

Mechanical Engineer	2	Maintenance and repair of the drilling machine and technology transfer regarding the above mentioned technique.
Testing Engineer	1	Conducting borehole logging, aquifer test, etc. and technology transfer regarding the above mentioned tests.

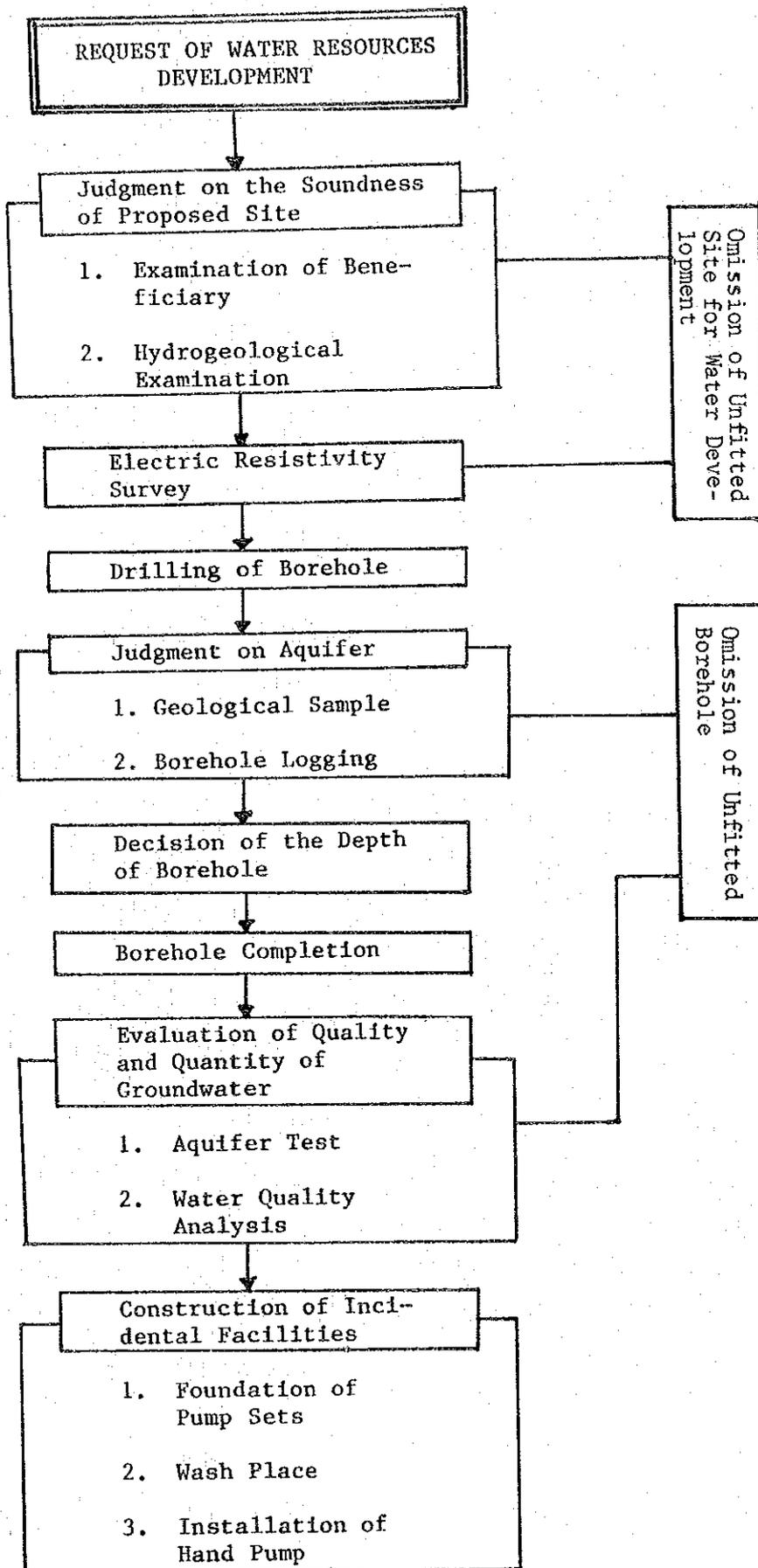
The despatch of the above-mentioned engineers will take place during the period of about 7 months after the commencement of the drilling operation, as the program is also in the framework of the grant-aid program.

4-5-3. Modus Operandi of Drilling Boreholes

As is previously mentioned, the proposed sites of boreholes were selected from the point of view of demand for water source, and hydrogeological consideration has not yet been given. Therefore, when this water source development project is implemented, all the potential problems will have to be solved, using the evaluation standard provided by the procedures required by the water source development planning before proceeding to the actual borehole drilling and constructing water supply facilities. (See Fig. 4-4.)

Toward this end, the Project may have a possibility of facing problems concerning the selection of sites for boreholes or evaluation of groundwater resources when it is implemented. The standard or technical specifications which will be prepared at the time of project implementation will be used to solve these problems. As data for the compilation of standard, some of the criteria collected by the survey team after its field study and its discussion with Zambian counterparts are described below.

Fig. 4-4. Modus Operandi of the Groundwater



(1) Suitability of site

° Population Element and Distance to the Boreholes

In this water supply project, first priority shall be given to the rural settlements of more than 50 inhabitants with the distance to the water source being more than 5 km. Then, by turns, the facilities are to be provided to the settlements closer to the sources.

According to Table 4-1, unit beneficiary population per one urgently needed borehole for the Project is between 500 and 1,000. But people who depend on the existing wells are included in this table, actual beneficiary population can be estimated at around 200. The locality with extremely small beneficiary population shall be excluded. Optimal beneficiary population will be decided by the actual village inhabitants living within the area which can be covered by a borehole (maximum diameter around 5 kilometer). Considering pumping capacity, water demand, etc., it is desirable to distribute boreholes in such a way that each borehole has around 300 beneficiaries.

However neither the number of the unit beneficiary population per borehole nor the unit planned volume of water supply per capita is specifically set for the Project.

° Hydrogeological Element

Geology and pumping rate of existing nearby boreholes will be examined. The site whose static water level can be estimated to be more than 50 meters will be discarded. The areas where shales and mudstones are distributed and thought to form impermeable layer are avoided.

° Electric Resistivity Survey

The suitability of site for drilling will not be judged only by the results of the electric resistivity survey. In order to make a consolidated judgment, conditions of geo-morphology and geology of the area, or the data of the existing nearby boreholes shall be taken into account.

(2) Judgment on Aquifer

To judge the permeability of weathered layer by geological sample and core logging. Rock fissure is to be detected by using the records of leakage, rate of drilling, micro logging, etc. during drilling operation. The screen section and the depth of the borehole are decided.

(3) Evaluation of Quality and Quantity of Groundwater

Hand pump sets will not be installed, when its static water level is more than 50 meters, but when it is found that its pumping rate is abundant, the construction of well will be carried out for future use by engine pumps.

When the static water level is between 30 to 50 meters, which is usually the maximum level for pumping by hand pumps, aquifer test will be carried out, and specific pumping rate is calculated. Whether construction of borehole and installation of pump set are carried out or not depend on the specific capacity.

Water quality is judged by the WHO standard. Even the quality does not satisfy it, with the request of beneficiaries, a pump may be installed as long as the water is judged not to harm the health of users. If the quality of water is found to be further deteriorated, the use of the water is to be limited for miscellaneous household use except for drinking purpose.

Although Zambian engineers of DWA have experienced many construction works of rural water supply facilities including the drilling of boreholes, many of them have not received systematic training on overall development method such as survey technique of groundwater resources, interpretation of borehole logging, evaluation of groundwater yield by aquifer test or operation technique of new type of drilling machines which are to be provided by grant-aid.

Thus, it is necessary that technology transfer be carried out through actual drilling operation and project implementation.

4-6. Project Cost to be Borne by the Government of Zambia

The Project cost to be borne by the Government of Zambia consists of the personnel and incidental expenses concerning the construction of 43 boreholes and water supply facilities.

Personnel cost	95,186 K
Fuel and material cost	<u>10,915 K</u>
Total	106,101 K

Following are the costs required for the drilling of remaining 59 boreholes and the construction of corresponding water supply facilities.

Personnel expenses	135,980 K
Fuel cost	272,750 K
Material cost	<u>26,471 K</u>
Total	435,201 K

Unit wages, unit material price, unit working days required by different category of work, consumption rate of fuel and chemicals, etc., which are the basis of this calculation, are attached to the Appendix.

CHAPTER 5. PROJECT IMPLEMENTATION PROGRAMME

5-1. Executing Agency

5-1-1. Project Implementation

The agency for the Project implementation is DWA, the Government of Zambia.

After the Exchange of Notes, DWA will contract with a Japanese consulting firm for designing, supervision, etc., then it will execute the formalities of tender to Japanese suppliers and contractors, under the supervision of the consultants concerning the procurement of equipment and materials and construction of 43 boreholes.

In the construction work, drilling of borehole will be carried out by the staffs of the drilling section of DWA, and installation of pumps and incidental works by the Southern Provincial Office of DWA, which is located at Choma.

Japanese consultants will give advice on the selection of 43 sites of the borehole out of 102 sites, planning of groundwater development and supervision of construction, etc.

Japanese contractor will drill the boreholes and construct boreholes using equipment and materials provided. All the necessary staff for the work will be provided by the Government of Zambia.

DWA will take full responsibility for drilling of remaining 59 boreholes and construction of corresponding water supply facilities.

Management and maintenance of the completed water supply facilities will be carried out for the time being by the Southern Provincial Office of DWA and the District Council. IDWSSD made a proposal that, in

future, the beneficiaries will be organized and they themselves will take care of the facilities.

5-1-2. Detailed Design and Construction Supervision

Service of design supervision regarding the procurement of various equipment and materials to be provided by the Government of Japan, and the advice on the management of Project formulation and planning regarding the construction of water supply facilities will be carried out by the Japanese consultants. After the Exchange of Notes for the Grant-Aid Program is formalized, the Government of Zambia will conclude consulting contract with a Japanese consulting firm regarding the services mentioned below.

- (1) To make tender documents such as detailed design concerning procurement of equipment and materials, technical instruction and advice on construction works and drilling technique and specifications (including technical specifications).
- (2) Execution of formalities of tender on behalf of the Government of Zambia, and to evaluate the tender offer.
- (3) To witness the inspection of equipment and materials while they are in the process of being manufactured and at the time of their delivery.
- (4) Supervision of construction of 43 boreholes.

Concerning the supervision of construction and planning for the Project implementation, consultants and will have discussions with Zambian counterparts will have discussions, and the former gives advice to the latter whenever necessary.

The Government of Zambia will execute the formalities of tender under the supervision of consultants, and will make a contract with a successful bidder.

Despatch of engineers for the technology transfer in the field of construction of water supply facilities including drilling technique during construction period will be done by the Japanese supplier of the equipment and materials.

5-2. Undertaking of Works in the Project Implementation

According to the conclusion reached at the discussion between the survey team and Zambian counterparts, each party will do her undertaking in the project. Undertaking of works for each party is described below.

5-2-1. Undertaking of Japanese side in the Project

- (1) Provision of drilling machine, supporting vehicles, equipment and materials of boreholes, etc. and transport them to the premises of the head office of DWA.
- (2) Construction of 43 water supply facilities.
- (3) Procurement of equipment and materials to be provided; and designing and supervising for implementation of construction work.

5-2-2. Undertaking of Zambian side in the Project

- (1) To take the necessary procedures for exempting customs duty for equipment and materials to be imported.
- (2) Inland transport of equipment and materials from DWA head office to the district office.

- (3) To take the necessary procedures for exempting customs duty for accompanied equipment and materials of the Japanese consultants and the contractors.
- (4) To bear the commissions for the banking service to the Japanese foreign exchange bank.
- (5) To arrange labourers for the construction of water supply facilities and to pay them wage.
- (6) To set up the Project team with the staff who are well versed with the aspects of management, planning and technology required by the project.
- (7) To make electric resistivity survey for the selection of sites of boreholes before the Project commences.
- (8) To manage and maintain equipment and materials provided by Japanese grant-aid program.
- (9) To provide the personnel and cost regarding the construction of remaining 59 water supply facilities, and to be responsible for the completion of these facilities.

5-3. Procurement of Equipment and Materials

Procurement of equipment and materials required by the Project will be made mainly in Japan and a part of equipment and materials will be from Zambia. The product of the third country may be used, if they are not available in both countries or if they are more economical.

The procurement of equipment and materials will be carried out by suppliers under the supervision of the consultants.

5-4. Implementation Program

The Project will actually start when the Exchange of Notes are formalized by the Governments of Japan and Zambia. Then, DWA will make a consultant contract with a Japanese consulting firm for the service of procuring equipment and materials and of the implementation of the Project. After the contract is signed, the consultant will prepare the tender documents. After obtaining approval from both Governments of Japan and Zambia, invitation of tenders will be given to Japanese suppliers, then it will witness the contract between the Government of Zambia and a successful bidder. It is estimated that about 4 months are required from the date of Exchange of Notes to the Government's contract with the supplier, about 6 months for manufacturing of drilling machine, procurement and packing of other equipment and materials and sea transport, and 2 months for land transport. In other words, one year will be required before construction work and technical guidance take place. Moreover, the validity of Exchange of Notes is up to March when Japanese fiscal year ends. So the maximum period of drilling operation would be 7 months, even considering the extension of the validity of Exchange of Notes for another year.

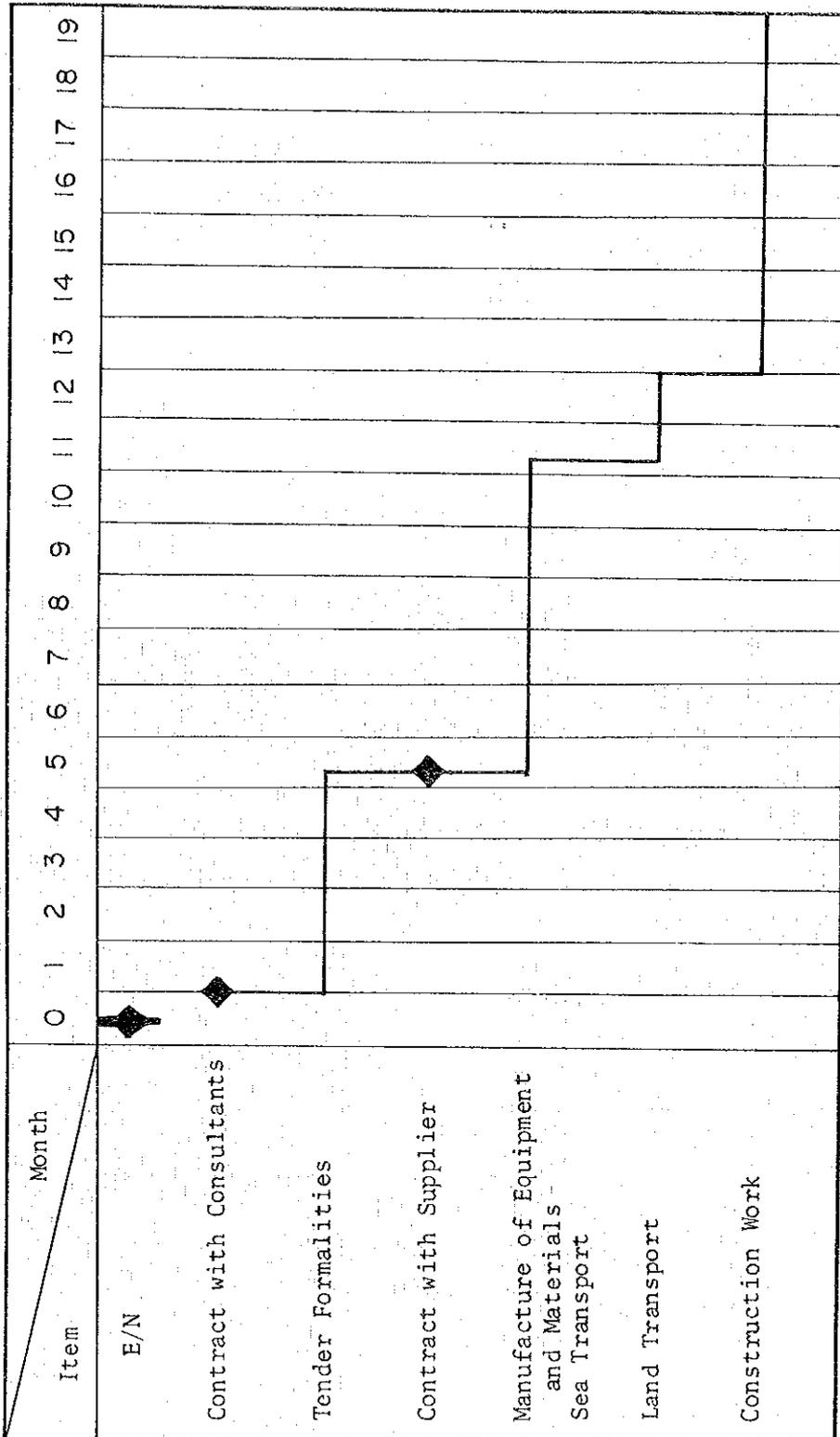
The program is shown in Figure 5-1.

5-5. Management and Maintenance Program

5-1-1. Drilling Machines

Management and maintenance of the equipment and materials, the principal items of which is the drilling machines, are carried out by the drilling section of DWA. As is described in Chapter 2, the drilling section is an organization (the headquarter of which is situated in Lusaka), which consists of 24 personnel of headquarter, 9 staff in workshops and 77 staff for operation at drilling sites. (See Table 2-9.)

Fig. 5-1. Implementation Program after E/N



The above-mentioned staff at the site of operation will manage and maintain the equipment and materials while they are at work with drilling machines. Repairs, etc. of the equipment and materials are done at the workshop in Lusaka headquarter.

5-5-2. Water Supply Facilities

(1) Management and Maintenance System

In principle, the management and maintenance of boreholes and pumps, etc. shall be carried out by provincial committee (District Council), but due to shortage of staff, it will be carried out by the Southern Provincial office of DWA. The office has 136 staffs, as is shown in Chapter 3. It has branches in each of five districts. Actual management and maintenance is being carried out by a team of two plumbers, a driver and two labourers with small vehicles.

The responsibility for operation and maintenance of the completed water supply facilities should in principle rest with each district, and the beneficiaries should be organized to take charge of the daily operation and the small repairs.

(2) Management and Maintenance Cost

Management and maintenance cost: the cost of daily management and maintenance is not appropriated in the budget because it is negligible. The cost of rehabilitation is not appropriated either because its element of uncertainty is considerable. Therefore, the cost of management and maintenance appropriated here is confined to the necessary cost for repairing 102 pump sets for 10 consecutive years. The average rate of occurrence of minor breakdown by wear and tear is set at once every 1.5 years per site. Following are the details:

- a) Total occurrences of repair: $(102 \times 10)/1.5 = 680$ times
- b) Formation of repair team
 - i) pick up: 1 unit
 - ii) staffs: plumber 2, driver 1, labourer 2
 - iii) average distance of movement: $100 \text{ km} \times 1 \text{ R/T} = 200 \text{ km/site}$
- c) Spare parts: 7,427/year (spare parts for first two years are included in the equipment provided)
- d) Equipment for repair: included in those provided under grant
- e) Repair hour: 1 day/site

As the price inflation rate cannot be estimated accurately for such a long term period, the unit cost per year in the time of calculation is used as a base for adding the cost of management and maintenance. The repair team should engaged itself in this work in the required hours for repair ($680/218 = 3.12 \text{ year} = 37.4 \text{ months}$), and the rest of the time during the period should engage itself in the same type of work in the other projects.

The detailed calculation of the cost of management and maintenance is attached to the appendix. Summary of its contents is as follows:

Management and maintenance cost of the 102 pumps for 10 years is as follows:

a) Salary and wages	=	K 39,831
b) Fuel and grease cost	=	69,016
c) Cost of spare parts	=	<u>89,302</u>
Total	=	K 198,149

5-6. Drilling of Remaining Boreholes after Japanese Cooperation

After the end of Japanese cooperation for drilling boreholes by its grant-aid program, Zambian counterparts of this project will carry out the drilling of the remaining 59 boreholes and the construction of the corresponding water supply system. As is mentioned in item 5-1, drilling of boreholes will be carried out by the drilling section of DWA, and the selection of borehole sites and installation of pump set will be carried out by the Southern Provincial office of DWA. The required number of the staff for this purpose has been explained in item 4-5. (See Table 4-4.)

Cost of construction materials (hand pump, casing and screen pipe), except those of boreholes and water supply facilities will be borne by the Government of Zambia. The estimated cost for this purpose is 435,000 Kwacha (refer to Attached Document 8).

CHAPTER 6. PROJECT EVALUATION

The Project is a part of the potable water sources development plan for about 220,000 rural inhabitants in the Southern Province, which is equivalent to 44 percent of total rural population of the Province.

The direct benefits of the Project is as follows:

- 1) Urgency is one of the most important factors for the installation of the rural water supply facilities to negotiate the coming drought which is difficult to forecast. Installation of boreholes and related water supply facilities is vital for the improvement of present water supply conditions of the Southern Province.
- 2) The rate of occurrence of diseases caused by mal-environmental conditions can be reduced by obtaining the source of good quality water supply suitable for drinking.
- 3) During the dry season when all the nearby hand dug wells dry up, many people have to carry potable water and water of household use on the ox-carts from sources of more than several kilometers away from their houses. If they can secure perennial water source in their vicinity, family labour used for carrying water will be liberated and used for either so far neglected household work or for agricultural production.

- 4) Many boreholes for water supply will be installed in the premises of village schools or village clinics. The boreholes will then provide beneficiaries of water supply a frequent meeting place, which will strengthen the social solidarity of the village.

Besides the above-mentioned direct benefits, psychologically induced indirect benefits could also be expected. The peace of mind derived from the fact that hygienic potable water is always within easy reach from their house will stabilize the villagers' daily lives and stimulate the healthy development of their bodies and minds, which will become the central force of vitalizing the potential of the rural area.

Judging from the length of the useful life of the equipment and materials which Japan will provide, the Project could continuously be an integral part of Zambian rural water supply project which covers wider area of the province, if Zambian executing agency pays proper attention to its operation and maintenance effort along with the continuous procurement of the spare parts after boreholes are commissioned.

Most important of all, the appropriate technology transferred to Zambian engineers during the execution period of the Project regarding the planning of groundwater development project, management technique of construction works, preservation and utilization of hydrogeological data and drilling operation will be of great use for the efficient execution of not only the future projects of rural water supply but also all the works carried out by DWA.

With the analysis so far made in this study, it is concluded that execution of this Project by the Japan's Grant-Aid Program is quite feasible.

CHAPTER 7. CONCLUSION AND RECOMMENDATION

7-1. Conclusion

The conclusion reached as a result of the discussion with the Government of Zambia in the field and of the basic design study made in Japan after returning from the field is as follows:

- a) It is perceived that the Government of Zambia is most urgent in her request of carrying out the construction of boreholes, which had been selected from the program of installing the rural water supply facilities in the Southern Province.
- b) For the execution of the Project, 2 units of drilling machines and related equipment and materials are to be required.
- c) As a result of examining the records of budget expenditure and allocation of staff to the rural water supply of the DWA, MAWD (Ministry of Agriculture and Water Development) which is Zambian executing agency of the Project, it would be found impossible for the Government of Zambia to carry out the drilling of boreholes and the construction of water supply facilities all by herself.
- d) If the Project is executed, and the urgently needed rural water supply facilities are installed, occurrence of the diseases caused by the mal-environmental conditions would be decreased due to the fact that people could secure good quality of potable water in the vicinity of their houses, and the surplus labour generated by eliminating the transport of water could be utilised in the more useful household activities or agricultural production.

The final conclusion drawn from the above is that it would be appropriate to provide the equipment and materials relating to the Project by the Grant-Aid Program of the Government of Japan, and that it would also be appropriate to bear the cost of construction of some of the boreholes, to transfer the technology of drilling and to supervise the construction within the framework of the same grant-aid program from the point of view of completing the construction of the borehole wells urgently.

7-2. Recommendation

- 1) It is estimated that the period of execution required for the drilling of boreholes and the construction of the facilities of the Project would be about 19 months after the Exchange of Notes is formalized. So the actual period for the drilling of 43 boreholes and installation of pumps is 7 months at the maximum, after reducing the necessary period for manufacturing the equipment and materials and for their transport. Technology transfer to the staff of DWA is to be also completed within this period. Therefore, drilling of remaining 59 boreholes will be carried out by DWA itself. The period required for the construction is estimated at about 9 months. So it is hoped that the Japanese side would ask the Zambian side to make efforts for self-reliance so that the Government of Zambia would provide sufficient budget for the construction of the remaining boreholes and facilities, and that the materials of water supply facilities provided by the Project would be utilised surely and effectively for the installation of rural water supply facilities of the Southern Province.

- 2) The volume of spare parts of the equipment and materials provided to the Project is sufficient for the period of one year with normal level of operation after the Project is completed. And, the volume of compounding materials of drilling mud provided is sufficient to drill 102 boreholes. As to replenishment of these spare parts of the equipment and materials, and of compounding materials, the Government of Zambia shall secure the further supply of these items, so that the equipment and materials provided could be utilised effectively and continuously in future. Especially, it should also be noted that compounding materials of drilling mud is expendable.

ATTACHED DOCUMENTS

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APPENDIX 1. MEMBER LIST OF THE SURVEY TEAM

<u>Position</u>	<u>Name</u>	<u>Firm</u>
Team Leader	Shinnichi YAMASHITA	Superintendent Engineer Ohi River Regional Water Supply Agency, Shizuoka Prefecture, Japan
Project Coordinator	Junji YOKOKURA	Grant Aid Department Japan International Cooperation Agency (JICA)
Groundwater Deve- lopment & Water Supply Facilities Engineer	Hisao ANDO	Sanyu Consultants Inc.
Boring Machine & Hydrogeological Engineer	Masao KOJIMA	Sanyu Consultants Inc.

APPENDIX 2. SCHEDULE OF THE FIELD SURVEY

<u>Date</u>	<u>Day</u>	<u>Work Schedule</u>
Feb. 24	Sun.	Trip (Tokyo to Paris).
25	Mon.	-do- (Paris to Lusaka)
26	Tue.	Arrival at Lusaka. Courtesy call to Embassy. Team Meeting.
27	Wed.	Courtesy call to Director, DWA, Min. of Agriculture and Water Department; to NCDP. Discussion with Specialist in Hydrogeology. Meeting with Mr. Nbae, Chief Engineer, DWA, Adviser, DECADE on collection of documents.
28	Thur.	Data collection (Bureau of Statistics, Publication Section, Meteorological Department, Geological Survey, Survey Department, NSC, etc.). Call to Drilling Section, DWA (Rig information).
Mar. 1	Fri.	Site investigation. Call to Drilling Section, DWA (Rig Information).
2	Sat.	Examination of Budget of Drilling Section, Drilling Machine.
3	Sun.	Arrangement of documents collected.
4	Mon.	Site investigation. Lusaka - Monze - Choma. Visit workshop at Monze. Briefing from Mr. Kyobe, Provincial Water Engineer, DWA at Choma.
5	Tues.	Investigation of boreholes with hand pump. Visit Shindowa Village. Visit Shiachia Village.
6	Wed.	Discussion with Mr. Kyobe on boreholes sites for urgent drilling in Southern Province. Discussion on electric resistivity, etc., at Monze. Back to Lusaka at night.
7	Thur.	Collection of data on drilling records at Drilling Section, DWA. Discussion with Chief Engineer on Equipment to be requested.

<u>Date</u>	<u>Day</u>	<u>Work Schedule</u>
8	Fri.	Discussion with Director, DWA and adviser to DECADE about contents of minutes. Affix of signatures to the minutes. Courtesy call to Minister, Min. of Agriculture and Water Development.
9	Sat.	Visit Chylund Village. Team Meeting on documents collection.
10	Sun.	Arrangement of documents collected.
11	Mon.	Visit Ministry of Welfare. Discussion with Provincial Water Engineer on borehole sites for urgently required wells.
12	Tue.	Discussion with Chief Engineer and Provincial Water Engineer on construction of wells and foundation of pump. Collection of information on costs. Get information from members of JOCV. Team Leader and Mr. Yokokura leave for Japan.
13	Wed.	Visit University of Zambia. Collect information on technical education. Discussion with Chief Engineer, Provincial water engineer, etc. on hand pumps.
14	Thur.	Collection of information on cost in the city. Discussion with chief engineer at DWA on foreign aid project.
15	Fri.	Collection of information on cost of construction material in the city. Discussion at DWA on cost. Courtesy call to Embassy. Leave for Japan at night (Lusaka to London).
16	Sat.	Trip (arrival at London).
17	Sun.	-do- (London to Tokyo).
18	Mon.	Arrival at Tokyo.

APPENDIX 3. LIST OF ORGANIZATIONS AND PERSONS CONTACTED

Ministry of Agriculture and Water Development

Chinkuli, G.K.G. Minister

Mbewe, F. Permanent Secretary

Ernest Mfamboh Economist

Department of Water Affairs

Kayombo, C.R.W. Director

Mbumwae, L.L. Chief Water Eng. Data and Planning

Kyuti, R.B. Chief Water Eng. Water Supply

Sangulube, O.L. Hydrogeologist, Data and Planning

Banda, S Chief, Drilling Section

Siamachoka, E.M. Hydrologist

Ngoma, R. Chemist

Lusaka Provincial Office

Sivaswarupan S. Provincial Water Engineer

Southern Provincial Office

Kyobe, D.E.M.K. Provincial Water Engineer

Mehta, M. Hydrogeologist, Monze Office

Kamlewe, P.B. Hydrogeologist

Shisala, S.F. Engineering Ass., Kalomo Office

International Drinking Water Supply and Sanitation Decade Program

Dr. Nyumbu, I.L. Adviser

Ministry of Health

Banda, M.F.C. Statistician

Dr. Himonga Epidemiologist

National Council for Scientific Research

Dr. Sharman, T.C. Hydrologist

University of Zambia

Dr. Jere Dean, School of Mines

Jayaranan, K. School of Civil Engineering

National Commission for Development Planning

Mtonga, J.M. Permanent Secretary

Meteorological Department

Mwengala, S. Chief, Meteorologist

Central Statistical Office

The Government Printer

Geological Survey

Survey Department



MINUTES OF DISCUSSION
ON
GROUND WATER DEVELOPMENT PROJECT
IN
THE REPUBLIC OF ZAMBIA

In response to the request made by the Government of the Republic of Zambia for the Ground Water Development Project in Southern Province, the Government of Japan has sent, through the Japan International Co-operation Agency (hereinafter referred to as "JICA") which is an official agency implementing the technical co-operation of the Government of Japan, a team headed by Mr. Shinnichi Yamashita, Superintendent Engineer, Chi River Regional Water Supply Agency, Shizuoka Prefecture, to conduct the survey for 18 days from February 26th to March 15th, 1985.

The team carried out a field survey, held a series of discussions and exchanged views with the authorities concerned of the Government of the Republic of Zambia.

Both parties have agreed to recommend to their respective Governments and the authorities concerned to examine the result of the survey attached herewith towards the realization of the Project.



11th March, 1985.

山下真一

SHINNICHI YAMASHITA
Head, Japanese Survey Team

F. MBEWE
ACTING PERMANENT SECRETARY
MINISTRY OF AGRICULTURE AND
WATER DEVELOPMENT.

J.N. MTONGA
PERMANENT SECRETARY
NATIONAL COMMISSION FOR DEVELOPMENT PLANNING



- 2 -

ATTACHMENT

- I. The objective of the Project is to construct boreholes and to provide the necessary equipment and materials in the area where drinking water for the people of the rural areas in Southern Province is urgently needed.
2. The Japanese Survey Team will convey to the Government of Japan the desire of the Government of the Republic of Zambia that the former takes necessary measures to co-operate in implementing the Project and bears the cost of the items requested by the letter shown in Annex I within the scope of Japanese economic co-operation programme in grant form.
3. The Government of the Republic of Zambia will take necessary measures listed in Annex II under the condition that the grant aid assistance by the Government of Japan is extended to the Project.
4. Both parties confirmed that the Survey Team explained Japan's grant aid programme and the Zambia side has understood it.



ANNEX I

The following items are requested by the Government of the Republic of Zambia as grant aid assistance:

- I. 2 Units of Boring Equipment Consisting of the Following items:
 - (1) Truck mounted Drilling Rig
 - (2) Air Compressor
 - (3) Electric logger
 - (4) Water Level Indicator
 - (5) Cargo Truck
 - (6) Water Tank which can be loaded on a cargo truck
 - (7) Wagon 4WD
 - (8) Pick Up 4WD
 - (9) Diesel Engine Welder
 - (10) Spareparts for items mentioned above.
2. 1 Unit of Testing Equipment
 - (1) Submersible Motor Pump
 - (2) Diesel Engine Generator.
 - (3) Water Analysis Kit (Portable Electric Conductivity Meter, PH Meter)
 - (4) Pick up 4WD
3. 1 Unit of Maintenance Equipment for Workshop in Monze
 - (1) Pipe threading machine
 - (2) Drilling Machine
 - (3) Grinder
 - (4) Pipe cutter
 - (5) Compressor
 - (6) Portable Grinder
4. Construction of boreholes on sites of high priority in Southern Province. All the Equipment given under the grant shall be used exclusively for the Project. No local contractors will be involved. All the personnel necessary for the construction shall be provided by the Zambian Government.



5. Training of Personnel of Department of Water Affairs on siting, boring, installation of well materials and advise for management on the Project Organization and Planning.



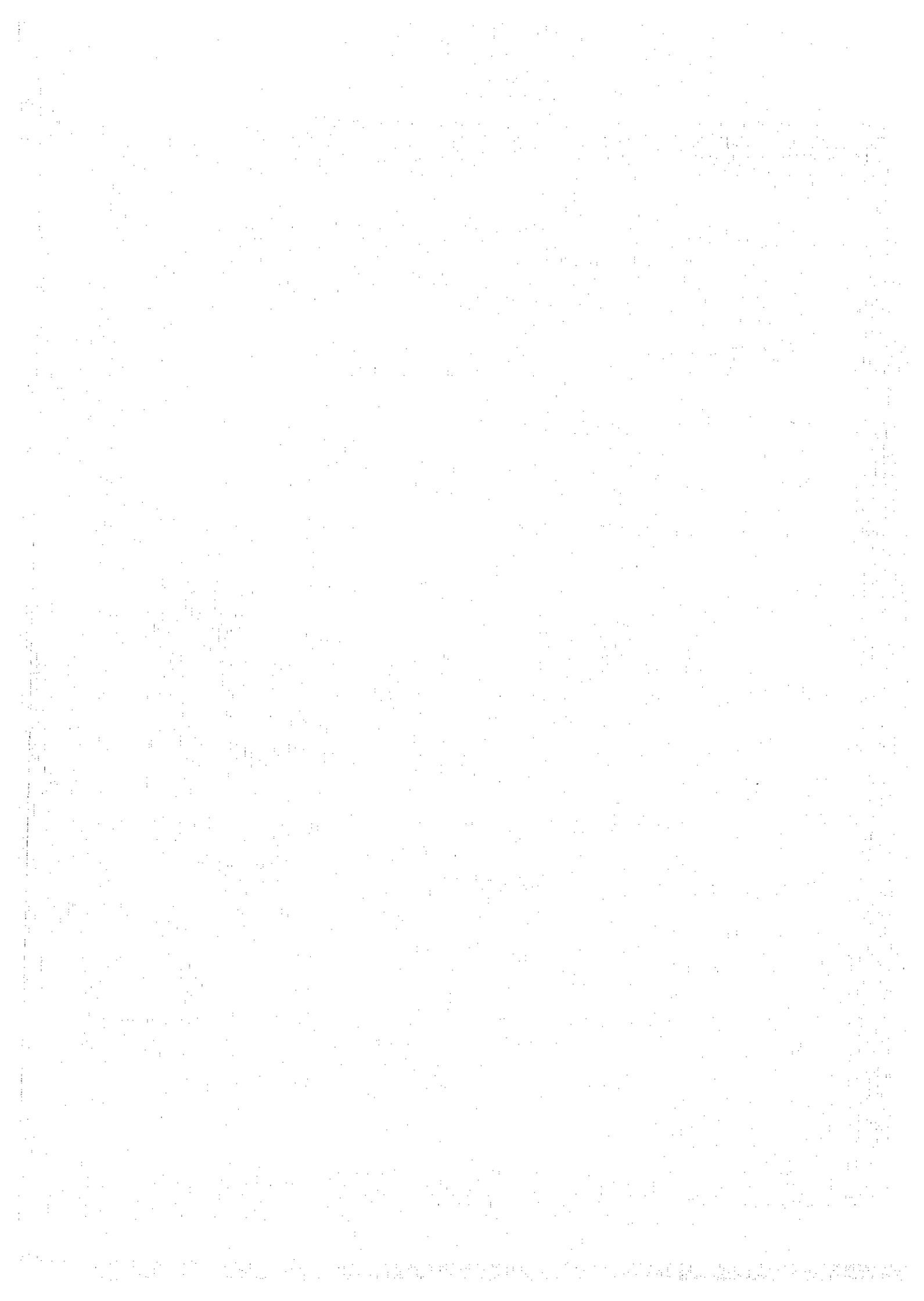
ANNEX II

The following arrangements are requested to be taken by the Government of the Republic of Zambia:

- I. To ensure customs clearance at the entry point in the recipient country.
 - (I) Tax exemption and custom clearance of the products at Lusaka
 - (2) Internal transportation from Lusaka to the Project site ✓
2. All goods, equipment and personal effects of the Japanese consultants and contractors brought under the Project shall be exempted from all duties and taxes.
3. To bear the following commissions to the Japanese foreign exchange bank for the banking services based upon the B/A.
 - (I) Advising commission of A/P
 - (2) Payment commission.
4. To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into recipient country and stay therein for the performance of their work.
5. The Zambian Government shall provide all the local personnel and bear all their expenses under the Project.
6. To provide convenience to allow Japanese consultants and contractors to use freely the workshops or other facilities/equipment of DWA not covered by the grant when necessary, and to provide consumed materials for the equipment.
7. To organize the Project team with sufficient number/knowledge/technics of personnel for management, planning and technical (siting, boring, installation of well materials etc) fields well in advance of the commencement of the Project. Especially members for the 2 units of the boring equipment are essentially necessary.
8. To carry out geo-electric survey prior to the commencement of the Project.
9. To use the equipment and materials given under the grant exclusively for the Project.



- IO. To maintain and use properly and effectively the equipment and materials purchased under the grant and to arrange the budget and personnel for the maintenance/operation of the equipment and for the construction of boreholes, after the termination of Japanese construction aid.
- II. To bear all the expenses other than those to be borne by the grant, necessary for the Project.



- | Publication | |
|-------------------------------------|---|
| 1) Central Statistical Office | Country Profile 1984 |
| 2) " | Census of Population and Housing 1969
Vol II Southern Prov. Nov. 1973 |
| 3) " | Selected Socio-Economic Indicators
Apr. 1984 |
| 4) " | Monthly Digest of Statistics
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| 5) " | Census of Population and Housing 1969
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| 6) " | 1980 Census of Population and Housing
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| 7) " | Annual Agricultural Statistical Bulletin
1983. Dec. 1984 |
| 8) Office of the President | Third National Development Plan 1979-83
Oct. 1979 |
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- 7) Survey Div. Topo-Map 1:250,000 (9 sheets)
- 8) Ministry of Health Health Statistics (Vol.1) 1978

APPENDIX 6. LIST OF PROPOSED BOREHOLES SITES URGENTLY REQUIRED

District/Village	Chief's Area	Population	No of Household
GWEMBE			
Chipepo Sec. School	Chipepo		
Makonkoto School	Sinazongwe		
Nang'ombe P. School	Sinazongwe		
Chirundu Siavong.R.			
Bunyete School	Sikoongo		
Sinakasikili School	Sinazongwe		
Sulwe-Gonde School	Mweemba		
Siasuntwe	Chipepo		
Jongola School	Munyumbwe		
Siamuluwa	Chipepo		
Manyonga	Sinazongwe		
Siameja Wasilundu	Mweemba		
Sinazongwe's Palace	Sinazongwe		
Simwene	Munyumbwe		
Kabuyu Halumba	Sinadambwe		
Sinadambwe School	"		
Sinaka imbi	Sikoongo		
Nabanda School	"		
Sialuselo	Chipepo		
Siambunda	"		
Sialuselo	North Chipepo		
Mwauangala	Simawba North		
Lumbende	Sikongo North		
Siampondo School	Mweemba		
Mwanakabira	Sinazongwe		
Siampande School	Center Chipepo		
Hamuchibozu	North Sinazombwe		
MAZABUKA			
Kalambakali	Mchingwala		
Shembekupola	"		
Kabobola	T/ship		

District/Village	Chief's Area	Population	No of Household
MAZADUKA			
Lusale	Naluama		
Nanduba	"		
Sikoswe	"		
Kanyeele	Mwenda		
Mabwetuba	"		
Chivuna	Sianjalika		
Munjile	"		
Mweemba School	"		
Sianjalika's Palace	"		
Mukwabila	M/Chingwala		
Chibulamakwebo	"		
Mugwagwa	"		
Village 6	"		
Namulonga Fish Camp	"		
CHOMA			
Mukumwa	Hamaundu	600	30
Sibajane	"	350	50
Kakuba School	"	875	61
Makomba	"	984	87
Ndondi	Moyo	1500	92
Hajamba	"	2000	120
Kauba	"	1800	110
Kasyongo	"	600	30
Mpampila	Mapanza	800	45
Nziye	"	650	32
Maanda	"	950	77
Namuswa	Singani	600	30
Masons School	Mapanza	625	31
Nakeempa	Singani	750	50
Masopo	"	800	55
Sikalongo	"	900	83
Macha's Palace	Macha	750	50
Sikuchokoma	"	600	30

District/Village	Chief's Area	Population	No of Household
CHOMA			
Chimuni	Macha	1 000	89
NAMWALA			
Kazunikalila	Muchila	230	
Mauluzhi	Muwezwa	290	
Sigwidi	Nalubamba	600	
Santi	Mungaila	500	
Kawina	Musungwa	150	
Shinampamba	Shezongo	350	
Shingalili	Musungwa	359	
Nakamboma	Nalubamba	350	
Banamwaze	Chilyabufu	500	
Shimukopola	Mungaila	450	
Shapopa	Mukobela	297	
Sichinkabenge	Nalubamba	159	
Mwachimpu	Mukobela	250	
Matapuka	Muchila	450	
Baunza	Shimbizhi	450	
Nyambo Hqs	Muwezwa	350	
Kapili	Muchila	250	
Tonga Lyamaala	Mungaila	350	
Musemu	Shimbizhi	1250	
MONZE			
Mwana Anwami	Hamusonde	450	39
Kambaza School	"	400	38
Mbamunya	Choongo	700	65
Nkaba School	"	400	39
Mwene-Njola	Mwanza	300	38
Sikabenga	"	700	63
Mwanamambo	Chona	610	61
Mwika	"	500	45
Mulonga Alwiili			
Hamakalu	Ufwenuka	600	51
Hamudebwe	"	1310	110

District/Village	Chief's Area	Population	No of Household
MONZE			
Gaali P. School	Monze	1025	92
Simausi	"	1300	109
Katiba Maize Depot	"	800	81
Hatontola P. School	"	800	80
Hachiiko		210	28
Mukampeka	Mwanza	300	30
Hachizangwe	Chona	250	48
Simwaalu	Choongo	310	35
Banakaila P. School	"	500	51
Keleete Branch	Monze	1150	98

APPENDIX 7. COUNTRY DATA

I. Basic Indices

1) Name:

The Republic of Zambia

Capital: Lusaka (population 690 thousand/ 1980)

Independence on 24 October 1964

2) Land, Population

Area: 750 thousand km² (about 2 times bigger than Japan)

Population: 5.68 million (1980)

Population Density: 7.5 capita/km²

Population Growth Rate: 3.1% (1980)

Urban Population Ratio: 43% (1980)

Life Expectancy: 41.8 years (Male)

45.0 years (Female) (1979-1984)

3) Political System

One Party Republic by United National Independence Party:

Socialism Head of the State:

President Kenneth Kaunda (since Independence)

4) Religion

Christianims (14%), Animisum, etc.

5) Language

Official Language is English.

More than 70 tribal languages.

6) Tribe

Multi-tribal State

7) Education

Adult Literacy Rate: 61% (Male) (1980)
35% (Female) (1980)

Rate of Primary School

Attendance: 84% (1980)

(Country Profile 1984)

8) Currency, Exchange Rate

Currency Unit: Kwacha (K)

Exchange Rate of Kwacha against US Dollar (World Bank)

1980	K 1.00	=	US\$1.27
1981	K 1.00	=	US\$1.14
1982	K 1.00	=	US\$1.07
1983	K 1.00	=	US\$0.81
1984, Jan.	K 1.00	=	US\$0.63

9) Climate, Geography, Latitude

Climate Nov.-April : Hot Rainy Season
 May - August : Cool Dry Season
 Sept.-December : Hot Dry Season

Average Temperature: 16-24°C at Lusaka

Average Yearly Rainfall: 830 mm at Lusaka (90% in Rainy Season)

Most of the country lies on the plateau whose altitude ranges between 1,000 and 1,300 meters from sea level. The peripheral zone consists of low-lying plain along Lake Tanganika and the river Zambezi.

Zambia is situated between Latitude 8°S and 18°S, and Longitude between 22 E and 34 E.

10) Public Health (1981)

No. of Hospitals : 81
No. of Clinics : 758
No. of Beds : 3.6 (per 1,000 persons)
No. of Medical Doctors: 821
No. of Medical Doctors: 14 (per 100,000 persons)
(Country Profile 1984)

11) Service Ratio of Water Supply

LUA (10) : 70%
SAT (75) : 45%
Rural Area : 32% (sources near the house)
(DECADE Report 1983)

12) Infrastructure (1981)

Service ratio of Telephone: 104 (per 10,000 persons)
" " " Post Office: 17 (per 1,000 ")
" " " Vehicles: 211 (per 10,000 ")
Power generated: 9,793 million KW
(Country Profile 1984)

13) Employment (1982)

Total Labour Force: 1,880 thousand
Normal Employment Rate: 20% (against Total Labour Force)
Employment Rate (Agriculture): 9.6% (-do-)
-do- (Mining): 16.2% (-do-)
-do- (Manufacture): 13.2% (-do-)
-do- (Service); 29.0% (-do-)

II. Socio-Economic Indices

1) Gross Domestic Production (GDP)

Year	Nominal GDP	Real Growth Rate	Nominal Per Capita GDP	
	(Mil. K)	%	K	US\$*
1978	2,240	2.6	418	514
1979	2,647	-7.7	479	604
1980	3,013	3.5	530	673
1981	3,449	4.7	588	670
1982	3,564	-2.0	589	630

(Country Profile 1984)

* --- Exchange Rate as of 1984.

2) Gross National Production (GNP)

GNP per capita 640 dollar (1982)
(World Bank)

3) Industrial Structure

GDP according to the Sector-Wise Contribution

(1970 Price, mil. K)

<u>Sector</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>
Agriculture (%)	166.4 (11.7)	180.0 (12.1)	159.0 (10.9)	172.3 (11.7)
Mining (%)	398.7 (28.1)	433.3 (29.2)	433.4 (29.8)	469.6 (31.8)
Manufacturing (%)	326.8 (23.1)	332.1 (22.4)	334.5 (23.0)	327.7 (22.2)
Service (%)	525.9 (37.1)	538.6 (36.3)	526.8 (36.3)	506.9 (34.3)
Total Growth Rate (%)	<u>1,417.8</u> 3.5	<u>1,484.0</u> 4.7	<u>1,453.7</u> -2.0	<u>1,476.5</u> 1.5

(Country Profile 1984)

4) Major Export Items (1981)

	<u>First (%)</u>	<u>Second</u>	<u>Third</u>
Export	Copper (84)	Cobalt (4)	Zinc (2)
Import	Machinery (34)	Manufac- tured goods (22)	Electricity, oil (22)

(OECD 1985)

5) Working Population and Employment Rate

Sector-Wise Employment Structure (thousand)

<u>Sector</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	
						<u>%</u>
Agriculture, Forestry	32	32	33	36	35	9.5
Mining	61	62	63	61	60	16.3
Manufacturing	46	45	48	48	48	13.0
Energy	7	8	8	8	8	2.2
Construction	45	42	44	37	33	9.0
Service	177	186	184	184	184	50.0
Total	<u>368</u>	<u>375</u>	<u>380</u>	<u>374</u>	<u>368</u>	<u>100</u>
Total Labour Force	1,641	1,698	1,761	1,824	1,880	
Employment Rate (%)	22	22	22	21	20	

(from Country Profile 1984)

6) Trend of Consumers' Price (500 items)

	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>
Price Index (1975=100)	163.9	180.1	201.2	228.5	257.2
Yearly Growth Rate (%)	15.8	9.9	11.7	13.6	12.6

(Country Profile 1984)

7) Balance of Payments

(Mil. US\$)

	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>
Trade Balance	213	653	330	-19	-46
- Export	869	1,376	1,245	1,063	1,059
- Import (FOB)	628	750	1,101	1,047	831
Current Balance	-320	23	-713	-776	-635
Grand Balance	-354	99	-189	-487	-271

(OECD 1985)

8) Foreign Currency Reserves External Debt

(Mil. US\$)

	<u>1981</u>	<u>1982</u>	<u>1983</u>
Foreign Currency Reserves	56	58	55
External Debt Balance	2,274	2,381	-
Repayment Ratio of Official External Debt (%)	23.2	17.4	-

(OECD 1985)

9) Trade with Japan

(Mil. US\$)

	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>
Import from Japan	40.53	54.73	51.70	51.41	27.60
Export to Japan	264.15	197.16	273.10	227.16	166.87

(OECD 1985)

Trade Value of Major Commodities (1983) (Mil. US\$)

Import from Japan -- Machinery	18.23;	Textile	1.87
		Non ferrous Base	
Export to Japan -- Copper, Copper		Metals	4.11
Products	161.08;		

10) Balance of Public Finance

Balance of National Government Finance & Trade

(Unit: Mil. K)

	<u>1982</u>	<u>1983</u>	<u>1984</u>
Balance of Public Finance	-525	-129	-57
Trade Balance	- 52	252	445
Official Debt:			
Internal	517	593	648
External	1,846	2,644	2,664

(Economic Report 1984)

11) Foreign Aid

ODA to Zambia

(Mil. US\$)

	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>
Bilateral Aid (Biggest donor country)	233.8 (U.K)	178.5 (U.K)	188.5 (W. Germany)	200.0
Multilateral Aid (Biggest donor organization)	58.9 (IMF)	42.6 (EEC)	50.9 (EEC)	50.9 (EEC)
ODA Total	292.7	221.1	239.4	250.9

(Economic Report 1984)

Japanese Economic Cooperation

(Mil. US\$)

	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>
ODA Bilateral				
Grant	1.38	4.15	10.18	11.37
Loan	11.70	9.64	13.56	7.74
Total	13.08	13.79	23.74	19.11
Other Govern- ment, Private	7.69	80.72	17.99	-8.75
Grand Total	20.77	94.51	41.73	10.36

(OECD 1985)

III. Development Indices

1) National Development Plan

First National Development Plan

Second National Development Plan (1972-1977)

Third National Development Plan (1979-1983)

Fourth National Development Plan is in the making.

(a) Major Targets and Priority Policies

- (i) To rectify the economic structure heavily dependent on Copper, and to promote the development of Agriculture and Industry.
- (ii) First priority to the rural development.
- (iii) Fill the gap of income between urban and rural work forces.
- (iv) To promote the development of the socio-economic potential of rural areas.
- (v) To increase the employment, so, to pay attention to the labour intensive industry.

2) Target

	<u>Actual</u> <u>Base Year (1978)</u>	<u>Target</u> <u>1983</u>	<u>Actual</u> <u>1982</u>
Total GDP (Mil. K)	2,030	2,565	3,564
Per Capita GDP (K)	371	399	589
Agriculture, Forestry and Fishery (Mil. K)	260	340	390
Mining and Industry (Mil. K)	695	874	1,062

(OECD 1985)

APPENDIX 8. BREAKDOWN OF PROJECT COST

1) Working Days Required for Construction Work

a) Borehole

i) Drilling and construction of boreholes (50 m/borehole on average)

Hard rock (air hammer)	5.0 days
Unsolidified strata	7.0 "

ii) Number of boreholes to be drilled

Total: $102 \times 1.1 \div 112$ (including 10% dry wells)

Hard rock $112 \times 80\% = 90$

Unsolidified strata $112 \times 20\% = 22$

iii) Days required for drilling

1) Total days required

Hard rock	$90 \times 5.0 = 450$ days
Unsolidified strata	$22 \times 7.0 = 154$ "
Total	<u>604 days</u>

$604 \text{ days} / 2 \text{ machines} = 302 \text{ days}$

$302 \text{ days} / 218 \text{ days (working days per year)} \div 1.39 \text{ years} \div$
17 months

2) Days required for drilling 43 boreholes

Hard rock	$35 \times 5.0 = 175$ days
Unsolidified strata	$8 \times 7.0 = 56$ "
Total	<u>231 days</u>

$231 \text{ days} / 2 \text{ machines} = 115.5 \text{ days}$

2) List of Unit Labour Cost in Zambia (1986 Forecast)

(Unit: K)

<u>Job Type and Category</u>	<u>Monthly Salary</u>	<u>Job Type and Category</u>	<u>Monthly Salary</u>
- Project Manager	800.00	Driller Assistant	209.10
- Site Manager	520.00	Mechanic	300.00
- Geology.Groundwater Engineer(A)	500.00	Plumber	246.42
- -do- (B)	300.00	Driver	219.31
- Accountant	277.09	Watchman	211.11
- Inventory Recorder	251.00	Labourer	177.06
- Typist	237.40		
- Driller	298.16		

(Drilling Section, DWA and Official Gazette)

3) Price List of Materials to be Procured in Zambia

(Unit: K)

<u>Item</u>	<u>Specifications</u>	<u>Unit</u>	<u>Price</u>
Gasoline	Regular at pump station	liter	1.34
Light Oil	At pump station	"	0.94
Lubrication Oil	Engine Oil	"	6.00
Grease		kg	4.00
Oxygen	7 m ³ /cylinder	piece	27.50
Acetylene	7 kg/cylinder	"	123.80
Crushed stone	ø20 mm	ton	19.00
Sand	ton		24.50
Gravel	Without screening	ton	25.00
Wood	For frame	m ³	695.50
Steel bar	ø9 mm	kg	0.85
Cement	Ordinary portland	bag	6.85

(Ex-factory market price)

4) Volume of consumption of fuel, grease, etc. (borne by the Government of Zambia)

Number of boreholes: $102 \times 1.1 = 43 \div 69$

i) Light oil

a) Drilling rig (air hammer)	15.5h/b	x 55b	x 211/h	= 17,900 litres
b) -do- (rotary)	21.5	x 14	x 60	= 6,320
c) Compressor (air hammer)	14.2	x 55	x 60	= 48,860
d) -do- (rotary)	8.0	x 14	x 60	= 6,720
e) Engine welder	2.0	x 69	x 3	= 414
f) Generator	6.0	x 59	x 4	= 1,416
g) Truck (rig mounted)	50 km/b	x 69b	x 1 unit/3.5km/1=	990
h) Cargo truck	400	x 69	x 1 /4.0	= 6,900
i) Pick up	500	x 69	x 2 /5.0	=13,800
j) Wagon	500	x 69	x 2 /5.0	=13,800
Total				<u>115,120 litres</u>

ii) Oil	115,120 litres	x 5%	= 5,756 litres
iii) Grease	115,120	x 1%	= 1,151 kg
iv) Oxygen	69b	x 0.3 piece	= 21 pieces
v) Acetylene	69b	x 0.3 "	= 21 pieces

5) Estimated volume of consumption of materials for construction of tubewells and water supply facilities (borne by the Government of Zambia)

i) Gravel

a) Number of wells, drilling diameter, volume of fill
Hard rock 47 wells, $\phi 152$ mm, $0.410 \text{ m}^3/\text{well}$
Unsolidified strata 12 " 216 mm, 1.224

b) Total volume of gravel required

$$(0.410 \times 47) + (1.224 \times 12) \div 34 \text{ m}^3$$
$$34.0 \times 1.3 \text{ (work loss 30\%)} / 0.5 \text{ (sieve loss 50\%)} \div 88 \text{ m}^3$$

ii) Material for concrete slab foundation

a) Cement : $320 \text{ kg/m}^3 \times 1.1 \text{ m}^3/\text{b} \times 59 \text{ b} = 20,768 \text{ kg}$
b) Sand : 640 x 1.1 x 59 = 41.6 ton
c) Gravel: 1180 x 1.1 x 59 = 83.1 ton
d) Steel bar: 14 kg/b x 59 b = 826 kg

iii) Cement for grouting

Mixing rate c:w = 1:0.5

Volume of cement per borehole 378 kg \div 8 bags

Total cement required 8 bag/b x 59b = 472 bags

6) Detailed Calculation of Project Cost

i) Rate of price escalation

<u>Item</u>	<u>Yearly Escalation Rate</u> (*1)	<u>Accumulated Escalation Rate up to 2 years and a month</u> (*2)
Fuel	40.9 %	85.1 %
Other materials	24.2 %	50.3 %

(*1) -- President Office economic report and others.

(*2) -- Period from the time of cost estimation (April 1985) to the middle term of construction period (May 1987)

ii) List of computation

a) Personnel expenses for construction work of 102 boreholes (borne by the Government of Zambia)

	<u>Number</u>		<u>K/day</u>		<u>month</u>		
Project Manager	1	x	800	x	17	=	13,600 K
Site Manager	1	x	520	x	17	=	8,840
Geology - Groundwater							
Engineer (A)	1	x	500	x	17	=	8,500
-do- Engineer (B)	1	x	300	x	17	=	5,100
Accountants	1	x	277	x	17	=	4,709
Inventory Clerk	1	x	251	x	17	=	4,267
Typist	1	x	237	x	17	=	4,029
Driller	2	x	298	x	17	=	10,132
-do- assistant	2	x	209	x	17	=	7,106
Mechanic	2	x	300	x	17	=	10,200
Plumber	3	x	246	x	17	=	12,546
Driver	13	x	219	x	17	=	48,399
Watchman	6	x	211	x	17	=	21,522
Labourer	24	x	177	x	17	=	72,216
Total	59						231,166 Kwacha

b) Personnel expenses for construction of 43 boreholes:

231,166 x 7 months/17 months = 95,186 Kwacha

c) Fuel and material cost (borne by the Government of Zambia)

Light oil	115,120 ltr	x 0.94	x 1.851	=	200,302
Lubricant	5,756 l	x 6.00	x 1.851	=	63,926
Grease	1,151 kg	x 4.00	x 1.851	=	8,522
Oxygen	21 pc	x 27.50	x 1.851	=	1,069
Acetylene gas	21 pc	x 123.80	x 1.851	=	4,812
Washed gravel	88 m ³ x 2t/m ³	x 25.00	x 1.503	=	6,613
Crushed stone	83.1	x 19.00	x 1.503	=	2,248
Sand	41.6	x 24.50	x 1.503	=	1,532
Cement	888 bag	x 6.85	x 1.503	=	9,142
Steel bar	826 kg	x 0.85	x 1.503	=	1,055
<u>Total</u>					<u>299,221 Kwacha</u>

d) Cost of management and maintenance (for 10 years)

1) Personnel expenses

	Person		K/month		month		
Plumber:	2	x	246	x	37.4	=	18,400
Driver :	1	x	219	x	37.4	=	8,191
Labourer:	1	x	177	x	37.4	=	13,240
<u>Total</u>							<u>39,831 Kwacha</u>

ii) Expenses of fuel and maintenance of vehicles

Light oil: $200 \text{ km/pace} \times 680 \text{ times/5km/1} \times 0.94 \text{ k/1} \times 1.851 = 47,326$

Lubricant: $1,360 \text{ l} \times 6.00 \text{ k/1} \times 1.851 = 15,104$

Grease: $272 \text{ kb} \times 4.00 \times 1.851 = 2,014$

Maintenance $6.5\% \times 3.12 \text{ year} \times 15,000 \times 1.503 = 4,572$

of vehicles:

Total

69,016K

iii) Expenses for spare parts

Hand pump spare parts: $7,427 \text{ K/year/102 well} \times 8 \text{ year} \times 1.503 = 89,302 \text{ K}$

$39,831 + 69,016 + 89,302 = 198,149$

TOTAL COST OF MANAGEMENT AND MAINTENANCE: 198,149 Kwacha/10 years

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