Appendix-IIIC

IRRIGATION AND DRAINAGE

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

FINAL REPORT

Volume-VII: Appendixes for Feasibility Studies for Priority/Urgent Projects

Appendix-IIIC

Irrigation and Drainage

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APPENDIX-IIIC: IRRIGATION AND DRAINAGE

Chapter IIIC-1 Present Condition of Irrigation and Drainage Facilities

IIIC-1.1 Irrigation System

IIIC-1.1.1 Canals

The Project Area of which command area is 580 ha, is covered with the existing irrigation system belonging to the West Phnom Penh Integrated Development Center Project. The breakdown of the system is given below:

Existing Canal System Covering the Project Area

Category of Canal	Canal Name	Length (km)
(1) Main Canal	South Main Canal	*7.8
(2) Secondary Canal	RS-3	2.4
	Others (no name)	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 name)	7.2
Total		**15.9**

Note:: 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 consideration of topographic condition, which results in difficulty in application of gravity irrigation for some areas. Some farmers are obliged to use portable pumps with high operation cost. Severe erosion is also observed from place to place at the side slope of them mainly due to dispersible soils and poor construction. Thus, these situations should be carefully studied when improvement plan of canals is worked out.

Watercourses subordinating to Tertiary Canals are not adequately constructed by farmers, which cause the ineffective water distribution to each paddy field.

The canal names mentioned above are randomly given. Most of existing canals are not named. In planning the new canal system, canal name should be given in a systematic manner for easy and proper O&M and water management.

IIIC-1.1.2 Related Structures

In the existing irrigation system, the following structures related irrigation canals are provided:

Canal Structures in the Existing Irrigation System in 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

The results of inventory survey for existing structures on South Main Canal for 7.8 km from Vat Krouch Intake to Phum Roung Intake with Check are shown in Attachment IIIC-1.

Most of these structures were constructed under the assistance of 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.

Measuring devices are not provided for the system at all, and appropriate water management is not materialized accordingly.

IIIC-1.1.3 Irrigation Type

The water supply in the Project Area is by gravity, portable pumps and the both. The inventory survey delineates the areas by respective irrigation types as shown in the right table. Figure IIIC-1.1.1 shows areas of respective irrigation types

Irrigation Type

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

IIIC-1.1.4 Current Irrigation Condition

The interview was carried out for 150 farmers, to clarify the current irrigation condition for paddy cultivation in the Project Area. The right table shows the current irrigation condition for paddy cultivation. About 35% of total area is cultivated two times in a year. Figure III-1.1.2 shows the present cropping system

Irrigation Condition for Paddy

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

IIIC-1.2 Drainage System

There are no artificial drainage systems in the area. The excess water is eliminated field by field, and eventually flows into the depreciated places and/or natural streams servicing as drain. In some cases, the existing canals have a double function of irrigation and drainage. In applying the water saved farming practice such as SRI, such the double function does not allow because timely and smooth irrigation and drainage are essential.

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

IIIC-1.3 O&M

IIIC-1.3.1 Responsible Organization

According to the inventory survey and information collected the Kampong Speu PDOWRAM, the responsibilities for O&M for irrigation system in the Project Area are

shared by the Kampong Speu PDOWRAM and FWUCs as follows:

Share of Responsibilities for O&M for Irrigation System

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

Note: Ou Veaeng FWUC and Phoum Roung FWUC

In the above table, O&M for secondary canal is jointly conducted by Kampong Speu PDOWRAM and FWUCs since FWUCs have not sufficient capability to fulfill O&M activities.

IIIC-1.3.2 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 and maintained. Operation of gates in the South Main Canal is carried out by FWUC concerned on the 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 main reason is lack of budget.

IIIC-1.3.3 Other Canals

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

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

IIIC-1.4 Water Management

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

In the Project Area, Kampong Speu PDOWRAM and relevant FWUCs currently execute water distribution on the demand basis without preparing an irrigation schedule. In the tertiary canal unit, water distribution is generally made continuously without application of rotational irrigation.

In the existing canal system, there are no water measuring devices such as broad-crest weir, Parshall flume and staff gauges. Thus, it can be said that systematic water management is not introduced in the Project Area.

IIIC-1.5 Current Problems for Irrigation and Drainage

Through site visit and activities of Pilot Project located in Bos Ta Ney upstream in the Project Area, the following problems have been found in the existing irrigation and drainage in the Project Area:

Current Problems Found

Item	Current Problems Found
(1) Kampong Speu PDOWRAM	(a) Lack of basic data such as cadastral map, water requirement and percolation rate
	(b) Less chances to accumulate working experiences in water management
	(c) Less budget for repairing/improving irrigation and drainage facilities
	(d) Insufficient support to FWUC on proper activities
(2) FWUC	(a) Formation of FWUC deviated from canal layout
	(b) No formation of FWUGs and WUGs
	(c) Less knowledge on roles and responsibilities of FWUC
	(d) Lack of awareness on water saving
	(e) Inactive administrative activities like collection of irrigation service fee
	(f) Poor maintenance activities for responsible canals
	(g) No office for FWUC activities
(3) Irrigation and Drainage System	(a) No systematic canal layout
	(b) Improper design of canal and structures
	(c) Double functions of irrigation and drainage in one canal
	(d) Lack of canal structures, especially division boxes and measuring devices
	(e) Less watercources

Out of them, current problems on irrigation and drainage system are minutely explained below:

(1) No Systematic Canal Layout

The Project Area is covered with the existing irrigation system. This canal system is not designed and constructed considering the execution of proper water management. For example, there are some tertiary canals branched of from the South Main Canal, not through the secondary canal. This causes the complicated water management. The command area of tertiary canal fluctuates largely. It should be determined from the viewpoint of water quantity that farmers can easily handle.

(2) Improper Design of Canal and Structures

Almost all the canals are excavated canals, so that the water supply could not be made by gravity, which compels farmers to use pump system with high operation cost. The canals also are designed and constructed without consideration of topographic condition. Due to this, water could not be effectively delivered to the farm plots. A spillway is provided at the upstream reach of secondary canal. The elevation of spilled-out-portion in the spillway is low, so that water level in the downstream canal could not be raised. It is observed that severe scouring upstream and downstream portions of the structure 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 make water management properly since necessary discharge for irrigation could not be grasped.

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

In the existing irrigation system, canal structures such as check, division boxes and measuring devises are less or lacked. In particular, there are no structures on the tertiary canals, so that farmers breach the canal bank to obtain water for his field. The breached banks are left and water is unnecessarily used accordingly. Measuring devices are not

provided at the existing canal system at all. They are essential for effective water distribution.

(5) Less Watercourses

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

Chapter IIIC-2 Estimate on Irrigation and Drainage Water Requirements

IIIC-2.1 General

Irrigation and drainage water requirements are needed for making a feasibility level design of irrigation and drainage system. The irrigation water requirement is estimated based on the proposed cropping patterns, focusing on the water saving to use the limited water source effectively and to expand the irrigable area as much as possible.

As for the drainage water requirement, consideration should be given to that the crop to be cultivated in the rainy season is paddy, which would allow the water stagnant at paddy field for certain period if water depth is lower than the height of paddy.

Taking into account the above, the irrigation and drainage water requirements are estimated as described hereinafter.

IIIC-2.2 Irrigation Water Requirement

IIIC-2.2.1 Basic Strategy

The Prek Thnot River has a large fluctuation of its discharge throughout a year. The average monthly discharge in the rainy season ranges from 6 $2m^3/s$ to $102.3m^3/s$, and that 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 end of the rainy season. Taking into consideration this discharge pattern and the cropping patterns of paddy, it could not be said that the Prek Thnot River is a plentiful water source for agriculture in the basin area as far as the water regulating facility is not constructed upstream.

The Project should thus focus on water-saving irrigation method which is proposed in the Master Plan Study. The applied water-saving irrigation method is as follows:

- To supply water to keep soil moisture content in the root depth at not less than 75% of full saturation, without storing water at paddy filed after land preparation and transplanting.
- To store water in the paddy field during a period of 30days starting at head initiation till the end of flowering.

The application of this method would bring about the remarkable water-saving, say 20% to 25% of total net irrigation water requirement.

IIIC-2.2.2 Procedure

The irrigation water requirement is estimated based on the following procedures and conditions:

Step-1

The Crop Evapotranspiration (ETo) is calculated for every month from 1991 to 2005, using the Penman-Montieth method with meteorological data observed at Phnom Penh International Air Port. The result is tabulated below:

ETo Calculated by Penman-Montieth method

Unit:mm/day

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
4.6	5.3	6.0	6.1	5.5	5.2	4.6	4.9	4.3	4.0	4.4	4.4

Step-2

The crop coefficients of paddy and other crops are determined using the “Crop Evapotranspiration, FAO Irrigation and Drainage Paper 56”. Based on the proposed cropping pattern, 5-day consumptive use of water is calculated.

Step-3

Water requirement for land preparation is determined at 120mm based on water layer

replacement in the paddy field.

Step-4

Effective rainfall is calculated for paddy and upland crops as follows:

(1) Paddy

- A daily rainfall less than 5 mm/day is neglected.
- In case of a daily rainfall between 5 mm/day and 80 mm/day, the effective rainfall is 80 % of it.
- In case of more than 80 mm/day, the effective rainfall is 64 mm/day.
- Relationship between monthly effective rainfall and monthly rainfall is clarified by correlation and regression analysis.
- Relationship clarified is as follows:
  Y=0.75X-0.4, where, X: monthly rainfall, Y: monthly effective rainfall
- Monthly dependable effective rainfall is calculated using the above equation.
- 5-day effective rainfall is determined by equally distributing the Monthly dependable effective rainfall.

(2) Upland crops

The monthly effective rainfall for upland crop is determined by applying monthly dependable rainfall to standard made by USDA. 5-day effective rainfall is determined by equally distributing the Monthly dependable effective rainfall.

Step-5

The net irrigation water requirement is calculated by summing up the consumptive use of water, percolation rate, and water requirement for land preparation and by deducting the effective rainfall. The percolation rate is determined at 8 mm/day by field observation.

Step-6

Irrigation efficiencies are assumes as follows:

Assumed Irrigation Efficiencies

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

Step-7

An irrigation water requirement is calculated by multiplying the net irrigation water requirement and irrigation efficiency together.

IIIC-2.2.3 Design Discharge for Canals

Using this procedure, the design discharge for respective canal is estimated as follows:

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

The design discharge for tertiary canal should be determined at land preparation time when more water is required for 20 days for one tertiary block.

The irrigation canal system in the Project Area is designed using these design discharges.

IIIC-2.3 Drainage Water Requirement

IIIC-2.3.1 Conditions

Paddy which is a main crop in the Project Area, is generally tolerant of water stagnant as compared with upland crops. However, paddy at booting stage also 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 stem generally becomes more than 30 cm. In consideration of these figures, 3-day continuous rainfall should be drained within 3 days.

IIIC-2.3.2 Drainage Water Requirement

The observed daily rainfall data at Kampong Speu from 2001 to 2006, shows the following maximum 3-day continuous rainfall:

Annual Maximum 3-Day Consecutive Rainfall Observed at PDA in Kampong Speu

Unit: mm

Year	Rainy Season						
	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
2001					130.2		
2002				112.9			
2003	115.0						
2004						114.5	
2005						136.7	
2006				119.8			

In general, drainage water requirement is determined for 1/5 to 1/10 years return period. As can be seen in the above, however, the observation data is available only for 6 years so that the largest rainfall is used for estimating the drainage water requirement.

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

Chapter IIIC-3 Irrigation and Drainage Improvement Plan

IIIC-3.1 Basic Strategies

The Project aims at demonstration of proper water management and increase of rice production in the model area by good harmonization of agriculture, irrigation and drainage and institutional development. To achieve this aim, the irrigation and drainage improvement plan is elaborated in line with the following basic strategies.

(1) Irrigation Improvement Plan

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

Maximum Use of Existing Facilities

The Main Canal, Secondary Canal 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 and/or improved in the most economical way possible. As for the additional structures including measuring devices, the number should be minimized through the 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 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 important factors to raise the crop yield. In particular, the Project Area is sometimes attacked by flood from the Prek Thnot River. The drainage system is thus essential for the agriculture in the Project Area., to drain not only the excess water by heavy rainfall, but also the flood water from the fields within possible extent. The drainage improvement plan is worked out with the following basic strategies:

Establishment of Independent Drainage System

Some existing canals in the Project Area have double functions of irrigation and drainage. From the proper water management and smooth drain, the drainage system should be designed independently. In this connection, provision of drainage structures should be taken into consideration.

Use of Natural Small Streams and Degraded Area as Drainage

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

IIIC-3.2 Irrigation Canal System

IIIC-3.2.1 Irrigation Method

Water supply under the Project is planned by combining the continuous supply and rotational supply systems, that is, water is supplied continuously down to the tertiary block, and then, a rotational water supply is made within the tertiary blocks since the division boxes/off-takes are provided on the tertiary canal and water application loss is less.

IIIC-3.2.2 Canal Layout

Taking into account the basic strategies mentioned above, the irrigation canal layout for the Project Area is designed. In particular, the water management is made centering the tertiary unit, so that the following are additionally considered in canal layout:

- Command Area by Tertiary Canal

There is a research result that the discharge to 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 farmers, the tertiary canal layout is in principle designed taking this discharge into consideration, but more discharge at land preparation time is not considered.

- Length by Tertiary Canal

In connection with the command area of tertiary canal and in view of the canal loss, the length of tertiary canal is generally less than 1.5 km except exceptional case.

- Command Area by Watercourse

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 corresponding farmers are less than 10 in number, a discussion would be easily settled, especially for water distribution along watercourse. Thus, a watercourse is provided at the rate of one no. per about 6 ha.

- One Tertiary Block Governed by One Tertiary Canal

According to the government policy, one FWUG should be formed for one tertiary block. From the viewpoint of smooth water management for tertiary block by FWUG, one tertiary canal should command one tertiary block only.

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

Canal (old name)	Length (m)	Canal	Length (m)
(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 IIIC-3.1.1. The proposed canal layout is given in Figure IIIC-3.1.2.

IIIC-3.2.3 Design of Irrigation Canals

(1) South Main Canal for 7.8 km from Vat Krouch Intake to Phum Roung Intake with Check

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

- Raising of Water Level for Making Gravity System Possible

The design water level at the Roleang Chrey Regulator is El.35.70 m. To realize the water supply by gravity, improvement plan of the South Main Canal should be elaborated in due consideration of this water level. In connection with raising of water level, additional embankment is required for some portions based on the hydraulic calculation using Manning formula. The result of hydraulic calculation is shown in Drawings, and designed typical cross sections for South Main Canal are shown in Figure IIIC-3.1.3

- Suitable Treatment to Dispersible Soil

The severe erosion is place to place observed at side slope of 7.8 km part of the South Main Canal. This severe erosion is caused mainly by the dispersible soil. To cope with such unexpected phenomenon by the dispersible soil, canal lining is effective. Taking into consideration the canal size, inconstant canal section, location of severe erosion portions, and cost saving, lining of clayey soil and sod-facing are proposed only for severe erosion portions.

(2) Secondary Canal

Four secondary canals of unlined type are proposed. These proposed secondary canals follow the existing ones. As a whole, these existing canals have enough capacity to flow the design discharge. From the viewpoint of cost-saving, the existing canal section is not touched accordingly. The minor improvement/repairing such as heightening of embankment, filling of holes are required.

The command area of secondary canal ranges 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 canal is shown in Figure IIIC-3.1.3

(3) Tertiary Canal

The unlined tertiary canals, of which length is 15.9 km in total, exist in the Project Area. These canals are incorporated into the proposed canal system as much as possible, as tertiary canal and/or watercourse. The following table shows the list of tertiary canals to be rehabilitated or newly constructed:

List of Tertiary Canals to be Rehabilitated/Newly Constructed

Name	Length (km)	Area (ha)	Discharge (l/s)	Countermeasure
(a) SMC-T-①	0.59	27	57	New
(b) SMC-T-②	0.46	34	71	New
(c) SMC-T-③	1.25	26	55	Rehabilitation
(d) SMC-S-1-T-①	0.56	27	57	New
(e) SMC-S-1-T-②(RT-2)	0.97	63	132	Rehabilitation
(f) SMC-S-1-T-③	0.45	24	50	Rehabilitation
(g) SMC-S-1-T-④	0.68	26	55	Rehabilitation
(h) SMC-S-1-T-⑤(RT-5)	0.48	17	36	Rehabilitation
(i) SMC-S-1-T-⑥(Rt-6)	0.95	33	69	Rehabilitation
(j) SMC-S-1-T-⑦	0.90	27	57	Rehabilitation
(k) SMC-S-1-T-⑧	0.85	32	67	New
(l) SMC-S-1-T-⑨	2.05	34	71	Rehabilitation
(m) SMC-S-2-T-①	1.70	17	36	New/rehabili.
(n) SMC-S-2-T-②	1.40	38	80	New
(o) SMC-S-3-T-①	0.65	22	46	New
(p) SMC-S-3-T-②	0.72	23	48	Rehabilitation
(q) SMC-S-3-T-③	1.50	28	59	Rehabilitation
(r) SMC-S-4-T-①	0.70	16	34	New
(s) SMC-S-4-T-②	0.51	23	48	New
(t) SMC-S-4-T-③	0.54	14	29	Rehabilitation
(u) SMC-S-4-T-④	0.43	16	34	Rehabilitation
(v) SMC-S-4-T-⑤		27	57	Rehabilitation
Total	**18.34**	594*	-	-

*Note: *Area of SMC-S-1-T-② includes that of SMC-S-1-T-③, so that 24 ha should be deducted from 594 ha. Thus, total area becomes 570 ha.*

Tertiary canal covers the command area of 14 ha to 38 ha, and their peak discharge ranges from 29 lit/sec to 80 lit/sec. Figure IIIC-3.1.3 shows the typical canal section for tertiary canal

IIIC-3.2.4 Design of Related Structures

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

Based on the results of inventory survey and hydraulic calculation using design discharge of 16.3 m^3/sec (=10,200 ha x 1.60 lit/sec/ha) at head, treatment of existing structures related to 7.8 km of South Main Canal from the Vat Krouch Intake to Phum Roung Intake with Check was examined. However, a box culver crossing with the National Road No.4 was studied using 17.4 m^3/sec considering the future development plan (=10,530 ha x 1.60 lit/sec/ha) and difficulty of improvement. The need of additional check structure was also studied to maintain the water level in proper position to enable gravity irrigation. The study results are as follows:

Proposed Canal Structures on South Main Canal (Vat Krouch Intake to 7.8 km)

Station	Structure	Countermeasures
No.2+94.206	Turnout (T-1)	New construction
No.2+94.206	Foot path bridge	New construction after demolishing existing one
No.2+790	Turnout (T-2)	New construction after demolishing existing one
No.2+929.702	Spillway	Minor modification
No.3+025	Intake to SMC-S-1	Change of gate
No.3+181.965	Box culvert	Provision of new culvert (double boxes)
No.3+293.112	Spillway	No rehabilitation
No.3+820.517	Concrete bridge	New construction after demolishing existing one
No.3+920	Drainage inlet	Minor rehabilitation
No.4+533.055	Concrete bridge	New construction after demolishing existing one
No.5+67.473	Existing check structure	Removal

Station	Structure	Countermeasures
No.5+545	Turnout (T-2)	New construction
No.5+584.205	Concrete bridge	New construction after demolishing existing one
No.5+778.572	Foot path bridge	New construction after demolishing existing one
No.6+142.765	Check with foot path	New construction after demolishing existing one
No.6+200	Drainage inlet	New construction after demolishing existing one
No.6+380	Drainage inlet	New construction
No.6+394.402	Intake to SMC-S-2	No rehabilitation
No.6+594.481	Foot path bridge	New construction after demolishing existing one
No.6+735.698	Concrete bridge	New construction after demolishing existing one
No.7+761.737	Concrete bridge	New construction after demolishing existing one
No.7+761.737	Intake to SMC-S-3	New construction
No.8+511.081	Intake to SMC-S-4	New construction after demolishing existing one
No.8+700	Spillway	Minor rehabilitation
No.9+359.681	Turnout to left side	Change of gate
No.9+359.681	Turnout to right side	No rehabilitation

The designed typical structures such as turnout, check, bridge and drainage inlet are shown in Drawings.

(2) Secondary Canal

The existing structures such as turnout and culvert 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 minor repairs, these are introduced into the proposed canal system.

The newly required structures are turnout, check and culvert. The required number of them including the existing ones is as follows:

Proposed Structures Related to Secondary Canals

Canal	Turnout	Check	Culvert
(a) SMC-S-1 (RS-3)			
No rehabilitation	4	-	-
Rehabilitation	-	-	1
New	3	3	-
(b) SMC-S-2			
No rehabilitation	-	-	-
Rehabilitation	-	-	-
New	1	1	-
(c) SMC-S-3			
No rehabilitation	-	-	-
Rehabilitation	-	-	-
New	2	1	-
(d) SMC-S-4			
No rehabilitation	-	-	-
Rehabilitation	-	-	-
New	3	1	-
Total			
No rehabilitation	4	-	-
Rehabilitation	-	-	1
New	9	6	-

*Note: *Rehabilitation*

As a measuring device, a staff gauge is installed in secondary canal and tertiary canal, respectively, because available head is limited.

(3) Tertiary Canal

There exist four pipe culverts on the existing tertiary canals. These pipe culverts are involved in the proposed canal system. No division boxes are provided at all, so that these should be constructed. Furthermore, pipe culverts are additionally required to cross the roads/paths. The required number of division boxes and pipe culverts are as follows:

Required Number of Division Boxes and Pipe Culverts

Name	Length (km)	Area (ha)	Division Box			Pipe Culvert
			Left	Right	Both	
(a) SMC-T-①	0.59	27	4	-	1	-
(b) SMC-T-②	0.46	34	-	4	1	-
(c) SMC-T-③	1.25	26	-	1	2	2
(d) SMC-S-1-T-①	0.56	27	2	-	1	-
(e) SMC-S-1-T-②(RT-2)	0.97	63	-	-	5	-
(f) SMC-S-1-T-③	0.45	24	1	-	1	-
(g) SMC-S-1-T-④	0.68	26	-	-	3	-
(h) SMC-S-1-T-⑤	0.48	17	-	--	3	-
(i) SMC-S-1-T-⑥	0.95	33	-	-	5	1
(j) SMC-S-1-T-⑦	0.90	27	2	-	1	1
(k) SMC-S-1-T-⑧	0.85	32	5	-	1	2
(l) SMC-S-1-T-⑨	2.05	34	-	1	4	2
(m) SMC-S-2-T-①	1.70	17	6	-	1	2
(n) SMC-S-2-T-②	1.40	38	-	3	1	2
(o) SMC-S-3-T-①	0.65	22	4	-	1	-
(p) SMC-S-3-T-②	0.72	23	-	-	4	-
(q) SMC-S-3-T-③	1.50	28	-	4	1	1
(r) SMC-S-4-T-①	0.70	16	2	-	1	1
(s) SMC-S-4-T-②	0.51	23	2	-	1	-
(t) SMC-S-4-T-③	0.54	14	3	-	1	-
(u) SMC-S-4-T-④	0.43	16	-	1	2	-
(v) SMC-S-4-T-⑤		27	-	-	3	-
Total	**18.34**	594*	31	14	44	14

*Note: *.Area of SMC-S-1-T-② includes that of SMC-S-1-T-③, so that 24 ha should be deducted from 594 ha. Thus, total command area becomes 570 ha.*

Typical drawings for division box and pipe culvert are given in Drawings.

IIIC-3.3 Drainage Canal System

IIIC-3.3.1 Drainage Method

Topography covering the Project Area allows that excess water can be eliminated by gravity from the paddy fields to the rivers/streams flowing nearby, so that this gravity system is applied.

IIIC-3.3.2 Canal Layout

The proposed drainage system consists of tertiary drain, secondary drain and main drain. The natural streams and the depreciated areas are used as drain as much as possible from the cost-saving and minimization of collapsed land by construction of drains. Some existing canals have double functions of irrigation and drainage. This system does not enable the proper water management of irrigation, and thus drainage system should be independently established apart from the irrigation system.

With these viewpoints, the proposed drainage layout is planed as shown in Figure IIIC-3.3.1

IIIC-3.3.3 Design of Drainage Canals

The drainage canal is only excavated canal. The required canal section is determined using the design discharge and Manning Formula. Figure IIIC-3.3.2 shows the typical canal section of tertiary drain, secondary drain and main drain. The design discharge, length and dimension of each drain are given in the following table:

Design Discharge, Length and Dimension of Each Drain

Drain	Discharge (lit/sec)	Length (km)	Bottom Width (m)	Height (m)	Side Slope
TD-1	330	1.3	0.8	0.8	1:1
-*	145	-	-	-	-
TD-2	400	1.1	0.8	0.8	1:1
-*	45	-	-	-	-
TD-3	360	1.5	0.8	0.8	1:1
TD-4	60	0.6	0.5	0.5	1:1
TD-5	65	0.6	0.5	0.5	1:1
TD-6	415	1.2	0.8	0.8	1:1
TD-7	140	1.7	0.6	0.6	1:1
TD-8	335	1.6	0.8	0.8	1:1
TD-9	140	1.3	0.6	0.6	
-*	155	-	-	-	-
-*	225	-	-	-	-
TD-10	170	0.8	0.6	0.6	1:1
-*	80	-	-	-	-
-*	50	-	-	-	-
TD-11	210	1.1	0.7	0.7	1:1
TD-12	225	0.5	0.7	0.7	1:1
-*	125	-	-	-	-
-*	85	-	-	-	-
TD-13	175	0.6	0.6	0.6	1:1
TD-14	115	1.2	0.6	0.6	1:1
SD-1	125	0.6	0.6	0.6	1:1
SD-2	715 – 1,435	7.1	1.0 – 1.2	1.0 – 1.2	1:1
SD-3	290	0.3	0.7	0.7	1:1
MD-1	1,725	0.3	1.3	1.3	1:1

Note:: Excess water at paddy field flows into Secondary drain/stream directly*

IIIC-3.3.4 Design of Related Structures

As the related structures to drains, a cross drain and a junction structure are proposed. The cross drain of pipe type is recommendable for easy construction. The junction structure is constructed using gabion mattress considering the higher flexibility to retrogressive erosion which would happen frequently at junction point. The required number of cross drain and junction structure is mentioned below:

Required Number of Cross Drain and Junction Structure

Drain	Cross Drain	Junction Structure	Drain	Cross Drain	Junction Structure
TD-1	-	1 no.	TD-10	3 nos.	1 no.
TD-2	1 no.	1 no.	TD-11	-	1 no.
TD-3	3 nos.	1 no.	TD-12	2 nos.	1 no.
TD-4	1 no.	1 no.	TD-13	-	1 no.
TD-5	-	1 no.	TD-14	2 nos.	1 no.
TD-6	4 nos.	1 no.	SD-1	1 no.	1 no.
TD-7	-	1 no.	SD-2	4 nos.	1 no.
TD-8	6 nos.	1 no.	SD-3	-	1 no.
TD-9	4 nos.	1 no.	MD-1	1 no.	1 no.

Drain	Cross Drain	Junction Structure	Drain	Cross Drain	Junction Structure
Total				32 nos.	18 nos.

Typical drawing for these structures are shown in Drawings.

IIIC-3.4 O&M

IIIC-3.4.1 Responsible Organization

The "Policy for Sustainability of Operation and Maintenance of Irrigation System, June 2000", promotes the transfer of irrigation system to FWUC as much as possible, to mitigate financial burden for O&M. However, the current capability of FWUCs, say Ou Veaeng and Phoum Roung FWUCs, are not sufficient for fulfilling the proper O&M. Furthermore, These FWUCs are not organized based on the canal layout. In this Project, the following responsibility share is proposed taking into consideration this policy, current capability of the FWUCs, size of respective canals and importance of facility for the project management:

Proposed Responsibilities Share on O&M

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

** : Establishment of Project office is discussed in Clause IIIC-4.2*

Although the O&M for secondary canal and subordinate canal system is made by FWUCs, it is necessary that the Kampong Speu PDOWRAM should timely provide them with proper advices on O&M activities.

IIIC-3.4.2 O&M Plan

Based on the proposed responsible organization mentioned above, the O&M activities to be executed by each organization is explained hereinafter.

(1) Operation Activities

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

According to the irrigation service plan, water supply to the South Main Canal shall be continuously made throughout a year except 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 the annual maintenance works by closing the gates of Vat Krouch Intake. These activities will be made by the Kampong Speu PDOWRAM.

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

Water level in the South Main Canal shall not be suddenly down except emergency case like danger to human life. This rule shall be observed to prevent the slipping of inside slopes of canal bank. And also, when water supply starts after completion of maintenance period, intake discharge shall be gradually increased up to the water demand.

Secondary Canals

The required discharge for the respective Secondary Canals shall be given in the water distribution schedule. Except maintenance period of February and March, all Secondary

Canals as well as the South Main Canal, shall be given a continuous water supply throughout a year. In February and March, the intake gates to the Secondary Canals shall be totally closed and all the canal systems shall be dried up for the purpose of annual maintenance.

Water level in the Secondary Canals shall be checked up to the design water level. If the check gate could not maintain the upstream water level by proper gate opening for releasing discharge for the downstream area, the turnouts and check gates located in the upstream side shall be checked whether these are in proper position or not.

In case the water level nearly reaches to the top of canal embankment by increase of canal water, a spillway located in the upstream reach shall be opened until the canal water level becomes down to the design water level. In this operation, careful attention shall be paid upon the gate operation of spillway so that the released discharge through spillway could not be over its drainage capacity.

In case of making empty of canal for maintenance, water level shall be gradually down in order to avoid the sliding of inside slope of canal, especially paying care upon where the groundwater table is higher than the canal bed.

Tertiary Canals

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

(2) Maintenance Activities

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

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

All these works are checked and listed up through daily patrol. The items to be inspected in the daily patrol are as follows:

Inspection Items in Daily Patrol

Facilities	Inspection Items
(a) Canal	Erosion of slope, settlement of bank, piping in canal bank, sediment removal and grasses cutting in canal
(b) Structures	Sediment removal in structure, cracking of structure
(c) Gates	Greasing of spindle and hoist, leakage through gate, staff gauge
(d) Inspection road	Road surface

Regular Maintenance

The regular maintenance refers to the day-to-day maintenance of project facilities to be carried out by regular workers of maintenance labour groups without needing special skills. It includes routine repair of embankment, clearance of silt, weeding, filling of holes on inspection roads with earth, oiling gates, etc. Satisfactory implementation requires an intensive daily inspection of project facilities as well.

Maintenance groups consisting of 3 to 4 labors each are to be assigned to the daily maintenance work for 3 km to 5 km of canal per day. A weekly schedule and reasonable length of canal shall be assigned to each group.

Periodic Maintenance

The periodic maintenance is defined as the repair of minor damage which does not cause immediate danger or malfunction to the canal system and which needs special skills to repair the damage. The periodic maintenance will be carried out by skilled workers and/or mechanics. Minor improvements to the existing facilities of the system are also included in the periodic maintenance.

Emergency Repair

Damage to the project facilities hamper the normal practices of irrigation. Therefore, repair of damaged facilities should be quickly and effectively carried out under the category of the emergency repair. The damage to the project facilities may result from flood, heavy rainfall, violation acts, and destruction by animals and vehicles.

Annual Maintenance

Maintenance works which involve a large work quantity or require special skills should be carried out under the category of annual maintenance. The annual maintenance is conducted in fallow season, that is February and March. In order to make annual maintenance smoothly, the annual maintenance program shall be prepared in advance.

IIIC-3.5 Water Management

IIIC-3.5.1 Responsible Organization

The responsible organization for water management is the same with that for O&M work.

IIIC-3.5.2 Water Management

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

The gates of Vat Krouch Intake are opened in line with irrigation service plan, to release water to the South Main Canal. Thus, the South Main Canal flows 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 shall be made using the staff gauges installed upstream and downstream and gate opening. In order to simplify the gate control, a H-Q curve shall be developed.

Secondary Canals

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

Tertiary Canals

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

- It can meet a peak water requirement, especially in the land preparation period for paddy when more water supply is required in a short time period.
- Equitable water distribution can be made for all farm plots.
- Rotational irrigation can maximize effective rainfall
- Application loss is less than continuous water supply.

The Tertiary Canals are provided with division box or off-take, for water distribution to watercourses. The division box or off-take is equipped with small-hand gate and staff gauge, which are used for discharge control.

Tertiary block is divided into several irrigation units, so-called watercourse blocks. The

watercourse block is defined as the area commanded by a watercourse, of which area is about 6 ha on an average in the Project Area. Rotational irrigation is made by a combination of watercourse blocks. The irrigation period of a watercourse block is decided based on the acreage of the commanding area of the watercourse.

Chapter IIIC-4 Implementation Plan

IIIC-4.1 Implementation Schedule of Project Facilities

The implementation of irrigation and drainage facilities is divided into three stages; design stage, tendering stage and construction stage.

Design Stage

Based on the design concept established in feasibility study, the detailed design will be carried out for the project facilities. The detailed design shall include the topographic survey, preparation of drawings, detailed cost estimate, detailed construction schedule, and the preparation of the tender documents. The design works would require about eight months.

Tendering Stage

The tendering stage shall include the pre-qualification, tendering, evaluation and award and contract signing. Generally, it would take four months.

Construction Stage

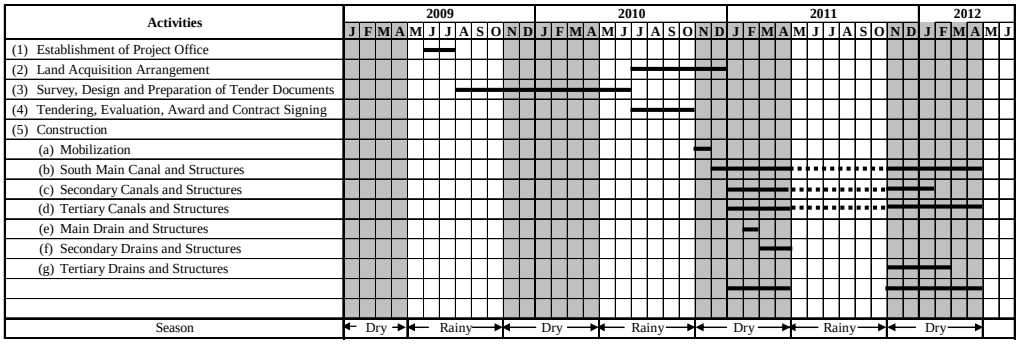
The project facilities are divided into 4 systems; the South Main Canal system, secondary and tertiary irrigation canals system, watercourses system and drainage canal system. The implementation schedule of these facilities shall be elaborated considering the following points:

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

Prior to commencement of construction of these facilities, the contractor will make mobilization in one month of November, 2008. Immediately after the mobilization, construction of the South Main Canal will be started in December 2009. In succession, the construction of secondary canal, tertiary canal, main drain, secondary drain and tertiary drain will follow. These canals, drains and related structures will be constructed in two dry seasons from December 2009 to April 2010 and November 2010 to April 2011. Concurrently, it is expected that construction of watercourses will be started by farmers under technical support of the Project Office.

The implementation schedule for irrigation and drainage works is shown below:

Implementation Schedule of Irrigation and Drainage Woks



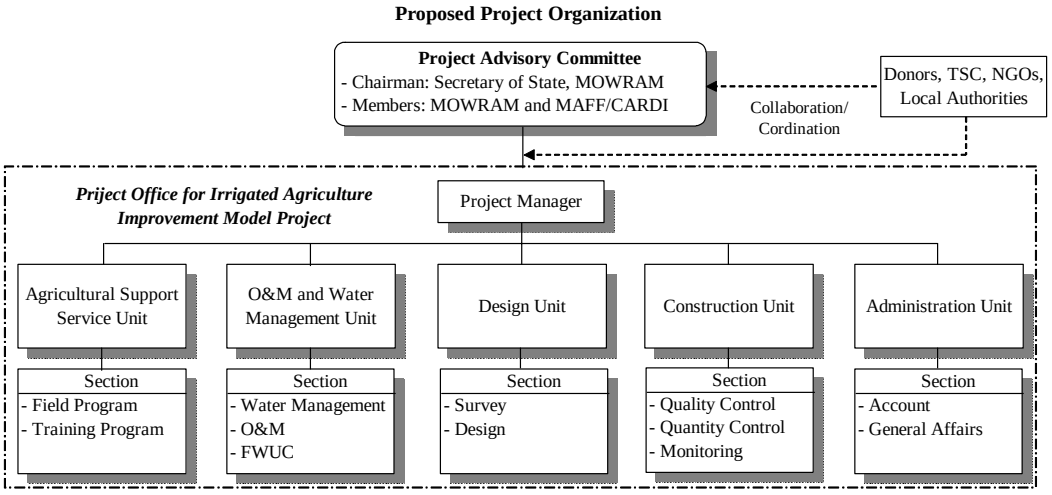
IIIC-4.2 Executing Agency for Project Implementation

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

IIIC-4.3 Organization and Staff Required

(1) Organization

Below shown is a proposed organization focusing on close coordination between MOWRAM and MAFF.



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 Project Office and providing the timely and proper advices for it as required. The Project Advisory Committee will be chaired by 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 in the committee.

The relevant donors, NGOs, local authorities and TSC are expected to make collaboration/coordination with not only the Project Advisory Committee, but also 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 Agricultural Support Service Unit, O&M and Water Management Unit, Design Unit, Construction Unit and Administration Unit. These Units should cooperatively fulfill their duties each other, to realize synergistic effect. In particular, careful attention should be paid upon 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, 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	Required No/Nos.
Agricultural Support Service		Unit Chief (Agronomist)	1
	Field Program	Extension Expert	1
	Training Program	Training 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

Chapter IIIC-5 Cost Estimate

IIIC-5.1 Condition of Cost Estimate

The basic conditions and assumptions employed for 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 market.
- Construction is undertaken on the contract basis.
- The Investment Cost consists of i) engineering service cost, ii) direct construction cost, iii) administration cost, iv) land acquisition arrangement cost, v) land acquisition cost, and vi) physical and price contingencies.
- Administration cost during construction time 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 foreign currency portion and 7.0% per annum for local currency portion.
- Conversion rate is assumed at US$ 1.0 = Riel 4,060 (as of January 2007)

IIIC-5.2 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 detail is shown in Table IIIC-5.1.1.

Summary of Investment Cost

(unit:'000)

Item	US$	Riel (equivalent)
(1) Engineering service cost	436	1,770,160
(2) Direct 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 PAD 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

IIIC-5.3 Replacement Cost

The replacement cost for the gate and appurtenances is estimated at US$187,000 equivalent to Riel 759,220,000, of which details are shown in Table IIIC-5.1.2. These replacement cost will occur at 25th year after installation.

IIIC-5.4 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 IIIC-5.1.3. In addition, the environmental

monitoring cost after completion of construction works will occur for 20 years, and its annual cost was estimated at US$ 648 equivalent to Riel 2,630,880.

Tables

Table IIIC-5.1.1 Construction 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
(4) Agricultural support service cost	46	186,760
(5) Formation and stregthening FWUC	60	243,600
(6) Farmer organization development	27	109,620
(7) Kampong Spue PDOWRAM Strengthening	6	24,360
(8) Coordination between Kampong Spue PDA and	1	4,060
(9) Land acquisition arrangement	6	24,360
(10) Land acquisition cost	120	487,200
Sub-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 IIIC-5.1.2 Replacement Cost

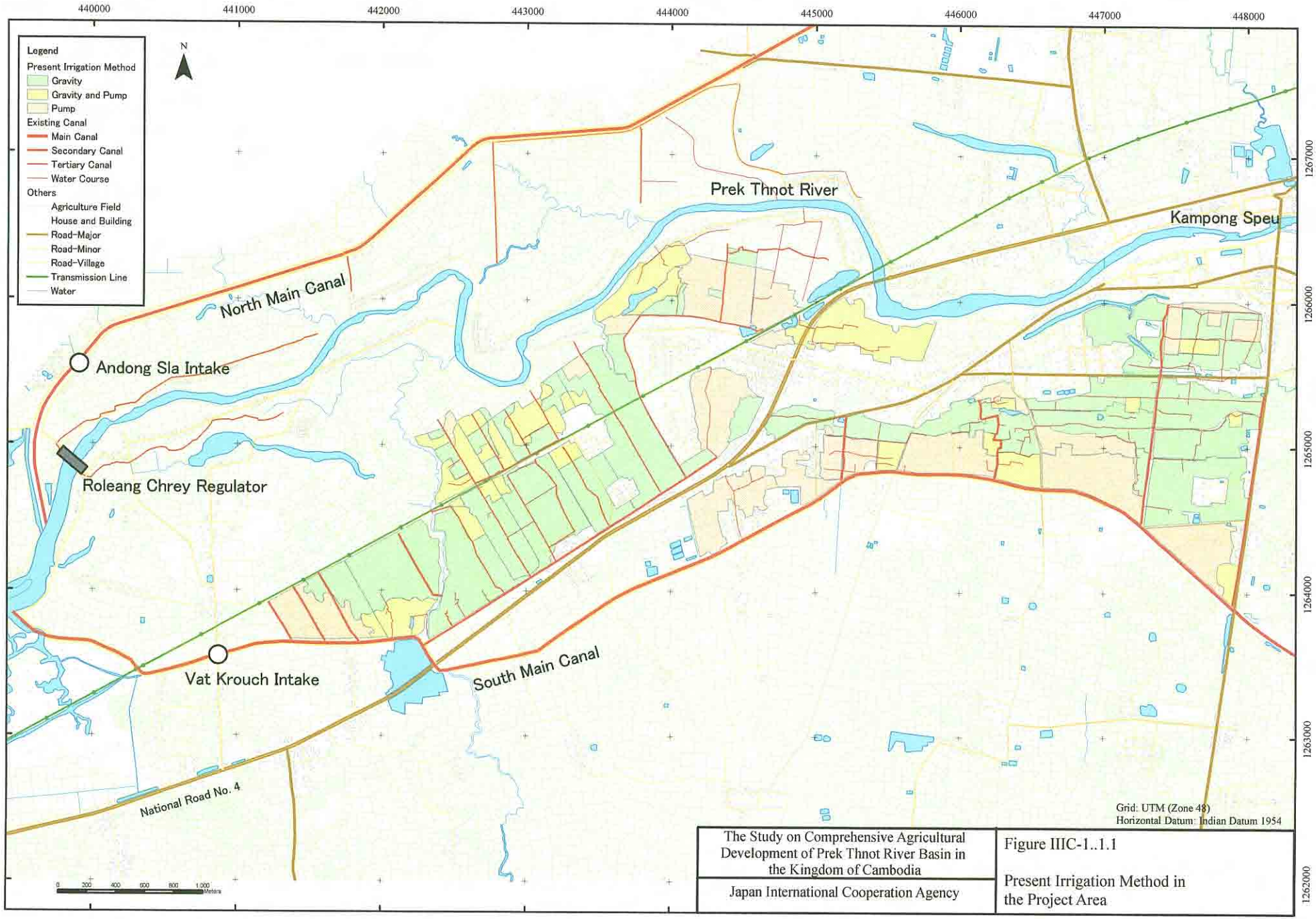
(Unit : '000)

Item		Dimension B x H	numbers	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	1,518,440

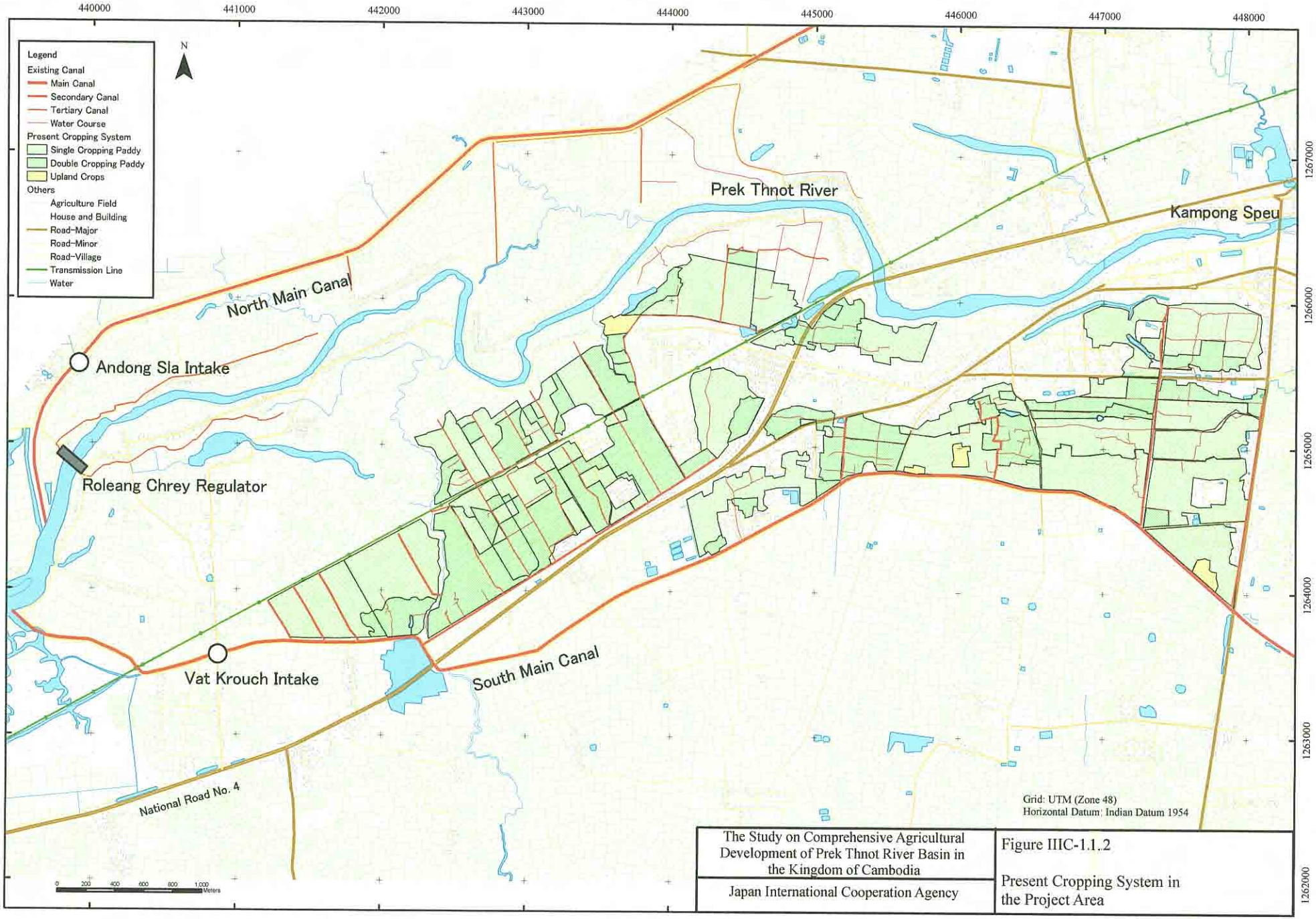
Table IIIC-5.1.3 O&M Cost

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

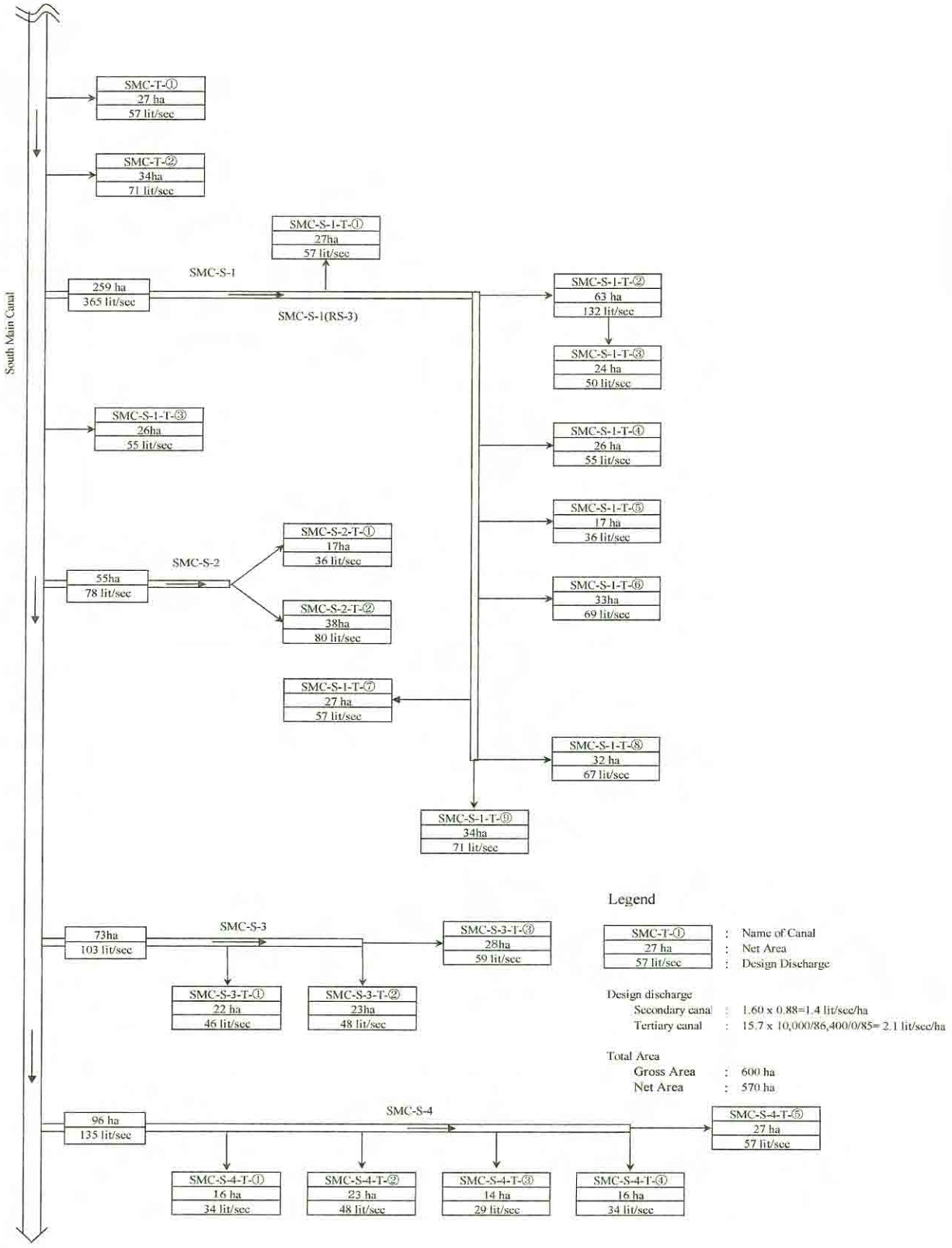
Figures



The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia	Figure IIIC-1..1.1
Japan International Cooperation Agency	Present Irrigation Method in the Project Area



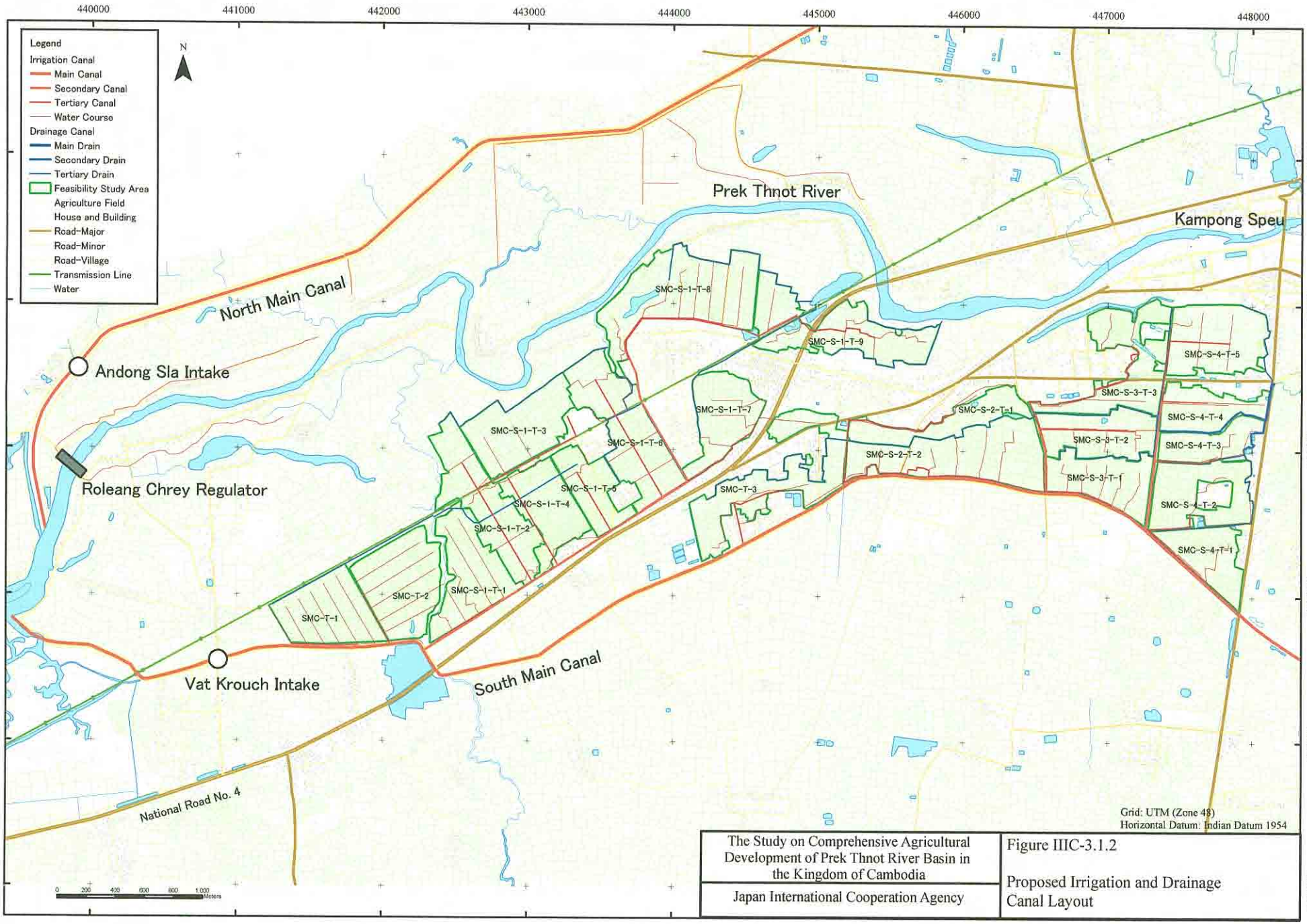
The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia	Figure IIIC-1.1.2
Japan International Cooperation Agency	Present Cropping System in the Project Area



The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

Japan International Cooperation Agency

Figure IIIC-3.1.1
Irrigation Diagram for Project Area

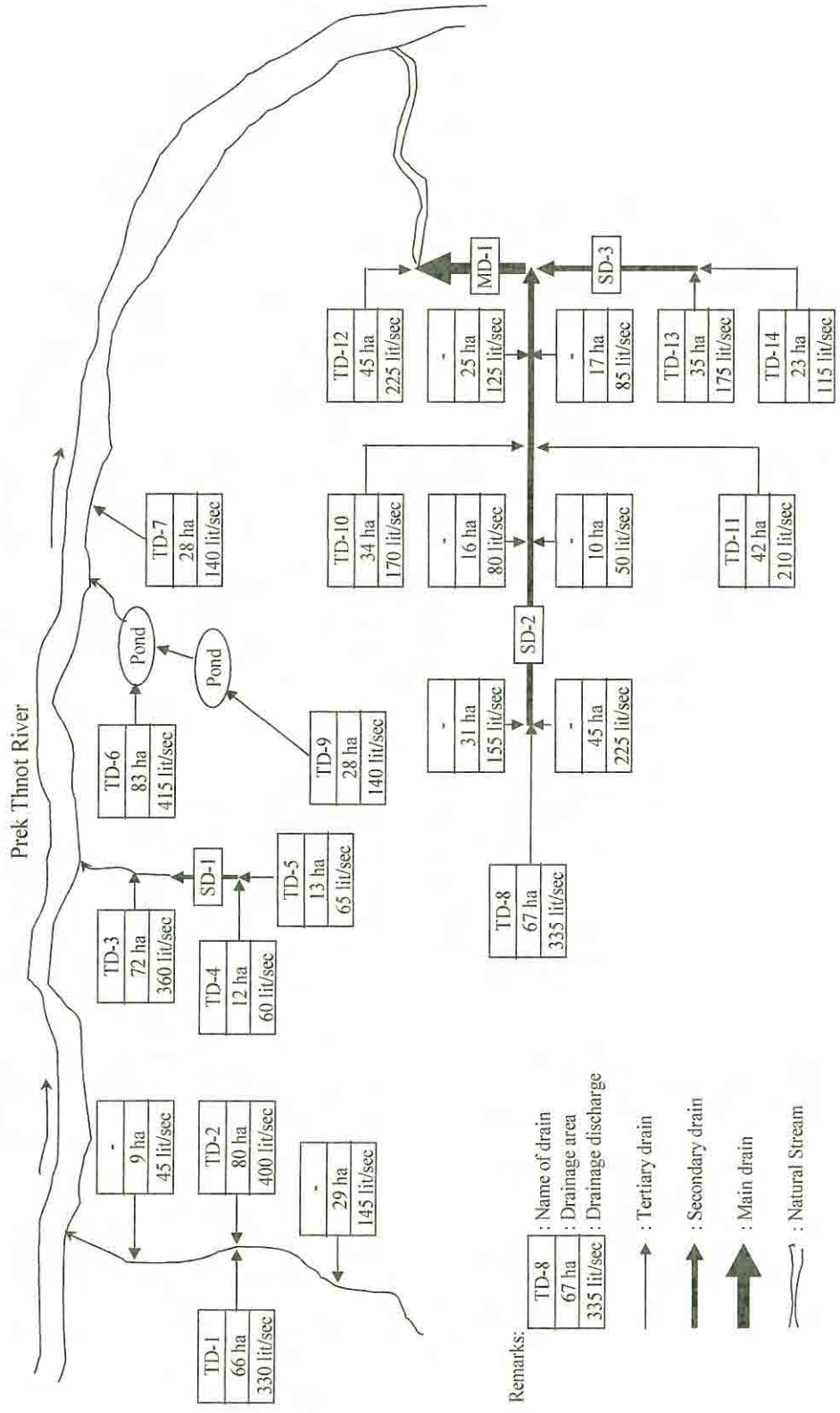


The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia	Figure IIIC-3.1.2
Japan International Cooperation Agency	Proposed Irrigation and Drainage Canal Layout

The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, The Kingdom of Cambodia

Japan International Cooperation Agency

Figure IIIC-3.1.3
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 IIIC-3.3.1
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

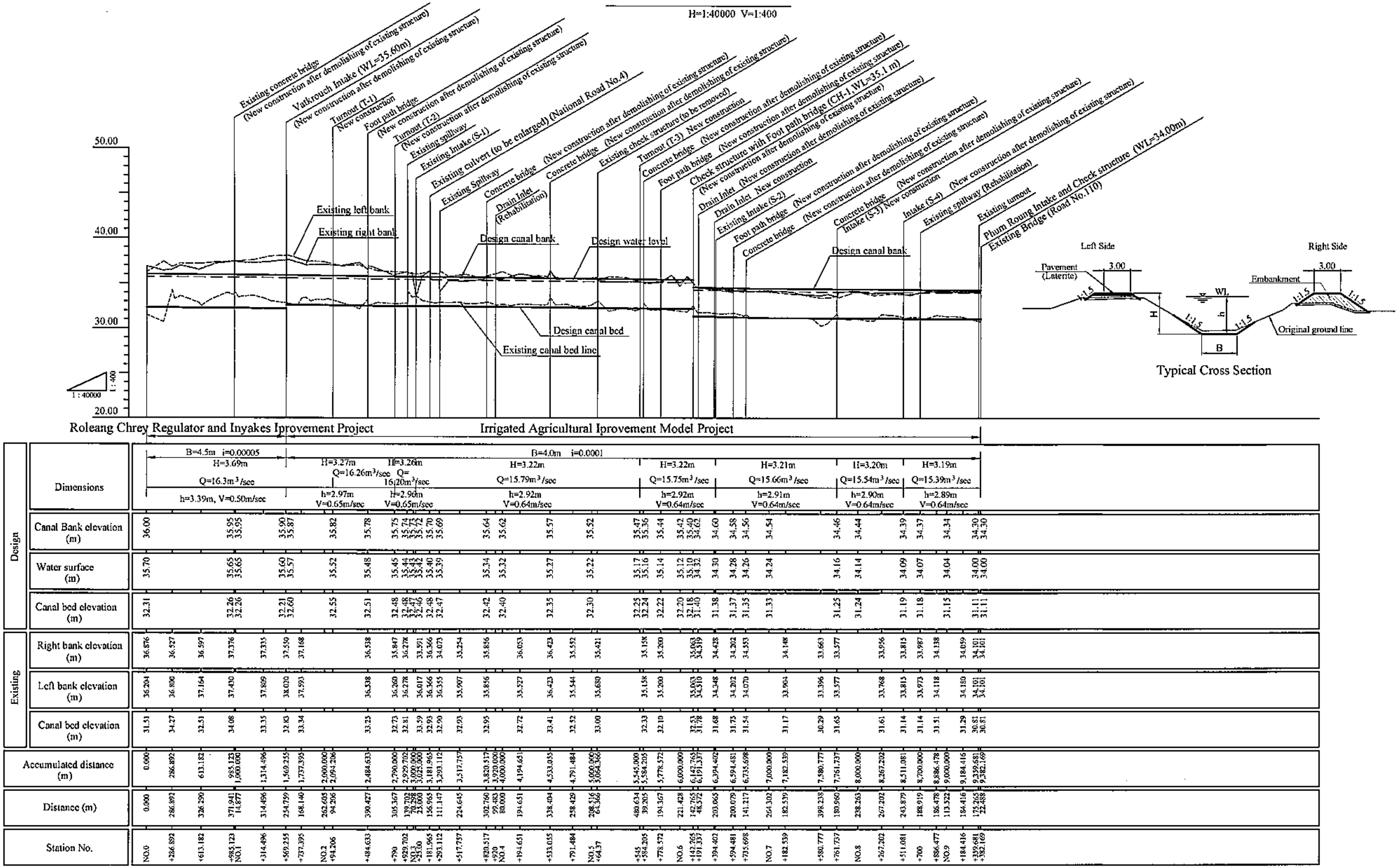
Figure IIIC-3.3.2
Typical Canal Section of Drainage Canals

Drawings

List of Drawings

PROFILE

H=1:40000 V=1:400



Dimensions
Q=Design dischrge (m ³/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

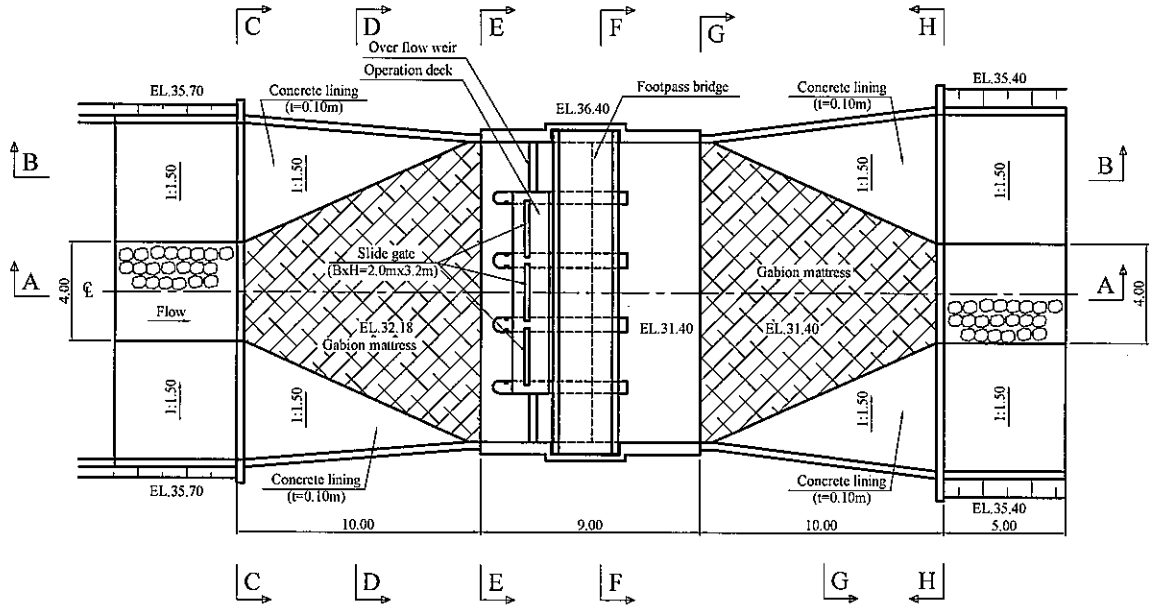
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (JICA)

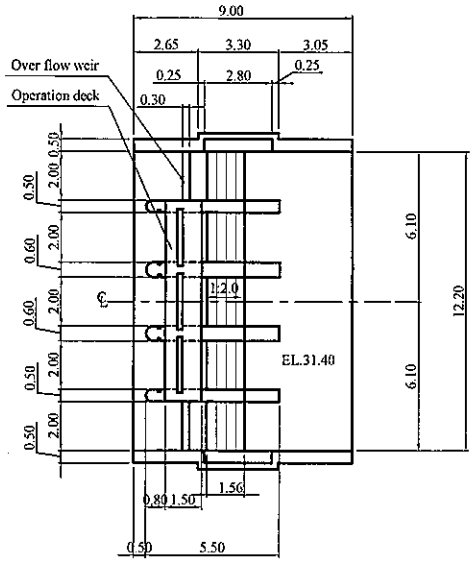
Drawing IIIC-1

Profile of South Main Canal

CHECK STRUCTURE



PLAN



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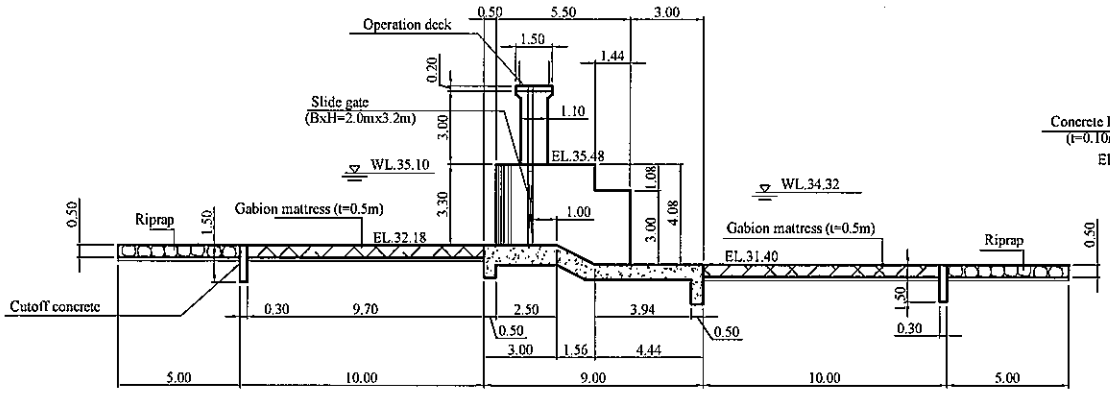
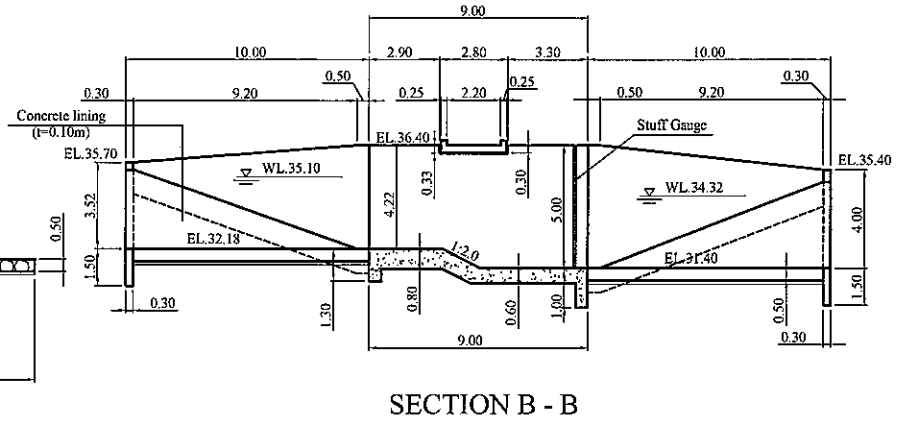


SECTION A - A

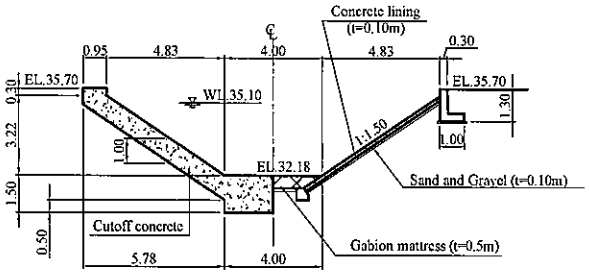


SECTION B - B

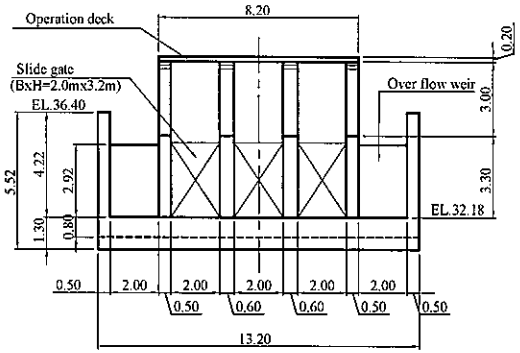
Scale 0 5 10

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing IIIC-2
Japan International Cooperation Agency (JICA)	Check structure for South Main canal (1/2)

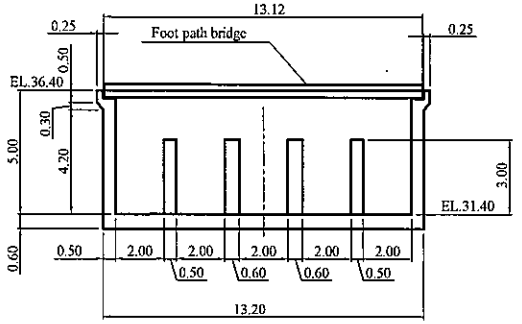
CHECK STRUCTURE



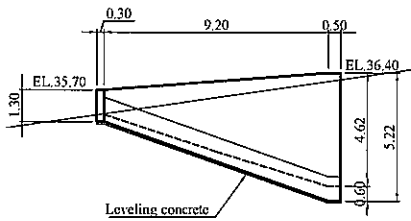
SECTION C - C



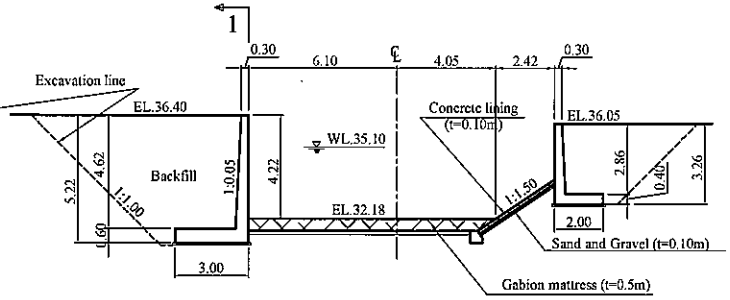
SECTION E - E



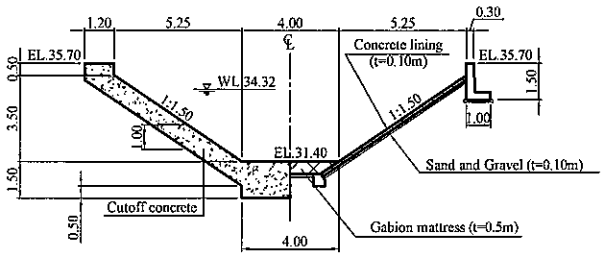
SECTION F - F



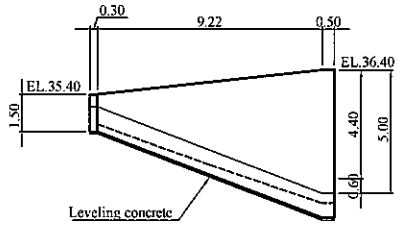
SECTION 1 - 1



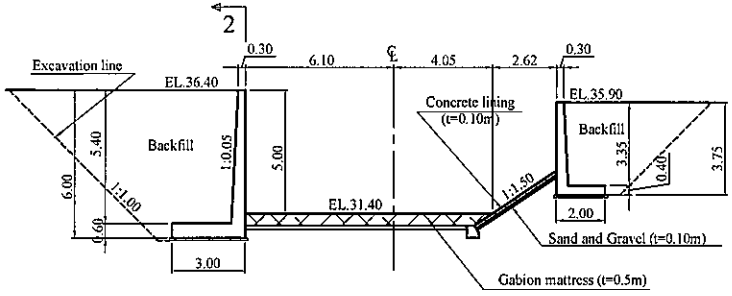
SECTION D - D



SECTION H - H



SECTION 2 - 2



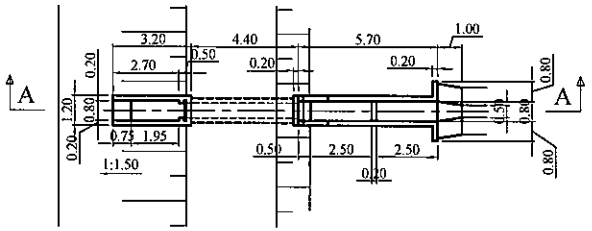
SECTION G - G

Scale 0 5 10

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing IIIC-3
Japan International Cooperation Agency (JICA)	Check structure for South Main canal (2/2)

VII - IIICD - 4

INTAKE
(to Secondary Canal)



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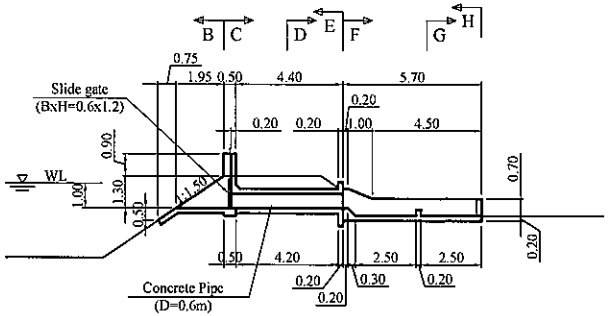
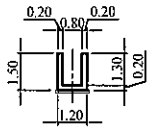
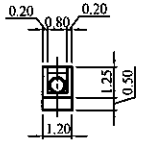


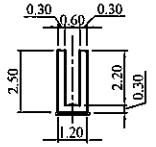
SECTION A - A



SECTION B - B



SECTION E - E



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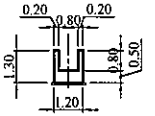
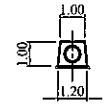
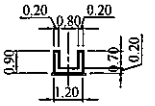


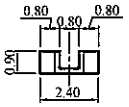
SECTION F - F



SECTION D - D

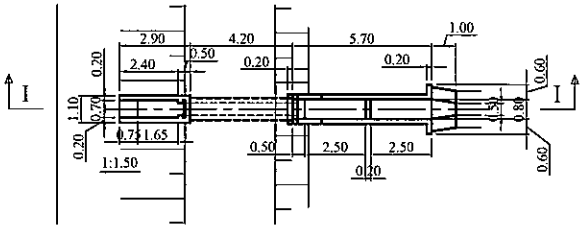


SECTION G - G



SECTION H - H

TURNOUT
(to Tertiary Canal)



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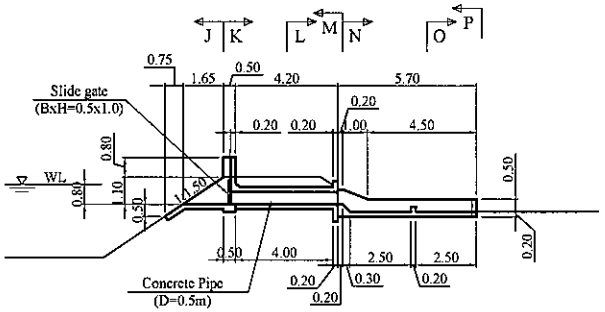
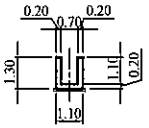
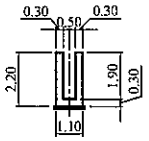


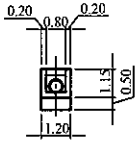
SECTION I - I



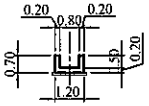
SECTION J - J



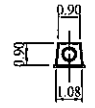
SECTION K - K



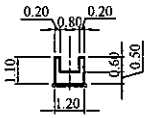
SECTION M - M



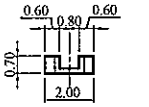
SECTION O - O



SECTION L - L



SECTION N - N



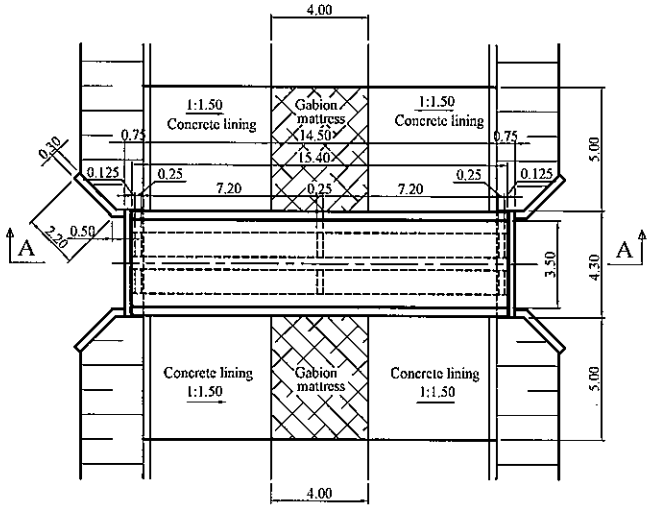
SECTION P - P

Scale: 0 5 10

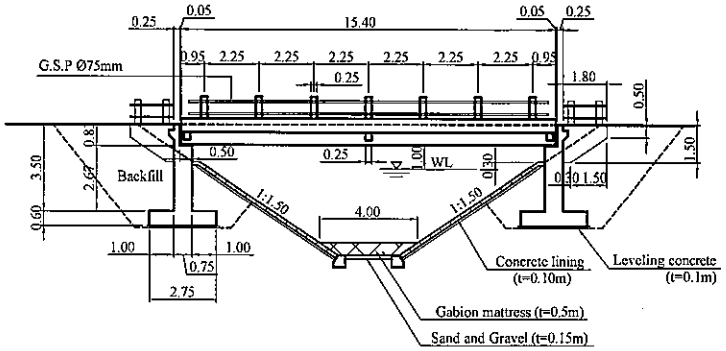
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing IIIC-4
Japan International Cooperation Agency (JICA)	Intake and Turnout for South Main canal

CONCRETE BRIDGE

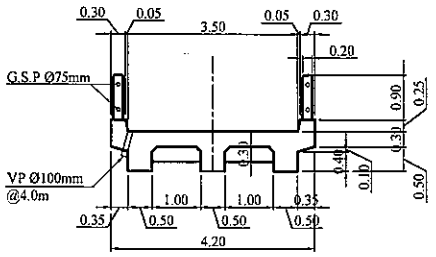
Scale 1:200



PLAN Scale A



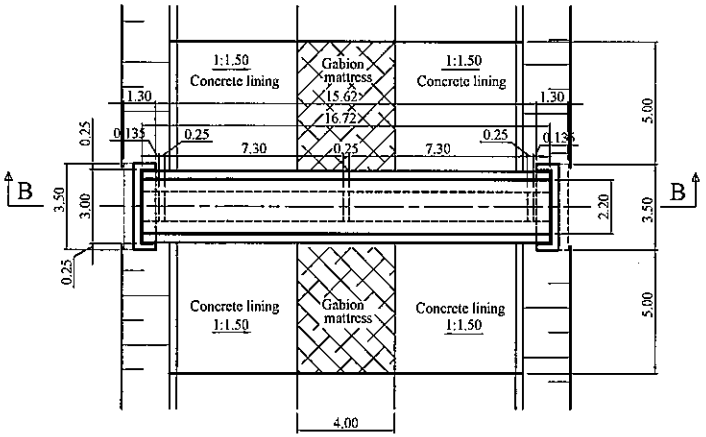
SECTION A - A Scale A



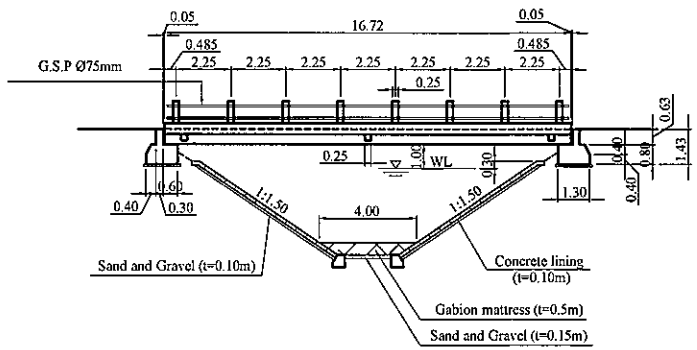
BRIDGE Scale B

FOOT PATH

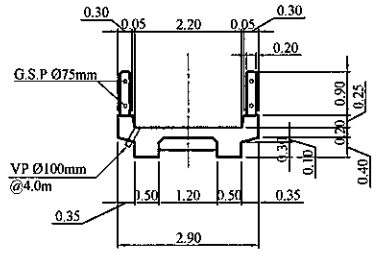
Scale 1:200



PLAN Scale A



SECTION B - B Scale A



FOOT PATH Scale B

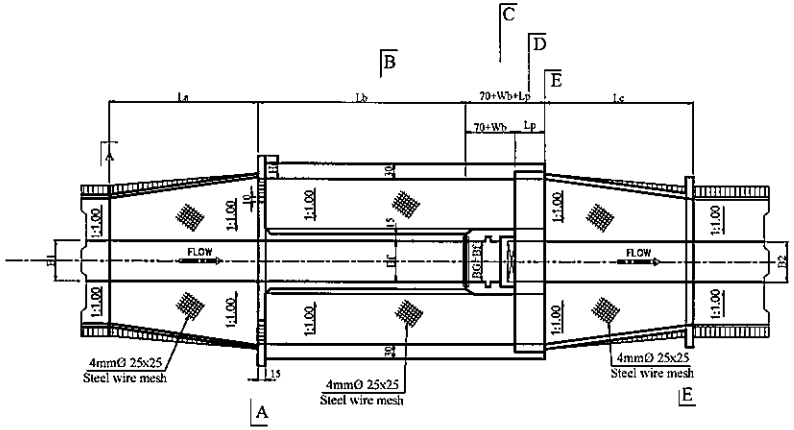
0 5 10
Scale A

0 5
Scale B

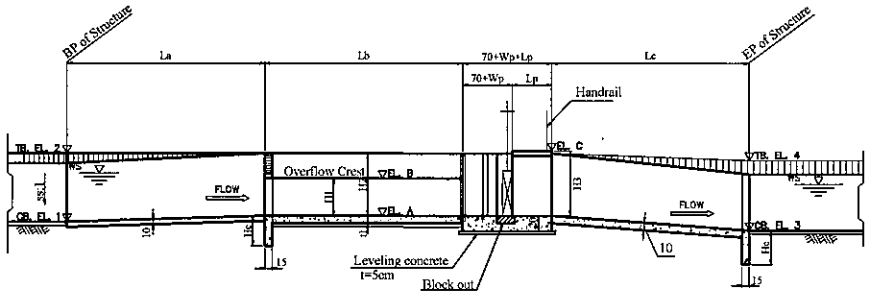
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing IIIC-5
Japan International Cooperation Agency (JICA)	Bridge and Foot Path for South Main canal

VII - IIICD - 5

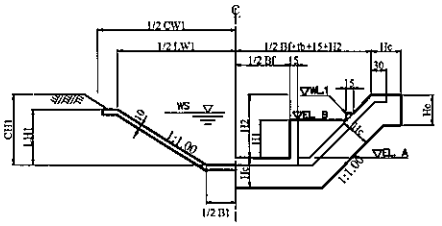
CHECK of SECONDARY CANAL



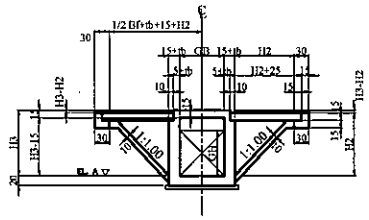
PLAN



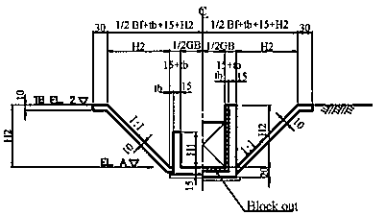
PROFILE



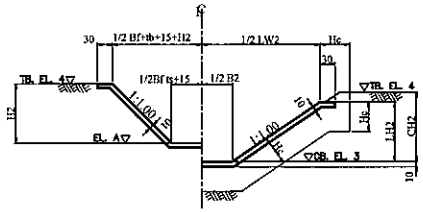
SECTION A–A



SECTION D–D



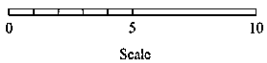
SECTION B–B SECTION C–C



SECTION E–E

DIMENSION TABLE FOR CHECK GATE

Discharge (m^3/sec)	La (cm)	Lb (cm)	Lc (cm)	Bf (cm)	H1 (cm)	H2 (cm)	H3 (cm)	Hc (cm)	t1 (cm)	La		
										Height (cm)	Width (cm)	Nos.
< 0.20	200	60	200	50	38	75	75	60	15	50	50	1
> 0.20	200	100	200	60	48	89	89	60	15	60	60	1



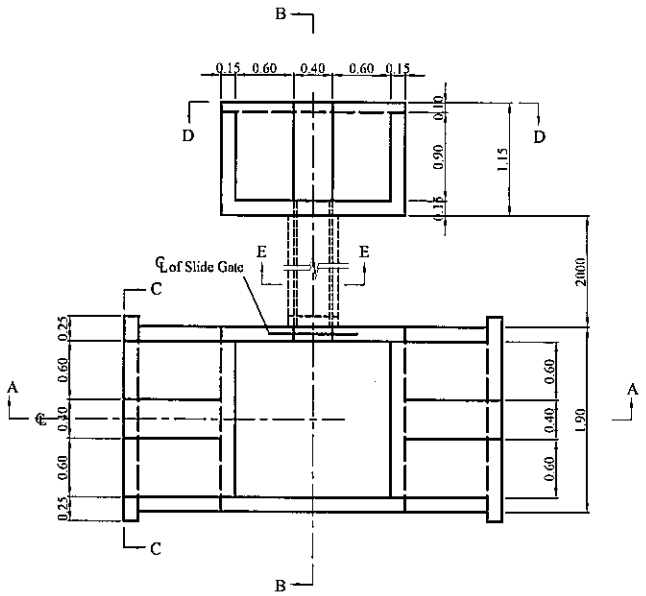
THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (JICA)

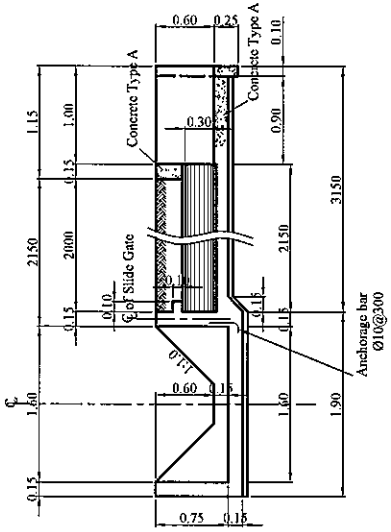
Drawing IIIC-6

Check Structure for Secondary Canal

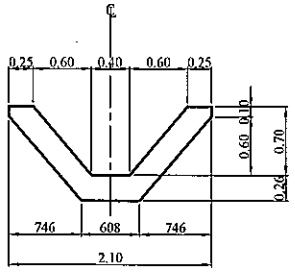
DIVISION BOX



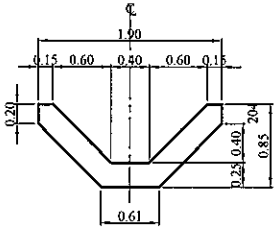
PLAN



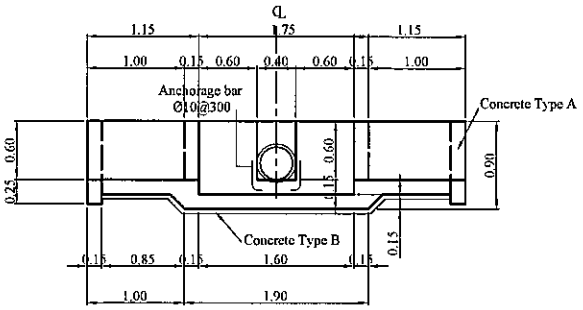
SECTION B-B



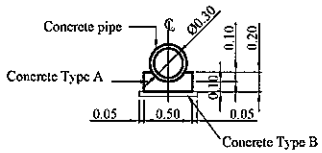
SECTION C-C



SECTION D-D



SECTION A-A



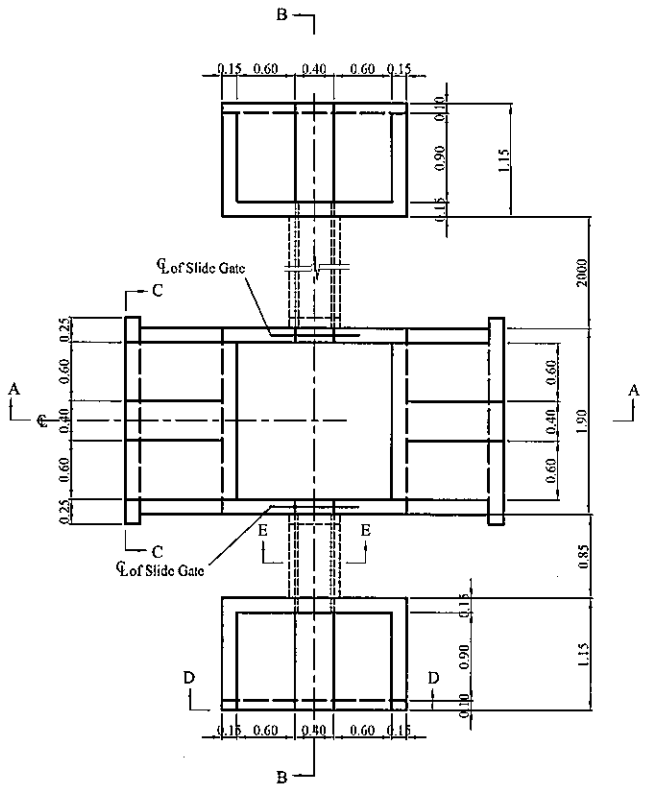
SECTION E-E

Scale A

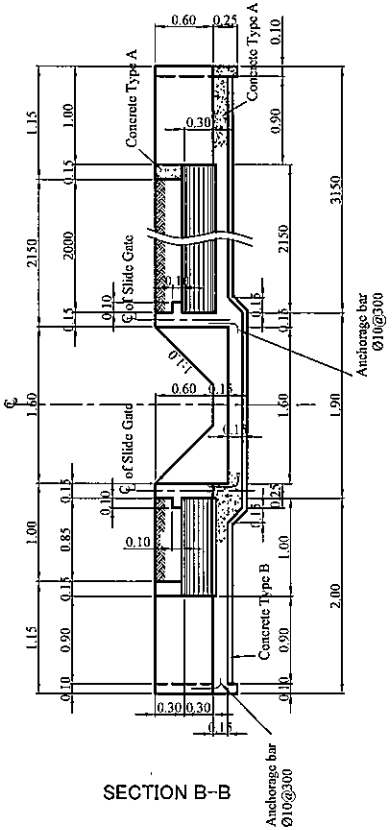
0 1 2 2.5

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing IIIC-7
Japan International Cooperation Agency (JICA)	Division Box for Tertiary Canal (1/2)

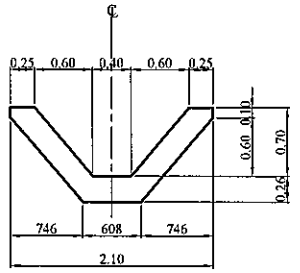
DIVISION BOX



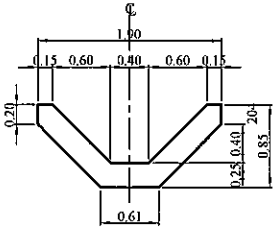
PLAN



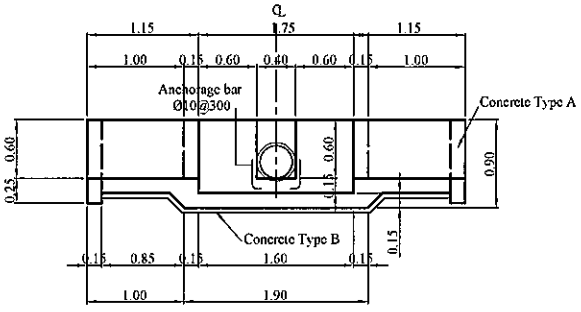
SECTION B-B



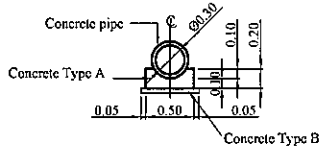
SECTION C-C



SECTION D-D



SECTION A-A



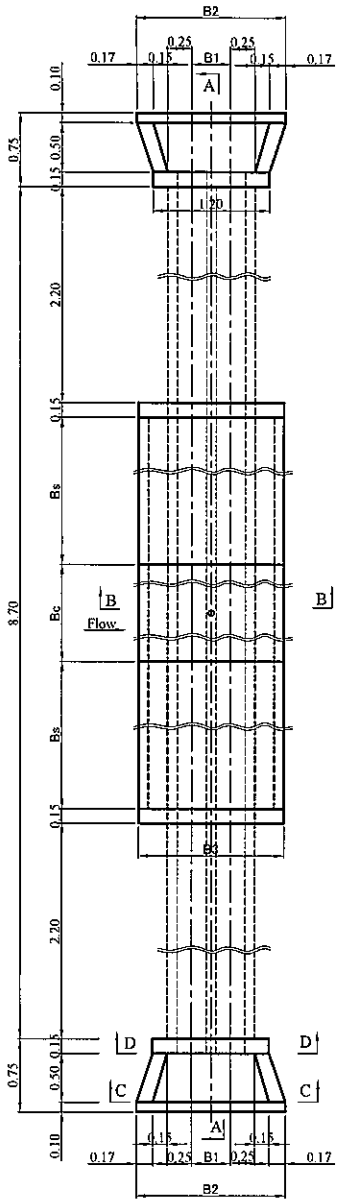
SECTION E-E

0 1 2 2.5

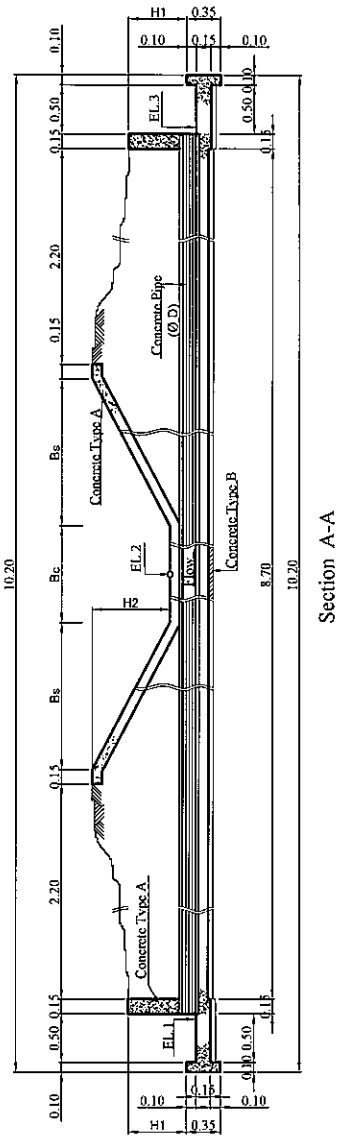
Scale A

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing IIIC-8
Japan International Cooperation Agency (JICA)	Division Box for Tertiary Canal (2/2)

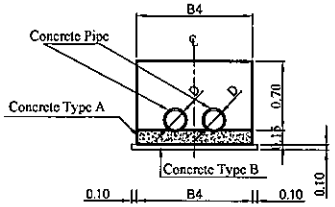
CROSS DRAIN



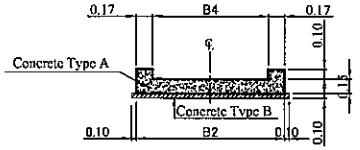
PLAN



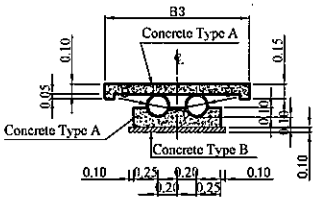
Section A-A



Section D-D



Section C-C



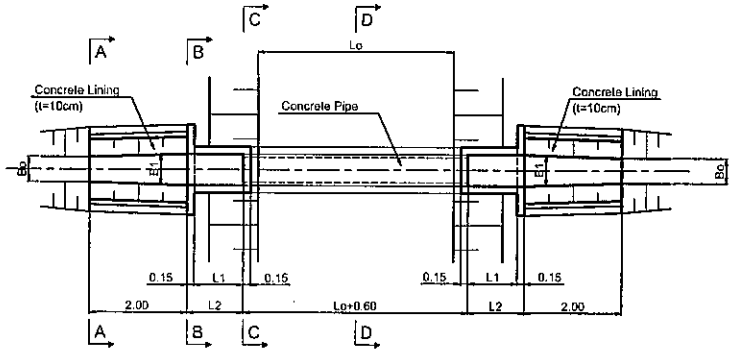
Section B-B

0 1 2 2.5

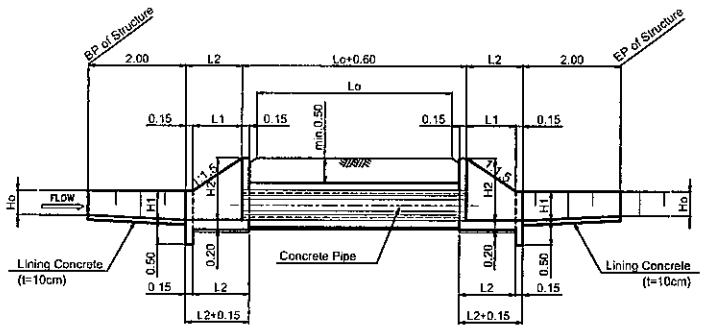
Scale

THE STUDY ON COMPREHENSIVE AGRICULTURAL DEVELOPMENT OF PREK THNOT RIVER BASIN IN THE KINGDOM OF CAMBODIA	Drawing IIIC-9
Japan International Cooperation Agency (JICA)	Cross Drain for Drainage Canal

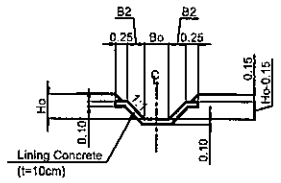
PIPE CULVERT for TERTIARY CANAL



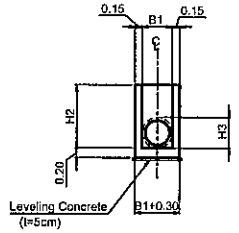
PLAN



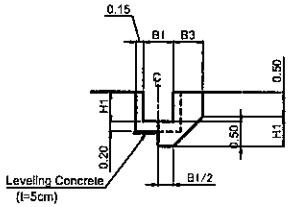
PROFILE



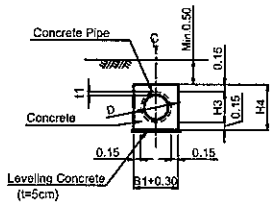
SECTION A-A



SECTION C-C



SECTION B-B



SECTION D-D

DIMENSION TABLE FOR PIPE CULVERT

Dicharge m^3/sec	D (m)	L1 (m)	L2 (m)	Bo (m)	B1 (m)	B2 (m)	Ho (m)	H1 (m)	H2 (m)	H3 (m)	H4 (m)
Q<0.05	0.5	(H2-H1)x1.50	L1+0.15	0.50	D+2 x t1	Ho-0.15	0.40	0.50	>0.65+D+2 x t1	D+2 x t1	H3+0.30
0.05<Q<0.10	0.6	(H2-H1)x1.50	L1+0.15	0.50	D+2 x t1	Ho-0.15	0.55	0.65	>0.65+D+2 x t1	D+2 x t1	H3+0.30
0.10<Q	0.7	(H2-H1)x1.50	L1+0.15	0.50	D+2 x t1	Ho-0.15	0.65	0.75	>0.65+D+2 x t1	D+2 x t1	H3+0.30

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 IIIC-10

Pipe Culvert for Tertiary Canal