No.

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT,
MINISTRY OF PLANNING AND INVESTMENT
SOCIALIST REPUBLIC OF VIETNAM

THE STUDY

ON

GROUNDWATER DEVELOPMENT IN

THE RURAL PROVINCES OF

THE CENTRAL HIGHLANDS

FINAL REPORT

VOLUME I

SUMMARY

AUGUST 2002

NIPPON KOEI CO., LTD.
NIKKO EXPLORATION & DEVELOPMENT CO., LTD

SSS
JR
02-115

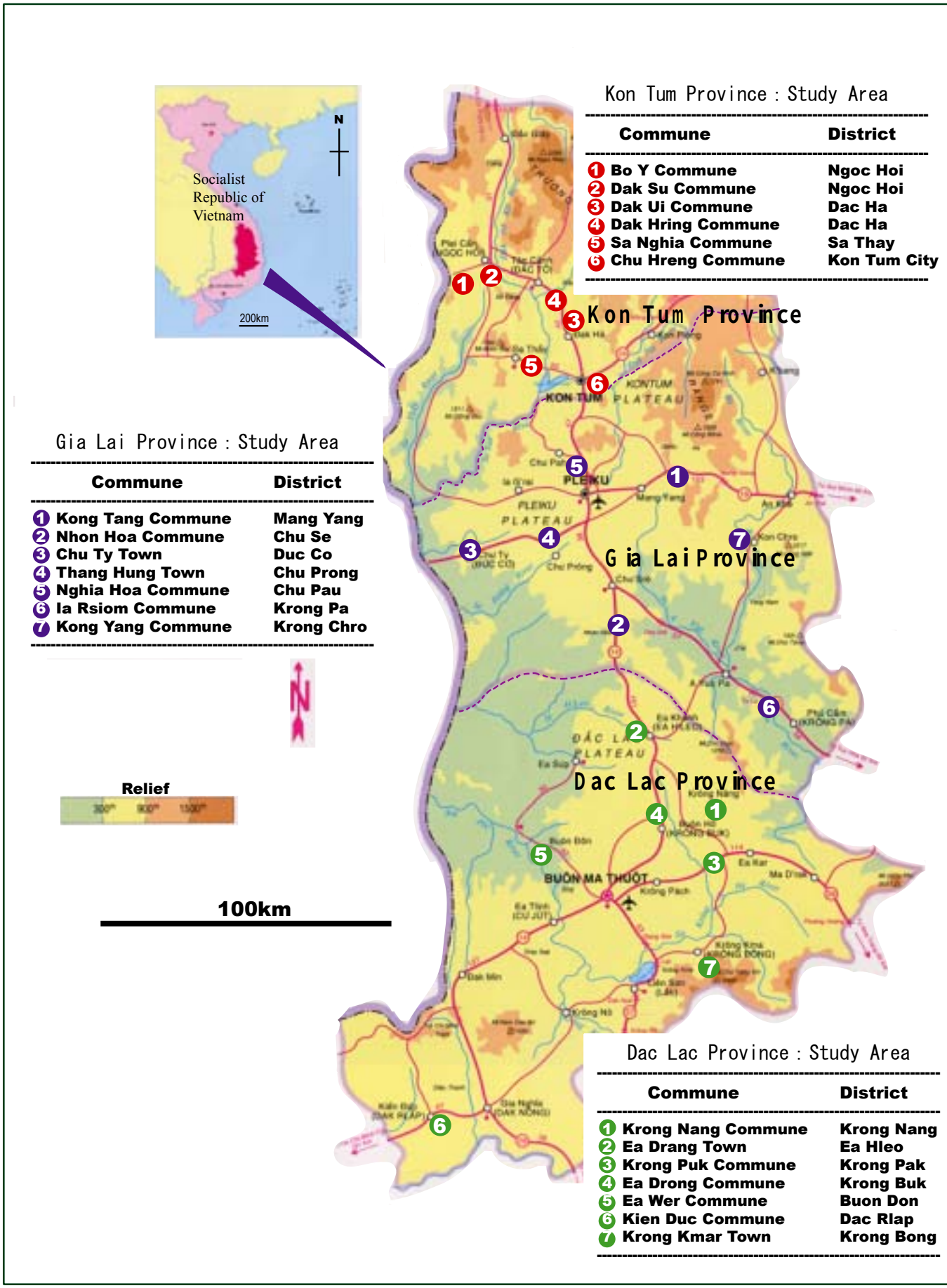
Composition of the Final Report

Volume Ⅰ	:	SUMMARY
Volume Ⅱ	:	MAIN REPORT
VolumeⅢ	:	SUPPORTING REPORT
VolumeⅣ	:	DATA BOOK
VolumeⅤ	:	SUMMARY in Japanese

Currency Exchange Rates Adopted for the Study

US$ 1.00 = VND 15,000 = JPY 120

As of August 2002



Kon Tum Province : Study Area

Commune	District
1 Bo Y Commune	Ngoc Hoi
2 Dak Su Commune	Ngoc Hoi
3 Dak Ui Commune	Dac Ha
4 Dak Hring Commune	Dac Ha
5 Sa Nghia Commune	Sa Thay
6 Chu Hreng Commune	Kon Tum City

Gia Lai Province : Study Area

Commune	District
1 Kong Tang Commune	Mang Yang
2 Nhon Hoa Commune	Chu Se
3 Chu Ty Town	Duc Co
4 Thang Hung Town	Chu Prong
5 Nghia Hoa Commune	Chu Pau
6 Ia Rsiom Commune	Krong Pa
7 Kong Yang Commune	Krong Chro

Dac Lac Province : Study Area

Commune	District
1 Krong Nang Commune	Krong Nang
2 Ea Drang Town	Ea Hleo
3 Krong Puk Commune	Krong Pak
4 Ea Drong Commune	Krong Buk
5 Ea Wer Commune	Buon Don
6 Kien Duc Commune	Dac Rlap
7 Krong Kmar Town	Krong Bong

Location Map

PREFACE

In response to a request from the Socialist Republic of Viet Nam, the Government of Japan decided to conduct a study on Groundwater Development in the Rural Provinces of the Central Highlands in the Socialist Republic of Viet Nam and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr.Suzumura Tadao of Nippon Koei Co., LTD. and consists of Nippon Koei Co., LTD. and Nikko Exploration & Development Co., LTD. between February 2001 and June 2002.

The team held discussions with the officials concerned of the Government of Viet Nam 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 Viet Nam for their close cooperation extended to the study.

August 2002

川上隆朗

Kawakami Takao
President
Japan International Cooperation Agency

August 2002

Mr. Takao Kawakami

President

Japan International Cooperation Agency (JICA)

Tokyo, Japan

LETTER OF TRANSMITTAL

Dear Sir,

It is with great pleasure that we submit to you the Final Report of the "The Study on Groundwater Development in the Rural Provinces of the Central Highlands " in the Socialist Republic of Viet Nam.

This report presents the study result for the evaluation of the groundwater resources potential, the results of water supply master plan, and the results of feasibility study for the selected 21 systems to be implemented as early as possible with priority order in the 20 target communes.

We hope this report will be helpful for realization of the importance of the implementation, and will be contributed for improvement of water supply, sanitation and environmental condition of the Central Highlands by construction of water supply system in early stage.

We wish to express our deep appreciation and gratitude to personal concerned of your Agency, JICA Viet Nam Office, the Embassy of Japan in Viet Nam, Ministry of Agriculture and Rural Development, Center for Rural Water Supply, Sanitation and Environment and the authorities concerned of the Government of Socialist Republic of Viet Nam, Province, District and Communities for courtesies and cooperation extended to us during our Study.

Very truly yours,

鈴村 忠男

Tadao Suzumura

Team Leader

The Study on Groundwater Development

in the Rural Provinces of Central Highlands

THE SOCIALIST REPUBLIC OF VIETNAM

THE STUDY ON GROUNDWATER DEVELOPMENT IN

THE RURAL PROVINCES OF THE CENTRAL HIGHLANDS

STUDY PERIOD: JANUARY 2001 – AUGUST 2002

COUNTERPART: THE MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT

ABSTRACT

1. Objective of the Study

The objectives of the Study are as follows:

1) To evaluate groundwater potential for the water supply scheme in the Study area of the three (3) provinces of Kon Tum, Gia Lai and Dac Lac.
2) To formulate a master plan for the water supply scheme in the Study area.
3) To conduct a feasibility study on 20 priority communes to be identified in the Study.
4) To pursue technology transfer to the counterpart personnel in the course of the Study.

The people in the Study area are mostly using contaminated surface water and/or shallow groundwater of dug wells or springs which is presently contaminated by fertilizer and extremely dwindling water volume by development. New water resources development is, therefore, urgent issues to be solved for the people.

2. Study Area

The study area is in the three provinces of Kon Tum, Gia Lai and Dac Lac in the Central Highlands of Vietnam. The 20 communes targeted within the three provinces were officially requested by the counterpart agency of the Socialist Republic of Vietnam.

2.1 Natural Condition

The Central Highlands region, located in the western part of Central Vietnam, covers most of the territory of the provinces, and has a total area of 57,373 km^2. The Central Highlands are surrounded by mountains area. Thirteen of the 20 targeted communes are located in the high mountain area. The climate in the study area is characterized by tropical monsoons. The temperature ranges from 19-24^oC depending on altitude. The highest temperatures are 28-30^oC and the lowest temperatures are around 15^oC. The annual rainfall is 1,200-2,000 mm. There are clearly distinguishable wet and dry seasons.

2.2 Hydrogeology

Groundwater can be found in the fissure zone of basalt, Mesozoic sedimentary rocks and granitic rocks.

2.3 Socio-economic Conditions

The total population of Kon Tum province (land area of 9,600 km^2) is 330,000 , 960,000 in Gia lai province (land area of 15,500km^2) and 1,800,000 in Dac Lac province (land area of 19,500km^2). The average population growth is reported as 1 to 3%. However, the values are variable depending on social and regional economic conditions. Income in Kon Tum province is the lowest among the three provinces. The people living in the mountainous areas of Kon Tum province may move internally to the target communes of K1-K6, due to rather good living conditions compared to the mountains.

2.4 Fied Survey Results

The poverty ratio in the Study area ranges from 7-24%. In the target area, 20 ethnic groups were identified. The proportion of ethnic minority for each province is 73% in Kon Tum, 29% in Gia Lai and 38% in Dac Lac, respectively. Water resources in the Study area are classified as dug wells, shallow wells with hand pump (UNICEF), deep wells, rivers, streams, springs, and rain water (rainy season only). The ethnic minorities had access to clean surface water before deforestation. Presently, although the surface water sources are contaminated and dwindling due to agricultural development, the people are compelled to use it for their economic conditions.

The following table shows the result of JICA exploratory test well:

Hydrogeological Characteristics of Drilling Wells

Commune/town		Aquifer geology	Well depth(m)	S/W/L (m)	Safe well yield (m^3/day)	Drawdown
▪ **Kon Tum province**						
K1	Bo Y	Neogene sediments and gneiss	150	1	100	32
K2A	Dak Su	Neogene sediments and gneiss	100	1	150	22
K3	Dak Ui	Gneiss	150	1	250	17
▪ **Gia Lai province**						
G1	Kong Tang	Basalt	150	35	300	22
G2	Nhon Hoa	Basalt	170	20	200	40
G3	Chu Ty	Basalt	150	25	350	32
G4	Thang Hung	Basalt	180	35	250	10
G5	Nghia Hoa	Basalt	160	35	200	26
G6	Ia Rsiom	Quaternary sediments and Jurassic sandstone	180	25	400	16
G7	Kong Yang	Basalt and granite	160	10	400	23
▪ **Dac Lac province**						
D1	Krong Nang	Basalt	150	15	350	16
D2	Ea Drang	Basalt	180	30	200	
D3	Krong Buk	Basalt	150	10	400	21
D4	Ea Drong	Basalt	180	25	250	30
D5	Ea Wer	Basalt and jurassic sandstone	150	5	300	22
D6	Kien Duc	Basalt	180	30	250	22
D7	Krong Kmar	Quaternary sediments and jurassic sandstone	50	5	500	10

High values of iron, well above those stipulated in the Vietnamese standard, were found in the waters of G1 (Kong Tang), G6 (Ia Rsiom), G7 (Kong Yang), D4 (Ea Drong), D5 (Ea Wer), D7 (Krong Kmar), K1 (Bo Y), K2A (Dak Su) and K3 (Dak Ui). High manganese contents were identified in K3 (Dak Ui), G4 (Thang Hung), G7 (Kong Yang), D5 (Ea Wer) and D7 (Krong Kmar). No organic pollution and dioxin contamination were confirmed from the water of the exploratory test wells.

3. Master Plan Study

3.1 Water Supply Plan

The National Rural Clean Water Supply and Sanitation Strategy up to the year 2020 (NRWSS) was published in August 2000.

Targets of Water Supply Plan		
NRWSS	Phase-1	Phase-2
Target Year	2010	2020
Population to be served	85 %	100 %
Water requirement per capita	60 L/d/c	
Duration of service	24 h/day	

The following three options are recommended in this Study in accordance with the NRWSS.

Option	Population served	Definition
Option 1 **Centralized piped system**	**2,000<**	**Several villages & hamlets shall be connected by one piped system.**
Option 2 Small piped system	1,000 - 2,000	Each village or hamlet or a few villages only served by simple piped system.

Option 3 Household system	<1,000	Individual house or a few houses shall be served by very simple method (improvement of dug well etc in general).

3.2 Selection of the Prioritized System

In order to meet the same goal of the NRWSS in this study, the 46 systems in the target 20 communes were identified. The 21 systems selected for feasibility study are highlighted.

Phase	Period	Targeted supply percentage	Implementation Schedule	
			Number of System to be implemented	Planned supply percentage
Phase 1	**2003-2010**	**85%**	**The prioritised 21 systems**	**Approx. 86%**
Phase 2	2010-2020	100%	Expansion of the 21 systems and/or implementation of the remaining 25 25 systems	Approx.100%

4. Feasibility Study and the Two Pilot Model Schemes

4.1 Development Plan of Water Resources

The results of 20 exploratory test wells by JICA Study team show that 17 wells were successful for production well. The result indicates that groundwater development is possible except with one system (K4-1: surface water).

4.2 Design for Water Supply Facilities

The most optimum design was carried out for the selected 21 systems by taking into account the topographic condition and households location. The result is shown below.

Commune/ Town Name	Number of Villages		Popu-lation 2010	Water demand 2010 Qav	Exist available wells (yiel)	Number of wells till 2010	Raw water pipeline	Treat-ment plant	Reservoir tank	Elevated tower	Distribu pipeline (km)
Kon Tum Province											
K1: Bo Y C.	**K1-1**	**7**	**7797**	**477**	**1(100)**	**4**	**6000**	**1**	**1**	**0**	**22**
K2: Dak Su C.	**K2-1**	**3**	**1612**	**99**	**1(150)**	**0**	**1500**	**1**	**1**	**0**	**11**
	K2-3	**9**	**4862**	**298**	**0(150)**	**2**	**1000**	**1**	**1**	**0**	**19**
K3: Dak Ui C.	**K3-1**	**5**	**2819**	**173**	**1(250)**	**0**	**0**	**0**	**0**	**0**	**10**
K4: Dak Hring C.	**K4-1**	**3**	**3136**	**192**	**river water**		**500**	**1**	**1**	**1**	**21**
Gia Lai Province											
G1:Kong Tang T.		**11**	**6988**	**428**	**1(300)**	**1**	**3000**	**1**	**1**	**1**	**48**
G2: Nhon Hoa C.		**15**	**13779**	**843**	**1(200)**	**5**	**2000**	**1**	**1**	**1**	**44**
G3: Chu Ty T.		**8**	**7698**	**471**	**1(350)**	**1**	**3000**	**1**	**1**	**1**	**44**
G4:Thang Hung C.	**G4-1**	**5**	**5080**	**311**	**1(250)**	**1**	**3000**	**1**	**1**	**1**	**16**
G5:Nghia Hoa	**G5-1**	**5**	**4008**	**245**	**1(200)**	**1**	**3000**	**1**	**1**	**1**	**21**
G6: Ia Rsion	**G6-1**	**7**	**4685**	**287**	**1(400)**	**0**	**1500**	**1**	**1**	**1**	**10**
G7: Kong Yang	**G7-1**	**5**	**1837**	**112**	**1(400)**	**0**	**1500**	**1**	**1**	**1**	**15**
Dac Lac Province											
D1: Krong Nang T.		**9**	**12903**	**790**	**1(350)**	**2**	**4500**	**1**	**1**	**1**	**37**
D2: Ea Drang C.		**13**	**18464**	**1130**	**200**	**6**	**10500**	**1**	**1**	**0**	**37**
D3: Krong Buk C.	**D3-1**	**7**	**8556**	**524**	**1(400)**	**1**	**3000**	**1**	**1**	**1**	**15**
	D3-2	**5**	**4463**	**273**	**1(400)**	**1**	**1500**	**1**	**1**	**1**	**27**
D4: Ea Drong C.	**D4-1**	**6**	**7775**	**476**	**1(250)**	**1**	**4500**	**1**	**1**	**1**	**27**
	D4-2	**4**	**2034**	**125**	**250**	**1**	**1500**	**1**	**1**	**1**	**15**
D5: Ea Wer C.	**D5-1**	**9**	**8920**	**546**	**1(300)**	**1**	**3000**	**1**	**1**	**1**	**25**
D6: Kien Duc T.		**8**	**10619**	**650**	**1(250)**	**2**	**4500**	**1**	**1**	**0**	**25**
D7:Krong Kmar T.		**8**	**7484**	**458**	**1(500)**	**1**	**1500**	**1**	**1**	**0**	**19**

4.3 Institution, Operation and Maintenance

The main outstanding aspect not examined in the master plan study was evaluation of the capacity of the proposed O&M management unit comprised of local residents. Self-support by users paying water charges is essential for sustainable O&M of the systems.

4.4 Cost Estimate for the Selected 21 systems

The following table show the result of the cost estimates:

No.	System	Construction Cost	Base Cost	Project Cost
1	K1-1	875,885	1,007,268	1,107,995
2	K2-1	156,290	179,734	197,707
3	K2-3	443,742	510,303	561,334
4	K3-1	205,461	236,280	259,908
5	K4-1	459,427	528,341	581,175
1	G1	607,639	698,785	768,663
2	G2	1,064,964	1,224,709	1,347,179
3	G3-1	593,946	683,038	751,342
4	G4-1	345,588	397,426	437,169
5	G5-1	340,560	391,644	430,808
6	G6-1	212,663	244,562	269,019
7	G7-1	227,251	261,339	287,473
1	D1	640,632	736,727	810,399
2	D2	926,850	1,065,878	1,172,465
3	D3-1	337,039	387,595	426,354
4	D3-2	321,530	369,760	406,735
5	D4-1	544,279	625,921	688,513
6	D4-2	246,098	283,013	311,314
7	D5-1	566,628	651,622	716,784
8	D6	574,724	660,933	727,026
9	D7	358,109	411,825	453,008
Total		10,049,305	11,556,701	12,712,371
VAT (10 %)				1,004,931
Grand Total				**13,717,301**

Note: Base Cost=Construction cost + Land acquisition cost + Engineering services cost (15%of construction cost)

Project Cost=Base cost + Physical contingency (10% of Base cost), excluding price contingenc

4.5 Environmental Impact Assessment (EIA)

The result of environmental impact assessment is the following, but they are not serious factor:

- Two well sites are feared a slightly lowering groundwater level when continuos pumping,
- Five test wells are abstracting the shallow groundwater because that relatively shallow aquifers only are available, then, water contamination from the surface is scared,
- Ten sites may be needed land acquisition for construction of water supply facility.

4.6 Feasibility Evaluation of the 21 systems

The results of the economic internal rate of analysis show that only ten systems have positive values. The other 11 systems are negative, meaning they are not economically feasible. However, the 11 systems are judged to be valuable for the reasons of providing basic human needs, social equity, large numbers of beneficiaries, and support for poverty and ethnic minority peoples. The schemes will ensure hygiene improvement of the people.

5. Two Pilot Model Plants Construction

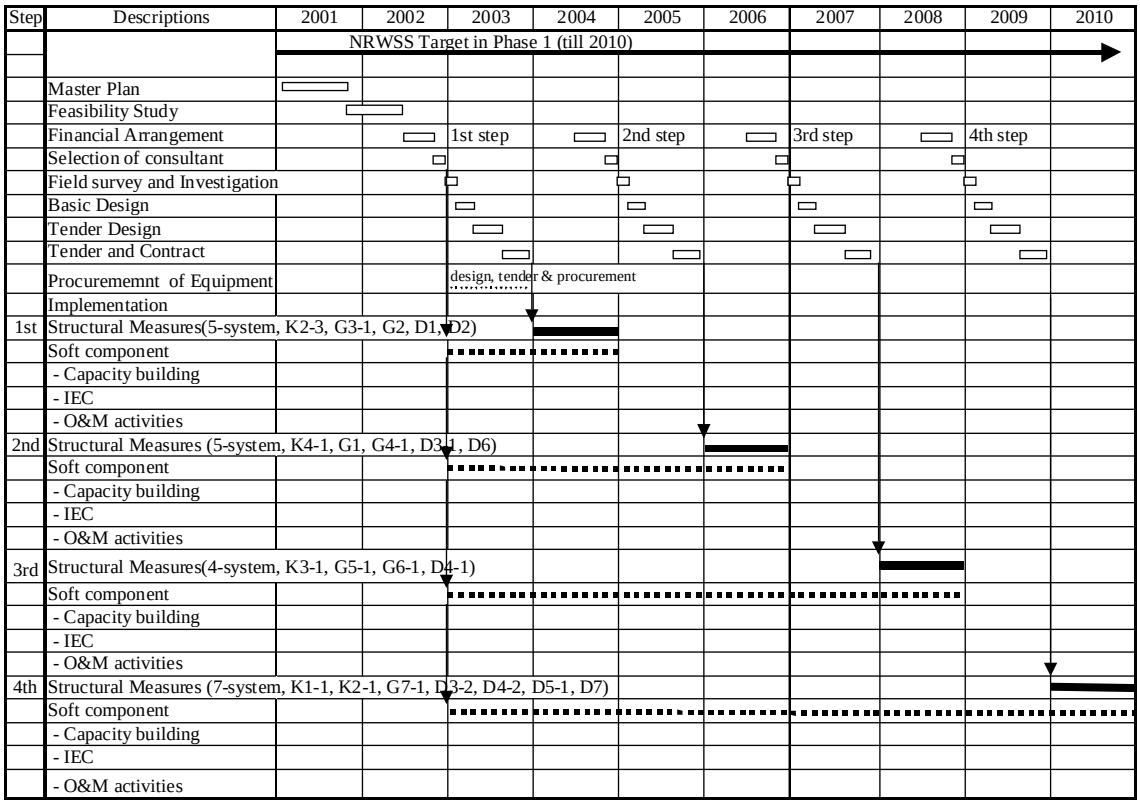
To examine practical O&M of the water supply unit, two pilot model plants were constructed, one in K3 commune of Kon Tum province and the other in G2 commune of Gia Lai province. The two communes are characteristic of the Central Highlands in terms of poverty and ethnic minorities. In K3-1 system, each public tap is shared by several poor households. In G2

commune, ethnic minority people of “E De” form the majority, approximately 80%, of the residents. The monitoring result of the two pilot models reveals that information, education and communication (IEC) is essential to increase users.

6. Step-wised Development of the 21 systems

The implementation program and pre-conditions that must be met prior to commencing facility construction were recommended based on the monitored results of the two pilot models for four months. The recommendations follow.

Implementation Schedule for the 21 systems



The implementation of the 21 systems was subdivided into four steps in consideration of the capability of the communes for management, ability to pay for water, and the social and political situation of each system. The five highest priority systems are included in step 1 (K2-3, G1, G3-1, D1 and D2). The next five highest priority systems form step 2 (K4-1, G1, G4-1, D3-1 and D6), the next four systems in order of priority represent step 3 (K3-1, G5-1, G6-1 and D4-1), and the remaining systems are step 4. The system of K2-3 shall be combined with the town water supply project financed by Asian development bank (ADB).

The communes included in step 3 require capacity building and strengthening in order to form a capable water supply unit. Therefore before these systems can be implemented, it is recommended that the soft components of information, education and communication (IEC) activities be commenced. The implementation schedule in these communes is placed in the

latter half of Phase 1 (2008–2010) as step 4, but the information, education, and communication (IEC) activity shall commence from early in Phase 1 to underpin the sustainability of these systems.

The cost is shown below table by four step-wised implementation plan.

Phase	Implementation Period	No. of System	US$ million including VAT
Step 1	**2002-2005**	**5**	**5.1**
Step 2	2004-2006	5	3.0
Step 3	2005-2008	4	1.8
Step 4	2007-2010	7	3.8

The electricity in the rural area is unstable and unreliable. To prevent loss of water supply through power failure, and to reduce the water tariff as much as possible in several poor communes, it is recommended that several sets of solar powered submersible motor pumps be procured in future. One drilling rig and associated accessories will ensure that future implementation by the Vietnamese authorities will be economic and effective. Also, four sets of 4 WD vehicles will be effective for information, education and communication (IEC) activities by Vietnamese side.

7. Project Evaluation

The project implementation will be effective to achieve the goal of the NRWSS, promotion of rural water supply, technical and institutional development, sanitation environment, hygiene improvement, gender improvement and social equity and so on. Beside, the project in the Central Highlands will specially support for poor people as BHN, reduction of the gaps between urban and rural area, large numbers of beneficiaries, and large numbers of ethnic minorities.

8. Recommendation

8.1 Implementation Schedule

In each implementation step as mentioned in Clause 6 “Step-wised Development”, construction of 5 systems in each step may be most suitable method from local contractor’s ability, and other factors. The 5 systems will be chosen 1 system from Kon Tum, and each 2 from Gia Lai and Dac Lac provinces for social equity consideration.

8.2 Subsidy to support poor communes by the government of Vietnam

It is recommended to consider the subsidy for poor communes for deficit in operation and maintenance, and information, education and communication (IEC) activities of WSUs.

8.3 Information, education and communication (IEC) activities

Prior to the project construction, IEC activities are essential by financial support from the Vietnamese government for poor communes.

8.4 Continuous Operation of the Two Pilot Models

The two pilot models will be example for rural water supply system not only for the rural area in the Central Highlands but also for all the areas in the Country. It is requested to operate well continuously as a good model case.

Location Map

Abstract

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List of Abbreviations

ADB	Asian Development Bank
As	Arsenic
ATP	Ability to Pay
AusAID	Australian Grant Aid
BARD	bank for Agriculture and Rural Development
B/D	Basic Design
CERWASS	Centre for Rural Water Supply and Sanitation
CHC	Community Health Centre
CIDA	Canadian International Development Assistance
CPC	Commune People's Committee
DANIDA	Danish International Development Assistance
DARD	Department of Agricultural Development
DF/R	Draft Final Report
DFID	UK, Department for International Development
DGMV	Department of Geology and Minerals of Vietnam
DHC or DHS	District Health (Services) Centre
DOF	Department of Finance
DOH	Department of Health
DOSTE	Department of Science, Technology and Environment
DPC	District People's Committee
DPI	Department of Planning and Investment
EIA	Environmental Impact Assessment
EM	Ethnic Minority
F	Fluorine
F/R	Final Report
F/S	Feasibility Study
FU	Farmer's Union
GAD	Gender and Development
GDP	Gross Domestic Product
GSO	General Statistical Office
HDPE	Hard PVC pipes
HRD	Human Resources Development
HC	House Connection
IEC	Information, Education and Communication

IC/R	Inception Report
IT/R	Interim Report
IEE	Initial Environmental Examination
JICA	Japan International Cooperation Agency
KI	Key Informant
kWh	kilo Watt(s) hours
lcd	litre per capita per day
LEP	Law on Environmental Protection
MARD	ministry of Agriculture and Rural Development
MCM	Million Cubic Meter
M/M	Minute of Meeting
MOC	Ministry of Construction
MOET	Ministry of Education and Training
MOF	Ministry of Finance
MOLISA	Ministry of Labour, Invalids and Social Affairs
M/P	Master Plan
NGO	Non-Governmental Organizations
NIPHEP	National Institute of Public health and Environmental Protection
NRWSS	National Rural Water Supply and Sanitation
VIWASE	Vietnam consultant for Water supply Sanitation and Environment
ODA	Official Development Assistance
O&M or O & M	Operation and Maintenance
PC	Portland Cement
PCERWASS	
PCM	Project Cycle Management
PDM	Project design Matrix
PDOSTE	Provincial Department of Science, Technology and Environment
PDPSC	Provincial Disease Prevention and Sanitation Centre
PHSC	Provincial Health Services Centre
PPC	Provincial People's Committee
P/R	Progress Report
PSCWS	Provincial Steering Committee for Water Supply and Sanitation
PE	Poly-Ethylene Pipe
pH or PH	Potential of Hydrogen
PT	Public Taps
PVC	Poly-Vinyl Chlorine Pipe

PWL	Pumping Water Level
QTT2	Quantification Theory Type II
RRA	Rapid Rural Appraisal
RWSS	Rural Water Supply and Sanitation
SPC	State Planning Committee
SRV	Socialist Republic of Vietnam
S/W	Scope of Work
SWL	Static Water Level
TEM	Transient Electromagnetic Method
TDEM	Time Domain Electromagnetic Method
THS	Town Health Services Centre
TPC	Town People's Committee
TV	Television media
UARD	Unit of Agriculture and Rural Development
UFW	
UNDP	United Nation Development Planning
UNICEF	United Children's Fund
USD	US Dollar
VHW	Village Health Worker
VIP	Ventilation type Improved Pit
VND	Vietnam Dong
VNYU or YU	(Vietnam) Youth Union
WB	World Bank
WATSAN	Water Supply and Sanitation
WHO	World Health Organization
WID	Women in Development
WTP	Willingness to Pay
WU or VWU	(Vietnamese) Women's Union

Unit

bar	Pressure
h	Hour
pH	Potential of Hydrogen
q_{max}	Maximum hourly demand
Q_{max}	Maximum daily demand
Q_{av}	Average day demand

mg/l	milligram per litre
l	Litre
m	Medium
vh	Very high
l/c/d	Litre per capita per day
l/s	Litre per second
m^3	Cubic meter
km^2	Square kilometre
μ	1×10^{-6}
ϕ	Diameter
°C	Centi-degree
%	Percent
γ	Gamma (electrical logging)
k	Permeability coefficient
S	Storage capacity

1. Background to the Study

1.1 Background

The Government of the Socialist Republic of Vietnam (the Government of Vietnam) has been promoting water supply and sanitation systems in the rural area to improve living standards and reduce the gap between rural and urban areas since 1982. The target planned in the year 1996 for water supply was 80% coverage for the rural area by the year 2000, and potable water service to the 13,000 primary schools in the whole country. The target was re-scheduled to the year 2005 by the National Program for Rural Water Supply and Environmental Sanitation (NPRWSS). However, the present coverage of potable water is only 9.25% in the rural area. In an earlier project, "the Study on Groundwater Development in the Rural Provinces of Northern Part in the Socialist Republic of Vietnam", the Japan International Cooperation Agency (JICA) proposed a target year of 2005. The National Rural Water Supply and Sanitation Strategy (NRWSS), which was approved by the Prime Minister in August 2000 (No.104/2000/QD-TTg), again re-scheduled its target set with the assistance of the Danish International Development Cooperation Agency (DANIDA) as follows:

Re-scheduled Target by NRWSS

Short term target Year : **2005**	To provide clean water services to all public offices in the rural area.
Interim term target year : **2010**	To provide clean water service to 85% of the population in the rural area, and 70% coverage with 60l/capita/day for sanitation and hygiene improvement.
Long term target year : **2020**	To provide 100% coverage to population in the rural area with 60l/capita/day or more for sanitation and hygiene improvement.

Noting the difficulty in achieving targets, and in order to minimise future slippage, the Government of Vietnam has requested assistance from the Japanese Government for the current study, titled "Study on Groundwater Development in the Rural Provinces in the Central Highlands".

In response to the official request of the Government of Vietnam, JICA dispatched a Preparatory Study Team to Vietnam from 16 August to 9 September 2000 to discuss the Scope of Work (S/W) for the Study. During their stay in Vietnam, the team carried out field surveys in the study area, and held a series of discussion with

the officials of the Ministry of Agriculture and Rural Development (MARD), Ministry of Planning and Investments (MPI), Centre for Rural Water Supply and Rural Development (CERWASS) and other authorities associated with the Government of Vietnam.

On the basis of the S/W, JICA formed a joint venture with Nippon Koei Co., Ltd. and Nikko Tankai Co., Ltd. in 9 January 2001 to conduct the Study. The JICA Study Team (Study Team), which was comprised of experts from the joint venture, was dispatched to Vietnam on 28 January 2001 for the commencement of the study.

1.2 Objectives of the Study

In this Study, it was very important that the targets be the same as those set by the NRWSS in August 2000 for the water supply program. Therefore, the Study focused on a target year of 2020 through discussion with and confirmation from the Vietnamese counterpart authorities The Study also analysed the reasons for the targets being put back several times.

The objectives of the Study were as follows:

1) To evaluate groundwater potential for the water supply scheme in the Study area.
2) To formulate a master plan for the water supply scheme in the Study area.
3) To conduct a feasibility study on water supplies for 20 priority communes to be identified in the Study.
4) To pursue technology transfer to the Vietnamese counterpart authorities during the course of the Study.
5) To conduct appropriate workshops for the Vietnamese personnel.

1.3 General Outline of the Study Area

The Study concerned the three Provinces of Kon Tum, Gia Lai, and Dac Lac. Twenty communes in the three provinces were identified and studied for the potential provision water supply by groundwater at the request of the Government

of Vietnam. The locations of the 20 target communes are shown in the Location Map in the front of this report and are listed in the following table.

The 20 Target Communes of this Study

Town/ Commune		No. of village	No. of Household	Population
Kon Tum province				
K1	Bo Y C.	8	795	3,364
K2	Dak Su C.	12	703	2,997
K3	Dak Ui C.	13	1,007	5,226
K4	Dak Hring C.	13	1,231	5,775
K5	Sa Nghia C.	3	338	1,553
K6	Chu Hreng C.	6	315	1,572
	Province total	**55**	**4,389**	**20,487**
Gia Lai province				
G1	Kong Tang T.	12	1,163	5,567
G2	Nhon Hoa C.	14	1,906	11,084
G3	Chu Ty T.	7	1,481	6,377
G4	Thang Hung C.	7	1,313	6,338
G5	Nghia Hoa C.	6	762	3,650
G6	Ia Rsiom C.	9	844	4,531
G7	Kong Yang C.	10	607	2,526
	Province total	**65**	**8,076**	**40,073**
Dac Lac province				
D1	Krong Nang T.	9	1,998	10,795
D2	Ea Drang T.	13	2,931	14,853
D3	Krong Buk C.	20	2,598	13,566
D4	Ea Drong C.	21	1,676	8,706
D5	Ea Wer C.	11	1,073	5,502
D6	Kien Duc T.	8	2,062	8,626
D7	Krong Kmar T.	8	1,169	5,735
	Province total	**90**	**13,207**	**67,783**
Area total		**210**	**24,672**	**128,343**

Source: The original data by CERWASS for the proposal, updated by the Study Team in 2001

1.4 Study Period

The study was initiated in January 2001 and completed in August 2002. The total study period is about 19 month by the following 4 stages.

Stage	Study name	Study term
Stage-1	Basic investigation and evaluation of water supply	From Jan. 2001 To Apr.2001
Stage-2	Investigation for the groundwater potential	From Feb. 2001 To Jul. 2001
Stage-3	Master plan study for groundwater development, water supply and sanitation	From May 2001 To Oct. 2001
Stage-4	Feasibility study for the selected priority project	From Oct. 2001 To Aug. 2002

2. Outline of the Study Area

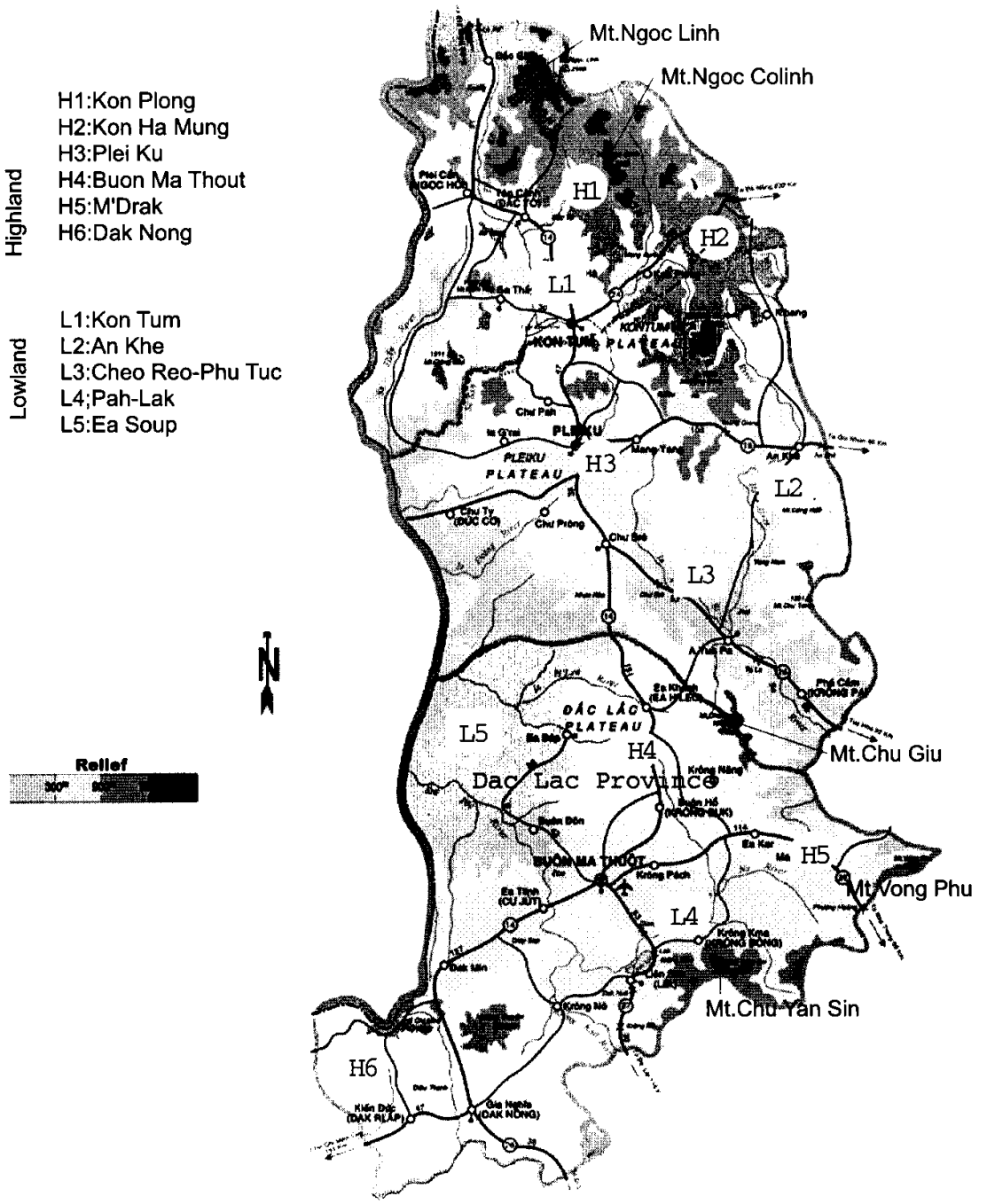
2.1 Natural Conditions

2.1.1 Geography, Topography and Climate

The Central Highlands region, located in the western part of Central Vietnam, covers most of the territory of Kon Tum, Gia Lai, Dac Lac and Lam Dong provinces, and has a total area of 57,373 km^2.

The Central Highlands region is surrounded by mountains. There are three major topographic characteristics, 1) High mountain area with elevations of 1300-2400 m, 2) Highland area with elevation of 300-1700 m, and 3) Limited depressions and plains having elevations of 400- 500 m. Thirteen of the twenty targeted communes are located in the high mountain area, and the other seven are located in the depression and plain areas.

The climate in the study area is characterized by tropical monsoons and influenced by the topographic conditions of the highlands. The temperature ranges from 19-24^oC depending on altitude. The highest temperatures of 28-30^oC are in April and the lowest temperatures, of around 15^oC, are in January. The annual rainfall is 1,200-2,000 mm, depending on the topographic conditions. There are clearly distinguishable wet and dry seasons. Wet season is from June to October, and Dry season is from November to May.



Source: JICA Study Team

Figure S. 1 Topographic Map of the Central Highlands

2.1.2 Geology

The following table shows the geological sequences in the Study area:

Table S. 1 Geological Sequences in the Study Area

Era	Period	Lithology	Intrusive rocks
Cenozoic	Quaternary (Q)	- Alluvium in plains/valleys (Q) - Basalt (β)	
	Lower Quaternary Upper Neogene	Basalts (βN_2-Q_1) in large areas of the plateau except northern Kon Tum province	
	Middle/Lower Neogene (N)	Sandstone, claystone and siltstone	
	Paleogene		-Granodiorite, granite and granosyenite of late Mesozoic to Early Cenozoic age -Diorite, granosyenite and granite in Dac Lac province
	Late Paleogene –Early Mesozoic		-Biotite & granite in Gia Lai province -Granite, granophyre and granodiorite in Gia Lai province and the northern Dac Lac and south-western Kon Tum provinces. - Diorite, granodiorite
Mesozoic	Cretaceous (K)	Sandstone, conglomerate and siltstone	
	Middle/Lower Jurassic (J)	Marine deposits of sandstone, siltstone, shale, limestone and conglomerate (J_{1-2}) in Dac Lac province	
	Triassic (T)	Volcano-sedimentary sequence of sandstone, siltstone, shale, limestone and conglomerate interbedded with rhyolite and dacite (T_2) in Da river basin of Gia Lai province and western Central Highlands	

Source: Department of Geology and Mines

(To be continued)

Paleozoic	Upper Permian	Basalts in Da river basin	
	Middle/Lower Permian (P)	- Siliceous shale interbedded with limestone and andesite in western Dac Lac province - Basalt, schist & siltstone in Da river basin of Gia Lai province	
	Carboniferous (C)		
	Lower Ordovician (O)	Schist, shale, quartzite and limestone in western Kon Tum province	
	Upper/Middle Cambrian		
	Lower Cambrian	Schist, quartzite and dolomite (PR_3) in northern Gia Lai and southern Kon Tum provinces	
Proterozoic	Upper Proterozoic		Granodiorite, granite and migmatite in eastern Kon Tum province and small parts of eastern Gia Lai and Dac Lac provinces
	Middle/Lower Proterozoic	Gneiss, amphibolite and quartzite (PR_{1-2}) in Gia Lai and Kon Tum provinces	
Archeozoic (AR)		Granulite and crystalline schist in upper Da river basin of Gia Lai province	Enderbite, charnokite, granite and migmatite in upper Da river basin of Gia Lai province

Source: Department of Geology and Mines

2.1.3 Hydro-geology

Groundwater can be found in the fissure zone of basalt, Mesozoic sedimentary rocks and granitic rocks. The hydro-geological classification is reported as, 1) Alluvial deposit, 2) Diluvial deposit, 3) Tertiary sedimentary rocks, 4) Old basalt lava, 5) Later basalt lava, 6) Cretaceous rock, 7) Jurassic rock, and 8) Granitic rocks of Pre-Mesozoic. Table S.2 shows the general hydro-geologic characteristics.

Table S. 2 Hydro-geological Parameters in the Study Area

Hydro-geological Classification	Geology	Thickness (m)	Yield (m^3/day/well)	Specific capacity (m^3/day /m)
Alluvial	Sand, silt and gravel	3 –5		4.3-28.5
Diluvial	Sand, silt and gravel	10-15	17-34	
Tertiary rocks	Sandstone, siltstone and conglo.	10-500		5.2-46.7
Old basalt lava	Peridotite basalt	10-150	14-1,270	0.8-264
Latest basalt lava	Solerite basalt	80-150	14-900	0.8-310
Cretaceous rock	Sandstone, siltstone and conglo.			1.7-17.3
Jurassic rock	Limestone, sandstone, conglo. And siltstone			4.3-28.5
Pre-Mesozoic Granitic rock	Gneiss and granite			0.8-2.6

Source: Department of Geology and Mines

2.2 Socio-economic Conditions

2.2.1 Population

In 1999, the total population of Kon Tum province (land area 9,600 km^2) was 330,000, Gia Lai province (land area 15,500km^2), 960,000 and Dac Lac province (land area 19,500km^2), 1,800,000. The average population growth in 1999 was reported as 1% in Kon Tum, 2% in Gia Lai, and 3% in Dac Lac. However, the values are variable depending on social and regional economic conditions. For instance, people living in the mountainous areas of Kon Tum province may move internally to the target communes of K1-K6, due to better living conditions than in the mountains, and some people may even move outside of the province. Table S.3 shows the results of the social survey. Additional data will be collected and included in the Master Plan (M/P) at the Feasibility Stage (F/S).

Table S. 3 Number of Villages, Households, Population in the Target Area

Town/ Commune		No. of village	No. of Household	Population	Average household size (persons/household)	Population growth rate*)(%)
Kon Tum province						
K1	Bo Y C.	8	795	3,364	4.2	18
K2	Dak Su C.	12	703	2,997	4.3	18
K3	Dak Ui C.	13	1,007	5,226	5.2	2.03
K4	Dak Hring C.	13	1,231	5,775	4.7	2.4
K5	Sa Nghia C.	3	338	1,553	4.6	1.9
K6	Chu Hreng C.	6	315	1,572	5.0	2.4
	Province total	**55**	**4,389**	**20,487**	**4.7**	
Gia Lai province						
G1	Kong Tang T.	12	1,163	5,567	4.8	2.3
G2	Nhon Hoa C.	14	1,906	11,084	5.8	2.2
G3	Chu Ty T.	7	1,481	6,377	4.3	1.9
G4	Thang Hung C.	7	1,313	6,338	4.8	1.7
G5	Nghia Hoa C.	6	762	3,650	4.8	2.0
G6	Ia Rsiom C.	9	844	4,531	5.4	2.0
G7	Kong Yang C.	10	607	2,526	4.2	2.0
	Province total	**65**	**8,076**	**40,073**	**5.0**	
Dac Lac province						
D1	Krong Nang T.	9	1,998	10,795	5.4	1.8
D2	Ea Drang T.	13	2,931	14,853	5.1	2.2
D3	Krong Buk C.	20	2,598	13,566	5.2	2.6
D4	Ea Drong C.	21	1,676	8,706	5.2	1.2
D5	Ea Wer C.	11	1,073	5,502	5.1	10.0
D6	Kien Duc T.	8	2,062	8,626	4.2	2.1
D7	Krong Kmar T.	8	1,169	5,735	4.9	3.4
	Province total	**90**	**13,207**	**67,783**	**5.1**	
Area total		**210**	**24,672**	**128,343**	**5.2**	

Source: RRA results

*): Population growth rate consists of both natural and immigration growth

Population growth rate and number of population will be reviewed at the F/S phase and fed back to M/P.

2.2.2 Regional Economy

Table S.4 shows monthly income per capita by income source in seven regions.

North East South region contains Ho Chi Minh City and surrounding provinces and has achieved outstandingly in most sectors. Central Highlands has the second highest per capita income among the seven regions. The agriculture sector in Central Highlands contributes the highest regional sector income in the country, and provides about 55% of the total income of the region.

Table S. 4 Monthly Income per Capita by Income Source and Region in 1999

Region	Total	Salary & wage	Agriculture Forestry & Fishery	Industry & construction	Service activities	Others
North West and North East	210.00	34.70	117.00	12.00	24.20	22.10
Red River Delta	280.30	75.70	93.30	23.00	42.30	46.00
North Central Coast	212.40	40.40	88.10	21.20	29.50	33.20
South Central Coast	252.80	70.50	83.90	13.70	54.10	30.60
Central Highlands	344.70	54.50	189.20	15.90	59.60	25.50
North East South	527.80	191.60	111.40	54.40	117.70	52.70
Mekong River Delta	342.10	69.40	164.90	17.10	57.50	33.20

Table S.5 presents income per capita by income source in each province.

Income in Kon Tum province is the lowest among the three provinces. The main reason is the low industrial crop production.

Table S. 5 Monthly Income per Capita by Income Source in Central Highlands

	Total (1000VND)	Salary & wage	Agriculture. Forestry & Fishery	Industry & construction	Service activities	Others
Dac Lac						
1996	309.52	10.84	59.69	3.68	17.03	8.76
1999	386.90	12.27	57.31	2.86	17.36	10.20
Gia Lai						
1996	168.96	20.64	47.79	5.39	16.06	10.12
1999	229.40	21.88	53.18	6.06	11.94	6.94
Kon Tum						
1966	162.91	20.67	48.96	4.37	16.50	9.50
1999	208.50	21.96	49.29	5.31	13.39	10.05

3. Present Conditions of the Study Area

3.1.1 Poverty

The social survey results were used to analyse the level of poverty in the 20 communes. The communes in Kon Tum province, except the K5 commune, have the highest poverty ratio of 15-30%. The poverty ratios in Gia Lai province are 11-46% and in Dac Lac province 7-24%. Details are described in Supporting Report-B.

3.1.2 Ethnic Groups

In the target area, 20 ethnic groups were identified. The proportions of ethnic minority for each province are 73% in Kon Tum, 29% in Gia Lai and 38% in Dac Lac. Ethnic minorities (EM) such as E De, Gia Rai, Ba Na, Xe Dang, Xo Dra, Ca Dong, Mnong, Gie, Mang, Brau and Romam, originate from the Central Highland areas. The E De people exist mainly in Dac Lac province. The Gia Rai, and Ba Na are found in both Gia Lai and Kon Tum provinces. The other original ethnic minority groups occur mainly in Kon Tum.

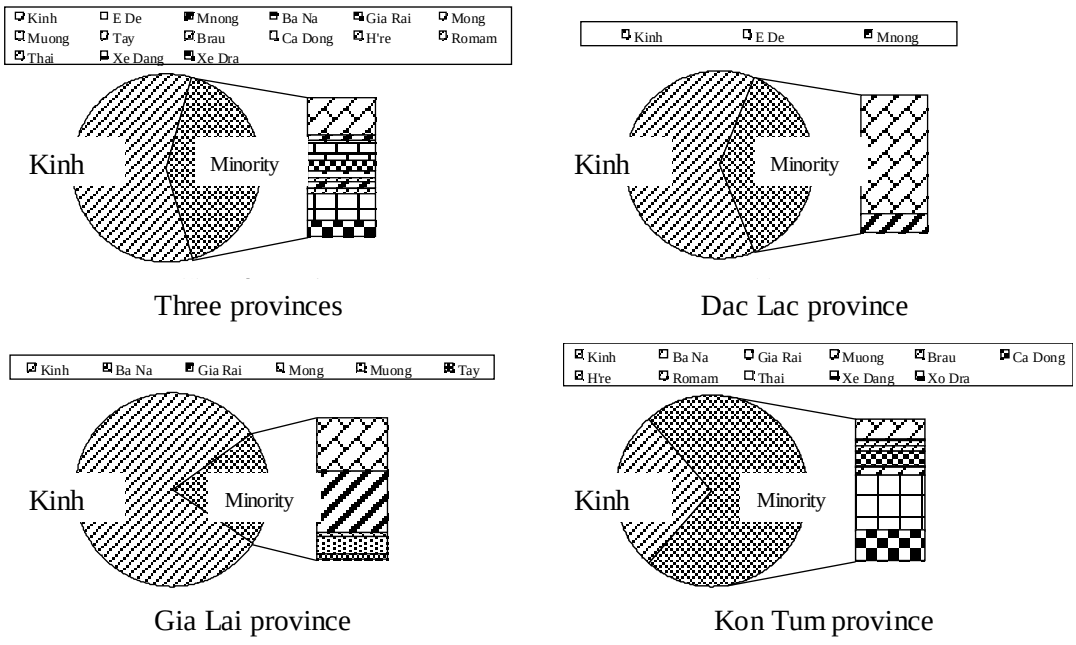


Figure S. 2 Proportion of Ethnic Minorities

3.1.3 Average Income, WTP and ATP

From the social survey, the average income, willingness to pay (WTP), and ability to pay (ATP) for a piped water supply were obtained and are summarised in Table S.6.

Table S. 6 Willingness and Ability to Pay for a Piped Water Supply

(Unit: VND)

Town/ Commune		Average annual income per capita	Willingness To Pay for Piped system (VND, %)		Ability To Pay	
					3% of the income	5%of the income
Kon Tum province						
K1	Bo Y C.	1,892,804	41,000	2.2%	56,784	94,640
K2	Dak Su C.	993,836	35,000	3.5%	29,815	49,692
K3	Dak Ui C.	1,067,566	25,700	2.4%	32,027	53,378
K4	Dak Hring C.	1,589,087	26,800	1.7%	47,673	79,454
K5	Sa Nghia C.	2,783,730	39,000	1.4%	83,512	139,187
K6	Chu Hreng C.	1,988,042	40,000	2.0%	59,641	99,402
Gia Lai province						
G1	Kong Tang T.	2,973,520	64,600	2.2%	89,206	148,676
G2	Nhon Hoa C.	5,350,492	55,700	1.0%	160,515	267,525
G3	Chu Ty T.	4,403,992	47,300	1.1%	132,120	220,200
G4	Thang Hung C.	1,960,873	81,700	4.2%	58,826	98,044
G5	Nghia Hoa C.	3,253,095	63,700	2.0%	97,593	162,655
G6	Ia Rsiom C.	2,527,044	63,100	2.5%	75,811	126,352
G7	Kong Yang C.	2,635,858	94,100	3.6%	79,076	131,793
Dac Lac province						
D1	Krong Nang T.	4,075,111	60,500	1.5%	122,253	203,756
D2	Ea Drang T.	3,015,873	53,600	1.8%	90,476	150,794
D3	Krong Buk C.	2,855,897	51,300	1.8%	85,677	142,795
D4	Ea Drong C.	3,026,693	55,700	1.8%	90,801	151,335
D5	Ea Wer C.	1,295,899	32,300	2.5%	38,877	64,795
D6	Kien Duc T.	4,668,492	209,500	4.5%	140,055	233,425
D7	Krong Kmar T.	3,287,566	62,900	1.9%	98,627	164,378

3.2 Water Sources and Hygiene Conditions

3.2.1 Present Water Sources

Water resources are classified as dug wells, shallow wells with hand pump (UNICEF), deep wells, rivers, streams, springs, and rain water (rainy season only). Present water sources surveyed by the Study team are shown in Table S.7. The same household often has several sources for different domestic purposes. They need to maintain a number of sources that can be accessed throughout the year, even in the driest year.

The ethnic minorities had access to clean surface water before deforestation. Presently, although the surface water sources are contaminated and dwindling due to

agricultural development, the people are compelled to use it for their economic conditions. In many instances the people spend more than 30 minutes carrying water.

According to a survey questionnaire, complaints about water use are as follows: 25% for carrying distance of water (ethnic minority people: 70%), 55% for equipment for watering and carrying, 48% for quality, and 60% for quantity.

Table S. 7 Present Water Sources in Target Area

Province	Commune	Dug well	Spring	Borehole	River	Stream	Vendor
Kon Tum	Bo Y	○	○				
	Dak Su	○					
	Dak Ui	○	○				
	Dak Hring	○	○				
	Sa Nghia	○	○				
	Chu Hreng	○	○				
Gia Lai	Kong Tang	○	○				
	Nhon Hoa	○	○				
	Chu Ty Town	○					
	Thang Hung	○	○				
	Nghia Hoa	○	○			○	
	Ia Siom	○			○	○	
	Kong Yang	○			○		
Dac Lac	Krong Nang	○	○				
	Ea Drang	○	○	○			○
	Krong Puk	○					
	Ea Drong	○	○				
	Ea Wer	○			○		
	Kien Duc	○		○			○
	Krong Kmar	○				○	

Dug well includes UNICEF shallow borehole, Borehole: private use only

Source: Study Team

3.2.2 Major Water-related Diseases

As shown in Table S.6, major water-related diseases in the target communes are usually diarrhoea, dysentery, typhoid, cholera, trachoma, and kidney stone. Malaria is also problematic in the rural areas of the Central Highlands. Trachoma is an infectious disease of the eyes caused by bathing, swimming and face washing with microbiologically contaminated water. Diarrhoea, malaria, shigellosis, and trachoma are prevalent in all the target communes, while dysentery and typhoid are prevalent in some.

Table S. 8 Major Water-related Diseases

No.	Water-related disease	Number of samples	Pecentage
1	Typhoid	85	14.3%
2	Cholera	33	5.5%
3	Dysentery	23	3.9%
4	Hepatitis	5	0.8%
5	Diarrhoea	166	27.9%
6	Trachoma	67	11.2%
any 1-6	at least one from No.1 to 6	246	41.3%
7	Kidney stone	15	2.5%

Source: Study Team

3.2.3 Causes of Water-related Diseases

According to WHO, infectious diseases are transmitted primarily through human and animal excreta, particularly faeces. If there are active cases or carriers in the community, then faecal contamination of water sources will result in the pathogens being present in the water. The use of such water for drinking or for preparing food, and contact during washing or bathing may result in infection.

3.2.4 Excreta disposal and Use of Latrines

Pit latrines and open defecation are the most common toilet methods in the target communes. Open defacation easily contaminates the soil and shallow groundwater. In addition, it is acknowledged that most pit latrines in the largest communes are located close to dug wells. The national guideline sets a minimum distance of 10 m between any kind of latrine and a well for drinking water. Without proper hygiene education, even clean groundwater extracted from deep aquifers may be contaminated by human and animal excreta due to improper casing of deep wells or intrusion of contaminants into pipe systems under negative pressure.

3.3 Related Water Law and Local Administrative Information

3.3.1 National Steering Committee for Rural Water Supply and Environmental Sanitation

The National Steering Committee for Rural Water Supply and Environmental Sanitation (NSCRWSS) was established in 1982 as a result of the completion of the National Master Plan for Rural Water Supply and Sanitation. The target area and planning period of the current study also stem from this master plan. Based on the NRWSS, the role and duties in each governmental organization level are shown in Figure S.3.

3.3.2 Provincial People's Committee

Provincial People's Committees (PPC) is in a position to promulgate decisions and directives under the general central level framework. The provincial level administration is a reflection of the national level structure.

3.3.3 Department of Agriculture and Rural Development and PCERWASS

The Department of Agriculture and Rural Development (DARD) exercises at the provincial level functions similar to those of MARD at State level. PCERWASS is the lead sector agency at the provincial level.

3.3.4 DPC, TPC and CPC

The District People's Committee (DPC) exercises powers similar to those of a PPC within its administrative area. The Town People's Committee (TPC) and the Commune People's Committee (CPC) as well as an elected People's Council are responsible for commune and town affairs.

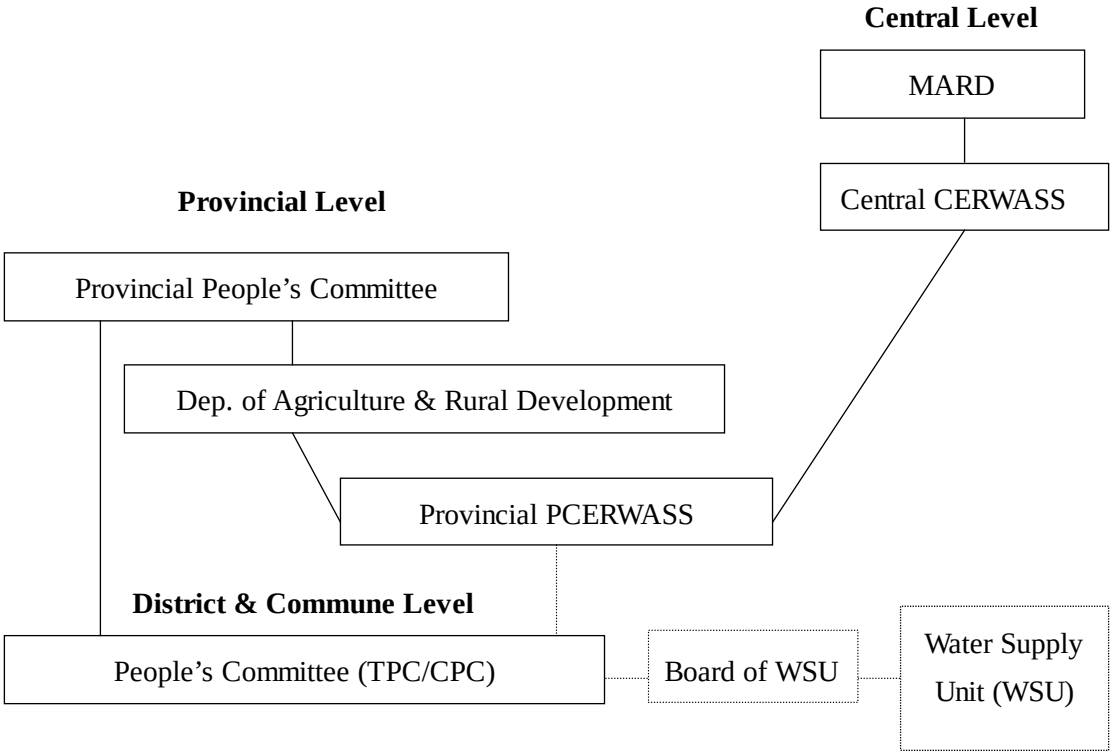


Figure S. 3 Role and duties in each governmental organization level

3.4 Groundwater Development Potential

The water resources development planning information was mainly derived from the analysis of the groundwater potential and the water quality of the successful 17 JICA wells in the target communes. The final outputs of the potential analysis, the safe well yields, were identified in the water supply plan. The details are described in Supporting Report A.

3.4.1 Well Constructions

A total of 22 sites were drilled. Of these sites, 18 wells were constructed successfully. The available and productive wells are 17. Four drilling sites were abandoned without installation of well pipes. Details are in the following tables:

(1) Well Construction in Kon Tum province

Commune	Depth (m)	Well	Geology and Drilling Result
K1: Bo Y	170	Completed	Surface soil, Tertiary rock and gneiss were in descending order. Aquifer found in weathered zone and fissure zone of sandstone and gneiss. At 100 m, gneiss appeared. Below 165 m, it was fresh gneiss without cracks. Drilling was stopped at 170 m. Safety yield: 1 L/sec.
K2: Dak Su	60	Abandoned	Surface soil, Tertiary rock and gneiss were in descending order. Aquifer found in weathered zone and fissure zone of sandstone and gneiss. Below 55 m, it was fresh gneiss without cracks. Drilling was stopped 60 m.
K2A: Dak Su	70	Completed	Re-drilling at abandoned K2 site was conducted approx. 1.5 km away from the commune centre. Aquifer found in Tertiary sandstone and weathered gneiss.
K3: Dak Ui	160	Completed	Surface soil, and Tertiary rock were in descending order. Aquifer found in weathered zone and fissure zone of gneiss. At 100m, gneiss appears. Below 155 m, it was fresh gneiss without cracks. Drilling was stopped at 160 m. Safety yield: 2.5 L/sec.
K4: Dak Hring	100	Abandoned	Surface soil, Tertiary rock and gneiss were in descending order. Aquifer not found. Drilling was stopped at 100 m.
K4A: Dak Hring	45	Abandoned	Re-drilling was conducted at abandoned K4 site. The new site is approx. 1.5 km from the centre of commune. No groundwater was found at new site.
K5: Sa Nghia	100	Abandoned	Surface soil and gneiss were in descending order. Aquifer not found even in weathered zone of gneiss. Below 100 m, it was fresh gneiss without cracks; then, drilling was stopped. There is no other potential area for groundwater.
K6: Chu Hreng	100	Completed	Surface soil, Tertiary rock and granite were in descending order. Aquifer found in weathered zone and fissure zone of sandstone and granite. Safety yield: 0.5 L/sec. Due to small discharge of only of 0.5 L/sec, this well was constructed as an observation well.

Source: Study Team

(2) Well Construction in Gia Lai province

Commune	Depth (m)	Well	Geology and Drilling Result
G1:Kong Tang	150	Completed	Surface soil and basalt were in descending order. Aquifer found in weathered zone and fissure zone. Below 145 m, it is hard basalt without cracks. Drilling was stopped at 150 m. Safety yield: 3.68 L/sec.
G2: Nhon Hoa	170	Completed	Surface soil, basalt and Jurassic rock are in descending depth order. Aquifer is found in weathered zone and fissure zone of basalt lava. At 104m, Jurassic rock appears. Below 165m, it is hard basalt without cracks, then, drilling was stopped 170m. Safety yield: 6 L/sec.
G3: Chu Ty	150	Completed	Surface soil and basalt were in descending order. Aquifer found in weathered zone and fissure zone. Below 145 m, it is hard basalt without cracks. Drilling was stopped at 150m. Safety yield: 3.6 L/sec.
G4:Thang Hung	180	Completed	Surface soil, basalt and granite were in descending order. Aquifer was found in weathered zone and fissure zone of basalt and granite. Safety yield: 2.5 L/sec.
G5:Nghia Hoa	160	Completed	Surface soil, basalt and granite were in descending order. Aquifer found in weathered zone and fissure zone of basalt lava. At 155 m, granite appears. It was fresh granite without cracks. Drilling was stopped at 160 m. Safety yield: 2 L/sec.
G6: Ia Rsion	180	Completed	Surface soil, basalt and granite were in descending order. Aquifer found in weathered zone and fissure zone of basal and granite. Below 155 m, it was fresh granite without cracks. Drilling was stopped at 160 m. Safety yield: 5 L/sec.
G7: Kong Yang	160	Completed	Surface soil, basalt and granite were in descending order. Aquifer found in weathered zone and fissure zone. Below 155 m, it was fresh granite without cracks. Drilling was stopped at 160m. Safety yield: 5 L/sec.

Source: Study Team

(3) Well Construction in Dac Lac Province

Commune	Depth (m)	Well	Geology and Drilling Result
D1: Krong Nang	140	Completed	Surface soil and basalt were in descending order. Aquifer found in weathered zone and fissure zone. Below 135 m, it was hard basalt without cracks. Drilling was stopped at 140 m. Safety yield: 4 L/sec.
D2: Ea Hleo	180	Completed	Surface soil, basalt and granite were in descending order. Aquifer found in weathered zone and fissure zone. At 122 m, granite appeared. Below 175 m, it was fresh granite without cracks. Drilling was stopped 180 m. Safety yield: 0.5 litres/sec.
D3: Krong Puk	140	Completed	Surface soil, basalt and Jurassic rock were in descending order. Aquifer found in weathered zone and fissure zone of basalt lava. Below 135 m, it was hard basalt without cracks. Drilling was stopped 140 m. Safety yield: 4 L/sec.
D4: Ea Drong	180	Completed	Surface soil and basalt were in descending order. Aquifer found in weathered zone and fissure zone. Below 175 m, it is hard basalt without cracks. Drilling was stopped at 180m. Safety yield: 3 L/sec.
D5: Ea Wer	150	Completed	Surface soil, basalt and Jurassic rock were in descending order. Aquifer found in weathered zone and fissure zone of basalt lava. Jurassic rock appeared at 11.4 m depth. Below 145 m, it is impervious mudstone without cracks. Drilling was stopped at 140 m. Safety yield: 3 L/sec.
D6: Kien Duc	170	Completed	Surface soil and basalt were in descending order. Aquifer found in weathered zone and fissure zone. Below 165 m, it was hard basalt without cracks. Drilling was stopped at 170 m. Safety yield: 3 L/sec.
D7:Krong Kmar	39	Completed	Surface soil, basalt and Jurassic rock were in descending depth order. Aquifer found in weathered zone and fissure zone of Jurassic rock. Jurassic rock appeared at 31 m in depth. Below 35 m, it was impervious mudstone without cracks. Drilling was stopped at 39 m. Safety yield: 6 L/sec.

Source: Study Team

3.4.2 Safety Yield and Groundwater Potential

The optimum yields of the test wells were evaluated based on the analyses of the pumping tests including step-drawdown tests and constant continuous tests. The safety yield ranged from 100 – 400 m^3/day for the successful 17 JICA exploratory wells.

The groundwater potential of each commune/town was found to be much greater than the demand for rural water supply. The maps of the most promising areas for drilling wells for future groundwater resources development in each target commune/town are included in Supporting Report A. Table S.9 is a summary of the hydro-geological characteristics of the drilling wells.

Table S. 9 Hydro-geological Characteristics of Drilling Wells

Target commune/town		Aquifer geology	Well depth (m)	Static water level (m)	Safe well yield (m^3/day)	Draw down (m)
a) Kon Tum province						
K1	Bo Y	Neogene sediments and gneiss	150	1	100	32
K2A	Dak Su	Neogene sediments and gneiss	100	1	150	22
K3	Dak Ui	Gneiss	150	1	250	17
b) Gia Lai province						
G1	Kong Tang	Basalt	150	35	300	22
G2	Nhon Hoa	Basalt	170	20	200	40
G3	Chu Ty	Basalt	150	25	350	32
G4	Thang Hung	Basalt	180	35	250	10
G5	Nghia Hoa	Basalt	160	35	200	26
G6	Ia Rsiom	Quaternary sediments and Jurassic sandstone	180	25	400	16
G7	Kong Yang	Basalt and granite	160	10	400	23
c) Dac Lac province						
D1	Krong Nang	Basalt	150	15	350	16
D2	Ea Drang	Basalt	180	30	200	
D3	Krong Buk	Basalt	150	10	400	21
D4	Ea Drong	Basalt	180	25	250	30
D5	Ea Wer	Basalt and Jurassic sandstone	150	5	300	22
D6	Kien Duc	Basalt	180	30	250	22
D7	Krong Kmar	Quaternary sediments and Jurassic sandstone	50	5	500	10

Source: Study Team

3.4.3 Water Quality

High values of iron, well above those stipulated in the Vietnamese standard, were found in the waters from the drilled wells of G1 (Kong Tang), G6 (Ia Rsiom), G7 (Kong Yang), D4 (Ea Drong), D5 (Ea Wer), D6 (Kien Duc), D7 (Krong Kmar), K1 (Bo Y), K2 (Dak Su) and K3 (Dak Ui). High manganese contents were identified in

K3 (Dak Ui), G2 (Nhon Hoa), G4 (Thang Hung), G7 (Kong Yang), D5 (Ea Wer) and D7 (Krong Kmar). The test results shown in Table S.10, particularly for coliform, NH_3, and NO_2 were more accurately analysed at the F/S phase. The results Table S.10 "Summary of Water Quality Test "show that deep groundwater is safe from contamination. However, careful sealing near the surface and sanitation improvement in and around the production wells is essential

The water quality of the G2 pilot model was analysed during the third round of fieldwork. The results revealed a high calcium and magnesium content of 40–60 mg/L, and high HCO3 and total hardness (42–50 mg/L). Although these contents are not harmful for drinking and are below Vietnamese standards, they may cause aesthetic or palatability problems. Fluoride (F) and arsenic (As) are in negligible amounts; below the Vietnamese standards in tests conducted in May 2002.

No dioxin was detected in the three (3) groundwater water samples.

Table S. 10 Results of Water Quality Analysis for the Wells Explored by Study Team and Alternative Resources

Sample. No.	Type	Temp.	pH	EC	DO	TDS	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	Total Fe	$NO_2^{-}N$	$NO_3^{-}N$	NH_4^{+}	PO_4^{3-}	COD/KMnO_4	F	As	Mn^{2+}	Coliform*
		(℃)		(μS/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	MPN/100r
K-1-0	Well	26.8	7.25	183.6	2.23	151.457	16.20	7.557	9.89	2.028	111.75	0.142	3.897	3.55	<0.001	0.01	0.028	0.09	0.315	0.0300	0.0010	0.1000	11
K-2-0	Well	24.1	7.23	178.7	1.75	151.873	16.28	8.432	9.66	1.950	112.61	1.985	0.96	2.64	<0.001	0.01	0.031	0.07	0.157	0.0100	0.0010	0.0650	17
K-3-0	Well	24.7	7.19	864	1.17	597.608	151.38	10.753	6.44	0.663	184.71	0.496	243.18	3.49	0.005	0.03	0.046	0.04	0.630	1.3200	0.0050	0.1211	33
K-4-0	River	26.7	7.13	66.6	3.15	50.979	5.12	3.074	2.30	1.833	36.66	0.071	1.92	1.88	0.002	0.11	0.035	<0.01	3.226	0.2100	0.0010	0.0050	130
K-5-0	River	25.6	7.15	68.8	3.64	51.037	4.62	2.151	3.45	4.095	33.49	0.496	2.75	4.58	0.005	0.12	0.059	<0.01	7.082	0.1900	0.0010	0.0150	180
K-6-0	River	33.2	7.60	89.4	3.04	68.223	2.46	5.346	5.06	3.822	48.25	0.351	2.94	3.02	0.005	0.06	0.073	<0.01	2.518	0.0800	0.0010	0.0210	2800
G-1-0	Well	27.5	7.32	198.7	1.16	170.062	4.34	2.807	31.97	2.535	124.32	0.915	3.19	0.82	0.030	0.06	0.052	0.03	0.157	0.6600	0.0010	0.0130	33
G-2-0	Well	28.1	7.00	338	3.04	211.444	24.72	12.758	12.65	4.062	142.62	0.993	13.10	0.21	0.002	0.19	0.074	0.10	0.157	0.2900	0.0032	0.1950	0
G-3-0	Well	27.0	7.20	61.7	2.56	166.645	14.38	11.900	7.13	2.964	126.88	0.213	3.89	0.40	<0.001	0.05	0.029	0.14	0.236	0.1007	0.0040	0.0975	34
G-4-0	Well	29.2	7.59	273	5.55	225.997	10.80	13.171	22.43	4.095	155.18	0.355	19.97	0.36	0.010	0.01	0.179	0.07	0.079	0.8000	0.0022	0.1740	5
G-5-0	Well	28.6	7.29	656	2.28	568.373	24.20	20.679	94.30	17.550	410.47	0.071	1.10	0.47	0.001	0.01	0.147	0.06	0.079	0.2900	0.0026	0.0630	23
G-6-0	Well	27.3	6.98	775	1.25	195.322	40.40	13.940	34.96	1.521	57.26	158.350	7.28	3.10	<0.001	9.09	0.138	0.04	0.779	0.0870	0.0034	0.0672	46
G-7-0	Well	27.0	7.18	501	1.42	426.749	42.12	23.219	28.75	1.989	311.34	15.775	3.55	2.07	0.002	0.01	0.098	0.05	0.866	0.2200	0.0010	0.2860	43
D-1-0	Well	25.3	6.43	153.0	2.63	125.028	8.80	7.946	9.66	1.833	93.88	1.407	1.50	0.11	0.001	0.06	0.035	0.06	0.079	0.1300	0.0010	0.0111	31
D-2-0	Well	26.4	6.42	100.6	2.56	64.614	4.92	3.900	5.29	1.599	39.10	0.780	9.02	0.39	0.002	0.02	0.049	0.12	0.157	<0.0001	0.0010	0.0410	11
D-3-0	Well	26.5	7.99	553	1.77	495.166	3.98	3.159	126.50	1.443	309.88	0.284	13.92	0.12	<0.001	0.60	0.103	0.08	0.551	0.2800	0.0060	0.0120	22
D-4-0	Well	25.9	7.85	401	1.59	335.710	2.52	0.620	94.30	3.354	215.70	3.332	15.90	3.76	0.080	0.12	0.071	0.14	0.630	0.6700	0.0010	0.0390	33
D-5-0	Well	27.7	6.93	558	2.35	340.127	70.96	6.051	12.88	1.356	240.65	0.355	7.87	0.82	0.020	0.06	0.233	0.06	0.236	<0.0001	0.0040	1.1110	8
D-6-0	Well	28.0	6.23	145.6	1.92	208.916	21.60	11.676	9.20	2.652	155.37	0.213	8.21	0.65	0.010	0.02	0.072	<0.01	0.630	0.0857	0.0046	0.0755	0
D-7-0	Well	28.1	6.54	186.0	2.02	126.073	9.04	6.282	11.96	3.042	86.56	0.071	9.12	4.09	0.011	0.01	0.293	0.03	0.236	0.0500	0.0010	0.3590	43
Total	nos.	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	max	33.2	7.99	864	5.55	597.608	151.38	23.219	126.50	17.550	410.47	158.350	243.18	4.58	0.080	9.09	0.293	0.14	7.082	1.3200	0.0060	1.1110	2800
	min	24.1	6.23	61.7	1.16	50.979	2.46	0.620	2.30	0.663	33.49	0.071	0.96	0.11	<0.001	0.01	0.028	<0.01	0.079	<0.0001	0.0010	0.0050	0
	average	27.2	7.13	318	2.35	236.570	23.94	8.771	26.94	3.219	149.83	9.333	18.66	1.83	0.009	0.53	0.092	0.059	0.940	0.2752	0.0023	0.1436	175
Standard 505 of MOH		-	-			1,000						250	400	0.5	0	10	3.0			1.5	0.05	0.1	

*tests were conducted in the first field survey and F/S. Source: Study Team

4. Water Supply Master Plan

In producing the Master Plan, the Study Team included:

1. identification of water supply systems needed for the targeted 20 communes,
2. identification of targets,
3. projection of demand and
4. identification of facility type.

The Study Team then prioritised the identified water supply systems to proceed to the Feasibility Study stage.

4.1 Number of Water Supply Systems Needed

After a comprehensive site reconnaissance survey the study team estimated that a total of 46 water supply systems would be required in order to supply water to almost all the inhabitants in the targeted 20 communes.

4.2 Water Supply Plan

4.2.1 Targets of Water Supply Plan

The National Strategy for Rural Clean Water Supply and Sanitation (NRWSS) of Vietnam sets targets to be achieved in two phases; i.e. 85% of the total population to have water supplied by the year 2010 (Phase 1), and 100 % by the year 2020 (Phase 2). The Study adopted this national target set by NRWSS.

Table S. 11 Targets of Water Supply Plan

Targets of Water Supply Plan		
NRWSS	Phase-1	Phase-2
Target Year	2010	2020
Population to be served	85 %	100 %
Water requirement per capita	60 L/d/c	
Duration of service	24 h/day	

4.2.2 Demand projection

(1) The Present Population Growth Rate

The present population growth rate was estimated based on the national census conducted in 2002, and on the information collected in the first field survey in this Master Plan study. The information was further updated in the second field survey

conducted during the Feasibility Study stage. This report incorporates the updated information. Four communes that enforce a policy of transmigration from the other communes show a range of high population growth rates (K1 and K2 - about 18 %, D2 - about 10%; D7 - about 3.5 %).The other 16 communes show a population growth rate of about 2%.

(2) Population Projection

Based on the above, the following population growth rates were assumed for planning purposes.

- The four communes that adopt transmigration policy: the present growth rates were adopted till the year 2005. The average growth rate of this area, thereafter, was adopted after the year of 2006 because the transmigration policy may be lifted.
- The other communes: Each present growth rate was adopted for each commune. The rate ranged form 1.4% (D4) to 2.6% (D3); the average was about 2.0%.

The result of the population projection is shown in the Table S.12.

(3) Demand Projection

The water demand projection was based on the following assumption:

System Leakage factor	20 %
Daily Maximum Water Consumption	1.3 times as Average Daily Water Consumption
Hourly Maximum Water Consumption	2.0 times as hourly consumption of Daily-Average-Water Consumption

Accordingly, the following equations are used for calculation.

Daily Average Water Consumption (Qav) = P * q * 1.2
Daily Maximum Water Consumption (Qmax) = Qav * 1.3
Hourly Average Water Consumption (Qav/h) =Qav/24
Hourly Maximum Water Consumption (q_{max}) = Qmax *2.0/24 =1.3 *2.0 Qav /24
(P: Population, q: water requirement per capita)

The water demand is shown in Table S.12 for the 46 systems identified in the 20 communes.

Table S. 12 Projected Population and Water Demand

Commune	Population Projection			Water Demand (m^3)					
	2000	2010	2020	2010			2020		
KON TUM				Ave. day demand	Max day demand	Max. hourly d.	Ave. day demand	Max day demand	Max. hourly d.
K1.1 Bo Y	3087	779	9505	477.2	**620.4**	**51.70**	684.4	**889.7**	**74.14**
K1.2	277	700	853	42.8	**55.7**	**4.64**	61.4	**79.8**	**6.65**
K2.1 Dak Su	638	161	1964	98.6	**128.2**	**10.68**	141.4	**183.9**	**15.32**
K2.2	198	500	610	30.6	**39.8**	**3.32**	43.9	**57.1**	**4.76**
K2.3	1925	486	5927	297.6	**386.8**	**32.24**	426.8	**554.8**	**46.23**
K2.4	236	596	727	36.5	**47.4**	**3.95**	52.3	**68.0**	**5.67**
K3.1 Dak Ui	2306	281	3447	172.5	**224.3**	**18.69**	248.2	**322.6**	**26.89**
K3.2	762	932	1139	57.0	**74.1**	**6.18**	82.0	**106.6**	**8.88**
K3.3	332	406	496	24.8	**32.3**	**2.69**	35.7	**46.4**	**3.87**
K3.4	975	1192	1457	73.0	**94.8**	**7.90**	104.9	**136.4**	**11.37**
K3.5	851	1040	1272	63.7	**82.8**	**6.90**	91.6	**119.1**	**9.92**
K4.1 Dak Hring	2474	313	3976	191.9	**249.5**	**20.79**	286.2	**372.1**	**31.01**
K4.2	277	351	445	21.5	**27.9**	**2.33**	32.0	**41.7**	**3.47**
K4.3	1222	1549	1964	94.8	**123.2**	**10.27**	141.4	**183.8**	**15.32**
K4.4	1323	1677	2126	102.6	**133.4**	**11.12**	153.1	**199.0**	**16.58**
K4.5	479	607	770	37.2	**48.3**	**4.03**	55.4	**72.0**	**6.00**
K5 Sa Nghia	1553	1875	2263	114.7	**149.1**	**12.43**	162.9	**211.8**	**17.65**
K6 Chu Hreng	1572	1993	2526	122.0	**158.5**	**13.21**	181.9	**236.4**	**19.70**
GIA LAI									
G1 Kong Tang	5567	698	8773	427.7	**556.0**	**46.33**	631.6	**821.1**	**68.43**
G2 Nhon Hoa	11084	1377	17128	843.3	**1096.2**	**91.35**	1233.2	**1603.2**	**133.60**
G3 Chu Ty	6377	769	9292	471.1	**612.4**	**51.04**	669.0	**869.7**	**72.48**
G4-1 Thang Hung	4292	508	6013	310.9	**404.2**	**33.68**	432.9	**562.8**	**46.90**
G4-2	249	295	349	18.0	**23.4**	**1.95**	25.1	**32.7**	**2.72**
G4-3	325	385	455	23.5	**30.6**	**2.55**	32.8	**42.6**	**3.55**
G4-4	1472	1742	2062	106.6	**138.6**	**11.55**	148.5	**193.0**	**16.09**
G5-1 Nghia Hoa	3288	400	4886	245.3	**318.9**	**26.57**	351.8	**457.3**	**38.11**
G5-2	362	441	538	27.0	**35.1**	**2.93**	38.7	**50.3**	**4.20**
G6-1 Ia Rsion	3843	468	5710	286.7	**372.7**	**31.06**	411.2	**534.5**	**44.54**
G6-2	688	839	1022	51.3	**66.7**	**5.13**	73.6	**95.7**	**4.42**
G7.1 Kong Yang	1507	183	2239	112.4	**146.2**	**12.18**	161.2	**209.6**	**17.47**
G7-2	212	258	315	15.8	**20.6**	**1.71**	22.7	**29.5**	**2.46**
G7-3	132	161	196	9.8	**12.8**	**1.07**	14.1	**18.4**	**1.53**
G7-4	547	667	813	40.8	**53.0**	**4.42**	58.5	**76.1**	**6.34**
G7-5	128	156	190	9.5	**12.4**	**1.03**	13.7	**17.8**	**1.48**
DAC LAC									
D1 Krong Nang	10795	1290	15423	789.7	**1026.6**	**85.55**	1110.5	**1443.6**	**120.30**
D2 Ea H´Leo	14853	1846	22953	1130.0	**1469.0**	**122.42**	1652.6	**2148.4**	**179.03**
D3-1 Krong Puk	6619	855	11060	523.6	**680.7**	**56.73**	796.3	**1035.2**	**86.26**
D3-2	3453	446	5770	273.2	**355.1**	**29.59**	415.4	**540.0**	**45.00**
D3-3	3494	4516	5838	276.4	**359.3**	**29.94**	420.3	**546.4**	**45.54**
D4-1 Ea Drong	6901	777	8760	475.8	**618.6**	**51.55**	630.7	**820.0**	**68.33**
D4-2	1805	203	2291	124.5	**161.8**	**13.48**	165.0	**214.5**	**17.87**
D5-1 Ea Wer	4992	892	10981	545.9	**709.7**	**59.14**	790.6	**1027.8**	**85.65**
D5-2	313	559	688	34.2	**44.5**	**3.71**	49.6	**64.4**	**5.37**
D5-3	197	352	433	21.5	**28.0**	**2.33**	31.2	**40.6**	**3.38**
D6 Kien Duc	8626	1061	13071	649.9	**844.8**	**70.40**	941.1	**1223.5**	**101.96**
D7 Krong Mar	5735	748	9123	458.0	**595.4**	**49.62**	656.9	**853.9**	**71.16**
Note: Shadow marked system means the 21 priority system									

4.3 Technical Option of Water Supply Methods

NRWSS has offered users several options to decide the preferred method of service and level of supply. The water supply plan proposes three main technical options for the study area. Option 1: centralized piped network, Option 2: small piped network, and Option 3: household system (See table S.13).

Table S. 13 Definition of Options

Option	Service Level	Population served	Definition
Option1 Centralized piped system	HC+PH	2,000<	Single piped system serves several villages and hamlets.
Option2 Small piped system		1,000 - 2,000	A simple piped system serves only in each village or hamlet.
Option3 Household system	PWS	<1,000	A point water supply system for individual house or a few houses.

Notes:
HC(House Connection):Water delivered to each house via a piped system
PH(Public Hydrant):Water delivered to public taps via a piped system and carried manually to each house
PWS (Point Water Supply): Water from individual household facility such as a dug well to the owner house occasionally including neighbouring houses

The summary of options identified is shown in Table S.14 and the water supply master plan for all 46 systems in the study area is shown in Table S.14.

Table S. 14 Water Supply Master Plan

System	Population			Recommended Options	Future Plans
	2000	2010	2020		
KONTUM					
K1-1 Bo Y	3087	7797	9505	Option 1	Extension of distribution pipes
K1-2	277	700	853	Option 3	Connection to K1-1, or Option 3
K2-1 Dak Su	638	1612	1964	Option 1	Extension of distribution pipes
K2-2	198	500	610	Option 3	Option 3
K2-3	1925	4862	5927	Option 1	Extension of distribution pipes
K2-4	236	596	727	Option 3	Connection to K2-3, or Option 3
K3-1 Dak Ui	2306	2819	3447	Option 1	Extension of distribution pipes
K3-2	762	932	1139	Option 3	Option 2
K3-3	332	406	496	Option 3	Connection to K3-1, or Option 3
K3-4	975	1192	1457	Option 3	Option 2
K3-5	851	1040	1272	Option 3	Option 2
K4-1 Dak Hring	2474	3136	3976	Option 1	Extension of distribution pipes
K4-2	277	351	445	Option 3	Option 3
K4-3	1222	1549	1964	Option 3	Option 2
K4-4	1323	1677	2126	Option 3	Option 2
K4-5	479	607	770	Option 3	Option 3
K5 Sa Nghia	1553	1875	2263	Option 3	Option 2
K6 Chu Hreng	1572	1993	2526	Option 3	Option 2
GIA LAI					
G1 Kong Tang	5567	6988	8773	Option 1	Extension of distribution pipes
G2 Nhon Hoa	11084	13779	17128	Option 1	Extension of distribution pipes
G3 Chu Ty	6377	7698	9292	Option 1	Extension of distribution pipes
G4-1 Thang Hung	4292	5080	6013	Option 1	Extension of distribution pipes
G4-2	249	295	349	Option 3	Option 3
G4-3	325	385	455	Option 3	Option 3
G4-4	1472	1742	2062	Option 3	Option 3
G5-1 Nghia Hoa	3288	4008	4886	Option 1	Extension of distribution pipes
G5-2	362	441	538	Option 3	Option 3
G6-1 Ia Rsion	3843	4685	5710	Option 1	Extension of distribution pipes
G6-2	688	839	1022	Option 3	Option 3
G7.1 Kong Yang	1507	1837	2239	Option 1	Extension of distribution pipes
G7-2	212	258	315	Option 3	Option 3
G7-3	132	161	196	Option 3	Option 3
G7-4	547	667	813	Option 3	Option 3
G7-5	128	156	190	Option 3	Option 3
DAC LAC					
D1 Krong Nang	10795	12903	15423	Option 1	Extension of distribution pipes
D2 Ea H´Leo	14853	18464	22953	Option 1	Extension of distribution pipes
D3-1 Krong Puk	6619	8556	11060	Option 1	Extension of distribution pipes
D3-2	3453	4463	5770	Option 1	Extension of distribution pipes
D3-3	3494	4516	5838	Option 3	Option 2
D4-1 Ea Drong	6901	7775	8760	Option 1	Extension of distribution pipes
D4-2	1805	2034	2291	Option 1	Extension of distribution pipes
D5-1 Ea Wer	4992	8920	10981	Option 1	Extension of distribution system
D5-2	313	559	688	Option 3	Option 3
D5-3	197	352	433	Option 3	Option 3
D6 Kien Duc	8626	10619	13071	Option 1	Extension of distribution pipes
D7 Krong Mar	5735	7484	9123	Option 1	Extension of distribution pipes

Note: The shaded areas correspond to with the priority systems.

4.4 Prioritisation of Projects

4.4.1 Methodology

The Government of Vietnam, in its request to the Government of Japan, selected 20 communes in the 3 Provinces of the Central Highlands for study. The criteria adopted is as shown in the Table S.15.

Table S. 15 Criteria for the Selection of the Urgent Communes

Province	Shortage of water	Population density	Groundwater potential	Poverty	Financial affordability	Infrastructure (road/electricity)
Kon Tum	◎			◎		○
Gia Lai	◎	◎	○			○
Dac Lac	◎	◎	◎		◎	○

◎ very important, ○ important

In addition to the criteria above, the Study Team proposed additional criteria for the prioritisation of the estimated 46 water supply systems.

1) urgency and necessity;
2) population density;
3) infrastructure condition;
4) groundwater potential (water quantity and water quality);
5) poverty and ethnic minority;
6) financial affordability;
7) operation and maintenance (O&M);
8) gender; and
9) environmental considerations.

4.4.2 Results of the Prioritisation

The result of the prioritisation is shown in Table S.16. This shows that the communes in Kon Tum province generally have lower ranking than the communes in the other two provinces. This is because the poverty level in Kon Tum is more severe than in Gia Lai and Dac Lac.

Table S. 16 Project Prioritisation

Item No.		Number of Villages	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Final Evaluation	
Description			Urgency	Population Density and Infrastructure	GW Potential	Poverty	Financial Affordability	O&M Potential	Gender	Environment	**Total Score**	Rank
Weight			**10**	**10**	**10**	**10**	**10**	**10**	**10**	**3**		
Kon Tum Province												
K1: Bo Y C.	K1-1	7	**Ba**	**B**	Bc	**B**	B	**B**	B	**Ba**	**147.5**	**12**
	K1-2	1	**C**	**C**	C	**C**	C	**B**	Bc	**B**	**91.0**	**40**
K2: Dak Su C.	K2-1	3	**Bc**	**B**	Bc	**C**	C	**B**	Bc	**Ba**	**112.5**	**21**
	K2-2	1	**C**	**C**	C	**C**	C	**Bc**	C	**B**	**81.0**	**46**
	K2-3	9	**Ba**	**B**	Bc	**Bc**	B	**Bc**	C	**Ba**	**127.5**	**17**
	K2-4	1	**C**	**C**	C	**C**	C	**Bc**	Bc	**B**	**86.0**	**44**
K3: Dak Ui C.	K3-1	5	**B**	**B**	B	**Bc**	C	**B**	B	**B**	**131.0**	**16**
	K3-2	3	**C**	**Bc**	C	**C**	C	**B**	B	**B**	**101.0**	**31**
	K3-3	1	**C**	**Bc**	C	**C**	C	**B**	B	**B**	**101.0**	**31**
	K3-4	2	**Bc**	**B**	C	**C**	C	**B**	B	**B**	**111.0**	**22**
	K3-5	2	**C**	**Bc**	C	**C**	C	**B**	B	**B**	**101.0**	**31**
K4: Dak Hring C.	K4-1	3	**Bc**	**A**	Bc	**C**	C	**B**	Bc	**B**	**121.0**	**18**
	K4-2	1	**C**	**C**	C	**C**	C	**Bc**	Bc	**B**	**86.0**	**44**
	K4-3	4	**C**	**Bc**	C	**Bc**	C	**Bc**	Ba	**B**	**106.0**	**26**
	K4-4	4	**C**	**Bc**	C	**Bc**	C	**Bc**	Ba	**B**	**106.0**	**26**
	K4-5	1	**C**	**C**	C	**C**	C	**Bc**	Ba	**B**	**96.0**	**38**
K5: Sa Nghia C.		3	**B**	**B**	Bc	**C**	C	**Bc**	Bc	**B**	**111.0**	**22**
K6: Chu Hreng C.		5	**Bc**	**B**	Bc	**Bc**	C	**Bc**	C	**B**	**106.0**	**26**
Gia Lai Province												
G1:Kong Tang T.		11	**C**	**A**	Ba	**B**	Ba	**B**	Ba	**A**	**164.0**	**7**
G2: Nhon Hoa C.		15	**A**	**A**	Bc	**A**	Ba	**B**	B	**A**	**179.0**	**4**
G3: Chu Ty T.		8	**Ba**	**A**	Ba	**Ba**	A	**B**	B	**A**	**184.0**	**2**
G4:Thang Hung C.	G4-1	5	**B**	**A**	Ba	**Bc**	Ba	**B**	Bc	**A**	**159.0**	**9**
	G4-2	1	**C**	**Bc**	C	**C**	C	**B**	Bc	**B**	**96.0**	**38**
	G4-3	1	**C**	**C**	C	**C**	C	**B**	Bc	**B**	**91.0**	**40**
	G4-4	3	**C**	**C**	C	**B**	Bc	**Bc**	Bc	**B**	**101.0**	**31**
G5:Nghia Hoa	G5-1	5	**B**	**A**	B	**Bc**	Ba	**B**	B	**A**	**159.0**	**9**
	G5-2	1	**C**	**C**	C	**C**	C	**B**	Bc	**B**	**91.0**	**40**
G6: Ia Rsion	G6-1	7	**A**	**Ba**	Ba	**Ba**	Ba	**B**	B	**A**	**179.0**	**4**
	G6-2	2	**Bc**	**Bc**	C	**Bc**	C	**B**	B	**B**	**111.0**	**22**
G7: Kong Yang	G7-1	5	**B**	**B**	Ba	**C**	Ba	**Bc**	B	**B**	**141.0**	**13**
	G7-2	1	**C**	**C**	C	**C**	C	**Bc**	A	**B**	**101.0**	**31**
	G7-3	1	**C**	**C**	C	**C**	C	**Bc**	A	**B**	**101.0**	**31**
	G7-4	2	**Bc**	**C**	C	**C**	Bc	**Bc**	Ba	**B**	**106.0**	**26**
	G7-5	1	**C**	**C**	C	**C**	C	**Bc**	A	**B**	**101.0**	**31**
Dac Lac Province												
D1: Krong Nang T.		9	**C**	**A**	A	**B**	Ba	**B**	Bc	**A**	**159.0**	**9**
D2: Ea Drang C.		13	**A**	**A**	B	**B**	A	**A**	Bc	**A**	**184.0**	**2**
D3: Krong Buk C.	D3-1	7	**Bc**	**A**	A	**Ba**	B	**B**	Bc	**A**	**164.0**	**7**
	D3-2	5	**Bc**	**B**	C	**Bc**	B	**B**	Bc	**B**	**121.0**	**18**
	D3-3	8	**Bc**	**C**	C	**Bc**	B	**B**	Bc	**B**	**111.0**	**22**
D4: Ea Drong C.	D4-1	6	**A**	**A**	B	**A**	B	**B**	Bc	**A**	**174.0**	**6**
	D4-2	4	**B**	**Ba**	C	**Bc**	C	**B**	C	**B**	**116.0**	**20**
D5: Ea Wer C.	D5-1	9	**A**	**Ba**	B	**C**	Bc	**B**	Bc	**B**	**141.0**	**13**
	D5-2	1	**C**	**C**	C	**C**	Bc	**B**	Ba	**B**	**106.0**	**26**
	D5-3	1	**C**	**C**	C	**C**	C	**B**	Bc	**B**	**91.0**	**40**
D6: Kien Duc T.		8	**A**	**A**	Ba	**Bc**	A	**A**	B	**A**	**189.0**	**1**
D7:Krong Kmar T.		8	**Bc**	**A**	B	**C**	B	**B**	Bc	**Ba**	**137.5**	**15**

Source: Study Team. Shadow marked system shows the ranking priority within the 21.

4.5 Phasing of the Projects

As described above, the NRWSS set up the two-phase development policy for the national water supply programme; i.e. Phase-1 by 2010 and Phase-2 by 2020. The Study Team discussed the prioritisation results with the NRWSS policy as explained below. CERWASS agreed to the phasing.

- The high ranking 21 systems shall be implemented by the year 2010; thus enabling the supply of water to 86% of the total population of the three provinces. This will satisfy the Phase-1 target of the NRWSS policy. The high ranking 21 systems solution consists of a centralised piped water supply.
- The remaining 25 systems shall be implemented by 2020, resulting in 100 % of inhabitants being supplied with water. This satisfies the Phase-2 target of the NRWSS policy.

NRWSS			Implementation Plan	
Phase	Target Year	Population to be served	Water Supply System	Population to be served
Phase-1	2010	85%	The high ranking 21 systems	86%
Phase-2	2020	100%	Extension of the Phase-1 systems. The remaining 25 systems	100%

5. Feasibility Study

5.1 Water Supply System for the Feasibility Study

In the Master Plan Study, the estimated 46 water supply systems needed for the 20 communes were prioritised. The 46 systems were then divided into two phases in accordance with the NRWSS policy. The highest ranking 21 water supply systems were categorised as Phase-1 and to be implemented by the year of 2010 and the other 25 systems as Phase-2 to be implemented by the year of 2020.

The study selected the high ranking 21 systems of Phase-1 for the Feasibility Study. There were many uncertainties in the remaining systems comprising the Phase-2 group..

5.2 Targets of Water Supply Program

The targets for the water supply program for the Feasibility Study were set as the same targets for Master Plan Study as shown below.

Targets of Water Supply Program

NRWSS	Phase-1	Phase-2
Target Year	2010	2020
Population to be served	85 %	100 %
Water requirement per capita	60 L/d/c	
Duration of service	24 h/day	

5.3 Water Demand Projection

The water demand Projection described in the Master Plan was based not only on the information collected in Master Plan stage but also on the information updated during the Feasibility Study. The water demand projection used for the Master Plan Study is therefore used also for this Feasibility Study.

5.4 Water Sources Development Plan

5.4.1 Test Wells

A total of 20 test wells were drilled, one in each commune. The water sources development plan was formulated principally based on the results of these test wells. Among the high priority 21 systems, groundwater development potential was

confirmed in 17 systems. In the other four systems, groundwater development potential was not identified.

The development plan is shown in Table S.16 and brief descriptions are as follows.

5.4.2 Systems with Confirmed Groundwater Potential

Out of 17 systems with groundwater potential, safe yield was able to measured in 15 systems. The measured safe yields were adopted for the plan. The yield capacities of the other two test-wells (D2, D6) were less than those of the existing wells, therefore the data for existing wells D2 and D6 were adopted for the plan

5.4.3 Systems without Confirmed Groundwater Potential

Out of four systems without confirmed groundwater potential, two test-wells (K2-3, and K4-1) were dry wells. Surface water was considered as water sources for these two systems. For the other two systems (D3-2, D4-2), test-wells were not drilled. The test data from the neighbouring test-wells (D3-1, D4-1) were used for planning purposes.

Table S. 17 Safe Well Yields of Explored Wells and Number of Required Wells

System No.	Commune /Town	Safe well yield (m^3/day)	Geology	Water source	Required wells	
					2010	2020
Kon Tum province						
K1-1	Bo Y	**86**	Neogene sediment (N), Gneiss (PR)	**Unconfined aquifer**	**7**	**3**
K2-1	Dak Su	**149**	Neogene sediment (N), Gneiss (PR)	**Unconfined aquifer**	**0**	**1**
K2-3	Dak Su	**-**	Neogene sediment (N), Gneiss (PR)	**Proposed supply from reservoir of Ngoc Hoi**	**-**	**-**
K3-1	Dak Ui	**259**	Gneiss (PR)	**Unconfined aquifer**	**0**	**1**
K4-1	Dak Hring	**-**	Neogene sediment (N), Gneiss (PR)	**River water will be used.**	**-**	**-**
Gia Lai province						
G1	Kong Tang	**322**	Basalt (β N_2-Q_1)	**Confined aquifer**	**1**	**1**
G2	Nhon Hoa	**173**	Basalt (β N_2-Q_1)	**Confined aquifer**	**6**	**3**
G3	Chu Ty	**317**	Basalt (β N_2-Q_1)	**Confined aquifer**	**1**	**1**
G4-1	Thang Hung	**259**	Basalt (β N_2-Q_1)	**Confined aquifer**	**1**	**1**
G5-1	Nghia Hoa	**173**	Basalt (β N_2-Q_1)	**Confined aquifer**	**1**	**1**
G6-1	Ia Rsiom	**406**	Quaternary sediment (Q), Jurassic sandstone (N)	**Confined aquifer**	**0**	**1**
G7-1	Kong Yang	**432**	Basalt (β N_2-Q_1)	**Confined aquifer**	**0**	**0**
Dac Lac province						
D1	Krong Nang	**346**	Basalt (β N_2-Q_1)	**Confined aquifer**	**2**	**2**
D2	Ea Drang	**225***	Basalt (βQ_{2-4})	**Existing boreholes will be used.**	**6**	**3**
D3-1	Krong Buk	**415**	Basalt (β N_2-Q_1)	**Confined aquifer**	**1**	**1**
D3-2	Krong Buk	**415**	Basalt (β N_2-Q_1)	**Not yet drilled**	**1**	**1**
D4-1	Ea Drong	**268**	Basalt (β N_2-Q_1)	**Confined aquifer**	**2**	**1**
D4-2	Ea Drong	**268**	Basalt (β N_2-Q_1)	**Not yet drilled**	**1**	**0**
D5-1	Ea Wer	**320**	Basalt (β), Jurassic sandstone (J)	**Unconfined aquifer**	**2**	**1**
D6	Kien Duc	**259***	Basalt (β N_2-Q_1)	**Existing boreholes will be used.**	**3**	**1**
D7	Krong Kmar	**518**	Sand (Q), Jurassic sandstone (J)	**Unconfined aquifer**	**1**	**0**

* Based on the pumping test of the existing boreholes for D2 and D6

5.5 Guidelines for Design of Piped System

The following design guidelines for the piped supply systems were suggested:

- Automatic or simple (or manual) pump controls are recommended;
- As far as possible gravity system shall be used for transport of water;
- Local materials shall preferably be used in order to ensure the future availability of spare parts;
- Pipe material and fittings shall be of good quality in order to minimize pipe bursts and leakage;

- Water meters are delicate equipment and only good quality shall be used, and
- Pumps with good efficiency shall be used in order to save operating costs.
- Water meters of good quality shall be used; and
- Appropriate pumps shall be used;
- Iron and Manganese treatment system shall be equipped to the facilities with excessive Iron or Manganese in water;
- Chlorinating treatment facility shall be equipped to all option-1 system.

5.6 Standard Design of Water Supply Facilities

Typical designs for the water supply works have been prepared. The designs have been detailed to an extent that they can easily be modified to suit individual communes by changing dimensions.

The following Standard Drawings are included:

- Typical deep well structure,
- Typical design of well head and well house building,
- Typical iron and manganese removal plant (aeration tower, reaction tank, and slow sand filter),
- Typical surface water treatment plant (horizontal roughing filter and slow sand filter),
- Chlorination system,
- Typical reservoirs tank,
- Pipelines and Typical public taps - Alternative 1 to 3, and
- Valve and water meters.

The standard drawings of a water supply facility and well structure are shown in Figure S. 4 and S.5.

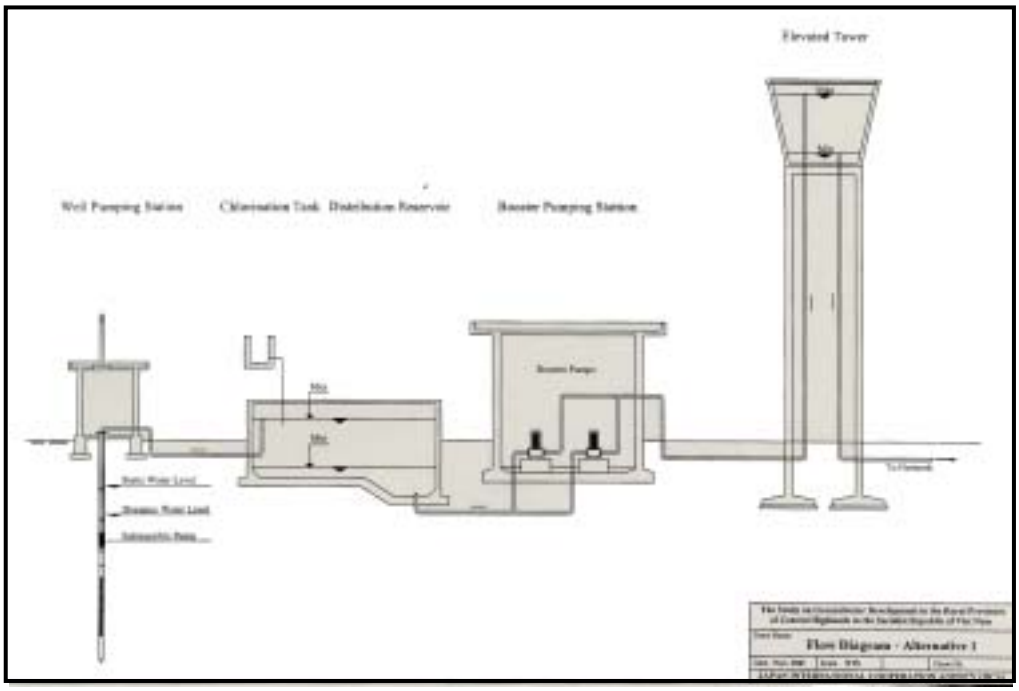
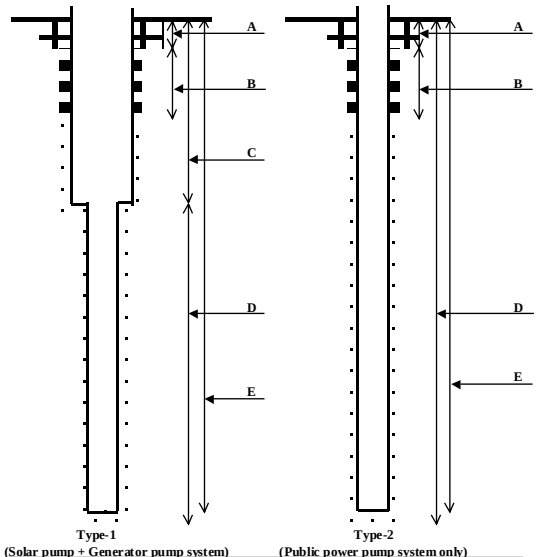


Figure S. 4 Standard Design for Water Supply System



Example of Wells	Well Dimension				
	A: concrete base (size)	B: Clay packing (m)	C: Installation depth of 12" pipes for pump chamber of 2 pumps	D: Installation depth of 6" casing/screen pipes	E: Drilling depth (m)
K1-1	L x W x D = 1.5 x 1.5 x 1.0	Average depth: around 10m in general. Below the clay packing, gravel pack will be done	42	120	125
K2-3			32	120	125
G-3			67	150	155
D4-1			58	150	155
D4-2			58	150	155
Others			40 - 60	50 - 150	55 - 155

Note: 1 Exploratory wells of 17 of the first investigation shall be used for production wells of stage-1 implementation
2 Remaining casing/screenn pipes in the first investigation stage will be used

Figure S. 5 Standard Design for Well Structure

5.7 Design Works

Designs works were conducted for the high priority 21 systems. Actual topographic conditions, water pressure, facility layout etc were all optimised. Standard drawings for each facility such as pump, elevated water tank tower, chlorination facility, valve and etc, were prepared.

Hydraulic calculations were undertaken to obtain the suitable water pressure in the system in order to send water to the extremities. In the process of these hydraulic calculations, it was necessary, for some systems, to adapt facilities with larger capacities in order to secure water requirement at the extremities for hourly maximum water consumption. As large capacity facilities are likely to cause difficulties in operation and maintenance, a standard design was adopted which would maintain the capacity for daily maximum water consumption. In these cases, there may be water shortages in peak demand hours in peak demand seasons.

Table S.18 shows the summary of the facility outline for the 21 systems.

Table S. 18 Summary of Facility Outline

Commune/ Town Name	Number of Villages	Popu-lation 2010	Water demand 2010 Qav	Exist available wells (yiel)	Number of wells till 2010	Raw water pipeline	Treat-ment plant	Reservoir tank	Elevated tower	Distribu pipeline (km)
Kon Tum Province										
K1: Bo Y C.	**K1-1**	**7**	**7797**	**477**	**1(100)**	**4**	**6000**	**1**	**1**	**0**	**22**
K2: Dak Su C.	**K2-1**	**3**	**1612**	**99**	**1(150)**	**0**	**1500**	**1**	**1**	**0**	**11**
	K2-3	**9**	**4862**	**298**	**0(150)**	**2**	**1000**	**1**	**1**	**0**	**19**
K3: Dak Ui C.	**K3-1**	**5**	**2819**	**173**	**1(250)**	**0**	**0**	**0**	**0**	**0**	**10**
K4: Dak Hring C.	**K4-1**	**3**	**3136**	**192**	**river water**		**500**	**1**	**1**	**1**	**21**
Gia Lai Province										
G1:Kong Tang T.		**11**	**6988**	**428**	**1(300)**	**1**	**3000**	**1**	**1**	**1**	**48**
G2: Nhon Hoa C.		**15**	**13779**	**843**	**1(200)**	**5**	**2000**	**1**	**1**	**1**	**44**
G3: Chu Ty T.		**8**	**7698**	**471**	**1(350)**	**1**	**3000**	**1**	**1**	**1**	**44**
G4:Thang Hung C.	**G4-1**	**5**	**5080**	**311**	**1(250)**	**1**	**3000**	**1**	**1**	**1**	**16**
G5:Nghia Hoa	**G5-1**	**5**	**4008**	**245**	**1(200)**	**1**	**3000**	**1**	**1**	**1**	**21**
G6: Ia Rsion	**G6-1**	**7**	**4685**	**287**	**1(400)**	**0**	**1500**	**1**	**1**	**1**	**10**
G7: Kong Yang	**G7-1**	**5**	**1837**	**112**	**1(400)**	**0**	**1500**	**1**	**1**	**1**	**15**
Dac Lac Province										
D1: Krong Nang T.		**9**	**12903**	**790**	**1(350)**	**2**	**4500**	**1**	**1**	**1**	**37**
D2: Ea Drang C.		**13**	**18464**	**1130**	**200**	**6**	**10500**	**1**	**1**	**0**	**37**
D3: Krong Buk C.	**D3-1**	**7**	**8556**	**524**	**1(400)**	**1**	**3000**	**1**	**1**	**1**	**15**
	D3-2	**5**	**4463**	**273**	**1(400)**	**1**	**1500**	**1**	**1**	**1**	**27**
D4: Ea Drong C.	**D4-1**	**6**	**7775**	**476**	**1(250)**	**1**	**4500**	**1**	**1**	**1**	**27**
	D4-2	**4**	**2034**	**125**	**250**	**1**	**1500**	**1**	**1**	**1**	**15**
D5: Ea Wer C.	**D5-1**	**9**	**8920**	**546**	**1(300)**	**1**	**3000**	**1**	**1**	**1**	**25**
D6: Kien Duc T.		**8**	**10619**	**650**	**1(250)**	**2**	**4500**	**1**	**1**	**0**	**25**
D7:Krong Kmar T.		**8**	**7484**	**458**	**1(500)**	**1**	**1500**	**1**	**1**	**0**	**19**

5.8 Project Cost Estimate

The construction cost for the 21 systems are summarised in Table S.19.

Table S. 19 Construction Cost for the 21 Systems

No.	System	Construction Cost	Base Cost	Project Cost
1	K1-1	875,885	1,007,268	1,107,995
2	K2-1	156,290	179,734	197,707
3	K2-3	443,742	510,303	561,334
4	K3-1	205,461	236,280	259,908
5	K4-1	459,427	528,341	581,175
1	G1	607,639	698,785	768,663
2	G2	1,064,964	1,224,709	1,347,179
3	G3-1	593,946	683,038	751,342
4	G4-1	345,588	397,426	437,169
5	G5-1	340,560	391,644	430,808
6	G6-1	212,663	244,562	269,019
7	G7-1	227,251	261,339	287,473
1	D1	640,632	736,727	810,399
2	D2	926,850	1,065,878	1,172,465
3	D3-1	337,039	387,595	426,354
4	D3-2	321,530	369,760	406,735
5	D4-1	544,279	625,921	688,513
6	D4-2	246,098	283,013	311,314
7	D5-1	566,628	651,622	716,784
8	D6	574,724	660,933	727,026
9	D7	358,109	411,825	453,008
Total		10,049,305	11,556,701	12,712,371
VAT (10 %)				1,004,931
Grand Total				**13,717,301**

Note: Base Cost=Construction cost + Land acquisition cost + Engineering services cost (15%of construction cost)

Project Cost=Base cost + Physical contingency (10% of Base cost), excluding price contingency

5.9 Organisation of Operation and Maintenance

5.9.1 Principles

An organisational model has been developed based on the NRWSS strategy including extensive discussions with stakeholders ranging from CERWASS and PCERWASS to commune leaders and user representatives.

5.9.2 Organisation of O&M

For the O&M of the piped water supply facilities already implemented it is recommended that a specific body, called the **Water Supply Unit** (WSU), be established under CPC/TPC for each scheme. It is also recommended that **the users be represented** in the management structure of the WSU. This will be materialized through representation of users on the **Board of the WSU**. The organisational chart for WSUs is shown in Figure S.5 below.

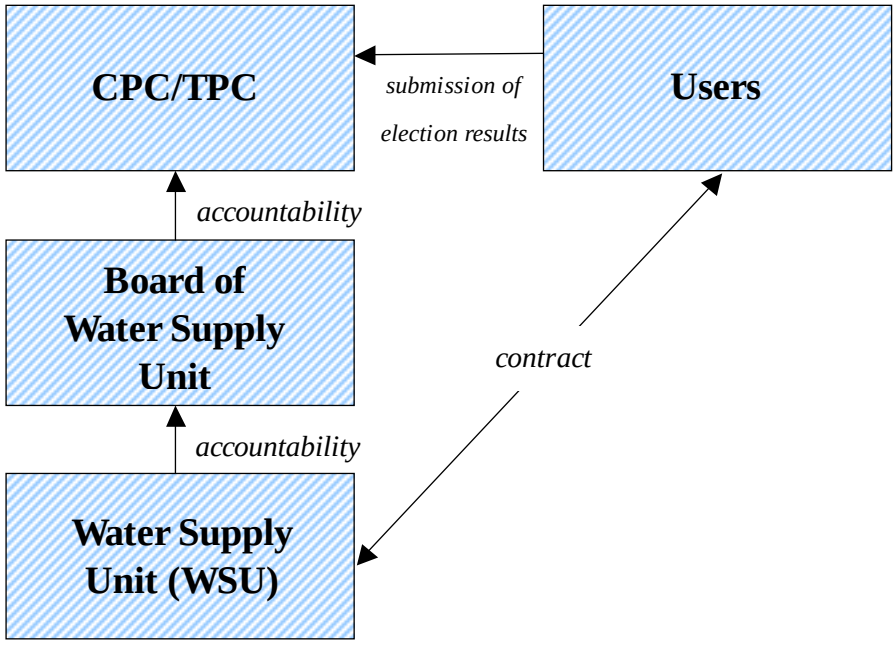


Figure S. 6 Organisation of WSU

The Board will comprise five members appointed by the People's Committee of the commune or town for a two-year period. At least two of the five members of the

Board should be elected by the users as their representatives. The chairperson of the Board will be accountable to the PC.

The main duties of the Board are to **monitor and supervise the financial and technical performance** of the WSU, and to **approve the annual plans** and **decide upon the water tariff** and other payments and fines related to water supply services provided by the WSU.

It is recommended that the Board grant WSUs reasonable autonomy whereas the Board, together with PC and water users, will undertake regulation and supervision functions.

5.9.3 Staffing and Duties

To achieve sufficient autonomy and handle the accounts, the WSUs should have their own staff. It will also be possible to outsource some functions to external personnel. It is proposed that the piped schemes will have the following staff:

- A manager;
- An accountant;
- A pump operator/treatment plant operator;
- A network inspector; and
- A number of meter readers.

It may be possible to begin operations with a small core team of part-time staff and increase the number of staff and upgrade them to full-time work when water sales increase. It is also possible that the staff members initially undertake a combination of duties. The best staffing set-up depends on the O&M requirements of each scheme with reference to the complexity of the technology, the size of the system, the number of users, and the revenue base.

The Board should appoint the manager of the WSU. The other staff members would also be appointed by the Board based on recommendations made by the manager.

5.9.4 Guideline for Operation and Maintenance

Prior to and during the second period of field work, the guidelines for operation and maintenance of the schemes were developed. **Model documentation** was developed and designed particularly to help the establishment and mobilisation of WSUs and

the Boards in the two pilot communes and to support them to develop working modalities. This model documentation includes *General Regulations of Services* and an *Application for a Connection to Piped Water Supply* (Supporting Report B), a *Contract for Water Supply between the user and the WS*U and a form for *Daily Operations Record*. These documents can be updated and further developed on the basis of experience from the two pilot schemes to be applied in other project schemes.

The *General Regulations* define the mission statement, service area, and organization of the WSU, the rights and responsibilities of the users, the WSU, the Board and the People's Committee, the responsibilities of the staff of the WSU, and implications of violations of the regulations.

The *Application for a Connection to Piped Water Supply* and the *Contract for Water Supply* are based on the *General Regulations* and they define the rights and responsibilities of the contracting parties and conditions of the contract.

The *Daily Operations Record* provides a format for collection and recording of the most necessary technical data.

5.10 Environmental Impact Assessment (EIA)

Five aspects were analysed and monitored during the EIA process before and after the construction of water supply facilities: water level fluctuations, water rights, land acquisition, water quality, and wastewater disposal. The results are as follows:

- All of the 21 priority systems proved to be environmentally feasible. However, technical solutions will be necessary for the systems in K 4 and G 7, and water quality analysis will be necessary for the water sources to be identified in the future in K2-3, D3-2, and D4-2. Hence, final assessment of these five systems is still pending;
- The water level was lowered in the shallow dug wells in K3-1 and D5-1 near the wells examined by the Study team. Appropriate solutions should be put in place by PCERWASS to alleviate water rights issues;
- The wells are structured to take water from an unconfined aquifer in K1-1, K2-1, K3-1, D5-1, and D7. The environment around the wells should be protected from possible contamination;
- Bad smell was identified in G7-1, and a high level of coliform in K4-1 during the F/S period. If the cause of the smell is not remedied, the system in G7-1 would not be feasible. The water taken from the river in K4-1 needs treatment (aeration, roughing filter, and slow sand filtration); and
- Land acquisition issues may be a problem in K4-1, G5-1, G6-1, D1, D2, D3-1, D4-1, D5-1, D6, and D7. If compensation is necessary, negotiations should be arranged by the people's committee and PCERWASS prior to the detailed design of the water supply facilities.

In conclusion, no serious obstacles to the implementation of the water supply project regarding environmental issue were observed.

5.11 Feasibility Evaluation

Feasibility of the high priority 21 systems was evaluated from the following points of view.

- Financial and Economic Viability
- Consideration on Operation and Maintenance of the Facilities
- Organisational Consideration
- Environmental Consideration

Each system was evaluated on the above factors and ranking levels developed. These rankings were then combined to provide an overall evaluation.

5.11.1 Financial and Economical Viability

(1) Financial Evaluation

a) Water Production Cost

Water production costs usually include initial investment costs, operation and maintenance (O&M) costs, re-investment costs and profit. For this case the initial investment costs and profit are not included in the study because a rural water supply project hardly ever recovers its initial investment costs.

The O&M costs consist of costs for electricity, personnel salary, minor repairs etc. Reinvestment costs comprise costs for replacement of major parts of the system such as pump or pipe line, and major repairs.

The water production costs were calculated for the two cases: (1) with reinvestment cost and (2) without reinvestment cost. Table S.20 shows the results of the water production costs and the summary is as shown in the table below.

Water Production Cost (VND/m^3)

Year	Without reinvestment costs	With reinvestment costs
2005	1,600 - 6,300	4,600 - 18,600
2020	700 - 2,600	1,600 - 6,400

b) Water Tariff

The **tariff** analysis was made on the basis of the following 3 principles:

- ♦ operation margin has to be positive, although sometimes marginally negative, every single year;

- actual cumulative savings (for reinvestments) have to account for at least 63% of the cumulative saving targets by 2020;
- break-even point between the actual cumulative savings and saving targets has to be reached within 25 years from the initial investment (by 2028);

The tariffs are estimated to be constant from 2003 to 2012. The tariffs are increased in 2013 and remain constant from 2013 to the end of the analysis period (2030). The tariff increase in 2013 is justified by the second phase of investment.

The calculated tariffs are shown in Table S.20 and a summary is as shown in the table below.

Water Tariff

Period	Water Tariff (VND/m^3)
from 2003 to 2012	1,850 (D2) – 8,000 (K2-1)
from 2013 to 2030	2,200 (D1, D2, D3-1) – 8,250 (K2-1)

The calculated water tariffs above are rather higher than those prevailing elsewhere in Vietnam. For an example, the upper limit of water tariff set up by PCP of Dac Lac Province is VND 1,800/m^3.

c) FIRR

The financial internal return rates (FIRR) are calculated on the basis of the above tariff calculations. The FIRRs obtained all show negative values, which suggests the projects are not financially justifiable. This is simply because that the reinvestment costs were not considered until 2013 and only 63% of the investment costs are to be recovered before 2023.

The provision of financial subsidies will have to be considered by the Government of Vietnam.

(2) Ability to Pay and Willingness to Pay

a) Ability to Pay (ATP)

The NRWSS suggests that each household can afford to pay 3% - 5% of annual incomes for water supply to the household. Table S.20 shows 'affordable water

tariffs' of 21 systems (communes). The annual incomes presented in the table are based on incomes for 2001.

Table S. 20 shows that in 19 systems by 2005 and 15 systems by 2020, households will be able to pay for water

Affordability

water tariff / annual incomes (%)	2005	2020
less than 3 %	15 systems	12 systems
3 % – 5 %	4 systems	3 systems
more than 5%	2 systems	6 systems

However, six communes (K1-1, K2-1, K2-3, D3-2, D4-2 and D5-1) where poor households are dominant may not be able to afford to pay the water tariffs. In particular, the water tariffs for the two facilities (K1-1 and K2-1) are higher than the others as larger facilities are required compared to the scale of the communes. It will also be difficult to collect tariffs in D5-1 for the water supply from the public taps.

Table S. 20 Cost of water per cubic meter, tariff requirement and affordability

Commu-ne	Annual unit costs (VND/m^3)						Tariff (VND/m^3)		Affordability (%)*	
	Cost excl. reinvestment			Cost incl. reinvestment						
	2005	2010	2020	2005	2010	2020	Up to 2012	After 2013-	2005	2020
K1-1	4,438	3,106	1,666	17,625	10,847	5,253	6,750	7,000	4.8	7.8
K2-1	6,258	5,195	2,550	18,573	12,425	6,416	8,000	8,250	10.9	17.5
K2-3	4,239	3,204	1,621	14,532	9,246	4,471	5,750	6,000	7.8	12.7
K3-1	3,455	2,748	1,486	8,146	5,502	2,969	3,750	3,800	4.8	7.5
K4	4,680	3,277	1,626	14,466	9,022	4,200	5,500	5,600	4.7	7.4
G1	2,952	2,129	1,221	9,075	5,723	2,818	3,400	3,750	1.5	2.7
G2	2,363	1,784	1,118	7,697	4,915	2,575	2,850	3,350	0.7	1.3
G3	2,767	2,153	1,353	7,853	5,139	2,678	3,100	3,500	1.0	1.7
G4-1	2,411	1,829	1,043	7,146	4,609	2,371	2,800	3,100	1.9	3.3
G5-1	3,034	2,283	1,293	8,721	5,621	2,835	3,300	3,800	1.4	2.5
G6-1	2,309	1,825	1,072	5,820	3,886	2,167	2,500	2,800	1.3	2.3
G7-1	5,002	3,789	1,776	13,739	8,919	3,781	5,300	5,400	2.7	4.3
D1	1,658	1,277	774	4,983	3,229	1,685	1,950	2,200	0.6	1.1
D2	1,609	1,259	860	4,632	3,034	1,714	1,850	2,200	0.8	1.5
D3-1	1,711	1,359	833	4,650	3,084	1,671	1,900	2,200	0.9	1.6
D3-2	2,355	1,727	995	7,352	4,661	2,493	2,700	3,250	1.3	2.4
D4-1	2,160	1,639	974	6,720	4,316	2,136	2,650	2,800	1.2	2.0
D4-2	3,470	2,878	1,419	10,868	7,221	3,223	4,000	4,500	1.8	3.1
D5-1	2,536	1,801	959	8,588	5,353	2,607	3,100	3,500	3.2	5.7
D6	1,956	1,584	1,048	5,568	3,704	2,028	2,300	2,600	0.7	1.2
D7	2,084	1,632	990	5,794	3,810	1,994	2,150	2,700	0.9	1.7

*Water tariffs more than ATP (5% of income) are highlighted.

b) Willingness to Pay (WTP)

Willingness to pay was investigated through the socio-economic investigation of the Study. The results were presented in Table S.6 above. Table S.6 indicates that the calculated water tariffs are higher than the amount people are willing to pay in 14 systems out of the 21 systems (year 2005). However, it is known that education on hygiene and water supply through Information, Education and Communication (ICE) activities can improve the 'willingness to pay' to a level of 'ability to pay'. The study has recommenced a comprehensive IEC program to achieve this change.

(3) EIRR

a) Positive and Negative Economical Effect

The calculation of cash flow analysis by the use of economic internal rate of return (EIRR) was based on the estimated economic merits and demerits.

The estimated economic benefits to be derived from rural water supply projects will be as follows.

Positive Economic Effects

B-1. Improvement of public health due to decrease in water-borne diseases;
B-2. Increase in work time or study time by reducing water transportation time;
B-3. Improvement of gender issues by B-1 to B-2, and through community activities in B-3;
B-4. Decrease in medical expenditure;
B-5. Increase in employment during construction of the systems and the need for O&M;
B-6. Increase in business activities to provide local materials for the systems;
B-7. Improvement of awareness on hygiene and sanitation through IEC; and
B-8. Higher living standard and longer life expectancy by the use of clean and safe water.

Negative Economic Effects

However, there may be some economic demerits as follows:

D-1. Decrease in vendor business in some areas;
D-2. Environmental impact of groundwater lowering in shallow wells raising

water rights issues; and

D-3. Land acquisition problems that may be troublesome unless resolved to the satisfaction of those concerned.

b) Results of Economic Cash Flow Analysis

The following are the results of the economic cash flow analysis:

- The EIRR of the systems in K3-1, D2, D4-2, and D6 is positive, even though the value is small (1 to 10%);
- The EIRR of K1-1 and K2-1 cannot be calculated because the balance is always negative, and that of K2-3 is as low as –10%. These systems are economically unfeasible; and
- The EIRR of the other systems varies between –3 to –7%.

From the economical point of view, most of the systems in the projects are not viable. Financial subsidies for O&M are required for some systems.

5.11.2 Difficulty Levels of Operation and Maintenance of the Facilities

The systems in K1-1, K2-1 and K2-3 include relatively long pipelines for small populations. The longer pipeline systems require more frequent maintenance. All systems except for G5-1, D1, D2 and D3-1 require treatment facilities for Iron and Manganese. These systems require special technical expertise to maintain the facilities. These factors may have a negative impact on sustainability. In addition, all systems require chlorination treatment facilities.

5.11.3 Organisational Consideration

Difficulties with levels of organisational activities have been considered. More complicated organisational arrangement may be required for K2, D3 and D4 where two water supply systems are proposed for one commune. Double tariff systems may be needed. These organisational factors may have negative impact on sustainability.

In comparison, K2-3 can be implemented in combination with a nearby ADB water supply project. The organisational arrangement of H2-3 can be included in the organisation of the district level. Organisational arrangements are then simpler for K2-3, which will have a positive impact on sustainability.

5.11.4 Environmental Considerations

As described before, the project will have environmental impacts although they are considered negligible. Some environmental impact may adversely affect the project sustainability and benefits. From the EIA, the following two may have negative impacts on the projects.

- groundwater contamination by organic compound in 5 systems (K1-1, K2-1, K3-1, D5-1 and D7)
- Acquisition of private lands may be required for 10 systems (K4-1, G5-1, G6-1, D1, D2, D3-1, D4-1, D5-1, D6 and D7)

5.11.5 Feasibility Evaluation (Prioritisation)

As mentioned, not all the projects are financially justifiable. Financial subsidy will be required to maintain the project as being financially viable. Provided that this financial subsidy is available, financial aspects are not critical criteria for the feasibility evaluation.

Feasibility of each system largely depends on 'soft component aspects' or 'preparedness' such as O&M capability, organisational capability etc. If sufficient preparedness is confirmed for some communes, the project can be judged feasible and can be implemented immediately. Otherwise, the project likely remains unfeasible.

'Soft component aspects' can be improved through IEC campaigns though it may require a long time. Some communes with little preparedness (unfeasible) can be lifted up to the level of a commune with sufficient preparedness (feasible) through an IEC campaign within the Phase-1 period.

Therefore the feasibility evaluation for the study should be regarded as a prioritisation of 21 systems to achieve the national target that 85% of population is to be provided with water within the Phase-1 period.

The prioritisation results are shown in Table 21.

Table S. 21 Prioritisation results

No.		1	2	3	4	5	6		
Item		Financial		Economic	O&M	Organization	Environment	Description	Feasibility
		WTP	ATP						
Weight		1	1	2	1	2	1		
Kon Tum									
K1: Bo Y C.	K1-1	C	C	C	B	B	B		C
K2: Dak Su C.	K2-1	B	C	C	B	B	B		C
	K2-3	B	C	C	B	C	A	ADB connection	C
K3: Dak Ui C.	K3-1	C	C	B	B	B	C	Pilot	C
K4: Dak Hring C.	K4-1	C	C	B	B	B	B	Surface water	B
Gia Lai									
G1:Kong Tang T.		C	A	B	B	B	A		A
G2: Nhon Hoa C.		C	A	C	B	B	A	Pilot	B
G3: Chu Ty T.	G3-1	C	A	B	B	B	A		A
G4:Thang Hung C.	G4-1	B	B	B	B	B	A		B
G5:Nghia Hoa	G5-1	C	A	B	A	B	B		B
G6: Ia Rsion	G6-1	C	A	B	B	B	B		B
G7: Kong Yang	G7-1	B	B	B	B	C	C	Bad smell	B
Dac Lac									
D1: Krong Nang T.		C	A	B	A	B	B		A
D2: Ea Drang C.		C	A	B	A	A	B		A
D3: Krong Buk C.	D3-1	C	A	B	A	B	B		A
	D3-2	C	A	B	B	B	A	No well	B
D4: Ea Drong C.	D4-1	C	A	B	B	B	B		B
	D4-2	C	B	B	B	B	A	No well	B
D5: Ea Wer C.	D5-1	C	C	C	B	B	C		C
D6: Kien Duc T.		B	A	B	B	A	B		A
D7:Krong Kmar T.		C	A	C	B	B	C		B

6. Pilot Model Project

6.1 Purpose of Pilot Models

The main purpose of the pilot models was to assess the feasibility and sustainability of the piped water supply systems with regard to following issues, and to feed the results of the pilot models back into the feasible study.

Operation and maintenance skills
Financial sustainability
Appropriateness of technology
User's comment

6.2 Selection of Pilot Model Commune

Two pilot systems were constructed in the communes under typical and difficult social situation in the central highlands. One is a poverty commune (K3-1) and the other is a minority-dominated commune (G2).

6.3 Overall Progress of Pilot Model

Construction work was implemented from October 2001 to January 2002. The basic parameters for the construction works were as shown in Table S.22.

Table S. 22 Basic Parameters for the Construction Work

Items	Dak Ui (K3-1)	Nhon Hoa (G2)
A. Water resource		
1. Permissible yield of JICA`s deep well	3.0 l/sec	2.0 l/sec
2. Altitude of JICA`s deep well	El 687 m	El 420 m
3. Elevation of reservoir tank	El 750 m	El 426 m
B Water demand		
1. Number of villages	5	2
2. Number of households	412	200
3. Number of population, 2001	2,164	1,150
4. Maximum hourly demand, 2001	2.0 m^3/h	1.1 m^3/h
5. Maximum daily demand, 2001	20.0 m^3/d	11.0 m^3/d
6. Minimum pressure at tapping point	3.0 m	3.0 m
7. House Connection (public taps) at 8 May 2002	4 (50)	38 (4)

6.3.1 Water Supply Management Unit

After discussion with the Centre for Rural Water Supply and Sanitation (CERWASS) Hanoi and CPC, the Water Supply Unit (WSU) was established for the management of water supply facilities during the construction stage (from Oct. 2001 to Jan.2002).

The job positions and their duties were decided in the presence of the JICA study team at the pilot model construction stage.

Table S. 23 Water Supply Management Unit

	K3-1 commune	G2 commune
Water Supply Unit	3 staff from CPC and users	Selected by CPC and users
Manager	Half time	Wageless
Accountant	Half time	Half time
Pump Operator	Full time	Full time
Network inspector/Meter reader	Half time	Half time

Transfer of technology and know-how for O&M to the WSU staff was carried out by the contractor and the JICA study team. The procedure for periodical water quality checks using portable kits was demonstrated to the operator of each WSU.

6.3.2 Implementation of the Two Pilot Models

The two pilot models in Dak Ui (K3-1) and Nhon Hoa (G2) were put into operation by the end of January 2002. Along with the official and recorded handing over of the facilities, a water quality kit, set of manuals, model reports, records and documents were distributed to each WSU. The contractor as well as PCERWASS of Gia Lai provided training, and operating and management instructions to CPCs and the initial personnel of the Water Supply Units (WSUs) to operate the schemes. The previous experience of PCERWASS in Kon Tum was limited to simple gravity schemes only.

A follow-up mission was undertaken in the period of May 04-08, 2002. The mission collected records and documents from the two WSUs, interviewed the managers and staff of the WSUs as well as customers, and visited sites, including pumping stations, treatment plant (in K3-1), public taps, and private connections.

6.3.3 Result of Pilot Model Implementation

(1) Institutional Aspects

a) Status of WSU

In the both communes of K3-1 and G2, the pilot model is managed and operated by a WSU. The general regulations have been approved by the respective CPCs.

b) Relationship between WSU and Users

In both communes, the WSU had signed contracts with the customers. The terms of the contract define the essential rights and responsibilities of both parties.

c) Technical capability

It is vital that the WSU is able to make connections and repair broken pipelines.

The WSU in G2 has been able to install new house connections, whereas the WSU in K3-1 requires more training before being capable of providing new connections.

d) Salary payment

In G2, the salaries and wages have been paid for VND 300,000 to each of the five members. In K3-1, WSU member have been paid for VND 250,000 including that of the manager.

e) Water tariff collection

Water tariff was collected at the end of every month for both pilot systems.

(2) Operation and Maintenance Skills

a) Operation record

Both WSUs have maintained daily operation records; G2 since late January and K3-1 since late March. The quality of these records seems more consistent in G2. G2 has also submitted monthly reports to PCERWASS in Gia Lai.

b) Operation mode

Both schemes have been operated more or less on a daily basis with some interruptions, reportedly resulting mainly from power failures. The most significant single reason for the high loss of pumped water was substantial overflow at the treatment plant due to long pumping periods at K3-1. Power failures have been more frequent in K3-1 (approximately six days per month without pumping) as against less than one day per month in G2.

(3) Water Tariff and Financial Sustainability

a) Water tariff

The water tariff in G2 is VND 2,000/m^3 for water consumption up to 20 m^3/month, and thereafter progressively increasing by VND 1,000 for each cubic meter per month.

The tariff in K3-1 is VND 1,500/m^3. This is sufficient to cover salary, electrical charges and minor repairs.

b) Financial sustainability

The tariff of VND 2,000/ m^3 in G2 will be financially sustainable, even for financing reinvestment in the longer term. The number of house connections is still less than half of that estimated on average for the first year in G2.

The tariff of VND 1,500/ m^3 in K3-1 and its water sales are almost equal to the original estimate for the first year due to high water consumption volume, though the house connection number is limited at present. IEC activities would be required to increase the house connection.

(4) Appropriateness of Technology

a) Iron removal plant

Since the operation commenced, the total amount pumped in K3-1 until May 07 has been about 4,500 m^3. Meters have been read twice. Based on limited and partly questionable data from the end of March, metered water use was about 930 m^3 against the total amount pumped of about 1,700 m^3. This suggests that non-revenue water use is some 45%, predominantly overflow from the reservoir. By the arrangement of communication tools, there is no overflowing from June 2002.

b) Water quality

According to the water analysis results the water quality in both schemes is in compliance with the Vietnamese and international water quality standards. However, users in G2 have complained about water quality. After boiling, a small volume of white/greyish sedimentation could be observed at the bottom of vessels. The water quality as perceived by the customers restricts the interest of existing customers to use water and that of potential new customers to register. Subsequent water analysis was carried out and results have confirmed that the problem is mainly aesthetic and does not involve any risks.

c) Electrical failure

One of the most serious technical problems is the vulnerability of the power supply. The unreliability of the power supply is an external factor. Its impacts can be reduced by taking this fact into account in the design of the water supply schemes.

(5) User's Comment

a) Water quality

In G2, many customers had complained about the water quality at the beginning of the service. However, after water quality was proven to be within the standard, no further complaints were received. A female teacher and a user of the public tap were satisfied with water quality. In K3-1, many interviewees, including some with the highest education in the commune, preferred the taste of shallow well water. Piped water was not so “sweet”, according to them. Further IEC activity will be required.

b) Water tariff and service level

No interviewee complained about the reliability of service or cost of water. One of the interviewed men plans to install internal plumbing in his premises to eliminate the burden of women to carry water between buildings.

In K3-1, customers had no general complaints about the pilot model. They were aware that sometimes water supply was affected by power failures.

One customer (male) was not fully satisfied with the reliability of service (his house was on a relatively high location) and another (female) was not happy with a minor

leak (before her meter) as a result of an extension of the pipeline made by the customer.

c) Gender

Interviewed teachers (female) living at the school also in K3-1 said that they now have more time for their work, families, and social contacts.

d) House connection

The number of house connections in G2 totalled 38 by May 08. There are also three public taps at schools and a public tap at the market managed and operated by a vendor. The number of beneficiaries, i.e., people using water from the scheme in G2 (excluding customers of the vendor) is estimated by WSU at about 170.

Ethnic minority people use water from public taps rather than house connections tap due to poverty condition. A lower house connection cost for these groups would result in an increased number of house connections.

In K3-1 there were three connections classified as house connections by the WSU at the beginning of May. The number of metered public taps was initially 50.

6.3.4 Lessons Learned from Pilot Model

(1) Capacity

Some of the communes selected for the Study, including Dak Ui (K3-1),have been generously supported by the Government of Vietnam through free or highly subsidized investments and services.

Where extensive capacity building and a changed attitude are still required at the provincial level, it is impossible to expect that the district level could take a substantial role in supporting the communes, WSUs and customers. It will take time – probably several years – before the Units of Agriculture and Rural Development in the district will be upgraded and prepared to play the role suggested in the NRWSS.

After short training course for each WSU, the respective people in K3-1 and G2 could start the management of WSUs.

(2) Taste of Water

Many users complained about the water "taste", claiming that it is different because the water is supplied through a metal pipe and has a ‘metal-like’ smell.

After introducing IEC activities, the users will likely accept the piped water.

(3) Local Construction Skills and Materials

It is considered that a simple system of rural water supply could be constructed by the local contractors. Almost all of the construction materials for the rural water supply facilities except submersible pump motors and control panels are available in the local markets of Vietnam. Document preparation, procurement of construction material, and organization of skilled workers was quickly done by the local contractor. However, understanding of the contract by the local contractor was limited and quality control is needed through external support.

It is possible to employ a local constructor judging from the results and quality of the construction for the two pilot schemes.

7. Phased Implementation of the Priority 21 Systems

7.1 Grouping of the Priority 21 Systems

In the feasibility study, the priority 21 systems were prioritised. Based on the prioritisation, two systems were selected for the Pilot Model Project in order to test the plan and to identify unknown problems during the study period.

The Pilot Model project suggested that careful consideration should be given to organisational aspects related to local entrenched habits that require changing

Another grouping of the 21 systems has been considered for the purpose of budgetary arrangement and consequently for the implementation priority. The following three aspects were taken into account for the grouping.

- Feasibility evaluation (Prioritisation)
- Results of the Pilot Model Project
- Equal opportunity for the targeted 3 provinces
- Requests from Vietnam Government

The 21 systems were grouped into 4 groups (A, B, C and D) as shown in the Table S.24. The following explains the reasons for the grouping for each province:

- Kon Tum province

In the previous Chapter 5.11.5 “Feasibility Evaluation (Prioritisation)” for Kon Tum province, K4-1 system was ranked as the top priority with a Rank B, followed by K1-1, K2-1, K2-3 and K3-1 systems (ranked as the Rank C). However, there is an opportunity for K2-3 to be combined with the ADB town water supply project in terms of WSU, water tariffs and O&M staff. The town water system will have a much higher sustainability than that of the small commune. Therefore, the K2-3 system will be advanced to top priority, from a sustainability point of view, ahead of K4-1, then K3-1, K1-1 and K2-1.

- Gia Lai province

As shown by the good performance of the G2 pilot scheme, most of the systems in Gia Lai have higher sustainability in economical terms than those of Kon Tum. Therefore, an implementation of two systems in each step has been applied. In the previous evaluation for Gia Lai province G1 and G3-1were ranked as top priority, followed by G2, G4-1, G5-1, G6-1, and G7-1. The G2 pilot scheme has been

successful although with only a 10% service coverage area at present. The expansion opportunities for G2 are considerable and with more financial subsidy would be a good model case for the Central Highlands region. Therefore, the implementation program of two systems per step was decided (firstly G2 and G3-1, secondly G1 and G4-1, followed by G6-1 and G7-1).

- Dac Lac province

In case of Dac Lac, the implementation schedule basically follows the previous evaluated result. However, as D3-2 and D4-2 systems required the drilling of new wells, the priority was re-ordered to D1 and D2 (first step), D3-1 and D6 (second), and the remainder in their original order.

7.2 Phased Implementation Plan

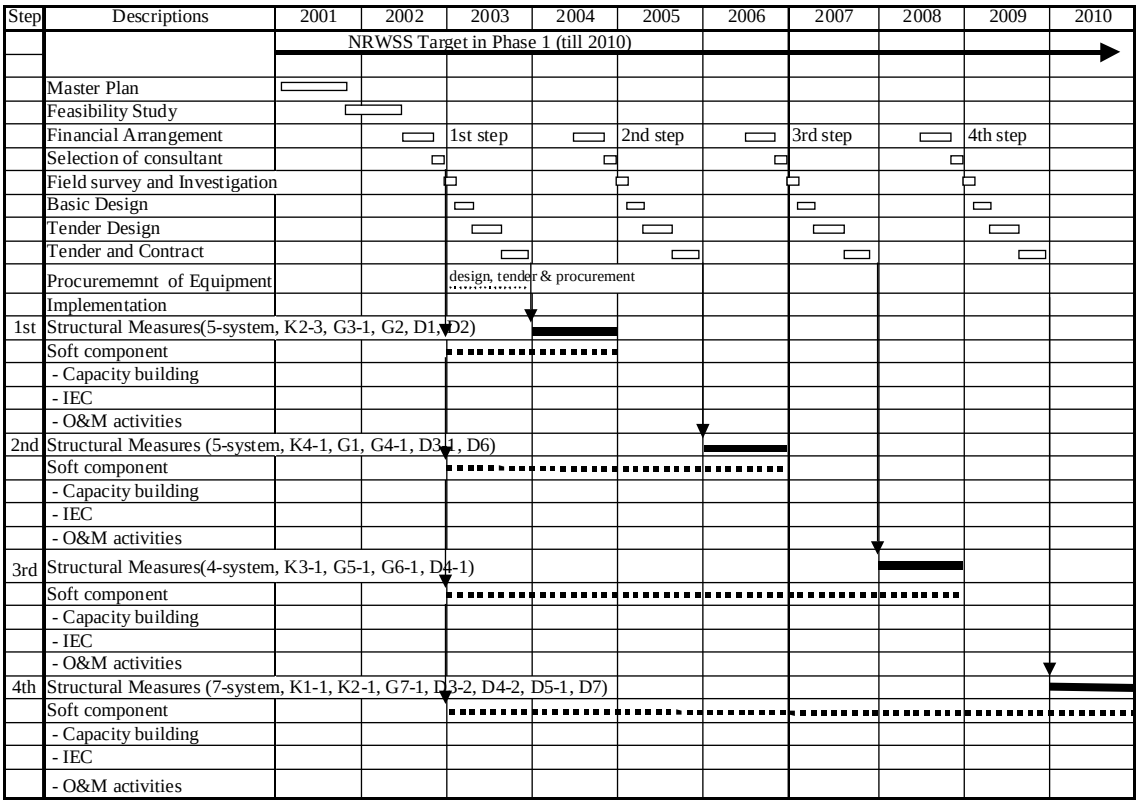
For the consideration of a phased implementation plan, three cases (implementation in 2 steps, 3 steps and 4 steps) were considered. Out of these three cases, implementation in 4 steps was considered to be most appropriate taking into account sustainability and preparedness of communes.

The phased implementation plan is presented in Table S.24 and S25. With this implementation schedule, systems with a high preparedness of inhabitants can be implemented at early stages, while systems with low preparedness of inhabitants may be implemented at a later stage, after sufficient IEC campaign to raise preparedness to a sufficient level.

Table S. 24 Plan of Phased Implementation of 21 Systems

Step	Implementation period	Group	Kon Tum	Gia Lai	Dac Lac	Number
1	2002-2005	A	K2-3	G2, G3-1	D1, D2	5
2	2004-2006	B	K4-1	G1, G4-1	D3-1, D6	5
3	2005-2008	C	K3-1	G5-1, G6-1	D4-1	4
4	2007-2010	D	K1-1, K2-1	G7-1	D3-2, D4-2, D5-1, D7	7

Table S. 25 Implementation Schedule of 21 systems



In case of Kon Tum province, the systems of K2-3, K4-1 and K3-1 were listed to be implemented with step 1, step 2 and step 3 in order, by the request from PCERWASS, Kon Tum. Because these systems have less sustainability for financial and technical points, K2-3 system in step 1 has been combined with the ADB town water supply project. The K4-1 and K3-1 systems in step 2 and step 3 should be financed (WSU's staff salaries and emergency expenditures for their operation) by consolidated subsidy from the Vietnamese government.

7.3 Collaboration with ADB Project

Though the systems in Kon Tum province were considered to be unsuitable for immediate implementation, the K2-3 system was selected with conditions. The system shall be combined with the on-going ADB town water supply project that will be constructed in the year 2003. The treated water reservoir tank of the ADB project will be connected to the K2-3 system and a distribution system then installed to the area. The O&M methods, including decisions on water tariff, billing, collection of water charge and accounting will strictly follow the ADB town WSU's procedures. The joint operation of the town system and the K2-3 system will

continue until the full design capacity of the reservoir tank of the town water supply is reached. When the joint capacity of the reservoir tank is almost fully used, a decision will have to be made on whether to invest in additional capacity for the town system or to develop the K2-3 system independently. Transfer of knowledge and capacity building of PCERWASS in Kon Tum will be ensured through the ADB project (town water supply system) and the K3-1 pilot model. After reaching an adequate level of O&M, technology and financial management, the K3-1system can be implemented as shown in Table S.23.

7.4 Allocation of the Project Costs

The construction cost for the development of the 21 prioritised systems has been estimated for a service coverage of 86 % of the population in the targeted communes and provinces of the Central Highlands.

The project cost was estimated at US$ 13.7 million or equivalent VND 205.5 billion with foreign currency and local currency components of 13 % and 87 % respectively, excluding the procurement cost for drilling equipment.

The project cost is summarised in Table S.26 and meets the 4-step proposed implementation up to the year 2010 in line with the NRWSS strategy.

Table S. 26 Summary of Construction Cost

Phasing	Implementation Period	No. of System	Project Cost excluding procurement of equipment (US$ million including VAT)
Step 1	2002-2005	5	5.1
Step 2	2004-2006	5	3.0
Step 3	2005-2008	4	1.8
Step 4	2007-2010	7	3.8
Total		21	13.7

7.5 Procurement of Necessary Drilling Equipment

The drilling rigs and all equipment used for the study were old and were subject to many mechanical troubles. They have been used for more than 25 years and were donated by the former Soviet Union. Resuming work for well construction after core drilling took much time and effort. Although aquifers were found at approximate 200m depth in Gia Lai province, it was difficult to ream the full depth. The generator,

air compressor and electrical logging instruments are old, have small capacity, and are in extremely poor condition.

The Vietnamese authorities considered the equipment would be suitable for the required drilling work provided repairs were undertaken promptly and the equipment was well maintained. In order to improve their drilling work, procurement of a new set of drilling equipment should be considered for the implementation stage. The equipment can be effectively utilized by the Vietnamese authorities after the first implementation, particularly for the financially and economically disadvantaged areas.

8. Project Evaluation

The project was evaluated from several points of view.

8.1 Contribution to the National Strategy

National Strategy for water supply (NRWSS) set up a target that 85% of the total population should be supplied with water by the year of 2010 (Phase-1). The project was programmed in accordance with the national strategy. Implementation of the project will contribute to the achievement of the target.

8.2 Demonstration Effects as Model Projects

The NRWSS also set up a target that the 100 % of the population should be water supplied by the year of 2020 (Phase-2). Although the study did not include Phase-2 in the feasibility study, implementation of Phase-1 will have positive impacts on the neighbouring communes. It is expected that the project could encourage the neighbouring inhabitants to increase their motivation and to prepare themselves for water supply projects. This could lead to the implementation of Phase-2 projects, which would contribute the full achievement of the national strategy.

8.3 Technical Aspects

Wherever possible, simplified designs were adopted for the water supply facilities to minimise operation and maintenance requirements. Locally available materials were also applied wherever possible. Therefore, the design and concept can also be introduced not only to the second stage (Phase-2) but also to the other unrelated projects. It is considered that the design concept of the project will contribute the technical development of the country. New technology using solar power and related pump systems can be introduced to reduce the running cost for the systems in the poor communes and improve the environmental effect by using clean energy.

8.4 Operation and Maintenance Aspects

The Study proposed organisational arrangement and introduction of comprehensive IEC campaigns. Through the implementation of the arrangement, organisational activities at various levels will be stimulated, clear role distinctions will be

recognised and definite responsibility of personal can be realised. This positive effect is expected to spread to other fields of activities.

8.5 Environmental and Hygiene Aspects

In all three provinces, rather high ratios of water related diseases are reported. Implementation of the project will provide those inhabitants with clean water and contribute to a decrease in the population suffering from such diseases. In particular, infant mortality can be drastically reduced.

8.6 Social Equality (Help for Ethnic Minorities)

The special issues inherent to the Central Highlands of Vietnam are said to be poverty and minority. Servicing clean water to the poverty areas and minorities is one of the crucial matters for social stabilisation of the area. Equal allocation of natural resources such as water is essential from this point of view.

The issues of poverty and ethnic minorities were taken into account in the selection of the priority projects, and the social equity issues were duly considered;

- Out of the total 4989 poverty households, 74% (3691 households) will be covered by the priority projects selected by the Study in phase 1; and
- Out of the total 10,139 ethnic minority households, 71% (7,174 households) will be supplied by piped schemes in phase 1.

Implementation of the project will accelerate the establishment of a society where every level of population can enjoy equal opportunities.

8.7 Gender Issues

Presently drinking water is delivered from nearby water sources. In dry seasons, water sources are sometimes very far from individual household. Women and children are currently responsible for drawing water. The water drawing activities impose on them physically heavy work and occupy a significant amount of their time. The project will alleviate such heavy work from women and children and create spare time in which women can participate in social activities (such as IEC activity through women's union). Children can also devote more time to schooling.

The implementation of the project will greatly contribute to the gender aspects.

8.8 Total Evaluation

The project, because it is a water supply project for poverty and minority, is hardly justifiable from an economical and financial point of view. Financial subsidies will be required for sustainable operation and maintenance. The Government of Vietnam expresses their firm commitment to subsidies for poor communes when required.

Provided that the initial investment costs and governmental subsidies are available, various unpredictable positive effects are expected. Among those, increasing of the social equality to the poverty and minority, improvement of hygiene conditions, reducing of infant mortality and contributions to gender aspects are significant.

Implementation of the project will contribute to satisfy the basic human needs of the inhabitants of the Central Highlands of Vietnam.

9. Recommendations

9.1 IEC and Hygiene Campaign by Vietnamese Side

9.1.1 Basic Approach for IEC

Formal meetings and home visits will be used for IEC. At least one promoter should be appointed by PCERWASS in each commune/town to implement IEC activities for promotion of piped water supply.

9.1.2 Parties Responsible for IEC

The parties responsible for IEC include:

- CERWASS/PCERWASS;
- CPC/TPC;
- Promoters; and
- Health centres/village health workers

It is recommended that CERWASS/PCERWASS should consider financial arrangements for IEC. Staff should be appointed by PCERWASS to organize IEC campaigns in each province for promotion of house water connections. In each commune/town, a promoter should be appointed by PCERWASS or CPC/TPC. Necessary finance should be earmarked beforehand for this purpose.

Promoters will in fact be engaged in IEC activities at the commune/town level, in co-operation with health centres. Promoters must be respected by local people, be able to communicate in the local languages, and know the benefits of safe and clean water. PCERWASS should first explain the necessary activities to promoters through training. It is advisable that health workers and promoters be involved in activities together.

Health workers are responsible for improving the health of the local people, especially, people living in the remote villages.

9.1.3 Points for IEC Promoters

The points to be highlighted for promoters are summarized below:

1) **Timing of IEC** activities should start 4-5 months before the completion of

construction works,

2) They need to first contact the **health centre** (CHC) to get its cooperation,
3) **Simple and clear messages** will be most effective;
4) Soft, polite, and friendly **attitude** toward the local people is essential;
5) **A Formal meeting** is a starting point for IEC;
6) **Home visits** should follow the formal meeting;
7) **The necessary information** should be clearly identified and transferred to participants;
8) **Leaflets** and a simple questionnaire should be provided after the meeting and home visits; and
9) The **local radio network** and loudspeakers are also useful if available.

9.1.4 Necessary Information for IEC

The information that needs to be distributed includes the following:

1) **Objectives** of the town meeting;
2) The **master plan** including the drawings and its implementation schedule;
3) The results of the **water quality analysis** and the benefits of safe and clean water;
4) **Benefits** of safe and clean water should be emphasized using pictures and drawings;
5) **Costs** for house connections and the water charge;
6) **Responsibilities** of the local people; and
7) **Operation and maintenance of public taps**

9.2 Short-term Measures

It would be very important to have the WSUs properly established through general regulations adopted by the respective CPCs. The articles should include provisions on the institutional structure of the WSU, rights and responsibilities of the WSU, its staff members and clients, management of public taps, and the implications of violating regulations. The regulations would clarify the roles of various parties and authorize the WSU to take measures in case of non-payment and vandalism K3-1 would need closer follow-up and support than G2, but Kon Tum PCERWASS itself would need additional resources. There is no easy solution. The support should come from a high level of the government hierarchy.

Much of the necessary IEC could not be carried out in the short time prior to and during the construction of the schemes. There is a great need to continue IEC as an ongoing project.

9.3 Long-term Measures

One of the most important aspects of successful implementation will be to give time for the communes to be ready for the investment. In practice this can take place by phasing the implementation such that the first stage of physical implementation will commence in about five of the communes (those with the most potential). Simultaneously, extensive IEC activities will need to be carried out in the other communes to build their capacity to implement the project in later stages.

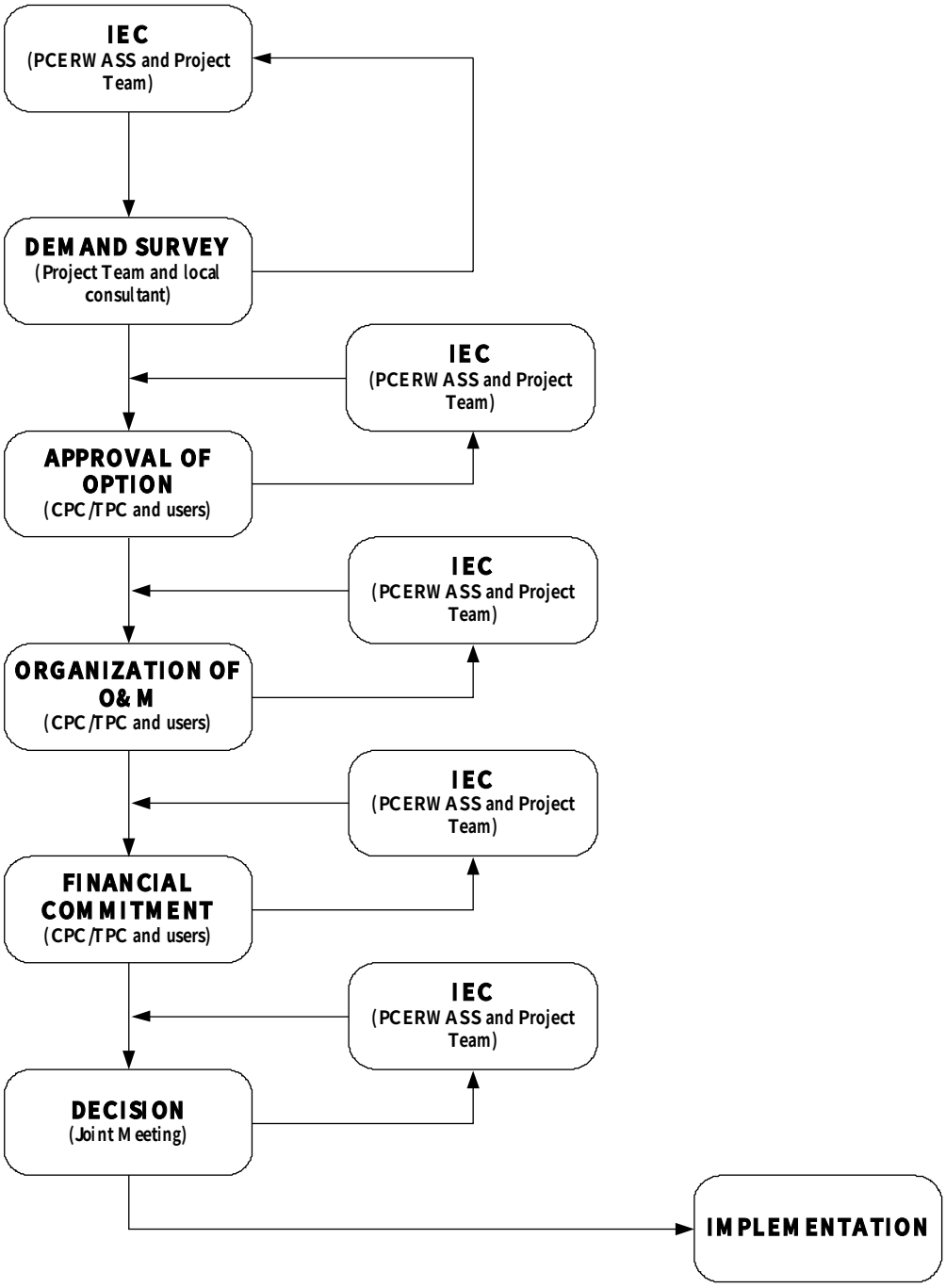


Figure S. 7 Flowchart of Community Sensitisation for Project Implementation

9.4 Preconditions for Construction

9.4.1 Central Level

Objectives:

- Adequate capacity of all relevant PCERWASS to assume responsibilities in accordance with NRWSS and the Project; and
- Assurance of timely and efficient IEC and support to be provided by PCERWASS.

Preconditions for decision on scheme construction:

- Prove capacity of PCERWASS to coordinate and support IEC, training, follow-up and long-term support;
- Secure budget allocations to relevant PCERWASS for IEC activities, training, follow-up and long -term support; and
- Appropriate IEC and training materials and management and O&M manuals made available by PCERWASS for distribution to Project communes

9.4.2 Provincial level

Objectives:

- Capacity to coordinate and support IEC; and
- Capacity to provide training (courses and on-the-job) to WSUs and board members, to follow-up their performance and provide them with long-term support.

Preconditions for the decision on scheme construction:

- Adoption of and commitment to NRWSS;
- Secured budget for IEC activities, training, follow-up and long-term support (from CERWASS/PCP); and
- Proven capacity to provide support to CPC/TPCs, and WSUs.

9.4.3 Commune Level

Objectives:

- Generation of demand for improved water supply (health, convenience, status,) through education and “social marketing”;
- Introduction of option(s) available, their impacts and related costs, rights and duties; and

- Introduction of Project concept: conditions, procedures, and contribution requirements

Preconditions for decision on scheme construction:

- Adequate demand for improved water supply: at least 35% of households to be willing (and able) to pay for water on a monthly basis that initially covers the cost of one cubic meter *per capita* per month at a tariff calculated to cover all costs in the long term;
- Acceptance of the option(s) provided by the Project: the location of facilities accepted by the community members, the service level and costs known and accepted by the users, and the decision on inclusion/exclusion of public taps made in consultation with the users;
- Management and operation of the system organized: WSU and its board established (the latter includes user representation), regulations adopted, rights and responsibilities of WSU and users defined and accepted by both parties, relevant documentation formats adopted, user groups of possible public taps established; and
- Measurable commitment to sustain the system[1]: households requiring connection to deposit at least 50% of the connection cost, user groups of public taps to have deposited at least 10% of the public tap cost, and CPC/TPC to have deposited sufficient amount to cover i) at least the salaries/wages of two WSU staff members for their participation in construction for the entire construction period, and ii) to cover the cost of necessary O&M tools.

9.5 Necessity of Subsidy from Government

Because of the rather unstable and difficult management of the small sized rural water supplies, it is recommended that support, by way of subsidy, be provided by the Vietnam government.

[1] On the other hand, the Project has to assure the community of the quality of the improved water supply. If the service level (including water quality) does not comply with what has been advertised, deposits shall be returned.

9.6 Sustainable Operation of Two Pilot Models

It is recommended that the two pilot models constructed by JICA study team should be properly and sustainably operated as a model case in the rural area in the central highlands and also as a model for the entire rural area of Vietnam.