Ministry of Water Resources and Meteorology,
Ministry of Agriculture, Forestry and Fisheries,
The Kingdom of Cambodia

THE STUDY
ON
COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN
IN
THE KINGDOM OF CAMBODIA

FINAL REPORT

Volume - III
Feasibility Study for Priority/Urgent Projects

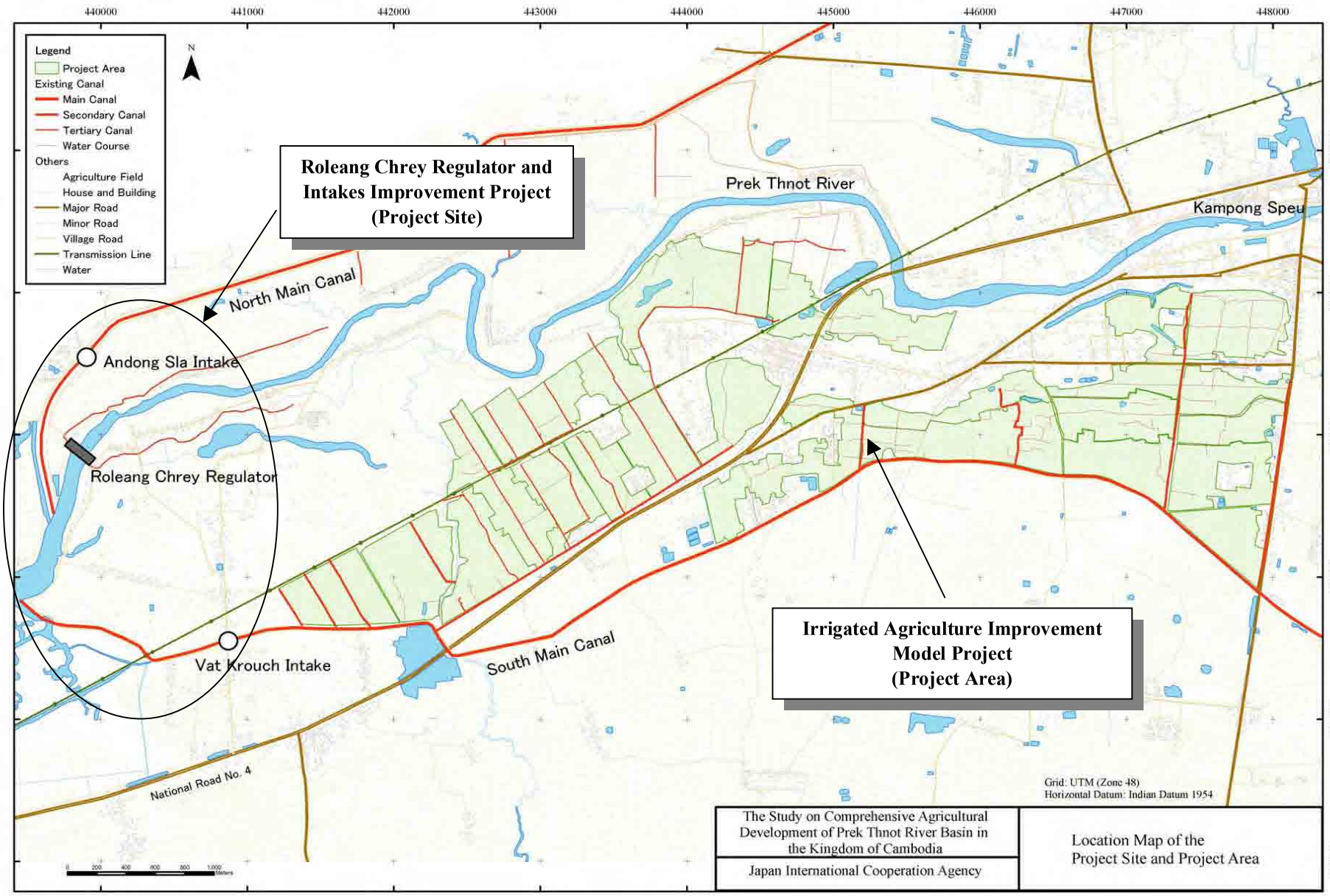
August 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

LIST OF VOLUMES

Volume-VII Appendixes for Feasibility Study for Priority/Urgent Projects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Legend
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Existing Canal
Main Canal
Secondary Canal
Tertiary Canal
Water Course
Others
Agriculture Field
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Japan International Cooperation Agency
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THE STUDY
ON
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OF
PREK THNOT RIVER BASIN
IN
THE KINGDOM OF CAMBODIA

FINAL REPORT
Volume-III: Feasibility Study for Priority/Urgent Projects

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PART-C: IRRIGATED AGRICULTURE IMPROVEMENT MODEL PROJECT

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Abbreviations

ACLEDA	Association of Cambodian Local Economic Development Agency
ADB	Asian Development Bank
AEA	Agro-Ecosystems Analysis
AEO	Agricultural Extension Offices
AEWs	Agricultural Extension Workers
AOG	Assemblies of God- Cambodia (NGO)
AusAID	Australian Agency for International Development
ASDP	Agriculture Sector Development Project
CAAEP	Cambodia Australia Agricultural Extension Project
CARDI	Cambodian Agricultural Research and Development Institute
CC	Commune Council
CDRI	Cambodia Development Research Institute
CDC	Council for Development of Cambodia
CEA	Cambodian Environment Association
CEC	Cation Exchange Capacity
CEDAC	Centre d'Etude de Development Agricole Cambodgien
CGA	Cambodia Global Action (NGO)
CIAP	Cambodian IRRI Australia Project
CMAC	Cambodia Mine Action Center
CNMC	Cambodian National Mekong Committee
CRS	Christian Relief Service
CWPD	Cambodian Women for Peace and Development (NGO)
DAALI	Department of Agronomy and Agricultural Land Improvement
DAFF	Department of Agriculture, Forestry and Fisheries, MAFF
DAE	Department of Agriculture Extension
DAO	District Agricultural Office
DAS	Days After Sowing
DAT	Days After Transplanting
DDFC	District Development Facility Committee
DTR	Department of Training and Research, MRD
ED	Engineering Department, MOWRAM
EDC	Electricite du Cambodge
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMC	Credit for Rural Area
EPP	Extension Program Package
EU	European Union
EXCOM	Executing Committee of SEILA
FAO	Food and Agriculture Organization of the United Nations
FAIEX	Fresh water Aquaculture Improvement & Extension Project
FFS	Farmer Field School
FLD	Farmer Livelihood Development
FO	Farmer Organization
F/S	Feasibility Study
FWUC	Farmer Water Users Community

FWUG	Farmer Water Users Group
GDP	Gross Domestic Product
GIS	Geographic Information System
GOC	Government of Cambodia
GOJ	Government of Japan
GPS	Global Positioning System
HYV	High Yielding Variety
IDA	International Development Association
IEE	Initial Environmental Examination
IFAD	International Fund for Agricultural Development
IPM	Integrated Pest and Crop Management
IRC	Inter-ministerial Resettlement Committee
ISF	Irrigation Service Fee
JICA	Japan International Cooperation Agency
MAFF	Ministry of Agriculture, Forestry, and Fisheries
MEF	Ministry of Economic and Finance
M&E	Ministry of Environment
MOWRAM	Ministry of Water Resources and Meteorology
M/P	Master Plan Study
MRD	Ministry of Rural Development
NPRS	National Poverty Reduction Strategy
NGO	Non-Government Organization
OJT	On the Job Training
O&M	Operation and Maintenance
PCM	Project Cycle Management
PDA	Provincial Department of Environment
PDOWRAM	Provincial Department of Water Resources and Meteorology, MOWRAM
PIMD	Participatory Irrigation Management and Development
PRA	Participatory Rural Appraisal
PRASAC	Support Program for the Agricultural Sector in Cambodia
RGC	Royal Government of Cambodia
RHAC	Reproductive Health Association of Cambodia (NGO)
RRA	Rapid Rural Appraisal
SEILA	Foundation Stone in Khmer: This word is used as national rural development program to 1- alleviate poverty and 2- Strengthen local governance and ownership of local government.
SLPP	Small holder Livestock Production Program
SRI	System of Rice Intensification
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TOT	Training of Trainers
UNICEF	United Nations Children's Fund
VDC	Village Development Committee
WB	World Bank
WFP	World Food Program
WPPIDCP	Western Phnom Penh Integrate Development Center Project
WUG	Water User Group

DOM	Department of Meteorology
DHRW	Department of Hydrology and River Works
TSC	Technical Service Center

Khmer Words Used in the Report

Khet	Province
Srok	District
Khum	Commune
Phum	Village
Krom	Group or Sub-Group
Krom Samak	Solidarity Group
Provasdai	Mutual Help

Measurement Units

Extent

cm^2 = Square-centimeters (1.0 cm x 1.0 cm)
m^2 = Square-meters (1.0 m x 1.0 m)

km^2 = Square-kilometers (1.0 km x 1.0 km)
a = Are(100 m^2 or 0.01 ha.)

ha = Hectares (10,000 m^2)
ac = Acres (4,046.8 m^2 or 0.40468 ha.)

Volume

cm^3 = Cubic-centimeters (1.0 cm x 1.0 cm x 1.0 cm or 1.0 m-lit.)
m^3 = Cubic-meters (1.0 m x 1.0 m x 1.0 m or 1.0 k-lit.)
lit l = Liter (1,000 cm^3)
MCM = Million Cubic Meter

Length

mm = Millimeters
cm = Centimeters (cm = 10 mm)
m = Meters (m = 100 cm)
km = Kilometers (km = 1,000 m)

Weight

gr = Grams
kg = Kilograms (1,000 gr.)
ton = Metric ton (1,000 kg)

Power and Energy

A = Ampere
V = Volt
W = Watt
kWh = Kilowatt hour
HP = Horse power

Others

ppm = parts per million
°C = degree centigrade
% = percent

Currency

US$ 1.0 = Riel 4060
(Official Midpoint Exchange Rate as of January, 2007)
US$ = United State Dollars
¥ = Japanese Yen
R, Riel = Cambodian Riel

Time

sec = Seconds
min = Minutes (60 sec.)
hr = Hours (60 min.)

PART-A
GENERAL INFORMATION

Roleang Chrey Regulator

PART-A: GENERAL INFORMATION

Chapter A-1 Introduction

A-1.1 Authority

This Volume-III: Feasibility Study for Priority/Urgent Projects is a part of final report which was prepared in accordance with the Scope of Work for the Study on Comprehensive Agricultural Development of Prek Thnot River Basin agreed between the Ministry of Water Resources and Meteorology, the Kingdom of Cambodia (MOWRAM) and the Japan International Cooperation Agency (JICA) on April 11, 2005.

A-1.2 Composition of Final Report

The final report consists of the following volumes:

- Volume-I: Summary
- Volume-II: Master Plan
- Volume-III: Feasibility Study for Priority/Urgent Projects
- Volume-IV: Pilot Projects
- Volume-V: Hydrological Study and Environmental Management Basic Capacity Strengthening
- Volume-VI: Appendixes for Master Plan
- Volume-VII: Appendixes for Feasibility Study for Priority/Urgent Projects

This Volume-III: Feasibility Study for Priority/Urgent Projects presents the results of feasibility study conducted from July 2006 to February 2007.

A-1.3 Background

A-1.3.1 Master Plan Study

The basin of the Prek Thnot River, which flows around Phnom Penh, is one of the major paddy cultivation areas in Cambodia. However, agriculture in this basin, as well as in other areas, necessarily depends on erratic rainfall due to a limited irrigation system. This results in low and unstable crop production with some farmers in the basin not even able to cover their own consumption of rice. In the rainy season, the basin also suffers from floods overtopping the Prek Thnot River almost every year. To seek a way to improve such situation, the master plan Study Phase 1 was carried out for the Target Area (about 110,000 ha) in the basin from July 28, 2005 to February 28, 2006.

Based on the survey and study results, the "*Improvement of Agricultural Productivity Centering on Rice*" was selected as the strategic target of the master plan. And to achieve this target, the "*Program Approach*" was elaborated in a concept of "*Well-harmonized Development of Irrigation and Drainage, Agriculture and Institutions*". There are 13 Scheme-wise Improvement Approach programs and 14 Subject-wise Improvement Approach programs as shown below:

Scheme-wise Improvement		
	Zone Based Projects (Zone-1),	
1	A.1(1)	Irrigated Agriculture Improvement Model Project
2	A.1(2)	Upper North Main Canal Irrigated Agriculture Improvement Project
3	A.1(3)	Upper South Main Canal Irrigated Agriculture Improvement Project
	Zone Based Projects (Zone-2)	
4	A.2(1)	Lower North Main Canal Irrigated Agriculture Improvement Project
5	A.2(2)	Lower South Main Canal Irrigated Agriculture Improvement Project

6	A.2(3)	Ou Krang Ambel Irrigated Agriculture Improvement Project
	Zone Based Project (Zone-3)	
7	A.3(1)	Water Harvesting Irrigated Agriculture Improvement Project
	Zone Based Project (Zone-4)	
8	A.4(1)	Rainfed Agriculture Improvement Project
	Zone Crosscutting Projects	
9	B.1(1)	Roleang Chrey Regulator Gates Urgent Improvement Project
10	B.1(2)	Roleang Chrey Regulator and Intakes Improvement Project
11	B.2(1)	Veterinary Services Strengthening and Livestock Raising Improvement Project
12	B.3(1)	Community Inland Fisheries Development Project
13	B.4(1)	Income Generation Projects for Marginal Farmers
Subject-wise Improvement		
14	C.1(1)	Coordination between MOWRAM and MAFF Strengthening Project
15	C.1(2)	Provincial Departments Strengthening Project
16	C.2(1)	Livestock Sub-sector Development Study
17	C.3(1)	Technical Guidelines Preparation Project
18	C.4(1)	Environmental Management Basic Capacity Development Project
19	C.4(2)	Environmental Management Applied Capacity Development Project
20	C.5(1)	Irrigated Agriculture On-Farm Technology Improvement Pilot Project
21	C.6(1)	Irrigation Facility Maintenance Capacity Strengthening Pilot Project
22	C.7(1)	Rainfed Agriculture Improvement Pilot Project
23	C.8(1)	Community Inland Fisheries Development Pilot Project
24	C.9(1)	River Basin Effective Water Use Awareness Raising Project
25	C.10(1)	Institutional and agricultural Support Services Strengthening Project
26	C.11(1)	Hydrological Observation Strengthening Project
27	C.11(2)	Flood Forecasting and Warning Study

The master plan Study recognized that its implementation would contribute to self-sufficiency in rice production in the Target Area and to increase the farm income to about 1.5 to 2.0 times the present income. It was thus recommended that the master plan should be implemented as early as possible.

A-1.3.2 Selected Priority/Urgent Projects for Feasibility Study

The objective of the Feasibility Study is to delineate appropriate development plans for the priority/urgent projects from technically appropriate, economically sound, sociologically suitable and environmentally friendly viewpoints, keeping urgent implementation of the master plan and early realization of project benefits in mind. The priority/urgent projects should thus contain the crucial factors for successful implementation of the master plan. Eventually, the following projects were selected from the 9 projects proposed in the Scheme-wise Improvement Approach:

- Roleang Chrey Regulator and Intakes Improvement Project
- Irrigated Agriculture Improvement Model Project

A-1.4 Hydrological Relationship between Two Selected Priority/Urgent Projects

Roleang Chrey Regulator and Intakes are situated in the upper-most portion of the Prek Thnot River in the Target Area, and they are key structures for all connected irrigation projects including the Irrigated Agriculture Improvement Model Project. In other words, the Irrigated Agriculture Improvement Model Project, as well as other connected irrigation projects, requires the improvement of Roleang Chrey Regulator and Intakes as the precondition for its own improvement.

A-1.5 Public Consultation Meeting

On February 1, 2007, a public consultation meeting was held at Wat Chamma in Kampong Speu Province. The meeting was begun with an explanation of the pilot projects and then the Feasibility Study for Roleang Chrey Regulator and Intake Improvement Project and Irrigated Agriculture Improvement Model Project since findings obtained in the pilot projects are to be incorporated into the Feasibility Study.

Public Consultation Meeting

The meeting was attended by 60 persons including staff of MOWRAM, MAFF, PDOWRAM and PDA, members of Ou Veang and Phoum Roum Rpung FWUCs, and Commune Chiefs. After explanation of the development plans for the two projects, as well as the activities of the pilot projects by PDOWRAM, PDA, CEDAC and the JICA study team, discussions were held by dividing participants into 3 groups, to give more participants a chance to speak. As a result, the proposed development plans are in principle accepted by them. In particular, they are concerned with the following matters:

Major Concerns Raised in the Meeting

Field	Major Matters of Concern
(a) Agriculture	- Transplanting in rows
	- Application of compost
(b) Irrigation and Drainage	- Water distribution
	- Budget for O&M of canal and structures
	- Contribution of lands for Tertiary Canals and watercourses
(c) FWUC strengthening	- Collection of irrigation service fees
	- Inadequate participation in FWUC activities

In the feasibility study, these matters are to be studied, and the results incorporated into the development plan.

A-1.6 Technology Transfer

The counterpart personnel assigned for the Feasibility Study were as follows:

Counterpart Personnel Assigned

Study Team	Position	Counterpart Personnel
Mr. H. Shimazaki	Team Leader/Agriculture Development Plan	Mr. Pich Veasna[1/]
		Mr. Chhear Bunrith
Mr. J. Tsurui	Irrigation & Drainage Plan/Water Management (2)	Mr. Khieu Visith
Mr. T. Shiraki	Agronomy	Mr. Am Phirum
	Extension Services	Mr. Khean Sovannara
	Marketing	Mr. Thong Aun
Mr. T. Imai	Hydrology/Flood Forecast and Warning (1)	Mr. Long Saravuth
Ms. A. Ishikawa	Socio-economy	Mr. Soun Sam Aun
		Mr. Chea Sivuta
Mr. T. Sugiyama	Project Evaluation	Mr. Sarun Sambath
Ms. S. Suwa	Environment	Mr. Koch Savath
		Mr.Tith Bone

Study Team	Position	Counterpart Personnel
		Ms.Pheng Sophada
Mr. S. Yakushiji	Facility Plan/Design. Cost Estimate	Mr. Koeut Kitimeath
Mr. R. Shimoda	Gate Facility/Operation	Mr. Ung Phaly
		Mr. Phiv Phalkun

1 : Chief Counterpart Personnel

Technology transfer for them has been carried out mainly by means of “On-the-Job training” and explanation of the corresponding parts of the reports.

Chapter A-2 Background

A-2.1 Natural and Socio-economic Conditions

National and socio-economic conditions related to the Roleang chrey Regulatopr and Intakes Improvement Project and Irrigated Agriculture Improvement Model Project are given in Section 2.1, Chapter 2, Volume-II master plan.

A-2.2 National Development Policies

As the related national development policies, there are the National Strategic Development Plan 2006-2010, Rectangular Strategy for Growth, Employment, Equity and Efficiency, and National Water Resources Policy (NWRP). These policies are explained in Section 2.2, Chapter 2, Volume-II master plan.

A-2.3 Sectoral Development Policies

The sectoral development policies to be considered for the feasibility study for priority/urgent projects are the Agriculture Development Plan for the Long, Medium and Short Terms 2001-2010, Action Program for Development of the Agricultural Sector 2001-2010, Strategic Development Plan for the Water Sector 2006-2010, and Policy for Sustainability of Operation and Maintenance of Irrigation Systems. These sectoral development policies are given in Section 2.3, Chapter 2, Volume-II master plan.

Tables

Table A-2.1 Socio-economic Indicators of Cambodia

1	GDP in Riel (Billion: 2005)	21,812	1)
	GDP in US$ (Million: 2005)	5,330	1)
	GDP Growth Rate (2000-2005 average)	9.1%	
2	GDP per Capita in US$ (2005)	385	1)
	GDP per Capita Growth Rate (2005)	9.0%	
3	GDP by Sector (2005)		
	Agriculture	31.4%	1)
	Industry	27.0%	1)
	Service	36.2%	1)
4	Balance of Trade (2005)		
	Export (US$ Million)	2,910	
	Import (US$ Million)	4,254	
5	Population		
	National (2006)	14.0 Million	2)
	Phnom Penh (2005)	1,313,851	2)
	Kampong Speu Province (2005)	729,552	2)
	Kandal Province (2005)	1,242,506	2)
6	Population Density (persons/km2)		
	National (2006)	82	2)
	Phnom Penh (2006)	4,969	2)
	Kampong Speu Province (2006)	110	2)
	Kandal Province (2006)	374	2)
7	Population Growth (2005)	1.9%	3)
8	Population Below Poverty Line (2004)	34.7%	
9	Total Number of Households (2005)		
	National (1998)	2,188,663	
	Phnom Penh (1998)	173,678	
	Kampong Speu Province (1998)	115,728	
	Kandal Province (1998)	206,189	
10	Inflation Rate (2005)	6.7%	
11	Unemployment Rate (2003-2004)	0.8%	4)
12	Exchange Rate to US$		
	2003	3,980	
	2004	4,023	
	2005	4,095	

Source: Statistical Yearbook 2006, National Institute of Statistic, Ministry of Planning

1) Preliminary estimates, at constant 2000 price

2) Projection based on 1998 General Population Census of Cambodia and 2004 Cambodian Intercensal Population Survey

3) Medium case projection (high case 2.06 and low case 1.75)

4) Labor force participation rate gaed 10 years and above is 74.6%

PART-B

ROLEANG CHREY REGULATOR AND INTAKES IMPROVEMENT PROJECT

Roleang Chrey Regulator, Andong Sla Intake Structure(Left side Photo) and Vat Krouch Intake Structure(Right side Photo)

PART-B: ROLEANG CHREY REGULATOR AND INTAKES IMPROVEMENT PROJECT

Chapter B-1 The Project Site

B-1.1 Location and Administration

(1) Location

The Roleang Chrey Regulator is located on the Prek Thnot River, about 100 km upstream from its confluence with the Bassac River. The Andong Sla and Vat Krouch Intakes are respectively provided at the heads of the North Main Canal and South Main Canal branched off from the Prek Thnot River upstream from the Roleang Chrey Regulator.

(2) Administration

The Roleang Chrey Regulator is located in Tumpung Village, Kahaeng Commune, Samraong Tong District, Kampong Speu Province.

B-1.2 Topography and Geology

The right bank of the Roleang Chrey Regulator is at an elevation of 39.651m. The longitudinal survey shows that the longitudinal slope of the upstream of Prek Thnot River where the Roleang Chrey Regulator is located midway, is 1/2,720, which is slightly steeper than the 1/3,000 average from the confluence with the Bassac River to Peam Khley (113,400 m in distance).

According to the tender drawings for Roleang Chrey Regulator which were prepared in 1968, it was constructed on fresh tuff after removal of the weathered tuff. In fact, it is observed that the tuff crops out after the downstream apron of the Roleang Chrey Regulator. The fresh tuff has sufficient bearing capacity to act as a foundation for the Roleang Chrey Regulator.

B-1.3 Hydrology

B-1.3.1 Prek Thnot River Condition

The Prek Thnot River flows between southeast and east from the Elephan mountain region, which is its origin. The elevation of the Prek Thnot River basin is El. 1,543 m above mean sea level. The Prek Thnot River system consists of 11 sub-basins. The area of each sub-basin is shown in the table to the right. According to the longitudinal survey from the Peam Khley, about 15 km upstream from the Roleang Chrey Regulator to the confluence with the Bassac River, slope of the Prek Thnot River ranges from 1/2,720 for the upstream reaches to 1/5,100 for the downstream reaches. The non-uniform calculation based on the results of the longitudinal survey, shows the following discharge carrying capacity of the Prek Thnot River:

Area of Sub-basin

Sub-basin	Area (km^2)
Trang Krang	294
Ta Sal	674
Aveaeng	431
Phleah	235
Aoral	502
Krang Ambel	455
Tang Haong	1,435
Anlong Ramlich	228
Bat Kmeng	300
Kandal	78
Residual	18
Total	4,650

Discharge Carrying Capacity of Prek Thnot River

Chainage (m)	Discharge Carrying Capacity
0 – Kandal Steung Weir (33,446)	200 m^3/s – 500 m^3/s
Kandal Steung Weir – 50,000	300 m^3/s – 800 m^3/s
50,000 – Krang Ambel River (73,587)	500 m^3/s – 800 m^3/s
73,587 – Thnuous Luong Station (90,038)	800 m^3/s – 1200 m^3/s
Thnuous Luong Station – Roleang Chrey Regulator (98,431)	1200 m^3/s – 1300 m^3/s
Roleang Chrey Regulator – Peam Khley (113,411)	1300 m^3/s – 1500 m^3/s

B-1.3.2 Water Level and Discharge Measurement

In 2005, the following water level gauging stations and discharge measurement stations were established:

Water Level Gauging Stations and Discharge Measurement Stations

No.	Station	Equipment	District/village	Water Level	Discharge
1	Peam Khley Bridge	Logger & SG	Phnom Sruoch	○	○
2	Thnuos Luong	Logger & SG	Chabar Mon	○	○
3	Krang Chek	Logger & SG	Phnom Sruoch	○	○
4	Cheneang Kpuos	Logger & SG	Phnom Sruoch	○	○
5	Sangkea Tasal	Logger & SG	Aoral	○	○
6	Trapeang Kyon	Logger & SG	Samrongtong	○	-
7	Roleang Chrey	SG	Samrongtong	○	○
8	Prey Mean	SG	Aoral	○	-

The observed discharge and water level data are shown in Table B-1.1.1. The discharge rating curves at those stations are given as well.

B-1.3.3 Floods

The past annual peak discharges of the Prek Thnot River are estimated as follows:

Past Annual Peak Discharge of Prek Thnot River

Year	Peak Discharge at Roleang Chrey	Peak Discharge at Peam Kley
1991	1,369 m^3/s	
1996		801 m^3/s
1997		826 m^3/s
1998		507 m^3/s
1999		798 m^3/s
2000	1,276 m^3/s	1,276 m^3/s
2001		788 m^3/s
2002		
2003		974 m^3/s
2004		
2005		
2006	1,192 m^3/s	

According to the operator of the Roleang Chrey Regulator, the flood peak in 1991 was the maximum in his career as the gate caretaker since 1969. Accordingly the flood peak discharge in 1991 was the maximum in the most recent 38 years. This means that the probable flood peak discharge of the Prek Thnot River would be around 1400 m^3/s for the probability of about 1/40 even though this may need to be studied more in the future since the caretaker did not work as the caretaker in the period of 1975 to 1978 due to the social and political situations in Cambodia.

On the other hand, the discharge carrying capacity of the Prek Thnot River in the upstream reaches of the Roleang Chrey Regulator site is estimated at 1300 m^3/s ~ 1500 m^3/s as discussed in Sub-section B-1.3.1. This corresponds to the past flood peak discharge of the Prek Thnot River at the Roleang Chrey Regulator site, which was 1369 m^3/s.

The available flood peak discharge data of the Prek Thnot River in the past is too limited to conduct a reliable numerical probability analysis for return periods of more than 20 years.

Accordingly, the probable flood peak discharge to be used as the design discharge of the headworks, which is generally equivalent to 1/50 probability, would be between 1300 m^3/s and 1500 m^3/s, or between 1400 m^3/s and 1600 m^3/s from a conservative view point on the condition that any river improvement works in the upstream reaches of the weir site would not increase the river discharge carrying capacity of the said reaches. Details are given in Appendix-IIA.

B-1.4 Roleang Chrey Regulator

B-1.4.1 Civil Works

The Roleang Chrey Regulator was constructed in 1974.

The retaining wall located on upstream side of the Roleang Chrey Regulator does not show any problems and thus is in stable condition as far as site inspection can show.

The gate piers, operation deck and bridge are in sound condition, and no rehabilitation is required.

The present, the downstream apron itself is in good condition; however its length is too short because the Roleang Chrey Regulator was designed under the condition that the Prek Thnot Multipurpose Dam was going to be constructed. The study shows that the length of the downstream apron would only stand against around a 5 year flood. In fact, the topographic survey shows that the riverbed after the downstream apron is eroded about 2 m in depth. Thus, countermeasures to combat this erosion should be considered although geological borings are essential at the detailed design stage to confirm the foundation condition.

The side slope protection on the downstream side is severely damaged on both the left side and the right side. In connection with the riverbed protection for the eroded portion, this side slope protection should be rehabilitated.

As mentioned above, the gates could not be operated in a manner that would permit only a small release discharge to the downstream reaches. To ensure such release discharge, especially in the dry season, appropriate countermeasures should be examined from technical and economical viewpoints.

B-1.4.2 Hydro-mechanical Works

The Roleang Chrey Regulator is a key structure for irrigated agricultural development in the Target Area. It is presently observed that some portions are deteriorated rather than damaged. In particular, the gates which are indispensable for proper water abstraction and flood control are in such a crucially severe condition that they do not function appropriately.

(1) General Information

General Information on hydro-mechanical Works for Roleang Chrey Regulator

Items	General Information
(a) Type	Fixed wheel gate
(b) Number	5
(c) Clear span	12.5 m
(d) Height	6.7 m
(e) Hoist	Electric driven, wire rope winding, one motor two drum, with counter weight

(2) Present Conditions and Findings

Through site inspection and review of the detailed drawings for the Roleang Chrey Regulator, the present conditions and findings are as follows:

Present Conditions and Findings

Place	Present Conditions and Findings
(a) Gate Leaves	- Almost none of the main wheels can rotate due to high resistance caused by rusting of the shafts. - Many water leaks are observed due to aging and cracks in the rubber seal. - The paint on the gate leaves peels off. - The four wheels installed in a side girder could not rotate smoothly, so that gate movement is obstructed.
(b) Guide Frame	- The guide frame is sound, and no problems were found.
(c) Hoist	- Electric motors, speed reducers, counter shafts and winding drums are still in working condition. - None of the brakes, position indicators or limit switches function at all. - The hoist wire ropes are still in service.

In addition, it was found that release of a small discharge to the downstream reaches could not be mechanically ensured by the present gates because of their large size. Thus, countermeasures to permit release of only a small discharge for some irrigation projects such as Kandal Stung Irrigation Project, Dangkor Pump Irrigation Project and Tonle Bati Irrigation Project, should be considered.

Downstream View of Gate
Roleang Chrey Regulator

B-1.5 Andong Sla Intake and Approach Channel

B-1.5.1 Civil Works

According to the hydraulic calculation based on the topographic survey, the approach channel has enough capacity to carry the design discharge mentioned later, and also, it does not show severe erosion at its side slope.

The intake structure, gate piers, operation deck and bridge are not envisaged to have any structural problems. However, the downstream portion of the intake is severely eroded and rehabilitation is absolutely needed. As mentioned above, the gates do not function properly, so the intake structure would need to be totally replaced with a new one according to the selected gate type.

The existing intake structure creates excessive head loss due to the four sealing edges of the gate, which results in one of the constraints for introduction of gravity irrigation.

B-1.5.2 Hydro-mechanical Works

The Andong Sla Intake was constructed in 1974 together with the Roleang Chrey Regulator. The general information of it is given below:

(1) General Information

General Information on Hydro-mechanical Works for Andong Sla Intake

Items	General Information
(a) Type	Steel radial gate, four sealing edges
(b) Number	4
(c) Clear span	4.0 m
(d) Height	2.7 m
(e) Hoist	Electric driven, wire rope winding, one motor two drums

(2) Present Condition and Findings

Through site inspection and review of the detailed drawings for the Andong Sla Intake, the present condition has been determined and some problems were found as follows:

Present Condition and Findings

Place	Present Condition and Findings
(a) Gate Leaves	- No serious corrosion was found on the gate leaves. - Much water is leaking through seals and wire rope holes of the gate leaf.
(b) Guide Frame	- No serious corrosion was observed on the gate leaves.
(c) Hoist	- The hoisting wire ropes are damaged. - The transmission line cables are missing.

As can be seen in the above table, no serious problems were found for the gate leaves or guide frame except for the hoist. However, this steel radial gate has original structural weak points as follows.

- The gate leaf is extremely slender which results in structural instability.
- Almost all the structural members are usually submerged in backwater or in wet condition due to leaking water, and the corrosion will get worse, which would lead to instability of the gate leaf.
- Proper maintenance is impossible because it is always submerged
- Good sealing would be structurally very difficult for this radial gate even if the seal rubber was not damaged.

Leakage through Gate Top Seal
Andong Sla Intake

B-1.6 Vat Krouch Intake and Approach Channel

B-1.6.1 Civil Works

The approach channel from the Prek Thnot River to the Vat Krouch Intake is unlined and does not have adequate sectional area to flow the design discharge which is discussed later. No serious erosion is seen at the side slope of channel.

The Vat Krouch Intake is structurally stable, but the downstream portion is severely eroded.

Since the Vat Krouch Intake is equipped with one steel radial gate of four sealing edges, head loss is large, which is one of the constraints for introduction of gravity irrigation.

B-1.6.2 Hydro-mechanical Works

The Vat Krouch Intake was constructed in 2002. Its general information is given below:

(1) General Information

General Information on hydro-mechanical Works for Vat Krouch Intake

Items	General Information
(a) Type	Steel radial gate, four sealing edges
(b) Number	1
(c) Clear span	4.00 m
(d) Height	2.54 m
(e) Hoist	Manually operated wire rope hoist

(2) Present Condition and Findings

Through site inspection for the Vat Krouch Intake, the present condition has been

determined and some problems were found as follows:

Present Condition and Findings

Place	Present Conditions and Findings
(a) Gate Leaves	- No corrosion was observed although the paint is damaged. - No water leakage was observed.
(b) Guide Frame	- The guide frame is sound.
(c) Hoist	- The wire ropes are damaged, and steel wire is being used temporally.

B-1.7 O&M

Kampong Speu PDOWRAM is in charge of the O&M for gates and accessories for the Roleang Chery Regulator, Andong Sla Intake and Vat Krouch Intake. But, O&M has not been properly conducted by the PDOWRAM mainly due to financial constraints. There is not even an O&M manual available now.

(1) Operation

As for gate operation for Roleang Chrey Regulator, in general, a small opening of the gate for a long period is not allowed due to the high possibility of damage by vibration. The operator does not know such operation rule at all. Generally, gates for the regulator are kept closed except at flood time when it is opened in reaction to observing the upstream water level in front of the gates and also information on the water level at Peam Khley. The gate is opened when the upstream water level exceeds EL 35.7m for flood control. This is the sole rule for gate operation for Roleang Chrey Regulator.

On the other hand, gate operation of Andong Sla Intake and Vat Krouch Intake is carried out on a demand basis, but not based on the irrigation service plan.

(2) Maintenance

Hardly any regular maintenance is being carried out for Roleang Chrey Regulator, Andong Sla Intake or Vat Krouch Intake by the Kampong Speu PDOWRAM. Emergency repairs such as replacement of wire are not made permanently but temporally. In particular, severe erosion around the structures has not been repaired at all. Such erosion is therefore progressing now.

In 2006, replacement of wire ropes connecting to the counter-weights and installation of a diesel generator for Roleang Chrey Regulator were completed under financial assistance of JICA. In addition, minor repairs such as replacement of a magnetic conductor and switch, were conducted using its own budget.

B-1.8 Environment

B-1.8.1 Social Environment

(1) People/ Community

Characteristics of the people and communities in and around the Project Site are summarized below.

Characteristics of the People and Communities in and around the Project Site

Items	Contents
Population	The Project Site is located in Andong Sla Village of Tang Krouch commune, Kahaeng village and Roleang Chrey village of Kahaeng commune. The population of these villages was 1,547 in 2005 according to SEILA Commune Data Base, 2005. The working population, which means the population between 15 and 65 years old, was 861. The annual growth rate has not changed much for the past few years.
Ethnic Group and Religion	The majority ethnic group is Kumer and most of them are Buddhist. Pagodas as religious facilities for Buddhists have spread within their life space.

Items	Contents
Education	Illiterate people over 15 yeas old account for 1.5% for men and 3.5% for woman. Almost 100% of the children go to school.

(2) Land Use

Within 1km of the Project Site, paddy fields account for about 20% of the land, while grass and shrubs cover 50%. Resettlement area occupies about 20%.

(3) Public Facilities/Services

(a) Water Usage for Domestic purposes

In terms of domestic water sources in the three villages in the Project Site, 41% of households rely on pond, river and rain water. A total of 33% use private facilities such as piped water and private pump wells and the remaining 26% use communal facilities.

Domestic Water Sources in the Three Villages in the Project Site

Commune	Village	No. of Families			
		Piped water, private pump wells, private ring wells, usable year round, less than 150m.	Communal taps, pump well ring wells, usable year around, within 150m	Most common source of water for other families (pond, river, rain water, other)	Total
Tang krouch	Andong Sla	11	60	50	121
Kahaeng	Roleang Chrey	50	20	20	90
	Kahaeng	40	0	53	93
Total (%)		101 (33%)	80 (26%)	123 (41%)	304

Source: SEILA Commune Data Base 2005

(b) Use of Bridge

The Roleang Chrey Regulator maintenance bridge is the only bridge across the Prek Thnot River near the project site. According to the gate operator of Roleang Chrey Regulator, around 450-660 people per day cross the bridge for school, jobs, shopping and so on as shown below.

Construction work caused to passage limitation

People	Purpose	Average number per day	Period of time to cross the bridge (popular time)
Children	Go to school	200-300	6:30-10:30, 11:00
Ordinary people	-	200-300	5:00-6:00, 10:30-11:00, 16:00-17:00, 18:00-20:00
Housewives	Go to market	50-60	7:00-8:00, 11:00-12:00
Total	-	450-660	

Source: Interview with the gate operator of Roleang Chrey Regulator, 2007

(4) Agricultural Activity

Most of the people living in the three villages where the Project Site is located are farmers. As shown below, around 90% of farmers own irrigated rice field and cattle/buffalo.

Agricultural Activity

Commune	Village	No. of Families			
		Total	Irrigated Rice Field	Cattle/Buffalo	Pigs
Tang krouch	Andong Sla	121	98 (81%)	121 (100%)	98 (65%)
Kahaeng	Roleang Chrey	90	80 (89%)	63 (70%)	27 (30%)
	Kahaeng	93	91 (98%)	91 (98%)	71 (76%)
Total		304	269 (88%)	275 (91%)	196 (65%)

Source: SEILA Commune Data Base 2005

B-1.8.2 Natural Environment

(1) Forest and Wildlife

As described above, there is no major forest area near the Project Site. A total of 50% is covered by grass and shrub land, where most people collect firewood for cooking fuel. Some shrub land extends along the Prek Thnot River as shown in the picture on the right.

Downstream of Roleang Chrey Regulator

Though there is no specific data or records, as far as the site inspection was able to determine, bio-diversity would be poor in and around the Project Site because of its limited habitat.

(2) Fish and their habitat

Major water resources as fish habitat around the Project Site are Prek Thnot River and irrigation canals. According to the local people, there were many fishes both in the rainy and dry seasons in the past; however the amount and variety of fish are decreasing presently. The one reason was pointed out by the local people that people started using electric fishing gear, which has wiped out the fish. In addition, exotic species discharged are changing the aquatic diversity.

According to knowledgeable people, including those from the Department of Fishery, MAFF, the following spices of fish exist in the Prek Thnot River.

Existing Fish in the Prek Thnot River

	Khmer Name	English name	Scientific Name	indigenous/exotic
1	Tilapia	Nile tilapia	*Oreochromis niloticus*	Exotic
2	Kranh Srai	Climbing perch	*Anabas testudineus*	Indigenous
3	Phtuok/Rous	Snakehead	*Channa striata*	Indigenous
4	Trey Andaing Roueng	Walking catfish	*Clarias batrachus*	Indigenous
5	Andaing Tonle	Gray eel-catfish	*Plotosus canius*	Indigenous
6	Kanhtor	Snake-skin gourami	*Trichogaster pectoralis*	Indigenous
7	Chhpin	--	*Hypsibarbus pierrei*	Indigenous
8	Trey Raw	Snakehead murrel	*Channa striata*	Indigenous
9	Trey chhpin	Silver barb	*Barbodes gonionotus*	Indigenous
10	Trey chhlonh chhnoht	Peacock eel	*Macrognathussiamensis*	Indigenous
11	Trey krormorm	Butter catfish	*Ompok bimaculatus*	Indigenous
12	Carp sor	Silver carp	*Hypophthalmichthys molitrix*	Exotic
13	Carp samanh	Common carp	*Cyprinus carpio*	Exotic
14	Kulriang	Giant barb	*Catlocapio siamensis*	Exotic
15	Klia	Finescale tigerfish	*Datnioides microlepis*	Indigenous
16	Crobey	Crocodile catfish	*Bagarius suchus*	Indigenous

Source; Interview with the Provincial Office of Fishery, PDE of Kampong Speu Province, the local people, 2006

B-1.8. 3 Pollution

(1) Water Quality/ Pollution

There are no analyzable data on water quality of the Prek Thnot River in and around the Project Site. The nearest are those from Kampong Toul in the Kandal Province more than 70km downstream. PDOWRAM had monitored water quality of the Prek Thnot River at Kampong Toul station located at the crossing of National Road No.3 for eight years beginning in 1996. The analysis of 2003 is presented in the following table.

Water Quality Monitoring Data in 2003

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Standard[1]
pH	7.28	6.57	7.30	7.03	7.03	7.15	6.90	6.41	6.50	6.52	6.67	6.72	6.5-8.5
TSS[2] (mg/L)	43	55	25	60	150	93	303	172	119	175	21	32	25-100
DO[3] (mg/L)	8.25	6.33	7.74	7.58	6.34	7.64	6.20	7.38	6.50	6.20	6.72	7.40	2.0-7.5

Note: 1 The sub-decree on water pollution control established river water quality standards for bio-diversity conservation. 2 TSS: Total Suspended Solids. 3 DO: Dissolved Oxygen

Source: PDOWRAM Kandal Province, 2003

In the four months from July to October, the TSS (Total Suspended Solids) exceeded the established river water quality standards for bio-diversity conservation. As for pH, almost all the data for every month fail to meet the standards except August. As for DO, January and March fail to meet the standards.

(2) Other Pollution

There are no available records about other pollution conditions, such as air quality, around the Project Site. As far as the site inspection was concerned, no serious problems of air pollution, noise or vibration have been observed because no pollution sources can be recognized around there.

B-1.9 Problems and Constraints to Improvement

As mentioned above, there were many problems found in the Roleang Chrey Regulator, Andong Sla Intake and Vat Krouch Intake. These problems are mostly due to improper design and insufficient O&M. As for the improper design, the selected gate as an intake gate, say steel radial gate, is not suitable from hydraulic and structural viewpoints, namely occurrence of much head loss and less reliability due to slender structure. The most significant issue is a lack of stoplog slot. Due to this, it is very difficult to maintain or replace the gates.

O&M activities are insufficient, too. Although the financial constraint is there, a reliable system for O&M has not been established. No O&M manual is available, so that gate operation at Roleang Chrey Regulator is only through the experience of the aged gate operator. Maintenance of gates and accessories is not conducted regularly.

Chapter B-2 The Project

B-2.1 Basic Approach to the Project

B-2.1.1 Need of Improvement

The Roleang Chrey Regulator and the Andong Sla Intake and its approach channel for the North Main Canal were constructed in 1974, aiming to irrigate 35,000 ha on the left riparian area of the Prek Thnot River. Presently, these facilities are severely deteriorated and do not function well. None of the gates of the Roleang Chrey Regulator could be easily closed after being opened one time. Therefore, effective water control of the Prek Thnot River can not be expected. The side slope protection downstream is severely eroded away.

The Andong Sla Intake has four steel radial gates, but two gates are totally damaged and left closed. The remaining two gates function only with difficulty due to much leakage. The hoisting wire ropes are damaged and were temporally repaired using steel wires. The electric driven system is totally damaged.

The Vat Krouch Intake was constructed in 2002 as an intake facility for the South Main Canal. One radial gate is currently in working condition although the wire ropes are damaged and repaired in a temporary fashion. This radial gate produces a great deal of head loss to abstract the design discharge of 16.3 m^3/sec from the river, which would create difficulty in introduction of a gravity irrigation system.

The current conditions of the Roleang Chrey Regulator, Andong Sla Intake and Vat Krouch Intake are so serious as mentioned above, and if left as they are, it is sure that the water supply to each command area would be difficult, or rather, impossible, and then the strategic target for the master plan, *improvement of agricultural productivity centering on rice*, could not be implemented by 2015. To ensure a stable water supply and also to achieve the said strategic target, improvement of these facilities is needed urgently.

B-2.1.2 Purpose and Development Concept

(1) Purpose

The Project aims to provide a stable water supply to the North Main Canal and South Main Canal, and also to the downstream area.

(2) Development Concept

In consideration of the current conditions and importance of the Roleang Chrey Regulator, Andong Sla Intake and its approach channel and Vat Krouch Intake and its approach channel and to attain the aforementioned aims, the JICA study team has elaborated a development concept of "***Realization of Proper Gate Operation through Improvement of Related Facilities"*** for the Project. Thus, the improvement plan for each facility should be worked out keeping this concept in mind.

B-2.2 Roleang Chrey Regulator Improvement Plan

B-2.2.1 Basic Considerations

In preparing the improvement plan for the Roleang Chrey Regulator, the following points are taken into account:

- Maximum Use of the Existing Facility

The site inspection and topographic survey indicated that some existing facilities such as gate leafs, guide frame, operation deck, piers, retaining walls, apron and bridges are still in working condition. These facilities shall be used without any improvement in the

Project to save cost.

- Easy Maintenance

In the review of the current condition of the existing facilities it was found that lack of proper maintenance was one of the major reasons why these did not function well. The improvement plan shall be therefore prepared paying attention to easy maintenance.

- Easy Operation

Irrigation water requirements vary from time to time. The gate operation shall be executed so as to satisfy these requirements aiming at effective water use although it should be simplified to some extent. This operation should be conducted by a combination of regulator gates with intake gates. Introduction of remote control is one of the effective ways to achieve this since a new generator of 75kVA was recently installed.

- Ensuring of the Safety of the Regulator

Structural stability is an important issue for the regulator, which is a linchpin of water utilization, because the Prek Thnot River has frequent floods in the rainy season. Thus, excess hydraulic energy due to floods should be dissipated within the sound structure.

- Smooth Release of Required Discharge to Downstream Area

There are some irrigation projects, such as Kandal Stung Irrigation Project and Tonle Bati Irrigation Project, located downstream from the Roleang Chrey Regulator. It is necessary to release the required discharge to these projects as well the required discharge for river maintenance. Since the present fixed wheel gates are too large to control such a small discharge, an appropriate measure should be taken into consideration.

B-2.2.2 Design Flood

According to the flood analysis mentioned in Sub-section B-1.3.3, the peak flood discharge of the Prek Thnot River at Roleang Chrey Regulator in the past 38 years is estimated at 1,369 m^3/sec. This means the probable peak flood discharge of the Prek Thnot River would be around 1,400 m^3/sec for the probability of about 1/40. On the other hand, the non-uniform calculation shows that the discharge carrying capacity of the Prek Thnot River in the upstream reaches would be between 1300 m^3/s and 1500 m^3/s. From these study results, it is concluded that the probable flood peak discharge as the design discharge of the Roleang Chrey Regulator for its improvement would be between 1300 m^3/s and 1500 m^3/s, or between 1400 m^3/s and 1600 m^3/s from a conservative view point. Following this conclusion and considering that the design flood for headworks is generally more than 1/50 probable flood, it is proposed to apply 1,600 m^3/s as the design flood of for improvement of Roleang Chrey Regulator.

B-2.2.3 Civil Works

As mentioned in Sub-section B-1.4.1, the facilities of the Roleang Chrey Regulator, except for the downstream slope protection, are presently in stable condition although small-scale scouring is observed immediately after the downstream apron. To keep or rather further strengthen such stable condition and to ensure the reliable release to downstream reaches, it is proposed to conduct the following works:

(1) Provision of Downstream Apron

The Roleang Chrey Regulator was designed and constructed subject to construction of the Prek Thnot Multipurpose Dam upstream. This means that the Roleang Chrey Regulator was designed only considering the flood from the area outside of the catchment area of the dam. In fact, the hydraulic calculation for the existing length of the downstream apron

shows that it could stand only against about a 300 m^3/sec flood. It is deemed that the reason that the Roleang Chrey Regulator is still stable is that it was constructed on a firm foundation. The regulator was structurally and hydraulically examined using the design flood of 1,600 m^3/sec. The examination showed that an additional downstream apron with baffle block and end sill should be provided. Its required length is 23.48 m. Additionally, backfill concrete for the excavated portion and riprap should be provided to protect the river bed from the scouring.

(2) Provision of Retaining Wall

In connection with provision of an additional downstream apron, an inverted T-shape retaining wall of 23.48 m length should be provided. Its required height ranges from 11 m to 12 m. In addition, the embankment supported by this retaining wall should be covered with riprap.

(3) Construction of By-pass

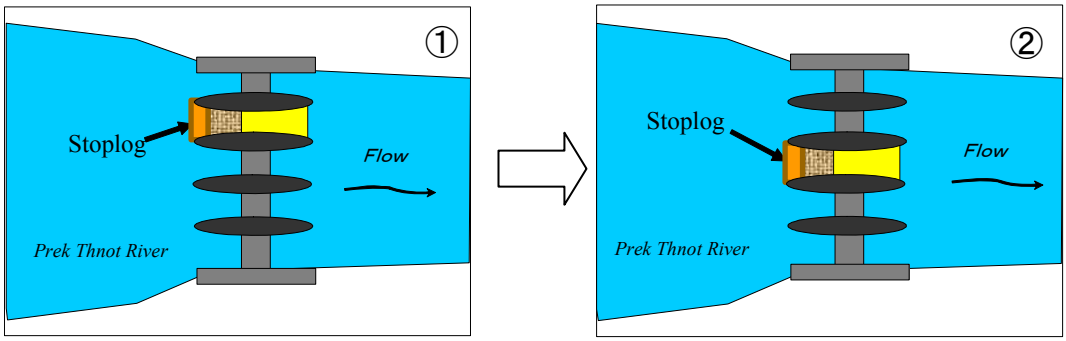
To ensure the release of a small discharge for the downstream reaches, it is proposed to construct a by-pass, which was selected as a suitable method from technical and economical viewpoints in the master plan Study. The capacity of the by-pass is 10 m^3/sec. The by-pass consists of an inlet, pipe conduit and stilling basin. The inlet is equipped with two slide gates of four sealing edges. The pipe conduit has two pipes of 1.0 m diameter and its length is 92.42 m. The stilling basin is of a box type with an end sill, and is to be provided with a broad-crest weir for discharge measurement.

B-2.2.4 Hydro-mechanical Works

In consideration of the present conditions of the gates and accessories as explained in Sub-section B-1.4.2, the required improvement works are composed of four items; closing of sluiceway, improvement of gate leaves, replacement of hoists and improvement of the operation system.

(1) Closing of Sluiceway

While the gate leaf improvement works are in progress, the gate leaf shall be raised to its highest possible level. Since the reservoir water level shall not be lowered during construction, the sluiceway of said gate shall be fully blocked. Two measures were considered for blocking the sluiceway; construction of a coffer dam and use of a stoplog (floating gate type). After comparison of these measures in the master plan Study, mainly from technical viewpoints such as ease of work and risk in rainy season, it was proposed to apply the stoplog for blocking the sluiceway. This method has another advantage in that the stoplog will be used for maintenance in future. The blocking of the sluiceway using a stoplog is illustrated as follows:



(2) Repair of Gates

There are three major works for repair of the gates:

- Repair of Wheels

To improve wheel resistance, the bearing metals shall be replaced by oil less bearings and wheel shafts by corrosion resisting steel shafts. A grease supply hole with nipple shall be equipped for the shaft for easy maintenance.

- Painting

Gate leaves shall be painted after cleaning by sand blasting.

- Repair of Rubber Seals

Rubber seals shall be removed and replaced with new ones.

- Renewal of Hoist

The entire hoisting mechanism shall be replaced with newly designed units.

- Control System

For the convenience and ease of the gate operation, it is proposed to employ a remote control system that can be actuated from the operator's house in addition to the local operation.

B-2.3 Andong Sla Intake and Approach Channel Improvement Plan

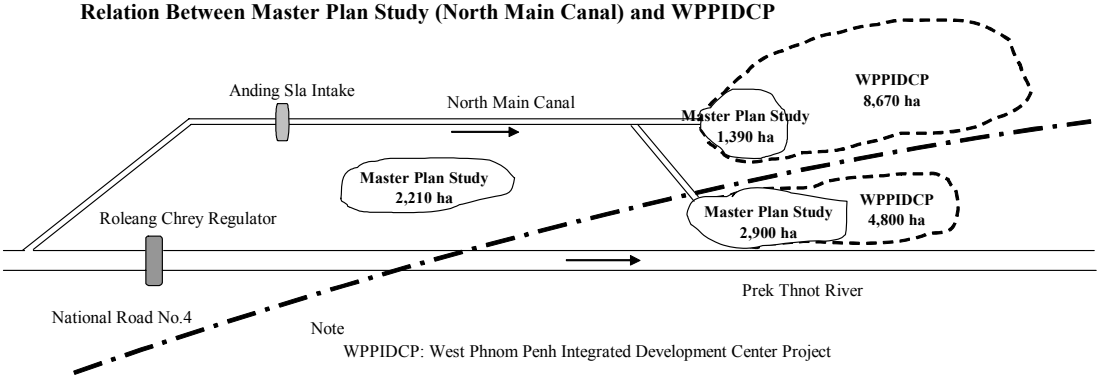
B-2.3.1 Basic Considerations

In preparing the improvement plan for Andong Sla Intake and its approach channel, the following points were taken into account:

- On-going Command Area Development Plan

As mentioned previously, the Andong Sla Intake and its approach channel were constructed in 1974 under the Prek Thnot Multipurpose Dam Project, aiming to irrigate 35,000 ha. The Andong Sla Intake was equipped with four radial gates (4 m wide and 2.2 m high each) and has a large flow capacity. But, this project was discontinued due to the political change. In 2001, the government started the Western Phnom Penh Integrated Development Center Project (WPPIDCP) using its own budget. Under this project, the North Main Canal after Andong Sla Intake has been constructed aiming to irrigate 13,470 ha of downstream area, provided that new water resources would be developed. At present, implementation of this project has progressed, but very slowly. In the master plan Study in 2005, the command area of the North Main Canal was re-studied through the water balance calculations, and it was estimated at only 6,500 ha using the available discharge of the Prek Thnot River, which is a precondition of the Study. The relationship between the master plan Study and the WPPIDCP in command area is figured as follows:

Relation Between Master Plan Study (North Main Canal) and WPPIDCP



As the government has a strong intension of implementing the WPPIDCP, it should be reflected upon the improvement plan of Andong Sla Intake and its approach channel.

- Reduction of the Hydraulic Impact on the Downstream Portion

The upstream and downstream portions of the Andong Sla Intake have a large canal section, about 50 m wide, as compared with the design discharge of 10.4 m^3/sec. If at the Andong Sla Intake, the flow section is drastically reduced, head loss would be larger and also impact to the downstream portion would be larger, which would cause severe erosion at the side slopes and bottom of the canal. To prevent such erosion, sound protection work would be required. In the improvement of Andong Sla Intake, consideration should be given to such hydraulic phenomenon.

- Selection of Appropriate Gate Type

The intake gate is required to be operated frequently based on water demand which fluctuates from time to time. In this sense, the applied gate should be reliable and easily operated. In particular, the Andong Sla Intake functions as a check gate for the South Main Canal from its location. This function requires high reliability and easy operation.

- Backwater Effect by Flood

Floods are currently controlled by Roleang Chrey Regulator by observing the upstream water level. Even with this control, backwater occurs at flood time. This backwater effect should be considered for determination of gate height in connection with gate type selection.

B-2.3.2 Civil Works

(1) Gate Capacity

As explained above, the required discharge for improvement of Andong Sla Intake and its approach channel is 10.4 m^3/sec to irrigate the command area of 6,500 ha, which was determined through a water balance calculation without consideration of new water resource development. On the other hand, the government has another development plan for the downstream area of 13,470 ha, although 4,290 ha are overlapped with the said command area. The required discharge is assumed to be 25.1 m^3/sec (= 1.60 lit/sec/ha x 15,680 ha/1000) using the same unit design discharge as the master plan Study from a conservative viewpoint. Taking into consideration such situation, it is proposed to apply the following improvement plan:

- To design the four gates portions.
- To install two of the four gates to ensure the discharge of 10.4 m^3/sec in this study.
- To provide a concrete wall for the remaining two gates, so as to enable the installation of a gate in each in the future.

(2) Retaining Wall

Retaining walls will be provided at the left and right banks. The retaining walls will be of L-shaped reinforced concrete.

(3) Gate Piers

Three gate piers are designed for the fixed wheel gate and also to function as the bridge abutment. The gate piers are is made of reinforced concrete, and their dimensions are 10.2 m long, 5.4 m high and 1.2 m thick.

(4) Downstream Apron

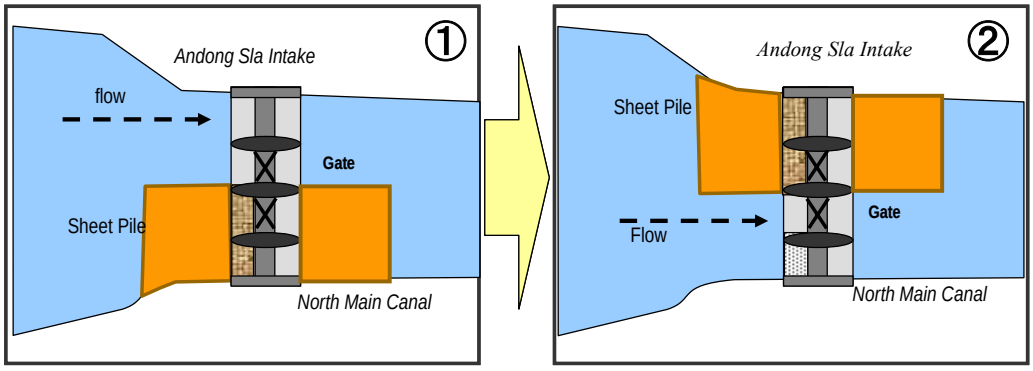
A reinforced concrete downstream apron will be constructed. The apron is to be provided with a baffle block and end sill to dissipate the hydraulic energy within the apron. After the apron, a concrete protection slab and gabion mattress will be provided to avoid scouring by sudden change of roughness coefficient of the river.

(5) Approach Channel

Since the approach channel has a flow capacity of about 70 m^3/sec according to the hydraulic calculations, which is larger than not only the design discharge of 10.4 m^3/sec, but also the future water demand of 25.1 m^3/sec, no expansion is required. In addition, no severe erosion is found at the channel side slope, so that rehabilitation is not required.

(6) Construction Method

Taking into consideration the width of the existing canal and use of canal water during construction, the following partially closing diversion method is proposed:



B-2.3.3 Hydro-mechanical Works

(1) Gate Type Selection

Three gate types were considered; radial gate, fixed wheel gate and slide gate. These gate types are compared from technical and economic viewpoints as shown below:

Comparison of Three Gate Types

Item	Radial Gate		Fixed Wheel Gate		Slide Gate	
	Characteristics	Judgment	Characteristics	Judgment	Characteristics	Judgment
Downstream water level	Influences	△	No influence	◎	No influence	◎
Operation	Easy	◎	Easy	◎	Very difficult	△
Maintenance	Slightly difficult	○	Slightly difficult	○	Easy	◎
Pier height	Low	◎	High	△	High	△
Cost	High	○	High	○	Low	◎
Hoisting load	Light	◎	Moderate	○	Large	△
Vibration	Yes	○	No	◎	No	◎
Reliability	Low	△	High	◎	High	◎
Height/width ratio	Influences	△	No influence	◎	No influence	◎

As can be seen in the above table, the fixed wheel type is the most suitable one judging from overall viewpoints. In particular, the fixed wheel type is superior to others on easy operation and reliability, which are important factors for the Project management. Thus, the fixed wheel type is selected as the intake gate for Andong Sla Intake.

(2) Design of Intake Gates

The design of the intake gates is shown in the Drawings. The general information regarding the designed fixed wheel gates is given below:

General Information on Intake Gates for Andong Sla

Item	General Information
Type	Vertical lift fixed wheel gate
Quantity	Guide frame: 4
	Gate leaf and hoist: 2
	Guide frame for stoplog: 4
	Stoplog leaf: 1
Clear span	4.00 m
Height	4.80 m
Design head	4.50m
Hoist	Electric driven wire rope winding hoist, one motor two drums
Control system	Local and remote control from Roleang Chrey Regulator

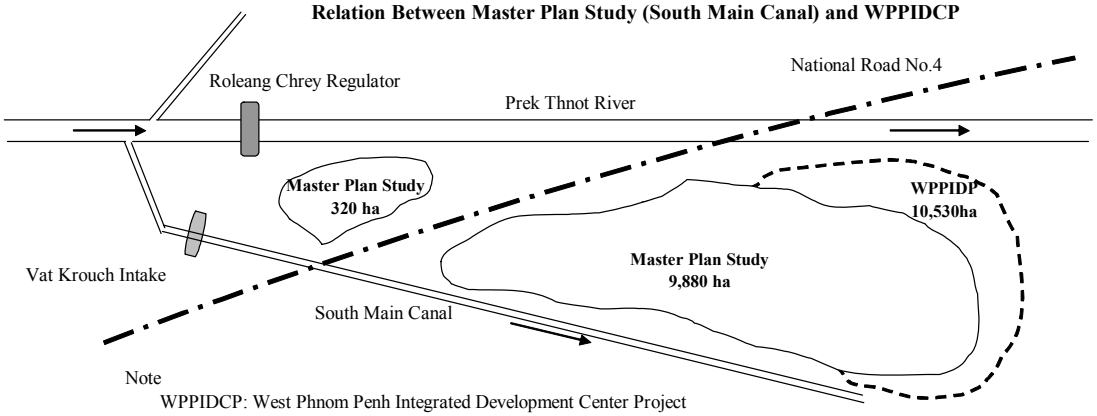
B-2.4 Vat Krouch Intake and Approach Channel Improvement Plan

B-2.4.1 Basic Considerations

In preparing the improvement plan for Vat Krouch Intake and its approach channel, the following points were taken into consideration:

- On-going Command Area Development Plan

The Vat Krouch Intake was constructed for supplying water to the South Main Canal in 2002. The South Main Canal was partly constructed in the Pol Pot's regime, and was subsequently completed under the WPPIDCP mentioned above, aiming at water supply to 10,530 ha. In the master plan Study, the irrigable area of the South Main Canal was estimated at 10,200 ha in the same manner as that of the North Main canal. The irrigable areas are almost the same, but 320 ha out of the 10,200 estimated in the master plan Study are located in areas outside the 10,530 ha area targeted in the WPPIDCP. The relationship between the master plan Study and the WPPIDCP in development area is illustrated as follows:



The government will implement the South Main Canal System as well as the North Main Canal System, the improvement plan for the Vat Krouch Intake and its approach channel should be prepared paying attention to the WPPIDCP.

- Application of Appropriate Gate Type

The Vat Krouch Intake Gate and the Andong Sla Intake need to be operated frequently based on irrigation water demand, which fluctuates time to time. In this sense, the applied

gate should be reliable and easily operated.

- Backwater Effect from Floods

As mentioned in Sub-section B-2.2.1, the backwater effect from floods should be considered for determination of gate dimensions in relation to the selection of gate type.

B-2.4.2 Civil Works

(1) Gate Capacity

According to the master plan Study, the required discharge for the South Main Canal is 16.3 m^3/sec, but it becomes 17.4 m^3/sec (=1.60 lit/sec/ha x 10,850 ha/1,000) under the WPPIDCP. Since the difference is only 1.1 m^3/sec, such increased discharge does not have much influence on the determination of gate size or cost. Furthermore, backwater from Roleang Chrey Regulator at flood time should be one of the factors to determine the gate height. From these study results and taking into account the difficulty in frequent improvement, it is proposed that gate capacity should be determined using the discharge of 17.4 m^3/sec. Consequently, two gates are required of 5.0 m high and 4.0 m wide.

(2) Upstream and Downstream Transitions

To smoothly connect the gated box culvert with the upstream and downstream canal of trapezoidal section, a reinforced concrete transition is to be provided at both side slopes of the canals. The canal bed at the transition is protected with gabion mattresses from scouring.

(3) Gate Pier and Box Culvert

A gate pier combined with a box culvert is proposed to save construction cost. The employed gate pier is 5.3 m high and 1.3 m wide, and the box culvert is of double box type 4.6 m high and 4.0 m wide each. This dimension of box culvert is determined using the discharge of 17.4 m^3/sec, in connection with gate capacity. On the bottom slab of the box culvert, a baffle block and end sill are provided to dissipate the hydraulic energy.

(4) Protection of Upstream and Downstream Canal Beds

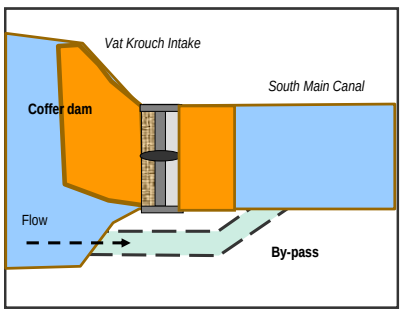
Gabion mattresses are to be provided on the canal bed before and after the transition, to protect the canal bed from scouring.

(5) Rehabilitation of Approach Channel

The present flow capacity of the approach channel is only 13.6 m^3/sec, and this is too small to carry the design discharge of 16.3 m^3/sec. Thus, the existing section needs to be enlarged. Sod-facing is proposed to mitigate erosion at the side slopes of the channel.

(6) Construction Method

Since the canal width is not adequate to apply the partially closing diversion method, a by-pass will be constructed so as not to interfere with the agricultural activities during construction as shown in the figure to the right:



B-2.4.3 Hydro-mechanical Works

(1) Gate Type

The Vat Krouch Intake is also provided with a fixed wheel type similar to that for the Andong Sla Intake.

(2) Design of Intake Gates

The design of the intake gates is shown in Drawings. The general information regarding the designed fixed wheel gates is given below:

General Information on Intake Gate for Vat Krouch

Item	General Information
Type	Vertical lift fixed wheel gate
Quantity	Gate and hoist: 2
	Guide frame for stoplog; 2
	Stoplog leaf: 1
Clear span	4.000 m
Height	5.000 m
Design head	4.720 m
Hoist	Electric driven wire rope winding hoist, one motor two drums
Control system	Local and remote control from Roleang Chrey Regulator

B-2.5 O&M Plan

B-2.5.1 Responsible Organization

The operation and maintenance for Roleang Chrey Regulator and Andong Sla and Vat Krouch Intakes shall be carried out by the Kampong Speu PDOWRAM under support of the Department of Irrigated Agriculture, MOWRAM. As for strengthening the Kampong Speu PDOWRAM, discussion is given in Sub-section B-2.7.3.

B-2.5.2 Operation Plan

(1) Sluiceway Gates of Roleang Chrey Regulator

Normal operation

The sluiceway gates shall be controlled by observing the upstream water level. According to the hydraulic calculation, the required intake water level for the North Main Canal and the South Main Canal is EL35.6 m. Thus, the water level at Roleang Chrey Regulator shall be kept at El.35.7 m considering canal conveyance loss. The gate operator shall adjust the opening of the sluiceway gates and also the intake gates, so as to satisfy the water demand stipulated in the irrigation service plan.

Since the sluiceway gates are too large to control minor discharge, minor adjustment shall be conducted using the by-pass, of which flow capacity is 10 m^3/sec.

After improvement of Roleang Chery Regulator and Andong Sla and Vat Krouch Intakes, these gates will be controlled at the operator house near the Roleang Chrey Regulator. Taking into consideration this remote control system, the daily operation of sluiceway gates, by-pass and intake gates shall be made based on the following procedure:

- Check of Upstream Water Level

The upstream water level of Roleang Chrey Regulator shall be checked using the staff gauge to determine whether it is nearly EL35.7 m or not.

- Control of Upstream Water Level

If the upstream water level is not nearly EL35.6 m, opening of sluiceway gate shall be adjusted for large difference or the by-pass for small difference in water level.

- Operation of Intake Gates

After the upstream water level becomes stable, the intake gates shall be operated so as to abstract the water demand based on the irrigation service plan. In order to simplify such

adjustment, it is proposed to prepare a graph showing the relation between the opening of gates and water level.

- Record of Intake Discharge

After the gate operation, the intake discharge, upstream water level and opening position of gates shall be recorded.

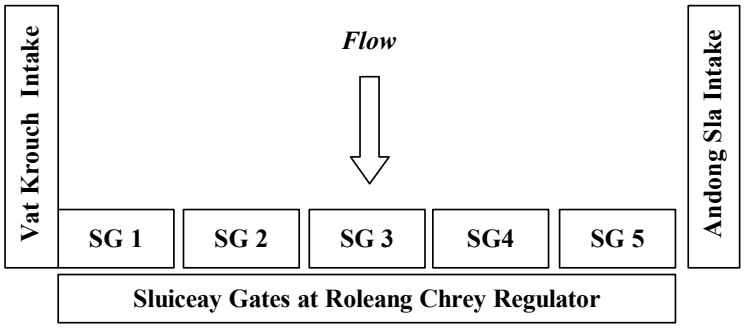
During Floods

At present, the gate control during floods is carried out by monitoring the upstream water level, say El 35.7 m. In other words, the gate control is so made as not to rise beyond El 35.7 m. This gate control system is acceptable. In addition to monitoring the upstream water level, the water level at Peam Khley shall be simultaneously monitored by strengthening the communication system between both observation stations. As the communication system, a portable phone is enough for the time being.

The gate control during floods shall be considered for two stages; flood rising and flood receding.

- Flood Rising

Prior to operating the sluiceway gates, the by-pass, if opened, shall be fully closed. And then, the sluiceway gates shall be controlled in the following sequence:



Prior to commencement of the rainy season, the gate opening of SG2 and SG4 shall be the same. As the river discharge further increases, the remaining sluiceway gates shall be partially opened one after another in the sequence of SG1, SG5 and SG3. In case the upstream water level still rises even after the partial opening of all sluiceway gates, full opening of all the sluiceway gates shall be made one after another in the same sequence as the river discharge increases. When the upstream water level exceeds El.35.7 m under full opening of all sluiceway gates, the intake gates of Andong Sla Intake and Vat Krouch Intake shall be closed.

- Flood Receding

When the monitoring of the water level at the Peam Khley shows a tendency of flood recession and river discharge decreases and the upstream water level at the Roleang Chrey Regulator site lowers from El.35.7 m, intake gates shall be opened.

When the upstream water level continuously falls, the sluiceway gates shall be partially closed in the sequence of SG3, SG5, SG1, SG4 and SG2. When the river discharge further decreases, the sluiceway gates shall be fully closed one after another, to keep the upstream water level of El.35.7 m in line with the above sequence, except for SG2 and SG4, which shall be kept partially open for releasing the extra water to the downstream reaches.

(2) Gates of Andong Sla and Vat Krouch Intakes

Gates of Andong Sla and Vat Krouch Intakes shall be controlled based on the irrigation service plan.

The discharge measurement shall be made at the intake gates, where staff gauges are installed on the upstream and downstream sides. In order to simplify the discharge measurement, a graph shall be prepared in advance showing the relationship in the difference between upstream and downstream water level, gate opening and discharge.

B-2.5.3 Maintenance Plan

In order to maintain the function of Roleang Chrey Regulator and Andong Sla and Vat Krouch Intakes as planned, it is indispensable to execute proper maintenance of them. Below mentioned are the proposed maintenance plans for Roleang Chrey Regulator and Andong Sla and Vat Krouch Intakes:

(1) Inspection for Maintenance

The gate operator shall be responsible for a daily inspection through operation. In case he finds some damage or trouble in his service facilities, these shall immediately be reported to his chief or the person in-charge of Kampong Speu PDOWRAM. The daily inspection shall be made for the following items:

Daily Inspection

- Condition of both concrete structure and embankment/backfilling portions for cracking, sinking and land sliding which might occur due to incomplete compaction after heavy rainfall and flood.
- Condition of all gates, particularly for leakage through the gates.
- Operating condition of gate lifting equipment and generators such as vibration of rotating parts, noise, overheating, bearings, etc.
- Condition of electric apparatus for the remote control system.
- Condition of approach channels and inspection road which shall be free from seepage and erosion for the embankment.

Periodic Inspection

Periodic inspection of the Roleang Chrey Regulator and Andong Sla and Vat Krouch Intakes shall be carried out at least once a month in order to inspect for defects which cannot be found through a daily inspection

(2) Annual Maintenance Program

An annual maintenance program for Roleang Chrey Regulator and Andong Sla and Vat Krouch Intakes shall be prepared by the Kompong Speu PDOWRAM. An annual budget for the maintenance works shall be estimated. The program shall be prepared taking the following into account:

- Estimated work volume and time required
- Repair method (by manpower and/or equipment)
- Capability of contractor
- Estimated cost
- Priority ranking in maintenance work listed.

(3) Maintenance Works

The maintenance works shall be commenced and executed in the approved annual maintenance program. Generally, the required major maintenance works for the Roleang Chrey Regulator and Andong Sla and Vat Krouch Intakes are as follows:

- Removal of floating debris in front of sluiceway gates, intake gates and by-pass.
- Daily maintenance of electric apparatus such as generator, control panel and transmission line.
- Daily maintenance of all moving mechanism of all electrically driven gate hoisting machines of sluiceway gates and intake gates including well oiling/greasing of all gears and wire ropes, referring to the maintenance instructions/guides prepared by the manufacturers.
- All riprap protection and gabion mattresses
- Painting of stoplogs, steel gate leaves of sluiceway gates, slide gates for the by-pass and intake gates of Andong Sla and Vat Krouch Intakes.
- Periodic cross section survey of the approach channels. If changes are found, reshaping shall be carried out to ensure the designed canal capacity.
- Sediment removal and weed clearance shall be executed periodically to recover flow capacity to that originally designed.
- Channel bank settlement and seriously slipped or eroded slopes shall be refilled back to design elevation and well compacted by equipment.

(4) Emergency Repair

Damage to the Roleang Chrey Regulator or Andong Sla and Vat Krouch Intakes will seriously hamper the normal Practices of irrigation. Therefore, repair of damaged facilities shall be quickly and effectively carried out as emergency repairs. Since the damage is not predictable either with respect to the time of occurrence or to scale of damage, Kampong Speu PDOWRAM shall always be ready to confront the occurrence of damage.

The damage to the facilities may result from flood, heavy rainfall, careless operation of the facilities, acts of vandalism, or destruction by animals and/or vehicles.

B-2.6 Environmental Considerations

In the process of preparation of the various improvement plans mentioned above, a series of environmental considerations were investigated in order to implement the Project in a more environmentally friendly and sustainable manner. The important points under the Project were i) water availability during the construction phase, ii) lining method of approach channels, and iii) air pollution by construction vehicles.

(1) Water Availability during Construction Phase

Currently, canal water in both the North and South Main Canals is used for agriculture and also for domestic use and drinking. The Socio-Economic Survey, which was conducted in 2007 for 100 sample households living in the Project Area, showed that about 40% of households are taking canal water for domestic use in the dry season. Moreover, 10% of households are taking canal water for drinking in the dry season.

When considering rehabilitation works of Andong Sla Intake Gate and Vat Krouch Intake Gate, which require 15 and 11 months respectively, stopping the water flow might cause significant impacts toward both agricultural activities and people's lives. Therefore, the following work methods were proposed in order to avoid stopping water flow in the

canals;

Andong Sla Intake Gate

Rotational construction work of Andong Sla Intake Gate was proposed to avoid interruption of water flow as explained in Sub-section B-2.3.2. Rotation work would be conducted as two-stage works. In the first stage, sheet piles will be temporarily provided to stop water in order to construct the new structures and reinstall gate No.2. As for the second stage, sheet piles will be shifted in order to construct the new structures and reinstall gate No.1. It is noted that passage will not be avoided by the construction work.

By adopting this method, water flow in the North Main Canal will not stop even in the construction period of Andong Sla Intake Gate.

Vat Krouch Intake Gate

During construction work for Vat Krouch Intake Gate, a temporary bypass canal for water flow will be established in the South Main Canal as explained in Sub-section B-2.4.2. It is noted that a temporary bridge over the bypass and the South Main Canal will also be provided to avoid obstructing passage across the canal.

By adopting this method, water flow in the South Main Canal will not stop even in the construction period of the Vat Krouch Intake Gate.

Approach Channels of North and South Main Canals

As for rehabilitation work on the approach channels, it requires stopping the water flow in the canals by some means during the work period, the duration of which will be a few months. As a conclusion, rehabilitation work on the approach channels will be conducted intensively in the fallow period from December to March in order not to impact to agricultural activities at all.

Though the duration is not long compared with the intake gate rehabilitation work, it will have some impact on people who rely on canal water for drinking and domestic use. In order to deal with this impact, a detailed survey of the affected people will be conducted in order to determine any possibility of another alternative water source for drinking and domestic use during the construction period. For the people who do not have any alternative water source, countermeasures such as distribution by water tanker would be proposed.

(2) Lining of Approach Channels

Two canal lining methods, i.e. concrete lining and earth lining were examined in consideration of environmental aspects.

As a conclusion, lining of the approach channels in both the North and South Main Canal will be earth instead of concrete. In case of concrete lining, concrete work will cause alkalified water that negatively affects the aquatic-biodiversity. In addition, biodiversity would be in risk of damage from the artificial surface of the canals. In that respect, earth lining will minimize these kinds of negative impacts to the environment.

Moreover, block sodding along the canal banks will be conducted in order to support the bank and avoid land slides using an environmentally friendly method.

Earthen road near the Project Site

(3) Air Pollution due to Construction Vehicles

Because most roads around the Project Site are earthen, the running of vehicles spreads dust in the air, especially in the dry season.

During the construction phase, construction vehicles

will increase the road traffic so that the dust problem will become more serious.

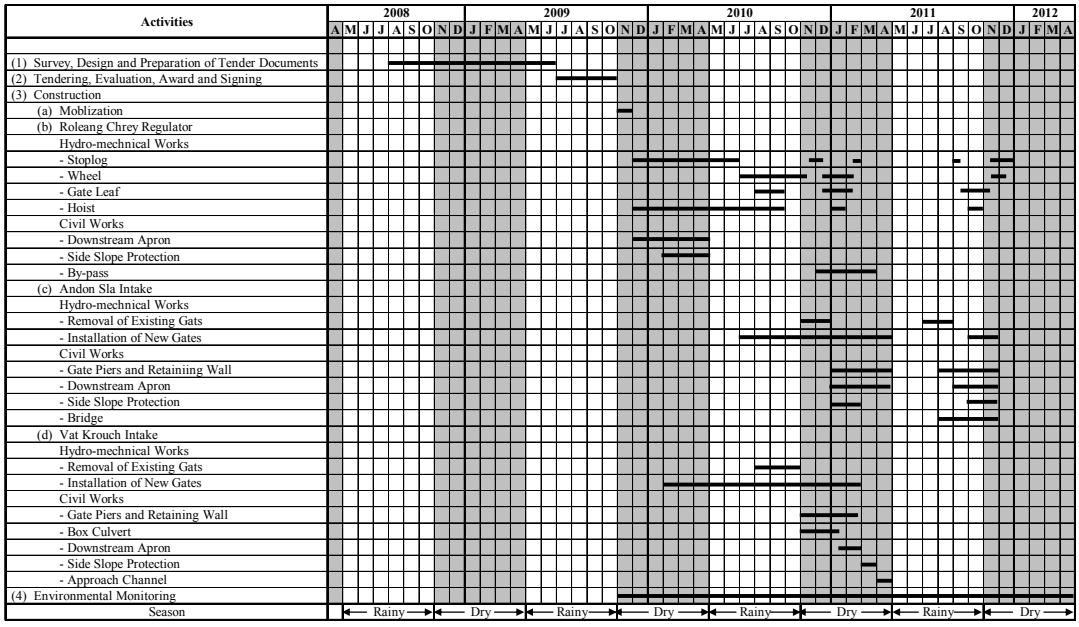
To cope with the dust problem, regular sprinkling of the roads by watering vehicles was included in the construction work items.

B-2.7 Implementation Plan

B-2.7.1 Implementation Schedule for the Project Works

The implementation schedule for the Project works is shown below:

Implementation Schedule of Project Works



The Project works are divided into four parts; (a) survey and design including preparation of tender documents, (b) tendering, (c) construction, and (d) environmental monitoring.

The survey and design will be carried out on a contract basis and will require about 11 months from August 2008. Immediately after completion of the design work, tendering would be started and about 4 months would be needed for the contract signing with the successful tenderer.

Immediately following, the construction work would be started. The construction work consists of mobilization, Roleang Chrey Regulator, Andong Sla Intake and Vat Krouch Intake and its approach channel. The mobilization is planned to take one month taking into consideration the scale of construction work. The construction work for Roleang Chrey Regulator would require 25 months from December 2009 to December 2011. In the construction work for Roleang Chrey Regulator, the critical path is to arrange the stoplog. The civil work such as construction of the downstream apron, rehabilitation of the side slope protection and the by-pass would be carried out in the 1st and 2nd dry seasons.

The construction work for the Andong Sla Intake would start in July 2010 and be completed in November 2011. The critical path in the construction work for the Andong Sla Intake would be the procurement and installation of the 5 new gates. The civil work, such as construction of the gate piers, retaining wall, downstream apron, side slope protection and bridge would be completed in the 11 months from January 2011 to November 2011.

The construction work for the Vat Krouch Intake and its approach channel would be commenced in February 2010 and completed by April 2011. The civil work such as construction of the gate piers, retaining wall, box culvert, downstream apron, side slope protection and rehabilitation of the approach channel, would be completed in one dry

season from November 2010 to April 2011.

Prior to commencement of the construction work, say November 2009, the environmental monitoring would begin by MOWRAM and run until April 2012, to examine the environmental impacts of the construction work.

B-2.7.2 Executing Agencies for Project Implementation

MOWRAM is an overall executing agency for implementation of the Project. Since the components of the Project are only the engineering works such as improvement of the Roleang Chrey Regulator, Andong Sla Intake and Vat Krouch Intake and their approach channels, the relevant departments of MOWRAM under the Secretary of State of MOWRAM, will be directly in-charge of respective stages of the Project.

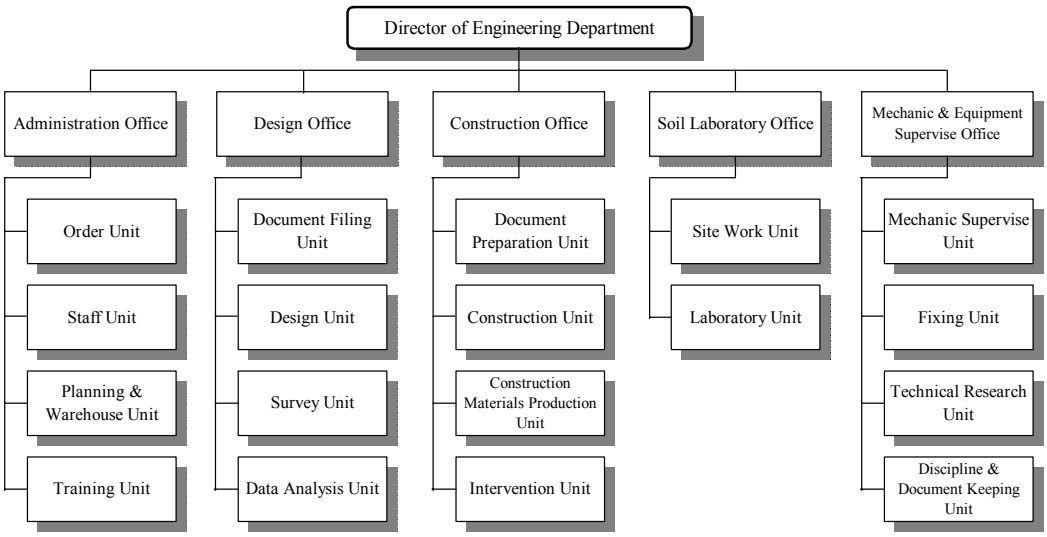
B-2.7.3 Organization for Project Implementation

There are three stages for the project implementation; design, construction and O&M. The Engineering Department will be responsible for the design and construction stages and the Department of Irrigated Agriculture for the O&M stage.

(1) Design and Constriction Stages

The present structure of the Engineering Department is as follows:

Present Structure of Engineering Department



The Design Office will be responsible for the design of the Project. The required design works do not need highly sophisticated technology; it is deemed that the present staff of the Design Office could fulfill them. However, it is proposed that the design works will be conducted on a contractual basis, to complete them quickly.

The Construction Office will be responsible for the construction work for the Project. The construction works will be conducted on a contractual basis so that the mission of the Construction Office will be to supervise the contractor. The Project Site is about 25 km from the Engineering Department office. It is thus proposed to establish a Construction Office at the Kampong Speu PDOWRAM. The required staff for construction supervision should be assigned from the Engineering Department and the Kampong Speu PDOWRAM.

(2) O&M Stage

The Department of Irrigated Agriculture is responsible for O&M for the Project facilities. Currently, O&M works for the Project facilities are carried out by the Kampong Speu

PDOWRAM under support from the Department of Irrigated Agriculture. This system is acceptable. However, Kampong Speu PDOWRAM should be strengthened so as to realize the proper O&M for the Project facilities, which is not presently being done as pointed out in Section B-1.7. The Kampong Speu PDOWRAM has five offices under the director, including administration, water management, agricultural hydrology, water sanitation and meteorology, and there is no office for O&M for the Project facilities. Taking into consideration that the Project facilities are key structures for irrigating the command area of 16,700 ha, one additional office for O&M for Roleang Chrey Regulator and the two Intakes should be established. At least, one mechanical engineer and one electrician should be assigned for this office.

B-2.8 Environmental Examination

B-2.8.1 Environmental and Social Conditions to be examined

Based on available information of the natural and social environment, environmental scoping for the Project was undertaken to identify anticipated impacts on the environment to be examined as shown below.

Environmental and Social Conditions to be examined

Potential Impact		Phase	
		Construction	Operation
Social Environment	Inflow of Construction Workers	- Degradation of sanitation conditions and security due to inflow of construction workers	―
	Accessibility	- Limitation of accessibility on bridges	―
	Water Availability	- Limitation of water usage downstream of the north and south canals during construction work on the approach channels	―
Pollution	Air Pollution	- Air pollution caused by emission gases	―
	Water Pollution	- Runoff of alkalified water from the concrete work	―
	Noise and Vibration	- Noise and vibration caused by construction vehicles and heavy equipment	―

Taking into consideration these anticipated impacts, scoping to be examined was set up by dividing the Project Site into six areas;

- Area-1: Andong Sla Intake and approach channel, and those surrounding areas
- Area-2: Command area of the North Main Canal
- Area-3: Roleang Chrey Regulator and its surrounding areas
- Area-4: Downstream of the Prek Thnot River from Roleang Chrey Regulator
- Area-5: Vat Krouch Intake and approach channel, and those surrounding areas
- Area-6: Command area of the South Main Canal

B-2.8.2 Consideration of Environmental/Social Impacts and Mitigation Measures

The results of the examination of each condition and the proposed mitigation measures are shown below.

Inflow of Construction Workers (Construction Phase)

Activities	- Construction/Rehabilitation work on the Andong Sla Intake and approach channel of the North Main Canal - Rehabilitation work on the Roleang Chrey Regulator - Construction/Rehabilitation work on the Vat Krouch Intake and approach channel of the South Main Canal
Affected Areas	Area-1: Andong Sla Intake and approach channel, and those surrounding areas Area-3: Roleang Chrey Regulator and its surrounding areas Area-5: Vat Krouch Intake and approach channel, and those surrounding areas
Projected	Due to inflow of construction workers from outside during the construction phase, the

Impacts	following impacts were anticipated; i) deterioration of sanitation, ii) deterioration of public security, iii) increased risk of diseases including AIDS/HIV, iv) local conflict among people and workers. Construction scale at the Project Site is not large and duration is at most 25 months.
Mitigation Measures	- To improve the sanitary condition of the workers by proper arrangement of accommodations, installation of toilets and proper water supply - To implement an education program for the workers about sanitation, security and rules/discipline of daily activities - To implement periodic patrols of workers in order to avoid occurrence of both local conflict and epidemics of diseases - To hold a series of public meetings for surrounding people in order to explain the construction work and its schedule.
Conclusions of Examination	Because the people around the Project Site are not familiar to construction workers from other areas, great attention toward management of construction workers and construction fields are important. However, taking into consideration the work scale, the numbers of construction workers will not be large. Therefore, serious negative impacts are not envisaged with proper implementation of mitigation measures.

Accessibility (Construction Phase)

Activity	- Rehabilitation work on the Roleang Chrey Regulator
Affected Area	Area-3: Roleang Chrey Regulator and its surrounding
Projected Impact	Passage across the maintenance bridge of the Roleang Chrey Regulator by both people and vehicles will be obstructed for several hours per day during a part of the construction phase. The construction period producing the temporary passage prohibition is, in total, around 6 months; July-Sep 2009 (3months), Oct-Nov 2009 (1month), Dec 2009-Feb 2010 (2months).  Passage on maintenance bridge of Roleang Chrey Regulator According to the gate operator of Roleang Chrey Regulator, around 450-660 people per day cross the bridge for school, jobs, shopping and so on. Moreover, the distance to the nearest neighboring bridge is around 8km downstream.
Mitigation Measures	- To hold a series of public consultation meetings for the surrounding people in order to explain, discuss and find a way to alleviate the inconvenience. - To post a bill to inform the commune council, village chief, social facilities like schools, pagodas and hospitals regarding the periods of restricted access after the work schedule is fixed with people's consensus. - To establish a temporary bridge, if possible.
Conclusions of Examination	Because the local people cross the bridge every day and the nearest neighboring bridge is located far away, some sort of limitation on people's lives might be expected. Consultation with the surrounding people and distributing information to the affected people will be necessary before the construction work starts.

Water Availability (Construction Phase)

Activities	- Rehabilitation work on the approach channel of the North Main Canal - Rehabilitation work on the approach channel of the South Main Canal
Affected Areas	Area-2: Command area of the North Main Canal Area-6: Command area of the South Main Canal
Projected Impacts	Rehabilitation works on the approach channels of both the North Main Canal and South Main Canal will stop water flow in the canals for few months in the fallow period from December to March. However, people living in the command areas of both the North and South Main Canals will be faced with reduced or no canal water in this period. By rough estimation, around 5,000 people living in the command areas of both the North and South Main Canals will be affected by a shortage of drinking water, while 20,000 people will be affected by a shortage of water for domestic use.

Mitigation Measures	- To conduct construction work in the fallow period as much as possible. - To hold a series of public meetings wherein a detailed construction work schedule will be planned in order to discuss the work schedule and make a decision on it with the affected people. - To consider other sources of water for drinking and domestic use for the affected people by detailed survey or consultation meetings with them, e.g. distribution by water tanker.
Conclusions of Examination	Though the impact on water availability can be minimized by implementation of the work in the fallow period, at most 20,000 people will be affected by water availability by the work on the approach channels for few months in the fallow period. Therefore careful attention to proposed mitigation measures will be necessary.

Air Pollution (Construction Phase)

Activities	- Construction/Rehabilitation work on the Andong Sla Intake and approach channel of the North Main Canal - Rehabilitation work on the Roleang Chrey Regulator - Construction/Rehabilitation work on the Vat Krouch Intake and approach channel of the South Main Canal
Affected Areas	Area-1: Andong Sla Intake and approach channel, and those surrounding areasArea-3: Roleang Chrey Regulator and its surrounding areas Area-5: Vat Krouch Intake and approach channel, and those surrounding areas
Projected Impacts	Running of construction vehicles and transportation/operation of heavy equipment, such as dump trucks, excavators, bulldozers, truck cranes, rollers for compacting and watering lorries, will exhaust gas including nitrogen dioxide (NO_2) and suspended particulate matter (SPM).
Mitigation Measures	- To educate construction workers for minimizing idling of construction vehicles
Related regulations	Sub-decree on Air and Noise Control (June 10, 2000); Ambient air quality standards (CO, NO_2, SO_2, Ozone, Pb, TSP)
Conclusions of Examination	Because most of the construction works are small scale rehabilitations, the numbers of both heavy equipment and construction vehicles for the work will not be many. Therefore the impact to air quality will not be serious with proper management and mitigation measures.

Water Pollution (Construction Phase)

Activities	- Construction work on the Andong Sla Intake - Rehabilitation work on the Roleang Chrey Regulator - Construction work on the Vat Krouch Intake
Affected Areas	Area-2: Command area of the North Main Canal Area-4: Downstream of the Prek Thnot River from Roleang Chrey Regulator Area-6: Command area of the South Main Canal
Projected Impacts	Construction works on the Andong Sla Intake and Vat Krouch Intake and rehabilitation work on the Roleang Chrey Regulator require concrete works. Therefore, alkalified water caused by the concrete works will be eliminated during construction phase. Total amount of concrete to be used is roughly 900t at Andong Sla Intake, 3,700t at Roleang Chrey Regulator and 500t at Vat Krouch Intake. This concrete will be brought from the concrete manufacturer to the Project Site by concrete mixer truck.
Mitigation Measures	- To dilute or neutralize alkalified water from the concrete mixer trucks by pooling in a regulating pond, before the water enters the canals. - If concrete plant will be set up near the Project Site, it will be necessary to pool discharging water from the plant for dilution or neutralization. - To install an adequate treatment system for alkalified water in the construction field.
Related regulations	Sub-decree on Water Pollution Control (April 6, 1999); Water quality standards in public water areas for bio-diversity conservation (pH, BOD, SS, DO, Coliform, TN, TP), Water quality standards in public water areas for public health protection (DDT, Cadmium, Lead, and so on)
Conclusions of Examination	Because the amount of concrete to be used is not large, alkalified water flowing out from the concrete in the canals might be diluted by canal water. However if alkalified

	water is observed, it will be necessary to install an adequate treatment system for alkalified water in the canal/river.

Noise and Vibration (Construction Phase)

Activities	- Construction/Rehabilitation work on the Andong Sla Intake and approach channel of the North Main Canal - Rehabilitation work on the Roleang Chrey Regulator - Construction/Rehabilitation work on the Vat Krouch Intake and approach channel of the South Main Canal
Affected Areas	Area-1: Andong Sla Intake and approach channel, and those surrounding areas Area-3: Roleang Chrey Regulator and its surrounding areas Area-5: Vat Krouch Intake and approach channel, and those surrounding areas
Projected Impacts	During the construction phase, heavy equipment will cause noise and vibration. Types of heavy equipment would be dump trucks, excavators, bulldozers, rollers for compaction and watering lorries. The distance from the Project site to neighboring houses is approximately 20m in Area-1, 60m in Area-3 and 60m in Area-4.
Mitigation Measures	- To limit construction time. e.g. at daytime only - To hold public meetings to obtain consensus about the construction time with the surrounding people.
Related regulations	Sub-decree on Air and Noise Control (June 10, 2000); Maximum permitted noise level in residential areas is 60dB from 6am to 6pm, 50 from 6pm to 10pm and 45 from 10pm to 6am.
Conclusions of Examination	Because most of the construction works are small scale rehabilitation with little heavy equipment, the impact of noise and vibration will not be serious with proper management and mitigation measures.

B-2.8.3 Environmental Management and Monitoring Plan

As a whole, serious environmental impacts will not be expected as explained above. However there is uncertainty regarding water quality during the construction phase. Therefore, water quality monitoring is proposed in the environmental management and monitoring plan. A brief summary of the proposed plan is as follows.

Water Quality Monitoring Plan

Items	General Outline
Background	During the construction phase, concrete work will be conducted at Andong Sla and Vat Krouch Intakes, and Roleang Chrey Regulator. Though mitigation measures for inflow of alkalified water will be conducted, there is still uncertainty regarding water pollution. Alkalified water might affect aquatic-diversity. In addition, people are taking water from the canals for both drinking and domestic use in the command areas of both the North and South Main Canals.
Objectives	To monitor water quality during the construction phase
Sampling Points	Water quality should be monitored at three points i) Downstream of Andong Sla Intake Gate in the North Main Canal, ii) Downstream of Vat Krouch Intake Gate in the South Main Canal, and iii) Downstream of the Prek Thnot River
Items to be surveyed	i) pH, ii) transparency (turbidity), iii) water temperature, odor, appearance
Frequency	Once a month
Monitoring period	November 2008-April 2011 (total 30 months) (from one month before construction works, to four months after completion of all construction works)
Executing Agency	Kampong Speu PDOWRAM

If alkalified water is observed or other environmental parameters are beyond the water quality standard values in public water areas set up by the Sub-decree on Water Pollution Control, it will be necessary to install an adequate treatment system for alkalified water in the canals or consider other countermeasures.

B-2.8.4 Comparative Evaluation of the Project

(1) Examination of the Condition without the Project

The following table shows the comparison of potential impacts between with and without the Project. It was assumed that the gates of Roleang Chrey Regulator will be out of order in the near future in the "without the Project" condition.

Comparison between With and Without the Project

Activity / Potential Impact	Without Project	With Project	Remarks
Social Environment			
Water Usage	--/A	++/A	No/little water in canals because of breakdown of Roleang Chrey gate (w/o)
Local economy (employment, livelihood etc)	--/A	++/B	Limitation of agriculture and fishery because of no/little water in canals (w/o)
Land use and utilization of local resources	--/B	++/B	Waste of water flow (w/o)
Social institutions	--/B	*	Failure of FWUC/FWUGs because of no/little water in canals (w/o)
Existing social infrastructures and services	--/A	++/C	Breakdown of regulator, intakes (w/o)
The poor, indigenous and ethnic people	--/C	*	Difficulty to find alternative water source (w/o)
Misdistribution of benefits and damage	--/C	*	Regional gap in water availability (w/o)
Local conflict of interests	--/B	*	Expansion of regional gap (w/o)
Sanitation	*	++/C	
Hazards (Risk), Infectious diseases	*	--/C	
Natural Environment			
Hydrological Situation (Hydraulic)	=/B	=/B	
Pollution			
Air Pollution	*	--/C	Construction work (w/)
Water Pollution	*	--/C	Construction work (w/)
Noise and Vibration	*	--/C	Construction work (w/)
Ground Subsidence	--/B	*	Excess of groundwater usage because of no/little water in canals(w/o)

*Note) --/B: left-hand side of each cell represents a direction of impact; right-hand side represents the magnitude of impact. ++: Positive impact, --: Negative Impact, =: Neutral Impact, A: relatively significant impact, B: medium-size impact, C: relatively small impact, *: No impact or no corresponding impact, w/: with the Project, w/o: without the project*

As a result of the comparisons, it is expected that the improvement Plan will raise or increase positive impacts related to water usage, agricultural activities, local society and land use conditions. On the contrary, under the "without the Project" condition, water availability in the canals might decline to a considerable degree and the local economy and the peoples' lives will be negatively impacted accordingly.

(2) Examination of the Condition without Environmental Considerations

In the process of formation of the improvement plan, a series of environmental considerations were investigated in order to develop the Project in an environmentally friendly and sustainable manner as mentioned in Section B-2.8. In order to examine the affects and validity of the Project components from the viewpoint of the environment, these environmental considerations were evaluated by comparing the condition with environmental considerations under the Project with conditions without environmental considerations. Project components in the case of without any considerations are shown below.

Project Component Without Environmental Considerations

Items	Project Component Without Environmental Considerations
A) Water Availability during Construction Phase	Rehabilitation work on the intake gates will stop water flow in canals for about 7-8 months. In addition, rehabilitation work on the approach channels will be conducted in the rainy season without any consideration of water usage.

Items	Project Component Without Environmental Considerations
B) Lining Method for Approach Channels	Lining of approach channels will be rehabilitated with concrete without earth and block sodding.
C) Air Pollution by Construction Vehicles	Water sprinkling to reduce dust from construction vehicles will not be managed.

The following table shows the comparison of potential impacts between with and without environmental considerations. The main difference of impacts between them is water availability that will cause relatively significant direct impacts to people's lives and agricultural activity. In addition, earth lining of canals will mitigate the impacts on aquatic-biodiversity, however, proper management of the canals is necessary in order to keep using the canals appropriately. As a conclusion, it is clear that these considerations might be effective and valid to local people directly and to the natural environment.

Potential Impact with and without Environmental Considerations

Potential Impacts	Without Considerations	With Considerations
A) Water Availability during Construction Phase		
Water availability during construction phase	People living in the command areas of both the North and South Main Canals cannot access canal water for at least 7-8 months because of stopping the water flow in the canals during the rehabilitation work on the intakes and approach channels.	People living in the command areas of both the North and South Main Canals will have limited access to canal water for only a few months in the fallow period.
Local economy during construction phase	Agricultural activities in the command areas of both the North and South Canals (in total around 17,000ha) will be limited during cultivation time.	Few/no impacts to agricultural activities by the construction work
B) Lining Method of Approach Channels		
Water pollution during construction phase	Alkalified water caused by the concrete works during the construction phase will negatively affect the biodiversity. People using canal water for drinking will be also affected in some way by alkalified water.	Murky water will increase in canals during the construction phase. However the impact will not be serious to biodiversity.
Impacts to biodiversity during operation phase	Biodiversity will be at risk of damage by the artificial surface of the canals.	Impact will be negligible during the operation phase.
Breakdown of the canal during operation phase	Few impacts	The canal is at a slight risk of land slides and breakdown of the embankment.
Disruption of water flow by grasses	No impacts	Without any management of the canals by the farmers, water flow will be disrupted or stopped.
C) Air Pollution by Construction Vehicles		
Air pollution by dust during construction phase	The dust will be spread, especially in the dry season. People living along the road which is traveled by the construction vehicles will be affected by the dust.	Little dust will be spread if any.

B-2.8.5 Conclusions

Initial environmental examination of the Project concludes as follows;

- As a whole, the development plan of the Project was evaluated to be acceptable from an environmental viewpoint if the proper mitigation measures presented previously are undertaken.
- Some of the likely negative impacts on both the social and natural environment including limitation of accessibility and water availability during construction were pointed out. Therefore, proper management with the proposed mitigation measures and monitoring plan should be implemented in order to avoid/mitigate anticipated

negative impacts as much as possible.

B-2.9 Cost Estimate

B-2.9.1 Conditions of the Cost Estimate

The basic conditions and assumptions employed for the cost estimation of the Project are as follows.

- Cost estimate refers to the prices as of January 2007.
- Unit prices of labor, construction materials, engineering works, etc., were collected from MOWRAM and the market.
- Construction is undertaken on a contractual basis.
- The Investment Cost consists of i) engineering service cost, ii) construction cost, iii) administration cost, iv) environmental monitoring cost, and v) physical and price contingencies.
- Administration cost during construction is assumed to be 10% of direct construction cost.
- The physical contingency is assumed to be 10% of the investment cost.
- Price escalation is evaluated based upon 4.5% per annum for the foreign currency portion and 7.0% per annum for the local currency portion.
- Conversion rate is assumed at US$ 1.0 = Riel 4,060 (as of January 2007)

B-2.9.2 Investment Cost

The investment cost consists of i) engineering service cost, ii) direct construction cost, iii) administration cost, iv) environmental monitoring cost, and v) physical and price contingencies. The total investment cost is estimated at US$ 4,991,000 equivalent to Riel 20,263,460. The summary of the investment cost is given below, and its details are shown in Table B-2.9.1

Summary of Investment Cost

(unit:'000)

Item	US$	Riel (equivalent)
(1) Engineer Services	652	2,647,120
(2) Construction Cost	2,943	11,948,580
(3) Administration Cost	294	1,193,640
(4) Environmental Monitoring	3	12,180
Total	3,892	15,801,520
(5) Physical Contingency	389	1,579,340
(6) Price Contingency	710	2,882,600
Total	4,991	20,263,460

Table B-2.9.2 shows the annual disbursement schedule for the investment cost which was prepared based on the implementation schedule for the project works.

B-2.9.3 Replacement Cost

The following replacement costs occur during the Project life of 50 years:

Summary of Replacement Costs

(unit:'000)

Item	Replacement Year	US$	Riel (equivalent)
(1) Roleang Chrey Regulator			
- Gate Leaves	25th year	428.4	1,739,304
- Accessories	25th year	752.4	3,054,744
(2) Andong Sla Intake			

- Accessories	25th year	85.5	347,130
(3) Vat Krouch Intake			
- Accessories	25th year	107.9	438,074

The details of the replacement costs are given in Table B-2.9.3.

Generally, gate leaves would have a life of 60 years if maintenance work is properly conducted. As for the gate leaves of Roleang Chrey Regulator, 32 years have already passed since 1974 when Roleang Chrey Regulator was constructed. The remaining life of gate the leaves was therefore estimated at 25 years from a conservative viewpoint considering the past maintenance condition.

B-2.9.4 O&M Cost

The annual O& M cost for the Project is estimated at US$ 9,300 equivalent to Riel 37,758,000, the details of which are shown in Table B-2.9.4.

B-2.10 Project Evaluation

B-2.10.1 General

The objectives of the project evaluation for the Feasibility Study are to evaluate the anticipated economic and social impacts of the Project with a higher degree of accuracy and updated data, as well as from angles, from qualitative terms as well as quantifiable monetary terms. The project evaluation for the Feasibility Study consists of three different types of evaluation approaches with each of them focusing on different aspects of the project, as listed below.

Evaluation Approaches Applied and Their Objectives

Evaluation Approaches	Objectives
(1) Economic Evaluation	To evaluate the economic impact of the Project in quantifiable, monetary terms from the viewpoint of the "national economy"
(2) Financial Evaluation	To evaluate the financial viability of the Project in quantifiable, monetary terms from viewpoint(s) of the project entity and/or beneficiaries
(3) Socio-Economic Impact Evaluation	To evaluate the Project's socio-economic impacts in non-monetary, qualitative terms

B-2.10.2 Economic Evaluation

(1) Evaluation Procedure

The project economic evaluation was carried out through standard methodology in the project appraisal process, i.e. estimation of Economic Internal Rate of Return (EIRR), Cost-Benefit Ratio (B/C), and Benefit minus Cost (B-C).

All prices for the Feasibility Study evaluation were expressed in constant prices as of January 2007 applying the average monthly official exchange rate of USD 1.0 = Riel 4,060. The economic life of the Project is assumed to be 50 years beginning from year 2008, the proposed commencement year for construction.

Economic farm gate prices of internationally traded agricultural inputs and outputs were based on their export and import parity prices derived from the World Bank Commodity Price Forecasts as of October 2006. The long term projected prices in 2010 at 2007 constant prices were used in the analysis. The average of export and import parity prices of farm products of rice, maize, and import parity prices of fertilizer were calculated and applied for the economic prices.

A standard conversion factor (SCF) of 0.98 and shadow wage rates (SWR) were applied for the adjustment of prices and labor costs reflecting the market distortion. Transfer payments such as tax, duties, subsidies, interest, etc., were excluded in estimating the

economic costs and benefits. Financial construction costs were converted into economic values by applying the construction conversion factors (CCFs).

(2) Economic Benefit

The economic benefit is usually estimated as the increment of net production value between future "with" and present "without" project conditions. However, for the evaluation of the Project, the economic benefit is estimated as the SAVING of net production value between future "with" and "without" project conditions.

The reason why saving of net production value is looked at is that Roleang Chrey Regulator is assumed to suffer complete malfunctioning of its gate from 2008 which mandates urgent improvement.[1] Its present status is judged quite serious and with very high probability, the gates will become inoperable before long. Thereby net production values for the case of the Project, 'with' and 'without' mean 'action taken' case and 'no action taken' case. The Project is aimed at maintaining the present production level in all the connected command areas by preventing the irrigation water supply deterioration. In other words, this is a project to save the costs of inaction.

The economic crop budgets of respective crops under the present condition were calculated by applying requirements for farm inputs and total labor, unit crop yields, and their economic prices. The economic benefit for the Project ("saving" of net production value) was estimated as follows.

Economic Benefit of the Project

Project Area (ha)	Cropping Intensity (%)		Net Production Value (Million Riels)		
	Without Project	With Project	Without Project	With Project	Saving
16,925*	**100.8	**103.3	7,084.7	8,618.2	**1,533.5**

* *Sum of present total physical cultivated area connected to Roleang Chrey Regulator (16,700ha of net irrigable area + 225ha of acquired area for canals and structures construction)*
** *Weighted average of connected irrigation schemes.*

No negative benefit is anticipated with the implementation of the Project.

(3) Economic Cost

The economic project investment cost was estimated by applying relevant conversion factors to the components of financial foreign and local currency costs comprising equipment, material and labor. The total economic project cost was estimated as follows.

Economic Investment Cost of the Project

Project Area (ha)	Economic Investment Cost (Riel)	Cost Per ha (Riel)
16,925	13,884,000,000	820,000

The financial O&M cost was converted to economic value by applying relevant conversion factors to the components of financial foreign and local currency costs in the same way as the project investment costs. The O&M cost of the Project was estimated as follows.

Economic O&M Cost of the Project

Project Area (ha)	O & M Cost (Riel, Million/year)	Cost Per ha (Riel)
16,925	29.9	1,767

The replacement costs of the project facilities and equipment were estimated in the same way as applied in the above. The useful life of the gates of the Project is 25 years and their economic replacement cost was estimated as Riel 4,518.5 Million.

[1] *In October 2006, Roleang Chrey Regulator received an urgent counterweight wire replacement and supply of an additional generator. However, this was a band-aid-like treatment and its effect is assumed to last only temporarily.*

(4) Economic Evaluation Results

The economic cost and benefit stream comprising (i) the cost for project investment, O&M and replacement, and (ii) the benefit from irrigation and drainage, as well as negative benefit was prepared for the economic life of the Project. Economic internal rate of return (EIRR) and other indicators were calculated and are summarized as follows.

Economic Benefit of the Project

EIRR (%)	NPV (Riel, Million) (7% discount rate)			B/C
	Benefit	Cost	B-C	
14.8	19,779	12,133	7,646	1.6

(5) Sensitivity Analysis

The project sensitivity in terms of EIRR was analyzed in respect of changes in project cost and benefit as follows:

1) Project cost increase 30%
2) Project benefit decrease 30%
3) Project cost increase 20% and benefit decrease 20%
4) Delay of 2 years for project benefit derivation

The result of the sensitivity test is summarized as follows.

Sensitivity of the Project

Cases of Change	Change in Variation	EIRR (%)	Change in Value EIRR: 7.0 %
Base case	-	14.8	-
- Cost increased	+ 30 %	10.1	+68 %
- Benefit reduced	- 30 %	8.6	-39 %
- Cost increased & benefit reduced	+ 20 % - 20 %	8.1	-
- Delay of benefit derivation	2 years	10.8	7 years

The sensitivity test revealed that the Project is relatively more sensitive to the benefit reduction rather than cost increase, though it can accommodate considerable changes in both these variables.

B-2.10.3 Financial Evaluation

(1) Cash Flow Analysis

The cash flow analysis was made under the following conditions and on the assumption that MOWRAM will implement the Project under the financial cooperation from a foreign aid agency.

1) Loan conditions of foreign aid agency

a) Interest rate : 2.3% per year
b) Grace period : 10 years
c) Repayment period : 30 years (including grace period)
d) Items not eligible for financing are listed below.

- General administration expense
- Taxes and duties
- Purchase of land and other real property
- Compensation

- Other indirect items

2) Raising capital other than foreign loans: the national treasury will cover all the costs other than foreign-aid loans under the condition of no interest and no repayment.

Based on these conditions, the total fund requirements and internal capital amount to be raised were estimated as follows.

Capital Cost of the Project to be Raised

(Unit: Riel, Million)

Cost Items	External Loan	National Budget	Total
a) Rehabilitation and improvement of regulator and intakes facilities	11,949	-	11,949
b) Administration cost	-	1,194	1,194
c) Environmental monitoring cost	-	12	12
d) Engineering service cost	2,647	-	2,647
e) Physical Contingency	1,460	119	1,579
f) Price contingency	2,652	231	2,883
Total	18,708	1,556	20,264

As shown in above table, the loan requirement from the foreign aid agency was estimated at about Riel 18,708 Million (US$ 4.6 Million). The MOWRAM's cash flow statement to this loan amount is presented in Table IIC-10 of Appendix IIC. The annual repayment of the fund is estimated to be Riel 1,366-957 million during the repayment period from 11th to 30th year. Repayment of the fund will have to be made by subsidy from government.

(2) Farm Budget Analysis

Farm budget analysis of typical farms on net returns from paddy fields under the present 'with' and future 'without'-project condition has been made for the financial analysis of the Project. The assumptions involved in the analysis are as follows;

Assumptions for Farm Budget Analyses

	Holding size of paddy field: 0.7 ha per farm household
Subject of Analysis	Net return from paddy field under without-project condition
Without-project & Present (with-project) Farm Net Return from Paddy Field	Present (with-project) & without-project crop budgets are applied for estimation

The results of the analyses are summarized in the following table.

Results of Farm Economic Analyses (unit: Riel)

Zone/Project	1. Present (with-project) Net Return from Paddy Field per Farm	2. Without-project Net Return from Paddy Field per Farm	Increment (saving of the loss) per farm (1 – 2)
Zone-1 [1/]			
- the Project	791,000	424,000	367,000
- UNMC	552,000	417,000	135,000
- USMC	486,000	417,000	68,000
Zone-2	469,000	417,000	51,000

[1/]: *Irrigated Agricultural Improvement Model Project*
Upper North Main Canal Irrigated Agricultural Improvement Project (UNMC)
Upper South Main Canal Irrigated Agricultural Improvement Project (USMC)

As shown in above table, the anticipated incremental net return, i.e. return to-be-saved from losses caused by complete malfunctioning of the regulator, from paddy fields under the with-project condition are estimated in the range of Riel 367,000 to 51,000 per farming household. In terms of proportion, it can be expressed that from 46 to 10% of the total farming income per household are at stake with the impending malfunctioning of the regulator.

B-2.10.4 Socio-economic Impacts

The primary objective of the Project is to prevent the impending malfunctioning of the existing irrigation facilities and the subsequent negative repercussions from occurring. While the anticipated negative impacts on agricultural production in quantitative terms have been discussed in previous chapters, other impacts that should be paid attention also exist since the Roleang Chrey Regulator deeply relates to the daily livelihoods of the residents in the Project Area.

(1) Poverty Incidence

It is not difficult to imagine that the poverty incidence in the Project Area will rise due to the (in some parts, drastically) decreased agricultural production. Poverty incidence affects not only those households but also society as a whole, for its integrity as well as security.

(2) Household Water Supply

Not a small number of the populace in the Project Area rely heavily or partially on the water flowing in the canal diverted from Roleang Chrey Regulator for their daily lives. Therefore the population to face the household water shortage due to the regulator's malfunctioning is considered to be large. This negative impact not only affects the convenience aspect of their lives in relation to water, i.e. washing, etc. but also for their health status. Unhygienic living conditions to be created by the water shortage, especially during the dry season would affect the illness rates in the Project Area.

(3) Gender Aspect

The water shortage to be caused by the malfunctioning of the regulator would also influence the gender relationships in the Project Area. Women in the Project Area are charged with relatively higher responsibility for household affairs than men and spend more time dealing with household water needs. Therefore the household water shortage may directly and immediately put additional burdens on women in the Project Area.

(4) Fishes as Supplementary Protein Source

Catching of fishes, especially small fishes along the canal is a quite popular daily activity in the Project Area, and is considered to be an important supplementary source of protein. Malfunctioning of the regulator would severely influence this activity, too.

As discussed above, "maintaining" the present condition and preventing the anticipated negative impacts from occurring by the implementation of the Project has a special significance for the social and economic welfare of the people in the Project Area.

Moreover, its significance encompasses, not only maintaining the present status but also is the foundation stone for future improvements of the various connected irrigation blocks. Implementation of this Project is the precondition for preserving the area's agricultural potential that one day in the future may come into blossom for the further improvement of the socio-economic welfare of the populace.

B-2.11 Conclusion and Recommendations

B-2.11.1 Conclusion

The feasibility study revealed that the Project is technically feasible and economically viable. From the social and natural environmental viewpoints, it is also justified that the Project is sound as a whole. Execution of the Project could accomplish the following principle objectives: i) stable water supply to 16,700 ha of agricultural land, ii) contribute

to mitigation of flooded areas by proper gate operation and iii) ensuring of reliable water release to downstream areas. Thus, it is concluded that the Project should be implemented in the manner proposed in the Study.

B-2.11.2 Recommendations

(1) Need of Urgent Implementation of the Project

The Roleang Chrey Regulator, Andong Sla and Vat Krouch Intakes are key structures for irrigated agriculture development in the Target Area in the Prek Thnot River basin. Nevertheless, these structures are not currently functioning well mainly due to their deterioration, and are anticipated to get worse in the near future. If these structures malfunction, needless to say, irrigation water could not be supplied to the fields. Their malfunction would seriously influence the flood control if the sluiceway gates are unable to open, as well as water supply for agriculture, and bring about inundation to the upstream area. In order to avoid such unsuitable situation, it is recommended that The Roleang Chrey Regulator, Andong Sla and Vat Krouch Intakes should be improved urgently.

(2) Strengthening of O&M

Proper O&M is indispensable for Roleang Chrey Regulator, Andong Sla and Vat Krouch Intakes since their major parts are hydro-mechanical facilities. Present O&M for them is, unfortunately, inadequate mainly due to financial and institutional constraints. This means that sustainability of them could not be ensured. It is thus recommended that the required budget for O&M for them should be arranged. To appropriate a part of the irrigation service fees might be one way after the planed irrigated agriculture development is in full operation. On the other hand, the Kampong Speu PDOWRAM, the responsible agency for O&M, has no office for O&M for Roleang Chrey Regulator, Andong Sla or Vat Krouch Intakes. In consideration of the importance of them, it is recommended that an office aiming at O&M for Roleang Chrey Regulator, Andong Sla and Vat Krouch Intakes should be established in the kampong Speu PDOWRAM, and then at least one mechanical engineer and one electrician should be assigned.

(3) Establishment of Communication System between Peam Khley Observation Station and Roleang Chrey Regulator Site

Proper gate operation at Roleang Chrey Regulator, Andong Sla and Vat Krouch Intakes is indispensable for effective use of the limited water source and also for timely management against floods. In particular, flood control needs to be made based on the information on flood condition in the upstream reaches. At present, there is a water level observation station at Peam Khley, about 14 km upstream from the Roleang Chrey Regulator. The water level data observed at Peam Khley is very useful for gate control at Roleang Chrey Regulator. Thus, it is necessary to keep close communication between the Peam Khley observation station and the Roleang Chrey Regulator site. As a method of communication, use of a movable phone is recommended.

PART-B: ROLEANG CHREY REGULATOR AND INTAKES IMPROVEMENT PROJECT

Tables

Table B-1.1.1 Discharge Measurement Records

1. Peam Khley		2. Thnous Luong		3. Krang Chek		4. Chneang Kpous		5. Sangkea Tasal		6. Roleang Chrey	
H(m)	Q(m^3/s)	H(m)	Q(m^3/s)	H(m)	Q(m^3/s)	H(m)	Q(m^3/s)	H(m)	Q(m^3/s)	H(m)	Q(m^3/s)
1.70	4.71	1.90	2.53	2.00	1.12	0.69	0.14	1.31	1.59	3.11	1.52
1.23	6.21	2.21	5.74	2.10	1.72	1.25	1.44	1.18	0.97	3.50	4.46
1.80	5.63	1.91	3.21	2.98	6.27	1.26	1.50	4.36	52.89	3.31	2.30
3.34	40.88	3.59	69.77	2.60	3.86	4.23	8.80	1.49	2.98	5.63	77.09
2.05	10.23	1.80	1.22	2.59	4.11	1.85	2.66	1.70	6.66	3.10	0.91
3.05	51.84	2.85	22.90	3.00	10.00	2.80	7.68	2.10	11.43	4.34	28.26
2.00	8.37	2.02	4.36			1.78	3.00	2.65	16.47	3.40	3.72
5.50	415.44	3.25	50.74			6.86	22.32	6.38	863.30	5.13	28.03
4.40	117.20	2.95	32.28			4.15	10.73	2.10	11.43	4.50	43.76
5.00	197.10	7.80	1647.36			5.35	16.38	2.31	12.42	10.99	2133.13
3.30	52.94	3.38	73.13			3.11	6.78	3.77	37.39	5.45	47.45
2.82	26.44	3.64	73.89			2.44	4.97	3.44	34.99	5.93	105.20
3.92	76.89	3.25	49.65			3.45	7.59	2.00	7.25	5.51	79.68
3.59	60.00	3.14	40.95			3.05	6.24	4.37	49.60	5.22	47.79
4.15	105.45	3.64	68.91			4.90	16.17	4.24	44.29	6.07	96.12
3.77	70.21	3.55	72.76			4.04	11.58	4.27	45.79	5.80	39.08
3.45	59.37	3.22	37.84			3.81	10.82	1.83	5.03	4.94	34.23
2.65	22.66	2.94	29.28			2.60	4.88	1.49	3.04	4.55	29.61

Table B-2.9.1 Investment Cost

(Unit : '000)

Item		Roleang Chrey	
		US$	Riel
(1)	Engineering service cost	652	2,647,120
(2)	Direct construction Cost		
	Roleang Chrey Regulator	1,877	7,620,620
	Inlet at Roleang Chrey Regulator	113	458,780
	Andong Sla Intake	482	1,956,920
	Vat krouch Intake	399	1,619,940
	Approach canal of south main canal	72	292,320
	sub-total	2,943	11,948,580
(3)	Administration cost	294	1,193,640
	Sub-total (1)+(2)+(3)	3,889	15,789,340
(4)	Environmental monitoring cost	3	12,180
	Sub-total (1)+(2)+(3)+(4)	3,892	15,801,520
(5)	Physical contingency	389	1,579,340
(6)	Price Contingency	710	2,882,600
	Total	**4,991**	**20,263,460**

Table B-2.9.2 Annual Disbursement Schedule of Investment Cost

(Unit : '000)

Description		2007		2008		2009		2010		Total	
		US$	Riel	US$	Riel	US$	Riel	US$	Riel	US$	Riel
(1)	Engineering service cost	130	527,800	196	795,760	163	661,780	163	661,780	652	2,647,120
(2)	Direct construction cost	0	0	147	596,820	1,618	6,569,080	1,176	4,774,560	2,941	11,940,460
(3)	Administration cost	0	0	15	60,900	161	653,660	118	479,080	294	1,193,640
(4)	Environmental monitoring cost	0	0	1	4,060	1	4,060	1	4,060	3	12,180
(5)	Contingency										
	1) Physical contingency	13	52,780	36	146,160	194	787,640	146	592,760	389	1,579,340
	2) Price Contingency	0	0	27	109,620	210	852,600	243	986,580	480	1,948,800
Total		**143**	**580,580**	**422**	**1,713,320**	**2,347**	**9,528,820**	**1,847**	**7,498,820**	**4,759**	**19,321,540**

Table B-2.9.3 Replacement Cost

(Unit : '000)

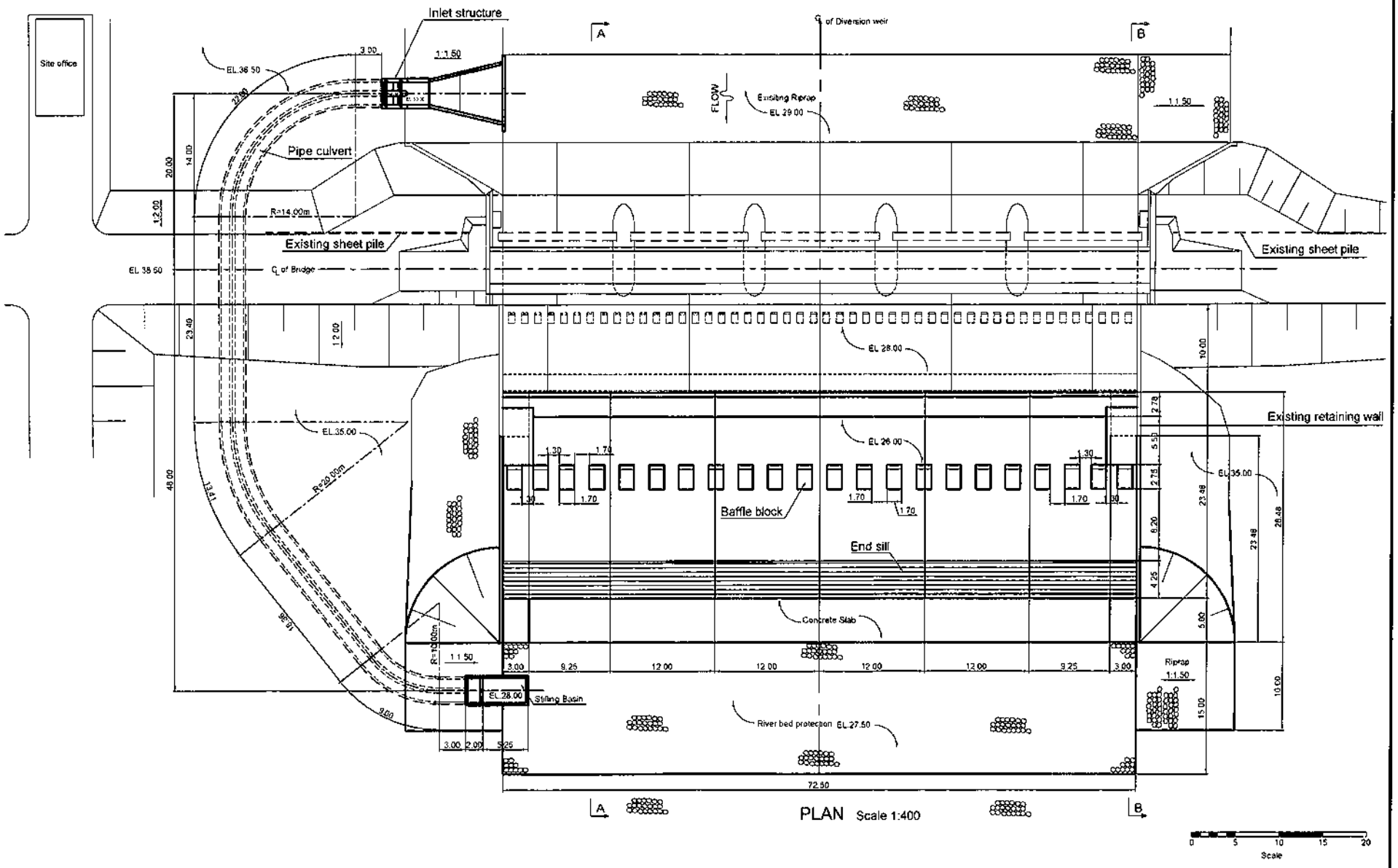
Item		Unit	Quantity	Unit price	Amount	
					US$	Riel
(1) Roleang Chrey Regulator	Gate leaf	nos.	5	122,400	428.4	1,739,304
	Hoist	nos.	5	180,000	630.0	2,557,800
	Local control panel	nos.	5	21,500	75.3	305,718
	Remote control panel	nos.	1	21,200	14.8	60,088
	Diesel generator	nos.	1	30,200	21.1	85,666
	Spare parts	set	1		11.2	45,472
	Total				1,180.8	4,794,048
(2) Andong Sla Intake	Local control panel	nos.	2	26,500	37.1	150,626
	Remote control panel	nos.	1	21,200	14.8	60,088
	Transmission line	km	1.0	40,000	28.0	113,680
	Spare parts	set	1		5.6	22,736
	Total				85.5	347,130
(3) Vat Krouch Intake	Local control panel	nos.	2	26,500	37.1	150,626
	Remote control panel	nos.	1	21200	14.8	60,088
	Transmission line	km	1.8	40,000	50.4	204,624
	Spare parts	set	1		5.6	22,736
	Total				107.9	438,074

Table B-2.9.4 O&M Cost

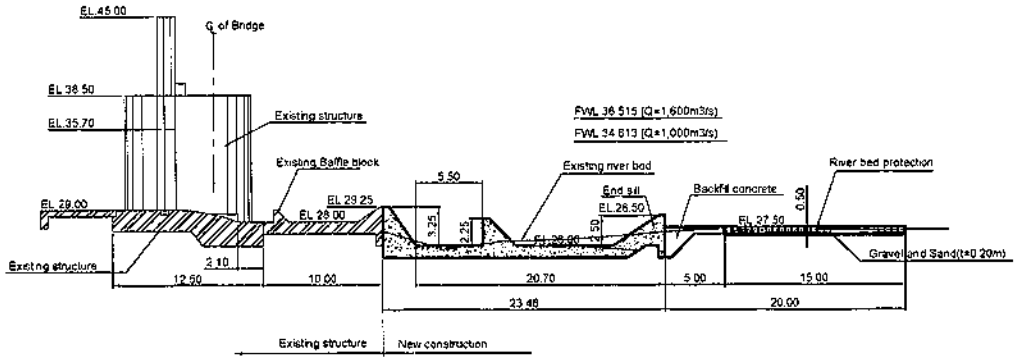
Item		Cost / year	
		US$	Riel
1. Hydro-mechanical works			
(1) Personal expense	Mechanic	390	1,583,400
	Electrician	390	1,583,400
	Operator	360	1,461,600
	sub-total	1,140	4,628,400
(2) General expense		162	657,720
(3) Cost of consumables	Fuel	702	2,850,120
	Lub.Oil	114	462,840
	Grease	180	730,800
	sub-total	996	4,043,760
(4) Repair cost	Roleang Chrey Regulator	3,250	13,195,000
	Andong Sla Intake	450	1,827,000
	Vatkrouch Intake	450	1,827,000
	sub-total	4,150	16,849,000
Total 1.		6,448	26,178,880
2. Civil works		1,806	7,332,360
3. Daily Inspection	200days/year	1,060	4,303,600
Total (1. +2. +3.)		9,314	37,814,840
	=	9,300	37,758,000

PART-B: ROLEANG CHREY REGULATOR AND INTAKES IMPROVEMENT PROJECT

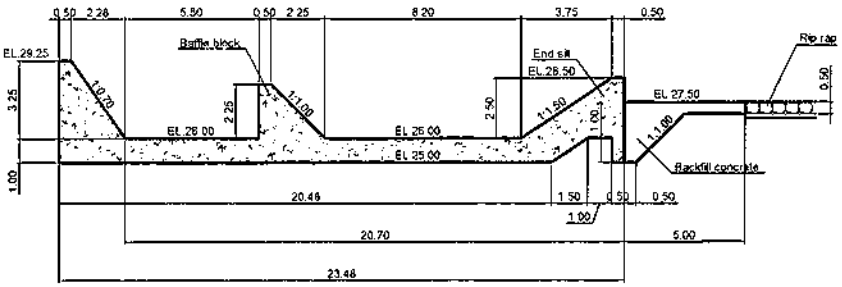
Drawings



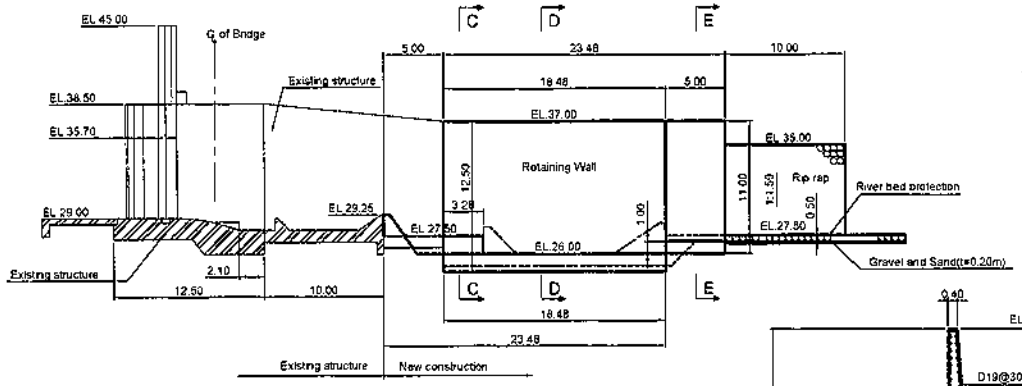
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing B-1
Japan International Cooperation Agency (JICA)	Rehabilitation of Roleang Chrey Regulator (1/2)



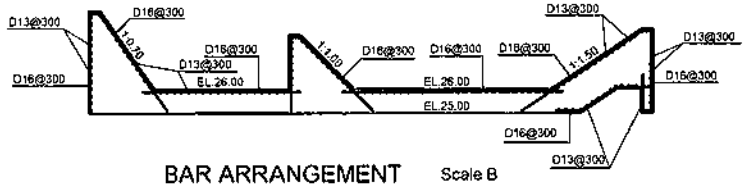
SECTION A - A Scale A



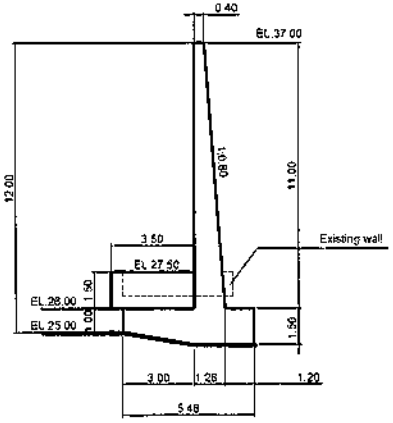
DETAIL Scale B



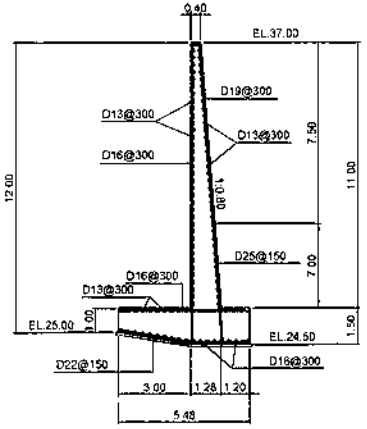
SECTION B - B Scale A



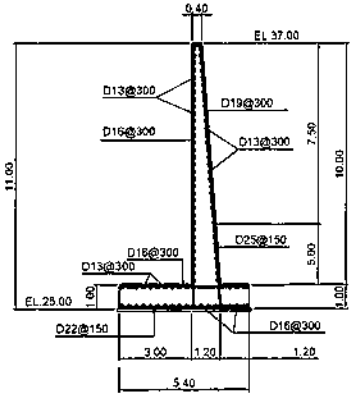
BAR ARRANGEMENT Scale B



SECTION C - C Scale B

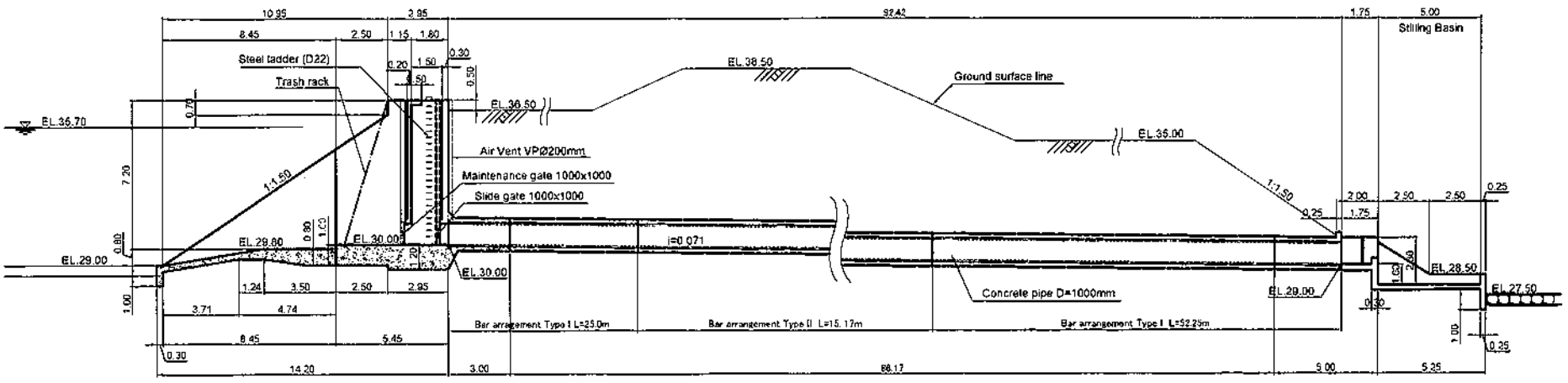


SECTION D - D Scale B

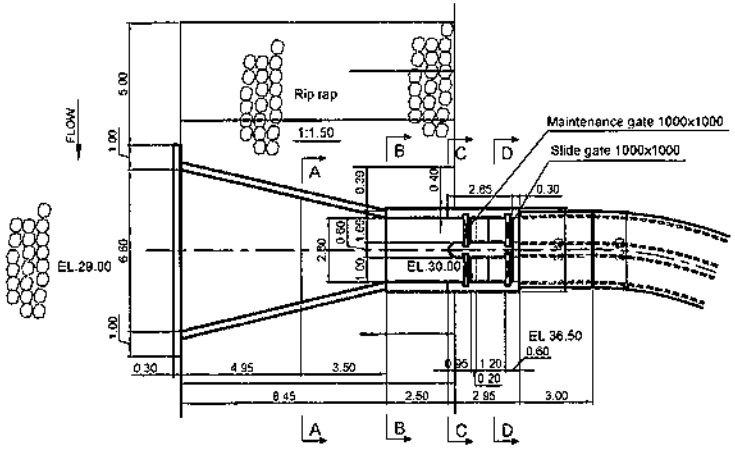


SECTION E - E Scale B

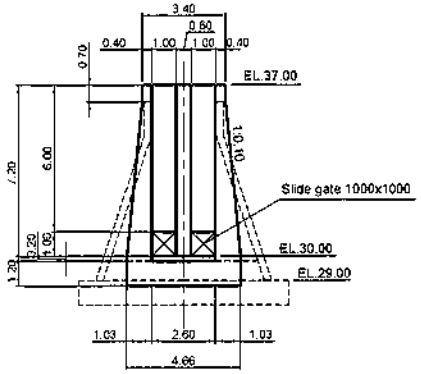
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing B-2
Japan International Cooperation Agency (JICA)	Rehabilitation of Roleang Chrey Regulator (2/2)



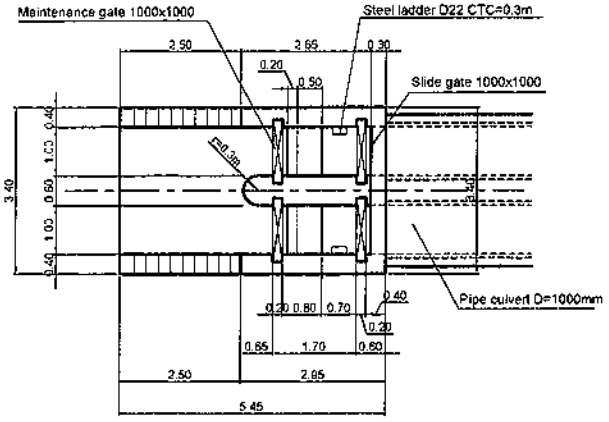
Longitudinal Section Scale A



PLAN of INLET Scale A



ELEVATION of INLET Scale A

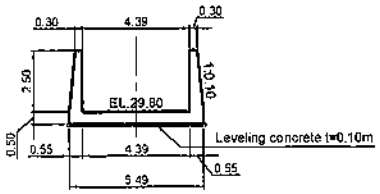


PLAN of INLET Scale B

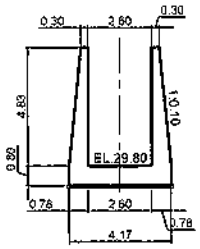
0 5 10
Scale A

0 5
Scale B

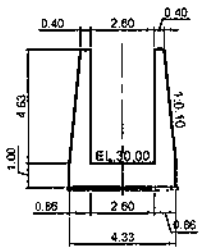
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing B-3
Japan International Cooperation Agency (JICA)	Inlet Structure at Roleang Chrey Regulator (1/2)



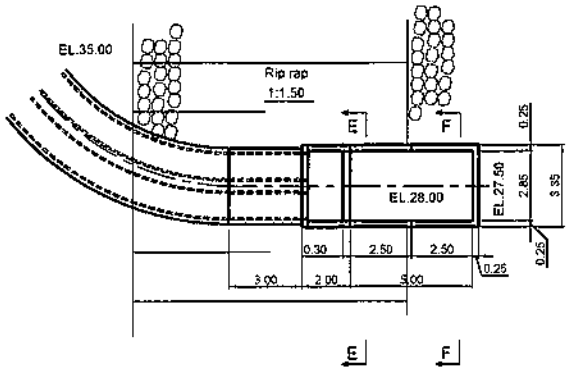
SECTION A - A
Scale A



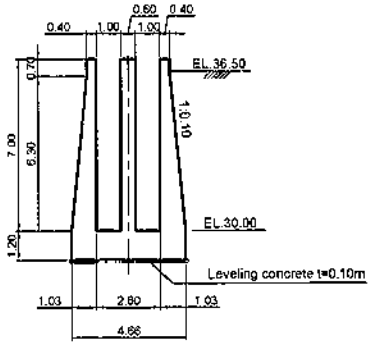
SECTION B - B(-)
Scale A



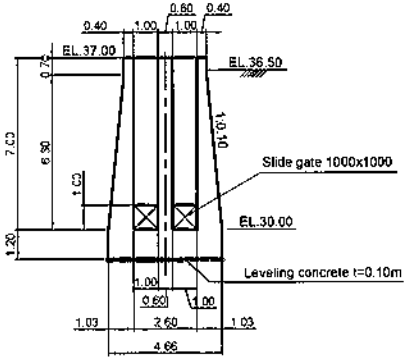
SECTION B - B(+)
Scale A



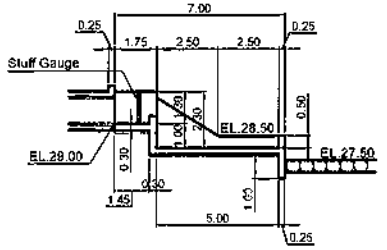
PLAN of STILLING BASIN Scale A



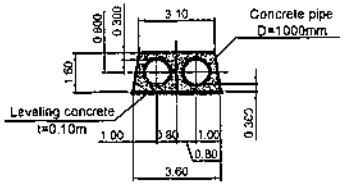
SECTION C - C
Scale A



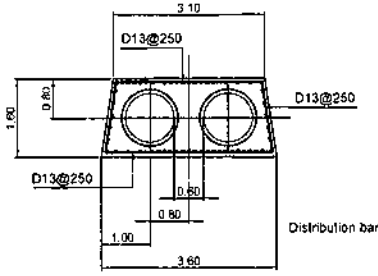
SECTION D - D
Scale A



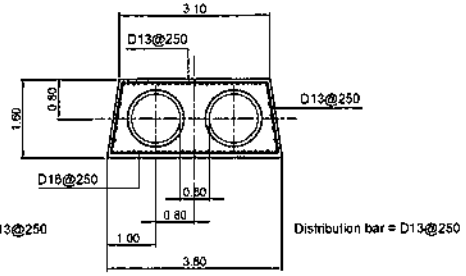
STILLING BASIN Scale A



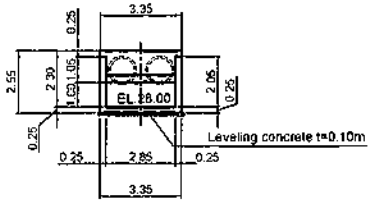
PIPE CULVERT
Scale A



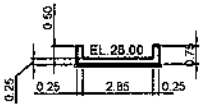
Culvert Type I Scale B



Culvert Type II Scale B



SECTION E - E
Scale A



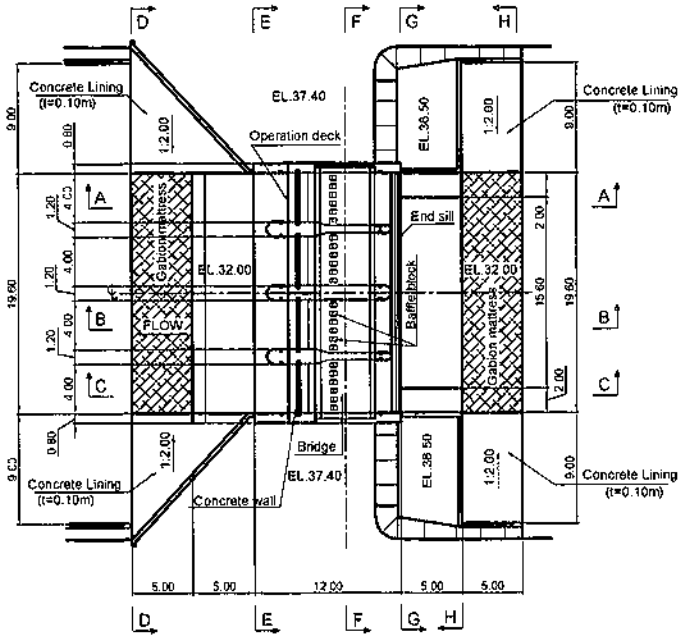
SECTION F - F
Scale A

Scale A: 0 5 10
Scale B: 0 5

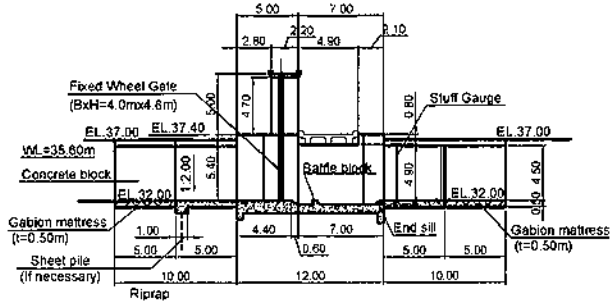
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing B-4
Japan International Cooperation Agency (JICA)	Inlet Structure at Roleang Chrey Regulator (2/2)

III - BD - 5

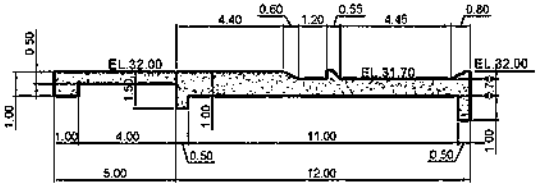
INTAKE STRUCTURE



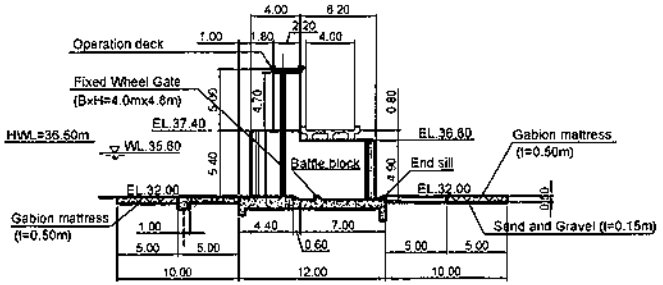
PLAN Scale A



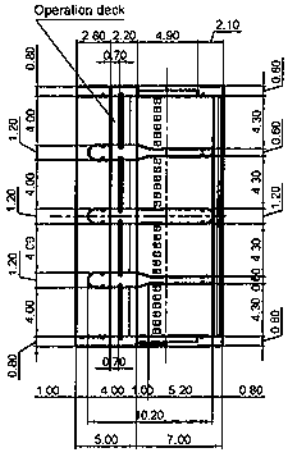
SECTION A - A Scale A



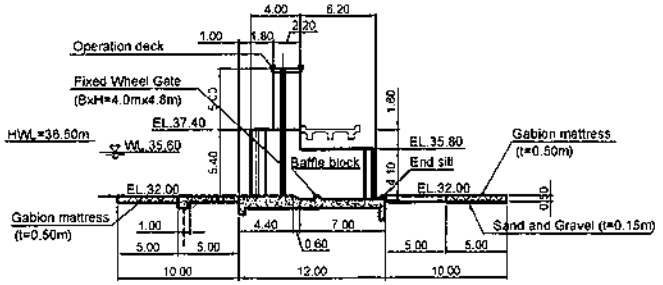
DETAIL Scale B



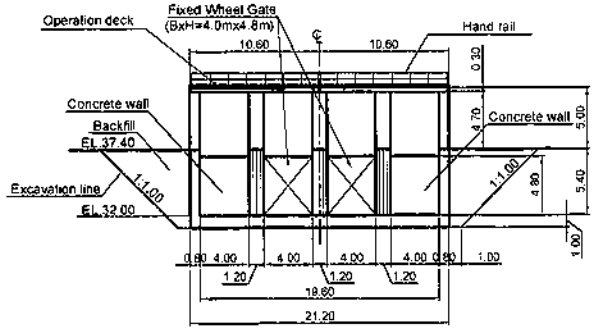
SECTION B - B Scale A



Scale A



SECTION C - C Scale A



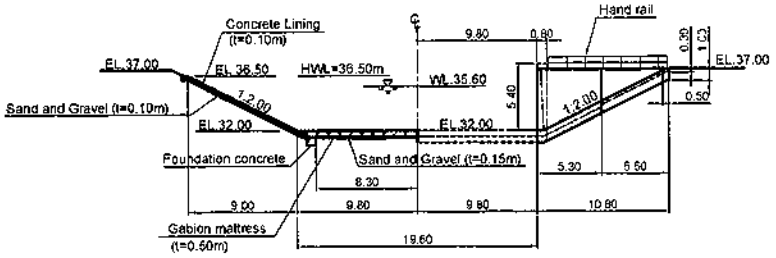
SECTION E - E Scale A

0 5 10 15 20
Scale A

0 5 10
Scale B

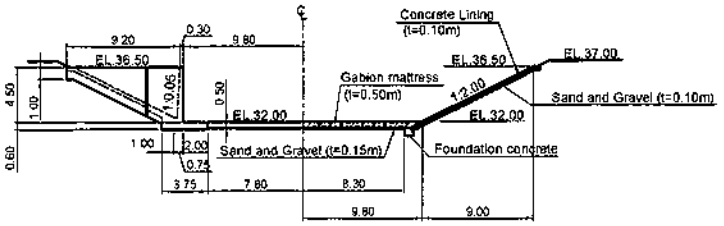
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing B-5
Japan International Cooperation Agency (JICA)	Andong Sla Intake Structure for North Main Canal (1/2)

INTAKE STRUCTURE



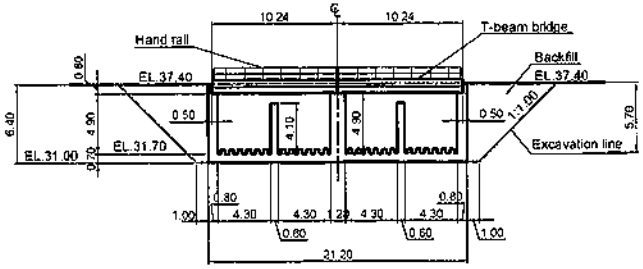
SECTION D - D

Scale A



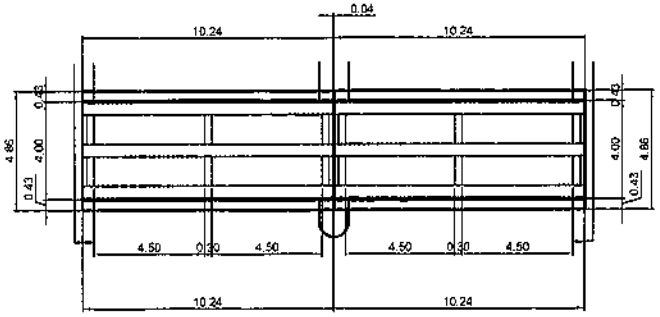
SECTION H - H

Scale A



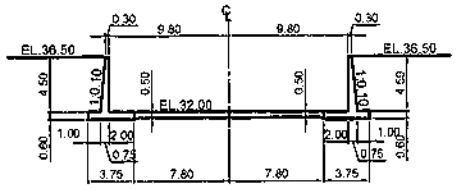
SECTION F - F

Scale A



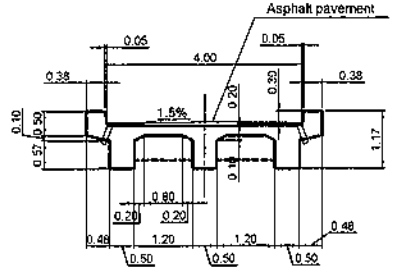
PLAN of BRIDGE

Scale B



SECTION G - G

Scale A



SECTION of BRIDGE

Scale C

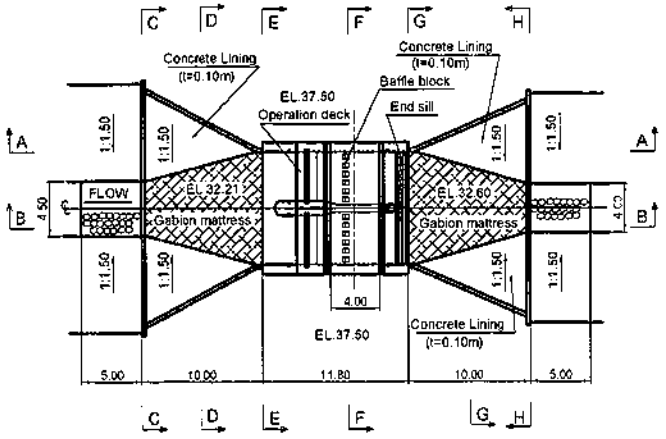
0 5 10 15 20
Scale A

0 5 10
Scale B

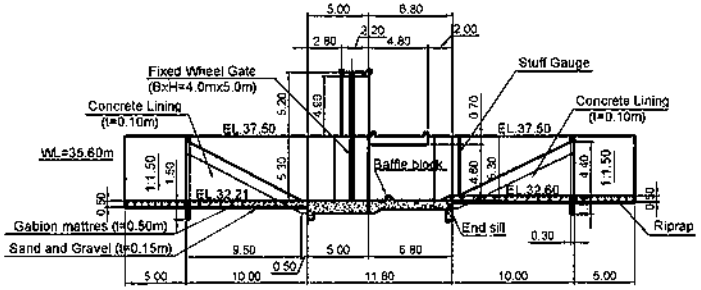
0 5
Scale C

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing B-6
Japan International Cooperation Agency (JICA)	Andong Sla Intake Structure for North Main Canal (2/2)

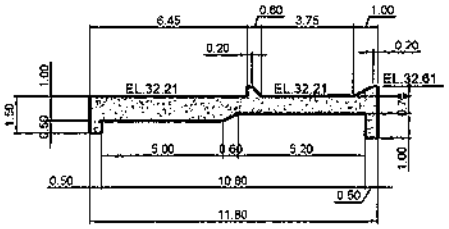
INTAKE STRUCTURE



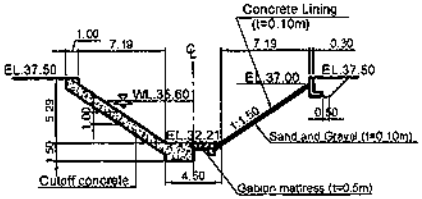
PLAN Scale A



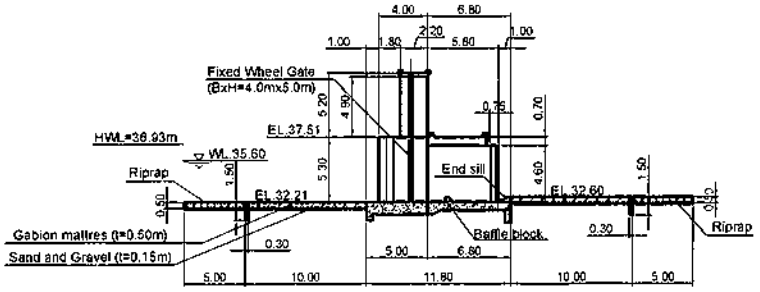
SECTION A - A Scale A



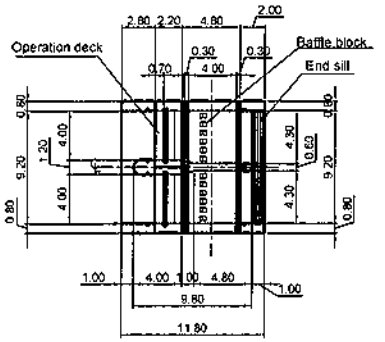
DETAIL Scale B



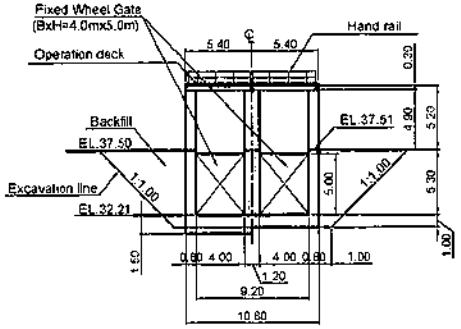
SECTION C - C Scale A



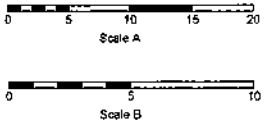
SECTION B - B Scale A



PLAN Scale A



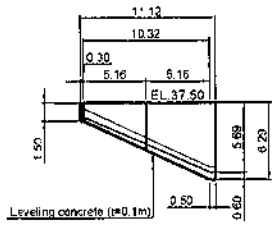
SECTION E - E Scale A



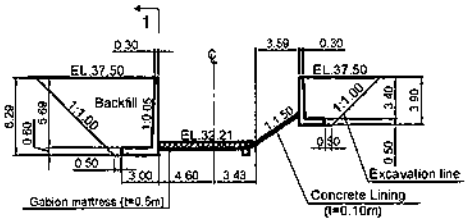
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing B-7
Japan International Cooperation Agency (JICA)	Vat Krouch Intake Structure for South Main Canal (1/2)

III - BD - 7

INTAKE STRUCTURE



SECTION 1 -1
Scale A



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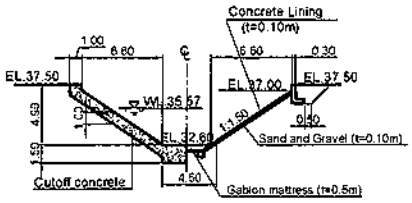

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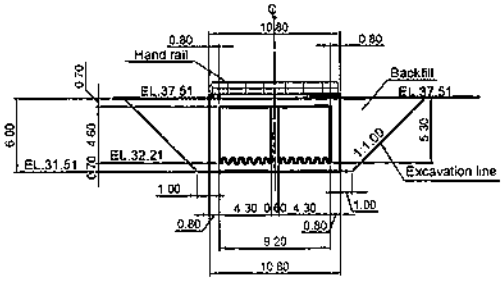
Scale A



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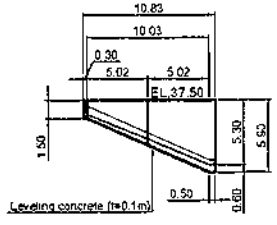
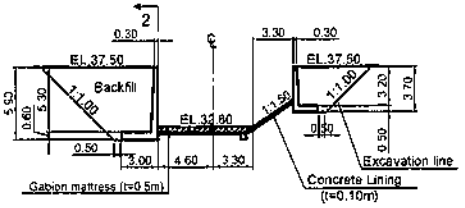


SECTION 2 -2
Scale A



SECTION G - G
Scale A

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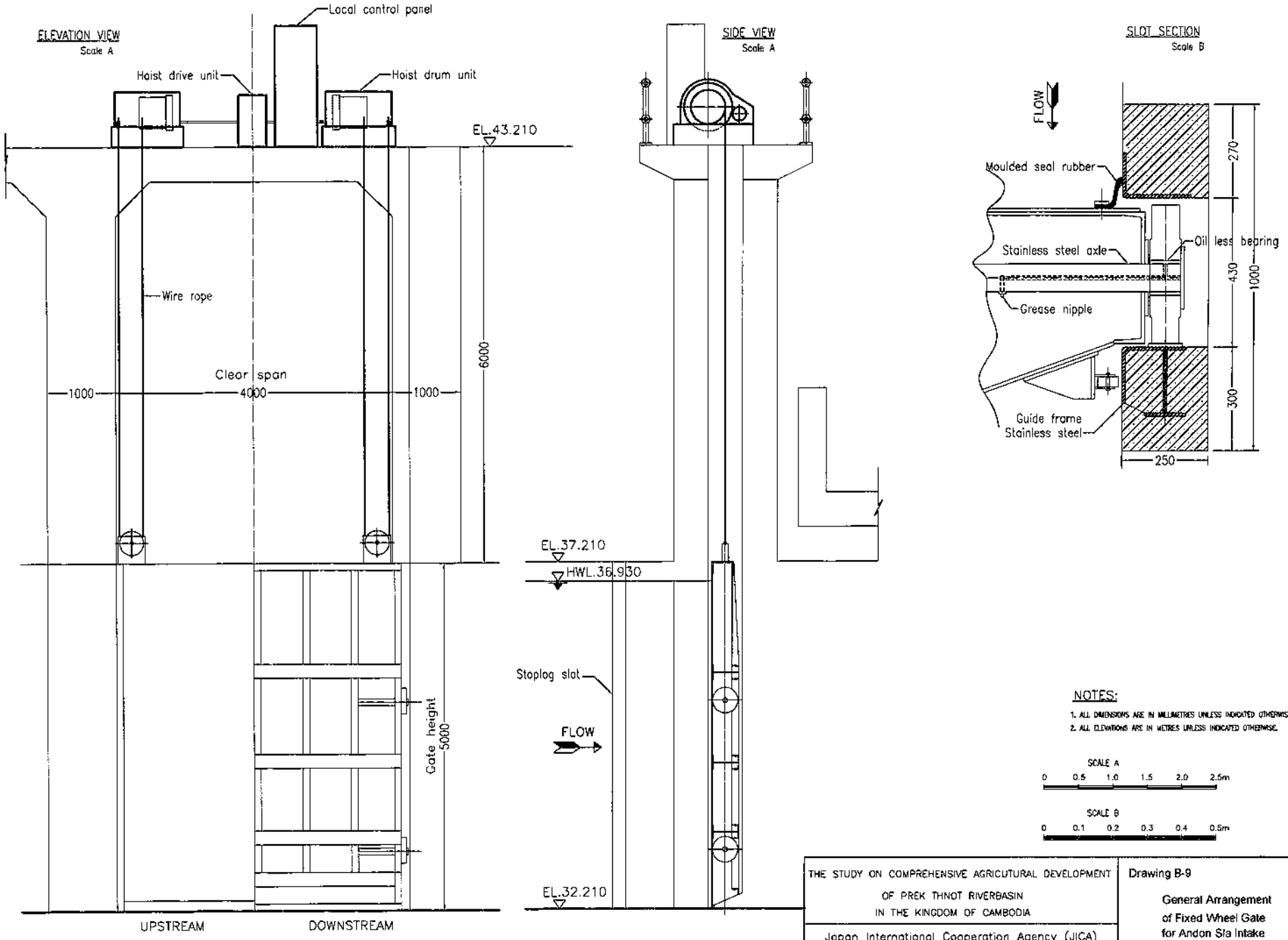
Scale 1:400

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing B-8
Japan International Cooperation Agency (JICA)	Vat Krouch Intake Structure for South Main Canal (2/2)



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS INDICATED OTHERWISE.
2. ALL ELEVATIONS ARE IN METRES UNLESS INDICATED OTHERWISE.

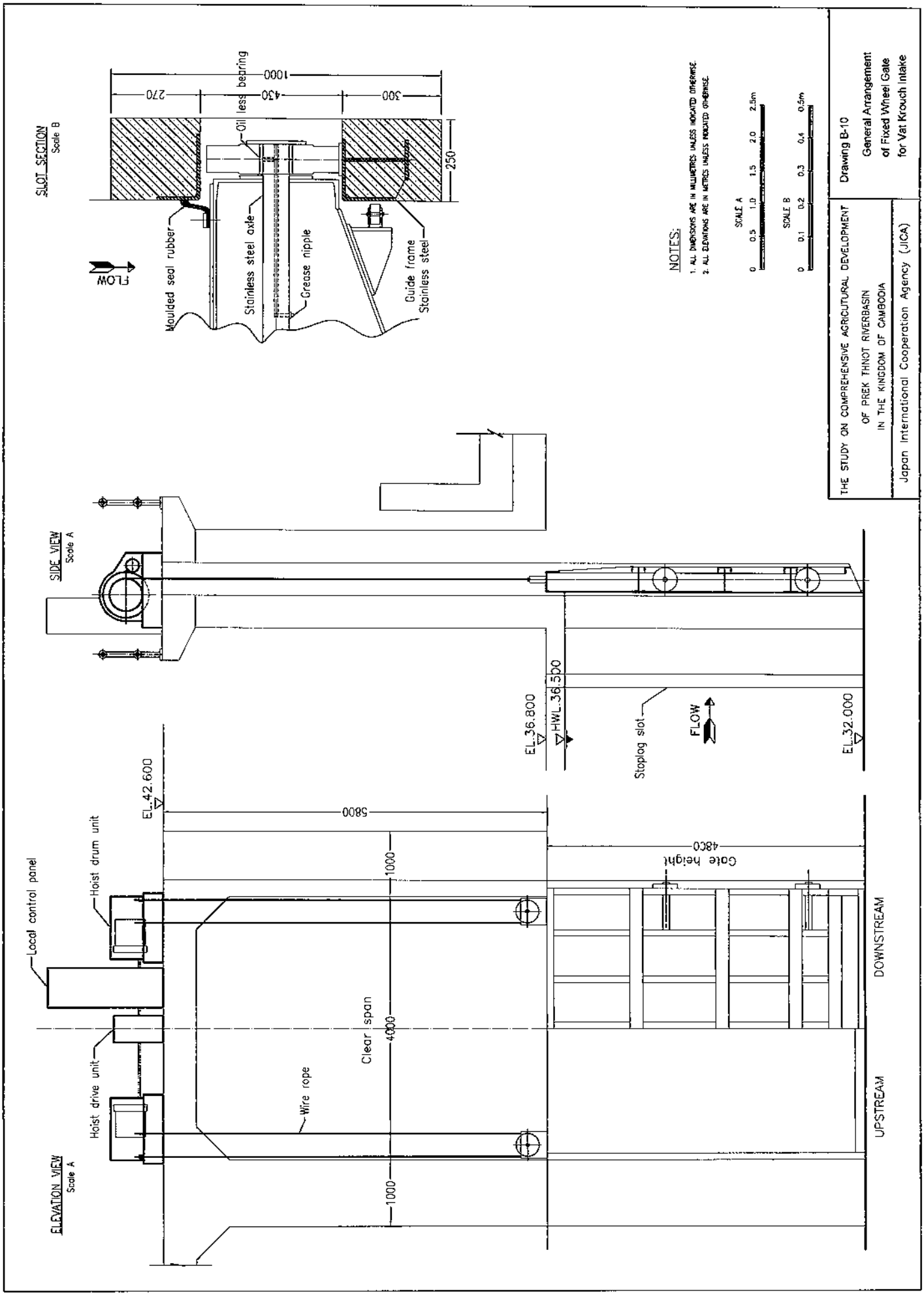
SCALE A

0 0.5 1.0 1.5 2.0 2.5m

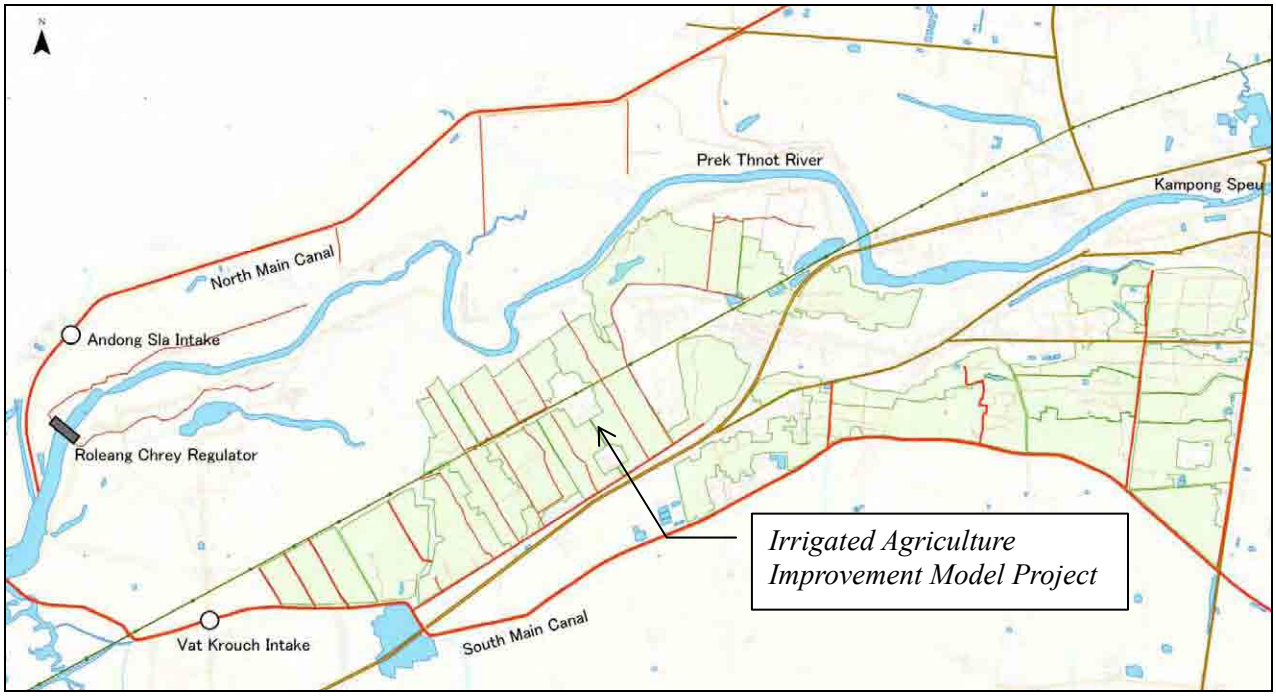
SCALE B

0 0.1 0.2 0.3 0.4 0.5m

THE STUDY ON COMPREHENSIVE AGRICUTURAL DEVELOPMENT OF PREK THNOT RIVERBASIN IN THE KINGDOM OF CAMBODIA	Drawing B-9
Japan International Cooperation Agency (JICA)	General Arrangement of Fixed Wheel Gate for Andon Sla Intake


SLOT SECTION
Scale B
1000
270
430
300
Oil less bearing
250
FLOW
Moulded seal rubber
Stainless steel axle
Grease nipple
Guide frame Stainless steel
NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS INDICATED OTHERWISE
2. ALL ELEVATIONS ARE IN METRES UNLESS INDICATED OTHERWISE
SCALE A
0 0.5 1.0 1.5 2.0 2.5m
SCALE B
0 0.1 0.2 0.3 0.4 0.5m
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVERBASIN IN THE KINGDOM OF CAMBODIA
Japan International Cooperation Agency (JICA)
Drawing B-10
General Arrangement of Fixed Wheel Gate for Vat Krouch intake
SIDE VIEW
Scale A
EL.36.800
HWL.36.500
Stoplog slot
FLOW
EL.32.000
EL.42.600
5800
1000
4800
Gate height
Local control panel
Hoist drum unit
Hoist drive unit
Wire rope
Clear span
4000
1000
DOWNSTREAM
UPSTREAM
ELEVATION VIEW
Scale A

PART-C
IRRIGATED AGRICULTURE IMPROVEMENT MODEL PROJECT



PART-C: IRRIGATED AGRICULTURE IMPROVEMENT MODEL PROJECT

Chapter C-1 The Project Area

C-1.1 Present Physical Conditions

C-1.1.1 Location

The Irrigated Agriculture Improvement Model Project (the Project) is located about 25 km west of Phnom Penh. The Project Area extends over the right riparian area of the Prek Thnot River, being sandwiched between the river and the upstream portion of the South Main Canal. The national road Route No.4 runs across the area.

C-1.1.2 Topography

The Project Area is a strip area along the Prek Thnot River developed as paddy fields and with approximately a 1:2,000 slope from west to east.

C-1.1.3 Meteorology

The Project Area is characterized as having a tropical monsoon climate with a definite rainy season from May to October and a dry season from November to April. Mean temperature shows small seasonal variation from 26.1℃ in December to 30.5℃ in April. Relative humidity ranges from 66% to 77% in February and March and 80% to 90% in September and October.

C-1.1.4 Soils and Land Suitability

Soils found in the Project Area are almost exclusively medium textured (SL) surface layers underlain with finer textured sub-soils, however, the distribution of a limited extent of surface soils with medium to fine or coarse textured are also identified. The distributions of the soils in the Project Area are shown in Figure C-1.1.1 and below.

Soil Distribution and Land Suitability in Project Area

Soil Type	Distribution		Land Suitability Class
	(ha)	(%)	
Gleyic Acrisol Coarse to Medium Textured Phase (GAm1)	327	54.5	S3
Gleyic Acrisol Medium Textured Phase (GAm2)	129	21.5	S2
Gleyic Acrisol Medium to Fine Textured Phase (GAf)	143	23.9	S2
Gleyic Acrisol Coarse Textured Phase (GAc)	1	0.2	S3C
Total	**600**	**100**	**S3**

Source: JICA study team

As shown in the table, 45.5% of the Project Area consists of GAm2 and GAf, which are classified as moderately suitable (S2) for crop production and 54.5% of the Project Area is GAm1, which is marginally suitable (S3). A limited area of GAc (0.2%) is classified as critical (S3C).

Chemical properties of the surface layers of the major soils are: i) slight acid reaction, ii) very low content of N & C, iii) low CEC & dystric exchangeable base saturation and iv) low content of exchangeable Ca, Mg & K. However, the soil analyses indicate high content of available P_2O_5 in both surface and sub-surface layers of all the soils.

C-1.2 Present Socio-economic Conditions

C-1.2.1 Administration and Population

The Project Area is administratively related to 18 villages, 3 communes, and 2 Districts in Kampong Speu Province.

According to the SEILA Commune Database, 2005, the population of the Project Area was 10,205. Out of that population, the working population, which means the population of 15 to 64 years old, was 6,111 in total.

Detailed information on the administration and population in the Project Area is shown below.

Administration and Population in Project Area

District	Commune	Village	Population	Working Population*
Chabar Mon	Kandaol Dom	Rumeleang	720	411
		Pongro	593	293
		Nhor	895	538
		Kandaol Dan	609	422
		Trapeang Preah	529	330
		Kab Tuk	344	220
		Srae Thnal	391	227
	Svay Kravan	Svay kravan	687	389
		Phsar Chas	984	691
		Thnal Bambaek	660	402
		Prey Kdei	594	367
		Tras	350	224
Samraong Tong	Kahaeng	Tumpung	705	352
		Roleang chrey	492	297
		Kouk Rumlich	235	156
		Kahaeng	436	275
		Bos Ta Ney	476	206
		Ou Veaeng	505	311
Total			10,205	6,111

Source: SEILA Commune Data Base 2005

** : 15 to 64 years old*

C-1.2.2 Food Supply Conditions

From the current features of land use, cropping patterns and land holding status, a surplus production of rice but an insufficient supply of other food crops for home use are predicted. The rice balance of the Project Area has been examined by way of examining the rice balance of an average farm family based on the Socio-economic Survey result as shown below.

Rice Balance of an Average Family in the Project Area

Average Family Size	Paddy Requirements (kg)			Paddy Production (kg) Season				Surplus (kg)
	/capita	/family (net)	/family (gross)	Rainy	Early Rainy	Rainfed	Annual	
5.1	223	1,137	1,307	1,380	504	456	2,340	1,033

As shown, the surplus paddy production of 1,033 kg/farm family or the paddy surplus of about 44% of total production are estimated in the average farm family in the Project Area.

The survey results also indicated the food supply conditions in the Project Area as shown below.

Food Supply Conditions in Project Area

Food	Proportion of Responses 1/		
	a. Surplus Production	b. Sufficient Production	c. Insufficient
Rice	72%	20%	9%
Beans	-	-	100%
Other cereals	1%	-	99%
Vegetables	5%	3%	92%

1/: a :household produced products exceed household demand b: household produced products just satisfy the household demand

c purchased to meet the household demand or insufficient

As shown, over 90% of the sampled farmers (100 samples) reported surplus or sufficient production of rice. However, production of cereals, beans and vegetables is extremely limited compared with household demands. The promotion of upland crops primarily aiming at fulfilling family consumption and secondary to market surplus through the introduction of such crops in the early rainy season should be implemented.

C-1.2.3 Poverty Status

The data gathered by the Socio-Economic Survey for the Project Area was processed to work out the daily income and expenditure per capita among sampled household population. As a result, the following figures were obtained.

Daily Income and Expenditure Per Capita of Sampled Population

Income Strata	Average Income/ HH/Year (US$)	Average HH Pop. (No.)		Per Capita Daily Income (US$)		Per Capita Daily Expenditure (US$)	
		total	*working*	total	*working*	total	*working*
1st	2,702	6.8	*4.8*	1.22	*1.68*	0.48	*0.68*
2nd	1,209	6.1	*4.4*	0.57	*0.86*	**0.37**	*0.54*
3rd	762	5.6	*3.6*	0.43	*0.69*	**0.29**	*0.46*
4th	504	4.7	*3.2*	0.34	*0.50*	**0.29**	***0.43***
5th	328	4.4	*2.6*	0.24	*0.43*	**0.21**	***0.38***

Source: Socio-Economic Survey (for Project Area) Results, November 2006

In the above Table, 100 sampled households were divided into 20 household intervals from the highest income household to the lowest, in order to form 1st to 5th income strata. The figures obtained in Cambodian Riels were converted into US Dollars with the current effective exchange rate (Riel 4,000 = 1 US$ widely practiced in daily lives).

Applying the poverty line (equal to per capita daily expenditures of US$ 0.46, as set for Cambodian rural areas by the Poverty Profile of Cambodia 1999) to the above Table, all strata except the 1st stratum (US$ 0.48/person/day) fall below the poverty line. However, since the survey questionnaires might not have captured all the household expenditures due to the way it asked about expenditures on selected items, the above figures are more than probably an underestimation.

Just for reference, "per working-family-member expenditures per day" instead of per capita, were worked out and shown in *italics* in the above Table. With this method, the strata averages that fall below the poverty line are reduced to the 4th and 5th strata. We cannot say for certain but this picture is considered to be relatively closer to reality.

C-1.2.4 Gender Aspect

The Socio-Economic Survey of the Project Area indicated that as far as the sampled households are concerned, there exist no serious gender problems. However, to some extent, male/female differences over "control" of the resources exist. For example, while females' "access" to the resources such as water, residential and farm land, and livestock, are not constrained, there are some restriction on females' "control" over residential and

farmland (though less than 18% of females' responded).

When looking at the main activities of both sexes a contrast appears as females are taking charge of both income generation as well as household responsibilities, while males are concentrating on income generation activities.

Females' and Males' Main Activities

	Females' Main Activities	n	%		**Males'** Main Activities	n	%
1	Farming	75	39	1	Farming	82	54
2	Housekeeping	43	22	2	Other (constructor, salaried worker, run business)	31	20
3	Cooking	32	16	3	Care of livestock	21	14
4	Other (garment worker, run small business)	30	15	4	Housekeeping	10	7
5	Care of children/elders	11	6	5	Cooking	4	3
6	Care of livestock	4	2	6	Care of children/elders	2	1
7	Hand crafting	0	-	6	Hand crafting	2	1
7	Making palm sugar	0	-	8	Making palm sugar	0	-
	Total	195	100		Total	152	100

C-1.2.5 Community Organizations

(1) Commune Council (CC)

The Commune is the smallest administrative unit under the Ministry of the Interior. There are three Communes in the Project Area; Kandaol Dom, Svay Kravan, and Kahaeng. Each Commune is governed by a Commune Council consisting of a Commune Chief, Deputy Commune Chief(s) and Commune Council members who are elected by Commune dwellers every three years. The latest election of a Commune Council was conducted in February 2002 according to the 18 Village Chiefs of the three Communes. The number of Commune Council members with sex ratio and their activities are summarized in the table below.

Features of Commune Council Members

Name of Commune	Nos. of Members (Male : Female)	Activities
Kandaol Dom	7 (7 : 0)	- To disseminate information to Village Chiefs and farmers - To arrange the meetings about development of agriculture and the community with Village Chiefs - To solve any kind of problems related to the Commune dwellers (roads, school, hospital, health center) - To develop and maintain the security of the Commune - To encourage the dwellers to join in the Commune development - To register births, marriages, and deaths - To arrange elections
Svay Kravan	7 (6 : 1)	
Kahaeng	7 (6 : 1)	

Source: Rapid Community Organization Survey conducted by the JICA study team

(2) Village Development Committee (VDC)

VDC is established according to the guideline approved by RGC in 1999. It is expected to be a facilitator of village wide community development. The VDC members work for village development without any payment. In the Project Area, all 18 Villages have VDC in their villages. Average number of VDC members is 4 persons (3-7 persons). The features of the VDC are i) about 86% of the VDC members are farmers, ii) 15 out of the 18 VDCs include the Village Chief, Deputy Chief, and/or Group Leaders, and iii) the members of 15 VDCs were selected by elections conducted from 2003 to 2007. Taking an example, the activities of Rumleang VDC are i) to motivate the villagers to develop

agriculture (arranging meetings about how to make a farming plan), ii) to strengthen the village security (educate gangsters and communicate frequently with police), iii) to strengthen the village solidarity, and iv) to motivate the villagers to cooperate with organizations which come to the village to give their assistance.

C-1.3 Agriculture

C-1.3.1 Land Use

The land use of the villages belonging to the Project indicates that farm land in the villages is used almost exclusively for rice fields as shown below;

Present Land Use in the Project Villages

	Rice Field		Upland Area		Others 1/		Total	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Project Villages	785	66	20	2	378	32	1,183	100

1/: Including village yards & others *Source: DAO ChbarMon/Kahaeng Commune Office*

The Project Area is irrigated rice fields with a gross area of 600 ha and a net area of 580 ha. On the basis of the detail irrigation survey conducted by the JICA study team, the Project Area was classified based on current irrigation status into two categories, i) fields irrigable for only a single cropping of rice and ii) fields irrigable for double cropping of rice as shown in the table below.

Present Land Use (irrigation Status)

Category	Area (ha)	Proportion (%)	
		To Net	To Gross
Fields irrigable for single cropping of rice	377	65	63
Fields irrigable for double cropping of rice 1/	203	35	34
Sub-total (net area)	580	100	97
Right of ways	20	-	3
Total	600 ha	-	100

1/: Including negligible extent of triple cropped area of 2ha *Source: JICA study team*

C-1.3.2 Agro-demography and Land Tenure and Holding

(1) Agro-demographic Features

The agro-demographic features of the project villages examined based on the secondary data provided by the commune offices and village-wise data of SEILA Commune Data Base 2005 are presented in the following table.

Agro-demographic Features of Project Villages

Items	Features
No. of Households (total)	1,982
No. of Farm Households	1,202
% of Farm Households to Total Households	61
%. of None Farm Households	39
Total Population	10,205
Average Family Size	5.1
Working Population (15 ~ 64 years old)	6,111
Working Population/ Household (15 ~ 64 years old)	3.1

Source: Project commune offices & SEILA Commune Data Base, 2005

As shown, farm households in the project villages account only for 61% of the total households as the 2 communes in Chbar Mon, Kandal Dom and Svay Kravan, are categorized as “urban” in SEILA data base. Average family size is 5.1 members and working population is estimated at 3.1 persons/ family.

(2) Land Tenure and Land Holding in Project Area

The results of the Socio-economic Survey indicate the land holding statuses in the Project Area as follows;

Holding Status of Rice Fields of Sampled Farmers

Land Type	No. of Respondents		Total Area	Average land holding (ha) per		Range
	No.	%	(ha)	Respondent	Sample	(ha)
Irrigated Rice Field.	100	100	61.2	0.60	0.60	0 - 4.5
Rainfed Rice Field	36	36	24.0	0.63	0.24	0 - 2.5
Total	-	-	85.2	-	0.84	-

1/: Socio-economic Survey by the JICA Study team, 2006; sample No. 100

As shown in the table, the average holding size of irrigated rice field and total rice field in the Project Area are roughly estimated at around 0.60 ha and 0.84 ha, respectively. The same survey indicated that 98% of the sample farmers in the Project Area are owner operators and share cropping of farm land is seldom practiced.

Holding size of upland fields is estimated to be negligibly limited to an average of 0.01 ha per family in the Area based on the Survey.

C-1.3.3 Crop Production in Rice Fields

(1) General

Rice production is the exclusive crop production activity in the Project Area. However, rice production in the Area could be characterized by rather low productivity even in irrigated fields and as having a prolonged rainy season rice cultivation period with the cultivation of rice varieties of different growth durations and traditional farming practices.

(2) Cropping Season and Rice Variety

Rice cropping seasons in the Area could be differentiated into: i) early rainy season rice planted in May, ii) rainy season rice planted from July to August and iii) a very limited amount of dry season rice planted from January to February.

Current predominant rice varieties grown in the Project Area are medium rice in the rainy season and non-photosensitive early rice in the dry or early rainy season. Major varieties include Riang Chey (improved medium local variety), Phka Mulis (medium local variety) and Neang Ming (late local variety) for rainy season and IR 66 for early rainy season. Currently, cultivated local varieties appear to have been selected by farmers in the past and have some characteristics suited to local agro-climatic conditions such as drought tolerance and tolerance to inundation.

(3) Cropping Calendar and Pattern

The prevailing cropping patterns in the Project Area depend on irrigation water availability and are categorized into a single cropping of rice and double cropping of rice as illustrated in Figure C-1.3.1 and as shown below.

Prevailing Cropping Patterns in Project Area

Cropping Pattern		Area (%)
Rice cropping: single	Rainy season rice – fallow	377 ha (65)
Rice cropping: double	Early rainy season rice - rainy season rice – fallow	203 ha (35)
Total	-	580 ha (100)

Source: JICA study team

Cultivation of vegetables in rice fields is practiced to a negligible extent in the dry season from December to April. Major vegetables grown include string beans, gourds and taro.

(4) Cropped Area and Cropping Intensity

The current cropped area and cropping intensity of rice in the Project Area have been estimated as shown in the following table.

Estimated Cropped Area and Cropping Intensity of Rice in the Project Area

Land Use Category	Area (ha) (net)	Indicator	Cropped Area & Intensity		
			ERS	RS	Annual
Fields irrigable for single cropping of rice	377	Cropped Area (ha)	0	377	377
		Cropping Intensity (%)	-	100	100
Fields irrigable for double cropping of rice	203	Cropped Area (ha)	203	203	406
		Cropping Intensity (%)	100	100	200
Project Area	580	Cropped Area (ha)	203	580	783
		Cropping Intensity (%)	35	100	135

As shown in the table, the current annual cropped area and cropping intensity of rice is estimated at 783 ha and 135% respectively.

(5) Paddy Yield and Production

Unit yields of paddy in the Project Area are estimated based on the Socio-economic Survey, the secondary data collected at the project commune offices and the statistical data of MAFF and PDA as shown in Table C-1.3.1 and as summarized below.

Estimated Present Paddy Yields in the Project Area

Season	Variety	Estimated Yield
Early rainy season rice	Early variety of rice	2.4 ton/ha
Rainy season rice	Medium/late variety of rice	2.3 ton/ha
Dry season rice	Early variety of rice	2.4 ton/ha

Annual production of paddy in the Project Area is estimated at 1,821 tons applying the estimated cropped area and unit yields as follows;

Estimated Annual Paddy Production in Project Area

Season	Cropped Area (ha)	Unit Yield (ton/ha)	Estimated Production (ton)
Early rainy season rice	203	2.4	487
Rainy season rice	580	2.3	1,334
Annual	783	-	1,821

Source: JICA study team

(6) Crop Losses

Because of unstable rainfall distribution and limitation of water resources for irrigation, rice production in the Project Area remains at low level and is unstable. The information on crop losses in the rainy season from 2003 to 2006 in the Area is presented below.

Rice Crop Losses in the Rainy Season in the Project Area

Causes	2004 Rainy Season		Average of 2003 – 2006	
	Area Completely Destroyed	Proportion to Cropped Area	Area Completely Destroyed	Proportion to Cropped Area
Drought	111 ha	15 %	47 ha	6 %
Flood	0 ha	-	1 ha	0.1 %
Pests & Disease	12 ha	2 %	8 ha	1 %
Total	123 ha	17 %	55 ha	7 %

Source: Project Commune Offices

According to the results of the Socio-economic Survey, about 80 % of farmers sampled reported the occurrence of seasonal inundation in the rainy season, however, the information on crop losses indicates that the seasonal inundation might not result in

serious damage to rice production in the Project Area.

C-1.3.4 Prevailing Farming Practices of Rice

Current prevailing farming practices in the Project Area are characterized by: i) cultivation of photosensitive local varieties in the rainy season, ii) use of home grown seed, iii) seldom replacing home grown seed with quality seed, iv) flat seed beds, v) high seeding rate, vi) planting of aged seedlings, vii) random planting and manual threshing using a threshing board or table. However, application of manure and substantial dressing of fertilizer are common practices in the Project Area as shown in Table C-1.3.2.

C-1.3.5 Crop Production in Upland Fields outside of Project Area

Compared with rice production, production of other crops such as upland crops, vegetables and fruits in upland fields are extremely limited in the project villages. Major upland crops grown in the project villages include mungbeans, corn, groundnuts, morning glory, pumpkin, water melon in the rainy season and string beans and morning glory in the dry season. Major perennial crops include mango, sugar palm, coconut, papaya and banana.

C-1.3.6 Livestock

Livestock raising is an important agricultural activity for farm economy and provides an essential source of draft power and manure for farming in the Project Area. The population of livestock and average holding size of livestock per family in the project villages are estimated as shown below.

Livestock Population & Holding Status in Project Villages

Item	Cattle Total	Cows	Draft Cattle	Pigs
Population	2,737	1,096	834	1,368
Holding Size/Farm	2.4	1.0	0.7	1.6

Source: Cabar Mon and Samraong Tong District Offices

An average holding size of total cattle, cows, draft cattle and pigs is calculated at 2.4, 1.0, 0.7 and 1.6 head per family, respectively, equivalent to 2.9 animal units in total. The holding size of poultry is calculated at 3.4 per family. However, as the statistic figures include livestock & poultry held by commercial farms, the actual holding size per farm is lower than the said estimates. There are five pig farms and two poultry farms in the villages belonging to the Project. Production figures for livestock in the Project Area were not available since the sale of live animals and poultry is common.

C-1.3.7 Farm Machinery and Equipment

The inventory of farm machinery and equipment in the Project Area is presented in the following table.

Inventory of Farm Machinery & Equipment in Project Villages

Hand	Water	Threshers		Rice Mills			
Tractors	Pumps	Engine	Pedal	Small	Medium	Plows	Ox-carts
26	78	4	26	38	8	455	274

1/: Chbar Mon & Saran Tong District Agriculture Office & Kahaeng Commune

The number of tractors is still limited and land preparation works by draft animals is the predominant practice, however, the use of hand tractors will expand in the future because there are many used hand tractor dealers in Kampung Speu town. The number of rice mills appears to be more than sufficient for milling demand in the Area because marketing of paddy is commonly carried out in the form of unhusked rice.

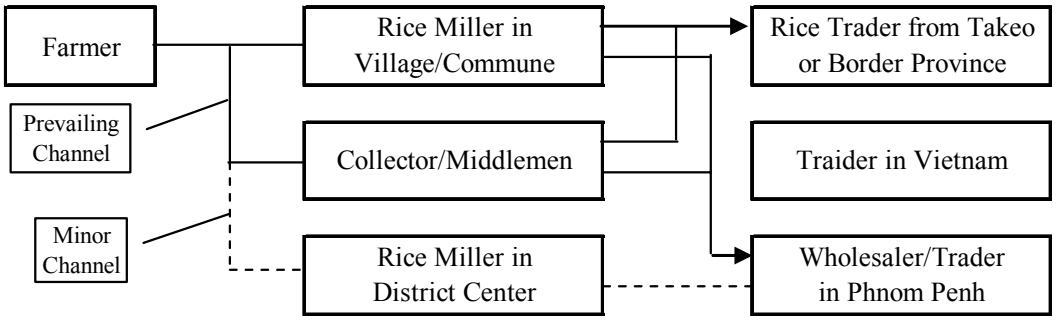
C-1.3.8 Marketing

(1) Rice Marketing

As the size of rice fields in the Project Area is estimated at around 0.8 ha per farm, marketing volumes of rice in the Project Area appear to be limited. The Socio-economic Survey indicates that the average volume of paddy marketed is 1,258 kg per consignment sent to market and 847 kg per farmer. The same result also indicates that the volumes of paddy account for 37% of total products marketed and 67% of the sample farmers reported marketing of paddy. Marketing of rice in the Project Area is carried out almost exclusively in the form of paddy (dry unhusked rice). Marketing timing appears to depend on individual farmers. However, common timing is when cash is needed followed by time when price is high.

The prevailing marketing channels of paddy in the Project Area as identified through the Socio-economic Survey, information provided by PDAs and rice millers and the field survey by the JICA study team are illustrated in the following figure.

Prevailing Marketing Channel of Paddy in Project Area



Paddy collected by rice millers or collectors from farmers is temporally stored in open places along route No. 4 and transactions between the rice millers or collectors and large traders are carried out. All transactions involved in rice marketing are done on a cash basis.

Seasonal fluctuations in the market prices of paddy are common phenomenon in the Project Area, and in Cambodia as well, since cultivation of photosensitive varieties of rice prevails. Generally, paddy prices are lowest around late November to December just after the peak harvesting season and are the highest from September to early November before the harvesting season. Price differences between lowest and highest peak is around 100 riel/kg. Further, price differences of about 50~100 riel/kg between local medium/late varieties and improved early varieties (IR varieties) due to consumers' preference are also reported in the Area. Because of limited market volume from individual farmers, farmers have little bargaining power in price setting. Major constraints for paddy marketing identified through the Socio-economic Survey are low and unstable market prices of paddy

(2) Marketing of Other Agricultural Products

Both production and, therefore, marketing volumes of other crops are limited in the Project Area. Common marketing destinations of upland crops and vegetables are the local markets in the commune centers followed by markets in villages. In contrast, a substantial number of animals and poultry are marketed as estimated from the population of those in the Project Area. Common market destinations of animals and poultry are collectors or middlemen followed by village markets and markets in the commune centers.

(3) Marketing Facilities

There exist 2 commune level markets and one district level market within or near the Project Area. The district level market in Chbar Mon has an important function as the marketing place for farm inputs and vegetables. The commune level markets also function as destination markets for agricultural products. There exists one slaughter house in Chbar Mon District.

C-1.3.9 Farm Household Economy

(1) Typical Farms

For defining typical farms, the farmers sampled for the Socio-economic Survey have been categorized into farm families having double cropped rice fields (Type A) and having only a single cropped rice fields (Type B)[1]. Such categorization excluded samples having income from non-farm activities far greater than incomes from farm activities in order to facilitate the farm economic analysis under the present and with-project condition. The average features of individual category of farm families are defined as the typical farms under the present Study as shown below.

Typical Farms & Their Economic Conditions

Farmers Having	Land Holding Size (ha)		Income (1000 riel) 1/	Expenditures (1000 riel) 1/
	Irrigated Field	Rainfed Field		
Double Cropped Rice Field (Type A)	0.57	0.22	3,104	3,017
Only Single Cropped Rice Field (Type B)	0.41	0.10	3,333	2,483

1/: Not including income from rice production and production cost of farm products

As shown in the tables, the average rice field size of farm families having only single cropped field is substantially smaller than those of farm families having double cropped fields.

(2) Present Farm Economy

The present farm economies of the typical farms are estimated as shown Table C-1.3.3 and as summarized in the following table.

Present Farm Economy (unit: Riel)

Description		Type A	Type B	Difference (A-B)
Gross Incomes	Rice Production	1,302	680	622
	Other Farm Income	1,066	1,145	- 79
	Non-farm Income	2,267	1,959	308
	Total Income	4,635	3,784	851
Expenditures	Production Costs of Farm Products	1,076	797	279
	Other Expenditures	3,017	2,483	534
	Total Expenditures	4,093	3,280	813
Net Surplus (Capacity to Pay)		542	504	38

Source: JICA study team

As shown in the tables, the net surplus (capacity to pay) of the typical farm is estimated at Riel 542,000 or 12% of the total gross income for Type A and Riel 504,000 or 13% of the same for Type B. Both the representative farm families appear to be at an economically marginal level and there is only a minor difference in the net surplus between the two types.

[1] *Assuming that both are in a gravity irrigation area*

C-1.4 Irrigation and Drainage

C-1.4.1 Irrigation Canals and Related Structures

(1) Irrigation Canals

The Project Area is covered with the existing irrigation system belonging to the West Phnom Penh Integrated Development Center Project. The following table shows the breakdown of canals:

Existing Canal System Covering Project Area

Category of Canal	Canal Name	Length (km)
(1) Main Canal	South Main Canal	***7.8**
(2) Secondary Canals	RS-3	2.4
	Others (no names)	1.6
Total		**4.0**
(3) Tertiary Canal	RS-0	0.3
	RS-01	0.4
	RT-1	0.7
	RT-2	1.2
	RT-3	1.1
	RT-4	1.0
	RT-5	1.0
	RT-6	1.1
	RT-7	1.9
	Others (no names)	7.2
Total		**15.9**

**: The length shows the distance from the ValKrouch Intake to PhumRoung Intake with Check.*

All the canals are unlined, and are not well maintained as a whole. The canals were mostly constructed without considering the topographic condition, which results in difficulty in application of gravity irrigation for some areas. Some farmers are obliged to use portable pumps with high operational cost. Severe erosion is also observed from place to place at the side slope of canals due to dispersible soils and poor construction. Watercourses subordinating to tertiary canals are not adequately constructed by farmers, which causes ineffective water distribution to each paddy field.

(2) Related Structures

In the existing irrigation system, the following structures related to the irrigation canals have been provided:

Canal Structures in the Existing Irrigation System in the Project Area

Category of Canal	Type of Structure	No./Nos.
(1) Main Canal	Turnout with check	2
	Turnout without check	5
	Culvert	1
	Spillway	2
	Bridge	11
	Inlet drain	2
Total		**23**
(2) Secondary Canal	Turnout	5
	Culvert	5
	Aqueduct	1
Total		**11**
(3) Tertiary Canal	Culvert	4
Total		**4**

Most of these structures were constructed under assistance from ADB, JICA and WFP. The structures, except some wooden bridges, are made from reinforced concrete, and mostly do not function well, so that some rehabilitation and/or improvement are required, especially for turnouts and check structures.

No measuring devices are provided for the system, and accordingly, appropriate water management can not be implemented.

C-1.4.2 Irrigation Type

The water supply in the Project Area is by gravity, portable pumps and both. The inventory survey delineates the areas by respective irrigation types as shown in the table to the right. Figure C-1.4.1 shows areas of respective irrigation types.

Irrigation Type

Irrigation Type	Area (ha)
(1) Gravity	306
(2) Portable Pumps	190
(3) Both	84
Total	**580**

C-1.4.3 Current Irrigation Condition

Interviews were carried out with 150 farmers, to determine the current irrigation condition for paddy cultivation in the Project Area. The table on the right shows the current irrigation condition for paddy cultivation. About 35% of the total area is irrigated twice a year. Figure C-1.4.2 shows the present cropping system.

Irrigation Applications for Paddy

Irrigation Applications	Area (ha)
(1) One time	377
(2) Two times	203
Total	**580**

C-1.4.4 Drainage Canals and Related Structures

(1) Irrigation Canals

There are no artificial drainage systems in the Project Area. The excess water is eliminated field by field, and eventually flows into the low areas and/or natural streams serving as drains. In some cases, the existing canals have a double function of irrigation and drainage. In applying water saving farming practices like SRI, such the double function is not possible because timely and smooth irrigation and drainage are essential.

(2) Related Structures

As drainage related structures, two cross drains have been provided under the canal by burying pre-cast concrete pipes.

C-1.4.5 O&M

(1) Responsible Organizations

According to the inventory survey and information collected from the Kampong Speu PDOWRAM, the responsibilities for O&M for irrigation systems in the Project Area are shared by the Kampong Speu PDOWRAM and FWUCs as follows:

Share of Responsibilities for O&M for Irrigation Systems

Facility	Kampong Speu PDOWRAM	FWUCs*
(a) South Main Canal	In-charge	X
(b) Secondary Canal	Jointly executed	
(c) Tertiary Canal	X	In-charge
(d) Watercourses	X	In-charge

Note: Ou Veaeng FWUC and Phoum Roung FWUC

O&M for secondary canals is jointly conducted by Kampong Speu PDOWRAM and FWUCs since FWUCs do not have sufficient capability to fulfill O&M activities.

(2) South Main Canal

Kampong Speu PDOWRAM is responsible for O&M for the South Main Canal. There is no written O&M manual. The South Main Canal is not well operated or maintained. Operation of gates on the South Main Canal is carried out by Kampong Speu PDOWRAM on a demand basis. The side slope is severely eroded and related structures are in poor condition. Although there are many reasons for insufficient O&M activities, one of the main reasons is lack of budget.

(3) Other Canals

As mentioned above, Ou Veang FWUC and Phoum Rong FWUC are in charge of O&M for Secondary Canals and other minor canals in the Project Area. However, proper O&M is not being done due to the following reasons:

- Poor irrigation canal system
- Formation of FWUC without consideration of canal layout
- No training for FWUCs on O&M
- No formation of FWUGs or WUGs

C-1.4.6 Water Management

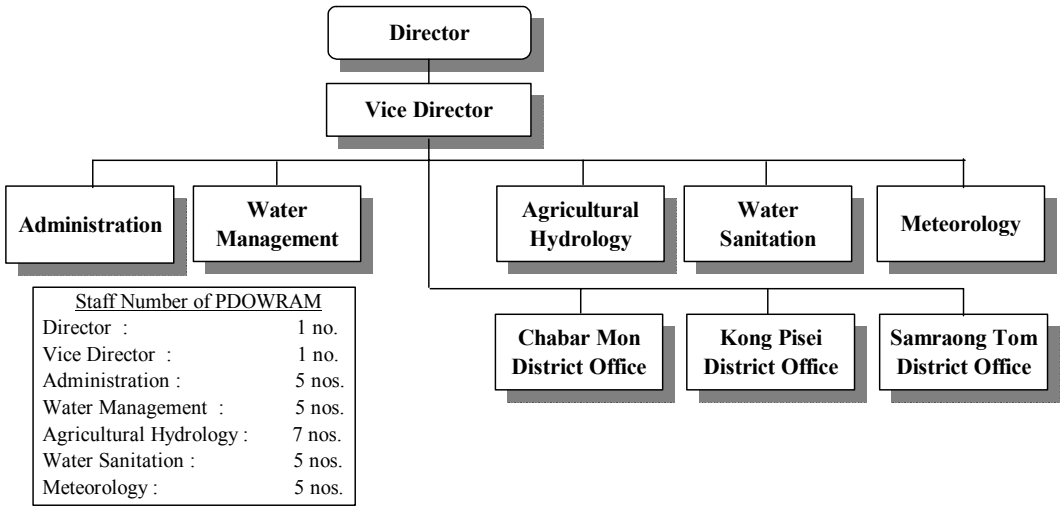
According to the socio-economic survey of 100 households in the Project Area, 83 households replied that they receive water from canal intermittently. Main reasons for such intermittent water distribution are that water level in the South Main Canal frequently lowers due to lack of check structures, improper operation of the Vat Krouch Intake Gates, and saving of fuel for pump operation.

C-1.5 Institutions

C-1.5.1 Kampong Speu PDOWRAM

The Kampong Speu Provincial Department of Water Resources and Meteorology (PDOWRAM) is one of 24 provincial departments of MOWRAM. The organizational chart of Kampong speu PDOWRAM is shown below:

Organization Chart of Kampong Speu PDOWRAM



Staff Number of PDOWRAM	
Director :	1 no.
Vice Director :	1 no.
Administration :	5 nos.
Water Management :	5 nos.
Agricultural Hydrology :	7 nos.
Water Sanitation :	5 nos.
Meteorology :	5 nos.

Major technical missions of PDOWRAM are to (a) prepare short, medium and long term development plans, (b) research and observe natural disasters, (c) collect meteorological and hydrological data, (d) implement operation and maintenance for the irrigation systems, (e) organize and train FWUCs and (f) study, plan, design and construct small scale projects.

The SWOT analysis showed that PDOWRAM staff had high motivation for their work but faced financial and physical difficulties in fulfilling the missions, such as limited capacity for accounting, administration and planning, few chances of participation in study tours and lack of means to work.

C-1.5.2 Kampong Speu PDA

(1) PDA

PDA is a provincial level agricultural agency under MAFF and is an agency responsible for agricultural development and provision of agricultural support services at the province, district, commune and village levels. As shown in Figure C-1.5.1, PDA is composed of six technical offices and three planning/administrative offices. Total number of staff including district level staff is 264.

Major functions of the Agronomy Office of PDA include technology development, seed production and plant protection and the major functions of the Extension Office are provision of extension services and human resources development. The Animal Health Office has functions of provision of veterinary services, technology development and extension services and the functions of the Fishery Office are fish fry and fingering production, technology development and extension services.

(2) DAO (District Agriculture Office)

PDA has branch offices at district level called District Agricultural Offices (DAO) as illustrated in Figure C-1.5.1 and their functions are statistical data collection, extension activities (project activities in collaboration with PDA) and animal vaccination. The offices covering the Project Area are DAO Samraong Tong and Chbar Mon. The staff deployments in the DAOs are 13 staff (10 technical staff) in Samaraong Tong and 9 staff (8 technical staff) in Chbar Mon.

C-1.5.3 Farmer Water Users Communities

There are two Farmer Water Users Communities (FWUC) in the Project Area; one is Ou Veaeng FWUC and the other is Phoum Roung FWUC. Both FWUCs were organized through the initiative of Kampong Speu PDOWRAM (hereinafter PDOWRAM) and donors; PRASAC for Ou Veaeng and WB for Phoum Roung.

(1) Ou Veaeng FWUC

(a) Location of Ou Veaeng FWUC Management Area

Ou Veaeng FWUC managed an irrigation area covering a total of 23 Villages in 4 Communes (Kahaeng and Tang Krouch Communes of Samraong Tong District, and Chbar Mon and Kandaol Dom Communes of Chbar Mon District in Kampong Speu Province) as of January 2007. It manages the upstream irrigation area spreading over 13 Villages in the Project Area. The size of irrigation area is 976ha, and 514ha of the 976ha is irrigable at present and the beneficiaries were 2,432 farm households as of January 2007. The size of the irrigation area and the number of benefited farmers are not accurate because these figures are estimated based on the report from Village Chiefs without a cadastral survey. Additionally, PDOWRAM does not keep track of these figures because the FWUC Committee Chief did not report them to PDOWRAM.

Generally and technically, a 976ha irrigation area is too large to be managed by one FWUC. The area should be divided into at least two; the irrigation area of the South Main Canal and that of the North Main Canal. Cadastre of the benefited farmers with their thumbprint was arranged by PDOWRAM in 2002 but has not been updated since. Moreover, the cadastre was made based on interviews with farmers without the cadastral survey. It means the data in the cadastre is not accurate. A cadastral map was not prepared

due to lack of budget.

(b) Organizational Structure

Ou Veaeng FWUC was organized in 2002. It consists of 4 FWUG (Farmer Water Users Group) and 23 Sub-FWUGs. As the subordinate organizations of FWUC, FWUG and Sub-FWUG were also formed in 2002. They were organized by administrative boundary; by Commune and by Village respectively. Nevertheless, these two groups have never been functioning since they were organized.

(c) Management Board

Ou Veaeng FWUC is managed by a Committee consisting of 4 persons; Chief, 1st Deputy Chief, 2nd Deputy Chief and an Accountant. They were selected in an election. The Committee partly works. It holds Committee meetings only 3 times a year and tries to collect irrigation service fee (ISF). A part of the reason for the lack of more meetings might be lack of a meeting place such as an office building. The main occupation of the members is farming. They do not receive any payment from the FWUC for their activities.

(d) Irrigation Service Fee (ISF)

By-laws were arranged by the Committee of the FWUC in November 2001 in accordance with the model by-laws presented in Circular No. 1 on the Implementation Policy for Sustainable Irrigation Systems prepared by MOWRAM in 2000. The by-laws define the method of calculating ISF, but the amount is not clearly mentioned in it. The table to the right mentions ISF according to Kampong Speu PDOWRAM Officers. The Chief of Ou Veang FWUC Committee claimed a different amount. It is Riel 40,000/household/ha for any type of irrigation. Collection rate of ISF is very low. The amount collected was Riel 600,000 (US$ 15 equivalent) in the year of 2004.

Irrigation Service Fee

Type of Irrigation	Amount
Gravity	Riel 30,000/ha/season
Pumped	Riel 10,000/ha/season
Gravity + Pumped	Riel 20,000/ha/season

Source: PDOWRAM Kampong Speu officers

(2) Phoum Roung FWUC

(a) Location of Phoum Roung FWUC Management Area

Phoum Roung FWUC manages an irrigation area covering a total of 11 Villages in Svay Kravan Commune. The irrigation area of Svay Kravan Commune used to be a part of Ou Veaeng FWUC management area but separated from it in 2004. Phoum Roung FWUC manages the downstream irrigation area spreading over 5 Villages in the Project Area. The size of the irrigation area is 518ha and the beneficiaries were 1,106 farm households as of January 2007, according to the reports from Village Chiefs to the FWUC Committee Chief. A cadastral map which covers about 50% of Phoum Roung FWUC management area was prepared by MOWRAM and PDOWRAM using the budget of World Bank's Flood Emergency Rehabilitation Project in 2004. Nevertheless, the cadastre of the benefited farmers with their thumbprints was arranged based on interviews with the farmers without a cadastral survey. This means that the data in the cadastre would not be accurate.

(b) Organizational Structure

Phoum Roung FWUC consists of 5 FWUGs and 11 Sub-FWUGs. The Sub-FWUGs were organized by canal layout. One Sub-FWUG consists of 2-3 villages which share one tertiary canal.

(c) Management Board

Phoum Roung FWUC is managed by a Committee consisting of 4 persons; the Chief, 1st Deputy Chief, 2nd Deputy Chief, an Accountant and the representatives of FWUGs and Sub-FWUGs. They were selected in an election. The representatives of the FWUG and Sub-FWUG generally work distributing information to the benefited farmers and collecting ISF. The FWUC functions rather properly. It holds 2 types of meetings depending on necessity; i) Committee member meetings and ii) Sub-FWUG meetings. The Committee member meetings are usually held in the FWUC office building. The main occupation of the members is farming. The Chief and 1st Deputy Chief additionally work as carpenters, and the Accountant is also the Tras Village Chief. The Chief is not a member of the Commune Council at present, but he closely works with it and will run as a candidate in the next Commune Council member election. He manages the FWUC with a strong leadership. Additionally, he understands well the condition of the irrigation system in his FWUC management area.

(e) Irrigation Service Fee (ISF)

By-laws were arranged by the Committee of the FWUC in June 2004 based on the model by-laws presented in Circular No. 1 on the Implementation Policy for Sustainable Irrigation Systems prepared by MOWRAM. The table to the right shows ISF as determined in the by-laws.

Irrigation Service Fee

Type of Irrigation	Amount
Gravity	R 40,000/ha/season
Pump-up	R 10,000/ha/season

Source: Interview with Phoum Roung FWUC Committee (Jan. 2007)

A total of 75% of collected ISF is utilized for repair and maintenance of gates and repair of damaged canals. The remaining 25 % is utilized for allowances for the Committee members (12%), the representatives of FWUG and Sub-FWUG (12%), and the Commune Council member who is actively involved in the FWUC's activities (1%). The collected amount was R 3,100,000 (US$ 775 equivalent) in the year of 2005. The majority of the benefited farmers pay the ISF but its amount is about 35% of the estimated one. The main reason for this is that they pay ISF levied on only a potion of their irrigated land, for example, a farmer holds 1ha of irrigated land, but pays ISF for only 0.5ha.

C-1.5.4 Other Farmers' Organizations

(1) Overview

In a narrow sense, "Farmers' Organization" can be defined as "a group in which farmers take active roles and are responsible for its management." Nevertheless, herein, "Farmers' Organization" is defined as "a group consisting of voluntary farmer members who have common interests and/ or objectives" because it is hard to apply the narrow sense meaning "Farmers' Organization" to the existing ones in the Project Area. According to the results of the rapid questionnaire survey of farmers' organizations, 36 farmers' organizations are identified in 15 out of 18 villages in the Project Area. It is commonly observed that they were organized currently (after 2000) through the initiatives of external actors such as NGOs (CEDAC, CGA, CWPD, RHAC), micro finance institutions (AMRET, ACLEDA Bank), and donors (PRASAC, SEILA) or government projects (IPM promoted by MAFF). Thus, it can be said that most of them are only a gathering of farmers who willingly join in the activities and/or in the training that the donors provide. These groups were roughly divided into three categories; rural finance (cash and in-kind), agriculture (farming and aquaculture), and the others. The table on the next page indicates an overview of farmers' organizations in the Project Area.

Overview of Farmers' Organization

Group Category		Supporting Agency	No. of Groups
Agriculture	Farming	MAFF･PDA	2
		IPM (MAFF/ NGO) CEDAC	3
		CWPD/ N.A.	3
	Aquaculture	IPM/ Others	2
			Total 10
Finance	Cash	CEDAC	4
		AMRET	5
		ACLEDA	1
		PRASAC	2
		IPM	2
		Self-support	1
			Total 15
	In-kind (Rice, cows, pigs)	CGA (pigs/ cows/ rice)	3
		AOG (cows/ rice)	3
		Chhei Program	1
			Total 7
Others	Health care	CGA	2
	Road construction	SEILA	1
	Village Security network	RHAC	1
			Total 4

Source: Rapid Community Organization Survey conducted by the JICA study team

(2) Objectives and Activities of Farmers' Organizations

(a) Agriculture

There are three types of farmers' groups whose main activities are related to agriculture; i) farming groups, ii) multiple farming groups and iii) aquaculture groups. These groups were mainly organized for improving farmers' living standard through receiving agricultural extension services to increase productivity. In other words, they are merely recipient groups for external support.

(b) Finance

There are three types of farmers' groups related to finance; i) joint guarantors' groups, ii) in-kind bank users' groups, and iii) saving groups. Totally, there are 22 groups. This means these types of farmers' groups are popular in the Project Area.

i) Joint guarantors' group

This is a group of debtors who borrow money from AMRET or ACLEDA. AMRET is a formal micro finance institution and ACLEDA is a bank. The farmers are required to organize the group for guaranteeing each other's performance and obtaining relatively low interest rates (3%/month). The problems they face are i) sometimes a debtor delays repayment, and ii) it is hard for farmers to prepare many kinds of documents for borrowing money. On the other hand, the advantage to be a member is that the members do not need to go to informal financial institutions for borrowing money when they face an emergency.

ii) In-kind bank users' group

Pig, Cow, and/or Rice Banks function in 7 out of 18 villages in the Project Area. These in-kind banks are not managed by farmers' groups. NGOs provide this service to the groups of the users. The users do not identify any serious problems with the Cow Bank and Rice Bank. They are satisfied with the system of the banks. On the

contrary, the farmers claimed that there were problems with the Pig Bank administrated by a Christian NGO, CGA. The farmers are required to convert to be a Christian to borrow a pig.

iii) Saving group

Only "Saving Groups" initiated by CEDAC, IPM, or PRASAC can be regarded as a being farmers' groups in a narrow sense. Strengths and opportunities of the saving groups identified through the survey are; i) easy access to loans in the village and ii) financial self-reliance for their own village development. Moreover, the depositors of the saving groups in IPM and PRASAC can obtain interest. Nevertheless, there are several problems in the saving groups. For instance, i) some villagers who do not have money to save cannot join in the group, and ii) some debtors delay repayment or become default debtors.

(c) Others

The other farmers' organizations were formed for dissemination of information on health care and hygiene, and for human rights protection against such things as trafficking. The SEILA program organized farmers for road construction and maintenance. The farmers do not identify any severe problems with them.

C-1.6 Agricultural Support Services

C-1.6.1 Research and Technical Development

The institutional set-up of the agricultural research and technology development activities in Cambodia is composed of the central institute for crop sector research (Cambodian Agricultural Research and Development Institute/CARDI) and the state farms and experimental stations belonging to DAALI of MAFF.

(1) CARDI

CARDI is a semi-autonomous, leading agricultural research and technology development public institute under the jurisdiction of MAFF and its core purpose is to improve the living standards of Cambodian farmers through agricultural research, technology development and technology transfer.

To meet the national mandates, CARDI currently has six research programs or units of: i) plant breeding, ii) agronomy & farming systems, iii) soil & water sciences, iv) plant protection, and v) agricultural engineering. In addition, the institute has a Training & Information Center for training and technology transfer purposes.

One of the important functions of CARDI has been rice seed development and production and the Institute has been established as a national provider of genetic rice resources, breeder seed and foundation seed.

The institute should be placed as a technical resource agency for the present project and close collaboration and cooperation should be sought during the Project operation.

(2) Prey Pdao Experimental Station

Another agricultural research and technology development institute under DAALI of MAFF is Prey Pdao located in Samraong Tong District. The major mandate of the Station is adaptive technology development and seed production. In 2006, technology development activities included variety trials and 15 tons of seed were produced in the rainy season and 6 tons in the dry season for 21 tons in total.

The Station has participated in the execution of the pilot project of the present Study as a technical support institute and members of the pilot project implementation team. The small scale adaptability trial on early varieties of rice for irrigated areas (Zone 1) under the Project was quite successfully implemented by the Station.

C-1.6.2 Extension Services

(1) Institutional Set-up for Agricultural Extension

The national mandate for agricultural extension in Cambodia has been given to the Department of Agricultural Extension (DAE) and Agricultural Extension Offices (AEO) of PDA in the provinces. Although extension staffs in the provinces and districts and district level Agricultural Offices (DAOs) for extension are deployed, the establishment of the extension system is yet to be implemented and the provision of extension services to farming communities are limited due primarily to the financial constraints of the institutions. In other words, the delivery systems of extension services to farmers are still in their infancy and a fully functioning national extension system does not exist.

(2) Extension Method

The approaches for the provision of agricultural extension services or the extension method envisaged in the current extension system include AEA (Agro-ecosystems Analysis) at the commune level as a participatory needs assessment methodology for planning agricultural extension and development programs. AEA is conducted by multidisciplinary teams from relevant government departments and local stakeholders such as commune councils and farmers.

The final output of AEA is EPP (Extension Programs Package; currently called TIP/Technical Implementation Procedures) to be implemented in a target commune. In the Project district, AEA under CAAEP II was implemented in 8 communes, 1 in Chbar Mon and 7 in Samraong Tong including 1 project commune of Kahaeng.

(3) Provincial and District Extension Agencies

Within the agencies mandated to provide agricultural extension services, those actually involved in such services are PDAs and their district level offices of DAOs. Those practical extension agencies are weakly established in various meanings.

(a) Staffing and Deployment of Agricultural Extension Staffs

Staffing of Agricultural Extension Workers (AEWs) of the Agricultural Extension Office (AEO) of PDA and technical staffs of DAO in the Project districts are as follows;

Deployment of Extension & Technical Staffs of AEO & DAOs

Office	Field of Activity/Unit					Total
	Extension	Crop	Livestock	Fishery	Farmer Org.	
AEWs of AEO	5	3	3	-	5	16
DAO Chbar Mon	2	5	1	-	-	8
DAO Samraong Tong	5	2	2	1	-	10
Total	12	10	6	1	5	34

1/: Subject Matter Specialist *Source: PDA Kampong Speu & project DAOs*

Among the AEWs, those involved in fulltime project activities are 7 for ASDP in 2007.

(b) Activities of AEWs

The envisaged extension activities of AEWs are reported to be demonstration activities on crops & livestock and farmer training (through meetings, courses, field days, field visits

etc.). However, provision of extension services through the implementation of projects of donors and NGOs are current the primary activities of AEWs.

(4) Farmers Opinions on Current Extension Services

The results of the Socio-economic Survey indicate that over 50% of the sampled farmers reported no access to extension services as shown below.

Farmers Responses regarding Current Extension Services

Enquiry	Proportion by Reponses
Technical capability of extension workers	Sufficient 33%; insufficient 15%; no service received 52%
Satisfied with current extension services	Satisfied 34%; not satisfied 15%; no service received 52%
Extension services needed	Rice farming 40%; compost 16%; livestock & agr. technique 12%

Source: Socio-economic Survey by the JICA Study team, 2006

C-1.6.3 Seed Production and Supply

The current predominant rice seed production and supply system in Cambodia consists of: i) production of breeder seed (B/S) by CARDI, ii) production of foundation seed (F/S) by State Farms, CARDI and the Agricultural Experimental Station and iii) commercial seed (certified seed) production by seed producers and seed growers. However, due to lack of a national seed policy and seed production and certification system, seed inspection and certification is implemented arbitrarily by individual seed producers and quality seeds produced are usually called commercial seed (C/S).

The major quality seed producers in the country include: i) CARDI, ii) State Farms and Agricultural Experimental Stations of DAALI, iii) AQIP Seed Company newly established as a business entity in 2006 by merging of the 4 Seed Companies inaugurated under AQIP of AusAID, and iv) seed growers/seed growers groups. In and around the Project Area, Prey Pdao Experimental Station, to a limited extent, and a branch of AQIP Seed Company in Kandal Stueng to a large extent, are producing certified seed for distribution to dealers, farmers or others. Commercial seed prices of the Seed Company were Riel 1,500/kg irrespective of varieties in 2006.

The most common channel for quality seed supply in and around the Project Area is through provision of seed under support programs of donors or others. Commercial seed suppliers are farm input suppliers in district centers but their supply volumes are limited.

According to the Socio-economic Survey, the predominant source of seed rice is home grown seeds (products of previous season plantings) followed by seeds exchanged with other farmers. The frequency of seed replacement with quality seeds is limited and demand for quality seeds is negligibly low at present.

Upland crop seed production is carried out by Chamkaleu Seed Production Farm and Kbal Koh Experimental Station and CARDI has started to produce upland crop seeds. The main upland crop seeds produced by the farms are beans and those by CARDI are beans and corn.

C-1.6.4 Farm Input Supply

Supply sources of chemical fertilizers and agro-chemicals in Cambodia solely depend on imported commodities since no fertilizer or agro-chemical industries have been established within the country. Since the introduction of privatization of farm input imports, the major role of distribution of such commodities is undertaken by the private sector. Major origins of such commodities are Thailand and Vietnam.

Farm input supplies in the Project Area are mostly carried by dealers in district centers and local markets at the commune or district level. Group purchasing of fertilizer is seldom practiced in the Project Area; however, introduction of such purchasing arrangements by

two of the farmers' cooperatives in the province is reported.

The results of the Socio-economic Survey indicate that there are no serious constraints for procurement of fertilizer except for price as follows;

Fertilizer Supply Conditions in the Project Area

Enquiry	Proportion by Reponses
Procurement of Wanted Fertilizer	Easy: 98%; difficult: 2%
Supply Timing of Fertilizer	On time: 99%; delayed: 1%
Fertilizer Price	Too expensive: 95%; acceptable: 4%

Source: Socio-economic Survey in the Project Area by the JICA Study team, 2006

C-1.6.5 Farm Credit

Formal banking financial systems for farm loan are limited in Cambodia and some institutions called, "Micro Finance Institutes (FMI)", having loan services are operating farm loan services to farmers or rural people. Such institutes that are operating in and around the Project Area include ACLEDA Bank (NGO involved in rural finance established as a commercial bank in 2003), PRASAC Micro Finance Institute, AMRET and Vision Fund. Further, NGOs providing micro finance services in the Project province include FLD, Enfant & Development and Asia URB. However, non-institutional loan providers such as rice millers, farm input suppliers and relatives or friends might be having a certain role in financing in the Project Area.

ACLEDA Bank and AMRET have their sub-branch offices in the province as follows;

Deployment of District & Commune Level Offices of ACLEDA Bank and AMRET

Institute	Sub-branch Offices (district level)	Service Post (commune level)
ACLEDA	3 Kong Pisei, Phnum Srouch, Ou Dhung	3
AMRET	3 Chbar Mon, Samraong Tong, Phnum Srouch	-

Source: ACLEDA Blankly & AMRET, Kampung Speu Branch Office

Some terms and conditions of the institutes for farm loan for individual are as follows;

Terms & Conditions of ACLEDA Bank and AMRET for Farm Loan for Individuals

Institute	Loan period & interest rate		Conditions
ACLEDA	6 months < R.400,000; 3.25%/month	12 months R.400,000 – 6million; 3.5%/month	Provision of collateral & guarantee;
AMRET	3 – 12 months; 3.5%/month R. 600,000 – 1,000,000	3 – 18 months; 3.5%/month R. 1,000,000 – 2.,500,000	

Source: ACLEDA Bank Plc & AMRET, Kampung Speu Branch Office

AMRET is also providing a group lending scheme covering beneficiaries of about 700 groups in Kampung Speu. ACLEDA Bank is currently providing loan for about 500 farmers for crop production purposes.

C-1.7 Environment

C-1.7.1 Social Environment

(1) People/ Community

Characteristics of the people and communities in and around the Project Area are summarized as follows.

Characteristics of the People and Communities in and around the Project Area

Items	Contents
Population	The Project Area consists of 18 villages, 3 Communes and 2 Districts. According to the SEILA Commune Data Base 2005, the population of these villages was 10,205 in total in 2005. Average family size was 5.2. The annual growth rate has not changed much for the past few years.
Ethnic Group and Religion	The majority ethnic group is Kumer and most of them are Buddhist. Pagodas as religious facilities for Buddhists have spread out around the area.
Gender Issues	The results of the Socio-Economic Survey conducted by the JICA study team in 2006 indicated that there were no serious gender problems as far as the sampled households were concerned. More than 90% of the people felt that there was no social discrimination against women in the Project Area. There are differences between male and female activities; housekeeping, cooking and care of children/elders are considered as female's main activities, while care of livestock seems to be a male's activity. Farming is undertaken by both sexes. An outstanding difference between male and female is the source of cash income. Income from the weaving factory is mainly earned by females, while there were no major differences in other cash income sources found among both sexes.
Education	SEILA Commune Data Base 2005 indicated that more than 90% of both sexes of children (6 to 14 years old) go to school in the 18 villages. Illiterate people over 15 yeas old account for 2.6% for men and 4.2% for women.
Local Community	The Commune, the smallest administrative unit under the Ministry of the Interior, is governed by a Commune Council. The Commune Council Chief and members are elected every 5 years. In some villages, there is a Village Development Committee (VDC). VDC members are elected through secret ballot by the villagers, and thus the villagers rely on the VDC and regard its members as their representatives. As for local communities related to agriculture, there are two Farmer Water Users Communities (FWUCs) in the Project Area. Both FWUCs were organized through the initiative of Kampong Speu PDOWRAM and donors. In addition, there are 36 farmers' organizations identified in 15 out of the 18 villages in the Project Area. These organizations' main activities are related to agriculture; i) farming, ii) multiple farming and iii) aquaculture. (See C-1.5.3)
Local Conflicts	According to the SEILA Commune Data Base 2005, 18 local conflicts over land issues have been recorded within the 13 villages of the Project Area in the past.

(2) Land Use

Within 2km of the Project Area, rice fields account for about 40% of the land, grass and shrub cover 40% and resettlement area occupies about 18%.

In the Project Area which is in total 580ha of irrigation area, field irrigable single cropping of rice accounts for 65% (377ha) of the total area and field irrigable double cropping of rice accounts for 35% (203ha).

(3) Public Facilities/Services

(a) Water Usage for Domestic purposes

The result of the Socio-Economic Survey regarding water sources for drinking and domestic use is summarized in the following table. Drinking water sources in the dry season are diverse; 34% of the sampled households rely on wells (tube wells and dug wells), while 23% purchase drinking water, followed by 9% on reservoirs or ponds and 12% on spring or river water. Distance to water sources from the residence is about 160m on average or 50m for the median. In the dry season, rainwater is utilized as the main source for both drinking and domestic use. The distance to water sources from residences in the wet season is around 130 m on average, while the median is 0 m.

The result also indicated that people living in the upstream area of the South Main Canal are apt to obtain reservoir or pond water for both drinking and domestic use, while the people living in the downstream area rely on piped water. It is notable that people replied that there is no water shortage among sampled households in either the dry or rainy season

(b) Energy

According to the Socio-economic Survey, 94% of households rely on firewood for cooking fuel because it is easy to obtain it from surrounding shrub land, while 3% use kerosene and 1% charcoal. As for lightning, around 40% of households use electricity and 20% use kerosene. It could be assumed that availability of electric power supply differs in the Project Area.

(4) Local Economy

According to the Socio-economic Survey result, more than 80% are predominantly farmers, followed by 10% salaried workers and 7% private business people. In actual fact, around 85% of households are earning money from both agricultural income and non-agricultural income, while both agricultural-income-only (8%) and non-agricultural-income-only (7%) households are small in number. Agricultural income includes sales from paddy, vegetables, fruits, palm sugar, livestock/poultry and fishes, while non-agricultural income includes permanent based salary, on-farm labor, off-farm labor, private business, remittance, selling of firewood/charcoal, handicraft/cottage industry products, forest vegetables and crops, and others. It should be noted that all sampled households including the "non-agricultural income only" households listed above are cultivating rice in their fields and some of them are not selling any of their rice but rather consuming it themselves.

As for expenditures, food expenses occupies more than 50% of total expenditure on average, followed by 14% for ceremonies and rituals, 11% for education, 7% for health and medicine, 6% for fuel and electricity, 6% for transportation, and so on. Moreover, the Socio-economic Survey result indicated that 31 out of 100 households answered that they purchase rice, while the rest are considered as self sufficient in rice.

In addition, the Socio-economic Survey result indicated that only 10% of households have savings in the form of cash followed by purchasing livestock. Nobody choose banks as a form of savings. On the other hand, around 25% of the people have loans or debts with commercial banks (50% of all loan schemes utilized), followed by friends/relatives (35%). Popular purposes for loans and debts were agricultural inputs and livestock animals, which cover 20% and 17% respectively.

(5) Land Tenure

The SEILA Data Base 2005 indicated that 507 households out of 554 households in 6 Project villages in Kahaeng commune have some irrigated rice fied[2]. According to the commune council of Kandaol Dom commune, currently there are no landless farmers.

As for land loss, according to the Socio-economic Survey[3] conducted in 2005, 46% of those interviewed that were living in the Project Area answered that in case they lose their land, they need compensation. Among them, 63% requested compensation in the form of land, while 37% wanted money.

[2] *Data of Kandaol Dom commune and Svay Kravan commune is not available.*

[3] *The Socio-Economic Survey was conducted in 2005 under the Study to gather socio- economic information and to determine the features of the Target Area of the master plan.*

Opinions regarding Land Loss

	Would not accept	Need compensation	No problem	No answer
To loose present cultivation	6%	26%	26%	43%
To loose land for irrigation facilities	0%	46%	49%	6%

Source: Socio-economic Survey, JICA study team, 2005

C-1.7.2 Natural Environment

(1) Forest and Wildlife

As described above, there is no major forest area in or around the Project Area. In figures, 40% is covered by grass and shrub land, and more than 90% of households collect firewood for cooking fuel.

Though there is no specific data or records, bio-diversity seems poor in and around the Project Area because of its limited habitat as indicated by the site inspection.

(2) Fish and their habitat

Major water resources for fish habitat around the Project Area are the Prek Thnot River, irrigation canals and ponds. People fish there mostly for domestic consumption. According to the local people, there were many fishes both in the rainy and dry seasons in the past; however the amount and variety of fish are presently decreasing. The one reason pointed out by the local people was that people started using electric fishing gear, which has wiped out the fish. In addition, exotic species discharged are changing the aquatic- diversity in the area.

C-1.7. 3 Pollution

(1) Use of Fertilizer

According to the Socio-economic Survey, on average, sampled households apply around 70kg/ha of Urea, 60kg/ha of DAP and 1,800kg/ha of manure/compost to paddy fields as shown below.

Usage of Fertilizer (Unit: kg/ha)

	Urea	DAP[*1]	15-15-15[*2]	Manure/Compost
Average	70	58	0	1,759
Max	225	200	0	20,000
Minimum	0	0	0	0

*Note*1; Diammonium phosphate, *2; 15-15-15 includes 15% Nitrogen, 15% P_2O_2, and 15% K_2O*

More than 95% of the sampled households answered that fertilizer prices are too expensive. In addition, around 20% of the sampled households considered that use of adequate doses of fertilizer is effective for improvement of rice productivity, while 50% considered use of quality seed.

(2) Other Pollution

There are no available records about pollution such as air quality or water quality in the Project Area. As far as the site inspection was concerned, no serious problems of air pollution, water pollution, noise or vibration have been observed because pollution sources can not be recognized in or around the Project Area.

C-1.8 Development Assistance in Agriculture by Donors and NGOs

C-1.8.1 Donors

In and around the Project Area, the following donors are extending assistance to the agricultural sector:

On-going Donors' Agricultural Projects in and around Project Area

Donor	Project	Executing Agency	Major Objectives/ Scope of Works	Project Period
EU	Smallholder Livestock Production Programme (SLPP)	MAFF	To reduce poverty and increase food security in rural areas by increasing the rate of growth of livestock GDP	2005 - 2010
JICA	Freshwater Aquaculture Improvement and Extension Project	MAFF	To achieve an increase in aquaculture production in the target area including Kampong Speu	2005 - 2009
ADB	Agricultural Sector Development Project (ASDP)	MAFF	- To promote sustainable growth of market based agriculture to contribute to overall economic growth and poverty reduction - 4 target provinces including Kampong Speu - 4 target districts in Kampong Speu including Samraong Tong	2005 - 2009

As can be seen in table, there are no irrigated agriculture projects currently assisted by donors. It is apparent that other donors target poverty reduction through improvement of farm income.

C-1.8.2 NGOs

More than 20 NGOs are actively participating in support of the livelihoods of the inhabitants in Kampong Speu. Out of them, the following 5 NGOs are contributing to agricultural development.

On-going NGOs' Agricultural Projects in Project Area

NGO	Project	Major Activities	Project Period
APCA	Integrate family agriculture	Agriculture	2000 – Present
CEDAC	- SRI Project - SLF	- Dissemination of SRI - Strengthening of savings groups - Technical training to farmers	In progress
DSO	Feeding cattle	- Pig community - Animal health	2004 – Present
MKD	Small agriculture program	- To provide drinking water - To assign 2 vets to check for animal diseases	2002 – Present
SEDOC	Food security	No information is available	

Out of them, only CEDAC is supporting the increase of paddy production through dissemination of SRI, but it does not focus on irrigation water management.

C-1.9 Constraints and Problems in Development

C-1.9.1 Agriculture

(1) Results of the Socio-economic Survey and Findings of Pilot Project

Under the present Study, the agro-economic survey aiming at identifying the current status of agricultural support services, problems and constraints for irrigated farming, activities implemented for improvement of rice productivity by farmers and expectations for improvement of farming activities have been carried out under the Socio-economic Survey.

The major findings obtained through the survey are explained in Table C-1.9.1. Similarly, constraints and problems for agricultural development of a practical nature identified through the implementation of the agricultural pilot project activities are also discussed in Table C-1.9.1.

(2) Constraints/Problems for Agricultural Development and Proposed Development Directions

On the basis of the findings discussed in the preceding sections, major constraints and problems in agricultural development, which should duly be addressed in the present Study in an integrated manner, have been studied by categorizing issues into: i) agronomic or technical issues, ii) agro-economic and farm economic issues, iii) marketing issues and iv) agricultural support services and institutional issues.

(a) Agronomic or Technical Issues

The captioned issues in this text include the aspects of production and post-harvest. The primary agronomic constraint in the Project Area is the unstable and low productivity of rice that is adversely affected by various factors. Major problems or constraints and proposed development directions to be taken are as follows;

- The primary constraint that is attributed to the unstable and low productivity of rice is the prevailing farming practices characterized by use of traditional varieties, continuous use of home grown seeds, aged seedlings, random planting, limited application of fertilizer, and inadequate post-harvest practices, which should be addressed by dissemination of improved farming practices through the strengthening of agricultural support services introduced in a well integrated manner and implemented in a farmer participatory manner.
- A constraint that is attributed to the unstable and low productivity of rice is the limited and unstable availability of irrigation water,
  which should be addressed through the development and rational utilization of available water resources to the greatest extent possible; implementation of water saving rice cultivation in the agronomic aspect.
- Rice cultivation is almost the only crop in the Area and annual land use intensity or cropping intensity as a whole is estimated at 135%. Production of upland crops is extremely limited in the Project Area,
  which should be addressed by introducing crop diversification in the Area to the greatest extent possible. Chances for introduction of upland crops or vegetables appear to exist in the early rainy season.

(b) Agro-economic and Farm Economic Issues

Problems in the captioned issues are closely related to low and unstable productivity of rice; therefore, agronomic or technical issues are as follows;

- Because of the limited land holding size and irrigation water availability, the economic situations of many farm households are at a marginal level. Such situations might be most serious with women headed households and farm households with small land holding size,
  which should be addressed through the income generating approaches introduced on a farmer group basis and through other development interventions as proposed in the

master plan.

(c) Marketing Issues

Production volume of paddy by most individual farmers is limited and marketing volumes of paddy is also limited. However, the anticipated production increase under the Project may invite marketing constraints in the future.

- Major paddy marketing constraints identified in the present Study are low market price of paddy and unstable market price of paddy. Production increase under the Project will bring about other marketing constraints,
  which could be addressed by: i) production of quality products through improvement of farming practices, ii) formation of farmer groups and seeking possibilities to introduce contract growing or partnership arrangements as an economic activity of the groups and iii) provision of market information to farmer groups as an activity of the extension services; although interventions in marketing issues under the scope of the present Project will be limited.

(d) Agricultural Support Services and Institutional Issues

Major constraints identified in agricultural support and institutional issues are as follows;

- Farmers anticipation and motivation for the improvement of farming practices appears to be high. Current extension services supported by donors and with weak ownership of PDA appear to be unresponsive to such needs,
  To respond well toward actual the beneficiaries' needs, the deployment of extension staff having sufficient practical skills should be implemented,
- Practical skills of extension staffs still appear to be limited,
  which should be addressed through the empowerment of extension staff by way of learning through doing. Enhancement of their self-confidence should be seriously sought.
- In the Project Area, agricultural support activities mostly depend on programs supported by donor agencies and NGOs because of financial constraints of PDA. Further, efficient utilization of extension staff is yet to be seriously sought,
  which should be addressed through further promotion of a farmers' participatory approach (farmer-to-farmer extension and farmer-led trials) and empowerment of extension personnel and their fielding for the efficient use of such resources.
- Coordination and collaboration among institutions concerned, especially MAFF and MOWRAM and PDA and PDOWRAM, is weakly established,
  which should be addressed through the establishment of a project office for those agencies as the model case for the future irrigated agriculture development.

C-1.9.2 Irrigation and Drainage

(1) No Systematic Canal Layout

The Project Area is covered with the existing irrigation system. This canal system was not designed or constructed considering the execution of proper water management. For example, there are some tertiary canals branched off from the South Main Canal, not through the secondary canals. This causes complicated water management. The command area of the tertiary canal fluctuates greatly. It should be determined from the viewpoint of

the water quantity that farmers can easily handle.

(2) Improper Design of Canals and Structures

Almost all the canals are excavated canals, so that the water supply could not be by gravity, which compels farmers to use pumps with high operation cost. The canals also were designed and constructed without consideration of topographic conditions. Due to this, water could not be effectively delivered to the farm plots. A spillway is provided at the upstream reach of the secondary canal. The elevation of the spilled out portion in the spillway is low, so that the water level in the downstream canal could not be raised. It is observed that there is severe scouring in the upstream and downstream portions of the structures in all cases.

(3) Double Functions of Irrigation and Drainage in One Canal

Some canals have double functions of irrigation and drainage. This system could not allow water management to be executed properly since the necessary discharge for irrigation could not be determined.

(4) Lack of Canal Structures, especially Division Boxes and Measuring Devices

In the existing irrigation system, canal structures such as checks, division boxes and measuring devises are inadequate or lacking. In particular, there are no structures on the tertiary canals, so that farmers breach the canal bank to obtain water for their fields. The breached banks are left unrepaired and water is unnecessarily lost accordingly. No measuring devices are provided in the existing canal system. They are essential for effective water distribution.

(5) Too few Watercourses

To deliver water to each field, it is essential to provide watercourses. Presently, watercourses are not sufficient in number.

C-1.9.3 Institutions

(1) Kampong Speu PDOWRAM

As for the irrigation development and O&M for the irrigation system, the Kampong Speu PDOWARM is confronted with the following problems:

- Kampong Speu PDOWRAM lacks the basic data, such as cadastral maps, water requirements, percolation rates and canal losses.
- Kampong Speu PDOWRAM staff have too few chances to accumulate working experience in water management and O&M.
- Budget for repairing and improving irrigation and drainage facilities is inadequate.

(2) Kampong Speu PDA

The SWOT analysis shows that the Kampong Speu PDA is facing the following problems:

- Skills of some staff are limited.
- Pay for the staff is limited.
- Kampong Speu PDA staff lack transportation means.

(3) Farmer Water Users Community (FWUC)

(a) Ou Veaeng FWUC

The problems and constraints Ou Veaeng FWUC faces are;

(i) Financial problems

- Ou Veaeng FWUC cannot receive continuous support from PDOWRAM due to lack of governmental budget.
- The Committee members and representatives of Sub-FWUGs do not receive any rewards or payments from the FWUC activities. Therefore, they are lowly motivated.
- Many of the benefited farmers do not pay the determined amount because their land holding size has never been measured accurately.
- The accounting system is not transparent. The accountant does not keep books appropriately and does not release financial reports of the FWUC to the member farmers.

(ii) Administrative problems

- Cadastre of the benefited farmers with their thumbprints was arranged by PDOWRAM but a cadastral map was not
- The FWUCs were organized according to administrative boundaries not to irrigation canal layouts.
- The Committee holds meetings only 3 times a year. A part of the reason for the lack of meetings might be lack of a meeting place such as an office building.
- The Committee faces lack of personnel to cover the large irrigation area.
- The representatives of Sub-FWUG who were elected in 2002 do not work.
- It takes a lot of time to organize the farmer water users but the Chief cannot spend much time for it due to his demanding family situation.
- The Chief has to do all the work of the FWUC by himself although the roles of each Committee member are determined in the bylaws.
- Farmers water users are not aware of the roles of the FWUC because it doesn't function properly.
- The official registration of the FWUC in MOWRAM is still in the process.

(b) Phoum Roung FWUC

The problems and constraints Phoum Roung FWUC faces are;

(i) Financial problems

- There is no punishment for non-payers of ISF.
- Some of the farmers do not want to pay ISF and cheat the FWUC.
- Representatives of FWUG and Sub-FWUG are not paid monthly. They can obtain a small amount of money only during ISF collection.
- The FWUC Committee members work throughout the year but they cannot get monthly payments.

(ii) Administrative problems

- The cadastre and cadastral map were prepared by MOWRAM and PDOWRAM but do not cover whole management area and have not been updated since 2004.
- The Committee members, except for Chief, want to resign because of low pay.
- Not all representatives of FWUG and Sub-FWUG work properly.
- The registration of the FWUC in MOWRAM is still in the process.

(4) Other Farmers' Organizations

Generally, the nature of the farmers' organizations in the Project Area is passive because they were organized mainly for receiving support from supporting agencies. It is difficult to expect most of them to grow to become self-reliant groups spontaneously. The other constrains and problems by group category are as follows.

(a) Agriculture (Farming and Aquaculture)

- It is hard for farmers to achieve the new techniques that they were informed of during the training due to their clinging to old techniques and fear of introduction of new techniques.
- The contents and concepts are too difficult for farmers to understand.
- Farmers cannot allow introduction of new techniques.
- Farmers cannot store water for aquaculture during the dry season.

(b) Finance (Cash and In-Kind)

- Debtors delay repayments
- Sometimes, debtors fall into default.
- It is difficult for farmers to prepare the documents for borrowing money if the creditor is a formal financial institution.
- Poor villagers cannot enjoy the benefits of existing saving groups in their village.

Chapter C-2 The Project

C-2.1 Basic Approach to the Project

C-2.1.1 Need of Implementation of Model Project

The irrigated agriculture in the Target Area is still in a primitive stage regarding the farming practices, water management and FWUC. In order to improve such situation, proper water management, improved farming practices and appropriate activities of FWUC should be disseminated throughout the irrigated agriculture area in the Target Area. For this, the master plan Study proposed to apply stepwise development.

As the first step, the irrigated agriculture at the on-farm level should be developed under the "Irrigated Agriculture On-farm Technology Improvement pilot project" which has been already completed as mentioned in Volume IV. In this pilot project, water management, farming practices and FWUC activities are to be improved at the on-farm level. The supporting system by the government agencies such as PDOWRAM and PDA was also studied in the pilot projects.

For the second step, the objective area should be increased in scale, and be selected from the surrounding area of the pilot project taking into consideration the strong relationship with the pilot project. In this area, a total irrigation system management from the canal to on-farm facilities should be established, and then proper water management, improved farming practices and strengthened FWUC activities should be enlarged and demonstrated as a Project for the remaining large irrigated agricultural area in the Target Area. In this Project, the government supporting system should be further strengthened so as to cope with the larger irrigation system, farming practices and FWUC activities beyond those for the pilot project. A participatory approach should also be applied in the planning and design of tertiary systems and construction of watercourses to heighten awareness of the FWUCs concerned.

The Project, "Irrigated Agricultural Improvement Model Project", which corresponds to the second step activities mentioned above, is duly a bridgehead for successful development of irrigated agriculture by good harmonization of agriculture, irrigation and drainage and institutional development. In this sense, the Project is greatly needed.

C-2.1.2 Purpose and Development Concept

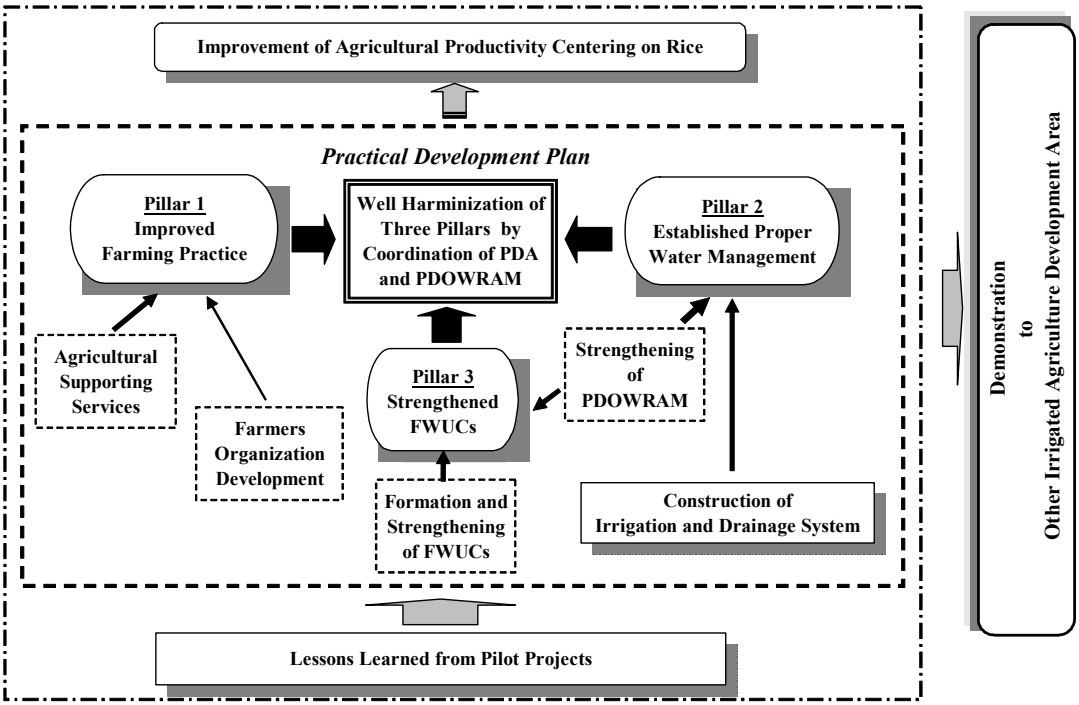
(1) Purpose

The Project aims at demonstration of proper water management and increase of rice production by the good harmonization of agriculture, irrigation and drainage and institutional development.

(2) Development Concept

In order to attain this aim, the elaborated basic strategy for the Project development is the *"preparation of a practical development plan focusing on dissemination of improved farming practices, established proper water management and strengthened FWUCs"*, in consideration of the lessons learned from the pilot projects. The image of the development concept for the Project is shown below.

Image of Development Concept



C-2.2 Agricultural Development Plan

C-2.2.1 Development Concept

(1) Development Objectives

The proposed development approach for irrigated agriculture development aiming at: i) improvement of productivity and increased production of rice through the improvement of farming practices and rational utilization of water resources, ii) improvement of land use intensity by introducing double cropping of irrigated rice to the greatest extent possible with the available irrigation water supply and iii) improvement of land use intensity through introduction of upland crop cultivation.

(2) Development Strategies

The strategies established for the attainment of the said development objectives include:

- Improvement of productivity and increased production of rice is envisaged through the introduction of: i) a double cropping of rice in the early rainy and rainy seasons in the areas where irrigation water supply is ensured for both seasons and a single cropping of medium rice in the rainy season in the rest of the Project Area, ii) double cropping of early rice aiming at rationalizing irrigation water use by growing rice varieties of shorter growth duration and iii) improved farming practices on the basis of experiences obtained through the implementation of pilot project by paying due consideration to current farming practices, which represent to a certain extent the capabilities of the farming communities, farming constraints and farmers' expectations,
- Improvement of productivity and increased production of rice supported by the strengthening of agricultural support services employing a farmer participatory concept,

- Introduction of water saving rice cultivation availing expansion of irrigation beneficiary areas to the greatest extent possible through the rational utilization of valuable water resources, and
- Introduction of a cropping pattern envisaging production of upland crops and vegetables in the early rainy season aiming at improving the supply of beans and vegetables for home consumption, increasing land use intensity and also promoting crop diversification is to be planned.

C-2.2.2 Land Use Plan

The results of the irrigation study indicate that double cropped areas in the Project Area will be expanded under the Project and, therefore, the land use will also change because of the increase in the irrigated area. The study also indicates that there is no irrigation water available in the dry season. Accordingly, the present and with-project land uses and irrigation status in the Area are estimated as shown below.

Land Use & Irrigation Status under Present & Without-Project Condition (ha)

Land Use	Present	With-Project	Increment
Fields irrigable for single cropping of rice	377	285	- 92
Fields irrigable for double cropping of rice	203	285	+ 82
Sub-total (net area)	580	570	- 10
Right of ways	20	30	+ 10
Total (gross area)	600	600	0

As shown, an increase of 82 ha of rice fields irrigable for a double cropping of rice and a conversion of rice fields of 10 ha to right of ways are planned under the Project. The net rice fields under the Project will become 570 ha from the present 580 ha.

C-2.2.3 Proposed Cropping Pattern and Cropped Area

(1) Crop Selection

As discussed earlier in the development concepts, the exclusive primary crop for the present plan is rice considering farmers' strong intention for rice production and the master plan development target of centering on rice production. However, the introduction of a limited extent of upland crops and vegetables is also envisaged as discussed in the concepts. Candidate upland crops include leguminous crops such as mungbeans, groundnuts and soybeans and a variety of vegetables such as morning glory, gourds, string beans and tomatoes could be introduced.

(2) Proposed Cropping Patterns and Cropped Area

The introduction of a double cropping of early rice in the early rainy and rainy season is proposed in areas where irrigation water supply in the early rainy season is ensured aiming at introduction of rationalized use of irrigation water by growing rice varieties of shorter growth duration. However, a single cropping of medium rice is planned in areas where irrigation water supply avails only a single cropping of rice in the rainy season.

Further, the introduction of upland crops and vegetables in 5% of the Area in the early rainy season is targeted as discussed earlier. The proposed cropping pattern formulated is illustrated in Figure C-2.2.1. The planned cropped area and cropping intensity are shown in the following table.

Proposed Cropping Pattern, Cropped Area & Cropping Intensity (units: ha & %)

Crop	Early Rainy Season		Rainy Season		Annual		Present		Area (%)	Intensity (%)
	Area	Intensity	Area	Intensity	Area	Intensity	Area	Intensity		
Early Rice	285	50	285	50	570	100	203	35	+362	+65
Medium Rice	-	-	285	50	285	50	580	100	-295	-50
Rice Total	285	50	570	100	855	150	783	135	+72	+15
Upland Crops 1/	30	5	-	-	30	5	-	-	+30	+5
Total	315	55	570	100	885	155	783	135	+102	+20

1/: including vegetables

As shown in the table, the increase in the cropped area of 72 ha of rice, 30 ha of upland crops and vegetables and 102 ha in total are planned. Similarly, the cropping intensity of 55% in the early rainy season, 100% in the rainy season and an annual intensity of 155 % are planned. The increase of annual rice cropping intensity of 15% and the same of overall annual intensity of 20% are anticipated under the Project.

C-2.2.4 Target Crop Yield and Production

(1) Results of Verification Tests under the Pilot Project

Verification tests and adaptability tests of the improved farming practices on improved early and medium varieties were implemented in the Project Area in 2006 as follows;

Verification and Small Scale Adaptability Tests Implemented in 2006

Activity	Variety	No. of Plots	Location
Verification Test	Early Rice	2	Project Area (RT2)
	Medium Rice	3	Project Area (RT2)
Small Scale Adaptability Test	Early Rice	1	Prey Pdao Station
	Medium Rice	1	Project Area (RT2)

The verification tests were conducted under moderate input levels (fertilizer), while the simple trials were carried out under high input levels to examine potential yield levels of the varieties. The results of the verification tests are presented in the following table.

Results of Verification and Small Scale Adaptability Tests

Activity	Variety	Yield (ton/ha) 1/	
		Range	Average
Verification Test	Early Rice (Sen Pidao)	4.0	4.0 2/
	Medium Rice (Riang Chey)	3.9 ~ 4.8	4.2

1/: Yield levels of a whole plot & not crop cut yields 2/: Estimated yield

(2) Target Crop Yields and Production

The target crop yields under the development plan are set based on the results of the verification tests under the pilot project on early and medium rice in the Project Area and other relevant information as shown in Table C-2.2.1 and the following table in comparison with the present yield levels.

Target Yields and Present Yield Levels

	Early Rainy Season	Rainy Season
	Yield (t/ha)	Yield (t/ha)

Crop	Target	Present	Increment	Target	Present	Increment
Early Rice 1/	3.8	2.4	1.4	3.8	-	--
Medium Rice	-	-	-	3.3	2.3	1.0
Upland Crops 2/	0.7	0.45	0.25	-	-	-

1/: Average yield of IR 66 & Sen Pidao

2/: Upland crops represented by mungbeans; present yield estimated in the master plan

Yield increases of 1.4 ton/ha in early rice in the early rainy season and 1.0 ton/ha in medium rice in the rainy season are envisaged under the plan.

On the basis of the planned cropped area and target yields of crops, crop production under the present and with-project condition are estimated as shown in the following table.

Annual Cropped Area and Crop Production under Present & With-project Conditions

Crop	Item	Present	With Project	Increase 1/	
				Area/Prod.	%
1. Early Rainy Season Rice (early rice)	- Cropped Area (ha)	203	285	+ 82	+ 40
	- Production (ton) 2/	487	1,083	+ 596	+ 122
2. Rainy Season Rice (early rice)	- Cropped Area (ha)	-	285	+ 285	-
	- Production (ton) 2/	-	1,083	+ 1,083	-
2. Rainy Season Rice (medium rice)	- Cropped Area (ha)	580	285	- 295	- 51
	- Production (ton) 2/	1,334	941	- 393	- 29
3. Rice Total	- Cropped Area (ha)	783	855	+ 72	+ 9
	- Production (ton) 2/	1,821	3,107	+1,286	+ 71
4. Upland Crops 3/	- Cropped Area (ha)	-	30	+30	-
	- Production (ton)	-	21	+21	-

1/(present/with project) x *100* *2/: Paddy production* *3/: represented by mungbeans*

Production increase of some 1,290 tons of paddy from the present 1,820 tons or the paddy production of 171% of the present level at full development is envisaged under the Project.

C-2.2.5 Proposed Farming Practices

The improved rice farming practices adopted in the said verification tests were formulated in consultation with PDA and CARDI. However, in the course of the implementation of the tests, it was found that several practices should be improved or revised to increase adoptability of such practices at the farm level.

The proposed rice farming practices are presented in Table C-2.2.2. Major improvements envisaged from the prevailing practices are: i) proper land leveling & preparation, ii) use of quality seed, iii) raised semi-dry nursery beds, iv) planting of young seedlings, v) regular planting, vi) reduced number of plants per hill, vii) fertilization (increased & timely application including manure or compost), viii) introduction of proper on-farm water management & water saving culture (intermittent irrigation), ix) intensified weeding and x) improvement of post-harvesting practices.

C-2.2.6 Labor Balance

The result of the labor balance study is indicated in Table C-2.2.3. As shown in the table, basically no labor shortage will be encountered under the with-project condition except for a minor shortage at rainy season harvesting times, which will be solved by labor exchange arrangements as are currently practiced in the Project Area.

C-2.2.7 Proposed Approaches for Improvement of Marketing

Major paddy marketing constraints identified in the present Study are the low market price of paddy and the unstable market price. However, the production increase expected under the with-project condition might invite other constraints in marketing such as limited market destinations.

The basic demand of the markets for agricultural products is supply of a constant (given) volume and quality of products over a given time period. Therefore, the prerequisite condition for market development of agricultural products is to meet such basic market demand.

The proposed approaches to cope with the slated constraints will be a time series or stepwise approaches: i) improvement of productivity and quality of products through improvement of farming practices, ii) formation of farmer groups and introduction of group economic activities such as group purchasing of farm inputs and technology transfer within a group and among groups, iii) introduction of contract growing or partnership arrangements, iv) intensification of group economic activities toward cooperative shipment and cooperative marketing and v) formation of cooperatives by uniting groups. The government support activities toward such approaches will be guidance/extension and farmer/farmer group training activities and provision of market information to farmer groups. The proposed approaches are illustrated in Figure C-2.2.2 and explained in the following;

(1) Improvement of Productivity and Quality of Products

The 1st and most essential step to take in the proposed approaches is to improve farming practices and technologies of the target groups (farmers) and to improve productivity and the quality of the subject crops or commodities through extension activities and by way of the efforts of the target groups themselves. In the proposed approaches, priority should be placed on productivity improvement through the improvement of farming practices and quality improvement of products should better be addressed after the attainment of productivity improvement.

(2) Formation of Groups of Interested Farmers

In parallel with the activities for the said improvement of productivity and the quality of products, formation of a group of interested farmers will be the 2nd step. As market demand is a given volume, a group formation is an essential approach because of the limitation of average land holding size in the Project Area.

As marketing is a business activity, marketing skills or the business mind set of the individual farmers or groups are be enhanced through extension activities. Further, within a group or among groups, technology transfer among members or farmer-to-farmer extension is to be institutionalized. Such technology improvement activities should better be promoted by advanced or key farmers in a group or groups. The external guidance or extension services are to be directed to those key farmers intensively and technologies, knowledge and experiences received by the key farmers are to be disseminated to fellow members through farmer-to-farmer extension. The technology transfer to those key farmers should cover both the technical, business and marketing skills aspects essential for improvement of marketing.

(3) Initial Group Economic Activities

The initial group economic activities will be group purchasing of farm inputs aiming at improvement of productivity and the quality of products and also saving farming costs. The introduction of contract growing or partnership arrangements could also be attempted

at this stage as an initial group economic activity.

(4) Improvement of Farmers Access to Market Information

Provision of market information will be a government intervention. However, the efforts of the groups for market development are also necessary activities toward the introduction of advanced group economic activities.

(5) Advanced Group Economic Activities

The advanced group economic activities include cooperative shipment of products followed by cooperative marketing when the product quality of the members becomes uniform. Processing of products or expansion of contract growing or partnership arrangements are also potential activities of those groups.

(6) Formation of Cooperatives

The formation of cooperatives to establish groups as legal entities will be the final step in the proposed approaches for improvement of marketing by uniting interested groups having common economic activities.

C-2.3 Irrigation and Drainage Improvement Plan

C-2.3.1 Development Concept

The Project aims at demonstration of proper water management and increase of rice production in the Project Area, which are to be accomplished through harmonized development of agriculture, irrigation and drainage and the related institutions. To achieve these aims, the irrigation and drainage improvement plan is elaborated in line with the following basic strategies.

(1) Irrigation Improvement Plan

The irrigation systems should be designed so as to ensure proper water management, namely, timely and equitable water distribution. Taking into consideration this concept and the conditions of the existing irrigation systems in the Project Area, the following basic strategies are proposed:

Maximum Use of Existing Facilities

The Main Canal, Secondary Canals and related structures in the Project Area were constructed under the Western Phnom Penh Integrated Development Center Project, so that these existing facilities should be used as much as possible, to save construction cost and to continue its development concept.

Minimum Rehabilitation/Improvement Works

The existing canals are excavated canals with comparatively large sections as compared with the required discharge. These canals should be rehabilitated or improved in the most economical way. As for the additional structures including measuring devices, the number should be minimized through site inspections followed by proper hydrological design.

Use of Suitable Borrow Materials for the Canal Embankments

Some parts of the existing canals were constructed using unsuitable soil, like dispersible soil, so that severe soil erosion has occurred. Such portions should be rehabilitated using suitable borrow materials, although the suitable excavated soils should be used for rehabilitation and/or improvement where possible. In addition, sod-facing should be provided for the embankment portion to prevent soil erosion.

Application of Gravity Method

The water level in most canals is lower than the ground level of the paddy fields so that irrigation water could not be supplied to the paddy fields by gravity. The portable pump irrigation system limits the irrigation area and produces higher operation cost. In this Study, gravity irrigation systems are planed by raising the water level in the canals through the provision of additional check structures.

Appropriate Density of Minor Canals

In order to supply irrigation water to each field from canals smoothly and effectively, the density of minor canals such as tertiary canals and watercourses should be increased, say to 30m/ha at least.

(2) Drainage Improvement Plan

Smooth elimination of excess water from the fields is one of the important factors to raise the crop yield. In particular, the Project Area is sometimes attacked by floods from the Prek Thnot River. The drainage system is thus essential for the agriculture in the Project Area, to drain the excess water by heavy rainfall and the flood water from the fields to the greatest possible extent. The drainage improvement plan has been worked out with the following basic strategies:

Establishment of Independent Drainage Systems

Some existing canals in the Project Area have the double functions of irrigation and drainage. For proper water management and smooth drainage, independent drainage systems should be designed.

Use of Natural Small Streams and Degraded Areas as Drains

There are many natural small streams and degraded areas in the Project Area. These are to be used as natural drains to minimize cost.

C-2.3.2 Irrigation System

(1) Design Discharge

Basic Consideration

The Prek Thnot River has a large fluctuation in its discharge throughout the year. The average monthly discharge in the rainy season ranges from 62m^3/s to 102.3m^3/s, and in the dry season from 1.2m^3/s to 8.5m^3/s at 80% dependability. The peak discharge occurs in October which is around the end of the rainy season. Taking into consideration this discharge pattern and the cropping patterns of paddy, the Prek Thnot River can not become a plentiful water source for agriculture in the basin area until a water regulating facility is constructed upstream.

The Project should thus focus on the water-saving irrigation methods which are proposed in the master plan Study. The applied water-saving irrigation methods are as follows:

- To supply water to keep soil moisture content at the root depth at not less than 75% of full saturation, without storing water in the paddy fields after land preparation and transplanting.
- To store water in the paddy fields for the period of 30 days beginning at head initiation and lasting until the end of flowering.

The application of this method would bring about a remarkable savings in water; say 20% to 25% of total net irrigation water requirements.

Calculation Procedure

The consumptive use of water for the proposed cropping pattern was estimated from the evapo-transpiration rate using the Penman-Montieth method. Then the net irrigation water

requirements were calculated by summing the consumptive use of water, percolation rate, and water requirements for land preparation and by deducting the effective rainfall. The percolation rate was determined to be 8 mm/day by field observation. The water requirements for land preparation were assumed to be 120 mm based on water layer replacement in the paddy fields. The design discharge at the head of each canal level was estimated by applying the following efficiencies:

Assumed Irrigation Efficiencies

Item	Paddy	Upland Crops
(1) Tertiary unit including application	85%	85 % x 80 %= 68%
(2) Secondary canals	88%	88%
(3) Main canals	88%	88%
(4) Overall efficiency	85 x 88 x 88 = 66 %	68 x 88 x 88 = 53 %

Design Discharge

Using this procedure, the design discharge for the respective canals was estimated as follows:

- Main canals : 1.60 lit/s/ha
- Secondary canals : 1.41 lit/s/ha (=1.60 x 0.88)
- Tertiary canals : 2.10 lit/s/ha (15.7 mm/day x 10,000 / 86,400 / 0.85)

The design discharge for tertiary canals should be determined at land preparation time when more water is required for 20 days for each tertiary block. The irrigation canal system in the Project Area is designed using these design discharges.

(2) Irrigation Method

Water supply under the Project was planned by combining the continuous and rotational supply systems, i.e., water is supplied continuously down to the tertiary block, and then, a rotational water supply is made within the tertiary blocks as the division boxes/off-takes are provided on the tertiary canals and water application loss is thereby reduced.

(3) Canal Layout

The irrigation canal layout for the Project Area was designed taking into account the basic strategies mentioned above. In particular, the canal layout is to be made centering on the tertiary unit, so that the following are additionally considered in canal layout design:

- Tertiary Canal Command Area

Research has indicated that the discharge that can be easily handled by farmers is 20 lit/sec to 40 lit/sec. Since the water management along the tertiary canal should be conducted by the farmers, the tertiary canal layout was, in principle, designed taking this discharge into consideration, but greater discharge at land preparation time was not considered.

- Tertiary Canal Length

In connection with the command area of the tertiary canals and in view of the canal losses, the length of the tertiary canals will generally be less than 1.5 km except for exceptional cases.

- Watercourse Command Area

The average paddy field holding size per farm household in the Project Area is 0.60 ha. With this holding size and considering that if there are fewer than 10 corresponding farmers, an agreement could be easily reached, especially for water distribution along the watercourse. Thus, a watercourse is provided at the rate of about one per 6 ha.

- One Tertiary Block Commanded by One Tertiary Canal

According to the government policy, one FWUG should be formed for each tertiary block. From the viewpoint of smooth water management by FWUG for its tertiary block, each tertiary canal should command only one tertiary block. The proposed irrigation system for the Project Area is as follows:

Proposed Irrigation Canal System

Canal (old name)	Length (m)	Canal	Length (m)
(1) Main Canal		(h) SMC-S-1-T-⑤(RT-5)	0.48
(a) South Main Canal	7.80	(i) SMC-S-1-T-⑥(RT-6)	0.95
Total	**7.80**	(j) SMC-S-1-T-⑦	0.90
(2) Secondary Canal		(k) SMC-S-1-T-⑧	0.85
(a) SMC-S-1 (RS-3/RT-7)	3.31	(l) SMC-S-1-T-⑨	2.05
(b) SMC-S-2	0.01	(m) SMC-S-2-T-①	1.70
(c) SMC-S-3	0.45	(n) SMC-S-2-T-②	1.40
(d) SMC-S-4	0.90	(o) SMC-S-3-T-①	0.65
Total	**4.67**	(p) SMC-S-3-T-②	0.72
(3) Tertiary Canal		(q) SMC-S-3-T-③	1.50
(a) SMC-T-①	0.59	(r) SMC-S-4-T-①	0.70
(b) SMC-T-②	0.46	(s) SMC-S-4-T-②	0.51
(c) SMC-T-③	1.25	(t) SMC-S-4-T-③	0.54
(d) SMC-S-1-T-①	0.56	(u) SMC-S-4-T-④	0.43
(e) SMC-S-1-T-②(RT-2)	0.97	Total	**18.34**
(f) SMC-S-1-T-③(RT-3)	0.45	(4) Watercourses	142,500
(g) SMC-S-1-T-④	0.68		

Note: Watercourses will be constructed by farmers themselves.

An irrigation diagram for the proposed irrigation system is shown in Figure C-2.3.1. The proposed canal layout is given in Figure C-2.3.2.

(4) Design of Irrigation Canals

South Main Canal for the 7.8 km from Vat Krouch Intake to Phum Roung Intake with Check

The South Main Canal has two problems; low water level in the canal and severe erosion of the side slopes. An improvement plan for the South Main Canal should be thus worked out focusing on these matters:

- Raising of Water Level to Make Gravity Distribution Systems Possible

The design water level at the Roleang Chrey Regulator is El.35.70 m. To provide water supply by gravity, the improvement plan of the South Main Canal should be elaborated in due consideration of this water level. In connection with the raising of the water level, additional embankment is required for some portions based on the hydraulic calculation using Manning's formula. Through hydraulic calculations, typical cross sections for South Main Canal were designed and these are shown in Figure C-2.3.3.

- Suitable Treatment of Dispersible Soil

Severe side slope erosion is observed along the 7.8 km part of the South Main Canal. This severe erosion is caused mainly by the dispersible soil. Canal lining would be effective to cope with such phenomenon. Taking into consideration the canal size, varying canal section, locations of severe erosion, and cost saving, lining with clayey soil and sod-facing are proposed only for the severely eroded portions.

Secondary Canals

Four unlined secondary canals are proposed. These proposed secondary canals follow the existing ones. As a whole, these existing canals have enough capacity to carry the design discharge. From the viewpoint of cost-saving, the existing canal sections will not be altered. Minor improvements and repairs such as heightening of the embankments, filling of holes, etc. are required.

The command areas of the secondary canals range from 55 ha to 259 ha, and design discharge varies from 78 lit/sec to 365 lit/sec accordingly. The typical canal section for secondary canals is shown in Figure C-2.3.3.

Tertiary Canals

In total, 15.9 km of unlined tertiary canals exist in the Project Area. These canals are to be incorporated into the proposed canal system as much as possible, as tertiary canals and/or watercourses.

Tertiary canals cover command areas of 14 ha to 38 ha, and their peak discharge ranges from 29 lit/sec to 80 lit/sec. Figure C-2.3.3 shows the typical canal section for tertiary canals

(5) Design of Related Structures

South Main Canal from Vat Krouch Intake to Phum Roung Intake with Check

Based on the results of the inventory survey and hydraulic calculations using a design discharge of 16.3 m3/sec (=10,200 ha x 1.60 lit/sec/ha) at the head, treatment of existing structures related to the 7.8 km of the South Main Canal from the Vat Krouch Intake to Phum Roung Intake with Check was examined. However, a box culvert crossing National Road No.4 was studied using 17.4 m3/sec considering the future development plan (=10,530 ha x 1.60 lit/sec/ha) and difficulty of its frequent improvement because it is part of the key route connecting Phnom Penh to Sihanoukvlle. The need of additional check structures to maintain the water level in proper position to enable gravity irrigation was also studied. The number of structures to be newly constructed or rehabilitated is 3 intakes, 4 turnouts, one check, 3 spillways, 4 bridges, one box culvert, 3 footpath bridges, and 3 drainage inlets. The designs for the typical structures such as turnouts, checks, bridges and drainage inlets are shown in the Drawings.

Secondary Canals

The existing structures such as turnouts and culverts, which were constructed under WFP in cooperation with JICA, are concentrated on the SMC-S-1 (RS-3). Since these structures are in working condition or need only minor repairs, these are to be introduced into the proposed canal system. The newly required structures consist of 13 turnouts, 6 checks and 1 culvert.

As a measuring device, a staff gauge is to be installed in each secondary canal and tertiary canal, because available head for application of gravity irrigation is limited.

Tertiary Canals

There exist four pipe culverts in the existing tertiary canals. These pipe culverts are to be used in the proposed canal system. No division boxes are provided, so that these should be constructed. Furthermore, additional pipe culverts are required to cross the roads/paths. A total of 89 division boxes and 14 pipe culverts are required.

C-2.3.3 Drainage System

(1) Drainage Requirements

Conditions

Paddy, which is the main crop in the Project Area, is generally tolerant of stagnant water as compared with upland crops. However, paddy at the booting stage is sensitive against submergence for more than 3 days. The booting stage starts about 6 days before flowering (heading). At this stage, the height of paddy stems is generally more than 30 cm. In consideration of these figures, 3-day continuous rainfall should be drained within 3 days.

Drainage Requirements

Using the observed daily rainfall data at Kampong Speu from 2001 to 2006, maximum 3-day continuous rainfalls were calculated; 130.2 mm in 2001, 112.9 mm in 2002, 115.0 mm in 2003, 114.5 mm in 2004, 136.7 mm in 2005 and 119.8 mm in 2006. Drainage requirements were determined for 5 and 10 year return periods. As can be seen in the above, however, the observation data is available for only 6 years so that the largest rainfall was used for estimating the drainage requirements.

Drainage requirements q=0.137 x 10,000/(3 x 86,400) x 1000 = 5 lit./s/ha

(2) Drainage Method

Topography over the Project Area allows excess water to be eliminated by gravity from the paddy fields to the rivers/streams nearby; therefore, a gravity system is to be applied.

(3) Canal Layout

The proposed drainage system consists of Tertiary Drains, Secondary Drains and Main Drains. The natural streams and low-lying areas are to be used as drains as much as possible for cost-saving and to minimize damage to the land by construction of the drains. Some existing canals have the double functions of irrigation and drainage. This system does not permit proper management of the irrigation, and thus independent drainage systems should be established apart from the irrigation system. A drainage diagram for the proposed drainage system is shown in Figure C-2.3.4. Figure C-2.3.2 shows the proposed drainage canal layout in the Project Area.

(4) Design of Drainage Canals

The drainage canals are to be excavated canals. The required canal section was determined using the design discharge and Manning's Formula. Figure C-2.3.5 shows the typical canal sections of tertiary drains, secondary drains and main drains. The total length of tertiary drains, secondary drains and main drains are 15.1 km, 8.0 km and 0.3 km respectively.

(5) Design of Related Structures

Cross drains and junction structures related to the drains are proposed. Cross drains made of pipe are recommended for easy construction. The junction structures are to be constructed using gabion mattresses considering their greater flexibility to retrogressive erosion which would happen frequently at the junction points. The required number of cross drains and junction structures is 32 and 18, respectively.

C-2.3.4 O&M

(1) Responsible Organizations

The "Policy for Sustainability of Operation and Maintenance of Irrigation Systems, June

2000", promotes the transfer of irrigation systems to FWUC as much as possible, to mitigate the financial burden for O&M. However, the current capability of FWUCs, such as Ou Veaeng and Phoum Roung FWUCs, are not sufficient for fulfilling the proper O&M. In this Project, the following share of responsibility is proposed taking into consideration this policy, the current capability of the FWUCs, size of respective canals and the importance of the facilities for the Project management:

Proposed Share of O&M Responsibilities

Responsible Organization	In-charge	Canal	O&M Responsibilities
Government	Project Office*	South Main Canal	South Main Canal and control of gates to Secondary Canals
Ou Veaeng FWUC and Phoum Roung FWUC	FWUG	Secondary Canals	Secondary Canals and control of gates to Tertiary Canals
	Sub-FWUG	Tertiary Canals	Tertiary Canals and control of division boxes/off-takes to Watercourses
	WUG	Watercourses	Watercourses and control of water distribution to each field

** : Establishment of Project office is discussed in Sub-section C-2.7.2*

(2) Operational Activities

South Main Canal for the 7.8 km from Vat Krouch Intake to Phum Roung Intake with Check

Based on the irrigation service plan, water supply to the South Main Canal shall be continuous throughout the year except for the two months of February and March. In February and March, it is proposed that all the canal facilities, including the Roleang Chrey Regulator, shall be given annual maintenance by closing the gates of Vat Krouch Intake. These activities will be executed by the Kampong Speu PDOWRAM under support of the Department of Irrigated Agriculture, MOWRAM.

When the design discharge of 16.3 m^3/sec is available, the check gate is to be fully opened. But, when the available discharge is less than 16.3 m^3/sec, the water level in the South Main Canal shall be raised by operating the check gates, to produce a smooth diversion to the Secondary Canals and Tertiary Canals branched off from the South Main Canal.

Secondary Canals

The required discharge for the respective Secondary Canals shall be given in the irrigation service plan. Except for the maintenance period in February and March, all Secondary Canals, as well as the South Main Canal, shall be given a continuous water supply throughout the year.

Water level in the Secondary Canals shall be checked for conformance to the design water level. If the check gate can not maintain the upstream water level by proper gate adjustment to release water to the downstream area, the turnouts and check gates located on the upstream side shall be checked as to whether or not these are in the proper positions.

When the water level nearly reaches the top of the canal embankment due to increase of canal water flow, a spillway located in the upstream reaches shall be opened until the canal water level comes down to the design water level. In this operation, careful attention shall be paid to the gate operation of the spillway so that the discharge released through the spillway will not be over its drainage capacity.

When emptying the canal for maintenance, the water level shall be gradually reduced in order to avoid causing sliding of the inside slope of the canal, taking special care where

the groundwater table is higher than the canal bed.

Tertiary Canals

Rotational water supply shall be applied block by block throughput the cropping season. When the available discharge is smaller than the required discharge, strict water management through the rotational irrigation method shall be conducted.

(2) Maintenance Activities

In parallel with proper operation, suitable and continuous maintenance of project facilities is indispensable to ensure proper and steady function and the realization of the full economic life of the facilities. The maintenance works broadly consist of:

- Regular maintenance works which are performed to maintain and improve the Project facilities;
- Periodic maintenance works, which include repair of minor damage;
- Emergency repair works, which include repair of unexpected damage to the Project facilities caused by floods, heavy rainfall or other causes; and
- Annual maintenance, which involves a large work quantity or requires special skills.

Inspection patrols are to be made on a daily basis to check for the need for maintenance work and reported as necessary. The annual maintenance will be completed in the two months of February and March, say, the fallow season.

C-2.3.5 Water Management

(1) Responsible Organizations

The organizations responsible for water management are the same as for the O&M work.

(2) Water Management

South Main Canal for the 7.8 km from Vat Krouch Intake to Phum Roung Intake with Check

The gates of Vat Krouch Intake are to be opened in line with the irrigation service plan to release water to the South Main Canal. Thus, the South Main Canal will flow continuously during the crop growing season. The irrigation service plan shall be prepared by simplifying the frequently varying irrigation water requirements throughout a crop season for easy operation. At the Vat Krouch Intake, discharge control through adjusting the gate shall be done using the staff gauges installed upstream and downstream. In order to simplify the gate control, an H-Q curve shall be developed.

Secondary Canals

The Secondary Canals are also to be supplied with water from the South Main Canal continuously in accordance with the irrigation calendar for the command area. As an intake gate is provided at the head of the Secondary Canal, discharge control shall be conducted using the staff gauges installed upstream and downstream and gate opening shall be in the same manner as the gates of Vat Krouch Intake for the South Main Canal.

Tertiary Canals

Rotational irrigation is provided along the Tertiary Canal in view of the following advantages:

- It can meet peak water requirements, especially in the land preparation period for

paddy when more water supply is required in a short time period.

- Equitable water distribution can be provided for all farm plots.
- Rotational irrigation can maximize effective rainfall
- Application loss is less than with a continuous water supply.

The Tertiary Canals are to be provided with division boxes or off-takes, for water distribution to the watercourses. The division boxes or off-takes are to be equipped with small-hand gates and staff gauges, which are used for discharge control.

Each tertiary block is to be divided into several irrigation units, called watercourse blocks. A watercourse block is defined as the area commanded by a watercourse, of which the area is about 6 ha on average in the Project Area. Rotational irrigation is provided by a combination of watercourse blocks. The irrigation period of a watercourse block is to be decided based on the acreage of the command area of the watercourse.

C-2.4 Agricultural Support Services Strengthening Plan

C-2.4.1 Basic Approaches

The results of the Socio-economic Survey and the findings of the pilot project indicated that farmers are well aware of the potential and need for productivity improvement of rice, however, their current accessibility to measures, knowledge and technologies to improve productivity appear to be limited because of restricted extension coverage.

The primary objective of the Project is productivity improvement of irrigated rice. To tackle development constraints faced in the Project Area, strengthening of agricultural support services will be essential in order to ensure the attainment of project targets at an early stage. Further, the Project is defined as the Irrigated Agriculture Improvement Model Project in the master plan, therefore, the establishment of coordination and collaboration among project institutions, especially between MAFF and MOWRAM and PDA and PDOWRAM, is an essential goal of the Project.

Accordingly, the present development interventions are proposed with the objectives of: i) development and extension of improved and sustainable farming technologies on rice production to enhance productivity of the primary agricultural activity in the Project Area, ii) empowerment of extension personnel by way of learning through doing, iii) promotion of farmer to farmer technology transfer and iv) development and dissemination of technologies for upland crops and vegetable farming practices and v) establishment of an institutional set-up responsible for the promotion of agricultural productivity improvement in and around the Project Area at an initial stage of the Project.

C-2.4.2 Strategies and Scope of Intervention

(1) Development Strategies

For the attainment of the objectives stated above, the development strategies of the present plan are set as follows;

- Intensive introduction of agricultural support services with the aim of attaining the Project target at as early a stage as possible,
- Insufficient coordination and collaboration between MAFF/PDA and MOWRAM/ PDOWRAM appears to be one of constraints for the irrigated agricultural development in the Project Area. As the execution of the Project, the development intervention aims at the establishment of a coordination and collaboration body at central and project level to tackle this sustained constraint to the development, and
- Establishing a Project Office for the Project implementation organized by staffs of

MAFF/PDA and MOWRAM/ PDOWRAM in the Project Area as an institute responsible for the integrated & collaborative activities of the agencies.

(2) Scope of the Intervention

The plan is formulated for the period of the 4 years from 2010 to 2013 aiming at strengthening agricultural support services. Such services should be provided through the establishment of an institution responsible for the provision of the services as stated earlier. The envisioned major activities under the plan include: i) field extension and technology development programs and farmer/farmer group training programs aiming at improvement of irrigated agricultural farming practices and a production system with farmers participation, ii) empowerment of extension personnel and their fielding, and iii) establishment of village extension agents (VEAs).

C-2.4.3 Agricultural Support Services Strengthening Plan

The agricultural support services required for the promotion of adoption of the proposed farming practices and for attaining the Project target cropping patterns, cropping intensity and crop yields at an earlier stage are as shown in the following table.

Proposed Agricultural Support Services

Activity	Program Required
Field Extension Programs	Plot & area demonstrations, adaptability tests, seed propagation
Farmer/Farmer Group Training Programs	Training programs, farmer field schools, study tours, village extension agent training & deployment
Mass Guidance/Workshops	Mass guidance/workshops
Farmer-to-farmer Extension Support 1/	Farmer-to-farmer extension support
Staff Empowerment	Staff training, logistical strengthening

1/: Provision of support for farmer-to-farmer extension by village extension agents

For the attainment of the Project targets at an earlier stage, the intensive provision of agricultural support services is proposed. The implementation and cost schedule for the proposed agricultural support services strengthening plan, which was formulated taking into account of experiences and lessons learned from the implementation of the pilot project executed in parallel, are shown in Table C-2.4.1.

C-2.5 Institutional Strengthening Plan

C-2.5.1 Government Institution Strengthening

(1) Background

(a) Necessity of Support from Government Institutions

Success of the "Irrigated Agriculture Improvement Model Project" surely requires the support and advice from the governmental agencies concerned; MAFF and MOWRAM at the central level and PDA and PDOWRAM at the provincial level. MAFF and PDA are involved in farming practices, while MOWRAM and PDOWRAM are in charge of irrigation management and development. It is essential that PDA and PDOWRAM work closely with farmers on the farm as supporting government institutions. Needless to say, the main actors in irrigated agriculture improvement are the farmers. PDA does not need to play a main role for farming practices because the irrigated areas are cultivated by the farmers themselves. Nevertheless, farmers need their technical support. PDOWRAM does not need to play a main role for irrigation management and development due to countrywide promotion of PIMD but it needs to remain a supporting agency for the farmers.

(b) Necessity of Coordination between PDA and PDOWRAM

As mentioned above, the support from both PDA and PDOWRAM is crucial to improve irrigated agriculture. Obviously, if the approach of both government institutions to farmers were not coherent, their support would not work effectively. Therefore, the coordination between PDA and PDOWRAM needs to be strengthened through the activities mentioned in (4) Coordination between PDA and PDOWRAM Strengthening.

(2) Kampong Speu PDA Strengthening

Kampong Speu PDA Strengthening is discussed from the viewpoint of agricultural support service strengthening as shown in Section C-2.4.

(3) Kampong Speu PDOWRAM Strengthening

(a) Objective and Activities of Kampong Speu PDOWRAM Strengthening

The objective of Kampong Speu PDOWRAM Strengthening is to improve the working capacity and capability of PDOWRAM for achieving the Strategic Target of the master plan "improved agricultural productivity centering on rice" in the "Irrigated Agriculture Improvement Model Project." Surely, efficient and effective planning, designing, and management and O&M of irrigation systems can make a prominent contribution to improve agricultural productivity. Nevertheless, it can be said that the technical knowledge and skills of the PDOWRAM officers in their specialized fields mentioned above, as well as administration, are still limited. Consequently, this plan will focus on capacity building of the PDOWRAM officers through executing the following activities.

1) Holding of Participatory SWOT Workshop

As the first step of strengthening PDOWRAM, it is necessary to hold a participatory workshop on SWOT (Strengths, Weaknesses, Opportunities, and Threats) for understanding the present situation of the PDOWRAM. SWOT is a method commonly utilized for institutional analysis. Application of SWOT in a participatory manner is useful for effective determination of the institutional condition from the viewpoint of PDOWRAM officers as well as for making it easy for them to realize their current situation.

2) Conducting of Capacity Building Activities

The capacity of PDOWRAM officers can be built through 3 ways; i) provision of training courses, ii) conducting study tours, and iii) OJT. During the training courses, they can learn how to plan, design, and manage irrigation facilities as well as how to administer their office works efficiently. The study tour can give them opportunities to see advanced organizations and/or advanced irrigation management areas. It is expected that the OJT during the Project with engineers or administrative experts of donors and MOWRAM could make a great contribution to capacity building of the PDOWRAM officers.

3) Continuation of Regular Inter-Office Meetings

The PDOWRAM holds weekly inter-office meetings for reporting to the Director and sharing information among the officers. Sharing and exchange of the information related to irrigation management and development, as well as administration, are very important for maintaining sound institutional function. Therefore, this activity should be continued regularly.

4) Monitoring and Evaluation

The process and outputs of the activities discussed above should be monitored and evaluated precisely. The results of monitoring and evaluation need a timely feedback to the on-going and future activities for better outcome.

(4) Coordination between PDA and PDOWRAM Strengthening

The objective of "Coordination between PDA and PDOWRAM Strengthening" is to strengthen the bond and the relationship between the two provincial departments concerned with development of irrigated agriculture for achieving the Strategic Target of the master plan; "Improved Agricultural productivity centering rice" in the Project.

During the workshop on promoting the coordination between PDA and PDOWRAM in June 2006, the following issues were identified; i) the officers of both provincial departments are personally associated with one another as ex co-workers because PDA and PDOWRAM used to be one department (PDAFF) from 1979 to 1999, ii) PDA and PDOWRAM continue to have weekly meetings that began in 1999, and iii) PDA and PDOWRAM have executed two projects; "Early Season Rice" and "Intervention during the Drought" jointly every April and May from 1999 although a joint team has not been officially organized. Accordingly, there are no severe problems with the coordination and cooperation between PDA and PDOWRAM for implementing a project jointly. There are only some points to be considered for smooth implementation of the Project. They are i) frequent sharing and exchange of information among donors and both agencies, and ii) offering the same amount of allowance. Moreover, their higher organizations; MAFF and MOWRAM respectively, allocate the tasks properly according to their specialties and instruct the continuation of coordination between both provincial departments. In the Project, it is proposed to establish a Project Office to implement the Project successfully. One of the reasons for establishing the Project Office is to settle the above and also to strengthen the coordination and cooperation between PDA and PDOWRAM by fulfilling the respective duties under the sole budget allocated to the Project.

C-2.5.2 FWUC Strengthening

(1) Background

(a) Participatory Irrigation Management and Development (PIMD)

The government intends to implement the PIMD strategy throughout the country. It expects that all donor-assisted development programs will follow the same strategy of organizing FWUCs, building their managerial, technical and financial capacity, adopting Irrigation Service Plans and Audits and transferring irrigation management authority to the FWUCs.

PIMD means that FWUC will take over primary responsibility and authority: i) to manage, repair and improve existing irrigation systems and ii) to develop new irrigation systems. Additionally, PIMD means that FWUC will take the lead role in promoting and guiding development of new irrigation systems. It does not mean that farmers will have to pay all the costs of irrigation management and development. Necessary assistance will be provided in ways that build the capacity of the FWUC to be self-reliant.

(b) Proposed Steps in creating Training Manuals for PIMD in Cambodia

"Steps for Organizing the Farmer Water Users Community" are proposed in the "Training Manual for Participatory Irrigation and Management (PIMD) in Cambodia" prepared by MOWRAM in 2003 with assistance from the Asian Development Bank (ADB Loan No. 1445-CAM, SF). These steps are strongly recommended by MOWRAM, and therefore, the FWUCs in the Project Area; Ou Veaeng and Phoum Roung FWUCs should be

strengthened in a similar manner considering their current condition. The proposed steps for organizing FWUC, building capacity, transferring authority and repairing and improving irrigation infrastructure are as follows.

Proposed Steps for Organizing FWUC, Building Capacity, Transferring Authority and Repairing and Improving Irrigation Infrastructure

Step	Proposed Steps
1	Hold initial meetings at system or sub-system level
2	Identify irrigation service area and potential members of FWUC and conduct Participatory Rural Appraisals (PRA)
3	Farmers agree to form FWUC and plan organizing activities
4	Farmers prepare and adopt FWUC Statute and By-laws
5	Farmers establish FWUC and select leaders
6	Build capacity of FWUC to prepare an Irrigation Service Plan
7	FWUC adopts and implements initial Irrigation Service Plan
8	Prepare and adopt Management Transfer Agreement (or Certificate of Management Authority)
9	Repair and improvement of irrigation infrastructure
10	Continue capacity building and provision of support services

Additionally, the most considerable issue to establish FWUC is that it requires the involvement of all the farmers in the entire FWUC irrigation management area for achieving fair and effective water distribution whether they want it or not.

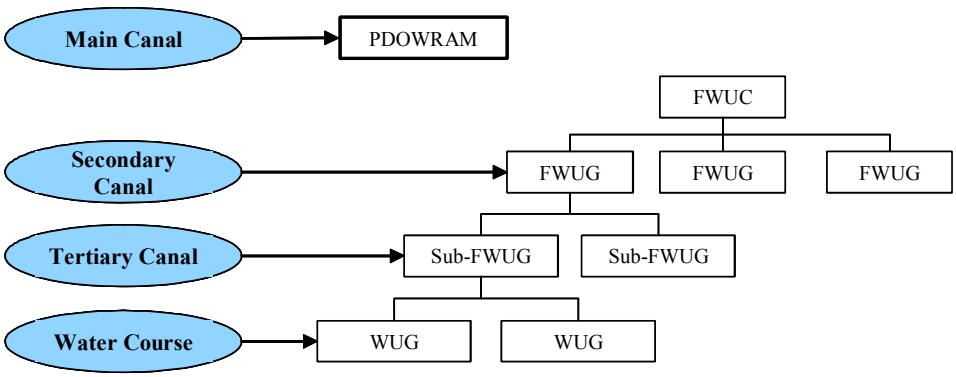
(2) Objectives of FWUC Strengthening

The objective of "FWUC Strengthening" is to develop and improve the function of the FWUCs referring to the experience of the pilot project, as complies with the Statute of the FWUC and the concept of PIMD. More concretely, the objectives are i) strengthening farmers abilities for O&M of the irrigation system and ii) increasing the rate of collecting ISF for the O&M to be done by the farmers. Strengthened FWUCs would surely contribute to achieving the objective of Irrigated Agriculture Improvement Model Project; "To demonstrate proper water management and increase rice production." There are two FWUCs in the Project Area; Ou Veaeng and Phoum Roung. The FWUCs aiming at this objective are described in detail in the following thematic sections.

(a) Demarcation of Water Management and O&M

According to the Policy for Sustainability of Operation and Maintenance of Irrigation Systems, main canals should be managed by FWUC and the FWUC Board, which is an Association of FWUCs. Nevertheless, the main canals need to be managed by PDOWRAM Kampong Speu for effective and efficient distribution of irrigation water and O&M of the irrigation facilities. Accordingly, it is proposed that the FWUCs would coordinate secondary canal water use of the FWUGs which would be in charge of O&M of each secondary canal. Sub-FWUGs and WUGs would be responsible for tertiary canals and water courses, respectively. The figure below describes the proposed O&M system.

Demarcation of Water Management and O&M



FWUC	Current Situations
1) Ou Veaeng	Ou Veaeng FWUC was organized by administrative boundary, and thus consists of 4 FWUG by Commune and 23 Sub-FWUGs by Village. The present FWUGs and Sub-FWUGs should be restructured by canal layout as proposed above.
2) Phoum Roung	In Phoum Roung FWUC, 5 FWUGs, and 11 Sub-FWUGs were organized by hydraulic boundary. Two to three Sub-FWUG commonly utilize one tertiary canal. Thus, the FWUC should organize additional WUGs for the newly constructed watercourses.

(b) Organizational Structure

The FWUC should be led by 4 Committee members; the Chief, 1st Deputy Chief, 2nd Deputy Chief, and Accountant, selected by the member farmers through election. The election should start with selecting the WUG representatives. Secondly, Sub-FWUG representatives would be elected from among the representatives of the relevant WUGs that had been organized by water course. Thirdly, the representatives of FWUG would be elected from among the representatives of the relevant Sub-FWUGs that had been organized by secondary canal, and then finally, the Committee members of FWUC would be elected from among the representatives of the relevant FWUGs. The first election, which selects the WUG representatives, needs to be conducted by the all the benefited farmers' participation for the sequential FWUC's activities. The number of the representatives of FWUG, Sub-FWUG, and WUG can be determined based on the area of the irrigated land managed by each Group; however, it is ideal if 4 representatives (Chief, 1st and 2nd Deputy Chiefs, and Accountant) were elected. The roles that each of them is expected to play are summarized in the table below.

Expected Roles of Each Committee Member

Position	Role
Chief	- To be in charge of general supervision. - To chair the meetings concerning irrigation. - To direct and prepare annual irrigation plans including budgeting. - To examine the activities of all subordinate groups.
1st Deputy Chief	- To be in charge of the maintenance and repair plan. - To monitor the irrigation system regularly (if possible, daily). - To define the scope of work for farmers to maintain and repair the canal network. - To report regularly on the repairs to the irrigation system
2nd Deputy Chief	- To be in charge of water supply and distribution and record keeping. - To prepare a water distribution plan. - To supervise the implementation of the water distribution plan regularly (if possible, daily)
Accountant	- To be in charge of finance. - To collect ISF from the Chiefs of FWUGs. - To keep track of revenues and expenditures. - To report revenues and expenditures to the other Committee members and the member farmers.

The expected roles of the representatives of each subordinate group are almost the same as those of the Committee members.

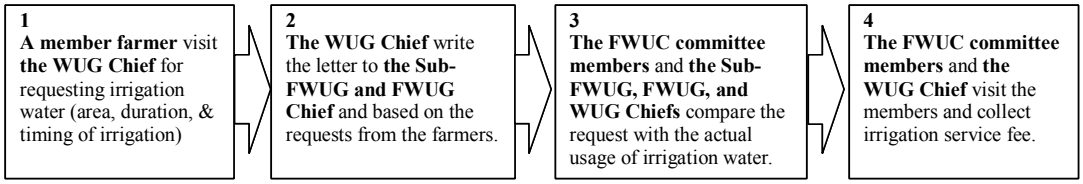
FWUC	Current Situations
1) Ou Veaeng	Ou Veaeng FWUC consists of 4 members; however, the Chief has to do all the work of the FWUC by himself. It is necessary to provide training for the members to become capable to carry out the roles of each as proposed in the table above. The representatives of FWUG and Sub-FWUGs have never worked. Therefore, new representatives should be elected by the benefited farmers in each management area.

2) Phoum Roung	Phoum Roung FWUC is managed mainly by 4 members of the Committee, and supportively by representatives of FWUGs and Sub-FWUGs. They are working relatively well. The representatives of FWUGs and Sub-FWUGs play an important role at the collection of ISF.

(c) Collection of Irrigation Service Fees (ISF)

A procedure proposed for collecting ISF is described in the figure below.

Procedure Proposed for Collecting Irrigation Service Fees



This is the actual procedure practiced by Ou Traeng FWUC in Prey Neat Commune, Kong Pisei District, Kampong Speu Province. This procedure is simple, but the fact that the relatively high rate of ISF (80-85%) is regularly collected proves its effectiveness. Among the 4 steps, 1 and 4 should be absolutely included. Irrigation water should be distributed according to the request from the farmers, and his/her request and the actual usage/ water distribution should be checked by the persons in charge of water distribution. Moreover, accounting should be properly kept and reported to the member farmers regularly for financial transparency. Otherwise, it is possible that most of the farmers would not pay ISF.

FWUC	Current Situations
1) Ou Veaeng	Collection rate of ISF of Ou Veaeng FWUC is very low, less than 10%. The Chief collects ISF by himself by visiting the benefited farmers from door to door. This method is very ineffective and time consuming. Therefore, it is recommended for the FWUC to try the proposed procedure with newly elected representatives of FWUGs, Sub-FWUGs, and WUGs.
2) Phoum Roung	The representatives of FWUGs and Sub-FWUGs are in charge of collecting ISF and currently are doing this. Nevertheless, the collection rate of ISF of the FWUC is not very high, about 35%. Thus, it is recommended that the FWUC should try the proposed procedure with the present representatives and newly elected ones of WUGs using the updated cadastre based on the newly prepared cadastral map.

(d) Meetings

Regular meetings should be held according to the need for monitoring the implementation of the irrigation service plan and for preparing the plan for the following months. It is recommended for the FWUC Committee to hold four types of meetings; i) the Committee meetings at least monthly, ii) the Committee members and representatives of FWUG, Sub-FWUG and WUG meetings at least monthly, iii) annual general assemblies, and iv) Inter-FWUCs (Ou Veaeng FWUC and Phoum Roung FWUC) Meetings led by PDOWRAM for coordinating irrigation water use and O&M of the common irrigation facilities. The FWUC Committee should invite local authorities to these meetings such as the Commune Chief, Deputy Commune Chief, member (s) of the Commune Council and/or Village Chiefs for seeking their support.

FWUC	Current Situations
1) Ou Veaeng	Currently, the Committee of Ou Veaeng FWUC holds meetings only 3 times a year. The intervals between the meetings are too large. It can be assumed that the Committee does not discuss enough things

	to be able to properly manage the FWUC. The Committee needs to receive training on how to organize and facilitate meetings by themselves.
2) Phoum Roung	The Committee of Phoum Roung FWUC has already gotten accustomed to having regular meetings.

(e) Repair, Improvement, and Construction of Irrigation Infrastructure

The FWUC Committee is expected to participate in simple feasibility studies and cost estimates on repairs, improvements, and construction of small-scale irrigation facilities. For medium and large-scaled projects, the Committee needs to make submit proposals to PDOWRAM and MOWRAM for assistance.

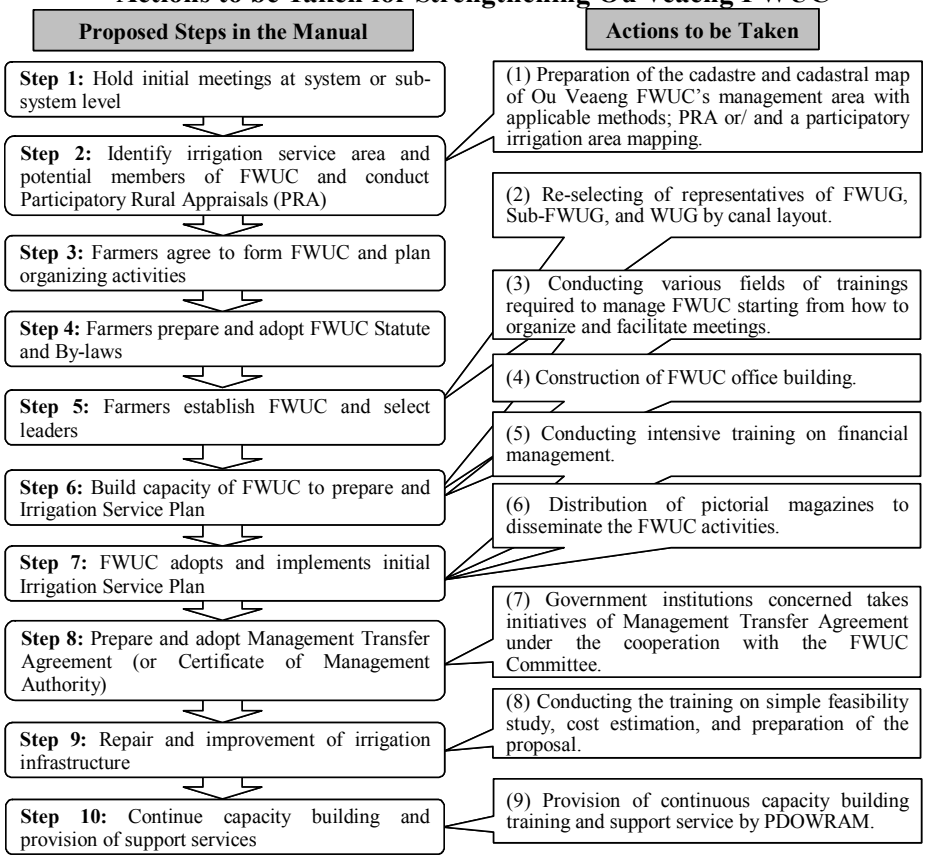
FWUC	Current Situations
1) Ou Veaeng	The Committee of Ou Veaeng FWUC has never been trained for the required works mentioned above. They need to receive the training concerning repairs, improvements, and construction of irrigation infrastructure.
2) Phoum Roung	The Committee of Phoum Roung FWUC has experience repairing small-scaled irrigation facilities and damaged canals; however, it has not tried to seek assistance of MORWRAM for medium and large-scaled projects. So, the Committee members need training on how to prepare a proposal for MOWRAM.

(3) Comparisons with the Proposed Steps in the "Training Manual for Participatory Irrigation and Management (PIMD) in Cambodia" are shown below.

Due to difference in the ability level of each FWUC, the necessary activities of "FWUC Strengthening" are described separately.

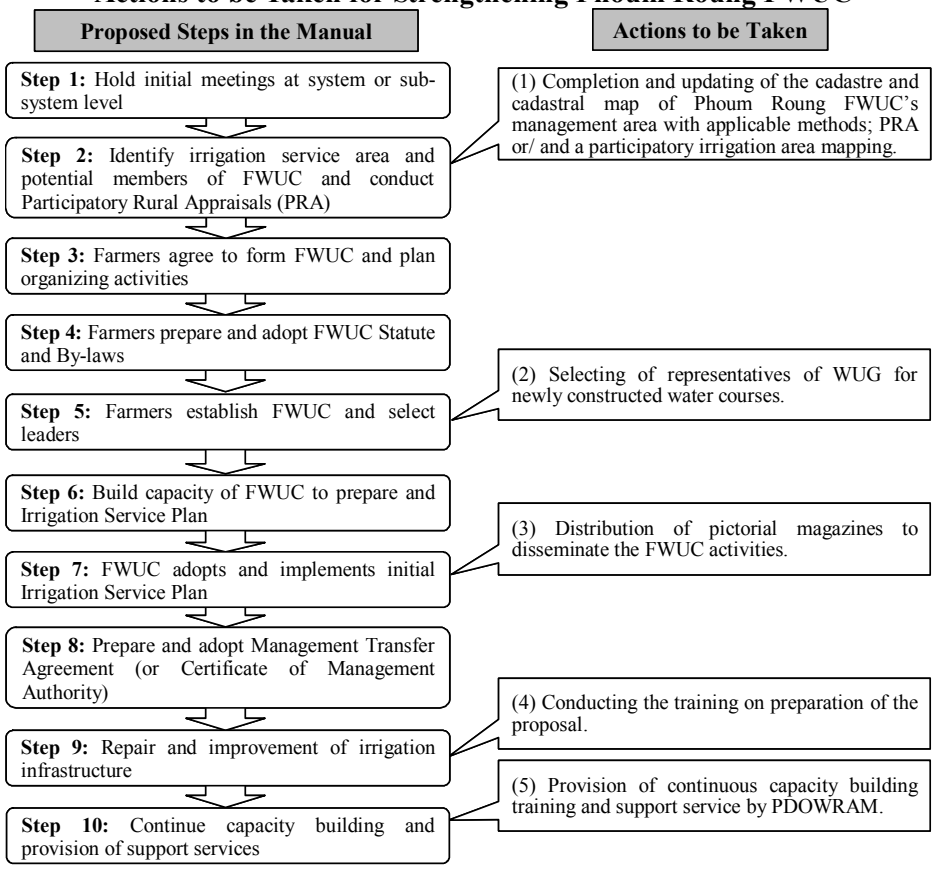
(a) Ou Veaeng FWUC

Actions to be Taken for Strengthening Ou Veaeng FWUC



(b) Phoum Roung FWUC

Actions to be Taken for Strengthening Phoum Roung FWUC



C-2.5.3 Farmers Organization Development

Achievement of the Strategic Target of the master plan, "Improved Agricultural productivity centered on rice" requires development of farmers' organizations because this target could be achieved only through good harmonization of agriculture, irrigation and drainage, and relevant institutional development. A farmers' organization is one of the important institutions which can contribute much to achievement of the target if it is developed by the midterm of the Project. The reason why it should be developed by the midterm is that the developed farmers' organization could be expected to create the basis of self-reliant and empowered farmers' unity, and this unity would become a driving force for promoting farmers' participation in the Project after its midterm. However, presently, the nature of most of the farmers' organizations is passive. If the farmers' organizations do not play an important role in the Project, they will remain only a recipient group of agricultural extension service and the other external support. Nevertheless, to repeat, to achieve the Strategic Target, it is necessary to strengthen and improve them so that they will aim at becoming self-reliant organizations by the midterm of the Project.

(1) Expected Functions of Farmers' Organizations

Future expected functions of the farmers' organization are i) joint purchase of agricultural inputs such as fertilizer, pesticide, and farming equipment, ii) collective shipment and sale of agricultural products, and iii) savings and loan. The organization which has these functions is called an Agricultural Cooperative. It would take much time to complete all the steps to establish the Agricultural Cooperative, in consideration of the present condition of the farmers' organizations in the Project Area. This means that establishment

of the Agricultural Cooperative could not succeed until the midterm of the Project. Therefore, "Farmers Organization Development" aims at developing a basic organization for the future Agricultural Cooperative in 2 years (by the midterm of the Project).

(2) Required Activities of Farmers' Organization Development

The basic farmers' organizations for the Preliminary Agricultural Cooperative can be developed from the existing savings groups organized through the initiative of CEDAC (NGO) or IPM (a project). There are 4 CEDAC's and 2 IPM's savings groups in the Project Area. These savings groups are gatherings of farmers who willingly join in the group to share the benefits of group activities; saving and borrowing money easily with relatively low interest rates. Their capital fund is money collected from the members (savings). In other words, it can be said that the savings groups are only farmers' groups which are democratically managed by their members in the Project Area. In this current circumstance, the proposed activities to improve the saving groups to become basic organizations of Preliminary Agricultural Cooperatives are the following.

1) Clarification/ Review of the existing regulations

The problems of existing savings groups are default and delay of repayments. The existing regulations should be clarified or reviewed to reduce the defaults and delay of repayments through meetings of all the members. During the meetings, the members need to make efforts to motivate each other and confirm the feed for compliance with the regulations determined by them.

2) Keeping/ Improving of financial transparency

One of the considerably important issues for continuing group activities is to sustain credibility among the members and committee members of the group. For this purpose, it is necessary to keep or improve accounting transparency. The books should be accessible to the members anytime. Accordingly, the person in charge of accounting should be selected very carefully from among the group members. It is risky if the group selects only one person to be responsible for money transactions. Thus, the group should be managed by a committee consisting of at least 2 persons; the Chief and the Accountant. When a certain amount of money is accumulated, the Chief and the Accountant should open a bank account to obtain interest and to keep the money collected safe.

3) Increase of capital funds

It is necessary to increase capital funds to expand the group activities and boost the number of beneficiaries. There are two recommendable ways to increase capital funds; i) increase the number of members and ii) increase of amount of compulsory saving. Here, it should be noted that the group needs to hold to the self-finance principle, although they intend to increase their capital fund easily and quickly. Introduction of capital funds from donors might possibly cause complicated accounting problems.

4) Preparation for developing into a Preliminary Agricultural Cooperative

Just before termination of the Project period, the group is required to start activities to prepare for gradually developing into a Preliminary Agricultural Cooperative. The savings group can consolidate with other farmers' groups, which have other objectives and activities related to agriculture, in order to organize a "Farmers' Association." One of the candidates is a group receives agricultural extension services. Or the savings group can start collective activities related to agriculture as a core of the association. In either manner, the savings group can organize a farmers' association and this association can be regarded as a Preliminary Agricultural

Cooperative (total number of members should be at least 25 physical entities). By the termination of the Project, the Preliminary Agricultural Cooperative would be mature enough to register as an Agricultural Cooperative. Then, the Preliminary Agricultural Cooperative would need to start preparing for official registration as an Agricultural Cooperative under the coordination of MAFF and PDA. As for the registration, the Preliminary Agricultural Cooperative should follow the legal framework mentioned below.

- Royal Decree NS/RKT/0701/234 on the Establishment and Functioning of Agricultural Cooperatives, Union of the Agricultural Cooperatives and the Preliminary agricultural Cooperatives, July 16, 2001
- Prakas promulgating the Model Statute and By-laws of Agricultural Cooperatives, 2003
- Model Statute of Agricultural Cooperatives, 2003
- Model by-law of the Agricultural Cooperatives, 2003

In Royal Decree NS/RKT/0701/234, a cooperative is defined as "a commercial enterprise, which is democratically managed by its members, who contribute their capital and hope for dividends, and are also willing to incur losses according to the proportion of their shares contributed."

(3) Role of Supporting Agency

External support is absolutely necessary. Nevertheless, it should be limited to capacity building during strengthening of savings group's activities (1) ~ 3)) and R&D (Research and Development) of the market for the agricultural products during (4)) preparation for developing into a Preliminary Agricultural Cooperative. The R&D of the market is necessary because it is frequently reported that existing farmers' organizations (production) face a lack of market for their products. These supports can be provided by PDA or an NGO like CEDAC. On the occasion of registering as an Agricultural Cooperative, PDA should assist the farmers' organization with preparing the official documents.

C-2.6 Environmental Considerations

In the process of formulation of the improvement plan, a series of environmental considerations were investigated in order to implement the Project in a more environmentally friendly and sustainable manner. The environmentally important points under the Project were i) water availability during the construction phase, ii) lining method for the canals, and iii) air pollution due to the construction vehicles.

(1) Water Availability during the Construction Phase

Currently, canal water in both the North and South Main Canals is used for agriculture and for domestic use and drinking. The Socio-economic Survey, which was conducted in 2007 for 100 sample households living in the Project Area, shows that about 40% of households are taking canal water for domestic use in the dry season. Moreover, 10% of households are taking canal water for drinking in the dry season.

However, the rehabilitation work on the canals requires stopping the water flow in the canals during the work period, which will be for a few months. As a conclusion, rehabilitation work on the canals would be concentrated in the fallow period from December to March in order to avoid impact to agricultural activities as much as possible.

Though the duration is not long, it directly impacts people who rely on canal water for drinking and domestic use. To deal with this impact, a detailed survey of the affected people will be conducted for finding an alternative water source for drinking and domestic

use during the construction period. For the people who do not have any alternative water source, countermeasures such as distribution by water tanker would be proposed.

(2) Lining of the Canals

Two canal lining methods, i.e. concrete lining and earth lining were examined for severely eroded side slopes in consideration of the environmental aspects.

As a conclusion, lining of the South Main Canal would be earth, instead of concrete. With concrete lining, the concrete work would create alkalified water that negatively affects the aquatic-biodiversity. In addition, biodiversity will be at risk of damage by the artificial surface of the canals. The earth lining will not cause these kinds of negative impacts to the environment. Moreover, sod-facing along the canal banks will be conducted in order to prevent the erosion on side slope using an environmentally friendly method.

(3) Air Pollution from the Construction Vehicles

Because most of the roads around the Project Area are unpaved, running of vehicles spreads dust in the air, especially in the dry season. During the construction phase, construction vehicles will increase the road traffic so that the dust problem will become more serious. Therefore, regular sprinkling of the roads by water vehicles was included in the construction work items.

C-2.7 Implementation Plan

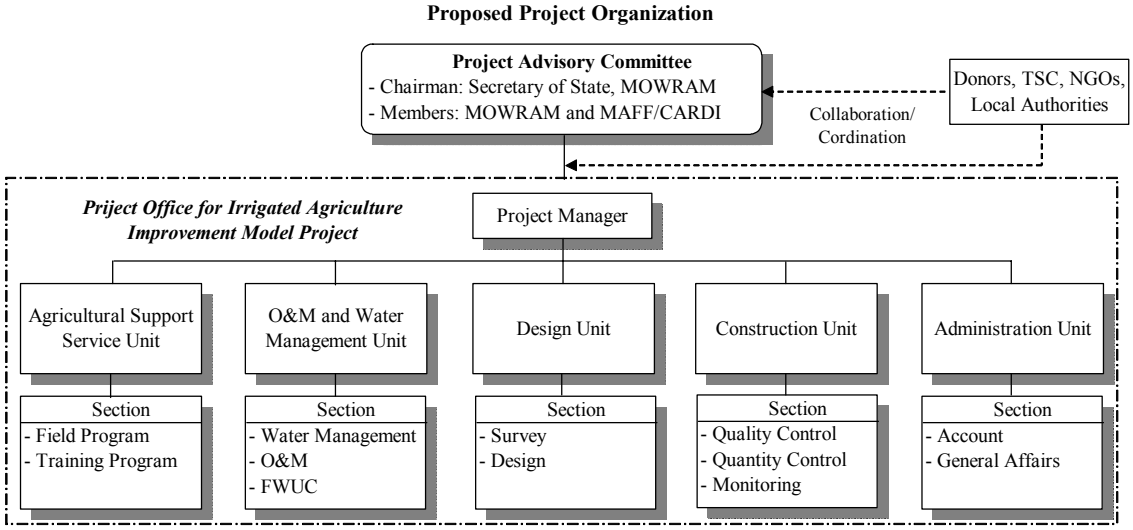
C-2.7.1 Executing Agencies

MOWRAM is the overall executing agency for the project implementation. The purpose of the Project is to demonstrate proper water management and increase rice production by harmonizing agriculture, irrigation and drainage and institutional development. This means that close coordination between PDOWRM and PDA is essential. In addition, the Project will be implemented using a participatory approach from the early stage. Taking into consideration the above, it is proposed to establish a Project Office directly belonging to the Under Secretary of State of MOWRAM

C-2.7.2 Organization and Staff Required

(1) Organization

Below shown is a proposed organizational chart focusing on close coordination between PDOWRAM and PDA.



The proposed organization should be established prior to commencement of design works.

There are three groups in the proposed project organization. These are the Project Advisory Committee, the Collaboration/coordination Group and the Project Office. The Project Advisory Committee will be responsible of reviewing the activities of the Project Office and providing timely and proper advice for that office as required. The Project Advisory Committee will be chaired by the Secretary of State, MOWRAM and its members will be composed of representatives of relevant departments of MOWRAM and MAFF. The Project Manager will serve as a coordinator of the committee.

The relevant donors, NGOs, local authorities and TSC are expected to collaborate and coordinate with the Project Advisory Committee and the Project Office for smooth implementation of the Project in reply to their requests or as needed.

The Project Office will consist of five units under the Project Manager, which are the Agricultural Support Service Unit, O&M and Water Management Unit, Design Unit, Construction Unit and Administration Unit. These Units should fulfill their duties to each other in a cooperative manner to realize synergistic effects. In particular, careful attention should be paid to the land acquisition for canal and structure construction. As for Tertiary Canals and Watercourses, the required land should be contributed by farmers according to the government regulation. However, this regulation could hardly be observed for many cases. In order to cope with this matter, the Construction Unit shall assign one staff.

(2) Staff Required

In principle, the staff of the Project Office is planned to be transferred from PDOWRAM and PDA or MOWRAM and MAFF if necessary. To operate and manage the Project Office, the following staff, in addition to a Project Manager, would be required:

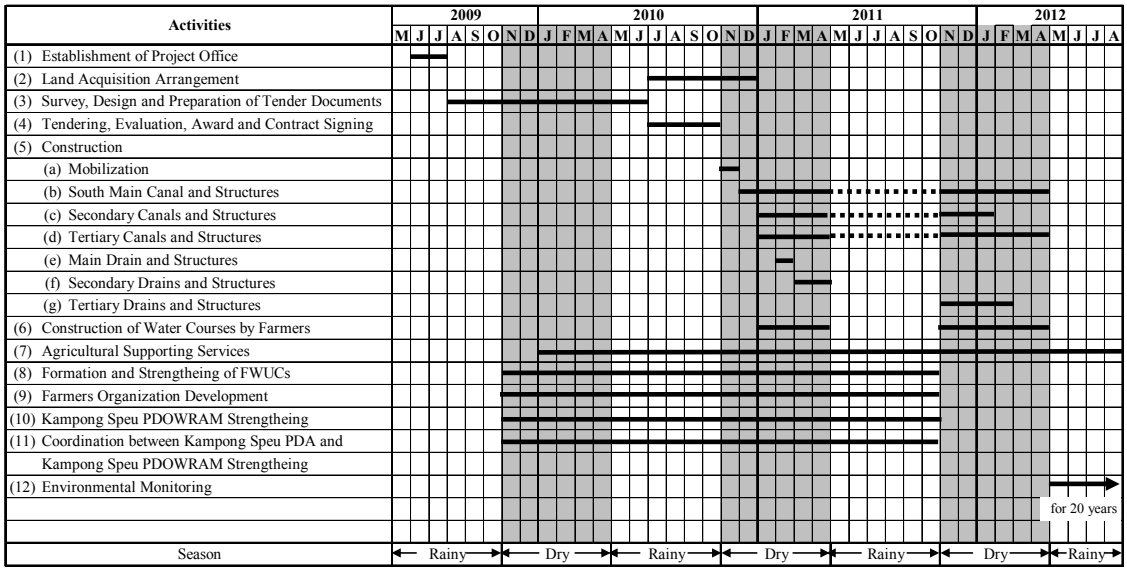
Required Staff for Project Office

Unit	Section	Occupation	No. Required
Agricultural Support Service		Unit Chief (Agronomist)	1
	Field Program	Extension Expert	1
	Training Program	Extension Expert	1
O&M and Water Management		Unit Chief (Engineer)	1
		Clerk	1
	O&M	O&M Expert	1
		Technician	1
		Un-skilled staff	1
	Water Management	Water Management Expert	1
		Extension Worker	1
Design		Unit Chief (Engineer)	1
	Survey	Surveyor	1
		Un-skilled staff	3
	Design	Designers	1
		Un-skilled staff	1
Construction		Unit Chief (Engineer)	1
	Quality Control	Supervisor	1
		Un-skilled staff	1
	Quantity Control	Supervisor	1
		Un-skilled staff	1
	Monitoring	Land Acquisition staff	1
		Computer operator	1
Administration		Unit Chief	1
		Clerk	1
		Driver	1
Total			**27**

C-2.7.3 Implementation Schedule for the Project Works

The proposed implementation schedule for the Project works is shown below:

Implementation Schedule of Project Woks



Beginning in June and July 2009, a Project Office will be established aimed to ensure close coordination between PDOWRM and PDA and to strengthen the participatory approach including farmers' contribution to the Project.

Immediately after the establishment of the Project Office, design works consisting of topographic surveys, detailed design and preparation of tender documents, will be carried out on a contractual basis. The required period would be the 11 months from August 2009 to June 2010. The canal layout should be explained to the stakeholders through public consultation meetings as one part of the participatory approach.

After completion of design works, the tendering will be conducted. The tendering works will include the pre-qualification, tendering, evaluation and award and contract signing. Generally, this would take four months.

In parallel with the tendering work, the Project Office shall start the land acquisition for canal construction and borrow pit areas. In addition, the Project Office shall explain and convince the farmers of the need for watercourse construction by the farmers themselves and contribution of lands for construction of tertiary canals and tertiary drains. It is expected that such preparatory work will be completed by December 2010.

The Project facilities are divided into 4 systems; the South Main Canal system, secondary and tertiary irrigation canal system, watercourse system and drainage canal system. The implementation schedule of these facilities shall be elaborated considering the following points:

- The construction for the Project facilities, except for the watercourses, is to be performed on a contractual basis.
- As the construction volume is not large, construction is to be done in one package.
- Each of project facilities mentioned above is to be constructed independently, paying attention on their order to produce early benefits.
- The construction schedule should be so worked out so as not to interfere with agricultural activities as much as possible.
- Watercourses should be constructed in a participatory manner by the farmers concerned under technical support from the Project Office.

Prior to commencement of construction of these facilities, the contractor will complete mobilization within the thirty days during the month of November 2010. Immediately after the mobilization, construction of the South Main Canal will be started in December 2010. In succession, the construction of secondary canals, tertiary canals, main drains, secondary drains and tertiary drains will follow. These canals, drains and related structures will be constructed in the two dry seasons from December 2010 to April 2011 and November 2011 to April 2012. Concurrently, it is expected that construction of the watercourses will be started by farmers under technical support of the Project Office.

To realize the Project sustainability, the Project support services will be started earlier than construction works, potentially during the design phase. The planned Project support services are formation of and strengthening of FWUCs, farmers' organization development, Kampong Speu PDOWRAM strengthening and strengthening of the coordination between Kampong Speu PDA and Kampong Speu PDOWRAM. The agricultural support services will be delivered during the construction period.

Environmental monitoring will be started after completion of construction works and will continue for 20 years, to assess any environmental impacts of the construction works.

C-2.8 Environmental Examination

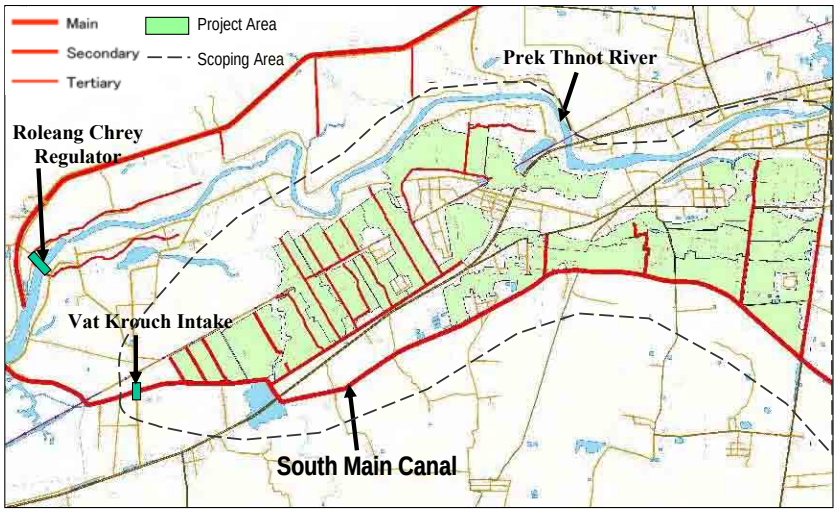
C-2.8.1 Environmental and Social Conditions to be examined

Based on available information on the natural and social environment, environmental scoping for the Project was undertaken to identify anticipated impacts on the environment to be examined as shown below.

Environmental and Social Conditions to be examined

Potential Impact		Phase		
		Designing	Construction	Operation
Social Environment	Land Acquisition	- Land acquisition due to expansion of the canal width and increase of length	―	―
	Inflow of Construction Workers	―	- Degradation of sanitation and security due to inflow of construction workers	―
	Water Availability	―	- Limitation of water usage in command area of the South Main Canal during rehabilitation work on the canals	―
Pollution	Air Pollution	―	- Air pollution caused by vehicular gas emissions	―
	Water Pollution	―	―	- Acceleration of nutrient load or chemical contamination in drain water by increase of farm input usage
	Noise and Vibration	―	- Noise and vibration caused by construction vehicles and heavy equipment	―

Taking into consideration of these anticipated impacts, the area to be examined was determined as shown below.



Area to be examined

C-2.8.2 Consideration of Environmental/Social Impacts and Mitigation Measures

The impacts and proposed mitigation measures are shown below.

Land Acquisition (Designing Phase)

Activity	Construction of irrigation and drainage canals
Affected Area	Total 10.0ha in the Project Area
Projected Impact	Required area for land acquisition that would be caused by expansion of existing canals and new construction of irrigation and drainage canals was preliminary estimated as shown below. Most land to be acquired is currently used as agricultural land.

Preliminary Estimation of Land Acquisition under the Project

	Irrigation Canals			Drainage Canals				Total
	Secondary	Tertiary	Total	Main	Secondary	Tertiary	Total	
Area (ha)	0.81	3.43	4.24	0.12	2.51	3.13	5.76	10.0

As for land tenure, more than 90% of farmers have their own irrigated land according to SEILA Data Base 2005, though there are no available data about tenure farming in the Project Area. At this moment, land users who will be acquired by the project are not identified.

Under the rules of Cambodia, land acquisition for irrigation and drainage canals of main and secondary levels are to be managed by the Government, while tertiary level canals are to be the responsibility of the local community. This means that the Government will compensate the owners for land required for main and secondary canals, but not land for tertiary canals. Based on the proposed plan, 3.44ha will be required for main and secondary canals, and 6.56ha for tertiary canals that will be managed by the local community, all as shown below. A total of 20, out of the 22 tertiary blocks in the Project Area will require land for new tertiary canals.

Responsible Organization for Land Acquisition

	Government	Local Community	Total
Area (ha)	3.44	6.56	10.0

Mitigation Measures	Land acquisition for main/secondary canals - To design canals in order to minimize land acquisition as much as possible through detailed investigation. - To cooperate with the Inter-ministerial Resettlement Committee (IRC) and adequately identify and evaluate the	Land acquisition for tertiary canals - To design canals in order to minimize total area of land acquisition and individual burdens as much as possible through detailed investigation. - To cooperate with local communities such as the commune councils and village chiefs

	property and owners affected by the Project. - To conduct stage wise discussions with local people on i) canal layout design, ii) compensation measures, and iii) support programs, in order to obtain consensus of the affected people. - To compensate and support land users (tenant farmers) and land owner who will lose cultivation fields	- To establish an appropriate implementation method for land acquisition and compensation through a series of discussions with local communities and local people. - To consider appropriate compensation measures for the affected people
Conclusions of the Examination	Considering the great sensitivity of the people, the land acquisition process should be conducted very carefully beginning in the design phase. In addition, average holding size of agricultural land is only 0.84ha per capita in the Project Area. Therefore, even in the narrow area to be acquired, it might constitute a large impact to the agricultural activities of the affected people. Especially land for tertiary canals, which will not be compensated for by the Government. As a conclusion, it can be said that this matter may have a high-risk of social problems for project implementation without paying great attention and implementing proper measures like the proposed mitigation measures.	

Inflow of Construction Workers (Construction Phase)

Activity	- Rehabilitation of South Main Canal and secondary canals - Construction of irrigation canals and drainage canals
Affected Area	In and around the Project Area
Projected Impacts	Due to inflow of construction workers from outside during the construction phase, the following impacts can be anticipated; i) deterioration of sanitation conditions, ii) deterioration of public security, iii) increase of risk of diseases including AIDS/HIV, iv) conflicts between the local people and workers. Construction scale is not large and duration is at most 18 months.
Mitigation Measures	- To improve sanitary condition of workers by proper arrangement of accommodations, installation of toilets and a proper water supply - To implement education programs for the workers about sanitation, security and rules and discipline of daily activities - To implement periodic patrols of workers in order to avoid both occurrence of local conflicts and epidemics of diseases - To hold a series of public meetings for the surrounding people in order to explain the construction work and its schedule.
Conclusions of the Examination	Because the people in and around the Project Area are not familiar with construction workers from other areas, great attention toward management of construction workers and construction fields will be significant. However, taking into consideration the work scale, the number of construction workers will not be large. Therefore, serious negative impacts are not envisaged with proper implementation of mitigation measures.

Water Availability (Construction Phase)

Activities	Rehabilitation of the South Main Canal and secondary canals
Affected Areas	Existing command area of the South Main Canal
Projected Impacts	Rehabilitation work on the South Main Canal and secondary canals will stop water flow in the canals in the fallow period from December to March. People living in the command area of the South Main Canal will be faced with little or no canal water in that period. By rough estimation, around 3,000 people living in command area of South Main Canal will lack drinking water, while 12,000 people will lack water for domestic use. In addition, some rehabilitation works will be conducted in the cultivation period in cases in which it is not avoidable. In these cases, agricultural activities will be limited during one cultivation period in some areas.

Mitigation Measures	- To conduct construction work in the fallow period as much as possible. - To hold a series of public meetings when the detailed construction work schedule is being planned in order to discuss the work schedule and decide it along with affected people. - To consider other sources of water for drinking and domestic use for the affected people by consultation meetings with them.
Conclusions of Examination	Though the impacts on water availability can be minimized by implementation of ECP, at most 12,000 people will be affected by lack of water availability due to the rehabilitation work in the canals in one fallow period. In addition, some areas will be limited in their agricultural activities during one cultivation period, but those exact areas are as yet undetermined. This will also be risk creating feelings of unfairness among the people. Therefore, careful attention to the proposed mitigation measures will be necessary.

Air Pollution (Construction Phase)

Activities	- Rehabilitation of the South Main Canal and secondary canals - Construction of irrigation canals and drainage canals
Affected Areas	In and around the Project Area
Projected Impacts	Operation of construction vehicles and transportation/operation of heavy equipment, such as dump trucks, excavators, bulldozers, rollers for earth compaction and water lorries, will exhaust gases including nitrogen dioxide (NO_2) and suspended particulate matter (SPM).
Mitigation Measures	- To educate construction workers to minimize idling of construction vehicles
Related regulations	Sub-decree on Air and Noise Control (June 10, 2000); Ambient air quality standards (CO, NO_2, SO_2, Ozone, Pb, TSP)
Conclusions of Examination	Because most of the construction works are small scale, the numbers of both heavy equipment and construction vehicles for the work will not be many. Therefore the impact to air quality will not be serious with proper management and mitigation measures.

Noise and Vibration (Construction Phase)

Activities	- Rehabilitation of the South Main Canal and secondary canals - Construction of irrigation canals and drainage canals
Affected Area	In and around the Project Area (Mainly along the South Main Canal)
Projected Impacts	During the construction phase, heavy equipment will cause noise and vibration. Types of heavy equipment would be dump trucks, excavators, bulldozers, rollers for earth compaction and water lorries. Along the South Main Canal, there are two settlement areas with several residences, while other areas are paddy fields.
Mitigation Measures	- To limit construction time. e.g. at daytime only - To hold public meetings with the surrounding people to obtain consensus about the construction time.
Related regulations	Sub-decree on Air and Noise Control (June 10, 2000); Maximum permitted noise levels in residential areas are 60dB from 6am to 6pm, 50 from 6pm to 10pm and 45 from 10pm to 6am.
Conclusions of Examination	Because most of the construction works are small scale with only a small amount of heavy equipment, the impact of noise and vibration will not be serious with proper management and mitigation measures.

Water Pollution (Operation Phase)

Activities	Operation of the irrigation and drainage canals after rehabilitation and construction
Affected Areas	In and around the Project Area, downstream of Prek Thnot River
Projected Impacts	Increased irrigation might encourage farmers to use higher levels of agrochemicals and fertilizer due to the reduction of crop risk when water is assured. In addition, the Socio-Economic Survey conducted in 2006 indicated that more than half of the

	households want to use more fertilizer than they are now using for improvement of rice productivity. In addition, based on the Project plan, the double cropping area would increase by 82 ha. Increased use of irrigation water might also result in greater amounts of water draining through irrigation systems and back into drainage canals and rivers. This might result in nutrient load or chemical contamination in the water.
Mitigation Measures	- To conduct a support program regarding appropriate agricultural management - To introduce composting activity to the farmers - To introduce the check system among the FWUC members regarding agricultural management - To monitor water quality and agricultural activities regularly.
Related regulations	Sub-decree on Water Pollution Control (April 6, 1999); Water quality standards in public water areas for bio-diversity conservation (pH, BOD, TSS, DO, Coliform, TN, TP), Water quality standards in public water areas for public health protection (DDT, Cadmium, Lead, etc.)
Conclusions of Assessment	Without any countermeasures against this anticipated impact, the amount of fertilizers or agrochemicals may increase and create a risk of nutrient load or chemical contamination in water from the irrigated areas. A total of 27% of households use canal water for domestic in the rainy season, while 3%use it for drinking. Though irrigation canals and drainage canals will be separated under the Project, people may use water from drainage canals, in which the water may contain higher nutrient loads or chemical contamination. However, taking into consideration that the Project Area is already an irrigated area, and most people in the Project Area are interested in using compost, water quality contamination may not become a serious problem when other components of the Project such as the agricultural support services strengthening plan will be implemented with proposed mitigation measures.

In addition to the above, people living in the project site are concerned with issues relating to the irrigation service fee. They are worried that some people may not pay the fee and the cost for water management cannot be collected. Currently, the system of the irrigation service fee has not been functioned yet.

Under the pilot project of the Study, Ou Veang FWUC has started to collect irrigation service fee as a trail. As a result, they could improve the rate of collection of the fee spectacularly. The factors of this success were considered that i) water was properly distributed to each field, ii) the ability of FWUC was strengthened through a series of training and practice, iii) minimum of irrigation facilities which were necessary for water management were repaired and/or improved, and iv) farmers were grouped by each tertiary canal/watercourse for water management. Following the result of the pilot project, irrigation service fee would be collected accurately when the system of water supply and appropriate organization were promoted and maintained.

C-2.8.3 Environmental Management and Monitoring Framework

Based on the environmental examination of the Project as explained above, two kinds of environmental management and monitoring plans are proposed as follows. By implementing these plans, the Project will be conducted in a more environmentally friendly and smooth manner with minimization of negative risks and impacts.

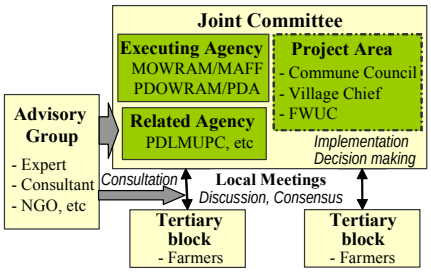
i) Participatory Process of Land Acquisition for Tertiary Canals

ii) Water Quality Monitoring

Brief explanations of the proposed plans are as follows.

Participatory Process of Land Acquisition for Tertiary Canals

Items	General Outline
Background	As mentioned above, land required for the main and secondary canals will be compensated for by the Government through their Inter-ministerial Resettlement Committee (IRC), of which the duties are determination of entitlements, land values and appropriate

Items	General Outline
	compensations through detailed surveys and public consultations. On the other hand, land acquisition for tertiary canals will be the responsibility of the local community. This means that the Government will not compensate the owners for the land for tertiary canals. It was preliminarily estimated in the proposed plan that around 7 ha of agricultural land will be required for the tertiary canals. These lands to be acquired are spread over 20 of the 22 tertiary blocks in the Project Area. Land acquisition for tertiary canals should be conducted very carefully in the beginning, because i) land acquisition is a very sensitive issue, and ii) there is no official process for land acquisition and compensation by the government for tertiary level improvements. It can be said that this matter has a high-risk of creating social problems for project implementation.
Objective	To conduct land acquisition for tertiary canals properly and smoothly with people's consensus.
Proposed activities	Since land acquisition should be the responsibility of the Government, the Government needs to develop proper processes for land acquisition. One of the conceivable processes is as follows;
	i) Establishment of Implementation Structure **- Joint committee;** A joint committee, consisting of executing agencies (PDOWRAM, PDA), related agencies (Provincial Department of Land Management, Urban Planning and Construction (PDLMUPC), etc) and local communities (Commune Council, village representatives, FWUC leaders, etc) as a decision making body should implement the land acquisition process **- Advisory group;** An advisory group, consisting of experts, consultants and/or NGOs, as an independent body should hold consultations regarding the implementation process with emphasis on identification of the validity of the process. **- Local meetings;** Local meetings should be called by the Joint committee to discuss the issues with the related farmers of each tertiary block. At the local meetings, explanations by the Joint committee, discussions among the related people and obtainment of people's consensus will be mainly conducted. 
	ii) Consideration of implementation process As a first step, the implementation process for land acquisition for tertiary canals including land compensation should be discussed at the Joint committee and next at local meetings. It is necessary to decide the process with people's consensus before practical implementation is begun.
	iii) Discussion on canal layout After the implementation process has been decided, layout of irrigation and drainage canals will be discussed by the Joint committee and next at local meetings. Because a drainage canal might cross through several tertiary blocks, joint meetings among all relevant tertiary blocks should be conducted as the need arises.
	iv) Identification of the affected people, implementation of a household inventory survey The affected people should be identified based on the developed tertiary canal layout. Targeted on the affected people, household inventory surveys should be conducted to collect socio- economic data, their opinions, impacts of the land acquisition, demands related to the land acquisition and so on. These activities should be implemented with the cooperation of the Advisory group.
	v) Implementation by proposed process Based on the developed implementation process and results of the household inventory survey, the Joint committee should implement the land acquisition and the compensation for the affected people. In the process, the Joint committee should prepare documents for the records and present all related information to the local people and the Advisory group.

Items	General Outline
	vi) Land acquisition with monitoring When the land acquisition is conducted, the Advisory group should monitor the process to check its implementation and the affected people's condition. If problems arise, Advisory group should request that the Joint committee consider countermeasures to solve them.
Anticipated issues	Although the land acquisition for the tertiary canals was proposed as mentioned above, there are still anticipated concerns as follows; **a) Small holding size of farmers** In the Project Area, the average holding size of agricultural land is only 0.84ha per capita and the land to be acquired to accommodate the width of the irrigation and drainage canals is about 6 m and 3.5 m respectively. For farmers holding small parcels, loosing this amount of land would have a significant impact on their agricultural activities. Therefore, it is necessary to argue on canal layout and compensation method thoroughly with concerned communities. It is important to give careful consideration to farmers who own small size of land. Under the pilot project of the Study, for example, almost all farmers who had lands to be acquired for construction of watercourses accepted to contribute their land, if they would obtain water whenever they want for agricultural activities. **b) Decision on drainage canal layout** Land acquisition for drainage canals might be more difficult than that of irrigation canals, because it is normally difficult for the farmers to understand their necessity. In addition, drainage canals would cross several tertiary blocks based on the proposed layout. Therefore, discussions on drainage canal layout may face difficulty in obtaining the people's consensus. When they discuss this matter, it will be needed to discuss compensation method in parallel for main and secondary drains. **c) Decision on compensation method** In Cambodia, there have been a few instances of land acquisition for tertiary canals with compensation by the community, supposedly because of the low density of the existing canals or utilization of old canals. Taking these examples into consideration, several methods of compensation by the community can be considered, although there might be merits and demerits to each method. One example is that the acquired area will be shared evenly by the entire community. This means that every farmer in a tertiary block would contribute a portion of their own land in a ratio proportionate to the size of their land holdings. This would require rearrangement of many of the land boundaries. Another way is that farmers will compensate the affected people by paying money, though the feasibility of this method depends on the people's economic condition. Or if there is public land near the land that needs to be acquired, the affected people could be compensated by receiving a similar amount of the public land instead. Eventually the compensation method will be chosen by each community, but the important point is that the compensation method should be considered by each community and decided with the people's consensus. **d) Forced contribution without the consensus of the affected people** It is anticipated that the affected people might have to contribute the land for the canals without any compensation because of pressure from their surrounding neighbors. In order to avoid that situation, the Advisory group should consult with the people regarding the land acquisition process and support the affected people. **e) Necessity of allowing enough time to complete the process** It might take a considerable amount of time to conduct the land acquisition process with the people's consensus. In addition will require a series of discussions among the stakeholders and the affected people. Therefore, it is better to begin the process in the beginning phase of the Project.

Water Quality Monitoring

Items	General Outline
Background	After irrigation and drainage canals become operational, nutrient load or chemical contamination may increase in the water running off from irrigated areas because of an increase in agrochemicals and fertilizer used in the fields or an increase in the irrigation water used as a whole. People are taking canal water for both drinking and domestic use. Therefore,

Items	General Outline
	there are some risks of water pollution and eventually risks of human-health hazards.
Objectives	- To monitor water quality flowing from the irrigated areas - To monitor primary factors that would directly present a human-health hazard by water pollution
Items to be surveyed	- Temperature of air/water, flow rate, color, odor, appearance - Physico-chemical properties (pH, EC, TSS, BOD, DO) - Organo-chemical substances (N, P) - Micro-organisms (bacteria, coliform groups) - Inorganic ions (Na, Mn, Fe, Zn, Cu, Cl)
Sampling points	Water quality should be monitored at six points including i) drain ditches from irrigation areas (2 points), ii) Ponds within the irrigation areas (2 points), iii) wells within the irrigation areas (1 point), and iv) downstream of the Prek Thnot River (1 point)
Frequency	Twice a year ; rainy season and dry season
Monitoring period	The 20 years after operation commences
Evaluation	Monitored values should be evaluated with reference to the related standards (WHO standards for drinking water and RGC water quality standards in public water areas). If a serious problem is recognized, proper countermeasures should be developed and implemented.
Executing Agency	PDOWRAM Kampong Speu Province

C-2.8.4 Comparative Evaluation of the Project

(1) Examination of the Condition without the Project

The following table shows the comparison of potential impacts between with and without the Project. It was assumed that the structures of the South Main Canal will be out of order and fail to operate properly in the near future in the "without the Project" condition.

As a result of the comparison, it is expected that the improvement plan will raise or increase positive impacts related to water usage, agricultural activities, local society and land use conditions. On the other hand, under the "without the Project" condition, water availability of the canals might decline and the local economy and their lives will be negatively impacted accordingly.

Comparison between With and Without the Project

Activity / Potential Impact	Without Project	With Project	Remarks
Social Environment			
Water Usage	--/B	++/B	Regional and seasonal gap of water availability because of no improvement of canal structures (w/o)
Local economy (employment, livelihood etc)	--/B	++/C	Limitation of agriculture and fishery because of worsening of water availability, improper management of land (w/o)
Land use and utilization of local resources	--/C	=/C	Wasteful of water (w/o), Land acquisition (w/)
Social institutions	--/B	++/C	Failure of FWUC (w/o)
Existing social infrastructures and services	--/B	++/C	No rehabilitation of canals or structures (w/o)
The poor, indigenous and ethnic people	--/C	*	
Misdistribution of benefits and damage	--/C	*	Misdistribution of water (w/o)
Local conflicts of interest	--/B	--/C	Land acquisition (w/)
Hazards (Risks), Infectious diseases	--/C	=/C	No drainage system (w/o)
Natural Environment			
Groundwater	--/B	*	Reliance on groundwater (w/o)
Hydrological Situation (Hydraulic)	=/B	=/B	
Flora, Fauna and Biodiversity	*	=/C	

Activity / Potential Impact	Without Project	With Project	Remarks
Pollution			
Air Pollution	*	--/C	Construction work (w/)
Water Pollution	--/C	--/C	Overload of agricultural inputs because of limitation of agricultural practices (w/o), Construction work (w/)
Noise and Vibration	*	--/C	Construction work (w/)
Ground Subsidence	--/C	*	Reliance on groundwater (w/o)
Accidents	*	--/C	Construction work (w/)

*Note) --/B: left-hand side of each cell represents the direction of the impact, right-hand side represents the magnitude of the impact. ++: Positive impact, --: Negative Impact, =: Neutral Impact, A: relatively significant impact, B: relatively medium-sized impact, C: relatively small impact, *: No impact or no corresponding impact, w/: with the Project, w/o: without the Project*

(2) Examination of the Condition without Environmental Considerations

In the process of formation of the improvement plan, a series of environmental considerations were investigated in order to implement the Project in an environmentally friendly and sustainable manner as mentioned in Section C-2.6. In order to examine the effectiveness and validity of the Project components from the viewpoint of the environment, these environmental considerations were evaluated by comparing the condition "with environmental considerations" with the condition "without environmental considerations".

The following table shows the comparison of potential impacts between with and without environmental considerations. The main difference in the impacts between them is water availability that will cause relatively significant direct impacts to people's lives and agricultural activity. In addition, earth lining of the canals will mitigate impacts to the aquatic biodiversity, but proper management of canals will still be necessary in order to maintain the canals appropriately. As a conclusion, it is clear that these considerations might be effective and valid for the local people directly and for the natural environment.

Potential Impacts with and without Environmental Considerations

Potential Impacts	Without Considerations	With Considerations
A) Water Availability during the Construction Phase		
Water availability during the construction phase	People living in the command area of the South Main Canal cannot access canal water in the cultivation period because the water flow in the canals would be stopped during the rehabilitation work on the South Canal.	People living in the command area of the South Main Canal will be limited to loss of canal water only in the fallow period.
Local economy during the construction phase	Agricultural activities in the command area of the South Canal (in total around 10,000ha) will be limited during a single cultivation period.	Few/no impacts to agricultural activities by the construction work
B) Lining of Canals		
Water pollution during the construction phase	Alkalified water caused by the concrete works during the construction phase will negatively affect the biodiversity. People using canal water for drinking will also be affected in by the alkalified water.	Murky water will increase in the canals during the construction phase. However the impact will not be serious to biodiversity.
Impacts to biodiversity during the operation phase	Biodiversity will be at risk of damage by the artificial surface of the canals.	Impacts will be negligible the during operation phase.
Breakdown of the canal during the operation phase	Few impacts	The canals are at slight risk of land slides and breakdown of the embankment.

Potential Impacts	Without Considerations	With Considerations
Disruption of water flow by grasses	No impacts	Without any management of canals by farmers, water flow will be disrupted or stopped.
C) Air Pollution by Construction Vehicles		
Air pollution in the form of dust during the construction phase	Dust will be raised, especially in the dry season. People living along the roads which are traveled by construction vehicles will be affected by the dust.	Little if any dust will be raised.

C-2.8.5 Conclusions

The initial environmental examination of the Project concludes as follows;

- As a whole, the Project Development Plan was evaluated to be acceptable from an environmental viewpoint if the proper mitigation measures presented previously are undertaken.
- Some likely negative impacts on both the social and natural environments were pointed out, such as limitation of water availability during the construction phase and deterioration of water quality during the operational phase. Therefore, proper management with proposed mitigation measures and the management/monitoring plan should be implemented in order to avoid/mitigate anticipated negative impacts as much as possible.
- Considering the peoples' great sensitivity toward the subject, the land acquisition process should be conducted very carefully with proper management and implementation of proposed mitigation measures and the management plan.

C-2.9 Cost Estimate

C-2.9.1 Conditions of the Cost Estimate

The basic conditions and assumptions employed for the cost estimation of the Project are as follows.

- Cost estimate refers to the prices as of January 2007.
- Unit prices of labor, construction materials, engineering works, etc., were collected from MOWRAM and the current market.
- Construction is to be undertaken on a contractual basis.
- The Investment Cost consists of i) engineering service cost, ii) direct construction cost, iii) administration cost, iv) agricultural support services, v) formation and strengthening of FWUC, vi) farmers organization development, vii) Kampong Speu PDOWRAM strengthening, viii) strengthening of the coordination between Kampong Speu PAD and Kampong Speu PDOWRAM, ix) land acquisition arrangement cost, x) land acquisition cost, and xi) physical and price contingencies.
- Administration cost during the construction is assumed to be 10% of direct construction cost.
- The physical contingency is assumed to be 10% of the investment cost.
- Price escalation is evaluated based upon 4.5% per annum for the foreign currency portion and 7.0% per annum for the local currency portion.
- Conversion rate is assumed to be US$ 1.0 = Riel 4,060 (as of January 2007)

C-2.9.2 Investment Cost

The total amount of investment cost is estimated at US$ 2,479,000 equivalent to Riel 10,064,740. The summary of the investment cost is given below, and its details are shown in Table C-2.9.1.

Summary of Investment Cost

(unit:'000)

Item	US$	Riel (equivalent)
(1) Engineering service cost	436	1,770,160
(2) Construction cost	1,065	4,323,900
(3) Administration cost	107	434,420
(4) Agricultural support services cost	46	186,760
(5) Formation and strengthening FWUC	60	243,600
(6) Farmer organization Development	27	109,620
(7) Kampong Speu PDOWRAM strengthening	6	24,360
(8) Coordination between Kampong Speu PDA and Kampong Speu PDOWRAM strengthening	1	4,060
(9) Land acquisition arrangements	6	24,360
(10) Land acquisition cost	120	487,200
Total	1,874	7,608,440
(11) Physical Contingency	161	653,660
(12) Price Contingency	444	1,802,640
Total	2,479	10,064,740

Table C-2.9.2 shows the annual disbursement schedule for the investment cost, which was prepared based on the implementation schedule of the project works.

C-2.9.3 Replacement Cost

The replacement cost for the gates and appurtenances is estimated at US$187,000 equivalent to Riel 759,220,000, of which, details are shown in Table C-2.9.3. These replacement costs will occur at the 25th year after installation.

C-2.9.4 O&M Cost

The annual O & M cost for the Project was estimated at US$ 5,900 equivalent to Riel 23,954,000, of which, details are shown in Table II-2.9.4. In addition, the environmental monitoring cost after completion of construction works will continue for 20 years, and its annual cost was estimated at US$ 648 equivalent to Riel 2,630,880.

C-2.10 Project Evaluation

C-2.10.1 General

The objectives of project evaluation for the Feasibility Study are to evaluate the anticipated economic and social impacts of the Project with a higher degree of accuracy and updated data, as well as from different angles other than quantifiable monetary terms but rather, from qualitative terms. The project evaluation for the Feasibility Study consists of three different types of evaluation approaches with each of them focusing on different aspects of the project, as listed below.

Evaluation Approaches Applied and Their Objectives

Evaluation Approaches	Objectives
(1) Economic Evaluation	To evaluate the economic impacts of the Project in quantifiable, monetary terms from the viewpoint of the "national economy"
(2) Financial Evaluation	To evaluate the financial viability of the Project in quantifiable, monetary terms from the viewpoint(s) of the project entity and/or beneficiaries
(3) Socio-Economic Impact Evaluation	To evaluate the Project's socio-economic impacts in non-monetary, qualitative terms

C-2.10.2 Economic Evaluation

(1) Evaluation Procedure

The project economic evaluation was carried out through standard methodology in the project appraisal process, i.e. estimation of Economic Internal Rate of Return (EIRR), Cost-Benefit Ratio (B/C), and Benefit minus Cost (B-C).

All prices for the Feasibility Study evaluation were expressed in constant prices as of January 2007, applying the average monthly official exchange rate of USD 1.0 = Riel 4,060. The economic life of the project is assumed to be 50 years beginning from year 2008, the proposed commencement year for construction.

Economic farm gate prices of internationally traded agricultural inputs and outputs were based on their export and import parity prices derived from the World Bank Commodity Price Forecasts as of October 2006. The long-run projected prices in 2010 at 2007 constant prices were used in the analysis. The average of export and import parity prices of farm products of rice, maize, and import parity prices of fertilizer were calculated and applied for the economic prices.

A standard conversion factor (SCF) of 0.98 and shadow wage rates (SWR) were applied for the adjustment of prices and labor costs reflecting the market distortion. Transfer payments such as taxes, duties, subsidies, interest, etc., were excluded in estimating the economic costs and benefits. Financial construction costs were converted into economic values by applying the construction conversion factors (CCFs).

(2) Economic Benefits

Irrigation and drainage benefits will accrue from the increase in cropping areas and productivity of target crops comprising paddy and upland crops such as mungbeans and vegetables. The economic benefit is estimated as the increase of net production value between the future "with" and present "without" project conditions.

The economic crop budgets of the respective crops for both "with" and "without" project cases were prepared by applying requirements for farm inputs and total labor, unit crop yields, and their economic prices.

The irrigation and drainage benefits (increase of Net Present Value: NPV) for the Project was estimated as follows.

Economic Benefit of the Project

Project Area (ha)	Cropping Intensity (%)		Net Production Value (Million Riels)		
	Without Project	With Project	Without Project	With Project	Increase
570	135	155	674.6	1,496.0	**821.4**

Annual economic benefit flow was estimated based on the progress of the area developed. Built-up period of increment of NPV is four years.

(3) Negative Benefit

Existing farmlands will be acquired and used for the construction of irrigation and drainage facilities. The agricultural production foregone is defined as the annual net production value under the without project condition was accounted for as a negative benefit in the evaluation, as follows.

Negative Project Benefit of the Project

Area to be Acquired for Construction (ha)	NPV Without Project Condition (Riel'000/ha)	Foregone Amount (Riel Million)
10	811.6	8.1

(4) Economic Cost

The economic construction cost was classified into (i) preparatory works, (ii) direct construction, (iii) agricultural support activities, (iv) formation and strengthening of FWUC, (v) farmers organization development, (vi) Kampong Speu PDOWRAM strengthening, (vii) strengthening coordination between PDA and PDOWRAM, (viii) land acquisition arrangements, (ix) administration, (x) engineering services, and (xi) physical contingencies. The economic project investment cost was estimated by applying relevant conversion factors to the components of the financial foreign and local currency costs comprising equipment, material and labor. The total economic project cost was estimated as follows.

Economic Investment Cost of the Project

Project Area (ha)	Economic Investment Cost (Riel, Million)	Cost Per ha (Riel '000)
570	6,357	11,152

The financial O&M cost was converted to economic value by applying relevant conversion factors to the components of the financial foreign and local currency costs, in the same way as the project investment costs. The O&M cost of the Project was estimated as follows.

Economic O&M Cost of the Project

Project Area (ha)	O & M Cost (Riel, Million/year)	Cost Per ha (Riel)
570	21.2	37,193

The replacement cost of the project facilities and equipment was estimated by applying the conversion factors to the respective financial cost for replacement. The useful life of the main, secondary and tertiary gates of the Project is 25 years and their economic replacement cost in total was estimated at Riel 615 Million.

(5) Economic Evaluation Results

The economic cost and benefit stream comprising (i) the cost for project investment, O&M and replacement, and (ii) the benefits as well as negative benefit from irrigation and drainage, was prepared for the economic life of the Project.

In this section, two different cost and benefit streams were created and used for evaluation, they are; (1) the Project as an independent project, and (2) the Project and Roleang Chrey Regulator and Intakes Improvement Project as one, integrated project. The reason being that while, in theory of evaluation, all previously-implemented-investments should be treated as sunk cost and therefore Roleang Chrey Regulator and Intakes Improvement Project and the Project should be evaluated separately, these two projects are proposed to be implemented in parallel and in fact they have a very strong hydrological relationship, i.e. implementation of Roleang Chrey Regulator is a precondition for implementation of the Project.

Based on this reasoning, two sets of evaluations were carried out and they both are presented following, though the second evaluation (Roleang Chrey Regulator and the Project as an integrated project) is just for referential purposes.

1) The Project as an independent project

Economic internal rate of return (EIRR) and other indicators for the Project as an independent project were calculated and summarized as follows.

Economic Benefit of the Project

EIRR (%)	NPV (Riel, Million) (7% discount rate)			B/C
	Benefit	Cost	B-C	
11.1	8,486	5,517	2,969	1.5

2) The Project and Roleang Chrey Regulator and Intakes Improvement as an integrated project

Economic internal rate of return (EIRR) and other indicators for the Project and Roleang Chrey Regulator and Intakes Improvement as an integrated project were calculated and summarized as follows.

Economic Benefit of the Project + R. C. Regulator and Intakes Improvement*

EIRR (%)	NPV (Riel, Million) (7% discount rate)			B/C
	Benefit	Cost	B-C	
13.2	28,220	17,645	10,575	1.6

** These figures are presented just for referential purposes.*

(6) Sensitivity Analysis

The project sensitivity in terms of EIRR was analyzed in respect of changes in project cost and benefit as follows:

1) Project cost increase 30%
2) Project benefit reduction 30%
3) Project cost increase 20% and benefit reduction 20%
4) Delay of 2 years in project benefit derivation

The results of the sensitivity test are summarized as follows.

Sensitivity of the Project*

Cases of Change	Change in Variation	EIRR (%)	Switching Value EIRR: 7.0 %
Base case	-	11.1	-
- Cost increased	+ 30 %	8.5	+57%
- Benefit reduced	- 30 %	7.6	-35%
- Cost increased & benefit reduced	+ 20 % - 20 %	7.3	-
- Delay of benefit derivation	2 years	9.2	6 years

** Sensitivity test was conducted for only the case of IAIMP as an independent project*

The sensitivity test revealed that the Project is relatively more sensitive to the benefit reduction than cost increase, though it can accommodate considerable changes in both these variables.

C-2.10.3 Financial Evaluation

(1) Cash Flow Analysis

The cash flow analysis was made under the following conditions and on the assumption that MOWRAM will implement the Project with financial cooperation from a foreign aid agency.

1) Loan conditions of foreign aid agency

a) Interest rate : 2.3% per year

b) Grace period : 10 years

c) Repayment period : 30 years (including grace period)

d) Items not eligible for financing are listed below.

- General administration expenses
- Taxes and duties
- Purchase of land and other real property
- Compensation
- Other indirect items

2) Raising capital other than foreign loans: the national treasury will cover all the costs other than foreign-aid loans under the condition of no interest and no repayment.

Based on these conditions, the total funds requirement and internal capital amount needed to be raised were estimated as follows.

Capital funding to be raised for the Project

(Unit: Riel Million)

Items	External Loan	National Budget	Total
a) Engineering service cost	1,770	-	1,770
b) Direct Construction cost	4,324	-	4,324
c) Administration cost	-	434	434
d) Agricultural Support Services	187	-	187
e) Formation and Strengthening of FWUC	244	-	244
f) Farmers Organization Development	110	-	110
g) Kampong Speu PDOWRAM Strengthening	24	-	24
h) Coordination Strengthening between Kampong Speu PDA and PDOWRAM	4	-	4
i) Land Acquisition Arrangements	-	24	24
j) Land Acquisition	-	487	487
k)Physical contingency	609	45	654
l) Price contingency	1.425	378	1,803
Total	8,697	1,368	10,065

Note: All costs shown above include VAT.

As shown in above Table, the loan requirement from the foreign aid agency was estimated at about Riel 8,697 Million (US$ 2.14 Million). The MOWRAM's cash flow statement to this loan amount is presented in Table IIIE-12. The annual repayment of the fund is estimated to be Riel 635-445 million during the repayment period from 11th to 30th year. Repayment of the fund will have to be made by subsidy from government.

(2) Farm Budget Analysis

A farm budget analysis of typical farms (Type A: farm families having double cropped rice fields, and Type B: having only single cropped rice fields) for present without-project and future with-project conditions was conducted as shown below (for details, see Section C-2.2 of this report).

Farm Budget Analysis: Type A (unit: Riel '000)

		Present	With	Increase
Gross Incomes	Rice Production	1,302	1,986	684
	Other Farm Income	1,066	1,066	0
	Non-farm Income	2,267	2,267	0
	Total Income	4,635	5,319	684
Expenditures	Production Costs of Farm Products	1,076	1,291	215

	Other Expenditures	3,017	3,017	0
	Total Expenditures	4,093	4,308	215
Net Surplus (Capacity to Pay)		542	1,011	469

Source: JICA study team

Farm Budget Analysis: Type B (unit: Riel '000)

		Present	With	Increase
Gross Incomes	Rice Production	680	1,385	705
	Other Farm Income	1,145	1,145	0
	Non-farm Income	1,959	1,959	0
	Total Income	3,784	4,489	705
Expenditures	Production Costs of Farm Products	797	1,054	257
	Other Expenditures	2,483	2,483	0
	Total Expenditures	3,280	3,537	257
Net Surplus (Capacity to Pay)		504	952	448

Source: JICA study team

(3) Improvement of Farm Economy

Under the with project condition, average gross income of farming households would increase 87% for Type A and 89% for Type B farming households, and the annual net increase in income would average Riel 469,000 for Type A and Riel 448,000 for Type B farming households. These would be accrued from increasing cropping intensity and crop yields through the improvement of irrigation facilities and strengthening of agricultural support services.

(4) Farmers' ability to pay Irrigation Service Fee

After the completion of the improvement works, all the irrigation facilities from the secondary canals to the field canals and their turnouts (except the turnouts in the main canals) will be maintained by the farmers themselves. All costs including material and labor required for O & M of facilities will be borne by the FWUC.

The farmers' ability to pay was evaluated as a ratio of the ISF to the annual net increase in income under the with project condition. The average ISF is estimated at Riel 47,400/year/household for Type A and Riel 15,300/year/household for Type B households. These amounts account for less than 11% of the annual net increase in income of Type A and less than 4% of Type B households. This will enable almost all farmers to pay the ISF.

With regard to the ISF collection, since the Project has a component aimed at formation and strengthening of the FWUC, the ISF collection rate should be high after the completion of the Project.

C-2.10.4 Socio-economic Impacts

(1) Improvement of Farmers' and Peoples' Income and Employment Opportunities

As a result of the improvement of the irrigation facilities and strengthening of agricultural support services, the farmers' income will improve considerably through an increase in crop yields. In addition, employment opportunities to be created for construction laborers to be employed for building the improvements will, in effect, reduce the present unemployment, especially in the lean production season.

(2) Self-sufficiency in Upland Crops and Vegetables in the Project Area

After the completion of the Project, the annual increase in the upland crop and vegetable production in the Project Area will be around 47 ton which is equivalent to Riel 26 million (US$6,400) at the farm gate value. Future with-project upland crop and vegetable production will partially substitute for the current volume of vegetable importation from outside of the Project Area.

(3) Activation of Regional Economy

In addition to the increase in production, marketing of farm inputs and outputs would expand through the Farmers Organization Development component of the Project. Under this activity, joint purchase of agricultural inputs, collective shipment and sale of agricultural products, and improved savings and credit, etc. will be carried out. Farmers' purchasing power as well as their collective bargaining power would increase along with the improvement of farmers' income. All these would contribute to the improvement of the regional economy.

(4) Capacity Development of Staff Concerned

The Project Development Plan includes the following programs: i) Agricultural Support Activities, ii) Formation and Strengthening of FWUC, iii) Farmers Organization Development, iv) Kampong Speu PDOWRAM Strengthening, and v) Strengthening Coordination between Kampong Speu PDA and PDOWRAM. All these activities involve the local government staff of the line service agencies, to a greater or lesser extent. Capacity building in these skills for these officials in dealing with farmers as well as among officials would largely contribute to the successful implementation of other development projects in the future.

(5) Ripple Effect into Neighboring and Other Areas as a Development Model

As its name (i.e. the Irrigated Agriculture Improvement Model Project) embodies, this project is not only aiming at the improvement of irrigation facilities and agricultural productivities in the Project Area, but also aiming at expanding its effects to the adjacent areas downstream of the Roleang Chrey Regulator and Intakes, as well as to other areas where irrigated agriculture is practiced in Cambodia. By dealing with all the multi-faceted aspects of the irrigated agriculture, i.e. irrigation water, agricultural technology, extension methodology, and various institutions that involve the stakeholders concerned in integrated manner, the Project is expected to become a model which will be replicated in the future and, accordingly, to bring about a multiplier effect in future Cambodian agricultural development.

C-2.11 Monitoring Project Effects

This is a model project to demonstrate proper water management and increase rice production by harmonizing improvements in agriculture, irrigation and drainage, and institutional development. By the completion of the construction of the project facilities, support services will have also been carried out to ensure maximum Project effects. For this purpose, monitoring of the results of the Project should be executed by the Project Office. The monitoring period is scheduled to be for 4 years from the completion of project facilities. Although there are many monitoring indicators to show the Project effects, these should be minimized taking into consideration the limited budget and staff numbers. The proposed indicators are as follows:

- Agriculture : Crop yield and cropping intensity
- Irrigation : Discharge measured at the head of the secondary canals
- Institutional : Collection rate of irrigation service fees

C-2.12 Conclusion and Recommendations

C-2.12.1 Conclusion

As a result of the feasibility study, the Project is proven to be technically feasible and economically viable. From the institutional and organizational, social and natural environmental aspects it is also shown that the Project is sound as a whole. Execution of the Project could accomplish the principle objective of demonstration of proper water management and increase of rice production through harmonization of agriculture, irrigation and drainage and relevant institutional development. Thus, it is concluded that the Project should be implemented in the manner as planed in this Study.

C-2.12.2 Recommendations

(1) Urgent Implementation of the Project

The Project is intended to clearly demonstrate proper water management and increase rice production through harmonization of improved farming practices, well planed irrigation and drainage systems and strengthened FWUCs. The mechanisms established through the implementation of the Project will thus be extremely useful for other irrigated agriculture areas in the Prek Thnot River basin. In other words, the Project will play the role of bridgehead for irrigated agriculture development. In this sense, it is recommended that the Project should be implemented as early as possible.

(2) Need of Timely Establishment of a Project Office

As mentioned above, the Project needs close communication between the Kampong Speu PDOWRAM and the Kampong Speu PDA, to attain its aims. In addition, the Project has two important subjects; participation of farmers and land acquisition, which are common issues for irrigated agriculture development throughout the country. In order to cope with such situations smoothly, establishment of a Project Office is recommended. The Project Office should be established in a timely manner prior to the commencement of the Project implementation. The staff of the Project office should be arranged through transfer from MOWRAM, MAFF, Kampong Speu PDOWARAM and PDA, without employing any new staff.

(3) Need of Financial Arrangements for Support Services

In the Project, various support services are proposed as the result of the analysis of the current problems facing the agricultural activities. These are agricultural support services, formation and strengthening of FWUCs, farmers' organization development, Kampong Speu PDOWRAM strengthening, and Coordination between PDA and PDOWRAM. Timely implementation of these support services is keenly crucial to the success of the Project. It is recommended that MOWRAM and MAFF should arrange the necessary financial source for them in due time.

(4) Need of Environmental Monitoring

Nowadays, environmental issues one of the inevitable matters for the implementation of the Project. The Project does not produce any severe environmentally negative impacts. However, environmental monitoring is indispensable for clarifying the impacts caused by the construction of the project facilities. It is therefore recommended that MOWRAM, as an executing agency, should make necessary arrangements and implement any necessary activities for environmental monitoring for 20 years after completion of the project facilities.

PART-C: IRRIGATED AGRICULTURE IMPROVEMENT MODEL PROJECT

Tables

Table C-1.3.1 Estimation of Present Yield Levels of Paddy in the Project Area

1. Results of Socio-economic Survey in the Project Area: Average yield of paddy 1/

Item	Early Rainy Season	Rainy Season	Dry Season	No. of Respondents
Variety	IR 66	medium variety	IR 66	Early rainy season: 69;
Average Yield	2.4 ton/ha	2.3 ton/ha	2.5 ton/ha	rainy season: :99; dry season: 8

1/: Results of Socio-economic Survey conducted in the Project Area by the JICA Study Team, 200

2. Secondary Data: Paddy yields in the Project Villages 2/

Subject Area	Dry Season		Rainy Season	
	Average	Range	Average	Range
Project Villages in Kahaeng Commune (average yield)	2.0	1.8 - 2.1	2.0	1.8 - 2.5
Project Villages in Kandal Dom Commune (average yiel	2.5	1.8 - 3.0	2.5	1.8 - 3.0
Project Villages in Svay Kravan Commune (average yiel	-	-	2.0	-
All Project Villages	2.2	1.9 - 2.3	2.2	2.1 - 2.2

2/: Secondary Data Provided Collected at the Project Communes; average of 4 years from 2003 to 2004
Details are presented in Attachment 6

3. Results of Socio-economic Survey: Average yield 3/

Irrigation Category	Paddy Yield (ton/ha)		Irrigation Status	Remarks
	Rainy Season Local Variety 2/	Dry Season Improved Variety		
Zone-1	2.13	2.40	Irrigated field	No. of respondents: 46

3/: Results of Socio-economic Survey conducted by the JICA Study Team, 2005

4. Results of Socio-economic Survey: Yield Distribution 4/

Irrigation Category	Paddy Yield (ton/ha)		Irrigation Status	Remarks
	Rainy Season Local Variety	Dry Season Improved Variety		
Zone-1	0.7 ~ 6.0	0 ~ 6.0	Fully irrigated field	No. of respondents: 46

4/: Results of Socio-economic Survey conducted by the JICA Study Team, 2005

5. Statistic Data: Paddy Yields in Province 5/

Province	Average Paddy Yield (ton/ha)			
	To Cropped Area		To Harvested Area	
	Rainy Season	Dry Season	Rainy Season	Dry Season
Kampong Speu	1.4	2.4	1.7	2.6

5/: Average of 2003/04 - 2004/05
Source: 2003-04: Commune Survey on Crops & Livestock, 2003, Statistic Office, MAFF; 2004-05: PDA

6. Estimated Present Yield Levels of Paddy in the Project Area

On the basis of the results of the Socio-economic Survey, the statistic data and information collected during the present study and information provided by PDA, the present yield levels of paddy in the Project Area estimated

Estimated Present Yield Levels in the Project Area

Item	Cropping Season			Remarks
	Early Rainy Season	Rainy Season	Dry Season	
Prevailing Variety	IR66	Medium/Local	IR66	Major local varieties: Riang Chey,
Yield Level	2.4 ton/ha	2.3 ton/ha	2.4 ton/ha	Phka Mulis, Neang Ming

Table C-1.3.2 Prevailing Farming Practices of Rice

Farming Practices	Rainy Season	Early Rainy & Dry Season
Major rice varieties	Medium Variety: Riang Chey, Phka Mulis, Kamping Puoy Late Variety: Neang Ming	Early Variety: IR 66, IR 36, Sen Pidao
Land preparation		
- Method	Mainly by a pair of draft animal & partly by a hand tractor	Mainly by a pair of draft animal & partly by a hand tractor
- Practices	1 plowing & 1 plowing + harrowing/leveling (1 to 2 plow + 1 harrowing)	1 plowing & 1 plowing + harrowing/leveling (1 to 2 plow + 1 harrowing)
Nursery		
- Seeding rate (kg/ha) 1/	Average: 72 kg/ha (23 ~ 133kg)	Average: 62 kg/ha (25 ~ 88 kg)
- Seed bed	Flat semi-wet to wet bed	Flat semi-wet to wet bed
- Seeding rate	Depending (> 60 g/m^2)	Depending (> 60 g/m^2)
- Uprooting seedling	Hand picking (not using a shovel)	Hand picking (not using a shovel)
Transplanting		
- Method	Random planting	Random planting
- Planting distance	Depending (mostly ≦ 25 cm interval)	Depending (mostly ≧ 20 cm interval)
- Age of seedling	45 days (most prevailing) 30 - < 45 days (2nd prevailing) > 45 days or < 30 days (3rd prevailing)	21 - 25 days (most prevailing) < 20 days (2nd prevailing) > 25 days (3rd prevailing)
- No. of plants/hill	4-5 plants/hill (most prevailing) 2-3 plants/hill (2nd prevailing)	2-3 plants/hill (most prevailing) 4-5 plants/hill (2nd prevailing)
Manure (cow dung/compost)		
- Timing	Before land preparation	Before land preparation
- Manure (kg/ha)	About 90% of farmers apply Average dosage: 1.8 ton/ha	About 90% of farmers apply Average dosage: 1.8 ton/ha
Basal Fertilizer		
- Timing	At the time of final land preparation	At the time of final land preparation
- Urea (kg/ha) 1/	Average dosage: 51 kg/ha	Average dosage: 27 kg/ha
- DAP (kg/ha) 1/	Average dosage: 43 kg/ha	Average dosage: 27 kg/ha
- KCl (kg/ha)	Not applied (not available at market)	Not applied (not available at market)
1st Top dressing		
- Applied or not	Common practice with Urea	Common practice with Urea
- Timing	Panicle initiation stage or 1 ~ 1.5 month after planting	Panicle initiation stage
- Urea (kg/ha) 1/	35 kg/ha	65 kg/ha
- DAP (kg/ha) 1/	30 kg/ha	45 kg/ha
2nd Top dressing	Not common; some farmers apply Urea at flowering stage	Seldom practiced
Total Doses (kg/ha)	Urea 70, DAP 60, total 130 kg/ha	Urea 80, DAP 60, total 140 kg/ha
Agro-chemical spray	Seldom applied	Seldom applied
Weeding	2 times per a cropping season	2 times per a cropping season
Harvesting	Manual; cutting at middle of plants	Manual; cutting at base of plants
Threshing		
- Place	Home yard	Home yard
- Method	Manual with threshing board/table Engine or pedal thresher (2nd common)	Manual with threshing board/table Engine or pedal thresher (2nd common)
Drying	Field drying prevailing Sun drying after threshing at home yard, if required	Drying at home yard prevailing Sun drying after threshing at home yard
Cleaning/winnowing	Engine winnower (most common) Manual winnower (2nd common) Manual winnowing (3rd common)	Engine winnower (most common) Manual winnower (2nd common) Manual winnowing (3rd common)
Transportation	Ox-cart (from field to home yard)	Ox-cart (from field to home yard)

Source: Socio-economic Survey by JICA Study Team, 2006 & field survey
1/: Source --- Crop budget survey in Socio-economic Survey, 2006
Source: JICA Study Team

Table C-1.3.3 Farm Economy under the Present Condition

Unit: 1000 riel

Item	Typical Farm: Type A (Family with Double Cropped Rice Field) 1/ — Cropping Intensity: 135%					Type B (Family with Only Single Cropped Rice Field) 2/ — Cropping Intensity: 100%					Remarks
	Cropped Area (ha)	Production (kg)	Unit Price (riel)	Amount (1000 riel)	(US$) 5/	Cropped Area (ha)	Production (kg)	Unit Price (riel)	Amount (1000 riel)	(US$) 5/	
1. Net Income				**3,559**	**868**				**2,987**	**729**	
1-1. Net Farm Income				**1,292**	**315**				**1,028**	**251**	
(1) Rice Production											
Rainy Season Irrigated Rice	0.57	1,311	600	787		0.41	943	600	566		yield: 2.3 t/ha
Early Rainy Season Irrigated Rice	0.20	480	550	264							yield: 2.4 t/ha
Rainfed Rice	0.22	418	600	251		0.10	190	600	114		yield: 1.5 t/ha
Gross Return				1,302					680		
Production Cost 3/				650					339		
Net Return				**652**					**341**		
(2) Other Farm Products											
Gross Return				1,066					1,145		
Livestock				829					994		
Fishery				73					39		
Other Crops				164					112		
Production Cost 4/				426					458		
Net Return				**640**	**156**				**687**	**168**	
1-2. Net Non-farm Income											
(1) Net Income				**2,267**	**553**				**1,959**	**478**	
Wage & Salary				1574					1320		
Trade				578					217		
Remittance from Family Members				115					9		
Selling Firewood				0					391		
Others				0					22		
2. Expenditure				**3,017**	**736**				**2,483**	**606**	
Food				1858					1508		
Health/Medical				156					109		
Education				217					233		
Clothes				120					126		
Fuel				132					100		
Others				534					407		
3. Net Surplus (Capacity to Pay)				**542**	**132**				**504**	**123**	

1/: Land holding size: Type A --- irrigated rice field 0.57ha & rainfed rice field 0.22ha, total 0.79ha

2/: Land holding size: Type B --- irrigated rice field 0.40ha & rainfed rice field 0.10ha, total 0.51ha

3/: Early rainy season rice: 49%; rainy season rice: 49%; rainfed rice: 54%

4/: Assumed to be 40% of gross return

5/: Estimated by applying conversion rate of 1US$ = Riel 4,100.-

Table C-1.9.1 Results of Socio-economic Survey and Findings of the Pilot Project

1. Results of Socio-economic Survey 1/	
Current Extension Services	The poor or extremely limited coverage of extension services is one of the most serious constraints for agricultural development in the Area and no accessibility to extension services is reported by over 50% of sample farmers in the Survey. Subject selected as most required for extension services is rice farming followed by compost fertilizer.
Farming Constraints	Major agronomic and farm management constraints responded by sample farmers are crop losses due to pest & disease followed by expensive farm inputs and low yield of paddy.
Marketing Constraints	Major marketing constraints are unstable market prices of paddy/rice followed by low market prices of paddy/rice.
Necessary Activities to Improve Rice Productivity	Activities necessary to improve rice productivity raised by sample farmers are: i) improvement of farming practices, ii) use of quality seed (high yielding variety) and iii) use of adequate doses of fertilizer.
Expectations for Improvement: Agronomy	Farmers expectations for improvement of farming conditions (agronomic & farm management) are: i) most expected: productivity improvement of dry season rice, ii) 2nd most expected: productivity improvement of wet season rice and iii) 3rd most expected: productivity increase of livestock/poultry.
Expectations for Improvement: Farming System	Farmers expectations for farming system to be adopted are: i) most expected: multiple farming composed of crop & livestock, ii) 2nd most expected: double cropping of rice and iii) 3rd most expected: crop diversification.
Expectations for Improvement: Extension Services	Agricultural support services required for improvement of agricultural productivity responded by sample farmers are: i) most required: field extension services (demonstration/field guidance), ii) 2nd required: provision of quality seed and iii) 3rd required: provision of fertilizer.

2. Findings of the Pilot Project

- Practical skills (such as seed bed preparation, seeding density, regular planting, preparation & application timing of manure, pest & disease control, etc.) of extension staffs appear to be still limited; might be attributed to limited chances for them to be involved in practical extension activities or for them to operate extension activities individually. The empowerment of extension staffs by way of learning through doing and enhancement of confident of them should be seriously sought.
- Farmers anticipation and motivation toward the improvement of farming practices appears to be high. Current extension services supported by donors with weak ownership of PDA appear to be less responding to such needs. To meet such farmers' attitude, the deployment of extension staffs having sufficient practical skills should be envisaged.
- There is room for improving farmers' rice farming capability (practices) in various meanings. The primary target of extension activities should better be placed on improvement of rice productivity, current exclusive crop.
- Field activities of extension staffs are restricted due partly to financial constraint of extension agencies. However, problems and hints for solutions are often found in fields. Field activities of the staffs should be intensified to an extent possible.

1/: Results of Socio-economic Survey, 2006, JICA Study Team

Table C-2.2.1 Yield Estimation for under With-Project Conditions

1. Results of Verification Tests Implemented in the Project Area (Zone 1) 1/

Variety	No. of Plots	Whole Plot Yield (ton/ha)		Crop Cut Survey Results (ton/ha)
		Range	Average	
Early Variety (Sen Pidao)	2	4.0	4.0	Avg.: 4.5; range: 3.7 ~ 5.2 (6 samples)
Medium Variety (Riang Chey)	3	3.9 - 4.8	4.2	Avg.: 5.2; range: 4.3 ~ 5.8 (13 samples)

1/: Details given in Table IIIB-4.4.1

2. Results of Adaptability Trial (Simple Trial) Implemented in the Project Area (Zone 1) 1/

Variety	Treatment	Whole Plot Yield (ton/ha) 2/
Early Variety (Sen Pidao)	Variety Trial	IR 66: 5.9; Sen Pidao: 4.5; IR Kesar 4.4.5 ton/ha
Medium Variety (Riang Che	Seeding Rate	Riang Chey: 40 g/m2: 5.4 ton/ha; 60 g/m2: 5.7 ton/ha

1/: Details given in Table IIIB-4.4.1 2/: Potential or reference yields; samples taken at point showing good growth

3. Results of Socio-economic Survey: Yield Distribution 1/

Irrigation Category	Paddy Yield (ton/ha)		Irrigation Status	Remarks
	Rainy Season Local Variety	Dry Season Improved Variety		
Category 1	0.7 ~ 6.0	0 ~ 6.0	Fully irrigated field	No. of respondents: 46

1/: Results of Socio-economic Survey conducted in 2005 by the JICA Study Team

4. Yield Estimated by PDAs

Province	Management Condition	Irrigated Paddy		Rainfed Paddy
		Rainy Season	Dry Season	Rainy Season
Kampong Speu	Well managed paddy field	5.0	6.0	2.5
	Poorly managed paddy field	2.0	3.0	1.5
	Average of the two	2.0 ~ 5.0	4.5	1.5 ~ 2.5
Kandal	Well managed paddy field	4.0	5.5	4.0
	Poorly managed paddy field	1.8	2.0	1.8
	Average of the two	2.5	3.0	2.5

5. Estimated Yield Levels of Paddy in the Project Area under With-Project

On the basis of the results of the verification tests and simple trials conducted in 2006 under the Pilot Project by the JICA Team and PDA/MAFF, the With-Project paddy yield level in the Area estimated as follows;

Estimated Anticipated/Target Yield Levels under the Project

	Early Rainy Season	Rainy Season
Early Variety (IR 66 & Sen Pidao)	3.8 ton/ha (average of IR 66 & Sen Pidao)	3.8 ton/ha (average of IR 66 & Sen Pidao)
Medium Variety (Riang Chey)	3.3 ton/ha	

1/: Yield improvement assumed through the improvement of irrigation conditions & intensive agricultural support services planned under the Project

Table C-2.2.2 Proposed Farming Practices of Rice

Farming Practices	Medium Variety	Early Variety
Varieties	Variety: Riang Chey (replacement per 3 croppings)	Variety: IR 66, Sen Pidao, IR 36 (replacement per 3 croppings)
Land preparation		
- Method	Draft animal or hand tractor	Draft animal or hand tractor
- Practices	1 plowing & 1 plowing + harrowing/leveling	1 plowing & 1 plowing + harrowing/leveling
Nursery		
- Seeding rate (kg/ha)	25 ~ 30 kg/ha	25 ~ 30 kg/ha
- Seed bed	Raised semi-dry seed bed	Raised semi-dry seed bed
- Seeding rate	40 g/m2	40 ~ 50 g/m2
- Uprooting seedling	Avoid damages to seedlings	Avoid damages to seedlings
Transplanting		
- Method	Regular Planting	Regular Planting
- Planting distance	25 x 25 cm	20 x 20 cm
- Age of seedling	15 ~ 20 days	10 ~ 20 days
- No. of plants/hill	2-3 plants/hill (to mitigate damage caused by crab)	2-3 plants/hill (to mitigate damage caused by crab)
- Quality of seedling	Stout & health seedlings	Stout & health seedlings
Manure (cow dung/compost)		
- Timing	At least 1 month before 1st plowing	At least 1 month before 1st plowing
- Manure (kg/ha)	Depending on availability (recommendation 3t/ha)	Depending on availability (recommendation 3t/ha)
Basal Fertilizer		
- Timing	At the time of final land preparation	At the time of final land preparation
- N:P:K	N : P_2O_5 : K2O = 20 : 27 : 15 kg/ha (15-15-15 = 100kg/ha & DAP = 25 kg/ha)	N : P_2O_5 : K2O = 20 : 27 : 15 kg/ha (15-15-15 = 100kg/ha & DAP = 25 kg/ha)
1st Top dressing		
- Timing	30 days after transplanting	30 days after transplanting
- Urea (kg/ha)	50 kg/ha	40 ~ 50kg/ha
2nd Top dressing		
- Timing	After panicle initiation	After panicle initiation
- Urea (kg/ha)	40 kg/ha	Not for moderate yield; 20 ~ 30 kg/ha for higher yield
Agro-chemical spray	Last option for pest & disease control	Last option for pest & disease control
Irrigation	Intermittent irrigation: Taking-root stage to before panicle initiation stage or up to booting stage	Intermittent irrigation: Taking-root stage to before panicle initiation stage or up to booting stage
Weeding	2 times per a cropping season	2 times per a cropping season
Harvesting	Manual	Manual
Threshing		
- Place	Home yard or field (preferable)	Home yard or field (preferable)
- Method	Manual with threshing board/table Engine or pedal thresher (2nd common)	Manual with threshing board/table Engine or pedal thresher (2nd common)
Drying	Field drying Sun drying after threshing at home yard, if required	Drying at home yard Sun drying after threshing at home yard, if required
Cleaning/winnowing	Engine or manual winnower	Engine or manual winnower
Transportation	Ox-cart (from field to home yard)	Ox-cart (from field to home yard)

Table C-2.2.3 Labor Balance under With-Project Condition

Labor Requirements of Average Farm Family: Rice Field Holding Size: 0.8 ha Labor Force/Family: 3.1
Cropping Pattern Assumed: early rainy season rice 50% (0.4 ha); rainy season rice 100% (0.8ha); upland crops 5% (0.04ha)

Farming Practices	Apr			May			June			July			Aug.			Sept.			Oct			Nov			Dec.			Jan			Total Requirements
Early Variety (0.4 ha x 2 crops)	Farming Calendar																														
Nursery																															
Land Preparation																															
Transplanting																															
Field Management																															
Harvesting																															
Pos-harvesting																															
	Labor Requirements per Decade																														
Nursery				1.5	0.5											1.5	0.5														
Land Preparation		1			3											4															
Transplanting						12												12													
Field Management						0.5	1	1	4	1	3	0.5	0.5	0.5				0.5	1	1	4	1	3	0.5	0.5	0.5					
Harvesting															12												12				
Pos-harvesting															1	3											1	3			
Sub-total		1		1.5	3.5	12.5	1	1	4	1	3	0.5	0.5	0.5	13	8.5	0.5	12.5	1	1	4	1	3	0.5	0.5	0.5	13	3			92
Medium variety (0.4ha)	Farming Calendar																														
Nursery																															
Land Preparation																															
Transplanting																															
Field Management																															
Harvesting																															
Pos-harvesting																															
	Labor Requirements per Decade																														
Nursery												1.5	0.5																		
Land Preparation										1			3																		
Transplanting														12																	
Field Management															1	1	4	1	3	0.5	1	0.5	0.5	0.5	0.5	0.5					
Harvesting																										12					
Pos-harvesting																										1	3				
Sub-total										1		1.5	3.5	12	1	1	4	1	3	0.5	1	0.5	0.5	0.5	0.5	13.5	3				48
Upland Crops (0.04ha) 1/	Farming Calendar																														
Land Preparation																															
Sowing																															
Field Management																															
Harvesting																															
Pos-harvesting																															
	Labor Requirements per Decade																														
Land Preparation			0.2																												
Sowing				0.6																											
Field Management				0.1	0.4	0.1	0.4		0.1		0.1																				
Harvesting												0.8																			
Pos-harvesting													0.4																		
Sub-total			0.2	0.7	0.4	0.1	0.4		0.1		0.1	0.8	0.4																		3
Total Labor Requirements	0.0	1.0	0.2	2.2	3.9	12.6	1.4	1.0	4.1	2.0	3.1	2.8	4.4	12.5	14.0	9.5	4.5	13.5	4.0	1.5	5.0	1.5	3.5	1.0	1.0	14.0	16.0	3.0	0.0	0.0	143
Labor Availability/Family 2/	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	690
Family Labor for Farming 3/	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	414
Labor Balance	13.8	12.8	13.6	11.6	9.9	1.2	12.4	12.8	9.7	11.8	10.7	11.0	9.4	1.3	**-0.2**	4.3	9.3	0.3	9.8	12.3	8.8	12.3	10.3	12.8	12.8	**-0.2**	**-2.2**	10.8	13.8	13.8	271

1/: Mungbeans assumed 2/: Average labor force per family 3.1 x 22 days = 68.2 labor days; 23 labor days per decade 3/: Assumed to be 60% of total labor force

Table C-2.2.4 Farm Economy under With-Project Condition

Unit: 1000 riel

Item	Typical Farm										Remarks
	Type A (Family with Double Cropped Rice Field)					Type B (Family with Only Single Cropped Rice Field)					
	Cropping Intensity: 150%					Cropping Intensity: 150%					
	Cropped Area (ha)	Production (kg)	Unit Price (riel)	Amount (1000 riel)	(US$) 5/	Cropped Area (ha)	Production (kg)	Unit Price (riel)	Amount (1000 riel)	(US$) 5/	
1. Net Income				**4,028**	**982**				**3,435**	**838**	
1-1. Net Farm Income				**1,761**	**429**				**1,476**	**360**	
(1) Rice Production											
Rainy Season Irrigated Rice	0.57	1,881	600	1,129		0.42	1,386	600	832		yield: 3.3 t/ha
Early Rainy Season Irrigated Rice	0.29	1,102	550	606		0.21	798	550	439		yield: 3.8 t/ha
Rainfed Rice	0.22	418	600	250.8		0.10	190	600	114		yield: 1.5 t/ha
Gross Return				1,986					1,385		
Production Cost 3/				865					596		
Net Return				**1,121**	**273**				**789**	**192**	
(2) Other Farm Products											
Gross Return				1,066					1,145		
Livestock				829					994		
Fishery				73					39		
Other Crops				164					112		
Production Cost 4/				426					458		
Net Return				**640**	**156**				**687**	**168**	
1-2. Net Non-farm Income											
(1) Net Income				**2,267**	**553**				**1,959**	**478**	
Wage & Salary				1,574					1,320		
Trade				578					217		
Remittance from Family Members				115					9		
Selling Firewood				0					391		
Others				0					22		
2. Expenditure				**3,017**	**736**				**2,483**	**606**	
Food				1,858					1,508		
Health/Medical				156					109		
Education				217					233		
Clothes				120					126		
Fuel				132					100		
Others				534					407		
3. Net Surplus (Capacity to Pay)				**1,011**	**247**				**952**	**232**	

1/: Land holding size: Type A --- irrigated rice field 0.57ha & rainfed rice field 0.22ha, total 0.79ha

2/: Land holding size: Type B --- irrigated rice field 0.40ha & rainfed rice field 0.10ha, total 0.51ha

3/: Early rainy season rice: 41%; rainy season rice: 44%; rainfed rice: 54%

4/: Assumed to be 40% of gross return

5/: Estimated by applying conversion rate of 1US$ = Riel 4,100.-

Table C-2.4.1 Implementation and Cost Schedules for Agricultural Support Services 1/

Activities	Unit	Unit Program Cost (US$) 2/	2010 Volume Early Rainy Season	2010 Volume Rainy Season	2010 Volume Annual	2010 Amount (US$)	2011 Volume Early Rainy Season	2011 Volume Rainy Season	2011 Volume Annual	2011 Amount (US$)	2012 Volume Early Rainy Season	2012 Volume Rainy Season	2012 Volume Annual	2012 Amount (US$)	2013 Volume Early Rainy Season	2013 Volume Rainy Season	2013 Volume Annual	2013 Amount (US$)	Overall Volume Early Rainy Season	Overall Volume Rainy Season	Overall Volume Annual	Overall Amount (US$)
1. Field Programs																						
1.1 Field Adaptability Test	unit	500	1	1	2	1,000	1	1	2	1,000		1	1	500				0	2	3	5	2,500
1.2 Demonstration Plot (0.1ha)																						
- Irrigated Rice	unit	40	3	5	8	320	5	5	10	400	5	3	8	320					13	13	26	1,040
- Upland Crops	unit	30	2		2	60	2		2	60	2		2	60	3		3	90	9	0	9	270
- Vegetables	unit	50					1		1	50	1		1	50	1		1	50	3	0	3	150
1.3 Demonstration Plot (1.0ha)																						
- Irrigated Rice	unit	370	1	2	3	1,110	1	2	3	1,110	1	2	3	1,110			0	0	3	6	9	3,330
- Upland Crops	unit	330			0	0	1		1	330	1		1	330	1		1	330	3	0	3	990
1.4 Demonstration Farm (5.0ha)																						
- Irrigated Rice	unit	910			0	0	1	1	2	1,820	1	1	2	1,820		1	1	910	2	3	5	4,550
1.5 Demonstration Area (20ha)																						
- Irrigated Rice	unit	2,330			0	0			0	0	1		1	2,330	1		1	2,330	2	0	2	4,660
1.6 Seed Multiplication	unit	330		1	1	330		1	1	330		1	1	330			0	0	0	3	3	990
Sub-total			7	9	16	2,820	12	10	22	5,100	12	8	20	6,850	6	1	7	3,710	37	28	65	18,480
2. Farmer/Farmer Group Training Programs																						
2.1 Training Course																						
- 5 Days (30 participants)	unit	340	1	1	2	680	2	2	4	1,360	1	1	2	680	1	1	2	680	5	5	10	3,400
2.2 FFS/IPM (50 participants)	unit	770			0	0	1	1	2	1,540			0	0			0	0	1	1	2	1,540
2.3 Study Tour	unit	300		1	1	300	1		1	300			0	0			0	0	1	1	2	600
2.4 VEA Training																						
- 10 Participants	unit	1,800	1		1	1,800	1		1	1,800	1		1	1,800	1		1	1,800	4	0	4	7,200
Sub-total			2	2	4	2,780	5	3	8	5,000	2	1	3	2,480	2	1	3	2,480	11	7	18	12,740
3. Mass Guidance/Workshop																						
3.1 50 Participants		110	1	1	2	220	1	1	2	220	1	1	2	220	1	1	2	220	4	4	8	880
4. Support Fund for Extension Staff																						
Farmer-to-farmer Extension Support	VEA	360			5	1,800			5	1,800			5	1,800			5	1,800	0	0	20	7,200
Field Guidance Staff	staff	600			2	1,200			2	1,200			1	600			1	600	0	0	6	3,600
Sub-total					7	3,000			7	3,000			6	2,400			6	2,400	0	0	26	10,800
5. Staff Empowerment	unit	500			1	500			1	500			1	500			1	500	0	0	4	2,000
6. Logistic Strengthening 3/																						
- Bicycle (VEA)	unit	100			5	500													0	0	5	500
- Motorcycle (field guidance staff)	unit	1,000			1	1,000													0	0	1	1,000
Sub-total					6	1500			0	0			0	0			0	0	0	0	6	1,500
Total						**10,820**				**13,820**				**12,450**				**9,310**				**46,400**

1/: Program direct cost

2/: Based on Base Costs for Extension Programs, 2006, DAE, MAFF; which are estimated in US$ and no changes in costs in dollar bases assumed for estimation

3/: Provision of transportation means to VEA & field guidance staff

Table C-2.9.1 Investment Cost

(Unit : '000)

Item		US$	Riel*
(1)	Engineering service cost	436	1,770,160
(2)	Direct construction cost		
	Main canal	462	1,875,720
	Secondary canal	83	336,980
	Tertiary canal	301	1,222,060
	Drainage canal	179	726,740
	Project office	40	162,400
	sub-total	1,065	4,323,900
(3)	Administration cost	107	434,420
	Sub-total (1)+(2)+(3)	1,608	6,528,480
(4)	Agricultural support services	46	186,760
(5)	Formation and strengthening FWUC	60	243,600
(6)	Formations organization Development	27	109,620
(7)	Kampong Speu PDOWRAM strengthening	6	24,360
(8)	Coordination between Kampong Speu PDA and Kampong Speu PDOWRAM strengthening	1	4,060
(9)	Land acquistion arrangement cost	6	24,360
(10)	Land acquistion cost	120	487,200
	Sub-total Σ (1)+(2).....(10)	1,874	7,608,440
(11)	Physical contingency	161	653,660
(12)	Price Contingency	444	1,802,640
Total		2,479	10,064,740

*: *equivalent to Riel*

Table C-2.9.2 Annual Disbursement Schedule of Investment Cost

(Unit : '000)

Description		2008		2009		2010		2011		2012		2013		Total	
		US$	Riel*	US$	Riel*	US$	Riel*	US$	Riel*	US$	Riel*	US$	Riel*	US$	Riel*
(1)	Engineering service cost	65	263,900	131	531,860	175	710,500	65	263,900	0	0	0	0	436	1,770,160
(2)	Construction cost	0	0	53	215,180	692	2,809,520	320	1,299,200	0	0	0	0	1,065	4,323,900
(3)	Administration cost	0	0	5	20,300	70	284,200	32	129,920	0	0	0	0	107	434,420
(4)	Agricultural support services	0	0	0	0	11	44,660	14	56,840	12	48,720	9	36,540	46	186,760
(5)	Formation and strengthening FWUC	6	24,360	30	121,800	24	97,440	0	0	0	0	0	0	60	243,600
(6)	Formations organization Development	2.7	10,962	13.5	54,810	10.8	43,848	0	0	0	0	0	0	27	109,620
(7)	Kampong Speu PDOWRAM strengthening	0.6	2,436	3.0	12,180	2.4	9,744	0	0	0	0	0	0	6	24,360
(8)	Coordination between Kampong Speu PDA and Kampong Speu PDOWRAM strengthening	0.1	406	0.5	2,030	0.4	1,624	0	0	0	0	0	0	1	4,060
(9)	Land acquistion arrangement cost	0.0	0	6.0	24,360	0.0	0	0.0	0	0	0	0	0	6	24,360
(10)	Land acquistion cost	0.0	0	120	487,200	0.0	0	0.0	0	0	0	0	0	120	487,200
(11)	Contingency														
	1) Physical contingency	7	28,420	19	77,140	93	377,580	42	170,520	0	0	0	0	161	653,660
	2) Price Contingency	4	16,240	45	182,700	166	673,960	99	401,940	5	20,300	4	16,240	323	1,311,380
Total		85	346,724	426	1,729,560	1,245	5,053,076	572	2,322,320	17	69,020	13	52,780	2,358	9,573,480

Table C-2.9.3 Replacement Cost

(Unit : '000)

Item		Dimension B x H	No./Nos.	Unit price	Amount	
					US$	Riel*
(1) Main canal	Check	2 x 3.2	3	7,200	22	89,320
	Intake	1.0 x 1.85	2	3,600	7	28,420
		1.0 x 1.0	1	3,000	3	12,180
		0.6 x 1.2	2	2,490	5	20,300
	Turnout	0.5 x 1.0	3	2,265	7	28,420
		1.0 x 2.6	3	4,500	14	56,840
	sub-total				58	235,480
(2) Secondary canal	Check	1.0 x 0.6	3	2,490	7	28,420
		0.5 x 0.6	3	1,175	4	16,240
	Turnout	0.6 x 0.6	3	1,605	5	20,300
		0.5 x 0.6	6	1,175	7	28,420
	sub-total				23	93380
(3) Tertiary canal	Division box	0.4 x 0.5	45	925	42	170,520
		0.3 x 0.4	88	725	64	259,840
	sub-total				106	430360
Total					187	759,220

**: equvalent to Riel*

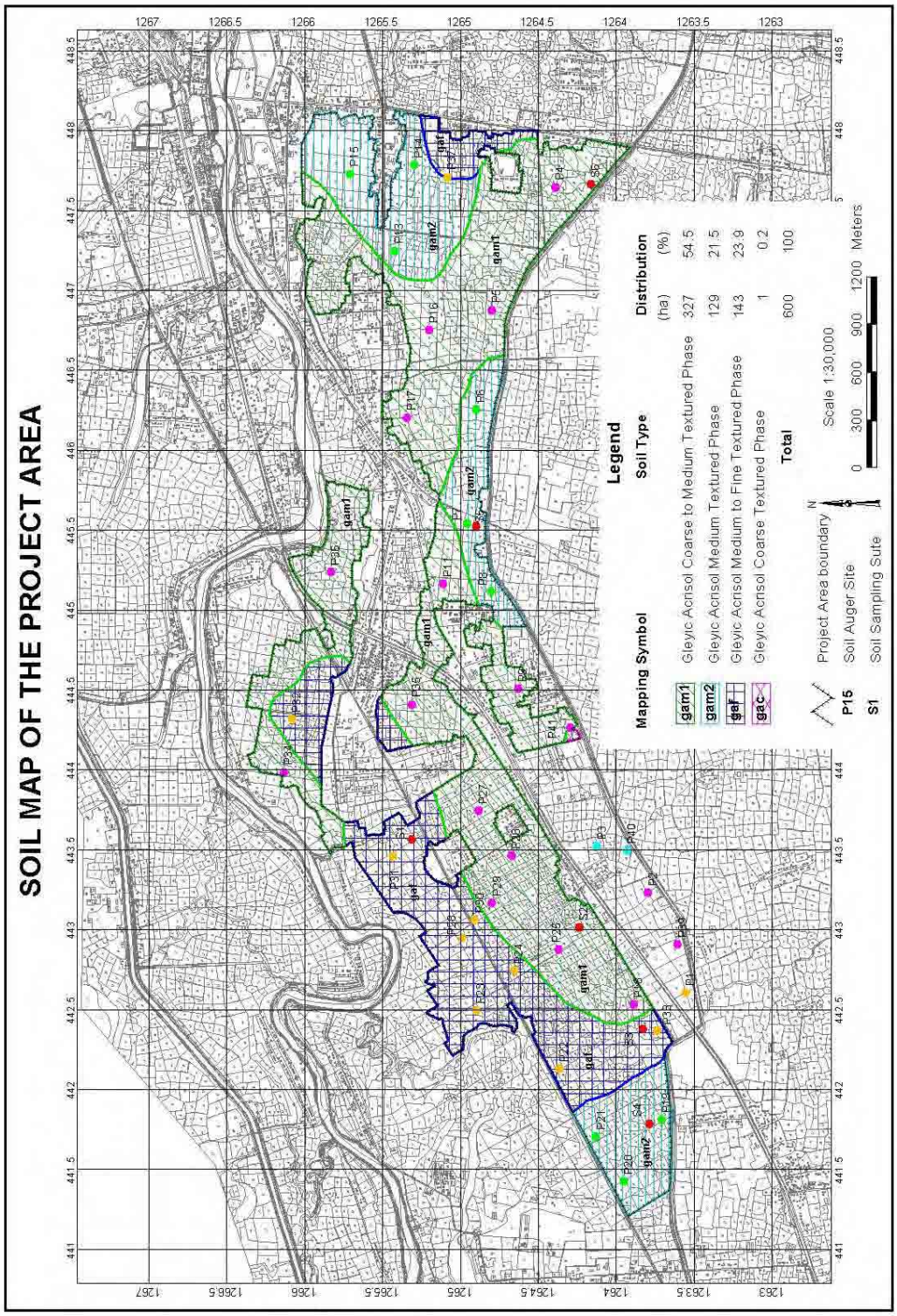
Table C-2.9.4 O&M Cost

Item		Cost / year	
		US$	Riel*
1. Hydro-mechanical works			
(1) Personal expense	Mechanic	39	158,340
	Electrician	39	158,340
	Operator	36	146,160
sub-total		114	462,840
(2) General expense		16	64,960
(3) Cost of consumables	Fuel	70	284,200
	Lub.Oil	11	44,660
	Grease	18	73,080
sub-total		99	401,940
(4) Repair cost		450	1,827,000
Total 1.		679	2,756,740
2. Civil works		3,870	15,712,200
3. Daily Inspection	240days/year	1,308	5,310,480
Total (1. +2. +3.)		5,857	23,779,420
	=	5,900	23,954,000

**: equvalent to Riel*

PART-C: IRRIGATED AGRICULTURE IMPROVEMENT MODEL PROJECT

Figures



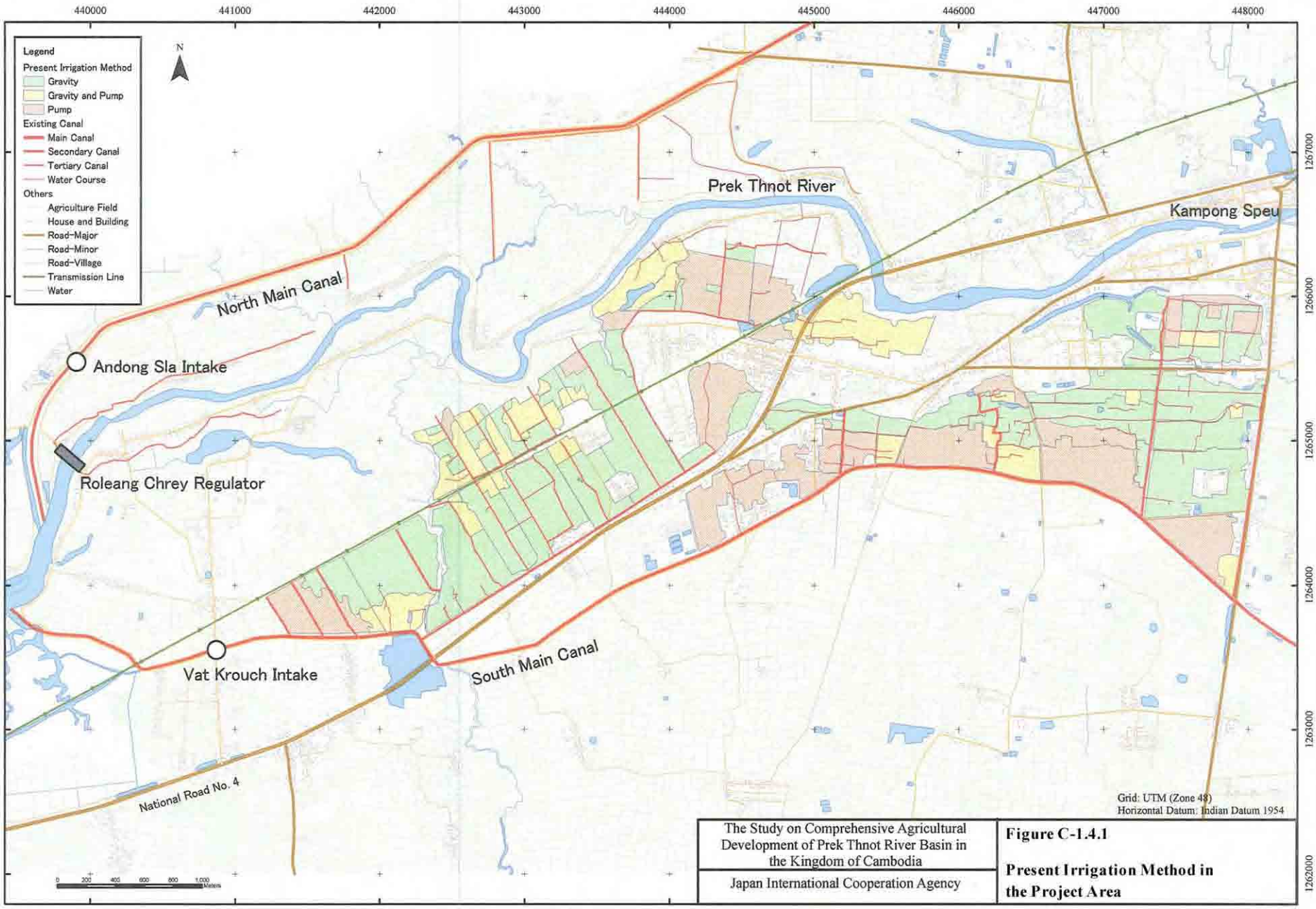
The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia	**Figure C-1.1.1** **Soil Map of the Project Area**
Japan International Cooperation Agency	

Rainfall: mean monthly rainfall at Kampong Speu from 1901~2004 except for 1973~1980 & 1991~1994
Probable discharge: At Roleng Chrey Headwork, Prek Khnot River
Sunshine hour/maximum temperature: 1995 to 2005, source Department of Meteorology

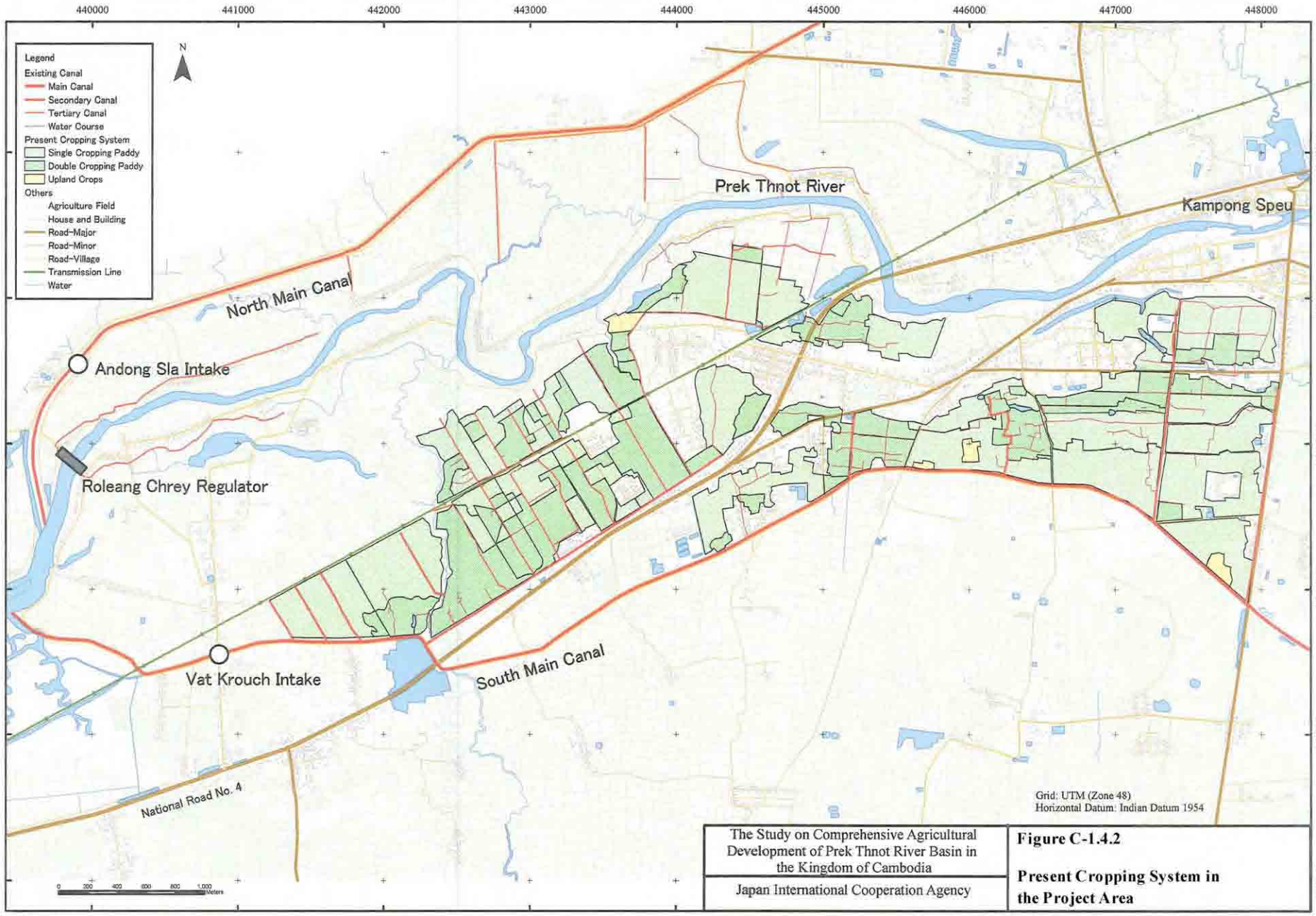
The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

Japan International Cooperation Agency

Figure C-1.3.1
Present Cropping Pattern



The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia	**Figure C-1.4.1**
Japan International Cooperation Agency	**Present Irrigation Method in the Project Area**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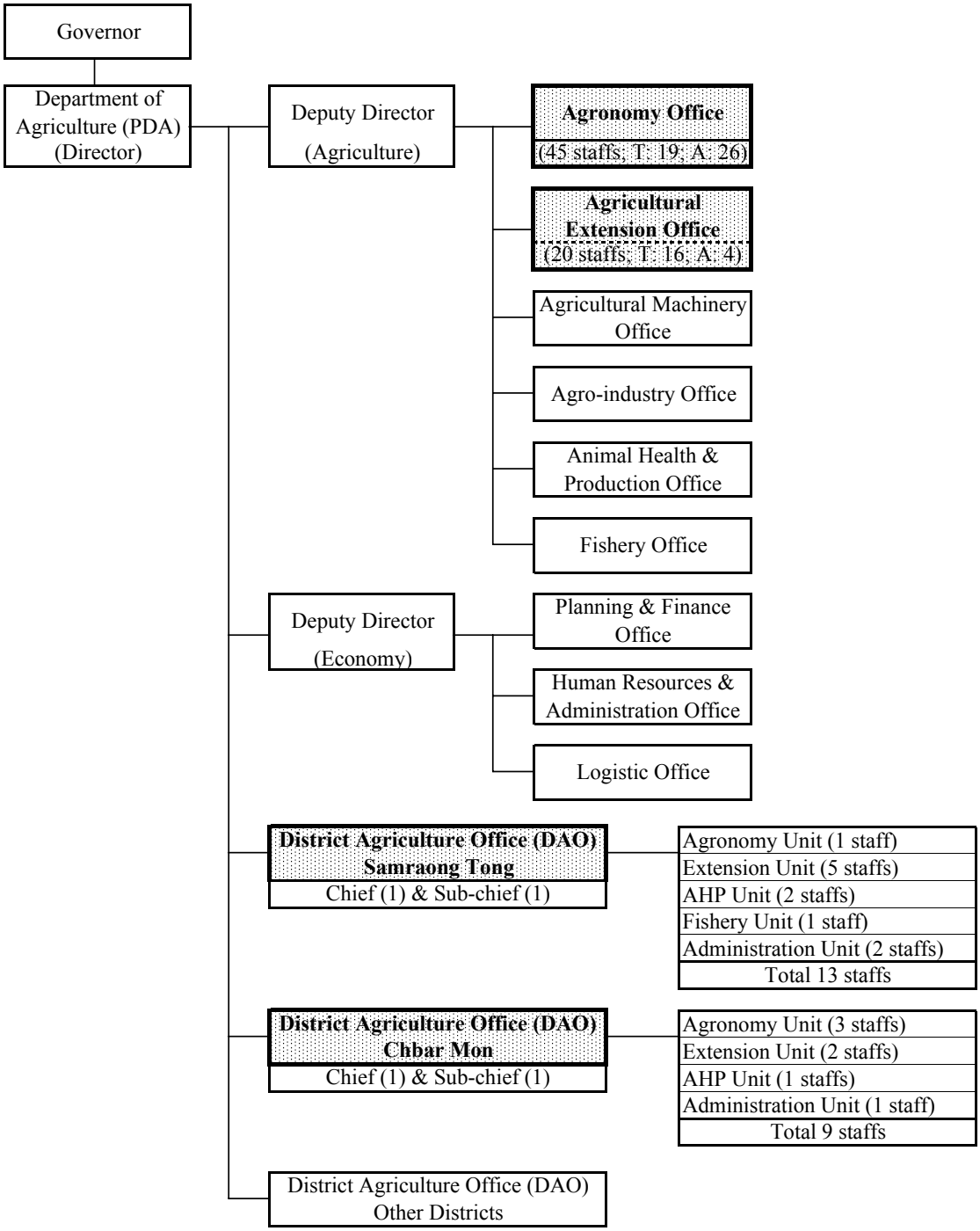
1267000
1266000
1265000
1264000
1263000
1262000
N
Legend
Existing Canal
Main Canal
Secondary Canal
Tertiary Canal
Water Course
Present Cropping System
Single Cropping Paddy
Double Cropping Paddy
Upland Crops
Others
Agriculture Field
House and Building
Road-Major
Road-Minor
Road-Village
Transmission Line
Water
Prek Thnot River
Kampong Speu
North Main Canal
Andong Sla Intake
Roleang Chrey Regulator
Vat Krouch Intake
South Main Canal
National Road No. 4
0 200 400 600 800 1,000 Meters
Grid: UTM (Zone 48)
Horizontal Datum: Indian Datum 1954
The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia
Japan International Cooperation Agency
Figure C-1.4.2
Present Cropping System in the Project Area



Staffing of PDA

Technical Offices 1/	137
Administrative offic	45
District Office	82
Total	264

1/: including director & deputies

Project related Offices

T: technical staffs
A: administrative & other staffs

AHP Unit: Animal Health & Production Unit

The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

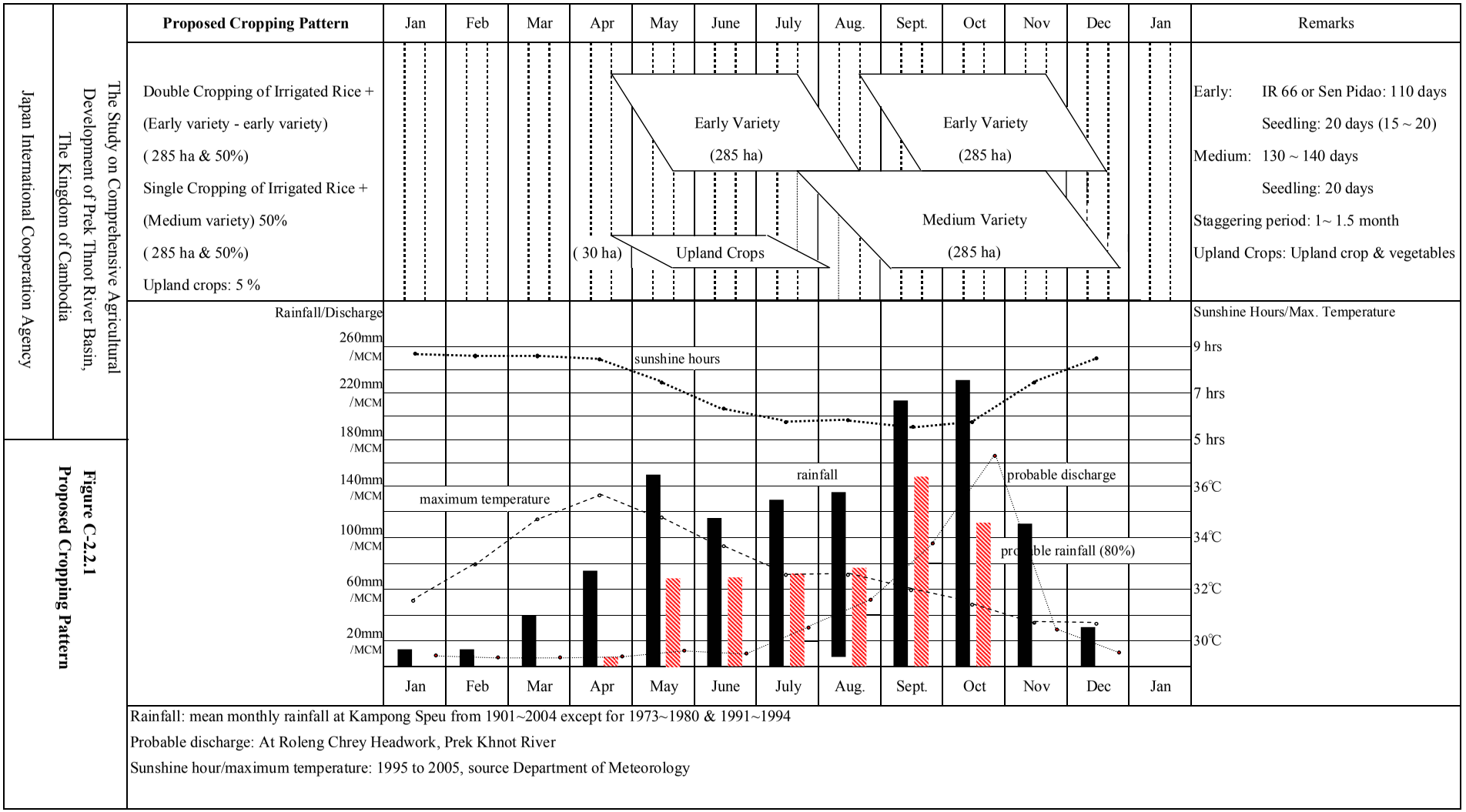
Japan International Cooperation Agency

Figure C-1.5.1
Organization Structure of PDA and Project DAOs

Japan International Cooperation Agency

The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

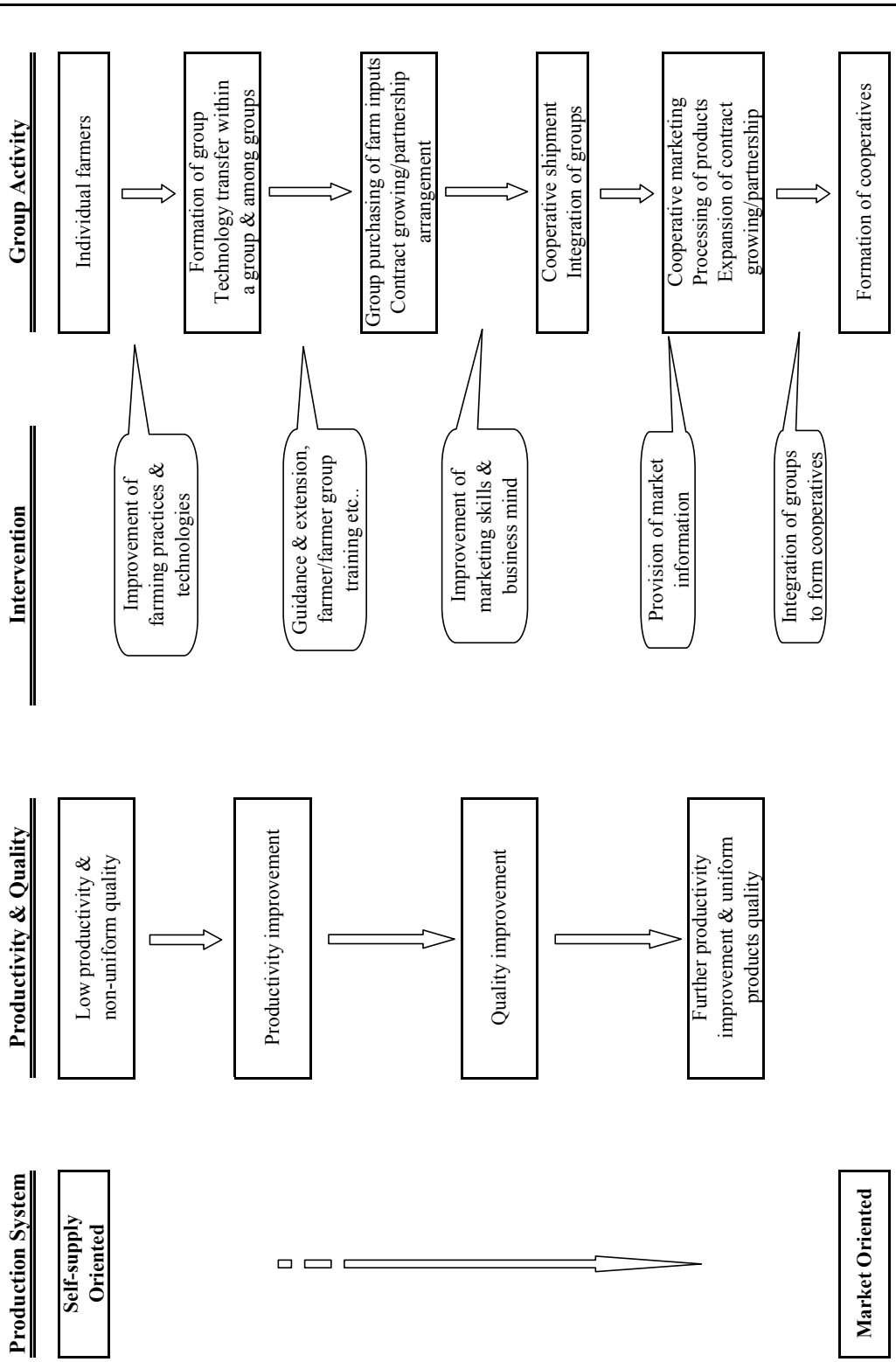
Figure C-2.2.1
Proposed Cropping Pattern



Rainfall: mean monthly rainfall at Kampong Speu from 1901~2004 except for 1973~1980 & 1991~1994

Probable discharge: At Roleng Chrey Headwork, Prek Khnot River

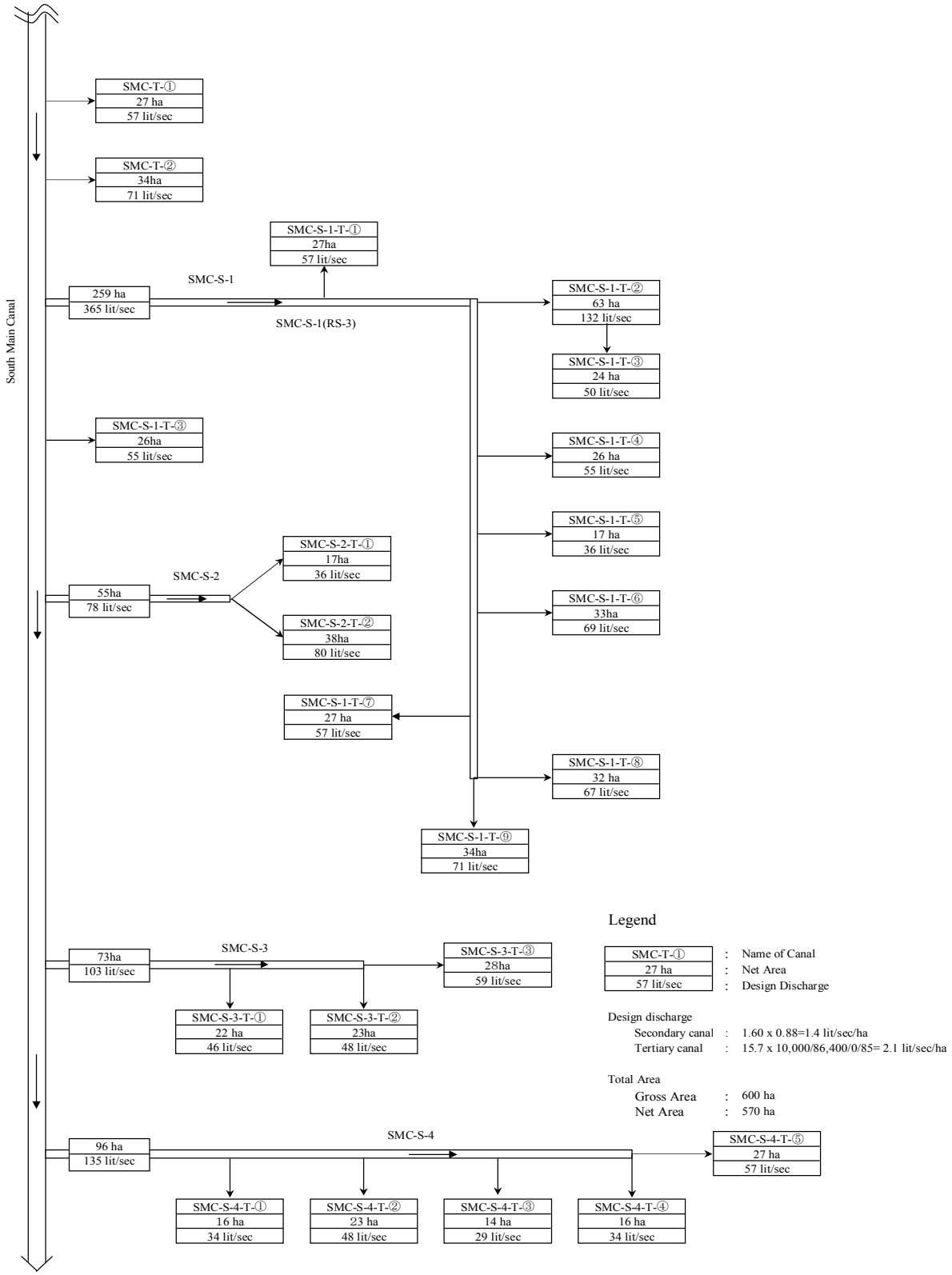
Sunshine hour/maximum temperature: 1995 to 2005, source Department of Meteorology



The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

Japan International Cooperation Agency

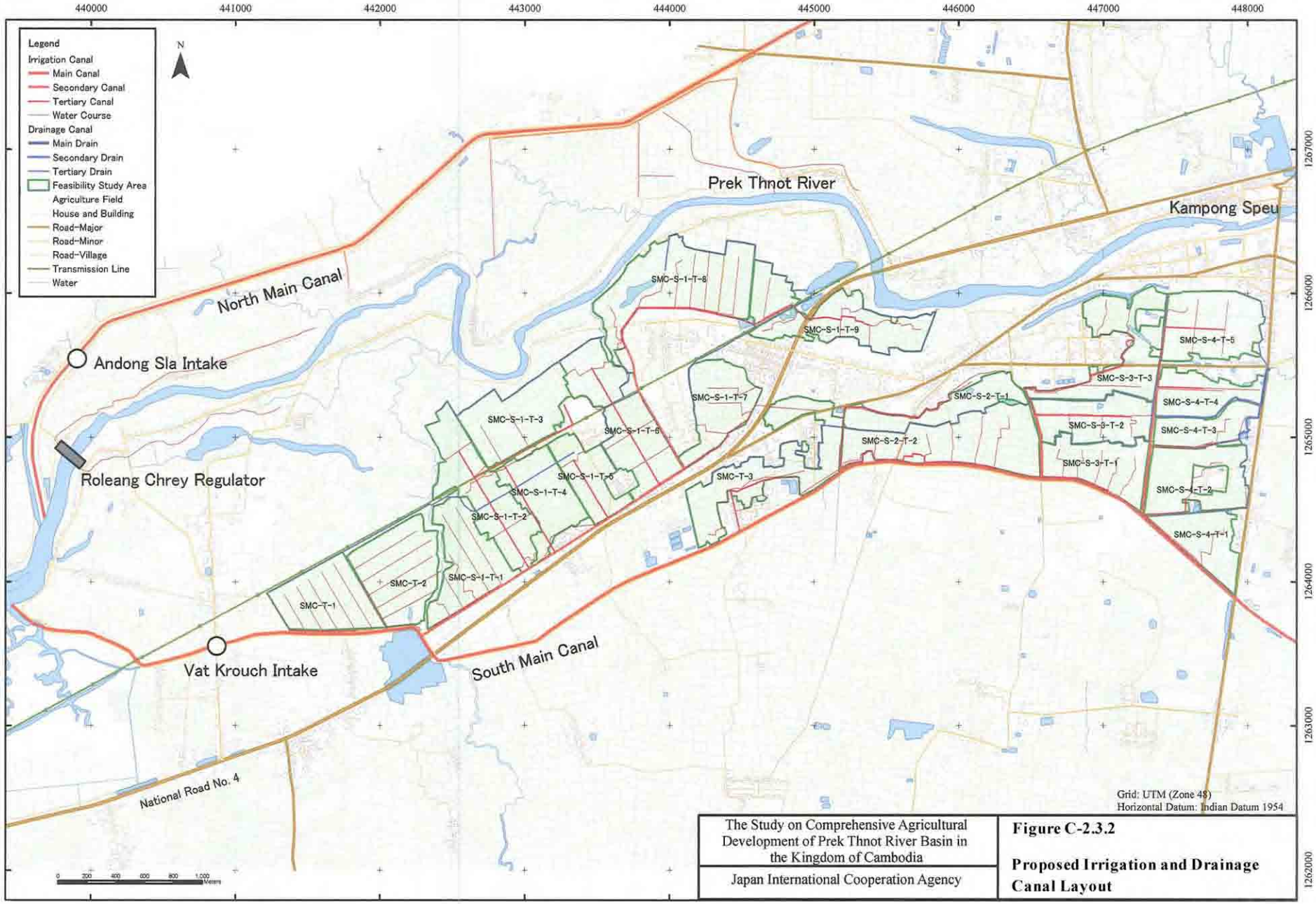
Figure C-2.2.2
Proposed Approaches for Improving Marketing



The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

Japan International Cooperation Agency

Figure C-2.3.1
Irrigation Diagram for Project Area


440000
441000
442000
443000
444000
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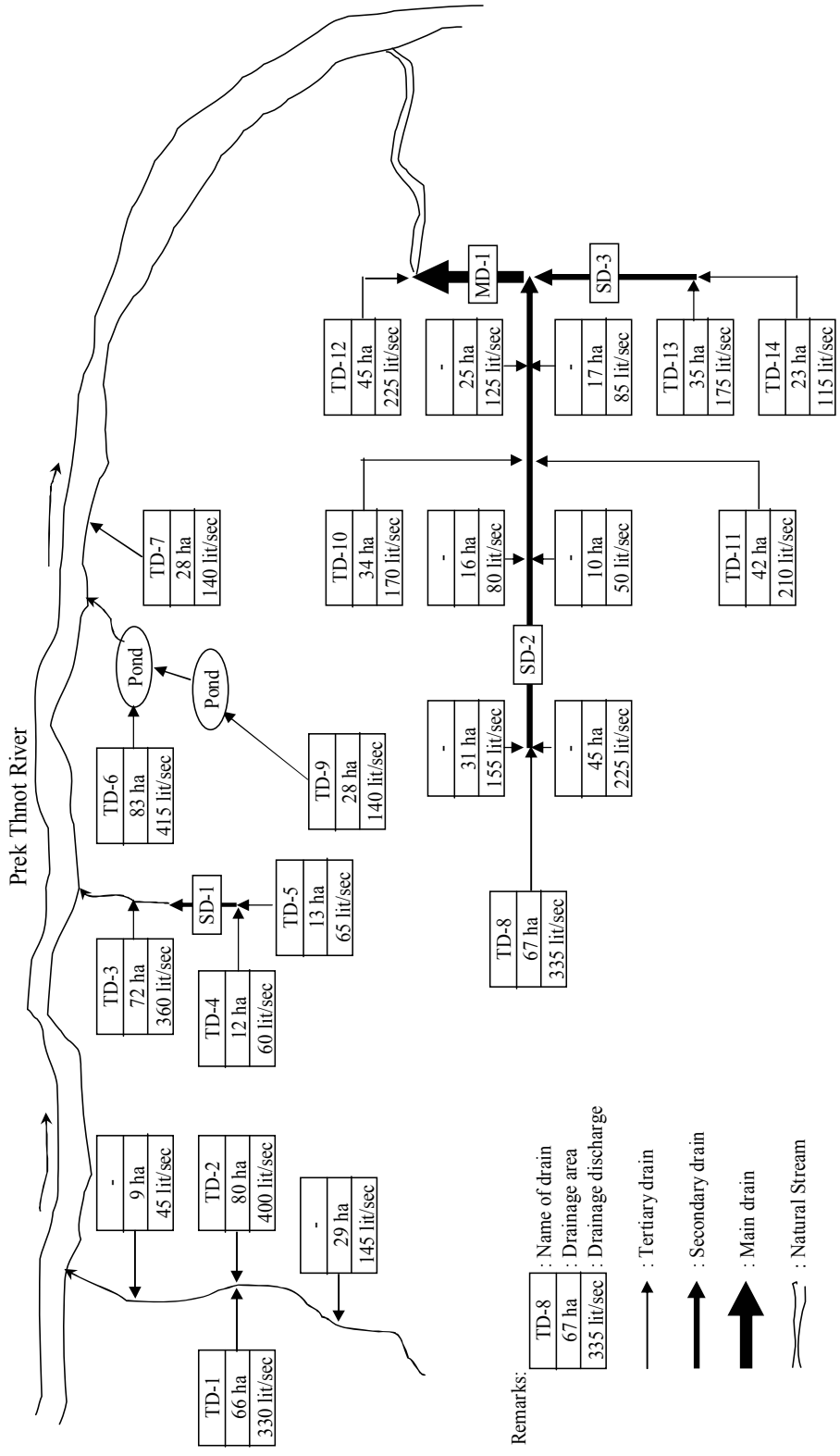
446000
447000
448000
1267000
1266000
1265000
1264000
1263000
1262000
N
Legend
Irrigation Canal
Main Canal
Secondary Canal
Tertiary Canal
Water Course
Drainage Canal
Main Drain
Secondary Drain
Tertiary Drain
Feasibility Study Area
Agriculture Field
House and Building
Road-Major
Road-Minor
Road-Village
Transmission Line
Water
Prek Thnot River
Kampong Speu
North Main Canal
Andong Sla Intake
Roleang Chrey Regulator
Vat Krouch Intake
South Main Canal
National Road No. 4
SMC-S-1-T-8
SMC-S-1-T-9
SMC-S-1-T-7
SMC-S-1-T-3
SMC-S-1-T-6
SMC-S-1-T-5
SMC-S-1-T-4
SMC-S-1-T-2
SMC-S-1-T-1
SMC-T-1
SMC-T-2
SMC-T-3
SMC-S-2-T-1
SMC-S-2-T-2
SMC-S-3-T-3
SMC-S-3-T-2
SMC-S-3-T-1
SMC-S-4-T-5
SMC-S-4-T-4
SMC-S-4-T-3
SMC-S-4-T-2
SMC-S-4-T-1
0 200 400 600 800 1,000 Meters
Grid: UTM (Zone 48)
Horizontal Datum: Indian Datum 1954
The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia
Japan International Cooperation Agency
Figure C-2.3.2
Proposed Irrigation and Drainage Canal Layout

The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

Japan International Cooperation Agency

Figure C-2.3.3
Typical Cross Sections of Irrigation Canals



The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

Japan International Cooperation Agency

Figure C-2.3.4
Drainage Diagram for Project Area

TYPICAL CROSS SECTION of DRAINAGE CANAL

Drainage Canal

Drain		Discharge (m^3/sec)	Length (km)	B (m)	H (m)	m
Tertiary	TD-1	0.330	1.3	0.8	0.8	1.00
	TD-2	0.400	1.1	0.8	0.8	1.00
	TD-3	0.360	1.5	0.8	0.8	1.00
	TD-4	0.060	0.6	0.5	0.5	1.00
	TD-5	0.065	0.6	0.5	0.5	1.00
	TD-6	0.415	1.2	0.8	0.8	1.00
	TD-7	0.140	1.7	0.6	0.6	1.00
	TD-8	0.335	1.6	0.8	0.8	1.00
	TD-9	0.140	1.3	0.6	0.6	1.00
	TD-10	0.170	0.8	0.6	0.6	1.00
	TD-11	0.210	1.1	0.7	0.7	1.00
	TD-12	0.225	0.5	0.7	0.7	1.00
	TD-13	0.175	0.6	0.6	0.6	1.00
	TD-14	0.115	1.2	0.6	0.6	1.00
Secondary	SD-1	0.125	0.6	0.6	0.6	1.00
	SD-2	0.715 - 1.435	7.1	1.0 - 1.2	1.0 - 1.2	1.00
	SD-3	0.290	0.3	0.7	0.7	1.00
Main	MD-1	1.725	0.3	1.3	1.3	1.00

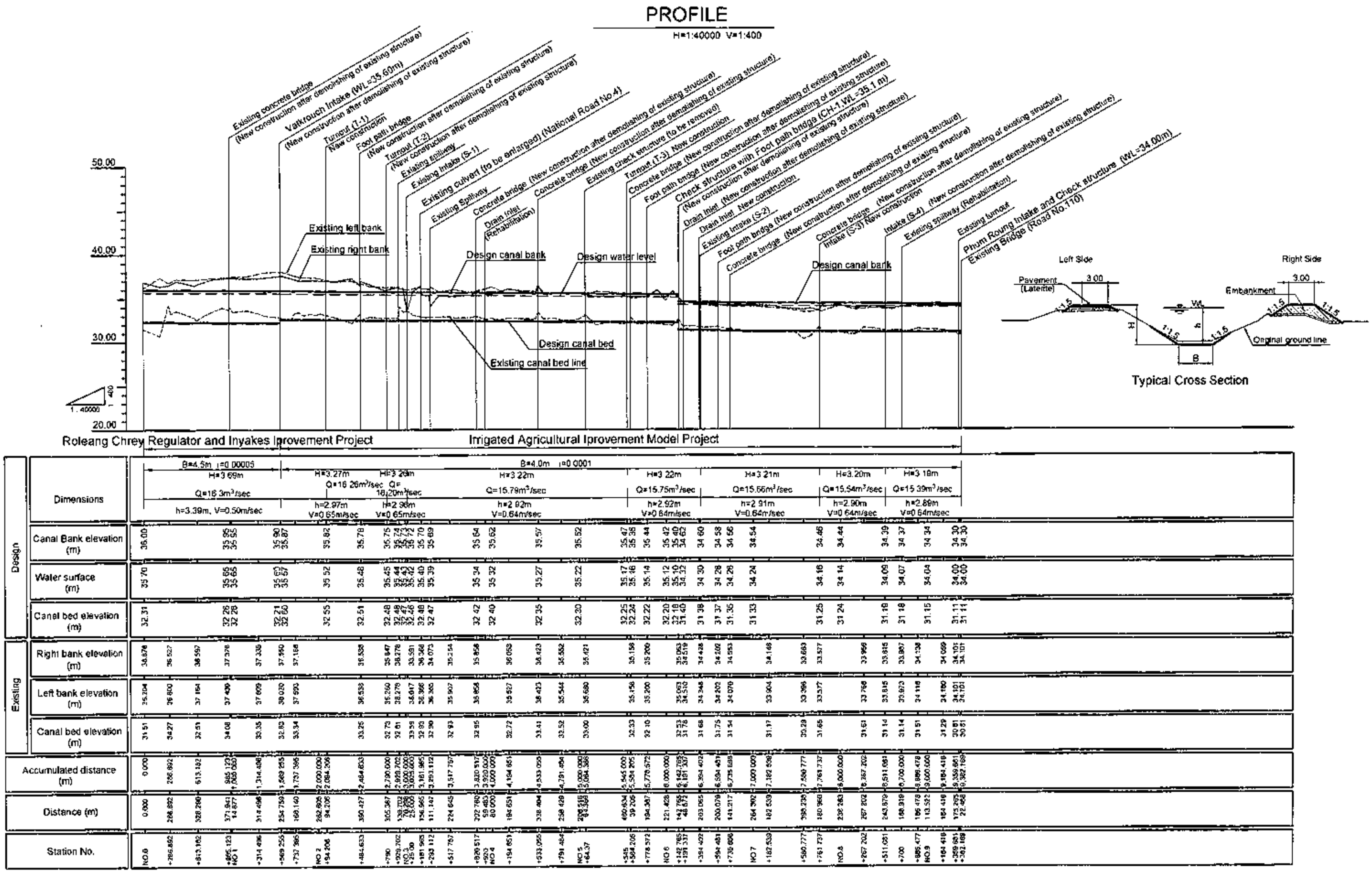
The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

Japan International Cooperation Agency

Figure C-2.3.5
Typical Canal Section of Drainage Canal

PART-C: IRRIGATED AGRICULTURE IMPROVEMENT MODEL PROJECT

Drawings



Dimensions
Q=Design dischrge (m³/sec)
i=Canal bed gradient
h=Design water depth (m)
V=Flow velocity (m/sec)
B=Width of canal bed (m)
H=Height of canal (m)
Canal slope (horizontal to vertical) m=1.50

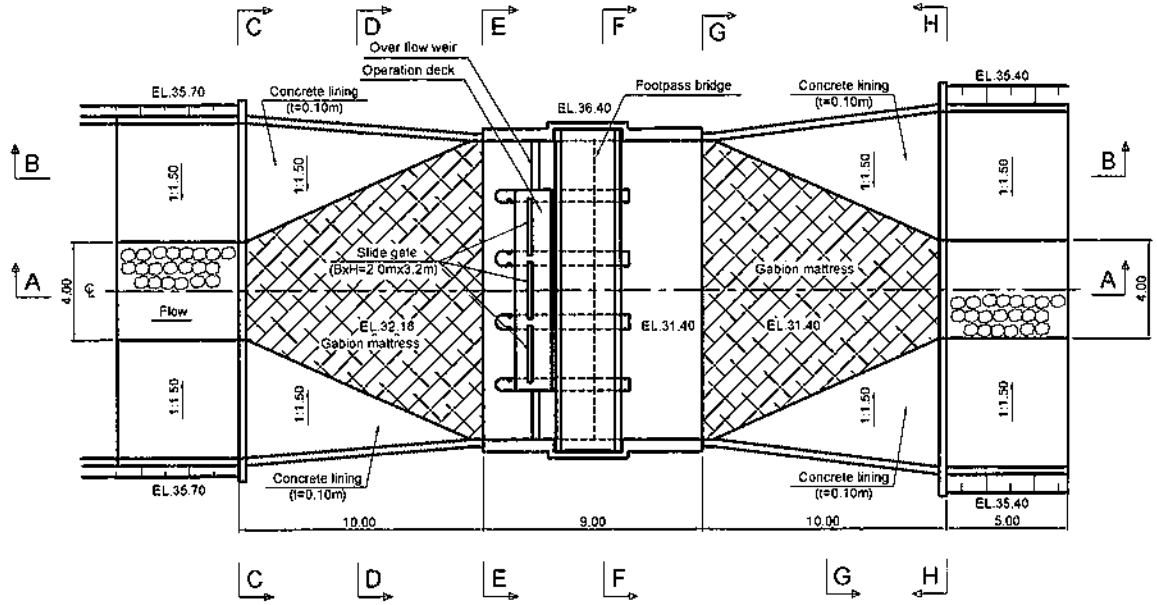
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (JICA)

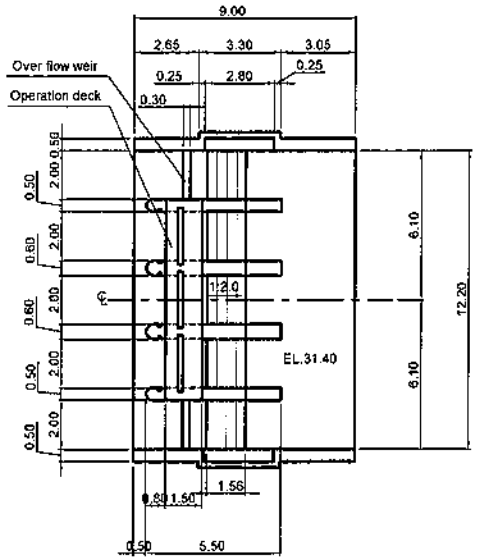
Drawing C-1

Profile of South Main Canal

CHECK STRUCTURE



PLAN



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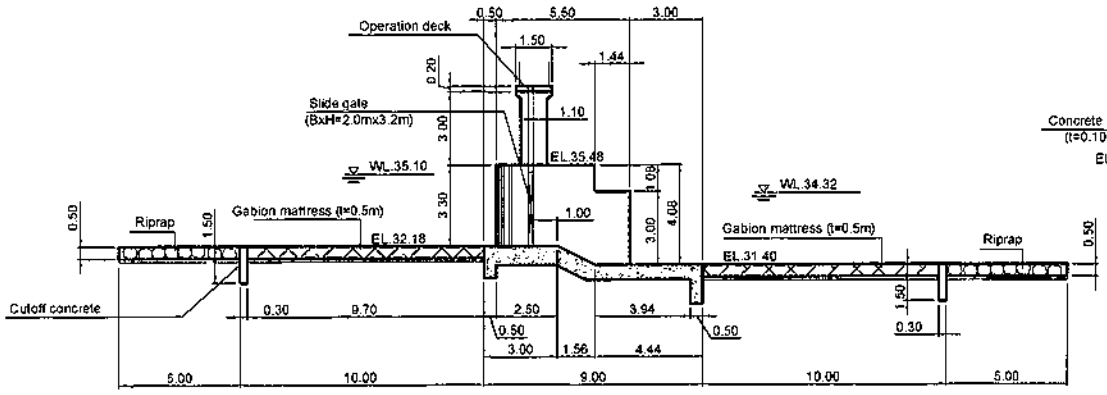
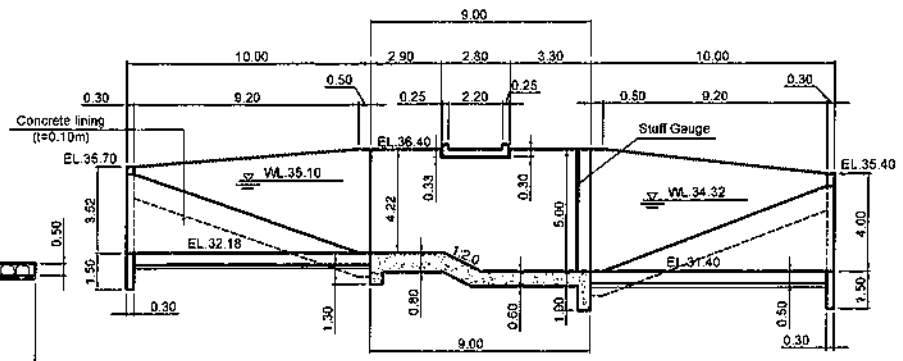


SECTION A - A

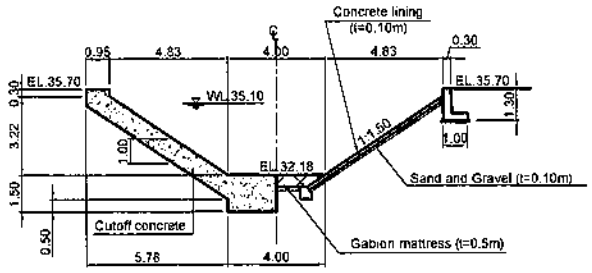


SECTION B - B

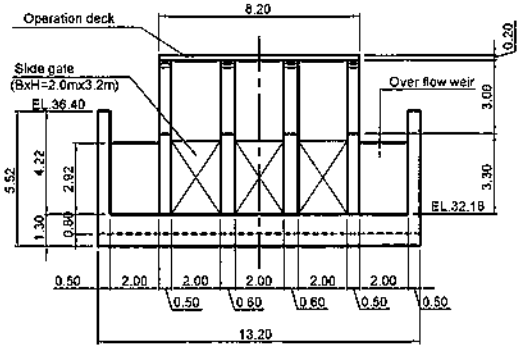
Scale 0 5 10

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing C-2
Japan International Cooperation Agency (JICA)	Check Structure for South Main canal (1/2)

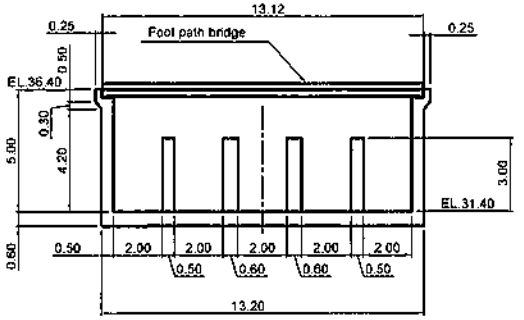
CHECK STRUCTURE



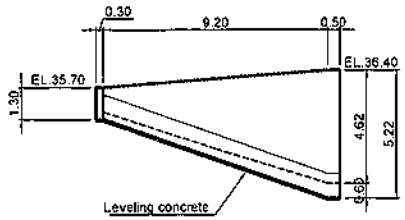
SECTION C - C



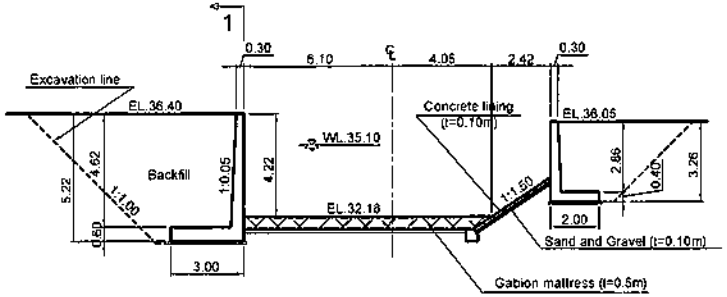
SECTION E - E



SECTION F - F



SECTION 1 - 1



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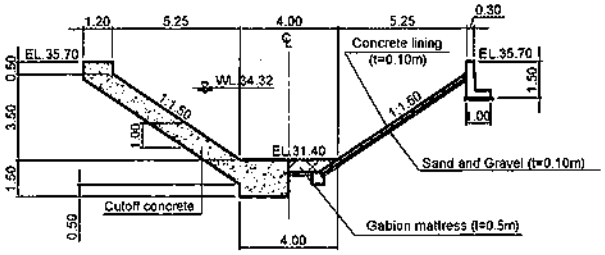
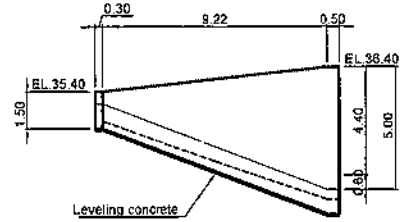
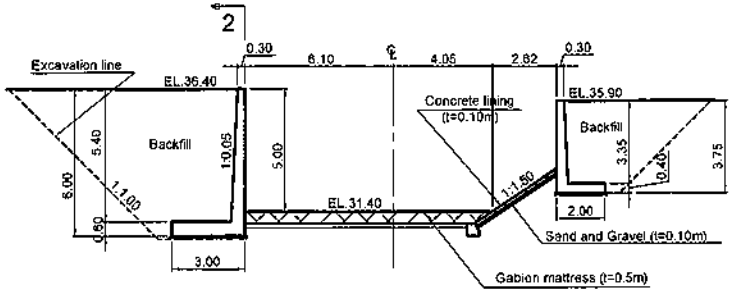


SECTION H - H



SECTION 2 - 2



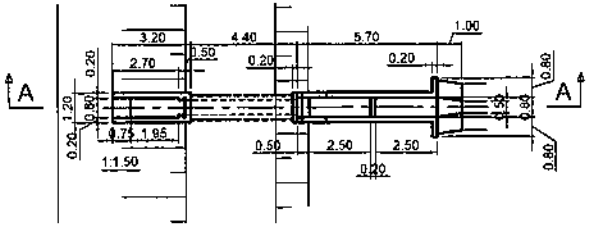
SECTION G - G

Scale 0 5 10

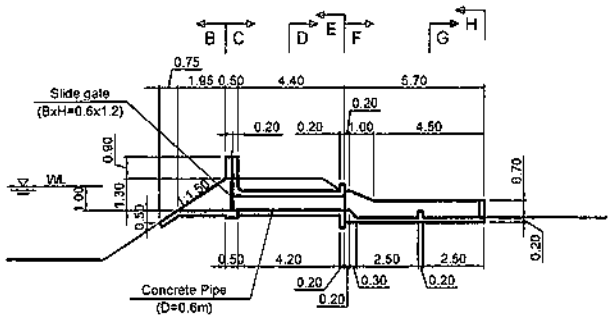
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing C-3
Japan International Cooperation Agency (JICA)	Check Structure for South Main canal (2/2)

III - CD - 4

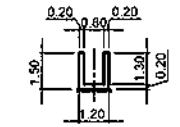
INTAKE
(to Secondary Canal)



PLAN



SECTION A - A



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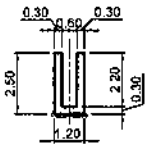
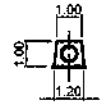


SECTION C - C



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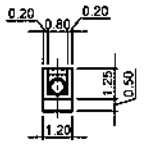

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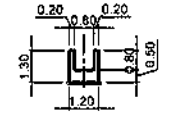

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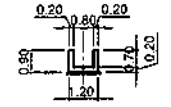
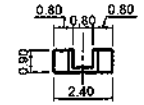
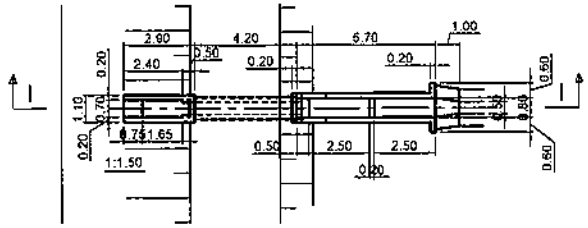


SECTION G - G

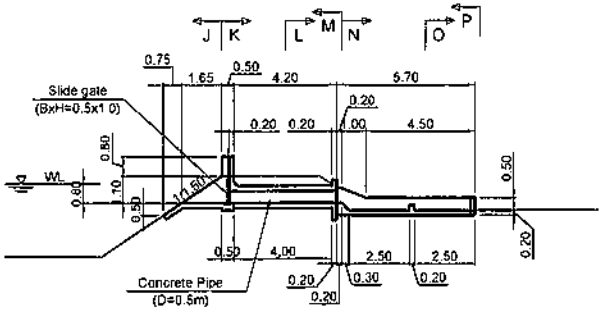


SECTION H - H

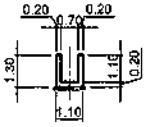
TURNOUT
(to Tertiary Canal)



PLAN



SECTION I - I



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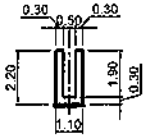
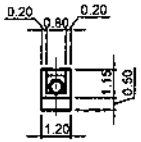
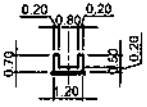


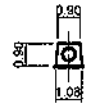
SECTION K - K



SECTION M - M



SECTION O - O



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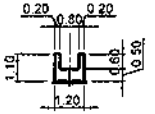
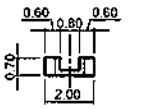
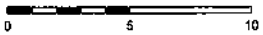


SECTION N - N



SECTION P - P

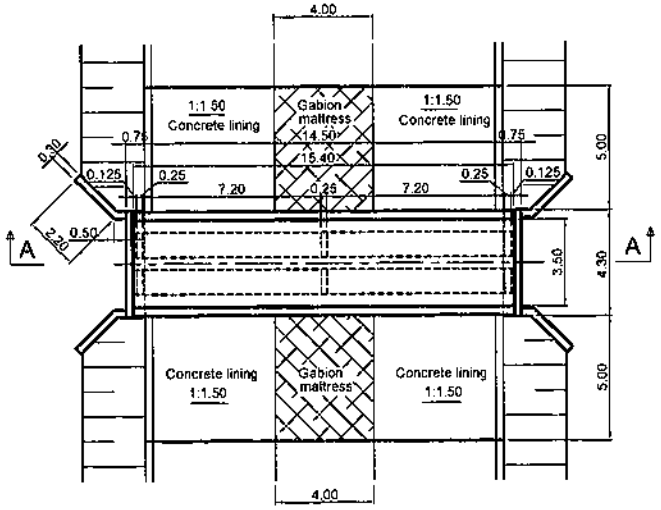


THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing C-4
Japan International Cooperation Agency (JICA)	Intake and Turnout for South Main canal

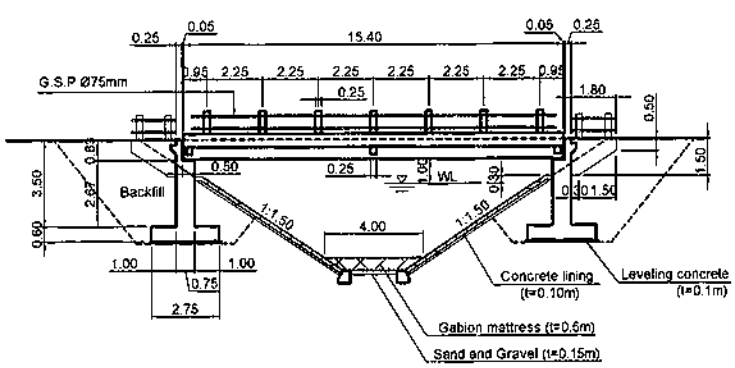
III - CD - 5

CONCRETE BRIDGE

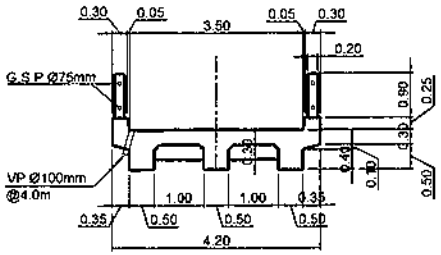
Scale 1:200



PLAN Scale A



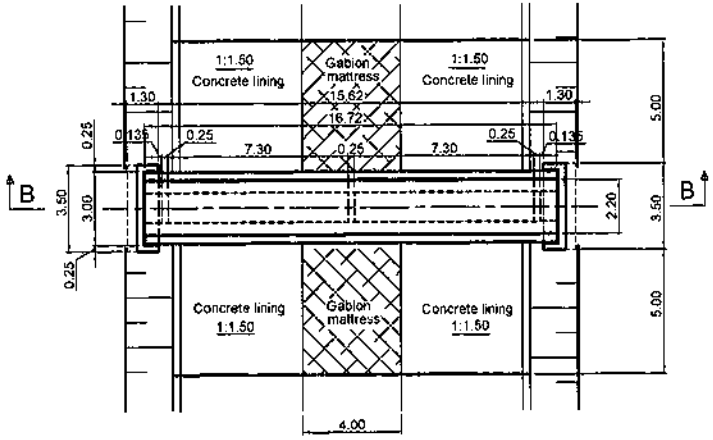
SECTION A - A Scale A



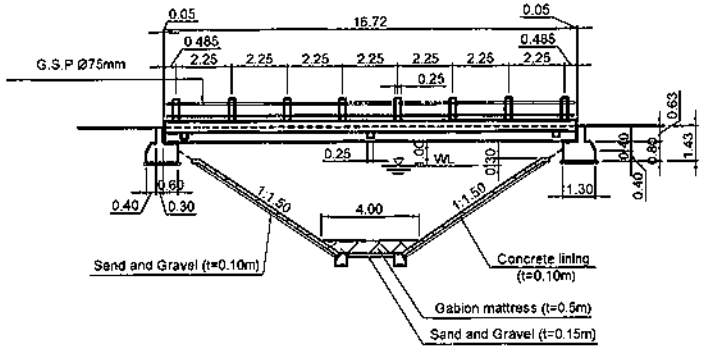
BRIDGE Scale B

FOOT PATH

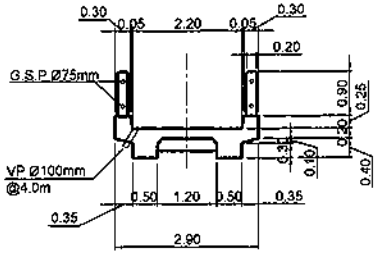
Scale 1:200



PLAN Scale A



SECTION B - B Scale A



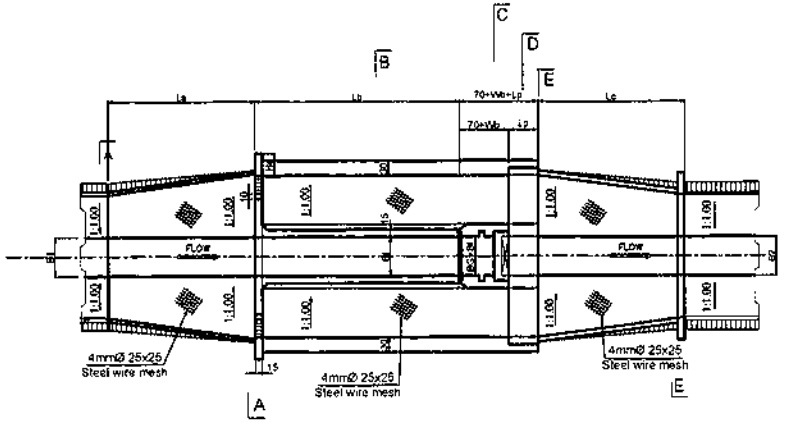
FOOT PATH Scale B

0 5 10
Scale A

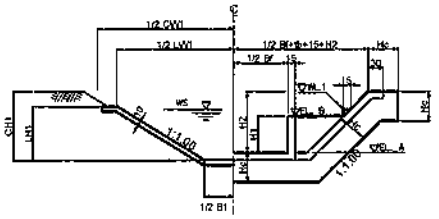
0 5
Scale B

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing C-5
Japan International Cooperation Agency (JICA)	Bridge and Foot Path for South Main Canal

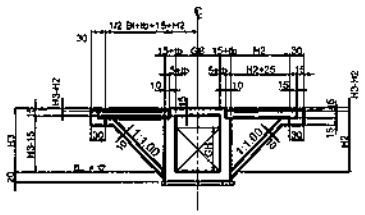
CHECK of SECONDARY CANAL



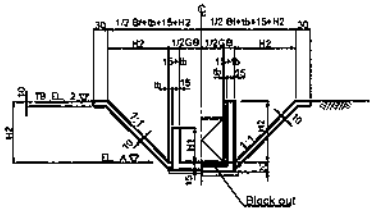
PLAN



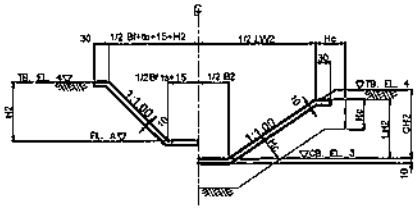
SECTION A–A



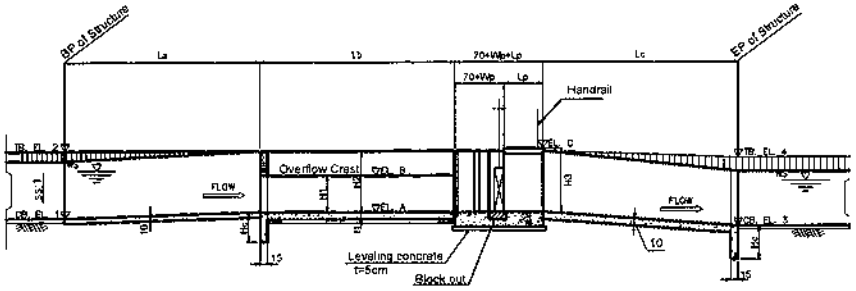
SECTION D–D



SECTION B–B SECTION C–C



SECTION E–E



PROFILE

DIMENSION TABLE FOR CHECK GATE

Discharge (m³/sec)	La (cm)	Lb (cm)	Lc (cm)	Bf (cm)	H1 (cm)	H2 (cm)	H3 (cm)	Hc (cm)	t1 (cm)	La Height (cm)	La Width (cm)	La Nos.
< 0.20	200	80	200	50	38	75	75	60	15	50	50	1
> 0.20	200	100	200	50	48	89	89	60	15	50	60	1

0 5 10
Scale

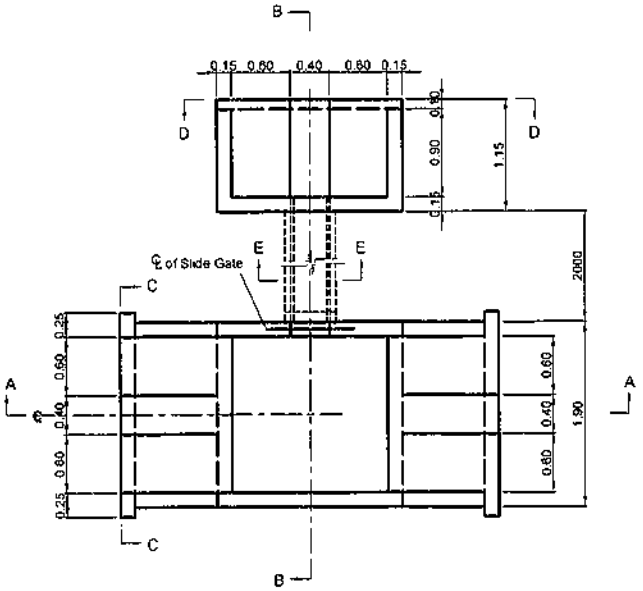
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (JICA)

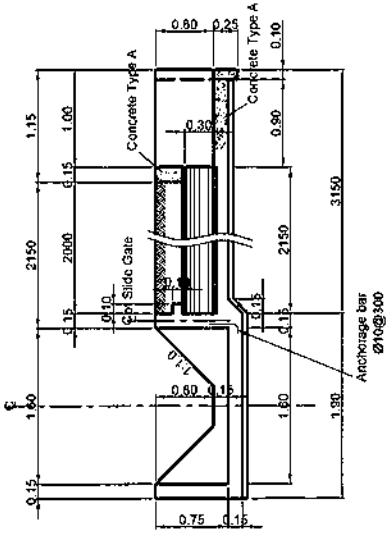
Drawing C-6

Check Structure for Secondary Canal

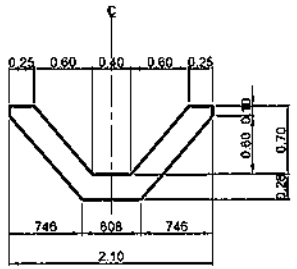
DIVISION BOX



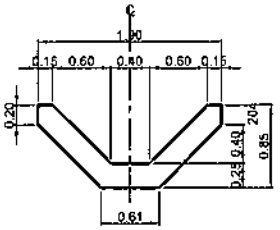
PLAN



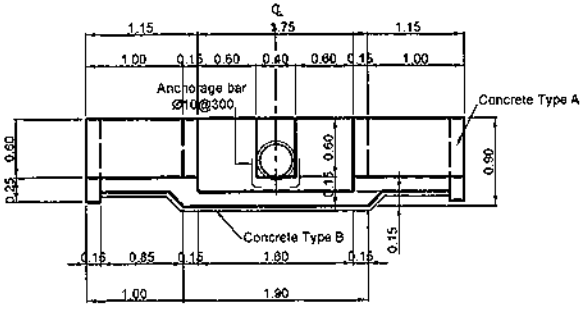
SECTION B-B



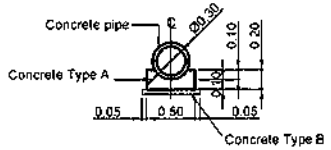
SECTION C-C



SECTION D-D



SECTION A-A

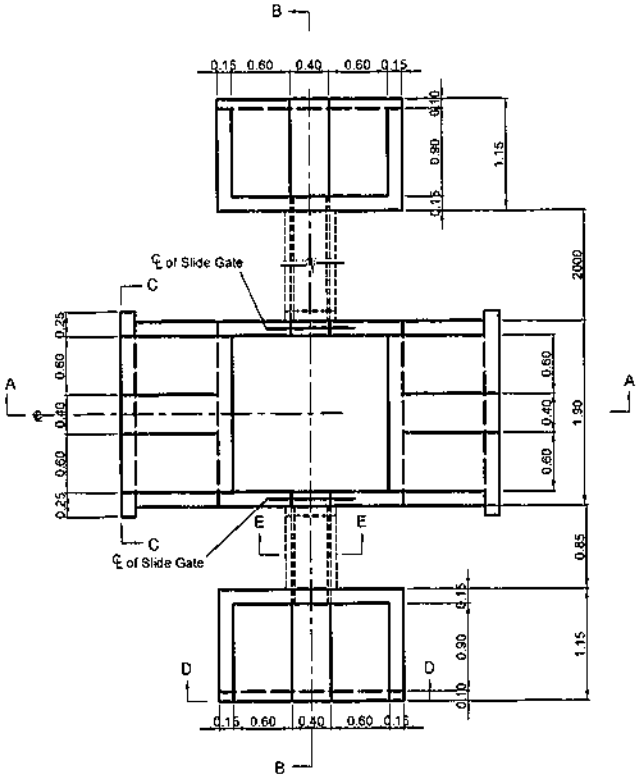


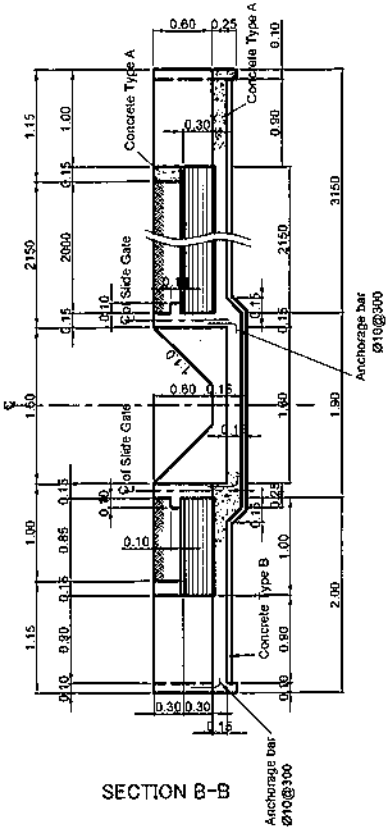
SECTION E-E

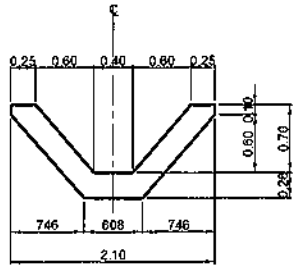
Scale A

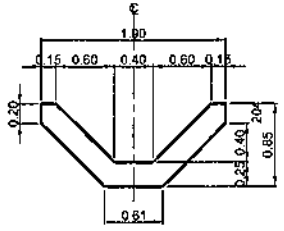
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing C-7
Japan International Cooperation Agency (JICA)	Division Box for Tertiary Canal (1/2)

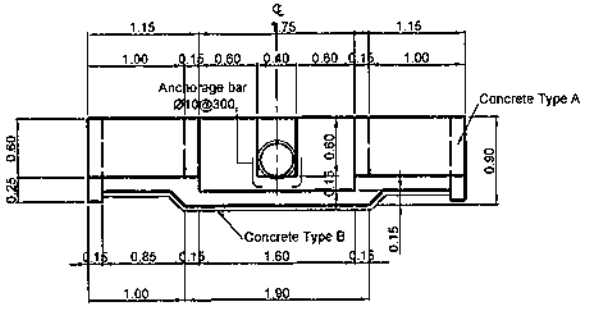
DIVISION BOX

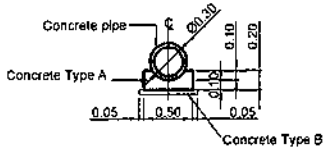


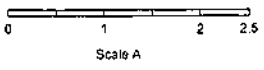






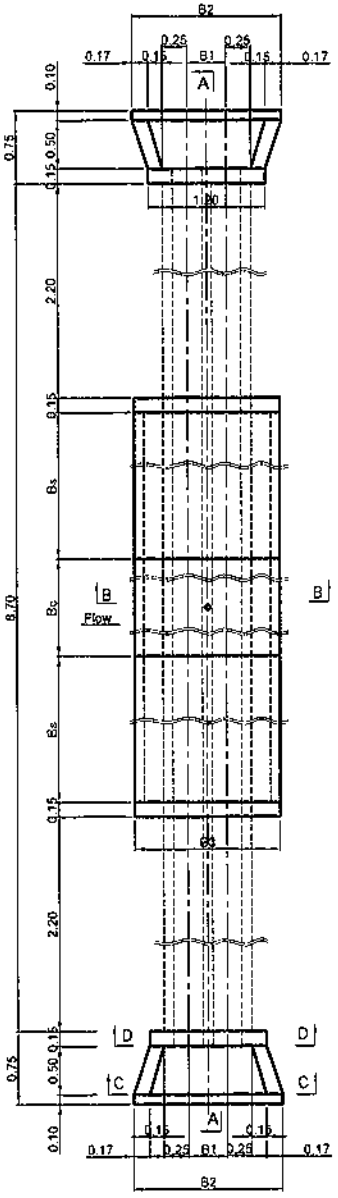




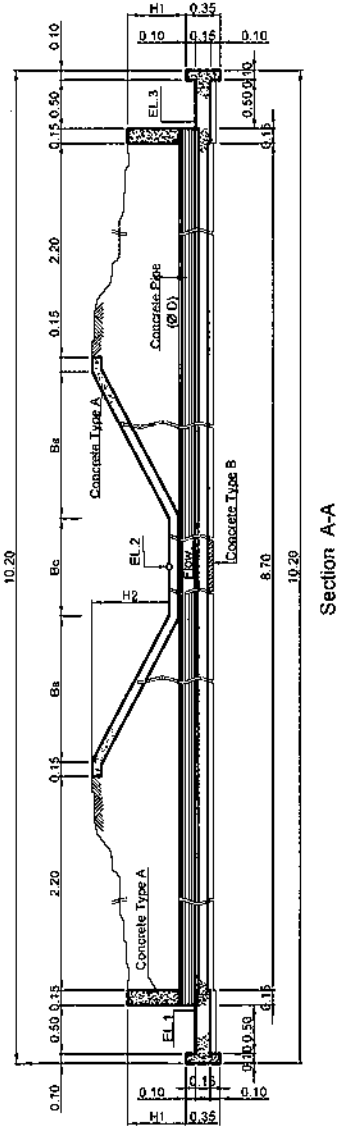


THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing C-8
Japan International Cooperation Agency (JICA)	Division Box for Tertiary Canal (2/2)

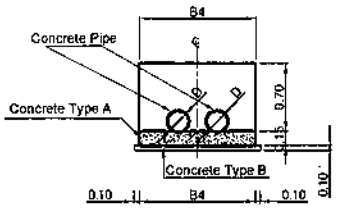
CROSS DRAIN



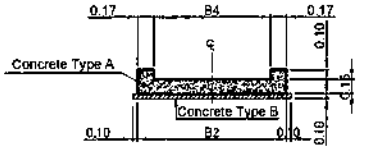
PLAN



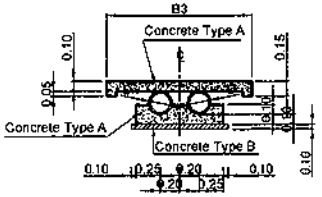
Section A-A



Section D-D



Section C-C



Section B-B

Scale 0 1 2 2.5

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing C-9
Japan International Cooperation Agency (JICA)	Cross Drain of Drainage Canal