JAPAN INTERNATIONAL COOPERATION AGENCY
FOOD, AGRICULTURE, LIVE STOCK AND COOPERATIVE DEPARTMENT
THE GOVERNMENT OF N.W.F.P.
ISLAMIC REPUBLIC OF PAKISTAN

# BASIC DESIGN STUDY REPORT

# ON

# THE PROJECT FOR GROUND WATER DEVELOPMENT AT N.W.F.P.

# IN

# ISLAMIC REPUBLIC OF PAKISTAN

MARCH, 1995



PACIFIC CONSULTANTS INTERNATIONAL (PCI)



JICA
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MARCH

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# PREFACE

In response to a request from the Government of Islamic Republic of Pakistan, the Government of Japan decided to conduct a basic design study on the Groundwater development at N.W.F.P. and entrusted the study to the Japan International Cooperation Agency (JICA).

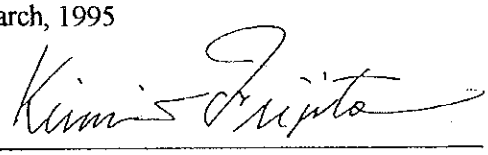
JICA sent to Pakistan a study team headed by Hiroyuki Kinomoto, First Basic Design Study Division, Grant Aid Study and Design Department, JICA and constituted by members of Pacific Consultants International from January 20th to February 2nd, 1995.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of Pakistan for their close cooperation extended to the study team.

March, 1995



Kimio Fujita

President

Japan International Cooperation Agency

March 28th, 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on Groundwater development at NWFP in Pakistan.

This study was conducted by Pacific Consultants International, under a contract to JICA, during the period January 13th to March 28th, 1995. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Pakistan and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

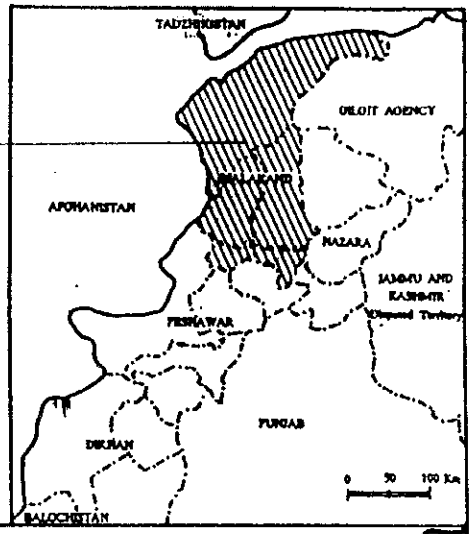
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA and the Ministry of Foreign Affairs. We would also like to express our gratitude to the officials concerned of the Directorate of Agricultural Engineering, Department of Agriculture, and other departments at N.W.F.P., JICA Pakistan Office and the Embassy of Japan in Pakistan for their cooperation and assistance throughout our field survey.

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

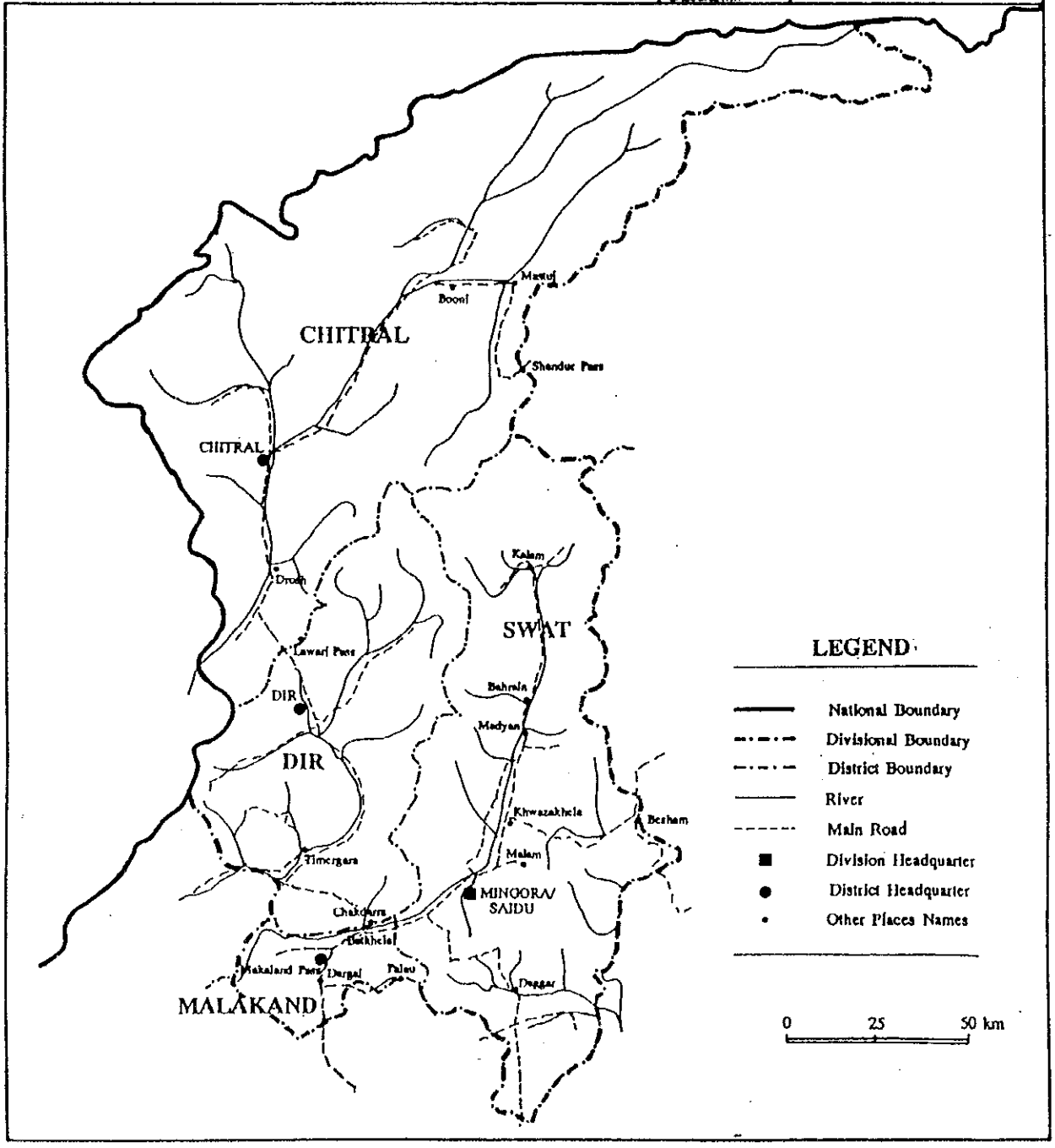
Very truly yours.

Masayuki Honjo,
Project manager
Basic design study team on
Groundwater Development Project at N.W.F.P. in Pakistan,
Pacific Consultants International

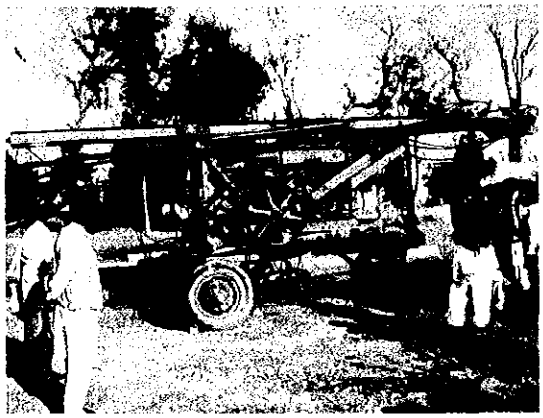
The Project Area


# Location Map



① Irrigation from Existing Tubewell (Dir District)



② Percussion Rig Out of Order
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③ Works in Workshop (Tarnab)

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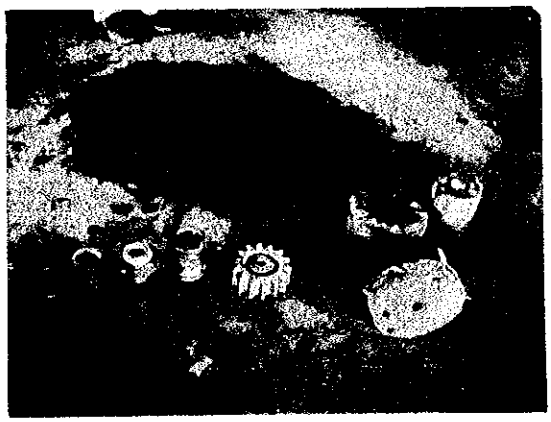
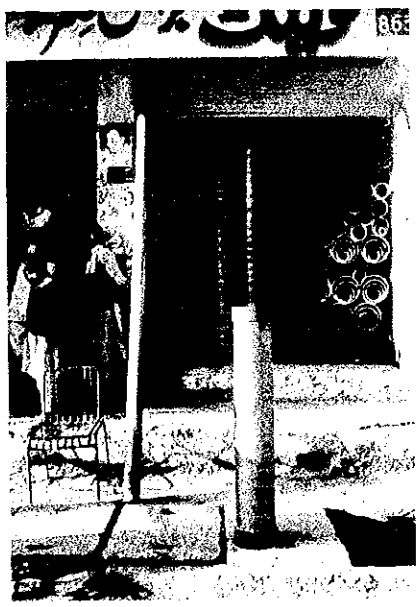


⑤ Works in Workshop (Tarnab)



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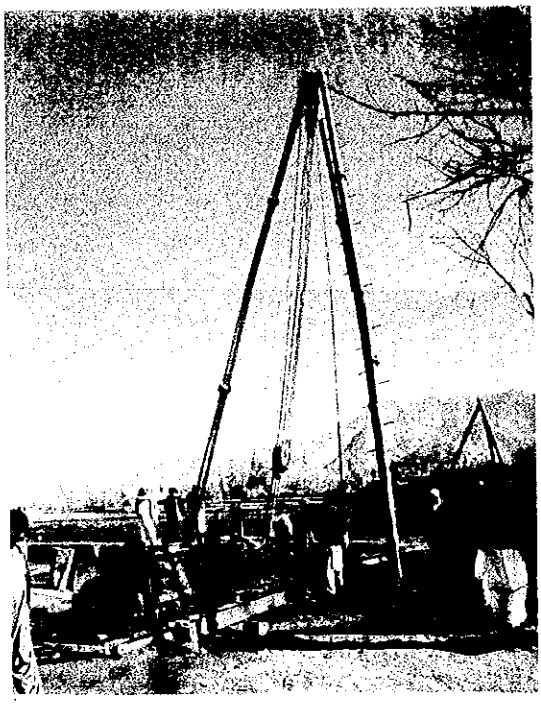
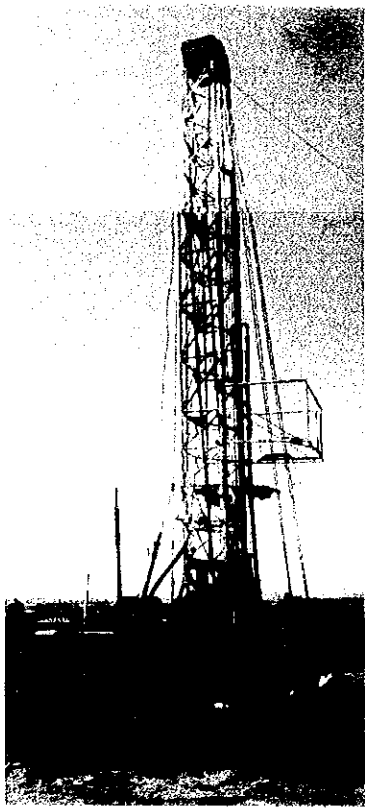
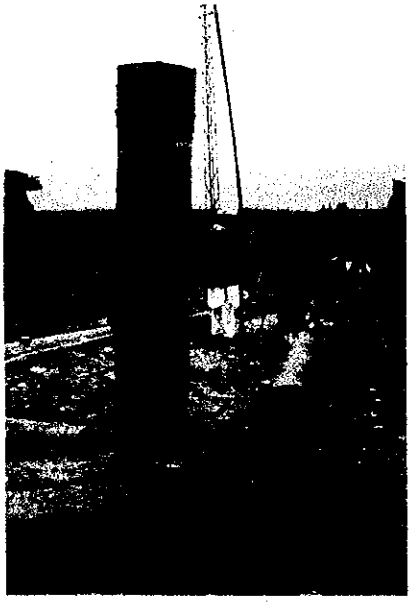
(Malakand Agency)



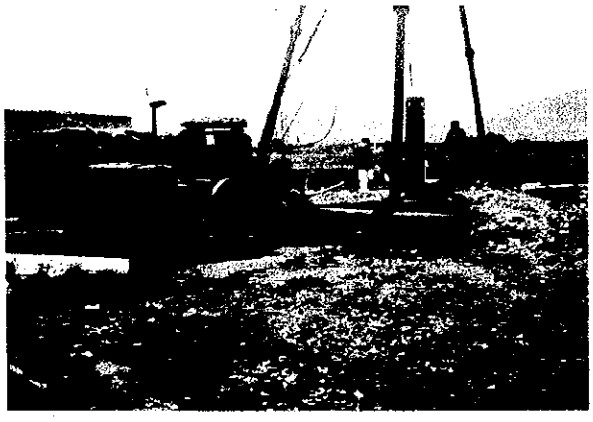
⑦ Drilling Works by Hand Plant (Dir District)





⑨ Drive Casing Insertion

⑧ Drilling Works by Rotary Rig Procured under Japanese Grant



⑩ Hand Plant Drilling Equipment

# SUMMARY

## SUMMARY

Pakistan lies in the northwestern part of the Southwest Asian Subcontinent, and is bordered by Afghanistan in the north and northwest, Iran in the west, the Arabian sea in the south and India in the east and southeast. There is a common border with the People's Republic of China in the north and northeast along Gilgit Agency and Jammu & Kashimir State (Disputed Area) respectively. The total area of Pakistan is 796,000 km2 with a north-south length of about 1,600 km and a maximum east-west width of about 1,000 km. The total estimated population (1993) was 125.213 million with an estimated annual growth rate of 3.1%.

There has been a considerable economic growth of 5.1% in the last 5 years by the contribution of the manufacturing sector. However, since the economical structure depends mainly on the agricultural sector which varies in accordance with international market prices and weather; the economic growth rate is very sensitive. The Agricultural sector is the largest of the economy of Pakistan accounting for 24% of the Gross Domestic Product (GDP), employing about 47.5% of the labor force.

As a part of its policy, the Government has developed its economy in accordance with the eighth consecutive Five Year National Development Plan since 1955. At present, the government has established the eighth National Development Plan (1993/94 - 1997/98) which has been planned for 15 consecutive years with the policy of upgrading social and economic welfare through the promotion of the economic sector and control of birth rate. The emphasis of the Eighth Five Year Plan is laid on utilizing the agricultural sector as a main instrument of growth and development. The primary sector's goal is the achievement of a growth rate higher than population growth, in order to ensure food security, self sufficiency and a large exportable surplus. High priority will be given to productivity optimization through the efficient use of the available land and water resources and other inputs, while conserving the resources. The main priorities are to develop agricultural and irrigation facilities in an integrated manner, to manage them in a coordinated way, and to improve land and water management practices.

Although agriculture is the main sector of NWFP where the project area is located, irrigation facilities are not fully developed yet. There is a lot of land where the introduction of irrigation

water is difficult due to its topography therefore the wish for the installation of tubewells is increasing. Under these circumstances, the Directorate of Agricultural Engineering (DAE), Food, Agriculture, Live Stock & Cooperative Department, NWFP, which is the executing agency of the Project, has planned the installation of 1,000 tubewells in NWFP, in accordance with the Five Year National Plan. However, the drilling capacity of the Directorate of Agricultural Engineering is not sufficient to achieve this goal due to the deterioration of the drilling machinery, which was procured 20 or 30 years ago, except for the drilling machinery procured in 1984 by the Japanese Government Grant Aid Assistance.

The Government of NWFP through the DAE planned to procure drilling machinery in order to achieve the Five Year Plan goals. However, the budget for the procurement of this machinery is not prepared yet.

The Project area, Malakand Division of North West Frontier Province (N.W.F.P.), is composed of 5 districts, namely, Malakand Agency, Chitral District, Dir District, Swat District, and Bunier District, and constitutes a typical agricultural area. Although the main agricultural products are wheat and maize, recently vegetable and orchard cultivation of apples are increasing. At the orchard and vegetable cultivation areas, willingness to install tubewells is high. This is in order to introduce an intensive farming practice through irrigated agriculture. Otherwise, the irrigation needs in this area would not be covered sufficiently. Most of the cultures depend on rainfed water.

Under these conditions, in July 1991, the Government of Pakistan made a request to the Government of Japan for grant aid assistance for the procurement of the Percussion Rigs and spare parts. In response to this request the Ministry of Foreign Affairs of the Government of Japan deemed the Project's objectives roughly appropriate for the Japanese grant aid and decided to carry out a study to examine the feasibility of the Project under this system.

Under these circumstances, Japan International Cooperation Agency (JICA), the governmental organization in charge of technical and financial cooperation to developing countries, carried out a Basic Design Study through a Study Team, headed by Hiroyuki Kinomoton of the First Basic

Design Study Division, Grant Aid Study and Design Department, JICA, and dispatched from January 20 to February 2, 1995.

The study team confirmed the rationality and necessity of the project and the NWFP Government understood the conditions of the Japanese grant aid system. The results of the site investigation by the study team also confirmed the contribution of the drilling rig and the associated equipment procured in 1984 through the Japanese grant aid assistance for the groundwater development. Furthermore, the study team observed that the DAE has to manufacture the spare parts for the existing drilling rig due to difficulties in procurement.

After the study team returned back to Japan, further studies were made on the requested Project based on the field survey, and the basic design study report was prepared. The report confirms the viability of the Project and the selection of equipment and machinery for the Project.

The Project aims to promote the irrigation project at Malakand Division through the installation of 25 tubewells annually.

| Item | | Unit | Requested | Procured |
|---|---|---|---|---|
| I. | Percussion Drill Rigs and Tools | | | |
| 1. | Cable-tool percussion rigs mounted Truck | Unit | 5 | 5 |
| 2. | Standard operational accessories | Set | 5 | 5 |
| 3. | Drilling tools | Pcs | 5 | 5 |
| 4. | Fishing tools | Set | 5 | 5 |
| 5. | Casing tools | Set | 5 | 5 |
| 6. | Miscellaneous ancillary equipment | Set | 5 | 5 |
| II. | Supporting Vehicles | | | |
| 1. | Cargo Truck | Unit | 5 | 3 |
| 2. | Water Tank Truck | Unit | 5 | 3 |
| 3. | Double-cab Pickup Truck | Unit | 3 | 5 |
| III. | Pumping Equipment | Set | 2 | 2 |
| IV. | Well Logging Equipment | Set | 2 | 1 |
| V. | Consumable Materials | Set | - | 1 |
| VI. | Spare Parts | Set | 1 | 1 |

The project will be implemented by the DAE, NWFP. The DAE will be responsible for the recruitment of additional staff for the operation and maintenance of the equipment to be

procured under this project. DAE is also responsible for the maintenance of existing equipment and the new equipment to be procured under this Project.

The project will be carried out with 3 months of detailed design and preparation of tender document and tendering, 8.5 months for the preparation , manufacturing, transportation and installation, totaling 11.5 months.

After the implementation of this Project, the drilling capacity of DAE will be improved and the Five Years Drilling Plan goal will be attained, drilling 25 tubewells annually by means of the drilling machinery to be provided. Through the introduction of irrigation water, the cultivation of cash crops such as vegetable and orchard will be carried out, at the benefiting areas. Consequently, a large number of small size farmers will be benefited.

In view of the points outlined above, it is deemed appropriate and extremely worthwhile to carry out the Project with the grant aid cooperation from the government of Japan.

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# ABBREVIATIONS

## 1) Organization

| | |
|---|---|
| ADBP | Agricultural Development Bank of Pakistan |
| EAD | Economic Affairs Division, Government of Pakistan |
| DAE | Directorate of Agricultural Engineering, Department of Agriculture Government of N.W.F.P. |
| FAO | Food and Agriculture Organization of the United Nations |
| FATA | Federally Administration Tribal Area |
| HD | Health Department, NWFP |
| ID | Irrigation Department, NWFP |
| JICA | Japan International Cooperation Agency |
| NWFP | North West Frontier Province |
| PATA | Provincial Administration Tribal Area |
| PE&D | Planning Environment and Development Department, NWFP |
| WAPDA | Water and Power Development Authority, Peshawar |

## 2) Others

| | |
|---|---|
| Barani | Rainfed Farming Area |
| GDP | Gross Domestic Product |
| GNP | Gross National Product |
| Kharif | Summer Season |
| Rabi | Winter Season |

3） Unit of Measurement

| | |
|---|---|
| mm | millimeter |
| cm | centimeter |
| m | meter |
| km | kilometer |
| $m^2$ | square meter |
| $km^2$ | square kilometer |
| $m^3$ | cubic meter |
| MCM | million cubic meter |
| Cusec | cubic feet per second |
| ppm | part per million |
| pH | potential of hydrogen |
| Ec | electric conductivity |
| g | gram |
| kg | kilogram |
| t | metric ton |
| El | elevation above mean sea level |
| m | minute |
| ha | hectare |
| hr. | hour |
| ℃ | degree centigrade |
| HP | horse power |
| O & M | operation and maintenance |
| Rs | Rupees (currency of Pakistan) |
| US$ | US Dollar |

4） Conversion Factors

| Unit | Comparison | English Equivalent |
|---|---|---|
| Unit of Length: | | |
| Millimeter (mm) | 0.001 meter | 0.0394 inch |
| Centimeter (cm) | 0.01 meter | 0.3937 inch |
| Meter (m) | 3.2800 feet | |
| Kilometer (km) | 1,000 meters | 0.6213 mile |
| Unit of Area: | | |
| Square centimeter (sq.cm) | 0.0001 sq.m | 0.155 square inch |
| Square meter (sq.m) | 10.764 square feet | |
| Hectare (ha) | 10,000sq.m | 2.471 acres |
| Square kilometer ($sq_o$ km) | 1,000,000 sq.m | 0.386 square mile |
| Unit of Volume: | | |
| Cubic centimeter (cu.cm) | 0.061 cubic inch | |
| Liter (lit) | 0.001 cu.m | 1.0567 quarts (liquid) |
| Cubic meter (cu.m) | 1,000 liters | 35.3145 cubic feet |
| | 0.811 x $10^{-3}$ acre feet | |
| Unit of Weight: | | |
| Gram (g) | 0.0353 ounce | |
| Kilogram (kg) | 1,000 grams | 2.2046 pounds |
| Metric Ton (t) | 1,000 kg | 2,204.6 pounds |
| Unit of Flow: | | |
| Liter per second (lit/sec) | 0.0353 cusecs | |
| Cubic meter per second (cu.m/sec) | 35.310 cusecs | |

# CHAPTER 1 BACKGROUND OF THE PROJECT

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## 1.1 Background of the Project

The agricultural sector is the largest sector of the economy of Pakistan accounting for 24% of the Gross Domestic Product (GDP), employing about 47.5% of the labor force. The government has developed its economy in accordance with the consecutive Five Year National Development Plan, and the Provincial government has developed a provincial program, in accordance with the National Plan. At present, the eighth Five Year Plan (1993 - 1998) lays emphasis on the agricultural sector, specially, on the improvement of social infrastructure in the rural area and diversification of rural development. Fundamentally, the rural development aims not only at raising farm productivity by means of agricultural development, but also raising the living standard as well as the employment opportunities in the rural area through the stabilization of rural society and economy. The executing agency of this project, Directorate of Agricultural Engineering, Food, Agriculture, Live Stock & Cooperative Department, N.W.F.P., has planned the installation of 1,000 tubewells in N.W.F.P. in accordance with the Five Year National Plan.

The Project area, Malakand Division of North West Frontier Province (N.W.F.P.), comprises 5 districts; Malakand Agency, Chitral District, Dir District, Swat District, and Bunier District, and constitutes a typical agricultural area. The main agricultural products were mainly wheat and maize, however, recently vegetable and orchard cultivation of apples are also increasing. At the orchard and vegetable cultivation areas, willingness to install tubewells is high. This is in order to introduce a farming practice. Otherwise, the irrigation needs in this area would not be covered sufficiently. Most of the agricultural farming depends on rainfall water. The executing agencies of the construction of irrigation facilities is the Directorate of Agricultural Engineering and Irrigation Department. The Directorate of Agricultural Engineering is carrying out the construction of tubewells and land consolidation on a request basis. At present, some requests are being implemented. However, a lot of requests are still pending.

The Directorate of Agricultural Engineering plans to install 1,000 tubewells in N.W.F.P. during the period of the Eighth Five Year Plan on a request basis. However, the drilling capacity of the Directorate of Agricultural Engineering is not sufficient to achieve this goal, due to the deterioration of the drilling machinery, which was procured 20 or 30 years ago, except for the drilling machinery procured in 1984 by the Japanese Government Grant Aid Assistance. Under these conditions, in July 1991, the Government of Pakistan made a request to the Government of Japan for grant aid assistance for the procurement of the Percussion Rigs and spare parts. In response to the request the Ministry of Foreign Affairs of the Government of Japan deemed the Project's objectives roughly appropriate for the Japanese grant aid and decided to carry out a study to examine the feasibility of the Project under this system.

## 1.2 Outline of the Request

The Directorate of Agricultural Engineering has formulated the Eighth FiveYear 1,000 tubewells installation plan, preparing the necessary budget for subsidies and so forth. At the project area, the DAE has planned to install 266 tubewells during the Eighth Five Year Plan. In compliance with this plan, the DAE made a request for the following equipment under the Japan grant aid assistance.

- Percussion Rig : 5 units
- Spare parts : 1 unit

Furthermore, the following equipments were requested during the field survey period.

- Crane Truck : 5 units
- Water Tank Truck : 5 units
- Pickup Truck : 3 units
- Equipment for Pumping test : 2 units
- Survey Equipment (Well logging equipment)

# CHAPTER 2 OUTLINE OF THE PROJECT

# CHAPTER 2 OUTLINE OF THE PROJECT

## 2-1 Objectives of the Project

### (1) Objectives of the Project

The target area, Malakand Division, has only underdeveloped irrigation schemes, although agriculture is the main activity of the area. Specially, in Swat and Bunir districts, the irrigated area is small compared with other districts. In those areas, intensive agricultural farming is increasing and the demand for the installation of tubewells is increasing accordingly. At present, the Government of NWFP is installing tubewells, using the drilling machinery of the government. However, these drilling machines are seriously deteriorated which makes the installation of the target number of tubewells quite impossible. This project aims at the promotion of tubewells installation through the provision of percussion rigs, at the Malakand Division where the irrigation facilities are not sufficient.

### (2) Project Area

Project site is the farming area of the Malakand Division which is composed of the following districts;

- Swat District
- Malakand Agency
- Bunir District
- Dir District
- Chitral District

Priority areas indicated by the DAE are as follows;

Priority Area

| District | Teshil/Subteshil | Location |
|---|---|---|
| Malakand Agency | Sam, Rarizai<br>(Heroshah/Dargai/Palain/Sher Khana) | . Dargai Area |
| Swat District | Matla/Kabal/Barikot | . Nikpilhe Area |
| Bunir District | Daggar<br>Chamla/Amanzai | . Daggar Valley<br>. Chamla Valley<br>Chingalai Basinf |
| Dir District | Khudukhel<br>Timergara | Totali Valley<br>Adinzai Valley |
| Chitral District | Jandool<br>Chitral | Jandool Area<br>Chitral Area |

In these areas, groundwater development potential is high. From the hydrogeological point of view, the development of areas with high groundwater potential is feasible. Taking the irrigation condition into account, it is reasonable to give priority to Swat and Bunir districts where non-irrigated areas prevail.

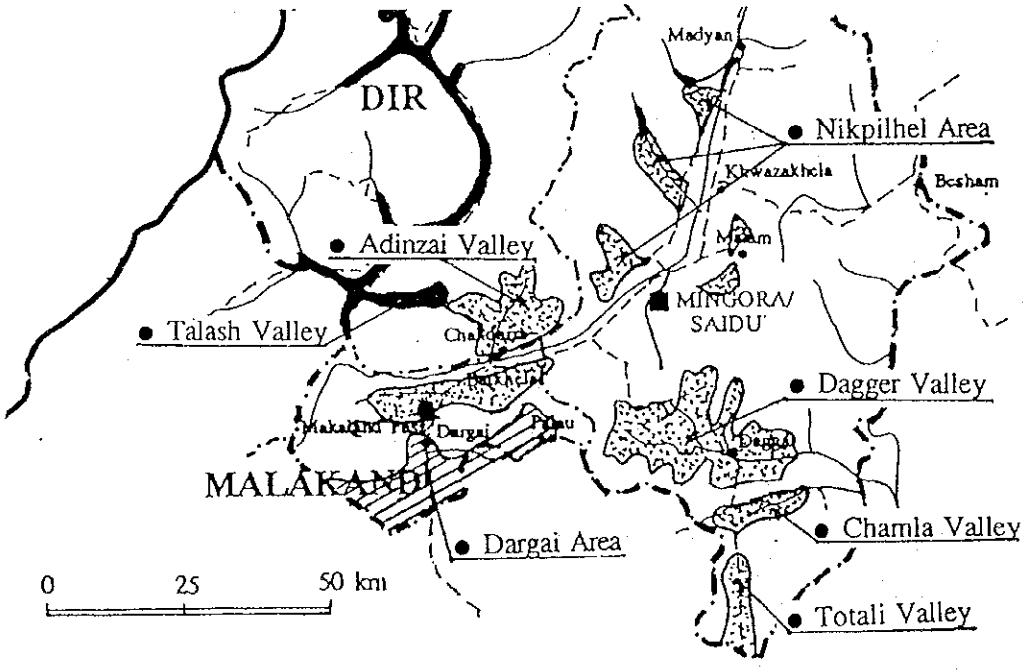



Fig.2.2.1 High Priority Area for the Groundwater Development

## 2-2 Examination of the Request

### (1) Contents of the Request

Contents of the request of this project consist of the Grant aid assistance for the procurement of 5 percussion rigs and spare parts. The Project area is the Malakand Division of the NWFP and its objective is to promote irrigation facilities with the installation of tubewells through the procurement of necessary equipment. This program forms part of the Eighth Five Year 1,000 Tubewells Installation Plan. At the Project site (Malakand Division), 266 tubewells will be installed during this period. With the percussion rigs to be procured under the Japanese grant aid program, 25 tubewells will be constructed annually. The equipment and machinery finally requested by the Government of NWFP are as follows;

| | | | |
|---|---|---|---|
| 1. | Percussion Drilling Equipment (Cable tool percussion type drilling machine, driven by water-cooled diesel engine, mounted on 4 x 4, diesel engine truck) | : | 5 units |
| 2. | Cab-back Crane Truck | : | 5 units |
| 3. | Water Tank Truck | : | 5 units |
| 4. | Double Cab Pick-up Truck | : | 3 units |
| 5. | Pumping Test Equipment | : | 2 sets |
| 6. | Well Logging Equipment | : | 2 sets |
| 7. | Spare Parts | : | 1 unit |

### (2) Contents of Five Year (1993 - 98) Plan

The Eighth Five Year 1,000 tubewells installation Plan is the base program for this project. According to this Five Year plan, 266 tubewells will be installed in the Malakand Division. The Eighth Five Year Tubewell installation plan is shown in Table 2.2.1

Table 2.2.1- Tubewells Installation Plan (1993 - 98)

| District | 93/94 | 94/95 | 95/96 | 96/97 | 97/98 | Total |
|---|---|---|---|---|---|---|
| Malakand | 8 | 12 | 16 | 16 | 16 | 69 |
| Swat | 9 | 12 | 16 | 16 | 16 | 69 |
| Bunir | 3 | 12 | 16 | 16 | 16 | 63 |
| Dir | 6 | 12 | 16 | 16 | 16 | 66 |
| Chitral | - | - | - | - | - | - |
| Total of Malakand Division | 26 | 48 | 64 | 64 | 64 | 266 |
| Others | 65 | 131 | 186 | 186 | 166 | 734 |
| Total of NWFP | 91 | 179 | 250 | 250 | 230 | 1,000 |

(3) Adjustment with the National Plan

In the Eighth Five Year National Plan, the emphasis is layed on using the agricultural sector as the main instrument of economic growth and development. The primary sector's goal is the achievement of an economic growth rate higher than the population growth, in order to ensure food security, self-sufficiency and a large exportable surplus. High priority will be given to the optimization of productivity making efficient use of the available land and water resources and other inputs, while conserving the resources base. The main priorities are developing agriculture and irrigation facilities in an integrated manner and manage them coordinately. This Project aims at improving irrigation facilities through the tubewells installation. In this concept, this project forms part of the National Plan.

(4) Justification and significance of the 5 year plan

Justification and significance of the Five Year tubewell installation plan were examined from the view point of the budget, necessity of irrigation and farmer's demand for installation of tubewells. The justification from these points are as follows;

Irrigation Necessity

The target area of this project has about 345.000 ha of agricultural fields, but only half of the area is irrigated. Particularly, the Bunir and Swat division have the least developed irrigation system. The main reason is the topography of the region that makes it difficult to implant a surface water irrigation system, because most of the region is situated in a place of high declivity. The irrigated area of each division is shown in table 2.2.2.

Table 2.2.2 Cultivated field and irrigated area by Division

| Division | arable field area (ha) | irrigated area (ha) | area lacking irrigation (ha) | area lacking irrigation (%) |
|---|---|---|---|---|
| Malakand | 45,680 | 34,376 | 11,304 | 24.7 |
| Swatl | 40,604 | 69,404 | 71,200 | 50.6 |
| Bunir | 55,153 | 11,279 | 43,874 | 79.5 |
| Dir | 85,885 | 54,797 | 31,088 | 36.2 |
| Chitral | 18,132 | 16,529 | 1,603 | 8.8 |
| Total of Malakand Division | 345,454 | 186,385 | 169,069 | 48.9 |
| NWFP | 1,907,590 | 849,506 | 1,058,084 | 55.5 |
| Total in Pakistan | 21,020,000 | 16,640,000 | 4,380,000 | 20.8 |

Cultivation is conducted in the Rabbi or in the Kalliff period, but in most of the months the crop water requirement is higher than the precipitation thus necessitating irrigation, specially in the Kallif period (July to September). The Swat and Bunir regions should be given priority during irrigation developments. It can be noticed that yield in irrigated areas is more than twice that the one in non irrigated areas. The harvests per unit area of important crops are shown in table 2.2.3.

Table 2.2.3 Comparison of important crops harvested per unit area in 1992/1993

| Crop | Irrigated Area (t/ha) | Non-Irrigated Area (t/ha) | (A/B) |
|---|---|---|---|
| Maize | 1.9 | 1.1 | 1.72 |
| Rice | 1.8 | 1.1 | 1.64 |
| Wheat | 1.9 | 1.0 | 1.90 |
| Garlic | 9.9 | 5.0 | 1.98 |
| Potato | 7.2 | 1.5 | 4.80 |
| Onion | 13.7 | 6.3 | 2.17 |

Recently, demand for irrigation facilities is increasing due to the increase in orchard cultivation.

Viability of the Tubewells Construction from the Farmers Side

Result of the viability study of the tubewells installation for farmers is as follows. For the study, production of maize and wheat were utilized for the economic viability study, taking into consideration the fact that the benefits of those crops are not high.

Items utilized for the economic analysis are;

| | | | |
|---|---|---|---|
| Cost: | Installation Cost (80m Depth) | | |
| | Gross Construction Cost | : | Rs270,000 |
| | Subsidy | : | Rs 40,000 |
| | Net Payment | : | Rs230,000 |
| | Operation Cost (40ha) | | |
| | Diesel Oil for Pump | | |
| | (Pumping Volume:2,500 m3,Head:30m) | | |
| | Rs 1,000/Crop/ha x 40ha | : | Rs 40,000/Crop |
| | Labor Cost(1,100/m x 2p x 3m) | : | Rs 6,600/Crop |
| | Total Operation Cost | : | Rs 46,600/Crop |
| | | : | Rs 93,200/Year |
| Benefit: | Maize 0.8t/ha increase, Price : Rs 3.4/kg | | |
| | Wheat 0.9t/ha increase, Price : Rs 3.6/kg | | |
| | Maize 0.8t/ha x 40ha x Rs3.4/kg | = | Rs108,800 |
| | Wheat 0.9t/ha x 40 ha x Rs3.6/kg | = | Rs129,600 |
| | Total Benefit | = | Rs238,400 |

(Note: Production cost for irrigated and non-irrigated land utilized the same cost)

From the results of the viability analysis, the value of the IRR for the installation of tubewells is estimated to be 63%, showing high return of investment. In case vegetable and orchard cultivations, which have high return, are carried out, the value of IRR will increase. From the view point of cost and benefit, the project of installation of tubewells is observed feasible and has high return for farmers..

Drilling Capacity of Existing Machines

Existing drilling machines of NWFP are the following;

| | | |
|---|---|---|
| - | Rotary rig | 5 units |
| - | Power Winch | 25 units |
| - | Hand Plant | 18 units |
| | Total | 48 units |

Total drilling capacity of NWFP is estimated in 143 tubewells assuming that the drilling capacities of rotary rig, power winch and hand plant, are 5, 4 and 1 respectively, which were estimated from the experience of the Directorate of Agricultural Engineering. This capacity is obviously insufficient for achieving the target . As a countermeasure to achieve 1,000 tubewells installation, the government planned to purchase drilling machines for Hazara and Kohat beside Malakand Division. However the financial condition of the Province is not good enough for the procurement of the drilling machines. Taking those conditions into consideration, the provision of drilling machines under the Japanese grant aid assistance would be of a great significance for the N.W.F.P.

Drilling capacity of the Malakand Agency is as follows

Available Drilling machines at Malakand Division

| | | | |
|---|---|---|---|
| - | Power Winch | : | 5 units |
| - | Hand Plant | : | 2 units |
| - | Rotary Rig | : | 1 unit |

Estimated drilling capacity of existing machine

| | | | |
|---|---|---|---|
| - | Power Winch | : | 5 x 4 wells/Year = 20 wells/Year |
| - | Hand Plant | : | 2 x 1 well/Year = 2 wells/Year |
| - | Rotary Rig | : | 1 x 4 well/Year = 4 wells |
| | Total | | 26 wells |

This capacity coincides with the number of tubewells drilled during the fiscal year of 1993/94. However, in the Five Year Plan, the number to be drilled during 1994/95 is 48 wells (increment of 22 wells), and 64 wells during 1995/96 - 97/98

(increment of 38 wells). With the existing drilling machines, achievement of the target number of tubewells installation is difficult. Through the drilling machines to be procured by the grant aid assistance, the Agriculture Engineering Department has planned to install 25 tubewells a year. This means that with the provision of 5 percussion rigs, there would still be a deficit of 18 wells. Considering the budget, the organization scheme and the drilling capacity, it is imperative that the drilling capacity be increased by the DAE side. For the completion of the target number of tubewells, a 25 % increment in drilling capacity will be required. Considering that the present drilling capacity is 4 tubewells/year, increasing to 5 tubewells/year is possible according to the installation schedule. Considering that the number of tubewells drilled during the seventh Five Year Plan were 1,000, completion of the tubewell installation with the drilling machines to be provided by this Project is possible, because of the increase in capacity of the drilling machinery.

Capacity of the Executing Agency and Demand of Farmers (Private)

The budget of the executing agency is 6.8 million rupees for the installation of 1,000 tubewells. However, the drilling capacity of the executing Agency is not sufficient to implement the targeted number of tubewells, due to the deterioration of existing drilling machines. Most of the drilling machines were procured 20 or 30 years ago, except for these obtained under the Japan Grant Aid system. The fact that existing machines have been utilized for more than 30 years proves the maintenance and management capacity of the executing agency is being sufficient, installation of tubewells is therefore justified, judging from the high demand for its installation.

From the above considerations, the Five Year 1,000 tubewells installation plan is considered appropriate. However the drilling capacity of the executing agency is insufficient. At present, the goal of the Five Year Tubewells Installation plan, with the installation of 250 tubewells annually, will be possible through the provision of the 5 percussion rigs.

## 2-3 Project Description

### 2-3-1 Organization for the Execution of the Project

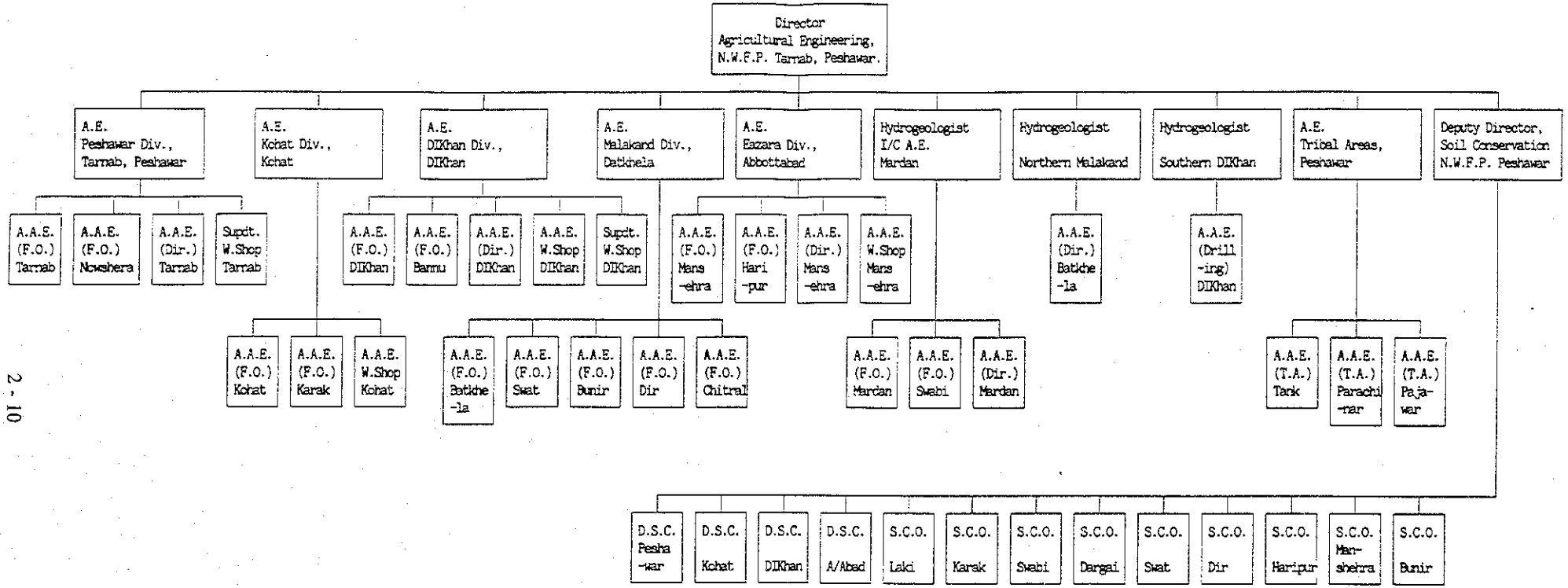
#### (1) Organization and Staffing

In compliance with the ongoing administrative system of Pakistan and the Government of N.W.F.P., DAE executes this Project, undertaking the operation and maintenance of the drilling equipment, the construction of tubewells and the technical support after the completion of well installation. Farmers shall be responsible for the operation and maintenance of the installed wells. The organization chart of DAE is shown in Fig. 2.3.1, and details of local setups to be directly engaged in actual work are presented hereinafter.

1) Setup for Well Construction

Well construction work is undertaken by DAE's Malakand division. A drilling crew is composed of one drill master, one assistant driller dispatched from DAE, and other laborers are to be arranged by the applicants(farmers). Five units of drill rig procured under the Project need ten (10) members specialized in drilling work. Of the 16 drilling technicians which Malakand division is currently staffed with, four (4) members that are now in charge of hand plants are planned to be posted to the newly procured rigs, with the remaining posts to be filled with recruitment. Financial arrangements for the recruitment has already been completed. Malakand division plans to recruit no less than ten (10) workers for the six (6) posts, since it intends to meet the requirement for two-shift operation in the future.

ORGANIZATION CHART




A.E. Agricultural Engineer
A.A.E. Assistant Agricultural Engineer
F.O. Field Operation
Dir. Drilling
Supdt. Superintendent
W. Shop Work Shop
D.S.C. District Soil Conservation
S.C.O. Soil Conservation Officer

Fig 2.3.1 Organization Chart of DAE

2) Setup for Maintenance and Repair

The maintenance and repair of drilling equipment are undertaken by Tarnab workshop in Peshawer division and various workshops in other divisions. Most troubles with drilling machines can be solved with the availability of spare parts. The present organizations of these workshops are judged to be adequately staffed to meet the requirements for maintenance and repair.

3) Setup for Well Testing

The operation of testing wells is conducted by hydrogeologist of Northern Malakand Division. Whenever personnel is short in this office, hydrogeologist of Southern DIKhan Division will supplement the shortages.

(2) Budget

Necessary budget for the Tubewells installation is as follows;

- Subsidy for farmers
- Cost for drilling
- Remuneration

The DAE has prepared 6.8 million Rupees for the subsidy during the fiscal year of 1994/95. During the Five Years Plan, the budgeted amount is 34 million rupees for the installation of 1,000 tubewells, equivalent to 40 thousand rupees for the Barani area and 20 thousand rupees for other areas. The remuneration for the existing staff has already been budgeted. However, the remuneration for new staff has not been budgeted yet. So it is necessary to prepare this part of the budget.

(3) Organization for the Operation and Maintenance

The operation and maintenance of the installed wells are mainly carried out by DAE and the benefited farmers themselves. Malakand division takes control of the Project until wells are completed, while farmers bear all the cost for the operation of wells including expenses for electricity and fuel, for repairing pumps and power units and for the rehabilitation of the wells. Fig. 2.3.2 shows the system of operation and maintenance.

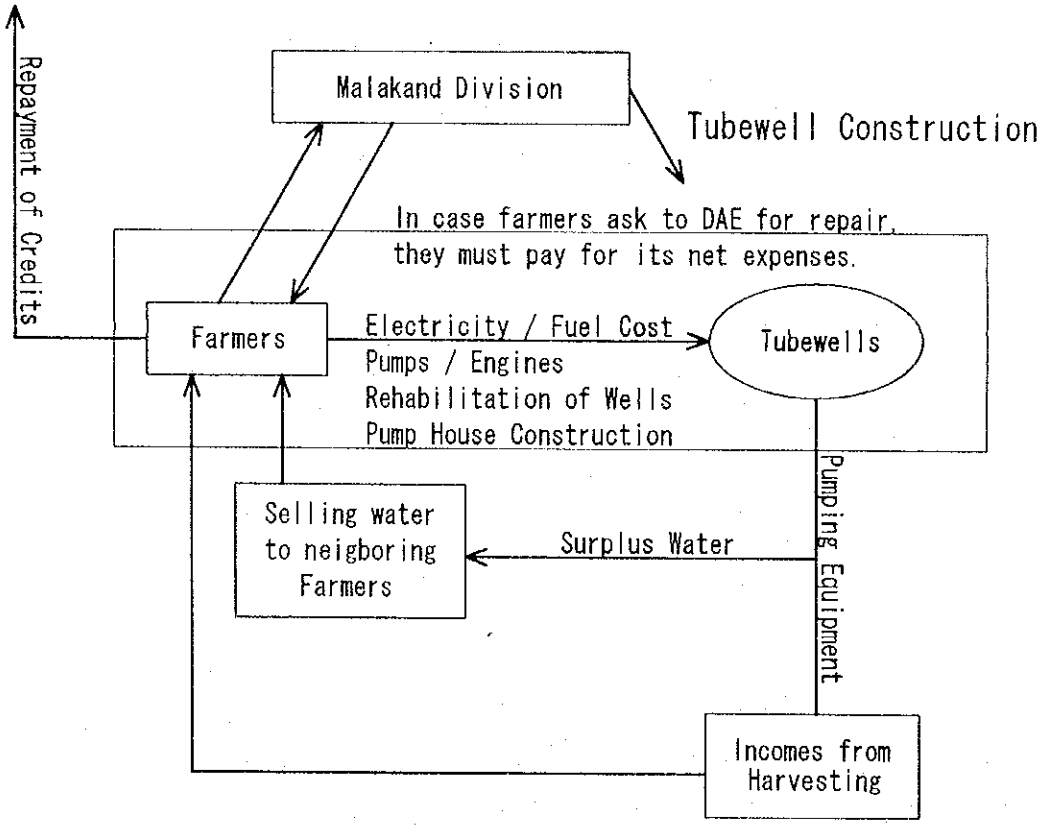



Fig 2.3.2 Operation and Maintenance System of Pumping Facilities

In the Project area, this system has taken roots as an established process for the execution of the irrigation projects. This Project, therefore, follows the ongoing system for the operation and maintenance.

## 2-3-2 Location and Condition of Project Site

### (1) Location

The Project area of Malakand Division is located in the west of the Indus River, in the northern portion of NWFP. The border between Afghanistan and Pakistan is at the north-western part of the Area. The area of the Project area is 29,872 km2 and is administratively divided into 5 districts as shown below:

| | | |
|---|---|---|
| Malakand Agency | 952km2 | EL 600-2,500m |
| Swat District | 7,028km2 | EL 700-6,000m |
| Bunir District | 1,760km2 | EL 600-3,000m |
| Dir District | 5,282km2 | EL 700-5,000m |
| Chitral District | 14,850km2 | EL1,000-6,500m |

Road network in the Area is developed and the capital of each district can be reached in 2-4 hours by vehicle from any district, except for Chitral District. Mountainous areas are found between Chitral and Dir Districts having more than 4,000m of elevation and a lot of snow during winter. As the road conditions in the mountainous area are not good, the transportation between Chitral and other districts is restricted. Airports which have routes to Isramabard or Peshwar, are located in Sidu Sharif in Swat District and Chitral in Chitral District.

### (2) Natural Conditions

#### 1) Topography and geology

Topography in the area is broadly separated into three; i.e. hilly areas between main rivers (EL 600-2,000m), mountainous areas of large relief in north/north-west (EL 2,000-6,000m) and gentle lands along main rivers (100-1,000m of width). The gradient of river beds are 3/1,000 on average and 10/1,000 in steeper parts. Considering the hydrogeological conditions of the Area, the following five topographical units can be found;

Table 2.3.1 Topographical Units in the Area

| Unit | Location | District |
|---|---|---|
| a) Marginal area of broad Alluvial plain | Southern margin of the Area | Malakand Agency |
| b) Alluvial plains along main river | lands along Swat R. | Malakand Agency<br>Swat District |
| c) Fans to main River | lands along tributaries of Swat & Indus Rs | Swat District<br>Dir District<br>Bunir District |
| d) Small basin in mountainous area | Lands along rivers in middle to northern part of the Area | Swat District<br>Dir District Chitral District |
| e) Hilly to mountainous lands | Other lands than the above units | All Districts |

Considering the topographical classification, geology of the area could be divided into four categories: i.e. base rocks of limestone, granite and schists in hilly to mountainous area, pebble to boulder deposits in small basins and in fans, fine to coarse deposits in alluvial plains along main rivers and fine to medium alluvial deposits in marginal areas of broad alluvial plains(see Fig. 2.3.3).

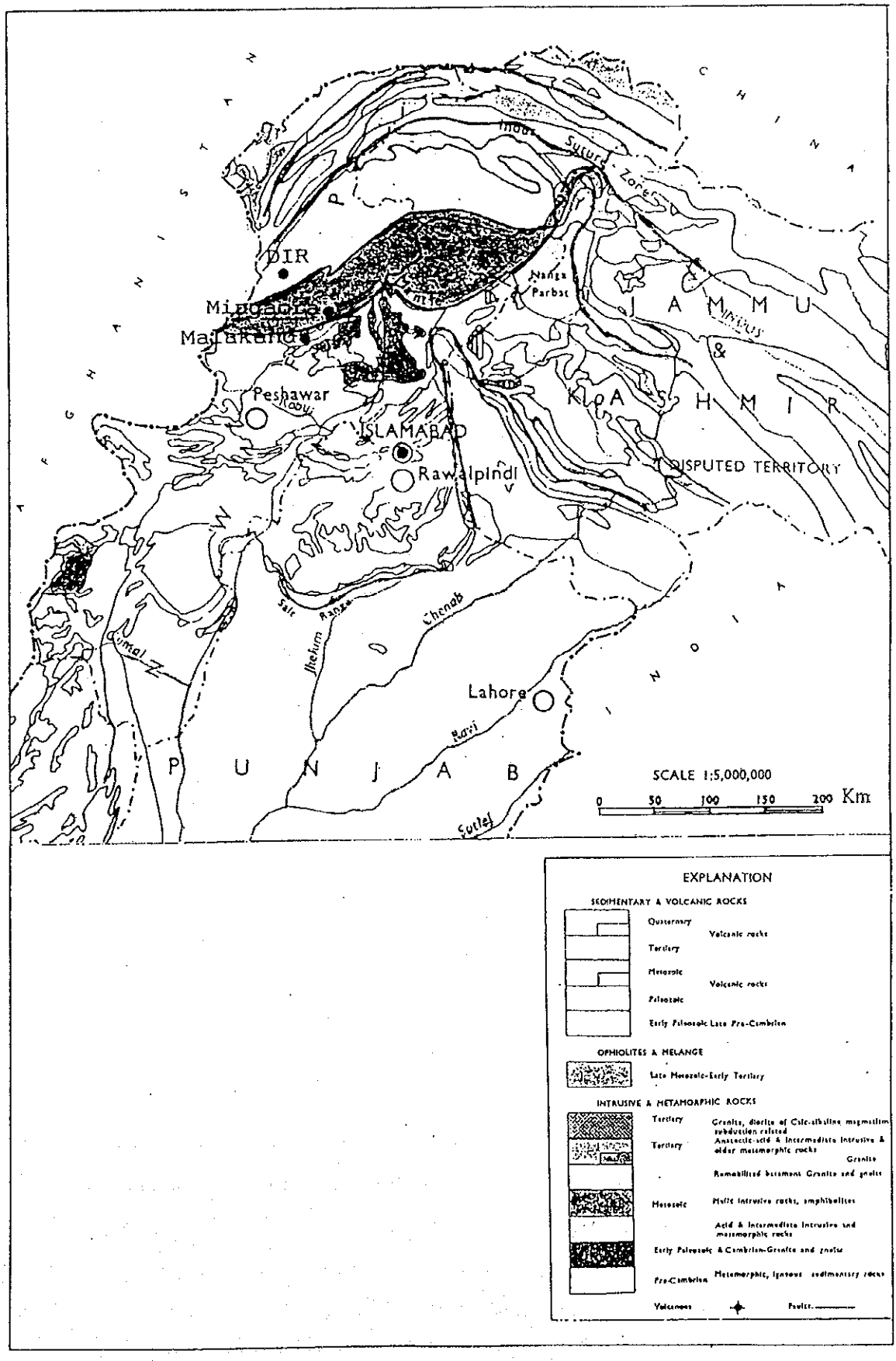



Fig. 2.3.3 Geological Map

2) Climate and hydrology

a. Temperature

Temperature in the area is not uniform as indicated below:

Southern parts (Malakand Agency, Bunir District)
26C-29C in summer(Jun.-Sept.)
6C- 8C in winter(Dec.-Jan.)

Middle to Northern Parts (Swat District, Dir District)
25C-28C in summer(Jun.-Sept.)
1C- 8C in winter(Dec.-Jan.)

Chitral is the coldest district in the area; snow, and temperatures bellow 0C are often observed in December and January. Average monthly temperature in Swat and Bunir Districts are given below:

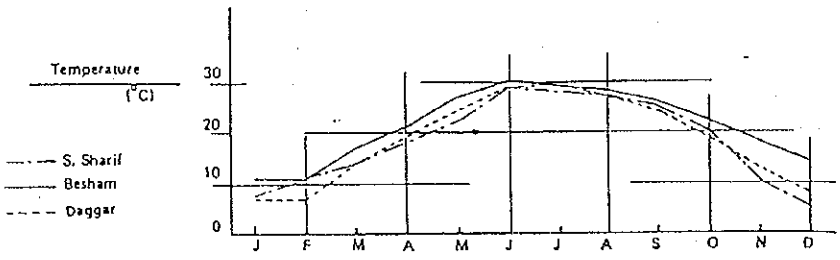
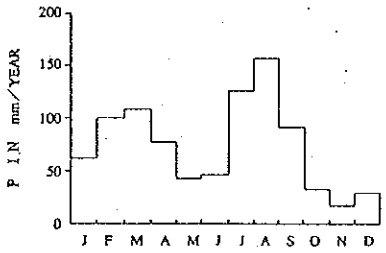



Fig 2.3.4 Average Temperature

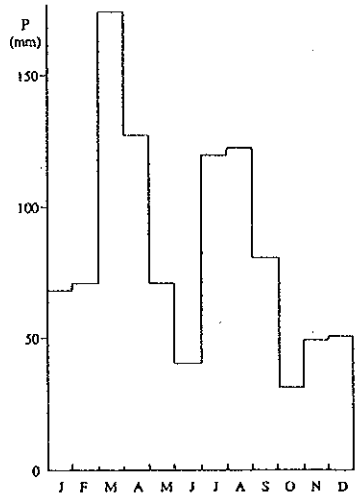
b. Precipitation

More than half of the annual precipitation is recorded in two rainy seasons(Rabi: Mar.-Apr. and :Jul.-Aug.), with 100-160mm of monthly rainfall. About 25% of annual precipitation is recorded from February to April and about 50% from July to September. In months out of the rainy seasons, under 50-100mm of monthly rainfall is observed. Especially, in June and October-November which are dry months, the monthly rainfall is less than 30mm/month at many locations in the Area. The annual

precipitation in the area ranges from 600 to 1,000mm and decreases from south/south-east to north/north-west within the area. In Chitral District, a few sites having less than 500mm of annual precipitation are found.




Monthly rainfall in Buner district




Monthly rainfall in Dir District

Fig 2.3.5 Monthly rainfall

c. Evapotranspiration

Annual evapotranspiration in the area differs by elevation. The potential of evapotranspiration is considered to be 2,000-2,500mm/year in the lands of EL 700-1,000m. Table 2.3.2 shows the pan evaporation in Daggar, Bunir District. Potential of more than 80mm/month is estimated for the period of April to September and more than 130mm/month is estimated for June and July.

Tab. 2.3.2 Monthly Evapotranspiration (mm/month)

| Observation place | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Daggar (1971-82) | 29.4 | 37.0 | 68.9 | 115.2 | 171.5 | 189.2 | 189.2 | 145.7 | 120.7 | 91.1 | 50.4 | 30.4 |
| 0.7 | 20.6 | 25.9 | 48.2 | 80.6 | 120.1 | 132.4 | 132.4 | 102.0 | 84.5 | 63.8 | 35.3 | 21.3 |

c. Runoff

The runoff of the main river has good correlation with rainfall in the Area. Maximum runoff, which is 5 times more than the minimum, is observed in August with the corresponding minimum runoff observed in May or June. Runoff of tributaries of main rivers is only observed in a one month period per year between July and September. Thus much precipitation is considered to be discharged through under ground of the fan as a base flow along the tributaries. Base flow in the Area is estimated as 0.3-0.5mm/day.

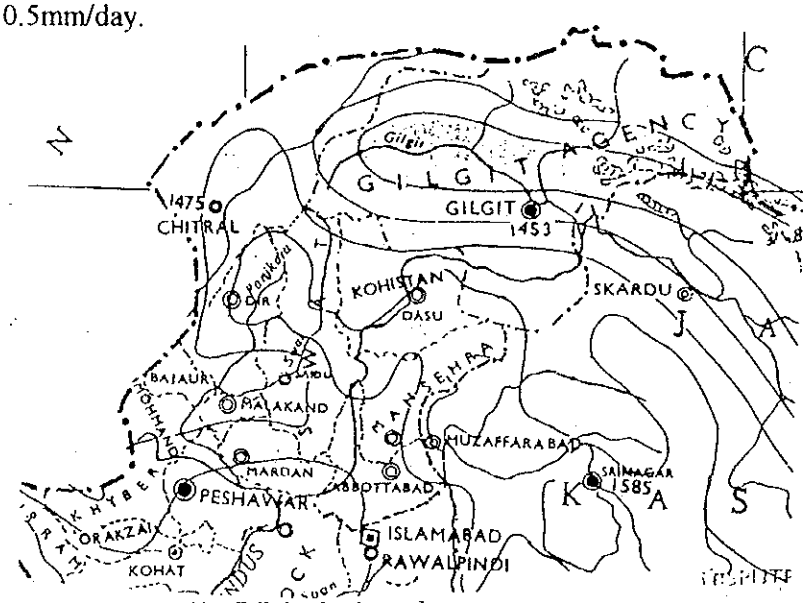



Fig 2.3.6 Isohyetal curve

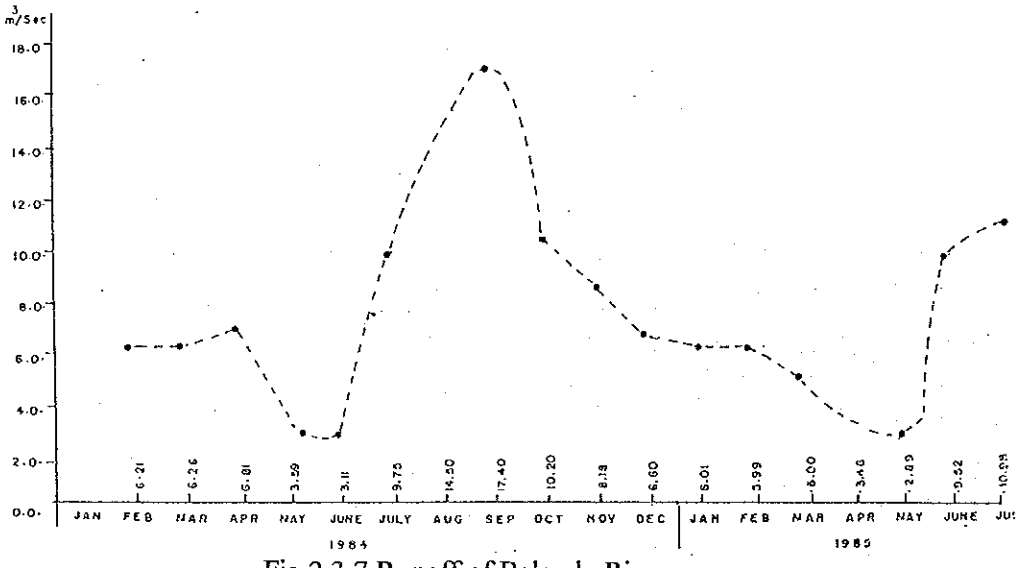



Fig 2.3.7 Runoff of Balandu River

## 3) Hydrogeology and Water Quality

### a. Outline

Referring to the Topographical Units mentioned above, the area could be classified into 5 Hydrogeological Units. Hydro-geological conditions of each Unit are described below:

A: Marginal area of broad Alluvial plain

Groundwater table is relatively deep but the recharge storage is not small as a part of groundwater spreading in broad alluvial plain. As the material of deposits is fine to medium, permeability of the aquifer may not be high. It is considered that groundwater is unconfined and flows to south or south-east.

B: Alluvial plains along main river

The groundwater is unconfined, relatively shallow and recharge and discharge of the groundwater is closely related to the surface water. The permeability is relatively high with coarse sedimentary materials and the type of this groundwater is mainly found in alluvial lands along Swat River.

C: Alluvial Fans to main River

The groundwater is considered to be under flow in fan deposits of rainfall in the drainage basin. The permeability is not low, as the materials of fan deposits are very coarse. The groundwater table may have close relationship with the basal rock depth and is deep in the center of the fan.

D: Small basin in mountainous area

The storage areas are limited by the thickness of alluvial deposits and the basal rocks depth. As generally the aquifer is not thick, the discharge capacity is not considered to be high. The permeability is varied by texture of the deposits.

E: Hilly to mountainous lands

In the area, no groundwater recharge is made. No groundwater development therefore is expected, except for a few fracture zones where confined groundwater is rarely found.

The spatial distributions of the hydrogeological classifications above are given in Fig. 2.38.

b. Hydrogeological Characteristics of Groundwater Development for the Project

The construction of tubewells in the potential areas for groundwater development in Fig. 3.5.6 is proposed for the Project. Many of the proposed sites for the Project are located in the areas of Topographical (Hydrogeological) Units c) and/or d). A few parts of Unit a) are also proposed for groundwater development.

The hydrogeological characteristics of these Units for groundwater development are outlined as follows:

A: Southern Part of Malakand Agency

(Marginal areas of broad Alluvial plain)

| | | |
|---|---|---|
| Geology | | Alluvial deposits of clay, sand and gravel 100m to 150m thick. |
| GWT | : | Deeper than 20-30m below surface |
| Aquifer | : | 15-30m thick up to 100m deep |
| Transmissivity | : | more than $1x10^3$m2/day |

C: Drainage Basin to Swat River and Dagger Valley, Buner

(Alluvial Fans to main River)

| | | |
|---|---|---|
| Geology | | Alluvial fan deposits of gravel 50m to 150m thick. |
| GWT | : | Deeper than 20-40m below surface |
| Aquifer | : | 40-50m thick up to 100m deep |
| Transmissivity | : | more than $1x10^3$m2/day |

D: River Valley in center to northern part of Dir and southern part of Chitral

(Small basin in mountainous area)

| | | |
|---|---|---|
| Geology | | Alluvial deposits of gravel, sand and silt alternations under 100m thick. |
| GWT | : | 20-100m below surface |
| Aquifer | : | less than 30-50m thick up to 100m deep |
| Transmissivity | : | around $1x10^3$m2/day |

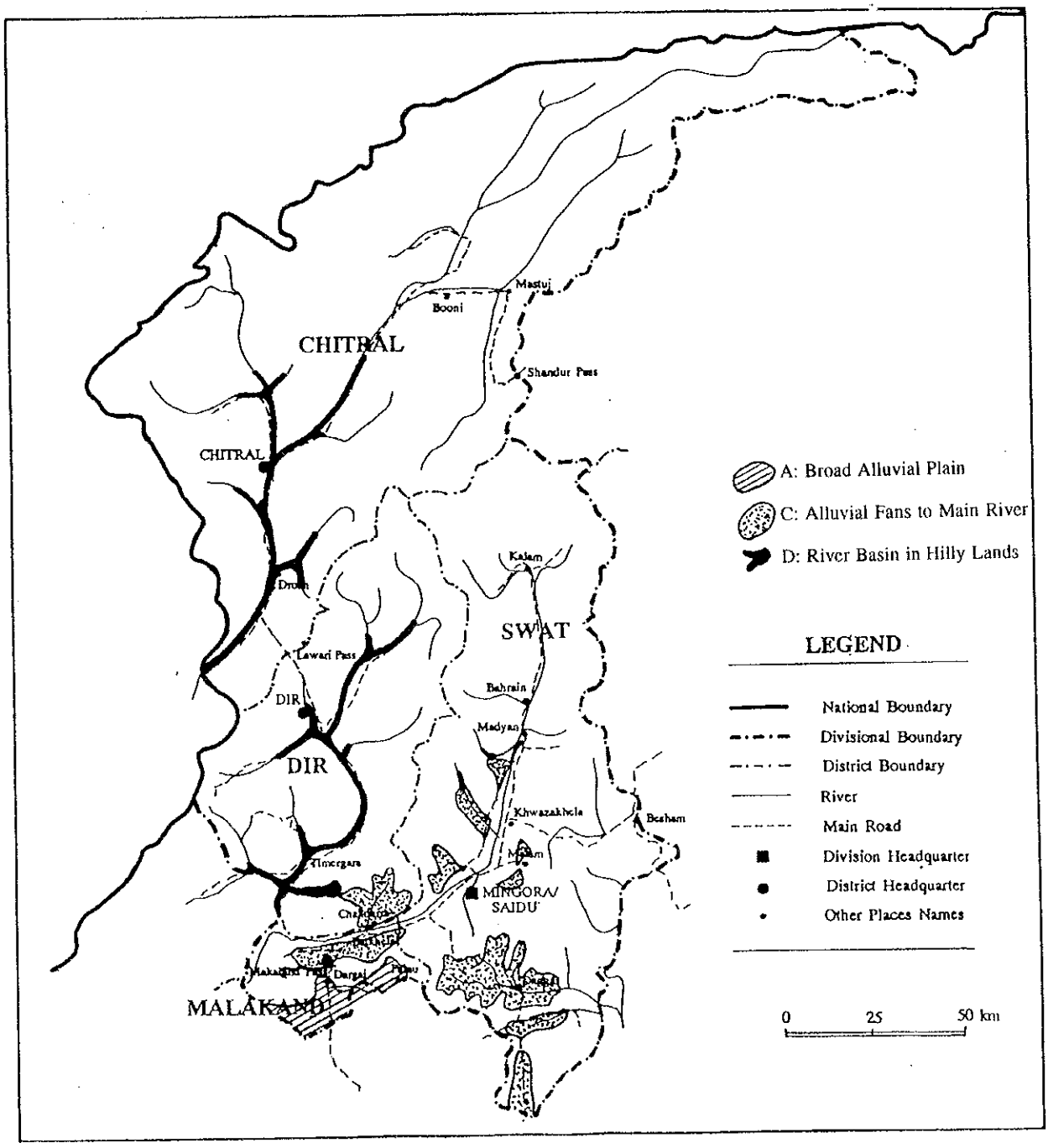



Fig 2.3.8 Special Distribution of the Hydrogeological Units with High Potential of Groundwater Development

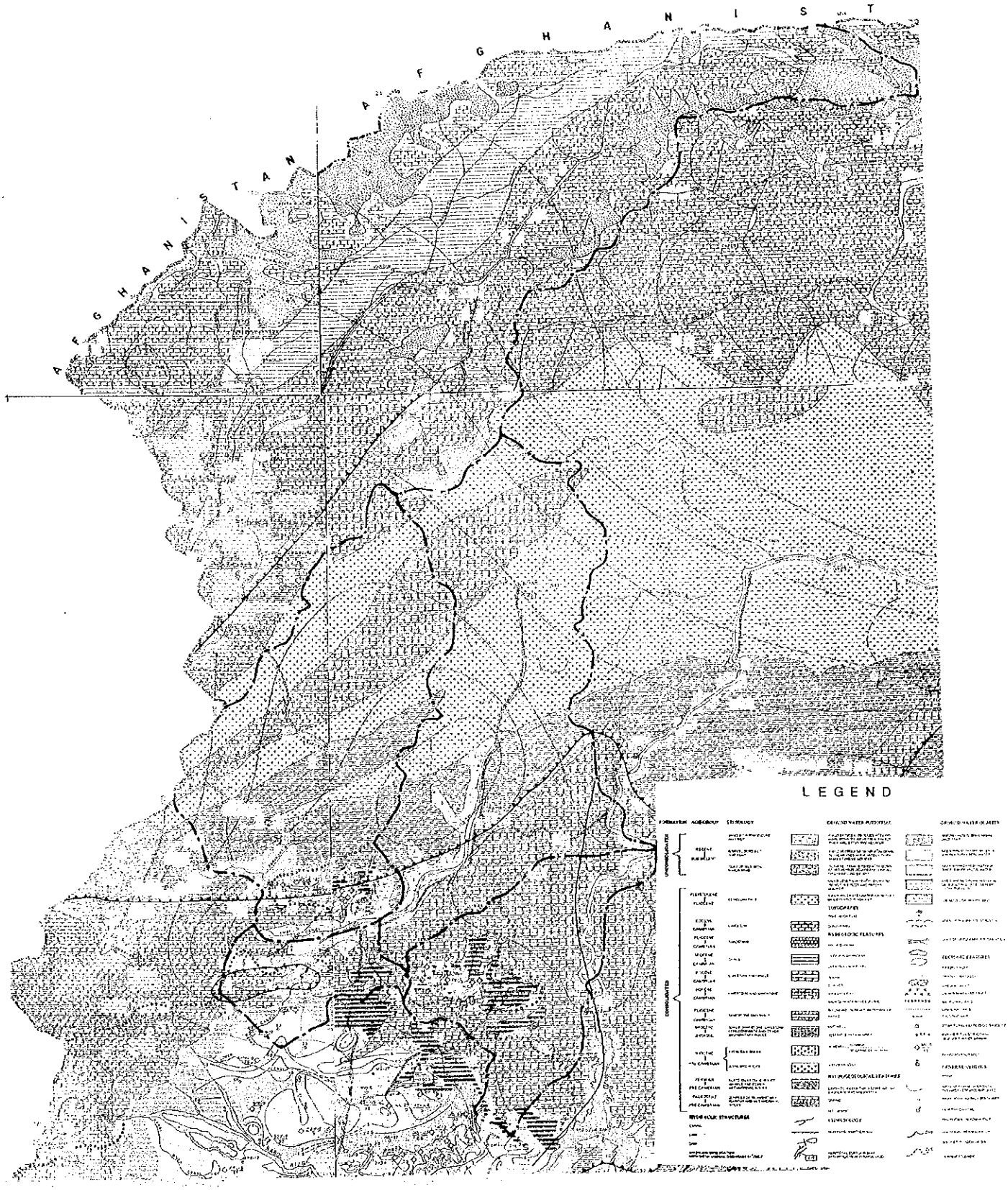



Fig. 2.3.9 Hydrogeological Map

c. Groundwater Quality

Existing groundwater quality records indicate that salinity of the water is medium to marginal as indicated below:

Electric Conductivity : 300-600uS/cm.
Calcium Content : 40-120mg/lit.
(Ca content of tube well is higher than that of open well)

According to existing data of groundwater quality, the following considerations could be made. The groundwater may stay in limestone rich deposits for a long period. Salinity of deep groundwater is higher than that of shallow groundwater. The results of the examination groundwater qualities in the area which was conducted by WAPDA are summarized in Table 2.3.4.

Tab. 2.3.3 Critera for the irrigation water quality

| | Problem's criterion values | | |
|---|---|---|---|
| Problems in the irrigation water | none | a little | problematic |
| Salinity (affects crop water availability) | | | |
| Electromagnetic waves (milliomhos/cm) | <0.75 | 0.75-3.0 | >3.0 |
| Permeability (affects infiltration rate into the soil) | | | |
| Ecw (millimhos/cm) | <0.56 | 0.5-0.2 | <0.2 |
| adj. SAR [a,b] | | | |
| montmorillonite (2:1 crystal lattice) | <6 | 6-9[c] | >9 |
| illite-vermiculite (2:1 crystal lattice) | <8 | 8-16[c] | >16 |
| kaolinite-sesquioxides (1:1 crystal lattice) | <16 | 16-2[c] | >24 |
| Specific minerals (affects sensitive crops) | | | |
| sodium [d,e] (adj. SAR) | <3 | 3-9 | >9 |
| chloride [d,e] (meq/l) | <4 | 4-10 | >10 |
| boron (mg/l) | <0.75 | 0.75-2.0 | >2.0 |
| Others (affect susceptible crops) | | | |
| $NO_3$-N (or) $NH_4$-N (mg/l) | <5 | 5-30 | >30 |
| HCO3 (meq/l) (overhead sprinkling) | <1.5 | 1.5-8.5 | >8.5 |
| pH | (normal range 6.5-8.4) | | |

Source: FAO (1976)

Tab. 2.3.4 Quality of Groundwater and spring Water

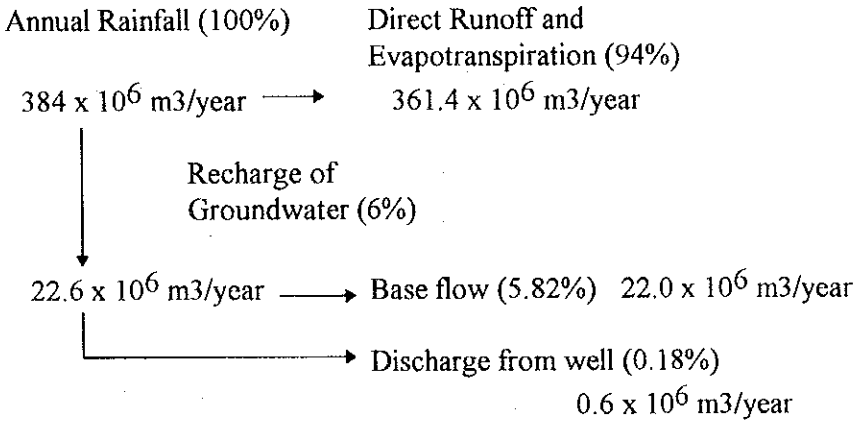
| | Ec (μs/cm) | pH |
|---|---|---|
| Deep well | 400 | 7.3 |
| | 370 | 7.6 |
| | 680 | 7.5 |
| | 350 | 7.2 |
| | 200 | 7.1 |
| Shallow well | 250 | 7.8 |
| | 250 | 7.7 |
| | 370 | 7.9 |
| | 310 | 7.9 |
| | 320 | 7.9 |
| | 440 | 7.8 |
| | 300 | 7.8 |
| | 320 | 7.9 |
| | 420 | 7.4 |
| | 460 | 7.9 |
| | 270 | 8.1 |
| | 380 | 7.7 |
| | 500 | 7.6 |
| | 530 | 7.8 |
| | 310 | 7.9 |
| | 640 | 7.6 |
| | 290 | 7.9 |
| | 400 | -- |
| | 360 | -- |
| | 700 | -- |
| | 350 | -- |
| | 200 | -- |
| Spring water | 500 | 7.4 |

Considering the water quality conditions mentioned above, the water quality standard for irrigation (see Table 2.3.3) and the annual rainfall of 700-1,000mm, the suitability of the groundwater quality in the area for the irrigation purpose is considered medium to marginal.

(3) Potential of Groundwater Development

1) Groundwater Balance

The following recharge and discharge balance of groundwater was determined as a result of water balance examinations in Barandu river basin by WAPDA.




According to the following conditions, maximum development potential is the same as recharge amount of groundwater. The groundwater flows in Alluvial fan and discharges in the main rivers' basins. The groundwater development for the Project is very limited only in lands of tributaries of the main rivers. However in the report, 70% of recharge amount is potential for groundwater development, considering domestic water use and any loss. Based on the conditions above and annual rainfall of 750mm, the development potential of each district is estimated as in Table 2.3.5.

Table 2.3.5 Volume of groundwater with development potential

| | Area ($km^2$) | Total precipitation ($10^6m^3$) | Volume developed ($10^6m^3$) | Volume of groundwater available for irrigation ($10^6m^3$) |
|---|---|---|---|---|
| Malakand district | 952 | 714 | 43 | 32 |
| Swat district | 7,028 | 5,271 | 316 | 237 |
| Bunir district | 1,760 | 1,320 | 79 | 59 |
| Dir district | 5,282 | 3,962 | 238 | 179 |
| Chitral district | 14,850 | 11,138 | 668 | 501 |
| Total | 29,872 | | | |

2) Crop Water Requirement

Crop water requirement was estimated on the basis of the maize cutivation during Karif season (July to November).Crop water requirement during the cultivation period are as follows;

Table 2.3.6 Irrigation Water Requirement

| Period | Eto (mm/d) | Crop Efic. (Kc) | ETc | ET/10day | Precip. (mm/10d) | Effect. Rain (mm/10day | Water Requirem. (mm/10day | Irrigat. Water (mm/10day |
|---|---|---|---|---|---|---|---|---|
| 10 | 6.7 | 0.3 | 2.01 | 20.1 | 43.3 | 34.6 | - | - |
| 20 | 6.7 | 0.35 | 2.35 | 23.5 | 43.3 | 34.6 | - | - |
| 30 | 5.7 | 0.45 | 2.57 | 25.7 | 43.3 | 34.6 | - | - |
| 40 | 5.7 | 0.65 | 3.71 | 31.7 | 46.0 | 36.8 | - | - |
| 50 | 5.7 | 0.90 | 5.13 | 51.3 | 46.0 | 36.8 | 14.5 | 18.1 |
| 60 | 5.0 | 1.05 | 5.25 | 52.5 | 46.0 | 36.8 | 15.7 | 19.6 |
| 70 | 5.0 | 1.10 | 5.50 | 55.0 | 20.0 | 16.0 | 39.0 | 48.8 |
| 80 | 5.0 | 1.10 | 5.50 | 55.0 | 20..0 | 16..0 | 39.0 | 48.8 |
| 90 | 3.8 | 1.05 | 3.99 | 39.9 | 20.0 | 16.0 | 39.0 | 48.8 |
| 100 | 3.8 | 0.95 | 3.61 | 36.1 | 16.3 | 13.0 | 23.1 | 28.9 |
| 110 | 3.8 | 0.80 | 3.04 | 30.4 | 16.3 | 13.0 | 17.9 | 21.8 |
| 120 | 2.4 | 0.65 | 1.56 | 15.6 | 16.3 | 13.0 | 2.6 | 3.2 |
| 130 | 2.4 | 0.55 | 1.32 | 13.2 | 7.3 | 5.8 | 7.4 | 9.3 |
| Total | | | | | | | 197.7 | 247.3 |

Required water volume is approximately 250 mm (2500m3/crop/ha).

3) Irrigable Area

On the other hand, irrigable area using groundwater estimated above is obtained by district as shown in Table 3.5.6, based upon the conditions of water requirement of 50m3/day for a period of 100 days for irrigation. According to the calculation, it is estimated that 30-100% of non-irrigated area of each district could be irrigated by the groundwater development of the Project.

Table 2.3.7 Area Irrigable with Groundwater

| | Water required per ha ($m^2$) | Irrigable volume ($10^6m^3$) | Irrigable Area (ha) | Percentage of non irrigated area (%) |
|---|---|---|---|---|
| Malakand district | | 32 | 12,800 | 100 |
| Swat district | | 237 | 94,800 | 100 |
| Bunir district | 5,000 | 59 | 23,600 | 54 |
| Dir district | | 179 | 71,600 | 100 |
| Chitral district | | 501 | 204,000 | 100 |
| Total | | | 403,800 | |

4) Capacity of Well

Existing well test data by WAPDA within Adinzai-site, Talash-site and Daggar-site of the Area where Alluvial fans are found are outlined in Table 2.3.8.

Table 2.3.8 Well test data

| | Pumping Rate (l/sec) | Draw-down (m) | Transmissivity ($m^2$/day) |
|---|---|---|---|
| Fans to main River | 35 | 4.8 | $4.5x10^3$ |
| (ADINZAI Unit) | 28.0 | 8.0 | $8.0x10^2$ |
| | 21 | 16.9 | $5.0x10^2$ |
| (DAGGAR Unit) | 21 | 12.8 | $4.4x10^2$ |
| Small basin in medium river | 12 | 12.7 | $1.5x10^2$ |
| (TALASH Unit) | 35 | 3.2 | $2.8x10^3$ |
| | 35 | 3.7 | $3.0x10^3$ |
| | 7 | 10.3 | $2.5x10^2$ |

According to the existing well data, wells in Alluvial fans are considered to have a pumping rate capacity of 20-35 lit./sec with 5-15m draw-down from statistic groundwater table. The well data indicate that it could be estimated that transsimitivity of aquifer for groundwater development ranges from $5x10^2$m2/day to $5x10^3$m2/day and necessary pumping rate of well in the Area is 500m2-5,000m2/day.

Considering 10 hrs. of operation a day at a pumping rate of 1 cusec (1.7m3/min=28 lit./sec) which makes a total pumping volume of 1,000m3/day based on the well characteristics above, the area irrigable per one well is estimated as 40 ha/well as shown below:

1,000m3/day
---------- = 40 ha
25m3/day.ha

Number of wells to be constructed in each district is estimated as given in Table 2.3.9, using conditions of groundwater development potential and yield per well examined above.

Tab. 2.3.9 Number of wells constructable

| District | Potencial volume to be developed $10^6m^3$ | Potential Number of wells | Required Number |
|---|---|---|---|
| Malakand district | 32 | 320 | 238 |
| Swat district | 237 | 2,370 | 1,780 |
| Bunir district | 59 | 590 | 1,096 |
| Dir district | 179 | 1,790 | 777 |
| Chitral district | 501 | 5,010 | 40 |
| | | | 3,931 |

(4) Social and Economic Condition

1) Land Resources

The Malakand Division covers an area of 29,872 $km^2$, of which 12% (3,455 $km^2$) is utilized as agricultural area. The forest area covers 4,282 $km^2$. Most parts of the division, specially Chitral District, are constituted of mountainous areas. Expansion of the agricultural area is limited because most of the plain parts are already being utilized for agricultural purposes. Land use on each district is shown in Table 2.3.10.

Table 2.3.10 Land Utilization

| District | Total Area ($Km^2$) | Agricultural Land ($Km^2$) | Forest ($km^2$) | Others ($Km^2$) |
|---|---|---|---|---|
| Chitral District | 14,850 | 181 | 416 | 14,253 |
| Dir District | 5,282 | 859 | 1,716 | 2,707 |
| Swat District | 6,945 | 1,406 | 1,689 | 3,850 |
| Bunir District | 1,843 | 552 | 415 | 876 |
| Malakand Agency | 952 | 457 | 46 | 449 |
| Total of Division | 29,872 | 3,455 | 4,282 | 22,135 |

2) Population

According to the population census carried out in 1981, the population of the Malakand Division was of approximately 2.46 million, and is estimated to be 4.12 million at present. The population of each district is as follows;

| | | 1993 Estimated (thousand) | | |
|---|---|---|---|---|
| District | 1981 | Total | Urban | Rural |
| Chitral District | 209 | 315 | - | 315 |
| Dir District | 767 | 1,351 | - | 1,351 |
| Swat District | 967 | 1,579 | 201 | 1,378 |
| Bunir District | 266 | 448 | - | 448 |
| Malakand Agency | 258 | 423 | - | 423 |
| Total of Division | 2,467 | 4,116 | 201 | 3,915 |

The agricultural sector absorbs 75 % of the total working population, followed by the commercial sector and the public service sector. Percentage of working population employed in each sector is as follows;

| | | | |
|---|---|---|---|
| Agriculture | : 75.2% | Transportation | : 2.4% |
| Mining | : 0.4% | Bank | : 0.3% |
| Industry | : 1.0% | Health | : 8.5% |
| Public Service | : 2.6% | Others | : 2.9% |
| Commercial | : 5.3% | | |

3) Land Ownership

Land ownership classification in the project area is shown in Table 2.3.11. The number of farmers are 260 thousand, most of who owns land smaller than 2.5 ha. Only 1.6% of farmers own land bigger than 25 ha.

Table 2.3.11. Number of Farmers According to Land Size

| Land Area (ha) | NWFP | Malakand Div. | Chitral District | Dir District | Swat District | Bunir District | Malakand Agency |
|---|---|---|---|---|---|---|---|
| 0 - 1.0 | 175,339 | 46,964 (17.9%) | 13,543 | 11,270 | 18,903 | 2,637 | 611 |
| 1.0 - 2.5 | 351,809 | 94,630 (36.1%) | 6,246 | 29,192 | 34,843 | 11,382 | 2,967 |
| 2.5 - 5.0 | 131,721 | 62,352 (23.8%) | 6,524 | 21,019 | 22,201 | 9,877 | 2,661 |
| 5.0 - 7.5 | 101,659 | 26,749 (10.2%) | 2,101 | 10,607 | 8,601 | 4,155 | 1,285 |
| 7.5 - 12.5 | 59,267 | 17,988 ( 6.9%) | 1,164 | 7,722 | 5,427 | 2,650 | 1,025 |
| 12.5 - 25.0 | 25,280 | 9,404 ( 3.6%) | 802 | 4,485 | 2,258 | 1,360 | 499 |
| 25.0 - 50.0 | 9,275 | 3,137 ( 1.2%) | 251 | 1,743 | 540 | 467 | 136 |
| 50.0 - 150.0 | 211,678 | 1,113 ( 0.4 %) | 162 | 569 | 141 | 219 | 32 |
| 150.0 - | 1,103 | 124 ( 0.0% ) | 13 | 40 | 9 | 56 | 6 |
| | | | 30,806 | 86,647 | 92,923 | 32,803 | 9,222 |
| Government | 44 | 10 | | 10 | | | |
| Total | 1,067,175 | 262,471 (100%) | 30,806 | 8,657 | 92,923 | 32,803 | 9,222 |

(5) Present Situation of Agriculture

1) Agricultural Production

Main agricultural products of the project area are maize and wheat, and recently, orchard cultivation, represented by apple, and vegetable cultivation, represented by tomato, are prevailing. Orchard cultivation is increasing specially in Malakand Division. Cultivated orchard area accounts for approximately 10 thousand hectares. The government of NWFP lays emphasis on the development of the orchard and vegetable cultivation. Research on these crops at Malakand division is being carried out with the assistance of the Swiss government.

Cropped area at Malakand Division is shown in Table 2.3.12.

Table 2.3.12(1). Cropped Area (1992/93)

| Crop | NWFP | Malakand Div. | Chitral District | Dir District | Swat District | Bunir District | Malakand Agency |
|---|---|---|---|---|---|---|---|
| Maize (Irrig.) | 243,402 | 45,719 | 6,273 | 9,461 | 20,200 | 4,347 | 5,438 |
| Maize (no-irrig.) | 284,402 | 129,221 | - | 5,195 | 86,347 | 37,643 | 36 |
| Total | 527,804 | 174,940 | 6,273 | 14,656 | 106,547 | 41,990 | 5,473 |
| Rice (Irrig.) | 62,056 | 35,102 | 2,680 | 15,856 | 9,323 | 357 | 6,886 |
| Rice (no-irrig.) | 75 | - | - | - | - | - | - |
| Total | 62,131 | 35,102 | 2,680 | 15,856 | 9,323 | 357 | 6,886 |
| Soybean (Irrig.) | 1,319 | 641 | - | 11 | 605 | 5 | 19 |
| Soybean (no-irrig.) | 1,984 | 242 | - | 22 | 210 | 10 | - |
| Total | 3,303 | 883 | - | 33 | 815 | 15 | 19 |
| Mung (Irrig.) | 3,429 | 190 | 77 | - | 43 | 19 | 51 |
| Mung (no-irrig.) | 5,172 | 2,492 | 49 | 1,397 | 398 | 648 | - |
| Total | 8,601 | 2,682 | 126 | 1,397 | 441 | 667 | 51 |
| Mash (Irrig.) | 547 | 264 | 212 | - | - | 19 | 33 |
| Mash (no-irrig.) | 2,556 | 1,960 | 69 | 1,383 | - | 508 | - |
| Total | 3,103 | 2,224 | 281 | 1,383 | - | 527 | 33 |
| Sugar Cane (Irrig.) | 98,972 | 5,635 | - | 71 | 16 | 628 | 4,920 |
| S. Cane (no-irrig.) | 904 | 84 | - | - | 10 | 74 | - |
| Total | 99,876 | 5,719 | - | 71 | 26 | 702 | 4,920 |
| Wheat (Irrig.) | 328,845 | 55,469 | 8,574 | 17,290 | 16,867 | 3,228 | 9,510 |
| Wheat (no-irrig.) | 520,761 | 139,811 | 9,510 | 22,433 | 59,710 | 41,103 | 16,565 |
| Total | 849,606 | 195,280 | 18,084 | 39,723 | 76,577 | 44,331 | 26,075 |
| Barley(Irrig.) | 12,782 | 4,989 | 4,605 | 78 | 212 | 79 | 15 |
| Barley (no-irrig.) | 46,526 | 14,204 | - | 7,452 | 2,189 | 1,021 | 3,542 |
| Total | 59,308 | 19,193 | 4,605 | 7,530 | 2,401 | 1,100 | 3,557 |
| Raple Mast. (Irrig.) | 2,562 | 224 | - | 7 | 78 | 37 | 102 |
| Raple Mast.(no-irrig.) | 34,502 | 12,341 | - | 6,756 | 2,073 | 814 | 2,698 |
| Total | 37,064 | 12,565 | - | 6,763 | 2,151 | 851 | 2,800 |
| Mattar (Irrig.) | 2,249 | 1,070 | 68 | 27 | 930 | 2 | 43 |
| Mattar (no-irrig.) | 799 | 43 | - | - | 32 | 11 | - |
| Total | 3,048 | 1,113 | 68 | 27 | 962 | 13 | 43 |
| Potato (Irrig.) | 7,200 | 2,419 | 344 | 1,508 | 515 | 10 | 42 |
| Potato (no-irrig.) | 1,469 | 393 | - | - | 393 | - | - |
| Total | 8,669 | 2,812 | 344 | 1,508 | 908 | 10 | 42 |
| Onion (Irrig.) | 6,344 | 3,832 | 12 | 400 | 3,139 | 54 | 227 |
| Onion (no-irrig.) | 255 | 254 | - | - | 246 | 8 | - |
| Total | 6,599 | 4,086 | 12 | 400 | 3,385 | 62 | 227 |

Table 2.3.12(2). Cropped Area (1992/93)

| Crop | NWFP | Malakand Div. | Chitral District | Dir District | Swat District | Bunir District | Malakand Agency |
|---|---|---|---|---|---|---|---|
| Karif Vegetable | | | | | | | |
| Lady Finger | 1,550 | 338 | 59 | 127 | 82 | 4 | 66 |
| Tinda | 713 | 140 | 51 | 33 | 40 | 2 | 14 |
| Bringal | 783 | 226 | 30 | 40 | 110 | 4 | 42 |
| Pumpkin | 431 | 104 | 28 | 26 | 37 | 2 | 11 |
| Tomato | 5,790 | 2,552 | 98 | 136 | 2,070 | - | 248 |
| Others | 15,886 | 210 | 26 | 5 | 73 | 13 | 93 |
| Total | 25,153 | 3,570 | 292 | 367 | 2,412 | 25 | 474 |
| Karif Orchard | | | | | | | |
| Apricot | 1,544 | 734 | 37 | 102 | 540 | 8 | 47 |
| Apple | 7,797 | 2,546 | 163 | 143 | 2,215 | 5 | 20 |
| Pears | 2,275 | 552 | 16 | 126 | 397 | 1 | 12 |
| Plum | 3,267 | 692 | - | 129 | 460 | 8 | 95 |
| Walnut | 1,710 | 1,449 | 115 | 313 | 1,021 | - | - |
| Almond | 332 | 142 | 5 | 72 | 65 | - | - |
| Persimmon | 1,032 | 490 | 3 | 65 | 330 | 5 | 87 |
| Others | 15,878 | 4,103 | 264 | 390 | 3,240 | 14 | 195 |
| Total | 22,218 | 6,876 | 387 | 969 | 5,116 | 27 | 377 |
| Rabi Vegetable | | | | | | | |
| Tulip | 2,085 | 528 | 32 | 168 | 240 | 5 | 83 |
| Spinach | 1,197 | 377 | 8 | 22 | 270 | 10 | 67 |
| Tomato | 2,786 | 1,268 | 15 | 23 | 422 | - | 808 |
| Cauliflower | 1,614 | 238 | 16 | 5 | 160 | 6 | 51 |
| Radish | 744 | 310 | 20 | 81 | 150 | 11 | 48 |
| Others | 2,302 | 282 | 126 | 11 | 116 | 11 | 18 |
| Total | 10,728 | 3,003 | 217 | 310 | 1,358 | 43 | 1,075 |
| Rabi Orchard | | | | | | | |
| Citrus | 3,911 | 1,789 | 1 | 504 | 790 | 60 | 434 |
| Others | 3,016 | 240 | - | 71 | 55 | 2 | 112 |
| Total | 6,927 | 2,029 | 1 | 575 | 845 | 62 | 546 |

### 3) Present Condition of Irrigation

Prevailing irrigation method at the Project site is the furrow irrigation by private canals covering 59 % of the total irrigated area. Sprinkler irrigation is not applied yet. In general, tubewell irrigated area varies from 10 to 40 ha. The percentage of the irrigated area is low compared with other parts of Pakistan, specially in Swat and Bunir Districts. Because of this reason, demand for installation of tubewells is high and interested farmers have to wait to have tubewells installed by the Directorate of Agricultural Engineering. The irrigated area is as shown in Table 2.3.13 .

2.3.13 Irrigated Area (ha)

| | Malakand Div. | Chitral Dist. | Dir Dist. | Swat Dist. | Bunir Dist. | Malakand Agency |
|---|---|---|---|---|---|---|
| Public Canal | 20,585 | 309 | 2,670 | 1,550 | 2,350 | 13,706 |
| Private Canal | 110,533 | 16,220 | 49,141 | 31,220 | - | 13,952 |
| Tank | 22 | - | - | - | - | - |
| Tubewells | 3,719 | - | 1,963 | 379 | 1,050 | 327 |
| Shallow wells | 12,829 | - | 190 | 9,150 | 1,110 | 2,379 |
| Lift Pump | 21,359 | - | 180 | 17,000 | 1,400 | 2,779 |
| Others | 17,338 | - | 631 | 10,105 | 5,639 | 1,233 |
| Total | 186,385 | 16,529 | 54,797 | 69,404 | 11,279 | 34,376 |

(6) Social Infrastructure

1) Roads

The main roads in the Project area are as follows;

- Road from Malakand to Kalam along the Swat river (Provincial Primary highway)
  This road runs through Malakand Division and is the Division's most important road. Improvement works are being carried out in the upper Swat area, from Baharain to Kalam, with foreign finance. In the Lower Swat area, there is a paved road from Kabal to Matta, which runs parallel to the main road on the opposite bank of the Swat river.

- Barikot - Daggar - Totali road (Provincial Secondary Highway)
  This road connects Barikot and Totali, which are on the main road from Swat to Daggar, which is the center of Bunir. This road is the trunk road of Bunir and runs through the Sub-division reaching Mardam.

- Khawazakhela - Alpuri - Besham road (Provincial Primary Highway)
  This road connects Khawazakhela, on the main road of Swat, and Besham on the Karakoram National highway, via Alpuri which is the capital of Shangla Par. This road is the trunk road of Shangla Par.

2) Power Demand and Supply

The domestic and commercial consumption constitutes 97% of the total electricity consumption, while industrial and irrigation consumption, the latter mainly for tubewell and lift pumps, constitute 2 and 1 % of the total consumption, respectively. The coverage of electricity supply is estimated at about 30% of the total households. Electricity supply to lift pumps for irrigation and drinking water is very important. However electric supply for drinking water supply is a problem due to the expansion of the water supply schemes and the negative attitude of the public to pay the charges. The schools, hospitals and other public facilities in the rural area do not have sufficient electricity supply.

The electricity supply system of WAPDA covers the midstream and the lower stream areas of the Swat river and Bunir, and are fairly maintained. However, electricity supply systems in the Upper Swat area and Shangla Par depend on mini-hydro power schemes which have very limited coverage.

(7) Present Condition of the Groundwater Development and Irrigation Project

1) Present Situation of Groundwater Development

1) Well Construction Works in NWFP

a. Executing Organization of the Well Construction

The groundwater development is being basically executed by the following organizations.

Agricultural Engineering Department

The Department is an executing organization of the Project. Private wells have been constructed in farmer's land on request by the farmers. Part of expense for the construction of the facilities was a subsidy.

Public Health Engineering Department

Wells are constructed by the Public Health Engineering Department to secure domestic water in the rural area. The majority of the wells in NWFP were constructed by this organization.

Irrigation Department

The well construction has been carried out to provide public facilities of auxiliary sources of surface water irrigation. However, generally the wells have been constructed for groundwater investigation and basically transferred to the farmers.

WAPDA

The well construction is carried out for hydrogeologic investigations. These investigations are generally executed by requests of the organizations mentioned above. The facilities constructed are transferred to the organizations after the completion of the investigation. The requests are mainly from the Public Health Engineering Department. The requests from the Agricultural Engineering Department to WAPDA are made in case technical problems exist .

3)Actual Situation of Well Construction by the Ministry of Agriculture

a. Results of Well Construction

The Agricultural Engineering Department began to construct wells in 1960. The number of constructed wells was 1,163 by 1970 and 2,024 in the period 1971-1980. The 1,000 Well Construction Program per every five years began in the sixth five-year plan, and the Program continues up

to the present. The well construction in Malakand Division has been carried out around Malakand Agency, Swat District, and Dir District since 1980. The construction results of the Agricultural Engineering Department show that the target of 1,000 wells established by the Ministry of Agriculture was almost achieved in five years (1988-1992) in the entire state as shown in Table 2.3.14.

Table 2.3.14 Well Construction Results Since the Sixth Five-year Plan by the Ministry of Agriculture

| | Year | NWFP | Malakand Div. | Malakand Agency | Swat District | Dir District |
|---|---|---|---|---|---|---|
| S | 1984 | 137 | 26 | 21 | 4 | 1 |
| i | 1985 | 175 | 32 | 22 | 6 | 4 |
| x | 1986 | 159 | 30 | 19 | 5 | 6 |
| | 1987 | 175 | 36 | 26 | 4 | 6 |
| | 1988 | 130 | 38 | 20 | 10 | 8 |
| S | 1989 | 100 | 20 | 7 | 7 | 6 |
| e | 1990 | 205 | 38 | 22 | 8 | 8 |
| v | 1991 | 296 | 54 | 24 | 17 | 13 |
| e | 1992 | 200 | 46 | 26 | 12 | 8 |
| n | 1993 | 205 | 40 | 18 | 13 | 9 |
| E | 1994 | | 26 | 8 | 12 | 6 |
| i | | | | | | |
| g | | | | | | |
| h | | | | | | |
| t | | | | | | |

The capacity of construction in Malakand Division is considered to be about 40 wells a year judging from previous experiences of the Agricultural Engineering Department. The life of the wells ranges between 13 to 25 years. The standard life of the well facilities is set by the Ministry of Agriculture as 15 years on average. Table 2.3.15 below shows the drilling results data of the period 1983-88 and the drilling results of Malakand Division in 1993-94.

Table 2.3.15 Results of Well Drilling

| | NWFP | | | Malakand Div. | | |
|---|---|---|---|---|---|---|
| | No. | L (m) | m/well | No. | L (m) | m/well |
| 1983 | 129 | 5,883 | 46 | 21 | 1,567 | 77 |
| 1984 | 143 | 5,530 | 37 | 24 | 587 | 24 |
| 1985 | 151 | 6,845 | 45 | 37 | 1,035 | 28 |
| 1986 | 136 | 7,159 | 53 | 30 | 1,581 | 53 |
| 1987 | 126 | 7,242 | 57 | 36 | 805 | 22 |
| 1988 | 139 | 7,395 | 53 | 14 | 685 | 49 |
| 1993 | | | | 20 | 1,175 | 59 |

The drilling ability improves every year and the construction ability after 1986 is 7,000m/year or more in NWFP. However, in Malakand Division, the deviation varies greatly year by year and the average depth reduction is 30-80m.

b. Situation of well construction

Drilling speed(m/day) and construction expenses per meter are estimated based on the construction results of 1993-94 of the Agricultural Engineering Department as shown in the Table 2.3.15.

The drilling speed is about 1.4m/day and 42 days are required in average to drill a well of 60m deep, according to Table 3.6.3. It is therefore estimated that the number of wells to be constructed within a year is 4.9 wells in average based on the drilling speed, the working days (205) during a year for field drilling works(assuming 250 total working days per year, 20 days for maintenance works and (de-)mobilization and 25 rainy days, which is 10% of the working days in a year). Therefore, the standard of 5 wells/year of the Ministry of Agriculture, based on its experience, is judged as accurate.

Expense of construction per meter (amount bearded by the farmer) becomes 4,000 Rs. and 244,000 Rs./well.

Table 2.3.16 Period of Well Construction and Cost

| Well Depth (m) | Drilling Period (day/well) | Cost of well Installation (Rs 1,000) |
|---|---|---|
| 56 | 40 | 240 |
| 98 | 86 | 350 |
| 91 | 65 | 340 |
| 57 | 60 | 325 |
| 56 | 48 | 340 |
| 44 | 54 | 280 |
| 34 | 39 | 210 |
| 91 | 52 | 350 |
| 57 | 40 | 200 |
| 51 | 88 | 180 |
| 61 | 27 | 230 |
| 57 | 36 | 300 |
| 49 | 25 | 340 |
| 36 | | 250 |
| 63 | 15 | 220 |
| 41 | 20 | 100 |
| 57 | 43 | 170 |
| 51 | 22 | 150 |
| 76 | 64 | 170 |
| 49 | 23 | 130 |
| 1,175 | 847 | 4,875 |

Note: Government expense is not included

(4) Drilling Efficiency and Working Days

1) Current status of the Agricultural Engineering Department

As mentioned above, existing well construction records indicate that the drilling efficiency is 4.9 wells/year/rig and drilling speed is 1.4m/day. However, the efficiency is estimated assuming the use of low drilling capacity equipment such as power winches. On the other hand, NWFP requires the following working days to construct a well of 60-100m deep drilling with percussion equipment.

- Percussion Method

| | |
|---|---|
| . Mobilization and Preparation Work | 2 days |
| . Drilling Works | 27 days |
| . Casing works and gravel pack | 4 days |
| . Pumping test (including preparation and analysis) | 5 days |
| . Pump facilities preparation | 1 day |
| . Foundation works | 4 days |
| . Pump installation | 2 days |
| . Demobilization | 2 days |
| | 47 days |

Rotary Rig

| | |
|---|---|
| . Mobilization and Preparation Work | 5 days |
| . Drilling Works | 16 days |
| . Casing works and gravel pack | 1 days |
| . Pumping test (including preparation and analysis) | 5 days |
| . Pump facilities preparation | 1 day |
| . Foundation works | 4 days |
| . Pump installation | 2 days |
| . Demobilization | 4 days |
| | 38 days |

Thus, the standard number of necessary days to construct a well with the rotary method is 38 and 47 days with the percussion method. The drilling speed determined by the standard working days is about 5m/day with rotary drilling equipment and 3m/day with percussion drilling equipment.

(5) Well structure

To be subjected to the government subsidy, it is a basic condition to install pump facilities that allow the well to pump up more than 1cusec (1.7m3/min.) of water as established by the Agricultural Engineering Department Standard. However wells with pumping rate of 0.5 cusec to 1 cusec are still judged as successful and those with less than 0.5 cusec are considered as failures. Any expense on pump facilities for unsuccessful wells are not provided by the Government and generally are paid by the farmers themselves.

Data of existing wells, such as depth of aquifer, length of screen, and diameter, investigated by the Agricultural Engineering Department and by WAPDA, are summarized in Table 3.6.4 below.

(6) Parameter of existing well

Existing wells in broad Alluvial plain and Alluvial fans are 70m deep in average (50-100m deep) and the groundwater table of the wells ranges within 15m-40m deep (30m deep in average). Wells along river valley in hilly lands range within 65-150m deep (90m deep in average) and groundwater table of the wells is 35-60m deep(45m deep in average. The installation depth of the screen is 15-35m (about 20m in average) and the diameter of the screen is 10 inches in general.

(7) Standard geological feature composition.

The rate of the boulder layer where drilling is difficult is estimated at 43%, as given in Table 2.3.17.

Table 2.3.17 Thickness of Boulder Layer

| Well Depth | Thickness of Boulder Layer (m) | % of Boulder Layer within total depth |
|---|---|---|
| 113 | 20 | 18 |
| 84 | 37 | 44 |
| 84 | 57 | 68 |
| 129 | 88 | 68 |
| 175 | 42 | 24 |
| 90 | 17 | 19 |
| 100 | 72 | 72 |
| 91 | 87 | 96 |
| 100 | 16 | 16 |
| 80 | 25 | 31 |
| 130 | 49 | 38 |
| 1,176 | 510 | 43.4 |

Materials other than the boulder layer are generally gravel and/or few clay.

| | | Well Depth (m) | G-water Table (m) | Screen Depth (m) | Diameter (inch) |
|---|---|---|---|---|---|
| A Broad Alluvial Plain | | 97 | 25 | | |
| | | 91 | 54 | | |
| | | 91 | 27 | | |
| | | 57 | 27 | | |
| | | 61 | 31 | | |
| | | 57 | 27 | | |
| | | 49 | 27 | | |
| | | 62 | 21 | | |
| | | 57 | 25 | | |
| | | 51 | 22 | | |
| | | 76 | 43 | | |
| | | 49 | 23 | | |
| | mean | 67 | 29 | – | – |
| C Alluvial Fans to Main River | | 56 | 31 | – | – |
| | | 57 | 26 | – | – |
| | | 56 | 34 | – | – |
| | | 44 | 31 | – | – |
| | | 34 | 16 | – | – |
| | | 51 | 30 | – | – |
| | | 36 | 27 | – | – |
| | | 41 | 16 | – | – |
| (ADINZAI Area) | | 62 | – | 19.5 | 10 |
| | | 66 | – | 18.3 | 8 |
| | | 64 | – | 24.4 | 8 |
| (DAGGAR VALLEY) | | 113 | 37 | 12.2 | 10 |
| | | 84 | 5 | 29.6 | 10 |
| | | 84 | 16 | 35.4 | 10 |
| | | 129 | 30 | – | – |
| | | 100 | 24 | – | – |
| | | 102 | 36 | – | – |
| | | 91 | 58 | – | – |
| | | 100 | 25 | – | – |
| | | 130 | 30 | – | – |
| | mean | 75 | 28 | 23.2 | – |
| D River Basin in Hilly Lands (TALASH Area) | | 75 | 27 | 24.0 | 8 |
| | | 66 | 35 | 18.3 | 8 |
| | | 90 | 59 | 15.9 | 8 |
| | | 65 | 49 | 18.3 | 8 |
| | | 144 | 55 | – | – |
| | mean | 88 | 45 | 19.1 | – |

## 2-3-3 Operation and Maintenance

### (1) Existing System for Tubewell Construction

The first step to be taken for the construction of tubewells for irrigation is for a farmer or a group of farmers to apply to DAE for drilling after he or they have secured a fund. The promoters of the projects are the farmers themselves, while all the concerned government agencies coordinate to assist them in financial and technical aspects of the project. Funds are credited by the Agricultural Development Bank of Pakistan (ADBP), while subsidies are granted by the government of N.W.F.P. On the other hand, the DAE undertakes the groundwater survey, the drilling work and the technical support for operation and maintenance of installed tubewells. Farmers are responsible for the repayment of credits and procurement of all the materials for tubewell construction such as well casings, screens, pumps, generators, etc. as well as for the operation and maintenance of their own tubewells. The Irrigation Department also plays a role in the projects, providing technical advise on how to direct irrigation water to farmland. Fig. 2.3.10 shows schematically the flow of the execution of the projects.

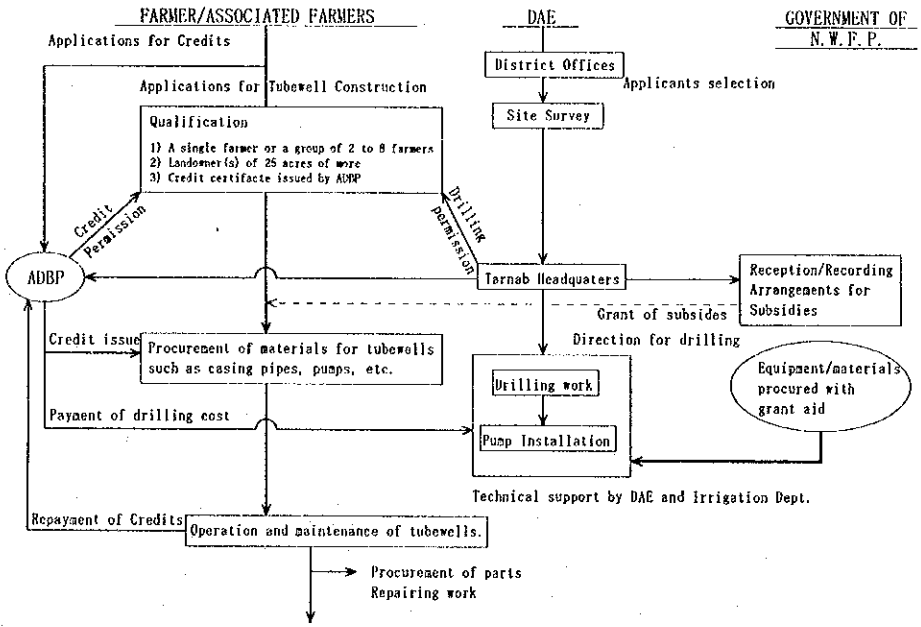



Fig 2.3.10 Scheme for Tubewells Construction

Any farmer who owns 25 acres of farmland or more, and any group of small farmers whose lands sum up to the required level are qualified to apply for tubewell construction, proved that he or they have the credit certificate issued by the ADBP. The applications for drilling are examined by DAE. Although its guidelines to pick up applicants remain unveiled, the decision seems to be made in view of (1) hydrogeological features of sites, (2) ongoing schedule for equipment posting, (3) order of applications, and (4) number of wells planned to be installed for the year. Remaining applications are likely to have priority in the following year's selection.

(2) Construction cost of Tubewells

15% of construction cost of tubewell is borne by the government subsidy and the rest is charged to the beneficiary farmer. The Directorate of Agricultural Engineering charges the following costs for drilling;

| | | | |
|---|---|---|---|
| - | Percussion rig | : | Rs 69/feet |
| - | Rotary rig (New) | : | Rs 186/feet |
| - | Rotary rig (Old) | : | Rs 91/feet |
| - | Power Winch | : | Rs 69/feet |
| - | Hand Plant | : | Rs 13/50/feet |

Estimated tubewell installation costs in Barani and other areas are shown in Table. 2.3.18.

Table 2.3.18 Construction Cost of Tubewell

| Area | Barani Area | Other Area |
|---|---|---|
| Standard Well Type | Depth :90m, Diameter: 12.5' | Depth 60m , Diameter 12.5' |
| Boring charge of tube-wells | 55,800 | 13,800 |
| Footage allowance | 37.5 | 23.5 |
| Depreciation Charge | 100 | 100 |
| Shifting and mobilization charge | 10,000 | - |
| 8" M.S lining pipe | 34,000 | 25,600 |
| Bross Strainer | 59,800 | 33,120 |
| One Bail Plug | 560 | 560 |
| Labor | 24,000 | 24,000 |
| Surrounding Material | 5,000 | 2,500 |
| Development Charge | 6,500 | 6,500 |
| Construction of Pumping House | 34,000 | 34,000 |
| Pumping Set 4' x 5' | 28,000 | 28,000 |
| Installation of Pumping Set | 2,000 | 1,500 |
| Main Switch One | 5,500 | 7,000 |
| Internal Electrification Charge | 5,000 | 5,000 |
| Starter One No. | 3,500 | - |
| | 269,797 | 187,203.5 |
| | (270,000) | (187,000) |

For instance, in the case of the installation of a tubewell 90 m deep, with rotary rig, the subsidy accounts for 40,000 rupees. The Directorate of Agricultural Engineering charges the benefiting farmer in concept of drilling charge, footage allowance, depreciation charge, shifting and mobilization charge and development charge, accounting for approximately 66,000 rupees. The remaining expenses are also to be paid by the benefitingy farmer.

(3) Conditions of Existing Drilling Equipment

1) Existing Drilling Equipment

The existing drilling equipment owned by DAE is classified into four types, depending upon their mechanism; (1) truck-mounted rotary rigs, (2) percussion rigs, (3) power winches operated with a winch and a tripod and (4) hand plants of percussion type operated manually with a tripod. Table 2.3.19 shows the list of these types of drilling equipment.

Table 2.3.19 List of Existing Drilling Equipment

| Type of Equipment | No.of Units | Condition | Remarks |
|---|---|---|---|
| Rotary Rigs | 5 | In service | Four (4) units were procured by Japan's preceding grant aid projects. |
| | 3 | Unusable | |
| Percussion Rigs | 0 | In service | |
| | 4 | Unusable | |
| Power Winches | 25 | In service | Include those under repair |
| | 0 | Unusable | |
| Hand Plants | 18 | In service | |
| | 3 | Unusable | |

The total number of machines so far employed amounts to 58 units, among which 48 units remain sound for operation. The following table shows the distribution of these usable machines in the divisions of N.W.F.P. province.

Table 2.3.20 Locations of Drilling Equipment

| Name of Division | Type of Machine | Unit No. | Remarks |
|---|---|---|---|
| Peshawar | Rotary Rigs | 1 | Japan's grant aid project |
| | Power Winches | 4 | |
| | Hand Plants | 4 | |
| Mardan | Rotary Rigs | 1 | |
| | Power Winches | 2 | |
| | Hand Plants | 1 | |
| Kohat | Power Winches | 1 | |
| Karak | Power Winches | 1 | |
| | Hand Plants | 1 | |
| DI. Khan | Rotary Rigs | 1 | Japan's grant aid project |
| | Power Winches | 9 | |
| Bannu | Power Winches | 5 | |
| | Hand Plants | 4 | |
| Haripur | Rotary Rigs | 1 | Japan's grant aid project |
| Abbottabad | Hand Plants | 4 | |
| Malakand (*) | Rotary Rigs | 1 | Japan's grant aid project |
| | Power Winches | 1 | |
| Swat (*) | Power Winches | 2 | |
| Dir (*) | Power Winches | 2 | |
| | Hand Plants | 2 | |
| Total: | | 48 | |

Note: The divisions with an asterisk mark are the sites covered by this Project.

In addition, DAE has a fleet of support vehicles as listed in the following table.

Table 2.3.21 List of Support Vehicles

| Category | Type | Unit No. | Remarks |
|---|---|---|---|
| Trucks | 6 to 10-ton cargo trucks | 56 (3) | |
| | Water tank trucks | 4 (1) | One each for rotary rigs |
| Vehicles for Passengers | 4-wheel drive (small) | 11 (3) | |
| | 4-wheel drive (middle) | 5 (1) | |

Note: The numbers in the parentheses are the units stationed in the Project areas.

(4) Existing Maintenance System

Major repairs of drilling materials and equipments are undertaken by two large-scale workshops at Tarnab in Peshawar district and at DI. Khan in DI. Khan district, while minor repairs including replacement of parts are handled by the

workshops in each district or by the drillers at site. The current practice of maintenance in these workshops is found to include some remarkable efforts as described herein:

a. Each kind of spare part has its own classification card, and stocks of spare parts are monitored and controlled constantly through management of these tags.

b. In case stocks of any spare parts run short, those that can be fabricated or molded at the workshops are directly produced, using their own facilities and equipment tools such as lathes or furnaces.

c. The power winches, which have so far been the mainstream drilling equipment in the province, are produced by the workshops with a combination of engines from abandoned bulldozers and used winches.

d. The percussion rigs introduced in the 1960s remained in service for nearly 30 years, as they underwent repeated repairing at these workshops.

These efforts show DAE's attitude to try to get the maxim benefit through proper management and maintenance under limited conditions. Although part of the equipments have now been left out of service, such situation arose because of lack of or unavailability of necessary parts, or equipments working far beyond their service lives. Parts of abandoned equipment, however, have been fully utilized as supplies of other usable machines.

(5) Comments on the Existing Maintenance System

In order to enhance the capabilities of local offices for maintenance and management, DAE is currently working hard to reinforce the district offices without workshops. In the Project area, a workshop is now under construction for Swat district, with the arrangements for its staffing already completed. With this measure, three districts of Malakand, Dir and Swat among five in the Project

area are satisfactorily equipped with facilities for relevant maintenance. Concerning workshops, it can be said that the current facilities together with their staff with high capabilities for management and maintenance will not raise any question about dealing with the supplies under this Project.

Contacts between headquarters, district offices and drilling sites, delivery of parts to the sites and dispatch of personnel for repairing, etc. all depend on vehicles for transportation. However, the existing fleet currently stationed for the entire division of Malakand is far from adequate in view of its broad area and bad road conditions, being composed of only 3 trucks with 6-ton payload capacity, 3 light-size 4-wheel drive vehicles and 1 mid-size 4-wheel drive vehicle,

In view of the current situation thus described, the following points are recommended to be taken into account for further enhancing DAE's capability for management and maintenance.

a. It is proposed that a workshop is planned for Bunir district since the area has a high priority in drilling work under the Project.

b. DAE shall formulate a plan to increase the number of vehicles, particularly pickup trucks usable for various purposes such as contacts between the concerned offices, parts delivery and transportation of personnel.

# CHAPTER 3 BASIC DESIGN

# CHAPTER 3 BASIC DESIGN

## 3-1 Concept for the Basic Design

The basic design was carried out assuming that the capacity of the drilling machines to be procured under this project is appropriate to drill 25 tubewells a year in accordance with the Five Year drilling plan at Malakand Division. For the selection of type and number of the drilling machines, geological condition of the site and drilling capacity of the existing equipment were taken into consideration. Design criteria used for the determination of the type and number of machinery are as follows;

## 3-2 Study and Examination on Design Criteria

### (1) Geological Characteristics of Formation to be Drilled

Materials to be drilled under the Project are alternation of boulder formation with sand/gravel layers (see Photo). The formation is quite different from the formation in central to southern parts of NWFP, which is formed by thick alluvial deposits of fine to medium texture. The rotary rig which was provided under a previous Grant Aid Program of Japan, is considered to be suitable for the thick deposits of fine to medium texture. On the other hand, the formation that is found in the Project Area mainly consists of ø20-100cm boulder and sandy matrix. Thus, the equipment shall be suited to the conditions of the materials to be drilled. Generally the percussion rig is considered as suitable for this formation.

### (2) Thickness of the Formation and Depth of Groundwater Table

Thickness of the formation to be drilled is estimated at 50-150m. The groundwater could flow in layers of high permeability along the basal rocks. The water table is generally deep (30-70m) in the center of alluvial fans and shallow on their edges.

Based on the hydro-geological conditions, wells with the following parameters shall be constructed to catch enough groundwater for irrigation in the central part of the alluvial fans where the surface water irrigation system can not be applied.

. Depth 60-100m (max. 150)
. Water table 20-70m under GL

Therefore, for the selection of the drilling equipment, maximum standard drilling depth of 150m and planned drilling depth of 80m deep in average shall be considered.

(3) Well Yield

Permeability of the aquifer in the area is estimated at $5x10^2$ - $5x10^3$ $m^2$/day (0.35 $m^2$/min-3.5$m^2$/min) and $1x10^3m^2$/day (0.69$m^2$/min) in average as mentioned above. Table 3.2.1 shows the relationship between well yield and diameter of well at the Permeability of $1x10^3m^2$/day.

Table 3.2.1 Well Yield

| Diameter (cm) | A : Circumference (m) | Yield ($m^3$/min) Permeability x A |
|---|---|---|
| 15 | 0.47 | 0.32 |
| 20 | 0.63 | 0.43 |
| 25 | 0.79 | 0.55 |
| 30 | 0.94 | 0.65 |
| 35 | 1.10 | 0.76 |
| 40 | 1.26 | 0.85 |
| 45 | 1.41 | 0.97 |

The diameter of well shall be ø40cm (16") at least to pump up more than 0.5 cusec-1cusec (0.85$m^3$-1.7$m^3$/min). Thus, the designed drilling diameter shall be 18' - 22'.

(4) Geological Condition of the Area to be Drilled

Design formation consists of 2 layers as given in Table 3.2.2.

Table 3.2.2 Design Formation and depth to be Drilled

| | % | Depth (m) |
|---|---|---|
| Boulder layer | 43.4 | 35 |
| Sand/Gravel layer | 56.6 | 45 |
| Total | 100 | 80 |

(5) Days Required for Drilling Works

1) Annual Working Days

205 working days a year is considered as standard in Pakistan for field drilling works. The number of working days is estimated with the following assumptions.

| | |
|---|---|
| . Gross Working Days | 250 days |
| . Maintenance/mobilization | 20 days |
| . Rainy days (10% of working days) | 25 days |
| . Net working days | 205 days |

2) Design Working Days for Drilling Works

Number of working days required for drilling works by the percussion method is determined considering the drilling efficiencies of both the Japanese Association of Well Drilling (JAWD) and the Japanese Association of Geological Surveys (JAGS). The following drilling speed and number of working days are estimated considering the drilling efficiencies, the design formation to be drilled and a bit weight of 2 ton.

Table 3.2.3 Design Working Days Required for Drilling Works

| | | Drilling speed by 2 ton bit (m/day) | Design Depth (m) | Working Days for Drilling (days) |
|---|---|---|---|---|
| JAWD | Boulder layer | 2.5 | 35 | 14 |
| | sand/gravel layer | 4.8 | 45 | 10 |
| JAGS | boulder layer | 2.1 | 35 | 17 |
| | sand/gravel layer | 6.4 | 45 | 7 |

* Diameter to be drilled is ø500mm

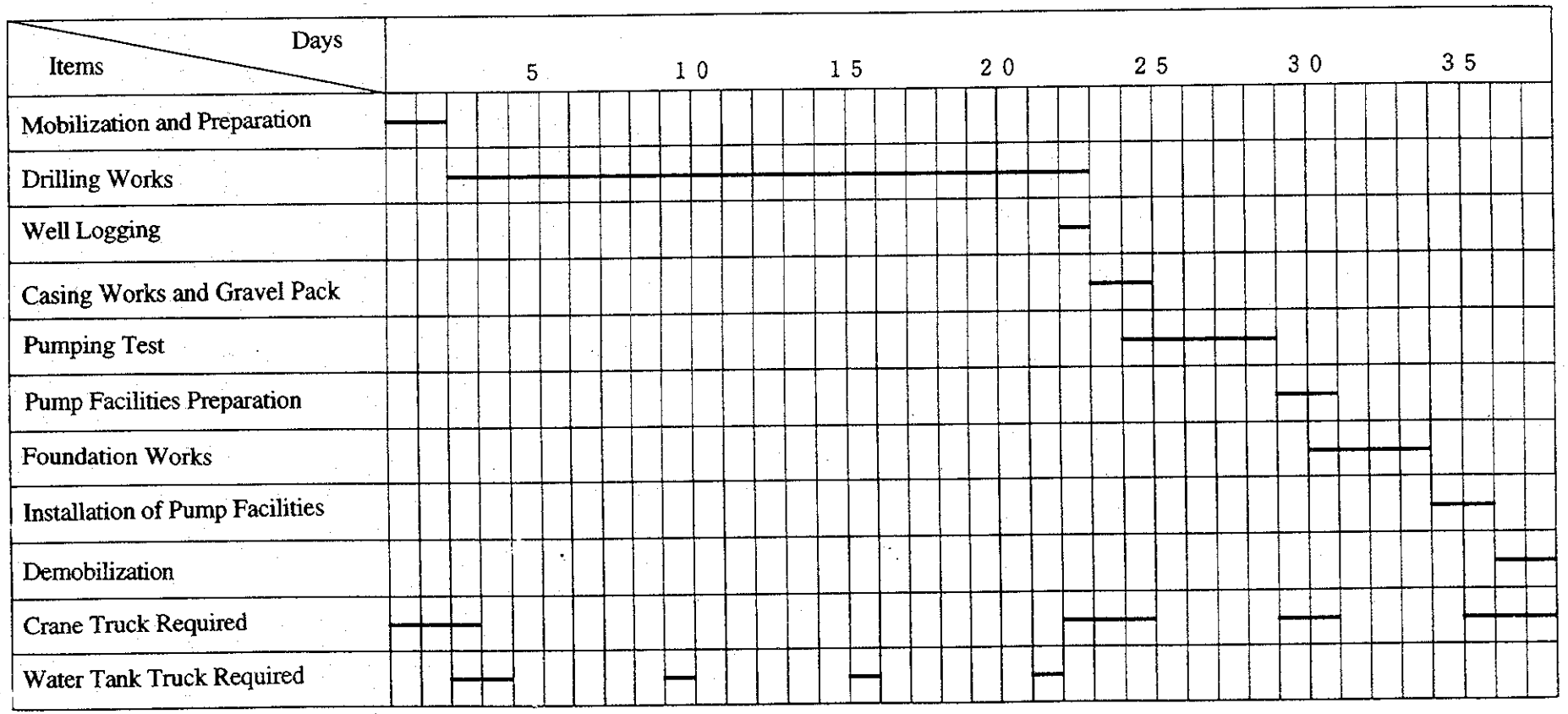
As a standard drilling day, the JAGS standard is employed. Therefore, 14 working days to drill boulder layer and 7 working days to drill sand/gravel layer are set up as standard design working days.

The days required for drilling in the "open hole percussion" method is equivalent to an average drilling speed of 4.5m/day and days for mobilization/demobilization are considered to be similar to those required in the "cased hole percussion" method.

Based on the number of days for drilling mentioned above and other works required, the following number of working days for construction works per well are required as a standard for the project.

| | |
|---|---|
| . Mobilization and Preparation Works | 2 days |
| . Drilling Works | 21 days |
| . Casing works and Gravel Pack | 1 day |
| . Pumping Test (including preparation and analysis) | 5 days |
| . Pump Facilities Preparation | 1 day |
| . Foundation Works | 4 days |
| . Pump Installation | 2 days |
| . Demobilization | 2 days |
| | 38 days |

Design work schedule for well construction is presented in Fig. 3.2.1 .




*Days required are presented by actual work days and work days per month is 20 days/month.
Well Designed: Depth=80 m, Diameter=18 in., Formation to be Drilled=boulder layer of 35 m and sand/gravel layer of 45 m.

Fig. 3.2.1 Well Construction Schedule

(6) Examination of Design Criteria

The following design criteria were taken into account to determine the number and the specifications of equipment.

1) Target Aquifer to be drilled

The target aquifer is a 50 to 150m thick boulder and sand/gravel formation that is widely distributed throughout the Project Area (Malakand Division). Design water table is 30 to 70m deep (50m in average) and maximum depth of dynamic water table is 85m deep, and the capacity of the rig shall be required to drill the depth of 150m.

2) Drilling Program

As mentioned above, 25 wells per year will be constructed in Malakand Division

3) Standard Design of Wells

To select the proper drilling rig and tools, it will first be necessary to decide upon the design of the well structures. Based on the results of the study, the maximum thickness of the target formations is considered to be 150m. Well diameters shall be 18 inches by taking into consideration the geological conditions, planned extraction, and the casing diameters to be provided. Since the conductor pipe will be installed near the top of the borehole, the drilling diameters shall be 26 inches. The upper part of the wells (10m to 30m ) shall be drilled using 26 inch bits. However, the actual drilling depth for the bits in use shall be determined by the driller who will take into account the hardness and weathering condition of the surface strata. The standard well structure designs are shown in Fig. 3.2.2. Combination of the casing pipes and arrangement of the casing and screen can be selected to correspond to the extraction rate and purpose of the wells.

Basic design conditions are summarized as follows:

a. Well diameters shall be 26 inches x 18 inches or 26 inches x 22 inches.

b. Maximum drilling depth shall be 150m. Conductor pipes shall be installed at 10m to 30m deep from the surface.

c. Maximum pumping head is 85m and the extraction rate is 1.7$m^3$/min. in pumping test.

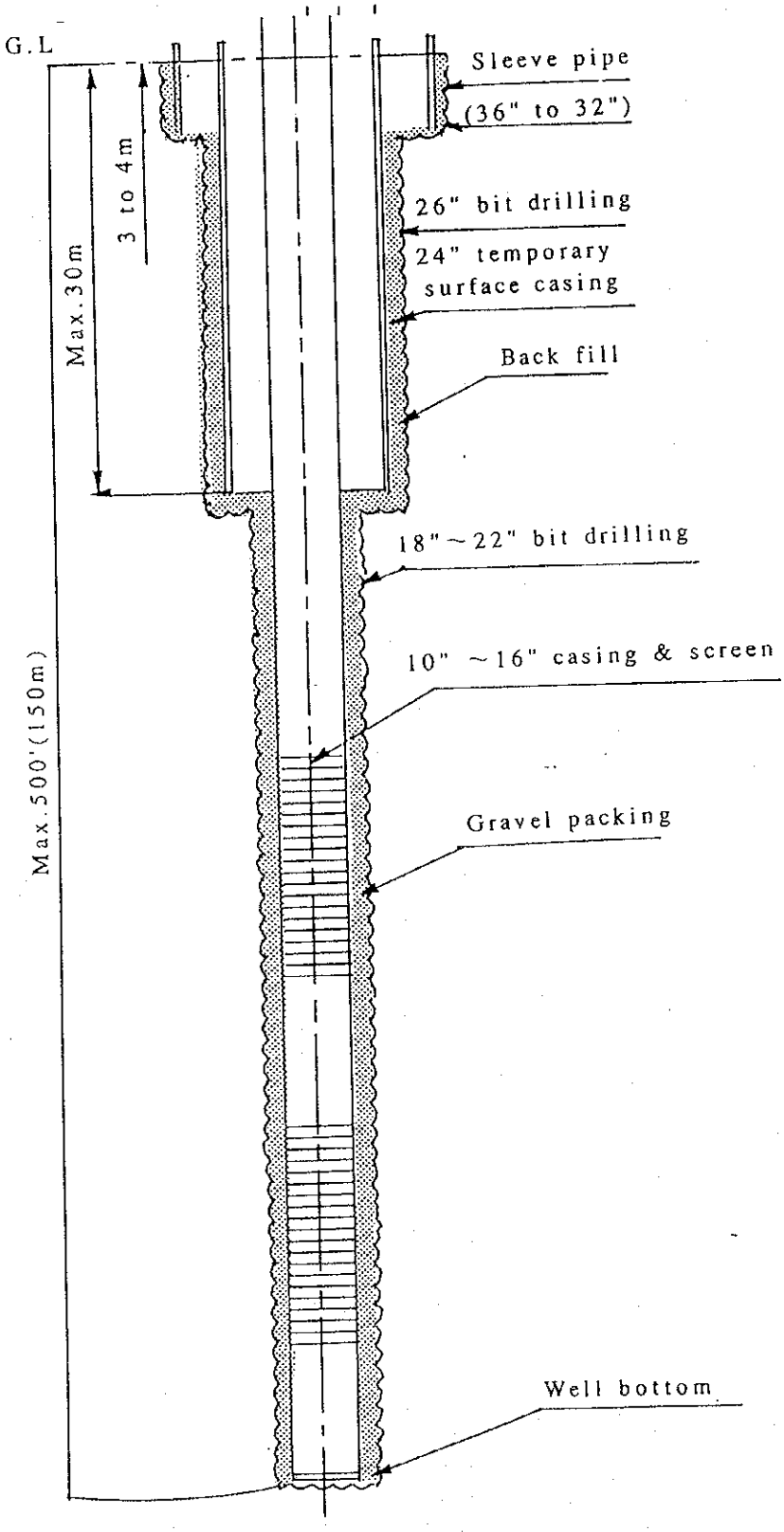



Fig. 3.2.2 Well Structure

## 3-3 Basic Plan

### 3-3-1 Equipment Plan

The following major equipment necessary for the implementation of the Project is selected based upon the results of the basic design plan described in the preceding section.

List of Well Construction Equipment

a. Percussion type drilling rigs and tools
b. Cargo trucks with crane
c. Water tank trucks
d. Double-cab pickup trucks
e. Pumping test equipment
f. Borehole logging equipment

The optimum types and capacities of the listed equipment are determined as follows:

(1) Percussion type drilling rigs and associated tools

1) Type of drilling rigs

The conventional drilling methods are largely divided into two types: "the rotary drilling method" which penetrates formations by rotating a drill bit and "the percussion drilling method" which break through formations with the up-and-down movement of a drill bit. Table 3.3.1 summarizes the comparison of the characteristics of these two methods. Either method has advantages and disadvantages, depending upon the feature of formations to penetrate, and the comparison shows that the percussion method is suitable for drilling sedimentary formations mainly consisting of cobbles and boulders.

Table 3.3.1 Comparison of Drilling Methods

| | Percussion Method | Rotary Method |
|---|---|---|
| Machine Structure | The power transmission system is of simple structure, composed of a mechanical winch, gearwheels, wire cables, etc. The percussion rig is usually smaller in size than the rotary one. | Power transmission is complex, involving both hydraulic and mechanical systems. Since the machine needs ancillary equipment such as mud pump for operation, its whole size becomes bigger than that of the percussion rig. |
| Capacity | During the operation, percussion drilling is suspended intermittently for removing cuttings by bailing. This process makes its drilling speed slow, compared with that for the rotary method. On the other hand, it assures more effective penetration through boulder/cobble-predominant formations, since it can precisely fracture them by delivering direct hitting with a heavy-duty drill bit. | Rotary drilling is regularly fast due to its continuous drilling operation enabled by mud circulation for the removal of cuttings while drilling proceeds. |
| Operation & Workability | The machine can be controlled without much difficulty, thanks to its simple mechanism and structure. Repairing bits does not require large equipment and is normally done at drilling sites. | The operation of a machine requires expertise in controlling hydraulic system, power transmission and mud circulation system. On-site repairing of bits is usually difficult. |
| Maintenance | The entirely mechanical construction of the machine can keep troubles/ damages to a minimal level, guaranteeing low cost for maintenance. | Special care is required for keeping hydraulic system in good order with daily inspection and maintenance work by an expert. |
| Geologic Information | Drill cuttings lifted in a bailer as drilling proceeds can offer samples of a formation just penetrated, which are helpful for obtaining its correct geological information. | Drill cuttings are lifted by circulating drill mud in suspension. The process tends to cause sorting of particles of fragmented formations during transportation, occasionally resulting in failing to provide accurate samples of the formation being penetrated. |

2) Percussion Drilling Method

Percussion drilling has two main variations: one is the open hole method and the other, the cased hole method. Pakistan has traditionally employed the latter, in which drive pipes are temporarily lowered right after drilling, for the purpose of protecting the borehole against caving. On the other hand, Japan has favored the open hole method, which protects the borehole with drill mud instead of pipes.

The same percussion machine can be applied for either method, with the only difference of drilling tools employed. For this Project, DAE is planning to adopt

the open hole method, since it is more advantageous in terms of cost and working period. Table 3.3.2 describes the comparison of these two sorts of percussion drilling.

Table 3.3.2 Comparison of the Open Hole and Cased Hole Methods

| | Open Hole Method | Cased Hole Method |
|---|---|---|
| Borehole Protection | This method uses drill mud to protect a borehole against caving. Lack of care for mud control leads to caving. | Drive pipes are installed right after drilling. Driving and/or pulling out pipes, however, they occasionally get stuck, depending upon the nature of formations, drilling depths or capacity of machines. |
| Drilling Depth | The machine can normally drill up to 300 m in depth. In Japan, the deepest borehole ever drilled was 500 m deep. | To reach greater depths, various sizes of drive pipes are necessary. Drilling proceeds with these pipes aligning in telescopic order from surface to bottom. Accordingly, deeper drilling by this method requires a heavier type of machine to withstand the weight of pipes. Drilling deeper than 100 m is not recommended for this method. |
| Drilling Speed | Drilling is fast, thanks to lack of processes of pipe driving and pulling-out. | The whole operation takes much more period of time than the open hole method. |
| Well Development | The use of drill mud during drilling demands longer and cautious development work to remove mud wall on the borehole. | Development work can have good effect, since no drill mud is used. |
| Aquifer Information | Drill mud filled inside the borehole during drilling does not allow collection of accurate information on possible aquifers. | When drilling reaches a probable aquifer, a rough estimate on its quantity and quality can be made by means of bailing. |

3) Selection of the Type of Drilling Machine

As a result of examination in the foregoing sections, the optimum type of drilling machine proposed for the Project is a percussion rig, which is suitable for the geological formations to be encountered in the Project site. The machine shall be mounted on a truck to cover a wide area of operation. It shall have capacity to drill up to 200 m with a borehole diameter of 18 in., based upon the well drilling plan. Based on the working days required for drilling works, five (5) units of drilling machines are required for the implementation of the Project.

4) Determination of the Number of Drilling Rigs

The optimum number of drilling rigs was determined based on the target number of tubewells to be constructed annually in the Malakand Division. Required number of working days was determined taking into consideration the geological condition and drilling efficiency of the percussion rigs to be procured. Working days in a year were estimated at 205 assuming 250 working days in a year as standard working days, 20 days for maintenance and mobilization works and 25 rainy days. The number of days required for a tubewell installation is;

| | |
|---|---|
| . Mobilization and Preparation Works | 2 days |
| . Drilling Works | 21 days |
| . Casing works and Gravel Pack | 1 day |
| . Pumping Test (including preparation and analysis) | 5 days |
| . Pump Facilities Preparation | 1 day |
| . Foundation Works | 4 days |
| . Pump Installation | 2 days |
| . Demobilization | 2 days |
| | 38 days |

Number of tubewells to be constructed by drilling rigs (drilling capacity)

= Working days/required period

= 205day/38day = 5.4 tubewells

Required number of machines

= Required number of tubewells/drilling capacity

= 25 tubewells/5.4 tubewells = 4.6 machines

= 5 machines

The required number of machines is 4.6. Thus, the optimum number of drilling rigs to be procured by this project is 5 machines.

(2) Cargo Trucks with Cranes

Cargo trucks with cranes shall be provided for transporting drilling tools, ancillary equipment and materials. To allow loading and unloading of heavier tools, the capacity

of cranes shall be no less than four (4) tons. In Pakistan where trucks with this heavy-duty crane are unavailable, loading and unloading for drilling works is mostly carried out by laborers. This practice requires painstaking and is time-consuming, requiring lots of hands. What is worse is that it puts laborers into high risk of injury as well as loads into risk of damage. The supply of the trucks with cranes for the Project can save much time and lower the risk involved in the work.

It is desirable that each drilling machine is equipped with one truck unit. For the Project, however, one (1) unit for two (2) drill rigs would be sufficient since it will be used mainly for loading works before and after drilling operation, assuming that the two rigs will be positioned in sites not so far from each other. The minimum number of trucks to support five rigs is therefore three (3) units.

(3) Water Tanks Trucks

For a smooth operation of drilling work, water for maintaining drill mud must constantly be supplied to the site for which water tank trucks are indispensable. Since the open hole method normally does not require as much water as the mud rotary method does, it is possible to share one water tank truck between two drill rigs, on the condition that each site has water storage tanks. Such arrangements can reduce the number of units to three (3) for operating five drill rigs.

(4) Double-Cab Pickup Trucks

The Malakand division office is at present equipped with barely seven vehicles including trucks, all of them in service beyond their normal service lives. Since the existing fleet is not enough to keep up with the demand of the crew for the Project, five (5) pickup trucks, one each for a rig, shall be provided in the Project.

(5) Pumping Test

Pumping tests are one of the essential elements of water well construction, providing accurate information on the potencial yield of aquifers. Water wells tapping aquifers of boulders distributed in the Project area are known to produce more than 2 tons/min in some places. Since pumps available from local manufacturers have limited capacities both in flows and heads, there are wells operating below their designed capacities, although their drilling costs are high.

Pumping test equipment is necessary to carry out tubewell development works. The open hole method to be employed by DAE for the Project uses highly viscous mud water for protecting drilled boreholes, resulting in shut pores or interstices on the borehole wall and in zones adjoinint to aquifers. Thus, to obtain the maximum production capacities of aquifers, immediately upon completion of drilling, mud filling these pores must be removed with the pumping test equipment.

In view of these conditions, pumping equipment shall be provided in the Project for both testing and development. Its capacity shall be no less than 2,000 liters/min. at a head of 90 m. A diesel power unit with a relevant output shall be provided for each unit. Two units of such pumping equipment can cover works done by five drill rigs. These units may be used for testing wells drilled by the existing six (6) machines whenever the schedule allows.

(6) Well Logging Equipment

The open hole method using drill mud offers only indirect information for the judgment of aquifers based on which well screens are to be installed, based only on drilling samples, experience of drillers and data from surrounding wells, if any. Geophysical logging of boreholes can help to correct the judgment on the position of well screens, based upon the distribution of resistivity through formations measured with an electrode lowering down the boreholes.

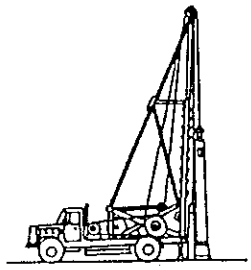
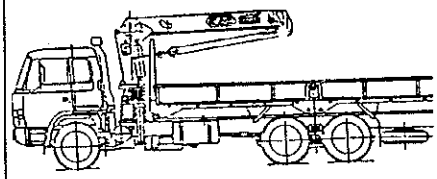
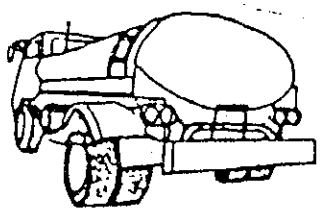
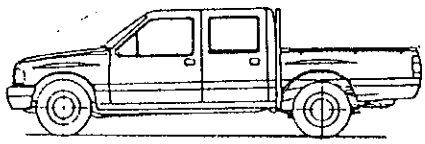
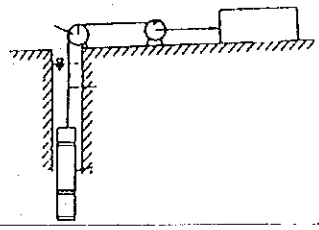
| Equipment | Specification | Q"ty | |
|---|---|---|---|
| Percussion Drilling Rig and Tools | Cable-tool Percusssion Drilling Rig Mounted on Truck (diameter:18 in., Depth: not less than 200m) | 5 units |  |
| Cargo Trucks with Crane | Payload Capacity: not less than 10 tons<br>Crane Capacity: more than 4 tons | 3 units |  |
| Water Tank Trucks | Capacity: 6,000liter and more | 3 units |  |
| Duble-cab Pickup Trucks | Seating Capacity: 6 or more | 5 units |  |
| Pumping Test Equipment | Capacity: 2,000liter/min. x 90 m | 2 sets |  |
| Well Logging Equipment | Capoacity: 200m | 1 set |  |

Fig 3.2.3 Equipment List

### 3-3-2 Specifications of Major Equipment

Based upon the results of the foregoing examination, the specifications of major equipment are determined as follows:

(1) Percussion Drill Rigs and Tools

a. Cable-tool percussion drill rigs mounted on trucks 5 units

- Capacity:
Capable of drilling not less than 200 m (660 ft.) in depth with a maximum borehole diameter of 450 mm (18 in.)

- Main structure:
Powered by a deck-mounted water-cooled diesel engine, the rig is equipped with bull reel, sand reel, casing reel, crank mechanism, lighting for night operation, etc. The mast is power-raised and lowered, and is equipped with wire line sheaves, shock absorber and other necessary accessories.

- Deck engine:
Water-cooled engine, having an output of not less than 55 ps

- Truck:

| | | |
|---|---|---|
| Drive system | : | 4 x 4 |
| Steering | : | Right hand |
| Accessories | : | Spare tire, hydraulic jack and standard hand tool kit |

b. Standard operational accessories

i. Drilling line wire ropes, 24 mm diameter 5 rolls

| | | |
|---|---|---|
| ii. | Sand line wire ropes, 12 mm diameter | 5 rolls |
| iii. | Casing line wire ropes, 18 mm diameter | 5 rolls |
| iv. | Travelling block for casing line, 30 tons | 5 pcs |
| v. | Mast-reinforcing legs/A-frame legs | 5 sets |
| vi. | Other necessary accessories | 5 sets |

c. Drilling tools

| | | |
|---|---|---|
| i. | Tubular bit for 26" diameter | 5 pcs |
| ii. | Tubular bit for 22" diameter | 5 pcs |
| iii. | Tubular bit for 18" diameter | 5 pcs |
| iv. | Bit gauge for 26", 22" and 18" bits | 5 sets |
| v. | Flat valve bailer, 14" O.D. | 5 pcs |
| vi. | Flat valve bailer, 12-1/2" O.D. | 5 pcs |
| vii. | Dart valve bailer, 12-1/2" O.D. | 5 pcs |
| viii. | Dart valve bailer, 8-1/2" O.D. | 5 pcs |
| ix. | Steel bailing ditch | 5 pcs |
| x | Wire grip for drilling line | 5 pcs |
| xi. | Wire clamp for drilling and sand line | 5 pcs |
| xii. | Solid type jar bumper, 150 mm diameter | 5 pcs |
| xiii. | Motor driven mud mixer | 5 sets |
| xiv | Sleeve pipe, 36" O.D., 2 m long/pc | 10 pcs |
| xv. | Surface casing, 24" O.D., 3 m long/pc | 20 pcs |
| xvi. | Casing clamp for 24" diameter | 5 sets |
| xvii. | Other necessary equipment | 5 sets |

d. Casing tools

| | | |
|---|---|---|
| i. | Casing clamp for 16" and 12-3/4" O.D. casing | 5 sets |
| ii. | Wrench and sling wire rope for clamps | 5 sets |

e. Fishing tools

| | | |
|---|---|---|
| i. | Fishing tools, hydraulic jack operated | 2 sets |
| ii. | Other necessary equipment | 2 sets |

f. Miscellaneous ancillary equipment and maintenance tools

| | | |
|---|---|---|
| i. | Oxygen/acetylene cutting and welding equipment | 5 sets |
| ii. | Diesel engine driven welder with accessories and welding electrodes | 5 sets |
| iii. | Diesel engine driven generator for mud mixer and pump etc., 17 KVA/AC440 V/3-phase | 5 sets |
| iv. | Folding water tank, 1,500-liter capacity | 5 sets |
| v. | Engine driven wire rope winding machine | 5 sets |
| vi. | Other necessary equipment | 5 sets |

(2) Support Vehicles

a. Cargo trucks with cranes 3 units

- Truck:

GVW: Not less than 26,000 kgf

Engine: Water-cooled diesel, not less than 260 ps

Payload capacity: Not less than 10 tons

- Crane:

Capacity: 4 tons

Boom: 2 sections

b. Water tank trucks 3 units

- Truck:

GVW: Not less than 10,000 kgf

Engine: Water-cooled diesel, not less than 160 ps

- Water tank:

Capacity: 6,000 liters or more

c. Double-cab pickup truck 5 units

- Truck:

GVW: Not less than 2,000 kgf

Engine: Water-cooled diesel, not less than 60 ps

Seating Capacity: 6 or more

(3) Pumping Test Equipment

a. Submersible motor pumps 2 sets

Capacity: 2,000 liters/min x 90 m head

Power: AC440 V/50 Hz

Minimum well diameter for pump installation: 10"

Accessories: Riser pipes, submersible cable/120 m, control panel, water level control cable with electrodes, valves, pressure gauges, etc.

b. Diesel engine generators for submersible pumps 2 sets

c. Triangular weir (max. 2.9 cu.m/min) 2 pcs

e. Water level indicator, portable type (for 200 m depth) 5 sets

(4) Well logging equipment (for 200 m depth) 1 set

(5) Consumable Materials

a. High carbon steel for center edge and its assembly 5 sets

(6) Spare Parts

a. Percussion drill rigs and tools

i. For drilling rigs including deck engines and trucks 5 lots
ii. For standard operational accessories 5 lots
iii. For miscellaneous ancillary equipment 5 lots

b. Support vehicles

i. For cargo trucks with cranes 3 lots
ii. For water tank trucks 3 lots
iii. For double-cab pickup trucks 5 lots

c. Testing equipment

i. Pumping equipment 2 lots
ii. Well logging equipment 1 lot

## 3-4 Implementation Plan

### 3-4-1 Project Implementing Agency

(1) Directorate of Agricultural Engineering, Department of Agriculture, Government of N.W.F.P.

The Project is implemented with the Department of Agriculture of the Government of N.W.F.P. playing the role of the executing agency, under the control of which the Directorate of Agricultural Engineering (DAE), N.W.F.P. directly undertakes the execution of the Project.

After the Government of Pakistan and the Government of Japan sign the Exchange of Notes for the Project, the DAE will immediately secure personnel necessary for the Project implementation, procure equipment and materials provided by the Japanese side as well as other necessary items not included in the supply and carry out the construction of tubewells planned in the Project.

The Department of Agriculture will sign all the official documents with the Japanese Government and, with the cooperation of other Pakistani and N.W.F.P. agencies concerned with the Project, will smoothly take various measures such as banking arrangement, tax exemption and customs clearance for equipment and materials to be imported for the Project, acquisition of drilling sites, tax exemption for Japanese nationals engaged in the Project, etc.

(2) Consultant

Immediately after the Exchange of Notes for the Project is signed between the Governments of Pakistan and Japan, the consultant will enter into an agreement for the consulting services with DAE to proceed with the implementation of the Project. His main services are as follows:

1) To carry out the detailed design for the procurement of equipment and materials and prepare tender documents.

2) To carry out the tender for and on behalf of the Client and assist him in evaluating its results.

3) To witness the negotiations between the Client and the lowest bidder and present relevant advises for the successful conclusion of the Contract.

4) To supervise the procurement and shipment of equipment and materials and control Japanese experts dispatched for technology transfer for the installation and operation of equipment.

5) Other related services

(3) Contractor

The Contractor shall procure equipment and materials required in the contract and deliver them to the DAE headquarters located in Tarnab. He shall dispatch a drilling expert to Pakistan for the period required in the contract to offer technology transfer concerning the installation and operation of equipment.

### 3-4-2 Scope of Responsibilities

The Project aims to procure equipment and materials for construction of tubewells including five units of drilling machines with grant aid from the Government of Japan. It shall be implemented under the framework of Japan's grant aid with responsibilities of both sides set as follows:

(1) Responsibilities of the Japanese Side

1) Procurement, shipment and delivery of equipment and materials described in "Specifications of Equipment and Materials."

2) Dispatch of a drilling expert for technology transfer concerning the installation and operation of supplied equipment.

3) Consulting services for designing and supervising the Project including the dispatch of consulting engineers.

(2) Responsibilities of the Pakistani Side

1) Payment of the bank commissions

2) Arrangements for smooth customs clearance and tax exemption of imported equipment and materials at the port of entry.

3) Arrangements for the smooth entry and return of the Japanese nationals who are engaged in the Project, the exemption of local taxes and levies for them and guarantee their security during their stay in Pakistan.

4) Management and maintenance of procured equipment and materials

5) Bearing costs for expenses not provided under grant aid from the Government of Japan.

### 3-4-3 Expert Dispatch Plan

Japanese drilling experts shall be dispatched to the Project for technology transfer concerning the installation and operation of the procured equipment and materials. They shall be posted in

the site immediately after the arrival of equipment and materials in Pakistan, and perform the following services with the assistance of the Pakistani counterparts.

a. Installation of equipment.
b. Test operation of equipment
c. Training of Pakistani counterparts on operation of equipment
d. Training of Pakistani counterparts on maintenance of equipment

The expert dispatch plan to meet the intended purpose is as follows;

Drilling expert One (1) person for a period of two (2) months

3-4-4 Implementation Schedule

The implementation of the Project commences with the signing of the Exchange of Notes between the Government of Pakistan and the Government of Japan. Immediately after this process, DAE shall make an agreement with a Japanese consulting firm for designing and supervising the Project, which comes into effect with the verification of the Japanese Government. Then, the Consultant shall prepare the detailed design and tender documents, and with the approval of documents by the Governments of both sides, he will conduct the tender for the Project in which only Japanese nationals tenderers can participate. The consultant will join the process of the negotiations and the conclusion of the contract between DAE and the lowest bidder. The contract shall be subject to the verification of the Japanese Government as well. It is expected that all this process from the Exchange of Notes to the verification of the contract will take approximately three (3) months.

After the contract is verified by the Japanese Government, the contractor will proceed with the procurement of equipment and materials required in the contract. It will take about five (5) months to manufacture, procure and pack all the equipment and materials. Further, their shipment from Japan and delivery to the designated destination in Pakistan is estimated to take one and a half (1.5) additional months. Thus, the whole process until the arrival of the supply in Pakistan takes roughly nine and a half (9.5) months , followed by two (2) months during which

technology transfer on the job site is to be carried out. Fig 3.4.1 shows the entire schedule of the procurement under the Project.

### 3-4-5 Method of Equipment Procurement

Equipment and materials to be procured for the Project are limited to either Japanese or Pakistani products under Japan's grant aid system. All material or equipment unavailable in Pakistan are to be procured in Japan.

Additional equipments and materials beyond the scope of provisions in the Exchange of Notes, which might be required for the execution of the Project, are to be procured by the Pakistani side at its own expense.

Fig. 3.4.1 Implementation Schedule

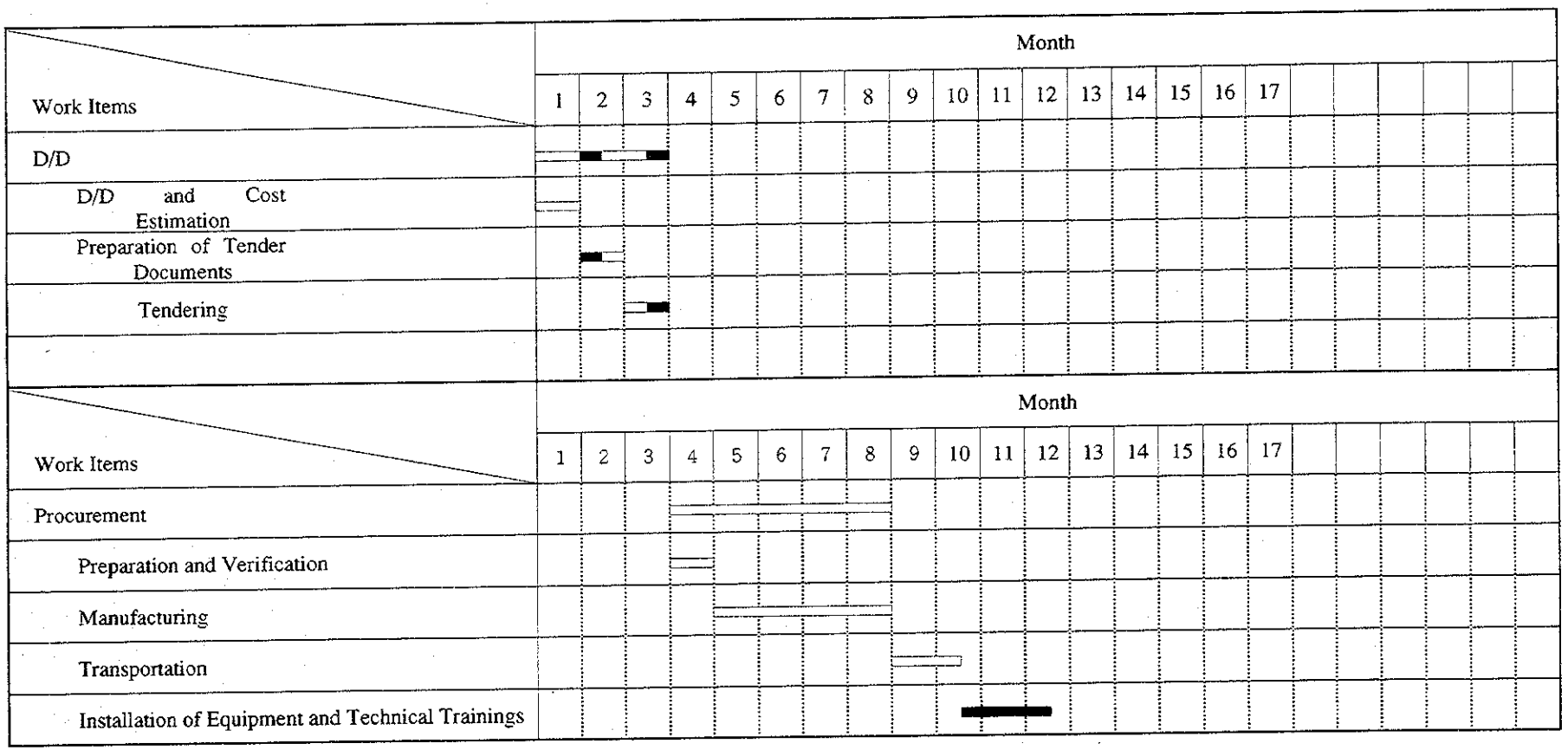



Fig. 3.4.1 Implementation Schedule

## 3-4-6 Operation and Maintenance Plan

DAE shall be responsible for the operation and maintenance of the drilling equipment and vehicles procured and delivered by the Japanese side under the Project. Maintenance and repairing of equipments, tools and vehicles; management of spare parts supplied under the Project shall be carried out properly either by the Tarnab workshop or the workshops in Malakand division of DAE. After the spare parts supplied under the Project are consumed, additional procurement will have to be borne by DAE.

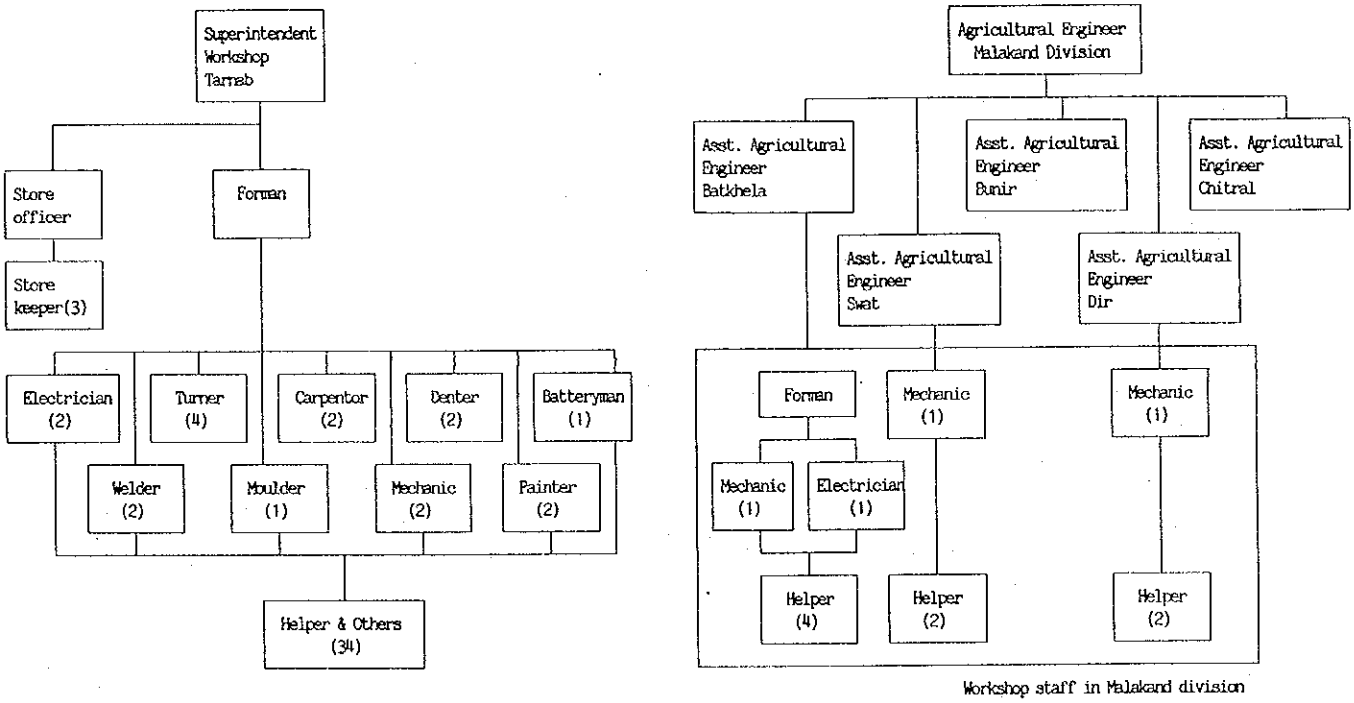



Fig 3.4.2 Organization Chart of Workshops

In the previous project in 1985, four (4) rotary drilling rigs were assigned to DAE. Those rigs have been maintained in good condition mainly because the office has a staff of well-trained experts. Equipments and materials procured under this Project are expected to be managed and maintained in the same manner.

Table 3.4.1 shows a list of rigs assigned to the Malakand division, and Fig. 3.4.2 presents the setups of Tarnab workshop and workshops under its control. The workshops, store-houses and stockyards of those facilities have enough space for receiving the new fleet of drilling equipment and vehicles under the Project.

Table 3.4.1 List of Rigs Assigned to Malakand Division

| Name of District | Type of Rigs | Units | Remarks |
|---|---|---|---|
| Malakand | Rotary rig (Model SM-450) | 1 | This rig is engaged in drilling work outside Malakand division, since its owner is N.W.F.P. government. |
| | Power winch | 1 | |
| Swat | * Percussion rig procured by this Project | 2 | These units are to cover drilling work in Malakand district as well. |
| | Power winch | 2 | |
| Dir | * Percussion rig | 1 | |
| | Power winch | 2 | |
| | Hand plant | 2 | These machines are to be abandoned upon acquisition of a percussion rig under this Project. |
| Bunir | *Percussion rig | 2 | |

Note: Percussion rigs with an asterisk mark are those procured under this Project.

(1) Maintenance and Management

The existing system for maintenance of drilling equipment is composed of three groups as follows;

a. Maintenance at Tarnab workshop
b. Maintenance at district workshops in Malakand division
c. Maintenance at drilling sites

Maintenance work taking place at each of the groups is described as follows:

1) Maintenance at Tarnab Workshop

The function of Tarnab workshop involves the storing and controlling of spare parts, their distribution to the districts, and repairing of equipment which cannot

be dealt with by the workshops in the districts. Since it has already been equipped with a spare part store-house under the control of a well-organized management system, it is unnecessary to hire additional personnel as well as to build a new store-house. Its repair section is adequately staffed as well so that the new fleet of equipment procured under this Project can be maintained by the existing staff members without any difficulty. This workshop so far has been managing and maintaining 200 bulldozers, 40 tractors and 48 drilling machines with support vehicles.

2) Maintenance at District Workshops in Malakand Division

Each of Batkhela, Swat and Dir districts has a workshop specialized in routine inspection of drilling equipment, replacement of parts and repairing work. Personnel is dispatched from these workshops to drilling sites for inspection and repairing whenever needed. This system is functioning so well that most of the machine troubles has been solved at the workshops in the districts or the drilling sites.

3) Maintenance at Drilling Sites

Drillers are responsible for daily inspection of equipment prior to starting the operation, replacement of minor parts, informing about machine troubles to the workshop, etc. Proper care of equipment at the sites, particularly daily inspection, is the most essential part of maintenance to avoid its breakdown. This point will be underscored during technology transfer at the site by a Japanese expert.

Thus, the existing system is judged as capable to deal with the management and maintenance of equipment and materials procured under the Project. Additional measures with special financial arrangements are deemed unnecessary.

### 3-4-7 Operation and Maintenance Cost

#### (1) Basic Factors for Cost Estimate

The cost estimate for the operation and maintenance of five drill rigs and supporting equipment is made, assuming the following:

a. The number of wells drilled yearly is estimated at 5.4. The drilling depths of these wells are assumed to be 80 meters on average.

b. Drilling work is carried out by one driller and one assistant. Unskilled labor shall be provided by the recipient farmer, and is not included in the cost calculation.

c. The geophysical logging of boreholes and pumping tests shall be performed by personnel dispatched from Hydrogeologist Northern Malakand.

d. The maintenance cost for five drilling units at Tarnab workshop is estimated to account for 3.5% of its total operation cost, based upon the following calculation:

5 new rigs / (200 dozers + 40 tractors + 46 rigs) / 2 workshops + 5 rigs)
= 3.37 %

e. The maintenance cost at the workshops in Malakand division is 7.5 % of its total operation cost, calculated as follows:

5 new rigs / (47 dozers + 10 tractors + 6 rigs + 5 new rigs) = 7.35 %

(2) Drilling Operation Cost

1) Personnel

| | | | |
|---|---|---|---|
| a. | Driller | Rs 25,600 / year x 5 | 128,000 |
| b. | Assistant | Rs 24,720 / year x 5 | 123,600 |
| c. | Engineers for testing | Rs 28,200 / year x 1 | 28,200 |
| d. | Driver for water tank truck | Rs 16,240 / year x 3 | 48,720 |
| | Total: | | Rs 441,320 |

2) Fuel Costs

| | | | | | | |
|---|---|---|---|---|---|---|
| a. | Drill rig (transport) | 10.0 lit./hr x 6 hr/day x 8 days x Rs6/lit =2,880 | | | | |
| b. | Ditto (for drilling) | 6.2 | 6 | 31 | 6 | = 6,919 |
| c. | Arc welding | 3.2 | 8 | 1 | 6 | =154 |
| d. | Generator | 13.0 | 24 | 4 | 6 | =7,488 |
| e. | Crane truck | 7.2 | 6 | 18 | 6 | =4,666 |
| f. | Water tank truck | 5.4 | 6 | 6 | 6 | =1,166 |
| g. | Pickup truck | 2.2 | 6 | 6 | 6 | =3,722 |
| | Sub total: | | | | | 26,995 |
| | | x 5.4 wells | | | | Rs 145,778 |

3) Annual Operation Cost

| | | |
|---|---|---|
| a. | Personnel cost | 441,320 |
| b. | Fuel cost | 194,365 |
| | Total: | Rs 635,685 |

(3) Maintenance Cost

1) Personnel Cost (Tarnab workshop)

| | | | | |
|---|---|---|---|---|
| a. | Foreman | 1 person | Rs 29,230/year | 29,230 |
| b. | Store officer | 1 | 23,580 | 23,580 |
| c. | Electrician | 2 | 16,240 | 32,480 |
| d. | Welder | 2 | 16,240 | 32,480 |
| e. | Turner | 4 | 16,240 | 64,960 |
| f. | Molder | 1 | 16,240 | 16,240 |
| g. | Mechanic | 2 | 16,240 | 32,480 |
| h. | Denter | 2 | 16,240 | 32,480 |
| i. | Painter | 2 | 16,240 | 32,480 |
| j. | Batteryman | 1 | 16,240 | 16,240 |
| k. | Store keeper | 3 | 15,800 | 47,400 |
| l. | Helper & others | 34 | 13,250 | 450,500 |
| | Total: | | | 810,550 |
| | | | x 3.5 % | Rs 28,370 |

2) Personnel Cost (Malakand division)

| | | | | |
|---|---|---|---|---|
| a. | Foreman | 1 person | Rs 24,720/year | 24,720 |
| b. | Electrician | 2 | 16,240 | 16,240 |
| c. | Mechanic | 5 | 16,240 | 81,200 |
| d. | Helper | 8 | 13,250 | 106,000 |
| | Total: | | | 228,160 |
| | | | x 7.5 % | Rs 17,112 |

3) Material/Equipment Repair Cost

Rs 3,000/rig x 5 rigs Rs 15,000
(estimated based on past experiences with power winches)

4) Fuel Cost

a. Number of inspections = 5.4 wells x 2 days x 5 rigs = 54 days
b. Fuel cost= 54 days x 6 hours x 2.2 lit/hour x Rs 6.0 = Rs 4,198

(4) Summary of Cost Estimate

| | | |
|---|---|---|
| 1) | Annual operation cost for five rigs | Rs 635,685 |
| 2) | Annual maintenance cost for five rigs | Rs 64,626 |
| 3) | Total cost (1) + (2) | Rs 700,311 |

From the above calculation, the annual operation and maintenance cost for the Project is estimated at Rs 700,311.

4) Recovery of cost

DAE now charges the beneficiary farmer in concept of drilling charge, footage allowance, etc., accounting for approximately 66,000 rupees. The total drilling charge per drilling rig is 256.4 thousand rupees (66 thousand x 5.4 tubewells). Total charge for 5 drilling rig units is 1,782 thousand rupees.