

**JAPAN INTERNATIONAL COOPERATION AGENCY
MINISTRY OF RURAL DEVELOPMENT, CAMBODIA**

**THE STUDY ON GROUNDWATER DEVELOPMENT
IN
CENTRAL CAMBODIA**

FINAL REPORT

MAIN REPORT

MAY 2002

KOKUSAI KOGYO CO., LTD.

PREFACE

In response to a request from the Government of Kingdom of Cambodia, the Government of Japan decided to conduct a study on Groundwater Development in Central Cambodia and entrusted to the study to the Japan International Cooperation Agency (JICA).

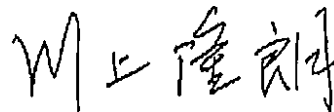
JICA selected and dispatched a study team headed by Dr. Kamata Akira of Kokusai Kogyo Co., Ltd. to Cambodia, three times between December 2000 and March 2002.

The team held discussions with the officials concerned of the Government of Cambodia and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Cambodia for their close cooperation extended to the study.

May 2002



Kawakami Takao
President
Japan International Cooperation Agency

Mr. Kawakami Takao
President
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

Dear Sir:

We are pleased to officially submit herewith the final report of "The Study on Groundwater Development in Central Cambodia".

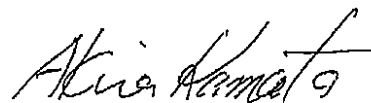
This report compiles the results of the study which was undertaken in the Kingdom of Cambodia, from December 2000 to March 2002 by the Study Team, organized by Kokusai Kogyo Co., Ltd.

We would like to express our deep appreciation and sincere gratitude to all those who extended their kind assistance and cooperation to the Study Team, particularly the officials concerned of Department of Rural Water Supply, Ministry of Rural Development, and other members of the Cambodian Counterpart Team.

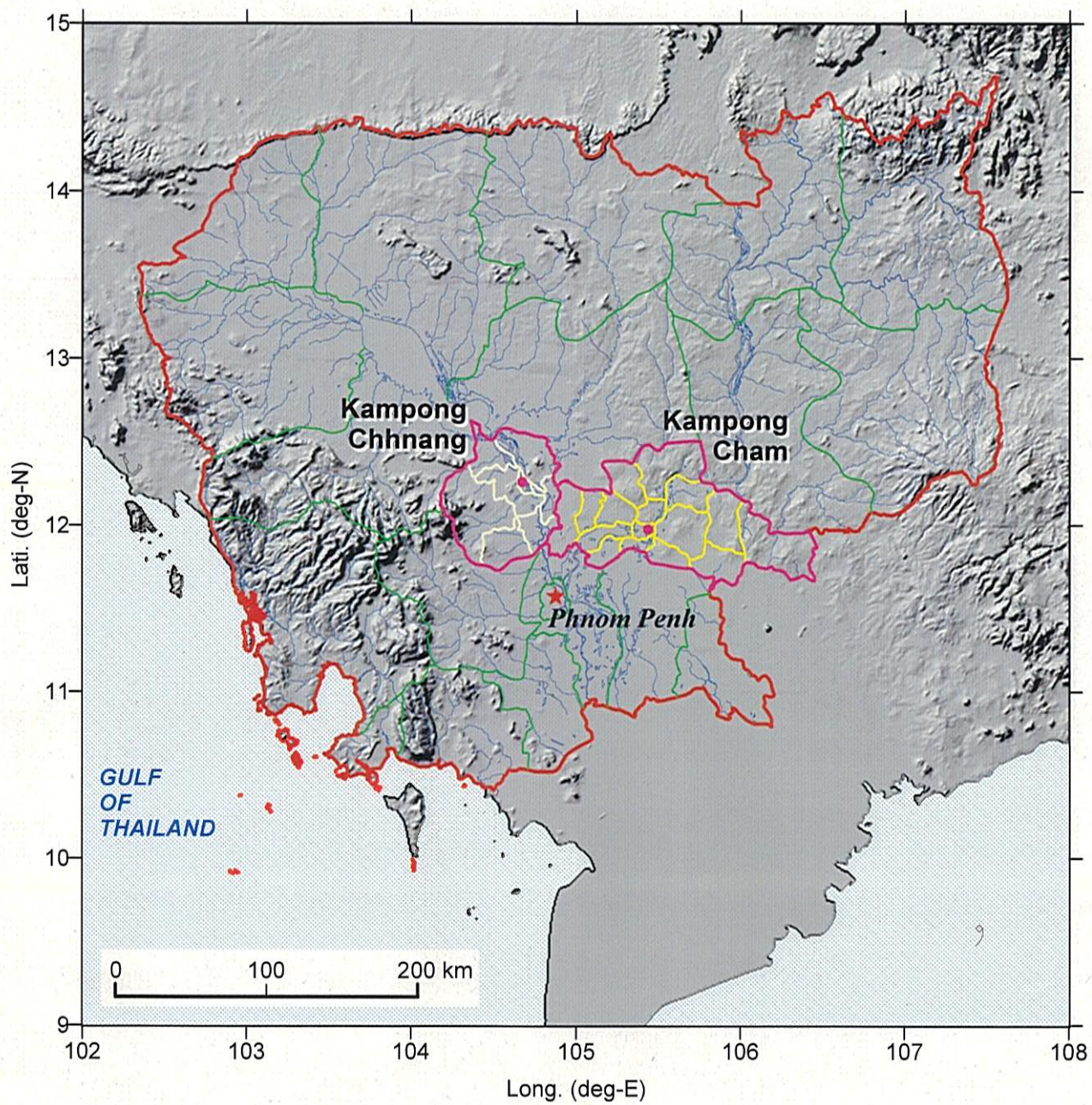
We also acknowledge and appreciate greatly the excellent support given by your agency, the JICA Advisory Committee and the Embassy of Japan in the Kingdom of Cambodia.

We sincerely hope that this report will be of help for the socio-economic development of the country as a whole. This report would be able to contribute really to Cambodian people and socio-economic development in the future.

Very truly yours,



Kamata Akira
Team Leader
The Study Team for the Study on
Groundwater Development in Central
Cambodia



Location of The Study Area

Exchange Rate

(February 2002)

US\$ 1.00 = 3,910 Riel = 133 Yen

1 Riel = 0.034 Yen = US\$ 0.00026

1 Yen = US\$ 0.0075 = 29.40 Riel

List of Abbreviation

ADB:	Asian Development Bank
ATP:	Affordability to Pay
CCC:	Cooperation Committee for Cambodia
CNHE:	National Center for Hygiene and Epidemiology
C/P:	Counterpart Personnel
CWS:	Central Water Base
DCD:	Department of Community Development
DPWS:	Department of Provincial Water Supply
DRWS:	Department of Rural Water Supply
EC:	Electric Conductivity
FHH:	Female –headed household
GDP:	Gross Domestic Product
IC/R:	Inception Report
IEE:	Initial Environmental Examination
IRC:	International Rescue Committee
JICA:	Japan International Cooperation Agency
KAFC:	Khmer Asian Friendship Community
Kg. Chhnang:	Kampong Chhnang
Kg. Cham:	Kampong Cham
LWS:	Lutheran World Federation
MAFF:	Ministry of Agriculture , Forestry and Fisheries

MIME:	Ministry of Industries, Mining and Energy
MOH:	Ministry of Health
MRD:	Ministry of Rural Development
NIS:	National Institute of Statistics
NGO:	Non-governmental Organization
OJT:	On the Job Training
ORP:	Oxidation-Reduction Potential
PDRD:	Provincial Department of Rural Development
PRA:	Participatory Rapid Appraisal
PRASAC:	Program de Rehabilitation et Acqui au Secteur Agricole du Cambodge
RGC:	Royal Government of Cambodia
RWSS:	Rural Water Supply and Sanitation Sector
S/W:	Scope of Work
TRT:	Trainer's Training
UNICEF:	United Nations Children's Education Fund
UNPA:	United Nations Population Fund
VDC:	Village Development Committee
VWC:	Village Water Committee
WATSAN:	Water and Sanitation
WHO:	World Health Organization
WID:	Women in Development
WPC:	Water Point Committee
WTP:	Willingness to Pay
WUHE:	Water Use and Hygiene Education
WVIC:	World Vision International Cambodia

The Study on Groundwater Development in Central Cambodia
Final Report
Executive Summary

Study Period : December 2000 to May 2002
Counterpart Agency : Department of Rural Water Supply of the Ministry of Rural Development

1. Background

The provinces of Kampong Cham and Kampong Chhnang, the study area, are rural regions in central Cambodia where there are hardly no water supply facilities and the residents rely on dug wells, rivers and ponds etc for water supply. Since most of these water sources get depleted in the dry season, only about 13% of the total population have access to stable drinking water supply. In addition, the groundwater resources are contaminated by man-made activities. Recently, iron, fluoride, nitrate and arsenic exceeding the WHO guide line value were also reported at several wells. These conditions underscore the importance of a steady supply of safe drinking water to majority of the population in the study area.

2. Study Objectives

The Study aims to achieve the following objectives;

- (1) To evaluate potential of groundwater resources
- (2) To formulate a groundwater development plan for the study area.
- (3) To transfer skills and technology of groundwater development method and management to the counterparts of the MRD in the course of the study.

3. Study Area

The study area covers the following two (2) provinces

- (1) Kampong Chhnang Province (Area:5,521km², Population:417,693 in 1998)
- (2) Kampong Cham Province (Area:9,799km², Population:1,608,914 in 1998)

4. Study Results

The results obtained from the survey conducted from December 2000 to March 2002 are summarized below:

(1) Natural Environment

The study area semiannually experiences dry season (from November to April) and wet season (from May to October). The annual rainfall is 1,200 to 1,900mm in the lowland along Tonle Sap River and Mekong River, and 2,000 to 3,000mm in the western mountain area and eastern plateau area. The 80% of the annual rainfall concentrates in wet season.

Topographically, the study area divided into the following three zones: western mountain zone, central lowland zone and eastern plateau zone.

The basement rocks including Mesozoic-Paleozoic sedimentary units and intrusive units are distributed widely in the western mountain zone. Basalt lavas erupted in Plio-Pleistocene and middle-upper Pleistocene are widely distributed in the eastern plateau zone. Holocene and recent sediments thickly deposit in the central lowland zone.

(2) Socio-economy and Water Supply

Farming is the main activity of the people in the study area. Most villagers (about 85 %) are engaged in rain-fed rice cultivation in small plots of land. The principal crops grown are rice, cassava, maize, beans, and vegetables. Apart from this, some of the target villages have natural forests that are rich in trees harvested for various uses such as timber, poles, fuel and charcoal. In addition, seven huge rubber plantations are being operated and produce annually 45,000 tons of raw rubber. Other sectors regarded as productive are inland fishery, and small industries.

Social services and infrastructure are very poor in the study area. For example, only 40% of the total villages have primary school, number of health center per 10,000 persons is less than one and road condition is very bad.

Shortage of clean water eventually impedes the development of active rural communities. In order to overcome such conditions, the Government has been implementing rural water supply program since 1983. The responsible organization for this program is the Ministry of Rural Development (MRD). The Department of Rural Water Supply (DRWS) under the MRD

is the main implementation agency and the Provincial Development of Rural Development (PDRD) supervises the projects relating to water supply and primary health care in each province.

The Second Five-Year Socio-Economic Development Plan (2001-2005) of MRD aims to access clean water supply from 29 % to 40 % by the end of year 2005. However, the Plan relies on external sources of financing and technical expertise provided by external agencies.

The Ministry of Health (MOH), the responsible organization for health service in Cambodia is going to establish the network of health centers and referral hospitals as operational districts (OD). In addition, PDRD has primary health care office.

(3) Geophysical Survey

Vertical electric sounding using Schlumberger electrode array was implemented at 102 points in the 34 priority villages, 129 points in Kg. Cham and 57 points in Kg. Chhnang to estimate the depth of aquifer and to understand hydro-geological structure. In addition, two dimensional electric survey was conducted at 8 measuring lines in Kg. Chhnang and 13 measuring lines in Kg. Cham. The prospecting depth was 100-200m.

In Kg Chhnang, low resistivity layer of less than 100 Ω m exists at depth of 10 to 40m. The relatively high resistivity layer of more than 100 Ω m is distributed in deeper place. This layer is thought to be basement rocks. The top of the basement rocks becomes deep toward the east. On the other hand, the low resistivity layer of less than 100 Ω m widely distributes at deep depth in Kg. Cham. However, the resistivity structure becomes more complicated toward the east. The resistivity structure may be reflected by complicated geology which is composed of Plio-Pleistocene sediments (low resistivity) and basalt (high resistivity) in Kg. Cham.

Based on the results of two dimensional electric survey, horizontal resistivity change was detected in Kg. Chhnang. The drilling locations were then placed at low resistivity zone, which indicates the fracture of the basement rock containing groundwater.

(4) Groundwater Levels and Water Quality

In order to examine distribution of water levels and water quality, simultaneous observation was carried out 4 times from January to February, May to June and July to August and November to December 2001 at around 250 wells (dug well, tube well and combined well).

Water level, water temperature, pH, ORP, EC were measured on-site. Arsenic, fluoride, iron, nitrate, ammonium, coliform group and bacteria were also examined on-site using field test kit.

In Kg. Chhnang, groundwater level was 1 to 2 m below ground level. In Kg. Cham, however, groundwater level is deeper than those in Kg. Chhnang in general. Particularly, groundwater level is deeper than 5m in Cham Kar Leu and Memot districts. Groundwater level declines to its lowest level in May and goes up in wet season. Maximum water level change was 2.5m in Kg. Chhnang and 1.5m in Kg. Cham, respectively.

EC and pH values of existing wells (both dug wells and borehole wells) are lower in eastern and western parts of the study area, and higher in central part lying between Tongle Sap River and Mekong River. However, high values were locally observed at the eastern part. On the other hand, ORP values show higher in eastern and western parts and lower in central part.

Arsenic more than 0.01mg/l was detected at the tube wells in the lowland along the Mekong River and the Tonle Sap River. Highest arsenic level (more than 0.05mg/l and less than 0.1mg/l) was detected from tube well near the Mekong River. Iron shows high concentration in the central area, however, it is low in the eastern and western area. Slightly high fluoride groundwater is sporadically distributed in the central and western areas. Nitrate and ammonium contamination was also found at several existing wells.

Coliforms were detected at almost all dug wells and almost half of the tube wells and combined wells. It was recognized that man-made contamination spreads over the existing wells.

(5) Test Well Drilling

In order to examine underground geology, distribution of aquifers and their characteristics, 39 bore holes were drilled at 32 priority villages. Total drilling depth was 2,100m (average depth: 54m). Out of 39 bore holes, 30 bore holes were successful, however, 9 holes were dry. Total length of casing was 1,313m (average casing depth: 44m). Number of the successful well was 10 in Kg. Chhnang and 20 in Kg. Cham, respectively. After pumping test, hand pump was installed and platform was constructed at the successful well. Iron removal device was installed where groundwater contains high iron content.

(6) Village Survey

303 target villages for village survey were selected from the requested 572 villages examining “1998 Census Village Level Data”. The criteria for selection were dug well depending ratio, village accessibility and urgency of water demand. A village survey was conducted using village questionnaire sheet and household questionnaire sheet on socio-economy, water use and hygiene conditions. In addition, a detailed village socio-economic survey was conducted at the 34 priority villages.

1) Results of 303 Village Survey

The average village population of the 302 villages is 855 and household number is 5. Female headed house hold occupies 17% of total households. Khmer lives in 80% of the villages and Cham, Vietnamese, Chinese and their mixture occupy 20%. Population growth rate is estimated at 2.2%.

Farm land per household shows 1.2 ha in average, 7 ha in maximum and 0.04 ha in minimum. Landless household exists 12% of the total households. The primary school exists within 5km from the village. The villages less than 60% of the literacy rate counts 70% of the total villages. According to recent government policy, Village Development Committee (VDC) is established in 159 villages. Of the 159 villages, 69 villages have Village Water Committee (VWC) and Water Point Committee (WPC).

Number of the shallow dug wells is large. It occupies 90 % of the water sources in the 303 villages. On the other hand, the tube well is 5% and the river and pond are less than 2%. Number of the shallow well is 41 per village in average which is utilized by 11 to 30 persons. Number of the tube well with hand pump per village is 2.4 which is utilized by 151 to 200 persons. However, no hand pump well exist in half of the surveyed villages. Rain water is used as a main water source in the wet season. Several villages located along the Mekong River and Tonle Sap River purchase drinking water at 5 to 10 Riel per liter.

The water sources are located within 500m from the residence. Most of them are located within 30m. Number of times for water fetching counts 3.7 time in the wet season and 4.4 times in the dry season. As for the number of water fetching, men is little bit higher than that of women. Children younger than 10 years old fetch water, however, it is 4% of the total. Water fetching is a role of the adult.

The diseases generally occurred in the villages are typhoid, skin disease, diarrhea and

fevers. They are mainly caused by the lack of clean water and bad sanitary conditions.

2) Results of the Priority Village Survey

The socio-economic survey was conducted for 34 priority villages to understand the socio-economic situation, water use and needs, health and hygiene status and economy.

VDC is established at 5 villages, however, VWC and WPC not yet established. 15 villages out of 34 villages do not have primary school. Medical facilities do not exist in almost all villages. The resident have to access health center which is located 5 to 13km away from their home.

Agriculture farming is main activities in these villages and an annual cash income per household is 800,000 Riel (about US\$ 200) in Kg. Chhnang and 1,160,000 Riel (US\$ 290) in Kg. Cham.

Main water source in the priority village is hand dug (shallow) well. 39 dug wells exist per village in average in Kg Chhnang. Only 4 villages have tube wells. The amount of water use per family per day is 40-100 l and each household has a water jar. The capacity of the jar is 200 to 250 l.

Main water source in Kg. Cham is also hand dug well and 38 dug wells per village exists in average. The tube well exists in 8 villages only. The amount of water use is 20-180 l/day per family. The average amount is 60 l/day.

3) Social Survey/ Gender Analysis

About 17% of the surveyed households are the Female Headed Household. Most of the villages are Khmer. About 12% of the surveyed villages are Cham and 10% is mixed with both tribes. As far as private owned agricultural land, economic difference between poor and rich cannot be neglected. About 12% of the villagers are landless farmers. Traditional community activities are weak. VDC and VWC have already been established in 160 villages and 69 villages, respectively.

In the villages where international organizations and NGOs constructed the tube wells with hand pumps, about 30% of the surveyed households is utilizing them. There are no clear social and economical difference among the households, however, there is a tendency that the number of hand pump users decreases in proportion to the increasing

distance from the tube well to their residence.

Gender gap still remains as seen in the adult literacy rate. However, gender division is generally small in terms of productive and reproductive activities. Women have opportunities to participate in the decision making for the community and also have various roles in socio- economy in the village life. Women's are responsible for water related matters such as cooking, washing, gardening and family health care etc. They are not only beneficiaries of the water supply project but also play an important role in maximization of the project benefits .

(7) Community Participation Program

The community participation program for water supply facility operation and maintenance (O&M) 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 priority villages. The VWC and the WPC were established and the guidance for the O&M of water supply facilities were conducted by the counterpart personnel and the study team. The hygiene education programs and training of O&M skill were also conducted after installation of the hand pump.

(8) Groundwater Resource Evaluation

Based on the geological survey and groundwater investigation, a hydrogeological map at a scale of 1:200,000 was prepared. The map legend was decided by the International Hydrogeological Society in order to utilize for future groundwater development planning. The map represents the specifics of the study area as well.

Considering the hydrogeological settings presented in the hydrogeological map, the pumping test and water quality test conducted on the sites, the groundwater potential of the study area is tentatively evaluated and summarized as the following table.

Evaluation of Groundwater Potential

Province	District	Main Aquifer	Specific Capacity (m ² /day)	Water Quality	Groundwater Potential
Kampong Chhnang	Kg.Tralaach Rolea Bier Saamakki Mean Chey Baribour	Fissure and Weathered Basement Rocks	0.2-11.1	Locally high Iron and Fluoride content	Low groundwater potential except fissure of the basement rocks.
Kampong Cham	Memot	Fissure and weathered Basalt	2.9-52.0	Low Iron content	High groundwater potential
		Fissure and weathered Sand Stone	18.7-115.8	Same as the above	Same as the above
	Ponhea Kraek Steung Trang Tboung Khmum Ou Reang Ov Chamkar Leu Cheung Prey	Plio-Pleistocene Sand	15.6-303.2	Locally high Iron content	Sandy aquifer is excellent and productive. Yield is high. Locally flowing well.

5. Groundwater Development

Groundwater potential is high in the left bank side of Kg. Cham Province, where Plio-Pleistocene sediments and basalt form excellent aquifers. The tube well of 4 inches in diameter and 50m depth at a screen openings of 3% yields 180 ~ 230 m³/day from Plio-Pleistocene aquifers and 60 ~ 90 m³/day from basalt aquifer. On the other hand, groundwater potential is low and water quality is inferior in the alluvial lowland along the Mekong River and Tonle Sap River of Kg.Cham and Kg.Chhnang Provinces. In the basement rocks of Kg. Chhnang Province, groundwater potential varies place to place. It is necessary to conduct a detailed geological and geophysical surveys to evaluate groundwater potential of the target village.

6. Water Supply Plan

From the 303 surveyed villages, 131 villages were selected as the target villages for water supply plan considering groundwater potential, needs of tube well and access to the village.

Target Year : Year-2005

Number of Village and Population : 131 Villages 118,320 population

Facility :	Deep tube well with hand pump 526points
Soft component :	Education on O&M and Hygienen

The cost of the proposed project is as follows:

(Unit : 1,000US\$)	
Condition/Construction	Contractors
Foreign and Cambodia	11,913

7. Hygiene Education Plan

A hygiene education program, which is concurrently implemented with the water supply plan, was prepared. The plan proposes an implementation system consisting of VDC and VWC as a core assisted by the central and provincial governments. It is expected that the plan will ultimately improve the hygiene environment of the village and construct an active and productive rural society.

8. Project Evaluation

The implementation of the project is not only expected to fulfill the Basic Human Needs but also save the water fetching time and improve hygiene and health conditions in the 131 villages of the central Cambodia. In addition, it will qualitatively improve the living conditions and increase the villager's participation in the community development.

9. Social Consideration and WID

The proposed plan should be implemented under the VDC, which will be established in the target village, in order to allocate project benefits fairly and minimize the negative impact of the project. Since the villagers have little experience in VDC management system, the plan should provide a training of VDC members in operation and management of the organization. VDC should be established in collaboration with NGOs in the target village where it has not been established.

The plan also has a component of hygiene education, which will be implemented for maximizing the project benefits, sustainable O&M and improvement of hygiene practice. It is indispensable for the villagers to recognize the value of sanitary safe water in order to increase the hand pump users. The water supply facility will be sustained along with the increase of the users. There are various and important roles for women's participation in the water supply from planning stage to operation stage.

10. Environmental Assessment

The implementation of this project is assessed to have very little impact on the groundwater basin environment.

11. Recommendations

(1) Early Implementation of the Project

Through the development of groundwater resources, the water supply plan will improve water supply conditions in 131 villages in the central Cambodia. Being one of the basic human needs, the supply of clean water will improve public health and environmental sanitation - the basis of socio-economic development - and bring about further benefits in the long run. Cambodia is currently enjoying stable political conditions. The nation's economic and social conditions are expected to develop at a fast pace with assistance from international organizations and donor countries. A new bridge was built across the Mekong River in Kg. Cham Province. As these foreseen socio-economic changes could radically alter village environmental conditions of the proposed area, the project should be implemented as soon as possible.

(2) Water Supply Plan Coupled with Sanitation Plan

The water supply plan ultimately aims at realization of lively and healthy rural community through improvement of sanitary environment by supplying the resident clean and safe water sufficiently all the year round. As a part of the plan, a hygiene education program is proposed to improve hygiene practice of the rural people. However, the hygiene education becomes effective if it is implemented concurrently with the water supply plan. It is therefore recommended that the water supply plan should be coupled with the sanitation plan. The sanitation plan should have a component of sanitation facility construction and hygiene

education to be implemented together with the O&M education of the water supply facility.

(3) Water Quality Survey, Measures and Management

Groundwater quality of some wells in the Study area exceeds the WHO guideline in terms of chloride, iron, manganese, arsenic, fluoride and nitrate. Although arsenic and fluoride slightly exceed the guideline, they are still in the level that does not affect human's health directly. However, considering the present rural water supply situation, a nation wide comprehensive measures and management of water quality should be undertaken.

(4) Promotion of Village Development with Emphasis on Water Supply

The VLOM and hygiene education assistance (soft component) proposed herein refers to helping out the villagers in facility operation and maintenance and hygiene improvement. This is foreseen to develop the villagers awareness of facility operation and maintenance, and will also be absolutely relevant to the development of the village as a whole. It is most desirable, therefore, that the PDRD actively promotes the establishment of the VDC. The zealous conduct of the activities of the VWC and WPC established under VDC would highly likely lead to additional improvements in the living environment (e.g, village roads, education, public health and sanitation), and further activate agricultural production.

The Study on Groundwater Development in Central Cambodia

Final Report

Main Report

LOCATION MAP

EXCHANGE RATE AND LIST OF ABBREVIATION

EXECUTIVE SUMMARY

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CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

This draft final report on the Study on Groundwater Development in Central Cambodia presents the results of the studies conducted from December 2000 to March 2002. The report contains the review of socio-economy and rural water supply as well as hydro-geological environment of the study area. An intensive field survey was conducted at the target villages in two provinces of central Cambodia, Kampong Chhnang and Kampong Cham, on the water levels and water quality of existing shallow and tube wells. A geophysical survey was also conducted at the 30 priority villages and 200 target villages. At the 303 target villages, socio-economic questionnaire survey and 5,175 household survey were conducted. At the priority villages, test wells were drilled in order to investigate aquifer productivity and hydrogeological features. Based on the field data, groundwater resource was evaluated and a groundwater development plan of the two provinces was finalized.

1.1 Background

Cambodia covers a total of approximately 180 thousand km² and holds a population of about 11,440 thousand with a per capita GDP of about US\$300 (all figures are for 1998). The civil war that began in 1965 and continued for 25 years devastated the nation's socio-economy. After the signing of the peace treaty in Paris, France, in 1991, assistance from international agencies and other donor countries flowed in, helping reconstruct national socio-economic state. Despite all this, other developments, e.g. improvement of the living environment of 85% of the national population, which resides in the rural area, and infrastructure development, are far behind.

The provinces of Kampong Cham and Kampong Chhnang, the study area, are rural regions in central Cambodia where there are hardly any water supply facilities and the residents rely on rivers, ponds (including irrigation pond), lakes and shallow wells for water supply. Since most of these water sources get depleted in the dry season, only about 13% of the total population has access to stable drinking water supply. In addition, the groundwater resources are also high in iron and observed to be contaminated by man-made activities. The groundwater quality survey carried out in 2000 by the MRD (Ministry of Rural Development) and MIME (Ministry of Industries, Mining and Energy), under the assistance of the WHO, confirmed the existence fluoride, nitrate and arsenic in some wells exceeding the WHO guide line value. These conditions underscore the importance of a steady supply of safe drinking water to majority of the population in the study area.

Given these circumstances, the Royal Government of Cambodia (RGC) requested assistance to the Government of Japan (GOJ) for the conduct of a groundwater development study in two (2) provinces of Central Cambodia to supply water in rural areas. In response to this request, Japan International Cooperation Agency (JICA) sent a preliminary study team in August 2000 to clarify the background and specifics of the request. The S/W for the implementation of the study was concluded on August 24, 2000 by representatives of the said two (2) agencies and, as stipulated in the S/W, the study team was dispatched to undertake the study on December 18, 2000.

1.2 Objectives and Scope

1.2.1 Objectives

The study on the groundwater resources of the two (2) provinces in Central Cambodia is a coordinated program on the groundwater resources potential in the lower Mekong area. The study will finally contribute to the construction of groundwater supply systems in the villages located in the study area. Specifically, the study aims to achieve the following objectives.

- (1) To evaluate potential of groundwater resources
- (2) To formulate a groundwater development plan for the study area.
- (3) To transfer skills and technology of groundwater development method and management to the counterparts of the MRD in the course of the study.

1.2.2 Scope

The study was carried out from December 2000 to March 2002. The study period was divided into three (3) phases covering all the major subjects of the study. The study items are as follows:

Phase I: Basic Study

Work in Cambodia

- (1) Explanation & discussion of the Inception Report (IC/R)
- (2) Selection of target villages and priority villages.
- (3) Additional collection and analysis of existing data and materials
- (4) Field survey
- (5) Aerial photo interpretation
- (6) Geophysical prospecting at priority villages
- (7) Groundwater level measurement at existing wells

- (8) Planning of community involvement program
- (9) Preparation and discussion of the Progress Report (P/R)

Phase II: Analysis and Evaluation of Groundwater Resources

Work in Cambodia

- (1) Workshop
- (2) Detailed village survey
- (3) Geophysical prospecting
- (4) Water quality analysis
- (5) Social/ WID analysis
- (6) Community involvement activities
- (7) Water balance analysis
- (8) Preparation of hydrogeological map
- (9) Evaluation of groundwater resources
- (10) Preparation /explanation of the Interim Report (IT/R)

Phase III: Formulation of Groundwater Development Plan

Work in Cambodia

- (1) Supplement study
- (2) Water demand forecast
- (3) Formulation of planning specifications
- (4) Examination of alternative water sources
- (5) Preparation of water supply plan
- (6) Preparation of well drilling plan
- (7) Facility design
- (8) Equipment and materials procurement plan
- (9) Operation and management, organization plan
- (10) Monitoring program
- (11) Hygiene education program
- (12) Cost calculation and investment plan
- (13) Health and hygiene improvement plan
- (14) Initial Environmental Examination (IEE)

Work in Japan

- (1) Project evaluation
- (2) Priority ranking for groundwater development
- (3) Project implementation plan
- (4) Preparation of Draft Final Report (DF/R)

Work in Cambodia

- (1) Seminar
- (2) Explanation and discussion of the DF/R

1.3 Study Area

Located on the southwestern region of Indochina, Cambodia lies between 10 ° 44' and 14 ° 44' of north latitude and 102 ° and 107 ° of east longitude. It covers 181,035 km² and is bordered by Thailand and Laos to the west and north, by Vietnam on the east and south, and the Gulf of Thailand on the southwest. From north to south, it is about 470km long and has a width of 570 km.

Mekong River flows southward through the country from the border of Laos to Kratie Province, then westward through Phnom Penh to join the Tonle Sap River. The Mekong and Bassac Rivers flow southward from Phnom Penh to the border of Vietnam, passing the Mekong Delta on its way to the South China Sea.

The Study was carried out in the central region of Cambodia, within the provinces of Kampong Cham and Kampong Chhnang. It is located in the central alluvial and basaltic plains along the Mekong and Tonle Sap Rivers. It comprises an area of about 16 thousand km² with a total population of about 2 million and lies between 11 ° 40' and 12 ° 40' of the north latitude, and between 104 ° and 106 ° of the east longitude.

The study area covers the following two (2) provinces (Figure 1.1).

Kampong Chhnang Province

Kampong Cham Province

The number of villages in the study area are as shown in the following table. The study area is made up of 2,294 villages and total population of about 2 million. Out of these 2,294 villages, the study covers the 581 villages (actually 572 villages as stated in CHAPTER 4) the RGC requested the study implementation for.

Population and Number of Villages in the Study Area

Province	Area (km ²)	District	Commune	Village	Population	Population Density
Kampong Cham	9,799	16	173	1,748	1,608,914	164
Kampong Chhnang	5,521	8	69	546	417,693	76
Total	15,330	24	242	2,294	2,026,607	133

1.4 Study Schedule

The study was implemented by phase as shown below.

Phase I	Basic Study (including field reconnaissance)
Phase II	Analysis and Evaluation of Groundwater Potential
Phase III	Formulation of Groundwater Development Plan

1.5 Study Team

For this study, the Department of Rural Water Supply (DRWS) which is under the MRD, acted as the counterpart agency. The JICA Study team experts and the counterpart personnel from the DRWS and the Provincial Department of Rural Development (PDRD) carried out the study jointly

JICA Study Team

Dr. Akira KAMATA	Team Leader/Hydrogeologist
Dr. Akira SUGIYAMA	Co-Team Leader/Geologist
Dr. Takayoshi KURATA	Hydrologist
Dr. Naoaki SHIBASAKI	Hydrogeologist
Mr. Shinichi ISEKI	Geophysicist
Mr. Jun MATSUO	Geophysicist
Mr. Masatoshi TANAKA	Drilling Supervisor
Mr. Satoshi ISHIDA	Civil Engineer
Mr. Shoji MASUMURA	Economist
Mr. Yoshiyuki SHIGA	Rural Planner
Mr. Akira DOI	Sanitary Engineer
Mr. Hiroshi OGAWA	Social Analyst
Mr. Masahiko TAKAHASHI	Coordinator

DRWS

Dr. Mao Saray	Director
Mr. Chan Darong	Deputy Director
Mr. Sam Bonal	Civil Engineer
Mr. Sok Chhun Hok	Civil Engineer
Mr. Seng Eam Hor	Civil Engineer
Mr. Lay Sitha	Civil Engineer
Mr. Chum Sopheanth	Civil Engineer

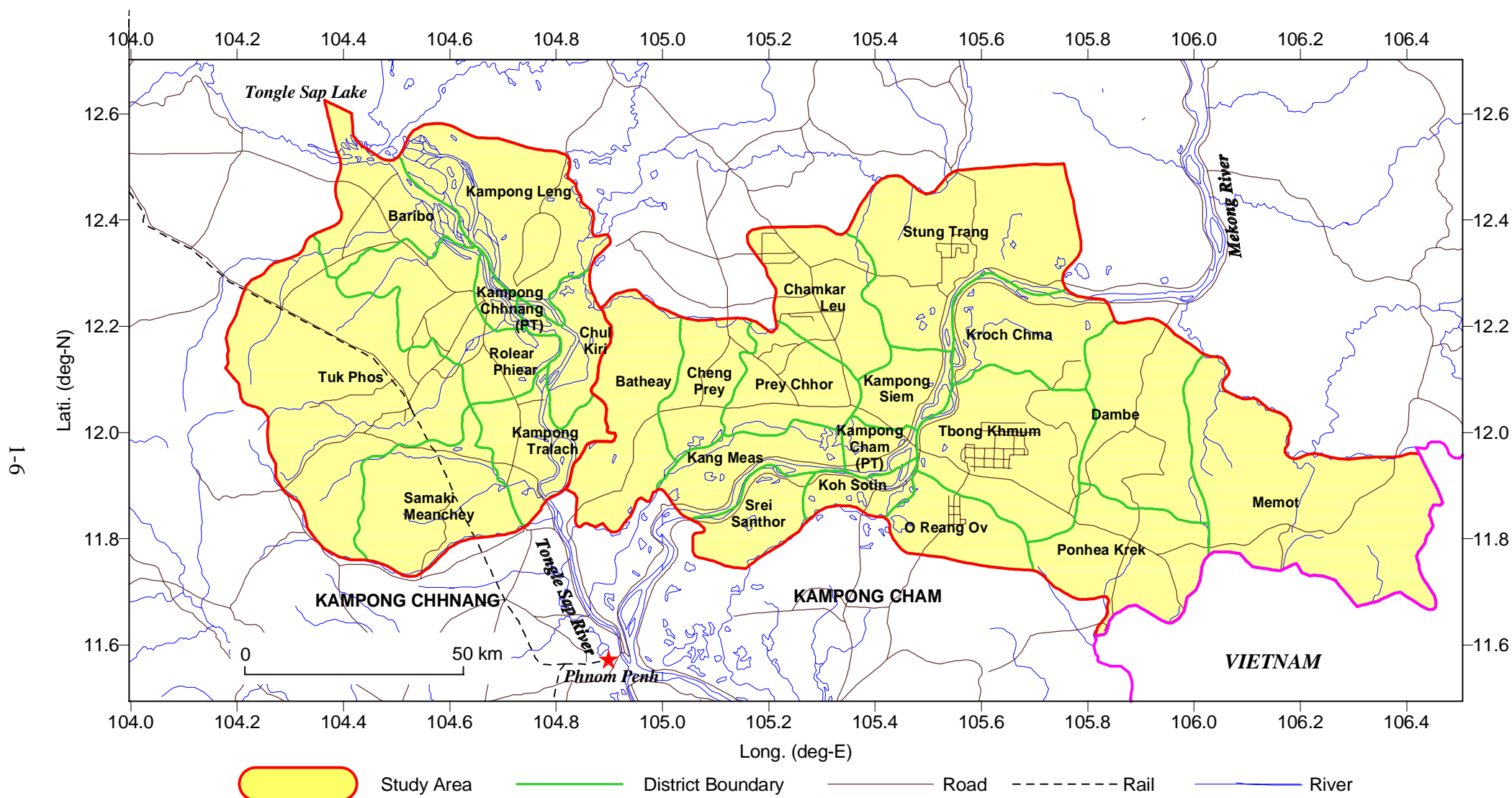


Figure 1.1 Districts in the Study Area