presently is in possession of the equipment and materials provided under the Phase I project and is proceeding with the rural supply project.

Repair and maintenance tools for the repair shop will be provided under the Project. It is considered that the repair shop's lot and facilities (see Fig. 7-1-1) will be sufficient for accomplishing the maintenance and management of the 322 wells.

Personnel of the "Management and Maintenance Center" shall be brought in from DWA's district offices -- one person from each office -- in order to smoothly introduce the management and maintenance system to each district office in the future (hopefully one year after the test period).
Table 7-1-1 indicates the number of personnel in each DWA District Office in the Southern Province. The person who is assigned from each District Office to the Project's maintenance and management system will become the District Office's maintenance and management chief once the system is introduced.

Fig. 7-1-1 PRESENT PLOT PLAN OF MONZE DISTRICT OFFICE, DWA

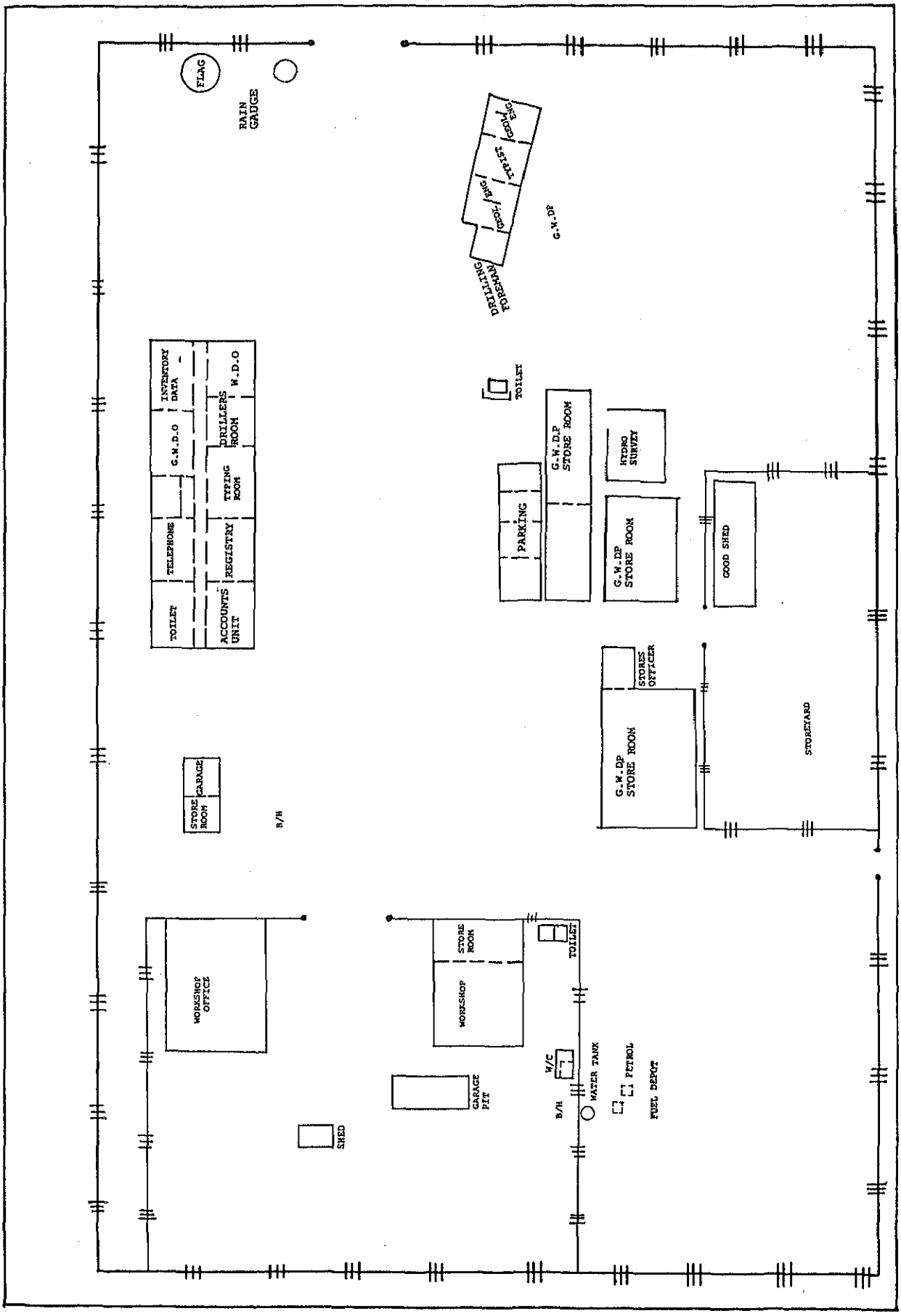


Table 7-1-1 THE CURRENT NUMBER OF DWA DISTRICT OFFICE STAFF MEMBERS IN THE SOUTHERN PROVINCE

District	Staff Number				
	Chief	Engineer or Eng. Assistant	Clerks	Others	Total
Mazabuka	1	2	1	14	18
Monze	1	4	9	44	56
Gwembe	1	3	3	12	19
Choma	1	4	3	9	17
Nomwala	1	1	2	8	12
Livingstone/Kalomo	1	1	3	8	13
Total	6	15	21	93	135

The Southern Province has an area of approximately 85,000 km^3. As shown in Fig. 2-3-1, Project sites are scattered throughout the Province with the highest density being in the Monze District. New well construction sites are widely distributed, particularly in the Livingstone, Namwala, and Gwembe districts. It is believed, however, that these sites will be covered by the maintenance and management personnel from each District Office.

The personnel of the Maintenance and Management Center will consist of the following members (the Japanese mechanical engineers to be dipatched under the Project shall participate in the maintenance and management system to provide the transfer of techniques upon the system's commencement, if possible):

a) Center manager (assistant engineer class): 1 person
b) Clerk: 1 person

c) Maintenance & management chief (mechanical engineer): 1 person

d) Workers (selected from each District Office): 6 person

TOTAL 9 persons

The manager will control the Center, conduct periodic inspections of the water supply facilities, check on well user complaints, evaluate any damages to the facility, and provide directions to the maintenance and management group for effecting damage repairs. The Center Manager will also be responsible for taking warehouse inventory.

In response to the manager's direction, the maintenance and management group will repair the damaged facility and replace damaged parts.

The clerk will prepare the periodic inspection reports and repair reports for each district and will clarify the documents in order to pave the way for smooth introduction of the maintenance and management system to other districts in the future.

The Maintenance and Management Center shall retain the repair tools and spare parts -- mostly for hand pump repairs -- in DWA's Monze Office's repair shop.

Three light vehicles (station wagons that are to be provided under the Project) for use when making periodic inspections and regular patrols will be assigned to the Center. The vehicles must, however, be utilized for Project implementation purposes having the highest priority.

The required inspection intervals of hand pumps generally vary depending upon the pump types. The shortest inspection intervals are required for the Indian Mark II model pumps (plunger type). The piston packings of Indian Mark II models must be replaced every six months. Therefore, the periodical inspections of Project wells must be conducted at six month intervals. The inspections are to start upon the completion of well construction.

(2) Maintenance and Management of Drilling Machines and Supporting Equipment

The maintenance and management of the drilling machines and supporting equipment, and of the vehicles to be provided by the Project Phase I and II is the responsibility of DWA's Monze Office.

Equipment, tools, and spare parts that will be provided under the Project for repair shop use shall be maintained either at the repair shop or at the warehouse of DWA's Monze Office. These items must be properly managed. Also, spare parts are limited and any replacement spare parts required by the Project, or any other project, must be made with costs borne by DWA.

7.2 MAINTENANCE AND MANAGEMENT COSTS

(1) Basis of the Cost Estimate

Maintenance and management costs are expenditures necessary to cover the periodic inspection and repair work of the 322 hand pumps at the 120 newly constructed wells, and 100 rehabilitated wells under the Project, and at the 102 wells previously constructed under the Phase I project.

Each hand pump will be inspected every six months. Necessary repair work will be performed at that time.

Maintenance and management costs were estimated based on the periodic inspections and repair work over a ten-year period. The cost estimate was made as follows:

a) The Number of Periodic Inspection and Repair Work Times:

$$(322 \text{ wells} \times 10 \text{ years}) \times \frac{\text{one time}}{0.5 \text{ year}} = 6,440 \text{ times}$$

By taking into account the distances between the wells, it was assumed that one work team would conduct the work at two well sites per workday. Three work teams -- each having a vehicle -- will carry out the inspection and repair work.

There are 218 workdays a year; thus, the actual work period for the periodic inspection and repair work for each work team will be:

$$6,440 \text{ times} \times \frac{\text{year}}{2 \text{ times}} \div 3 \text{ teams} \div 218 \text{ workdays/year} = 4.92 \text{ years} = 59 \text{ months.}$$

The teams shall engage in similar work during the remaining work months within the 10-year period.

b) Repair and Maintenance Work Teams:

i) Vehicles: 3 Jeep

ii) Number of Personnel:

Center Manager:	1
Clerk:	1
Group Chief:	1
Workers:	6

iii) Average Daily Traveling Distance:
The average distance from DWA's Monze Office to a well site (see Fig. 2-3-1) was obtained as being 93 km (trip distance = 186 km/trip) by weighting the distance to each well site as follows:

Distance from the Monze Office	% of number of wells	Weighted average
Within a20 km radius:	9%	1.8 km
40 km :	19%	7.6 km
60 km :	14%	8.4 km
80 km :	14.5%	11.6 km
100 km :	15%	15.0 km
120 km :	9%	10.8 km
140 km :	5%	7.0 km
160 km :	2.5%	4.0 km
180 km :	3.5%	6.3 km
200 km :	1.0%	2.0 km
220 km :	2.0%	4.4 km
240 km :	3.0%	7.2 km
260 km :	2.0%	5.2 km
280 km :	0.5%	1.4 km
	TOTAL	93.0 km (Average)

c) Cost of Parts:
536 kwachas/year/well X 322 wells
= 172, 592 kwachas/year

The cost of parts for the first two years after the completion of the Project are to be covered by Japanese grant aid cooperation.

d) Repair Tools and Equipment:
The tools and equipment necessary for repair and maintenance work are to be provided under the Project

e) Repair and Maintenance Work Time: Two sites/day.

The cost estimate for repair and maintenance work was made covering a ten year period. As the inflation rate for that period remains unknown, the cost estimate was made based on present prices.

(2) Management and Operation Cost Estimate

a) Personnel Costs:

i) Center Manager: 1 TS/3 956 kwachas/month X 59 months = 56,404 kwachas

ii) Clerk: 1 S/15 466 kwachas/month X 59 months = 27,494 kwachas

iii) Group Chief: 1 TS/6 688 kwachas/months X 59 months = 40,592 kwachas

iv) Workers: 6 TS/9 528 kwachas/month X 59 month = 186,912 kwachas

Subtotal 9 persons 311,402 kwachas

b) Fuel and Vehicle Maintenance Costs:

i) Gasoline:
186 km/site x 1,073 times ÷ 5 km/L X 3.78 kwacha/L = 150,880 kwachas

ii) Oil
399.342 km (total travel distance) X (25 kwachas/1,000 km) =9,975 kwachas

iii) Grease:
858 kg X 31.6 kwachas/kg =27,113 kwachas

iv) Vehicle Maintenance:
25,590 kwachas (10%/year) X 4.92 years X 3 vehicles = 377,708 kwachas

Subtotal: 565,676 kwachas

* Note: Total number of inspection times is;

6,440 ÷ 3 days ÷ 2 times (Repair work per
day) = 1073 times

c) Costs of Repair Parts:
For hand pumps: 172,592 kwachas/year X 8 years
= 1,380,736 kwachas

Total Maintenance and Management Costs: 2,257,814/10 years. Therefore, the average annual maintenance and costs will be 225,781 kwachas.

7.3 PROBLEMS AND RECOMMENDATIONS RELATING TO MANAGEMENT AND MAINTENANCE

The Project's management and maintenance system can be divided into two groups, one for handling the hand pump operated wells, the other for handling the equipment and materials used in the construction and rehabilitation of Project wells. As described in Section 7.1, DWA established the system, but, as far as management and maintenance work is concerned, it has not been properly carried out.

From the outset of Project implementation the management and maintenance system will play an important supporting role, especially in connection with the hand pump operated wells.

(1) Management and Maintenance of the Hand Pump Operated Wells:
The deep wells at the water supply facilities must be periodically inspected, repaired, and maintained to ensure that a sufficient amount of safe, clean groundwater is supplied to the people throughout the year. It will also be important

to provide the well users with the necessary guidance to make them aware of the value and advantages of living in a sanitary environment.

In Section 7.1 it was proposed to establish a maintenance and management system with the main constituents being DWA personnel. In view of the primary nature of the rural water supply facilities, however, it would, in the future, be desirable for the well users, as a village unit, to participate in the system. By doing so, these people could conduct the periodic well maintenance and management chores with DWA providing the technical and economic assistance.

One of the methods to increase the residents' awareness of the wells being public facilities is the collection of water fees. In the urban areas of Zambia, water fees are based on water meter readings. In rural areas, however, there is no charge for the use of well water. As in other African nations, the economic situations, geographical conditions, and the difficulties that would be encountered in measuring the amount of water used in rural areas make it virtually impossible to collect water fees.

The Government of Zambia does have a future plan for collecting small fees for water usage in urban areas. The rates to be charge will not be a burden to those who use the water supply facilities that were constructed by foreign aid, such from Japan, NORAD, etc. The fees to be collected will in now way cover facility maintenance and management costs.

Not only will the water fee collection system be helpful in increasing the residents' awareness of

the importance of the well facilities, it will be instrumental in establishing a maintenance and management system that can be participated in by the villagers as a unit.

In view of the above, the Study Team presents the following recommendations for the future maintenance and management system for well facilities:

a) Select suitable persons from each village to manage the wells. Impart well maintenance and management techniques to these individuals in order to qualify them as well inspectors.

b) Establish well maintenance and management systems in each village, township, and district to take care of well facility related problems.

c) Provide guidance to residents to increase their awareness of public health.

d) Engage in publicizing the Project. In this manner the residents will be afforded the opportunity to gain a full understanding of the purpose and intent of the Project. The people will discover how much the well will benefit them as individuals and as groups.

e) Conduct periodic inspections of well facilities, and provide necessary well repairs and maintenances. Give guidance to the residents in matters concerning water quality, well facilities, and sanitation.

(2) Maintenance and Management of Equipment and Materials

DWA has a repair shop and a warehouse that will be able to accommodate the equipment and materials that will be provided under the Project. Unfortunately, the shop's capability for repairing equipment and vehicles is very limited. Also, the shop is in definite need of repair tools.

The borehole drilling equipment to be provided under the Project will last about ten years if it is properly maintained and repaired, and if there is an adequate supply of consumable parts. It should be possible, during that span of time, to utilize the equipment for borehole drilling even after the Project completion. Thus, it will be necessary for DWA to establish an equipment and material maintenance and management system that will be solely operated by DWA.

For the above reasons, the Study Team presents below their recommendations concerning the equipment and material maintenance and management system:

a) At the present time, DWA's mechanical engineers are not familiar with the repair and maintenance procedures for Japanese made equipment. Thus, it will be necessary for the engineers to upgrade their technical levels by learning all they can from the Japanese engineers assigned to the Project.

b) To make effective use of the equipment and vehicles, it must be inspected, repaired and maintained periodically and must not be used beyond their rated capabilities.

c) the materials and spare parts must be properly classified, marked, and stored in

the warehouse. They are not to be kept in open storage. Their use conditions, consumption rates, and problems related to them must be recorded in order to provide the basic data that will be required two years later for reordering purposes.

CHAPTER 8. PROJECT EVALUATION

CHAPTER 8 PROJECT EVALUATION

The Project is a part of the Groundwater Development Project in the Southern Province which was established, based on the Government's rural water supply development policies, to construct 880 new boreholes as a countermeasure to the three-year continuous drought that began in 1981.

The objectives of the Groundwater Development Project are: (1) to reduce the number of diseases related to insanitary drinking water; (2) to stabilize the livelihood of the people living in the rural areas; (3) to improve the country's social conditions by providing safe drinking water sources that will not become exhausted at any time during the year.

Phase I of the project was implemented in 1985 with grant aid from the Government of Japan. It was completed in 1987.

The Project (Phase II) is a continuation of the Phase I project. Under the Project, 120 new boreholes are to be constructed, and 100 malfunctioning hand pump wells are to be rehabilitated in an effort to supply drinking water to 55,000 people. It is assumed, however, that all of the residents (158,974 persons) in the Project site areas might use these wells during drought seasons.

Through Project implementation, the following direct benefits will be achieved:

① Disease occurrence rates and the number of death cases related to the use of insanitary drinking water will be reduced by providing safe, reliable drinking water sources that will not become exhausted at any time during the year.

Diarrhoea is a disease related to the use of insanitary drinking water. In 1986, 27.7% (186,081 persons) of the country's population were outpatients suffering from this disease. 0.868% (5,829 persons) of the total population were inpatients, while 0.0170% (114 persons) died.

Considering the number of people in the Project site areas and the number of those who will benefit from the deep wells, the Project will contribute greatly to the reduction of diseases.

② After 1981 the annual precipitation has often been less than it had been during the previous thirty years. As a result, there have been frequent droughts.

Taking into consideration the climatic conditions, the number of people who will use Project wells, the present disease occurrence rates, and the need to minimize drought damage, there is a definite urgency for implementing the Project.

③ Most of the water sources presently being used in the Project areas run dry during dry seasons. At these times, the residents must obtain drinking water from distant water sources. The Project will substantially alleviate this problem.

④ The livelihood of the people living in the rural areas will be stabilized, and the country's social conditions will be improved by providing safe drinking water throughout the year.

The following indirect benefits will be achieved by the implementation of the Project:

⑤ By making it easier for residents to draw water, by stabilizing the livelihood of the people, and by

improving social conditions, the Project will contribute to the expansion of the country's agricultural production, and will stimulate rural economies.

⑥ Plans call for Project wells to be located in school yards, village centers, hospital complexes, and in market and field areas where many residents tend to gather. As people will engage in conversation at the well sites, their understanding of one and other will grow and, as a result, the solidarity of the villages will be strengthened.

If the equipment and materials that are to be provided under the Project are properly maintained and managed, and if the consumable tools, spare parts, and materials will continue to be supplied after the completion of the Project (Phase II), the Zambia team will be able to go forward on their own with the Groundwater Supply Project in the Southern Province (a rural water supply project).

The transfer of techniques effected by the Japanese engineers during the Project will become a very important factor for the further smooth implementation of the rural water supply project and for the successful accomplishment of its objectives. To clarify, without the transfer of techniques by the Japanese engineers, it will be extremely difficult for the Zambian team to successfully carry on with the rural water supply project after the completion of the Project.

For humanitarian, social and economic reasons, the implementation of the Project with grant aid cooperation from the Government of Japan will be a most worthwhile undertaking. Project implementation will contribute a great deal to the international community, and will serve in strengthening Japanese and Zambian relationships.

CHAPTER 9. CONCLUSION AND RECOMMENDATIONS

CHAPTER 9 CONCLUSION AND RECOMMENDATIONS

9.1 CONCLUSION

The following conclusion for the Project's basic design was arrived at as a result of the series of discussions held with the Zambian officials concerned, the field surveys, and the design analyses that was made in Japan:

① The Project (Phase II) is a part of the Groundwater Development in the Southern Provinces (a rural water supply project). Under the project, 880 new boreholes are to be constructed. Project (Phase II) is a continuation of the Phase I project that was previously implemented with grant aid cooperation from the Government of Japan.

② The Groundwater Development Project (Phase I) that was implemented in the Southern Province with Japanese grant aid cooperation achieved the following results:

- It is believed that the implementation of the Project with Japanese grant aid cooperation was highly appreciated by the Zambian officials as well as by the residents in the project site areas. The Phase I project was evaluated as being a great success.

- The equipment and materials provided under the Phase I project continue to be used efficiently. The Zambian officials concerned appear to have taken great efforts in making effective use of the equipment and materials.

- Zambian engineers have learned the basic techniques of borehole drilling and equipment operations that were passed on to them by the Japanese engineers who were dispatched under

the Phase I project. However, the consumption rates of drilling tools among Zambian engineers are high, and their capability to apply the techniques to different types of geological conditions, drilling troubles, and other unexpected but related problems remains insufficient. Thus, it will be necessary for the Japanese engineers assigned to the Project to provide the transfer of techniques needed to upgrade the Zambian engineers' technical levels.

- Frequent breakdowns of high-pressure air compressors, DTH hammers, and drilling machines occurred during the Phase I project construction period due to the drilling teams' insufficient technique application capabilities, improper operations, or as a result of equipment overuse. Each breakdown caused drilling work to come to a halt until repairs could be effected. Therefore, it is not only necessary that the Zambian engineers' technical levels be upgraded, but the Japanese mechanical engineers must transfer equipment repair and maintenance related techniques to them.

  DWA strongly advises that the above mentioned transfer of techniques be provided under the Project.

③ One of the objectives of the Project is to reduce the number of diseases related to insanitary drinking water by providing safe, reliable drinking water.

In the Southern Province, where the Project Area is located, the occurrence rate of diarrhoea (a

disease related to insanitary drinking water) is very high. In 1986, 27.7% (186,081 persons) of the country's population were outpatients suffering from this disease. 0.868% (5,829 persons) of the total population were inpatients, while 0.0170% (114 persons) died.

④ Precipitation in the Southern Province is less than in the other provinces of Zambia. The annual precipitation after 1981 has generally been less than the average annual precipitation during the previous 30 years. As a result, there have been frequent droughts.

⑤ The Project calls for constructing 120 new deep wells and for rehabilitating 100 malfunctioning wells in order to provide safe drinking water to 55,000 residents. It is believed, however, that all of the 158,974 people in the Project well site areas might use these wells during drought seasons.

⑥ Judging from the number of diseases related to the drinking of insanitary water, the frequently occurring droughts, and the number of people who are expected to benefit from the use of the Project wells, it can be considered that there is an urgent need to implement the Project.

⑦ DWA's budget is mostly allocated for operating expenses. There are practically no funds available for any new projects. Thus, foreign aid has to be relied upon for the implementation of water supply projects.

⑧ After examining the Project from the above viewpoints, the following results were obtained:

- The responsible agency for Project implementation will be the Ministry of Agriculture and Water Development (MAWD). Actual Project construction will be undertaken by the Department of Water Affairs (DWA).

- The Project includes the following two work items to be accomplished in order to provide safe drinking water that will not become exhausted at any time during the year in the seven districts of the Southern Province:

• Construction of new hand pump operated deep wells:	120 sites
• Rehabilitation of malfunctioning hand pump wells:	100 sites
TOTAL	220 sites

The average depth of the new wells shall be 50 m.

- The Project will be constructed by using both the equipment and materials that were provided under the Phase I project and those to be provided under the Project.

The equipment and materials to be provided under the Project will be as follows:

• Supporting vehicles:	8 units
• Various testing equipment:	one or two sets
• Wireless communications equipment:	1 set
• Repair tools:	1 set
• Air compressors:	1 set
• Hand pump service vehicles:	4 units
• Spare parts:	1 set
• Hand pumps:	220 each
• Casing pipe:	for 140 boreholes
• Screen pipe:	for 140 boreholes
• Guide pipe:	for 140 boreholes

For Project implementation, the Japanese side will dispatch engineers to provide technical guidance and advice, and for conducting cooperation and construction supervision.

⑨ Project implementation will result in the following benefits:

- Direct benefits:
  - Decrease the number of diseases resulting from the use of insanitary drinking water.
  - Minimization of drought damage.
  - Alleviation of the situation whereby residents must labour for drawing water from distant water sources.
  - Stabilization of the people's livelihood in the rural areas and the improvement of social conditions
- Indirect benefits:
  - Strengthening the solidarity of the residents in the rural areas.
  - Contribution to the expansion of agricultural production and to stimulate rural economies.

- Other benefits:
  - In order to achieve the initial objectives of the rural water supply project the Zambian team will be able to proceed with its implementation through the use of the transferred techniques and the equipment and materials provided under the Project.

In view of the above background, it can be considered that Project implementation with grant aid cooperation from the Government of Japan will be quite appropriate.