The Study on Groundwater Development in Central Cambodia
Final Report

Main Report

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COMMUNITY PARTICIPATION PROGRAM

CHAPTER 6 COMMUNITY PARTICIPATION PROGRAM

6.1 Objectives and Policy

6.1.1 Objectives

The community participation program for water supply facility operation and maintenance entails: a) activities that would make the villagers fully understand the importance of O&M activities, b) guidance in village water supply management methods, c) training in hand pump repair, d) hygiene education programs, and e) the development of the villagers' O&M skills (empowerment of villagers). This program also aims to decentralize O&M responsibilities and authority, and the transfer of skills, along with the TRT (Trainer's Training) program for the PDRD and MRD staff. The program was implemented in the 30 prioritized villages.

6.1.2 Community Participation Policy

As a part of the PRA (Participatory Rapid Appraisal), a meeting was held with the residents to discuss water supply facility O&M. The input of outsiders during the meeting was limited to information and methods concerning O&M, and assisting the residents in decision making.

MRD prepared the guidelines for VLOM (Village Level Operation & Maintenance). During the meeting, the guidelines was used as a reference in explaining the O&M methods to be taken and the VWC (Village Water Committee)/WPC (Water Point Committee) regulations, and visual aids were utilized to enhance the villagers' awareness of the problems.

6.2 Water Supply Facility

The water supply facilities were constructed in the 30 prioritized villages consist of deep wells, hand pumps, platforms and iron removal devices.

The design of facilities is based on the experience of the Study in Southern Cambodia and "National Guideline for Hand Pump Platform (MRD/VLOM Steering Committee), 1993".

6.2.1 Deep Well

Test wells have an average depth of 65 m, and 6 inch PVC for casing. The screen has an opening ratio of 5 % (drawing shown in Figure 6.2.1).

Casing pipes and screen pipes are specified as the followings.

- Material: PVC
- Diameter: 6 inches
- Screen opening ratio: 5 %

During construction of the deep well, following works were carefully done:

- Well development works were completed carefully before installation of hand pump.
- Space between borehole and casing pipe were filled completely by filter materials and sealing materials.

6.2.2 Hand Pump

As the result of village survey, several types of hand pump exist in the study area, such as No.6, Afridev, India Mark II/III, Giant, Tara, etc.

According to the "National Guideline for Hand Pump Platform (MRD/VLOM Steering Committee), 1993", Afridev, Tara and No.6 hand pumps are adopted as the National Standard Hand Pumps.

Tara Hand Pump

No. 6 Hand Pump

Afridev Hand Pump

Table 6.2.1 shows the comparison of the three (3) types of hand pump.

Table 6.2.1 Comparison of Hand Pumps

Type	Pumping Lift	Corrosion Resistance	Abrasion Resistance	Ease of Operation	Ease of Maintenance
Afridev	15~45 m	A	B	A	A
Tara	8~12 m	A	B	B	A
No.6	2~6 m	C	C	A	A

The meaning of the rating for corrosion resistance is:

A: All down-the-hole components are manufactured from non-corroding materials, such as stainless steel or plastic cylinder.

B: Most down-the-hole components are corrosion resistant, except for some small, inexpensive, replaceable components.

C: Down-the-hole components are susceptible to corrosion (e.g. mild steel or galvanized rods).

The rating of the abrasion is explained as follows:
A: The design minimizes the damage from abrasion
B: Adequate abrasion resistance
C: Inadequate abrasion resistance

The ease of operation is judged as follows:
A: Very easy and safe of operation
B: Easy and safe of operation
C: Difficult and not safe of operation

The ease of maintenance is judged as follows:
A: The village level caretaker can replace spares, if he has the minimum training and simple tools
B: The area mechanics must come to replace spare parts
C: The centralized maintenance is necessary
D: The pump must be repaired outside the country

The requirement for the hand pumps in the program is the followings.

- Discharge rate: 20 – 30 litter/minutes
- Ranges of pumping lift: 20 – 30 m
- Materials: Anticorrosive and abrasion resistance
- Ease for operation: Easy operation for woman and children
- Ease for maintenance: Village level or area mechanic maintenance is possible

As the result of comparison of hand pumps and consideration of the requirement, Afridev hand pump is adopted in the program. In consideration with the corrosion in the future, materials of riser pipes and pump rods are specified as the followings.

- Riser pipes: PVC
- Pump rods: Stainless steel

6.2.3 Platform and Drainage (drawing shown in Figure 6.2.2)

Based on the experience of the Study in Southern Cambodia and “National Guideline for

Hand Pump Platform (MRD/VLOM Steering Committee), 1993", specification of the platform design in the program is planned as follows,

- Platform:

Foundation:	Embankment up to 30 cm above ground
	Crushed stone (thickness 10 cm)
	Lean concrete (thickness 10cm)
Structure:	Reinforced Concrete
Inner Dimension:	Width 2.5 m × Length 3.8 m
Section Dimension:	Slab Thickness 15cm, Wall Thickness 15cm
Concrete Strength:	21 N/mm^2 (Cylinder Test Piece)
Reinforcing Steel:	Round Bar dia. 9 mm @ 15 cm × 15 cm
Slope:	2 %

- Drainage:

Structure:	Reinforced Concrete
Inner Dimension:	Width 35cm × Depth 20cm × Length 5.0m
Section Dimension:	Slab Thickness 15cm, Wall Thickness 15cm
Concrete Strength:	21 N/mm^2 (Cylinder Test Piece)
Reinforcing Steel:	Round Bar dia. 9 mm @ 15 cm × 15 cm
Slope:	Minimum 2 %

6.2.4 Iron Removal Device (drawing shown in Figure 6.2.3)

The most common problem about ground water encountered in Cambodia is the high iron concentration which affect taste, smell and color to reduce villager's willingness to use the ground water.

Iron removal devices are installed at 10 wells of which iron content of the water exceeded that of WHO standard (0.3 mg/l). Before installation, the following will be examined.

- Examine the maximum limit of iron content quantitatively in which the villagers may accept to use.
- Examine the effectiveness of the device by measuring the concentration of iron in the water before and after removing iron of the water.
- Examine the villager's purpose of water usage before and after removing iron.
- Hear the villager's opinion about method of using the device and feed back to the

improvement of the device.

- Establish the maintenance method of the device to be easier for the villagers.
- Educate villagers on its purpose, effectiveness and method of using iron removal device.

Iron Removal Device (IRD) is designed in the Study in Southern Cambodia based on the design of "Iron Removal Plant by Water and Sanitation Section, UNICEF, Colombo, Sri Lanka in 1987". This device is designed for deep wells with hand pumps to reduce iron from the groundwater by aeration, sedimentation, adsorption and filtration.

Iron Removal Device

6.3 Establishment of VWC and WPC

6.3.1 Central and Provincial Level Activities

(1) Central Level

Prior to the meeting with the residents of the prioritized village on VWC/WPC establishment, discussions was held with DRWS regarding the VLOM guidelines, roles of the VWC/WPC, and O&M methods, to determine the materials and methods to employ for the TRT program for the PDRD staff.

(2) Provincial Level

Interviews were carried out to determine the current organizational structure of PDRD and ways to improve the agency, and the countermeasures to be taken by DRWS. Interviews were also carried out regarding O&M equipment, spare parts availability and storage conditions, and the means of communication adopted by the province, commune and villages. For the PDRD staff, an On-the-Job Training program were carried out in one prioritized village regarding the establishment and functions of an O&M system, conduct of health and sanitary education activities, hand pump operation and maintenance, preparation of a users' register.

6.3.2 Village Level Activities

The trained PDRD staff hold a village meeting in every prioritized village to start the community based operation and maintenance system.

(1) Activities prior to facility construction

1) Encourage resident participation and the distribution of pamphlets during village meetings.
2) Distribution of manuals

A place where the residents can gather and discuss relevant issues (e.g. need for water supply facilities, place for the facilities, willingness to participate in facility operation and maintenance, willingness and ability to pay the water fee), and pamphlets and manuals were distributed to encourage the residents to establish a system for independent water supply facility construction.

(2) Preliminary activities during facility construction

1) Provide guidance in the formation and operation of a village committee
2) Establish a maintenance fund
3) WID considerations (interview of women, promote women's participation in the activities)

With the guidance of the PDRD staff, the residents were made to independently form a VWC and a WPC, the latter serving as the smallest unit of facility operation and maintenance. The active participation of female residents in the committee was encouraged. The residents was also encouraged to volunteer services (for the acquisition of site for well construction, construction of access roads, fencing for facility protection, construction of ditches) and establish a maintenance fund by collecting money for facility construction. In this phase, the study team provided guidance in the operation and management of the VWC and the WPC through the DRWS staff. Further, enlightenment activities focusing on sanitary education was carried out to make the residents understand the beneficial impacts of the water supply facilities.

(3) Activities after facility construction

1) Education on water facility operation and maintenance
2) Education on environmental sanitation
3) Guidance in the operation of resident organizations (leadership, fee collection, fund management, etc.)
4) Monitoring (interviews regarding facility use conditions, water quality, groundwater level observation, changes in lifestyle, time spent on water fetching activities and prevailing diseases)

These activities were performed from October 2001 as a part of the Phase III study. The WPC members were trained in hand pump operation and maintenance. An agreement with the committee was already made and guidance was provided in facility operation and maintenance – which is focus on fee collection and daily activities – and in environmental sanitation management. The DRWS and PDRD staff carried out a follow up education on the O&M and train the caretakers of WPC the hand pump maintenance. The study team also carried out monitoring to determine the following: facility use conditions, groundwater level and quality, time spent on water fetching, improvements in sanitary conditions.

6.4 Health and Hygiene Education

Posters and leaflets were utilized to explain the importance of safe water and encourage the use of hand pumps instead of contaminated water sources, e.g. ponds, rivers, shallow wells, etc. The importance of sanitary practices, e.g. keeping the surroundings of the platform clean, washing of hands, bathing, and use of clean utensils, etc., were also be pointed out.

6.5 Operation and Maintenance Education

Table 8.1 summarizes the result of VWC and WPC establishment in Phase II study. The test drilling was carried out in several new villages. These new villages are the substitute of the villages where the test wells were abandoned due to geological conditions. The VWC and WPC have not been established yet in these new villages.

In order to realize village level operation and maintenance (VLOM) and long sustainability of test wells, operation and maintenance education will be carried out in accordance with the following plan in phase III.

6.5.1 Purpose of Education

- To enhance village people's awareness to meet necessity of O&M at village community level
- To introduce village level operation and maintenance management methodology
- To transfer hand pump maintenance technology through training in the field
- To build the capacity for MRD and PDRD officials and to decentralize the authority to the provincial level through training of trainers

6.5.2 Scope of Education Program

(1) Operation and Maintenance Management Education

- Why is Operation and Maintenance necessary for the well?
- Role of DRWS and PDRD
- Role of Village Water Committee (VWC) and Water Point Committee (WPC)
- Role of each member of committee
- Scope of Member's work
- Rules
- Users registration
- Management of water fund

*Spare parts price and sale place to be given as an indicator to estimate the charge to be collected

(2) Operation & Maintenance Education

- Role of Caretaker
- Explanation on pump mechanism
- Guideline for the hand pump-use and maintenance
- Cleaning of pump environment
- Periodical checking and maintenance of the hand pump
- Maintenance record and report to PDRD
- Recording skill

(3) Practical Training

In the test well of the study, hand pumps are installed. In this training, the following performance and explanation will be made on hand pumps:

- Explanation of hand pump mechanism
- Explanation of most consumable parts
- How to inspect the pump
- How to use tools
- How to dismantle, reassemble and reinstall hand pump
- How to replace spare parts

6.5.3 Development of Education Materials

Employed materials in this program are as the followings:

- Agreement on Hand Pump Construction
- Manual for Establishment and Management of Community Organization
- Operation and Maintenance Manual

6.5.4 Main Topics of Education

(1) Management of WPC

Trainers introduce and suggest management methodology such as rules of the committee, management of water fund to be collected, members' work and user registration to village community. Trainers encourage village people to arrange these suggestions at each village in a democratic way, considering users' ideas. Decision-making is in village community.

WPC consists of only users. WPC is the smallest unit for efficient O&M activities. Therefore WPC is recommendable for mobilization of users for O&M activities at each well.

1) User Registration

In order to identify number of users of each hand pump, the Study team will introduce registration skill to record household head's name and number of family member on notebook to WPC members. The notebook will be delivered to each WPC by the study team. The registration book is useful to collect the charge and manage the fund. WPC is the most appropriate committee to implement user registration as user-based committee or the smallest unit.

2) Management of Water Fund

Budget-making skill will be introduced. Annual expected expenses for O&M activities such as minimum cost of spare parts, allowance to provincial or national repair teams in case and fuel for that is introduced to village community. This concept will help in deciding the charge to be collected from each household.

Second point is to share information with all of members by systematic report whenever the fund is utilized. All information shall be open to the public. Book keeping is also indispensable factor for good management. Management of the fund is the most interested and critical issues among users. Therefore it should be managed strictly and precisely.

(2) Operation and Maintenance Education

Trainees will be selected from WPC caretakers. Trainers are PDRD officials. The objective is to transfer minimum technology for hand pump O&M and daily inspection skills.

1) Hand Pump Repair

In the test wells of the study, Afridev type of hand pump is installed. The pumps shall be considered as cost effective facilities. It is absolutely necessary for user level O&M to transfer minor repair technology to WPC caretakers. Manuals shall be well-visualized materials and very useful materials for easy understanding.

2) Delivery of Spare Parts and Maintenance Tools

Maintenance tools and spare parts will be delivered to village caretakers and extra spare parts will be delivered to each PDRD office. Each person has a responsibility to take care of them. In case delivered spare parts are finished, WPC will purchase spare parts from PDRD office with order sheet. Furthermore, the O&M manuals, which are illustrated for easy understanding, are delivered to WPC caretakers.

3) Proper Use

To instruct all of users on proper use of hand pump is one of the most essential matters to prevent any trouble in hand pumps. One of the causes to breakdown hand pumps is improper use of the hand pumps. In order to train all users on this point, daily-based instruction is the only suggested solution way. Duplication to use properly will be expected to extend among users.

6.5.5 Education Approach by Level

(1) National Level

The Study team closely collaborates with DRWS officials to plan and prepare the program. DRWS officials are trainers to PDRD officials and village community in this program as the Study team members. The Study team consists of DRWS.

Basically, DRWS officials are in charge with operation and maintenance. Community participation and community organization are taken care of by DRWS in this program.

1) Guideline for Training of Trainers

Fundamental policy, objectives and methodology of this program are discussed and confirmed with DRWS. Village community is at the center of the program. Outsider like the Study team and PDRD will support behind them. VLOM concept will be pervaded to village community in the program. Facilitation and Empowerment are key issues for the program. At the same time through the program activities, capacity building at PDRD level and MRD level are enhanced.

2) Position of the Study Team

The main purpose is to clarify the position of the Study team (DRWS officials) in the program and have a consensus within them. Village community is at the center of the program. PDRD is in the position to facilitate community participation directly. Basic concept of attitude of the Study team in the program is not only trainer but also facilitator to PDRD in the training. In village training they are advisers to PDRD to support from behind. This understanding in advance among concerning members results in smooth implementation and good communication system.

(2) Province Level

1) Interview on Village-Support Condition

Official administrative supporting structure will be strengthened for comprehensive O&M support structure. The objective of the interview is to interpret present situations and issues to be improved and to recommend necessary measures to DRWS.

The Study team will interview PDRD officials on support capabilities such as stock status of spare parts and maintenance tools, availability of pump mechanics and communication structure with national district, commune and village level.

2) Training of Trainers

DRWS officials of the Study team will train officials from Rural Water Supply Bureau of PDRD for this program. After the training, the PDRD officials duplicate training to WPC in the test well village to disseminate VLOM concept.

3) On the Job Training (OJT) at Test Well Villages

After training conducted by DRWS, PDRD officials train village community supported by DRWS in one (1) test well village in each province as an OJT of PDRD officials. After the OJT program, only those trained PDRD staffs conduct training in other test well villages so that the approach methodology in this program will be developed and consolidated on the basis of the field experiences.

(3) Village Level

The Study team will mobilize village community in collaboration with PDRD officials to make training to WPC in the program. In the first selected village PDRD officials conduct training and have a meeting supported by DRWS officials. From the second village in each province, only PDRD officials conduct training with WPC.

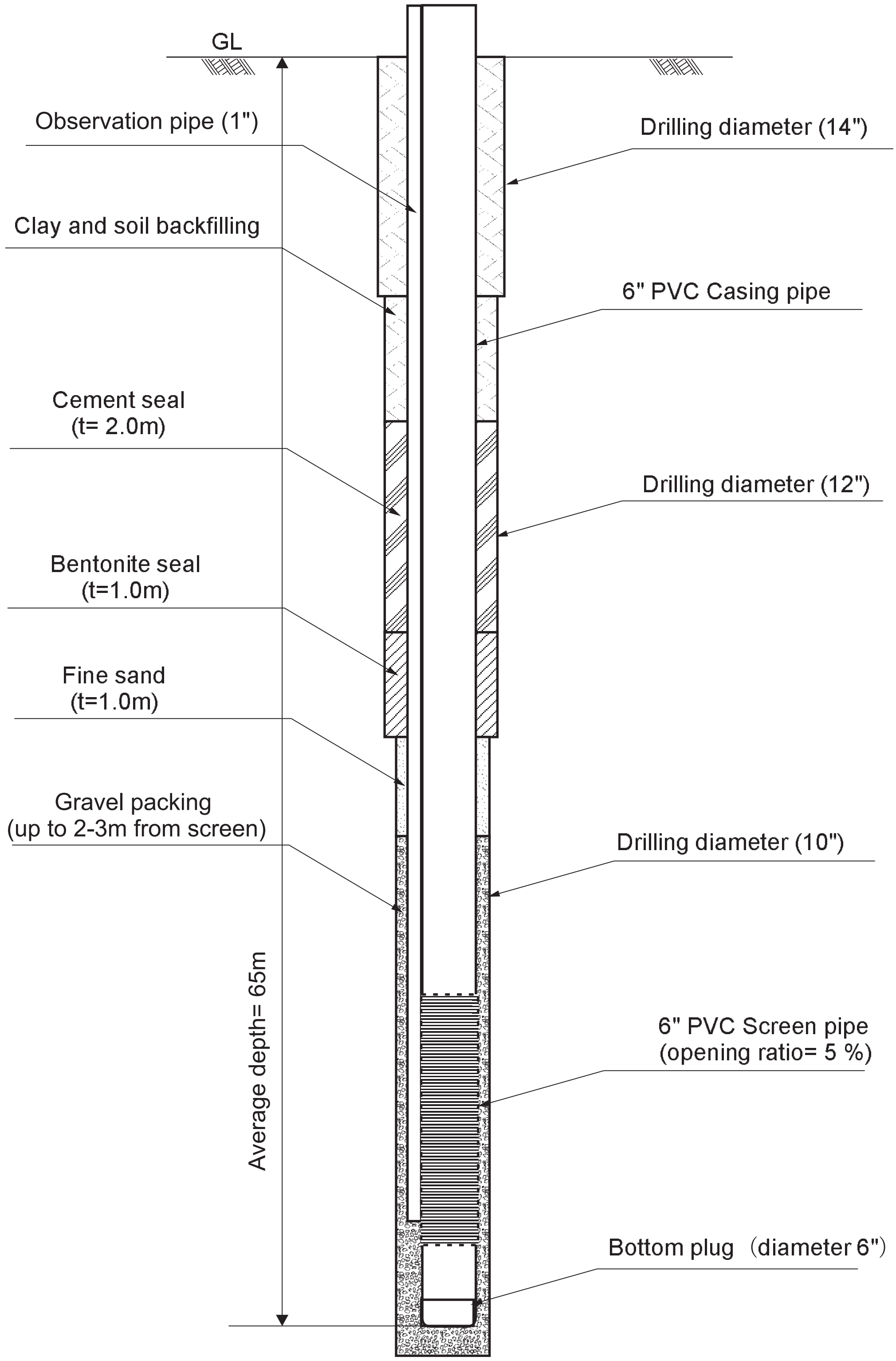


Figure 6.2.1	Structure of Test Well

THE STUDY ON THE GROUNDWATER DEVELOPMENT IN CENTRAL CAMBODIA

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

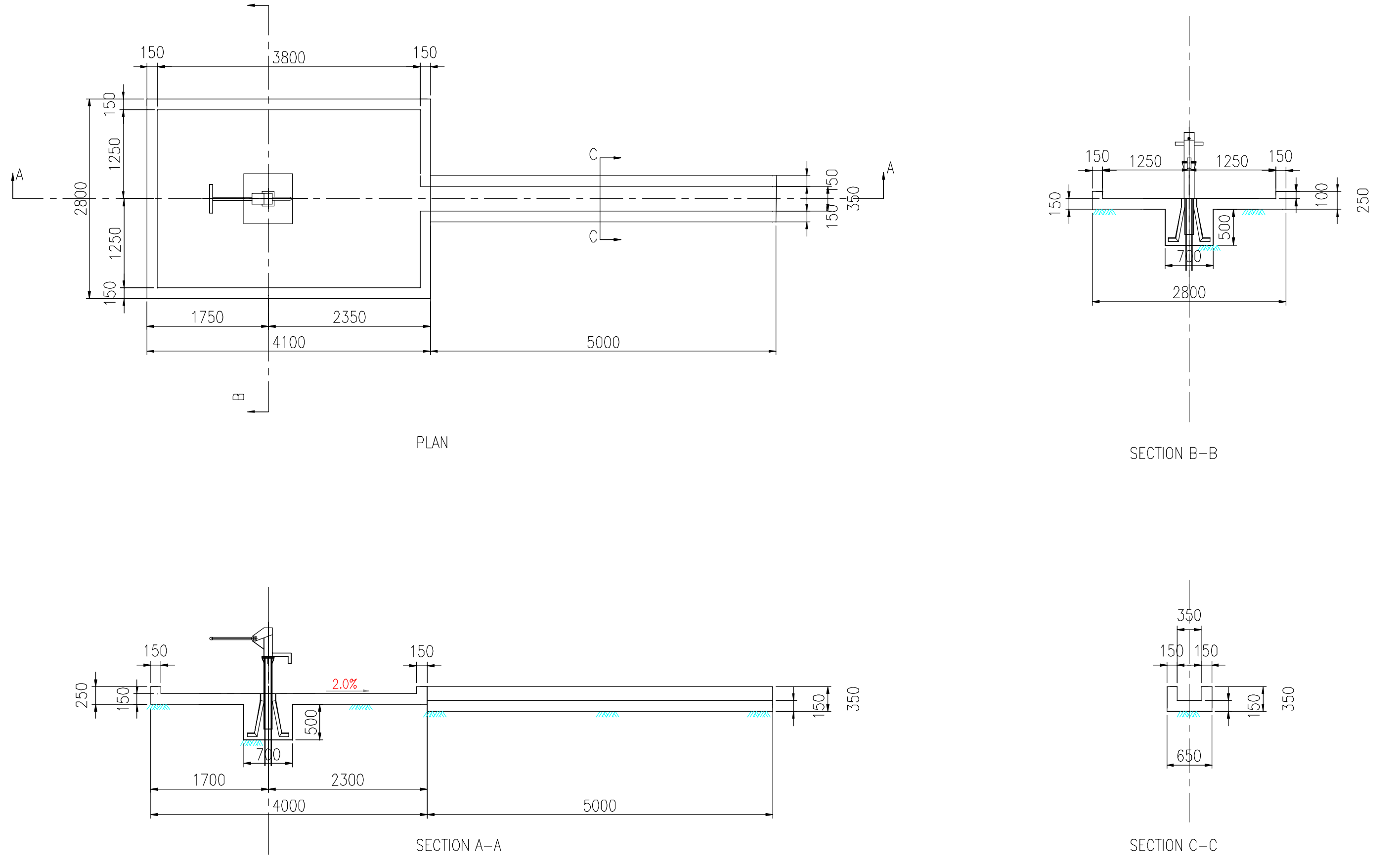
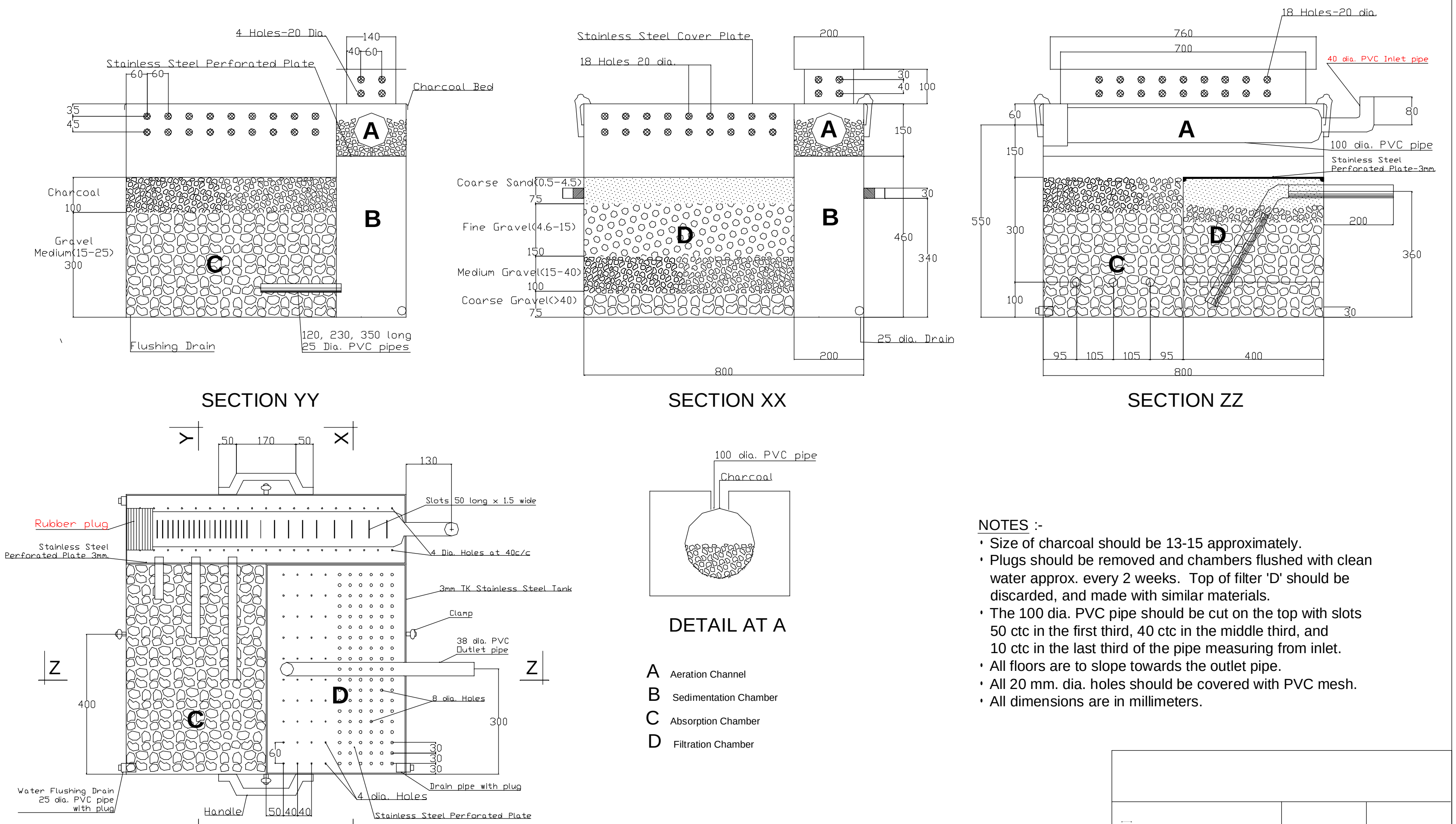


Figure 6.2.2 Design of Platform and Drainage

S=1/40

REMARK
Concrete Strength: 21 N/mm2
Reinforcing Steel Bar: ϕ9mm @ 150mmX150mm



A Aeration Channel

B Sedimentation Chamber

C Absorption Chamber

D Filtration Chamber

NOTES :-

- Size of charcoal should be 13-15 approximately.
- Plugs should be removed and chambers flushed with clean water approx. every 2 weeks. Top of filter 'D' should be discarded, and made with similar materials.
- The 100 dia. PVC pipe should be cut on the top with slots 50 ctc in the first third, 40 ctc in the middle third, and 10 ctc in the last third of the pipe measuring from inlet.
- All floors are to slope towards the outlet pipe.
- All 20 mm. dia. holes should be covered with PVC mesh.
- All dimensions are in millimeters.

Figure 6.2.3 Iron Removal Device (IRD)

SCALE	1:5

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Table 6.1 VWC and WPC Members Established in the Priority Villages

Kampong Chhnang Province

SEQ	Village		District	Village Water Committee (VWC)			Water Point Committee (WPC)				Remark
	No.	Name	Name	Chair man	Secretary	Accounting	Caretaker 1	Caretaker 2	Caretaker 3	Caretaker 3	
1	R035G	Trapeang Khtum	Kg Tralaach	Mr. Chu Taim	Mr. Hak Chanty	Mrs. Nos Kha	Mr. Man Ya	Mr. Keu Krim	Mrs. Hak Salla	Mrs. Sa Roh	
2	R045G	Prey Pis	Kg Tralaach	Mr. Eng Sat	Mr. Ly Smann		Mr. Sit Vansine	Mr. Chou Him			
3	R061G	Sapor	Kg Tralaach	Mr. Tuy Nim	Mrs. Seng Suy	Mrs. Duong Sot	Mr. Sek Hut	Mr. Keo Choy	Mrs. Ma Yen	Mrs. Keo Ly	
	R065G	Sdok Kabbas	Rolea Bier								cancelled
4	R072G	Teuk Laak	Rolea Bier	Mrs. Chou Oeun	Mr. Pho Sok	Mr. Kort Rin	Mr. So Nhel	Mr. Preap Phally	Mrs. Pel saron	Mrs. Mao Chanthy	
5	R082G	Prasneb	Rolea Bier	Mr. Dung Pom	Mr. Nhov Kimsan	Mrs. Uch Sam	Mr. Pok Sam At	Mr. Phou Pheu	Mrs. Tourt Chy	Mrs. Kao Sos	Appointment (17/May)
	R083G	Chor	Rolea Bier								cancelled
6	R085G	Chamkar Tamao	Rolea Bier	Mr.Sor Chanvut	Mrs. Ke Yeang	Mrs. Tep Samet	Mr. Seav Cheun	Mr. Huot Hak	Mrs. Poul Soben	Ms. Som Phon	
	R096G	Krasang Doh Laeung	Tuek Phos								cancelled
	R114G	Damark Ampil (Kdol)	Tuek Phos								cancelled
7	R162G	Peareach	Saamakki Mean Chey	Mr. In Yeun	Ms. Om Neun	Ms. Chort Rom	Mr. Nop Pin	Mr. Mang Vom	Mrs. Long Y	Mrs. Ou Yen	
8	R168G	Tbeng Khposh	Saamakki Mean Chey								
9	R189G	Ponley	Baribour	Mr. Vun Lay	Mr. Meun Sao Heng	Mr. Svay Dieb	Mr. Pen Thea	Mr. Kou Valy	Mrs. Mean Sochea	Mrs. Tan Sokhim	
10	R197G	Kbal Damrei	Baribour	Mr. Chhan Chhay	Mr. Ven Sarin	Mr. Nay Kim Lom	Mr. Kiat Ka Y	Mr. Pin Sor Phea	Mrs. Sar Saray	Mr. Pen Sopheap	

Kampong Cham Province

SEQ	Village		District	Village Water Committee (VWC)			Water Point Committee (WPC)				Remark
	No.	Name	Name	Chair man	Secretary	Accounting	Caretaker 1	Caretaker 2	Caretaker 3	Caretaker 3	
11	R008M	Dar Lech	Memot	Mr. Prik Sophon	Mr. Kang Rey	Mr. Uy Khan	Mr. Kang Sokha	Mr. Sok SengPhom	Ms. Chea Im	Ms. Ly Heat	
12	R015M	Meack Puk	Memot	Mr. Sao Seng	Mr. Yean Ra	Ms. Yim Sinoun	Mr. Yim Yon	Mr. Thy Ry	Ms. Yim Sok Mao	Ms. Mov Noeun	
	R016M	Srae Chroam	Memot								cancelled
	R017M	Chhngar Cheung	Memot								cancelled
13	R019M	Samrong Chheung	Memot	Mr. Chea Sophal	Mr. Boeun Kea	Ms. Hou Yen	Mr. Hinh Hon	Mr. Thong Phuong	Ms. Chung Narith	Ms. Moun Samin	
	R033M	Soutey	Memot								cancelled
14	R046M	Kdol Phsar	Memot	Mr. Mork Oeun	Mr. Em Lak	Mr. Luon Han	Mr. Khim Phat	Mr. Chea Oeun	Ms. Thiv Meng	Ms. Thang Thai	
15	R055M	Sla Phnum	Memot	Mr. Sa Tot	Mr. Lep Ro Sik	Mr. Sim El	Mr. Tou Loheary	Mr. Ly Him	Ms. Sa Ro Kaya	Ms. Lep Soury	
16	R092M	Chhuk	Memot	Mr. Chum Hean	Mr. Nim Nhok	Ms. Chou Phou	Mr. Vet Nhor	Mr. Leang Eng	Ms. Ma Chhan	Ms. Yen Saborn	
17	R101M	Lour	Memot	Mr. Him Hong	Mrs. Kung Sokhom	Ms. Chhy Saroun	Mr. On Bom	Mr. Chhay Mao	Ms. Khibuk Leang	Ms. Khon Arth	
18	R115M	Kngaok	Memot	Mr. Nhork Nhim	Mr. Chheang Heang	Mr. Nhork Nhem	Mr. Chem Chhem	Mr. Yun Mom	Ms. Nhork Samin	Mr. Men Map	
19	R126M	Kantuot	Memot	Mr. Khiev Bul	Mr. Sar My	Mr. Sar Dong	Mr. Keut Som	Mr. Pao Tha	Ms. Vom Mao	Ms. Sar Pen	
20	R127M	Angkam	Memot	Mr. Seang Reth	Mr. Chhe Ann	Mr. Yan Cheam	Mr. Luy Bean	Mr. Treng Run	Ms. Pao Saroeun	Ms. Ka Heng	
21	R171M	Khsak	Ponhea Krek	Mr. Dong Kamom	Mr. Mom Saroeun	Mr. Hom OI	Mr. Hom Chhay Van	Mr. Va Sim	Ms. Em Huch	Ms. Kren Chhouk	
22	R214M	Tuol Pou	Steung Trang	Mr. No Sos	Mr. Sit Min	Mr. Lep Mat	Mr. Sayu Sos	Mr. Sos Sen	Mr. Sok Mousa	Mr. Lep Kriya	
23	R248M	Phum Ti Prammuoy	Krouch Chhmar	Mr. Ly Va	Mr. Bun Hong Sokhom	Mr. Kim San	Mr. Hap Nhork	Mr. Khem Mom	Ms. Uy Ky	Ms. Chan Youheang	
	R256M	Phum Pram	Krouch Chhmar								cancelled
24	R264M	Veal Khmum	Tboung Khmum	Mr. Sen To Yep	Mr. Sos Run	Mr. Ly Him	Mr. Sles Patry	Mr. Sa Notim	Mr. Van Him	Mr. No Mosa	
25	R269M	Mong Ti Prampir	Tboung Khmum	Mr. Choung Srin	Mr. Bun Thy	Mr. Chea Y	Mr. Sat Keo	Mr.Choung Saran	Ms. Yeng Rin	Mr.Khat Heng	
26	R273M	Chheu Teal Chrum	Tboung Khmum	Mr. Chom Ton	Mr. Yen Tha	Mr. Chhan Nhem	Mr. Sok Chham	Mr. Prak Meung	Ms. Chhem Oeunn	Ms. Phat Ye	
27	R321M	Cheung Voat	Ou Reang Ov								
28	R337M	Thma Da Lech	Ou Reang Ov	Mr. Sim Chhen	Mr. Yin Savoeun	Mr. Phy Chhy	Mr. In May	Mr. Yon Pon	Ms. Kou Ry	Ms. Sip Nary	
29	R363M	Lvea Cheung	Chamkar Leu								
30	R376M	Khnaor Dambang	Cheung Prey	Mr. Yem Yorn	Ms. San Sophear	Mr. Preab Kreung	Mr. Saing Sun	Mr. Eang Neim	Ms. Thon Yann	Mr. Houn Soeun	

Note : Caretaker 1–2 is in charge of Handpump repairing, and 3–4 is maintenance.

CHAPTER 7

GROUNDWATER DEVELOPMENT PLANNING

CHAPTER 7 GROUNDWATER DEVELOPMENT PLANNING

7.1 Groundwater Development Policy

7.1.1 Area distinction by groundwater potential

Mountain and hill composed of the basement rocks are distributed in western part of the Study area. Most of Kg. Chhnang Province is located on the gentle slope which is less than 100m in elevation and contiguous to western mountain and hill. Pleistocene sand and clay layers cover the area. In eastern part of this Province, alluvial plain extends along the Tonle Sap River and isolated small mountains are sporadically located in the plain. The mountains are composed of the basement rocks.

On the other hand, western part of Kg. Cham Provice is the alluvial lowland encircled by the Mekong River and Tonle Sap River. The alluvial lowland is contiguous to Kg. Chhnang Province. In northern part of Kg. Cham Town, Plio-Pleistocene sand and clay sediments and basalt are widely distributed. Plio-Pleistocene and middle to upper Pleisotocene sand and clay sediments and basalt are distributed widely in eastern part of Kg. Cham Province, which is located on the left bank of the Mekong River.

According to geological conditions mentioned above, the Study area can be divided into 3 regions by groundwater potential (See Table 4.5.2, Chapter 4).

Table 7.1 Area Distinction by Groundwater Potential

Region	Geology	Main Aquifer	Groundwater Potential
Kg. Chhnang Province	Hill, Gentle slope and Lowland composed of basement rocks, Pleistocene and alluvial sediments.	Fissure and weathered zone of the basement rocks.	Alluvial and Pleistocene aquifer yield small amount and inferior water quality, high in iron and salinity. Arsenic is locally contained. Basement rock aquifer has greater yield and good water quality. Exploration is difficult.
Western Kg. Cham Province	Alluvial Lowland • Plateau composed of Plio-Pleistocene sediments and basalt	Plio-Pleistocene sediments and basalt	Alluvial aquifer is same as the above. Plio-Pleistocene and basalt aquifers have greater yield. Flowing well can be seen. Water quality is slightly high in iron.
Eastern Kg. Cham Province	Hill and Plateau composed of Plio-Pleistocene sediments and basalt.	Plio-Pleistocene sediments and basalt and basement rocks.	Plio-Pleistocene aquifers are same as the above. Flowing well can be seen. Basalt and basement rock aquifers have greater yield . Water quality is excellent.

7.1.2 Development policy

(1) Kg. Chhnang Province

Groundwater potential of this province is low. Existing hand dug wells and tube wells are penetrating Alluvial and Pleistocene layers but their yield is small. Water quality is generally high in iron and arsenic is detected locally. Thickness of Alluvial and Pleistocene sediments is from 10m to 20m. It is about 30m in the vicinity of the Tonle Sap River. Basement rocks lying under Alluvial layer are sandstone, granite and rhyolite. Weathered and fissured zone of these rocks become aquifers. Yield depends of degree and scale of the fissure and weathering. If the borehole meets a large fissure zone, the aquifer yields great amount of groundwater. Water quality is generally good but slightly high fluoride is detected locally.

Main target aquifer of groundwater development is the fissure and weathered zone of the basement rocks. It is necessary to explore the basement rocks for the groundwater development. In the Study, the electric resisitivity survey was conducted in vertical and two dimensional methods. The vertical survey intended to detect the depth of surface of the basement rock. Two dimensional survey intended to detect fissure zone of the basement rock. No.35G (Trapeang Khtum), 82G (Prasneb) and 197G (Kbar Damrei) were dry holes at first test drilling. Therefore, two dimensional survey was carried out and based on the survey new drilling locations were decided. As a result, the boreholes were successful.

Considering hydrogeological conditions, it is not so easy to develop basement rock aquifers. In order to explore and develop groundwater, the following steps of investigations in the requested village are needed. The detail of investigation methodology is mentioned in Section 7.4.

1) Topographical and geological reconnaissance survey
2) Water level and water quality survey
3) Electric resistivity survey（Vertical and Two dimensional）
4) Drilling
5) Pumping Test
6) Water quality analysis

(2) Western Kg. Cham Province

Thick Alluvial and Pleistocene sediments are distributed in western part of Kg. Cham. According to the test drilling at No.376M (Knaor Dambang), which is located on the central lowland, thick brown clay layer deposits up to depth of 100m and no aquifer was found. Groundwater occurs only gravel bed with clay at depth of 19 to24m. Water quality of the aquifer is high in salinity. Water quality of existing well is also high in iron or salinity and small yield. Groundwater potential of Alluvial lowland is low from the points of areal extent and water quality of the aquifer.

On the other hand, groundwater potential of basalt and Plio-Pleistocene aquifers is high in this area. The test well at No.214M (Tuol Pou) became a flowing well. It penetrates basalt and alternation of sand and clay up to depth of 81m. Groundwater quality and quantity are excellent. As many tube wells have been already constructed in this area, groundwater development shall be implemented with increase of water demand in the future.

(3) Eastern Kg. Cham Province

Located on the left bank of the Mekong River, Plio-Pleistocene sediments and basalt are distributed widely in this area. The aquifers consist of Plio-Pleistocene sand and gravel layer, basalt and the fissure and weathered zone of underlying basement rocks. Many hand dug wells exist in this area. Although water looks transparent and good quality in some dug wells, most of the dug well water is turbid. There are no well cover, concrete seal and curb so that the groundwater is contaminated by colon bacillus without exception.

Plio-Pleistocene aquifer is artesian and flowing well can be seen locally. Basalt and fissure and weathered zone of the basement rocks form good aquifers. Therefore, groundwater potential of eastern Kg.Cham Province is extremely high. Water quality indicates slightly low pH but iron and manganese are low. Arsenic was not detected. Since unsanitary hand dug wells are being utilized, this area is prioritized for groundwater development by deep tube well.

7.2 Target Aquifers

7.2.1 Aquifers and Drilling Depth

(1) Plio-Pleistocene Formation and Basalt

In the Plio-Pleistocene and basalt area of Kg.Cham Province, sand, gravel and basalt become aquifers. According to the test well drilling, the drilling depth ranges from 40m to 100m. Drilling depth is about 40m in basalt. If basalt does not exist or compact, the basaltic aquifer is not encountered. In this case, drilling depth exceeds 50m and sand and gravel formations form aquifers at depth from 50m to 60m. Therefore, the target drilling depth is 40m to 50m in the basaltic plateau and 60m to 70m in other area.

(2) Basement Rocks

In eastern part of Kg. Cham, thickness of laterite and basalt is 10m to 15m. Basement rock is lying under the laterite and basalt and forms an aquifer in its fissure and weathered zones. As thickness of the laterite exceeds 20m locally, the drilling depth can be 30m to 50m. If the laterite is thick and the basalt is compact, the drilling depth occasionally becomes more than 80m in order to reach the basement rock.

7.2.2 Development Scale

In the future groundwater development plan proposed by the Study, the water supply level is set as Level I. Considering the hydrogeologic conditions, water demand for drinking and domestic use, the socio-economic conditions and O&M capacity of each target village, the number of necessary wells should be allocated.

If the groundwater is saline water, the water cannot be used for drinking, but it can be used for domestic purpose. If the yield is small, the number of well should be increased to meet the water demand. According to the village survey in the Study, water supply conditions in the eastern part of the Study area is more critical because they depends on the unsanitary hand dug wells. Therefore, higher priority should be given to the villages in the eastern part such as Memot District. However, it should be carefully evaluated that the hydrogeologic conditions and water quality in the target villages. Based on the socio-economic conditions and water demand as well as the O&M capacity of the target village, the development scale for the village should be determined. It might be necessary to drill two (2) or three (3) wells in a village after the consideration of such conditions.

Groundwater potential of the western Kg. Chhnang is around 3-5 m^3/day to 40-50 m^3/day in the basement rocks, according to the pumping test. It depends of the degree and scale of the fissure. More than 20 % of unsuccessful borehole may be anticipated.

On the other hand , groundwater potential of Plio-Pleistocene aquifer is around 30-40m^3/day to 200m^3/day. It is possible to pump up a large volume of groundwater by using electric submersible pump.

7.3 Standard Well Design

The standard well design can be made based on the experience of test well drilling. It is recommended that the well has a diameter of 4 inches. The drilling diameter should be, therefore, 6 to 8 inches. The well depth and screen position should be decided based on the drilling logs and geophysical logs. The space between casing/screen pipes should be filled with particular size of gravel selected by the aquifer geology. The upper part of the space between the casing pipes and borehole should be filled with cement to avoid seepage from the upper shallow contaminated groundwater.

7.3.1 Target Depth

As mentioned previously, the maximum target depth of the future production wells is more than 80 m. In the eastern part of the Study area where the aquifer geology is Plio-Pleistocene sediments, the target depth shall be 60 to 70 m.

In the eastern part of the Study area where only basement rock aquifer is available for future groundwater development, the target depth shall be within a range of 30 to 50 m.

7.3.2 Drilling Method

In the eastern part of the Study area that is underlain by Plio-Plestocene aquifer(s), a rotary method is suitable. In the area basalt and basement rock occur within the target depth, the shallow portion can be drilled by rotary method. However, it is necessary to employ the down-the-hole method to drill basalt and basement rock in the target villages.

7.3.3 Well Completion

The work of well development is very important to obtain the maximum desired amount of groundwater from the well. It will take several days when the pumped water is still not clean, particularly in the case of the Quaternary aquifer layer(s) consisting of soft and fine materials. An airlift pump or a submersible pump having enough capacity for well development should be used for the work.

7.4 Groundwater Investigation Methodology in Kg.Chhnang

As mentioned in 7.1.2, groundwater investigations shall be conducted to locate a drilling point in the basement rock area of Kg. Chhnang. Surface and subsurface investigations provide direct or indirect indications of groundwater.

7.4.1 Topographical and geological reconnaissance survey

A geological reconnaissance survey should begin with the collection, analysis, and hydrogeologic interpretation of existing topographical maps, aerial photographs, geological maps and logs. The hydrogeological map attached to this report should be utilized to understand the general hydrologic conditions of the proposed groundwater development sites. It is possible to know approximate depth of the basement rocks in the proposed site from this map. Geological logs of exiting wells should also be interpreted so that the nature and thickness of overlying beds could be estimated. Such an approach should be regarded as a first step in investigations because no expensive equipment is required.

7.4.2 Water level and water quality survey

The second step of investigation is measurement of water level and water quality of existing dug well, tube well and combined well. Groundwater leveling provides depth to the water table and its aerial distribution if it is measured at several existing wells. This is useful indication for selection of pump.

Water quality survey should be conducted by using field test meters for EC, pH, ORP, field test kit such as AAN-Hironaka type for As and pack test for Fe, F, NH_4, NO_3, coliform and bacteria. Field water quality survey provides information on groundwater salinity, turbidity, odor, taste, presence of iron and fluoride and affection of human and animal wastes.

7.4.3 Electric resistivity survey（Vertical and Two dimensional）

Underground geologic structure can be estimated from the resistivity itself or resistivity changes caused by the electrical property of rocks and their structure. In Kg. Chhang, three resistivity layers can be recognized according to the resistivity survey conducted in the Study : a high resistivity layer in the shallow part, low resistivity in the middle part and relatively high resistivity layer in deep part. The high resistivity layer is estimated as the layer of un-saturation of water. The low resistivity layer is estimated as a clay layer. The deep layer is estimated as the basement rock (sand stone etc) or sandy formation. This was verified by the

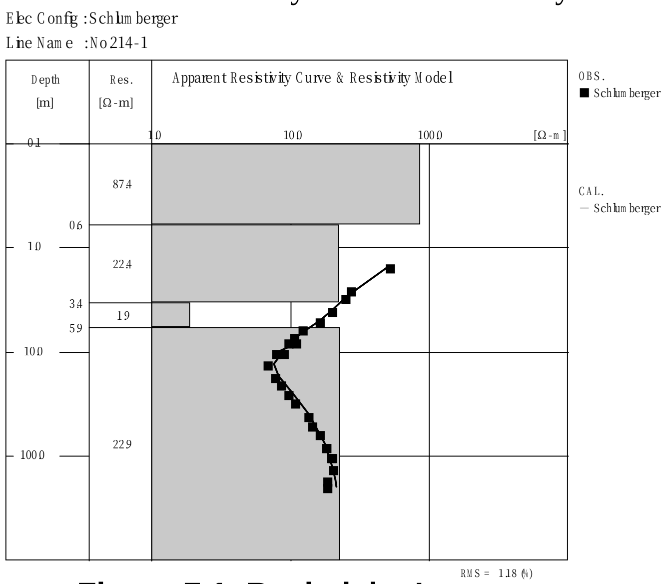


Figure 7.1 Resistivity Layers

test well drillings. Therefore, it is possible to know the depth of the basement rock by resistivity survey using Schlumberger electrode array.

However, it is difficult to interpret whether the basement rock is water bearing formation or not. Groundwater may exist in the middle low resistivity layer, which is thought to be clay layer of overlying Alluvial and Pleistocene sediments or weathered portion of the basement rock. Existing tube wells mainly tapped to this layer although it can be an aquifer of poor water quantity and quality.

In order to detect a fissure zone of the basement rock, two dimensional resistivity survey is an effective way of geophysical exploration.

Figure 7.2 shows the schematic diagram of the field measurement of two-dimensional resistivity survey. This configuration is called “pole-pole array”. The procedure of the measurement is the following.

(i) Setting remote electrodes
Current electrode (C2) and potential electrode (P2) are set as remote electrodes at two points located far from the measuring line (ten times by exploration depth or more). These electrodes are called “remote electrode”. Then, these electrodes connect to resistivity survey equipment with cable.

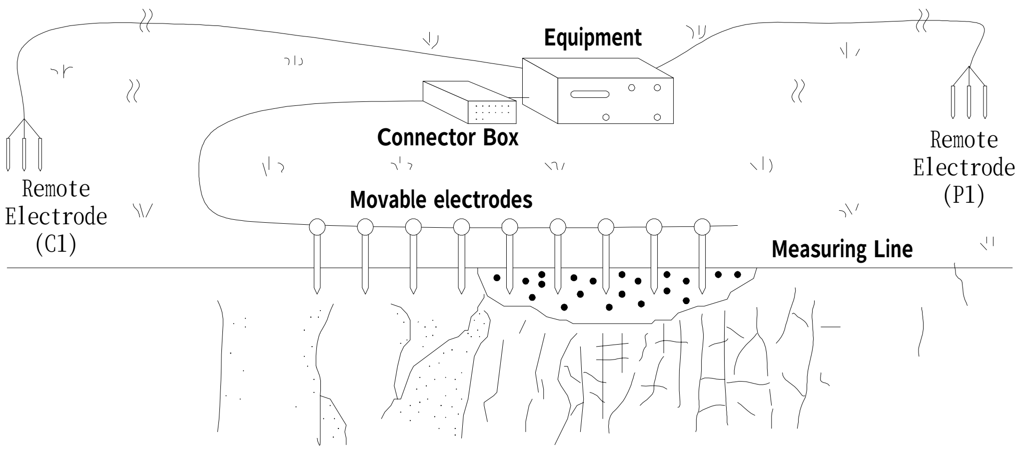


Figure 7.2 Schematic diagram of 2-dimensional resistivity survey.

(ii) Setting and connecting the electrodes along measuring line
Electrodes are set with 10m spacing along measuring line. These electrodes are called “movable electrode”. These electrodes connect to resistivity survey equipment with cable through connector box.

(iii) Measurement of voltage

Figure 7.3 shows the procedure of measurement. Current electrode (C1) is fixed, and electric current is injected between C1 and C2. Electrical potential difference is measured between potential electrodes (from P1-1 to P1-n) and remote electrode (P2), respectively. If maximum electrode spacing was 100m, measurement is repeated from P1-1 to P1-10 (1st Spread).

Next, current electrode (C1) and potential electrode (P1-1 to P1-n) are moved 10m each. Then, measurement is repeated as same as the first Spread (2nd Spread).

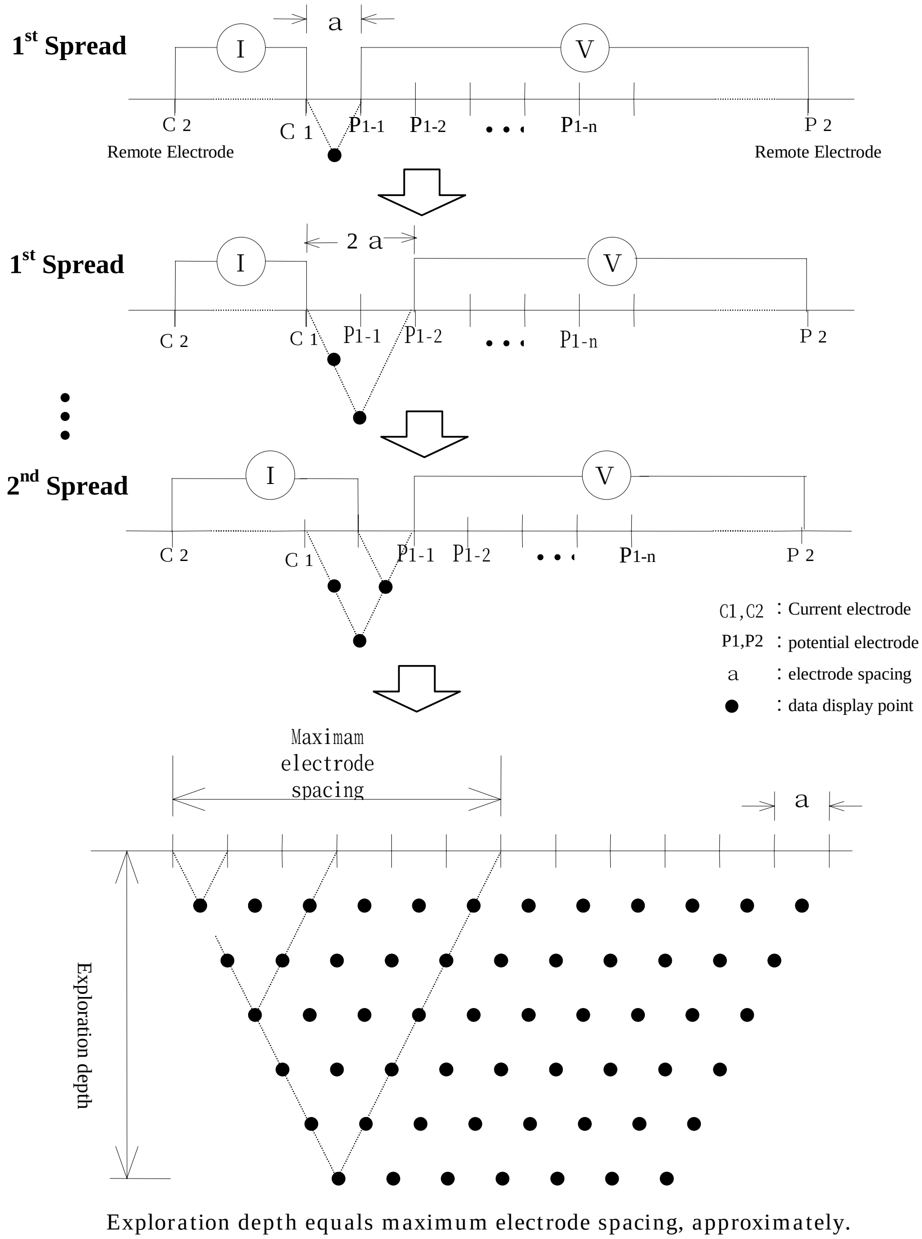


Figure 7.3 Procedure of 2-dimensional resistivity survey

According to the two dimensional survey, a test well drilling was successful at No.R035G (Trapaeng Khtum). The survey suggested existence of fissure zone based on the horizontal change of resistivity at a profile.

7.5 Considerations for Water Quality

According to the water quality survey, some chemical constituents in the groundwater of existing wells and the test wells exceed the WHO guideline value. In order to assure safety of water supply in the rural communities, it is necessary to conduct water quality analysis at newly constructed well.

7.5.1 Arsenic and Fluoride

The WHO guideline value of arsenic is 0.01mg/l. This is based on the risk of skin cancer. However, tentatively, it is recommended that 0.05mg/l should be kept in Cambodia. Because even in developed countries like Japan and USA, the water quality standard of arsenic was 0.05mg/l until quite recently. After sometime, the water quality standard should be established in Cambodia considering the socio- economic, water supply and health conditions.

On the other hand, the WHO guideline value of fluoride is 1.5 mg/l. It is recommended to follow this guideline in Cambodia. If water containing more than 2mg/l of fluoride is taken for drinking for a long time, teeth may become brittle because fluoride affects tooth density.

7.5.2 Nitrate

The WHO set a safe nitrate limit of 50mg/l. Water containing as much as 20mg/l of nitrogen or 90mg/l nitrate is considered harmful to infants. It should be noted that nitrate cannot be removed from water by boiling, but must be treated by demineralization or distillation. Because nitrate in groundwater originates most often from sewage waste, its presence is taken as evidence of contamination.

7.5.3 Acceptability aspects in the WHO Guideline

In the following summary statements, reference is made to levels likely to give rise to complaints from consumers by WHO. These are not precise numbers, and problems may occur at lower or much higher levels, depending on individual and local circumstances.

(1) Ammonia

The WHO guideline is set at 1.5mg/l. Ammonia is not of immediate health relevance, and no health-based guideline value has been proposed.

(2) Chloride

High concentrations of chloride give an undesirable taste to water and beverages. Taste thresholds for the chloride anion depend on the associated cation and are in the range of 200–300 mg/l for sodium, potassium, and calcium chloride. Consumers can become accustomed to concentrations in excess of 250 mg/litre. No health-based guideline value is proposed for chloride in drinking water.

(3) Hardness

Public acceptability of the degree of hardness of water may vary considerably from one community to another, depending on local conditions. The taste threshold for the calcium ion is in the range of 100–300 mg/l, depending on the associated anion, and the taste threshold for magnesium is probably less than that for calcium. In some instances, a water hardness in excess of 500 mg/litre is tolerated by consumers. No health-based guideline value has been proposed for hardness.

(4) Iron

Anaerobic ground water may contain ferrous iron at concentrations of up to several milligrams per litre without discoloration or turbidity in the water when directly pumped from a well. On exposure to the atmosphere, however, the ferrous iron oxidizes to ferric iron, giving an objectionable reddish-brown colour to the water.

Iron also promotes the growth of "iron bacteria," which derive their energy from the oxidation of ferrous iron to ferric iron and in the process deposit a slimy coating on the piping.

At levels above 0.3 mg/l iron stains laundry and plumbing fixtures. There is usually no noticeable taste at iron concentrations below 0.3 mg/l, although turbidity and colour may develop. Iron concentrations of 1–3 mg/l can be acceptable for people drinking anaerobic well-water. No health-based guideline value is proposed for iron .

(5) Manganese

Although manganese concentrations below 0.1 mg/l are usually acceptable to consumers, this may vary with local circumstances. At levels exceeding 0.1 mg/l, manganese in water supplies stains sanitary ware and laundry and causes an undesirable taste in beverages. The presence of manganese in drinking water, like that of iron, may lead to the accumulation of deposits in the distribution system. Although concentrations below 0.1 mg/l are usually acceptable to consumers, this may vary with local circumstances. The provisional health-based guideline value for manganese is 5 times higher than this acceptability threshold of 0.1 mg/l .

(6) Sodium

The taste threshold concentration of sodium in water depends on the associated anion and the temperature of the solution. At room temperature, the average taste threshold for sodium is about 200 mg/litre.
As no firm conclusions can be drawn regarding the health effects of sodium, no health-based guideline value has been derived .

(7) Sulfate

The presence of sulfate in drinking water can cause noticeable taste. It is generally considered that taste impairment is minimal at levels below 250 mg/l. As sulfate is one of the least toxic anions, no health-based guideline value has been derived.

(8) Total dissolved solids

Total dissolved solids (TDS) can have an important effect on the taste of drinking water. The presence of high levels of TDS may be objectionable to consumers owing to excessive scaling in water pipes, heaters, boilers, and household appliances. Water with concentrations of TDS below 1000 mg/l is usually acceptable to consumers, although acceptability may vary according to local circumstances. No health-based guideline value for TDS has been proposed .