MINISTRY OF WATER RESOURCES
AND METEOROLOGY,
THE KINGDOM OF CAMBODIA

PREPARATORY SURVEY
FOR
IRRIGATION AND DRAINAGE SYSTEM
REHABILITATION AND IMPROVEMENT PROJECT
IN
THE KINGDOM OF CAMBODIA

FINAL REPORT

VOLUME - III

ANNEXES (2/3)

SEPTEMBER 2012

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIPPON KOEI CO., LTD.

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IRRIGATION AND DRAINAGE

CHAPTER AD-1 GENERAL INFORMATION

AD-1.1 Overview of Irrigation in Cambodia

AD-1.1.1 Agriculture and Land Use

The agriculture sector in Cambodia is a major component of its economy contributing to 27% of GDP, say US$7,061 million in 2008. About 80% of population of the country dwells in the rural area, where about 90% of poverty people lives. Agricultural development plays an important role for the poverty reduction as well as the economic development. The main crop in the country is paddy. The paddy field was estimated to be approximately 2,610,000 ha in 2008. Out of this, irrigation water was supplied only for about 582,000 ha (22%) in the rainy season and about 245,000 ha (9%) in the dry season. Rainfed cultivation is dominant in the country, which results in low and unstable agricultural production.

AD-1.1.2 Geography and Climate

The Mekong River flowing in the eastern half of the country and a tributary of the Mekong, the Tonle Sap River locating in the western half of the country have formed a huge low-lying alluvial plain suitable for paddy production. On the center of the Tonle Sap River, Tonle Sap Lake, the largest freshwater Lake in the Southeast Asia, is located having the enormous surface area of 16,000 km^2 (9 m deep at the maximum) in the rainy season and only 2,700 km^2 at the end of the dry season. Tonle Sap Lake functions as a water source for Mekong Delta area in Viet Nam in the dry season. Mountainous area is limited to the country border and nearby the Gulf of Thailand called Kravanh Mountains having the highest peak at Mt. Aoral (1,771 m). Phnom Penh, the capital of Cambodia, is located at the confluence of the Tonle Sap and the Mekong Rivers.

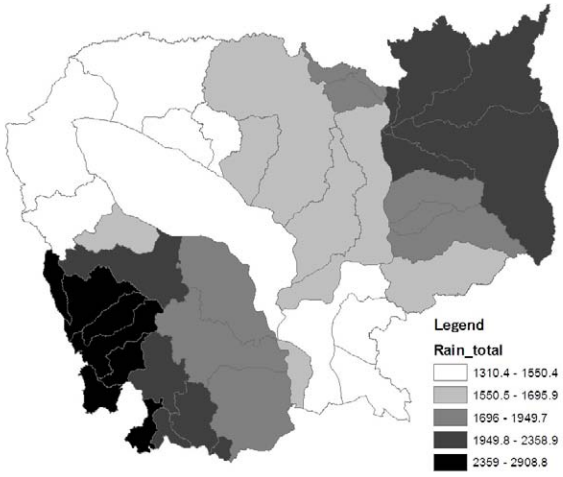


Figure AD-1.1.2.1 Average Annual Rainfall between 2003 and 2006

Source: Review on Nationwide Irrigation Development in Cambodia, JICA, 2010

The climate of Cambodia is characterized by two tropical monsoons; the southwest monsoon (rainy season) from May to October and the northeast monsoon from November to April (dry season). Annual rainfall in the low-lying plain between the Tonle Sap River and the Mekong River is about 1,400 mm, while the Kravanh Mountains receive rainfall about 3,800 mm per year. Annual average air temperature is 27°C.

AD-1.1.3 Recent Development History of Water Resources and Irrigation

Following establishment of the Mekong Committee in 1957, many project locations for large-scale dams were identified in 1960s. A cascade of large hydropower dams, mainly in combination with irrigation schemes (up to 200,000 ha) was planned in the mainstream and major tributaries. Most of these projects hardly reached the feasibility phase. In Cambodia, only the Prek Thnot Project (about 70,000 ha) had been initiated before the war broke out in 1970.

Most part of irrigation systems in Cambodia was constructed during the Khmer Rouge regime from 1975 to 1979 by the policy to evacuate urban population into countryside to work as farmers. In other word, almost the entire population was forced to grow rice during the rainy season and to construct water management and irrigation systems during the remaining five to eight months of the year. It is said that irrigation development for about 720,000 ha with canal systems of 14,000 km in total length was almost constructed by manpower at that period. However, irrigation canals were not laid - out according to contour lines, but on the coordinates which were drawn on most 1:50 000 scale topographical maps. As a result, canals from this period are situated in North - South or in East - West directions having a distance between them of one km. Due to the inclination of the terrain, sections of these canals often slope in different direction than other sections. Because of such background, quality of canal systems in planning, design and construction is technically poor and not function well accordingly. Only some part of those irrigation systems has been used after rehabilitation.

To improve agricultural productivity through irrigation system improvement and development, especially for rice, RGC has continued to receive technical and financial assistance from foreign donors such as ADB, JICA and KOICA by means of grant and/or soft loan.

AD-1.1.4 Major Constraints on Crop Production

A major constraint on crop production is substantially seasonal and year by year differences in water availability, which severely limits the ability of rural households to consistently provide for their own food needs, much less grow crops for sale. This is due to problems in water management in Cambodia, including the abundance of water in the rainy season and its shortage in the dry season. In the rainy season, the main tasks of water management include additional water for supplementary irrigation, controlling, regulating, and managing floods to protect human lives, property and crops. In the dry season, available water resources should be shared, for instance, among domestic use, irrigation, navigation, fisheries, livestock and forestry.

Farmers and local authorities often do not have the knowledge to improve and repair systems that are technically unsound. Many structures failed shortly after rehabilitation, e.g. the system did not service well as expected, and caused inundation problems accordingly. As a result, farmers are still confronted with water management problems, and their energy and resources are unnecessary wasted.

AD-1.1.5 Updated Inventory Survey by MOWRAM

In 2003, the design team for NWISP reported that there were more than 3,000 irrigation schemes in the country and of these only some 10% were fully operational and up to 70% of the agricultural area was not readily irrigable. In 2004, MOWRAM compiled updated irrigation inventory based on the previous studies as tabulated in Table AD-1.1.5.1, which was the first nationwide irrigation inventory data of Cambodia. The data shows that there are 2,403 irrigation systems extending 1.05 million ha (total cultivation area in rainy and dry season). Of the total of 2,403 systems, 1,415 systems (59%) are

reported small scale, 955 systems (40%) are categorize into medium, while 33 systems (1%) are large scale irrigation systems. Among 24 provinces, three provinces of Svay Rieng, Takeo and Siem Reap irrigate more than 100,000 ha in total, while provinces of Pailin, Kep and Mundulkiri irrigate less than 5,000 ha.

Table AD-1.1.5.1 Irrigation Inventory in Cambodia Prepared by MOWRAM (2004)

(Unit: ha)

No	Province/Town	Total Irrigation System	Total Irrigation Area	Small Scale		Medium Scale		Large Scale	
				No	Total*	No	Total*	No	Total*
1.	Phnom Penh	10	6,328	4	950	6	5,378	0	0
2.	Kandal	252	68,927	172	23,577	78	45,350	2	0
3.	Kompong Cham	340	85,277	235	23,918	104	53,359	1	8,000
4.	Prey Veng	241	71,221	148	16,449	92	48,772	1	6,000
5.	Svay Rieng	43	102,256	16	2,838	24	17,615	3	81,803
6.	Takeo	114	121,295	22	3,565	86	79,946	6	37,784
7.	Kompong Chhnang	134	48,940	58	7,909	76	41,031	0	0
8.	Pursat	64	25,435	16	1,060	45	22,375	3	2,000
9.	Battambong	60	59,292	26	1,947	29	29,295	5	28,050
10.	Pailin	1	520	0	0	1	520	0	0
11.	Banteay Meanchey	125	35,576	95	9,213	27	18,283	3	8,080
12.	Oddor Meanchey	29	48,364	7	936	19	15,018	3	32,410
13.	Siem Reap	224	122,203	110	14,814	111	81,189	3	26,200
14.	Kompong Thom	204	77,162	122	14,998	82	62,164	0	0
15.	Sihanuk Ville	20	15,530	13	1,870	6	1,660	1	12,000
16.	Kep	9	3,786	5	538	4	3,248	0	0
17.	Kompot	75	69,707	21	2,862	53	41,845	1	25,000
18.	Koh Kong	13	5,307	5	1,193	8	4,114	0	0
19.	Preah Vihear	94	30,366	65	8,796	29	21,570	0	0
20.	Steung Treng	25	5,693	18	3,073	7	2,620	0	0
21.	Rattanakiri	32	6,997	26	4,396	6	2,601	0	0
22.	Mondulkiri	18	3,001	14	1,765	4	1,236	0	0
23.	Kratie	169	9,235	155	4,686	14	4,549	0	0
24.	Kompong Speu	107	23,845	62	8,879	44	14,966	1	0
Total:		**2,403**	**1,046,263**	**1,415**	**160,232**	**955**	**618,704**	**33**	**267,327**

*Note: *: Total extent of rainy and dry seasons*

Scale	Area
Small	Less than 200 ha
Medium	200 to 5,000 ha
Large	More than 5,000 ha

Source: MOWRAM (2000), Policy for Sustainability of Operation and Maintenance Irrigation Systems, p2

Source: MOWRAM

According to MOWRAM Strategic Plan (2009), in the period of 2004-2008 MOWRAM increased the irrigation area from 560,149 ha in 2003 to 827,000 ha in 2008 (representing 31.6% of the total cultivated area under paddy). This comprises 582,000 ha of the rainy season irrigation and 245,000 ha of the dry season irrigation.

Table AD-1.1.5.2 Irrigation Inventories

(Unit: ha)

Source	Nos. of System	Rainy Season	Dry Season	Total
Irrigation Inventory (2004) of MOWRAM	2,403	629,028	417,235	1,046,263
National Strategic Development Plan Updated 2009-2013	n.a.	582,000	245,000	827,000
Proportion of Irrigation area out of total paddy area of 2,610,000 ha		(22%)	(9%)	

Source: JICA Survey Team

It is noted that in 2006 (but based on 1994 data), the World Bank reported that some 473,000 ha (20% of total rice growing area) was under irrigation but of that only 53% (250,000 ha) actually receives sufficient water for irrigation. Most irrigation developed serves as "supplementary irrigation for the

rainy season", and only a much reduced area can be used for dry season rice growing of which a significant portion is actually recession rice (1% of the total cultivation area of fully irrigated area).

AD-1.2 National and Sectoral Policies Related to Irrigation Development

AD-1.2.1 National and Sectoral Policies

There are six national and spectral policies related to the Project. These are (i) Rectangular Strategy-Phase II, (ii) National Strategic Development Plan update 2009-2013, (iii) Strategy for Agriculture and Water Program 2010-2013, (iv) Agriculture Strategic Development Plan 2009-2013, (v) Action Plan on Water Resources and Meteorology Management and Development 2009-2013, and (vi) Action Plan for Implementing Government Policy on Promotion of Paddy Production and Rice Export. Of these six policies, Rectangular Strategy-Phase II is the most fundamental policy for RGC. Other policies are therefore formulated by referring to it. Rectangular Strategy –Phase II accords top priority to the "Enhancement of the Agriculture Sector" as Rectangle 1, and takes up the "Improving agricultural productivity and diversification" as the crucial strategy in Rectangle 1. In the Strategy for Agriculture and Water (SAW) Program 2010-2013, the following quantifiable indicators are shown:

- Agriculture output will be increased by 20% over 4 years from 2010-2013
- Beneficiary income will be increased by 20% over 4 years from 2010-2013
- The area of cropping land with access to irrigate service will be increased by 100,000 ha over 4 years from 2010-2013

AD-1.2.2 Strategy for Agriculture and Water 2010-2013

Technical Working Group on Agriculture and Water has already completed "Program Design Document for Strategy for Agriculture and Water (SAW) 2010-2013" with six pillars of the strategy as 3 enabling pillars and 3 core implementing pillars. Pillar A is the roof setting the overarching policies and enabling environment for SAW. Pillar B and C are the supporting beams providing the capacity building to MAFF and MOWRAM for them to implement SAW activities. Pillar D, E and F are the well serving as the main implementation vehicle for SAW including water resources development and management. Their output and proposed budget are tabulated as follows:

Table AD-1.2.2.1 Six Pillars of SAW 2010-2013 and Proposed Budget

Pillar	Output	Proposed Budget	
		US$ Million	%
(a) Policy & Regulation	A sound policy and legal framework to enable development of the Agriculture and Water sectors	6.210	1.24
(b) Institutional Capacity Building and Human Resource Development	A sound institutional, administrative, research and education basis for effective work performance in agricultural and water resource development and management	16.145	3.22
(c) Research and Education	A comprehensive and coordinated capacity to assemble and utilize agricultural and water-related knowledge, information and technology transfer	57.245	11.42
(d) Food Security	Agricultural systems and community arrangements that enable poor and food insecure Cambodians to have substantially improved physical and economic access to sufficient, safe and nutritious food at all times to meet their dietary needs and food preferences for an active and healthy life	44.665	8.91
(e) Water Resource Management and Agricultural Land Management	Sustainable and pro-poor management of water resources, water management facilities, water-related hazards, and land resources that is integrated, efficient, and carried out in a river basin context: major output is construction of 100,000 ha of wet-land and dry-land irrigation areas and securing suitable water management	283.790	56.61

Pillar	Output	Proposed Budget	
		US$ Million	%
(f) Agricultural Business and Marketing	Agriculture and agri-business that make effective use of inputs and market opportunities, are steadily intensifying and diversifying production, and deliver full benefits to farmers, rural communities, and other stakeholders	81.760	16.31
Sub-total		498.815	97.71
Program Management Support		11.480	2.29
Grand Total		501.295	100.00

Source; Technical Working Group on Agriculture and Water, Program Design Document for Strategy for Agriculture and Water 2010-2013, , by Task Management Support Group for with Financial Support from the AFD and TWGAW, April 2010

AD-1.2.3 Action Plan on Water Resources and Meteorology Management and Development (2009-2013)

The Action Plan on Water Resources and Meteorology Management and Development (2009-2013) was prepared by MOWRAM as a part of the National Strategy Development Plan (2006-2010) of RGC and align with the Rectangular Strategy Phase 2 (2009-2013). The plan aims to elaborate necessary actions to be taken during 2009-2013 based on the review of the lessons learnt and achievement in the past 5 years (2004-2008). The achievement in the past 5 years is described in terms of: (i) legal framework, (ii) rehabilitation of irrigation infrastructure, (iii) drought intervention, flood mitigation and management, (iv) hydrological and meteorological basic information preparation and (v) human resources development.

Focal actions to manage water resources and irrigation are:

- To ensure sufficient water and water quality to meet the need for water for the whole year and to maintain eco-system,
- To mitigate flood damage by developing necessary infrastructures,
- To appropriately manage irrigation water through the improvement of irrigation and drainage systems,
- To avoid water pollution so as to maintain eco-systems surrounding irrigation systems, and
- To promote establishing and maintaining infrastructure to improve employment opportunity in the rural areas.

MOWRAM's challenge on irrigation development in 2009-2013 is to increase irrigated farming areas at a rate of 25,000 ha/year. Irrigation works to be implemented with national budget from 2010 onward are:

- Rehabilitation of 30 irrigation schemes in all provinces,
- Repair and maintenance of 35 pumping stations,
- Construction of 40 pumping stations,
- Repair of 420 medium pumping machines,
- Rehabilitation and repair of 85 canals at pumping stations, and
- Rehabilitation of Koskrolo main canal of Bassac irrigation system.

Budget plan to implement the projects listed in the Action Plan 2009-2013 is US$ 735 million, consisting of US$ 99 million from national budget and US$ 636 million from foreign assistance expected as shown below.

Table AD-1.2.3.1 Budget Plan for Water Resources and Meteorology Development and Management (2009-2013)

Year	Government Budget (US$ 1,000)	Foreign Aids and Development Partners (US$ 1,000)		Total (US$ 1,000)
		Committed	Not Committed	
2009	13,902	31,200	0	45,102
2010	23,942	38,700	86,885	149,527
2011	22,625	50,300	98,863	171,788
2012	17,980	46,500	114,496	178,976
2013	20,971	39,500	129,730	190,201
Total	99,420	206,200	429,974	735,594

Source: MOWRAM (2009), Action Plan on Water Resources and Meteorology Management and Development to contribute to the implementation of the Royal Government of Cambodia, Rectangular Strategy Phase 2 (2009-2013)

AD-1.3 Related Laws and Regulations

Water resources management and irrigation -related laws and regulations are tabulated as follows:

Table AD-1.3.1 Irrigation and Agriculture-Related Law and Regulation

Title	Issued in	Provisions
Water Resources Policy and Law		
National Water Resources Policy for the Kingdom of Cambodia	2004	- It is a basic policy for using water resources in Cambodia. It is aim to ensure the effective, sustainable, wise and equitable use of water resources referring to all over the aspect for water use and consists of 4 chapters: (i) Introduction, (ii) Vision for water in Cambodia, (iii) Fundamental principles, (iv) The national water resources policy and (v) Implementation of the national water resources policy, vi) Conclusion.
Law on Water Resources Management	June 2007	- The law, giving the framework to effective utilize water resources in an integrated manner, and role and responsibility of MOWRAM. It is comprised of 11 chapters: (i) General provisions, (ii) Water resources inventory and olanning, (iii) Water resources use and development, (iv) Farmer water use community. (v) Groundwater, (vi) Protection of water resources, (vii) Flood control, (viii) Servitudes, (ix) International rivers, (x) Incentive and penalties, and (xi) Final provisions.
Basin Management		
Sub-decree on Basin Management	Draft	- It aims to begin the implementation of water management plans an the creation of basin organizations to matches the Integrated Water Resources Management (IWRM) principles in Cambodia.
Water management		
Circular No.1 on the Implementation Policy for Sustainable Irrigation Systems	1999	- MOWRAM defines the role of FWUC in the policy for Sustainability of Operation and Maintenance Irrigation Systems. Circular No.1 defines organizational flame of FWUC and is attached The Statute of The FWUC. The statute defines the objectives, criteria, organization, finance management, rules and punishment of FWUC, and enhances the establishment of FWUC.
Policy for Sustainability of Operation and Maintenance Irrigation Systems	2000	- It defines the ways of operation and maintenance of irrigation system. In this policy, the management responsibility and water allocation transfer to FWUC. The functions and roles of FWUC, the system of irrigation service fee (ISF) and supporting system for maintenance activity of FWUC, Monitoring and Evaluation system are mentioned. - It consists of 5 chapters, (i) Introduction, (ii) Operation and Maintenance Irrigation System, (iii) Environment, (iv) Human Resource Development, (v) Miscellaneous.
Steps in the Formation of a Farmer Water Users Community	2000	- FWUC has the responsibility for operation and maintenance of irrigation system. MOWRAM enhance to establish FWUC and shows steps in the formation of FWUC in this document. FWUC finally will be registered by MOWRAM.
Training Manual for Participatory Irrigation Management and Development (PIMD)	2003	- The manual was prepared with the aim of promoting Participatory Irrigation Management and Development (PIMD) based on decentralization and Irrigation Management Transfer policy of the Government.
Sub-Decree on Farmer Water User Community	Draft	- The objective of this Sub-decree is to effectively and sustainable manage and use the irrigation systems. This sub-decree consists of 12 chapters and is to define the basic principles and process, function and supporting system etc. - The sub-decree also fosters farmers' participation in the operation and maintenance of irrigation system through FWUC based on PIMD and IMT.
Sub-decree on Water Allocation and Licensing	Draft	- It is with the purpose of beginning an activity of water licensing by MOWRAM.

Source: MOWRAM

AD-1.4 Organization for Irrigation Development

AD-1.4.1 Ministry of Water Resources and Meteorology

MOWRAM was independently of MAFF in 1999 with the mission of development and management of water resources of the country in effective, equitable and sustainable manner. MOWRAM is composed of seven technical departments, three administrative departments, Technical Service Center for Irrigation and Meteorology (TSC) and twenty four PDOWRAMs. There are five categories in staff qualification; (i) engineer, (ii) technician, (iii) vocational staff, (iv) qualified staff and (v) non-qualified staff. Total number of staff is 666 at central level and 623 at provincial level as of March 2011.

Table AD-1.4.1.1 Number of Categorized Staff in MOWRAM

Level	Engineer	Technician	Vocational	Qualified	Non-qualified	Total
Central	330	160	29	11	136	666
Provincial	97	120	69	23	314	623

Source: Government Officer Statistic, MOWRAM March 31, 2011

The duties and responsibilities imposed on MOWRAM stipulated in the "Law on Water Resources Management" and MOWRAM's guide paper are:

- Develop policy and strategy of water resources management conservation, and development taking into account the specific requirements and demand of each zone/ region.
- Study and research potential water resources including surface water, ground water and weather, to confirm technical field fitting to national frame work.
- Develop the short, medium and long term plan for business development and preservation on water resources and meteorology to serve national economic for alternative livelihood of urban and rural people.
- Manage and control all business making on water resources directly and indirectly, and minimize the disaster.
- Develop the regulation, legislation and other documents to ensure the management and monitoring on the implementation of water resources.
- Collect and document information on meteorology and hydrology, and use them to serve national and international related sectors for national benefits.
- If necessary, provide support and technical advice to stakeholders such as private sector, NGOs, community and people to appropriately correct/better balance on water resources business making.
- Widen and introduce more model technology in order to better train and propagate widely it.
- Participate in executing all works related to Mekong River Basin in accordance with duties and responsibilities of MOWRAM.
- Strengthen and promote national and international cooperation on water resources and meteorology.

The annual budgets and actual expenditures of MOWRAM are shown below.

Table AD-1.4.1.2 Summary of Budget and Expenditures of MOWRAM

(Unit: million Riel)

Item	2007	2008	2009	2010	2011
Budget	13,210	14,327	18,756	90,366*	113,954*
(US$ 1,000)**	3,210	3,482	4,558	21,960	27,692
Actual Expenditure	12,392	15,650	17,268	88,316*	n.a
(US$ 1,000)**	3,011	3,803	4,196	21,462	

Source: Department of Finance, MOWRAM

**: including investment budget for irrigation system (70millin Riel in 2010 and 90 million Riel in 2011)*

***: 1US$=4115 Riel*

AD-1.4.2 Provincial Department of Water Resources and Meteorology

PDOWRAM is placed at each province as sub-ordinate agency of MOWRAM. It generally consists of five offices such as (i) administration and personnel office, (ii) irrigated agriculture office, (iii) water resources management and conservation office, (iv) water supply and sanitation office and (v) hydro-meteorological office. Under PDOWRAM, there is a district office, of which the total is 183 in the whole country.

AD-1.4.3 Farmer Water Users Community

In 1999, RGC issued Circular No.1 on Implementation Policy for Sustainable Irrigation Systems. This Circular No.1 indicates that Farmer Water Users Community (FWUC) shall be responsible for O&M of irrigation system, payment of Irrigation Service Fee (ISF) for O&M and water distribution to fields under support of MOWRAM. In Prakas 306 issued in July 2000, the structure and functions of FWUC including collection of ISF are mentioned. MOWRAM is finalizing a Sub-degree on establishing FWUC by following the said Circular No.1 and Prakas 306. The Sub-degree will relate the organization structure, statute, establishment procedures and roles and responsibility of FWUC.

According to MOWRAM, there are some 328 FWUCs established nationally as of the end of 2007, of which total of 144 have been registered by MOWRAM. Depending upon the source of project support, some FWUCs have been registered at provincial level only.

AD-1.5 Major Irrigation Projects and Technical Assistance

Since the MOWRAM was established in 1999, large amount of investment in irrigation sector has been carried out to increase agricultural production in the country. In this process, many donor agencies are involved such as: World Bank, Asian ADB, JICA, French Development Agency (AFD), KOICA, Food and Agriculture Organization of the United Nations (FAO), China, India, Kuwait and NGOs, etc. Major irrigation projects completed by 2010 are listed as follows:

Table AD-1.5.1 List of Irrigation Projects Completed by 2010

Project	Donor	Completed Year	Amount (US$ Million)	Province
Colmatage Irrigation Rehabilitation Project (2,122 ha)	Japan	2002	8.7	Kandal
Stung Chinit Irrigation and Rural Infrastructure Project (3,000 ha)	ADB+AFD	2008	25.6	Kampong Thom
Integrated Development in Battambang Province (1,950 ha)	FAO	2008	3.3	Battambang
Batheay Irrigation Construction Project (8,000 ha)	Korea	2010	4.3	Kampong Cham
Tamouk Reservoir Dike Rehabilitation Project (4,051 ha)	Korea	2004	1.4	Kandal
Bassac Dam Rehabilitation Project in Battambang Province (20,000 ha)	Japan	2006	2.0	Battambang
Rehabilitation of the Kandal Stung Irrigation System in the lower Prek Thnot River Basin	Japan	2007	16.3	Kandal
Grant Assistance for Grass-Roots Human Security Project (11 Sub-projects, 11 River basin, 12,200 ha)	Japan	2005-2009		
Study on Comprehensive Agricultural Development of Prek Thnot River Basin	Japan	2008	4.0	Kampong Speu
River Basin and Water Use Study for Northwest Irrigation Sector Project (NWISP)	ADB+AFD	2006	30.9	Pursat, Battambang, Banteay Measchey, Siem Reap
M/P on Water Resources Development in Cambodia	Korea	2008	1.5	Whole Country
The Basin-Wide Basic Irrigation and Drainage M/P Study	Japan	2009	4.0	Kampong Chang, Pursat, Battambang
Technical Cooperation for TSC-Phase 2	Japan	2009	7.2	Kandal, Pursat, Takeo

Source: Irrigation Development in Cambodia, Status as of March 2011

The list of on-going projects as of March 2011 is given as follows:

Table AD-1.5.2 List of On-going Projects

Project	External Support		Implementation		Province	Project Cost (US$' 000)	Fund Resource (US$ '000)		Status as of March 15, 2011
	Donor	Fund Type	From	To					
North West Irrigation Sector Project	ADB+ AFD	Loan+ Grant	2005	2011	Pursat, Battambang, Banteay Measchey, Siem Reap	30,870	21,740	9,130	On-going
Eastern Rural Irrigation Development Project	IMF	MDRI	2007	2011	Kampong Cham, Prey Veng, Svay Rieng, Kratie, Stung Treng, Rotanak Kiri, Mondul, Kiri	33,380	32,763	617	On-going

Project	External Support		Implementation		Province	Project Cost (US$' 000)	Fund Resource (US$ '000)		Status as of March 15, 2011
	Donor	Fund Type	From	To					
Krang Ponley Multipurpose Water Resources Project	Korea	Loan	2008	2012	Kampong Spue	29,505	26,098	3,407	On-going
Tonle Sap Lowlands Rural Development Project (TSLRDP)	ADB	Loan+ Grant	2008	2015	Kampong Chhnang, Pursat, Kampong Thom	24,000	20,000	4,000	On-going
Water Resources Management Sector Development Program (WRMSDP)	ADB+ OPEC +AFD	Loan+ Grant	2011	2018	Kampong Thom, Siem Reap, Bantey Meanchey	31,900	24,800	7,100	On-going
Kampong Trabek River Flood Control Project	China	Loan	2010	2014	Prey Veng	31,010	31,010	0	On-going
Stung Sreng Irrigation Development Project	China	Loan	2011	2015	Preah Vihear, Kampong Thom	65,000	54,780	10,220	Loan Processing
Mongkol Borey Dam Development Project	Korea	Loan	2009	2013	Battambang	24,301	18,700	5,601	On-going
Kong Hort Irrigation Development Project	China	Loan	2010	2014	Battambang	61,000	49,900	11,100	On-going
Dauntri Multipurpose Dam Development Project	Korea	Loan	2009	2013	Battambang	45,958	40,283	5,675	Loan Processing
Stung Pursat Dam No.3 and No.5 Development Project	China	Loan	2011	2014	Pursat	80,000	66,460	13,540	On-going
Stung Tasal Storage Reservoir Development Project	India	Loan	2011	2013	Kampong Speu	19,000	19,000	0	On-going
Surrounding Bayong Kouv Reservoir Improvement Project	Korea	Grant	2010	2013	Takeo	3,012	3,012	0	Committed
Prek Stung Kev Water Resources Development Project	China	Loan	2011	2015	Kampot	52,000	42,620	9,380	On-going
Technical Cooperation for TSC-Phase 3	Japan	Grant	2009	2014	Battambang, Pursat, Kampong Chhnang	4,625 (¥370 million)	4,625	0	On-going

Source: Irrigation Development in Cambodia, Status as of March 2011

CHAPTER AD-2 SOUTHWEST PHNOM PENH IRRIGATION AND DRAINAGE REHABILITATION AND IMPROVEMENT PROJECT

AD-2.1 Roleang Chrey Headworks Rehabilitation Sub-project

AD-2.1.1 Irrigation and Drainage Development Plan

AD-2.1.1.1 General

(1) Objective

The current conditions of the Roleang Chrey Headworks show very high possibility which the gates will become inoperable before long. To ensure a stable water supply, the rehabilitation should be executed to renovate them so as to realize the proper function being of an extent and quality that will provide for another 50 years of service life. Upper reaches of NMC and SMC are left unattended from the recent rehabilitation by MOWRAM and require urgent rehabilitation works such as enlargement of narrow and/or shallow canal sections, raising of low canal bank, repair/replacement of deteriorated structures and so on. Objective of RCHRSP is to ensure water resources for irrigation for the Roleang Chrey Irrigation System by rehabilitating the existing headworks and irrigation and drainage facilities.

(2) Location and Water Resources

The regulators in RCHRSP are 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 NMC and SMC branched off from the Prek Thnot River upstream from the regulator. The headworks are located in Tumpung Village, Kahaeng Commune, Samraong Tong District, Kampong Speu Province.

The right bank of the Roleang Chrey Regulator is at EL. 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 (113.4 km 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.

AD-2.1.1.2 Present Conditions of Irrigation and Drainage

(1) Roleang Chrey Headworks

The Roleang Chrey Headworks are the most important key structures for the Roleang Chrey Irrigation System, which was constructed on the Prek Thnot River about 100 km upstream from its confluence with the Bassac River. The headworks consist of (i) Roleang Chrey Regulator, (ii) Andong Sla Intake

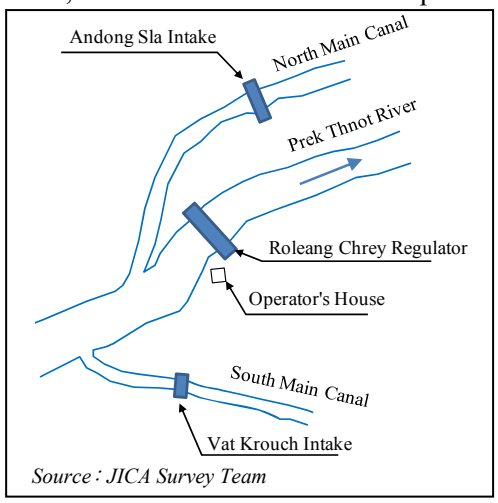


Figure AD-2.1.1.2.1 General Layout of Roleang Chrey Headworks

and (iii) Vat Krouch Intake and (vi) their approach channels, locations of which are shown in the layout map in Figure AD-2.1.1.2.1. The major features of the hydro-mechanical facilities are summarized in Table AD-2.1.1.2.1.

Table AD-2.1.1.2.1 General Information on Hydromechanical Facilities for Roleang Chrey Headworks

Structure	Items	General Information
Roleang Chrey Regulator	Type	Fixed wheel gate
	Number	5 nos.
	Clear span	12.5 m
	Height	6.7 m
	Hoist	Electric driven, wire rope winding, one motor two drum, with counter weight
Andong Sla Intake	Type	Steel radial gate, four sealing edges
	Number	4 nos.
	Clear span	4.0 m
	Height	2.7 m
	Hoist	Electric driven, wire rope winding, one motor two drum
Vat Krouch Intake	Type	Steel radial gate, four sealing edges
	Number	1 nos.
	Clear span	4.00 m
	Height	2.54 m
	Hoist	Manually operated wire rope hoist

Source：The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008

The present conditions of these structures were reviewed through field reconnaissance, review of previous studies and hearing from Kampong Speu PDOWRAM, and confirmed that there were no changes from the D/D Time. The review results are summarized below.

(a) Roleang Chrey Regulator

Roleang Chrey Regulator

Though the Roleang Chrey Regulator was constructed in 1974, its structural components remain stable, such as the retaining walls, gate piers, operation deck and bridge. However, its downstream apron and river side are severely eroded, for which protection works need to be improved to protect the regulator. The regulator gates have not been well maintained since it was constructed, therefore almost all the gate wheels could not rotate due to rusting of shafts causing overload to the hoist mechanism, which makes it difficult to operate precisely. A lot of water leakage was observed due to aging and cracks in the rubber seal. In 2006, replacement of wire ropes connecting with counter-weight and installation of diesel generator for the Roleang Chrey Regulator were made as emergency treatment under financial assistance of JICA.

For the hydro-mechanical works, electric motors, speed reducers, counter shafts and winding drums of the hoists are still in running condition in spite of the fact that they are quite old. None of the brakes, position indicators or limit switches functions at all. The operation of the hoist is carried out only by means of the experience and sense of the operator. The hoist wire ropes are aged but in service. Rehabilitation of the severely deteriorated rollers equipped with gate leaves should be thus required since there would be high possibility to bring about sudden malfunction.

(b) Andong Sla Intake

The Andong Sla Intake was constructed for supplying water to the North Main Canal (NMC) in 1974 together with the Roleang Chrey Regulator. The related facilities such as gate piers, operation deck and bridge do not exhibit severe conditions. Its downstream protection works however are severely damaged. The approach channel does not require any improvement since it has adequate flow capacity and show no indications of serious erosion.

Andong Sla Intake

The intake has not been well maintained since it was constructed, and a very large amount of leakage is observed from the gates. The existing steel radial gate leaks excessively through the seal and wire rope holes. In addition, the hoist wires are also damaged, and currently temporally repaired using steel wires connected with the arm of the gate leaf. The steel radial gate also exhibit structural deficiencies such as instability due to the extremely slender gate leaf, susceptibility to corrosion of the structural components, difficulty of maintenance due to being constantly submerged, and perennial difficulty in sealing. The electric parts, such as motors and control cabinets for gates No.3 and No.4 were removed. This removal obliges us to operate these gates by manual cranking in limited openings.

(c) Vat Krouch Intake

The Vat Krouch Intake was constructed in 2002 as an intake facility for the South Main Canal (SMC). Though the approach channel from the Prek Thnot River to the Vat Krouch Intake is not large enough to accommodate the design discharge, no serious erosion is observed on its side slopes. The Vat Krouch Intake appears structurally stable, but, its downstream portion is severely eroded. The intake is equipped with one steel radial gate with four sealing edges. This induces large head loss, which is one of the constraints of gravity irrigation.

Vat Krouch Intake

One radial gate is currently in working condition although the wire ropes are 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.

(d) Present Condition of Hydromechanical Equipment

Based on the site inspection on all the gate facilities provided in Roleang Chrey Regulator and information from Kampong Speu PDOWRAM on present operation conditions of them, present condition of all the gate facilities remains largely unchanged from the previous studies as ever and they are very serious condition as mentioned below.

Table AD-2.1.1.2.2 Present Condition of Hydromechanical Equipment

Equipment	Present Condition
Regulator gates	- It is very difficult to operate all 5 gates; the gate leaf can be opened with difficulty, however, the gate cannot be lowered without lowing upstream water level until approximately EL. 30.0 m (1 m from gate sill). - Large amount of water leakage is observed. - Almost all of paint materials on all gate leaves are peeled off and all surfaces rust. - Wire ropes for counter weight for some gates are deteriorated and some fuses of electrical panel are blown out.
Andong Sla intake gates in NMC	- Three (3) out of 4 gates cannot be operated absolutely. - One operable hoist system is damaged and the gate operation is very difficult. - Large amount of water leakage is observed. - Almost all of paint materials on all gate leaves are peeled off and all surfaces rust
Vat Krouch intake gate in SMC	- The gate operation is very difficult since the gate leaf and hoist are damaged. - Large amount of water leakage is observed. - Almost all of paint materials on gate leaf are peeled off and all surfaces rust.

Source : JICA Survey Team

(e) Operation and Maintenance

1) Operation

At present, Kampong Speu PDOWRAM is responsible for O&M for gates and accessories for the Roleang Chrey Regulator, Andong Sla and Vat Krouch Intakes. O&M for them has not been properly conducted by PDOWRAM mainly due to financial constraint. Even O&M manual is not available. It is practically executed by one aged person who has been working since 1970.

As for the gate operation for the Roleang Chrey Regulator, generally, the gates for the regulator are kept closed, and at flood time, are opened by observing the upstream water level in front of the gates. At flood time, the gates are opened one by one from center when the upstream water level becomes over EL. 35.7 m. This is a sole rule for gate operation for the Roleang Chrey Regulator.

The gate operation of the Andong Sla and the Vat Krouch Intakes is carried out on the demand basis, but not based on the irrigation schedule. The intake gates are operated customarily based on the request from farmers of NMC and SMC. Although the gates are operated by skillful operator, such operation results in much loss of water source as well as high risk of damages of facilities. The gates have to be rehabilitated as soon as possible including communication system among the gate operators, PDOWRAM offices and MOWRAM.

2) Maintenance

Regular maintenance for the Roleang Chrey Regulator, the Andong Sla Intake and the Vat Krouch Intake are hardly made by the Kampong Speu PDOWRAM. Emergency repair such as replacement of wire is made not permanently but temporally. Minor repairs such as replacement of magnetic conductor and switch, are conducted at own budget of PDOWRAM, while major serious problems have not been repaired after the urgent repair by JICA in 2006. In addition, severe erosion around structures has not been repaired.

(2) Irrigation and Drainage

(a) Irrigation System

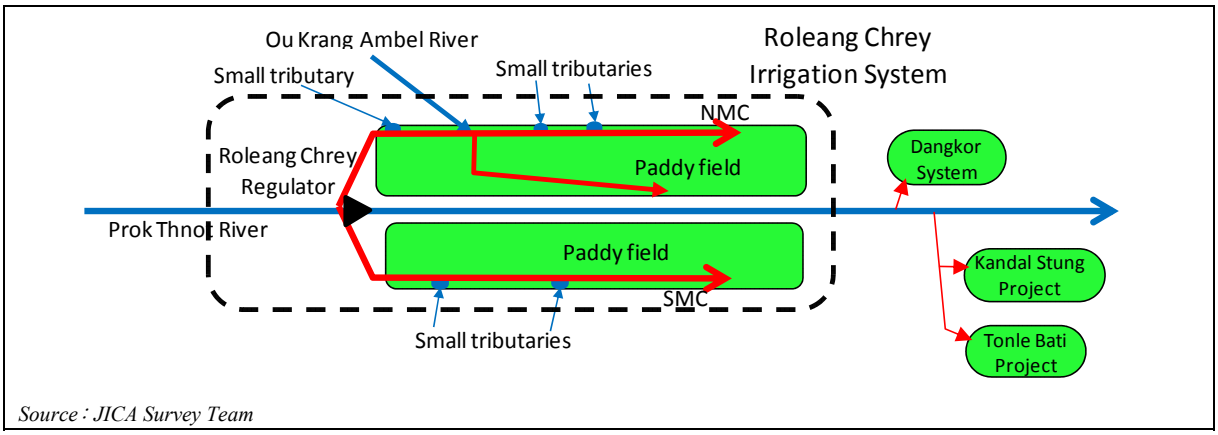
The construction of Roleang Chrey Regulator, Andong Sla Intake, and NMC was planned in late 1960s and started early 1970s as a part of Prek Thnot Multi Purpose Project, aiming to irrigate 35,000 ha. This project was however discontinued due to the civil war and political change, and the Government started the Western Phnom Penh Integrated Development Center Project (WPPIDCP) in 2001 using its own budget. Under WPPIDCP, NMC after the Andong Sla Intake has been constructed

aiming to irrigate 13,470 ha of the downstream area, provided that new water resources would be developed. The Vat Krouch Intake was constructed in 2002, and SMC was planned to irrigate 2,320 ha under WPPIDCP. The major features of the Roleang Chrey Irrigation System under WPPIDCP are summarized below. Location map is attached in Figure AD-2.1.1.2.2 and the general layout of the irrigation system is illustrated in Figure AD-2.1.1.2.3.

Table AD-2.1.1.2.3 Outline of Roleang Chrey Irrigation System

Item	Outline
- Water source	Prek Thnot River: Roleang Chrey Regulator and Intakes, Pump stations (1)
- Service area	24,000 ha* in Kampong Speu, Kandal, and Takeo Provinces
- Main canals	NMC: 8,670 ha*, Design capacity 15 m^3/sec, Lum Hack Canal : 4,800 ha*, starts from Ou Krang Ambel Pond, SMC: 2,320 ha*, Design capacity 15 m^3/sec Ou Speandek canal: 3,360 ha* Chrey Ou Phnoy Canal: 4,850 ha*
- SCs	19 SCs*: 62 km
- Tertiary canals	50 Tertiary Canals*: 192 km
- Drainage canals	26 drains*: 95 km
- Major structures	Spillways, Turnouts , Inlets, Bridges, Culvert

**: Original plan as WPPIDCP*
Source : The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008



Source : JICA Survey Team

Figure AD-2.1.1.2.3 General Layout of Roleang Chrey Irrigation System

(b) Irrigation Canals and Related Facilities

1) North Main Canal and Ou Krang Ambel System

In downstream of NMC at about 800 m from the Roleang Chrey Regulator, Andong Sla Intake was constructed to control irrigation water taking from the river to the northern area of the Prek Thnot River. The construction of NMC was ceased completely because of war activities. After 1979, the construction was resumed by the Government under the own budget. The most downstream part of NMC has been recently constructed by MOWRAM. A total length of NMC is about 32 km from the Roleang Chrey Regulator to the end point in Angk Snuol District in Kandal Province.

North Main Canal

Ou Krang Ambel Irrigation System is also located in the geographic area of NMC. It has a reservoir in the Ou Krang Ambel River, which is a tributary of the Prek Thnot River in this irrigation system, and its catchment area is estimated at 453 km^2 at the reservoir located along the National Road No.4 near Kampong Speu town. However, two reservoirs were further constructed for the irrigation development in the upstream of the Ou Krang Ambel River. Accordingly available water source to the downstream area remarkably decreased, and the system therefore mainly receives water from NMC.

2) South Main Canal

Vat Krouch Intake Gate was constructed for 1.5 km south from the Roleang Chrey Regulator to divert water from the Regulator to southern area of the Prek Thnot River. Since then, the Government has continued construction of SMC, and completed it by 2002. A total length of SMC is about 38.5 km from the Roleang Chrey Regulator to the end point i.e. crossing point with the National Road No.3 in Kong Pisei in Kampong Speu Province. There are 18 irrigation systems branched off from SMC.

South Main Canal

3) Reservoirs

There are three and eight reservoirs on NMC and SMC respectively, which are level crossing of local rivers with single band along the main canals, collecting the runoff of the small tributaries and supplementing the discharge into the main canals. Most of reservoirs have intake gates on the Main Canals to supply water to the adjacent Secondary or Minor Canals and spillways to evacuate the excess water in flood season. Three systems embankment was seriously or partly damaged by flood, but repaired recently by MOWRAM and are currently functioning now.

4) Pump Systems

Pumps were installed by the Government to take water from the Main Canals or directly from the Prek Thnot River. On NMC, there is one existing pump station at 5.3 km point and planed one at 10.2 km point from the Andong Sla Intake, while there is no pump station operating on SMC.

In addition, PDOWRAM is operating 14 mobile pumps, which are transported and operated according to the request from FWUCs or village chief. There are three types of pumps being operated by the beneficiaries, which are fixed, mobile, and floating type. Due to shortage of operation cost, these pumps are operated for limited time only. The condition of pumps is fairly good.

5) Secondary and Tertiary Canals

Subordinate canals such as Secondary and Tertiary Canals are not sufficiently constructed in number and in length, causing difficult to distribute water properly from Main Canals to paddy fields. To solve this problem, farmers excavated canal and bury pipes in many places. In the Secondary and Tertiary Canals, related structures such as turnouts, checks, culverts are also not sufficiently constructed in number due to lack of budget. This obstructs proper water management, and needs high pumping cost and blocking of canal by soil for crossing.

(b) Irrigation Area

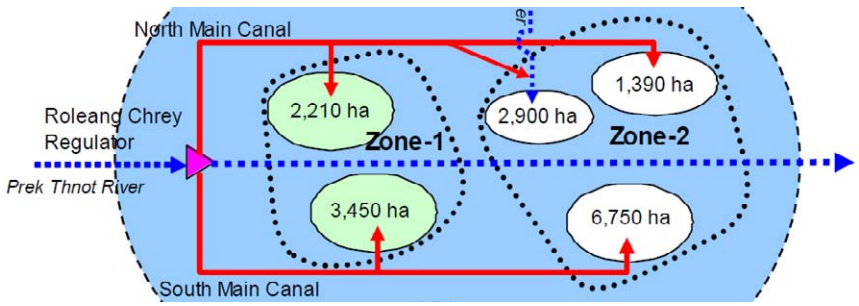
WPPIDCP was planned aiming to irrigate about 24,000 ha, which extend over Kampong Speu Province, Kandal Province, Phnom Penh Metropolitan Area, and Takeo Province. However, the water resources

are not enough at all the planned area, because the system was designed without rationale water balance study. In the previous JICA M/P Study in 2006, it was proposed to classify the beneficiary area into two dependability, namely with 80% dependability (4 in 5 years, categorized as Zone-1), and with 50% dependability (3 in 6 years, categorized as Zone-2) taking into consideration the available water from the Prek Thnot River. Zone map is shown in Figure AD-2.1.1.2.4 and irrigation area by different dependability is shown below.

Table AD-2.1.1.2.4 Irrigation Area by Different Dependability of Roleang Chrey Irrigation System

Dependability	Area	Area	Total
80% (Zone-1)	NMC Area, Upstream	2,210 ha	5,660 ha
	SMC Area, Upstream	3,450 ha	
50% (Zone-2)	NMC Area, Downstream	1,390 ha	11,040 ha
	Ou Krang Ambel Area	2,900 ha	
	SMC Area, Downstream	6,750 ha	
Total (Zone-1+Zone-2)	All area commanded by NMC	6,500 ha	16,700 ha
	All area commanded by SMC	10,200 ha	

**: Ou Krang Ambel System is mainly supplied by NMC.*
Source：The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008



Source：The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008

Figure AD-2.1.1.2.5 Irrigation Area by Different Dependability

(c) Drainage Conditions

In the field survey and the experiences in the pilot projects in the previous JICA Study from 2005 to 2008, it was observed that on-farm drains were not available in irrigated areas, and the small rivers and/or natural streams are utilized as drains to evacuate the excess water from the area.

According to the inventory survey during the JICA Study in 2005, about 13% of the inventory area affected or damaged by flood every year or once in a few years suffered from flood or poor drainage. These are scattered in the western and central parts in the Roleang Chrey Irrigation Area, and the flood or drainage damage seemed to occur only in the depressed area in which insufficient drain was provided in the irrigation systems concerned. Thus, drainage is not serious for farmers in the Roleang Chrey Irrigation Area. Through site visit and interview with farmers, it was confirmed that these situation are not changed from the M/P Time.

(d) Operation, Maintenance and Water Management

1) Operation and Maintenance

There is no written O&M manual of main canal facilities. Operation of the irrigation facilities of the main system (Roleang Chrey Headworks, NMC, SMC, SCs and pumps on the Prek Thnot River) is carried by the Government (MOWRAM and Kampong Speu PDOWRAM), while the Tertiary Canal systems are managed by FWUC.

There is no clear boundary of their responsibilities between MOWRAM and PDOWRAM, but generally relatively large works are being carried out by MOWRAM, while small works are done by PDOWRAM. Whenever needed, PDOWRAM requests MOWRAM for execution of rehabilitation works, based on which MOWRAM executes necessary works after approval of MEF on budgetary arrangement. The works including rehabilitation and construction of additional facilities, the contractor is selected through local bidding. The rehabilitation works carried out by MOWRAM during the period from 2006 to 2010 are summarized in the table below.

Table AD-2.1.1.2.5 Rehabilitation Works of Roleang Chrey Irrigation System Carried Out by MOWRAM from 2006 to 2010

Year	Rehabilitation Works	Rehabilitated Facilities	Cost (Million Riel)
2006	Repair of canal system and construction of structures on SMC	4 check structures	1,865
		3 check structures	
		6 drain structures	
		2 spillways	
		Repair of main canal (29 km)	
	Repair of Roleang Chrey Regulator	Repair of Roleang Chrey Regulator	512
	Repair of canal system and construction of structures on NMC	Repair of 1 gate structures	471
		2 spillways	
2008	Construction of canals on SMC	Construction of canal (2.9 km)	2,533
		Construction of Say canal (1 km)	
	Repair of canal system and construction of structures on SMC	3 gate Structures	2,207
		1 gate Structure	
		5 culvert and drain structures	
		1 spillway	
		Repair of main canal (29 km)	
	Repair of canal system and construction of structure on NMC	3 gate structure	4,810
		5 culvert structures	
		Repair of canal (18.9 km)	
2009	Repair of canal system and structures on Main Canal	7 check structures	5,777
		14 culvert structures	
		3 stone bridges	
		3 check structures	
		3 culvert structures	
		Repair of main canal dike (700 m)	
	Repair of canal system and structures on SMC	4 check structures	5,860
		Repair of Secondary Canal (SC) (5.6 km)	
		Rehabilitation of 3 SCs (12 km)	

Source: Engineering Department, MOWRAM

2) Water Management

Six FWUCs in total have been established in NMC and SMC irrigation areas, and registered to the Government, which are however presently not yet activated. There is no written irrigation service plan and no water management guidelines for the irrigation system recommended by the Government. Farmers in the irrigation system do not have sufficient experience in exercising water management, so that they do not enjoy effect of executing water management activity. The conditions of structures are poor due to lack of maintenance, which results in much water loss, discourage of stakeholders to participate in water management activity and less collection of ISF.

AD-2.1.1.3 Examination of Previous Development Plans

(1) Basic Concept for Development

(a) Application of Integrated Approach of Hardware and Software Aspects

The JICA M/P Study[1] has formulated the mid-term comprehensive agricultural development plan of the Prek Thnot River Basin, covering 10 years from 2006 through 2015, in which the top priority has been given to the Roleang Chrey Headworks Improvement, followed by various projects including both hardware and software components. The comprehensive agricultural development depends on the suitable planning and implementation of project facilities in hardware components and also the empowerment and strengthening of the government organization and FO under software components. In consideration of the above, the Project scope should be discussed with the basic concept of "integrated approach of hard aspect and soft aspect to ensure the smooth implementation and the sustainability of project".

(b) Improvement of Roleang Chrey Headworks from Appropriate Permanent Treatment Viewpoint

The current conditions of the Roleang Chrey Headworks are judged quite serious because of very high possibility which the gates will become inoperable before long. If left as they are, it is sure that the water supply to the Roleang Chrey command area would be difficult, or rather impossible. To ensure a stable water supply, improvement of these facilities is needed urgently. The highest priority of the objective is given to ensure proper gate operation for irrigation water supply and flood water, aiming to maintain the present production level at least in all the connected command areas by preventing the deterioration of the irrigation water supply. Based on the findings through review on the relevant reports and the site investigation, the countermeasures for those malfunctioned water gates are to be studied from the viewpoints of the appropriate permanent treatment, which aims to renovate them so as to realize the proper function being of an extent and quality that will provide for another 50 years of service life.

(c) Priority Ranking on Scope of Sub-project as Loan Project

The Japanese Yen's loan projects require that the project should be implemented as planned, the project effect should be realized as planned and that the project sustainability should be ensured. The main objective of RCHRSP is to ensure the proper operation of the headworks and major irrigation facilities maintaining or improving the present water supply level. In accordance with this concept, the scope of the project works should be carefully studied and determined. Meanwhile, the Roleang Chrey Irrigation System presently requires various types of the improvement works including new construction, large scale improvement, simple rehabilitation, minor repairing works, and so on listed in the proposal by PDOWRAM. To meet with the requirements of the Loan project, these proposed improvement works will be categorized and evaluated with priority ranking by the proper criteria, such as (i) objectives of the works, (ii) urgent necessity, (iii) scale of the works, (iv) maturity of the plan, taking into due consideration technical and economical viewpoints.

(d) Reflection of Lessons Learnt from Japan's Grant Aid Project

The tendering for the last grant aid project of Roleang Chrey Headworks Improvement was failed. One of the reasons for this failing was the harsh work scope including construction schedule. The rehabilitation work planned in the project was confirmed to be technically possible through B/D and

[1] *The Study on Comprehensive Agricultural Development of Prek Thnot River Basin, JICA, 2008, in which M/P was formulated in 2006.*

D/D. But if considering the scope of the construction works, cost and period, merit and risk of contractor, relation between civil contractor and gate manufacturer, it is deemed that this work scope must be so severe for the Japanese contractor. In this Survey, therefore the work scope will be elaborated based on not only technical and economical viewpoints, but also the work scale, the time schedule and the contract amount suitable for the ICB contractors.

(2) Water Balance Study

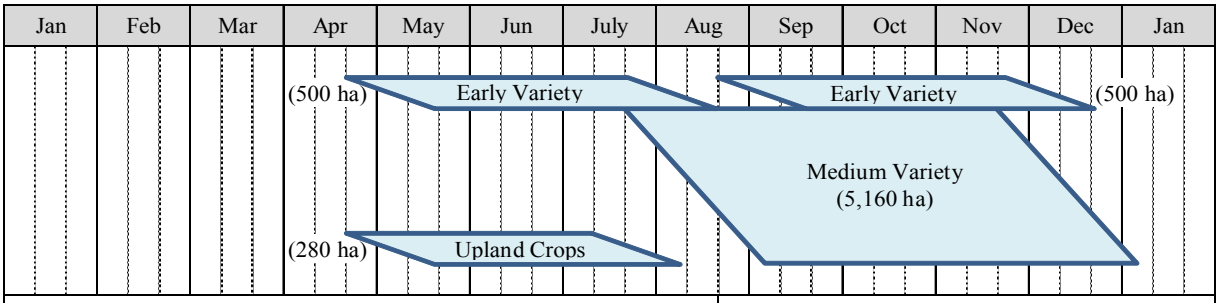
(a) Water Demands

1) General

The water balance study was reviewed and updated in this Survey in order to confirm the possible extent of the irrigable area estimated in M/P. In M/P, water demand was estimated using statistically estimated monthly rainfall both with 80% and 50% dependability. The water demand consists of irrigation water requirement in the Roleang Chrey Irrigation System and responsible discharge both for river maintenance flow and responsible release for the irrigation demand in downstream irrigation projects.

2) Irrigation Water Requirement

Irrigation water requirement was calculated based on the proposed cropping pattern mentioned in Figure AD-2.1.1.3.1, which consists of early variety and medium variety of paddy and upland crop in a year with overall cropping intensity of 114% with 80% dependability.



Source: The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008

Figure AD-2.1.1.3.1 Proposed Cropping Patterns in F/S Review in 2011

The water requirement was calculated by the same procedure in M/P with some modifications, which is summarized in the following table with comparison to those in M/P.

Table AD-2.1.1.3.1 Conditions for Estimate of Irrigation Water Requirement

Item	M/P Study	This Survey
Calculation interval	5-day basis	Remain unchanged
Method for estimating potential evapo-transpiration	Penman-Montieth method	Remain unchanged
Meteorological data	Pochentong Station (Phnom Penh)	Remain unchanged
Rainfall data	Kampong Speu Station (Base year statistically estimated)	Pochentong Station (Phnom Penh) year 1911 (80% dependable) year 1948 (50% dependable)

Item	M/P Study	This Survey
Percolation rate	8 mm/day With introduction of water saving irrigation Method	Remain unchanged
Irrigation efficiency	Paddy; 66% Upland crop; 53%	Remain unchanged

Source: JICA Survey Team

The diversion water requirements at the Roleang Chrey Headworks estimated in this Survey is summarized below;

Table AD-2.1.1.3.2 Summary of Estimated Diversion Water Requirement for Roleang Chrey Irrigation System with 80% and 50% Dependability

(Unit: m^3/sec)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
80% Dependability (Reference Year : 1911)												
1 - 5	0.0	0.0	0.0	0.1	0.5	0.5	1.0	7.0	2.0	6.3	10.6	2.9
6 - 10	0.0	0.0	0.0	0.1	0.6	0.5	2.0	7.6	1.8	6.5	9.2	1.7
11 - 15	0.0	0.0	0.0	0.3	0.6	0.5	3.3	8.1	1.5	6.6	8.1	0.8
16 - 20	0.0	0.0	0.0	0.4	0.7	0.5	4.9	8.0	1.9	7.1	6.9	0.0
21 - 25	0.0	0.0	0.0	0.5	0.7	0.6	5.3	7.5	2.4	7.6	5.8	0.0
26 - end	0.0	0.0	0.0	0.5	0.6	0.6	5.7	6.8	2.5	7.7	4.6	0.0
50% Dependability (Reference Year : 1948)												
1 - 5	0.0	0.0	0.0	0.1	0.6	0.5	1.3	7.1	0.4	4.1	7.0	3.2
6 - 10	0.0	0.0	0.0	0.1	0.6	0.5	2.3	7.7	0.3	4.3	6.0	1.9
11 - 15	0.0	0.0	0.0	0.3	0.7	0.5	3.6	8.3	0.2	4.5	5.3	1.0
16 - 20	0.0	0.0	0.0	0.4	0.7	0.6	5.1	8.3	0.3	4.9	4.5	0.0
21 - 25	0.0	0.0	0.0	0.5	0.8	0.6	5.9	7.8	0.6	5.4	3.8	0.0
26 - end	0.0	0.0	0.0	0.5	0.7	0.6	6.8	7.2	0.6	5.5	3.1	0.0

Source: JICA Survey Team

3) River Maintenance Flow and Responsible Discharge to Downstream

The river maintenance flow to downstream from the Roleang Chrey Regulator was estimated at 0.6 m^3/sec throughout a year referring to the guidelines of Japan[2]. Minimum responsible discharge from the Roleang Chrey Regulator to downstream was estimated by summing the following water requirement of three irrigation systems located downstream: Kandal Stung, Dangkor and Tonle Bati Irrigation Systems, in the same way as mentioned in M/P.

Table AD-2.1.1.3.3 Summary of Monthly Water Requirement of the Downstream Irrigation Projects

(Unit: m^3/sec)

Irrigation System		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Kandal Stung		0.8	0.7	0.0	0.1	0.8	1.3	2.33	1.0	0.3	0.6	1.3	1.5
Dangkor		0.0	0.0	0.0	0.2	0.05	0.05	0.16	0.3	0.18	0.21	0.23	0.03
Tonle Bati	1 - 15	0.95	0.66	0.0	0.02	0.4	0.91	1.66	1.14	0.34	0.82	0.75	0.98
	16 - end	0.57	0.64	0.0	0.05	0.84	0.99	1.42	0.68	0.50	0.64	0.82	1.21

Source : The Study on Comprehensive Agricultural Development of Prek Thnot River Basin In the Kingdom of Cambodia, JICA, 2008

(b) Water Balance Calculation

1) Calculation Method and Conditions

In M/P, the water balance was simulated applying the probable river run off and water demand estimated with statistically analyzed for 80% dependability and 50% dependability. In this Survey, these two cases are applied. The water balance simulation in the review in this Survey is summarized as below with comparison to those in the previous the M/P Study.

[2] *River maintenance flow; between mean annual draught runoff and 1/10 dependable draught runoff*

Table AD-2.1.1.3.4 Comparison of Water Balance Simulation between M/P and this Survey

Item	M/P Study	This Survey
Calculation interval	5-day basis	Remain unchanged
Method for estimating potential evapo-transpiration	Penman-Montieth method	Remain unchanged
Runoff data	Estimated from the data at Peam Khley station	Remain unchanged
Water balance in Ou Krang Amble system	Storage effect of two upstream reservoirs are considered	Remain unchanged
Simulation model	Refer to Figure AD-2.1.1.3.2	Remain unchanged
Reference year	Kampong Speu Station (Reference year statistically estimated)	Kampong Speu Station year 1911 (80% dependable) year 1948 (50% dependable)
Irrigation fail	Continuous deficit in 10 days	Remain unchanged

Source: JICA Survey Team

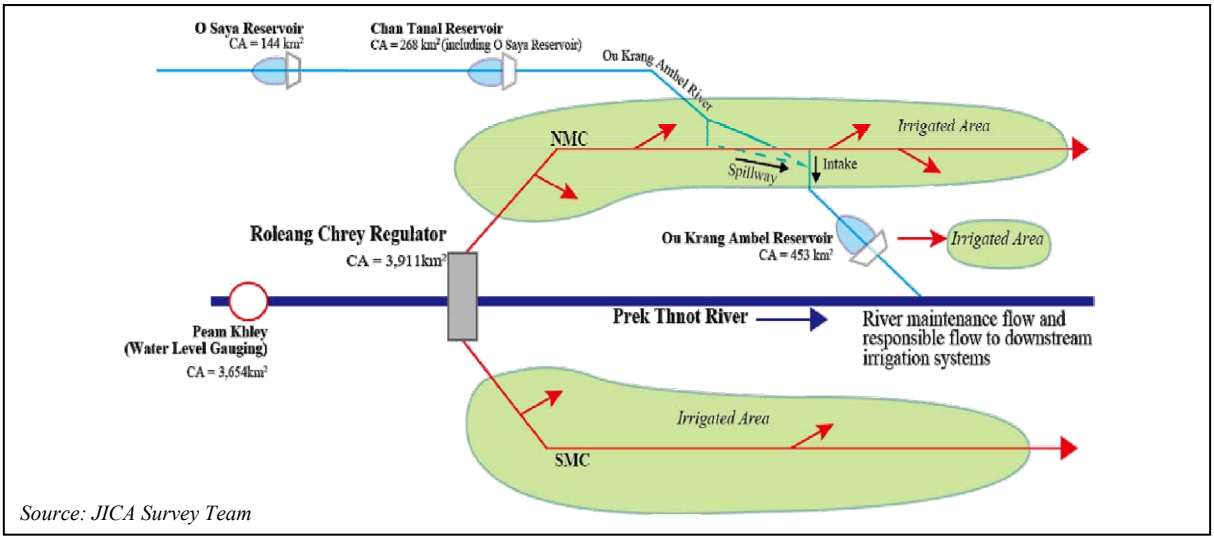


Figure AD-2.1.1.3.2 Water Balance Simulation Model

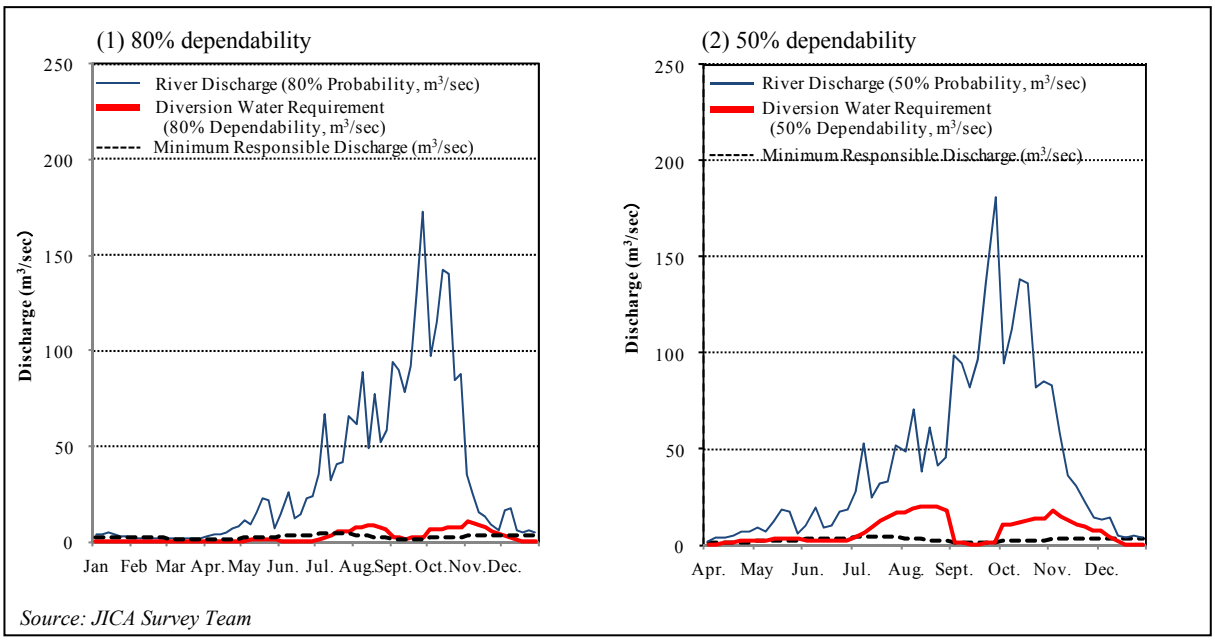
2) Result of Water Balance Calculation

As the results of water balance calculation with supplemented rainfall data of recent 5 years, the 80% dependable area was estimated at 6,500 ha against 5,660 ha in M/P, and 50% dependable area was estimated at 18,100 ha against 16,700 ha in M/P. For both cases, the review results are about 10% higher than those in M/P due to modifications of operation simulation of the Ou Krang Ambel Reservoir. Taking into consideration the calculation method and reliability of meteo-hydrological data, it could be considered that the difference in both cases would be rather positioned within allowable extent. From the reasons mentioned above and the conservative viewpoint, it is proposed to use the 80% and 50% dependable areas in M/P. The probable irrigation area for each crop is shown in the right table:

Table AD-2.1.1.3.5 Probable Irrigation Area

Dependability	Early Rainy	Rainy Season
80%	500 ha	5,660 ha
50%	2,100 ha	16,700 ha

Source: The Study on Comprehensive Agricultural Development of Prek Thnot River Basin



Source: JICA Survey Team

Figure AD-2.1.1.3.3 Result of Water Balance Study for Roleang Chrey Irrigation System

(3) Improvement Works for Hydro-mechanical Works at Roleang Chrey Headworks

(a) General Concept for Rehabilitation Work

The rehabilitation work for the hydro-mechanical equipment shall be implemented taking into account:

- easiness for operation and maintenance system,
- review for the function and structure so as to resolve the problem on O&M so far, and
- elapsed years of the equipment, wear, durability and aging of the parts, technology obsolescence and frequency in use should also be considered.

(b) Facilities to be Rehabilitated

A discussion was made between the JICA Survey Team and MOWRAM in middle July 2011 to determine the scope of rehabilitation works based on the rehabilitation plan prepared at the B/D Stage and the D/D Stages in 2008 and 2009. As the result of discussion, it is proposed that the following facilities should be rehabilitated in line with the general concept mentioned above.

1) Roleang Chrey Regulator Gates

- Renewal of 5 sets of fixed wheel gate leaves, wire rope wound hoists with steel hoist decks and staircase including remote control operation covering each gate opening of 12.5 m in width and 6.7 m in height

2) River Outlet Structure

- Construction of 4 sets of river outlet slide gates with each guide frame and spindle screw or rack type hoist covering each opening of 1.0 m in width and 1.0 m in height
- Construction of 4 sets of fixed trash racks for the river outlet gates covering each opening of 1.0 m in width and 3.0 m in vertical height
- Construction of 2 sets of trash racks for end structure of river outlet covering each opening of 1.0 m in diameter

3) Andong Sla Intake

- Reconstruction of 2 sets of Andong Sla Intake radial gates with each guide frame, spindle screw or rack type hoist and hoist deck covering each opening of 4.0 m in width and 2.7 m in height

4) Vat Krouch Intake

- Reconstruction of 1 set of intake fixed wheel gates with each guide frame, spindle screw or rack type hoist and hoist deck covering each opening of 4.0 m in width and 5.0 m in height

(c) Renewal of Gate Leaves for Regulator Gates

The scope of works for rehabilitation of regulator gate leaves under JICA Grant Aid is as follows.

- Replacement of total 40 sets of bushings and pins of main wheels for all gate leaves with new ones,
- Repair painting of all gate leaves upon performing sand blasting of all gate leaves, and
- Replacement of rubber seals provided on all gate leaves.

Such partial rehabilitation works of gate leaves are technically acceptable through the field investigation and study performed at the B/D Stage and the D/D Stages in 2008 and 2009 as follows.

- Enough strengthening for the main gate structure such as main girders and skin plate at the present stage even though it was observed that some auxiliary members such as bracings were deteriorated.
- No observation on the main structure although the painting material on them is peeled off and all surfaces rusted.

However, it is proposed that all gate leaves should be renewed with complete new ones instead of such replacement and repainting mentioned in the above. The necessity of renewal of gate leaves is explained hereinafter.

1) Changing Wheel Assembly Type

The wheel assembly should be designed that its bushing shall be replaced with new one easily without any modification of civil structure since the standard renewal interval of bushing under the proper maintenance is 23 years as shown below.

Table AD-2.1.1.3.6 Standard Renewal or Replacement Interval of Hydro-mechanical Equipment1

Facility/Equipment/Part			Kind	Standard Renewal or Replacement Intervals (year)
Gate leaf	Structure member		Renewal	56
	Main wheel assembly	Wheel	Replacement	50
		Shaft	Replacement	53
		Bushing	Replacement	23
	Auxiliary roller		Replacement	55
	Wire sheave assembly		Replacement	50
	Rubber seal		Replacement	Not set replacement interval since unexpected damage often happens.
Wire rope winch type hoist	Electric motor		Replacement	38
	Electromagnet brake		Replacement	30
	Hydraulic lift brake		Replacement	27
	Changeover device		Replacement	29
	Gear reducer		Replacement	29
	Open gears		Replacement	44
	Wire rope sheave assembly		Replacement	45

Facility/Equipment/Part			Kind	Standard Renewal or Replacement Intervals (year)
	Bearings		Replacement	29
	Shaft couplings		Replacement	29
	Wire ropes		Replacement	14
	Wire rope end		Replacement	27
Hydraulic hoist	Hydraulic cylinder		Replacement	16
	Hydraulic unit		Replacement	16
Rack type hoist	Main structure (Actuator and rack)		Renewal	19
Spindle type hoist	Main structure (Actuator and spindle)		Renewal	25
Control cabinet	Limit switch		Replacement	24
	Gate position indicator		Replacement	25
	Local control cabinet	Panel	Replacement	19
		Relays	Replacement	15
		Circuit breaker	Replacement	19
		Switches	Replacement	19

Reference: Inspection, Maintenance and Replacement Manual for River Gates issued by Ministry of Land, Infrastructure and Transport, Japan 2008.
Source: JICA Survey Team

The existing wheel assembly is as shown in attached Figure AD-2.1.1.3.4 (1). It has a disadvantage that the wheels assembly cannot be disassembled and bushing replaced with new one if the hole is provided in the concrete columns of hoist deck.

Considering the above renewal interval of bushing, the bushings shall be replaced with new ones again after 23 years reckoned from the year of finishing such replacement.

To replace with new bushing, it is necessary to make the large scale of replacement work again by providing the cofferdam. In order to replace the bushing easily within the short period without any modification of the concrete column, it is proposed that the wheel assemblies should be provided at the downstream side of the end beams as shown in attached Figure AD-2.1.1.3.4 (2).

It is necessary to renew the gate leaf completely to accommodate the wheel assemblies at the downstream side of gate leaf since existing gate leaves cannot be modified to do so.

2) Renewal Interval of Gate Leaf

The regulator was completed in 1974 and 37 years elapsed until now. It is necessary to renew the gate leaf within the lifetime of Roleang Chrey Regulator as explained below.

In general, the lifetime of civil structures such as regulator is about 80 years subject to provision of regular maintenance. On the other hand, the renewal interval of gate structure is 56 years as shown in Table AD-2.1.1.3.6. The gate leaves are to be renewed approximately in 2030 which is within the lifetime of the Roleang Chrey Regulator. Such renewal of gate leaves needs the large scale of construction works and the long term construction period again. From the economical view point considering the total costs for maintenance and rehabilitation works, it is better that the gate leaf should be renewed with the proposed type at one time.

3) Work Volume of Rehabilitation Work of Regulator Gates

The notice of Prequalification for Tender for the Project for Improvement of Roleang Chrey Headworks under JICA Grant Aid and the issue of the Prequalification Documents were made on August 3, 2009 upon preparing Tender Documents in July 2009. However, any applicant did not submit his Prequalification Documents by closing date of August 10, 2009 and then the tender was not carried out.

The causes of such situation are deemed as follows:

- Small work volume of gate rehabilitation,

- Very difficult and complicated replacement work for bushings and shafts of main wheels of regulator gates.
- Very tight work period, say only 4.3 months for disassembly, procurement and installation of bushings and shafts of main wheels of regulator gates.

It is assured that work volume to be increased by the renewal of all gate leaves of regulator gates becomes adequate work scale to be implemented under International Competitive Bidding (ICB) so that there is a possibility which a number of the gate manufacturers participate actively in the Tender as a Sub-contractor. Table AD-2.1.1.3.7 shows the summary of review results in comparison with the previous studies.

Table AD-2.1.1.3.7 Review on Proposed Hydro-mechanical Works

Item	Proposal of Grant Aid Project	Review in 2011
Roleang Chrey Regulator		
(i) Regulator gates - Type: Fixed wheel gates - Quantity: 5sets - Clear span: 12.5 m - Gate height: 6.7 m	(i) Rehabilitation of all regulator gates and hoists: - Renewal of bushings and shafts of main wheels of all gate leaves - Repainting of all gates leaves after rust removal - Replacement of rubber seals of all gate leaves - Renewal of all hoist with local control panels upon modifying hoist deck - Construction of remote control panel	Based on the review study, the following works are proposed. a) Rehabilitation of all regulator gates and hoists: - Renewal of all gate leaves - Renewal of all hoist system with local control panels - Renewal of all host decks with staircase - Construction of remote control panel
(ii) River outlet structure Type: Slide gates Quantity: 4 sets Clear span: 1.0 m Clear height: 1.0 m	(ii) Construction of river outlet facilities - Construction of gates with guide frames and manually operated hoists	Based on the review study, construction of remote control panel is proposed in addition to construction of gates with guide frames and electrically driven hoists
- Inlet fixed trashrack Quantity: 4 sets Clear span: 1.0 m Vertical height: 3.0 m	- Construction of inlet trashracks	According to the review study, the following proposed works remain unchanged. - Construction of inlet trash racks
Outlet fixed trashrack Quantity: 2 sets Clear span: 1.25 m Vertical height: 1.4 m	- Construction of outlet trashracks	- Construction of outlet trash racks
Andong Sla Intake		
- Intake gates Type: Radial gates Quantity: 2 sets Clear span: 4.0 m Gate height: 2.7 m	Reconstruction of gates with guide frames and manually operated hoists	Based on the review study, proposed works are ; - Reconstruction of gates with guide frames and electrically driven hoists - Construction of remote control panel
Vat Krouch Intake		
- Intake gates Type: Radial gates Quantity: 2 sets Clear span: 4.0 m Gate height: 2.7 m	- Not included	Based on the review study, proposed works are ; - Construction of gates with guide frames and electrically driven hoists Type: Radial gates Quantity: 2 sets Clear span: 4.0 m Gate height: 2.7 m - Construction of remote control panel

**: Proposal in F/S (Proposal in F/S was not adopted in grant aid project)*
Source: JICA Survey Team

(d) Priority of Rehabilitation Works

The proposed rehabilitation works for the hydro-mechanical equipment is considered in the following categories for the preliminary evaluation.

- First priority: the works should be carried out urgently to recover and/or maintain the function of the equipment with reliability and durability.
- Second priority: the works should be carried out to improve convenience for gate operation.

The result of categorization is shown in Sub-clause AD-2.1.1.4.

(4) Civil Works for Improvement of Roleang Chrey Headworks

(a) Roleang Chrey Regulator

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. In the previous F/S in 2008 and subsequent B/D in 2009, it was proposed to conduct the improvement works to keep or rather further strengthen such stable condition and to ensure the reliable release to downstream reach. In the review study, it was confirmed that there were no remarkable change in the above conditions, and thus the proposed improvement works in B/D is referred in principle. The proposed works are (i) provision of downstream apron, (ii) provision of retaining wall, and (iii) construction of by-pass river outlet.

(b) Andong Sla Intake

The required discharge for improvement of Andong Sla Intake and its approach channel is referred to the JICA F/S and subsequent B/D, as (i) 10.4 m^3/sec without consideration of new water resource development, and (ii) 25.1 m^3/sec in future. Taking this condition into consideration, the proposed improvement works were confirmed to apply the improvement plan to (i) design the four gates portions, (ii) install two of the four gates to ensure the discharge of 10.4 m^3/sec, and (iii) provide a concrete wall for the remaining two gates, so as to enable the installation of a gate in each in the future. In addition, retaining walls and downstream apron will be provided to protect the downstream of the structures. Rehabilitation work for the upstream approach channel is also proposed by PDOWRAM.

(c) Vat Krouch Intake

According to the design discharge for SMC estimated in F/S and the review in this Survey, gate capacity should be determined using the discharge of 17.4 m^3/sec. Consequently, two radial gates are required of 2.7 m high and 4.0 m wide. 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.

A gate pier combined with a box culvert was proposed to save construction cost. On the bottom slab of the box culvert, a baffle block and end sill are provided to dissipate the hydraulic energy. Gabion mattresses are to be provided on the canal bed before and after the transition, to protect the canal bed from scouring.

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, according to F/S. The existing section needs to be enlarged, which was also pointed out by PDOWRAM during the joint inspection at this time.

The review results of the proposed improvement on the civil works of Roleang Chrey Headworks are summarized below.

Table AD-2.1.1.3.8 Review of Proposed Civil Works

Item	Proposal of Grant Aid Project	Review in 2011
Roleang Chrey Regulator		
	- Construction of the downstream river bed protection - Rehabilitation of the downstream river bank protection - Construction of river outlet structure	As no remarkable change in the present condition and design values in the review study, proposed works in B/D remain unchanged.
Andong Sla Intake		
	- Curtain walls: W 4.0 m × H 2.5 m × 2 nos. (w/ new gate sections) W 4.0 m × H 5.2 m × 2 nos. (gate-dismantled sections) - Operation deck: W 2.0 m × L 4.0 m × 4 nos. - Protection of up & downstream of intake and rehabilitation of approach channel	As no remarkable change in the present condition and design values in the review study, proposed works in B/D remain unchanged.
Vat Krouch Intake		
	- Not included	Based on the review and investigation in this Survey, the following works are included in the Sub-project. - Construction of upstream and downstream transitions* - Replacement of gate pier and box culvert* - Protection of upstream and downstream canal beds - Rehabilitation of approach channel*

**: Proposal in F/S (Proposal of grant aid project is)*
Remarks; W: Width, H: Height, L= Length
Source: JICA Survey Team

(5) Rehabilitation Works for North Main Canal, South Main Canal and Related Structures

(a) General

In M/P, RCHRSP was formulated to solely cover the improvement of the Headworks consisting of the Roleang Chrey Regulator, Andong Sla Intake, Vat Krouch Intakes and their approach channels, while improvement of the irrigation system was separately formulated as UNMC and USMC Irrigated Agriculture Improvement Projects, and Irrigated Agriculture Improvement Model Project. During the discussion between MOWRAM and JICA Mission on implementation program of the Preparatory Survey (this Survey) in February 2011, MOWRAM proposed to JICA Mission to include the improvement of main canals into the Project scope in addition to the rehabilitation of the Headworks. As a result, it was mutually agreed between RGC and JICA that the rehabilitation of upstream of NMC and SMC with length of 10 km each with related structures was included in the Scope of Sub-project, as concluded on February 25, 2011. The following table summarizes the comparison of components of improvement works of the Roleang Chrey Headworks in the past and present studies.

Table AD-2.1.1.3.9 Comparison of Project Components of Headworks Improvement Works in Past and Present Studies

M/P	F/S	Japan's Grant Aid Project	This Survey
Improvement of Roleang Chrey Headworks	Improvement of Roleang Chrey Headworks	Improvement of Roleang Chrey Headworks	Improvement of Roleang Chrey Headworks
Improvement of Andong Sla Intake	Improvement of Andong Sla Intake	Improvement of Andong Sla Intake	Improvement of Andong Sla Intake
Improvement of Vat Krouch Intake	Improvement of Vat Krouch Intake		Improvement of Vat Krouch Intake
NMC and SMC Improvement projects formulated separately.	Improvement of upper SMC in Model Project (7.8 km)		Improvement of upper NMC and SMC (approximately 10 km each)

Source: JICA Survey Team

(b) Improvement Works Proposed by PDOWRAM

NMC and SMC rehabilitation works have been proposed by MOWRAM to be included in the scope of the Sub-project works during the visit of JICA Mission to Cambodia in February 2011, however the details of proposed plan is not available. Kampong Speu PDOWRAM has a strong intention to the improvement works of NMC, SMC and also improvement of SCs and related structures even including new construction of additional facilities with general and rough idea, on which basic data, technical investigation, topographic survey results, and design have not been studied.

During the period of the first filed works of the Survey, Kampong Speu PDOWRAM prepared the list of their proposed improvement works to be included in RCHRSP with their priority ranking. Based on the list, PDOWRAM, MOWRAM and the JICA Survey Team jointly inspected them in order to clarify the present conditions and possibility to be included in the Scope of Sub-project.

The proposed works both for NMC and SMC are summarized in the following table:

Table AD-2.1.1.3.10 Summary of Improvement Works on NMC and SMC of Roleang Chrey Irrigation System Proposed by PDOWRAM

(Unit: No/Nos.)

Proposed Works	NMC			SMC			Total
	Approach Channel*	NMC	NMC Total	Approach Channel*1	SMC	SMC Total	
Improvement of canal embankment	2	0	2	1	1	2	4
Enlargement of canal section	0	1	1	1	0	1	2
Improvement of bank of canal crossing reservoir	0	1	1	0	2	2	3
Replacement or improvement of structures	2	11	13	3	9	12	25
Construction of pump station	0	1*2	1	0	0	0	1
Construction of structures	0	2	2	1	7	8	10
Rehabilitation of SCs	3	9	12	1	7	8	20
Total	7	25	32	7	26	33	65

**1: Approach channel from the Prek Thnot River to Intakes*
**2: Proposed pump station on NMC to supply water to the existing SC that was already constructed by MOWRAM*
Source: JICA Survey Team

AD-2.1.1.4 Proposed Development Plan (Proposed Scope of Sub-project)

(1) Objective of RCHRSP

M/P in 2008 formulated the overall rehabilitation scenario in the Prek Thnot River basin, in which the highest priority was given to RCHRSP consisting of rehabilitation of the Roleang Chrey Regulator and the intakes with the condition that the other projects, such as rehabilitation of upper and lower reach of NMC and SMC, will follow in future. The objective of RCHRSP is to maintain the present production level at least in all the command area by preventing the deterioration of the irrigation water supply due to malfunctioning of the Roleang Chrey Regulator and Andong Sla and Vat Krouch Intakes in near future.

(2) Examination of Scope of RCHRSP Proposed by MOWRAM

Scope of RCHRSP is listed in the M/D dated on February 25, 2011, however is not mentioned in detail. The proposed scope of RCHRSP was examined though review on the previous studies such as M/P, F/S, B/D and D/D by JICA, site investigation with detailed drawings in hand, and discussions with MOWRAM and PDOWRAM.

As for NMC and SMC, it was confirmed that rehabilitation works were executed by MOWRAM for the middle to lower reach (from 8 km point of NMC in 2003-2005 and from 7 km point of SMC in

2005-2007), while the upper reaches of these canals have not yet been rehabilitated so far. Through the inventory and topographic survey for the upper reaches, there find canal sections and structures that require large scale improvement works. Also it is confirmed that MOWRAM has strong intention to implement the Model Area development proposed in M/P under RCHRSP, which is covered by the upstream part (up to 7.8 km) of SMC. Existing irrigation and drainage facilities within the length of the above in RCHRSP are listed in Table AD-2.1.1.4.1.

The examined scope of RCHRSP is shown in the following table.

Table AD-2.1.1.4.2 Examined Scope of RCHRSP

Scope Proposed by MOWRAM in M/D[*1]	Examined Scope of RCHRSP
(a) Project Area Not specified	(a) Project Area 350 ha excluding 220 ha to be implemented by TSC-3, but influences to 16,910 ha for project evaluation
(b) Cropping Pattern and Intensity - Rice-based cropping system with upland crops - Crop intensity:101% - 114%	(b) Cropping Pattern and Intensity - Rice-based cropping system with upland crops - Crop intensity:101% - 114%
(c) Hardware Components	
- Rehabilitation of Roleang Chrey Headworks	The rehabilitation works of the regulator gates are urgently required with the top priority of RCHRSP, aiming at restoration of the appropriate function of the gates so as to maintaining or increasing the present production level by preventing the deterioration of the function. Based on the Survey, the following works are highly required. (a) Renewal/Construction of regulator gates, - Renewal of all gate leaves - Renewal of all hoist system with local control panels - Renewal of all host decks with staircase - New construction of remote control panel (b) New construction of river outlet structure gate with guide frames and manually operated hoists (c) New construction of inlet and outlet fixed trash racks (d) New provision of downstream protection works (e) New provision of retaining wall (f) New construction of by-pass for releasing low water to the downstream reach
- Rehabilitation of Andong Sla Intake including Replacement of Radial Gate	The results of review showed the urgent necessity of reconstruction of gates and related facilities. The proposed works are; (a) Renewal/Provision of intake gates, - Renewal of gate leaves - Renewal of guide frames - Renewal of electrically driven hoists - New provision of gate remote control operation - Renewal of manually driven hoists (b) New construction of gate piers, (c) New construction of downstream protection, and (d) Partial rehabilitation of approach channel
- Rehabilitation of Vat Krouch Intake Structure	Through the review, it was confirmed that the following are needed urgently: (a) Renewal of intake gates, - Renewal of gate leaves - Renewal of guide frames - Renewal of electrically driven hoists - Provision of gate remote control operation - Renewal of manually driven hoists (b) Partial improvement of supply canals*[2], and (c) New construction of structures on supply canals*[2]
- Rehabilitation of NMC and SMC with Related Structures, of which the length are 10.0 km respectively	After the site investigation, Length of NMC and SMC to be rehabilitated were determined as 9.1 km and 9.8 km, respectively. Required rehabilitation works on NMC and SMC are identified in the Survey, most of which need urgent improvement to ensure the water supply to the downstream part of the irrigation system. The works required under RCHRSP are; (a) Partial improvement of canal embankment, (b) Partial enlargement of canal section, (c) Partial improvement of bank of canal crossing reservoir, (d) Replacement or partial improvement of structures on Main Canals, (e) Additional construction of structures on Main Canals.

Scope Proposed by MOWRAM in M/D[*1]	Examined Scope of RCHRSP
- Rehabilitation of Secondary Canals with Related Structures related to the NMC and SMC of 10.0 km respectively.	In connection with rehabilitation for upstream 9.1 km of NMC and 9.8 km of SMC, MOWRAM and PDOWRAM requested to include improvement of relevant SCs and their related structures the scope because of urgent and higher necessity of them and also accruing the benefits from the irrigated fields. It is deemed that this request is appropriate from technical viewpoint The works to be additionally requested consist of; (a) Rehabilitation, improvement and repair of canals section, and (b) Rehabilitation and new construction of related structures
- Development of tertiary system in Model Area	MOWRAM requested to include the model area development proposed in M/P in the area of upstream part (upto 7.8 km) of SMC (a) Rehabilitation and improvement tertiary irrigation canals, and (b) Rehabilitation and improvement of tertiary drains

**1; Minutes of Discussions on Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project, signed on February 25, 2011*
**2; Supply canal; Canals directly branched from approach channels between the Regulator and Intakes*
Source: JICA Survey Team

(3) Priority Ranking for Works included in Scope of RCHRSP

As mentioned above, the works originally included in scope of RCHRSP are increased as per the request of MOWRAM and PDOWRAM in connection with the rehabilitation of upstream 10 km of NMC and SMC. It is not sure presently that all of these works could be implemented at the same time in the available loan amount. These examined works are given priority ranking based on the following criteria:

- The works indispensable for attaining at the objective of RCHRSP (rehabilitation of the regulator and the intakes at Roleang Chrey Headworks) are given high priority.
- Urgently required works for proper operation of irrigation system are given priority.
- The facilities which need large scale rehabilitation to convey irrigation water are given priority.
- The facilities which require only minor rehabilitation like maintenance works, are accorded to not high priority.
- The facilities for which the basic data/information on survey, plan and design is available, are given high priority.

Table AD-2.1.1.4.3 Priority Ranking of Each Work

Examined Scope by JICA Survey Team		Priority
(a) Hardware Components		
1) Rehabilitation of Roleang Chrey Headworks	a) Renewal/Construction of regulator gates,	◎
	b) New construction of river outlet structure gate with guide frames and manually operated hoists	○
	c) Introduction of remote control system	◎
	d) New construction of inlet and outlet fixed trash racks	◎
	e) New provision of downstream protection works	◎
	f) New provision of retaining wall	◎
	g) New construction of by-pass for releasing low water to the downstream reach	◎
2) Rehabilitation of Andong Sla Intake including Replacement of Radial Gate	a) Renewal/Provision of intake gates	◎
	b) New construction of gate piers	◎
	c) New construction of downstream protection	◎
	d) Partial rehabilitation of approach channel	◎
3) Rehabilitation of Vat Krouch Intake Structure	a) Renewal/Provision of intake gates	◎
	b) Partial improvement of supply canal	△
	c) New construction of structures on supply canal	△
4) Rehabilitation of NMC and SMC with Length of	a) Partial improvement of canal embankment	○
	b) Partial enlargement of canal section	○

Examined Scope by JICA Survey Team		Priority
9.1 km and 9.8 km respectively, with Related Structures	c) Partial improvement of bank of canal crossing reservoir	○
	d) Replacement or improvement of structures on Main Canal	○
	e) New construction of structures on Main Canal	○
5) Rehabilitation of secondary canals and Related Structures	a) Partial rehabilitation, improvement and repair of canals section	△
	b) Partial rehabilitation and new construction of related structures	△
6) Development of Tertiary Canal System in Model Area	a) Partial rehabilitation and improvement Tertiary Canals	△
	b) Partial rehabilitation and improvement of Tertiary Drains	△

**: High Priority: ◎, Medium Priority: ○, Low Priority: △*
Source: JICA Survey Team

Table AD-2.1.1.4.3 Priority Ranking of Each Work

Examined Scope by JICA Survey Team		Priority
(a) Hardware Components		
- Rehabilitation of Roleang Chrey Headworks	(a) Renewal/Construction of regulator gates,	◎
	(b) River outlet structure gate with guide frames and manually operated hoists	○
	(c) Introduction of remote control system	◎
	(d) Inlet and outlet fixed trash racks	◎
	(e) Provision of downstream protection works	◎
	(f) Provision of retaining wall	◎
	(g) Construction of by-pass for releasing low water to the downstream reach	◎
- Rehabilitation of Andong Sla Intake including Replacement of Radial Gate	(a) Renewal/Provision of intake gates	◎
	(b) Construction of gate piers	◎
	(c) Construction of downstream protection	◎
	(d) Rehabilitation of approach channel	◎
- Rehabilitation of Vat Krouch Intake Structure	(a) Renewal/Provision of intake gates	◎
	(b) Improvement of supply canal	△
	(c) Construction of structures on supply canal	△
- Rehabilitation of North and South Main Canals with Length of 10 km each with Related Structures	(a) Improvement of canal embankment	○
	(b) Enlargement of canal section	○
	(c) Improvement of bank of canal crossing reservoir	○
	(d) Replacement or improvement of structures on Main Canal	○
	(e) Construction of new pump station	○
	(f) Construction of structures on Main Canal	○
- Rehabilitation of SCs and Related Structures	(a) Rehabilitation, improvement and repair of canals section	△
	(b) Rehabilitation and new construction of related structures	△
- Tertiary Canal in Model Area	(a) Rehabilitation, improvement and repair of canals section	△
	(b) Rehabilitation and new construction of related structures	△

**: High Priority: ◎, Medium Priority: ○, Low Priority: △*
Source: JICA Survey Team

AD-2.1.1.5 Irrigation and Drainage Water Requirements and Design Discharges

(1) Estimate of Irrigation Water Requirement and Design Discharge

Irrigation water requirement in previous F/S was reviewed based on the proposed cropping pattern, which consists of early variety and medium variety of paddy and upland crop in a year with overall cropping intensity of 114% with 80% dependability, as mentioned in Clause AD-2.1.1.3. The irrigation efficiencies to determine the design discharge of the respective irrigation facilities are assumed as follows:

Table AD-2.1.1.5.1 Assumed Irrigation Efficiencies

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

Source：The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008

The design discharge for the respective canals is then calculated with the above irrigation efficiency as follows:

Table AD-2.1.1.5.2 Irrigation Water Requirement and Design Discharge for RCHRSP

Description	Design Value
Irrigation water requirement	
- Main canals	1.60 lit/sec/ha
- Secondary canals	1.41 lit/sec/ha (=1.60 x 0.88)*[1]
- Tertiary canals	2.10 lit/sec/ha (15.7 mm/day × 10,000 / 86,400 / 0.85)*[2]
Design discharge	
- NMC	10.4 m^3/sec (1.60 lit/sec/ha × 6,500 ha)
- SMC	16.3 m^3/sec (1.60 lit/sec/ha ×10,200 ha)
- River outlet structure	5.0 m^3/sec*[3]

Remarks: 1; Irrigation efficiencies for paddy are assumed at 66% for overall and 88% for main and secondary canal
2; Design discharge for tertiary canal should be determined at land preparation time when more water is required for 20 days for one tertiary block
3: Basic Design Report of Japan's Grant Aid Project. 2009

Source： The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008

(2) Design Flood Discharge and Water Level at Headworks

Basic design values such as design flood discharge and water levels for the rehabilitation of the headworks are referred to those in the D/D of the Japan's Grand Aid project and remain unchanged, as summarized below.

Table AD-2.1.1.5.3 Design Flood Discharge and Water Level of Roleang Chrey Headworks

Description	Design Value
Design flood discharge for headworks	1,600 m^3/sec (1 in 50 years)
Water Level at headworks	
- High water level	36.00 m
- Low water level at Intakes	35.70 m

Source: Basic Deign Report of Japan's Grant Aid Project, 2008

(3) Design discharge for Irrigation Facilities

Drainage water requirement in F/S was applied, which was estimated with the condition that 3-day continuous rainfall should be drained within 3 days, using the maximum 3-day rainfall data in Kampong Speu from 2001 through 2006. The drainage water requirement was estimated at 5.0 lit/sec/ha

AD-2.1.2 Design of Irrigation and Drainage Facilities

AD-2.1.2.1 General

RCHRSP aims at securing stable water distribution to whole Roleang Chrey Irrigation System through (i) rehabilitation of the key irrigation facilities, consisting of the headworks and upper reaches of the NMC and SMC and (ii) demonstration of proper O&M of rehabilitated tertiary irrigation system in the Model Area. The total area covering whole Roleang Chrey Irrigation System is estimated at 16,910 ha of existing physically cultivated area in this irrigation system, which will be used for project evaluation of RCHRSP.

Table AD-2.1.2.1.1 Relation of Whole Roleang Chrey Irrigation System Area and RCHRSP Area

Description	Area
Roleang Chrey Irrigation System	16,910 ha for project evaluation
RCHRSP Area South Upstream area directly benefited from the rehabilitation of upstream parts of SMC (9.8 km) and secondary canals	570 ha including 220 ha to be implemented by TSC-3

Source: JICA Survey Team

AD-2.1.2.2 Roleang Chrey Headworks

(1) Hydromechanical Works of Roleang Chrey Regulator

(a) Alternatives for Renewal of Regulator Gates

For the rehabilitation of the Roleang Chrey Regulator gates, the following alternatives plans are examined.

- Alternative-1 : Renewal of regulator gates as shown in Figure AD-2.1.2.2.1
- Alternative-2 : Renewal of regulator gates and construction of stoplog with monorail hoist for future maintenance as shown in Figure AD-2.1.2.2.2

The above two alternatives have been studied comparatively, considering convenience for maintenance and repair works, construction period and cost. The results of the study are shown in Table below.

Table AD-2.1.2.2.1 Comparison Study for Renewal of Regulator and Construction of Stoplog

Item	Alternative-1 Renewal of Regulator Gates		Alternative-2 Renewal of Regulator Gates and Construction of Stoplog	
Rehabilitation Plan	- Renewal of gates, hoists with hoist deck and staircase - Construction of gate remote operation system		- Renewal of gates, hoists with hoist deck and staircase - Construction of gate remote operation system - Modification of piers and abutment provided on inlet portion of regulator - Construction of stoplog with monorail hoist and operation bridge	
Construction Procedure	1) Construction of river diversion 2) Removal of existing hoists, hoist decks and gate leaves 2) Installation of gates, hoist deck and hoists 3) Dry test 4) Removal of cofferdam,		1) Construction of river diversion 2) Modification of piers and abutment to extend them to providing stoplog facility 3) Installation of stoplog 4) Installation of gates, hoist deck and hoists 5) Dry test 6) Removal of cofferdam	
Maintenance and Repair of Gate Leaf	- Very difficult to carry out since the gate cannot be opened fully for maintenances without lowering upstream water level.	△	- Easy to carry out one by one without lowing the upstream water level.	○
Construction Period	- Short (2 dry seasons for gate installation)	○	- Long (1 dry season for stop log installation and 3 dry season for gate installation)	×
Construction Cost	- Low (US$4.0 million for gates)	○	- High (US$4.9 million for gates and stop logs)	×
Evaluation	- Excellent for construction cost and construction period. - The repair work such as gate repainting and replacement of rubber seals can be carried out at off-crop season since such works were made about every 15 years.	○	- Inferior to construction cost and construction period. - Modification work of piers and abutments is complicated and is required for long construction period and for high cost. - Renewal work of one regulator gate is made in one dry season without river diversion.	×

Remarks : ○: Recommendable, △: Medium, ×: Not recommendable
Details of comparison of cost and construction period are referred to Table AD-2.1.2.2.2
Source : JICA Survey Team

As the result of the comparative study, Alternative-1 is selected.

(b) Design Features

The general features for the proposed regulator gates are summarized as follows.

1) Quantity : 5 sets
2) Gate
   - Type of gates : Steel made plate girder construction fixed wheel type gate
   - Clear span : 12,500 mm
   - Gate height : 6,700 mm
   - Design water level : EL. 36.000 m
   - Sill elevation : EL. 29.000 m on datum line
   - Design head : 7.0 m
   - Sealing method : 3 edges rubber seal at the upstream face of gate
3) Hoist and hoist decks
   - Type of hoist : Electrically driven wire rope wound type stationary hoist without counter weight (Two drums with one motor type).
   - Operation head : 7.0 m
   - Hoisting speed : 0.3 m/min + 10%
   - Operation method : Local and remote control

(2) Hydromechanical Works of River Outlet Structure

It is required to supply water having regulating capacity of 5 m^3/sec to the downstream irrigation area constantly. Such small amount of discharge cannot be handled from a regulator gate continuously by the technical point of view that it is hardly possible that the gate is partially opened at 4 to 5 cm opening and kept its position in long period since the gate leaf is damaged by the harmful vibration and noise caused by such small partial gate opening. Therefore, the river outlet structure is to be constructed at the right bank of the regulator. The hydromechanical equipment consists of four sets of river outlet gates, four sets of inlet trashracks and 2 sets of outlet trashrack. Four sets of river outlet gates is to be installed at the inlet; two sets for regulating discharge, and another two sets for repair and maintenance purposes. The inlet trashrack will be installed in front of the gates in order to prevent entrance of foreign materials and floating logs. The outlet trashracks are to be provided at the outlet to ensure safety of the local residents. The general features for the proposed hydromechanical equipment to be provided in the river outlet structure are summarized as follows.

(a) River Outlet Gates

1) Quantity : 4 sets
2) Gate
   - Type of gates : Steel made plate girder construction slide type gate
   - Clear span : 1,000 mm
   - Clear height : 1,000 mm
   - Design water level : EL. 36.000 m
   - Gate operation water level : EL. 36.000 m
   - Sill elevation : EL. 31.000 m
   - Design head : 5.000 m
   - Sealing method : 4 edges rubber seal at the downstream face of gate
3) Hoist
   - Type of hoist : Electrically driven single rack type stationary hoist
   - Operation head : 5.000 m

- Hoisting height : Not less than 1.2 m
- Hoist deck elevation : EL. 37.000 m
- Operation method : Local and remote control

(b) Inlet Trashracks

- Type : Slant type fixed trash rack
- Quantity : 4 sets
- Clear span : 1,000 mm
- Vertical height : 3,000 mm
- Gradient : 1:0.3
- Slant length : 3,132 mm
- Bar pitch : 75 mm (center to center)
- Design head : Water head difference of 1.0 m

(c) Outlet Trashracks

- Type : Vertical type fixed trashrack
- Quantity : 2 sets
- Width : 1,250 mm
- Height : 1,400 mm
- Bar pitch : 150 mm (center to center)
- Design head : Water head difference of 0.4 m

(3) Hydromechanical Works of Andong Sla Intake

The intake gates provided in Andong Sla Intake in NMC should be renewed with new ones in order to recover their function since they are deteriorated. It is decided that two gates provided in the center portions of intake are to be renewed and the inlet portions of another two intake gates are plugged upon dismantling all existing gates judging from 10.4 m^3/sec of design discharge. The general features of the proposed Andong Sla Intake gates are summarized as follows.

(a) Quantity : 2 sets

(b) Gate

- Type of gates : Steel made plate girder construction radial gate
- Clear span : 4,000 mm
- Clear height : 2,700 mm
- Radius of gate : 5,000 m
- Design water level : EL. 36.000 m
- Gate operation water level : EL. 36.000 m
- Sill elevation : EL. 32.000 m
- Design head : 4.000 m
- Pin elevation : EL.36.000 m
- Sealing method : 4 edges rubber seal at the upstream face of gate

(c) Hoist

- Type of hoist : Electrically driven rack type stationary hoist
- Operation head : 4.000 m
- Hoisting height : Not less than 2.8 m
- Operation method : Local and remote control

(4) Hydromechanical Works of Vat Krouch Intake

The intake gates provided in Vat Krouch Intake in SMC should be renewed with new ones in order to recover their function since they are deteriorated. The size and quantity of intake gates are to be changed as per the reconstruction of intake structure due to increase of water supply to SMC. The general features for the proposed Vat Krouch Intake gates are summarized as follows.

(a) Quantity : 2 sets

(b) Gate

- Type of gates : Steel made plate girder construction radial gate
- Clear span : 4,000 mm
- Clear height : 3,000 mm
- Design water level : EL. 36.000 m
- Gate operation water level : EL. 36.000 m
- Sill elevation : EL. 32.000 m
- Design head : 4.000 m
- Sealing method : 4 edges rubber seal at the upstream face of gate

(c) Hoist

- Type of hoist : Electrically driven rack type stationary hoist
- Operation head : 4.000 m
- Hoisting height : Not less than 3.0 m
- Operation method : Local and remote control

(5) Civil Works at Headworks

(a) Roleang Chrey Regulator

The Roleang Chrey Regulator, except downstream side slope protection, is presently in stable condition although small-scale scouring is observed at immediately after downstream apron. To keep or rather heighten such stable condition and to ensure the reliable release to downstream reach, it has been proposed to conduct the following works in the previous F/S and D/D of the Grant Aid Project:

1) Provision of Downstream Apron

The downstream apron with baffle block and end sill should be provided additionally. Its required length is 23.48 m. Besides, backfill concrete for excavated portion and riprap will be provided to protect the river bed from the scouring. The USBR III type dissipater to dissipate the hydraulic energy within downstream apron is selected in the previous studies. The bottom elevation of downstream apron is provided at EL.26.00 based on the topographic survey that shows the existing river bed elevation is from EL.26.00 to EL.27.00. The main features of downstream apron are as follows, and the general plan of rehabilitation for Roleang Chrey Regulator is shown in Drawings.

- Length = 23.48 m
- Bottom elevation = EL.26.00 m
- Baffle block Height = 2.25 m
  Width = 1.70 m
  Space = 1.70 m
  Slope = 1:1.00
- End sill Height = 2.50 m
  Slope = 1:1.50

2) Provision of Retaining Wall

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

3) Construction of River Outlet Structure

To ensure the release of small discharge for the downstream reach, it has been proposed to construct a by-pass with river outlet structure. The capacity of the river outlet structure is 5.0 m^3/sec. The structure consists of inlet, pipe conduit with 1.0 m diameter and outlet impact box. The design drawings are shown in Drawings.

(b) Andong Sla Intake

1) Improvement plan of Gate

It is proposed to apply the following improvement plan:

- To design the four gate portions.
- Out of them, to install two gates to ensure the discharge of 10.4 m^3/sec.
- To provide a concrete wall for remaining two portions, so as to enable to install a gate each in the future.
- Height of gate = Flood water level of EL.36.00 m
- Design bed elevation of EL.32.00 m + free board of 0.30 m = 4.80 m

2) Retaining Wall

The retaining wall will be provided at left and right banks. The retaining wall will be of L-shaped reinforced concrete type.

3) Downstream Apron

The reinforced-concrete-made downstream apron will be constructed. The apron is provided with baffle block and end sill as USBR III type due to hydraulic calculation to dissipate the hydraulic energy within the apron. After the apron, concrete protection slab and gabion mattress will be provided to avoid scouring by sudden change of roughness coefficient.

4) Approach Channel

Since the approach channel has a flow capacity of about 70 m^3/sec according to the hydraulic calculation, 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, any expansion is not required. In addition, no erosion is found at the side slope of channel, so that rehabilitation is not required. The design drawings for Andong Sla Intake are shown in Drawings.

(c) Vat Krouch Intake

1) Upstream and Downstream Transitions

To smoothly connect the culvert with upstream and downstream canal with trapezoidal section, the reinforced concrete transition is provided at the both side slopes of canals. The canal bed at transition is protected with gabion mattress. The pervious Japan' Grant Aid Project did not include the rehabilitation of Vat Krouch, and hence the design in this Survey is based on the previous design in JICA M/P with modification of that gate type was changed from slide gate into radial gate.

2) Protection of Upstream and Downstream Canal Beds

Gabion mattress is provided on the canal bed before and after the transition, to protect the canal bed from scouring.

3) Rehabilitation of Approach Channel

The existing section needs to be enlarged, and the proposed rehabilitation works as shown in Sub-clause AD-2.1.1.4 is also included in the Sub-project

AD-2.1.2.3 Irrigation and Drainage System

Based on the basic concept for irrigation and drainage rehabilitation plan discussed in Sub-clause AD-2.1.1.3, facilities to be rehabilitated and/or reconstructed under RCHRSP are shown in the following table.

- Sub-project Area : 16,910 ha
- (Model Area) : (350 ha)
- NMC : Upstream part of the length of 9.1 km from Andong Sla Intake
  Design discharge: 10.4 m^3/sec at beginning point
  Bottom width : 4.00 m, Canal height 3.0 m, bank width 3.0 m
  Inspection road : width 4.0 m, Laterite pavement: 3.0 m width
  Side slope of canal bank: 1:1.50 (vertical to horizontal),
- SMC : Upstream part of the length of 9.8 km from Vat Krouch Intake
  Design discharge: 16.3 m^3/sec at beginning point
  Bottom width : 4.00 m, Canal height 3.0 m
  Inspection road : width 4.0 m, Laterite pavement: 3.0 m width
  Side slope of canal bank: 1:1.50 (vertical to horizontal),
- Structures : Proposed structures for rehabilitation are listed in the following table.

Table AD-2.1.2.3.1 List of Structures on Main Canals to be Rehabilitated

Proposed Structure to be Rehabilitated	Unit	Quantity	
		NMC	SMC
Check structure. New	nos.	0	1
Check structure. Removing	nos.	0	1
Check structure. Replacement	nos.	0	1
Turnout, New	nos.	0	2
Turnout, Replace	nos.	11	5
Bridge, New	nos.	0	3
Bridge, Removing	nos.	0	1
Bridge, Replace	nos.	2	0
Foot Pass, New	nos.	1	0
Spillway	nos.	1	2
Box culvert	nos.	0	0
Drain inlet	nos.	6	5

Source: JICA Survey Team

The profiles of NMC and SMC and related structures are shown in Drawings. Quantities of earthworks are estimated based on the preliminary hydraulic design with the sample topographic survey on the sections which requires large scale works (refer to Attachment AD-A3 and Drawings).

In principle, the canals and structures are design referring and based on the previous design made in F/S, however design of spillway is additionally done in this Survey. There are some level crossing reservoirs with single band on NMC and SMC where there are constraints on keeping design water level in the canal and evacuating flood discharge from existing spillways. Therefore, additional embankment at the reservoir and spillway are designed in order to disassociate their functions of reservoir and canals. Preliminary design is shown in the Drawings.

Rehabilitation of secondary canal are designed based on the proposal by PDOWRAM and justification by the Survey Team with reference to the previous designs in JICA F/S and topographic survey for the sample canals (refer to Attachment AD-A-3 and Drawings). Proposed rehabilitation works for secondary canals are summarized as below.

Table AD-2.1.2.3.2 List of secondary canals to be Rehabilitated

Name of Secondary Canal	Length (m)	Proposed Structures to be Rehabilitated (nos.)		
		Check	Turnout	Drain Inlet
(1) NMC area				
Thmey-1	2,500		3	3
Phum Thmey-2	850	2	2	
Thmey-3	3,000	3	3	
Kravein-1	2,450	3	8	
Kravein-2	810		3	2
Sampove-1	5,000	2	2	
Prey Beng-1	1,640	6	6	
Sampove-2	1,200	3	3	
Prey Beng-2	1,800	4	4	
Sub-total		23	34	5
(2) SMC area				
Koh Té-1	1,000	3	3	
Koh Té-2	1,750	3	3	
Thnol Bom Bek	2,150	6	6	
Phum Roung	3,000	6	6	
Phum Skous-1	2,000	2	2	
Phum Skous-2	2,800	5	5	2
Bak Thmenh	6,000	5	5	
Sub-total	6,000	30	30	2
Total	37,950	53	64	7

Source: JICA Survey Team

AD-2.1.3 Rehabilitation Method and Construction Schedule

AD-2.1.3.1 Hydromechanical Works

(1) Regulator Gates

The critical path of the construction works will be the rehabilitation of the hydromechanical works at the Roleang Chrey Headworks. The rehabilitation of regulator gates is carried out by the procedure mentioned in Table below.

Table AD-2.1.3.1.1 Installation Procedure for Regulator Gates

Step No.	Procedure	Description of Work	Main Construction Equipment	Works by
1	Preparatory Work	(a) Arrangement of stock yard and site office. (b) Preparation of construction equipment/materials to site upon stockyards.	-	Hydromechanical works
		- Leveling pavement of bridge to work 20 to 40 ton class mobile crane. - Reinforcement of bridge to be required, if it is judged that strength is not enough for working crane on it.	-	Civil works
2	River diversion	- Coffer dam to be provided	-	Civil works
3	Demolishing Existing Equipment	(a) Demolishing existing hoists and hoist decks upon disassembling them (b) Demolishing existing gate leaf upon cutting in blocks (c) Cleaning the installation area	- 20 ton mobile crane provided on bridge - Gas cutting machine - Welding machines - Chain blocks, etc. - Scaffolding	Hydromechanical works

Step No.	Procedure	Description of Work	Main Construction Equipment	Works by
4	Installation of gate leaf	(a) Setting out through survey (b) Installation of track rails (c) Temporary works such as setting steel supports, scaffolding and anchoring (d) Lowering segments of gate leaf (e) Assembling gate leaf (f) Welding field joints upon aligning	- Survey instrument - 35ton rough terrain crane or 40 t crawler crane provided on bridge - Welding machines - Chain blocks, etc. - Scaffolding	
5	Installation of hoist deck	(a) Setting main girders and fixing anchor (b) Assembling and fixing aux. beams to main girders (c) Installation of new staircase		
6	Installation of hoists	(a) Lifting drum units, shafts and motor unit (b) Assembling and aligning hoist (c) Electrical wiring and setting control cabinets (d) Connecting wire ropes with gate leaf and adjusting (e) Overall adjusting and trial operation		
7	Dry test	(a) Dry test by local control panel (b) Dry test by remote control panel	-	
8	Demolishing coffer dam	- Coffer dam to be demolished.	-	Civil Works

Source :JICA Survey Team

The rehabilitation of regulator gates should be carried out during the limited period between December 11 and April 20 since the water cut-off period should be set up during the dry season of December to April and the water cut- period for construction of cofferdam is required for 10 days from December 1 to 10 and its removal work is also 10 days from April 20 to 30. It is estimated that the rehabilitation of all 5 gates cannot be carried out in one dry season since the dry test for all gates is inevitably finished on May 15. The rehabilitation plan for 3 gates per one dry season is considered and such rehabilitation is completed by April 20. Therefore, it is planed that the rehabilitation of regulator gates is to be carried out dividing two dry seasons; three gates in first dry season and remaining two gates in second dry season.

(2) River Outlet

The construction of hydromechanical equipment provided in river outlet structure is carried out by the procedure mentioned in the following table.

Table AD-2.1.3.1.2 Installation Procedure for Hydromechanical Equipment for River Outlet Structure

Step No.	Procedure	Description of Work	Main Construction Equipment	Works by
1	Preparatory Work	(a) Arrangement of stock yard and site office. (b) Preparation of construction equipment/materials to site upon stockyards.	-	Hydromechanical works
2	River diversion	- Coffer dam to be provided	-	Civil works
3	Construction of Civil Structure	- Construction of civil structure	-	Civil works
4	Installation of Guide Frames and Supporting Beams of Gate and Trashracks	(a) Setting out through survey (b) Temporary works such as setting steel supports, scaffolding and anchoring. (c) Installation of guide frames of slide gates, anchor frames for spindle supports and hoist base frames in the blockouts (d) Installation of embedded parts and supporting beams of trashracks in the blockouts	- Survey instrument - Welding machines - Chain blocks, etc. - Scaffolding	Hydromechanical works
5	Second Stage Concrete	- Placement of second stage concrete in the blockouts - Curing the second stage concrete	-	Civil works

Step No.	Procedure	Description of Work	Main Construction Equipment	Works by
6	Installation of Gate and Hoist	(a) Setting gate leaf with rack bars (b) Installation of hoist and hoist decks (c) Connection rack to hoist (d) Electrical wiring and setting control cabinets (e) Connecting wire ropes with gate leaf and adjusting (f) Overall adjusting and trial operation	- Survey instrument - 10 t track crane - Welding machines - Chain blocks, etc. - Scaffolding	Hydromechanical works
	Installation of Trashrack	(a) Setting and fixing trashrack panels (b) Connecting panels with supporting beams with bolts		
7	Dry test	(a) Dry test by local control panel (b) Dry test by remote control panel	-	
8	Demolishing coffer dam	- Coffer dam to be demolished.	-	Civil Works

Source: JICA Survey Team

The rehabilitation of hydromechanical equipment to be provided in the river outlet structure should be carried out during the limited period between December 11 and April 20. The required construction period of hydromechanical equipment to be carried out in dry condition upon providing cofferdam is estimated as shown bellow.

Table AD-2.1.3.1.3 Required Construction Period for Hydromechanical Equipment for River Outlet Structure[1]

Work Item	Work Period (Days)	Remarks
Installation of Guide Frames and Supporting Beams of Gate and Trashracks	10	- Installation of trashracks to be done in parallel with that of gates
Installation of Gate and Hoist	12	- Including dry test - Electrical wiring to be carried in advance of installation of gates

1: Reconstruction works for civil works do not include.
Source: JICA Survey Team

(3) Andong Sla Intake Gates

The rehabilitation of Andong Sla Intake gates is carried out by the procedure mentioned in Table below.

Table AD-2.1.3.1.4 Rehabilitation Procedure for Andong Sla Intake Gates

Step No.	Procedure	Description of Work	Main Construction Equipment	Remarks
1	Preparatory Work	(a) Arrangement of stock yard and site office. (b) Preparation of construction equipment/materials to site upon stockyards.	-	Hydromechanical works
2	River diversion	- Coffer dam to be provided	-	Civil works
3	Demolishing Existing Equipment	(a) Demolishing existing gate leaves hoists and hoist decks upon disassembling them (b) Cleaning the installation area	- 10 ton mobile crane provided on bridge - Gas cutting machine - Welding machines - Chain blocks, etc. - Scaffolding	
4	Demolishing and Construction of Civil Structure	- Demolishing piers, walls and decks of existing civil structure - Construction of civil structure except for the portion for anchorage to be installed.	-	Civil works
5	Installation of Anchorages	(a) Setting out through survey (b) Temporary works such as setting steel supports and anchoring in side piers (c) Installation of anchorages	- Survey instrument - Welding machines - Chain blocks, etc. - Scaffolding	Hydromechanical works
6	Second Stage Concrete	- Placement of second stage concrete for side piers - Curing the second stage concrete	-	Civil works
7	Installation of Guide Frames	(a) Setting out through survey (b) Temporary works such as setting steel supports, scaffolding and anchoring. (c) Installation of guide frames of slide gates, anchor frames for spindle supports and hoist base frames in the blockouts	- Survey instrument - Welding machines - Chain blocks, etc. - Scaffolding	Hydromechanical works

Step No.	Procedure	Description of Work	Main Construction Equipment	Remarks
8	Third Stage Concrete	- Placement of third stage concrete in the blockouts - Curing the second stage concrete	-	Civil works
9	Installation of Gate and Hoist	(a) Setting gate leaf with rack bars (b) Installation of hoist and hoist decks (c) Connection rack to hoist (d) Electrical wiring and setting control cabinets (e) Connecting rack with gate leaf and adjusting (f) Overall adjusting and trial operation	- Survey instrument - 10 t track crane - Welding machines - Chain blocks, etc. - Scaffolding	Hydromechanical works
10	Dry test	(a) Dry test by local control panel (b) Dry test by remote control panel	-	
11	Demolishing coffer dam	- Coffer dam to be demolished.	-	Civil Works

Source: JICA Survey Team

The rehabilitation of the intake gates should be carried out during the limited period between December 11 and April 20. The required reconstruction period is in dry condition upon providing cofferdam is estimated bellow.

Table AD-2.1.3.1.5 Required Rehabilitation Period for Andong Sla Intake Gates[1]

Work Item	Work Period (Days)	Remarks
Demolishing existing gates and hoists	4	
Installation of Anchorages	8	- Excluding the working days for second stage concrete placement
Installation of Guide Frames	10	- Excluding the working days for third stage concrete placement
Installation of Gate and Hoist	14	- Including dry test - Electrical wiring to be carried in advance of installation of gates

1: Reconstruction works for civil works do not include.

Source :JICA Survey Team

(4) Vat Krouch Intake Gates

The rehabilitation of Vat Krouch intake gates is carried out by the same procedure as Andong Sla Intake gates. The required reconstruction period is the same period as Andong Sla Intake gates. The minimum requisite periods for design, material procurement, manufacturing and transportation to the site which are performed by the gate manufacture after the signing of Contract are estimated as mentioned in Table below.

Table AD-2.1.3.1.6 Minimum Requisite Periods for Design, Manufacturing and Transportation to Site

No.	Description	Minimum Requisite Period (month)
1	Design works including site survey	4
2	Approval of design by Engineer	2
3	Procurement of material	6
4	Transportation to Site	2

Source: JICA Survey Team

The overall implementation schedule for the hydromechanical works for Roleang Chrey Headworks is shown in attached Figure AD-2.1.3.1.1.

AD-2.1.3.2 Civil Works at Headworks and Irrigation and Drainage System

Main and secondary canals with related structures should be completed within the dry season in 3 years. Contractor for the work will be selected through international competitive bidding (ICB), while ones for tertiary development will be executed by the national contractor selected through the national competitive bidding (NCB). Time required from the commencement of D/D to the end of rehabilitation work would be 6 years as shown in Figure AD-2.1.3.2.1. Overall implementation schedule of SPPIDRIP is attached in Figure AD-2.1.3.2.2 including both RCHRSP and USISRSP.

Work Item	Year								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
1. Detailed design including preparation of tender documents									
2. Tendering, evaluation, and contract									
3. Rehabilitation Works									(4 years)
(1) Mobilization and preparatory works									
(2) Project site office									
(3) Design, fablication and transportation of hydromechanical works									
(4) Installation of hydromechanical works									
(5) Civil works at headworks									
(6) Main and secondary canals, drains and related facilities									

: Rainy season (May to Oct.)

Source: JICA Survey Team

Figure AD-2.1.3.2.1 Implementation Time Schedule for Main System of RCHRSP

Tertiary development in Model Area of 350 ha consisting of construction and rehabilitation of tertiary canals and drains will be implemented following the rehabilitation work for headworks and main and secondary canals. D/D for tertiary development would be prepared by the national consultant with close coordination with PDOWRAM, FWUC and TSC-III, and based on the design for the main system. The delineation of tertiary block and alignment of Tertiary Canals are to be agreed by FWUC and land owners. Period of detailed design is estimated at one year and construction period is estimated at set at 2 years depending on land acquisition process as shown below.

Work Item	Year								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Construction of Tertiary System									
(1) Detailed design									
(2) Tendering, evaluation, and contract									
(3) Construction work for tertiary system									

Source: JICA Survey Team

Figure AD-2.1.3.2.2 Implementation Time Schedule for Tertiary Development in Model Area of RCHRSP

AD-2.2 Upper Slakou Irrigation System Rehabilitation Sub-project

AD-2.2.1 Irrigation and Drainage Development Plan

AD-2.2.1.1 General

(1) Objective

Objective of irrigation and drainage development plan for USISRSP is to ensure water resources for irrigation for the Upper Slakou Area by rehabilitating the existing irrigation and drainage facilities.

(2) Location and Irrigation Area

The USISRSP Area of 3,500 ha in total is located about 70 km southwest from Phnom Penh and extends mainly on the right bank of the Slakou River. The irrigation area of USISRSP Area is administratively extending in Takeo Province, bordering on the Slakou River in the north, National Road 130A in the south and the west, and on the national road No.2 in the east.

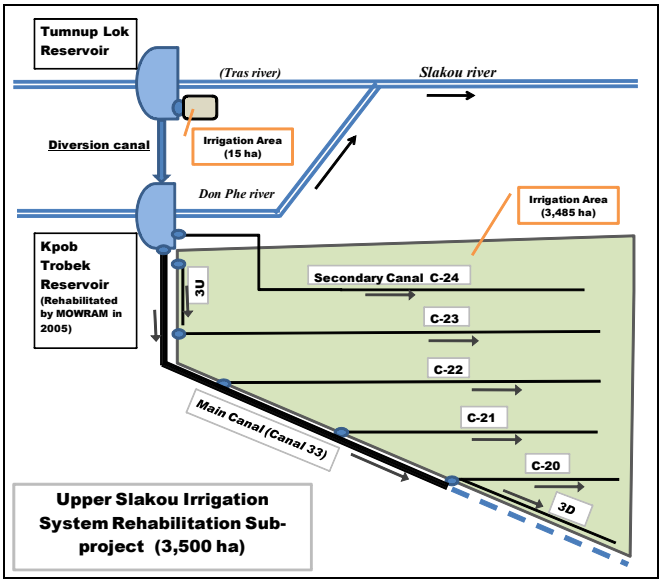


Figure AD-2.2.1.1.1 Schematic Diagram of Sub-project

(3) Water Resource and Irrigation Facilities

Water resources and diversion facilities of USISRSP are (i) Tumnup Lok reservoir on the upstream of the Slakou River (Tras Stream), (ii) Kpob Trobek reservoir on the Don Phe Stream, which is a tributary of the Slakou River, and (iii) diversion canal from Tumnup Lok Reservoir to Kpob Trobek Reservoir. It is noted that the left bank of Tumnup Lok Reservoir is in Kampong Speu Province and the drainage area of the Don Phe River originates in Kampot Province. The target irrigation area consists of (i) 3,485 ha commanded by Main Canal 33 (7.3 km), Canal 24 and six Secondary Canals which branch off from Main Canal 33 (44.7 km in total of the Secondary Canals), and (ii) 15 ha commanded directly by Tumnup Lok Reservoir. The existing irrigation facilities, major roads and the proposed irrigation area are shown in Figure AD-2.2.1.1.2 and Drawing USS-01.

AD-2.2.1.2 Present Conditions of Irrigation and Drainage

(1) Tumnup Lok Reservoir

Tumnup Lok Reservoir on the Slakou River was constructed in 1976 under the Pol Pot regime. The main dike runs north-to-south at about 1.3 km across the Slakou River, along which three gated spillways exist and an intake facility to the Diversion Canal existed on the right bank at 600 m from the existing river course. The dike was damaged by floods that occurred in 1980s and at the beginning of 1990s, then was finally flushed away for about 180 m in length beside the northern-most spillway on the left. Since then, the reservoir has lost its function as a reservoir and also as a diversion facility. The existing river bed level is at about EL. 36.0 m, while the dike top level lies at about E. 43.5 m. The spillways and the intake facilities are not being used at all. Another part of the main dike was also flushed away for about 120 m in length at about 480 m on the left bank from the river course.

Slakou River and Breached Dike of Tumnup Reservoir

The geological formation inside the reservoir below 2 to 7 m from the ground surface is silty sand, and sandy silt and has N value of 10 to 37 (rather dense). The geological formation below such layer is clay layer with a thickness of 3 to 4 m, and its N value is 10 to 50. Below this layer, weathered rock (silty stone) exists, of which the N value is more than 50. The clay layer and weathered rock have a high enough bearing capacity for 5-7 m high embankment and ordinary concrete irrigation structure.

The dike made by clayey sand (SC) and silty sand (SM) seems safe against slope failure, but it has a possibility of piping by water seepage and erosion by rainfall and waves in the reservoir that could result in collapse of dike. Therefore, the existing dike should be protected by borrowed material on the inner surface of the dike and filter material on the toe of the outer surface. River bed materials near the reservoir will be collected and utilized as the filter material.

(2) Diversion Canal

The Diversion Canal starting at Tumnup Lok Reservoir runs southward for about 5 km into Ou Krouch River. Then, another canal starts at O Saray Reservoir and runs for about 5 km toward Kpob Trobek Reservoir. Even having some sedimentation, the enough canal section has been maintained and the canals could be utilized although certain minor rehabilitation works are required. However, for a stretch

of 3 km at O Saray, a new canal connecting the Diversion Canal should be constructed to make a detour around the river. The Diversion Canal does not currently have the function of "diversion from the Slakou River", but part of it works as a drain to catch the surface water from the western part of the area and to drain it to the Slakou River via the Ou Krouch Stream.

Canal Condition of the Diversion Canal

According to the inventory survey made in 2011, 4 bridges are on the canal route, and one place near the temple was embanked for road crossing. Erosion of canal slopes seems progressed due to sandy soils and inflows of rain water, and no maintenance. Detailed information of the survey points are presented in ANNEX D, ATTACHMENT -4.

(3) Kpob Trobek Reservoir

Kpob Trobek Reservoir is located on the Don Phe River, a tributary of the Slakou River. The main dike runs from west to east for 2.9 km, and two sub-dikes about 600 m in length were constructed southward on both ends of the main dike. The Diversion Canal was connected at the west-side sub-dike, and 2 gated spillways were constructed along the main dike. An intake structure with a pipe culvert to Canal 24 was constructed at 350 m from the east end of the main dike. Another intake structure for Main Canal 33 exists at the eastern end of the main dike, while another intake for Koh Kaek Main Canal is located 150 m along the eastern sub-dike. The geological formation inside the reservoir is alternating layers of silty sand (SM), and sandy clay (CL) with a thickness of 6 to 10 m and N value of 10 on average. Below such layers, a firm sandy clay exists which has N value of more than 50. The material of the existing dike is silty sand and sandy clay which have N value of 20 to 50. The material of existing dike has the same soil mechanical nature with that of Tumnup Lok Reservoir dike.

Gated Spillway and Bridge on Kpob Trobek Reservoir

The dike was breached at the center of the main dike and flushed away for about 180 m by a flood that occurred in 1990s. The gates of all intake structures were damaged and did not function. The damaged portion of the dike was repaired but the dike top elevation remains lower by 2 m than that of the adjacent part of the main dike. Under the urgent rehabilitation work of MOWRAM in 2005, the following structures were rehabilitated and re-constructed:

- dike at breached portion of 180 m,
- flood spillway with automatic gates (6 nos.) at the breached section,
- bridge of 80 m on National Road 130A at the above spillway,
- two intake structures for Main Canal 33 and Secondary Canal (C-24), and
- two maintenance gate structures (west and east gates)

The risk against floods is high at the present and urgent repair is expected. Seepage and erosion are also reported on the repaired dike. The dike is used as National Road No. 130A and paved by asphalt in 2008.

(4) Automatic Spillway Gates on Kpob Trobek Reservoir

(a) Present condition of spillway gates

Six sets of flap type spillway gates having 8.0 m wide by 1.8 m high provided on Kpob Trobek Reservoir were completed in 2005. The conditions of these spillway gates were examined through site inspection and hearing from Takeo PDOWRAM early in July 2011.

As the result of hearing, the operation record of 6 gates is as shown below.

Table AD-2.2.1.2.1 Gate Operation Record

Gate No.	Gate Operation Record*
1, 2 ,6	These gates have never been opened since they were completed
3	This gate was opened 3 times per the past year.
4	This gate was opened 1 time per the past year.
5	This gate was opened only one time after completion.

**: Water levels when the gates were opened were unknown.*
Source: JICA Survey Team

Further, the following defects were observed by the visual inspection.

- Any lubricant is not applied to all bearing blocks since all grease nipples are removed from all bearing blocks of hoists. Therefore, all bearings of hoists are contaminated by rust and dust.
- Painting material is peeled off from some surfaces of all gates and hoists and such areas become rusty.
- Some counter weight chambers are contaminated by trash and rubble of concrete.

(b) Design concept of automatic gates

The flap gates are operated automatically by the counter weight provided in the chambers of both sides of piers as shown on Figure below.

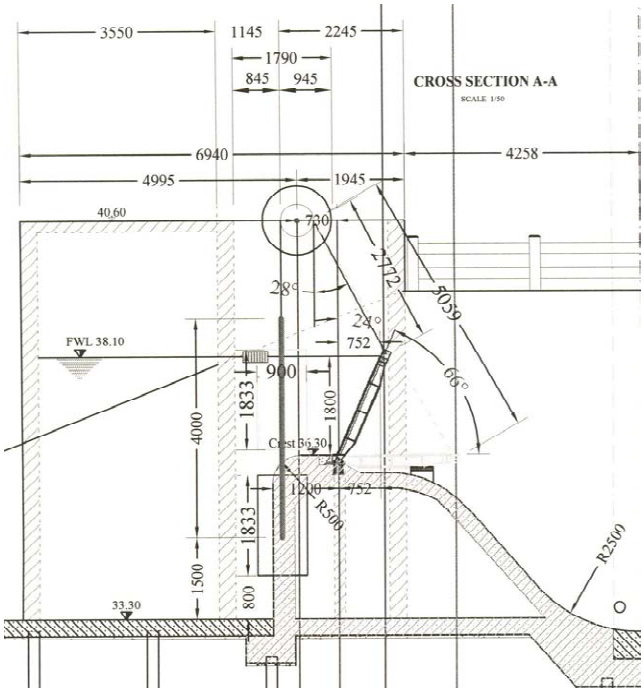


Figure AD-2.2.1.2.1 Profile of Spillway Gates

The automatic operation of gates is designed by the following design concept.

- The gates are kept in closed position by the dead weight of counter weight until the reservoir water level reaches around FWL.38.1 m since the load to open the gate due to rotation moment

by the water pressure load, dead weight of gate and other friction forces are lower than the dead weight of counter weight.

- When the reservoir water level reaches FWL. 38.1 m, firstly No.3 gate is opened fully because the load to open the gate at such water level overcomes the dead weight of counter weight.
- In order to avoid simultaneous opening operation for all gates, it is designed that the dead weight of counter weights for other gates is heavier than that for No.3 gate and the other gates are opened in order when the reservoir water level reaches above FWL. 38.1 m.
- All gates are closed again when the dead weight of counter weight overcomes the load to open the gate at a certain water level.

(5) Main Canal 33

Main Canal 33 starts at Kpob Trobek Reservoir, and runs eastward along National Road No. 130A and No. 132 for about 16 km to National Road No.3. Of 16 km, a 7.3 km stretch of the canal is used for USISRSP from the beginning point to Ta Phem Commune.

According to the inventory survey made in 2011, shape of the most canal sections still remains enough to flow the irrigation water as well as drainage water from the southern high lands. Most of the canal sections have a capacity of 5.0 m^3/sec or more. These sections could be utilized by re-shaping of section as proposed in F/S. Many structures are found on the canal as tabulated below. All related structures have malfunctioned due to deterioration or loss of gates, erosion of surrounding slopes, etc., which requires reconstruction. It is noted that many structures were constructed on the canal. Removal of these obstructions might be needed prior to start the implementation of USISRSP by MOWRAM.

Table AD-2.2.1.2.2 Nos. of Structures on Main Canal 33

Canal	Survey Length (m)	Division Structure	Culvert with Grooves (Regulator)**	Public Bridge/ Culvert	Private Bridge /Culvert	Buildings within ROW	Total
Main Canal 33*	7,730	4	7	7	45	25	88

**: Since Main Canal 33 run along National Road 130A, many buildings were constructed.*
***: Grooves are provided at inlet of culverts to place planks, but no gate is placed.*
Source: JICA Survey Team

(6) Secondary Canals

Seven existing secondary canals would be rehabilitated under USISRSP. One secondary canal, Canal 24, starts at Kpob Trobek Reservoir, but other six canals are branched off from the Main Canal 33. The intake structure of Canal 24 commanding 561 ha in net was reconstructed in 2005 under the urgent rehabilitation of MOWRAM. First 1 km section is functional as an irrigation canal, but downstream sections are not used as an irrigation canal, but for the drainage canal.

Canal 24 and Deteriorated Division Structure

Six existing secondary canals along Canal 24 would also be rehabilitated under USISRSP. These are Canal 23 (net command area is 774 ha), Canal 22 (609 ha), Canal 21(490 ha), Canal 20 (619 ha) and Canal 3U and 3D (432 ha, opposite side of Canal 33). These canals run eastward at an interval of 1 km from north to south. The top width of the canals ranges from 5 to 10 m. Most of the related structures such as diversion and off-take structures have deteriorated and should be replaced.

According to the inventory survey made in 2011, shape of the most canal sections still remain to flow the irrigation water as well as drainage water from the southern high lands. Due to no supply of irrigation water for more than nearly 30 years and no substantial maintenance work for flow sections by PDOWRAM and beneficial farmers, canal section has become flat and widened. Re-shaping of canal sections taking into account the capacity of drainage requirement as proposed by F/S would be needed. Many structures are found on the canal as tabulated below. It is found that no water control structure such as gated check structures and turnout were designed and constructed, though water conveyance structure such as bridge and culverts were only constructed. All related structures except culverts under public roads have malfunctioned due to deterioration, erosion of surrounding slopes, etc., which require reconstruction. All necessary water control structures needed to be replaced and additionally be constructed.

It is noted that many structures were constructed on the Secondary Canals, especially along secondary canals of 3U and 3D which run along the National Road 130 A. Removal of these facilities might be needed prior to start the implementation by MOWRAM.

Table AD-2.2.1.2.3 Nos. of Structures on secondary canals

Canal	Survey Length (m)	Division Structure	Culvert with Grooves (Regulator)**	Public Bridge/Culvert	Private Bridge/Culvert	Buildings within ROW	Total
Total	53,840	1	21	58	212	25	317
C20	(7,930)	(0)	(2)	(9)	(28)	(3)	(42)
C20S	(990)	(0)	(0)	(1)	(8)	(1)	(10)
C21	(8,280)	(0)	(6)	(9)	(26)	(0)	(41)
C22	(9,850)	(0)	(2)	(8)	(26)	(1)	(37)
C23	(10,700)	(0)	(4)	(14)	(40)	(1)	(59)
C24	(6,050)	(1)	(0)	(6)	(12)	(0)	(19)
3U*	(1,510)	(0)	(2)	(1)	(7)	(5)	(15)
3D*	(8,530)	(0)	(5)	(10)	(65)	(48)	(128)

**: Since SCs 3U and 3D run along National Road 130A, many buildings were constructed.*
***: Grooves are provided at inlet of culverts to place planks, but no gate is placed.*
Source: JICA Survey Team

(7) Tertiary Canals

There are no systematic Tertiary Canal systems, though some small scale canals are branched off from SCs. It seems that area of about 100 ha surrounded by SCs is irrigated by field-to-field (plot-to plot) irrigation. Such irrigation practice requires longer time for irrigating the tail-end than irrigation through Tertiary Canal system, and makes irrigation efficiency lower. Formation of systematic Tertiary Canal system would be required to utilize the irrigation water efficiently and timely.

(8) Drainage Facilities

In the USISRSP Area, most of the existing canals have double functions of irrigation and drainage. The irrigation canal has the same cross-section (capacity) from the beginning to the tail end, for draining inflow from the surrounding field to the downstream area. The drained water is re-used as “return flow” in the downstream areas. Considering the present drainage condition and difficulty in securing land for drainage canals, it is judged that that drainage of the area should be maintained as it is as proposed in F/S. In other word, neither construction of new drainage canal nor drainage improvement is planned, but the improvement of the irrigation condition would be focused.

AD-2.2.1.3 Examination of Previous Development Plans

(1) Basic Concept for Development

Low and unstable agricultural production under the mono culture of rain-fed paddy in the USISRSP Area has caused mainly by (i) non-availability of irrigation water due to serious damages of water

resource facilities as well as deteriorated and mal-designed irrigation system, and (ii) less knowledge and poor experience on improved farming technologies. Since the aim of Sub-project is to attain the improvement of agricultural productivity through timely and stable water supply to fields and provision of agricultural support services in the area, the review on the project scope proposed by MOWRAM will be carried out under the basic concept of "integrated approach of hardware and soft ware aspects to ensure the smooth implementation and the sustainability". This Sub-clause deals with hardware component of USISRSP.

Most of the existing irrigation facilities were constructed in the mid1970s during the Pol Pot regime, and they now require significant rehabilitation and/or reconstruction to ensure stable irrigation farming. The basic policy of rehabilitation of these facilities is to make both initial construction cost and O&M cost as low as possible with due consideration to maintain sufficient function, safety and durability. To meet this, the purpose of the plan would not be to seek for the "perfect" outcome, but to provide the minimum function required for ensuring water resources for irrigation.

Considering the above, the required rehabilitation works will be planned in the following basic concept:

- Reliability level of irrigation supply is set at 4 in 5 years or 80%
- Design flood discharge of 1-in-100-year recurrence period is adopted for rehabilitation of reservoirs
- 24-hour water conveyance will be applied for diversion, main and secondary systems
- Existing dikes of the reservoirs would be utilized as much as possible
- Existing canal section would be utilized and canal lining would not be considered in principal
- Related structures of the canal, both in terms of structure and materials, would be designed to conform with those that PDOWRAM generally design and construct in Takeo Province
- No substantial improvement is considered for drainage system

The review and examination on the irrigation and drainage development plan is carried out based on (i) field reconnaissance including interviews to and discussions with concerned agencies and farmers, and (ii) inventory survey of the existing canals for 71 km and related structures of 102 nos. on the canals. The inventory survey conducted for examining the conditions of canal at every 500 m and those of every structure, as well as all obstructions such as huts and buildings of 50 nos. and private bridges and culverts of 260 nos. on canals. Details of the survey results are presented in Attachment -4.

(2) Water Balance Study

(a) Water Demands

1) General

The water demand consists of (i) irrigation water requirement for the irrigation area, and (ii) river maintenance flow for the Slakou River to conserve the riverain environment downstream of the Tumnup Lok Reservoir. The maintenance flow was not considered in F/S in 2002. According to Takeo PDOWRAM, no downstream users exist at present.

2) Irrigation Water Requirement

Based on the revised cropping pattern, which consists of two times rice crops and one diversified crop per year as mentioned in ANNEX C, the irrigation water requirement was re-calculated. The calculation is made for half monthly basis and using updated potential evapo-transpiration rate at

Pochentong Observatory, and rainfall data at Basedth instead of that at Takeo. Rainfall station at Basedth is located at 11 km northwest from the irrigation area, but Takeo station used in F/S is at 25 km west. Other conditions such as water saving irrigation method, percolation rate, irrigation efficiency are not changed from those applied in F/S. As a result, peak water requirement of the revised cropping pattern for 3,500 ha having 80% dependability is estimated at 3.5 m^3/sec, which is the same value estimated in F/S. Details of the estimate are presented in the following Sub-clause of AD-2.2.1.5.

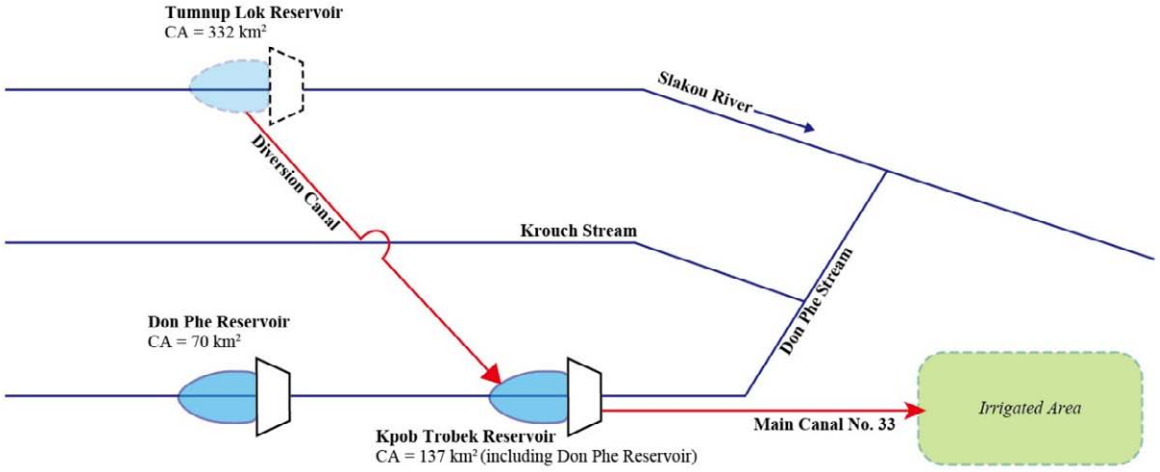
3) River Maintenance Flow

The river maintenance flow is considered for the Slakou River too. The maintenance flow at the Tumnup Lok Reservoir having catchment area of 332 km^2 is set at 0.051 m^3/sec (or 51 lit/sec) throughout a year. The flow is estimated based on that applied for the Roleang Chrey Headworks on the Prek Thnot River. Namely maintenance flow at the Roleang Chrey Headworks having catchment area of 3,911km^2 is estimated at 0.6 m^3/sec as explained in ANNEX C, then that for the Slakou river is estimated at 0.051 m^3/sec in proportion to the catchment area.

(b) Water Balance Calculation

1) Calculation Method and Conditions

Water balance study was executed for 20 years from 1966 to 2000 in F/S. In the review in 2011, the water balance calculation is made for 30 years by adding 10 years from 2001 to 2010. The water balance is calculated on the half-monthly basis as applied in F/S. The system has two reservoirs, Tumnup Lok on the Slakou River and Kpob Trobek on the Don Phe River. Two reservoirs are connected by the Diversion Canal as shown in Figure AD-2.2.1.3.1. The effect of Don Phe Reservoir, located 13 km upstream of the Kpob Trobek Reservoir with irrigation area of 700 ha, is also taken into account in the same manner with F/S.



Source: JICA Survey Team

Figure AD-2.2.1.3.1 Schematic Diagram of Water Resources

On the other hand, as for irrigation area by Don Phe Reservoir, Kampot PDOWRAM planed that irrigation area after rehabilitation by International Fund for Agricultural Development (IFAD) in 2006 would be 2,000 ha in the rainy season and 500 ha in the dry season. However, this irrigation plan of Kampot PDOWRAM, say 2,000 ha in the rainy season and 500 ha in the dry season would be so large as compared with the specific irrigable area per catchment area related to the USISRSP Area, say 9 ha/km^2 (3,500 ha/ (332 km^2 of Tumnup Lok Reservoir + 67 km^2 of Kpob Trobek Reservoir) =

9 ha/km^2). Assuming this specific irrigable area per catchment area and 70 km^2 of catchment area of Don Phe Reservoir, the irrigation area by Don Phe Reservoir would be roughly calculated to be approximately 630 ha. Considering the result of this review and accuracy of calculation, it can be said that 700 ha of the assumed irrigation area in F/S as mentioned above is applicable for the water balance study.

Runoffs for these streams are estimated on a monthly basis at Kpob Trobek Reservoir and Tumnup Lok Reservoir, respectively. The dimensions of concerned reservoirs applied for the water balance calculation are tabulated as below.

Table AD-2.2.1.3.1 Storage Capacity Applied for Water Balance Study

Item	Unit	Tumnup Lok	Kpob Trobek	Don Phe
Effective Storage Volume	(MCM)	1.00	2.63	2.50
Catchment area	(km^2)	332	137	70

Source: JICA Survey Team

2) Result of Water Balance Calculation

Possible irrigation area is estimated using irrigation water demand per 1,000 ha of each crop proposed, the river maintenance flow, river runoffs, and storage effects of reservoirs. As a result, the following extent of crops could be realized with 80% dependability.

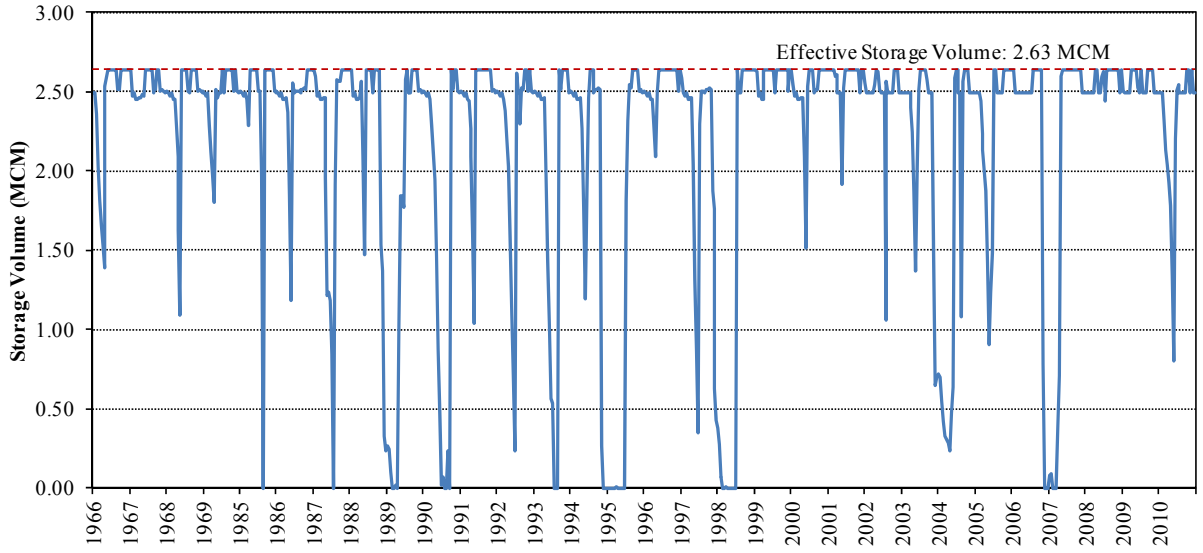
Table AD-2.2.1.3.2 Results of Water Balance Study (Unit: ha)

Stage	Medium Paddy (RS)	HYV-1 Paddy (RS)	HYV-2 Paddy (Early RS)	Diversified Crop-1 (Early RS)	Diversified Crop-2 (Early RS)	Crop Intensity Per Year
F/S in 2002	2,400	1,100	-	500	550	130%
Review in 2011	2,400	1,100	200	-	200	111%

Source: JICA Survey Team
Note: RS means "Rainy Season".

Extent of rainy season paddy is 3,500 ha in total as estimated in F/S. Paddy in the early rainy season and diversified crops in the late rainy season is limited at 200 ha, respectively. Cropping intensity of the irrigation area would be 111%. USISRSP would provide supplemental irrigation water for the rainy season, but not for the dry season due to lack of water resources.

The changes of storage volumes of the Kpob Trobek Reservoir under the above cropping pattern for 30 years are shown below.



Source: JICA Survey Team

Figure AD-2.2.1.3.2 Changes of Storage Volumes of Kpob Trobek Reservoir

Serious deficits more than half month occur six times in 1989, 1990, 1993, 1994～1995, 1998, 2006～2007, and short time deficits for a half month occur in years of 1985 and 1987.

(3) Reservoir Rehabilitation Works

(a) Tumnup Lok Reservoir

No rehabilitation/reconstruction work has been implemented for the reservoir since the F/S in 2002. So, there is no significant change of the existing conditions and facilities, but some 20 houses have been constructed inside the reservoir since 2007. The flood discharge with return period of 1 in 100 years is revised at 450 m^3/sec, through the hydrological review in 2011. Revised discharge is increased by 7% from 420 m3/sec estimated in F/S in 2002. Consequently, the width of weir-type spillway is to be lengthened to 230 m from the proposed length of 215 m in F/S. The review results of the proposed work in F/S are tabulated below and the general layout plan of the reservoir is given in Figure AD-2.2.1.3.3 and Drawings USS-04 and 05.

Table AD-2.2.1.3.3 Review of Tumnup Lok Reservoir

Item	F/S	Review in 2011
(a) Compensation for submergence of the existing farm land	Since 1990's, farmers have used the reservoir area as cultivated land, mainly paddy fields. The estimated area of affected land would be 130 ha (220 ha at FWL). Compensatory work for the land use is to be provided by MOWRAM	MOWRAM is confident of successful implementation of the compensation for the land within the reservoir area and has started part of compensation work.
(b) Dike	Bearing capacity of the foundation is suitable for concrete structures and /or constructing dike of about 5-7 m high. Re-shaping of the existing dike, protection of the slope on the reservoir side with impervious	The proposed work is acceptable with condition that further investigations about the foundation and embankment materials will be made in the design stage.
	materials such as borrowed material, and laying filter materials on the opposite slope of the dike would be required.	
(c) Spillway	An overflow-type fixed weir of 215 m long is proposed for preventing damage to the dike due to operational failure.	Considering remote location of the site and future maintenance of the spillway, over-flow type is suitable. Width of spillway would be lengthened to 230 m due to change of flood discharge.
	Design flood discharge of 420 m^3/sec, which is 1-in-100-year recurrence period, is adopted.	Design Manual of MOWRAM recommends to take 50-200 years return period. Updated design flood discharge is estimated at 450 m^3/sec (107% of 420 m^3/sec)
	No bridge over the spillway is proposed for the spillway portion, but the crest width of 4 m for access during dry season is provided	Access to the right bank from the left bank is available via Basedth town. No provision of bridge is suitable for saving construction cost.
(d) Maintenance gate	Sand flushing gate is needed to reduce the sediment in the reservoir. Provision of one maintenance gate structure with two manual gates of 1.5 m × 1.5 m	The gate would also be used for releasing river maintenance flow to the downstream
(e) Intake structures	Three intake structures were planned: one is for the diversion canal and other two are for two tertiary blocks of 15 ha in total downstream the reservoir	Two intake structures for tertiary blocks might be integrated into one. These two structures are located within 200 m.

Source: JICA Survey Team

(b) Kpob Trobek Reservoir

Based on the results of M/P Study and F/S in 2002, MOWRAM has implemented a part of the proposed works, namely urgent rehabilitation work for the Kpob Trobek Reservoir in 2005. The urgent work implemented by MOWRAM consists of (i) re-construction of breached dike for 180 m and raising dike elevation for full length of 3.3 km, (ii) construction of gated spillway with bridge, (iii) replacement of intake structures for the Main Canal 33 and Canal 24, and (iv) replacement of 2 maintenance gate structures on the dike, as illustrated in Figure AD-2.2.1.3.4. Above works of MOWRAM for Kpob Trobek Reservoir is examined as tabulated below, based on the design drawings

of gated spillway of MOWRAM (refer to Drawing USS-13), and updated flood discharge of the Don Phe River at the reservoir site.

Table AD-2.2.1.3.4 Comparison of Design Values of Spillway on Kpob Trobek Reservoir

Item	F/S (2002)	Existing Spillway Constructed by MOWRAM* (2005)	Remarks
FWL	EL. 38.1 m	EL. 38.1 m	No change
HWL	EL. 37.3 m	EL. 37.3 m	No change
LWL	EL. 34.2 m	EL. 34.2 m	No change
Length of spillway	160 m	48 m	about 1/3 of one proposed in F/S
Nos of gates	0	6	F/S proposed non-gated spillway considering future operation and maintenance
Type and size of gate	-	Automatic flap gate with counter weight, 8 m wide × 1.8 m high	
Crest EL. of fixed weir	EL. 37.3 m	EL. 36.3 m	1 m below than one proposed in F/S
Road (dike) surface elevation	EL. 39.0 - 39.3 m	EL. 39.0 - 39.3 m	No change
Bridge on the spillway	Causeway was proposed	Road bridge of 80 m long for national road No.130A	The road surface was paved by asphalt in 2008
Design flood discharge	195 m^3/sec Return period of 100 year	203 m^3/sec Updated flood discharge with 100 years return period	Design Manual of MOWRAM recommends to take 50-200 years return period
Flow capacity of Spillway	196 m^3/sec OK	209 m^3/sec OK	Gated spillway has C value of 1.8 (narrow weir)

Source: JICA Survey Team

As the result of the above examination, it is judged that the new spillway and dike have been constructed as proposed in F/S and new spillway has enough capacity even against updated flood discharge. Intakes and maintenance gates are also in good condition. The current problem is some seepage and erosion of the dike.

(c) Proposed Improvement work for Automatic Spillway Gates on Kpob Trobek Reservoir

Judging from the present condition, operation record and design concept, it could be said that all gates function. However, it is proposed that the following improvement work on flap gates should be carried out to operate the gate surely and safely.

- The existing concrete made of counter weights of all gates should be replaced with steel made counter weights which should be divided into several pieces to easy adjust their weight in order to open the designated water levels of each gate.
- The designated water levels and weight of counter weight of each gate should be decided in the coming D/D Stage after due consideration of the reservoir operation.
- All bearings of hoists should be renewed with new ones since it is deemed that the sticking of such bearing due to rust and no lubricant are increased friction force for the rotation of wire drums. It is noted that such necessity of replacement was confirmed by the joint inspection the mechanical engineers of MOWRAM and the JICA Survey Team on July 25, 2011.
- The repair painting should be applied to the damaged area of all gate leaves.

(4) Diversion Canal Rehabilitation Works

Proposed alignment of the Diversion Canal in F/S for 9.4 km was planned to utilize the existing canal route, except detour route near passing point with the Krouch River by a siphon structure, then connects the existing Diversion Canal to Kpob Trobek Reservoir (FigureAD-2.2.1.3.5). The designed longitudinal gradient of the canal was set at 1 in 4,400, and canal bed width of 2.0 m. The water depth is 1.4 m for the designed discharge of 3.5 m^3/sec. The section was planned to be lined with borrowed

material as the results of alternative study on lining. Review results of the Diversion Canal based on the observation in the fields are tabulated as below.

Table AD-2.2.1.3.5 Review of Diversion Canal

Item	F/S	Review in 2011
(a) Canal route	Utilizing the existing canal except crossing point with Krouch river	No serious obstruction is found, the proposed route in F/S could be applicable to avoid land acquisition.
(b) Canal Cross section and lining	Due to low degree of erosion resistance of existing canal bank materials, the canal bank is to be lined by borrowed material	Serious erosion of side slopes of the canal is observed. Erosion of side slopes has progressed. Lining of 0.5 m thickness is to be planned as proposed in F/S
(c) Siphon across the Krouch River	75 m long with double barrel of 1.3 × 1.3 m each was proposed through comparison with aqueduct.	Topography is flat and no suitable site to construct aqueduct; according to the study in M/P, construction of the O Saray Reservoir is not economical. The siphon plan is reasonable.
(d) Excavation of sediments on the canal bed	Excavate the canal bed for 1-1.5 m	After Sta. 0+700 m, sedimentation on the bottom of the canal has been increased due to erosion of slopes and inflows from adjacent areas
(e) Road bridge	Three road bridges were proposed at crossing point with National Road 130A and commune road near temple and O Saray River	Since one bridge near O Saray River was constructed in 2006, road bridge to be constructed would be two only
(f) Slope protection for outer bend portion	Not included	Serious erosion is found at the bend portion near the Temple (Sta. 2+800)

Source: JICA Survey Team

As the result of review, minor adjustment of proposed plan of F/S for number of road bridge, and additional work for slope protection by solid material would be needed.

(5) Irrigation and Drainage Canal Facility Rehabilitation Works

(a) Main Canal 33

According to F/S, the design discharge of Main Canal 33 at the beginning point is 3.2 m^3/sec, and reduces to 1.0 m^3/sec by the end point (diversion point to Canal 20). However, the canal would also have function as a drain. The existing canal section has the capacity to serve as a drain at the bottom part of the section. Using the unit drainage requirement of 1.6 lit/sec/ha, the drainage capacity of 2.0 m^3/sec for a catchment of 12 km^2 would be needed as the minimum capacity of the Canal.

The following are the review results of Main Canal 33 based on the observation in the fields:

Table AD-2.2.1.3.6 Review of Main Canal 33

Item	F/S	Review in 2011
(a) Canal route	Utilizing the existing canal	Full utilizing the existing canal is acceptable
(b) Canal cross section and lining	Proposed canal dimensions are: bed width of 2.0 m, design water depth of 1.2-1.6 m with flow velocity of 0.4 - 0.6 m/sec. No lining is proposed	The present canal is used for dual purpose of irrigation and drainage. So the section is much larger than the proposed section, namely bottom width of more than 5 m and height of 2 - 3 m. Canal sections remain as proposed in F/S as the minimum section.
(c) Off-takes with regulating structures	Six off-takes with regulating structures were proposed.	All the existing off-takes and regulating structures are found not functional and new structures are needed. No change from the proposal in F/S
(d) Drop structures	Four nos. of drops were proposed to keep allowable velocity in the canal	All the existing drops are found not functional and new structures are needed. No change from the proposal in F/S
(e) Private access over the canal	No description	Several private access structures across the canal are found, other than road culverts identified in F/S. Integration of these access would be needed

Source: JICA Survey Team

No significant change from proposal in F/S would be needed, except treatment of private accesses over the canal.

(b) Secondary Canals

Seven SCs of 44.7 km in total were planned to distribute irrigation water to farm land through Tertiary and Watercourses. Although the design capacity from the irrigation requirement varies from 0.2 to 0.85 m^3/sec, the capacity of the existing SCs would also be maintained to drain the excess water flowing from the surrounding fields. Assuming that the area of tertiary blocks along a stretch of the SC is 120 ha, a capacity of about 200 lit/sec (120 ha × 1.6 lit/sec/ha ≈ 200 lit/sec) would be maintained for the stretch. The drained water (200 lit/sec) would be discharged through a side spillway constructed at the end of the stretch into a lateral drain

The following are review results of SCs based on the observation in the fields:

Table AD-2.2.1.3.7 Review of SCs

Item	F/S	Review in 2011
(a) Canal route	Utilizing the existing canal	No serious obstruction is found , except SC of 3U, and 3D along National Road 130A Removal of obstructions would be needed
(b) Canal section and lining	Most of canals are proposed to be unlined canal, but 10.3 km (or 23%) out of 44.7 km is proposed to be lined by earth or soil cement, to maintain the minimum permissible velocity	Canal lining would not be required for maintaining the minimum velocity, but for preventing leakage and grass growth. 5 km or about 10% of total length might be needed for the canal lining for the permeable sections.
(c) Related structures	Diversion structures, off-takes, regulators, drops, road crossing structures and cross drains are proposed	All existing structures are seriously deteriorated and not functional, except some culverts and bridges on commune and village roads. So, all the required structures shall be newly constructed in principal

Source: JICA Survey Team

Treatment of obstructions on the canal routes especially for 3D and 3U, such as private access constructed by backfilling the canal, concrete access and temporary huts, would be needed by MOWRAM. Lining could be reduced to 10% of the total length of SCs.

(c) Tertiary blocks

As stated previously, there is no systematic Tertiary Canal system at present. The irrigation area was planned to be divided into 106 tertiary blocks with average area of 33 ha in F/S. Assuming 1,000 m long of Tertiary Canal per 33 ha, its total length would be estimated at 110 km. In each tertiary block, Watercourses are proposed for commanding 5 ha per watercourse. Length of the Watercourse may be 1,200 m per 5 ha, or 1,260 km for whole area of 3,500 ha. Construction of Tertiary Canal was considered to be conducted by local contractors, while Watercourses would be constructed by beneficial farmers. Alignment of Tertiary Canals as well as size of tertiary blocks would be determined by FWUC under support of PDOWRAN. Land required for Tertiary Canals and Watercourses would be provided by beneficial farmers. The following are review results of the tertiary blocks:

Table AD-2.2.1.3.8 Review of Tertiary Blocks

Item	F/S	Review in 2011
(a) Tertiary blocks	Irrigation area of 3,500 ha is divided into 106 tertiary blocks with average extent of 33 ha	Although the "Design Manual of MOWRAM" in 2004 recommended the maximum extent of block of 25 ha, the layout of blocks seems to meet the actual filed conditions. Layout plan of tertiary blocks would be finalized based on the manual and intensions of concerned beneficiaries
(b) Provision of land for canals	Land for tertiary canals is assumed to be provided by the beneficiary farmers.	According to the experience of TSC, it took very long time to provide the land for tertiary canal. The work for the tertiary development would be implemented by RGC's fund.

Source: JICA Survey Team

Although the necessity of the development for tertiary system is well recognized, it would take long time to provide the land for Tertiary Canals and Watercourses. MOWRAM is therefore requested to take time actions for land acquisition for constructing them

(6) Embankment Materials for Rehabilitation

The soils of the irrigation areas are mainly silty sand, clayey sand, sandy clay, and clay. The embankment materials of rehabilitation of dikes and canals should be borrowed material, clayey gravel, excavated material of the existing dikes, and excavated materials in the area inside the reservoirs and project areas. It is confirmed that the borrowed material and clayey gravel is available at the borrow area adjacent to Prey Kdouch village located about 5 km westward from Trapeang Kranhung. The borrowed material and clayey gravel should be used for slope and surface protection of dike and canals, and surface pavement of roads.

(7) Provision of Operation and Maintenance Equipment

O&M of the irrigation facilities was proposed to be conducted substantially by FWUC in F/S after completion of the construction works and taking over of the facilities. However, the government policy states that O&M of major irrigation facilities should be made by PDOWRAM and that of minor facilities by FWUC. A site office was planned to be constructed independently for the construction management and future O&M. As for office and operational equipment, the following were planned to be procured under USISRSP, while no provision of heavy construction equipment for the maintenance works was proposed by F/S, considering heavy burden for maintaining these heavy equipment:

- O&M office with floor space of 450 m^2; the office is used for both construction management for 11 technical staff and 2 administrative staff, and O&M activities by PDOWRAM
- A four-wheel drive vehicle,
- Eight motorcycles,
- Three walky-talkies,
- One generator,
- Two sets of survey equipment and one set of meteo-hydrological equipment
- Office equipment including the photo copy machines and computers and furniture

It is judged that the proposed procurement plan for O&M facilities is reasonable and acceptable to ensure efficient implementation of project activities by PDOWRAM.

(8) Facilities for Realizing Irrigation Service Fee

ISF collection would be one of the fundamental activities under 6 SC-FWUGs that will be organized by respective SC command area. It was considered in F/S that ISF was usually collected as in-kind paddy and sold to buyers or at markets to provide funds for O&M activities. In the area, there was no suitable place and facility for ISF collection and storage. So F/S proposed to construct and provide the following:

- Community office with storage (500 m^2): 6 numbers
- Drying yard (108 m^2): 6 numbers
- Platform scale (200 kg): 6 numbers

According to the information of the existing Kpob Trobek FWUC, ISF has been collected in cash at Riel 30,000 /ha/year at present. Therefore, it is not necessary to provide any drying yards, platform scale and community office of 6 nos. under USISRSP

AD-2.2.1.4 Proposed Development Plan (Proposed Scope of Sub-project)

(1) Examination of Scope of USISRSP Proposed by MOWRAM

In the previous Sections and Clauses, the works proposed by MOWRAM were examined from technical and economical viewpoints and also considering application of Japan Yen's loan, through review on previous studies like M/P and F/S, site visits, hearing from farmers and a series of discussions with MOWRAM and PDOWRAM. The results of examination are shown in the following table, comparing with the works proposed by MOWRAM:

Table AD-2.2.1.4.1 Examined Scope of USISRSP

Scope Proposed by MOWRAM in M/D*	Examined Scope by JICA Survey Team	Remarks
(a) Irrigation Development Area	(a) Irrigation Development Area	
- 3,500 ha	- 3,500 ha	Justified through water balance study
(b) Cropping Pattern and Crop Intensity	(b) Cropping Pattern and Crop Intensity	
- Rice-based cropping system with upland crops - Crop intensity: 130%	- Rice-based cropping system with upland crops - Crop intensity: 111%	Application of double cropping of rice considering present cropping pattern
(c) Hardware Components	(c) Hardware Component	
- Rehabilitation of two reservoirs including spillway, outlet structures and a diversion canal between the two reservoirs with related structures Tumnup Lok Reservoir Kpob Trobek Reservoir	- Tumnup Lok Reservoir Partial rehabilitation of the existing dike (2.3 km), and new construction of the reservoir facilities including over-flow type spillway of 230 m, one maintenance gate, and 2 intakes for diversion canal. - Kpob Trobek Reservoir Partial minor repairs of flap gates on spillway (6 nos.) and new provision of slope protection for dike (3.3 km).	- Construction of tertiary canal for 15 ha is not included in scope of USISRSP
- Diversion Canal	- Full reshaping and lining of existing canal section (9.4 km), including new construction of 2 bridges, one cross drain and one siphon (75 m long) crossing the Krouch River.	
- Main Canal and related structures	- Partial rehabilitation of Main Canal 33 (7.3 km) including new construction of related structures	
- SCs and related structures	- Partial rehabilitation of 7 secondary canals (44.7 km in total) including new construction of related structures	
- Tertiary Canals and related structures	- New construction of tertiary canals for 110 km and related structures with condition that MOWRAM will provide special arrangement for acquiring land for tertiary canals	Development plan and design for tertiary canals and related structures will be made by employing national consultant. Construction of tertiary canals and related structures will be carried out by local contractors to be selected through LCB. All of the works will be under the responsibility of PMU Japan Support Fund.
	- New provision of O&M facility and equipment	FWUC office is included. But heavy construction equipment is not included.

**: Minutes of Discussion dated February 25, 2011*
Source: JICA Survey Team

(2) Priority Ranking

The examined Sub-project scope consists of many works. It is not sure presently that all of these works could be simultaneously implemented in the available loan amount. Thus, these examined works are given priority ranking based on the following criteria

- The works indispensable for attaining at the aim of USISRSP mentioned above are given high priority.
- Urgently required works for proper operation of irrigation system are given high priority.
- The facilities related to ensuring water resources should be given high priority since USISRSP severely suffers from shortage of irrigation water.
- The facilities which need large scale rehabilitation to convey irrigation water are given high priority.
- The facilities which require only minor rehabilitation like maintenance works, are accorded to not high priority.

Table AD-2.2.1.4.2 Priority Ranking for Each Work (Hardware Component)

Examined Scope by JICA Survey Team		Priority*
(a) Hardware Components		
- Tumnup Lok Reservoir	- Partial rehabilitation of the existing dike (2.3 km)	◎
	- New construction of the reservoir facilities including over-flow type spillway of 230 m, one maintenance gate, and 2 intakes for diversion canal.	◎
- Kpob Trobek Reservoir	- Partial minor repairs of flap gates on spillway (6 nos.)	○
	- New provision of slope protection for dike (3.3 km)	○
- Diversion canal with related structures	- Full reshaping and lining of existing canal section (9.4 km)	◎
	- New construction of 2 bridges, one cross drain and one siphon (75 m long) crossing the Krouch River	◎
- Main canal with related structures	- Partial rehabilitation of Main Canal 33 (7.3 km)	◎
	- New construction of related structures	◎
- Secondary canals with related structures	- Partial rehabilitation of 7 secondary canals (44.7 km in total)	○
	- New construction of related structures	○
- Tertiary canals and related structures	- New construction of tertiary canals (110 km in total). MOWRAM will make special arrangement for acquiring land for tertiary canals timely	△
	- New construction of related structures	△
- Provision of O&M facility and equipment	- New procurement of O&M equipment (vehicle and motor cycles excluding heavy construction equipment, and FWUC office)	△

Source: JICA Survey Team

**: High Priority: ◎, Medium Priority: ○, Low Priority: △*

AD-2.2.1.5 Irrigation and Drainage Water Requirements and Design Discharges

(1) Conditions for Estimating Irrigation Water Requirement

Due to updating of proposed cropping pattern and meteorological data, irrigation water requirement is revised. Major changes are revision of proposed cropping pattern and change of rainfall station from Takeo to Basedth in Kampong Speu. Major conditions revised and/pr updated from the F/S and updated potential evapo-transpiration are tabulated as below.

Table AD-2.2.1.5.1 Comparison of Conditions for Estimating Irrigation Water Requirement

Item	F/S	Review in 2011	Remarks
1 Proposed cropping pattern	One rice crop and two times diversified crops per year	Two times rice crops and one time diversified crop per year	Refer to ANNEX C
2 Irrigation method for paddy	Water saving method* is applied	Considering limited water resource for the area, same method is applied	*: Moderate submergence is only planned during head initiation and flowing period

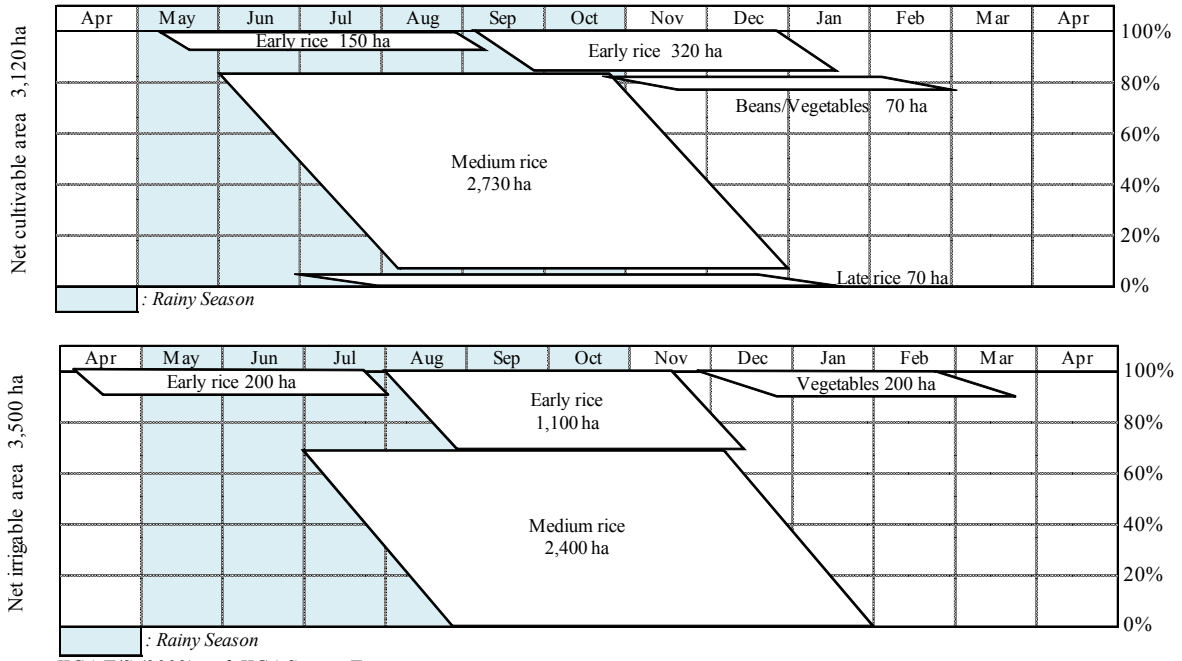
Item	F/S	Review in 2011	Remarks
3 Potential Evapo-transpira-tion	Estimate by Penman method applying metrological data at Pochentong Observatory from 1991-2000	Updated by using same method and including additional data from 2001 to 2011; about 3% increased	No observatory is still available near USISRSP site
4 Rainfall Station	Takeo Takeo Province	Basedth Kampong Speu Province	Basedth station exists 11 km north-west from the center of the irrigation area; Takeo station located at about 25 km west from the irrigation area
5 Duration of rainfall data	1966-1969, and 1985-2000 20 years	1966-1969, and 1983-2010 32 years	Data of 1966-1986, 1995 and 2004 are estimated based on correlation rate with Phnom Srouch station
6 Effective rainfall	Estimate basically based on daily rainfall for 7 years above, One for the other years are estimated by using co-relation of monthly rainfall and effective rainfall at75% for both paddy and upland crops	Applying 75% of monthly rainfall as effective monthly rainfall for paddy and upland crops	In Review stage, effective rainfalls are estimated half-monthly basis for 32 years to provide irrigation water requirement for water balance study
7 Irrigation efficiency	60% for paddy and 55% for upland crops	Do as left	No change
8 Percolation rate for paddy	Assumed 2 mm/day	Do as left	No change
9 Calculation step of irrigation requirement	Half-monthly basis	Half-monthly basis	No change

Source: JICA Survey Team

Table AD-2.2.1.5.2 Updated Potential Evapo-transpirations at Pochentong Observatory

Period	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
At F/S	162	174	216	206	191	167	153	159	140	133	146	156	2,000
Review	165	173	217	208	195	178	164	170	146	142	152	161	2,070

Source: JICA Survey Team



Source: JICA F/S (2002) and JICA Survey Team

Figure AD-2.2.1.5.1 Proposed Cropping Patterns in F/S and Review in 2011

(2) Estimate of Irrigation Water Requirement

Based on the revised and updated data, irrigation water requirements of each proposed crops are estimated as shown in Table AD-2.2.1.5.3 and 2.2.1.5.4. Half monthly irrigation requirements of Local

Paddy (135 days) and HYV Paddy -1 (105 days), which are the major proposed crop for USISRSP. Peak requirements of Local Paddy and HYV-2 Paddy with 80% dry conditions are estimated at 0.92 lit/sec/ha and 1.13 lit/sec/ha. These peak requirements occur in first half-month of November.

Through water balance study based on the revised river runoffs of the Slakou and Don Phe rivers, maintenance flow to downstream to the Slakou River from the Tumnup Lok reservoir, and the updated irrigation water requirement for 30 years, possible irrigation development area with 80% dependability is estimated at 3,500 ha with the following extent of crops:

- Local (Med.) Paddy (135 day in wet season) 2,400 ha
- HYV Paddy-1 (105 days in wet season) 1,100 ha
- HYV Paddy-2 (105 days in early wet season) 200 ha
- Diversified crops (90 days, in late wet season.) 200 ha

Diversion irrigation water requirement at the head of the water resources for the above proposed cropping pattern with 80% dry condition is estimated at 3.45 m^3/sec.

(3) Design Discharge for Irrigation Facilities

Based on the above review, the diversion irrigation water requirement is estimated at 3.5 m^3/sec as estimated in F/S. As for the unit irrigation water requirement for canal design, it is proposed to apply 110% of averaged irrigation requirement of 1.0 lit/sec/ha, considering rather long calculation step of 15 days. Thus, the unit irrigation water requirement is calculated at 1.1 lit/sec/ha, which is equivalent to the peak unit requirement of HYV-2 Paddy. The following is the summary of discussions about irrigation design discharges:

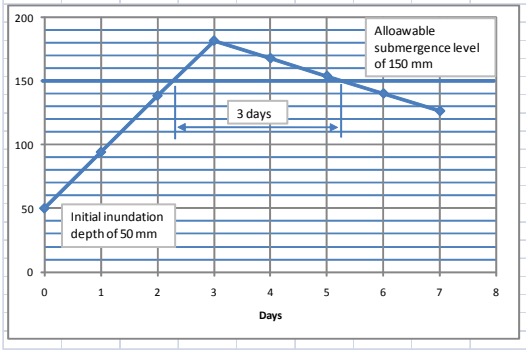
Table AD-2.2.1.5.5 Comparison of Design Discharge of Irrigation Canals

Item	F/S	Review in 2011	Remarks
- Diversion water requirement	3.5 m^3/sec	3.5 m^3/sec	No change
- Unit requirement for main and secondary canals	1.1 lit/sec/ha	1.1 lit/sec/ha	No change

Source: JICA F/S (2002) and JICA Survey Team

(4) Estimate of Drainage Requirement

According to the basic planning concept, substantial drainage improvement was not proposed in F/S, but the utilization of the existing irrigation canals as drainage canal with securing the required flow capacity for drainage was planned. Considering difficulty in land acquisition for drainage canals and main crop of paddy, which has strong resistance against inundation, the proposed concept is acceptable. The unit drainage requirement was estimated for providing the supplemental flow capacity of the irrigation canals.



Source: JICA F/S (2002)

Figure AD-2.2.1.5.2 Estimate of Drainage Requirement

Unit drainage requirement for paddy of 1.6 lit/sec/ha was estimated by F/S based on the following conditions and assumptions:

- Allowable inundation depth 150 mm
- Allowable inundation period 3 days
- Design rainfall 173 mm at Takeo with 1-in-10-year 3-day rainstorm
- Initial water depth in the paddy field 50 mm

For the upland crops, F/S recommended to grow them on the raised ridge of more than 150 mm, considering difficulty in provision of perfect drainage system and less extent of upland crop in the rainy season.

Considering the conditions of USISRSP, no change of drainage requirement of 1.6 lit/sec/ha is made for the review study.

AD-2.2.2 Design of Irrigation and Drainage Facilities

AD-2.2.2.1 General

Irrigation area of USISRSP is located on the left bank of the Slakou River in Tramkak District of Takeo Province. The target irrigation area of USISRSP is 3,500 ha in total, consisting of 3,485 ha fed by Main Canal 33 (7.3 km) and Secondary Canal 24 originated from Kpob Trobek Reservoir, and 15 ha directly fed by Tumnup Lok Reservoir (refer to Drawings USS-01 to USS-03).

Water resources and diversion facilities are Tumnup Lok Reservoir on the Slakou River (the Tras Stream), Kpob Trobek reservoir on the Don Phe Stream, which is a tributary of the Slakou River, and a diversion canal from Tumnup Lok Reservoir to Kpob Trobek Reservoir.

AD-2.2.2.2 Tumnup Lok Reservoir

(1) Main Features (refer to Drawings USS-04 to USS-07)

Tumnup Lok reservoir on the Slakou River was constructed in 1976 under the Pol Pot regime. The main dike runs north-to-south at about 1.3 km across the Slakou River, along which three gated spillways exist and an intake facility to the diversion canal exist on the right bank at 600 m from the existing river course. The dike was damaged by floods that occurred in 1980s and at the beginning of 1990s, then was finally flushed away for about 180 m in length beside the northern-most spillway on the left. Since then, the reservoir has lost its function as a reservoir and also as a diversion facility. Reconstruction of the reservoir is the most desired work in the area. Main features of the reservoir are summarized as below.

Table AD-2.2.2.2.1 Main Features of Reservoir and Related Structures

Item	Description
Water resource and catchment area	Slakou river at 332 km^2
Location of the reservoir	Right bank: Takeo Province, Left bank: Kampong Speu Province
Flood discharge with 100 year probability	450 m^3/sec
Effective storage volume	1.0 million m^3
Storage area at Flood Water Level	220 ha
Flood Water Level (FWL)	EL. 42.4 m
High water level (HWL)	EL. 41.3 m
Low Water Level (LWL)	EL. 40.4 m
Length of reservoir dike	2,468 m
Spillway	Overflow type rock spillway, overflow length of 230 m
Intake structures	One for diversion canal for 3,485 ha and one for tertiary block of 15 ha
Maintenance gate	For flushing sediment and releasing river maintenance flow of 0.051 m^3/sec

Source: JICA Survey Team

(2) Rehabilitation of Dike

According to the results of core boring made in the F/S stage, there is a sandy soil layer of 2~7 m on the surface, which is well compacted with N-values ranging from 10 to 37. Clayey layer under the surface layer has a thickness of 3~4 m with higher N-values of 10 to 50. Both layers would provide sufficient bearing capacity either for concrete structures or embankment of about 5 m in height. According to the results of the soil mechanical test for the embankment materials of the existing dike, it was judged that

the dike has sufficient stability against sliding. However, it was suggested in the F/S report that without any countermeasures, collapse of the dike by infiltration leading to piping might occur. F/S also pointed out risk of erosion on the slope by rain water or waves inside slope of the reservoir. Thus, re-shaping of the existing dike, protection of the slope on the reservoir side with impervious materials such as borrowed material, and laying filter materials (mixture of sand and gravel) on the opposite slope of the dike is planned. The dike top elevation is set at EL. 43.3 m and the width of the dike top is set at 5 m. The general layout plan and profile of the reservoir are given in Drawings USS-04 and 05. As seen in the profile, the right bank side is needed to reshaping with protection work, but left bank side needs new embankment of about 1.2 to 1.5 m high with protection work for 1.5 km long.

For the new embankment section, earth fill type embankment with impervious inclined core zone and semi-pervious shell zone was proposed in F/S. The inclined surface protection on upstream slope using impervious material is also adopted for the rehabilitation of existing dike. The materials for the impervious zone will be borrowed material, clayey gravel and mixed material of borrowed material and clayey gravel with excavated material of the existing dikes and earth inside the reservoir. F/S suggested that the excavated material of the existing dikes and inside the reservoir could be used for shell zone. The proposal of F/S is acceptable considering the low embankment height of a few meters at the maximum and full utilization of available material in the reservoir area.

(3) Spillway

The spillway will be constructed at the damaged portion that was flushed away for 180 m across the existing river course. The overflow length was set at 230 m for an overflow depth of 1.1 m in F/S. Rock spillway type was adopted.

Original spillway constructed in 1970's for the reservoirs were gate type, and the reservoir dike was damaged by improper operation of the spillway gate at flood time in early 1990's. An overflow-type fixed weir was proposed by F/S for preventing damage to the dike due to operational failure. The spillway type was selected in accordance with the following considerations:

- To make both initial construction cost and O&M cost as low as possible in due consideration of function, safety and duration,
- To avoid operation failure for protection of reservoir function

The selection of overflow-type fixed weir in F/S is reasonable considering remote location from the residential area and to avoid operation failure.

F/S proposed to apply the Rock Spillway type through comparison with ordinary ogee type spillway, especially the construction cost. According to F/S, direct construction cost of the rock spillway type is 45% cheaper than one of ogee type (rock spillway of US$ 0.8 million and ogee type of US$ 1.5 million).

The length of spillway (overflow weir) is revised to 230 m from 215 m in F/S, based on the revised design flood discharge of 450 m^3/sec as shown below:

$$B=Q / (C \times H^{3/2}) = 229 \text{ m, say } 230 \text{ m}$$

where, Q : Discharge (m^3/sec): 450 m3/sec
C : Coefficient of overflow: 1.70
B : Effective length of overflow weir (m)
H : Total head above weir crest (including approach velocity head): 1.1 m

Since unit discharge per meter on the overflow weir is calculated at 1.95 m which is same value of one applied in F/S, hydraulic dimensions of the overflow spillway do not need revision. The maximum

size of rock is also estimated at 0.8 m in diameter. Stability of spillway structure was also checked in F/S against overturning, sliding, and ground reaction under no seismic inertia force condition. Principal features of spillway are listed as below and illustrated in Drawing USS-07.

- Type of spillway — Overflow type rock spillway
- Design flood discharge — 450 m^3/sec
- Length of over-flow weir. — 230 m
- Flood Water Level (FWL) — EL. 42.4 m
- Crest elevation of the overflow weir — EL. 41.3 m
- Design over-flow depth — 1.1 m

(4) Intake Gate to Diversion Canal

The existing intake structure on the right bank edge was constructed in 1970's and has been deteriorated seriously due to no maintenance. The existing intake is planned to be replaced by new one at the same location. Two manual operation steel gates with dimensions of 1.2 m x1.2 m are planned to be installed. Main features of the intake are tabulated as below and illustrated in Drawing USS-06.

- Discharge — 3.50 m^3/sec
- Intake Width — 3.00 m
- Gate Size and Nos. — 1.20 × 1.20 m × 2 nos.
- Conduit Size and Nos. — 1.20 × 1.20 m×2 nos.
- Low water level of the reservoir — EL. 40.4 m
- Intake Sill Elevation — EL. 39.0 m

(5) Intake Gate for Tertiary Blocks

For supplying irrigation water directly to the irrigation area of 15 ha expanding the downstream of the reservoir dike, one intake structure is planned. Single concrete pipe of 600 mm diameter and a steel gate of 0.6 m × 0.6 m would be installed for each intake structure. Main features of the structure are listed as below:

- Discharge — 16.5 lit./sec
- Intake Width — 0.60 m
- Gate Size and Nos. — 0.60 × 0.60 m×1 no.
- Conduit Size and Nos. — φ0.60 m × 1 no.
- Dike Top EL. — EL. 43.3 m
- Intake Sill EL. — EL. 39.0 m

(6) Maintenance Gate

Maintenance gate for removing sediment on the upstream of the spillway and releasing river maintenance flow is planned on the left bank of the spillway. The maintenance gate equipped with two manual operation sluice gates of 1.5 m × 1.5 m. Sill level of gate is set at EL. 37.5 m, or 2.9 m lower than LWL of EL. 40.4 m to flushing the sediments below LWL. Double barrels have dimension of 1.5 m wide and 1.5 m high each and 18 m long. Both inlet and outlet portion is protected by riprap. Main features of the structure are listed as below:

- Inlet Width — 3.60 m
- Gate Size and Nos. — 1.50 × 1.50 m × 2 nos.
- Conduit Size and Nos. — 1.50 × 1.50 m × 2 nos.
- Dike Top EL. — EL. 43.30 m
- Intake Sill EL. — EL. 37.50 m
- Discharge of river maintenance flow — 0.051 m^3/sec

AD-2.2.2.3 Diversion Canal

(1) Alignment of Canal and Hydraulic Design

According to the route determined in F/S, the Diversion Canal would make a detour around O Saray Reservoir (it does not exist at present) passing the Krouch Stream by a siphon structure, then connects the existing Diversion Canal to Kpob Trobek Reservoir. Total length of the Diversion Canal is 9.4 km. The canal bed width is 2.0 m and the water depth is 1.4 m at the designed discharge of 3.5 m^3/sec. The longitudinal gradient of the canal is set at 1 in 4,400.

According to the results of soil mechanical test made in the F/S Stage, the soils on the cut slopes of existing canals are silty-sand (SM), clayey sand (SC) or clay (CL), which soils are less resistance against erosion by water flow. Thus the design of canal sections are proposed to have side slopes of 1: 2.0 both for the cut and embankment portion, and proposed to be lined with borrowed material through comparative study of lining types as shown below. Excavated materials could be used for the embankment with sufficient compaction.

(2) Selection of Lining Type

It is noted that permissible velocity of flow was set at 0.4 m/sec, and inside slope of canals were set at 1:2.0 for all lining types. In consideration of such factors, hydraulic dimensions of two alternative lining types, earth lining and soil cement, were set up as below.

Table AD-2.2.2.3.1 Hydraulic Dimensions of Alternatives

Lining	Qd (m^3/sec)	Vd (m/sec)	B (m)	h (m)	H (m)	Gradient	n	WL. BP (EL. m)	WL. EP (EL. m)	Remarks
Earth lined	3.5	0.52	2	1.39	1.7	1/4400	0.025	38.86	36.46	material of lining is borrowed material and thick is 0.5 m
Soil cement	3.5	0.62	1.8	1.3	1.6	1/8000	0.015	38.86	37.44	Cement of 7% and lining thick of 0.07 m

Note: Qd: design discharge, Vd: design velocity, B: canal bed width, h: design water depth, H: canal height, n: roughness coefficient, BP: beginning point, EP: End point

Source: JICA F/S, 2002

Direct costs for constructing the both lining alternatives estimated in the F/S as well as assumed durable year of lining method are tabulated as below. It is assumed that 0.5% of each direct construction cost is appropriated for annual maintenance cost of linings and 5% for periodical repairing cost in every following year of the durable year. Taking into account this assumption coupled with discount rate of 12% and 60-year span of project life, unit annual equivalent cost is estimated for the respective alternatives.

Table AD-2.2.2.3.2 Comparison of Direct Construction Cost and Unit Annual Equivalent Cost

Lining	Direct Cost (US$ 1,000)	Unit Cost (US$/ m)	Assumed Durable Year	Unit Annual Equivalent Cost (US$/m)	Remarks
Earth lining by borrowed material	1,770	188	10 years	2.94	Cost estimated in F/S
Soil cement	2,169	231	12 years	3.56	
Soil bag (reference)		1,248	20 years	19.13	Geosynthetic bags filled by mortar (US$ 130/m^2)

Source: JICA F/S (2002, and JICA Survey Team (2011)

In addition, cost of the "soil bag reinforcement", which was recently developed by National Institute for Rural Engineering, Japan, is also presented in the above table. "Soil bag reinforcement" is method for piling up soil bags with tail filled by mortal (1:6). Dimension of a bag is 0.5 m wide, 0.85 m long and 0.125 m thick. Bag is made by geosynthetic sheets. It is expected to apply for constructing reinforced wall against serious erosion by waves in developing countries, since low input of heavy

machinery and easy construction by man-power, though initial cost is considerably higher than the conventional method. The cost of the soil bag reinforcement method is considerably higher than those of others.

Considering availability of borrowed material suitable for earth lining nearby the Diversion Canal route (within 5 km at Prey Kdouch) and the lowest annual equivalent construction cost as mentioned above, it is judged that the proposed earth lining method of F/S is reasonable and applicable.

(3) Krouch Siphon

The siphon method was selected through comparative study between siphon and aqueduct from the views of topography, easiness of construction, and construction cost. The length of the siphon across the Krouch Stream is 75 m in total including closed barrel portion of 31 m. A side spillway is designed on the both sides of approach section upstream of the inlet. The siphon structure has a 2-barrel reinforced concrete box culvert of 1.3 m by 1.3 m for safety of the structure. Main features of the siphon are summarized as below and presented in Drawing USS-11.

- Canal design discharge: 3.50 m^3/sec
- Total length: 75.0 m
- Size of barrel: 1.30 × 1.30 m × 2 nos.
- Length of barrel 31 m
- Design water level at inlet transition: EL. 38.87 m
- Design water level at outlet transition: EL. 38.67 m
- Head loss: 0.20 m
- Flow velocity in upstream canal: 0.52 m/sec
- Flow velocity in barrels: 1.04 m/sec
- Design flood discharge of Krouch stream: 100 m^3/sec (100-years-flood)

Two control gates with 2.0 wide and 1.7 m high added at the inlet for easier performance of O&M and to maintain sufficient velocity even during low discharge period, using single barrel.

AD-2.2.2.4 Kpob Trobek Reservoir

(1) General

Proposed re-construction and rehabilitation by F/S in 2002 was basically done by MOWRAM in 2005. The work done by MOWRAM includes re-construction of gated spillway, re-constriction of intakes for Main Canal 33 and for Secondary Canal 24, reconstruction of maintenance gates, and upgrading of dike. Therefore, objective works on the reservoir under USISRSP are (i) supplemental rehabilitation for dike and (ii) improvement of gates on the spillway.

(2) Supplemental Rehabilitation for Dike

According to the information of Takeo PDOWRAM, some seepage near the structures on the dike and erosion of upstream slope of dike are the main structural problem of the reservoir. Observation made during the Survey period in 2011, no serious seepage is observed near spillway and other structures due mainly to low water level in the reservoir, but some erosion on the slope by wave actions is found due to lack of protective work for the dike. Therefore, the provision of dike rehabilitation cost consisting of the work cost for stripping, riprap with filter and sod facing is proposed. It is assumed that about 20% length of dike of 3.3 km would be the subject of the work (refer to Drawing USS-12).

(3) Improvement of Automatic Spillway Gates

According to the information of Takeo PDOWRAM the spillway gates constructed by MOWRAM in 2005-06 have not been smoothly operated. Judging from the present condition, operation record and design concept, it could be concluded that all gates are functional. However, it is proposed that the following improvement work on flap gates should be carried out to operate the gate surely and safely (refer to Drawing USS-13).

- The existing concrete made of counter weights of all gates should be replaced with steel made counter weights which should be divided into several pieces to easy adjust their weight in order to open the designated water levels of each gate.
- The designated water levels and weight of counter weight of each gate should be decided in the coming D/D Stage after due consideration of the reservoir operation.
- All bearings of hoists should be renewed with new ones since it is deemed that the sticking of such bearing due to rust and no lubricant are increased friction force for the rotation of wire drums. It is noted that such necessity of replacement was confirmed by the joint inspection by the mechanical engineers of MOWRAM and the JICA Survey Team on July 25, 2011.
- The repair painting should be applied to the damaged area of all gate leaves.

AD-2.2.2.5 Main and Secondary Canals

(1) Present Conditions

Main Canal 33 starts at Kpob Trobek Reservoir, and runs eastward beside National Road 130A for about 16 km to National Road No.3, then joins Canal 17. Of 16 km, a 7.3 km stretch of the canal is used for USISRSP from the Kpob Trobek Reservoir to Ta Phem Commune. The canal has deteriorated to some extent particularly on the right slope. The related structures have malfunctioned due to deterioration of gates, erosion of surrounding slopes, etc., which requires either rehabilitation or reconstruction. Most of the canal sections have a capacity of 5.0 m^3/sec. However, due to the low elevation of the canal bed, the water cannot be diverted to the irrigation area without a control structures. Most of the existing canal section has been used for both irrigating to a part of the area and draining water from the southern or western catchment of Canal 33.

Canal 24 starts at Kpob Trobek Reservoir but other 6 SCs branch off from Main Canal 33. Seven SCs run eastward at an interval of one km from north to south (refer to Drawing USS-01). The width of the canals ranges from 5 to 10 m. In the rainy season, the canals collect and drain water from the surrounding area, and the water is utilized for irrigation. Most of the canal related structures such as diversion and off-take structures have deteriorated and should be replaced.

(2) Canal Layout and Cross Section

Irrigation canal layout and irrigation diagram are shown in Drawings USS-01 to 03, respectively. In the system, no tertiary block is irrigated directly from Main Canal. Canal length, command area and design discharge at beginning point of each canal, which are planned and designed in F/S, are summarized in the following table:

Table AD-2.2.2.5.1 Principal Features of Irrigation Canals

Irrigation Canal	Canal Length	Command Area	Design Discharge at B.P.
Main Canal	7,300 m	2,924.0 ha	3.21 m^3/sec
Secondary Canal			
Canal 24	5,715 m	561.0 ha	0.62 m^3/sec
Canal 3U	1,410 m	137.4 ha	0.15 m^3/sec

Irrigation Canal	Canal Length	Command Area	Design Discharge at B.P.
Canal 23	9,245 m	773.6 ha	0.85 m^3/sec
Canal 22	8,040 m	608.8 ha	0.67 m^3/sec
Canal 21	6,930 m	489.8 ha	0.54 m^3/sec
Canal 20*	6,690 m	619.0 ha	0.68 m^3/sec
Canal 3D	6,675 m	295.4 ha	0.32 m^3/sec
Total (Secondary Canal)	44,705 m	3,485.0 ha	

Note: Irrigation area of 15 ha is directly supplied by the Tumnup Lok reservoir
Source: JICA F/S (2002)

It should be noted that 17 km (or 38%of total planned length) of Secondary Canals was designed in F/S based on the results of topographic survey, but design for the remaining 28 km (or 62%) was made based on the available topographic map, results of inventory survey and field reconnaissance, due mainly to uniform and flat topography and limitation of study period at the time. It would be needed to carry out a canal route survey for full stretch of canals in D/D stage for preparation of tender drawings and accurate work quantities.

Most of Main and Secondary Canals were proposed to be unlined canal in F/S, but for some sections, earth lining or soil cement lining was proposed to be adopted so as to keep the minimum permissible velocity. F/S proposed the lining and lining type as summarized in the following table:

Table AD-2.2.2.5.2 Proposed Lining Plan of F/S

Irrigation Canal	Unlined	Earth Lining	Soil Cement	Total
Main Canal (Canal 33)	7,300 m	0 m	0 m	7,300 m
Secondary Canal				
Canal 24	5,715 m	0 m	0 m	5,715 m
Canal 3U	1,410 m	0 m	0 m	1,410 m
Canal 23	7,595 m	1,200 m	450 m	9,245 m
Canal 22	5,705 m	0 m	2,335 m	8,040 m
Canal 21	3,745 m	2,075 m	1,110 m	6,930 m
Canal 20	5,180 m	1,510 m	0 m	6,690 m
Canal 3D	5,070 m	1,605 m	0 m	6,675 m
Total (Secondary Canal)	34,420 m	6,390 m	3,895 m	44,705 m

Source: JICA F/S (2002)

As mentioned previously that the lining is not applied for keeping the minimum permissible velocity and considering the actual survey length in the F/S stage, the proposed lining plan in F/S might not be so realistic. However, there might be some sections required for lining treatment due to permeable soils and soils having less resistance character against flows, it is proposed to provide the cost for 50% length of proposed lining in F/S. A simple soil mechanic investigation along Secondary Canals would be needed to identify the necessity of lining.

Standard cross sections as well as hydraulic properties and profiles of the main and secondary canals are presented in Drawings USS-14 to 18. As for Main Canal, base width of canal varies from 2.0 to 1.5 m, design water depth ranges from 1.1 m to 1.62 m, flow velocity is in a range of 0.4 and 0.6m, and hydraulic gradient of canal ranges 1:5,000 and 1: 1,500. Inspection road along the canal would be National Road 130A. Base widths of secondary canals vary 0.6 m to 1.0m, and hydraulic gradients of canals are rather steep with range of 1: 500 to 1: 1,250. Width of inspection roads along the secondary canals and berm were set at 2 m and 1 m as the minimum width in F/S.

(3) Design Discharge

Unit requirement of main and secondary canal is set at 1.1 lit/sec/ha. The design discharge of Canal 33 at the beginning point was set at 3.2 m^3/s (= 2,924 ha × 1.1 lit/sec/ha), and which reduces to 1.0 m^3/sec (for 914 ha) by the end section (downstream the diversion point to Canal 21). However, Canal 33 is proposed to use double function canal as irrigation and drain purpose, considering topographic

conditions and difficulty in land acquisition for new drainage canal. F/S confirmed that the existing Canal 33 had the flow capacity to serve as a drain at the bottom part of the section. According to the unit drainage requirement of 1.6 lit/sec/ha, the drainage capacity for a catchment of 12 km^2, i.e., 2.0 m^3/sec is regarded as the minimum capacity of Canal 33.

As for secondary canals, these canals are also planned to be dual functions as for irrigation and drainage due to same reasons of the Canal 33. The capacity of the secondary canals would also be maintained to drain the water flowing from the surrounding fields. Assuming that the area of tertiary blocks along a stretch of the secondary canal is 120 ha, a capacity of about 200 lit/sec (120 ha × 1.6 lit/sec/ha= 200 lit/sec) would be maintained for the stretch. The excessive water due to the inflow of drain water is planned to evacuate at cross drain point through side spillway made by protecting lowered section of canal bank by stone masonry. Same design concept for setting design discharge of the Canal 33 and secondary canals could be applied for the design (refer to Table AD-2.2.2.5.3).

(4) Related Structures on Canal

F/S proposed to reconstruct and rehabilitate the minimum level requirement for conveyance and distribution of water and some protective structures against floods, such as diversion structure, off-takes, culverts/ bridges, and cross drains. No proposal for water level and discharge measurement devices is found in F/S. It is proposed to plan the discharge measurement devices wherever hydraulic head is available for the device in D/D.

Main functions of proposed related structures are shown below and illustrated in Drawings USS-20 to 24.

- Diversion structure — to control the water level for off-takes upstream and discharge to downstream of the structure
- Off-takes — diverting irrigation water to secondary or tertiary canals from the main or secondary canals.
- Culverts/ bridges — to cross the canal without obstructing canal flow, including public road crossing and farm/ house access for private use
- Cross drains — to convey the drainage water safely at crossing point with irrigation canal

Through review of design made in F/S and results of inventory survey made by the JICA Survey Team in 2011, following structures would be needed on the canals:

Table AD-2.2.2.5.4 Nos. of Structures on Irrigation Canals (Unit: nos.)

Canal	Diversion structure	Off-take	Road Crossing	Farm/House Access	Cross Drain
Main Canal	5	6	3	0	0
Secondary Canals					
1. C-20	12	20	3	16	4
2. C-21	9	17	2	11	4
3. C-22	11	21	1	6	5
4. C-23	15	23	8	16	5
5. C-24	9	9	5	13	4
6. 3U	2	3	0	4	0
7. 3D	8	9	4	7	0
Total (Secondary Canals)	66	102*	23	73	22

Note: Nos. of off-take from Tumnup Lok reservoir (1 no.)
Source: JICA Survey Team

AD-2.2.2.6 Tertiary Canals

There are no systematic Tertiary Canal systems and even Secondary Canals have malfunctioned. F/S divided the irrigation commanding area into 106 tertiary blocks, with average area of 33 ha (refer to Drawing USS-02). In each tertiary block, Watercourses were proposed for commanding 5 ha. It was assumed that the land required for Tertiary Canals and Watercourses would be provided by the beneficial farmers. Concept of "provision of land by beneficial farmers" is the critical path for realizing the construction of canals. It was also assumed in F/S that construction of Tertiary Canals is supposed to be contracted to local contractors, while Watercourses would be constructed by beneficial farmers themselves. FWUC members would participate in the construction works as hired labor as a sort of training of maintenance works. Proposed design concept is reasonable and acceptable; however, it is expected rather long period to realize the Tertiary Canals and Watercourses in the field because of the concept of "provision of land by beneficial farmers".

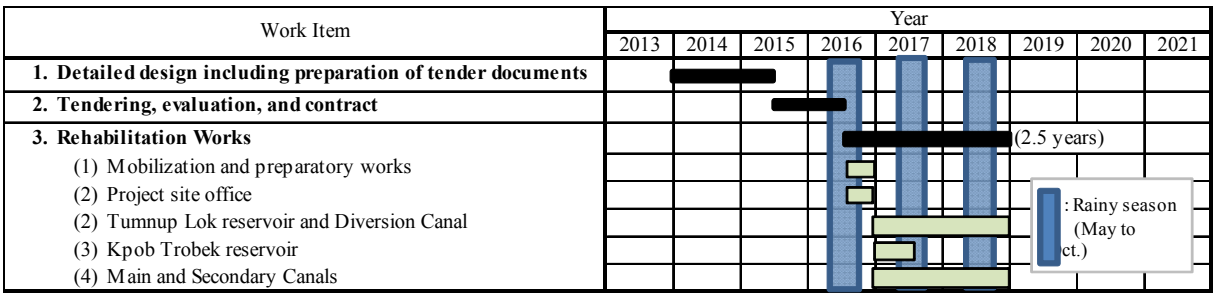
Irrigation water conveyed by Secondary Canals is diverted into Tertiary Canal through off-take, and delivered to each plot through Watercourse. Standard layout of tertiary block is illustrated in Drawing USS-19. Typical dimensions of Tertiary Canal are as follows:

Canal Bed Width	0.5 m
Canal Depth	0.6 m
Canal Side Slope (Inside and Outside)	1:1.0
Width of Dike Top	0.5 m

AD-2.2.3 Construction Schedule

(1) Construction of Main and Secondary Canal System

Main Canal System of USISRSP consists of 2 Reservoirs, a Diversion Canal and Main/Secondary Canals and related structures. The rehabilitation works of the main system will require a period of two and half years or two dry seasons after procurement procedure of the construction contractor based on D/D prepared by the employed consultant. It is assumed D/D including preparation of tender documents would be completed within one year. Rehabilitation of the Kpob Trobek Reservoir, Diversion and Main canals will be completed in the first year, but the Tumnup Lok Reservoir and Secondary Canals will be rehabilitated for the whole construction period. Contractor for the work will be selected through ICB, while ones for tertiary canals will be selected through LCB. Time required from the commencement of D/D including mapping to the end of rehabilitation work would be 5 years as shown below.



Source: JICA Survey Team

Figure AD-2.2.3.1 Implementation Time Schedule for Main Canal System of USISRSP

(2) Construction of Tertiary Canal System

Construction and rehabilitation of tertiary canals covering 3,500 ha will be implemented following the rehabilitation work for Main Canal System. D/D for Tertiary Canal would be prepared by the national consultant with close coordination with PDOWRAM and FWUC, and based on the design for the Main Canal System. The delineation of tertiary block and alignment of Tertiary Canals are to be agreed by FWUC and land owners. It would take rather longer period, since private lands should be provided for Tertiary Canals by land owners free of charge. Therefore, period of detailed design is estimated at 2 years including confirmation of alignment of Tertiary Canals. Assuming the progress rate of work at about 1,000 ha per year, construction period is set at 3.5 years (4 dry seasons) as shown below. It is expected the Tertiary Canal System will be handing over to FWUC after 1-year maintenance period.

Work Item	Year								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Construction of Tertiary Canals									
(1) Detailed design									
(2) Tendering, evaluation, and contract									
(3) Construction work for on-farm facilities									

Source: JICA Survey Team

Figure AD-2.2.3.2 Implementation Time Schedule for Tertiary Canals of USISRSP

AD-2.3 Kandal Stung - Bati Irrigation System Rehabilitation Sub-project

AD-2.3.1 Irrigation and Drainage Development Plan

AD-2.3.1.1 General

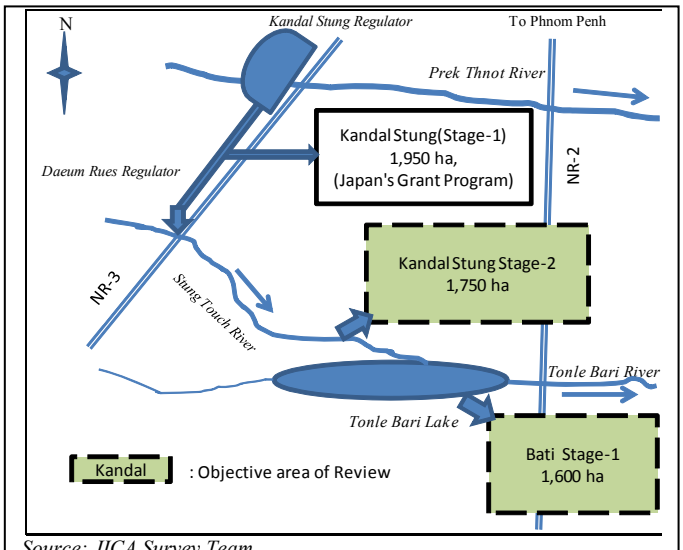
(1) Objective

Objective of the development plan for KSBISRSP is to ensure irrigation water for the Kandal Stung and Tonle Bati Areas through rehabilitating and upgrading the existing irrigation and drainage facilities.

(2) Location, Topography and Development History (refer to Drawing No.KSB-01)

(a) Kandal Stung Area

The objective area is situated in Kandal Stung District of Kandal Province about 20 km south of Phnom Penh. It is broadly bounded by Notional Road No. 2 in the east, Notional Road No. 3 in the west, Priority development area completed in 2007 by Japan's Grant Aid program in the north, and the Tonle Bati River in the south. The area covers about 2,400 ha which is mostly agricultural and residential lands. The Stung Touch River runs center of the area from northwest to southeast direction. The land is generally sloping toward the southeast with the average slope of 1:2,000 to 1:3,000, and drained to Lake Tuk Chou and Lake Tonle Bati.



Source: JICA Survey Team

Figure AD-2.3.1.1.1 Schematic Diagram of KSBISRSP

In 1975 to 1979 (Pol Pot regime), the irrigation canal system was constructed, including the Tuk Thla and the Kompong Tuol regulators on the Prek Thnot River. Canals were constructed following latitude and longitudinal grid lines, but regardless of the topographic conditions. Major canals are located 1 km by 1 km. Drain water in the area discharges to Lake Cheung Loung through Pol Pot canals.

From 1987 to 1991, the rehabilitation/ construction of the irrigation facilities were executed by the Department of Hydrology of MAFF (predecessor of MWORAM) with financial assistance of Mennonite Central Committee (MCC) for northern part of the objective area of 3,100 ha, consisting of the priority development area of about 2,000 ha and Kou Kurasang area (refer to Figure AD-2.3.1.2.1). In 1992 (after flood in 1991), rehabilitation of some parts of the damaged canal embankment and structures was executed by the Mekong Secretariat with the financial assistance of UNDP under the "Rehabilitation of Hydraulic/ Irrigation Structures Damaged by 1991 Floods" project. Therefore, the Master Plan study concentrated the survey for the said 3,100 ha area, but not for the remaining area.

No systematic rehabilitation/ improvement work has been executed in the objective area of the Survey (2012), since 1980's, except ad-hoc repair and construction of culverts/ bridges and diversion weir on the Stung Touch by MOWRAM, local government (communes) and NGOs.

Upon completion of construction works for Kandal Stung new diversion weir on the Prek Thnot in 2007 and promising the completion of the Stung Tasal reservoir very soon, MOWRAM prepared the official proposal to develop the objective area of 1,750 ha by using the original flow of Stung Touch river and supplemental water from the Prek Thnot.

(b) Bati Area (refer to Drawing No.KSB-02)

The priority area is situated in Bati District of Takeo Province about 30 km south of Phnom Penh. The national road No.2 crosses the western part of the area. The area covers about 2,100 ha in gross, which is mostly agricultural and residential. The ground elevation varies from 7.5 m to 5.8 m, sloping toward Lake Chenug Loung. There is slightly elevated flat land in the central part where numbers of villages are located.

Intake and Pump Station at Lake Tonle Bati

In 1975 to 1979, the irrigation canal system was constructed based on the water source from Lake Tonle Bati (gross storage of 16.7 MCM). The canals were constructed following latitude and longitudinal grid line, but regardless of the topographic conditions as applied to Kandal Stung Area. The intake and pump station were constructed at the head of North-South Canal 84 (NS84 canal). A spillway for Lake Tonle Bati was provided, with stop-logs at the outlet of the lake. In 1985, the World Council of Churches (WCC), Geneva, prepared a plan of the integrated agricultural development plan. It consists of the rehabilitation of an irrigation canal system for an area of about 6,000 ha including pump station, setting up of an agricultural development center, and the provision of some agricultural extension services. During period of 1987 to 1990, the rehabilitation of an irrigation system for an area of 900 ha was executed with the assistance of WCC. In August 1991, the irrigation facilities were damaged by the flood. In February 1992, rehabilitation of some parts of the damaged canal embankment was executed by the Mekong Secretariat with the financial assistance of UNDP

under the "Rehabilitation of Hydraulic/ Irrigation Structures Damaged by 1991 Floods" project. However, at the F/S in 1994, it was not functioning well mainly due to insufficient water level/ storage of Lake Tonle Bati and the lack of a systematic O&M system. Improvement of the spillway was made in 1992 with provision of 4 slide gates in front of the previous outlet of stop-logs. Although some ad-hoc repair and construction of culverts/ bridges and check structures as well as dredging of canal bed have been executed by MOWRAM and NGOs, substantial rehabilitation of irrigation system including pump station has not been executed.

AD-2.3.1.2 Development Area under the Sub-project

Suitable irrigation area identified by M/P was 8,400 ha in total from the total study area of 18,000 ha, in accordance with soils and topographic conditions and the availability of irrigation water source in the Prek Thnot River. Selected area of 8,400 ha consists of 4,200 ha in Kandal Stung Area and 4,200 ha in Bati Area with the augmentation of irrigation water source by the Prek Thnot reservoir (storage capacity of about 1,100 MCM). M/P selected priority development area of 1,950 ha in Kandal Stung Area and 1,600 ha in Bati Area which could be developed without construction of the Prek Thnot Reservoir, and F/S was made for two priority areas in 1994-95.

Table AD-2.3.1.2.1 Suitable Irrigation Area Identified in Master Plan in 1995

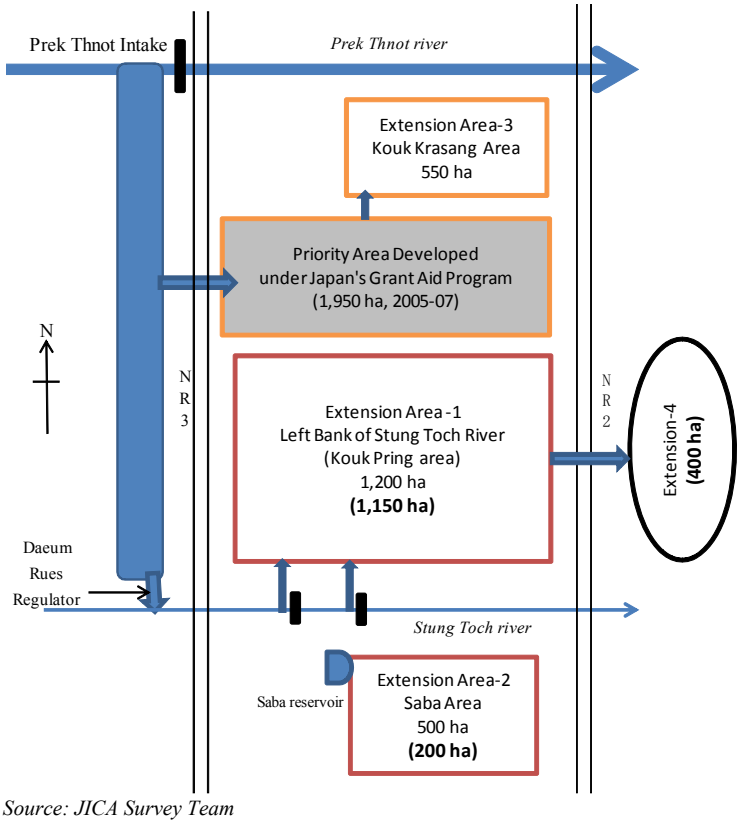
(Unit: ha)

Item	Kandal Stung	Tonle Bati	Remarks
Study area of M/P	11,000	7,000	
Suitable area for irrigation development	4,200	4,200	With Prek Thnot reservoir
Priority development area	1,950	1,600 ha	Without Prek Thnot reservoir

Source: Master Plan Study on the integrated Agricultural and Rural Development Project in the Suburbs of Phnom Penh, JICA, 1995

Development of main system for the first priority area of 1,950 ha in Kandal Stung Area including headworks on the Prek Thnot River has been completed in 2007 under the Japan's grant aid program. MOWRAM has continued further development in the area (refer to Figure AA-2.8.5.1).

Objective area of this Survey (2012) is: (i) southern part of the first priority area of 1,750 ha in Kandal Stung Area as proposed by MOWRAM with condition of supplemental water supply from the Stung Tasal reservoir which is under construction, and (ii) the first priority area of 1,600 ha in Tonle Bati Area, where substantial rehabilitation has not been carried out.



Source: JICA Survey Team

Figure AD-2.3.1.2.1 Schematic Diagram of Kandal Stung Area

From the topography and present land use, possible irrigation development area in Kandal Stung (Extension) area consists of 1,150 ha in Kouk Pring area, about200 ha near Lake Tonle Bati and existing paddy field in eastern part of NR-2 of 400 ha as shown below. Kouk Krasang area of 550 ha and Saba area of 300 ha (=500 -200) would be considered after completion of the extension area of 1,750 ha.

AD-2.3.1.3 Present Conditions of Irrigation and Drainage

(1) Kandal Stung Area

(a) Irrigation canals and related structures

Due to absence of substantial improvement or rehabilitation work for the canals and related structures for more than 30 years since 1980's, not like northern part of the area (Priority area and Kouk Krasang area) where some rehabilitation works has been done in 1987 and 1991 as well as 2005-2007, deterioration degree of irrigation facilities are rather severe than one of northern part.

The inventory survey is made by the JICA Survey Team in 2011-12 for 8 Pol Pot canals for about 29 km in total. Most of canal sections are eroded considerably due to lack of maintenance for long time. Some canal sections are checked by earth bund and small size culverts, private checks and fish fence. Downstream sections of some canals are obstructed by heavy sediments, water plants (water hyacinth) and bush. Inspection/ farm road along the canals have been narrowed by erosion, growing of plants and less maintenance. Out of five existing intakes on the Stung Touch River, one intake for KC-31 is equipped control gates, but other 4 are not. Irrigation as well as flood waters have flowed into canals without control. This situation caused sedimentation, erosion of canal bank and damages of slopes. Related structures for water management are few, but bridges/ culverts counts at 45 nos. No house and hut on the canal bank is observed. Summary of inventory survey is tabulated as below and its details are in Attachment of ANEEX D.

Table AD-2.2.1.3.1 Inventory Survey of the Existing Canals

(Unit: nos.)

Canals	Survey length (m)	Off take	Regulator*	Public bridge/ culvert	Private bridge/ culvert	Huts and houses **	Total
KC-1 (EW-61)	4,850	2	1	3	3	0	9
KC-2 (EW-60)	4,530	5	6	9	8	0	28
KC-3-1 (EW-58)	3,400	3	3	3	1	0	10
KC-3-2 (EW-58)	800	0	0	0	0	0	0
KC-4 (NS82)	3,500	1	1	4	0	0	6
KC-5 (NS83)	3,000	1	2	2	1	0	6
KD-1 (EW-59)	4,250	1	0	5	3	0	9
NS-78	4,800	1	0	3	0	0	4
Total	29,130	14	13	29	16	0	72

**: including culvert with bridge **: buildings on the banks on the canals*
Source: JICA Survey Team

(b) Existing weir on Stung Touch River at Phoum Thmei commune

There is one gated diversion weir at Phoum Thmei commune, which was rehabilitated with financial assistance of NGO (World Vision) in 2006. The weir was constructed to provide stable water for NW-60 (KC-2) and equipped with 3 manual operation steel slide gates. Dimensions of gates are 2.8 m wide and 2.0 m high each. Considering the existing gated weir is rather newly rehabilitated of 6 years old as token of friendship of goodwill as well as saving the project cost, the existing structure shall be remained as it is. However, it is obvious that flow capacity of the existing gated weir is much less than the design flood of 57 m^3/sec with return period of 100 years. It is needed to construct additional overflow type spillway at the site.

(2) Bati Area

(a) Irrigation canals and related structures

Tonle Bati Area is fed by water flowing into Lake Tonle Bati. Due to higher elevation of irrigation area comparing with water level of the lake, lifting irrigation is needed especially in dry season. After rehabilitation in 1992, no substantial rehabilitation and improvement has been executed, except ad-hoc works such as dredging of canal bed and construction of regulators. Generally, canals are heavily deteriorated and nos. of structures for water management of irrigation is short.

The inventory survey is made for 9 existing canals and one dike/road along Lake Tonle Bati for about 30 km by the JICA Survey Team in 2011 - 12. According to the survey, most of canal sections except MR-3 have been heavily eroded and considerable sediments are seen on the canal beds. Most of stretch for MR-3 has been dredged by MOWRAM in 2011, but excavated materials remains along the canal. Among the canals, MR-3 was provided water management structures such as off-takes (turnouts) and regulators which were constructed by NGOs. Bridges and culverts to across the canals are counted at 61 nos. Many culverts on laterals for house and farm access by farmers have insufficient flow area. Summary of inventory survey is tabulated as below and its details are in Attachment.

Table AD-2.2.1.3.2 Summary of Inventory Survey of the Existing Canals and Dike (Tonle Bati Area)

(Unit: nos.)

Canals	"Survey length (m)"	Off-take	Regulator*	Public bridge/ culvert	Private bridge/ culvert	Huts and houses**	Total
MR-1	6,370	0	2	10	1	5	19
MR-2 (Drain)	3,810	1	0	4	0	8	13
MR-3	5,700	10	4	7	7	0	28
L3	2,050	0	0	0	4	0	4
L4	640	0	1	0	0	0	1
L5	1,110	0	0	1	3	0	4
L6	2,010	0	0	1	10	0	11
L7&L8	2,200	0	0	2	5	0	7
Flood Protection dike	6,000	0	0	6	0	0	6
Total	29,890	11	7	31	30	13	93

**: including culvert with bridge **: buildings on the bank s within priority area of 1,600 ha*
Source: JICA Survey Team

There are 13 houses / huts on the canal bank of MR-1 and MR-2. Houses and huts are constructed since 1994 and 57 people are staying at houses and huts. Details of these houses are as below.

Table AD-2.2.1.3.3 Status of Houses on the Canal Bank of MC-1 and MC-2 (Drain)

Canal	Sta.	No.	Appearance	Interview Results			
				Year constructed	Main purpose of hut/house	Reason to select the location	Nos. of people staying
MR-1	730	1	Thatches (hut)	2008	Temporary staying	near relatives and no land in the village	5
		2	Thatches (hut)	2009	Permanent staying	safety security near family, no land in the village	6
		3	Thatches (hut)	2008	permanent staying	no house & disabled, no land in the village	1
		4	Thatches (hut)	2007	Temporary staying	near Phnom Penh, no place to go, no land in the village	4
		5	Thatches (hut)	2002	Permanent staying	near family, no land in the village"	8
Sub-total (1): to be moved							24
MR-2	2310	1	Zinc roof + concrete wall	1982	Permanent staying	near relatives/family land from ancestor before Pol Pot, and canal was constructed in 1977"	2

Canal	Sta.	No.	Appearance	Interview Results			
				Year constructed	Main purpose of hut/house	Reason to select the location	Nos. of people staying
	2900	1	Zinc roof	1996	Permanent staying	closed to his/her parent's rice field, no land in the village	5
		2	Zinc roof	1994	Permanent staying	closed to his/her parent's rice field, no land in the village	5
		3	Zinc roof	1994	Permanent staying	closed to his/her parent's rice field, no land in the village	5
		4	Zinc roof	1994	Permanent staying	closed to his/her parent's rice field, no land in the village	7
		5	Zinc roof	1994	Permanent staying	closed to his/her parent's rice field, no land in the village	4
		6	Zinc roof	1994	Permanent staying	closed to his/her relatives' rice field, no land in the village	5
		7	Left bank of canal	NA	Temporary hut	In front of the house	0
Sub-total (1): No need to move							33
Total							57

Source: JICA Survey Team

It is needed to request 5 huts on MR-1 to move off from the bank since the rehabilitation work is planned for the section. In case of houses on MR-2, no movement might be needed since the present canal section has enough flow capacity as drain due to very small drainage area at the section.

(b) Intake and Pumping station for Tonle Bati Area

Due to small difference between water level of the lake and elevations of irrigation area, intake discharge has been suffered by draw down of the lake water level especially in the dry season. The existing intake gates at the head of main canal with three gates are heavily deteriorated and nearly mal-functioned. Three diesel engine driven pumps of 18 m^3/min in total are still functioning, and have been operated based on the request of District Governor for 2-3 months in a year, but no written record of operation is available at Takeo PDOWRAM. According to Takeo PDOWRAM, the amount of lifting water is much insufficient to desired beneficiaries due to less capacity of the existing pumps. The operation cost has not been collected from the beneficiaries, but fully born by MOWRAM.

AD-2.3.1.4 Examination of Previous Development Plans

(1) Development Concept

The project works planned in M/P and F/S in 1995 will be reviewed in the following basic concept paying attention upon the current conditions of the KSBISRSP Area.

(1) Integrated Approach of Hardware and Software Components

Irrigated agriculture development for KSBISRSP is planned in the concept of integrated approach of hardware and software components which is the same with USISRSP, in order to heighten the project effect and to maintain the project sustainability.

(2) Consideration of New Water Source

Irrigation development for KSBISRSP, especially for Kandal Stung Area, is planned taking into consideration the released water from the Stung Tasal dam located upstream of Prek Thnot River.

(3) Determination of Project Scale through Water Balance Study

Irrigation development should be planned mainly based on available water, available land and the water demand by crops. Since KSBISRSP has enough farm land for irrigation, its project size will be determined through a water balance study.

(4) Full Utilization of Existing Canal System

There are the existing irrigation canals which were constructed in Pol Pot regime, in the KSBISRSP Area. In order to save construction cost and lighten the burden for land acquisition, these existing irrigation canals are used as much as possible.

(5) Application of Concrete Lining to Canals

In the priority area (1,950 ha) in the Kandal Stung, main canal was provided with concrete lining, which was financed by JICA. Considering gradual expansion of advanced/modern irrigation system in Cambodia and easy O&M, MOWRAM strongly desires to apply the same system to KSBISRSP. Thus, concrete lining will be applied only for main canals in due consideration of saving the project cost, taking into account such MOWRAM's desire.

(6) Use of Pol Pot Canals as Main Drains

In order to eliminate the excess water from field smoothly and considering easy water management, the existing Pol Pot canals will be used as main drainage canals with reshaping work, but no other drains are planned considering difficulty in land acquisition and saving construction cost.

(7) Priority Ranking on Sub-project Scope by Criteria

As KSBISRSP requires many project works, these will be prioritized so as to use the limited budget. High priority should be given to (i) the works indispensable for attaining at the aim of USISRSP, (ii) Urgently required works for proper operation of irrigation system, (iii) the facilities related to ensuring water resources, and (iv) the facilities which need large scale rehabilitation to convey irrigation water.

Basic concept in M/P and F/S in 1995 and its review results is tabulated as below, and its details are shown in ANNEX B (refer to Sub-clause AB-2.3.2.5).

Table AD-2.3.1.4.1 Review of Basic Concept for Facility Improvement

Proposal in M/P and F/S in 1995	Review in 2012
Realization of solid headwork (regulators on the Prek Thnot river), which was repeatedly damaged by floods to ensure the irrigation water supply to the project area, especially for the Kandal Stung Area	The proposed headworks on the Prek Thnot River were realized under Japan's Grant Aid Program in 2007. By this realization, supplemental water from the Stung Tasal reservoir will be diverted to Kandal Stung extension area and Lake Tonle Bati
Full utilization of the existing canal system which was constructed in Pol Pot regime	For utilization of the past investment in agony as well as lighten the burden for land acquisition, this concept is applicable for the area
Concrete lining is planned for main and lateral canals to ensure the slope protection of the canal	Concrete lining requires two to three times higher cost than one for earth canal. On the other hand, considering expansion of advanced/ modern irrigation system, which was realized in the Priority area in Kandal Stung by JICA, is desired to upgrade the existing canals as much as possible. But, the lining shall be limited to main irrigation canals only, due consideration for saving the project cost.
Drainage canals system are separately provided from the irrigation system	The existing Pol Pot canals will be used as main drainage canals with reshaping work, but no other drain is planned considering difficulty in land acquisition and saving construction cost.
Additional construction of related structures and improvement of the existing ones	Most of related structures are deteriorated and mal-functioned at present, except some culverts and bridges. Additional construction or replacement of the existing structures is needed to activate the system.
Tertiary canal system covering about 50 ha and quaternary block of 7-10 ha is planned for efficient water management	Tertiary canal system will be constructed by both the Sub-project and beneficiaries: land for canals is to be provided by the beneficiaries, but it takes long time to secure the land for canals.

Source: JICA Survey Team

Previous plan seeks complete set of irrigation and drainage systems with considerable investment cost of US$ 21.7 million for 3,550 ha or US$ 6,100 per ha (excluding headworks and on-farm development cost, refer to Clause AA-2.9.6 of ANNEX A) at 1994 price level. It should be planed suitable improvement plan within the reasonable investment cost[3]. Major cost items other than the irrigation and drainage canals estimated in M/P and F/S are: concrete lining for main and lateral canals (US$ 4.2 million), pump station for Tonle Bati Area (2.2 million), and connection canal (out of 3.3 million, lining cost is 2.6 million or 80% of the cost).

(2) Water Balance Study

(a) Summary of Review

Water balance study was executed for 10 years from 1961 to 1970 in M/P and F/S. In the review (2012), the water balance calculation is made for 30 years from 1982 to 2011. The water balance is calculated on the half-monthly basis in F/S, but 5-day basis in the review. Main points of water balance study regarding the Kandal Stung and Bati Areas are tabulated as below and details are presented in ANNEX B.

Table AD-2.3.1.4.2 Main Points of Water Balance Study regarding the Kandal Stung and Bati Area

Item	M/P in 1995	Review in 2012
1) Conceivable reservoir	Prek Thnot Reservoir with storage capacity of 1,120 MCM	Stung Tasal reservoir under construction (123 MCM) and three proposed reservoir (36 MCM in total)
2) Simulation period and calculating step	10 years from 1961 to 1970 and half monthly basis	30 years from 1982 to 2011 and 5-day basis
3) Conceivable irrigation area other than Kandal Stung and Tonle Bati	33,000-35,000 ha is expected with the Prek Thnot reservoir condition, by referring to the Re-appraisal Study on Prek Thnot Multipurpose Project (1992);	Roleang Chrey (16,700 ha), Dangkor (300 ha), O Sya (1,120 ha), Chan Tanal (2,270 ha), Kampong Damrey (200 ha); 20,590 in total
4) River maintenance flow and other demand	Not considered for the Prek Thnot River, but recession farming area of 600 ha in the Bati Area (location and its details is not described)	Min. of 0.6 m^3/sec for the Prek Thnot River as a river maintenance flow, and irrigation water supply to Kampong Damrey area of 200 ha downstream Lake Tonle Bati
5) Conditions of Bati Area development	Water level of Lake Tonle Bati; HWL=7.8 m and LWL of 5.5 m Supplemental water supply from Prek Thnot river through Connection Canal	Do. As left
6) Results of Water Balance Without reservoir (s)	Kandal Stung Area: 1,950 ha with cropping intensity of 174% Tonle Bati Area: 1,600 ha with cropping intensity of 180%	Kandal Stung Area: 1,950 ha with cropping intensity of 174% Tonle Bati Area: 1,600 ha with cropping intensity of 180% The results of M/P(1995) is confirmed
7) Results of Water Balance With reservoir(s)	Kandal Stung Area: 4,200 ha with cropping intensity of 200% Tonle Bati Area: 4,200 ha with cropping intensity of 200%	Kandal Stung Area: 3,700 ha (1,950 + 1,750) with cropping intensity of 180%; Tonle Bati Area: 4,200 ha with cropping intensity of 180% Irrigation area of Roleang Chrey with 80 % dependability will be increased to 15,400 ha from 5,660 ha

Source: JICA Survey Team

The main features of concerned reservoirs applied for the water balance study in the Review (2012) are tabulated as below.

Table AD-2.3.1.4.3 Storage Capacity Applied for Water Balance Study

No.	Name of Propose Dam	River	CA[km^2]	Effective Vol.(MCM)
1)	St.Tasal	Stueng Ta Sal	495.0	122.70
2)	New Stueng Aveaeng Dam	Stueng Aveaeng	155.8	21.78
3)	Peam Levear	Stueng Aveaeng	237.5	8.31
4)	O Tang	Ou Khlong	53.6	5.76

Source: JICA Survey Team

[3] *According to the information, MEF intends to limit the direct construction cost of the rehabilitation work of the irrigation project to less than US$ 3,000 per ha*

(b) Water Demands

1) General

The water demand consists of (i) irrigation water requirement for the irrigation area, (ii) river maintenance flow for the Prek Thnot River to conserve the riverine environment downstream of the Kandal Stung Regulator (0.6 m^3/sec for throughout year), and (iii) irrigation demand of downstream users of Lake Tonle Bati.

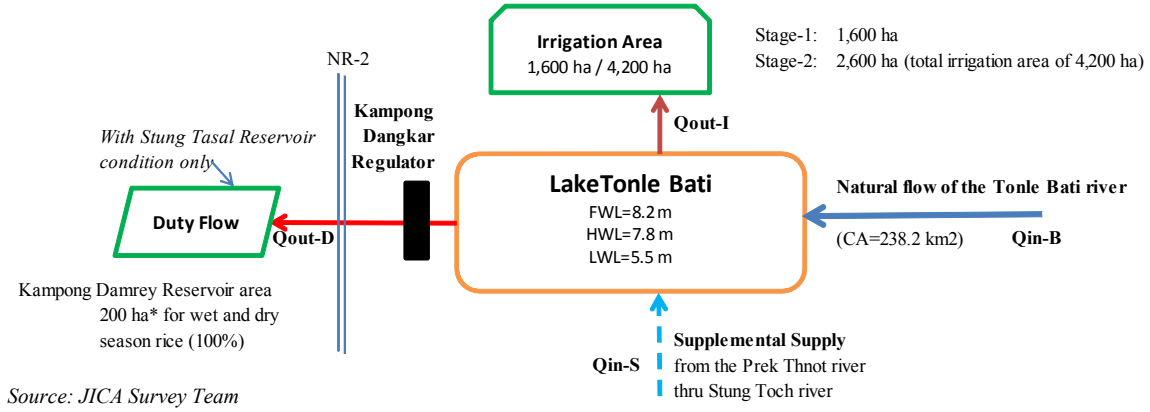
2) Irrigation water requirement

Based on the revised cropping pattern, which consists of two times rice crops per year as mentioned in ANNEX C, the irrigation water requirement is re-calculated for 30 years. The calculation is made for 5-day basis and using updated potential evapo-transpiration rate at Pochentong Observatory, and rainfall data at Tonle Bati instead of that at Phnom Penh. Rainfall station at Tonle Bati has operated since 2003. Other conditions such as percolation rate, irrigation efficiency are not changed from those applied in F/S. As a result, peak water requirement of the revised cropping pattern having 80% dependability is estimated at 1.4 lit/sec/ha, which is the same value estimated in F/S. Details of the estimate are presented in the subsequent Sub-clause of AD-2.3.1.6.

3) Responsible release to downstream users of Lake Tonle Bati

Based on the following assumptions, irrigation supply from Lake Tonle Bati to the Kampong Damrey reservoir of 200 ha is assumed for water balance study as F/S intimated it:

a) Storage volume of Kampong Damrey Reservoir: 2.6 MCM in gross, then net volume is assumed at 2 MCM (80% of gross)
b) Assuming 1 m supply for dry season paddy, irrigation area is estimated at 200 ha, though no canal system is found at present.
b) According to Takeo PDOWRAM, extent of wet season rice is registered at 200 ha, and dry season at 725 ha, and some amount of water has been released based on the request of downstream farmers.
d) Same irrigation demand as one applied for irrigation area is assumed



Source: JICA Survey Team

Figure AD-2.3.1.4.1 Schematic Diagram of Responsible discharge from Lake Tonle Bati

2) Possible Irrigation Areas

Possible irrigation area is estimated using irrigation water requirement per ha of each crop proposed, the river maintenance flow, river runoffs, and storage effects of reservoirs. As a result, the following extent of crops could be realized under without and with dam condition with 80% dependability.

Table AD-2.3.1.4.4 Results of Water Balance Study (Without Dam Case (Present Condition))

(Unit: ha)

Roleang Chrey Irrigation Area

No.	R.C. Total (ha)	R.C. Early Rice-1	R.C. Medium Rice	R.C. Early Rice-2	R.C. Upland Crop	Crop Intensity
1. (80%)	5,660 ha	500 ha	5,162 ha	500 ha	280 ha	114%
2. (50%)	11,040 ha	975 ha	10,069 ha	975 ha	546 ha	114%
Total	16,700 ha	1,475 ha	15,231 ha	1,475 ha		

Kandal Stung-Bati Irrigation Area

1. (JICA grant)	KS(G) Total	KS(G).E.R.1	KS(G).M.R.	KS(G).E.R.2	KS(G).U.C.	Crop Intensity
	1,950 ha	975 ha	975 ha	900 ha	540 ha	174%
2.	KS(E) Total	KS(E).E.R.1	KS(E).M.R 1	KS(E).M.R.2		
(Extension)	0 ha	0 ha	0 ha	0 ha	0	0
3.	T.B. Total	T.B.E.R.1	T.B.M.R.1	T.B.M.R.2		
(Stage-1)	1,600 ha	80 ha	800 ha	800 ha	480	180
Total	3,550 ha	1,775 ha	1,775 ha	1,700 ha	1,020 ha	

Dangkor Irrigation Area

1. Present	KS(G) Total	KS(G).E.R.1	KS(G).M.R.	KS(G).E.R.2	KS(G).U.C.	Crop Intensity
300 ha	300 ha	42 ha	258 ha	42 ha		114%

Table AD-2.3.1.4.5 Results of Water Balance Study (With Dam Case (Future Condition))

(Unit: ha)

Roleang Chrey Irrigation Area

No.	R.C. Total (ha)	R.C. Early Rice-1	R.C. Medium Rice	R.C. Early Rice-2	Crop Intensity	Dependability
1. (80%)	15,400 ha	12,320 ha	3,080 ha	12,320 ha	180%	80 77
2. (50%)	1,300 ha	390 ha	910 ha	390 ha	130%	
Total	16,700 ha	12,710 ha	3,990 ha	12,710 ha		

Kandal Stung-Bati Irrigation Area 5,460ha

1. (JICA grant)	KS(G) Total	KS(G).E.R.1	KS(G).M.R.1	KS(G).M.R.2	Crop Intensity	
	1,950 ha	1,560 ha	390 ha	1,560 ha	180%	97
2. (Extension)	KS(E) Total	KS(E).E.R.1	KS(E).M.R 1	KS(E).M.R.2	Crop Intensity	
	1,750 ha	1,400 ha	350 ha	1,400 ha	180%	93
3. (Stge-2)	T.B. Total	T.B.E.R.1	T.B.M.R.1	T.B.M.R.2	Crop Intensity	
	4,200 ha	3,360 ha	840 ha	3,360 ha	180%	80
Total	7,900 ha	6,320 ha	1,580 ha	6,320 ha		

Dangkor Irrigation Area

1. Dangkor	KS(G) Total	KS(G).E.R.1	KS(G).M.R.	KS(G).E.R.2	Crop Intensity	
300 ha	300 ha	240 ha	60 ha	240 ha	180%	93

Kampong Damrey Irrigation Area

1. K. Damrey	Total	E.R.1(ha)	M.R (ha)	E.R.2(ha)	Crop Intensity	
200 ha	200 ha	200 ha	0 ha	200 ha	200%	80

Ou Krang Ambel Irrigation Area

O Sya	Total	E.R.1(ha)	M.R (ha)	E.R.2(ha)	Crop Intensity	
730 ha	1,120 ha	160 ha	800 ha	160 ha	153%	8
Chan Tanal	Total	E.R.1(ha)	M.R (ha)	E.R.2(ha)	Crop Intensity	
1,470 ha	2,270 ha	400 ha	1,470 ha	400 ha	154%	77

Source: JICA Survey Team

In case of development of Bati Area, the simulation is made considering the effective storage between EL. 5.5 m (LWL) and EL. 7.8 m (HWL), inflow of the Tonle Bati river, irrigation demands of the Tonle Bati irrigation area and Kampong Damrey areas, as well as supplemental supply from the Prek

Thnot River through Connection canal from Stung Touch River. As a result, by full use of effective volume of the, it is confirmed that development of 4,200 ha in Tonle Bati Area could be developed with Stung Tasal Reservoir. Peak supply to Lake Tonle Bati from the Prek Thnot River with 80% dependability is estimated at 5.29 m^3/sec and for the case of 4,200 ha development with reservoirs condition.

(3) Irrigation and Drainage Facilities

(a) Diversion weir and intakes on Stung Touch River

In M/P, no diversion structure was planned on the Stung Touch River, but supplied from the main canal of priority area. Considering prior completion of 1,950 ha area in 2007, provision of 2 diversion weirs on the Stung Touch River was proposed by MOWRAM, one is upgrading the existing weir at Thmei commune and the other is construction of new weir just downstream of crossing point between EW-58 and NS-82 (near Lake Saba).

One new diversion weir would be needed to divert the water to KC-31 (EW-58) and NS-82 (connection canal to Tonle Bati). Considering the existing gated weir is rather new structure of 6 years old and token of friendship of goodwill, the existing one shall be remained as it is. However, it is obvious that flow capacity of the existing gated portion is much less than the design flood of 57 m^3/sec (probable flood with 100 years). It is proposed to construct overflow type spillway at the same site.

In addition, the following arrangement would be needed for intake gates of the upstream Pol Pot canals:

- no water enter to canal in low flow case (less than 10 m^3/sec)
- some amount of flood flow within the flow capacity of canals will enter to these canal in flood flow
- realizing the above condition, constructing fixed weir or low gates is needed.

(b) Connection Canal to Lake Tonle Bati from Stung Touch River

For conveying water from Prek Thnot river to Lake Tonle Bati through Stung Touch river for further development of 2,600 ha (=4,200 ha-1,600 ha), activation of NS-78 canal with construction of diversion weir on the Stung Touch River was proposed in F/S. Flow capacity of connection canal was set at 7 m^3/sec for full development of 4,200 ha. Considering augmentation of irrigation water source by construction of Stung Tasal Reservoir on the Prek Thnot River by MORAM, and high demand of irrigation development in the area, construction of connection canal from the Stung Touch River to Lake Tonle Bati is now desirable. It is proposed to include the connection canal with condition that MOWRAM will start necessary arrangement for the further development of remaining area of 2,600 ha. The proposed route of NS-78 (4.8 km), however, has problems: namely, high cost

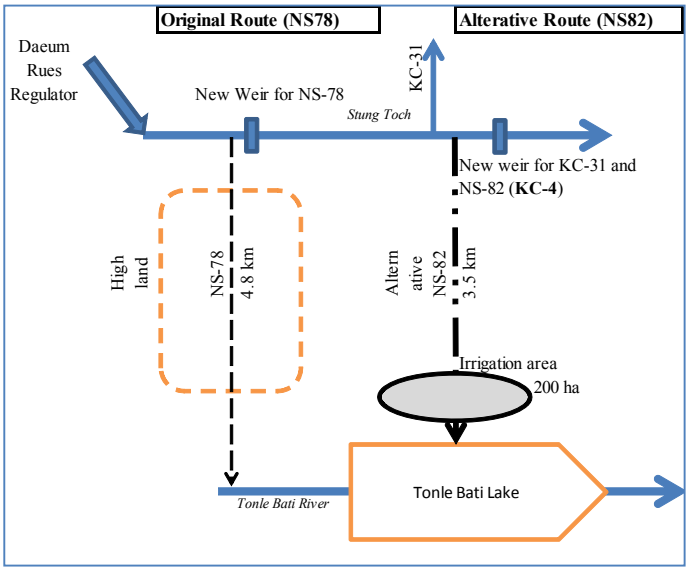


Figure AD-2.3.1.4.2 Alternative Route of Connection Canal

of concrete lining due to dispersive soils, necessity of construction of diversion weir and intake newly. And no suitable irrigation area is expected along the route (5-6 m lifting is needed for irrigation).

The connection canal of NS-87 of 4.6 km long (Original Route) was originally constructed in Pol Pot regime and MWORAM has tried to activate it in early 1990, but no diversion weir has been constructed due to difficulty in provision of construction fund. F/S estimated the construction cost at US$ 4.0 million consisting of US$ 3.3 million for connection canal and US$ 0.7 million for diversion weir with intake. This amount of US$ 4.0 million accounts to be about 30% of total construction cost for irrigation and drainage work under Stage 1 for 1,600 ha. It is noted that the cost for lining work of the NS-78 account to about 80% of the total construction cost for treatment against dispersive soils along the route by self-retaining 2 phased reinforced concrete canal lining. Unit rehabilitation cost for Tonle Bati Area including the cost for connection canal (US$ 4.0 million) and pump station (US$ 2.2 million) was thus estimated at US$ 8,700 per ha in F/S. For reducing the cost of connection canal, an alternative route is prepared. The alternative route (Alternative Route) is enlargement of the existing canal of NS-82 which was also constructed in Pol Pot regime. The intake site of the Alternative route is set at about 9 km downstream from one for NS-78 canal and length to Lake Tonle Bati is 3.5 km long.

It is proposed to alter the canal route to NS-82 of 3.5 km due to less construction cost, though soil mechanics investigation would be needed in design stage. In addition, the NS-82 canal could supply the irrigation water to the area near the Tonle Bati Area of about 200 ha. Further, only one diversion structure could contribute to KC-31 (EW-58), and the Connection canal (NS-82). Comparison of two alternative routes is tabulated as below.

Table AD-2.3.1.4.6 Comparison of Alternative Route for Connection Canal from Stung Touch to Lake Tonle Bati

Item	NS-78 (Original Route in F/S (1995))	NS-82 (KC-4) Alternative Route
1) Existing situation	Canal runs high elevated area. The canal is so deep and the canal berm encounters dispersive clay layers and many eroded soils deposit on the existing canal bed. Canal bed rises from EL. 10.3 m at Sta.500 m to EL. 13.2 m at Sta. 1,600 m and then goes down gradually to the Tonle Bati River.	The canal is partially used as pond and canal, but side slope of canal bank remains rather in good condition. This canal is also incomplete canal. The canal bed raises from EL. 8.2 m at Sta. 600 m to EL. 10.5 m till Sta. 2,600 m, and then goes down gradually to the lake.
2) Soil mechanics condition	Huge and serious erosion is observed due to dispersive soils and easy to eroded away soils	No serious erosion is observed except some short stretch of 300-400 m, though additional investigation will be required
3) Possible irrigation area on the way to Lake Tonle Bati	Rainfed rice field spread on the both sides, but elevation of these fields are higher than EL. 16 m; lifting of 5-6 m high is needed for irrigation: lifting irrigation is not realistic	Irrigation area of 200 ha located near Lake Tonle Bati is expected, though some lifting arrangement for 2-3 m high is needed.
4) Diversion weir	Construction of new diversion weir with intake is proposed for NS-78	Construction of a new diversion weir is proposed for NS-82 (KC-4) and the main irrigation canal of EW-58 (KC-31)
5) Canal section	Self-retaining 2 phase canal lining (1.8 m high, reinforced concrete) for full stretch, considering dispersive soils	Canal lining by un-reinforced thin concrete (75 mm thick) could be assumed for full stretch, though soil mechanics investigation would be needed

Item	NS-78 (Original Route in F/S (1995))	NS-82 (KC-4) Alternative Route
6) Earth work quantity	Huge cut volume of about 250,000 m^3 is additionally required	Additional excavation volume is estimated at about 230,000 m^3, which is similar to one for NS-78
7) Estimated construction cost Total Lining Earth work Weir	About 80% of total cost is account of lining cost against dispersive soils (Quoted from F/S report) US$ 4.0 million) US$ 2.6 million (79%) US$ 0.7 million (21%) US$ 0.7 million	It is expected to reduce the cost by nearly 50% due to less need of lining (rough estimate based on F/S cost only) US$ 2.1 million Assuming 40% of NS-78: US$ 1.0 million 90% of NS-78* US$ 0.7 million Half of F/S for dual use: US$ 0.4 million
8) Conclusion	Proposed to construct NS-78 with intake structure and diversion weir as originally planned by MOWRAM, though possibility for realization of the Prek Thnot Reservoir was expected to be low.	Although further soil mechanics investigation would be needed, Alternative route (NS-82) has more advantage than NS-87. It is proposed to change the route to NS-82 mainly for saving construction cost

Source: JICA Survey Team

F/S set the design discharge of 7 m^3/sec, which is equivalent to 1.67 lit/sec/ha equiv (= 7 m^3/sec/4,200 ha). This amount of 1.67 is just 120% of design diversion requirement of 1.4 lit/sec/ha. This requirement was estimated rather safety side since there is original flow of the Tonle Bati River which has catchment area of 240 km^2 and storage of the lake. Water balance study made in 2012 shows that the peak requirement for supplemental supply to Lake Tonle Bati from the Prek Thnot River is 5.29 m^3/sec for 4,200 ha with 80% dependability

(c) Intake and Pumping station for Tonle Bati Area

Followings are the review results based on the observation in the field and results of water balance study:

Table AD-2.3.1.4.7 Review of Pump Station at Lake Tonle Bati

Item	F/S in 1995	Review in2012
Existing condition	Three sets of diesel engine driven pumps with capacity of 8 m^3/min (one set) and 5 m^3/min (other two sets); Total capacity is 18 m^3/min (or 0.3 m^3/sec); The pump capacity is not sufficient to supply irrigation water to the whole project area; The pumps are used for providing supplemental water in low water level season of Lake Tonle Bati	Three same pump sets are still functioning, with minor maintenance such as replacement of a diesel engine in 2011; Pump operation and water level of Lake Tonle Bati has not been recorded by PDOWRAM and no operation cost is charged to beneficiaries; Pumps have been operated depending on the request of District Governor, and for 2-3 month per year only
Basic consideration for the improvement	Water level of Lake Tonle Bati will be lowered in dry season even after augmentation from the Prek Thnot river through connection canal. The required pump up water will be about 20% of the annual irrigation demand.	Water level of the lake will vary from EL. 5.5 m and HWL of 7.8 m for full use of effective water in the lake. The required pump up water will be about 27% of the annual irrigation demand in average.
Capacity of pumps	Four sets (including one spare set) of horizontal volute type pump with capacity of 45 m^3/min and 30kW per set; total head is 4.5 m ; (Total capacity of 3 sets of pumps is 2.25 m^3/sec)	Assuming the pumps will be operated between HWL (EL. 7.8 m) and LWL (EL. 5.5 m), the required pump up discharge is estimated at 2.0 m^3/sec. The proposed capacity of F/S is confirmed.

Item	F/S in 1995	Review in2012
Conclusion	Replacement of pump station with 4 pump units including one stand-by set	No change is needed and apply as proposed in F/S, with condition that water users community will be organized for sustainable use of the pumps

Source: JICA Survey Team

Assuming fuel consumption rate of 0.4 lit/kw-hr, operation period of 3 month with 30 kW and diesel oil price of US$ 1.25/ lit, total cost of fuel is calculated at US$ 32,400 for 1,600 ha, or US$ 20/ ha. Sustainable O&M of pumps shall be realized through organization of water users association with strong assistance of MOWRAM.

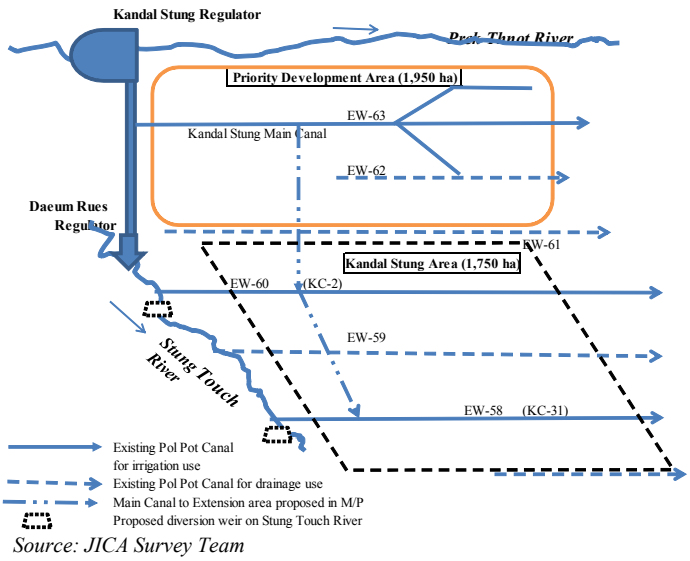
(d) Daeum Rues Regulator

For supply irrigation water from the Prek Thnot River to Stung Touch River, the Daeum Rues regulator was provided at the end of supply channel from the Kandal Stung Regulator on the Prek Thnot River. Basic dimensions of the existing regulator are; 3 nos. of manual operation steel slide gates with 2.2 m high and 1.5-1.7 m wide each. Replacement of the existing Deum Russ Regulator due to lack of flow capacity and difficulty in operation is proposed by MOWRAM. According to MOWRAM, difficulty in operation of gates is caused by present layout of gates which are set with flow direction diagonally and no protection work downstream the regulator. The gates of the regulator were heightened to match the intake water level of new Kandal Stung Regulator on the Prek Thnot River under the Japan's Grant Aid program in 2005-07.

Present flow capacity is estimated at 10 -15 m^3/sec based on the flow area and assumed flow velocity of 1.5 m/sec, which is more than the requirement of 9 m^3/sec, equivalent to the irrigation requirement of 6,000 ha (=4,200 ha in Tonle Bati + 1,750 ha in Kandal Extension). Considering frequent operation of gates would be required after completion of Stung Tasal Reservoir and importance of the structure for about 6,000 ha, it is proposed to replace the said regulator as proposed by MOWRAM. Major points of new regulator would be: provision of easy lifting gear for gates, setting the gate surface to be right angle to the flow direction, water level gauge for discharge measuring, and downstream protection.

(e) Main and Secondary Canals

Main irrigation canal system consisting of main and secondary canals is formulated by full use of the existing Pol Pot canals. In case of Kandal Stung Area of 1,750 ha (called as "Extension area"), M/P planned to supply irrigation water to the Extension area through main canal for the priority area (EW-63 canal). However, EW-63 canal was already improved for the priority area of 1,950 ha only, and no capacity for further development of the Extension area. Then, MOWRAM proposed to supply water to the Extension area of 1,750 ha through Stung Touch River by constructing new diversion



Source: JICA Survey Team

Figure AD-2.3.1.4.3 Schematic Diagram of Kandal Stung Area of 1,750 ha

weirs and improvement of Daeum Rues Regulator.

Bati Area has 2 existing main irrigation canals of MR-1 and MR-3 and 6 laterals. Theses canals cover all area of 1,600 ha. One drainage canal of MC-2 (or MD-1) runs along the western edge of the irrigation area.

Most of the existing canals were constructed by excavating the ground surface, and dikes and roads along canals which were formed by excavated soils. Main purposes of the canals were just conveyance of the irrigation water as near as possible to the fields, and drainage of excessive water from the paddy fields. Gravity irrigation is not aimed for many canals. Deterioration and eroded condition of the existing canals is mainly caused by (i) dual use of canals for irrigation and drainage purposes, (ii) erosive soils used for canals, and (iii) lack of periodic maintenance. Lack of maintenance by beneficiaries was mainly caused by insufficient water supplies to the canals. M/P proposed to reshape canal sections and place a concrete lining of 150 mm thickness for canal slopes of main and secondary (lateral) canals. Cost of lining work accounted for about 60% of the total rehabilitation cost of main canal and 40% of laterals. Assuming that the unit direct construction cost for rehabilitation work is desired to be lower than US$ 3,000 per ha from the economic view point (by MEF), concrete lining as proposed in M/P and F/S is to be limited. However, followings are to be considered to rehabilitate and upgrading the existing irrigation canals which were originally constructed in Pol Pot regime in late 1970':

- Main canal for priority are of 1,950 ha, which was rehabilitated and upgraded with Japan's assistance, has been lined by concrete as a model development;
- The above development is expected to contribute toward developing the advanced/ modern irrigation system
- Objective areas of Kandal Stung Area of 1,750 ha and Tonle Bati Area of 1,600 ha are located just adjacent to the priority area above;
- Expansion of model area is strongly desired by MOWRAM as a model case for modernization of Pol Pot canals
- Lightening the budgetary burden of O&M activities is strongly desired due to limited budget for maintenance works of canals
- Lining cost should be reasonable range of total project cost, but not excessively like one proposed in F/S.

Through discussion with MOWRAM, it is finally decided to apply Portland cement concrete lining of 75 mm thickness with wire mesh of Ø6 mm @ 25cm grid, for the main canals (EW-60 and EW-58 in Kandal Stung Area, and MR-1 and MR-3 of Tonle Bati Area), but just apply re-shaping of cross sections and longitudinal profiles only for secondary (lateral) canals.

Table AD-2.3.1.4.8 Review of Main and Secondary Canals

Item	M/P and F/S in 1995	Review in 2012
1) Improvement of main and secondary canals	Kandal Stung Area: 0 km and 18.3 km Bati Area: Main canal of 8.3 km (rehab) and secondary canals of 10 km (rehab of 6.9 km and new of 3.1 km)	Kandal Stung: Two Main canals of 11.3 km (rehab) from Stung Touch River and two secondary canals of 5.0 km (rehab and new) Bati Area: Two main canal of 7.6 km (rehab) and six secondary canals of 8.6 km (rehab)
2) Lining of canals	Two phased concrete lining (lining of 150 mm thickness for slopes) and sod facing for main and secondary (lateral) canals: Total length of 36.6 km	Concrete lining of 75 mm thick is limited to main canals of 18.9 km only, for saving construction cost and extending the advanced or modern irrigation system

Source: JICA Survey Team

(f) Drainage canals

F/S proposed to improve the main and secondary drains of about 21 km in Kandal Stung Area and 24 km in Tonle Bati Area for realizing complete drainage system. Considering difficulty in: (i) land acquisition for construction of new drains, and (ii) no report about serious drainage problems except caused by large floods, no substantial drainage improvement is considered except main drainage canals as applied to Priority development area in Kandal Stung Area. Main drainage canals will be improved through re-shaping of the existing canal sections and providing drain inlets and bridges/ culverts.

Table AD-2.3.1.4.9 Review of Main Drainage Canal

Item	M/P and F/S in 1995	Review in 2012
1) Main drainage system	Kandal Stung Area: 21 km, and Bati Area: 24 km	Re-shaping of the existing Pol Pot canals as main drains only is planned; Kandal Stung Area of 12.1 km and Bati are of 6.7 km, considering difficulty in land acquisition and resistance to inundation of paddy
2) Related structures	Bridges, culverts, and closing bunds	In addition to one proposed in M/P and F/S, drainage inlets are to be included.

Source: JICA Survey Team

(4) Flood Protection Facilities of Lake Tonle Bati

(a) Flood protection dike

1) Flood water level of the Lake

F/S set the HWL at 7.8 m and crest of flood protection dike at EL. 8.7 m, considering the effects to Tonle Bati Pagoda and recreation center. Based on the study on Kampong Dangkor Spillway against flood taking into account the retardation effect of the lake, Flood Water Level (FWL) is set at EL. 8.4 m, which has a freeboard of 0.3 m against 1 in 100 year flood. Bank crest of 8.7 m, HWL of 7.8 m and LWL of 5.5 m as proposed in F/S remains unchanged, considering the effective use of stored water in the lake and existence of the Tonle Bati Pagoda and recreation facilities as pointed out in F/S.

2) Flood protection dike

According to the topographic survey for northern dike of 5.9 km long made by the JICA Survey Team in 2012, elevation of almost portion of the dike is higher than EL. 9 m, except section from Sta. 0.5 to Sta. 1.0 km and from Sta. 5.1 km to EP (Sta. 5.9 km). The northern dike needs some additional embankment of 0.3 to 0.5 m high in average for 1.5 km long. In addition, supplemental flood dike for the Pagoda will be needed as proposed in F/S, though it is reported that some additional embankment of about 0.5 m was made by the Pagoda's fund in 2008-09.

According to the interviews to the village people, a bridge (17 m span) across the Tonle Bati river at Sta. 5.56 km was submerged about 0.5 - 1 m depth at 2010 flood, though no flood problem occurred at the Tonle Bati Pagoda (Pagoda's staff). Elevation of the crown of roadway on the bridge is EL. 8.2 m and its connection road across the river ranges from 8.0 m to 8.2 m. At the time of flood in 2010, flood flowed over the bridge and connection road, but some flow retarded upstream of the bridge and road. For ensuring road access, it is needed to replace the bridge and protection of connection canal on the river section. Results of the review are tabulated as below.

Table AD-2.3.1.4.10 Flood Protection Dike along Lake Tonle Bati

Item	F/S in 1995	Review in 2012
Crest elevation of dike	EL. 8.7 m	Do as left
Length to the heightening section (for north dike)	2.1 km	1.5 km
(for Pagoda and south dike)	1.2 km	Do as left
Replacement of one bridge on the western edge on the Tonle Bati river	1 no.	Do as left

Source: JICA Survey Team

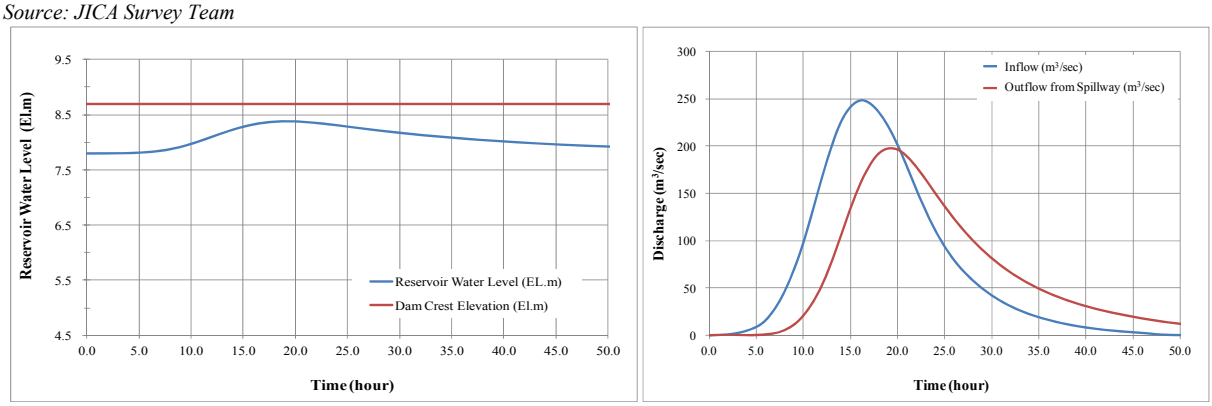
(b) Kampong Dangkor Spillway (Spillway at Outlet of Lake Tonle Bati)

In 1992, four manual operation wooden slide gates were provided by the Department of hydrology (predecessor of MOWRAM) for the spillway instead of stop-logs provided in Pol Pot regime. Gate size is 1.1m-1.2m wide and 3 m high. Crest elevation of gate is at about EL. 7.5 m. In November 2011, the wooden made slide gates were replaced by NGO (Cambodia Peoples Party), since the gate leaves were nearly collapsed. A review result of the structure is tabulated as below, and its details are shown in ANNEX B (refer to Sub-clause AB-2.3.2.7).

Table AD-2.3.1.4.11 Kampong Dangkor Spillway at Outlet of Lake Tonle Bati

Item	F/S in 1995	Review in 2012
Existing condition	There is some operation conflict between farmers in the Tonle Bati irrigation system and one benefited by the Kampong Kamrei reseroir. Supply of the lake water to Kampong Damrei reservoir would be needed.	No operation rule is prepared for the spillway gates by Takeo PDOWRAM. According to the request of downstream users, gates are partially opened for 5-7 days per month in dry season. For mitigating the conflicts, duty flow for rice cultivation of 200 ha in wet and dry season is considered in water balance study.
Flow capacity of the existing spillway	No description	According to the flood routine study, the existing spillway can only manage the 20 year probable flood of 189 m^3/s at FWL of EL. 8.7 m, though design flood discharge with 100 year probability is 249 m^3/sec.
Proposed work	No improvement plan for the spillway is proposed, since the spillway was newly constructed by MOWRAM in 1992 The bridge on the National Road No. 2, which is located immediately downstream of the spillway and is severely damaged, will be replaced.	Construction of new spillway with 4 nos. of 4 m wide gates and 16 m overflow weir. With this structure, regulated peak outflow of 197 m^3/sec at the lake water level of EL. 8.37 m (considering freeboard of 0.3 m to EL. 8.7 m) will be spilled out safely. (refer to figure below) The proposed steel bridge in F/S was already constructed, but span is only 6 m. Although no detailed condition of the Tonle Bati river downstream of the spillway is available at present, enlargement of the existing bridge span (more than 20 m) will be needed to evacuate the design regulated flood flow of 197 m^3/sec.

Source: JICA Survey Team



Source: JICA Survey Team

Figure AD-2.3.1.4.4 Flood Flow and Lake Water Level with Proposed Spillway

(5) Tertiary development

There is no systematic tertiary canal system at present, though some canals were constructed in the past. The irrigation command area of the tertiary block was planned to be about 50 ha in F/S. Assuming the canal density of 30 m per ha, its total length is estimated at 52.5 km in Kandal Stung and 48 km in Bati Area. In each tertiary block, watercourses (or quaternary canal) were proposed for commanding 7-10 ha. Length of the watercourse was estimated at 1,200 m per 7-10 ha. Construction of Tertiary Canal was considered to be conducted by local contractors, while watercourses would be constructed by beneficial farmers. Alignment of tertiary canals as well as size of tertiary blocks would be determined by FWUC under support of concerned PDOWRAM. Land required for tertiary canals and watercourses would be provided by beneficial farmers. The following are review results of the tertiary blocks:

Table AD-2.3.1.4.12 Review of Tertiary Blocks

Item	M/P and F/S in 1995	Review in 2012
1) Existing canals	Tertiary canals for 900 ha in Bati Area has been developed though there are presently not functioning. In case of Kandal Stung Area, no description is found	No functional tertiary canal is observed, though some trace of canals are found in both areas
2) Average size of tertiary block	47-50 ha in average varying from 30-100 ha	Although the "Design Manual of MOWRAM" in 2004 recommended the maximum extent of block of 25 ha, the layout of blocks seems to meet the actual filed conditions. Layout plan of tertiary blocks would be finalized based on the manual and intensions of concerned beneficiaries
3) Tertiary irrigation canals	Kandal Stung (1,750 ha) of 65.5 km and Bati Area (1,600 ha) of 48 km	Assuming 30 m/ha, Kandal Stung (1,750 ha) of 53 km and Bati Area (1,600 ha) of 48 km
4) Tertiary drainage canals	Kandal Stung (1,750 ha) of 74.5 km and Bati Area (1,600 ha) of 66.6 km	No tertiary drainage canal is planned considering difficulty in land acquisition and resistance to inundation of paddy
5) Related structures	Division boxes, measuring devices, culverts, etc.	Plan for provision of a measuring device is not realistic, considering no available hydraulic head of canals.

Source: JICA Survey Team

Although the necessity of the development for tertiary system is well recognized, it would take long time to secure the land for Tertiary Canals and Watercourses. MOWRAM is therefore requested to take timely actions for land acquisition for constructing them.

AD-2.3.1.5 Proposed Development Plan (Proposed Scope of Sub-project)

In the previous Sections and Clauses, the works proposed by MOWRAM were examined from technical and economical viewpoints and also considering application of Japan Yen's loan, through review on previous studies like M/P and F/S, site visits, hearing from farmers and a series of discussions with MOWRAM and PDOWRAM. The results of examination are shown in the following table, comparing with the works proposed by MOWRAM:

Table AD-2.3.1.5.1 Examined Scope of KSBISRSP

Scope Proposed by MOWRAM in M/D*	Examined Scope by JICA Survey Team	Remarks
(1) Irrigation Development Area	(a) Irrigation Development Area	
Not specified	3,350 ha in total, consisting of 1,750 ha in Kandal Stung Area and 1,600 ha in Bati Area	The extent of irrigation area is confirmed through basin wide water balance study on Prek Thnot River
(2) Cropping Pattern and Crop Intensity	(b) Cropping Pattern and Crop Intensity	
Not specified	- Rice-based cropping system with cropping intensity of 180% per year	Application of double cropping of rice considering present cropping pattern

Scope Proposed by MOWRAM in M/D*	Examined Scope by JICA Survey Team	Remarks
(3) Hardware Components	(c) Hardware Component	
Rehabilitation of Main Canals and secondary canals including related structures	Kandal Stung Area: Full rehabilitation of two main canals of 11.3 km and two secondary canals of 5.0 km long Bati Area: Full rehabilitation of two main canals of 7.6 km and six secondary canals of 8.6 km long	Concrete lining of 75 mm thick is provided for main irrigation canals of 18.9 km
Rehabilitation of third canals including related structures	Tertiary irrigation canals of 53 km for Kandal Stung (1,750 ha) and 48 km for Bati Area (1,600 ha)	No tertiary drainage canal is planned considering difficulty in land acquisition and resistance to inundation of paddy
Gate installation for diversion works, intakes and checks,	Construction of one new diversion weir and rehabilitation of one gated weir, and replacement of 3 intakes on the Stung Touch River. New construction of check and turnout structures on main and secondary canals Replacement of Daeum Rues Regulator on the Prek Thnot River for supplying water to the Stung Touch River	Three intakes are; for EW-60, EW-58 and NS82
Rehabilitation of intake, pumping station, spillway, embankment etc. around Lake Tonle Bati	Replacement of intake structure and pump station for Bati Area on Lake Tonle Bati, Kampong Dangkor spillway and heightening of flood dike for 2.7 km	
Rehabilitation of Stung Touch Gate and NS78*Canal **: NS87 in MD is clerical error*	Enlargement of NS-82 as a connection canal for future development of Bati Area, and construction of new diversion weir on the Stung Touch River	Through comparative study between NS78 and NS82, NS82 was selected due to less construction cost; same diversion weir for the main canal EW-58 could be used

**: Minutes of Discussion dated February 25, 2011*
Source: JICA Survey Team

(1) Priority Ranking

The examined Sub-project scope consists of many works. It is not sure presently that all of these works could be simultaneously implemented in the available loan amount. Thus, these examined works are given priority ranking based on the following criteria

- The works indispensable for attaining at the aim of KSBISRSP mentioned above are given high priority.
- Urgently required works for proper operation of irrigation system are given high priority.
- The facilities related to ensuring water resources should be given high priority since KSBISRSP severely suffers from shortage of irrigation water.
- The facilities which need large scale rehabilitation to convey irrigation water are given high priority.
- The facilities which require only minor rehabilitation like maintenance works, are accorded to not high priority.

Table AD-2.3.1.5.2 Priority Ranking for Each Work (Hardware Component)

Examined Scope by JICA Survey Team		Priority*
Rehabilitation of Main Canals including related structures	Full rehabilitation of 2 Main irrigation canals of 11.3 km in Kandal Stung Area and 2 Main canal of 7.6 km in Bati Area (total; 18.9 km)	◎
Rehabilitation of secondary canals including related structures	Construction and rehabilitation of secondary canals of 5.0 km in Kandal Stung Area and full rehabilitation of the existing canals for 8.6 km in Bati Area (total; 13.6 km)	○
Gate installation for diversion works, intakes and checks	Construction of one new diversion weir and rehabilitation of one existing weir, and replacement of 3 intakes on the Stung Touch River. Replacement of Daeum Rues Regulator on the Prek Thnot River	◎

Examined Scope by JICA Survey Team		Priority*
Rehabilitation of intake, pumping station, spillway, embankment etc. around Lake Tonle Bati	Replacement of intake structure and pump station on Lake Tonle Bati, Kampong Dangkor spillway and heightening of flood dike for 2.7 km	◎
Construction of Connection Canal through rehabilitation of NS82	Rehabilitation of NS-82 of 3.5 km as a connection canal for future development of Bati Area (the canal is not needed for the first stage development of 1,600 ha, but strongly desired it for future development by MOWRAM)	△
Tertiary canals including related structures	Tertiary irrigation canals of 53 km for Kandal Stung (1,750 ha) and 48 km for Bati Area (1,600 ha)	△

Source: JICA Survey Team

**: High Priority: ◎, Medium Priority: ○, Low Priority: △*

Regarding the Connection Canal, it is recommendable to include it into the Sub-project in case of that the economic viability is confirmed and construction fund is available. MOWRAM has strong intension to develop remaining are of 2,600 ha in Tonle Bati Area by himself as Stage 2.

AD-2.3.1.6 Irrigation and Drainage Water Requirements and Design Discharges

(1) Conditions for Estimating Irrigation Water Requirement

Due to updating of proposed cropping pattern and meteorological data, irrigation water requirement is revised. Major changes are revision of proposed cropping pattern and change of rainfall station from Phnom Penh to Tonle Bati in Takeo. Major conditions revised and/or updated from the F/S and updated potential evapo-transpiration are tabulated as below

Table AD-2.3.1.6.1 Comparison of Conditions for Estimating Irrigation Requirement

Item	M/P and F/S (1995)	Review (2012)	Remarks
1) Proposed cropping pattern	Double crops of rice and one diversified crop in dry season (CI=174% for Kandal Stung Area and 180% for Bati Area)	Double crops of rice with crop intensity (CI) of 180% is proposed for both areas through water balance study with Stung Tasal Reservoir	Balanced development in both Roleang Chrey and Kandal Stung-Bati Areas are also considered
2) Potential evapo-transportation (ETo)	Estimated by Penman method using the available data of Pochentong in Phnom Penh, but no details about data period is mentioned	Same method is applied, but estimated based on the updated meteorological data from 1991 to 2010 at Pochentong	Revised ETo is about 10 % higher than one estimated in F/S
3) Rainfall Station	Phnom Penh and Slakou (Takeo) were used, but for 1961 to 1970 only	Tonle Bati from 1982 to 2011	Observed rain at Tonle Bati station is available from 2003 to 2010 and extended by correlation curve between Sdock and Tonle Bati,
4) Effective rainfall	Based on the daily water balance between rainfall and requirement, half monthly effective rainfall is set at about 67% of half monthly rainfall.	Referring to the recent studies for Slakou and R-Chrey, 75% of monthly rainfall	No details of calculation condition is described in M/P and F/S (1995)
5) Percolation rate of paddy field	1 mm/day based on the field observation at four points.	No change	Additional observation data is not found yet
6) Irrigation efficiency	65% for paddy and 53% for upland crops	No change	
7) Calculation step of irrigation requirement	Half monthly	5-days for water balance with dam (reservoir) condition	Water balance of the Prek Thnot river with committed and planned dams is assessed.

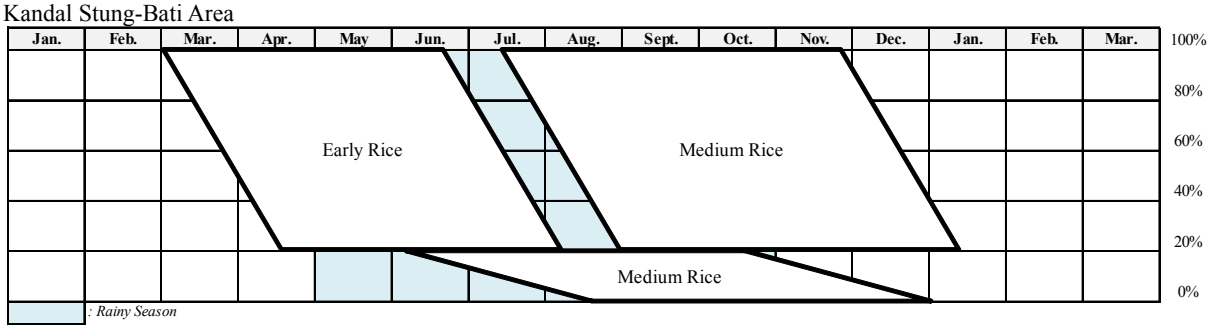
Source: JICA Survey Team

Table AD-2.3.1.6.2 Updated Potential Evapo-transpirations at Pochentong Observatory

Period	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
At F/S (1995)	145	161	206	188	165	149	150	147	132	136	135	142	1,856
Review	165	173	217	208	195	178	164	170	146	142	152	161	2,070

Source: JICA Survey Team

Kandal Stung-Bati Area



Source: JICA Survey Team

Figure AD-2.3.1.4.5 Proposed Cropping Calendar for Kandal Stung - Bati Area

(2) Estimate of Irrigation Water Requirement

Based on the revised and updated data, irrigation water requirements of each proposed crops are estimated for 30 years from 1982 to 2011.

Unit water requirement of Kandal Stung Area of 1,750 ha with 80% dependability is estimated at 1.31 lit/sec/ha with the following extent of crops:

- Early rice (110 day in early wet season) 1,400 ha
- Medium Rice-1 (130 days in wet season) 350 ha
- Medium Rice-2 (130 days in wet season) 1,400 ha

Considering the some allowance, the unit irrigation water requirement is set at 1.4 lit/sec/ha, which is the same value used in F/S. Since same cropping intensity and crop calendar is applied to Bati Area, same unit water requirement is applied. Diversion irrigation water requirement at the head of the water resources for the above proposed cropping pattern with 80% dry condition is estimated at 2.45 m^3/sec for Kandal Stung Area of 1,750 ha, and 2.24 m^3/sec for Bati Area of 1,600 ha.

(4) Estimate of Drainage Requirement

Considering difficulty in land acquisition for drainage canals and main crop of paddy, which has strong resistance against inundation, some inundation depth and period is allowed. Unit drainage requirement for paddy is thus estimated at 1.6 lit/sec/ha, based on the following conditions and assumptions:

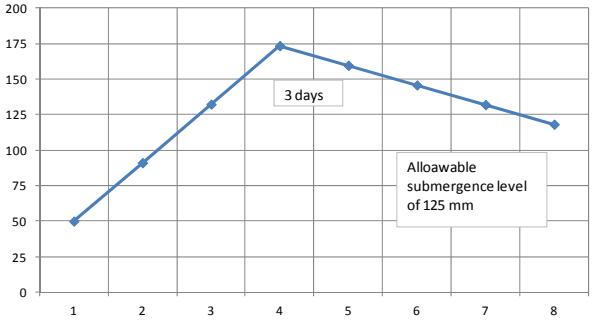


Figure AD-2.3.1.4.6 Estimate of Drainage Requirement

- Allowable inundation depth 150 mm
- Allowable inundation period 3 days
- Design rainfall 165 mm at Tonle Bati with 1-in-10-year 3-day rainstorm
- Initial water 50 mm

For the upland crops, F/S recommended to grow them on the raised ridge of more than 150 mm, considering difficulty in provision of perfect drainage system and less extent of upland crop in the rainy season.

AD-2.3.2 Design of Irrigation and Drainage Facilities

AD-2.3.2.1 General

The target irrigation area of KSBISRSP is 3,350 ha in total, consisting of 1,750 ha in Kandal Stung Area in Kandal Province, and 1,600 ha in Bati Area in Takeo Province (refer to Drawing No. KSB-01).

Water resources of the KSBISRP are augmented Prek Thnot River by the Stung Tasal reservoir, the Stung Touch and the Tonle Bati Rivers, and Lake Tonle Bati.

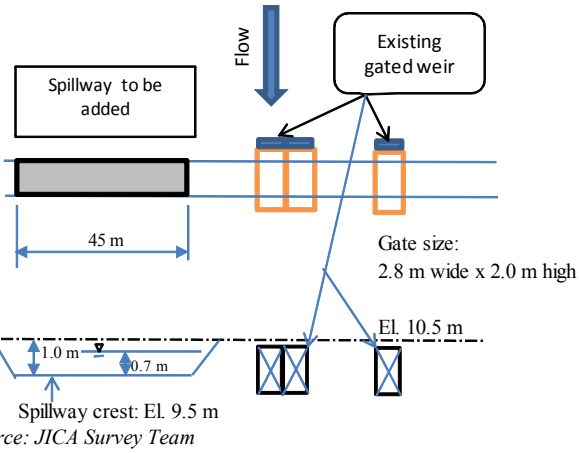
For confirming the previous design in F/S and preparing preliminary design of project facilities, following topographic survey are carried out through subletting local survey contractor:

- Route survey (long and cross sections) of the existing canals for 7 routes of 22.5 km in total
- Route survey (long and cross sections) of flood protection dike along Lake Tonle Bati for 6 km
- Site survey of six conceivable major structure sites

AD-2.3.2.2 Diversion Weir and Intake on the Stung Touch River

(1) Improvement of Existing weir on Stung Touch River at Phoum Thmei commune

There is one gated diversion weir at Phoum Thmei commune, which was rehabilitated with financial assistance of NGO (World Vision) in 2006. The weir was constructed to provide stable water for NW-60 (KC-2) and equipped three manual operation steel slide gates. Dimensions of gates are 2.8 m wide and 2.0 m high each. Probable flood of the river with return period of 100 years (catchment area of 148 km^2 at the crossing point with National Road No. 3) is estimated at 57 m^3/sec, but flow capacity of the gated weir is estimated at 13 m^3/sec or 25% of the 100 year flood, assuming flow velocity of 1 m/sec at the gates. However, no serious flood damage or overtopping of the gates is recorded. It is considered that most of flood flow entered into upstream Pol Pot canals, which has no intake gate at present, then flood discharge was reduced at the existing weir site.



Source: JICA Survey Team

Figure AD-2.3.2.2.1 Improvement Plan of Existing Weir on Stung Touch at Thmei

Considering the existing gated weir is rather newly rehabilitated of 6 years old as token of friendship of goodwill as well as saving the project cost, the existing structure shall be remained as it is. However, it is obvious that flow capacity of the existing gated portion is much less than the design flood of 57 m^3/sec. It is proposed to construct additional overflow type spillway at the site as illustrated above.

In addition, following arrangement would be needed for intake gates of the upstream Pol Pot canals:

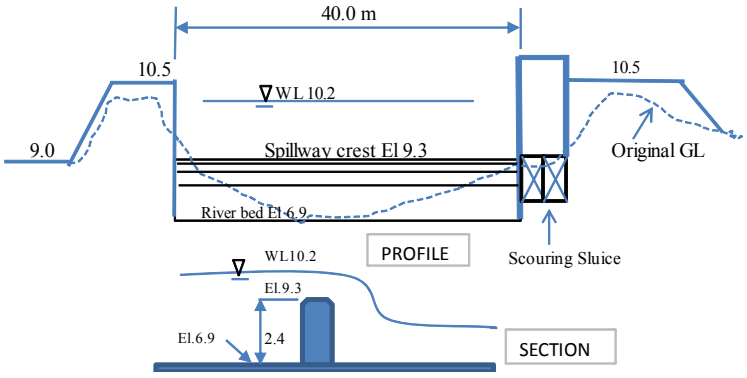
- no water enter to canal in low flow case (less than 10 m^3/sec)
- some amount of flood flow within the flow capacity of canals will enter to these canal in flood flow
- realizing the above condition, constructing fixed weir or low gates is needed.

(2) New diversion weir for Connection Canal and EW-58 (refer to Drawing No.KSB-03)

The proposed diversion weir site is just downstream of the existing intake for EW-58 (KC-31). According to the topographic map prepared by the Survey Team in 2012, elevation of bank crest is around EL. 10.0 m for both banks. Ground elevation of the site is around 9.0 m. Width of river between the banks is 50 m and the deepest canal bed is around EL. 6.9 m. Flow area is estimated at about 55 m^2 at the full bank level. Assuming the flow velocity at 1.0 m/sec, the river flow section may be able to flow the flood with 100-year-return period, namely 57m^3/sec. The weir could divert the

water to EW-58 (KC-31) and NS-82 (KC-4 as Connection Canal) as well as supply canal to Lake Saba in future.

Considering remote location and long durability, an overflow weir type spillway is planned. Assuming flood water level of EL. 10.2 m and overflow depth of 0.9 m with 40 m overflow section, the crest elevation is set at EL. 9.3 m. It is expected all canals from the weir will be ensured the enough water level, namely for the Connection Canal of WL 9.2 m, KC-31 of WL 8.5. Scouring sluice consisting of two sets manual operation slide gate is also planned.



Source: JICA Survey Team

Figure AD-2.3.2.2.2 Basic Plan of Proposed Diversion Weir on Stung Touch River

AD-2.3.2.3 Connection Canal from Stung Touch River to Lake Tonle Bati

Through alternative study, canal route of NS-82 is selected. For minimizing conveyance loss and lighten the burden for maintenance, it is planned to line the canal by thin (75 mm thick) unreinforced concrete lining. Water balance study made in the Review shows that the peak requirement for supplemental supply to Lake Tonle Bati from the Prek Thnot River with 80% dependability is estimated at 5.29 m^3/sec for 4,200 ha. Design discharge at BP of the canal is thus set at 5.57 m^3/sec (5.29 + 0.28 for 200 ha demand). Considering possible intake water level of 9.3 m at the diversion weir site, and for reducing excavation volume as well as concrete volume for lining, canal section is designed as follows:

- Design discharge: 5.57 m^3/sec
- Type of canal Unreinforced concrete lined open channel with trapezoidal section
- Bed width 5 m
- Height of lining section 1.8 m
- Design water level 1.53 m
- Design velocity 0.50 m/sec
- Gradient of canal 1: 15,000
- Roughness coefficient 0.017
- Inside slope 1 : 1.5
- Freeboard 0.27 m
- Application of lining Canal slopes for full length of 3,500 m
- Thickness of lining 75 mm (3 inches)

AD-2.3.2.4 Intake and Pumping Station at Lake Tonle Bati (refer to Drawing No.KSB-04)

(1) Intake at Lake Tonle Bati

Development of Bati Area is divided into 2 stages, namely priority development for 1,600 ha and future development of remaining 2,600 ha. Facilities for priority development include intake, main canal, related structures which area related to the future extension. They have to be given the capacities for future development. Therefore, the capacity of intake is set for 4,200 ha or 5.88 m^3/sec. The same design as proposed in F/S is applied for the intake as below.

- Design discharge 5.88 m3/sec (for 4,200 ha)
- High water level EL. 7.8 m
- Bottom of intake EL. 6.0 m
- Nos. and size of gates 3 nos., 4-side-tight gate with 2.0 m wide x 2.0 m high
- Related structures Screen, operation deck and road culvert of 4.0 m wide

(2) Pumping Station at Lake Tonle Bati

As stated in previous section, the proposed capacity of F/S is confirmed in the Review. Therefore, 4 sets (including one spare set) of horizontal volute type pump with capacity of 45 m^3/min and 30 kW per set, and total head is 4.5 m is planned. One set of diesel generator of 90 kW is also needed.

Same design as proposed in F/S is applied for the pump station as below.

- Design discharge 2.25 m^3/sec by 3 sets of pump
- High water level EL. 7.8 m
- Low water level EL. 5.5 m
- Nos. and type of pumps four sets (including one spare set) of horizontal volute type pump with capacity of 45 m^3/min
- Related facilities Diesel generator of 90 kW, Pump house of 155 m^2, Screen, Distribution pipe

AD-2.3.2.5 Main and Secondary Irrigation Canals

(1) Canal Layout and Cross Section (refer to Drawing No.KSB-05)

Layout plan of irrigation canal in Kandal Stung Area is just similar to one applied for the priority area developed in 2005-07. Namely, two existing Pol Pot canals of EW-58 and EW-60 will be used as main irrigation canals, which are supplied irrigation water from the intakes on the Stung Touch River. Two secondary canals are diverted from EW-58 and NS-82. Most of tertiary canals are branched off from the main canal directly as applied to the priority area.

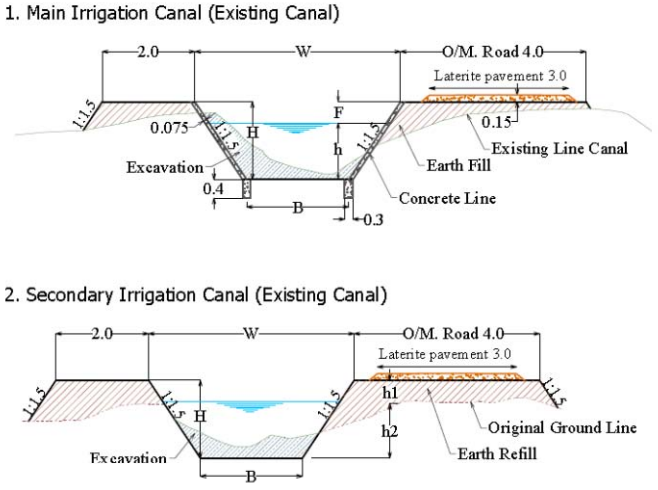
In case of Tonle Bati Area, canal layout was prepared based on the topographic condition in F/S. Main canal (MR-1) from the intake on Lake Tonle Bati runs along the ridge of the area. The main canal (MR-1) diverts MR-3 about 150 m downstream of the intake. Six secondary canals are diverted from MR-1 (five canals) and MR-3 (one canal). For saving the project cost, 2 phased thin concrete lining is applied for the 4 main irrigation canals of 18.9 km in total, but not for the secondary canals of 13.6 km. In other word, re-shaping of canal cross sections with removal of sediments and earth fill for embankment are applied for the secondary canals. The principal features of main and secondary canals are tabulated as below and typical cross sections of canals are illustrated in Figure AD-2.3.2.5.1.

Table AD-2.3.2.5.1 Principal Features of Irrigation Canals

Canal	Length (km)	Command Area (ha)	Design Discharge at BP (m^3/sec)	Lining Plan	Remarks
(Kandal Stung: 1,750 ha)					
1) KC-2 (EW-60)	6.6	900	1.26	Concrete lining	
2) KC-31 (EW-58)	4.7	650	0.91	Concrete lining	
3) SC-311	2.5	200	0.28	Unlined	
4) SC-41	2.5	150	0.21	Unlined	
(Bati: 1,600 ha)					
1) MR-1	4.6	4,200	5.88	Concrete lining	Area includes future extension
2) MR-3	3.0	967	1.35	Concrete lining	- do. -

Canal		Length (km)	Command Area (ha)	Design Discharge at BP (m^3/sec)	Lining Plan	Remarks
3)	L3	1.4	228	0.32	Unlined	
4)	L4	0.8	148	0.21	Unlined	
5)	L5	0.8	232	0.32	Unlined	
6)	L6	2.4	165	0.23	Unlined	
7)	L7	2.0	217	0.30	Unlined	
8)	L8	1.2	319	0.45	Unlined	
	Sub-total	32.5				

Note: Unit irrigation requirement: 1.4 lit/s/ha, Concrete lining is planned for main canals only
Source: JICA Survey Team



Source: JICA Survey Team

Figure AD-2.3.2.5.1 Typical Cross Section of Irrigation Canals

Considering almost all the existing canal structures are severely deteriorated and mal-functioned condition due to absence of repair and maintenance for long time as well as mal-design, construction of following structures are planned for ensuring water management and public access in the area (refer to Drawings No.KSB-06 and 07):

- Diversion structure — to control the water level for off-takes upstream and discharge to downstream of the structure
- Off-takes — diverting irrigation water to secondary or tertiary canals from the main or secondary canals.
- Culverts/ bridges — to cross the canal without obstructing canal flow, including public road crossing and farm/ house access for private use

Through review of design made in F/S and results of inventory survey made by the JICA Survey Team in 2011-12, following structures would be needed on the canals:

Table AD-2.3.2.5.2 List of Related Structures on Main and Secondary Irrigation Canals

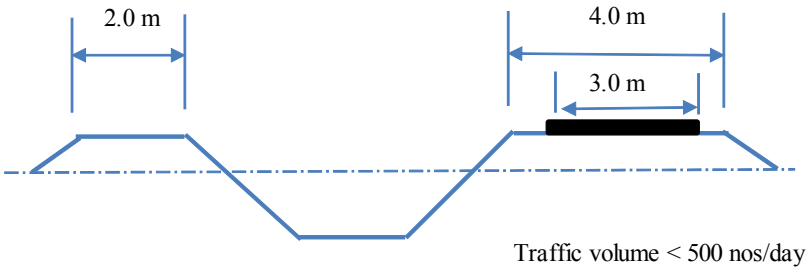
(Unit: nos.)

Canal		Intake	Diversion Structure	Off-take	Road Crossing
(Kandal Stung Area)					
1)	KC-2 (EW-60)	1	6	29	9
2)	KC-31 (EW-58)	1	5	21	3
3)	SC-311		2	5	2
4)	SC-41		1	4	3
(Bati Area)					
1)	MR-1	1	4	18	10
2)	MR-3		2	3	7
3)	L3		2	9	1
4)	L4		0	3	1

Canal		Intake	Diversion Structure	Off-take	Road Crossing
5)	L5		1	6	1
6)	L6		1	7	2
7)	L7		1	5	1
8)	L8		1	7	1
	Total	3	26	107	41

Source: JICA Survey Team

Road along the canals are designed as below based on the expected traffic volume of less than 500 nos. per day and cost saving of the work.



Source: JICA Survey Team

Figure AD-2.3.2.5.2 Typical Section of Road along Irrigation Canals

AD-2.3.2.6 Drainage Canals

Considering difficulty in (i) land acquisition for construction of new drains, and (ii) no report about serious drainage problems except caused by big floods, no substantial drainage improvement is considered except main drainage canals as applied to Priority development area in Kandal Stung Area. Main drainage canals will be formed through re-shaping of the existing Pol Pot canal sections and providing drain inlets and bridges/ culverts. The following 4 main drainage canals are planned to evacuate excess water in the irrigation area.

Table AD-2.3.2.6.1 Principal Features of Main Drainage Canals

Canal		Length (km)	Drainage area (ha)	Design Discharge at EP (m^3/sec)	Remarks
	(Kandal Stung Area)				
1)	KD-1 (EW-59)	6.5	1,400	2.24	
2)	KD-2 (EW-56 & 57)	5.6	900	1.44	
	(Bati Area)				
1)	MD-1	3.9	547	0.88	Haknuman canal
2)	MD-3	2.8	730	1.17	
	Sub-total	18.8			

Note: Unit irrigdrainage requirement: 1.6 lit/s/ha
Source: JICA Survey Team

Table AD-2.3.2.6.2 List of Related Structures on Main Drainage Canals

(Unit: nos.)

Canal		Road crossing	Drain inlet	Remarks
	(Kandal Stung Area)			
1)	KD-1 (EW-59)	4	28	
2)	KD-2 (EW-56)	3	20	
	(Bati Area)			
1)	MD-1	1	4	Bridge on NE-2 in not included
2)	MD-3	2	11	MD-2 locates in Extension area
	Total	10	63	

AD-2.3.2.7 Flood Protection Dike along Lake Tonle Bati (refer to Drawing No.KSB-08)

According to the topographic survey for northern dike made by the JICA Survey Team in 2012, elevation of almost all portion of the dike is higher than EL. 9 m, except section from Sta. 0.5 km to

Sta. 1.0 km and from Sta. 5.1 km to EP (Sta. 5.9 km). The northern dike needs some additional embankment of 0.3 to 0.5 m high in average for 1.5 km long. In addition, supplemental flood dike for the Pagoda will also be needed though it is reported that some additional embankment of about 0.5 m was made by the Pagoda's fund in 2008-09.

The bridge (17 m span) across the Tonle Bati River at Sta. 5.56 km was submerged about 0.5 - 1 m depth at 2010 flood, though no inundation problem occurred at the Tonle Bati Pagoda (Pagoda's staff). Elevation of the crown of roadway on the bridge is EL. 8.2 m and its connection road across the river ranges from 8.0 m to 8.2 m. At the time of flood in 2010, flood flowed over the bridge and connection road, but some amount of flow retarded upstream of the bridge and road. For ensuring road access, it is needed to replace the bridge and protection of connection canal on the river section. Proposed works for the dike are tabulated as below.

Table AD-2.3.2.7.1 Flood Protection Dike along Lake Tonle Bati

Item	Proposed Work
Crest elevation of dike	EL. 8.7 m
Length to the heightening section (for north dike)	1.5 km
(for Pagoda and south dike)	1.2 km
Replacement of the bridge on the western edge on the Tonle Bati river	1 no.

Source: JICA Survey Team

AD-2.3.2.8 Kampong Daungkar Spillway at Outlet of Lake Tonle Bati

Based on the flood routine study for the spillway, two alternative plans are prepared for selecting best suitable type of spillway. One is overflow type weir, which is free from any operation and replacement of metal works and the other is combination of gates and overflow weirs. Considering freeboard of 0.3 m at 100 year flood for the flood dike, the maximum flood water level is set at El 8.4 m and assuming that downstream bridge on the NR-2 would be enlarged enough. As shown in the following table, overflow type weir needs 135 m long overflow section. Such a long spillway crest length is not realistic considering the site condition. It is decided to select the combined type of gates and weir.

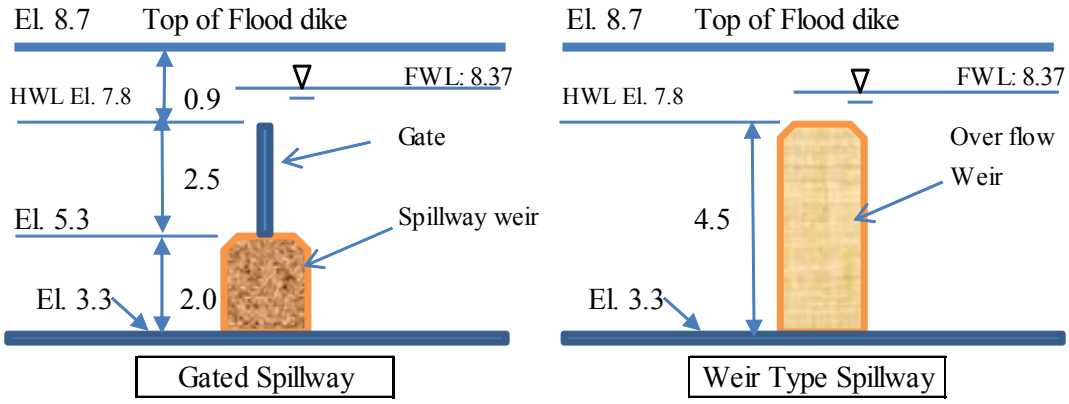
Table AD-2.3.2.8.1 Alternatives of Proposed Spillway

Item	Alternative-1 Overflow type weir only	Alternative-2 Gates and Overflow type weir
Required length of flow section	Crest length of 135 m	Total of 32 m, Gate of 16 m and Weir of 16 m
Regulated design flood discharge (lower than 8.4 m)	FWL 8.41m	FWL 8.37m

Source: JICA Survey Team

As a result, the following basic dimensions are obtained (refer to Drawing No. KSB-08):

- Design flood discharge (Peak inflow to the lake; 100 year) 249 m^3/sec
- Design flood discharge (regulated flow by the lake) 197 m^3/sec
- Dike crest elevation EL. 8.70 m
- High water level EL. 7.80 m
- Low water level EL. 5.50 m
- Peak flood water level at regulated design flood discharge EL. 8.37 m
- Crest elevation of gates EL. 5.30 m
- Crest elevation of overflow type spillway EL. 7.80 m
- Gated spillway 16 m wide in total
- Overflow weir type spillway 16 m wide in total



Source: JICA Survey Team

Figure AD-2.3.2.8.1 Basic Plan of Kampong Dangkor Spillway

Although no detailed condition of the Tonle Bati River downstream of the spillway is available at present, enlargement of the existing bridge on NR-2 to more than 20 m will be needed to evacuate the design regulated flow of 197 m^3/sec, since present span is only 6 m.

AD-2.3.2.9 Tertiary Canal System Development

There is no systematic tertiary canal system. In each tertiary block, watercourses were proposed for commanding 7-10 ha. It was assumed that the land required for tertiary canals and watercourses would be provided by the beneficial farmers. Concept of "provision of land by beneficial farmers" is the critical path for realizing the construction of canals. It was also assumed in F/S that construction of tertiary canals is supposed to be contracted by local contractors, while Watercourses would be constructed by beneficial farmers themselves. FWUC members would participate in the construction works as hired labor as a sort of training of maintenance works. Proposed design concept is reasonable and acceptable; however, it is expected rather long period to realize the tertiary canals and watercourses in the field because of the concept of "provision of land by beneficial farmers".

Irrigation water conveyed by main and secondary irrigation canals is diverted into tertiary canals through off-take, and delivered to each plot through watercourse. Typical dimensions of tertiary canal are as follows:

Canal Bed Width	0.5 m
Canal Depth	0.6 m
Canal Side Slope (Inside and Outside)	1:1.0
Width of Dike Top	0.5 m

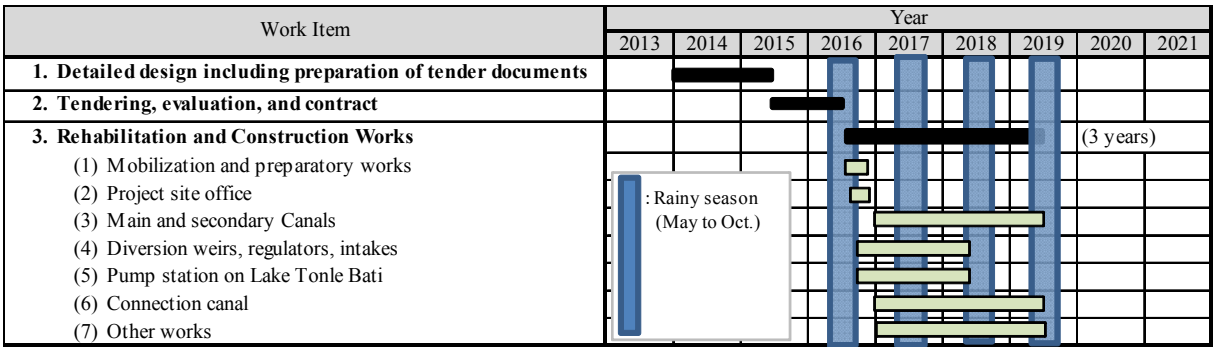
It is noted that no drainage system in the tertiary block is considered as applied in Model Farm of TSC in the Kandal Stung Priority area due to serious difficulty in securing land for drainage canals.

AD-2.3.3 Construction Schedule

(1) Rehabilitation of Water Resource Facilities and Main and Secondary Canal System

Facilities of the main system of KSBISRSP consists of 2 diversion weirs (headworks) and 3 intake gates on the Stung Touch River, a connection canal from the Stung Touch river to Lake Tonle Bati, a pumping station at Lake Tonle Bati, flood protection dike and a spillway of Lake Tonle Bati, and main and secondary canals with related structures. The rehabilitation works of the main system will require a period of 2.5 years or 2 dry seasons after procurement procedure of the construction contractor based

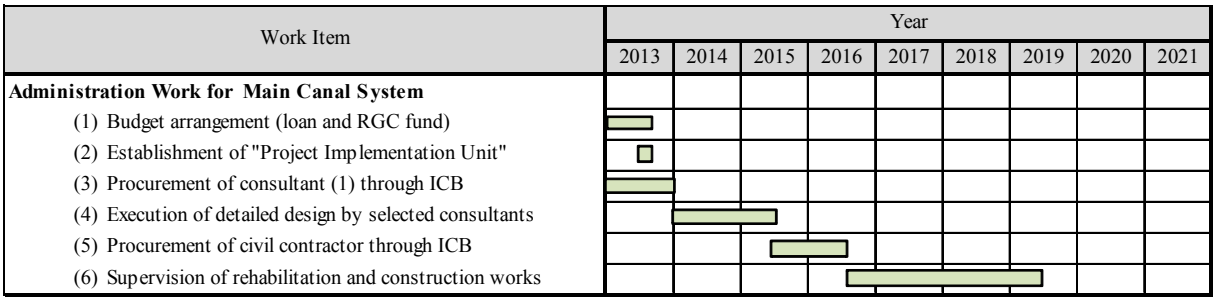
on D/D prepared by the employed consultant. It is assumed that D/D including preparation of tender documents would be completed within 1.5 years. Rehabilitation of the main canals, flood dike and spillway, diversion weir and intakes will be completed in the first year, but the pump station and the connection canal will be for the whole construction period due to rather long procurement time of pumps and huge amount of excavation volume of about 200,000 m^3. Contractor for the work will be selected through ICB, while ones for tertiary canals will be selected through LCB. Time required from the commencement of D/D including mapping to the end of rehabilitation work would be 5.5 years as shown below.



Source: JICA Survey Team

Figure AD-2.3.3.1 Implementation Time Schedule for Main Canal System of KSBISRSP

For fulfilling the activities mentioned above, required administration works of MOWRAM and PDOWRAM would be as follows.



Source: JICA Survey Team

Figure AD-2.3.3.2 Administrative Activities for Main Canal System of KSBISRSP

(2) Construction of Tertiary Canal System

Construction and rehabilitation of tertiary canals covering 3,350 ha will be implemented following the rehabilitation work for main canal system. D/D for tertiary canal would be prepared by the national consultant with close coordination with PDOWRAMs and FWUCs, and based on the design for the main canal system. The delineation of tertiary block and alignment of tertiary canals are to be agreed by FWUCs and land owners. It would take rather longer period, since private lands should be provided for tertiary canals by land owners free of charge. Therefore, period of detailed design is estimated at 2 years including confirmation of alignment of tertiary canals. Assuming the progress rate of work at about 800-1,000 ha per year, construction period is set at 3 years (3 dry seasons) as shown below. It is expected the tertiary canal system will be handed over to FWUC after 1-year maintenance period.

Work Item	Year								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Construction of Tertiary Canal System									
(1) Detailed design									
(2) Tendering, evaluation, and contract									
(3) Construction work for tertiary canal system									

Source: JICA Survey Team

Figure AD-2.3.3.3 Implementation Time Schedule for Tertiary Canals of KSBISRSP

In order to execute the above activities successfully, the required administration works of MOWRAM and PDOWARAM are as shown below.

Work Item	Year								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
2. **Administration for Tertiary Canal System**									
(1) Budget arrangement									
(2) Procurement of consultant through LCB									
(3) Execution of detailed design with selected consultants									
(4) Acquring lands thru obtaining the consents of land owners									
(5) Procurement of civil contractor through LCB									
(6) Supervision of rehabilitation works									
(7) Handing over of tertiary canal system to FWUC									

Revision of design will be done by Project staff

Source: JICA Survey Team

Figure AD-2.3.3.4 Administrative Activities for Construction of Tertiary Canal System of KSBISRSP

AD-2.4 Small-scale Irrigation System Rehabilitation Sub-project

AD-2.4.1 Selection of Representative Sub-projects for Pre-feasibility Study

AD-2.4.1.1 Outlines of Small-scale Irrigation Project

(1) Background

According to the updated irrigation inventory by MOWRAM in 2004, there are 2,403 irrigation systems extending 1.05 million ha (total cultivation area in rainy and dry seasons). Out of this, 59% (1,415 systems) are reported small scale irrigation system having irrigation area of less than 200 ha, and 40% (955 systems) are categorized into medium scale having irrigation area of more than 200 ha and less than 5,000 ha. However, only some 10% of irrigation scheme were fully operational and up to 70% of the agricultural area was not readily irrigable[4]. The MOWRAM's Action Plan[5] aims to elaborate necessary actions to be taken during 2009-2013 based on the review of the lessons learnt and achievement in the past 5 years (2004-2008), which focuses on the rehabilitation of existing irrigation infrastructure.

Under such situation, RGC requested to JICA for rehabilitation of 84 small scale irrigation systems in 23 provinces all over the country as well as the other Sub-projects of RCHRSP, USISRSP and KSBISRSP. In response, the original scope of this JICA Preparatory Survey for Small-scale Irrigation System Improvement Project (SISIP) included (i) preparation of selection criteria for high priority area, (ii) revision of the long list of sub-projects, (iii) classify all the proposed sub-projects into categories, (iv) F/S for one site from each category and (v) estimate and evaluate the overall cost, (vi) preparation of implementation schedule of the project, and (vii) preparation of manuals for conducting F/S and procedures for appraisal by MOWRAM, etc, which envisaged the project implementation under the Japanese ODA sector loan. During the survey period, however JICA revised the scopes as below.

[4] *Reported in NWISP in 2003*
[5] *Action Plan on Water Resources and Meteorology Management and Development (2009-2013)*

- Regarding the SISIP, from 2-3 viable projects would be selected from the 84 sub-projects based on the criteria, combining those viable projects with other three sub-projects of RCHRSP, USISRSP and KSBISRSP. Therefore, the project package for the loan project will be composed of the said three sub-projects and 2-3 small scale irrigation system projects.
- With regard to the rest of the projects in the SISIP except for the above 2-3 viable projects, the prioritized project list based on the criteria and manuals for MOWRAM, to conduct F/S, would be prepared as originally agreed.

(2) Long List Prepared by MOWRAM

Total of 84 sub-projects in the long list were nominated from 23 provinces, the whole country except Phnom Penh. Table AD-2.4.1.1.1 summarizes the nominated sub-projects by provinces. Original list prepared by MOWRAM and location map of 84 proposed sub-projects are attached in Table AD-2.4.1.1.2 and Figure AD-2.4.1.1.1, respectively.

Table AD-2.4.1.1.1 Summary of Long Listed Sub-projects by Province

Code	Province	Nos.	Total Area (ha)	Code	Province	Nos.	Total Area (ha)
01	Banteay Mean Chey	3	5,166	13	Siem Reap	3	2,996
02	Mondul Kiri	2	1,440	14	Pailin	1	4,000
03	Kampong Chhnang	3	2,647	15	Ratanakkrir	1	90
04	Kampong Speu	3	7,668	16	Kampong Cham	5	2,856
05	Battambang	2	5,460	17	Prey Veng	6	9,373
06	Takeo	5	5,715	18	Svay Rieng	11	7,251
07	Sihanuk Ville	2	646	19	Kampong Thom	2	1,250
08	Pursat	7	5,275	20	Kratie	3	1,311
09	Kandal	5	6,965	21	Koh Kong	2	583
10	Stung Treng	3	4,121	22	Preah Vihear	2	760
11	Kep	4	1,231	23	Odar Mean Chey	2	2993
12	Kampot	7	5,268		Total	84	85,065

Source: MOWRAM

(3) Project Proposal

Project proposal documents for the rehabilitation of the 84 small-scale irrigation systems were submitted to MOWRAM in October 2009 prior to the JICA Survey. These proposals were prepared by PDOWRAM by filling up standard proposal forms that were given by MOWRAM under assistance of TSC-2. The proposal consisted of an application form and annexes including the following descriptions, in principle,

Table AD-2.4.1.1.2 Components of Project Proposal Documents for Small-scale Irrigation System Improvement Project

Application form	Annexes
(1) Applicant's information (PDOWRAM) - Name and address of responsible person - Number of staff and annual budget - Project implementation system - Experiences of project implementation (2) Project information - Project site - Background of project - Purpose of project - Outline of project - Project cost with breakdown cost estimation - Beneficiaries - O&M cost - FWUC establishment - Expected project effect/impact - Economic evaluation (IRR)	(1) Map - Location map - Layout map - Command area map (before project) - Command area map (after project) (2) Photo (3) Project work plan (4) Project cost estimation (5) Design documents (6) Answer to questionnaire on : - FWUC, - Land mine, - Consensus of villagers, - Necessary land acquisition, etc

Source: JICA Survey Team

(4) Problems of Proposals

These documents indicated various information necessary for the project appreciation, however the following problems are observed on the existing project proposals and its preparation process through scrutiny of them, discussion with the PDOWRAM and confirmation at the representing project sites.

(a) Definition of Small Scale

According to MOWRAM's criteria, the small-scale irrigation project is defined with its irrigation area less than 200 ha. However, the project was not proposed according to such definition, but included medium scale projects, which were totaled of more than 95% of all the proposed projects.

(b) Lack of Technical Information on Water Resources

Though one of the most important issues is water resource for the project evaluation of the technical soundness, the proposal documents do not describe any information of the project water source, such as mane and type of water source, catchment area, observed and/or estimated discharge, capacity of reservoirs, etc, causing difficult to evaluate the suitable size of irrigation area. In addition, the proposals were prepared without consideration of the other irrigation systems located in the same river basin taking water from the same river in up and down stream of the basin.

(c) Overestimate of Targeted Irrigation Area

Most of the proposed projects have their origin in Pol Pot regime, in which the canals (Pol Pot Canals) had targeted maximum extent of their command area without water balance study, and hence they did not guarantee the amount of irrigation water supply with certain dependability. The rehabilitation works were proposed to cover the area commanded by the existing Pol Pot Canals networks, which are mostly overestimate of the irrigation area.

(d) Less Understanding on the Project Area in Project Evaluation

Distribution of land use is not clear and the project area is misunderstood in project evaluation to compare before and after the project, such as irrigated and rainfed paddy, upland field, fallow area and non-agricultural land. The project area totaled of each land use shall be the same in the project area before and after the rehabilitation. The project area shall include the existing fallow area and non-agricultural land before rehabilitation, in case these area will be irrigated after the project. The project area in the proposal is not the same before and after the rehabilitation in most cases. In addition, the area is not clearly categorized, such as the actually irrigated, irrigable, and rainfed area.

(e) Incomplete Rehabilitation Plan Proposed

In many cases, the proposed rehabilitation works does not include all necessary works for the complete irrigation system. For example in some cases, the rehabilitation is limited to main canal and structures, while secondary canals and other facilities are not considered. In other cases, rehabilitation of only upper reach of main canal are proposed, but project benefit was considered for the whole area including lower reach of main canal.

(f) Insufficient back Data and Breakdown

Some items of the unit cost and benefit estimate were referred to uniform standard values given by MOWRAM assisted by TSC-2, for instance (i) agricultural extension service, (ii) increase of agricultural input for existing cultivated area, (iii) increase of agricultural input for newly cultivated area, and (iv) O&M cost, etc. As there is no breakdown and source for IRR calculation in the application form, it is difficult to review and update the result.

(g) Insufficient Data Storage System in PDOWRAM

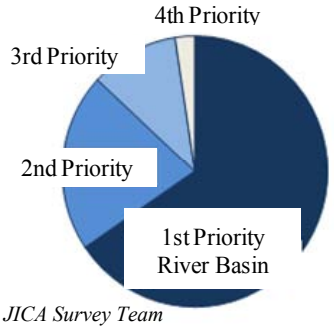
The proposal was prepared in 2009 and more than 2 years has passed before the JICA Survey, in which some of the technical data including topographic survey data, design calculation, drawings and work quantity and cost estimate have been lost or misplaced. This also causes difficulty in review and updating.

(3) Distribution of Long Listed Sub-projects

Based on 84 proposals submitted by each PDOWRAM, the small scale irrigation system rehabilitation projects scattered in whole country, the JICA Survey Team examined the summary of the outline of the projects.

(a) Distribution of Candidates by River Basin Priority

Previous study has prioritized all 42 river basins in the country using criteria of natural and human resource and social conditions and so on, determining from the 1st to 4th priority river basins in turn. The location of 84 proposed sub-projects in theses river basin are shown in Figure AD-2.4.1.1.1. As shown in Figure AD-2.4.1.1.2, 55 sub-projects (66% of total 84 Sub-projects) are located in the first priority river basins, 18 Sub-projects (21%) are in the second priority river basins, and eleven sub-projects (13%) are located in 3rd and 4th river basins.



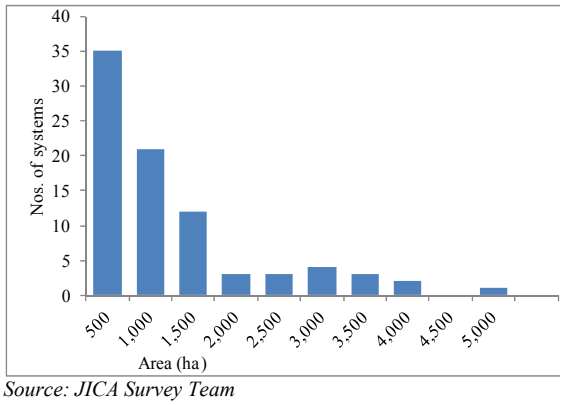
Source : JICA Survey Team

Figure AD-2.4.1.1.2 Distribution of Candidates by River Basin Priority

(b) Distribution by Irrigation Area

The irrigation area of 84 proposed projects are varied as shown in Figure AD-2.4.1.1.3.

Irrigation systems of which irrigation areas are less than 500 ha occupy more than 40% in number, and those having the area of less than 1,000 ha accounts about two-third. Irrigation systems of more than 2,000 has are totaled about 15%.



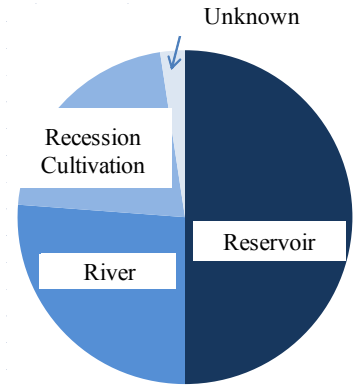
Source: JICA Survey Team

Figure AD-2.4.1.1.3 Distribution of Candidates by Irrigation Area

(c) Distribution by Irrigation Type

All candidate projects are categorized as gravity type and neither lift irrigation nor groundwater irrigation project was proposed. The water sources for the proposed projects are further categorized into three types, which area (i) river run-off without reservoir, (ii) reservoir, and (iii) flood recession water. Distribution of irrigation type is therefore classified by these types of water resources.

Distribution by water resources are shown in Table AD-2.4.1.1.2 and summarized below and in Figure AD-2.4.1.1.4.



Source: JICA Survey Team

Figure AD-2.4.1.1.4 Distribution of Candidates by Irrigation Type

- Reservoir irrigation system (50%),
- River irrigation without reservoir (26%),
- Recession cultivation (21%)

AD-2.4.1.2 Selection of Representative Sub-projects

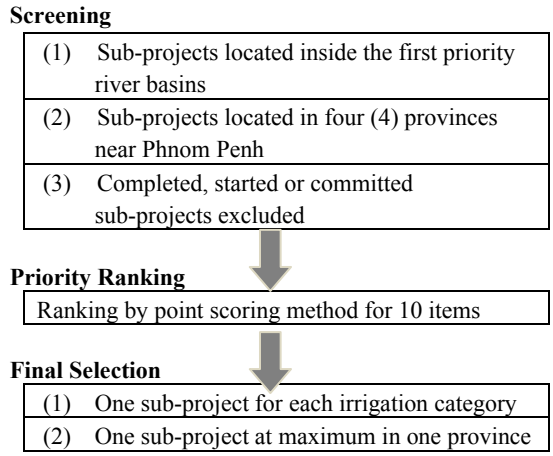
(1) Selection Procedure and Criteria

The purposes of pre-F/S are: i) to confirm the technical and economical viability of the selected sub-project to be implemented under the Japanese ODA Loan together with RCHRSP, USISRSP and KSBISRSP, and ii) to feed-back to the remaining Sub-projects in the long list, and hence the Sub-projects to be selected should be representing as a model case of the other small-scale irrigation system rehabilitation projects in the long list. Under this understanding, the following steps and criteria were considered to select representative pre-F/S area as viable projects under SPPIDRIP, and as models for other small scale-irrigation rehabilitation projects. The flowchart of the selection process is illustrated in Figure AD-2.4.1.2.1. A detailed description of the two-stage is provided below.

(2) First Screening

At first, prior to priority ranking, the candidate projects were screened by the following criteria.

- Only the Sub-projects located inside the first priority river basins were considered.
- Only the Sub-projects located in 4 provinces of Kampong Chhnang, Kampong Speu, Kandal and Takeo Provinces were considered.
- Sub-projects that has been completed, started or committed to start already by the government budget and/or other donor's fund were omitted.



Source : JICA Survey Team

Figure AD-2.4.1.2.1 Flowchart for Selection of Pre-F/S Sites

(3) Priority Ranking

The priority ranking was carried out by use of the following 10 ranking criteria on the basis of the proposed existing irrigation schemes from the selected four provinces in south-west Phnom Pen, which are the target area of SPPIDRIP. Point score in ranking is set up in the items, such as data availability, social conditions, and so on, which are 10 points each and 100 points in total, and priority sub-projects are ranked according to the total score.

Table AD-2.4.1.2.1 Point Score for Priority Ranking

Item	Conditions	Point
Data availability		
(1) Survey data	Partly available	10 points
	Not available	0 points
(2) Design and cost estimate	Partly available	10 points
	Not available	0 points
(3) Satellite image	Available	10 points
	Not Available	0 points
(4) Social conditions (Farmers' consensus)	100% Concurred	10 points
	More than 80% concurred	5 points

Item	Conditions	Point
	Less than 80% concurred	0 points
(5) Social conditions (Risk of land mine)	No risk	10 points
	Risk or not known	0 points
(6) Social conditions (Land acquisition)	All government land	10 points
	All government land with illegal occupation	5 points
	Land acquisition required	0 points
(7) Scale of irrigation area	More than 500 ha and less than 1,500 ha	10 points
	Less than 500 ha	5 points
	More than 1,500 ha	0 points
(8) Effect of sub-project (Incremental irrigation area)	More than 100% increased	10 points
	More than 50% and less than 100% increased	5 points
	Less than 50% increased	0 points
(9) Access for packaging	Near Phnom Penh	10 points
	Far from Phnom Penh	0 points
(10) PDOWRAM's priority	1st priority	10 points
	2nd priority	5 points
	Others	0 points

Source : JICA Survey Team

Based on the above point scouring, total scour of each sub-project are summarized in Table AD-2.4.1.2.2.below.

Table AD-2.4.1.2.2 Summary of Priority Ranking

Code[1]	Province	Name of Sub-project	Area (ha)	Point Score											Type
				1	2	3	4	5	6	7	8	9	10	Total	
3 - 2	Kg.Chhnang	Daun Pue	1,151	10	10	10	10	10	10	10	10	10	10	100	River
4 - 1	Kg.Speu	Main Canal 35	800*2	10	10	10	10	10	5	10	10	10	10	95	Reservoir
9 - 1	Kandal	Srass Prambai	1,200*3	0	10	10	5	10	0	10	5	10	10	70	Recession
4 - 2	Kg. Speu	O Kontorom	500	0	10	10	10	10	5	10	10	0	5	70	Reservoir
4 - 3	Kg. Speu	O Ta Peen	1,400	0	10	10	10	10	5	10	10	0	0	65	Reservoir
9 - 2	Kandal	Tom Or	247	0	10	10	5	10	0	5	10	10	5	65	Recession
6 - 3	Takeo	Sen Priem	567	0	0	10	10	10	0	10	0	10	5	55	Recession
6 - 4	Takeo	Potatsu	1,756	0	0	10	10	10	10	0	0	0	10	50	Reservoir
6 - 5	Takeo	Potawa	2,872	0	0	10	10	10	10	0	0	0	0	40	Reservoir
3 - 3	Kg.Chhnang	Canal Steung Sdach	1,046	Under construction by PDOWRAM											
6 - 1	Takeo	Chroy Samrong	300	Under construction by PDOWRAM											
6 - 2	Takeo	Chroy Veng	220	Committed under World Bank Project (2012)											
9 - 4	Kandal	Chak Khaek	226	Completed by PDOWRAM											
9 - 5	Kandal	Mlech	3,820	Under construction by PDOWRAM											

Remarks ; 1 : Code No. is referred to the original long list prepared by MOWRAM
2 : PDOWRAM proposed only upstream part (800 - 1,000 ha) out of the entire system of more than 3,000 ha as a first stage
3 : Original proposal showing 2.500 ha was revised according to confirmation with PDOWRAM

Source: JICA Survey Team

(4) Final Selection

Based on the results of priority ranking, the representing pre-F/S areas were selected with the following selection conditions.

- One sub-project for each irrigation (water resource) category
- One sub-project at maximum in one province

(5) Selected Priority Sub-projects

As a result of the above screening and priority ranking, draft list of the pre-F/S sites were prepared, based on which selection criteria and results were discussed with MOWRAM and concurred on December 19, 2011 upon confirmation to respective PDOWRAM.

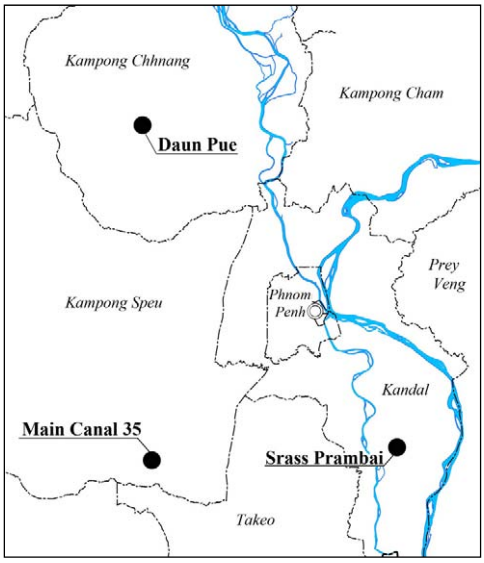
The selected three project sites consists of (i) irrigation system with reservoir in Kampong Speu Province, (ii) irrigation system under recession cultivation in Kandal Province and (iii) River irrigation

system without reservoir in Kampong Chhnang Province and general features are summarized in Table AD-2.4.1.2.3 and location map is shown in Figure AD-2.4.1.2.2. Pre-F/S for the above selected sites was commenced in the third field work period from December 2011 through March 2012.

Table AD-2.4.1.2.3 Summary of Selected Sub-projects

Sub-project Name	Main Canal 35	Srass Prambai	Daun Pue
Commune	Katplug	Chue Khmao	Chiep
District	Basedth	Kaoh Thum	Teuk Phos
Province	Kampong Speu	Kandal	Kampong Chhnang
River basin priority	1	1	1
Water source	Kat Phluk River	Flood recession water from Bassac and Mekong Rivers	Stung Oukhley River
Irrigation type	Reservoir	Recession	River
Proposed Irrigation area	800 - 1,000 ha	1,200 ha	1,150 ha
Proposed crop intensity	Paddy in rainy & early rainy seasons	Paddy in dry & early rainy seasons	Paddy in rainy & early rainy seasons
Proposed project works	Canal and related structures	Reservoir dike and related structures	Headworks, canals and related structures

Source: Prepared by the Survey Team based on the proposal documents submitted by PDOWRAM



Source: JICA Survey Team

Figure AD-2.4.1.2.2 Location of Pre-F/S Sites

AD-2.4.2 Main Canal 35 Rehabilitation Sub-project

AD-2.4.2.1 Present Conditions of Irrigation and Drainage

(1) Outline of Sub-project

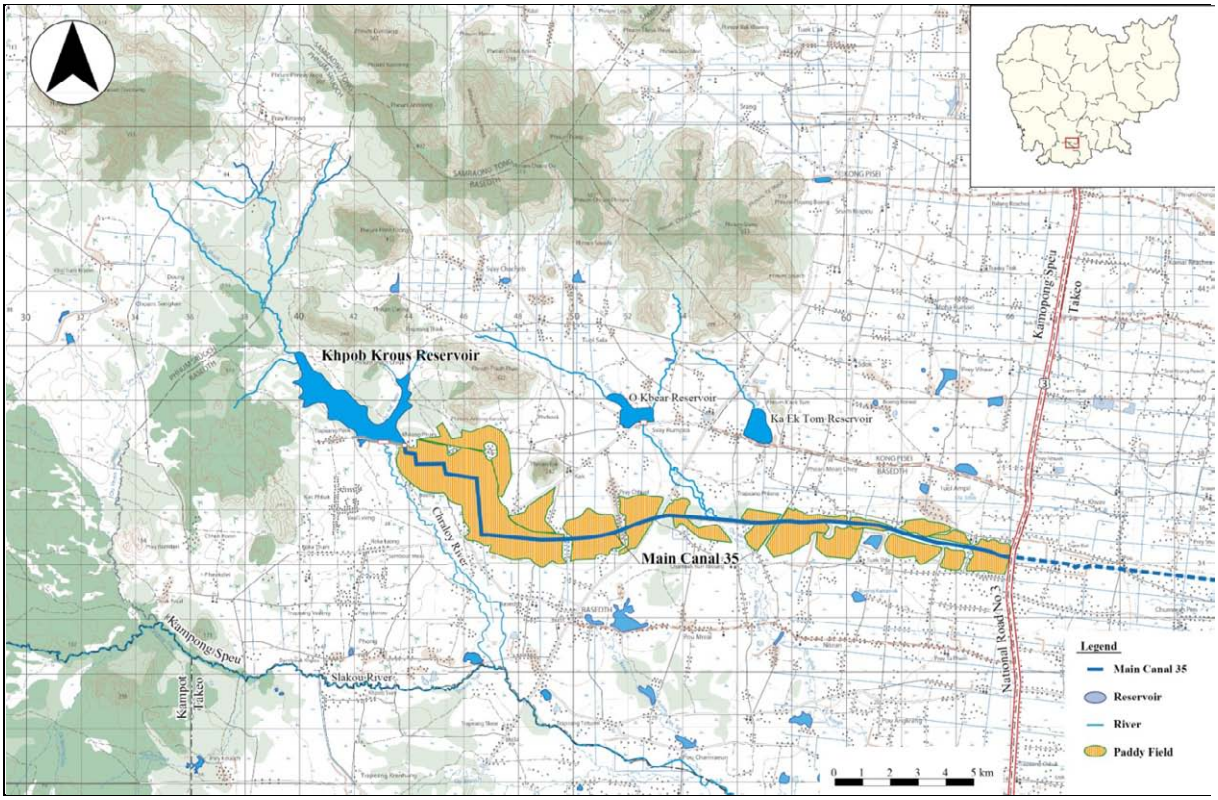
Main Canal 35 irrigation system, consisting of three reservoirs and main and secondary canals, was originally constructed during Pol Pot regime (1975-1977) targeting to irrigate more than 3,000 ha of the existing paddy field. The system is located in the upstream of the Stung Slakou River basin, and situated in the plateau and mountainous region, west of Phnom Penh. The irrigation command area lies in the left bank of the Chraloy River along the provincial road, having long and narrow shape extending from west to east with gentle slope as shown in the location map in Figure AD-2.4.2.1.1.

The area is administratively situated mainly in Basedth District, Kampong Speu Province bordering to the national road No.4, and partly extending in the western part of Takeo Province.

This system is facing to insufficient irrigation water supply since long time due to damage of the reservoir dike by flood and deterioration of irrigation facilities. The latest rehabilitation works were conducted by MOWRAM in 2009 and 2010, which however only covered the dikes of 2 upstream reservoirs and new construction of spillways and intakes, while the other facilities such as main and secondary canals remained as they were, therefore rehabilitation of canals has been proposed by PDOWRAM in order to maximum utilize the water source impounded in the rehabilitated reservoirs.

The expected irrigable area of whole irrigation system with 3 reservoirs are too large (3,018 ha, reported by PDOWRAM) to deal with MC35RSP as a small-scale irrigation system rehabilitation project. The command area of MC35RSP can be divided into 3 reservoirs, namely Zone-A (1,935 ha) with the Khpob Krous Reservoir, Zone-B (705 ha) with the O Kbear Reservoir and Zone-C (378 ha) with the Ka Ek Tom Reservoir. In consideration of the scale of Sub-project area and irrigation water

availability, the upstream area (Zone-A) from the intake of the Khpob Krous Reservoir to the confluence of the Main Canal 35 and the connection canal from the O Kbear Reservoir was given priority by PDOWRAM/MOWRAM of rehabilitation works to be implemented under the Project, while in the downstream areas (Zone-B and Zone-C), from the confluence to downward is not assigned high priority.



Source: JICA Survey Team

Figure AD-2.4.2.1.1 Location Map of Main Canal 35 irrigation System

The rehabilitation of this sub-project is selected as one of the model areas of the pre-F/S in this Survey, which is also the highest priority project proposed by Kampong Speu PDOWRAM.

(2) Existing Irrigation System

Major components of the irrigation system consist of three reservoirs and main and secondary canals, of which general features are summarized as below.

Table AD-2.4.2.1.1 General Features of Main Canal 35 Irrigation System

Item	Features
Water source	Stung Kat Phluk River and Ou Kat Srov River: Khpob Krous Reservoir Doun Angk River: O Kbear Reservoir Boeng Toap River: Ka Ek Tom Reservoir
Command area*	Whole system : 3,018 ha in Basedth district, Kampong Speu Province Zone-A: 850 ha (examined by water balance (refer to Sub-clause II-2.6.3.2))
Reservoirs	1) Khpob Krous Reservoir 2) O Kbear Reservoir 3) Ka Ek Tom Reservoir
Main Canal 35	Length in whole system : 25 km Length in Zone-A : 14 km Design capacity: No data
Secondary canals	Whole system : 27 secondary canals: 36km Zone-A : 22 secondary canals; 26 km

*Remarks *: Proposed by MOWRAM*

Source: Main Canal 35 Rehabilitation Project in Basedth District, Kampong Speu Province, Project Proposal Document To Small Scale Infrastructure Project (2009)
JICA Survey Team

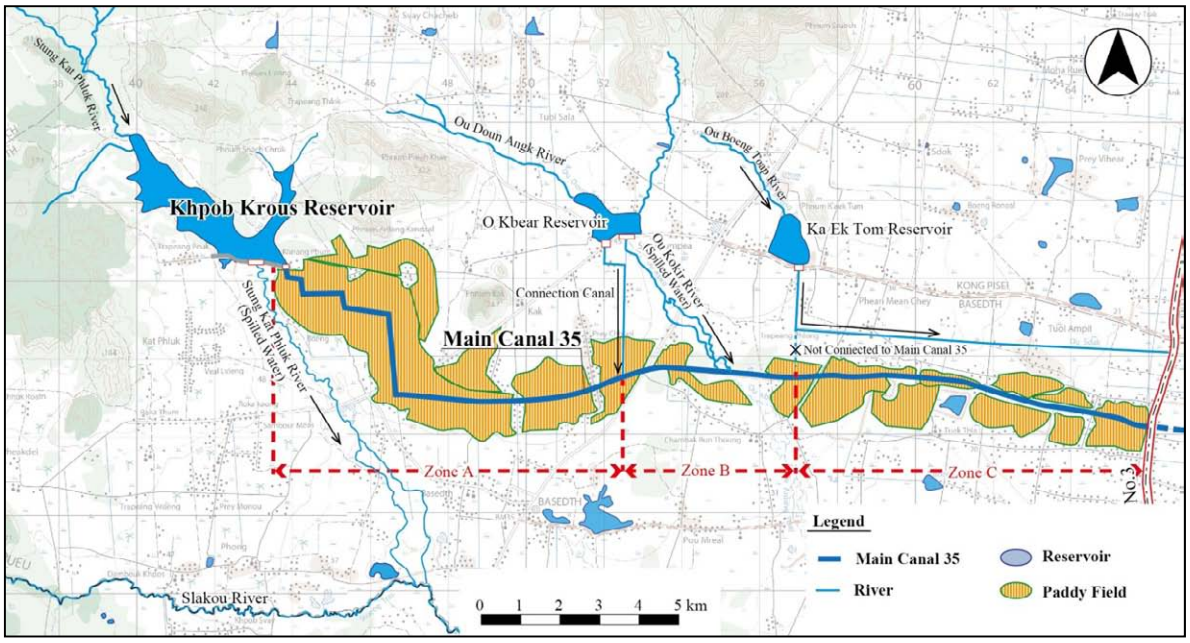


Figure AD-2.4.2.1.2 Schematic Layout of Main Canal 35 Irrigation System

(3) Present Condition of Irrigation and Drainage

(a) Reservoirs

1) Outline of Khpob Krous and O Kbear Reservoirs after last rehabilitation in 2009 and 2010.

Intake of Khpob Krous Reservoir (Downstream View)

The Khpob Krous and the O Kbear Reservoirs are located in Khnang Phum Village, Preah Khe Commune, and Kbear Village, Savay Rumpea Commune, respectively in Basedth District, Kampong Speu Province. Both reservoirs were rehabilitated in 2009 and 2010. The works for the Khpob Krous Reservoir consisted of (i) rehabilitation of the dike of 1,300 m in length, (ii) new construction of a spillway with provision of automatic flap gates and (iii) construction of an intake (outlet structure to the main canal). On the other hand, the works for the O Kbear Reservoir consisted of (i) new construction of a spillway with provision of automatic flap gates and (ii) new construction of intakes of pipe culverts. The outline of the rehabilitated facilities and their present conditions are summarized below.

Table AD-2.4.2.1.2 Present Conditions of Khpob Krous Reservoir and O Kbear Reservoir

Reservoir	Item	Conditions
Khpob Krous Reservoir	(i) Dike	(i) Length: 1,300 m Crest Elevation: EL. 55.5 m
	(ii) Spillway	(ii) Gate Type (nos.): Automatic Flap Gate (4 nos.) Gate Height: 2.2 m Gate Width: 8.0 m
	(iii)Intake	(iii)Gate Type (nos.): Slide Gate (3 nos.) Gate Height: 3.0 m Gate Width: 1.5 m
O Kbear Reservoir	(i) Spillway (ii) Intake	(i) Gate Type (nos.): Automatic Flap Gate (2 nos.) Gate Height: 2.3 m Gate Width: 8.0 n (ii) Type (nos.): Pipe Culvert with slide gate (2 nos.) Culvert Diameter: 0.8 m Culvert Length: 9.6 m Gate Height: 1.06 m Gate Width: 1.10 m

Source: Project Proposal for Khpob Krous Reservoir Rehabilitation Project in Kampong Speu Province, MOWRAM, 2008
Project Proposal for O Kbear Reservoir Rehabilitation Project in Kampong Speu Province, MOWRAM, 2008

2) Intakes (Outlet Structures) at Khpob Krous and O Kbear Reservoirs

As mentioned above, one intake was constructed at the Khpob Krous Reservoir in 2010, while another intake of pipe culvert had been installed at the O Kbear Reservoir before the rehabilitation conducted in 2009. Although there are 3 intakes in total on the O Kbear Reservoir, only one intake rehabilitated in 2009 can supply water from the reservoir to the main canal through connection canal as shown in Figure AD-2.4.2.1.2. According to chiefs of the villages around the Main Canal 35, gate operation of each reservoir intake is entrusted to some of them and operation rules are based on farmers' water request.

Culvert of O Kbear Reservoir (Downstream View)

3) Other Reservoir

a) Ka Ek Tom Reservoir

Ka Ek Tom Reservoir is located at 4.5 km east from O Kbear Reservoir and 3 km north from

An intake is installed on the reservoir without any gates. As of 2012, rehabilitation works were not conducted on this reservoir and any information related to the reservoir is not available.

Intake of Ka Ek Tom Reservoir (Upstream View)

5) Connection Canals from Reservoirs to Main Canal 35

a) O Kbear Reservoir

The connection canal starting at one of 3 intakes on the O Kbear Reservoir runs southward for about 4 km into the Main Canal 35. The other 2 intakes are not connected to the Main Canal 35. Existing related structures on the connection canal are partially broken, however they still have functional roles. Using these structures, farmers around the connection canal draw water from the canal to their paddy fields. According to some villagers, check structures are controlled by commune leaders based on farmers' requests for irrigation water.

Main Canal 35 (Downstream of Kokir River Confluence)

On the other hand, spilled water from the O Kbear Reservoir also flows into the Main Canal 35 via the Kokir River. Villagers say that the spillway gates rehabilitated in 2009 would open every rainy season. The spilled water flows to Takeo Province through culvert on the National Road No.3 and reaches a reservoir in Samraong District, which is the end point of the Main Canal 35. According to some farmers in Takeo Province, they can use water for irrigation during the limited period that the Main Canal 35 is suffused with spilled water from O Kbear Reservoir.

b) Ka Ek Tom Reservoir

According to the staff of Kampong Speu PDOWRAM, the Ka Ek Tom Reservoir and Main Canal 35 were originally connected by a canal. Due to the partial sedimentation and erosion, the canal sections nearby Main Canal 35 have become flat and finally lost a function to convey water from Ka Ek Tom Reservoir to the main canal. The canal currently runs south at first and then turns east at just 500 m north from Main Canal 35. Consequently, the canal from Ka Ek Tom Reservoir would never be confluent with Main Canal 35.

(b) Main Canal 35 and Related Structures

The Main Canal 35 runs in Basedth District, Kampong Speu Province. The canal starts at the Khpob Krous Reservoir and runs eastward firstly, then turns southward and finally turns eastward again, which crosses the National Road No.3 and reaches to a reservoir in Takeo Province.

The Main Canal 35 has been damaged totally and lost a functional role to convey water from the Khpob Krous Reservoir and the O Kbear Reservoir to paddy fields because of the reason mentioned as below. Generally, canals constructed in the Pol Pot regime commonly have some problems, namely (i) canal route was determined without considering topological conditions therefore canals were originally inverse draft in many cases, which prevents water flow and accelerate sedimentation, and (ii) farmer had to apply pumps to draw water from the canal to their paddy because construction of the canal mainly consisted of excavation work and consequently elevation of canal bed as well as designed water level were relatively lower than neighboring paddy field. Furthermore, the Main Canal 35 was excavated with inadequate design that spilled water from the O Kbear Reservoir flows into the canal as mentioned above, which caused severe erosion in downstream. Actually, water flow from the Khpob Krous Reservoir is completely stopped about 1 km downstream from the beginning point of the canal.

There exist canal related structures, mostly constructed in upstream area, as shown in Table AD-2.4.2.1.3 (refer to Table AD-2.4.2.1.4 in detail. In the rainy season, rain water is pooled in lower parts in the Main Canal 35 and used for irrigation by the farmers with these structures and small portable pumps.

Table AD-2.4.2.1.3 Related Structures Existing on Main Canal

Canal	Turnout	Drain Inlet	Check Structure	Culvert	Road Bridge	Footpath Bridge
Main Canal	5	11	3*1	8*2	2	1*3

**1: under construction: 1 no., totally broken (only foundation is left): 1 no.*
**2: under construction: 1 no.*
**3: under construction*
Source: JICA Survey Team

(c) Secondary Canals and Related Structures

Twenty seven secondary canals are branched off from the Main Canal 35 toward south. Due to malfunction of the main canal, water does not flow from the main canal to the secondary canals. Moreover, some secondary canals are filled with soil and cultivated as paddy field.

There are some structures on the secondary canals, such as pipe culverts for crossing canals at entrance of houses, diversion structures for the tertiary canals. They would function to store rain water in the secondary canals and convey it to neighboring paddy fields in the rainy season.

(d) Tertiary Canals

There is no systematic tertiary canal system, while some small canals are extended from the secondary canals or the Main Canal 35. In the upstream area where the Main Canal 35 functions to flow water from the Khpob Krous Reservoir, some tertiary canals are directly branched off from the main canal and deliver water to the paddy fields. Even these working tertiary canals are tortuous and it seems to be difficult to use water efficiently and timely because of their hydraulic design conditions.

(e) Drainage System

In the Sub-project Area, it deemed that irrigation canals could function as drains concurrently because elevation of canal bed is generally lower than surrounding paddy field. Considering the present

conditions and difficulty in acquiring land for drainage canals, it is judged that the drainage should be maintained as the same manner as the present situation.

(4) Constraints and Rehabilitation Needs

According to MOWRAM/PDOWRAM, farmers in the Sub-project Area are suffering water shortage in rainy season as well as dry season every year. In order to provide enough water to the farmers, rehabilitation works of the Khpob Krous Reservoir, the main water source of the area, have been conducted in 2009. Although the condition of water source has been improved, canal system in this area is still malfunction as described above. In accordance with this situation, MOWRAM requested JICA rehabilitation works as below:

- Rehabilitation of Main Canal 35 by shaping proper canal section with appropriate design
- Rehabilitation of canal related structures in order to realize the designed irrigation canal system

AD-2.4.2.2 Irrigation and Drainage Development Plan

(1) Basic Concept for Development

Primary problem constricting stabilization and development of agricultural production in the MC35RSP Area is the shortage of irrigation water. In order to alleviate water shortage, it would be a waste not to make the most of 3 reservoirs, the Khpob Krous Reservoir and the O Kbear Reservoir rehabilitated in 2009/2010 and the Ka Ek Tom Reservoir. Considering the situation, the basic concept of MC35RSP is determined as: (i) utilization of existing facilities of canal system constructed in Pol Pot regime and Khpob Krous Reservoir rehabilitated in 2009/2010, (ii) realization of gravity irrigation by reshaping canal section/profile and rehabilitation/additional construction of canal related structures.

(a) Integrated Approach of Hardware and Software Components

Irrigated agriculture development for MS35RSP is planned in the concept of integrated approach of hardware and software components which is the same as the other sub-projects, in order to heighten the project effect and to maintain the project sustainability.

(b) Priority Area for Rehabilitation under the Project proposed by PDWORAM/MOWRAM

All the area of the Main Canal 35 Irrigation System totaled more than 3,000 ha commanded by 3 existing reservoirs, as reported by PDOWRAM, which is too large to deal with as a small-scale irrigation system rehabilitation project. In consideration of the scale of sub-project area and irrigation water availability, the upstream area (Zone-A) out of 3 zones is only considered to be implemented under MC35RSP, as concurred with PDOWRAM/MOWRAM

(c) Determination of Project Scale through Water Balance Study

Irrigation development should be planned mainly based on available water, available land and the water demand by crops. Since MC35RSP has reservoirs and enough farm to be served by the existing reservoirs, its project size will be determined through a water balance study.

(d) Utilization of Existing Canal System

There are the existing irrigation canals which were constructed in Pol Pot regime. In order to save construction cost and lighten the burden for land acquisition, these existing irrigation canals are used as much as possible.

(e) Priority Ranking on Sub-project Scope by Criteria

As MC35RSP requires many project works, these will be prioritized so as to use the limited budget. High priority should be given to (i) the works indispensable for attaining at the aim of MC35RSP,

(ii) Urgently required works for proper operation of irrigation system, (iii) the facilities related to ensuring water resources, and (iv) the facilities which need large scale rehabilitation to convey irrigation water.

(2) Examination of Proposal by MOWRAM

In project proposal document, MOWRAM proposed the rehabilitation works as listed in Table AD-2.4.2.2.1, which include construction/ rehabilitation works of related structures on only the main canal. Though 18 secondary canals in Zone-A and 8 out of 18 secondary canals in the irrigable area are branched off from Main Canal 35, no rehabilitation works for secondary canals as well as tertiary canals are proposed by MOWRAM.

(3) Water Balance Study and Irrigable Area

(a) General

The water balance simulation study was conducted in order to estimate the possible extent of the service area and cropping intensity (cropping area in rainy and early rainy seasons) with 80% dependability in Zone-A. The methods and procedures of the water balance simulation study are described below and details are referred to ANNEX-B.

Table AD-2.4.2.2.1 Rehabilitation Works Proposed by MOWRAM

Description	Proposed by MOWRAM
1) Target irrigation area	- 2,648 ha in rainy season - 120 ha in early rainy season - 250 ha in dry season (with 3 reservoirs)
2) Main Canal 35 - Related structures(new)	Length: 25,299 m in total - Check structure: 19 nos. - Culvert: 1 no. - Spillway: 1no. - Water gate: 7 no.

Source: Main Canal 35 Rehabilitation Project in Basedth District, Kampong Speu Province, Project Proposal Document To Small Scale Infrastructure Project (2009)

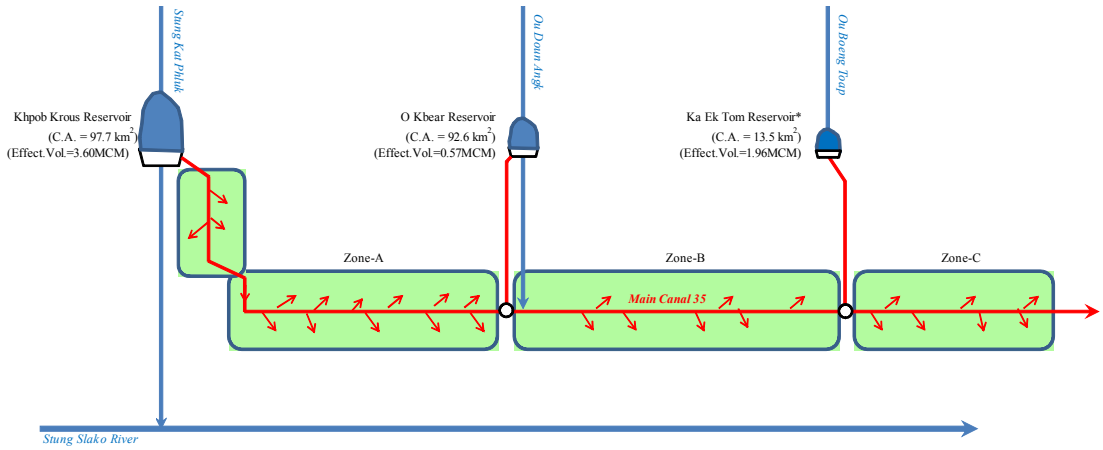
(1) Calculation Method and Conditions

In this Survey, long-term water balance simulation method was applied. The water balance simulation in this Survey is summarized in Table AD-2.4.2.2.2 and the water balance model is schematically described in Figure AD-2.4.2.2.1, respectively.

Table AD-2.4.2.2.2 Condition of Water Balance Simulation for MC35RSP Area

Item	This Survey
Calculation interval	Half-monthly basis
Method for estimating potential evapo-transpiration	Penman-Montieth method
Runoff data	Estimated from the data at Peam Khley station
Reservoir Operation	Storage effect of 3 reservoirs are considered
Simulation model	By the long-term (1992-2011; 20years) simulation
Irrigation fail	Continuous deficit in 15 days

Source: JICA Survey Team

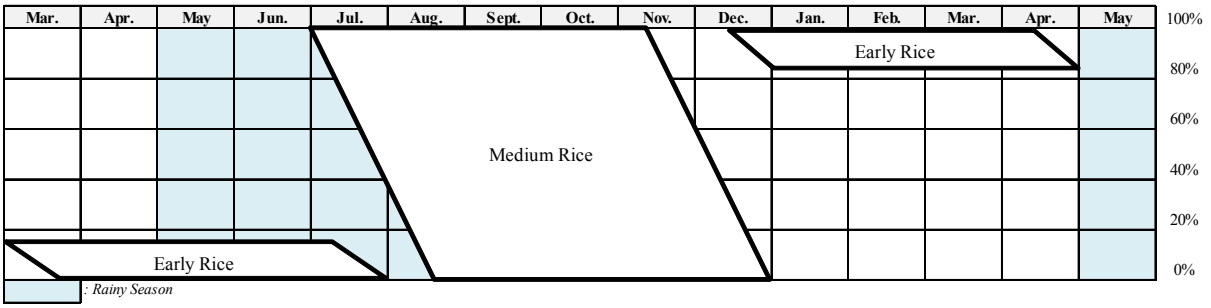


Source: JICA Survey Team

Figure AD-2.4.2.2.1 Schematic Layout of Water Balance Model for MC35RSP

(b) Irrigation Water Demand

For the purpose of the water balance study, unit irrigation water requirement per hectare is estimated based on the proposed cropping calendar shown in Figure AD-2.4.2.2.2, which consists of two crop seasons of medium rice in the rainy season and early rice in the early rainy season in a year. Irrigation water demand was estimated half monthly basis using the rainfall data at Basedth station for the period from 1992 to 2011.



Source: JICA Survey Team

Figure AD-2.4.2.2.2 Cropping Calendar for MC35RSP

The water requirement is calculated by the same conditions in other sub-projects with some variations, which is tabulated in Table AD-2.4.2.2.3 and the results are summarized in Table AD-2.4.2.2.4 and Figure AD-2.4.2.2.3

Table AD-2.4.2.2.3 Conditions for Estimate of Irrigation Water Requirement

Item	Description
Calculation interval	Half monthly basis
Method for estimating potential evapo-transpirationi	Penman-Montieth method
Meteorological data	Pochentong Station (Phnom Penh)
Rainfall data	Basedth Station (Kampong Speu) 20 years from 1992 to 2011
Effective rainfall	Applying 75% of monthly rainfall as effective monthly rainfall for paddy
Percolation rate	2 mm/day
Irrigation efficiency	Conveyance efficiency: 42% (Main canal 70% × Secondary canal 60%)

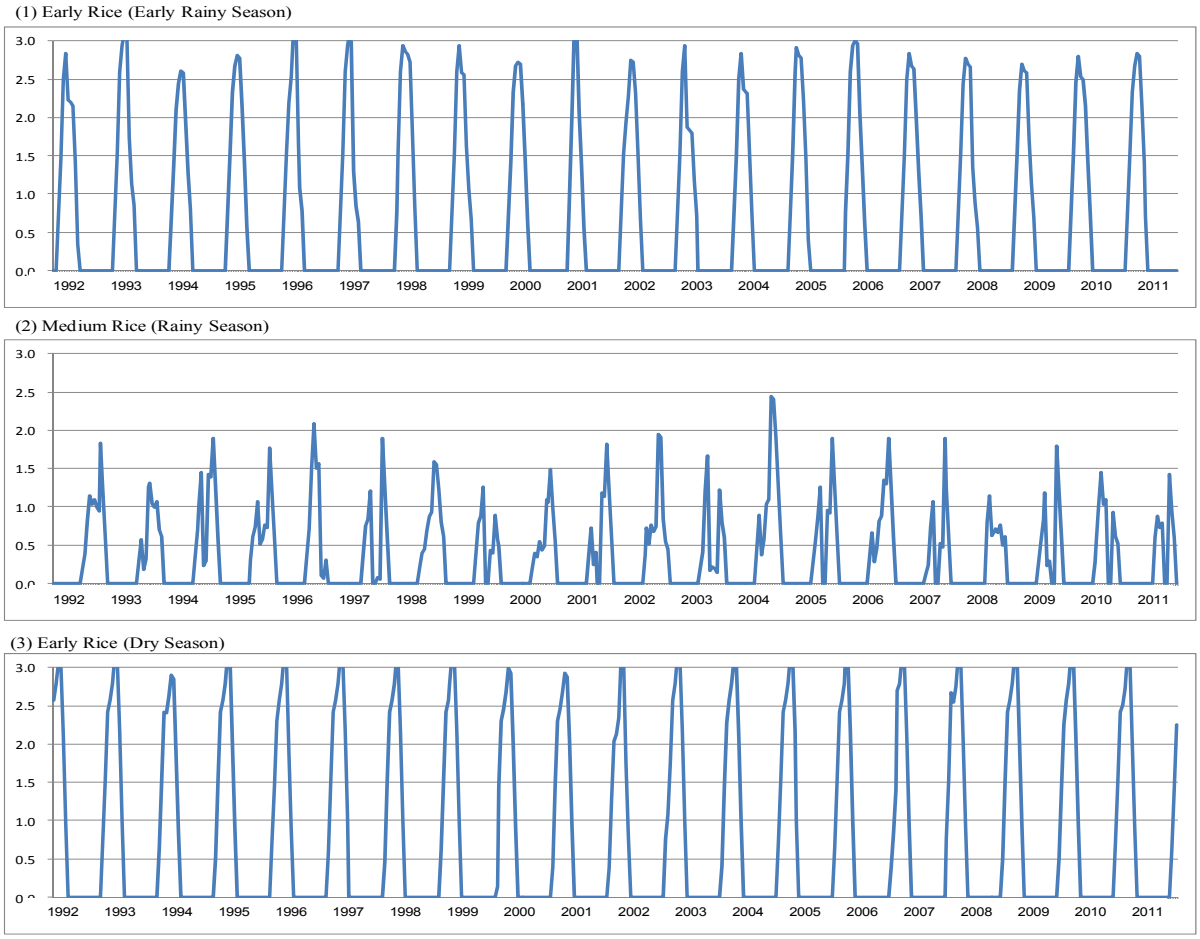
Source: JICA Survey Team

Table AD-2.4.2.2.4 Summary of Estimated Unit Water Requirement (Average of 20 years; 1992-2011)

(Unit: m^3/sec/ha)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
(1) Early Rice (Early Rainy Season)												
1-15	0.00	0.71	2.35	2.73	1.98	0.66	0.00	0.00	0.00	0.00	0.00	0.00
16-end	0.00	1.43	2.73	2.69	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(2) Medium Rice (Early Rainy Season)												
1-15	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.71	0.56	0.84	1.44	0.56
16-end	0.00	0.00	0.00	0.00	0.00	0.00	0.53	1.03	0.60	0.80	0.94	0.00
(3) Early Rice (Dry Season)												
1-15	2.53	3.11	2.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43
16-end	2.74	3.06	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	2.29

Source: JICA Survey Team



Source: JICA Survey Team

Figure AD-2.4.2.2.3 Estimated Unit Water Requirement from 1992 to 2011

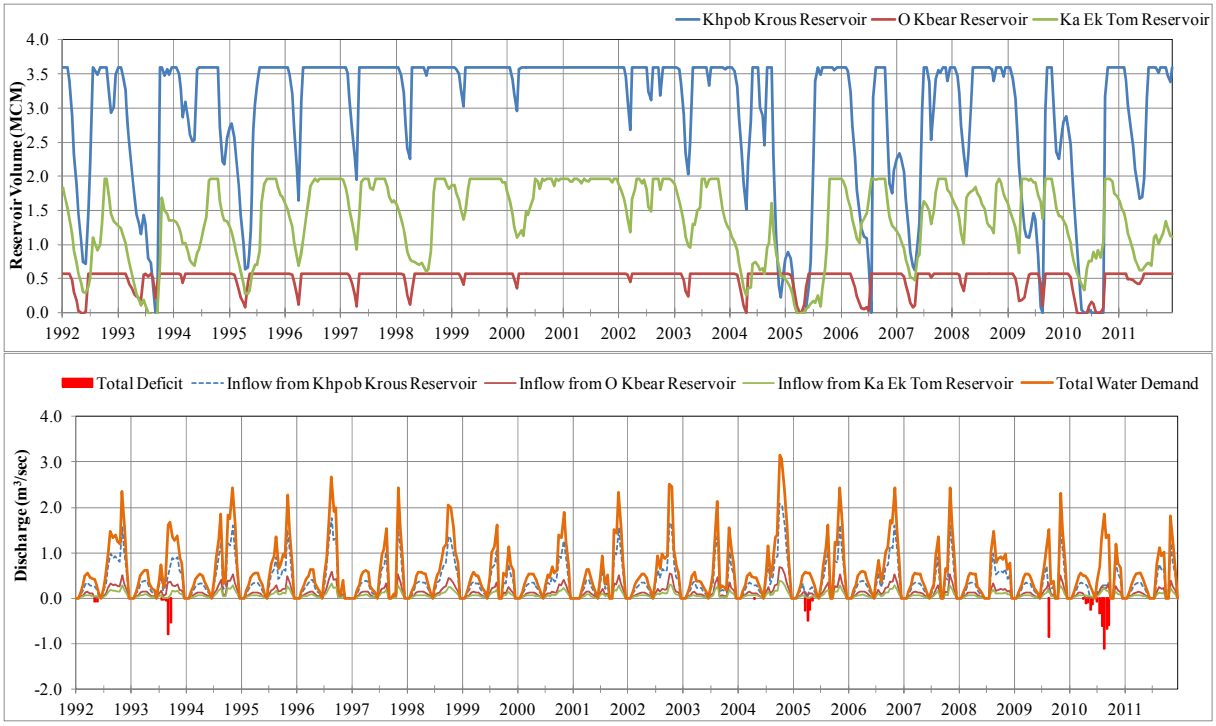
(c) Water Balance Study

Water balance study is executed for 20 years from 1992 to 2011 in MC35RSP on the half-monthly basis with 80% dependability. The main features of reservoirs are shown in Annex B. Result of reservoir operation of above 3 reservoirs is shown in below:

Table AD-2.4.2.2.5 Features of Khpob Krous Reservoir

Name	River	C.A.	Effective Volume
Khpob Krous Reservoir	Ou Chraloy River Ou Kat Srov River	97.7 km^2	3.60 MCM

Source: JICA Survey Team



Source: JICA Survey Team

Figure AD-2.4.2.2.4 Results of Reservoir Operation of MC35RSP Area

Table AD-2.4.2.2.6 Results of Water Balance Study of MC35RSP Area

Zone	Max. Irr. Area	Total Irr. Area	Early Paddy (Early Rainy)	Mid Paddy	Early Paddy (Dry Rainy)	Crop Intensity	Dependability	Deficit Year (times)
A	1,935 ha	850 ha	130 ha	850 ha	0 ha	115%	80%	4
B	705 ha	280 ha	45 ha	280 ha	0 ha	116%	80%	4
C	378 ha	150 ha	25 ha	150 ha	0 ha	117%	80%	4
Total	3,018 ha	1,280 ha	200 ha	1,280 ha	0 ha	116%		

Source: JICA Survey Team

Although water balance study is conducted for 3 zones, the target area of MC35RSP is only Zone-A. The irrigation area for MC35RSP comes to 850 ha according to water balance study.

(4) Examination of Present Capacity of Existing Spillway

As mentioned above, the spillways of Khpob Krous Reservoir and O Kbear Reservoir were constructed in 2009/2010. They have been functioning and floods overflowing the top of dike have not occurred during the period from 2009 to 2011. In MC35RSP, the present flow capacity of these spillways is examined by comparing the capacity and probable flood discharge on each reservoir. The results of examination are summarized in the following table and details of the examination are presented in ANNEX-B. In conclusion, the maximum reservoir water level will not be over the dike crest elevation in the return period of 1/200 years flood at each reservoir.

Table AD-2.4.2.2.7 Results of Examination of Spillways on Khpob Krous and O Kbear Reservoir

Reservoir	C.A. (km^2)	Elevation of Dike Crest (EL. m)	Probable Peak Discharge* (m^3/sec)	Peak Water Level (EL. m)
Khpob Krous	97.7	55.50	170.3	55.31
O Kbear	92.6	47.80	172.0	46.47

**: Return Period is 200 years.*
Source: JICA Survey Team

(5) Proposed Rehabilitation works

(a) Intake of Khpob Krous Reservoir

According to the topographic survey along Main Canal 35 conducted by Kampong Speu PDOWRAM in 2008, the elevation of paddy field along the main canal is higher than the low water level of the

Khpob Krous Reservoir (EL. 52.0 m). That is, some area near the reservoir would not be irrigable when water level in the reservoir is almost low water level in the end of the dry season. However, these area can be irrigated when water level is enough high above the low water level during the other seasons keeping the present cropping pattern. On the other hand, raising low water level will cause the decrease of effective volume of the reservoir, which brings reduction of total irrigable area. In order to conserve the irrigable area, excavation of reservoir area or raising dike would be necessary, which will be a drastic construction. Furthermore, the intake was constructed in 2009 and functioned without significant hitch. Considering these conditions, it is judged that the intake of the Khpob Krous Reservoir should not be rehabilitated or reconstructed in MC35RSP.

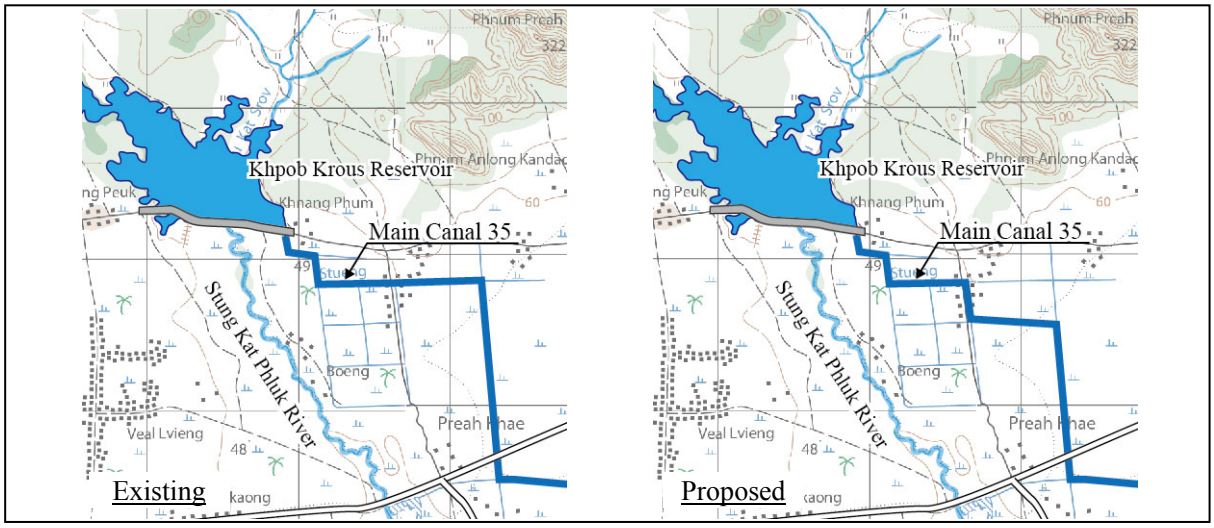
Table AD-2.4.2.2.8 Scope of Intake

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) Intake	Not proposed.	Do. As left

Source: JICA Survey Team

(b) Main Canal 35 and Related Structures

As mentioned in previous Sub-clause, Main Canal 35 is not functioning at all and the present canal route is deemed inadequate due to the inverse draft section. According to the topographic survey executed in 2012, route of Main Canal 35 is proposed to change partly as shown in Figure AD-2.4.2.2.5, which leads to shorten the canal length about 300 m.



Source: JICA Survey Team

Figure AD-2.4.2.2.5 Existing and Proposed Route of Main Canal 35

The location and feature of related structures on the main canal are figured out through the inventory survey conducted by JICA Survey Team in 2012. The result is shown in Attachment-6. The Existing structures in Zone-A should be basically demolished because canal reshaping works will be executed whole section of the main canal in Zone-A and the structures would be obstacle for the construction works. The layout of existing and proposed structures is described in Figure AD-2.4.2.2.6 and 7, respectively.

Table AD-2.4.2.2.9 Scope of Main Canal and Related Structures

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) Canal length	25.299 m (whole Main Canal 35)	14.0 km (Zone-A) out of 25,299 m
2) Canal route	Not proposed	Serious inverse draft is found at 2.0 km downstream from Khpob Krous Reservoir. Canal route should be changed as shown in Figure AD-2.4.2.2.5, which is utilizing existing secondary canal.

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
3) Canal section	- Reshaping canal cross section with one basic design - Design canal gradient: 0.0001 ~ 0.0005	Section and profile of canal are designed in accordance with designed diversion water requirement and topographic condition.
4) Related Structures	Check structures, water gates, a culvert and a spillway are proposed.	All existing structures are to be demolished and new structures, i.e. check structures, drain inlets, Turnouts, culverts, drops, bridges and a cross drain are proposed

Source: Main Canal 35 Rehabilitation Project in Basedth District, Kampong Speu Province, Project Proposal Document To Small Scale Infrastructure Project (2009)
JICA Survey Team

(c) Secondary Canals and Related Structures

Due to the catastrophic situation of Main Canal 35, secondary canals and related structures are not in service as canal system. According to the sample inventory survey, there are a few structures on secondary canals. Though rehabilitation works for secondary canals and related structures are not proposed by MOWRAM, 6 secondary canals and related structures are proposed by JICA Survey Team so as to make the most of the limited water resources. Scopes of works for secondary canals and related structures are tabulated in the following table.

Table AD-2.4.2.2.10 Scope of Secondary Canal and Related Structures

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) Canal quantity and length	Not Proposed	Six secondary canals, 11.4 km in total (Rehabilitation: 5 nos., 9.3 km in total New Construction: 1 no., 2.2 km)
2) Canal section		Section and profile of canal are designed in accordance with designed diversion water requirement and topographic condition.
3) Related Structures		All existing structures are to be demolished and new structures, i.e. check structures, drain inlets, Turnouts, culverts, drops, bridges and a cross drain are proposed

Source: Main Canal 35 Rehabilitation Project in Basedth District, Kampong Speu Province, Project Proposal Document To Small Scale Infrastructure Project (2009)
JICA Survey Team

(d) Drainage System

Canals constructed in Pol Pot regime are relatively lower than surrounding land and, therefore, they are used as drainage canal in general. In the MC35RSP Area, the main and the secondary canals are seems to have been used as drain and some of them have drain inlets to convey water from drains to the main canal. In order to realize smooth drainage, not only replacement of drain inlets but also new construction of crossdrain are proposed by JICA Survey Team. The proposed works for drainage system are shown as below.

Table AD-2.4.2.2.11 Scope of Drainage System

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) New Drain	Not proposed.	Do. As left
2) Drain inlet		Drain inlet is proposed at every confluence of main canal and drain, even there are not any structures existing at the point.
3) Cross Drain		Two cross drains, one for main canal and the other for secondary canal, are proposed.

Source: Main Canal 35 Rehabilitation Project in Basedth District, Kampong Speu Province, Project Proposal Document To Small Scale Infrastructure Project (2009)
JICA Survey Team

(e) Tertiary Canals

Currently, there is no systematic tertiary canal system in the MC35RSP Area. The irrigable area in this sub-project is proposed to be divided into 42 tertiary blocks as shown in Drawing MC-01. Alignment

of tertiary blocks and design of the canal route would be prepared by related FWUC with assistance of Kampong Speu PDOWRAM. Land for tertiary canals and watercourses would be offered by beneficial farmers.

Table AD-2.4.2.2.12 Scope of Tertiary Blocks

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) Tertiary Canals	Not proposed	n MC35RSP, the blocks are divided on the basis of aerial photographs. Layout plan of tertiary canals should be finalized in accordance with the "Design Manual of MOWRAM", actual field conditions and intensions of beneficiaries.

Source: Main Canal 35 Rehabilitation Project in Basedth District, Kampong Speu Province, Project Proposal Document To Small Scale Infrastructure Project (2009)
JICA Survey Team

(6) Proposed Development Plan (Proposed Scope of Sub-project)

(a) Examination of Scope of MC35RSP Proposed by MOWRAM

In project proposal document, MOWRAM proposed the rehabilitation works as listed in Table AD-2.4.2.2.13, which include earthworks and construction/rehabilitation works of related structures on only the main canal. Based on the investigation, the proposed works and scopes of the rehabilitation works under MC35RSP are examined as shown in fallowing table.

Table AD-2.4.2.2.13 Scope of MC35RSP

Proposed by MOWRAM*	Examination in this Survey**	Remarks
(a) Irrigation Development Area		
- 2,648 ha in rainy season - 120 ha in early rainy season - 250 ha in dry season (with 3 reservoirs)	- 850 ha in rainy season - 130 ha in early rainy season (with 1 reservoir)	Justified through water balance study
(b) Cropping Pattern and Crop Intensity		
- Rice Cropping System - Crop Intensity: 116%	- Rice Cropping System - Crop Intensity: 115%	Application of double cropping of rice considering present cropping pattern
(c) Hardware Component		
1) Reservoir - Dike, Spillway, Intake Not proposed	1) Reservoir - Dike, Spillway, Intake Not proposed	Reservoir related to MC35RSP has been rehabilitated in 2009
2) Main Canal 35 and Related Structures - Main canal Reshaping of existing canal section for whole main canal (25,299 m) - Related structures (New Construction) Check structure: 19 nos. Culvert: 1 no. Spillway: 1no. Water gate: 7 no.	2) Main Canal 35 and Related Structures - Main canal Rehabilitation of existing canal section for Zone-A (12,800 m out of 25,299 m) and construction of new canal (1,200m) - Related structures (in irrigable area)[1] Check structure: 9 nos. (9 nos.) Turnout: 16 nos. (12 nos.) Culvert: 8 nos. (4 nos.) Drain inlet: 10 nos. (5 nos.) Drop: 5 nos. (0 nos.) Cross Drain: 1 no. (1 no.) Road Bridge: 1 no. (1 no.) Footpath Bridge: 9 nos. (4 nos.)	It is judged that rehabilitation of whole main canal section is unsuitable for SISIP.
3) Secondary canals and related structures Not Proposed	3) Secondary canals and related structures - Secondary canals Rehabilitation of existing secondary canals (5 nos., 9,250 m) and construction of a new canal (1 no., 2,150 m) - Related structures Check Structure: 20 nos. Turnout: 35 nos. Culvert: 26 nos. Drop: 1 no.	Rehabilitation of only main canal is insufficient to realize efficient irrigation system.

Proposed by MOWRAM*	Examination in this Survey**	Remarks
4) Drainage system Not proposed	4) Drainage system Construction of drain structures	Rehabilitation/ construction of drain is not proposed
5) Tertiary canals Not proposed	5) Tertiary canals - Tertiary canal development : 850 ha	MOWRAM will provide special arrangement for land acquisition for tertiary canals. Tertiary canals will be constructed by local contractors to be selected through LCB

Source *: *Main Canal 35 Rehabilitation Project in Basedth District, Kampong Speu Province, Project Proposal Document To Small Scale Infrastructure Project (2009)*
**: *JICA Survey Team*

(b) Priority Ranking

As shown above, the examined scope of MC35RSP consists of many works. Since available loan amount is not clear, implementation of these works at an instance could not be ensured. Therefore these examined works are given priority ranking in accordance with the criteria as below.

- The works indispensable for attaining at the purpose of MC35RSP are given high priority
- Urgently required works for adequate operation of irrigation system are given high priority
- The rehabilitation works for facilities needed to recover their functions are given high priority

The priority ranking of each work based on the criteria is summarized in the following table.

Table AD-2.4.2.2.14 Priority Ranking of Each Work

Scope Examined by JICA Survey Team		Priority*
- Rehabilitation of Main Canal 35 and related structures	- Reshaping canal section (12,800 m) and construction of new canal (1,200 m) - Replacement and new construction of related structures	◎
- Rehabilitation of secondary canals and related structures	- Reshaping canal section (5 nos., 9,250 m) and construction of new canal (1 no., 1.250 m) - Replacement and new construction of related structures	◎
- Tertiary development	- Construction of tertiary canals	○
- Construction of project office	- Office building (300 m^2) - Parking shed, gate and fencing - Well drilling and electric works	○

*: *High priority: ◎ , Medium priority: ○ , Low priority: △*
Source: JICA Survey Team

AD-2.4.2.3 Design of Irrigation and Drainage Facilities

(1) General

The target irrigation area of MC35RSP is 850 ha could be supplied water through Main Canal 35 after completion of rehabilitation works. The main canal starts from Khpob Krous Reservoir on the Ou Chraloy River and Ou Kat Srov River, which is the water source of the target area.

(2) Canal System

Irrigation canal layout and irrigation diagram are shown in Drawings MC-01 and MC-02, respectively. In the target area, 6 tertiary blocks are supplied water directly from Main Canal 35. Canal length, command area and design discharge at beginning of each canal are designed as shown in Table AD-2.4.2.3.1. Unit water requirement of main canal and secondary canals is set at 2.45 l/sec/ha.

Table AD-2.4.2.3.1 Principal Features of Main Canal 35 and Secondary Canals

Canal Name	Canal Length	Command Area	Design Discharge at Beginning Point
Main Canal 35	14,000 m (Zone-A)	850 ha	2.34 m^3/sec
Secondary Canal			
SC-1	1,600 m	66.ha	0.28 m^3/sec

Canal Name	Canal Length	Command Area	Design Discharge at Beginning Point
SC-2	1,100 m	51 ha	0.32 m^3/sec
SC-3	2,200 m	166 ha	0.52 m^3/sec
SC-4*	3,000 m	199 ha	0.52 m^3/sec
SC-5	1,400 m	67 ha	0.18 m^3/sec
SC-6	2,100 m	173 ha	0.44 m^3/sec
Total of secondary canal	11,400 m	722 ha**	

**: 2,150 m out of 3,000 m will be newly constructed.*
***: 130 ha out of 850 ha are irrigated the tertiary canals directly blanched from main canal*
Source: JICA Survey Team

Among 6 secondary canals, some part of SC-4 will be constructed and the others including the remaining part of SC-4 will be rehabilitated. All of the main canal and secondary canals are designed to be unlined.

Profile of Main Canal 35 are presented in Drawings MC-03 to 06. Hydraulic properties of all cross sections are tabulated in Table AD-2.4.2.3.2. Dimension, base width, design water depth, flow velocity and hydraulic gradient of canal are designed as below.

Table AD-2.4.2.3.2 Design of Main Canal 35 and Secondary Canals

Canal	Base Width (m)	Design Water Depth (m)	Design Flow Velocity (m/sec)	Hydraulic Gradient	Width of Bank Crest (m)	Width of Inspection Road (m)	Canal Side Slope*
Main Canal 35	0.5 – 5.0	0.6 – 1.3	0.30 – 0.59	0.0001 – 0.0020	2.0 m	4.0 m	1:1.5
SC-1	0.8	0.4	0.51	0.0020			
SC-2	0.8	0.4	0.57	0.0025			
SC-3	0.8 – 1.0	0.4 – 0.6	0.46 – 0.51	0.0010 – 0.0020			
SC-4	0.8 – 1.0	0.4 – 0.6	0.46 – 0.57	0.0010 – 0.0020			
SC-5	0.8	0.4	0.32	0.0008			
SC-6	0.6 – 0.8	0.4	0.58 – 0.60	0.0020 – 0.0030			

**: The same slope is applied to inside and outside of canal.*
Source: JICA Survey Team

(3) Drainage System

Main Canal 35 and secondary canals could be used as drain as well as irrigation canal. According to topographic condition, drainage water would flow from northeast to southwest in the upstream half of Zone-A, which extent up to the turnout of Secondary Canal 6. Based on the assumption of USISRSP, unit drainage requirement would be estimated at 1.6 l/sec/ha in the USISRSP Area, which is deemed to be applicable to MC35RSP since the USISRSP Area is located at just 10 km south of the MC35RSP Area. Drainage basin of the upstream area is about 450 ha and drainage requirement is estimated at 0.7 m^3/sec. Therefore, minimum capacity of Main Canal 35 should be set at higher than 0.7 m^3/sec.

On the other hand, the purpose of rehabilitation works for the downstream half of main canal, which is the remaining area of Zone-A, is drainage of residual water floated out from the irrigable area and surrounding area of the main canal. Though some interview is conducted during site reconnaissance and inventory survey, complaints about drainage in this area would not be mentioned by Kampong Speu PDOWRAM and villagers living vicinity. Canal section of downstream side is segmentalized and malfunctioning at present. Actually, rehabilitation for the main canal in this portion would not affect seriously to MC35RSP. Considering above conditions, the rehabilitation works for downstream side of the main canal in Zone-A are to be minimized as much as possible.

(4) Related Structures

In order to ensure the conveyance of irrigation water, a check structure will be constructed with turnout at each diversion point from main canal to secondary canal or tertiary canal and secondary canal to tertiary canal. Turnouts on the main canal connected to existing secondary canals not to be rehabilitated will be replaced. Existing drain inlets will be replaced as they are and some drain inlets will be newly constructed at the confluence of main canal and drains. Culverts will be installed where they are existing or the crossing point of Main Canal 35 and road. Drops will be constructed just upstream of confluence of main canal and Kokir River. A road bridge at the beginning point of new route of main canal, where village road would be crossing with old route, will be replaced. Footpath bridge will be installed every 500 m wherever the distance of the neighboring structures, e.g. check structures or culverts is more than 500 m. A cross drain will be constructed at crossing point of main canal and drain existing along the main road. Layout and standard design of related structures are described in Drawings SS-01 to SS-02. Quantities of these related structures on main canal and secondary canals are tabulated as below.

Table AD-2.4.2.3.3 Quantities of Related Structures on Main Canal and Secondary Canals

(Unit: no. /nos.)

Canal	Check Structure	Turnout	Drain Inlet	Culvert	Drop	Road Bridge	Footpath Bridge	Cross Drain
Main Canal	9	16	6	8	5	1	9	1
Secondary Canal								
SC_1	4	5	0	3	0	0	0	0
SC_2	2	5	0	2	0	0	0	0
SC_3	5	7	0	12	0	0	0	0
SC_4	3	5	0	3	1	0	0	1
SC_5	3	5	0	2	0	0	0	0
SC_6	3	8	0	4	0	0	0	0
Total (Secondary Canal)	20	35	0	26	1	0	0	1

Source: JICA Survey Team

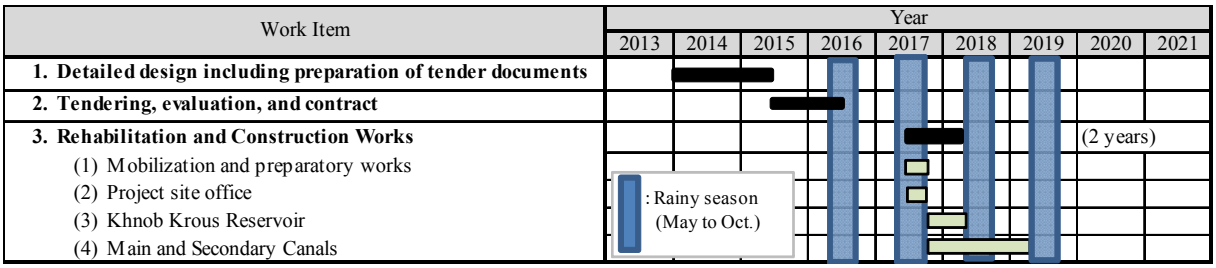
(4) Tertiary Canals

As mentioned in previous Sub-clause, there are no tertiary systems in the MC35RSP Area. Since the location and situation of MC35RSP are similar to USISRSP, the same manner of construction as USISRSP should be adopted. That is, while construction of tertiary canals is supposed to be contracted to local contractors, watercourse would be constructed by beneficiary farmers themselves. In order to realize the proposed tertiary systems promptly, design concept would be reasonable and acceptable to stakeholders.

AD-2.4.2.4 Construction Schedule

(1) Rehabilitation of Reservoir and Main and Secondary Canal System

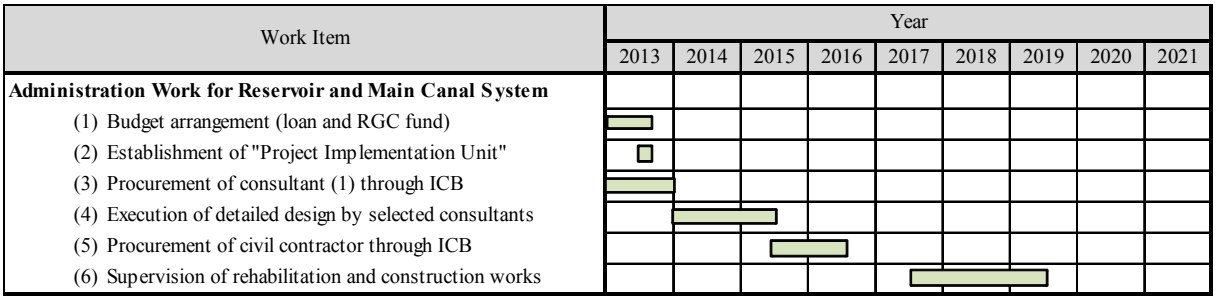
Major facilities included in MC35RSP are the Khpob Krous Reservoir, main canal and secondary canals and related structures. These are required to partially rehabilitate one main canal and 6 secondary canals. Besides, one secondary canal is newly constructed. In these systems, new construction is made for 141 structures in total. As for construction of them, ICB is applied. Time required from the commencement of D/D including mapping to the end of rehabilitation work would be 5 years as shown below.



Source: JICA Survey Team

Figure AD-2.4.2.4.1 Implementation Time Schedule for Reservoir and Main Canal System of MC35RSP

For fulfilling the activities mentioned above, required administration works of MOWRAM and PDOWRAM would be as follows.



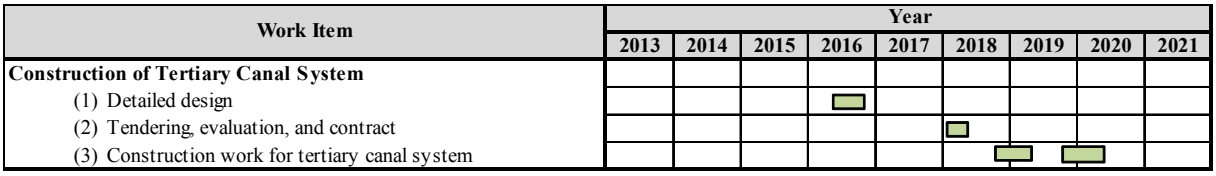
Source: JICA Survey Team

Figure AD-2.4.2.4.2 Administrative Activities for Reservoir and Main Canal System of MC35RSP

The budget arrangement and procurement of the foreign consultant are assumed to be completed within one year respectively. Out of 6 secondary canals, one secondary canal will be constructed newly, therefore MOWRAM and PDOWRAM are requested to execute land acquisition it on time. After completion of rehabilitation work, the construction management office of MCS35RSP would be handed over to PDOWRAM for O&M purpose.

(2) Construction of Tertiary Canal System

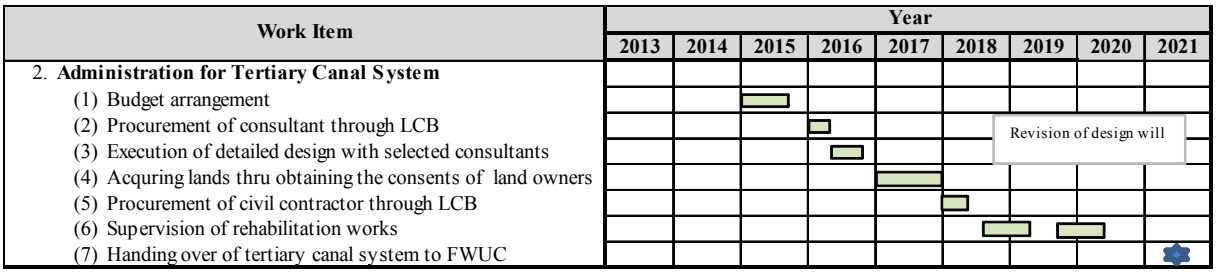
Tertiary canals covering 850 ha, of which the length is 26 km in total, will be constructed following the rehabilitation work for main and secondary canal system. D/D for tertiary canal would be prepared by the national consultant in close coordination with PDOWRAM and FWUC, and based on the design for the main and secondary canal system. The delineation of tertiary block and alignment of tertiary canals are to be agreed by FWUC and land owners. It would take rather longer period, since private lands should be provided for tertiary canals by land owners free of charge. Therefore, period of D/D is estimated at 6 months including confirmation of alignment of tertiary canals. Assuming the progress rate of work at about 1,000 ha per year, construction period is set at 9 months (1 dry season) as shown below. It is expected the tertiary canal system will be handed over to FWUC after 1-year maintenance period of construction.



Source: JICA Survey Team

Figure AD-2.4.2.4.3 Implementation Time Schedule for Tertiary Canal System of MC35RSP

For realizing the above activities, MOWRAM and PDOWRAM are requested to conduct the following administration works.



Source: JICA Survey Team

Figure AD-2.4.2.4.4 Administrative Activities for Construction of Tertiary Canal System

It is expected that the budget arrangement would be completed about 10 months and procurement of the national consultant for 3 months. Land acquisition for tertiary canal would require about one year. After completion of tertiary canal system, it would be handed over to FWUC after 1-year maintenance period.

AD-2.4.3 Srass Prambai Water Recession Rehabilitation Sub-project

AD-2.4.3.1 Present Conditions of Irrigation and Drainage

(1) Outline of Sub-project

Srass Prambai Irrigation System, consisting of the Srass Prambai Reservoir and main and secondary canals was originally constructed during Pol Pot regime targeting to irrigate the flood recession cultivation area in the flood plain between the Bassac and the Mekong Rivers. The area lies at the left side of the Bassac River in its lower reach, about 20 km from the national border with Vietnam, as shown in the location map. The area is administratively situated in Po Ti Ban Commune, Kaoh Thum District, Kandal Province.

The system was sufficiently operated till 2000, however the reservoir dike was damaged in 2000 by flood. The low land paddy areas were then abandoned, and some farmers have shifted their cultivation into the reservoir that has been dried without stored water during rainy season. After 2000, the flood recession cultivation lands have been facing the shortage of irrigation water, and hence the farmers and the local authority requested to MOWRAM for urgent rehabilitation. Previously, rehabilitation works of the reservoir dike with about 7 km were executed by the local religious party under the assistance of PDOWRAM, and the rest of the dike remains untreated.

This area is selected as one of the representative areas of the pre-F/S for the rehabilitation of small scale irrigation systems in this Survey, which is also the highest priority project proposed by Kandal PDOWRAM. Objective of the Srass Prambai Irrigation Sub-project is to ensure water supply for the recession cultivation area in the dry season by rehabilitating the existing reservoir dike and related structures with provision of new slide gates.

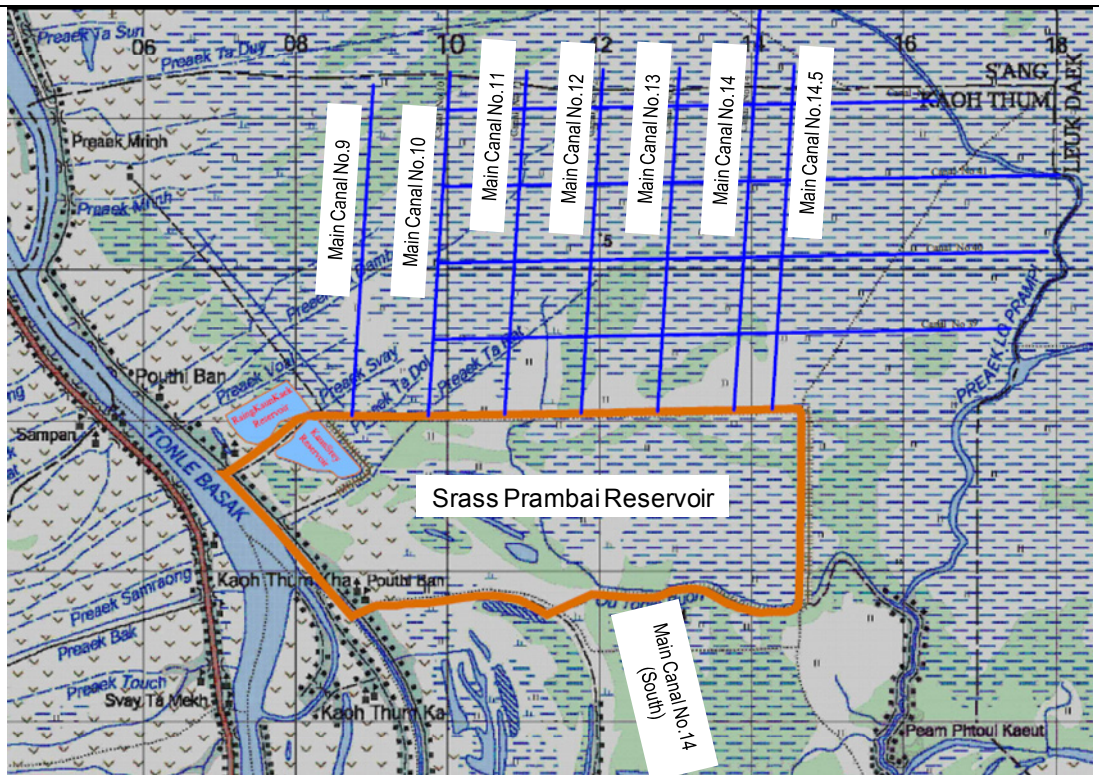
(2) Flood Recession Cultivation in Srass Prambai Irrigation System

Agricultural production system in this area is characterized by the flooding cycle of the Mekong and the Bassac Rivers in the category of colmatage, lowland irrigation and rain fed agriculture. Flood recession cultivation of paddy is prevailing in the flood plain along these rivers as well as the Tonle Sap River. Water from the preceding flood flows into the lands directly or through the colmatage canals, spreading and submerges the paddy field, and also flows into the reservoir through the intake culverts constructed on the reservoir dike. After the flood season, inundated water level on the paddy fields decreases gradually from the higher to the lower lands, according to which paddy cultivation

starts from November in higher lands to February in lower lands. Supplementary irrigation water is then conveyed by gravity from the reservoir in the rainy season into the Pol Pot canal system. The farmers use their own small portable pumps to lift the water in the canal system to their lands. The recession cultivation is locally and traditionally developed without water balance study, and the available water is fully depending on the natural flood conditions.

(3) Existing Irrigation System

The components of the irrigation system consist of the Srass Prambai Reservoir and main and secondary canals. The canals, having the function as a creek, are called as Pol Pot Grid Canals, which were excavated with 500 m interval as shown in Figure AD-2.4.3.1.1.



Source: JICA Survey Team based on Proposal Document prepared by PDOWRAM, 2009

Figure AD-2.4.3.1.1 General Layout of Srass Prambai Irrigation System

The general features of the existing irrigation system are summarized as below.

Table AD-2.4.3.1.1 General Features of Srass Prambai Irrigation System

Item	Features
Water source	Mekong River and Bassac River
Command area*	Total potential land resources : 2,000 ha (reported by PDOWRAM) Existing irrigated area : 700 ha Target area for rehabilitation : 1,200 ha[1]
Reservoirs	Srass Prambai Reservoir
Main canals	Nos. : 12 nos. Length in total : 66 km
Secondary canals	Nos. : 9 nos. Length in total : 57 km

*Remarks *: Proposed by MOWRAM*
Source: Project Proposal Document To Small Scale Infrastructure Project(2009)
JICA Survey Team

(a) Srass Prambai Reservoir

The Srass Prambai Reservoir was constructed in Pol Pot regime. The reservoir is surrounded by the dike at the northern, western and southern sides and the road at eastern side as shown in Figure AD-2.3.4.1.2. The total length of dike is 12.3 km, and 7 m in height at maximum with top width of 5 m. The reservoir dike was eroded at many places and damaged. The northern part of the dike was rehabilitated by a religious party under assistance of MOWRAM in 2008. However the eastern and southern parts of the dike of around 9 km remain unrehabilitated.

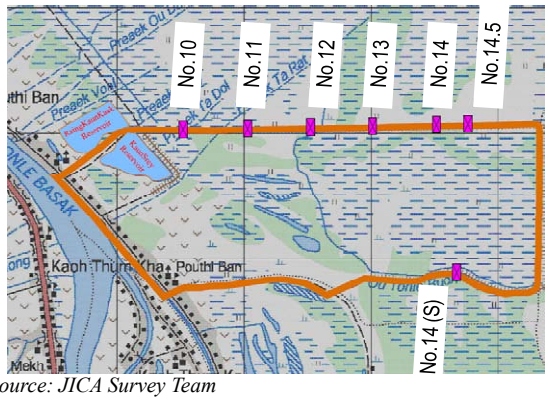
Existing Srass Prambai Reservoir Dike (Rehabilitated Section)

(b) Intake Culverts at Srass Prambai Reservoirs

There are 7 existing culverts on the reservoir dike as shown in Figure AD-2.4.3.1.2, which were originally constructed during Pol Pot regime. These culverts have two flow directions. The flooded water in the low land flows into the reservoir according to the increase of water level outside in the rainy season, and the opposite direction from the reservoir to outside after peak flood water level according to the water recession on the lands.

Existing Intake Culvert

These culverts were equipped with wooden stop logs inner side the reservoir, however all of them are malfunctioning at present, and therefore the reservoir is not able to store the water. The existing 7 culverts are listed in Table AD-2.4.3.1.2.



Source: JICA Survey Team

Figure AD-2.4.3.1.2 Layout of Intake Culverts on Reservoir Dike

Though Kandal PDOWRAM is responsible for O&M for this irrigation system, no activities are required because all of the control facilities are malfunctioning, while water management is executed by the farmers themselves at on-farm level.

There was no written operation rule and guideline of reservoir operation including stop log of the culverts, but they were operated by their rules given traditionally through their experiences. When the stop-logs of culvert were operational, the farmers group themselves was responsible for day-to-day operation, which was adjusting the stop log opening height, etc.

Table AD-2.4.3.1.2 List of Intake Culverts at Srass Prambai Reservoir

No,	Name of Off-taking Canal	Culvert		Length (m)	Base EL. (m)	Water control facility
		Box	Pipe			
1	Main Canal 10	-	Ø 1.2m x 1	9.0	4.46	Stoplog
2	Main Canal 11	-	Ø 1.2m x 1	9.0	4.49	Stoplog
3	Main Canal 12	-	Ø 1.2m x 1	9.0	4.59	Stoplog
4	Main Canal 13	-	Ø 1.2m x 1	9.0	4.04	Stoplog
5	Main Canal 14	-	Ø 0.6m x 2	9.0	4.00	Stoplog
6	Main Canal 14.5	-	Ø 0.6m x 2	9.0	4.03	Stoplog
7	Main Canal 12(South)	1.0 m x 1.5 m	-	5.0	4.60	Stoplog

Remarks: Elevation is surveyed from local bench mark

Source: JICA Survey Team based on the inventory survey in January 2012

(c) Main and Secondary Canals

The Pol Pot grid canal system was constructed according to latitude and longitude direction, with the concept that their access to water was shortened, and the gravity irrigation was not premised. Most of farm lands are irrigated subject to the operation of small portable pumps owned by the farmers themselves. The main and secondary canals in the system are summarized in Figure AD-2.4.3.1.3 and Table AD-2.4.3.1.3.

Main Canal under Recession Water

Table AD-2.4.3.1.3 List of Canals in Srass Prambai Irrigation System

Name of Canal	Length (km)	Structure and Remarks
Main Canal 9	4.47	- No structure
Main Canal 10	4.36	- Intake culvert Ø 1.2m at reservoir dike - Pipe culvert at 500 m from intake
Main Canal 11	4.21	- Intake culvert Ø 1.2m at reservoir dike
Main Canal 12	4.28	- Intake culvert Ø 1.2m at reservoir dike
Main Canal 13	4.30	- Intake culvert Ø 1.2m at reservoir dike
Main Canal 14	4.28	- Intake culvert (Double line) Ø 0.6m at reservoir dike
Main Canal 14.5	4.27	- Intake culvert (Double line) Ø 0.6m at reservoir dike
Main Canal 39	8.64	- No structure
Main Canal 40	8.67	- No structure
Main Canal 41	8.89	- No structure
Main Canal 42	8.97	- No structure
Main Canal 14(South)	1.0	- Intake culvert (Box culvert) at reservoir dike
Secondary Canal 9.5	4.52	- No structure
Secondary Canal 10.5	4.43	- No structure
Secondary Canal 11.5	4.25	- No structure
Secondary Canal 12.5	4.26	- No structure
Secondary Canal 13.5	4.3	- No structure
Secondary Canal 38.5	8.6	- No structure
Secondary Canal 39.5	8.88	- No structure
Secondary Canal 40.5	9.12	- No structure
Secondary Canal 41.5	8.84	- No structure

Source: JICA Survey Team based on the inventory survey in January 2012

In principle, no structure was constructed on the Pol Pot Gird Canal system. At present, only one structure on the canal system is observed, which is a pipe culvert with a diameter of Ø 0.5m on Main Canal No.10 at 500 meters from the beginning point, installed by farmers themselves.

The canal grid, as well as the reservoir, is also utilized for fishery activities and transportation by water for the local peoples

(d) Tertiary System and Drainage

In this system, drainage conditions are fully depending on the flood inundation from the Bassac and the Mekong Rivers and its recession water level. In the dry season, the water level is gradually reduced and the lands are dried accordingly, but the some areas remain wet and swampy.

AD-2.4.3.2 Irrigation and Drainage Development Plan

(1) Basic Concept for Development

The project works proposed by PDOWRAM/MOWRAM are reviewed in the following basic concept paying attention upon the current conditions of SPWRRSP.

(a) Integrated Approach of Hardware and Software Components

Irrigated agriculture development for SPWRRSP is planned in the concept of integrated approach of hardware and software components which is the same as the other sub-projects, in order to heighten the project effect and to maintain the project sustainability.

(b) Appreciating Present Irrigation System under the Recession Cultivation

There is the existing irrigation canal system constructed in Pol Pot regime, which are currently well functioning and suitable locally and traditionally under the present water management practices for the recession cultivation in this area. Therefore, accepting the present conditions, this canal system is to be utilized without rehabilitation in order to save construction cost and lighten the burden for land acquisition.

(c) Determination of Project Scale through Water Balance Study

Rehabilitation plan should be planned mainly based on available water, available land and the water demand by crops. Since SPWRRSP has reservoirs and enough farm to be served by the existing reservoirs, its project size will be determined through a water balance study.

(d) Priority Ranking on Sub-project Scope by Criteria

As SPWRRSP requires many project works, these will be prioritized so as to use the limited budget. High priority should be given to (i) the works indispensable for attaining at the aim of SPWRRSP, (ii) Urgently required works for proper operation of irrigation system, (iii) the facilities related to ensuring water resources, and (iv) the facilities which need large scale rehabilitation to convey irrigation water.

(2) Examination of Proposal by PDOWRAM

In the project proposal document in October 2009, Kandal PDOWRAM requested the rehabilitation works, which includes the earthworks and related structures on only the reservoir. Based on the investigation, the proposed works and scopes of the rehabilitation works under the SPWRRSP are examined as described in the following sub-sections.

(3) Water Balance Study and Irrigable Area

(a) General

The water balance simulation study is conducted in order to estimate the possible extent of the service area as well as cropping intensity (cropping area in the dry and the early rainy seasons) with 80% dependability, and to determine the design values for the proposed irrigation facilities.

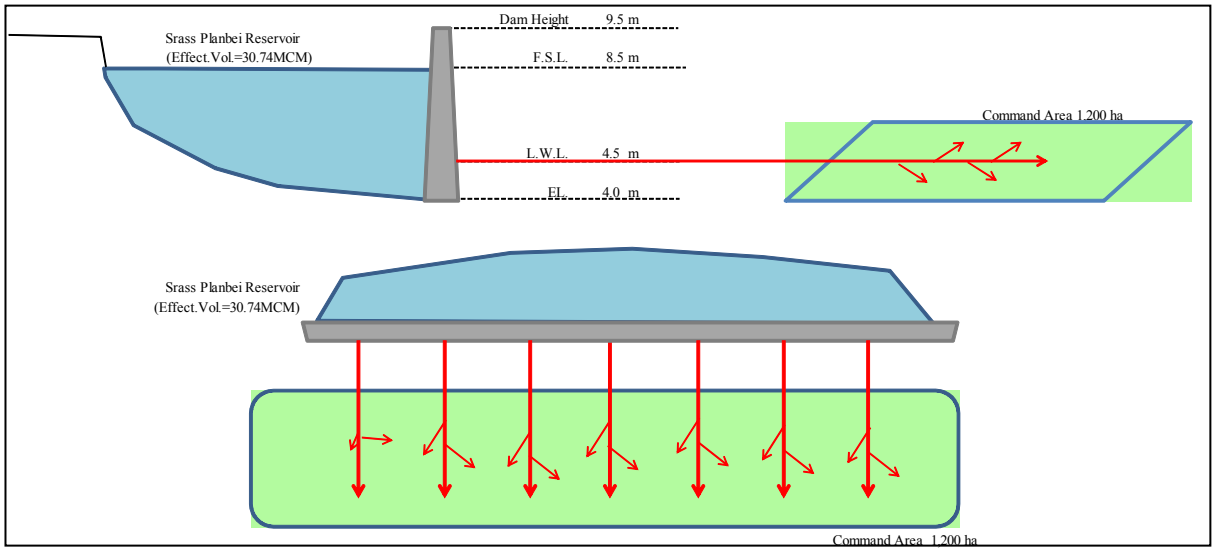
(b) Calculation Method and Model

In this Survey, long-term water balance simulation method was applied. The water balance simulation in this Survey is summarized in Table AD-2.4.3.2.1 and the simulation model is as sown in Figure AD-2.4.3.2.1.

Table AD-2.4.3.2.1 Condition of Water Balance Simulation for SPWRRSP Area

Item	This Survey
Calculation interval	Half-monthly basis
Method for estimating potential evapo-transpiration	Penman-Montieth method
Runoff data	Estimated from the data at Koh Khel station
Reservoir Operation	Storage effect of Srass Prambai reservoirs are considered
Simulation model	By the long-term (1992-2011; 20years) simulation
Irrigation fail	Continuous deficit in 15 days

Source: JICA Survey Team

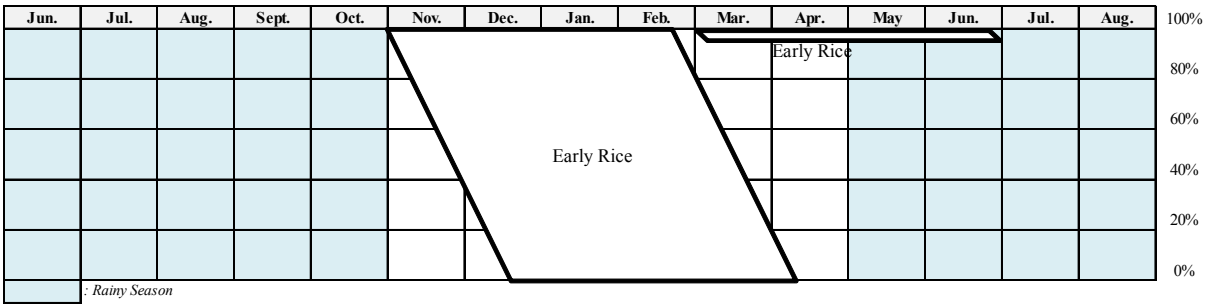


Source: JICA Survey Team

Figure AD-2.4.3.2.1 Schematic Layout of Water Balance Model for SPWRRSP

(c) Irrigation Water Demand

For the purpose of the water balance study, unit irrigation water requirement per hectare is estimated based on the proposed cropping calendar shown in Figure AD-2.4.3.2.2, which consists of two crop seasons of medium rice in the dry season and early rice in the early rainy season in a year. Irrigation water demand was estimated half monthly basis using the rainfall data at Pochentong station for the period from 1992 to 2011. The water requirement is calculated by the same conditions in other sub-projects with some variations, which is tabulated in Table AD-2.4.3.2.2.



Source: JICA Survey Team (Refer to Annex C)

Figure AD-2.4.3.2.2 Proposed Cropping Calendar for SPWRRSP

Table AD-2.4.3.2.2 Conditions for Estimate of Irrigation Water Requirement

Item	Description
Calculation interval	Half monthly basis
Method for estimating potential evapo-transpirationi	Penman-Montieth method
Meteorological data	Pochentong Station (Phnom Penh)
Rainfall data	Pochentong Station (Phnom Penh) 20 years from 1992 to 2011
Effective rainfall	Applying 75% of monthly rainfall as effective monthly rainfall for paddy
Percolation rate	2 mm/day
Irrigation efficiency	Overall irrigation efficiency: 70% (Conveyance efficiency 70% and no application loss is considered)

Source: JICA Survey Team

The estimated unit water requirement per hectare is summarized as below.

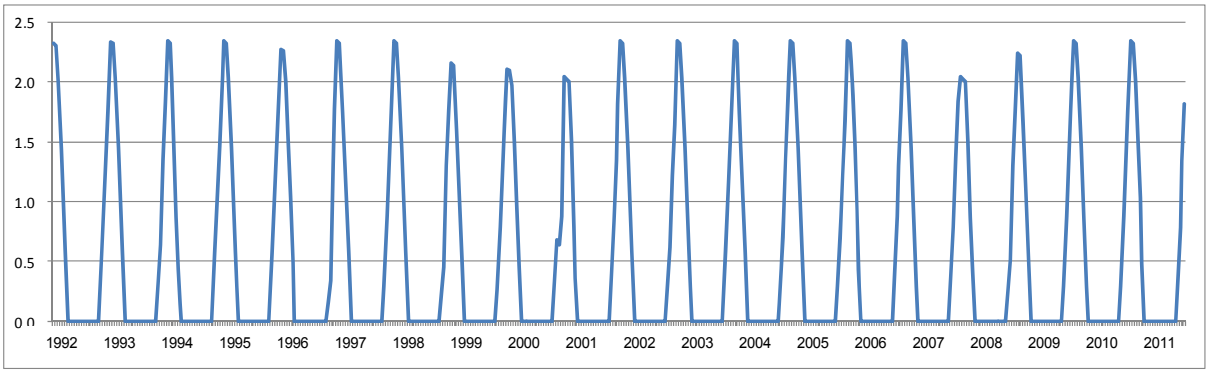
Table AD-2.4.3.2.3 Summary of Estimated Unit Water Requirement (Average of 20 years; 1992-2011)

(Unit: l/sec/ha)

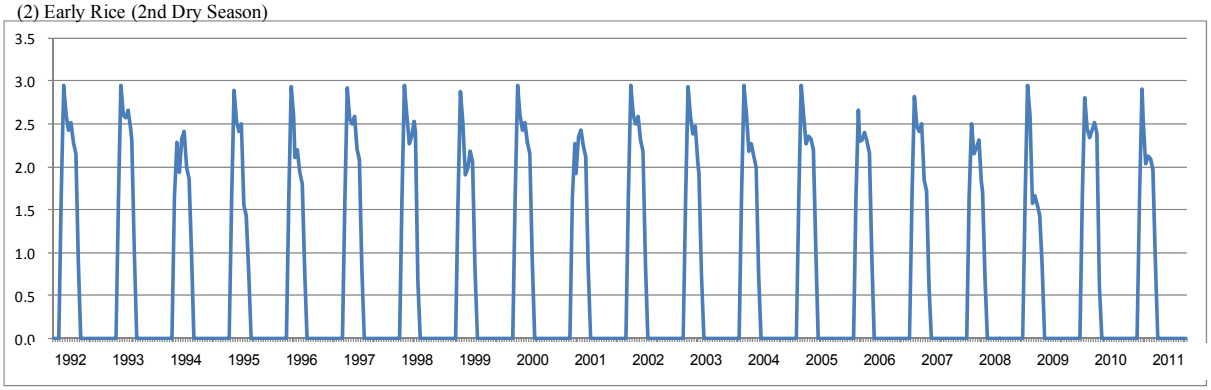
Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
(1) Early Rice (Recession)												
1-15	2.28	1.99	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	1.28
16-end	2.26	1.50	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	1.74
(2) Early Rice (2nd Dry Season)												
1-15	0.00	0.00	2.82	2.28	2.13	0.83	0.00	0.00	0.00	0.00	0.00	0.00
16-end	0.00	1.65	2.46	2.36	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: JICA Survey Team

(1) Early Rice (Recession Cultivation)



(2) Early Rice (2nd Dry Season)



Source: JICA Survey Team

Figure AD-2.4.3.2.3 Estimated Unit Water Requirement from 1992 to 2011

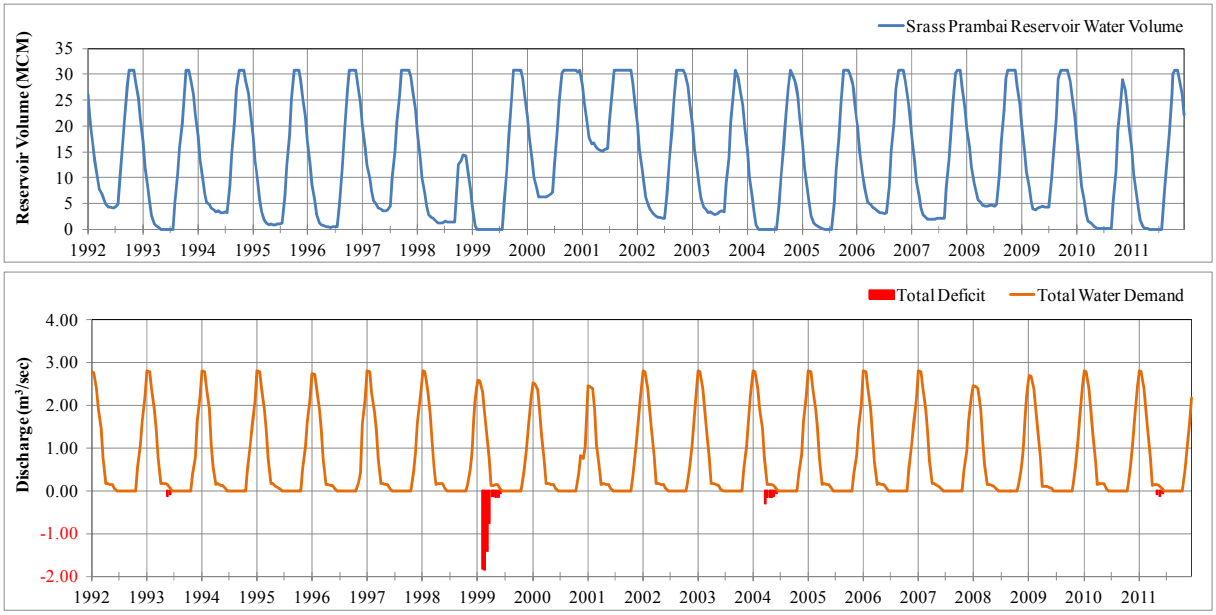
(c) Water Balance Study

1) General

Because irrigation for the recession cultivation is applied in the dry season, the water balance study was conducted by considering of flood water level of the Tonle Bassac River. During flood season from September to November, river water flows from the Tonle Bassac River into the Srass Prambai Reservoir. After the flood season, inundation area is drying up and in those areas is cropping for recession rice crop. Water balance simulation was conducted by using storage capacity curve of the Srass Prambai Reservoir and the estimated unit irrigation water requirement. In this water balance study, irrigation water for the command area was assumed to supply from only the Srass Prambai Reservoir.

2) Result of Water Balance Simulation

As the results of water balance simulation study is the reservoir operation curve with comparison to irrigation water requirement and inflow into the reservoir is shown in Figure AD-2.4.3.2.4.



Source: JICA Survey Team

Figure AD.2.4.3.2.4 Results of Reservoir Operation Simulations of Srass Prambai Reservoir

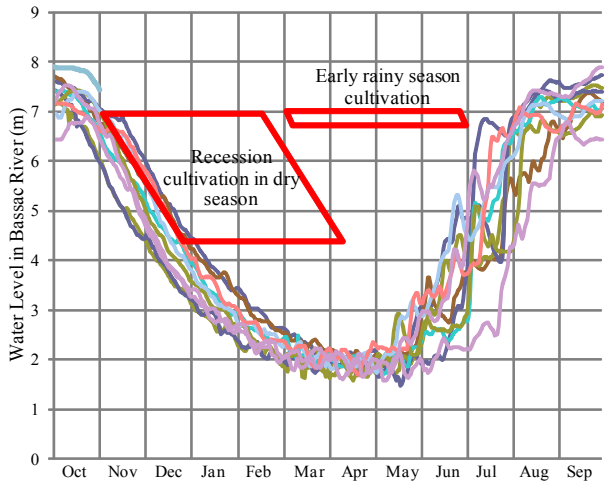
Based on the above water balance study, the following extent of each proposed cropping could be realized with 80% dependability. The proposed Sub-project area is then determined to be 1,200 ha. .

Table AD-2.7.3.2.4 Irrigable Area of each Cropping based on Result of Water Balance Study

Medium Rice (Rainy Season)	Early Rice (Early Rainy Season)	Crop Intensity
1,200 ha	70 ha	106%

Source: JICA Survey Team

Typical cropping pattern with comparison of the water recession level is illustrated in Figure AD-2.4.3.2.5 and the proposed cultivation area in SPWRRSP is shown in Figure AD-2.4.3.1.3.



Source: JICA Survey Team

Figure AD-2.4.3.2.5 Typical Cropping Pattern with Comparison to Water Recession Level

(4) Proposed Rehabilitation works

(a) Dike of Srass Prambi Reservoir

The Srass Prambai Reservoir that was constructed in Pol Pot regime is surrounded by the dike at the northern, western and southern sides and the road at eastern side. The total length of dike is 12.3 km, and 7 m in height at maximum with top width of 5 m. The reservoir dike was eroded at many places and damaged. The northern part of the dike was recently rehabilitated in 2008, while the eastern and southern parts of the dike remain untreated. PDOWRAM proposed the rehabilitation of the embankment of the dike of 5.0 km, which are examined by the Survey Team with topographic survey for confirmation of the present conditions of longitudinal and cross sections of the dike. As a result, the rehabilitated section in the northern part are still sufficient sections both of height, width and side slopes. Therefore, the remaining parts are proposed to be rehabilitated in the

Sub-project in order to enlarge the embankment section to meet the same height of the rehabilitated sections. The length of the proposed rehabilitation is estimated at 9.1 km based on the topographic survey.

(b) Intake Culvert on Reservoir Dike

There are 7 existing culverts on the reservoir dike originally constructed during Pol Pot regime. These culverts were equipped with wooden stop logs inner side the reservoir, however all of them are malfunctioning at present. Though Kandal PDOWRAM proposed new construction of 2 culverts in his proposal document, during the Survey period the Survey Team and PDOWRAM concluded that the existing intake culverts be replaced with new provision of steel gates based on the investigation of the conditions. The required works include (i) removing existing structures, (ii) construction of new structures maintaining original capacity, (iii) installation gate and screen, and (iv) protection at both sides. Proposed intake culverts are listed as below.

Table AD-2.4.3.2.5 List of Proposed Intake Culverts at Srass Prambai Reservoir

No,	Name of Off-taking Canal	Culvert		Length (m)	Gate
		Box	Pipe		
1	Main Canal 10	-	Ø 1.2 m x 1	10.0	1.2 m x 1. 2 m (4-edge sealing)
2	Main Canal 11	-	Ø 1.2 m x 1	10.0	1.2 m x 1. 2 m (4-edge sealing)
3	Main Canal 12	-	Ø 1.2 m x 1	10.0	1.2 m x 1. 2 m (4-edge sealing)
4	Main Canal 13	-	Ø 1.2 m x 1	10.0	1.2 m x 1. 2 m (4-edge sealing)
5	Main Canal 14	-	Ø 1.0 m x 1	10.0	1.0 m x 1. 0 m (4-edge sealing)
6	Main Canal 14.5	-	Ø 1.0 m x 1	10.0	1.0 m x 1. 0 m (4-edge sealing)
7	Main Canal 12(South)	1.0 m x 1.5 m	-	6.0	1.0 m x 1. 5 m (4-edge sealing)

Source: JICA Survey Team based on the inventory survey in January 2012

(c) Other Facilities

The present conditions of canal system are operational and well matching to the recession cultivation in this area, and hence the rehabilitation of the canal system is not proposed in this Survey according to the basic concept described in Sub-clause AD-2.4.3.2 (1).

(5) Proposed Development Plan (Proposed Scope of Sub-project)

(a) Examination of Scope of SPWRRSP Proposed by MOWRAM

In project proposal document, MOWRAM proposed the rehabilitation works as listed in Table AD-2.4.3.2.6, which include earthworks and construction/rehabilitation works of related structures on only the reservoir dike. Based on the investigation, the proposed works and scopes of the rehabilitation works under SPWRRSP are examined as shown in fallowing table.

Table AD-2.4.3.2.6 Examination of Scope of Rehabilitation

Proposed Works by PDOWRAM[1]	Examination in this Survey[2]
1) Target irrigation area - 1,200 ha in dry season (2,500 ha originally proposed, and revised during the Survey period)	Irrigable area is evaluated with water balance simulation study.
2) Reservoir - Dike 5,000 m with top width of 5 m - Top soil removal; 120,000 m^3 - Embankment; 254,200 m^3 - Structures New Intake culvert ; 2 nos.	Rehabilitation of existing reservoir dike is urgently required as proposed by PDOWRAM Rehabilitation length is determined through topographic survey. All existing intake culverts need to be replaced with provision of gates.

Proposed Works by PDOWRAM[1]	Examination in this Survey[2]
3) Main and secondary canals Not proposed	Rehabilitation of existing Pol Pot canal system is not required.
4) Drain and tertiary canals Not proposed	Not proposed

Source : JICA Survey Team

(2) Proposed Scope of Sub-project

Based on the basic concept for irrigation rehabilitation plan mentioned above, facilities to be rehabilitated and/or reconstructed under SPWRRSP are shown in the following table:

Table AD-2.4.3.2.7 List of Irrigation and Drainage Facilities to be Rehabilitated under SPWRRSP

Description	Quantities
(a) Irrigation Development Area	(a) Irrigation Development Area - 1,200 ha
(b) Hardware Components	(b) Hardware Component
- Rehabilitation of reservoirs dike	- Rehabilitation of the existing dike (9.1 km)
- Replacement of intake culverts on reservoir dike	- Replacement of 7 intake culverts with provision of new slide gates
- Construction of project office	(a) Office building (300 m^2) (b) Parking shed, gate and fencing (c) Well drilling and electric works, etc.

Source: JICA Survey Team

(2) Priority Ranking

There are many works in hardware and software components in the examined scope of SPWRRSP. It is not sure presently that all of these works could be simultaneously implemented in the available loan amount. Thus, as mentioned in Sub-clause AD-2.4.3.2 (1), these examined works are given priority ranking based on the following criteria

- The works indispensable for attaining at the purpose of SPWRRSP are given high priority
- Urgently required works for adequate operation of irrigation system are given high priority
- The rehabilitation works for facilities needed to recover their functions are given high priority

The priority ranking of each work based on the criteria is summarized in the following table.

Table AD-2.4.3.2.8 Priority Ranking of Each Work

Scope Examined by JICA Survey Team		Priority*
- Rehabilitation of reservoir dike	- Rehabilitation of dike (9.1 km)	◎
- Replacement of intake culverts on reservoir dike	- Replacement of intake culverts (7 nos.) with slide gates	◎
- Construction of project office	- Office building (300 m^2) - Parking shed, gate and fencing - Well drilling and electric works	○

**: High priority: ◎ , Medium priority: ○ , Low priority: △*
Source: JICA Survey Team

AD-2.4.3.3 Design of Irrigation and Drainage Facilities

(1) General

The existing Srass Prambai Reservoir requires urgent and significant rehabilitation and improvement to ensure stable irrigation farming in the recession cultivation area. The basic concept of rehabilitation of these facilities is to make both initial construction cost and O&M cost as low as possible in due consideration of maintaining sufficient function, safety and durability, accepting current irrigation practices using portable small pump at on-farm level under the existing Pol Pol Canal Grid system.

Considering the above, the required rehabilitation works will be planned in the following basic concept:

- Rehabilitation of the Srass Prambai Reservoir is given highest priority both for the reservoir dike and related intake culverts.
- Existing Pol Pot Canal Grid would be utilized as it is without rehabilitation.
- Irrigation facilities is planned with conditions that (i) reliability level of irrigation supply is set at 4 in 5 years or 80%, and (ii) 24-hour water conveyance will be applied for diversion, main and secondary systems
- Tertiary canal system is not considered because current irrigation practice seems to be suitable for the recession cultivation in this area.
- Rehabilitation of dike and related structures are designed preliminarily at pre-F/S level in this Survey. The facilities should be designed in detail at next stage after preparation of topographic map.

(2) Irrigation Water Requirement

Irrigation water requirement is calculated based on the water balance study as discussed in Sub-clause AD-2.4.3.2(3). As a result, unit water requirement at a main and secondary canal level is set at 2.4 l/sec/ha, applying overall irrigation efficiency of 70%. Based on the unit water requirement, the peak diversion water requirement from the Srass Prambai Reservoir is estimated at 2.8 m^3/sec.

(3) Design Inflow Discharge at Reservoir

In order to determine the capacity of the intake culverts on the reservoir, designed inflow discharge from the Tonle Bassac River into the reservoir is assumed to be 4.0 m^3/sec through the water balance simulation study as discussed in ANNEX B-2.5.2.4.

(4) Rehabilitation of Irrigation and Drainage Facilities

Based on the basic concept for the rehabilitation plan mentioned above, facilities to be rehabilitated and/or reconstructed under SPWRRSP are shown in the following table.

Table AD-2.4.3.3.1 Principal Features of SPWRRSP

No.	Description	Quantities
1	Irrigation Development Area	1,200 ha
2	Rehabilitation of reservoirs dike	Rehabilitation of the existing dike (9.1 km) - Top width : 5.0 m - Bank EL. : 8.75 m - Side slop : 1:2.5 for both sides
3	Replacement of intake culverts on reservoir dike	Replacement of 7 intake culverts with provision of new slide gates
4	Construction of project office	(a) Office building (300 m^2) (b) Parking shed, gate and fencing (c) Well drilling and electric works, etc.

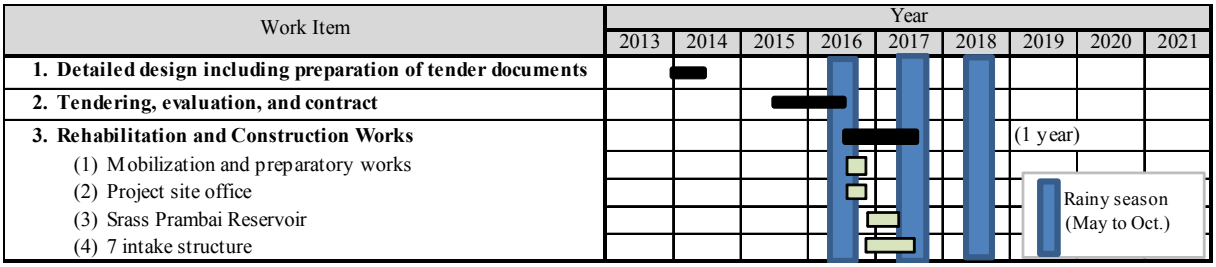
Source: JICA Survey Team

AD-2.4.3.4 Construction Schedule

(1) Rehabilitation of Reservoir and Related Structures

In SPWRRSP, the required works are to rehabilitate of the existing reservoir and to construct 7 intake structures at the reservoir. Command area development is not included in SPWRRSP since the existing irrigation canal system could be used as they are. If the existing irrigation canal system is damaged, it will be repaired by FWUC as one of maintenance works as usual because it is submerged in the rainy

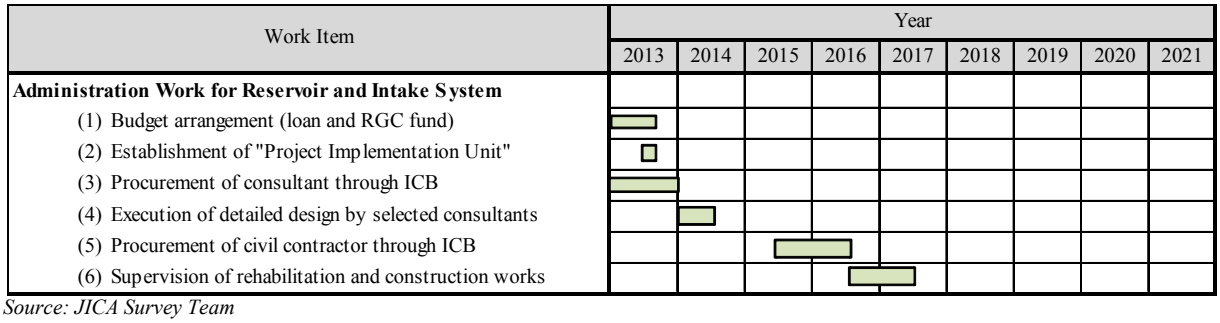
season every year. D/D of them including topographic survey and preparation of tender documents will be started immediately after selection of consultant and be completed within 6 months. The rehabilitation of the existing reservoir and construction of 7 intake structures will be completed within the first year after selection of contractor through ICB since the work volume is not large. Period required from the commencement of D/D to the end of rehabilitation work would total to 3 years as shown below.



Source: JICA Survey Team

Figure AD-2.4.3.5.1 Implementation Time Schedule for Main Canal System of SPWRRSP

In order to materialize the above activities, MOWRAM and PDOWARM are required to fulfill the following administration works.



Source: JICA Survey Team

Figure AD-2.4.3.5.2 Administrative Activities for Reservoir and Intake System

It is expected that the required budget arrangement would be completed within one year and procurement of foreign consultant for one year. As one of careful approaches, attention should be paid so as not to cause the conflict between farmers and fishermen.

AD-2.4.4 Daun Pue Irrigation System Rehabilitation Sub-project

AD-2.4.4.1 Present Conditions of Irrigation and Drainage

(1) Outline of Sub-project

Daun Pue Irrigation System is located in the upstream of the Chieb River basin, about 40 km from its confluence with the Tonle Sap River. The irrigation command area lies in the left bank of the Chieb River and along the provincial road, having long and narrow shape extending from west to east as shown in the location map. Administratively, the area lies in Chieb, Khlong Porpork and Aphivath Communes in Teuk Phos District.

The Daun Pue Irrigation System was constructed in Pol Pot regime (1975-1977) for targeting water supply from the Chieb Stream to its command area of about 1,400 ha in Teuk Phos District in Kampong Chhnang Province. The intake of the system was constructed in the upstream of the Chieb River basin, about 40 km upstream from its confluence with the Tonle Sap River. The irrigation command area lies in the left bank of the Chieb River and along the provincial road, having long and

narrow shape extending from west to east with gentle slope as shown in the location map in Figure AD-2.4.4.1.1.

When it was originally constructed in Pol Pot regime, this irrigation area consisted of two systems, one was commanded by the existing intake and the other was irrigated by the headworks constructed at Chiprong Village. The Chiprong headworks was however totally damaged by flood and hence no more used. The area that was irrigated by the Chiprong headworks have been included in the existing Daun Pue irrigation System by additional canals and using natural stream connecting with Daun Pue canal network.

The existing Daun Pue Irrigation System has been seriously deteriorated, and only limited parts near the main canal is currently irrigated supplementary in the rainy season. The local authority therefore requested to MOWRAM for urgent rehabilitation, and Kampong Chhnang PDOWRAM has given a highest priority to this area. In this Survey, this sub-project DPISRSP is selected as one of the areas of the pre-F/S for the rehabilitation of the small scale irrigation system, representing the irrigation with water source of river run-off without reservoir.

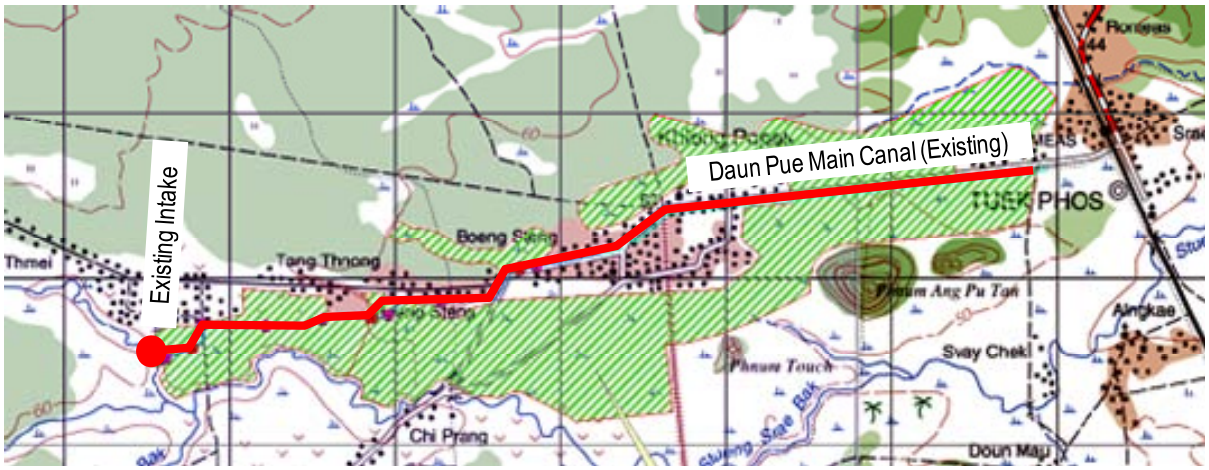


Figure AD-2.4.4.1.1 General Layout of Daun Pue Irrigation System

(2) Existing Irrigation System

The command area of Daun Pue Irrigation System is reported by PDOWRAM to be 1,151 ha in total, extending on the left bank of the Stung Chieb River. The sole water source is the Stung Chieb River, having catchment area of 225 km^2 at the existing intake site.

Existing Temporary Headworks

The Daun Pue Irrigation System consists of temporary headworks and main and secondary canals, which has originally poor designed and constructed facilities. The intake has no permanent structure, and a temporary low diversion weir was constructed manually by the farmers with wooden material and sand bags. The general features of Daun Pue Irrigation System are summarized as below.

Table AD-2.4.4.1.1 General Features of Daun Pue Irrigation System

Item	Features
Water source	Chieb River
Command area	1,150 ha
Headworks	Temporary weir constructed by farmers with wooden material and sand bags. Length ; 45 m, approx Height ; 0.5 - 1.0 m, approx Intake has no permanent structure

Item	Features
Main and secondary canals	Main canal Nos. : 1 Length : 11.5 km Secondary canal Nos. : 14 Length : 22.9 km
Tertiary canal system and drainage	No tertiary system and no drainage system

Source: JICA Survey Team

(3) Main and Secondary Canals

The Daun Pue Main Canal starts at the intake site on the left bank of the river and runs eastward to the end point near Tuek Phos Village. In the lower part of the main canal, the Pol Pot grid canal system is found, which is however not functioning due to the wrong selection of canal route and poor hydraulic designs of the canal system. The canals are generally shallow, eroded and burried with the sediment deposit transported from the intake during the flood regime at many parts of the canals.

Existing Main Canal and Culvert

On the main canal, check structures and off-taking structures are quite limited, and most off-taking canals are diverted without permanent facilities. Only few water control structures are found on the canal. All related structures have malfunctioning due to deterioration or loss of gates, erosion of surrounding slopes, etc., which mostly requires reconstruction. Pipe culverts were provided to cross the roads, and additionally constructed by the villagers for crossing the canal to approach their residential place, which are uncontrolled by PDOWRAM. According to the inventory and topographic survey by the JICA Team in 2012, the most canal sections are not sufficiently designed, constructed and maintained causing much less capacity enough to flow the irrigation water to the fields. Furthermore, sample topographic survey of secondary canals by the JICA Team indicated that some secondary canals run to inverse draft from lower to higher lands, especially secondary canals in the right bank in the downstream reach of the main canal. Some canal routes in the left bank of the main canal might be utilized by re-excavation of the canal sections and or raising of the canal banks.

Existing Secondary Canal

Table AD-2.4.4.1.2 Summary of Canals and Structures on Main and Secondary Canals

Item	Quantity	Item	Quantity
(1) Main Canal Nos. and total length	1 no. 11.5 km	Secondary Canals Total length	14 nos. 22.9 km
Main canal related structures		Secondary canal related structures	
(1) Check structure	2 nos.	(1) Pipe culvert	7 nos.
(2) Box culvert	7 nos.		
(3) Pipe culvert	6 nos.		
(4) Pipe culvert (for access to house)	34 nos.		
(5) Bridge	6 nos.		

Source : Inventory Survey by JICA Survey Team

The canals in this system, originally developed during Pol Pot regime, have the following fundamental problems and issues.

a) The target area was demarcated without water balance study, and therefore the canal network covered the existing land resource more than the irrigable area with certain dependability (80%) that should be determined based on the available water source.

b) The Pol Pot grid canal system was constructed according to latitude and longitude direction, with the concept that their access to water was shortened, and the gravity irrigation was not premised. Most of farm lands are irrigated subject to the operation of small portable pumps owned by the farmers themselves. In many cases, the canal runs to inverse draft causing water not flowing.

c) The canal route was determined without considering topological situations therefore canals were excavated inverse draft in many cases, which prevents water flow.

d) The canals and related structures were not adequately designed in engineering sense based on hydraulic and structural calculations, which caused malfunction of facilities in many cases, such as submerged overflow, insufficient capacity of pipe, insufficient protective works at the structures, and so on, causing easy destruction.

e) The facilities have not been maintained and rehabilitated due to the social ferment in and after the civil war, and hence they have been seriously deteriorated or damaged.

(4) Tertiary Canal and Drainage System

There is neither systematic tertiary irrigation canal nor drain. It seems that only limited area surrounded by the secondary canal grid is irrigated supplemental by field-to-field irrigation only in case that sufficient water head is available by gravity. Otherwise, the water is taken from the main or secondary canals into the fields by using small portable pump owned by the farmers. Formation of the tertiary canal system is required to utilize the irrigation water efficiently and timely. Most of the existing canals constructed in Pol Pot regime have double functions of irrigation and drainage.

The small rivers and/or natural streams are utilized as drains to evacuate the excess water from the area. According to the interview to the local people, however the upstream areas near the Chieb River are frequently affected or inundated by flood once in a few years.

AD-2.4.4.2 Irrigation and Drainage Development Plan

(1) Basic Concept

The project works proposed by PDOWRAM/MOWRAM will be reviewed in the following basic concept paying attention upon the current conditions of DPISRSP.

(a) Integrated Approach of Hardware and Software Components

Irrigated agriculture development for DPISRSP is planned in the concept of integrated approach of hardware and software components which is the same as the other sub-projects, in order to heighten the project effect and to maintain the project sustainability.

(b) Determination of Project Scale through Water Balance Study

Irrigation development should be planned mainly based on available water, available land and the water demand by crops. Since DPISRSP has enough farm to be served by the proposed headworks, its project size will be determined through a water balance study, taking other irrigation systems located up and downstream in the same river basin.

(c) Utilization of Existing Canal System

There are the existing irrigation canals which were constructed in Pol Pot regime. In order to save construction cost and lighten the burden for land acquisition, these existing irrigation canals are used as much as possible.

(d) Priority Ranking on Sub-project Scope by Criteria

As DPISRSP requires many project works, these will be prioritized so as to use the limited budget. High priority should be given to (i) the works indispensable for attaining at the aim of DPISRSP, (ii) Urgently required works for proper operation of irrigation system, (iii) the facilities related to ensuring water resources, and (iv) the facilities which need large scale rehabilitation to convey irrigation water.

(2) Examination of Proposal by MOWRAM

In project proposal document, MOWRAM proposed the new construction of headworks and rehabilitation of an upstream part of main canal with related structures, which does not include downstream of main canal and secondary canals. The scope under DPISRSP is examined in the Survey and discussed in the following sections.

(3) Water Balance Study

(a) General

The water balance simulation study is conducted in order to estimate the possible extent of the service area as well as cropping intensity (cropping area in the rainy and the early rainy seasons) with 80% dependability, and to determine the design values for the proposed irrigation facilities. There is no existing reservoir in the DPISRSP Area and the basin. Therefore, simplified water balance study was conducted for DPISRSP Area.

For the water source of DPISRSP, there are 2 alternative intake sites, one is the existing intake site on the Stung Chieb River and the other is about 1 km downstream from the existing intake, where the Stung Chieb River confluents into the Stung Srae Bak River. Water balance simulation is studied these 2 alternative intake sites, as discussed in detail in ANNEX B.

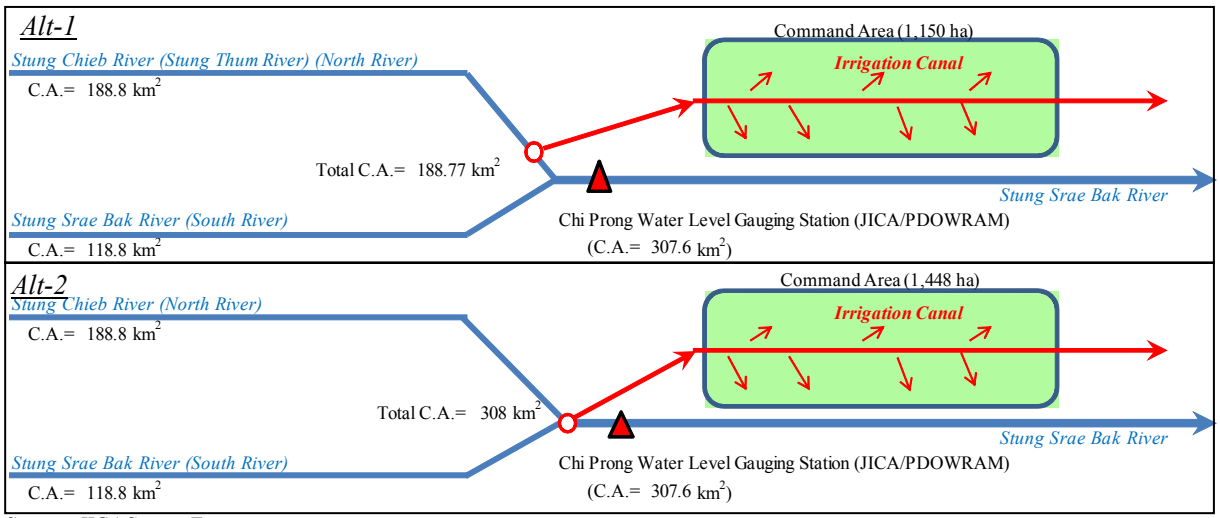
(b) Calculation Method and Conditions

In this Survey, long-term water balance simulation method was applied. The water balance simulation in this Survey is summarized in Table AD-2.4.4.2.2 and the water balance model is schematically described in Figure AD-2.4.4.2.1, respectively.

Table AD-2.4.4.2.2 Condition of Water Balance Simulation for DPISRSP Area

Item	This Survey
Calculation interval	Half-monthly basis
Method for estimating potential evapo-transpiration	Penman-Montieth method
Runoff data	Estimated from the data at Peam Khley station
Reservoir Operation	no reservoir in the area
Simulation model	By the long-term (1992-2011; 20years) simulation
Irrigation fail	Continuous deficit in 15 days

Source: JICA Survey Team

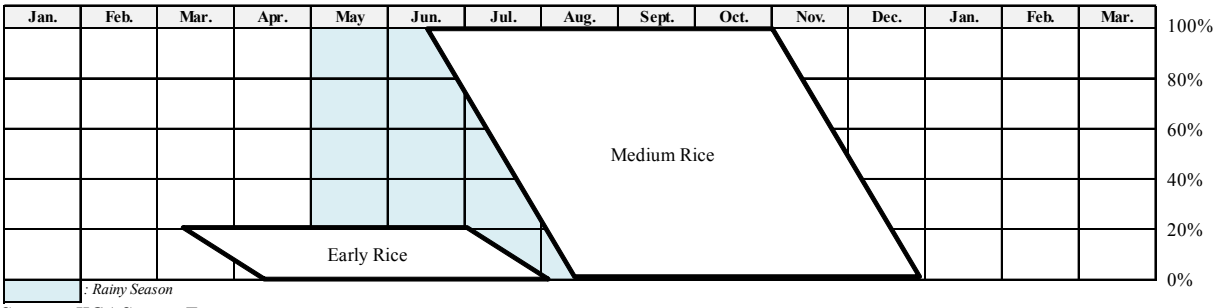


Source: JICA Survey Team

Figure AD-2.4.4.2.1 Schematic Layout of Water Balance Model for DPISRSP

(c) Irrigation Water Requirement

For the purpose of the water balance study, unit irrigation water requirement per hectare is estimated based on the proposed cropping calendar shown in Figure AD-2.4.4.2.2, which consists of single crop season of medium rice in the rainy season in a year. Irrigation water demand was estimated half monthly basis using the rainfall data at Tuek Phos station for the period from 1992 to 2011.



Source: JICA Survey Team

Figure AD-2.4.4.2.2 Cropping Calendar for DPISRSP

The water requirement is calculated by the same conditions in other sub-projects with some variations, which is tabulated in Table AD-2.4.4.2.3 and the results are summarized in Table AD-2.4.4.2.4 and Figure AD-2.4.4.2.3

Table AD-2.4.4.2.3 Conditions for Estimate of Irrigation Water Requirement

Item	Description
Calculation interval	Half monthly basis
Method for estimating potential evapo-transpiration	Penman-Montieth method
Meteorological data	Pochentong Station (Phnom Penh)
Rainfall data	Tuek Phos Station (Kampong Chhnang) 20 years from 1992 to 2011
Effective rainfall	Applying 75% of monthly rainfall as effective monthly rainfall for paddy
Percolation rate	2 mm/day
Irrigation efficiency	Conveyance efficiency: 42% (Main canal 70% × Secondary canal 60%)

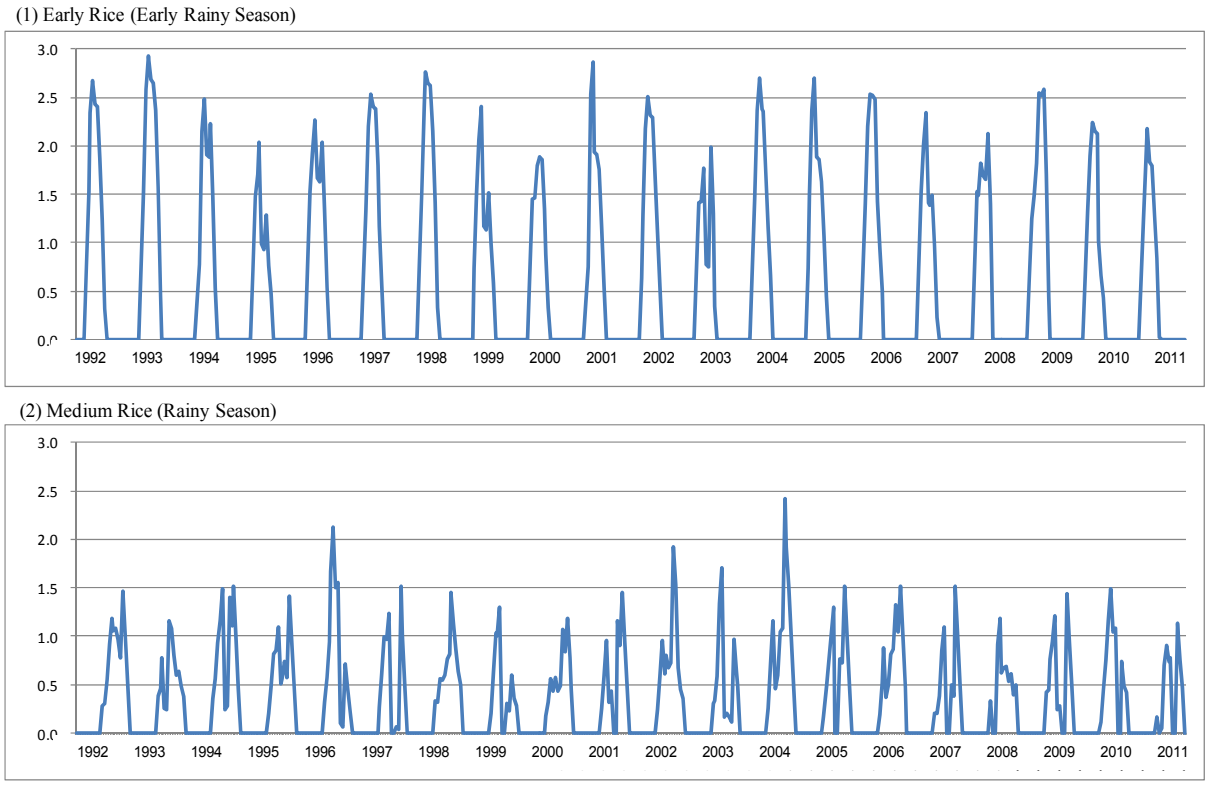
Source: JICA Survey Team

Table AD-2.4.4.2.4 Estimated Unit Irrigation Water Requirement (Average of 20-years; 1992-2011)

(Unit: l/sec/ha)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
(1) Early Rice (Early Rainy Season)												
1-15	0.00	0.00	0.68	2.03	1.96	1.77	0.42	0.00	0.00	0.00	0.00	0.00
16-end	0.00	0.00	1.36	2.37	1.93	1.16	0.00	0.00	0.00	0.00	0.00	0.00
(2) Medium Rice (Rainy Season)												
1-15	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.83	0.55	0.79	1.15	0.44
16-end	0.00	0.00	0.00	0.00	0.00	0.26	0.72	1.05	0.58	0.63	0.76	0.00

Source: JICA Survey Team

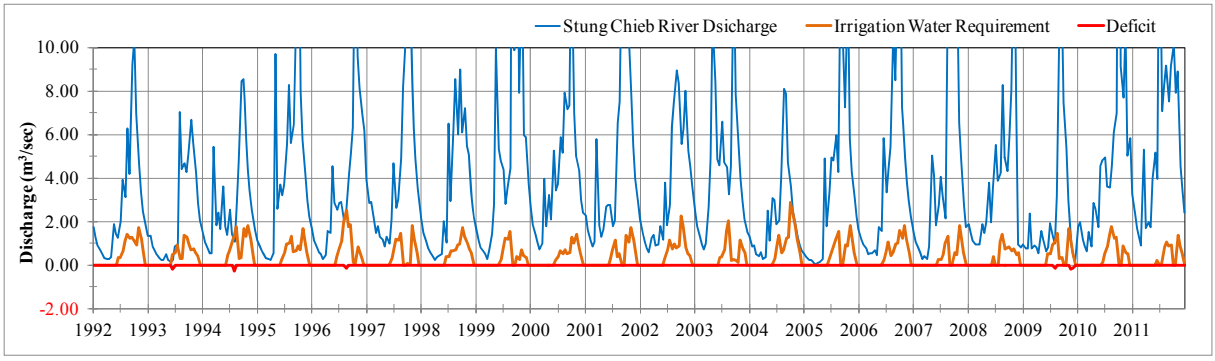


Source: JICA Survey Team

Figure AD-2.4.4.2.3 Estimated Unit Water Requirement from 1992 to 2011

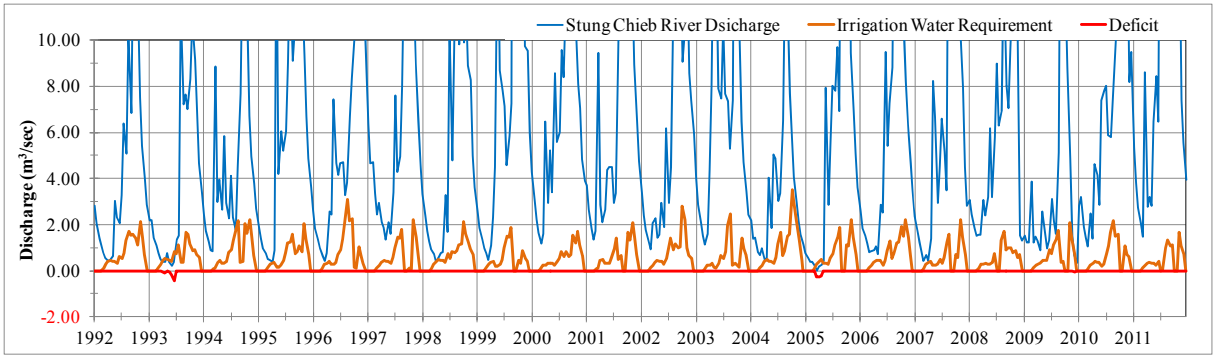
(3) Water Balance Study

Two case of intake sites, which are (i) only the Stung Chieb River before confluence and (ii) the Stung Chieb River + the Stung Srea Bak River after confluence, were simulated for water balance study for DPISRSP Area. Results of water balance simulations of DPISRSP are shown in Table AD-2.4.4.2.5. According to the water balance simulations, total 1,150 ha of command area with crop intensity of 100% will be able to be irrigated with 80% dependability in case-1. Schematic results of 80% dependability are shown in Figures AD-2.4.4.2.4 and AD-2.4.4.2.5.



Source: JICA Survey Team

Figure AD-2.4.4.2.4 Results of Water Balance Study for DPISRSP (Alt-1)



Source: JICA Survey Team

Figure AD-2.4.4.2.5 Results of Water Balance Study for DPISRSP (Alt-2)

Table AD-2.4.4.2.5 Results of Water Balance Study of DPISRSP (80% Dependability)

Study Case	Total Area	Early Rice (Early Rainy)	Mid Rice	Crop Intensity	Dependability	Deficit Year (times/20years)
Alt-1: Only Stung Chieb River	1,150 ha	0 ha	1,150 ha	100%	80%	4
Alt-2: Stung Chieb River + Stung Srae Bak River	1,448 ha	174 ha	1,448 ha	112%	80%	4

Source: JICA Survey Team

(4) Alternative Sites of Proposed Headworks

As mentioned in Sub-clause AD-2.4.4.2 (3), there are 2 alternative intake sites, one is the existing intake site (Alt-1) on the Stung Chieb River and the other is about 1 km downstream from the existing intake (Alt-2), where the Stung Chieb River confluents into the Stung Srae Bak River. Based on the result of water balance study, the proposed intake at existing intake site has sufficient water source for irrigating the proposed target area of 1,150 ha in the rainy season.

In addition, the following conditions are considered to determine the proposed intake site.

(a) Designed flood discharges are estimated for both sites in Clause AB-2.6.2.6 in Annex B, in which the results shows 236 m^3/sec for Alt-1 and 377 m^3/sec for Alt-2 with return period of 50 years. In order to reduce the construction cost, Alt-A site is advantageous to Alt-2.

(b) There exists another irrigation system named Canal Steung Sdach Irrigation System, which is also one of the proposed rehabilitation sub-project for the JICA Survey. This system lies in downstream of DPISRSP, of which intake is located about 16 km downstream of the confluence of two rivers, the Stung Chieb River and the Stung Srae Bak River. In order to ensure the water source for this system, it is proposed that the water source in the Stung Srae Bak River basin be allocated for the system in downstream.

Taking the above conditions into consideration, the intake for DPISRSP is proposed to be constructed at Alt-1.

(5) Proposed Rehabilitation Works

(a) Headworks

In the project proposal prepared by PDOWRAM, construction of the regulator (called as spillway in his proposal) is proposed at the existing intake site, which consists of two sections of (i) flood gate section (1.5 m (H) x 1.5 m (W), 13 spans) and (ii) stoplog section (1.8 m x 0.7 m, 18 spans each in both sides). Based on the investigation taking the above conditions into consideration, the proposed works of the headworks is summarized as below.

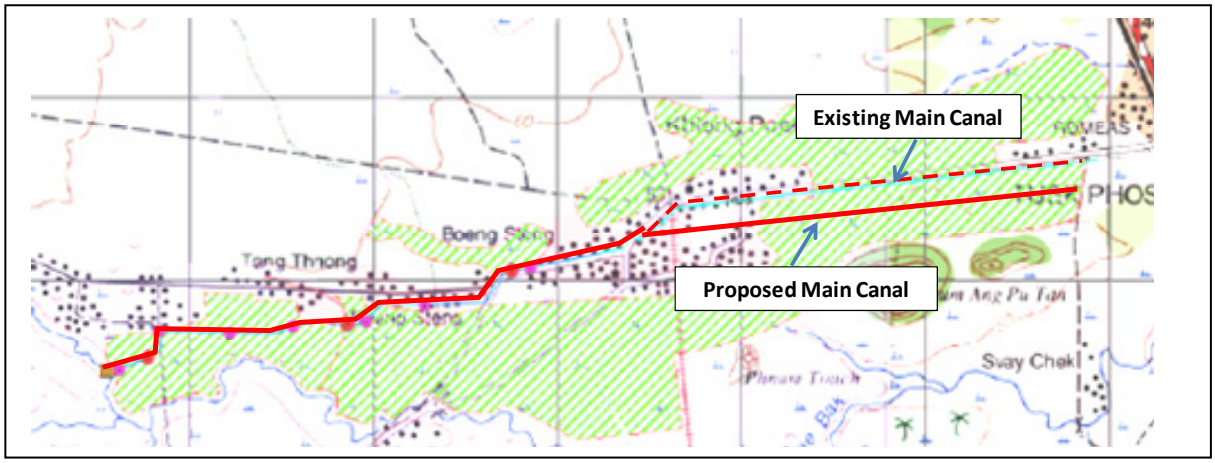
Table AD-2.4.4.2.6 Scope of Headworks

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) Regulator and hydro-mechanical works	- Fixed weir with and flood gate stoplog section Flood gates : 1.5 m (H) x 1.5 m (W), 13 spans Stoplog section 0.7 m (H) x 1.8 m (W), 8 spans each in both sides	- Movable weir Flood gates (Automatic flap gate) 2 m (H) x 10 m (W) x 4 span
2) Intake	Not proposed	- Intake gates (Slide gate) 1.5 m (H) x 1.5 m (W) x 2 span
3) River training and protection	Protection with stone pitching	- Up and downstream, 1 km approx. - Protection with gabion

Source: JICA Survey Team

(b) Rehabilitation of Main and Secondary Canals

As mentioned in previous Sub-clauses, the main canal is not functioning due to the deterioration and original poor hydraulic designs. The present canal route is deemed inadequate especially downstream reach of the area. In the right bank of the main canal from P6+200 (6.2 km from the intake) to the end, secondary canals taking-off from the main canal runs inverse draft from north to south. Based on the sample topographic survey on the secondary canals, the route of main canal is proposed to change as shown in Figure AD-2.4.4.2.6.



Source: JICA Survey Team

Figure AD-2.4.4.2.6 Existing and Proposed Route of Daun Pue Main Canal

The proposed scopes for the main canal are summarized below

Table AD-2.4.4.2.6 Scope of Main Canal and Related Structures

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) Canal length	6.0 km (only upper reach)	11.1 km
2) Canal route	On the existing route	Canal route is proposed to change from 6.2 km point to end.
3) Canal section	Design discharge : not mentioned Canal gradient: 0.0001 ~ 0.0005	Design discharge ; 2.8 m^3/sec - 0.2 m^3/sec Section and profile of canal are designed in accordance with designed diversion water requirement and topographic condition.
4) Related Structures	Check structures, water gates, a culvert and a spillway are proposed.	All existing structures are to be demolished and new structures, i.e. check structures, turnouts, culverts, drops, bridges and a cross drain are proposed

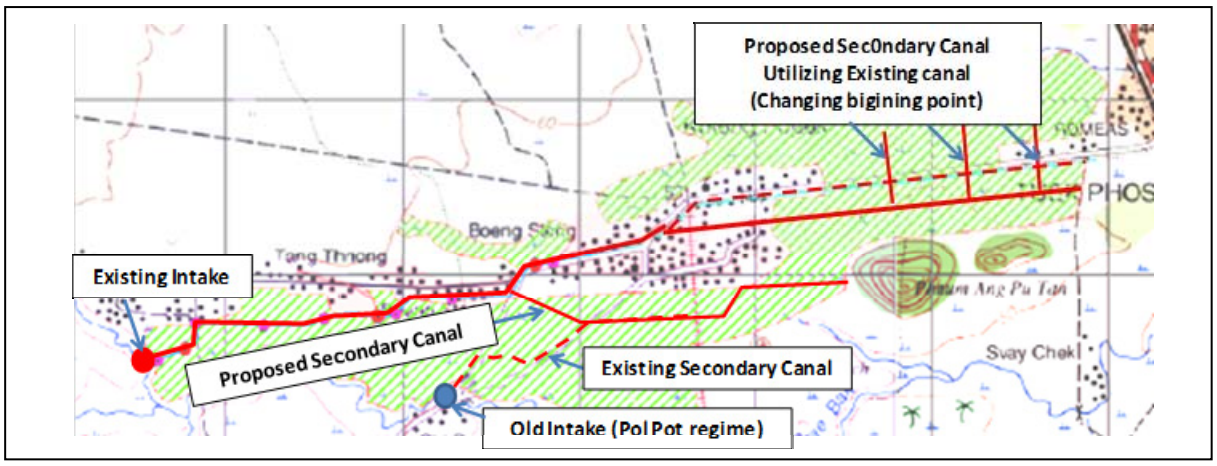
Source: JICA Survey Team

(2) Secondary Canals

Due to the route change of the main canal mentioned above, alignment of the secondary canals is also changed in the downstream part of the area. Their routes however remain unchanged, while taking-off

point from the main canal will be shifted according to the changed route of the main canal as shown in Figure AD-2.4.4.2.7.

In addition, the route of one secondary canal named No.2 will be changed, because it starts from the old intake constructed in Pol Pot regime, which are totally damaged at present, and hence this system is to be included in Daun Pue Irrigation System. In this survey, the canal is proposed to connect the main canal directly and the other secondary canal as shown in Figure AD-2.4.4.2.7.



Source: JICA Survey Team

Figure AD-2.4.4.2.7 Proposed Routes of Secondary Canals

The proposed scopes for the secondary canals are summarized below

Table AD-2.4.4.2.7 Scope of Secondary Canal and Related Structures

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) Canal quantity and length	Not Proposed	Four secondary canals, 4.6 km in total
2) Canal route		Changed as shown in Figure AD-2.4.4.2.7
3) Canal section		Section and profile of canal are designed in accordance with designed diversion water requirement and topographic condition.
4) Related Structures		All existing structures are to be demolished and new structures, i.e. check structures, drain inlets, Turnouts, culverts, drops, bridges and a cross drain are proposed

Source: JICA Survey Team

(c) Drainage System

In the DPISRSP Area, the existing canals seem to have double functions of irrigation and drainage. Some of the existing canals will be rehabilitated as irrigation canals with raising designed water level and subsequent embankment, while the other canals will remain as it is which will be utilized as drains after shaping of canal sections. Natural streams are also functioning as drains. Under such situation, construction of new drainage canal is not proposed, because land acquisition for drains is difficult and no serious drainage problem is observed in the area, except some areas near the river affected by the flood inundation due to the high backwater from the river within only few days. The proposed works for drainage system are shown as below.

Table AD-2.4.4.2.8 Scope of Drainage System

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) Drainage canal	Not proposed.	Improvement and reshaping of existing canal sections

Source: JICA Survey Team

(d) Tertiary Canals

Currently, there is no systematic tertiary canal system in the DPISRSP Area. The irrigable area in this sub-project is proposed to be divided into 30 tertiary blocks. Alignment of tertiary blocks and design of the canal routes would be prepared under the consensus of the related FWUC with assistance of Kampong Speu PDOWRAM. Land for the tertiary canals and watercourses would be offered by beneficial farmers.

Table AD-2.4.4.2.9 Scope of Tertiary Canals

Item	Scope Proposed by MOWRAM	Scope Examined by JICA Survey Team
1) Tertiary Canals	Not proposed	In DPISRSP, the blocks are divided on the basis of aerial photographs. Layout plan of tertiary blocks would be finalized based on the manual and intensions of concerned beneficiaries

Source: JICA Survey Team

(5) Proposed development Plan (Proposed Scope of Sub-project)

(a) Examination of Scope of Daun Pue Irrigation System Rehabilitation Sub-project Proposed by MOWRAM

Based on the basic concept for irrigation rehabilitation plan mentioned above, facilities to be rehabilitated and/or reconstructed under DPISRSP are shown in the following table:

Table AD-2.4.4.2.10 Examined Scope of DPISRSP

Proposed by MOWRAM*	Examined Scope by JICA Survey Team	Remarks
1) Irrigation Development Area		
- 1,150 ha	- 1,150 ha	Justified through water balance study
2) Cropping Pattern and Crop Intensity		
- Rice Cropping System - Crop Intensity: 100%	- Rice Cropping System - Crop Intensity: 100%	
3) Hardware Component		
a) Construction of headworks (i) Protection with stone pitching (ii) Fixed weir with and flood gate Flood gates: 1.5 m (H) x 1.5 m (W), 13 spans Stoplog section: 0.7 m (H) x 1.8 m (W), 8 spans each in both sides (iii)Construction of intake structure Not Proposed	a) Construction of headworks (i) River training of up and down stream of proposed headworks (ii) Construction of headworks with provision of flood gates (2 m x 10 m x 4 sets) (iii)Construction of intake structure	
b) Rehabilitation of Daun Pue Main Canal (i) Improvement of canal (6.0 km, only upper reach) on the existing route - New construction of canal related structures; - Check structure 7 nos. - Culvert 3 nos. - Spillway 1 no.	b) Rehabilitation of Daun Pue Main Canal (i) Improvement of canal (6.2 km from BP to P6+200, raising of embankment and/or enlargement of canal section), (ii) Changing route of main canal (4.9 km from P6+200 to EP, Upgrading of secondary to main canal) (iii)Construction of canal inspection road (iv)Replacement or new construction of canal related structures; - Check structure 14 nos. - Turnout 34 nos. - Culverts 13 nos.	- Section and profile of canal are designed in accordance with designed diversion water requirement and topographic condition. - All existing structures are to be demolished and new structures.
c) Rehabilitation of secondary canals Not Proposed	c) Rehabilitation of secondary canals (i) Improvement of canal (3.4 km in total) (ii) Construction of new secondary canal from main canal to existing secondary canal (1.2 km) (iii)Construction of canal inspection road (iv)Replacement or new construction of canal related structures; - Check structure 9 nos. - Turnout 15 nos. - Culverts 8 nos.	- Section and profile of canal are designed in accordance with designed diversion water requirement and topographic condition. - All existing structures are to be demolished and new structures.

Proposed by MOWRAM*	Examined Scope by JICA Survey Team	Remarks
d) Rehabilitation of drains Not Proposed	d) Rehabilitation of drains (i) Improvement and reshaping of drains	Improvement and reshaping of existing canal sections
e) Development of tertiary system Not Proposed	e) Development of tertiary system (i) Development of tertiary canal system: 35 km (1,150 ha)	
f) Construction of Project Office Not Proposed	f) Construction of Project Office - Office building (300 m^2) - Parking shed, gate and fencing - Well drilling and electric works	

Source: JICA Survey Team

(2) Priority Ranking

There are many works in hardware and software components in the examined scope of DPISRSP. It is not sure presently that all of these works could be simultaneously implemented in the available loan amount. Thus, as mention in Sub-clause AD-2.4.4.2 (1), these examined works are given priority ranking based on the following criteria

- The works indispensable for attaining at the purpose of DPISRSP are given high priority
- Urgently required works for adequate operation of irrigation system are given high priority
- The rehabilitation works for facilities needed to recover their functions are given high priority

The priority ranking of each work based on the criteria is summarized in the following table.

Table AD-2.4.4.2.11 Priority Ranking of Each Work

Scope Examined by JICA Survey Team		Priority*
(a) Hardware Component		
- Construction of headworks	1) River training of up and down stream of proposed headworks 2) Construction of headworks with provision of flood gates (2 m x 10 m x 4 sets) 3) Construction of intake structure	◎
- Rehabilitation of Daun Pue Main Canal	1) Improvement of canal (6.2 km from BP to P6+200, raising of embankment and/or enlargement of canal section), 2) Construction of canal inspection road 3) Replacement or new construction of canal related structures	◎
- Rehabilitation of secondary canals	1) Improvement of canal (3.4 km in total) 2) Construction of new secondary canal from main canal to existing secondary canal (1.2 km) 3) Construction of canal inspection road 4) Replacement or new construction of canal related structures;	◎
- Tertiary canal system development	- Construction of tertiary canals (35 km)	○
- Construction of project office	1) Office building (300 m^2) 2) Parking shed, gate and fencing 3) Well drilling and electric works	○

Source: JICA Survey Team

AD-2.4.4.3 Design of Irrigation and Drainage Facilities

(1) General

At present, irrigation water is diverted from the river by temporary weir without permanent facilities, which causes difficulty and low efficiency of sufficient water diversion. Therefore, new construction of headworks is indispensable for DPISRSP. In addition, most of the existing irrigation facilities were constructed in the Pol Pot regime, and they now require significant rehabilitation and/or reconstruction to ensure stable irrigation farming. The basic concept of rehabilitation of these facilities is to make both initial construction cost and O&M cost as low as possible in due consideration of maintaining sufficient function, safety and durability. To meet these, the purpose of the plan would not be to seek for the "perfect" outcome, but to provide the minimum function required for ensuring water resources for irrigation.

Considering the above, the required rehabilitation works will be planned in the following concepts:

- New construction of the headworks instead of the existing temporary weir including gated intake structure is indispensable for the Sub-project.
- Irrigation facilities is planned with conditions that (i) reliability level of irrigation supply is set at 4 in 5 years or 80%, (ii) gravity irrigation systems are proposed as much as possible by raising the water level in the canals, except physically difficult (high) land, and (iii) 24-hour water conveyance will be applied for diversion, main and secondary system.
- Most of existing canal routes would be utilized and canal lining would not be considered. In case that the existing canal route is not topographically suitable for rehabilitation, the canal route would be modified based on the topographic situations.
- No construction of new drainage canal would be proposed, because land acquisition for drains is difficult and no serious drainage problem is observed.
- Canal and related structures are designed preliminarily at pre-F/S level in this Survey, because no topographic map with large scale and detailed counter line are available. The facilities should be designed in detail at next stage after preparation of topographic map.

(2) Irrigation Water Requirement

Irrigation water requirement is calculated based on the water balance study as discussed in Sub-clause AD-2.4.4.2 (3). As a result, unit water requirement of main canal and secondary canals is set at 2.4 l/sec/ha, applying overall irrigation efficiency of 42% consisting of conveyance efficiency of 70% and application efficiency of 60%. Based on the unit water requirement, the peak diversion water requirement from the Stung Chieb River is estimated at 2.8 m^3/sec.

(3) Design Flood Discharge for Headworks

Design flood discharge is estimated at 129 m^3/sec and 236 m^3/sec for the return period of 10 and 50 years, respectively.

(4) Rehabilitation of Irrigation and Drainage Facilities

Based on the basic concept for the rehabilitation plan mentioned above, facilities to be rehabilitated and/or reconstructed under DPISRSP are shown in the following table.

Table AD-2.4.4.3.1 Principal Features of DPISRSP

Descriptions	Quantities
(a) Project Area	(a) Sub-project Area 1,150 ha
(b) Hardware Components	
- Construction of headworks	(a) River training of up and down stream of proposed headworks (b) Construction of headworks with provision of flood gates (2 m x 10 m x 4 sets) (c) Construction of intake structure
- Rehabilitation of Daun Pue Main Canal	(a) Improvement of canal (6.2 km from BP to P6+200, raising of embankment and/or enlargement of canal section), (c) Changing route of main canal (4.9 km from P6+200 to EP, Upgrading of secondary to main canal) (d) Construction of canal inspection road (e) Replacement or new construction of canal related structures; - Check structure 14 nos. - Turnout 34 nos. - Culverts 13 nos.

Descriptions	Quantities
- Rehabilitation of secondary canals	(a) Improvement of canal (3.4 km in total) (b) Construction of new secondary canal from main canal to existing secondary canal (1.2 km) (c) Construction of canal inspection road (d) Replacement or new construction of canal related structures; - Check structure 9 nos. - Turnout 15 nos. - Culverts 8 nos.
- Rehabilitation of drains	(a) Improvement and reshaping of drains
- Construction of project office	(a) Office building (300 m^2) (b) Parking shed, gate and fencing (c) Well drilling and electric works, etc.
- Development of tertiary system	(a) Rehabilitation and improvement tertiary irrigation canals, and drains

Source: JICA Survey Team

AD-2.4.4.4 Construction Schedule

(1) Construction of Headworks and Rehabilitation of Main and Secondary Canal System

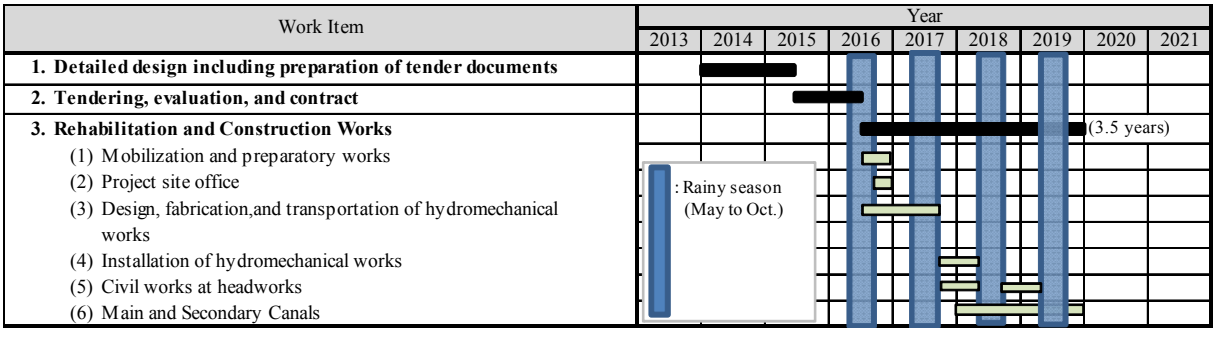
DPISRSP needs construction of headworks and rehabilitation of main and secondary canals to abstract and deliver irrigation water for command area of 1,150 ha. The headworks to be newly constructed are of barrage type to cope with flood. The partially rehabilitated main and secondary canals are 11.7 km and 5.2 km, respectively.

Total construction period of construction and rehabilitation works will require 3.5 years after procurement procedure of the contractor. It is expected that D/D including mapping and preparation of tender documents would be completed within 1.5 years.

Critical path of the rehabilitation works of DPISRSP will be the hydro-mechanical works, requiring 21 months in total, which is broken down as shown below.

- Site survey and design by gate manufacture : 4 months
- Approval of the Project Engineer (foreign consultant) : 2 months (1 month overwrap with above)
- Material procurement : 8 months (2 month overwrap with above)
- Fabrication : 6 months (3 month overwrap with above)
- Transportation to site : 2 months (1 month overwrap with above)
- Installation of new gates : 6 months

Main and secondary canals and related structures will be completed in 2 years from 2018 to 2019. Contractor for rehabilitation and construction will be selected through ICB. Period required for rehabilitation and construction works from the beginning of D/D including orthographic mapping to the end of all construction/rehabilitation works would be 6 years as shown below.



Source: JICA Survey Team

Figure AD-2.4.4.4.1 Implementation Time Schedule for Headworks and Main Canal System of DPISRSP

For realizing the above activities, MOWRAM and PDOWRAM are requested to conduct the following administration works.

Work Item	Year								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Administration Work for Headworks and Main Canal System									
(1) Budget arrangement (loan and RGC fund)									
(2) Establishment of "Project Implementation Unit"									
(3) Procurement of consultant through ICB									
(4) Execution of detailed design by selected consultants									
(5) Procurement of civil contractor through ICB									
(6) Acquring of lands and compensation									
(7) Supervision of construction and rehabilitation works									
(8) Transfer the site office to O&M office									

Source: JICA Survey Team

Figure AD-2.4.4.4.2 Administrative Activities for Headworks and Main Canal System

(2) Construction of Tertiary Canal System

Tertiary canal system of DPISRSP covers 1,150 ha, of which the length is 35 km in total. It will be newly constructed following the rehabilitation work for main and secondary canal system. D/D for tertiary canal system would be prepared by the national consultant in close communication with PDOWRAM and FWUC, and based on the design for the main and secondary canal system. The tertiary block and alignment of tertiary canals should be delineated with consent of FWUC and land owners. It would take rather longer period, since private lands should be voluntarily provided for tertiary canals by land owners. Therefore, period of D/D is estimated at 6 months including confirmation of alignment of tertiary canals. Assuming the progress rate of work at about 1,000 ha per year, construction period is set at 9 months (1 dry season) as shown below. It is expected the tertiary canal system will be handed over to FWUC after 1-year maintenance period of construction.

Work Item	Year								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Construction of Tertiary Canal System									
(1) Detailed design									
(2) Tendering, evaluation, and contract									
(3) Construction work for tertiary canal system									

Source: JICA Survey Team

Figure AD-2.4.4.4.3 Implementation Time Schedule for Tertiary Canal System of DPISRSP

For realizing the above activities, MOWRAM and PDOWRAM are requested to conduct the following administration works.

Work Item	Year								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
2. **Administration for Tertiary Canal System**									
(1) Budget arrangement									
(2) Procurement of consultant through LCB									
(3) Execution of detailed design with selected consultants									
(4) Acquring lands thru obtaining the consents of land owners									
(5) Procurement of civil contractor through LCB									
(6) Supervision of rehabilitation works									
(7) Handing over of tertiary canal system to FWUC									

Revision of design will be done by Project staff

Source: JICA Survey Team

Figure AD-2.4.4.4.4 Administrative Activities for Construction of Tertiary Canal System

The budget arrangement and procurement of the national consultant area assumed to be completed for 10 months and 3 months respectively. Land acquisition for tertiary canal would require about 1.5 years.

After completion of tertiary canal system, it would be handed over to FWUC after 1-year maintenance period.

AD-2.4.5 Updating Long List and Preparation of Short List of Small Scale irrigation Rehabilitation Project

AD-2.4.5.1 Updating Long List

Project proposal documents for the rehabilitation of 84 small-scale irrigation Sub-projects were submitted to MOWRAM in October 2009 prior to the Survey. These proposals were prepared by PDOWRAM by filling up standard proposal forms that were given by MOWRAM under assistance of TSC-2. Out of 84 Sub-projects, 3 Sub-projects consisting of (i) Main Canal 35 Irrigation Sub-project, (ii) Srass Prambai Water Recession Irrigation Sub-project and (iii) Daun Pue Irrigation Sub-project are selected for pre-F/S and studied in the Survey after screening and priority ranking.

The original long list was prepared in 2009 and almost 3 years have already passed. Situations have been changed since then, and hence it needs updating for the future possible implementation by RGC or other donors. The original list prepared by MOWRAM and location map of 84 proposed Sub-projects is shown in Figure AD-2.4.1.1.1 in Section AD-2.4.1. This Section describes the updated long list and the proposed short list based on the proposed screening and ranking criteria by the JICA Survey Team.

(2) Updated Long List

As mentioned above, the original long list was prepared in 2009, after when some projects have already been completed, commenced or committed to start by the other financial source like RGC or international organizations. According to MOWRAM, the following 17 irrigation Sub-projects are to be excluded from the long list, the Sub-project Area of which is totaled 15,700 ha as of March, 2012.

Table AD-2.4.5.1.1 Sub-projects Excluded from the Long List

Province	Name of Sub-projects	Area (ha)	Remarks
Kompong Chnnang	Daun Pue	1,151*[1]	Under the JICA Survey
Kompong Speu	Main Canal 35	3,018*[1]	Under the JICA Survey
Takeo	Chroy Samrong	300	Study completed to be funded by RGC
Takeo	Thra Peng Veng	200	Study completed to be funded by World Bank
Takeo	Sen Presh Ream	567	Study completed to be funded by RGC
Pursat	Kompeang Reservoir	380	Will be signed with MOWRAM to be funded by Grass Root,
Pursat	Wat Leap	600	Under study with assistance of World bank
Kandal	Ta Tray	172	Under rehabilitation (50%) by RGC
Kandal	Chak Kaek	226	Study completed to be funded by RGC
Kandal	Srass Prambai	2,500*[1]	Under the JICA Survey
Kep	Dem Pring	160	Started to Rehabilitation commenced by RGC
Kompot	Ou Chranieng Reservoir	310	Rehabilitation completed by World Bank
Pailin	Thnal Bot	4,000	Rehabilitation completed by World Bank
Prey Veng	Char	888	Study completed to be funded by RGC
Svay Rieng	Krang Leav	642	Rehabilitation completed by RGC
Koh Kong	Saray Polder	342	Rehabilitation completed by RGC
Koh Kong	Tanni Polder	241	Rehabilitation completed by RGC
Total	17 sub-projects	**15,697**	

Remarks 1; Project area is referred to the original list prepared by MOWRAM
Source: Prepared by JICA Team based on the data of MOWRAM

After dropping out of the above Sub-projects, 67 Sub-projects in total remain in the updated long list in Table AD-2.4.5.1.2, which are nominated from 21 provinces, the whole country except Phnom Penh,

Pailin and Kaoh Kong. Table AD-2.4.5.1.3 summarizes comparison between the original and updated Sub-projects by provinces. The updated long list and location map of 67 proposed Sub-projects are shown in Figure AD-2.4.5.1.1.

Table AD-2.4.5.1.3 Summary of Original and Updated Long by Province

Code	Province	Original Long List (2009)		Updated Long List (2012)		Remarks
		Nos	Total Area (ha)	Nos	Total Area (ha)	
01	Banteay Mean Chey	3	5,166	3	5,166	
02	Mondul Kiri	2	1,440	2	1,440	
03	Kampong Chhnang	3	2,647	2	1,496	1 sub-project have been dropped out
04	Kampong Speu	3	7,668	2	4,650	1 sub-project have been dropped out
05	Battambang	2	5,460	2	5,460	
06	Takeo	5	5,715	2	4,628	3 sub-projects have been dropped out
07	Sihanuk Ville	2	646	2	646	
08	Pursat	7	5,275	5	4,295	2 sub-projects have been dropped out
09	Kandal	5	6,965	2	4,067	3 sub-projects have been dropped out
10	Stung Treng	3	4,121	3	4,121	
11	Kep	4	1,231	3	1,071	1 sub-project have been dropped out
12	Kampot	7	5,268	6	4,958	1 sub-project have been dropped out
13	Siem Reap	3	2,996	3	2,996	
14	Pailin	1	4,000	0	0	1 sub-project have been dropped out
15	Ratanakkrir	1	90	1	90	
16	Kampong Cham	5	2,856	5	2,856	
17	Prey Veng	6	9,373	5	7,497	1 sub-project have been dropped out
18	Svay Rieng	11	7,251	10	6,609	1 sub-project have been dropped out
19	Kampong Thom	2	1,250	2	1,250	
20	Kratie	3	1,311	3	1,311	
21	Koh Kong	2	583	0	0	2 sub-projects have been dropped out
22	Preah Vihear	2	760	2	690	
23	Odar Mean Chey	2	2993	2	2,993	
	Total	**84**	**85,065**	**67**	**68,290**	

Source: MOWRAM

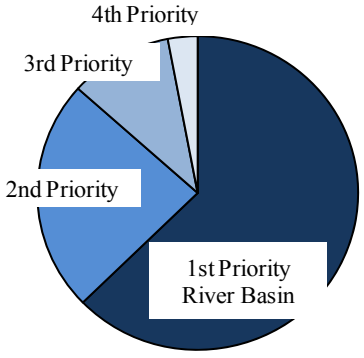
(3) Outline of Sub-projects in Updated Long List

(1) Distribution of Sub-projects in Updated Long List

Based on the remaining 67 proposals submitted by each PDOWRAM, the Small-scale Irrigation System Rehabilitation Projects are scattered in whole country, the JICA Survey Team examined the summary of the outline of the projects.

(a) Distribution of Candidates by River Basin Priority

Previous study[6] has prioritized all 42 river basins in the country using criteria of natural and human resource and social conditions and so on, determining from the 1st to 4th priority river basins in turn. As shown in Figure AD-2.4.5.1.2, 42 Sub-projects (63% of total 67 sub-projects) are located in the 1st priority river basins, 16 Sub-projects (24%) are in the 2nd priority river basins, and 9 Sub-projects (13%) are located in 3rd and 4th river basins.



Source: JICA Survey Team

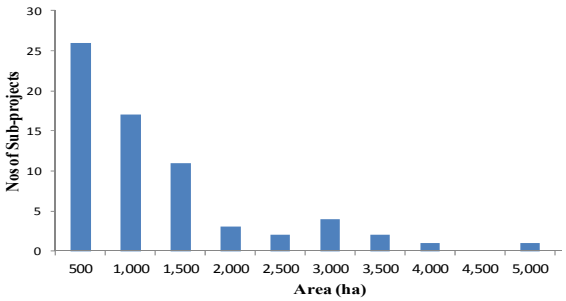
Figure AD-2.4.5.1.2 Distribution of Candidates by River Basin Priority

[6] *Review on Nationwide Irrigation Development, March 2010*

(b) Distribution by Irrigation Area

The irrigation area of 67 proposed projects are varied as shown in Figure AD-2.4.5.1.3..

Irrigation systems of which irrigation areas are less than 500 ha occupy about 40% in number, and those having the area of less than 1,000 ha accounts about two-third. Irrigation systems of more than 2,000 ha are totaled about 15%.



Source : JICA Survey Team

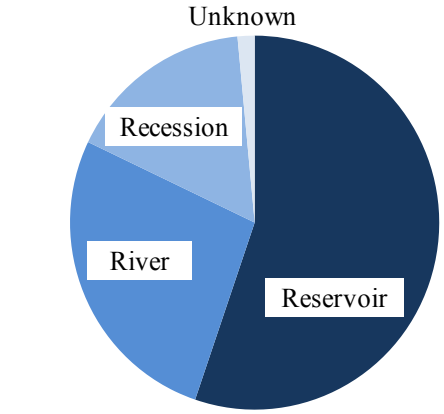
Figure AD-2.4.5.1.3 Distribution of Candidates by Irrigation Area

(c) Distribution by Irrigation Type

All candidate projects are categorized as gravity type and neither lift irrigation nor groundwater irrigation project was proposed. The water sources for the proposed projects are further categorized into three types, which area (i) reservoir, (ii) river run-off without reservoir, and (iii) flood recession water. Distribution of irrigation type is therefore classified by these types of water resources.

Distribution by water resources are summarized below and in Figure AD-2.4.5.1.4.

- Reservoir irrigation system (55%)
- River irrigation without reservoir (27%)
- Recession cultivation (16%)



Source : JICA Survey Team

Figure AD-2.4.5.1.4 Distribution of Candidates by Irrigation Type

AD-2.4.5.2 Preparation of Short List

(1) General

As mentioned in Section AD-2.4.5.1, small-scale irrigation system rehabilitation project covering the whole country is proposed to be implemented in near future by RGC or other possible donors, based on the experiences to be obtained through the Survey and the expected JICA loan project. Therefore, short list is prepared in the Survey for necessary action and arrangement by MOWRAM.

The purposes of preparation of the short list are: (i) to confirm the potential projects for future implementation and (ii) to indicate the sample flowchart and criteria.

(2) Criteria for Preparation of Short List

(a) Updated long list

In Clause AD-2.4.5.1, the original long list prepared by MOWRAM in 2009 is updated based on the information of the completed, on-going and committed sub-projects during the period from 2009 through March, 2012.

(b) Priority Ranking

The priority ranking is carried out based on the following 7 ranking criteria. These criteria is almost similar to the selection criteria for the pre-F/S sites in this Survey, however, that are modified based on the experience obtained through the Survey.

As experienced in the Survey, one of the most important technical information is the available water resource, which is however not clearly explained in PDOWRAM's proposal documents. Available

water resource is estimated based on the catchment area on the available topographic map and evaluated by the ratio of the proposed irrigation area and the catchment area, of which the point score is given double to the other items.

Other point score in ranking is set up in the items, such as the river basin priority, project scale, effects of project, social conditions, and so on, which are 10 points each and 80 points in total including the above points on water source. Priority projects to be nominated in the short list are ranked according to the total score. Based on the score, the short list includes the Sub-projects which have more than 50 points as a 1st priority group.

Table AD-2.4.5.2.1 Point Score for Priority Ranking

Item	Conditions	Point
(1) River basin priority	First priority river basin	10 points
	Second priority river basin	5 points
	Other river basin	0 points
(2) Suitable scale of irrigation area	More than 500 ha and less than 1,500 ha	10 points
	Less than 500 ha	5 points
	More than 1,500 ha	0 points
(3) Effect of project (Incremental irrigation area)	More than 100% increased	10 points
	More than 50% and less than 100% increased	5 points
	Less than 50% increased	0 points
(4) Available water resource	Catchment area / Irrigation area > 20	20 points
	20 > Catchment area / Irrigation area > 10	10 points
	Catchment area / Irrigation area < 10	0 points
(5) Social conditions (Farmers' consensus)	100% Concurred	10 points
	More than 80% concurred	5 points
	Less than 80% concurred	0 points
(6) Social conditions (Risk of land mine)	No risk	10 points
	Risk or not known	0 points
(7) Social conditions (Land acquisition)	All government land	10 points
	All government land with illegal occupation	5 points
	Land acquisition required	0 points

Source : JICA Survey Team

AD-2.4.5.3 Sub-projects Selected in Short List

Based on the above point scoring, total score of each sub-project are shown in Table AD-2.4.5.3.1, and the sub-projects selected in the short list are 20 nos. in number and 19,000 ha in total area out of the long listed 67 sub-projects as summarized in Table AD-2.4.5.3.2.

Table AD-2.4.5.3.2 Summary of Short Listed Sub-project

Code	Province	Name of Project	Type of Irrigation (Water source)	Irrigation Area (ha)
1-1	Banteay Mean Chey	Mongkolborey Main Canal	River without Reservoir	1,116
1-3	Banteay Mean Chey	An longrot Reservoir	Reservoir	1,350
3-1	Kampong Chhnang	Khla Krap	Recession cultivation	450
3-3	Kampong Chhnang	Canal Stung Sdatch	River without Reservoir	1,046
6-4	Takeo	Portasu	Reservoir	1,756
8-4	Pursat	Kab Kralanh	River without Reservoir	550
8-6	Pursat	Tram Canal	Reservoir	350
8-7	Pursat	Ken Seng	River without Reservoir	235
9-2	Kandal	Torn Or	Recession cultivation	247
9-5	Kandal	Mlech Krabai Kon	Recession cultivation	3,820
11-1	Kep	Rones	Reservoir	621
11-3	Kep	Prek Tanen	Reservoir	75
11-4	Kep	Veal Vong	Reservoir	375

Code	Province	Name of Project	Type of Irrigation (Water source)	Irrigation Area (ha)
13-1	Siem Reap	Neary Canal	River without Reservoir	611
13-2	Siem Reap	Louk Canal	River without Reservoir	1,085
13-3	Siem Reap	Trabek Canal	River without Reservoir	1,300
16-4	Kampong Cham	Bay Dei Reservoir	Reservoir	894
17-5	Prey Veng	Anlong Cha Canal	Recession cultivation	2,226
18-10	Svay Rieng	So Pha	Recession cultivation	650
18-11	Svay Rieng	Svay Year	Recession cultivation	350
	Total	20 sub-projects	Reservoir : 7 River without Reservoir : 7 Recession cultivation : 6	19,107

Source: JICA Survey Team

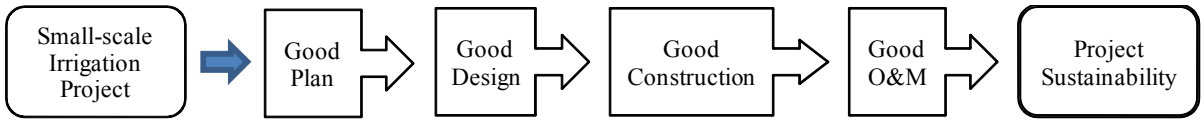
AD-2.4.5.4 Execution of Preliminary Feasibility Study

(1) General

As for proceeding to next step for implementation of the sub-projects in the short list and updating the short list as well, it is expected that PDOWRAM will carry out the preliminary feasibility under direction of MOWRAM for implementation in future. As far as the project proposals on them prepared by PDOWRAM are concerned, however unfortunately, these would not attain at the satisfactory level from the technical and economical viewpoints. Thus, it is essential to take necessary arrangement for enabling PDOWRAM to carry out the preliminary feasibility study in a proper way.

(2) Need of Preliminary Feasibility Study

The purpose of the preliminary feasibility study is to prove that the project is technically viable and economically sound. The project is always requited to be sustainable. To realize this requirement, the project needs to follow the flow of "good plan", "good design", "good construction" and "good O&M". The project sustainability of the project could not be attained even if one of them is lacked.



Source: JICA Survey Team

Figure AD-2.4.5.4.1 Flow of Appropriate Procedure to Project Formulation

In this flow, the feasibility study plays a role of seeking for the "good plan" of the project. The meaning of "good plan" is nothing other than satisfying both technical and economical requirements.

(3) Manual on Execution of Preliminary Feasibility Study

For the purpose mentioned above, the manual is prepared in this Survey to strengthening the PDOWRAM capability for execution and examination of preliminary feasibility study. The objective of the manual is to provide the PDOWRAM staff with the procedure of execution of preliminary feasibility study for small-scale irrigation projects, which is worked out mainly by reflecting the experiences obtained through the preliminary feasibility study for the selected 3 Sub-projects. On the other hand, even the preliminary feasibility study covers many fields such as hydrology, agronomy, irrigation, drainage, economy and environment. In order to cope with such complicated situations, the manual should be therefore elaborated in a more simple and practical manner, so that the PDOWRAM staff can bear mind to easily use it.

In general, the preliminary feasibility study should be carried out by the limited staff within the limited time. In order to effectively and smoothly execute the preliminary feasibility study, it is imperative to

know the whole works in advance, and then to take the necessary steps on time to complete it as scheduled.

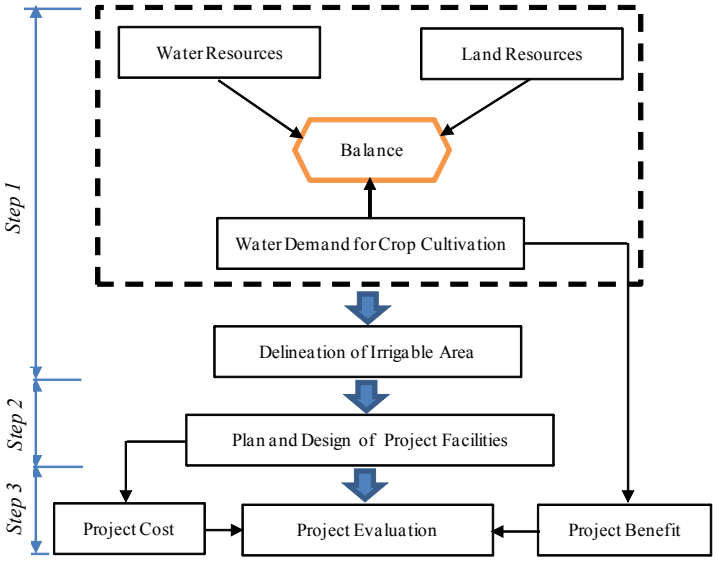
The preliminary feasibility study is largely divided into the following three steps (See Figure AD-2.4.5.4.2)

Step 1: Delineation of Irrigable Area

Balance of water resource, land resource and water demand for crop cultivation

Step 2: Plan and Design of Project Facilities

Execution of good plan and good design for project facilities to effectively distribute irrigation water to field

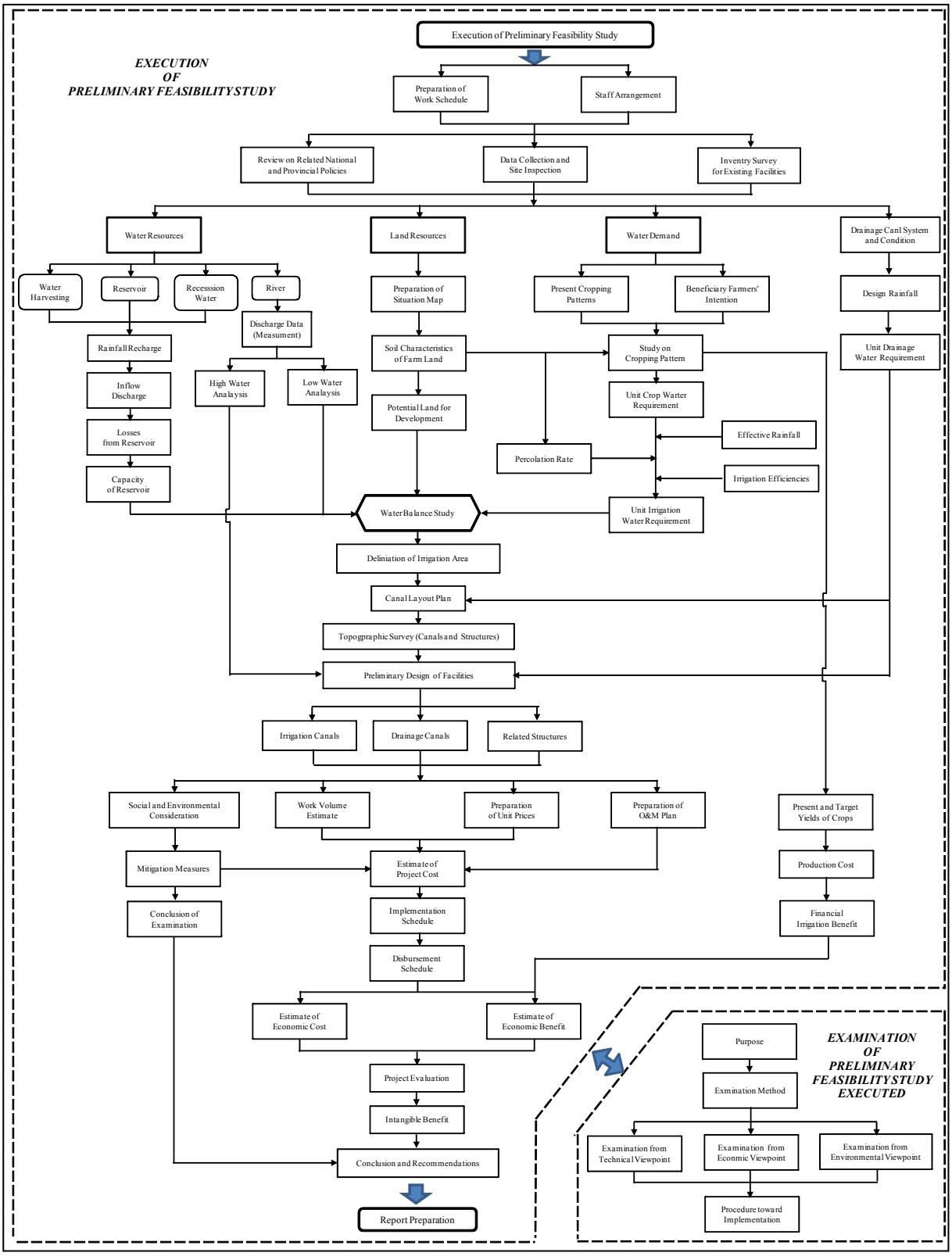


Source: JICA Survey Team

Figure AD-2.4.5.4.2 Outline of Work Procedure

Step3: Project Evaluation

Execution of appropriate project evaluation using project cost, project benefit by crop production and project implementation plan. Detailed work flow for preliminary feasibility study is shown in Figure AD-2.4.5.4.3..



Source: JICA Survey Team

Figure AD-2.4.5.4.3 Detailed Work Flow for Preliminary Feasibility Study

ANNEX D

Tables

Table AD-2.1.1.4.1 List of Existing Irrigation and Drainage Facilities in the Upstream of NMC and SMC

(1) Secondary Canal

Dist. from Intake[*1]	Name of SC	Command Area (ha)	Length (km)	Bottom Width (m)	Canal Depth (m)	Major Structures (nos.)							Remarks
						Check	Turnout	Outlet	Drain Inlet	Box Culvert	Pipie Culvert	Bridge	
(1) North Approach Channel													
0.60 (L)	Phum Thmey Andong Sla SC	210	4.1	5.1 - 3.0	3.1 - 1.0	1	1	1		1	2		
0.68 (R)	Andong Thor SC	120	1.7	5.2 - 0.2	1.5 - 0.6						1		
(2) South Approach Channel													
0.95 (L)	Tompoung-1 SC	10	0.2	1.9 - 1.4	1.2 - 0.7								Farmers take water by their handmade tertiary canal
1.35 (L)	Tompoung-2 SC	10	0.2	1.2 - 0.8	0.8 - 0.6								
0.56 (R)	Vor Breng SC	40	0.8	5.7 - 2.3	1.6 - 0.5						1		
2.60 (L)	Kraheng SC	125	4.0	4.9 - 0.3	1.7 - 0.6						9		
(3) North Main Canal													
1.95 (L)	Phum Thmey SC-1	300	3.1	4.9 - 0.8	2.0 - 0.8								Farmers take water by their handmade tertiary canal
2.40 (R)	Phum Thmey SC-2	30	0.9	2.5 - 0.6	0.9 - 0.4								
2.43 (L)	Phum Thmey SC-3	300	3.0	4.3 - 1.2	1.2 - 0.4								
3.35 (R)	Kravein SC-1	20	1.8	5.0 - 1.6	2.1 - 1.2		1				2		
3.35 (R)	Kravein SC-2	40	0.8	7.7 - 1.2	1.8 - 0.8						1		
3.45 (L)	Sampove-1 SC	100	2.6	3.5 - 0.4	1.1 - 0.2						1		
4.30 (R)	Sub Kravein-1 SC	140	2.0	2.1 0.2	1.7 0.4	3	2				1		
5.10 (R)	Prey Beng SC-1	60	2.7	6.2 - 1.5	1.5 - 0.3						10	1	
5.05 (R)	Ktom Kraing SC	10	1.0	3.6 0.2	0.9 - 0.3	2							
5.20 (L)	Sampove SC-2	100	1.2	13.8 - 0.8	1.6 - 0.3			1				1	
5.60 (R)	Prey Beng SC-2	70	2.3	3.5 - 1.3	3.7 - 0.9						15	2	
8.00 (R)	Chbar Morn SC-1	30	0.8	2.8 - 0.5	0.7 - 0.3								Farmers take water by their handmade tertiary canal
8.50 (R)	Chbar Morn SC-2	40	0.8	5.1 - 3.0	3.1 - 0.8								
8.90 (R)	Thmat Pong SC-1	265	6.2	8.0 - 0.8	2.4 - 0.7						16	2	
(4) South Main Canal													
0.52 (L)	Tompoung-3 SC	10	0.3	1.3 - 0.8	0.5 - 0.5								Farmers take water by their handmade tertiary canal
0.75 (L)	Tompoung-4 SC	10	0.4	1.6 - 0.3	0.7 - 0.6								
0.98 (L)	Tompoung-5 SC	40	0.5	1.6 - 0.1	0.8 - 0.4								
1.50 (L)	TSC Model SC	260	2.4	5.4 - 1.6	1.8 - 0.8								
4.75 (R)	Koh Té SC-1	110	1.8	3.1 - 1.5	1.2 - 0.8			1			1		
4.75 (L)	Koh Té SC-2	10	0.4	6.4 - 0.9	1.6 - 0.8								Farmers take water by their handmade tertiary canal
5.00 (R)	Koh T'e SC-3	10	0.3	1.5 - 0.2	0.9 - 0.5								
5.85 (L)	Thnol Bom Bek SC	100	2.2	2.7 - 1.1	1.5 - 0.7						2		
6.95 (L)	Phum Roung SC	100	3.0	0.8 - 0.1	0.6 - 0.5								Farmers take water by their handmade tertiary canal
7.80 (L)	Road 110 SC	30	2.2	7.7 - 0.8	1.3 - 0.5					*			*Many culverts: because this canal is located between the main road and houses
8.40 (L)	Phum Skous SC-1	20	2.2	3.6 - 0.1	1.3 - 0.7		1	1					
8.70 (L)	Phum Skous SC-2	100	2.8	3.7 - 0.8	1.8 - 0.9		1			1	5		
9.62 (L)	Bak Thmenh SC	60	6.0	8.8 - 2.2	1.8 - 0.9						2		

Remarks *1 ; (L) ; Left side, (R) ; Right side

*2 ; including TSC Model Site (222 ha)

Note: Command area is estimated based on field invnetory survey executed by JICA Survey Team and topographic map, not including extension area proposed by MOWRAM/PDOWRAM.

(2) Check Structure

BP Dist. from Intake	Canal	Canal Dimesions		Structure Dimesions			Gate			
		W (top, m)	H (m)	Span	B (m)	H (m)	Type	Nos	W (m)	H (m)
(a) North Main Canal										
8.60	NMC	24.4	4.2	1	10	3.8	Slide	2	2	2.3
(b) South Main Canal										
3.50	SMC	15.2	3	1	2.7	3.9	Slide	2	1.8	1.5
7.80	SMC	17	2.4	1	6	3.3	Radial	1	R=3.5	L=2.8

(3) Turnout

BP Dist. from Intake*1	Name of Off-taking Canal	Dimensions									
		Gate			Culvert				Concrete Pipe		
		Nos	B (m)	H (m)	Nos of barrel	B (m)	H (m)	L (m)	Nos.	Dia. (m)	L (m)
(a) North Approach Channel											
0.60 (L)	Phum Thmey Andong Sla SC				1	1.4	2	3.2			
0.68 (R)	Anlong Thor SC								1	0.5	8
(b) South Approach Channel											
0.95 (L)	Tompoung SC-1								1	0.3	7
1.35 (L)	Tompoung SC-2								1	0.3	5.5
2.60 (L)	Kraheng SC	1	1	1.4					1	0.8	8.7
(c) North Main Canal											
1.95 (L)	Phum Thmey SC-1								2	0.8	8
2.40 (R)	Phum Thmey SC-2								1	0.5	13
2.43 (L)	Phum Thmey SC-3								1	0.4	18
3.35 (R)	Kravein SC-1 and 2								1	1.2	11
3.45 (L)	Sampov SC-1								1	0.3	10.5
5.20 (L)	Sampov-2 SC								1	0.6	6.6
5.25 (R)	Prey Beng SC-1								1	1	8.4
8.55 ~ 9.1 (R)	Small irrigation area										
8.05 (R)	Chbar Morn-1 SC				1	0.8	0.8	8			
8.55 (R)	Chbar Morn-2 SC				1	1.6	1.1	12			
9.00 (R)	Thmat Pong-1 SC								1	1.5	8
(d) South Main Canal											
1.23 (L)	Tompoung SC-6								1	5.5	0.8
1.50 (L)	Bostaney*2 SC	2	1	1.5	1	2.4	1.8	2			
1.74 (L)	Road No 4 (Only	1	1.6	1.2	1	1.5	2	7.4			
4.75 (L)	Koh Té SC-1	1	1	1.2					1	0.8	7.5
4.75 (R)	Koh Té SC-2 (No										
5.85 (L)	Thnol Bom Bek SC								1	0.3	7
6.95 (L)	Phum Roung SC								1	0.3	15
7.80 (L)	Road-110 SC	3	1.2	1.8	1	4.1	2	2.8			
8.40 (L)	Phum Skous SC-1	1	1.2	1.2					1	1	5.2
8.70 (L)	Phum Skous SC-2	1	1.5	1.2	1	1.2	1.4	5.2			

Remarks ; *1: (L): Left bank, (R): Right bank

*2: including TSC Model Site (222 ha)

(4) Turnout

Canal	BP Dist. From	Materials	Type	Major Dimensions			
				Span	W (m)	H (m)	L (m)
	(a) South Approach Channel						
SAC	0.57	Concrete	Road Bridge	1	11.0	3.4	7.5
	(b) Nouth Main Canal						
NMC	2.10	Wooden	Footpath	3	4.7	3.8	34.0
NMC	3.84	Wooden	Road Bridge	9	2,3	4.3	31.0
NMC	6.20	Concrete	Road Bridge	3	5.5	2.6	25.0
NMC	10.27	Steel	Road Bridge	1	4.0	4.9	15.0
	(c) South Main Canal						
SMC	0.91	Wooden	Footpath	5	2.0	3.3	16.0
SMC	1.65	Concrete	Road Bridge	1	12.5	3.5	3.6
SMC	2.25	Concrete and wood	Road Bridge	1	3.6	3.3	5.4
SMC	3.00	Steel	Road Bridge	3	4.7	2.7	15.1
SMC	4.00	Concrete and wood	Footpath	4	3.2	3.3	13.0
SMC	4.12	Concrete	Road Bridge	2	3.7	3.8	10.2
SMC	4.20	Concrete and wood	Footpath	2	3.0	3.1	12.7
SMC	4.57	Wooden	Footpath	6	2.4	2.4	17.1
SMC	5.00	Wooden	Footpath	5	3.0	2.6	13.3
SMC	5.15	Concrete	Road Bridge	2	4.0	3.2	10.0
SMC	6.20	Steel	Road Bridge	1	5.2	3.0	18.0

(5) Drainage Gate

BP Dist. from Intake[*1]	Strcuture			Gate		
	Span	W (m)	H (m)	Nos.	W (m)	H (m)
(a) South Main Canal						
9.62 (L)	2	2.5	2.5	4	1.0	2.5

Remarks *1 ; (L) ; Left side, (R) ; Right side

(6) Spillway

Canal	Stn. No. (Dist. from Intake)	L m	Crest width	Heigh m
SMC	1.40 (L)	25.76		2.5
SMC	7.15 (L)	37	3	1.5
SMC	9.40 (L)	72	3	1.5

Source: JICA Survey Team

Table AD-2.1.2.2.2 Comparison of Cost and Construction Period for Renewal of Regulator and Construction of Stoplog

Item	Alternative-1 Renewal of Regulator Gates	Alternative-2 Renewal of Regulator Gates and Construction of Stoplog	
Construction Period	2 dry seasons for gate installation (Proposed plan, refer to AD-2.1.3)	Installation of stoplog and monorail hoist (Mechanical works)	4 months (1 dry season)
		Installation of regulator gates with cofferdam (Mechanical and civil works)	4.3 months x 2 (2 dry seasons)
		Installation of regulator gates using stoplog and monorail hoist (Mechanical work)	6 months x 3 (3 dry seasons)
		Total : 1 dry season for stop log installation and 3 dry season for gate installation	
Construction Cost	US$3,968,000 (Proposed plan, refer to Annex F)	Reguilator gates	US$ 3,968,000
		Stoplog leaf with lifting beam	US$368,000
		Guide frame	US$374,000
		Monorail hoist	US$88,000
		Operation bridge	US$77,000
		Total (Refer to breakdown below)	US$4,875,000

Breakdown of cost estimate for stoplog

	Item	Q'ty	Weight	Unit price (US$)	Amount (US$)
1	Soplog leaf with lifting beam	1	46	8,000	368,000
2	Guide frame	5	34	11,000	374,000
3	Monorail hoist	1		Lump sum	88,000
4	Operation bridge	5	22	3,500	77,000
	Total				907,000

Table AD-2.2.1.5.3 Updated Estimate of Irrigation Water Requirement of Paddy

HYV Paddy-1 (105 days)

(Unit: MCM/1,000 ha)

Year		July		August		September		October		November		December	
		1	2	1	2	1	2	1	2	1	2	1	2
1	1966	0.00	0.00	0.00	0.10	1.32	1.45	0.27	0.53	0.66	0.11	0.00	0.00
2	1967	0.00	0.00	0.00	0.10	1.38	1.57	0.23	0.44	1.28	0.42	0.00	0.00
3	1968	0.00	0.00	0.00	0.10	1.14	1.09	0.50	0.86	1.38	0.47	0.00	0.00
4	1969	0.00	0.00	0.00	0.10	1.09	1.00	0.22	0.42	1.16	0.36	0.00	0.00
5	1983	0.00	0.00	0.00	0.10	1.22	1.25	0.89	1.27	1.39	0.48	0.00	0.00
6	1984	0.00	0.00	0.00	0.10	1.29	1.39	0.71	1.08	1.29	0.43	0.00	0.00
7	1985	0.00	0.00	0.00	0.10	1.20	1.21	0.18	0.33	0.89	0.23	0.00	0.00
8	1986	0.00	0.00	0.00	0.10	1.28	1.37	1.08	1.47	0.47	0.02	0.00	0.00
9	1987	0.00	0.00	0.00	0.10	1.32	1.45	0.52	0.87	0.22	0.00	0.00	0.00
10	1988	0.00	0.00	0.00	0.10	1.09	1.00	0.80	1.17	1.65	0.60	0.00	0.00
11	1989	0.00	0.00	0.00	0.10	1.16	1.13	0.16	0.29	1.65	0.60	0.00	0.00
12	1990	0.00	0.00	0.00	0.10	1.41	1.62	0.66	1.03	0.58	0.07	0.00	0.00
13	1991	0.00	0.00	0.00	0.10	1.31	1.44	0.10	0.16	1.65	0.60	0.00	0.00
14	1992	0.00	0.00	0.00	0.10	1.21	1.24	0.00	0.00	1.29	0.43	0.00	0.00
15	1993	0.00	0.00	0.00	0.10	1.27	1.36	0.12	0.21	0.97	0.26	0.00	0.00
16	1994	0.00	0.00	0.00	0.10	1.43	1.68	1.14	1.53	1.50	0.53	0.00	0.00
17	1995	0.00	0.00	0.00	0.10	1.09	1.00	0.50	0.85	1.24	0.40	0.00	0.00
18	1996	0.00	0.00	0.00	0.10	1.09	1.00	0.00	0.00	0.78	0.17	0.00	0.00
19	1997	0.00	0.00	0.00	0.10	1.36	1.54	1.04	1.43	1.26	0.41	0.00	0.00
20	1998	0.00	0.00	0.00	0.10	1.12	1.05	0.28	0.54	0.18	0.00	0.00	0.00
21	1999	0.00	0.00	0.00	0.10	1.09	1.00	0.00	0.00	0.60	0.08	0.00	0.00
22	2000	0.00	0.00	0.00	0.10	1.47	1.76	0.00	0.00	0.55	0.06	0.00	0.00
23	2001	0.00	0.00	0.00	0.10	1.09	1.00	0.00	0.00	1.65	0.60	0.00	0.00
24	2002	0.00	0.00	0.00	0.10	1.52	1.85	0.37	0.71	0.63	0.09	0.00	0.00
25	2003	0.00	0.00	0.00	0.10	1.30	1.42	1.61	2.03	1.65	0.60	0.00	0.00
26	2004	0.00	0.00	0.00	0.10	1.09	1.00	0.60	0.96	1.13	0.35	0.00	0.00
27	2005	0.00	0.00	0.00	0.10	1.33	1.47	0.00	0.00	0.55	0.05	0.00	0.00
28	2006	0.00	0.00	0.00	0.10	1.09	1.00	0.75	1.12	1.65	0.60	0.00	0.00
29	2007	0.00	0.00	0.00	0.10	1.10	1.02	0.09	0.15	0.95	0.26	0.00	0.00
30	2008	0.00	0.00	0.00	0.10	1.28	1.38	0.00	0.00	0.95	0.25	0.00	0.00
31	2009	0.00	0.00	0.00	0.10	1.12	1.05	0.56	0.91	1.54	0.55	0.00	0.00
32	2010	0.00	0.00	0.00	0.10	1.30	1.41	0.04	0.03	1.25	0.40	0.00	0.00
Max		0.00	0.00	0.00	0.10	1.52	1.85	1.61	2.03	1.65	0.60	0.00	0.00
Lit/sec/ha		0.00	0.00	0.00	0.07	1.17	1.43	1.24	1.47	1.27	0.47	0.00	0.00
Ave.		0.00	0.00	0.00	0.10	1.24	1.29	0.42	0.64	1.08	0.33	0.00	0.00
Lit/sec/ha		0.00	0.00	0.00	0.08	0.95	0.99	0.32	0.46	0.83	0.25	0.00	0.00
80% dry condition						1.34	1.50	0.77	1.11	1.46			
Lit/sec/ha						1.03	1.16	0.59	0.80	1.13			

Local Paddy (135 days)

(Unit: MCM/1,000 ha)

Year		July		August		September		October		November		December	
		1	2	1	2	1	2	1	2	1	2	1	2
1	1966	0.04	0.52	0.54	0.61	0.79	0.98	0.22	0.21	0.56	0.49	0.38	0.11
2	1967	0.04	0.46	0.71	0.87	0.88	1.09	0.18	0.18	1.05	0.86	0.58	0.22
3	1968	0.04	0.56	0.70	0.86	0.49	0.61	0.42	0.40	1.13	0.91	0.59	0.22
4	1969	0.04	0.59	0.58	0.66	0.44	0.49	0.18	0.17	0.96	0.79	0.60	0.23
5	1983	0.04	0.65	0.45	0.46	0.62	0.77	0.81	0.81	1.14	0.92	0.58	0.22
6	1984	0.04	0.63	0.71	0.87	0.74	0.92	0.63	0.61	1.06	0.86	0.61	0.23
7	1985	0.04	0.62	0.88	1.14	0.60	0.74	0.14	0.13	0.74	0.62	0.61	0.23
8	1986	0.04	0.63	0.73	0.90	0.72	0.90	1.00	1.01	0.40	0.37	0.35	0.10
9	1987	0.04	0.73	0.59	0.68	0.78	0.97	0.44	0.41	0.17	0.17	0.67	0.26
10	1988	0.04	0.49	0.85	1.10	0.44	0.46	0.72	0.71	1.34	1.07	0.67	0.26
11	1989	0.04	0.44	0.85	1.10	0.53	0.66	0.13	0.11	1.34	1.07	0.67	0.26
12	1990	0.04	0.67	0.81	1.04	0.92	1.15	0.58	0.56	0.49	0.43	0.67	0.26
13	1991	0.04	0.49	0.44	0.44	0.77	0.96	0.08	0.06	1.34	1.07	0.67	0.26
14	1992	0.04	0.59	0.85	1.09	0.62	0.76	0.00	0.00	1.06	0.86	0.67	0.26
15	1993	0.04	0.70	1.01	1.35	0.71	0.88	0.10	0.09	0.80	0.67	0.67	0.26
16	1994	0.04	0.44	0.86	1.12	0.97	1.20	1.06	1.07	1.22	0.98	0.60	0.23
17	1995	0.04	0.61	0.66	0.79	0.44	0.48	0.42	0.39	1.02	0.83	0.57	0.21
18	1996	0.04	0.44	0.68	0.82	0.44	0.40	0.00	0.00	0.65	0.56	0.67	0.26
19	1997	0.04	0.71	0.62	0.74	0.85	1.06	0.96	0.97	1.04	0.85	0.67	0.26
20	1998	0.04	0.59	0.76	0.95	0.47	0.58	0.22	0.22	0.15	0.15	0.62	0.24
21	1999	0.04	0.59	0.44	0.44	0.44	0.41	0.00	0.00	0.51	0.45	0.63	0.24
22	2000	0.04	0.57	0.70	0.86	1.03	1.29	0.00	0.00	0.47	0.42	0.52	0.19
23	2001	0.04	0.48	0.59	0.68	0.44	0.42	0.00	0.00	1.34	1.07	0.42	0.13
24	2002	0.04	0.67	0.77	0.97	1.10	1.37	0.29	0.29	0.53	0.46	0.62	0.24
25	2003	0.04	0.44	0.60	0.71	0.76	0.94	1.53	1.57	1.34	1.07	0.67	0.26
26	2004	0.04	0.68	0.86	1.11	0.44	0.47	0.52	0.49	0.93	0.77	0.58	0.21
27	2005	0.04	0.51	0.86	1.11	0.80	0.99	0.00	0.00	0.46	0.42	0.29	0.07
28	2006	0.04	0.65	0.44	0.44	0.44	0.49	0.67	0.65	1.34	1.07	0.67	0.26
29	2007	0.04	0.50	0.72	0.89	0.45	0.55	0.08	0.06	0.79	0.66	0.67	0.26
30	2008	0.04	0.62	0.63	0.75	0.73	0.90	0.00	0.00	0.78	0.66	0.61	0.23
31	2009	0.04	0.56	0.66	0.79	0.47	0.58	0.48	0.45	1.26	1.01	0.67	0.26
32	2010	0.04	0.49	0.84	1.09	0.75	0.93	0.03	0.01	1.02	0.84	0.61	0.23
Max		0.04	0.73	1.01	1.35	1.10	1.37	1.53	1.57	1.34	1.07	0.67	0.26
Lit/sec/ha		0.03	0.57	0.78	0.98	0.85	1.06	1.18	1.14	1.04	0.83	0.52	0.20
Ave.		0.04	0.57	0.70	0.86	0.66	0.79	0.37	0.36	0.89	0.73	0.60	0.22
Lit/sec/ha		0.03	0.41	0.51	0.62	0.51	0.61	0.29	0.26	0.69	0.53	0.43	0.16
80% dry condition					1.06	0.83	1.03	0.70	0.70	1.19			
Lit/sec/ha					0.77	0.64	0.79	0.54	0.51	0.92			

Table AD-2.2.1.5.4 Upgraded Estimate of Diversion Irrigation Water Requirement

(Unit: m^3/sec)

Year		January		February		March		April		May		June		July		August		September		October		November		December	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1	1966	0.11	0.14	0.16	0.17	0.05	0.00	0.00	0.02	0.21	0.23	0.12	0.17	0.17	0.92	1.01	1.13	2.58	3.05	0.63	0.79	1.59	0.99	0.70	0.20
2	1967	0.09	0.12	0.14	0.15	0.04	0.00	0.00	0.02	0.23	0.26	0.14	0.19	0.13	0.80	1.31	1.60	2.80	3.36	0.54	0.66	3.03	1.94	1.11	0.45
3	1968	0.12	0.14	0.17	0.18	0.05	0.00	0.00	0.02	0.24	0.28	0.08	0.13	0.19	1.00	1.29	1.57	1.88	2.05	1.21	1.37	3.26	2.09	1.14	0.47
4	1969	0.09	0.11	0.14	0.14	0.04	0.00	0.00	0.02	0.22	0.25	0.21	0.26	0.22	1.07	1.07	1.22	1.74	1.76	0.52	0.63	2.76	1.76	1.16	0.49
5	1983	0.12	0.14	0.17	0.18	0.05	0.00	0.00	0.02	0.28	0.36	0.20	0.26	0.26	1.18	0.84	0.89	2.18	2.49	2.26	2.42	3.29	2.11	1.12	0.46
6	1984	0.12	0.14	0.17	0.18	0.05	0.00	0.00	0.02	0.26	0.32	0.15	0.21	0.25	1.15	1.31	1.59	2.46	2.87	1.76	1.92	3.06	1.96	1.17	0.49
7	1985	0.12	0.14	0.17	0.18	0.05	0.00	0.00	0.02	0.23	0.27	0.23	0.28	0.24	1.12	1.62	2.06	2.12	2.40	0.42	0.49	2.13	1.35	1.17	0.49
8	1986	0.09	0.12	0.14	0.15	0.04	0.00	0.00	0.02	0.28	0.36	0.18	0.23	0.24	1.14	1.35	1.65	2.42	2.83	2.77	2.92	1.14	0.70	0.65	0.17
9	1987	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.30	0.41	0.30	0.35	0.32	1.37	1.09	1.26	2.57	3.03	1.25	1.40	0.50	0.32	1.29	0.57
10	1988	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.26	0.32	0.08	0.13	0.15	0.86	1.58	2.00	1.74	1.70	2.01	2.16	3.88	2.50	1.29	0.57
11	1989	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.27	0.35	0.29	0.34	0.12	0.76	1.58	2.00	1.96	2.17	0.37	0.43	3.88	2.50	1.29	0.57
12	1990	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.26	0.33	0.25	0.30	0.27	1.23	1.51	1.89	2.90	3.51	1.64	1.80	1.39	0.86	1.29	0.57
13	1991	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.25	0.31	0.07	0.12	0.15	0.86	0.81	0.84	2.54	3.00	0.23	0.24	3.88	2.50	1.29	0.57
14	1992	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.22	0.25	0.29	0.34	0.22	1.07	1.57	1.98	2.17	2.47	0.00	0.00	3.05	1.96	1.29	0.57
15	1993	0.11	0.14	0.16	0.18	0.05	0.00	0.00	0.02	0.24	0.28	0.27	0.32	0.30	1.30	1.86	2.42	2.40	2.79	0.29	0.32	2.30	1.46	1.29	0.57
16	1994	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.25	0.31	0.17	0.22	0.12	0.76	1.60	2.02	3.00	3.65	2.92	3.08	3.53	2.27	1.15	0.48
17	1995	0.12	0.14	0.17	0.18	0.05	0.00	0.00	0.02	0.27	0.35	0.25	0.31	0.23	1.10	1.21	1.44	1.74	1.74	1.20	1.36	2.94	1.88	1.09	0.45
18	1996	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.19	0.19	0.20	0.25	0.12	0.76	1.26	1.51	1.74	1.59	0.00	0.00	1.87	1.17	1.29	0.57
19	1997	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.29	0.39	0.28	0.33	0.30	1.31	1.16	1.36	2.74	3.27	2.66	2.82	2.99	1.92	1.29	0.57
20	1998	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.22	0.24	0.22	0.27	0.22	1.06	1.41	1.73	1.82	1.97	0.65	0.81	0.42	0.27	1.20	0.51
21	1999	0.12	0.15	0.17	0.18	0.06	0.00	0.00	0.02	0.26	0.32	0.20	0.25	0.22	1.06	0.81	0.84	1.74	1.61	0.00	0.00	1.46	0.90	1.21	0.52
22	2000	0.12	0.15	0.18	0.19	0.06	0.00	0.00	0.02	0.25	0.30	0.16	0.21	0.20	1.02	1.30	1.57	3.17	3.88	0.00	0.00	1.34	0.83	0.99	0.38
23	2001	0.07	0.10	0.12	0.12	0.03	0.00	0.00	0.02	0.27	0.34	0.22	0.27	0.14	0.84	1.09	1.26	1.74	1.62	0.00	0.00	3.88	2.50	0.77	0.24
24	2002	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.23	0.26	0.23	0.28	0.27	1.22	1.43	1.77	3.33	4.11	0.85	1.06	1.51	0.94	1.19	0.51
25	2003	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.27	0.34	0.24	0.29	0.07	0.76	1.12	1.30	2.51	2.95	4.19	4.34	3.88	2.50	1.29	0.57
26	2004	0.10	0.13	0.15	0.16	0.05	0.00	0.00	0.02	0.24	0.28	0.11	0.16	0.28	1.25	1.59	2.01	1.74	1.71	1.46	1.62	2.69	1.72	1.10	0.45
27	2005	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.25	0.29	0.19	0.24	0.16	0.89	1.59	2.01	2.61	3.08	0.00	0.00	1.32	0.82	0.53	0.11
28	2006	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.24	0.29	0.23	0.28	0.26	1.19	0.81	0.84	1.74	1.76	1.87	2.02	3.88	2.50	1.29	0.57
29	2007	0.14	0.17	0.19	0.20	0.07	0.00	0.00	0.02	0.20	0.20	0.16	0.22	0.15	0.87	1.33	1.62	1.76	1.88	0.22	0.23	2.27	1.44	1.29	0.57
30	2008	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.22	0.25	0.22	0.27	0.24	1.13	1.17	1.38	2.43	2.84	0.00	0.00	2.25	1.43	1.17	0.50
31	2009	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.25	0.31	0.24	0.30	0.20	1.00	1.21	1.45	1.82	1.97	1.36	1.51	3.64	2.34	1.29	0.57
32	2010	0.13	0.16	0.18	0.19	0.06	0.00	0.00	0.02	0.25	0.31	0.23	0.28	0.14	0.85	1.56	1.96	2.49	2.92	0.09	0.05	2.95	1.89	1.17	0.49
	Max	0.14	0.17	0.19	0.21	0.07	0.00	0.00	0.02	0.30	0.41	0.30	0.35	0.32	1.37	1.86	2.42	3.33	4.11	4.19	4.34	3.88	2.50	1.29	0.57
	Average	0.13	0.15	0.18	0.19	0.06	0.00	0.00	0.02	0.25	0.30	0.20	0.25	0.20	1.03	1.30	1.57	2.27	2.56	1.04	1.14	2.56	1.64	1.14	0.48
	Min	0.07	0.10	0.12	0.12	0.03	0.00	0.00	0.02	0.19	0.19	0.07	0.12	0.07	0.76	0.81	0.84	1.74	1.59	0.00	0.00	0.42	0.27	0.53	0.11
	D80																	2.67	3.18	1.95	2.09	3.45			

Note:D80: Irrigation requirement with 80% dependability

say, 3.5 m^3/s

Crop	ha	Crop	ha
Med Paddy (135 days)	2,400	HYV Paddy-2 (105 days)	200
HYV Paddy-1 (105 days)	1,100	Diversified Crops (90 days)	200

Source: JICA Survey Team

Table AD-2.2.2.5.3 Hydraulic Property of Irrigation Canals

Canal	Design discharge (m^3/sec)	Canal bed width (m)	Gradient of canal	Design water level (m)	Velocity at design dis. (m/sec)	Remarks
Main canal (L=7.3 km)						Drainage discharge of
Type A-1	3.216	2.0	1/5,000	1.62	0.38	2 m^3/sec is considered
Type A-2	3.065	2.0	1/1,500	1.19	0.59	as the minimum
Type A-3	2.214	1.5	1/1,500	1.10	0.54	discharge, since the canal
Type A-4	1.544	1.3	1/1,500	0.96	0.50	has dual functions for
Type A-5	1.006	1.0	1/1,500	0.80	0.49	irrigation and drainage
Secondary Canals (44.7 km)						Drainage discharge of
Type A20-1	0.681	0.8	1/ 800	0.62	0.51	200 lit/sec is considered
Type A20-2	0.613	0.8	1/ 800	0.60	0.50	as the minimum discharge,
Type A20-3	0.542	0.8	1/ 800	0.57	0.48	since the canal has dual
Type A21-1	0.539	0.8	1/1,000	0.60	0.44	functions for irrigation
Type A21-2	0.448	0.8	1/1,000	0.55	0.42	and drainage
Type A21-3	0.415	0.7	1/ 750	0.51	0.46	
Type A21-4	0.369	0.7	1/ 750	0.48	0.45	
Type A21-5	0.295	0.7	1/1,150	0.48	0.36	
Type A22-1	0.670	0.8	1/ 600	0.59	0.57	
Type A22-2	0.584	0.8	1/ 600	0.55	0.55	
Type A22-3	0.512	0.8	1/ 600	0.52	0.53	
Type A22-4	0.412	0.8	1/ 900	0.51	0.43	
Type A22-5	0.332	0.7	1/1,000	0.49	0.39	
Type A22-6	0.243	0.7	1/1,200	0.44	0.34	
Type A23-1	0.851	1.0	1/ 600	0.62	0.60	
Type A23-2	0.752	0.9	1/ 600	0.60	0.58	
Type A23-3	0.713	0.9	1/ 600	0.59	0.57	
Type A23-4	0.661	0.8	1/ 600	0.58	0.56	
Type A23-5	0.606	0.8	1/ 700	0.58	0.52	
Type A23-6	0.525	0.8	1/ 930	0.58	0.45	
Type A23-7	0.473	0.8	1/1,100	0.58	0.41	
Type A23-8	0.384	0.8	1/1,250	0.54	0.37	
Type C24-1	0.617	1.0	1/1,100	0.61	0.44	
Type C24-2	0.544	1.0	1/1,100	0.59	0.43	
Type C24-3	0.460	0.8	1/ 850	0.55	0.46	
Type C24-4	0.387	0.8	1/ 850	0.51	0.44	
Type C24-5	0.299	0.8	1/ 850	0.44	0.41	
Type A3U-1	0.137	0.5	1/ 600	0.30	0.38	
Type A3U-2	0.091	0.5	1/ 600	0.26	0.34	
Type A3U-3	0.047	0.5	1/ 500	0.18	0.30	

Note: Applied roughtness coefficent and inside slope for all canal sections are 0.035 and 1:2.0

Source: Drawings attached to the JICA F/S (2002)

Table AD-2.4.1.1.2 List of Small Scale Irrigation Rehabilitation Projects (1/3)

No.	Name	Location		Beneficiaries		Irrigation Area (ha)	Cost for Civil Works (USD)	Cost/ha (USD)	EIRR (%)	Agricultural Production Area (ha)							
										Without Project (ha)				With Project (ha)			
		Commune	District	Households	Persons					Early Wet	Wet	Dry	Upland C.	Early Wet	Wet	Dry	Upland C.
1- Banteay Mean Chey																	
1	Mongkolborey Main Canal	Bontey Neang	Mongkol Borey	559	1,815	1,116	897,565	804	14.3%		1,116				1,116	345	
2	Kanseng Reservoir	Soeng	Ochrouve	858	3,785	2,700	2,207,111	817	17.0%		2,700			400	2,700	500	
3	An longrot Reservoir	Svay Chek	Svay Chek	654	3,270	1,350	1,732,120	1,283	13.6%		1,350	36		150	1,350	180	
	Subtotal 1			2,071	8,870	5,166	4,836,796			0	5,166	36	0	550	5,166	1,025	0
2-Mondul Kiri																	
1	O'Yes	Sre Angkum	Koh Nhek	450	2,450	1,080	1,105,000	1,023	13.1%		870				1,080	170	15
2	Sre Khum	Sre Khtum	Kao Seima	359	1,415	360	300,830	836	13.3%		275				360	75	15
	Subtotal 2			809	3,865	1,440	1,405,830			0	1,145	0	0	0	1,440	245	30
3-Kampong Chhnang																	
1	Khla Krap	Koh Thkov	Cholkiri	194	970	450	699,948	1,555	14.3%			250				450	
2	Daun Pue	Chiep	Teuk Phos	1,569	7,077	1,151	862,697	750	14.6%		150				1,151		
3	Canal Stung Sdatch	Tang Krasang	Teuk Phos	1,393	7,356	1,046	861,512	824	14.0%		125				1,046		
	Subtotal 3			3,156	15,403	2,647	2,424,157			0	275	250	0	0	2,197	450	0
4-Kampong Speu																	
1	Main Canal 35km	Katplug	Basedth	10,022	50,204	3,018	1,538,995	510	12.1%		3,018			120	3,018	250	
2	O Kontrom	Dambok Rung	Phnom Sruch	5,502	27,152	3,250	1,593,586	490	12.5%		3,250			250	3,250	150	
3	O Ta Pann	Rassmei Samaki	Oral	486	2,392	1,400	811,847	580	12.1%		1,400			150	1,400	60	
	Subtotal 4			16,010	79,748	7,668	3,944,429			0	7,668	0	0	520	7,668	460	0
5-Battambang																	
1	N5 Canal	Bon Say Treng	Thmarkol	4,971	24,898	4,750	1,322,478	278	16.3%	910	4,750			2,400	4,750		
2	Anlong Rum Canal	Anlong Run	Thmarkol	1,996	9,203	710	619,586	873	12.3%	52	710			300	710		20
	Subtotal 5			6,967	34,101	5,460	1,942,064			962	5,460	0	0	2,700	5,460	0	20
6- Takeo																	
1	Choy Samrong	Baray	Doun Keo	1,135	6,174	300	828,660	2,762	14.4%		100	200			100	350	
2	Thra Peang Veng	Kampeng	Prey Kabas	419	1,966	220	245,788	1,117	15.2%		60	160			60	160	
3	Sen Presh Ream	Prey Pdav	Prey Kabas	1,312	6,467	567	445,717	786	18.8%		147	420			147	420	
4	Portasu	Kampang	Kirivong	815	3,716	1,756	506,474	288	19.3%		1,756			760	1,756		
5	Potawa	Angprasat	Kirivong	1,451	6,423	2,872	899,775	313	15.0%		2,072			350	2,872		
	Subtotal 6			5,132	24,746	5,715	2,926,415			0	4,135	780	0	1,110	4,935	930	0
7-Sihanuk Ville																	
1	Sea Protection dike	O'oknhheng	Prey Nob	140	560	260	262,183	1,008	15.8%		50				261		
2	Bot Koki Reservoir	O oknaheng	Prey Nob	2,467	13,392	386	196,534	509	12.4%		386		40		386		80
	Subtotal 7			2,607	13,952	646	458,717			0	436	0	40	0	647	0	80
8- Pursat																	
1	Beoung Preah Ponley Reservoir	Ptas Roop	P. Kravahh	2,795	16,672	2,800	1,699,643	607	13.3%		2,400				2,800	150	
2	Tuol Lopov	Svay At	Pursat City	564	4,048	360	189,893	527	23.7%		50				360	60	
3	Kom Peang Reservoir	Prangil	P. Kravahh	701	3,505	380	330,572	870	15.2%		200	30			380	100	
4	Kab Kralanh	Trapeang Chorng	Bakan	959	4,998	550	716,089	1,302	14.0%		50				550	50	
5	Wat Leap	Meteuk	Bakan	1,019	4,888	600	425,821	710	16.8%		250	100			600	170	
6	Tram Canal	Tnout Chum	Krakor	565	2,918	350	219,230	626	21.5%		50				350	50	
7	KenSeng	Ansa Cham Bok	Krakor	357	1,920	235	219,421	934	17.6%		120				235		
	Subtotal 8			6,960	38,949	5,275	3,800,669			0	3,120	130	0	0	5,275	580	0

Table AD-2.4.1.1.2 List of Small Scale Irrigation Rehabilitation Projects (2/3)

No.	Name	Location		Beneficiaries		Irrigation Area (ha)	Cost for Civil Works (USD)	Cost/ha (USD)	EIRR (%)	Agricultural Production Area (ha)							
										Without Project (ha)				With Project (ha)			
		Commune	District	Households	Persons					Early Wet	Wet	Dry	Upland C.	Early Wet	Wet	Dry	Upland C.
9- Kandal																	
1	Sras PramBai	Pothy Ban	Koh Thom	3,000	6,272	2,500	949,700	380	16.6%			700				2,500	
2	Tom Or	Samrong Lei	Ansnol	344	1,437	247	244,042	988	15.0%			123				247	
3	Ta Tray	Pouk Resey	Khasach Kandal	1,501	6,636	172	317,744	1,847	13.1%			50				172	
4	Chak Kaek	Prek Chrey	Kandal	346	1,842	226	147,688	653	14.9%			179				226	
5	Mlech Krabai Kon	Chheu Kmoa	Koh Thom	6,660	51,512	3,820	3,565,000	933	15.6%			1,790				3,820	
	Sbutotal 9			11,851	67,699	6,965	5,224,174			0	0	2,842	0	0	0	6,965	0
10-Stung Treng																	
1	O Kheh	Preak Meas	Siem Pang	384	1,652	2,895	904,662	312	17.0%		10,228	161		150	1,736	1,009	50
2	Khom Den	Samaki	Stung Treng	181	942	242	375,068	1,550	15.1%		125	16	8	35	242	93	15
3	Sre Choam	Sam Ang	Thalaborivat	236	1,109	984	830,936	844	17.7%		111	12	8	111	984	213	30
	Subtotal 10			801	3,703	4,121	2,110,666			0	10,464	189		296	2,962	1,315	
11-Kep																	
1	Rones	Poun Teuk	Dam Nak Chnag	639	2,913	621	799,298	1,287	17.6%		180	20	30	172	621	180	120
2	Dem Pring	Poun Teuk	Dam Nak Chnag	206	963	160	155,130	970	23.5%		10		10	60	160	20	80
3	Prek Tanen	Poun Teuk	Dam Nak Chnag	202	986	75	102,380	1,365	16.8%		75			40	75		
4	Veal Vong	Pong Teuk	Dam Nak Chnag	300	1,208	375	169,073	451	21.0%		100	22	20	80	375	40	80
	Subtotal 11			1,347	6,070	1,231	1,225,881			0	365	42	60	352	1,231	240	280
12-Kampot																	
1	Tra Pang Boeung Reservoir	trapang Boeung	Chhuk	1,506	7,148	1,430	1,131,373	791	18.4%	25	1,430			450	1,430	380	40
2	Kandal	Kandal	Teuk Chhu	585	2,985	650	714,850	1,100	21.9%		650			150	650	280	15
3	Pey Phdav Reservoir	Srae Knong	Chum Kiri	1,506	7,148	390	734,363	1,883	20.6%	10	194	13	15	195	390	158	40
4	Mlach	Chres	Chum Kiri	1,557	5,608	1,600	1,151,282	720	16.5%	340	1,600	500	20	500	1,600	800	55
5	Ou Chranieng Reservoir	Kampong Trach	Kampong Trach	517	2,833	310	516,894	1,667	17.0%		310			100	310	96	50
6	77 Reservoir	Sre Cheng	Chum Kiri	517	2,525	578	487,877	844	21.1%		578			50	578	86	50
7	Prawoek Pong Resevior	Trapaing Pring	Teuk Chhu	585	2,885	310	450,542	1,453	16.3%		310			100	310	51	20
	Subtotal 12			6,773	31,132	5,268	5,187,181			375	5,072	513	35	1,545	5,268	1,851	270
13-Siem Reap																	
1	Neary Canal	Kampong Thko	Kralanh	478	1,243	611	220,823	361	14.9%		611				611		
2	Louk Canal	Ta An	Kralanh	450	1,135	1,085	300,582	277	18.1%		572				1,085		
3	Trabek Canal	Damdek	Sothnikum	766	2,216	1,300	340,001	262	13.4%		814				1,300		
	Subtotal 13			1,694	4,594	2,996	861,406				1,997				2,996		
14-Pailin																	
1	Thnal Bot	Sala Krao	Sala Krao	910	4,962	4,000	926,311	232	14.9%	400	1,600	950	260	850	4,000	1,450	260
	Subtotal 14			910	4,962	4,000	926,311			400	1,600	950	260	850	4,000	1,450	260
15-Ratanakkrir																	
1	Som Trok Reservoir	Som Thom	O'Ya Dav	354	1,819	90	378,395	4,204	12.9%		40			40	90	40	
	Subtotal 15			354	1,819	90	378,395				40			40	90	40	
16- Kampong Cham																	
1	Samaki 75 Reservoir	Batheay	Batheay	359	1,415	703	830,342	1,181	16.2%			225				703	
2	Beung Khtum Reservoir	Prek Romdeng	Srey Santhor	203	1,003	393	336,401	856	17.6%			86				393	
3	ChamLork Cham Reservoir	Prek Romdeng	Srey Santhor	102	510	379	282,811	746	18.4%			105				379	
4	Bay Dei Reservoir	Baray	Srey Santhor	1,263	6,791	894	992,756	1,110	16.5%			220				894	
5	Simang Reservoir	Preaks Theart	Ou rang Ov	1,350	6,284	487	460,108	944	17.0%		487	116			487	487	
	Subtotal 16			3,277	16,003	2,856	2,902,418	4,838			487	752			487	2,856	

Table AD-2.4.1.1.2 List of Small Scale Irrigation Rehabilitation Projects (3/3)

No.	Name	Location		Beneficiaries		Irrigation Area (ha)	Cost for Civil Works (USD)	Cost/ha (USD)	EIRR (%)	Agricultural Production Area (ha)							
										Without Project (ha)				With Project (ha)			
		Commune	District	Households	Persons					Early Wet	Wet	Dry	Upland C.	Early Wet	Wet	Dry	Upland C.
17-Prey Veng																	
1	Phum Nheat Canal	Thmor Pun	Kanh Chreach	1,291	5,752	3,009	1,711,000	569	13.0%		1,000			400	3,009		
2	Thmor Tek Datch Canal	Kokkong Keut	Kanh Chreach	805	3,308	1,012	736,248	728	14.1%		111		40	100	1,012		70
3	Kbal Kapal Dam	Prek Tasor	Pea Raing	116	611	400	375,100	938	13.5%			350				400	
4	Char	Cheach	Kamchaymea	675	2,969	888	500,000	563	12.7%		285			100	888		
5	Anlong Cha Canal	Prah Sdach	Preah Sdach	2,135	10,675	2,226	866,470	389	13.9%			1,659		1,310		2,226	
6	Kra Chab Dam	Prey Khla	Svay Antor	1,748	8,766	850	921,255	1,084	13.5%		300			100	750		
	Subtotal 17			6,770	32,081	8,385	5,110,072				1,696	2,009	40	2,010	5,659	2,626	70
18- Svay Rieng																	
1	Preak Than	Kampong Chark	Rumdoul	1,294	5,976	2,334	1,629,058	698	12.6%		2,334				2,334	120	
2	Ta Nou	Cham Bak	Svay Chrum	739	3,761	452	897,129	1,985	15.5%		330	122		40	223	452	
3	Monourum	Monourum	Svay Teap	267	1,175	661	1,000,908	1,514	12.3%		98			70	661	145	
4	Krang Leav	Svay Chrum	Svay Thom	1,150	4,698	642	1,135,933	1,769	13.7%			182			200	642	
5	Svay Tayean	Koki	Kampong Ro	1,102	5,318	653	1,049,613	1,607	12.4%		110			120	653	135	
6	O Damrey Chlang	Kampong Ro	Bantey Krang	156	599	398	836,175	2,101	14.2%		223	175		90	398	260	
7	Sandort	Dun Sar	Svay Chrum	705	3,022	618	921,665	1,491	13.9%		102				618	266	
8	Veal Knach	Kroko	Svay Chrum	277	1,148	214	348,398	1,628	12.1%		62			35	214	56	
9	Chies Rossey	Kompong Chamlo	Svay Chrum	697	2,814	279	817,944	2,932	16.1%		224	55		75	195	279	
10	So Pha	Bantey Krang	Kampong Ro	337	1,538	650	985,940	1,517	13.1%		120	350			120	650	
11	Svay Year	Sam Roung	Chan Trea	725	3,319	350	880,006	2,514	12.7%		50	92			130	350	
	Subtotal 18			7,449	33,368	7,251	10,502,768			0	3,653	976	0	430	5,746	3,355	0
19-Kampong Thom																	
1	O Andeng Reservior	Tainkrosao	Prosat Sambo	429	1,716	600	425,084	708	15.5%		600				600	150	
2	Hun Sen Canal	Baray	Baray	2,120	13,141	650	570,397	878	16.7%	30	650	5		50	650	150	
	Subtotal 19			2,549	14,857	1,250	995,482			30	1,250	5	0	50	1,250	300	0
20- Kratie																	
1	Po	Bosleav	Chetra Borei	275	1,295	445	969,164	2,178	16.3%		95				445	368	
2	O Streung Kdach	Preak Prasob	Preakprasob	233	1,332	365	540,034	1,480	17.0%		43				365	160	14
3	O Lork	Thmor Andek	Chetra Borei	421	2,124	501	969,000	1,934	16.0%		154				501	346	
	Subtotal 20			929	4,751	1,311	2,478,199			0	292	0	0	0	1,311	874	14
21- Koh Kong																	
1	Saray Polder	Chroy Svay	Sre Ambel	225	953	342	531,615	1,554	12.2%		120				342		
2	Tanni Polder	Chikhor Leou	Sre Ambel	191	889	241	175,469	728	15.3%		70				241		
	Subtotal 21			416	1,842	583	707,083			0	190	0	0	0	583	0	0
22- Preah Vihear																	
1	Promy Reservoir	Promey	Tbeng Mean Che	270	1,700	300	264,071	880	13.1%		300				300	70	
2	Osarakareach Reservoir	Rie Riey	Rovang	285	1,950	390	350,000	897	17.1%		100			100	390	100	
	Subtotal 22			555	3,650	690	614,071			0	400	0	0	100	690	170	0
23- Odar Mean Chey																	
1	Chong Kal	Chong Kal	Chong Kal	600	2,400	1,450	1,713,082	1,181	13.5%		500	10			1,450	535	
2	Ta Enn	Pong Rer	Chong Kal	960	4,714	1,543	658,812	427	19.5%		450	8	10		1,543	345	35
	Subtoatal 23			1,560	7,114	2,993	2,371,894			0	950	18	10	0	2,993	880	35
Grand Total / Average				90,947	453,279	84,007	63,335,076	754	15.5%	1,767	55,861	9,492	445	10,553	68,054	26,612	1,059

Source : MOWRAM

Table AD-2.4.5.1.2 Updated Long List (1/3)

	Name	Location		Beneficiaries		Irrigation Area (ha)	Agricultural Production Area (ha)							
							Without Project (ha)				With Project (ha)			
		Commune	District	Households	Persons		Early Wet	Wet	Dry	Upland C.	Early Wet	Wet	Dry	Upland C.
Banteay Mean Chey														
1	Mongkolborey Main Canal	Bontey Neang	Mongkol Borey	559	1,815	1,116		1116				1116	345	
2	Kanseng Reservoir	Soeng	Ochrouve	858	3,785	2,700		2700			400	2700	500	
3	An longrot Reservoir	Svay Chek	Svay Chek	654	3,270	1,350		1350	36		150	1350	180	
Mondul Kiri														
1	O'Yes	Sre Angkum	Koh Nhek	450	2,450	1,080		870				1080	170	15
2	Sre Khum	Sre Khtum	Kao Seima	359	1,415	360		275				360	75	15
Kampong Chhnang														
1	Khla Krap	Koh Thkov	Cholkiri	194	970	450			250				450	
2	Canal Stung Sdatch	Tang Krasang	Teuk Phos	1,393	7,356	1,046		125				1046		
Kampong Speu														
1	O Kontrom	Dambok Rung	Phnom Sruch	5,502	27,152	3,250		3250			250	3250	150	
2	O Ta Pann	Rassmei Samaki	Oral	486	2,392	1,400		1400			150	1400	60	
Battambang														
1	N5 Canal	Bon Say Treng	Thmarkol	4,971	24,898	4,750	910	4750			2400	4750		
2	Anlong Rum Canal	Anlong Run	Thmarkol	1,996	9,203	710	52	710			300	710		20
Takeo														
1	Portasu	Kampang	Kirivong	815	3,716	1,756		1756			760	1756		
2	Potawa	Angprasat	Kirivong	1,451	6,423	2,872		2072			350	2872		
Sihanuk Ville														
1	Sea Protection dike	O'oknhheng	Prey Nob	140	560	260		50				261		
2	Bot Koki Reservoir	O oknaheng	Prey Nob	2,467	13,392	386		386		40		386		80
Pursat														
1	Beoung Preah Ponley Reservoir	Ptas Roop	P. Kravahh	2,795	16,672	2,800		2400				2800	150	
2	Tuol Lopov	Svay At	Pursat City	564	4,048	360		50				360	60	
2	Kab Kralanh	Trapeang Chorng	Bakan	959	4,998	550		50				550	50	
3	Tram Canal	Tnout Chum	Krakor	565	2,918	350		50				350	50	
5	KenSeng	Ansa Cham Bok	Krakor	357	1,920	235		120				235		

Table AD-2.4.5.1.2 Updated Long List (2/3)

	Name	Location		Beneficiaries		Irrigation Area (ha)	Agricultural Production Area (ha)							
							Without Project (ha)				With Project (ha)			
		Commune	District	Households	Persons		Early Wet	Wet	Dry	Upland C.	Early Wet	Wet	Dry	Upland C.
Kandal														
1	Tom Or	Samrong Lei	Ansnol	344	1,437	247			123				247	
2	Mlech Krabai Kon	Chheu Kmoa	Koh Thom	6,660	51,512	3,820			1790				3820	
Stung Treng														
1	O Kheh	Preak Meas	Siem Pang	384	1,652	2,895		10228	161		150	1736	1009	50
2	Khom Den	Samaki	Stung Treng	181	942	242		125	16	8	35	242	93	15
3	Sre Choam	Sam Ang	Thalaborivat	236	1,109	984		111	12	8	111	984	213	30
Kep														
1	Rones	Poun Teuk	Dam Nak Chnag	639	2,913	621		180	20	30	172	621	180	120
2	Prek Tanen	Poun Teuk	Dam Nak Chnag	202	986	75		75			40	75		
3	Veal Vong	Pong Teuk	Dam Nak Chnag	300	1,208	375		100	22	20	80	375	40	80
Kampot														
1	Tra Pang Boeung Reservoir	trapang Boeung	Chhuk	1,506	7,148	1,430	25	1430			450	1430	380	40
2	Kandal	Kandal	Teuk Chhu	585	2,985	650		650			150	650	280	15
3	Pey Phdav Reservoir	Srae Knong	Chum Kiri	1,506	7,148	390	10	194	13	15	195	390	158	40
4	Mlach	Chres	Chum Kiri	1,557	5,608	1,600	340	1600	500	20	500	1600	800	55
5	77 Reservoir	Sre Cheng	Chum Kiri	517	2,525	578		578			50	578	86	50
6	Prawoek Pong Resevior	Trapaing Pring	Teuk Chhu	585	2,885	310		310			100	310	51	20
Siem Reap														
1	Neary Canal	Kampong Thko	Kralanh	478	1,243	611		611				611		
2	Louk Canal	Ta An	Kralanh	450	1,135	1,085		572				1085		
3	Trabek Canal	Damdek	Sothnikum	766	2,216	1,300		814				1300		
Ratanakkrir														
1	Som Trok Reservoir	Som Thom	O'Ya Dav	354	1,819	90		40			40	90	40	
Kampong Cham														
1	Samaki 75 Reservoir	Batheay	Batheay	359	1,415	703			225				703	
2	Beung Khtum Reservoir	Prek Romdeng	Srey Santhor	203	1,003	393			86				393	
3	ChamLork Cham Reservoir	Prek Romdeng	Srey Santhor	102	510	379			105				379	
4	Bay Dei Reservoir	Baray	Srey Santhor	1,263	6,791	894			220				894	
5	Simang Reservoir	Preaks Theart	Ou rang Ov	1,350	6,284	487		487	116			487	487	

Table AD-2.4.5.1.2 Updated Long List (3/3)

	Name	Location		Beneficiaries		Irrigation Area (ha)	Agricultural Production Area (ha)							
							Without Project (ha)				With Project (ha)			
		Commune	District	Households	Persons		Early Wet	Wet	Dry	Upland C.	Early Wet	Wet	Dry	Upland C.
Prey Veng														
1	Phum Nheat Canal	Thmor Pun	Kanh Chreach	1,291	5,752	3,009		1000			400	3009		
2	Thmor Tek Datch Canal	Kokkong Keut	Kanh Chreach	805	3,308	1,012		111		40	100	1012		70
3	Kbal Kapal Dam	Prek Tasor	Pea Raing	116	611	400			350				400	
4	Anlong Cha Canal	Prah Sdach	Preah Sdach	2,135	10,675	2,226			1659		1310		2226	
5	Kra Chab Dam	Prey Khla	Svay Antor	1,748	8,766	850		300			100	750		
Svay Rieng														
1	Preak Than	Kampong Chark	Rumdoul	1,294	5,976	2,334		2334				2334	120	
2	Ta Nou	Cham Bak	Svay Chrum	739	3,761	452		330	122		40	223	452	
3	Monourum	Monourum	Svay Teap	267	1,175	661		98			70	661	145	
4	Svay Tayean	Koki	Kampong Ro	1,102	5,318	653		110			120	653	135	
5	O Damrey Chlang	Kampong Ro	Bantey Krang	156	599	398		223	175		90	398	260	
6	Sandort	Dun Sar	Svay Chrum	705	3,022	618		102				618	266	
7	Veal Knach	Kroko	Svay Chrum	277	1,148	214		62			35	214	56	
8	Chies Rossey	Kompong Chamlo	Svay Chrum	697	2,814	279		224	55		75	195	279	
9	So Pha	Bantey Krang	Kampong Ro	337	1,538	650		120	350			120	650	
10	Svay Year	Sam Roung	Chan Trea	725	3,319	350		50	92			130	350	
Kampong Thom														
1	O Andeng Reservior	Tainkrosao	Prosat Sambo	429	1,716	600		600				600	150	
2	Hun Sen Canal	Baray	Baray	2,120	13,141	650	30	650	5		50	650	150	
Kratie														
1	Po	Bosleav	Chetra Borei	275	1,295	445		95				445	368	
2	O Streung Kdach	Preak Prasob	Preakprasob	233	1,332	365		43				365	160	14
3	O Lork	Thmor Andek	Chetra Borei	421	2,124	501		154				501	346	
Preah Vihear														
1	Promy Reservoir	Promey	Tbeng Mean Ch	270	1,700	300		300				300	70	
2	Osarakareach Reservoir	Rie Riey	Rovang	285	1,950	390		100			100	390	100	
Odar Mean Chey														
1	Chong Kal	Chong Kal	Chong Kal	600	2,400	1,450		500	10			1450	535	
2	Ta Enn	Pong Rer	Chong Kal	960	4,714	1,543		450	8	10		1543	345	35

Source : MOWRAM

Table AD-2.4.5.3.1 Score of Sub-projects for Short List (1/2)

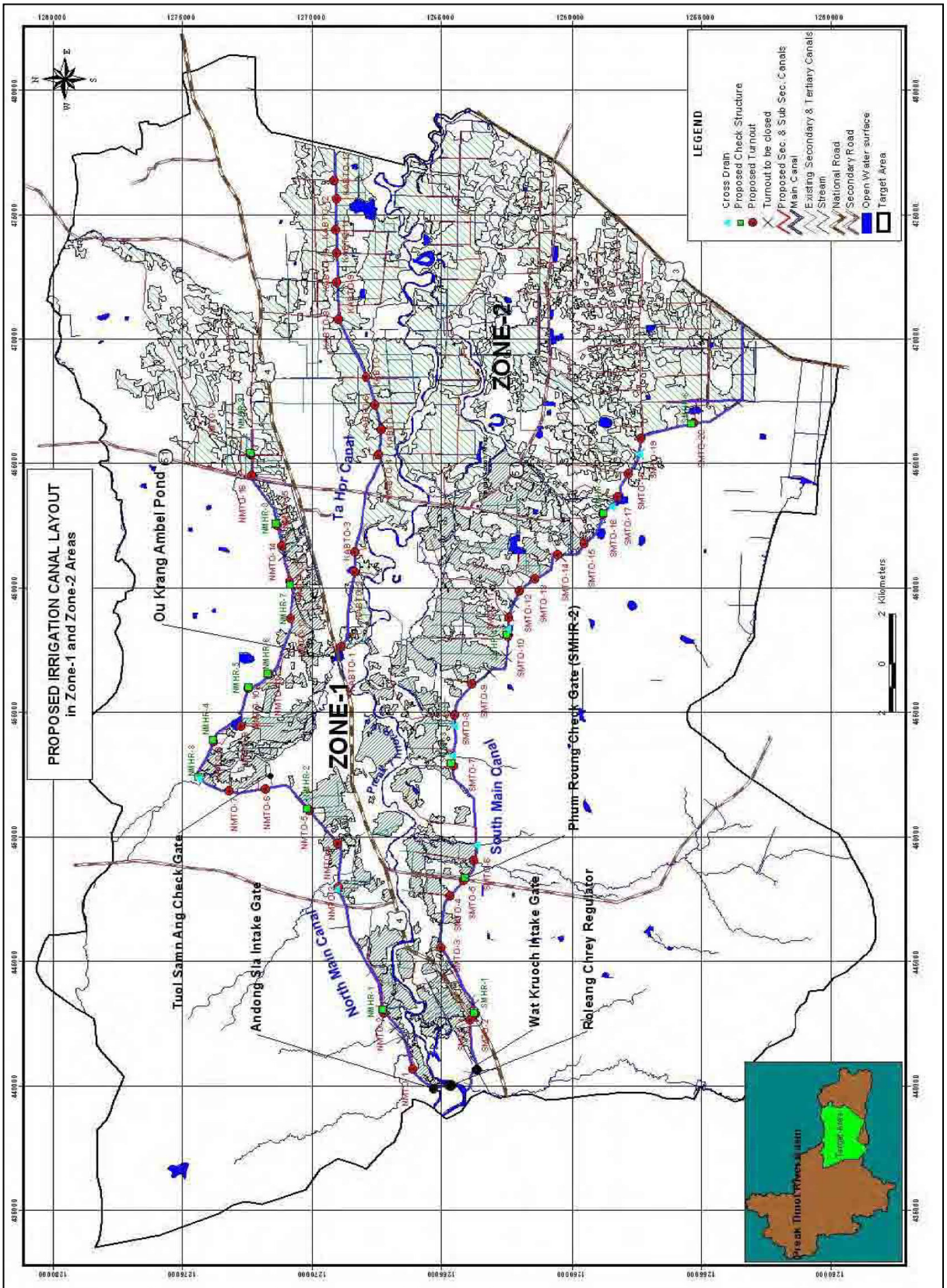
Sub-project Name	Privince	River Basin Priority	Irrigation Area (ha)	Type	Point Score							
					River Basin Priority	Irri. Area	Sub-peoject Effect	Water Source	Farmers' Concensus	Risk of Landmine	Land Acqistion	Total
Canal Stung Sdatch	Kampong Chhnang	1	1,046	River	10	10	10	10	10	10	10	80
Louk Canal	Siem Reap	2	1,085	River	5	10	5	10	10	10	10	70
Khla Krap	Kampong Chhnang	2	450	Recession	5	5	5	10	10	10	10	65
Tram Canal	Pursat	2	350	Reservoir	5	5	10	10	10	10	5	65
Neary Canal	Siem Reap	2	611	River	5	10	0	10	10	10	10	65
Trabek Canal	Siem Reap	2	1,300	River	5	10	5	5	10	10	10	60
Mongkolborey Main Canal	Banteay Mean Chey	1	1,116	River	10	10	0	10	10	10	0	60
An longrot Reservoir	Banteay Mean Chey	1	1,350	Reservoir	10	10	0	10	10	10	0	60
Portasu	Takeo	1	1,756	Reservoir	10	0	0	10	10	10	10	60
Kab Kralanh	Pursat	1	550	River	10	10	10	0	10	10	5	55
Veal Vong	Kep	1	375	Reservoir	10	5	10	0	10	10	10	55
Torn Or	Kandal	1	247	Recession	10	5	10	10	5	0	5	55
So Pha	Svay Rieng	1	650	Recession	10	10	5	10	10	0	0	55
Svay Year	Svay Rieng	1	350	Recession	10	5	10	10	10	0	0	55
KenSeng	Pursat	1	235	River	10	5	10	0	10	10	5	50
Rones	Kep	1	621	Reservoir	10	10	10	0	10	10	0	50
Prek Tanen	Kep	1	75	Reservoir	10	5	5	0	10	10	10	50
Mlech Krabai Kon	Kandal	1	3,820	Recession	10	0	10	10	5	0	5	50
Bay Dei Reservoir	Kampong Cham	1	894	Recession	10	10	10	10	0	0	0	50
Anlong Cha Canal	Prey Veng	1	2,226	Recession	10	0	10	10	10	0	0	50
O Ta Pann	Kampong Speu	1	1,400	Reservoir	10	10	0	0	10	10	5	45
Potawa	Takeo	1	2,872	River	10	0	5	0	10	10	10	45
Tuol Lopov	Pursat	1	360	River	10	5	5	0	10	10	5	45
Tra Pang Boeung Reservoir	Kampot	1	1,430	Reservoir	10	10	5	10	0	0	0	45
ChamLork Cham Reservoir	Kampong Cham	1	379	Recession	10	5	10	10	0	0	0	45
Kbal Kapal Dam	Prey Veng	1	400	Recession	10	5	0	10	10	0	0	45
Samaki 75 Reservoir	Kampong Cham	2	703	Recession	5	10	10	10	0	0	0	45
Thmor Tek Datch Canal	Prey Veng	1	1,012	River	10	10	10	0	10	0	0	40
Monourum	Svay Rieng	1	661	Reservoir	10	10	10	0	10	0	0	40
Svay Tayean	Svay Rieng	1	653	Reservoir	10	10	10	0	10	0	0	40
Sandort	Svay Rieng	1	618	Reservoir	10	10	10	0	10	0	0	40

Table AD-2.4.5.3.1 Score of Sub-projects for Short List (2/2)

Sub-project Name	Privince	River Basin Priority	Irrigation Area (ha)	Type	Point							
					River Basin Priority	Irri. Area	Sub-peoject Effect	Water Source	Farmers' Concensus	Risk of Landmine	Land Acqistion	Total
O Streung Kdach	Kratie	3	365	River	5	5	10	0	10	10	0	40
Anlong Rum Canal	Battambang	1	710	River	10	10	0	10	0	0	0	40
O Kontrom	Kampong Speu	1	3,250	Reservoir	10	0	0	0	10	10	5	35
Beoung Preah Ponley Reservoir	Pursat	1	2,800	Reservoir	10	0	0	0	10	10	5	35
Veal Knach	Svay Rieng	1	214	Reservoir	10	5	10	0	10	0	0	35
Chies Rossey	Svay Rieng	1	279	Reservoir	10	5	10	0	10	0	0	35
Chong Kal	Odar Mean Chey	2	1,450	Reservoir	5	10	10	0	10	0	0	35
O'Yes	Mondul Kiri	3	1,080	unknown	0	0	5	0	10	10	10	35
Osarakareach Reservoir	Preah Vihear	3	390	unknown	0	0	10	0	10	10	5	35
Sre Khum	Mondul Kiri	2	360	Reservoir	5	5	5	10	0	0	0	35
Hun Sen Canal	Kampong Thom	2	650	Reservoir	5	10	0	10	0	0	0	35
Kanseng Reservoir	Banteay Mean Chey	1	2,700	Reservoir	10	0	0	0	10	10	0	30
Phum Nheat Canal	Prey Veng	1	3,009	River	10	0	10	0	10	0	0	30
Kra Chab Dam	Prey Veng	1	850	Reservoir	10	10	10	0	0	0	0	30
Ta Nou	Svay Rieng	1	452	River	10	5	5	0	10	0	0	30
O Damrey Chlang	Svay Rieng	1	398	River	10	5	5	0	10	0	0	30
Po	Kratie	3	445	unknown	0	0	10	0	10	10	0	30
O Lork	Kratie	3	501	unknown	0	0	10	0	10	10	0	30
Promy Reservoir	Preah Vihear	3	300	unknown	0	0	0	0	10	10	10	30
Kandal	Kampot	2	650	Reservoir	5	10	5	5	0	0	0	30
Pey Phdav Reservoir	Kampot	1	390	Reservoir	10	5	10	0	0	0	0	25
Beung Khtum Reservoir	Kampong Cham	1	393	Reservoir	10	5	10	0	0	0	0	25
Sre Choam	Stung Treng	2	984	Reservoir	5	10	10	0	0	0	0	25
Ta Enn	Odar Mean Chey	2	1,543	Reservoir	5	10	10	0	0	0	0	25
77 Reservoir	Kampot	1	578	Reservoir	10	10	0	0	0	0	0	20
Simang Reservoir	Kampong Cham	1	487	Reservoir	10	5	5	0	0	0	0	20
Preak Than	Svay Rieng	1	2,334	Reservoir	10	0	0	0	10	0	0	20
Sea Protection dike	Sihanuk Ville	2	260	River	5	5	10	0	0	0	0	20
Prawoek Pong Resevior	Kampot	2	310	Reservoir	5	5	5	0	0	0	0	15
N5 Canal	Battambang	1	4,750	River	10	0	0	0	0	0	0	10
Mlach	Kampot	1	1,600	Reservoir	10	0	0	0	0	0	0	10
Bot Koki Reservoir	Sihanuk Ville	2	386	River	5	5	0	0	0	0	0	10
Khom Den	Stung Treng	4	242	unknown	0	0	10	0	0	0	0	10
Som Trok Reservoir	Ratanakkrir	3	90	unknown	0	0	10	0	0	0	0	10
O Kheh	Stung Treng	4	2,895	unknown	0	0	0	0	0	0	0	0
O Andeng Reservior	Kampong Thom	3	600	unknown	0	0	0	0	0	0	0	0

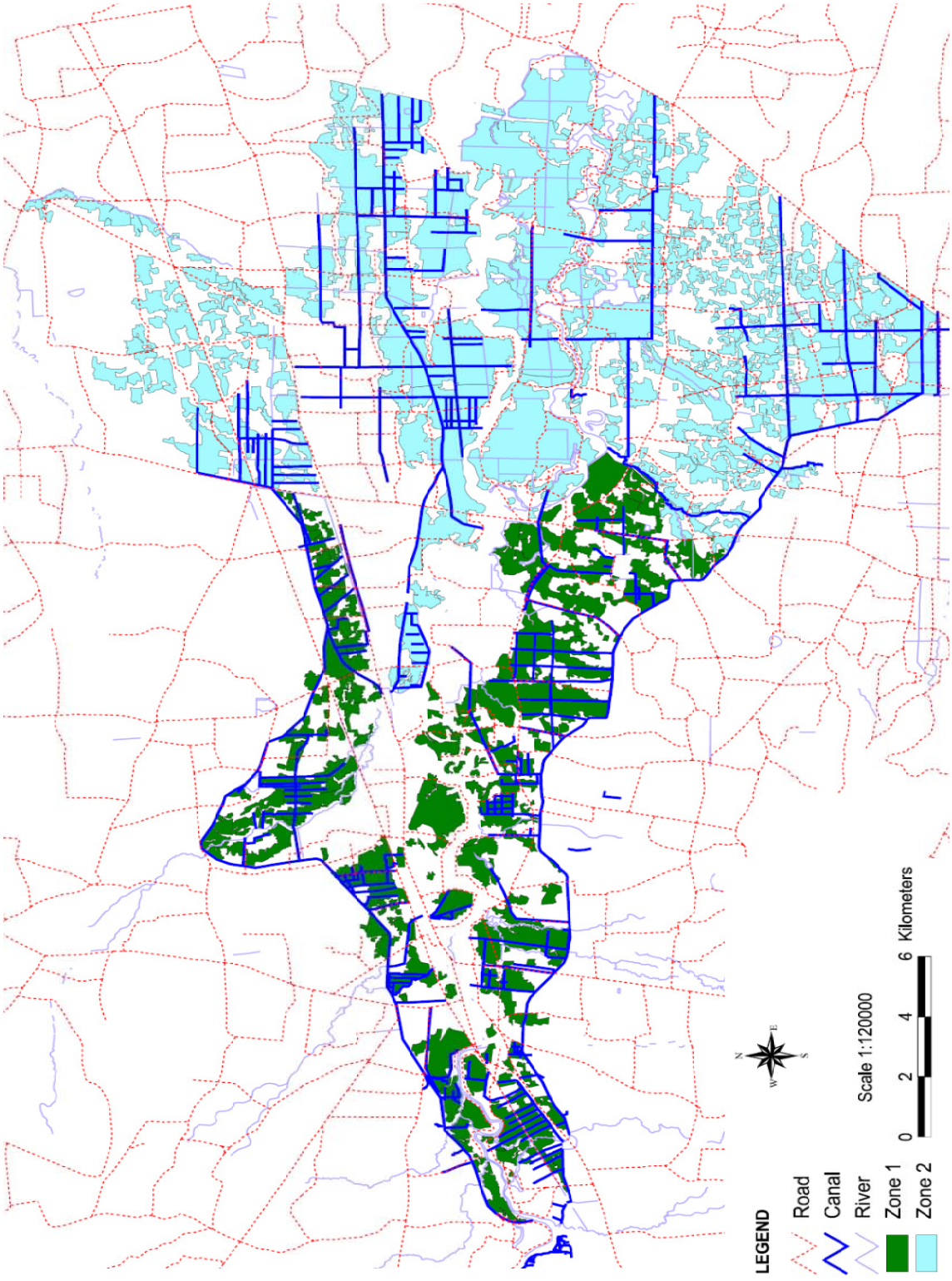
ANNEX D

Figures



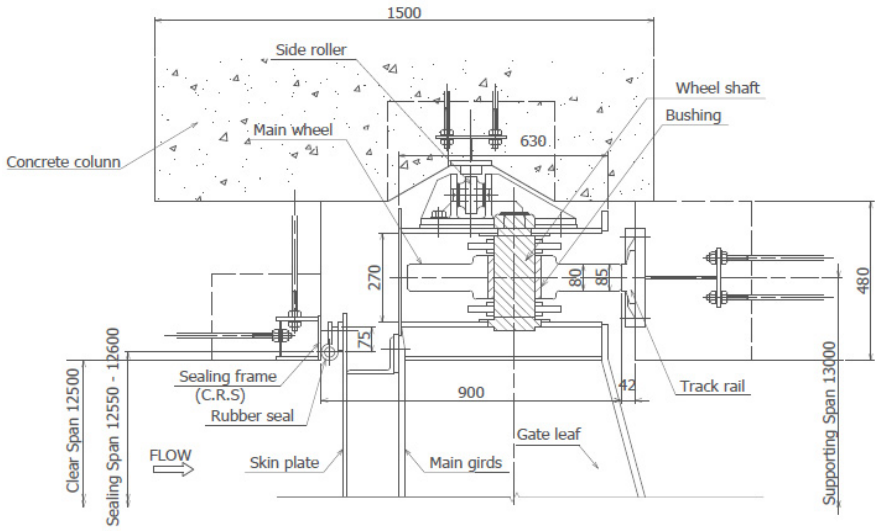
Source: The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008]

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project	**Figure AD-2.1.1.2.2**
Japan International Cooperation Agency	**General Layout of Roleang Chrey Irrigation System**

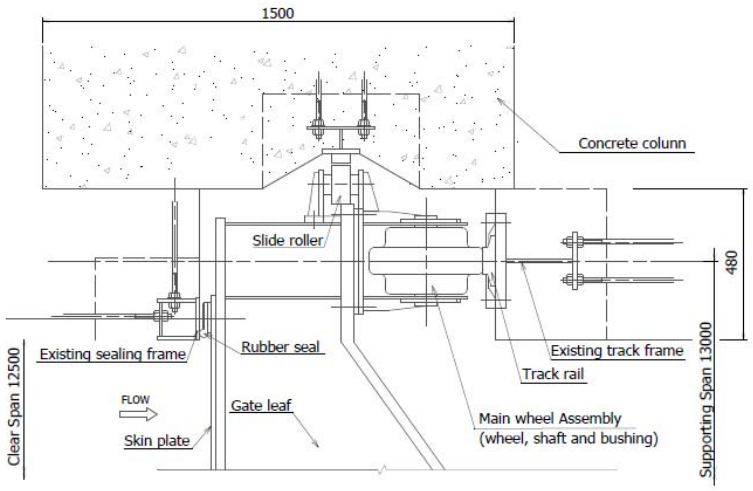


Source: The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project	**Figure AD-2.1.1.2.4**
Japan International Cooperation Agency	**Zone Map of Roleang Chrey Irrigation System**



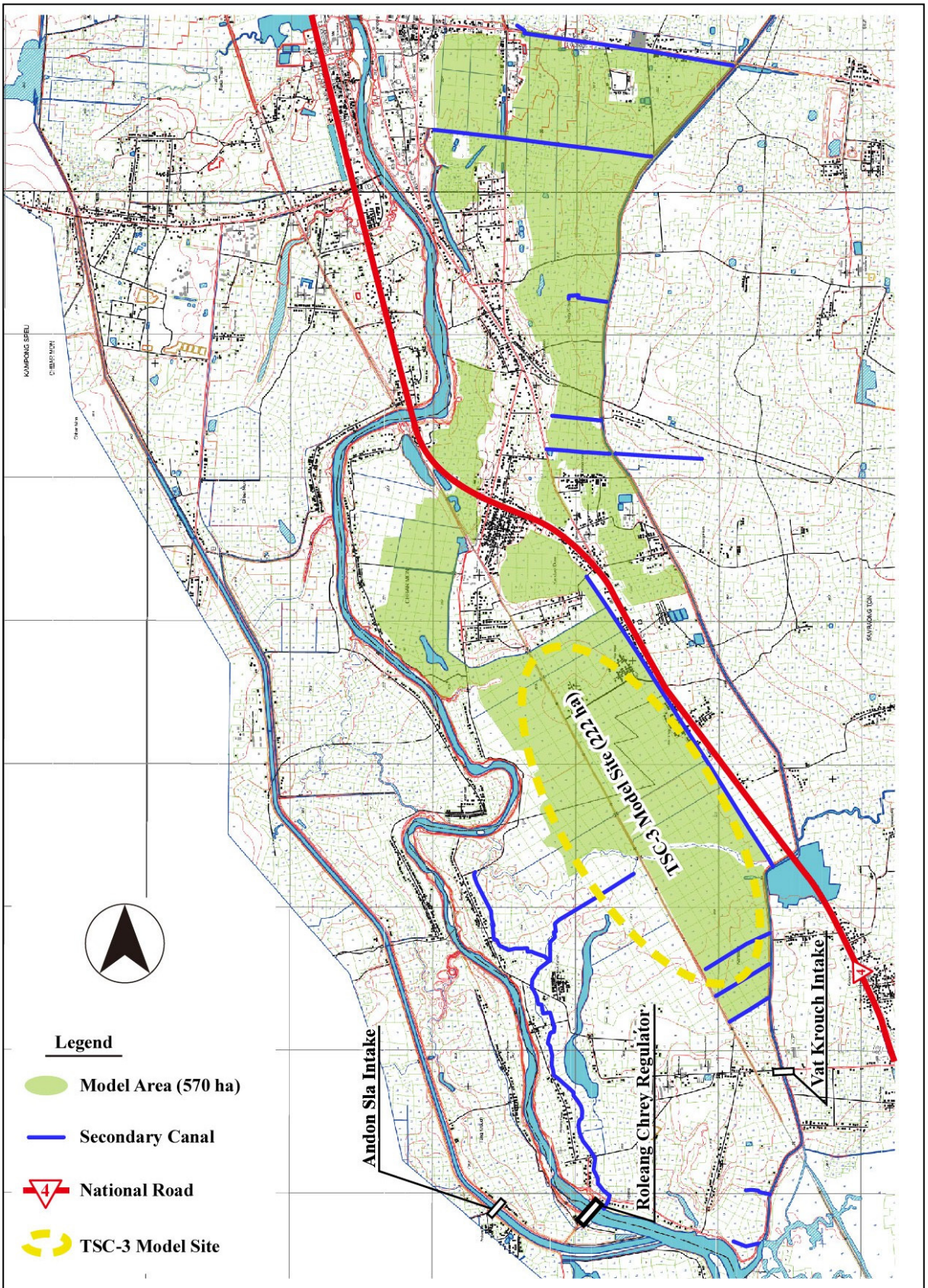
(1) Wheel Assembly of Existing Regulator Gate



(2) Proposed Wheel Assembly of Regulator Gate

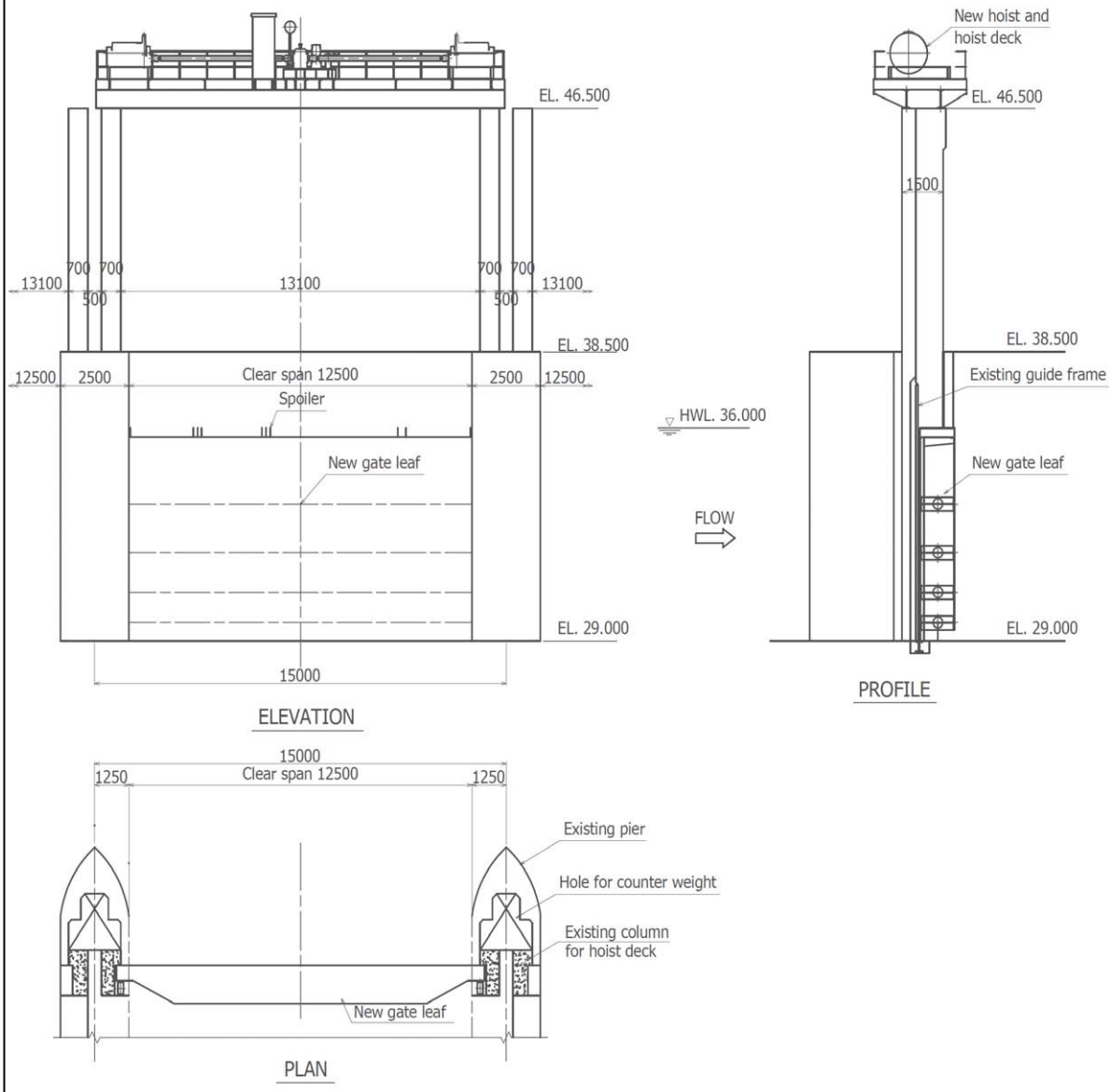
Source: JICA Survey Team

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project	**Figure AD-2.1.1.3.4**
Japan International Cooperation Agency	**Existing and Proposed Wheel Assembly of Regulator Gate**



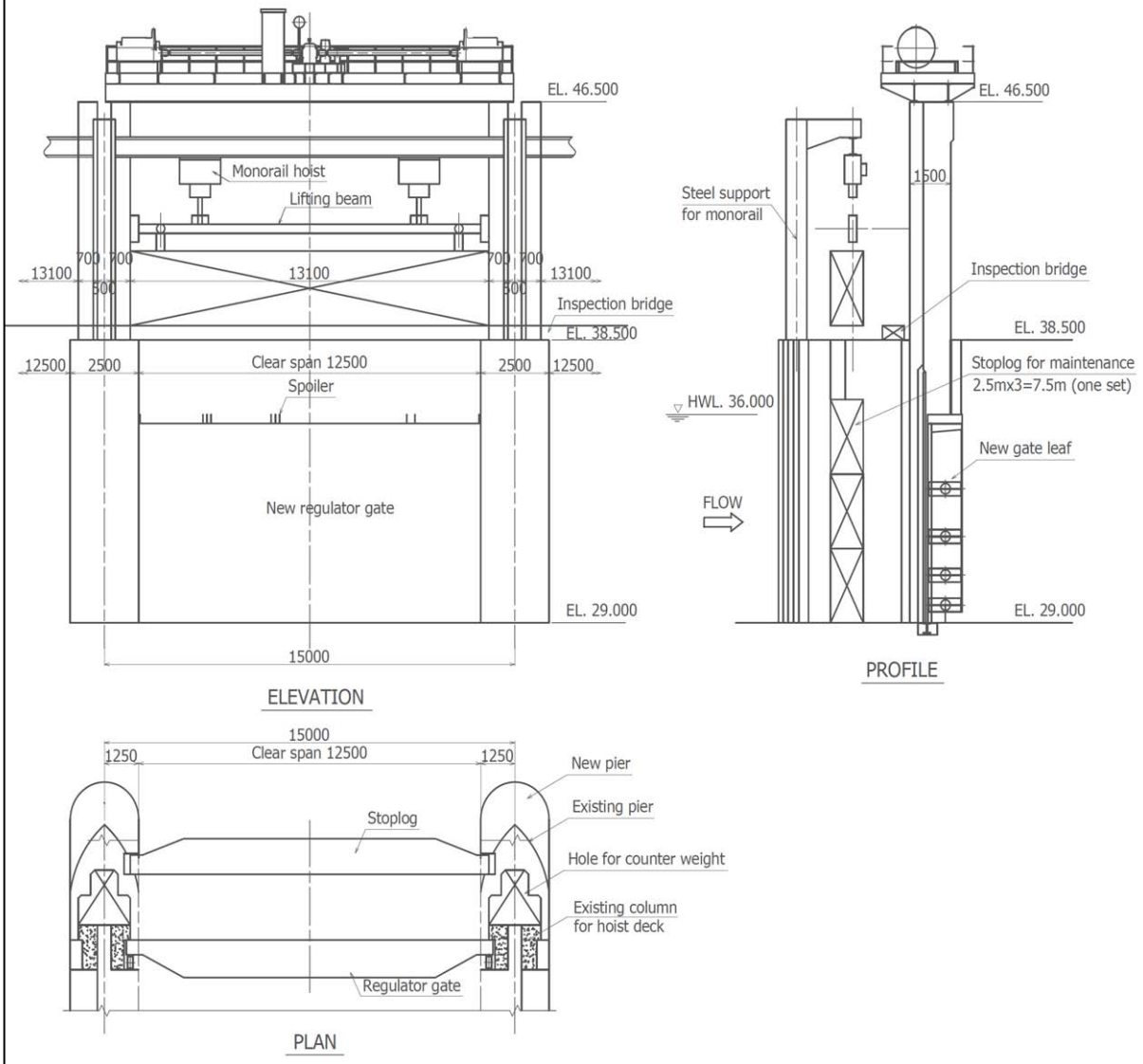
Source: JICA Survey Team

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project	**Figure AD-2.1.2.1.1** **Location Map of Model Area**
Japan International Cooperation Agency	



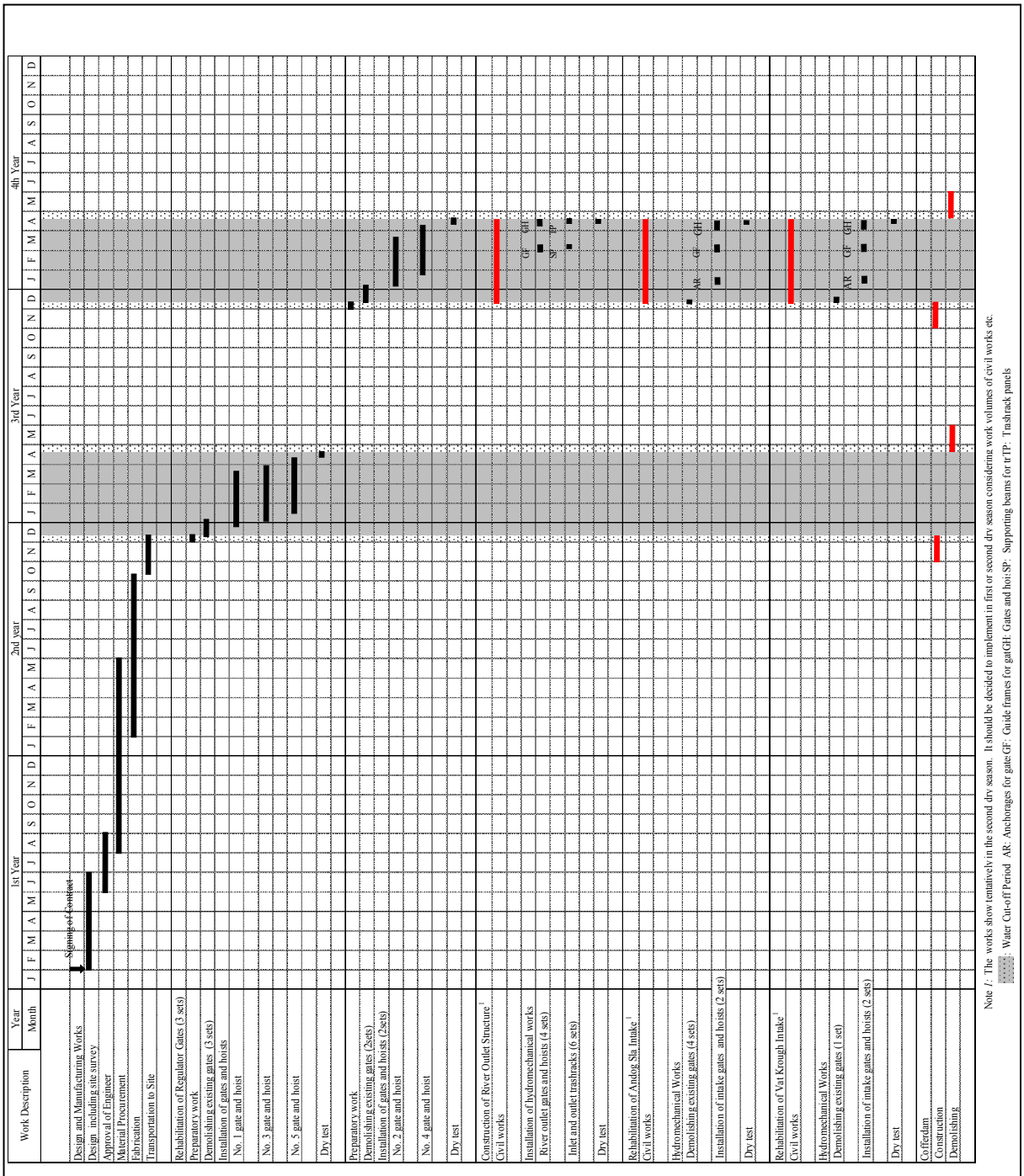
Source: JICA Survey Team

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project	**Figure AD-2.1.2.2.1**
Japan International Cooperation Agency	**Roleang Chrey Regulator Gates and Hoists (Alternative-1)**



Source: JICA Survey Team

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project	**Figure AD-2.1.2.2.2**
Japan International Cooperation Agency	**Roleang Chrey Regulator Gates with Stoplog (Alternative-2)**



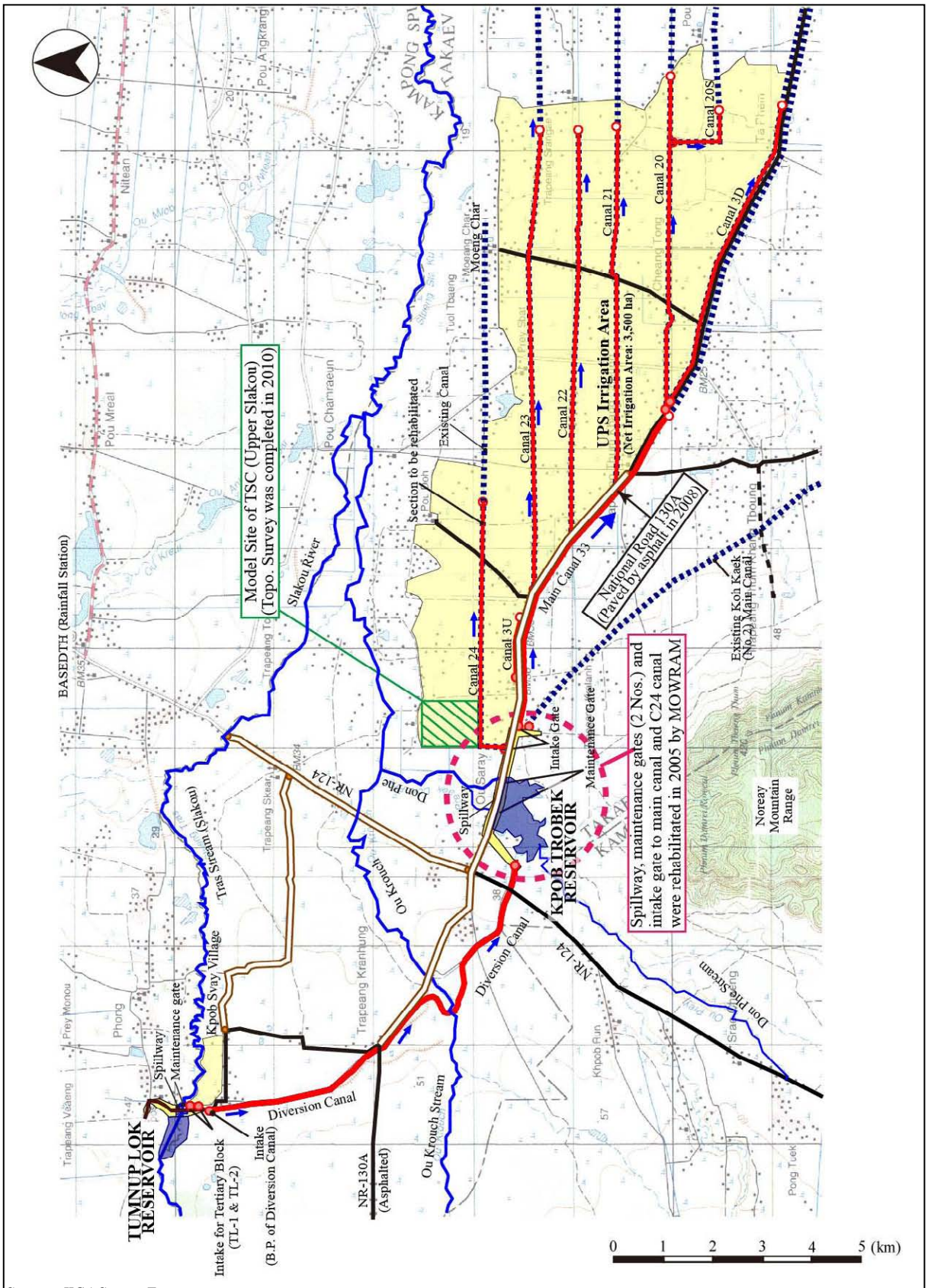
Source: JICA Survey Team

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project

Japan International Cooperation Agency

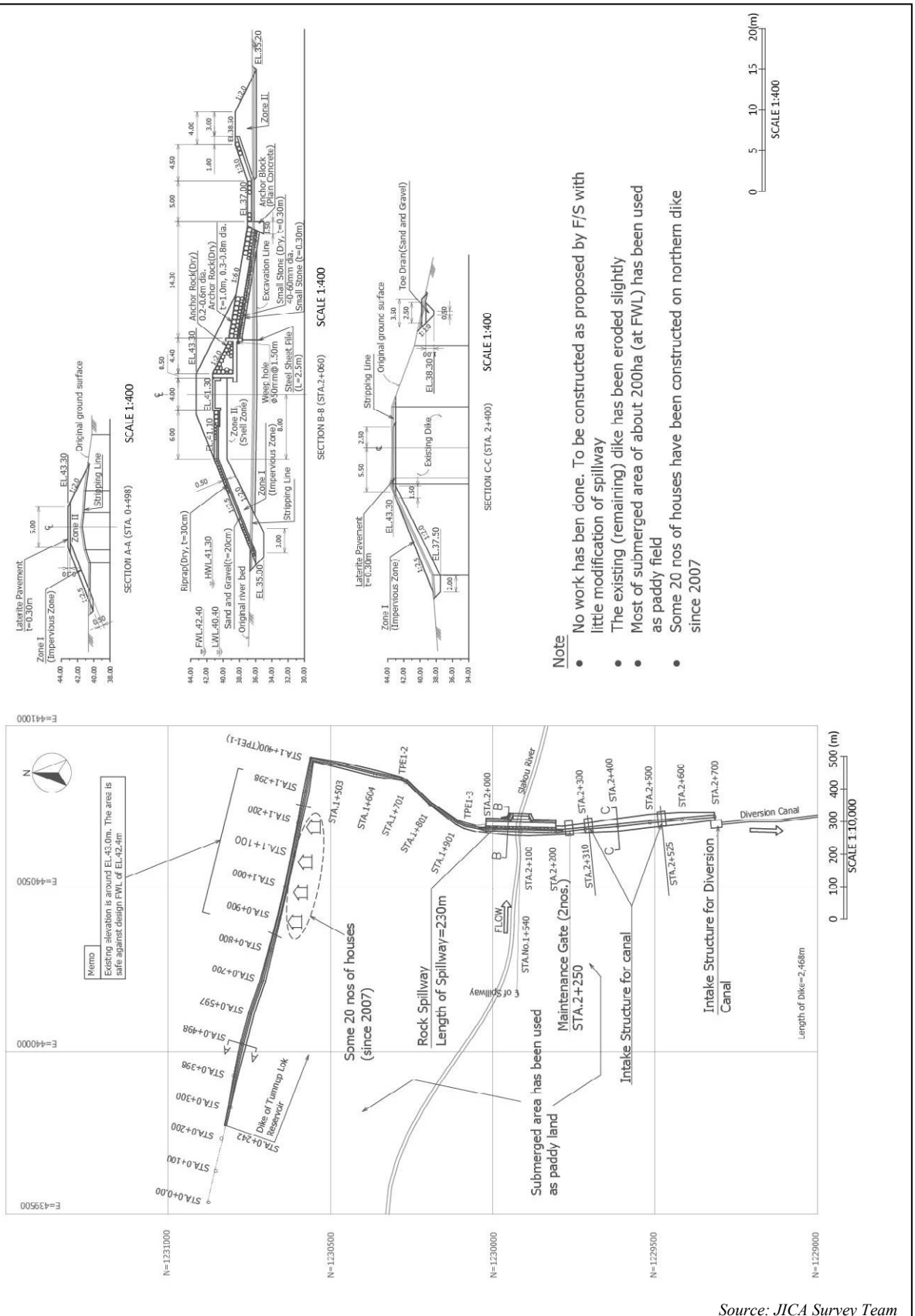
Figure AD-2.1.3.2.2

Implementation Schedule for Hydromechanical Works of Roleang Chrey Headworks



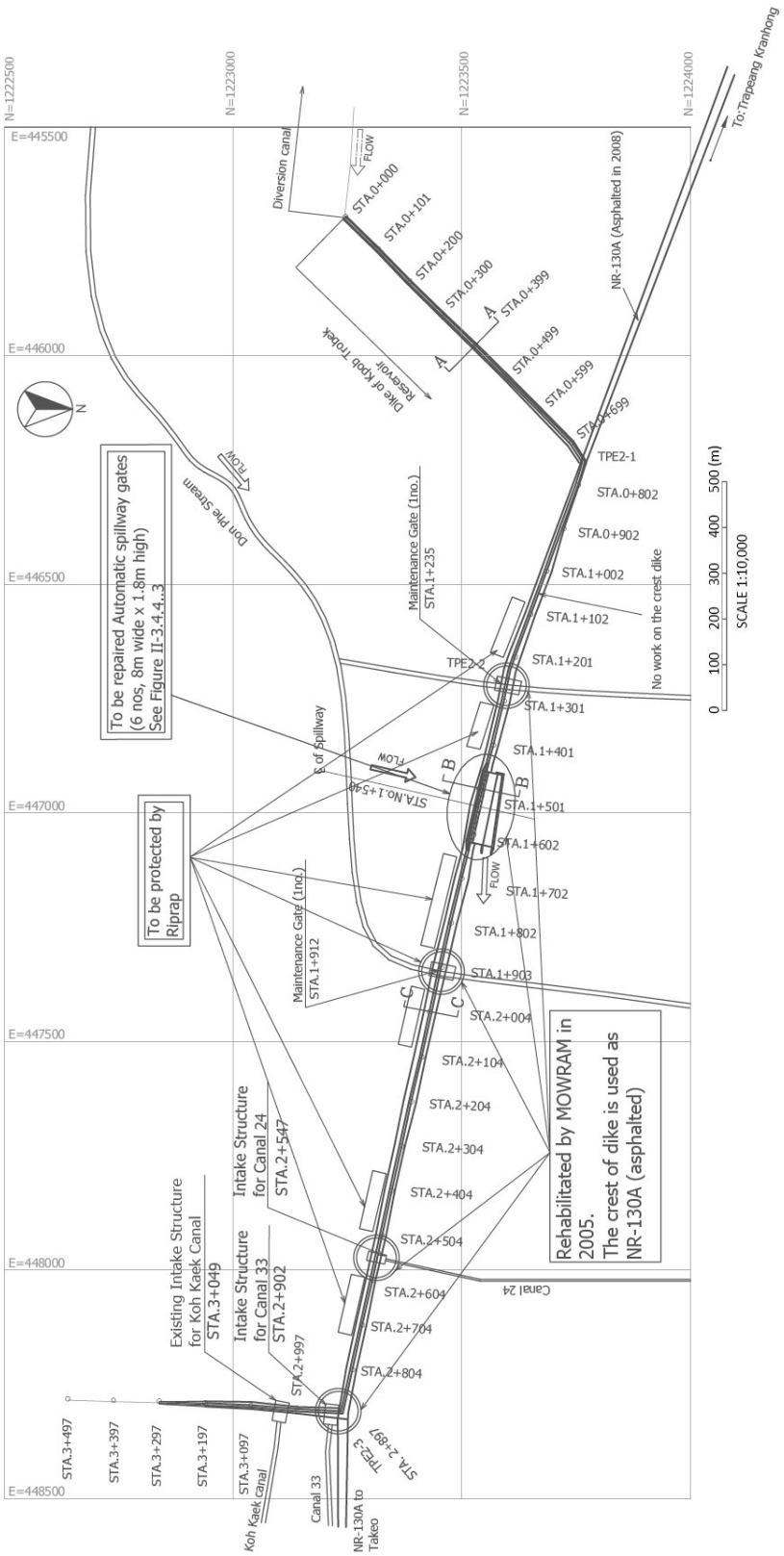
Source: JICA Survey Team

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT	**Figure AD-2.2.1.1.2 General Layout of Upper Slakou Irrigation System Rehabilitation Sub-project**
Japan International Cooperation Agency	



Source: JICA Survey Team

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT	**Figure AD-2.2.1.3.3**
Japan International Cooperation Agency	**General Plan of Tumnup Lok Reservoir**



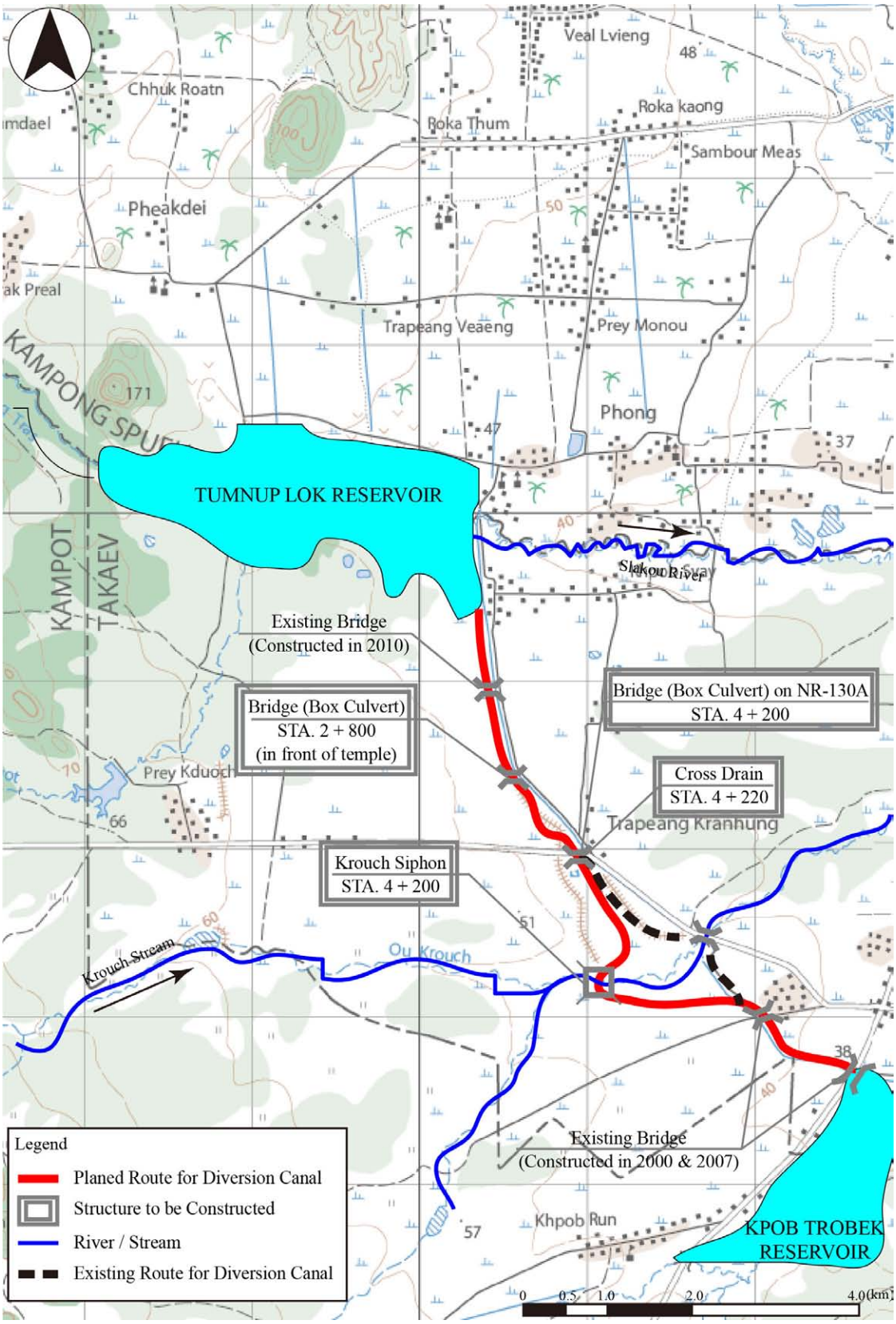
Source: JICA Survey Team

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT

Japan International Cooperation Agency

Figure AD-2.2.1.3.4

General Plan of Kpob Trobek Reservoir



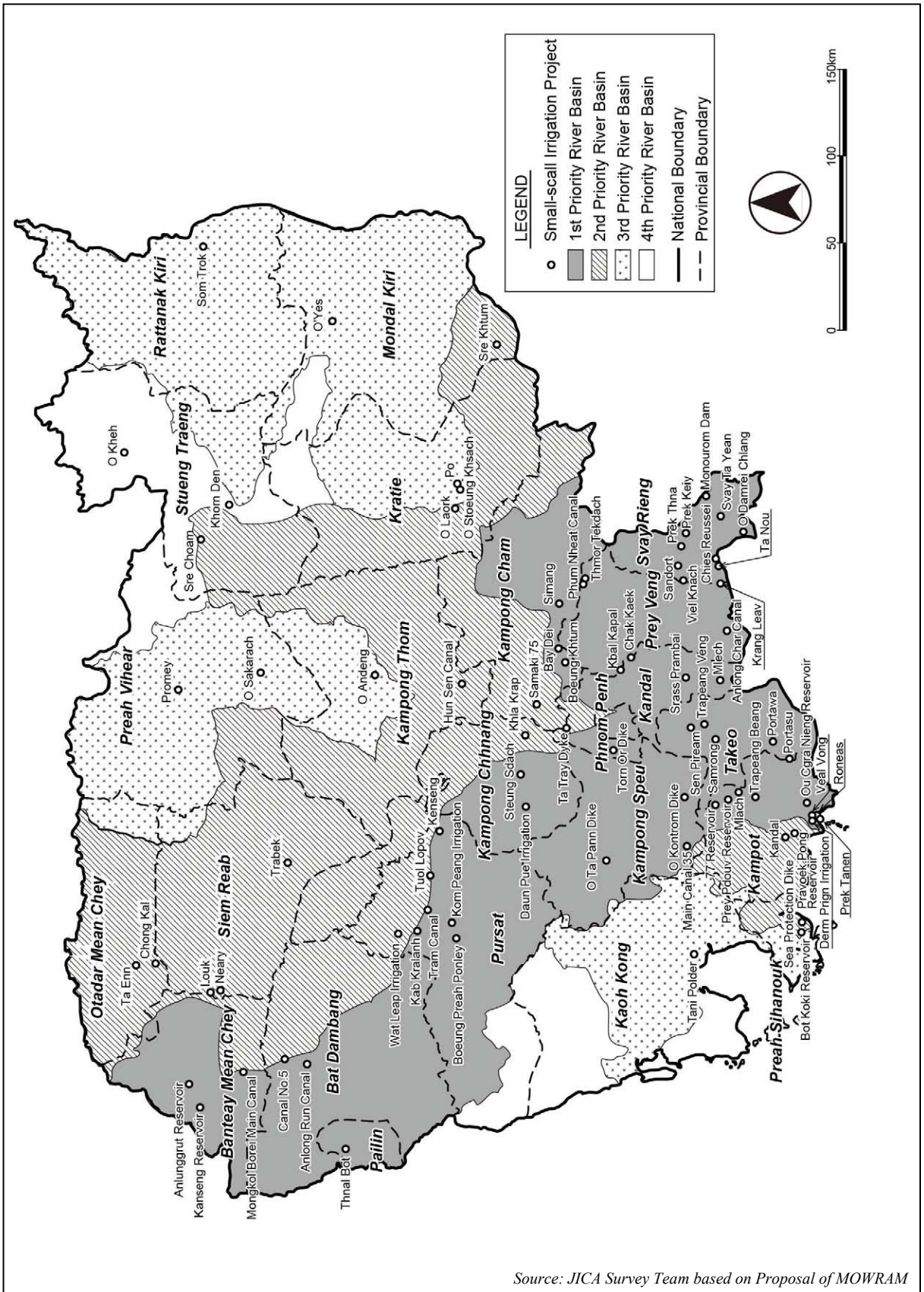
Source: JICA Survey Team

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT

Japan International Cooperation Agency

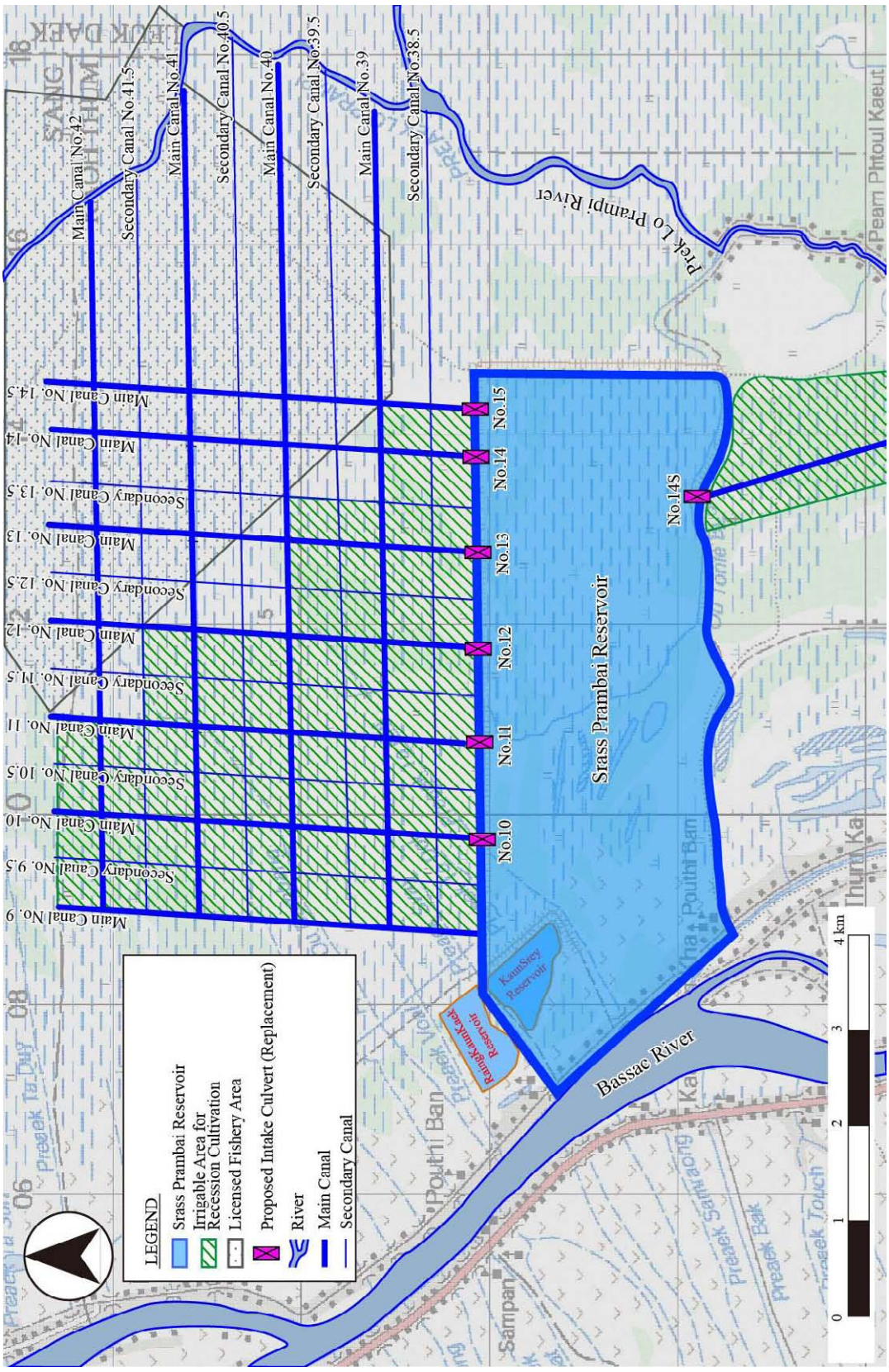
Figure AD-2.2.1.3.5

Layout Plan of Diversion Canal



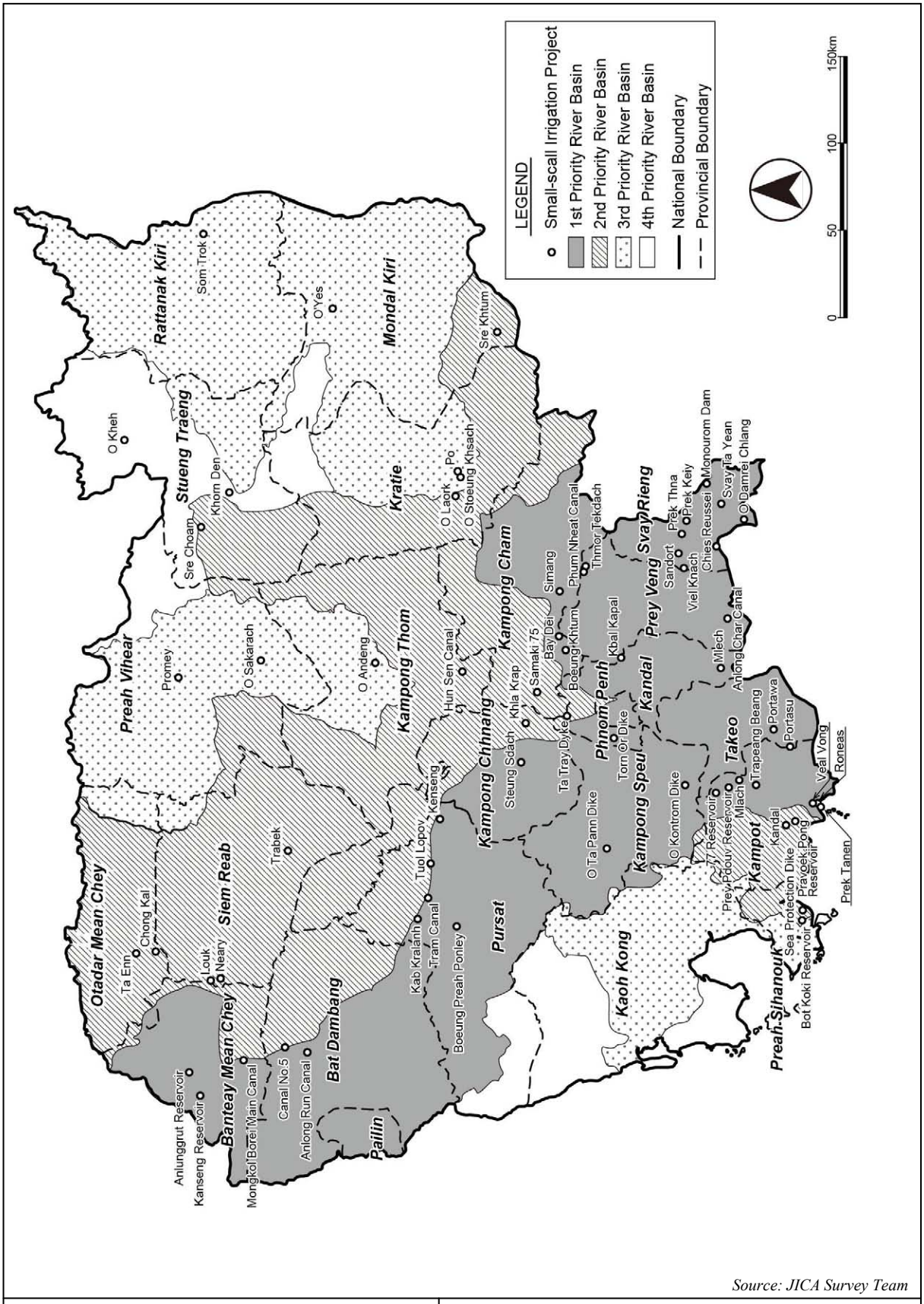
Source: JICA Survey Team based on Proposal of MOWRAM

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project	**Figure AD-2.4.1.1.1**
Japan International Cooperation Agency	**Location Map of 84 Small-scale Irrigation Rehabilitation Projects**



Source: JICA Survey Team based on Proposal of MOWRAM

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project	**Figure AD-2.4.3.1.2**
Japan International Cooperation Agency	**General Layout of Main and Secondary Canals in Srass Prambai Irrigation System**

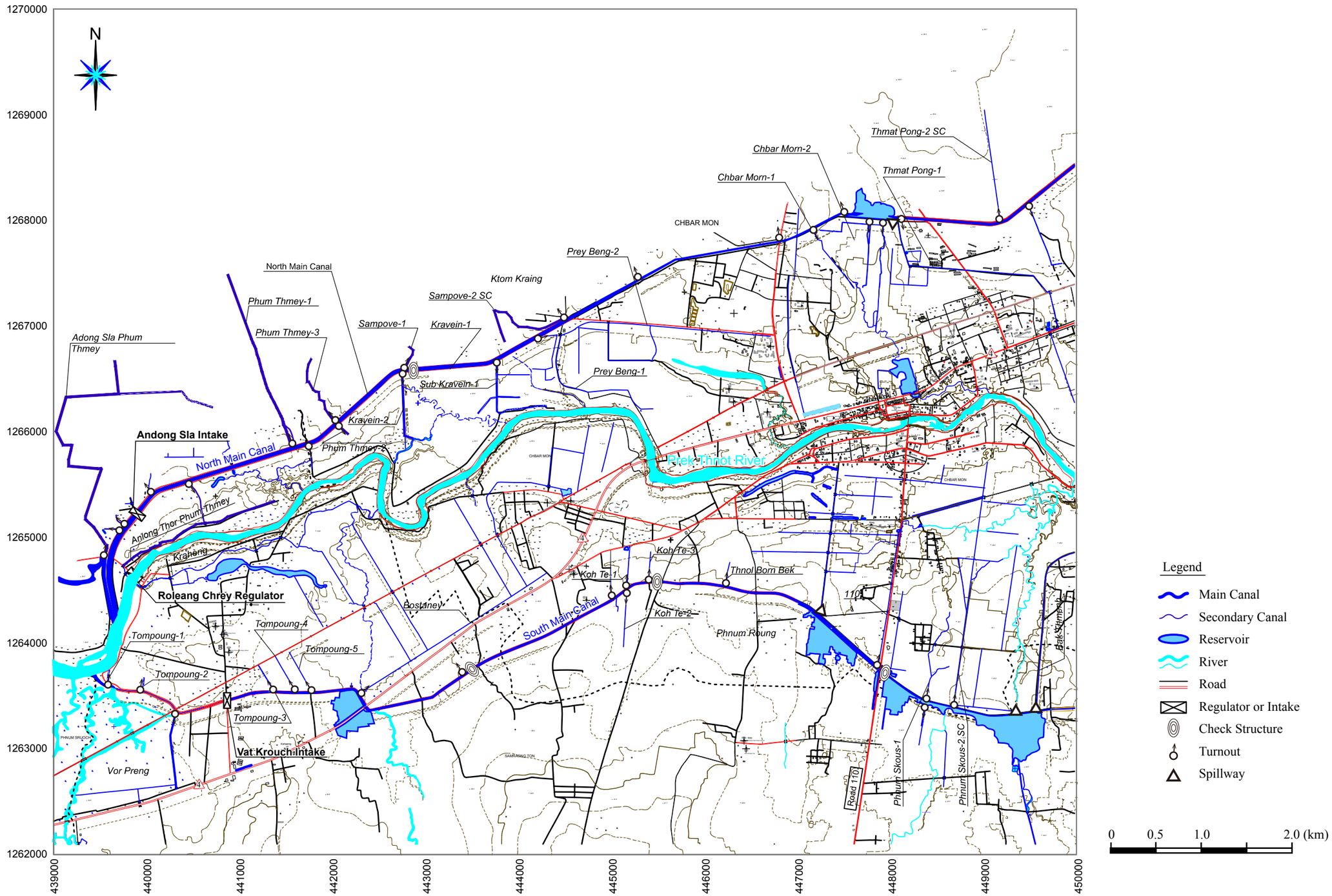


Source: JICA Survey Team

Preparatory Survey for Irrigation and Drainage System Rehabilitation and Improvement Project	**Figure AD-2.4.5.1.1**
Japan International Cooperation Agency	**Location Map of 67 Small-scale Irrigation Rehabilitation Projects in Updated Long List**

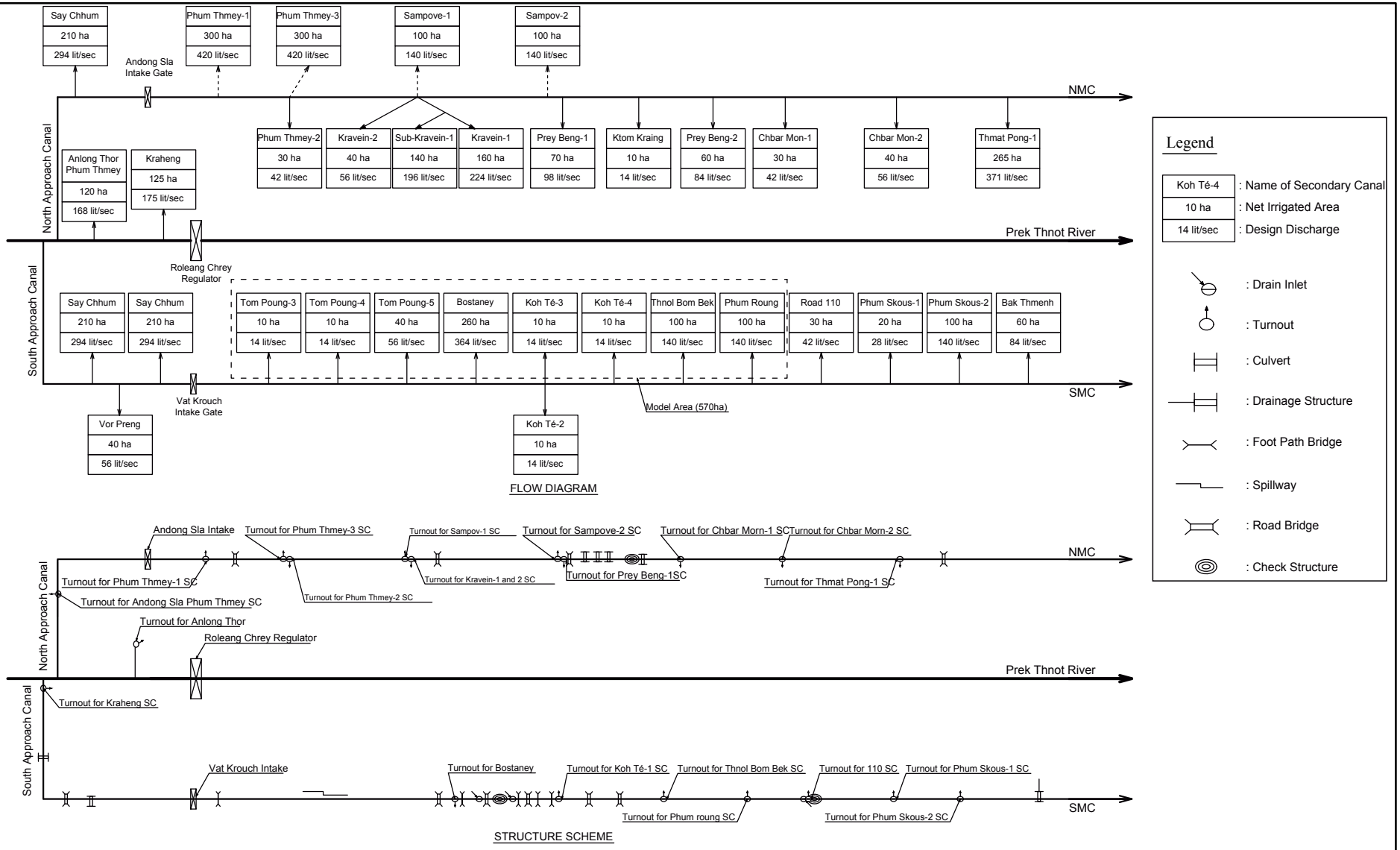
ANNEX D

Drawings



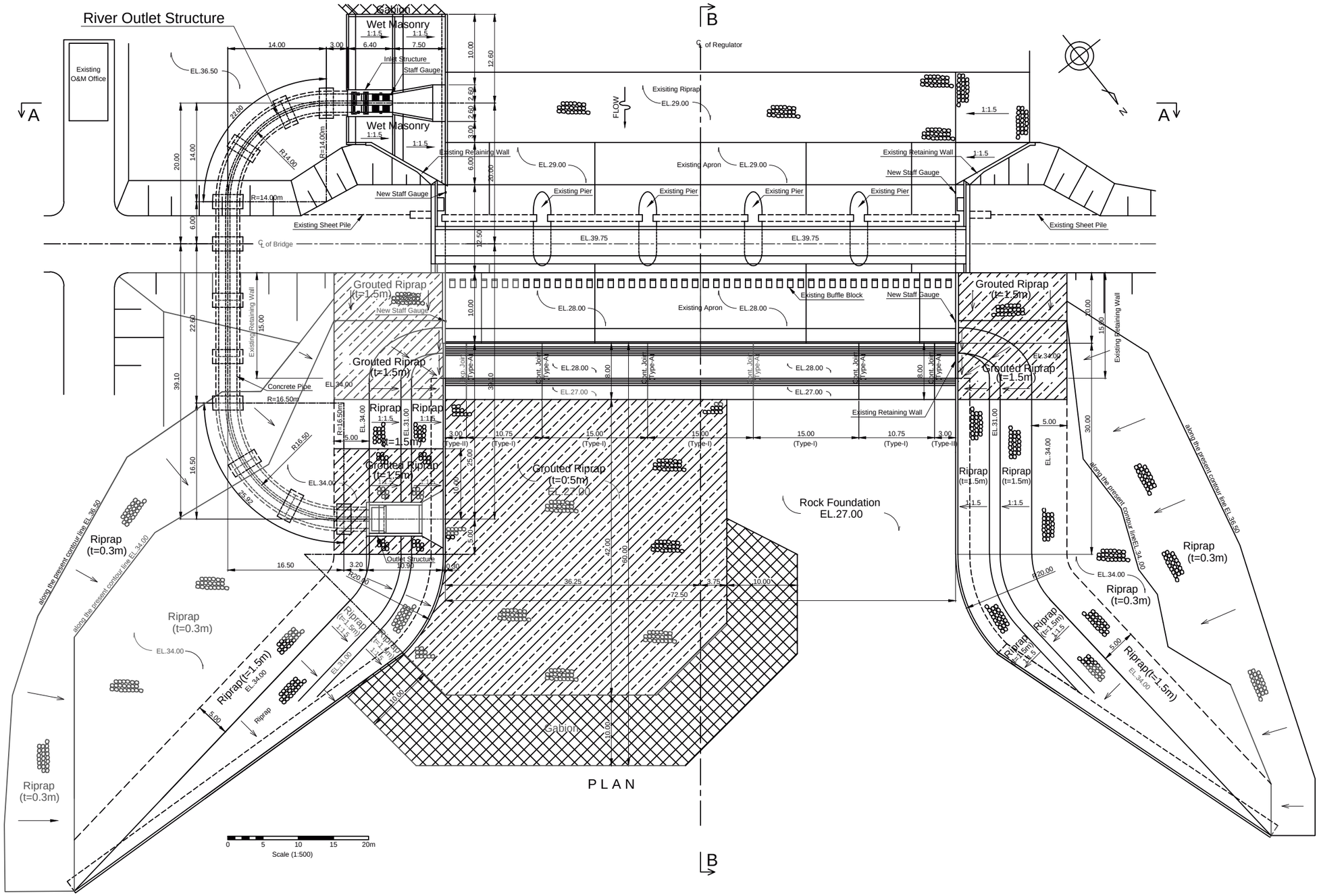
Source: JICA Survey Team

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **General Layout of Roleang Chrey Headworks Rehabilitation Sub-project**	Date: Mar. 2012
Japan International Cooperation Agency **(JICA)**		DWG. No. RCH-01



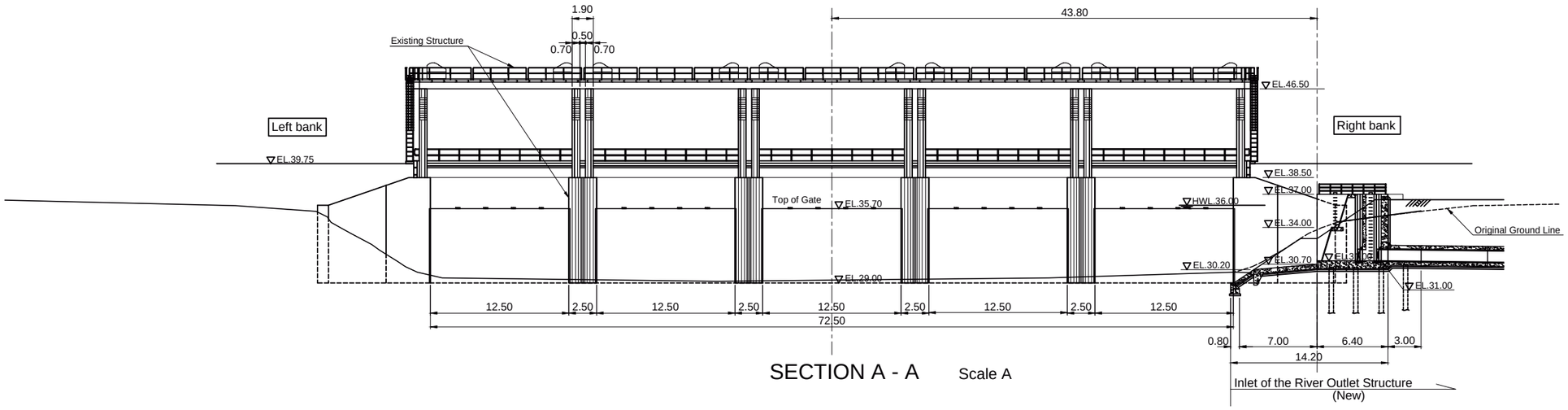
Source: JICA Survey Team

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA Japan International Cooperation Agency **(JICA)**	Title of Drawing **Irrigation Flow Diagram and Structure Scheme of Upstream of NMC and SMC**	Date: Mar. 2012 DWG. No. RCH-02

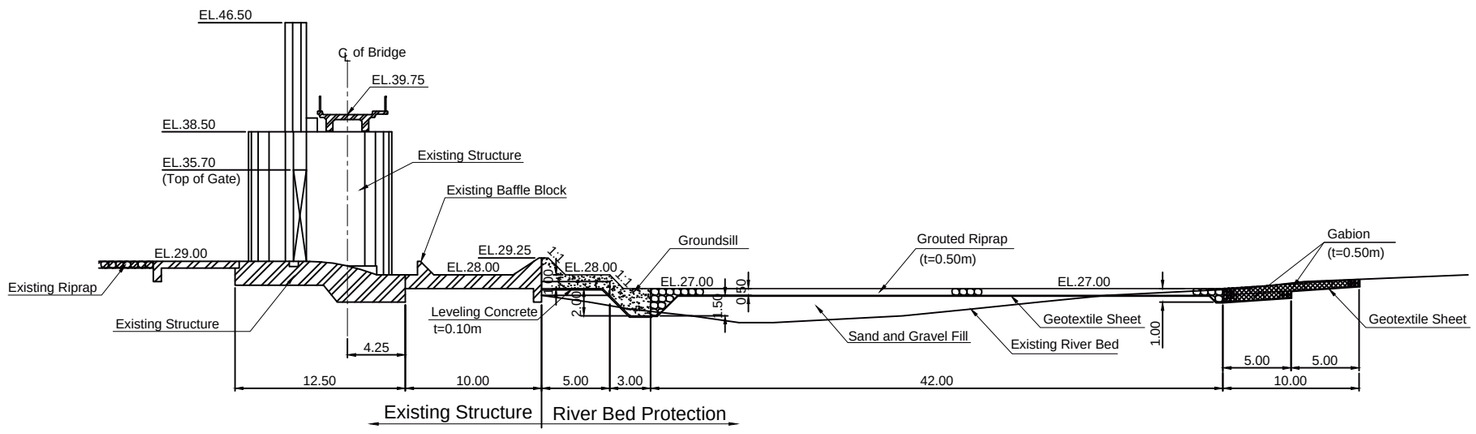


Source : Abstracted from D/D drawings for Japan's Grant Aid Project

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Plan of Roleang Chrey Regulator**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH - 3



SECTION A - A Scale A

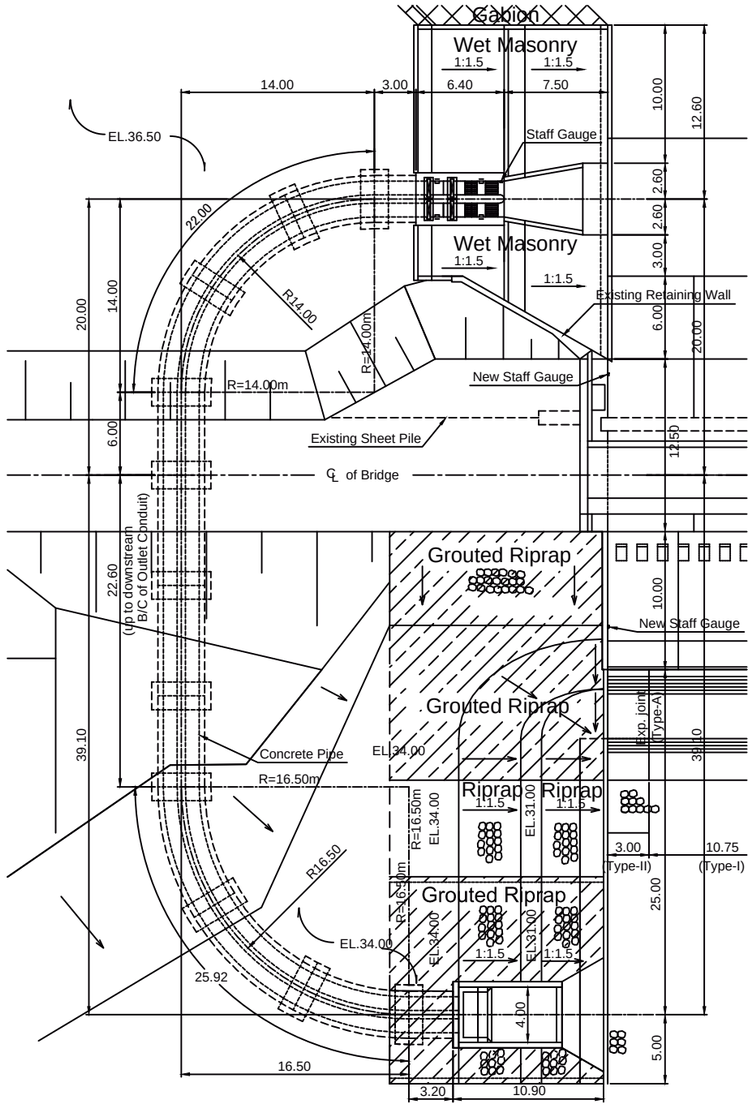


SECTION B - B Scale A

0 5 10 15 20m
Scale A (1:450)

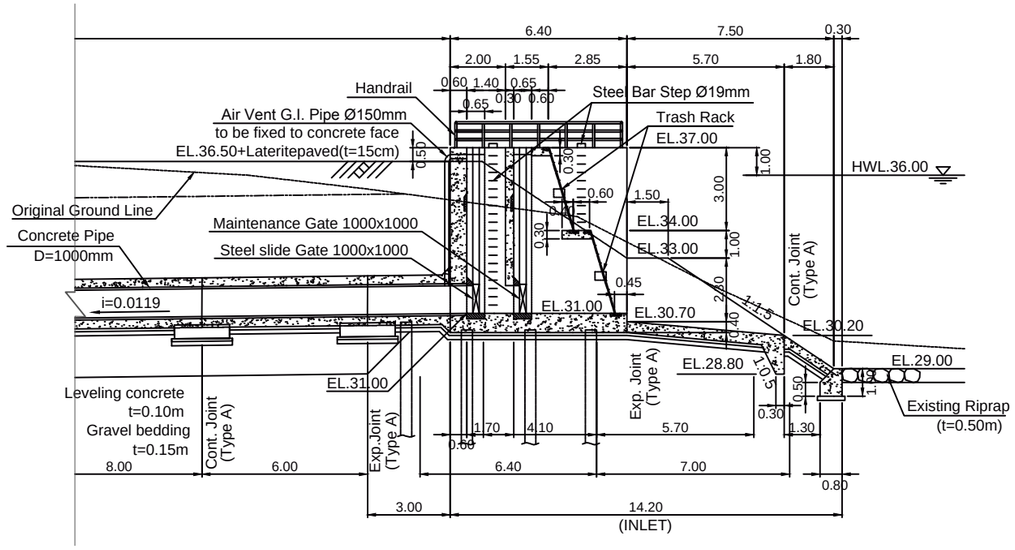
Source : Abstracted from D/D drawings for Japan's Grant Aid Project

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date
	Longitudinal & Cross Section of Roleang Chrey Regulator	Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH - 4



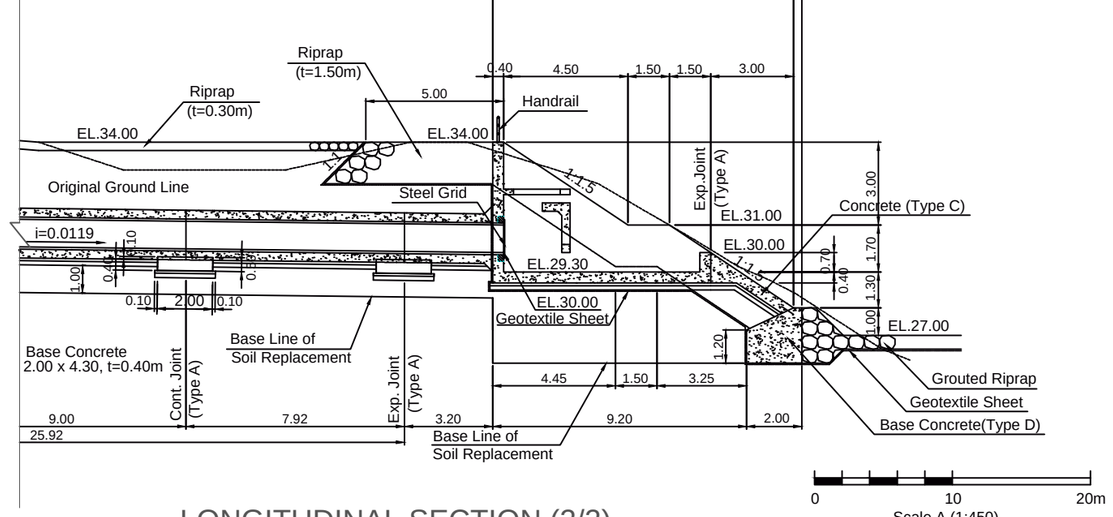
PLAN

Scale A



LONGITUDINAL SECTION (1/2)

Scale B



LONGITUDINAL SECTION (2/2)

Scale B

0 10 20m

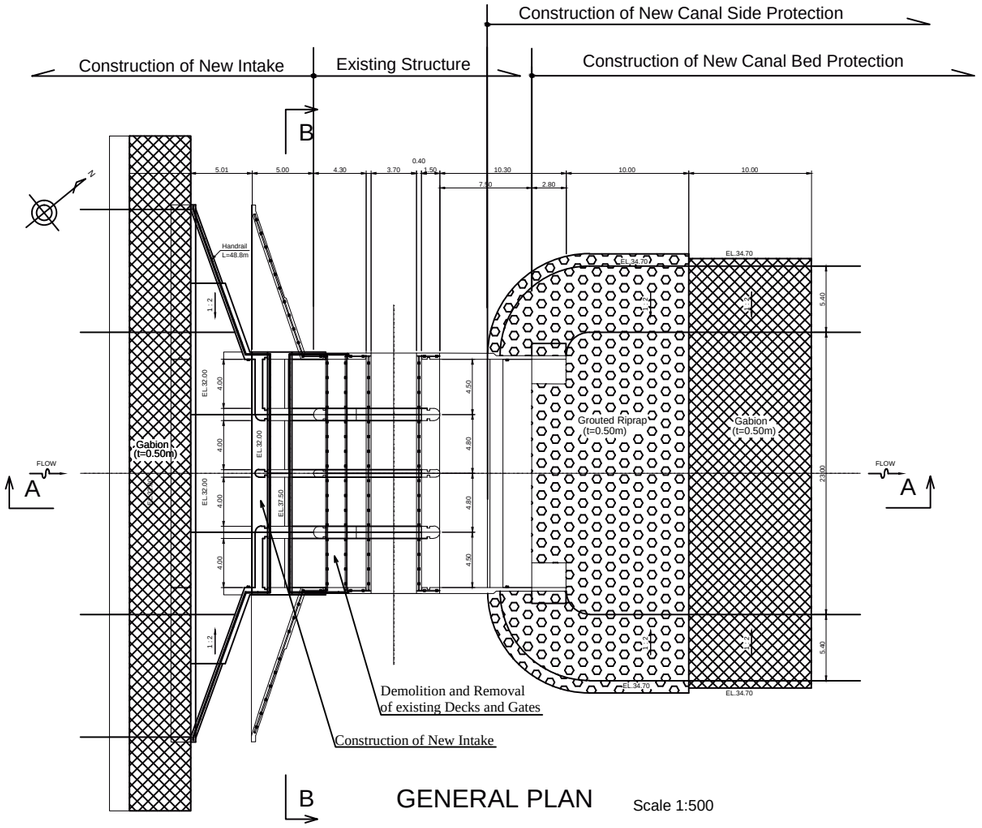
Scale A (1:450)

0 5 10m

Scale B (1:225)

Source : Prepared by JICA Survey Team and abstracted from
D/D drawings for Japan's Grant Aid Project

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date
	Plan and Profile of River Outlet Structure	Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH - 5



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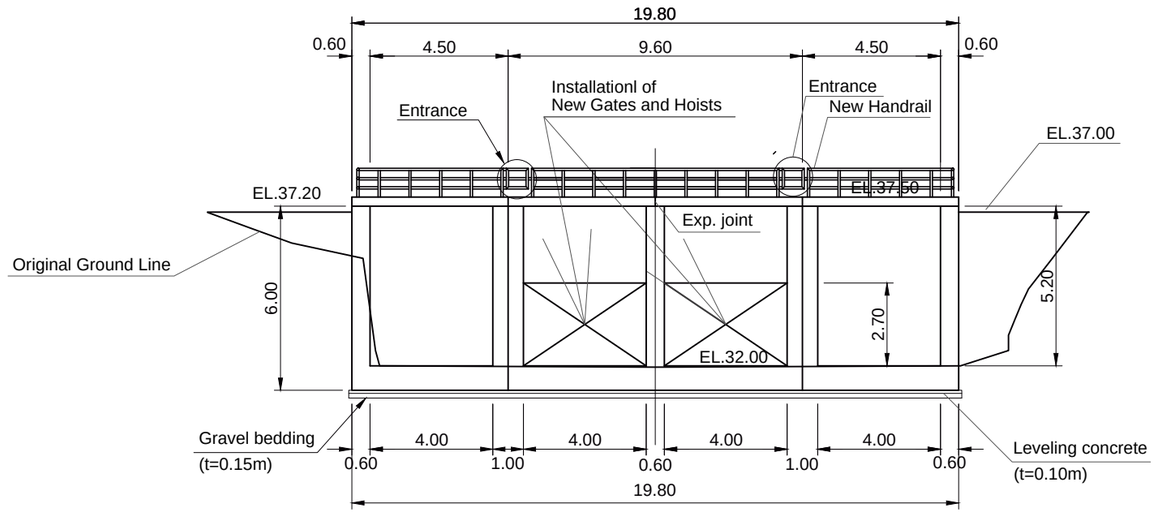
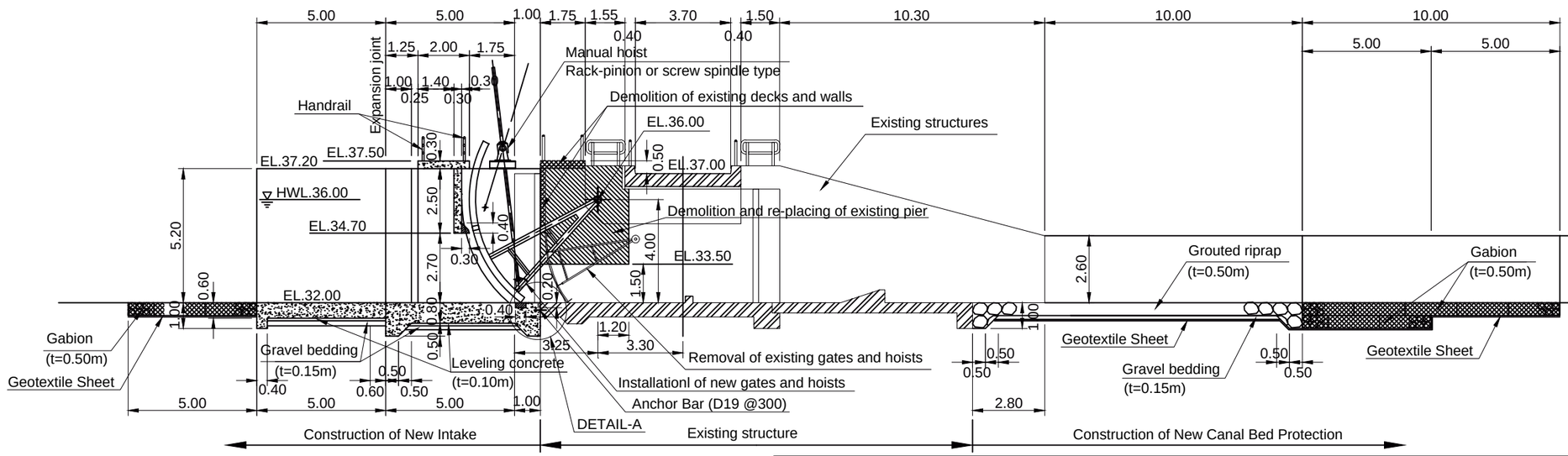


SECTION B - B Scale 1:200



SECTION A - A Scale 1:200

Source: Prepared by JICA Survey Team

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

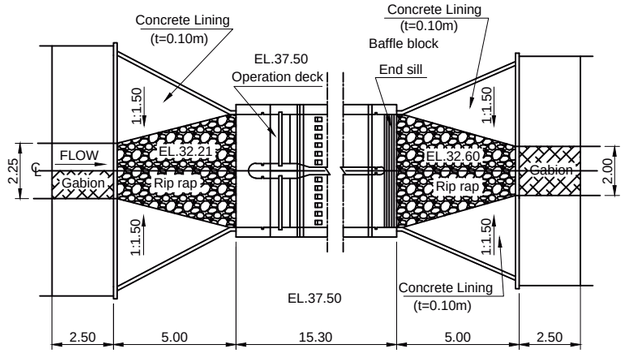
Japan International Cooperation Agency (**JICA**)

Title of Drawing

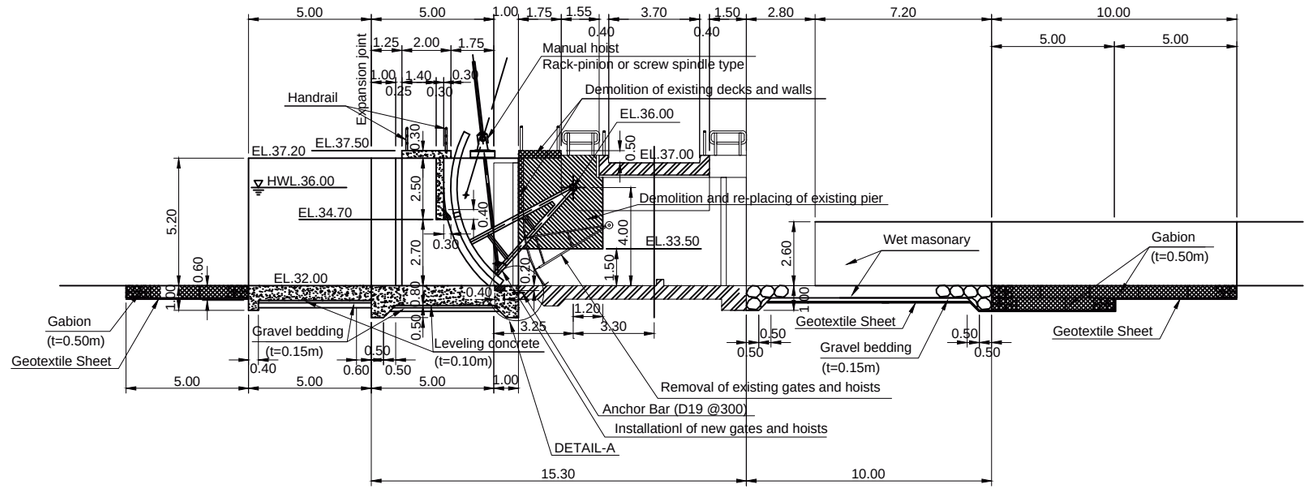
Plan and Section of Andong Sla Intake Structure

Date
Sept. 2011

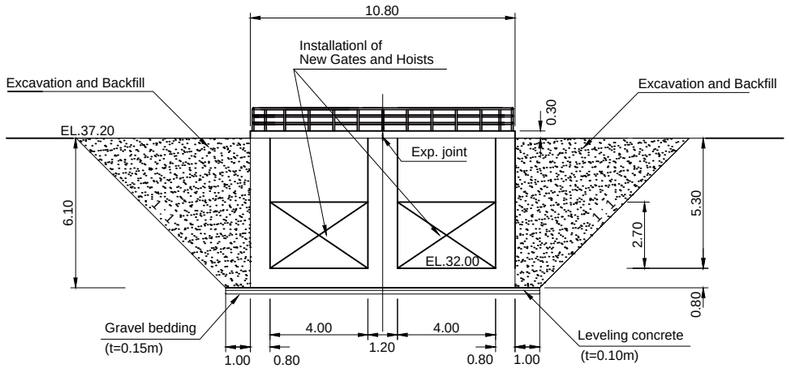
DWG. No.
RCH-6



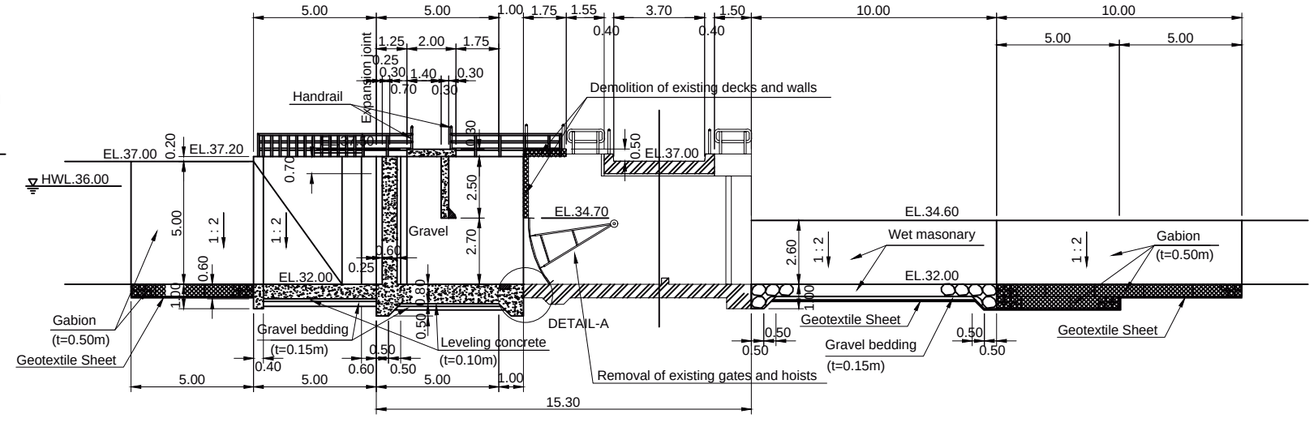
PLAN Scale A



SECTION A - A Scale A



SECTION F - F Scale A



SECTION B - B Scale A

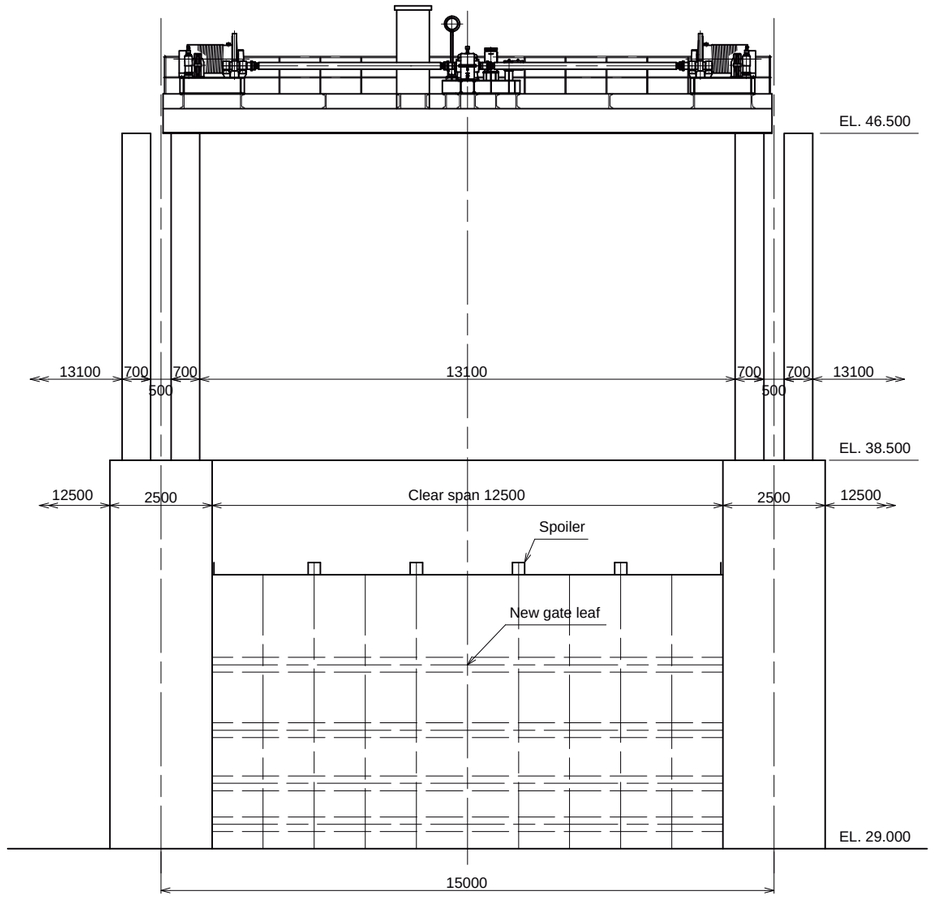
NOTE :
For Grouted Riprap, boulder with a size of 30cm - 50cm shall be used.

0 5 10m

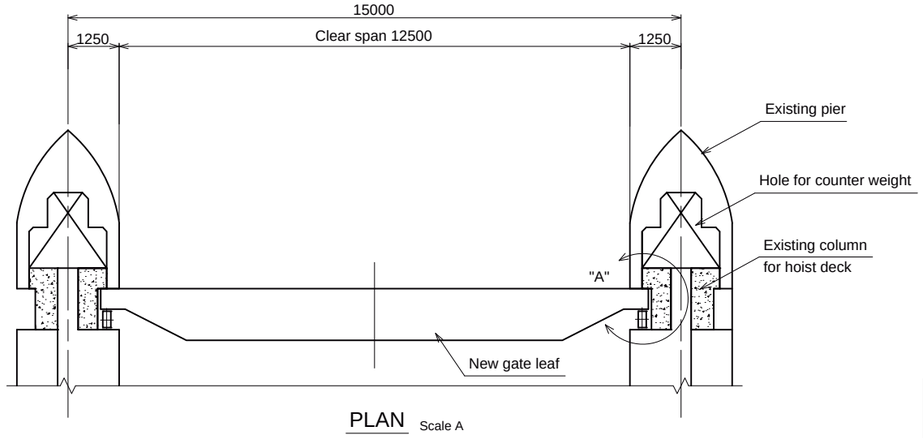
Scale A (1:250)

Source : Prepared by JICA Survey Team and abstracted from D/D drawings for Japan's Grant Aid Project

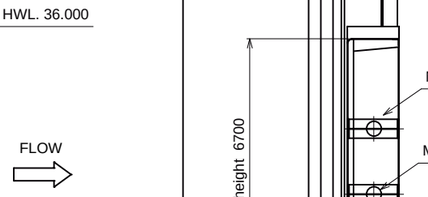
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date
	Plan and Section of Vat Krouch Intake Structure	Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH - 7



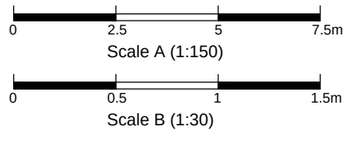
ELEVATION Scale A

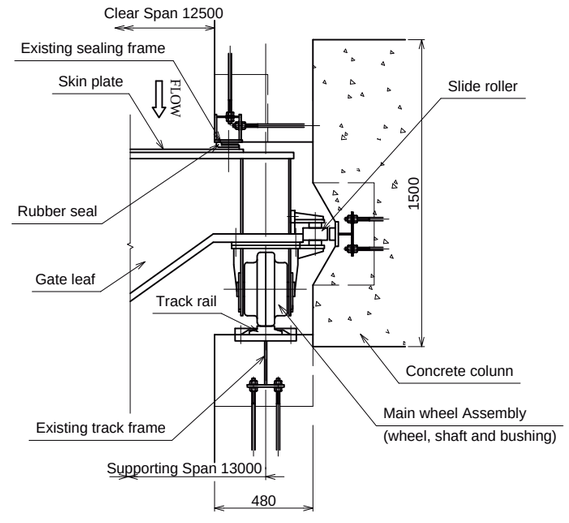


PLAN Scale A



PROFILE Scale A

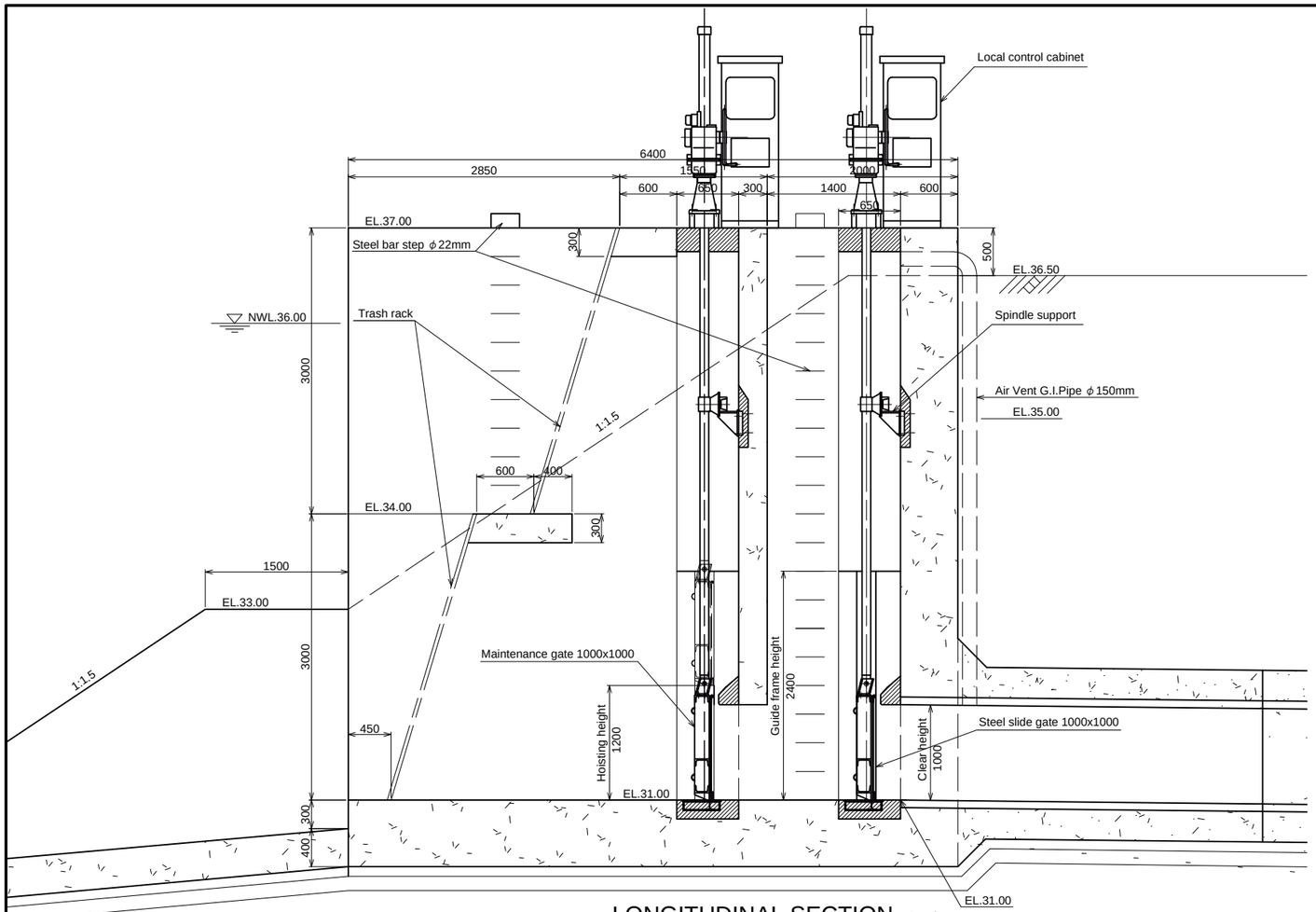




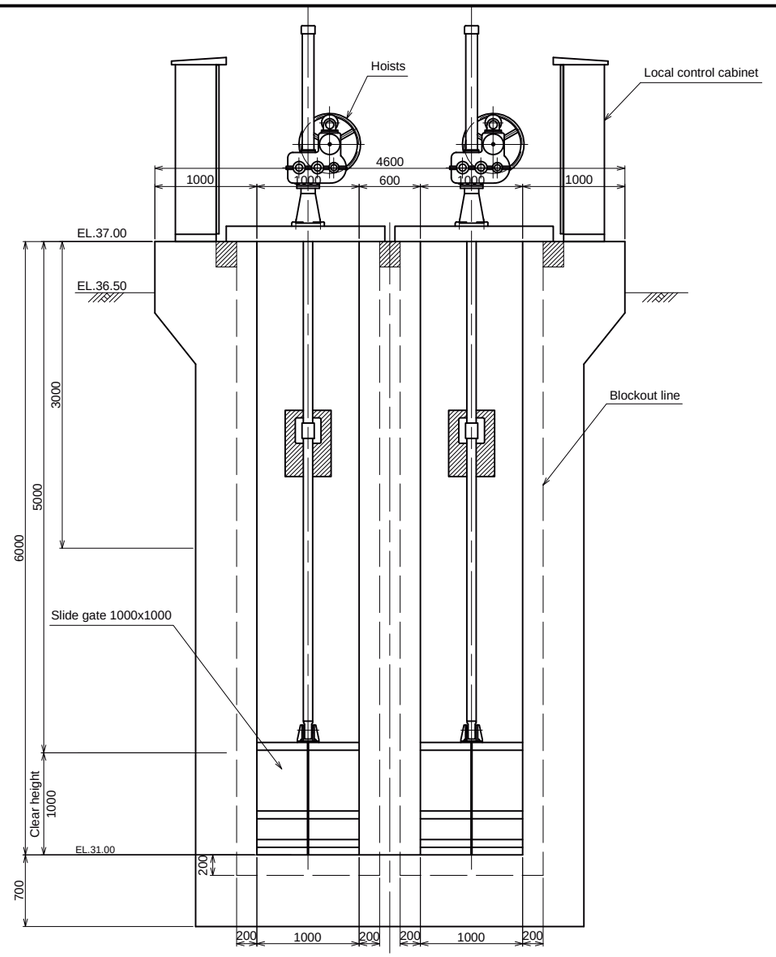
DETAIL "A" Scale B

Source: Prepared by JICA Survey Team and Abstracted from D/D Drawings for Japan's Grant Aid Project

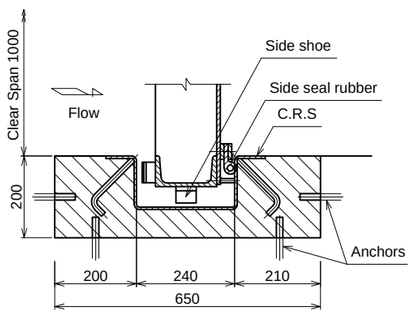
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **General Arrangement of Regulator Gates and Hoists**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH-8



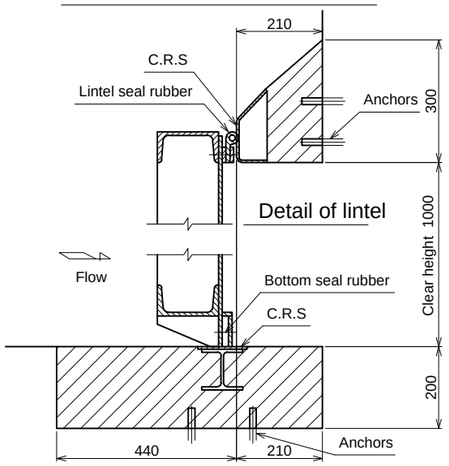
LONGITUDINAL SECTION Scale A



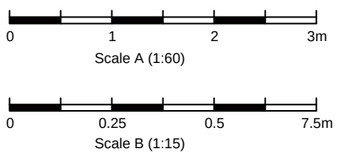
ELEVATION OF INLET Scale A



DETAIL OF SIDE SEAL AND SIDE SHOE Scale B



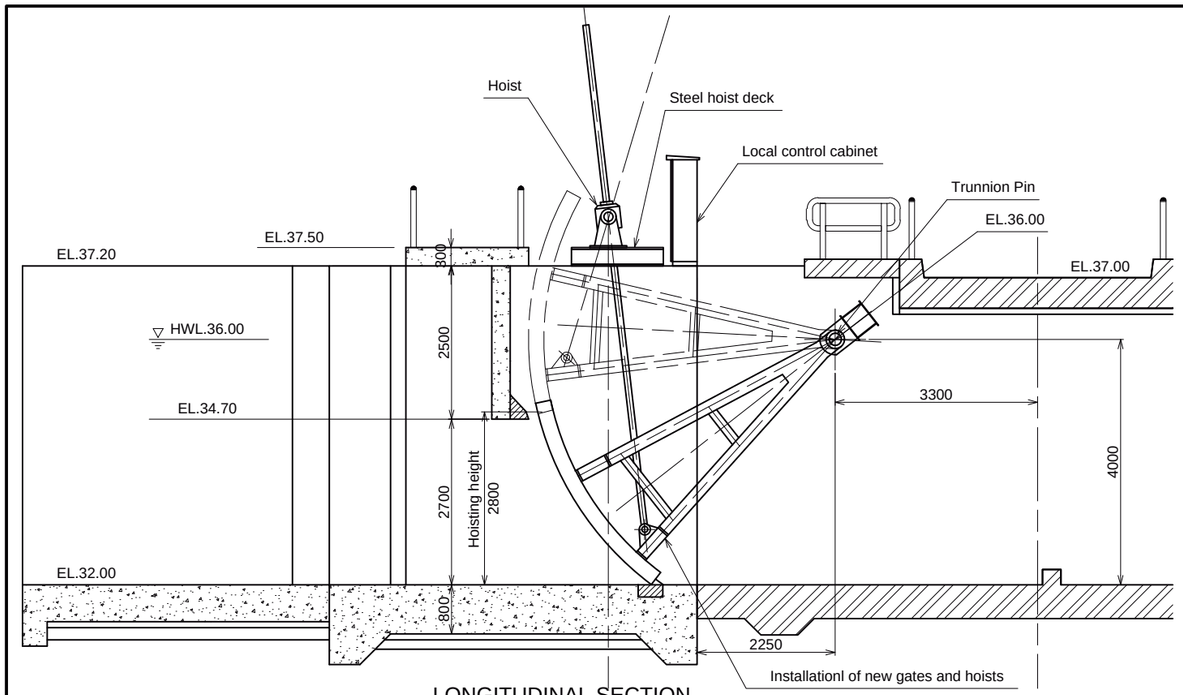
DETAIL OF SILL Scale B



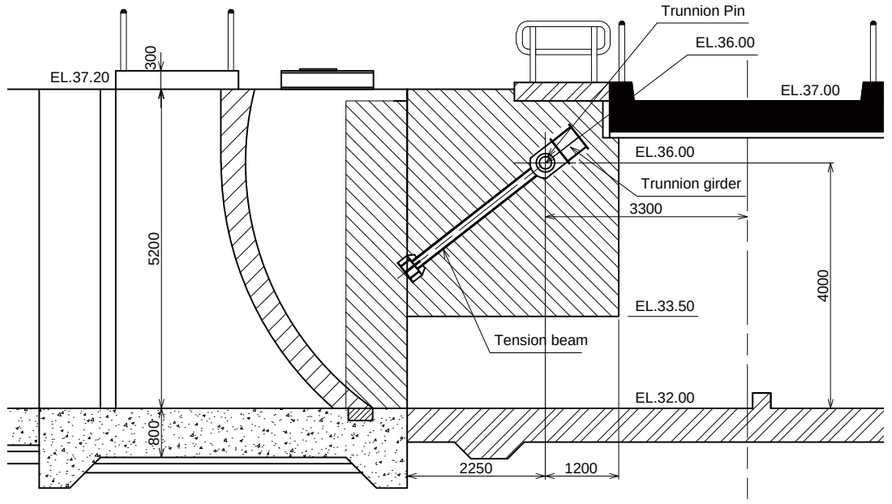
Note
1. C.R.S. means corrosion resisting steel.

Source: Prepared by JICA Survey Team and Abstracted from D/D Drawings for Japan's Grant Aid Project

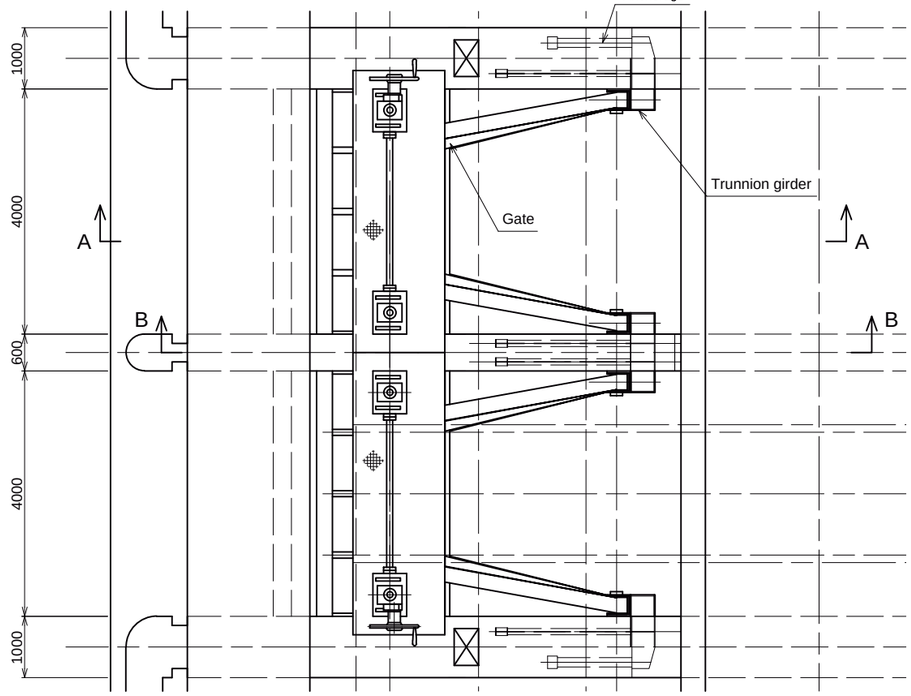
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **River Outlet Gates and Hoists**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH-9



LONGITUDINAL SECTION
SECTION A-A Scale A

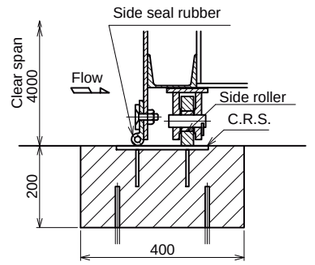


LONGITUDINAL SECTION Scale A

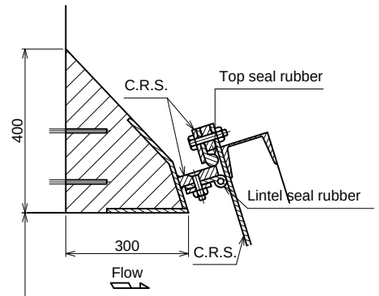


PLAN Scale A

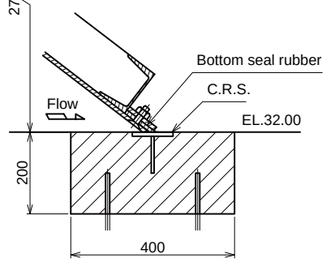
LONGITUDINAL SECTION Scale A
SECTION B-B



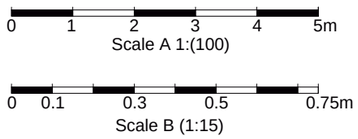
DETAIL OF SIDE SEAL
AND SIDE ROLELR Scale B



DETAIL OF INLET Scale B



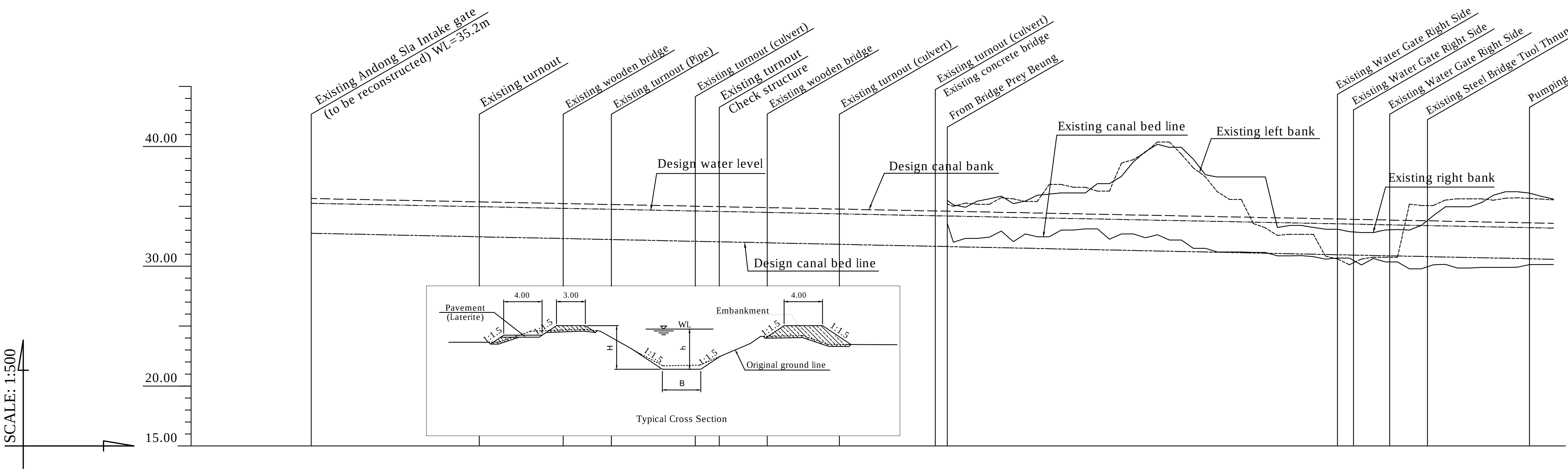
DETAIL OF SILL Scale B



Notes :
1. C.R.S. means corrosion resisting steel.

Source: Prepared by JICA Survey Team and Abstracted from D/D Drawings for Japan's Grant Aid Project

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Intake Gate and Hoists**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH-10



Design

Canal Bank elevation (m)	Water surface (m)	Canal bed elevation (m)
35.65	35.25	32.75
35.64	35.24	32.74
35.62	35.22	32.72
35.60	35.20	32.70
35.58	35.18	32.68
35.56	35.16	32.66
35.54	35.14	32.64
35.52	35.12	32.62
35.50	35.10	32.60
35.48	35.08	32.58
35.46	35.06	32.56
35.44	35.04	32.54
35.42	35.02	32.52
35.40	35.00	32.50
35.38	34.98	32.48
35.36	34.96	32.46
35.34	34.94	32.44
35.32	34.92	32.42
35.30	34.90	32.40
35.28	34.88	32.38
35.26	34.86	32.36
35.24	34.84	32.34
35.22	34.82	32.32
35.20	34.80	32.30
35.18	34.78	32.28
35.16	34.76	32.26
35.14	34.74	32.24
35.12	34.72	32.22
35.10	34.70	32.20
35.08	34.68	32.18
35.06	34.66	32.16
35.04	34.64	32.14
35.02	34.62	32.12
35.00	34.60	32.00
34.98	34.58	31.98
34.96	34.56	31.96
34.94	34.54	31.94
34.92	34.52	31.92
34.90	34.50	31.90
34.88	34.48	31.88
34.86	34.46	31.86
34.84	34.44	31.84
34.82	34.42	31.82
34.80	34.40	31.80
34.78	34.38	31.78
34.76	34.36	31.76
34.74	34.34	31.74
34.72	34.32	31.72
34.70	34.30	31.70
34.68	34.28	31.68
34.66	34.26	31.66
34.64	34.24	31.64
34.62	34.22	31.62
34.60	34.20	31.60
34.58	34.18	31.58
34.56	34.16	31.56
34.54	34.14	31.54
34.52	34.12	31.52
34.50	34.10	31.50
34.48	34.08	31.48
34.46	34.06	31.46
34.44	34.04	31.44
34.42	34.02	31.42
34.40	34.00	31.40
34.38	33.98	31.38
34.36	33.96	31.36
34.34	33.94	31.34
34.32	33.92	31.32
34.30	33.90	31.30
34.28	33.88	31.28
34.26	33.86	31.26
34.24	33.84	31.24
34.22	33.82	31.22
34.20	33.80	31.20
34.18	33.78	31.18
34.16	33.76	31.16
34.14	33.74	31.14
34.12	33.72	31.12
34.10	33.70	31.10
34.08	33.68	31.08
34.06	33.66	31.06
34.04	33.64	31.04
34.02	33.62	31.02
34.00	33.60	31.00
33.98	33.58	30.98
33.96	33.56	30.96
33.94	33.54	30.94
33.92	33.52	30.92
33.90	33.50	30.90
33.88	33.48	30.88
33.86	33.46	30.86
33.84	33.44	30.84
33.82	33.42	30.82
33.80	33.40	30.80
33.78	33.38	30.78
33.76	33.36	30.76
33.74	33.34	30.74
33.72	33.32	30.72
33.70	33.30	30.70
33.68	33.28	30.68
33.66	33.26	30.66
33.64	33.24	30.64
33.62	33.22	30.62
33.60	33.20	30.60
33.58	33.18	30.58

Station No.	Accumulated distance (m)	Distance (m)	Existing Right bank elevation (m)	Existing Left bank elevation (m)	Existing Canal bed elevation (m)
No.0					
+800	0,000	800			
No.1	0,200	200			
+800	1,000	800			
No.2	1,200	200			
+200	1,400	200			
+800	2,000	600			
No.3	2,200	200			
+800	3,000	800			
No.4	3,200	200			
+200	3,400	200			
+800	4,000	600			
No.5	4,200	200			
+800	5,000	800			
No.6	5,200	200			
P0	5,250	050	35.49	35.18	33.58
P1	5,350	100	34.85	34.10	32.01
P2	5,450	100	35.32	35.27	32.33
P3	5,550	100	35.74	35.32	32.66
P4	5,650	100	36.13	35.17	32.43
P5	5,750	100	35.86	35.72	32.93
P6	5,850	100	35.76	35.62	32.06
P7	5,950	100	35.38	35.45	32.93
P8	6,050	100	35.83	35.41	32.70
P9	6,150	100	36.21	36.83	32.46
P10	6,250	100	35.07	36.08	33.06
P11	6,350	100	35.35	36.77	33.02
P12	6,450	100	35.61	36.59	33.13
P13	6,550	100	35.33	36.27	32.81
P14	6,650	100	36.90	36.81	32.27
P15	6,750	100	37.72	38.61	32.64
P16	6,850	100	37.37	38.18	32.69
P17	6,950	100	37.63	38.90	32.38
P18	7,050	100	38.66	39.51	32.63
P19	7,150	100	39.02	40.36	32.40
P20	7,250	100	37.74	39.35	32.19
P21	7,350	100	37.38	38.20	31.54
P22	7,450	100	35.91	37.45	31.49
P23	7,550	100	35.69	36.22	31.20
P24	7,650	100	34.74	35.57	31.38
P25	7,750	100	35.14	35.31	31.28
P26	7,850	100	32.71	33.56	31.25
P27	7,950	100	32.65	33.31	31.16
P28	8,050	100	32.57	33.21	31.21
P29	8,150	100	32.09	32.57	30.87
P30	8,250	100	31.91	32.66	30.88
P31	8,350	100	31.73	32.61	30.89
P32	8,450	100	31.03	30.84	30.80
P33	8,550	100	30.74	30.61	30.60
P34	8,650	100	30.86	30.65	30.69
P35	8,750	100	30.32	30.13	30.11
P36	8,850	100	30.80	30.60	30.65
P37	8,950	100	30.84	30.74	30.66
P38	9,050	100	32.02	32.65	30.37
P39	9,150	100	33.16	34.00	30.81
P40	9,250	100	34.03	34.45	29.79
P41	9,350	100	33.94	35.18	30.16
P42	9,450	100	33.89	35.07	30.12
P43	9,550	100	34.27	35.52	30.17
P44	9,650	100	33.97	35.53	29.86
P45	9,750	100	33.99	35.63	29.90
P46	9,850	100	33.99	35.42	29.97
P47	9,950	100	34.12	35.51	30.12
P48	10,050	100	33.98	35.68	29.93
P49	10,150	100	34.03	35.72	30.14
P50	10,250	100	33.66	35.25	29.66
P51	10,350	100	33.79	35.54	29.94

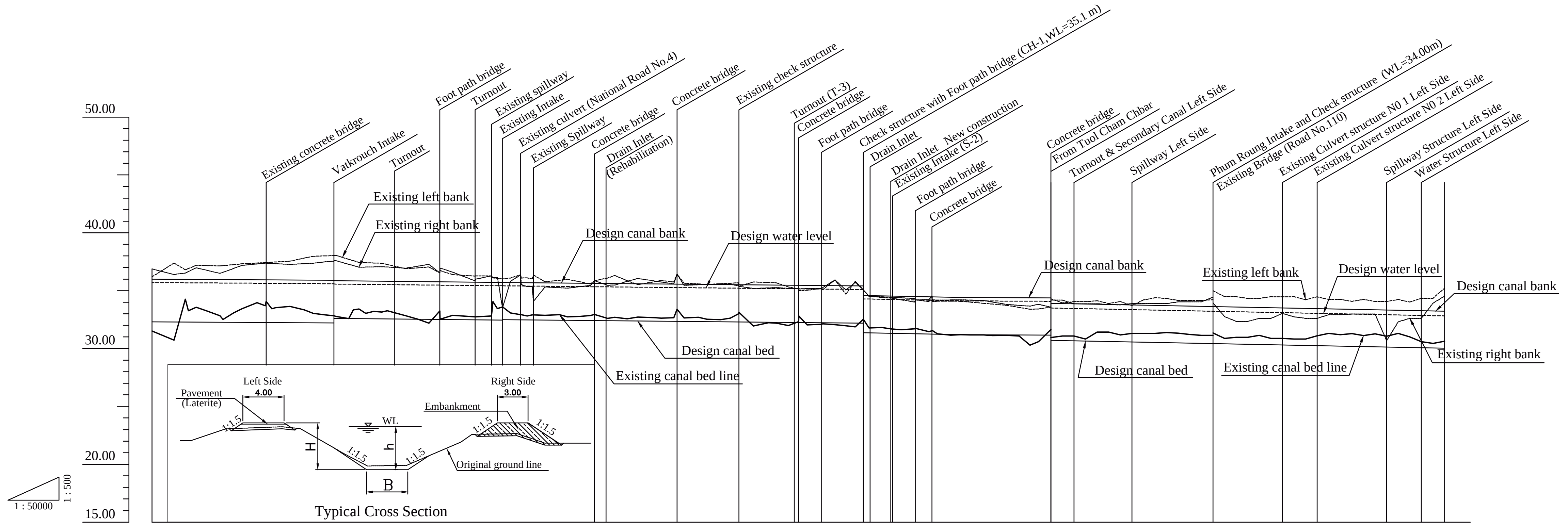
PROFILE

Dimension

Q :Design discharge (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 verticeal) m=1.50

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date: Sept. 2011
Japan International Cooperation Agency (**JICA**)	**Longitudinal Profile of NMC (Upstream)**	DWG. No.: RCH-11



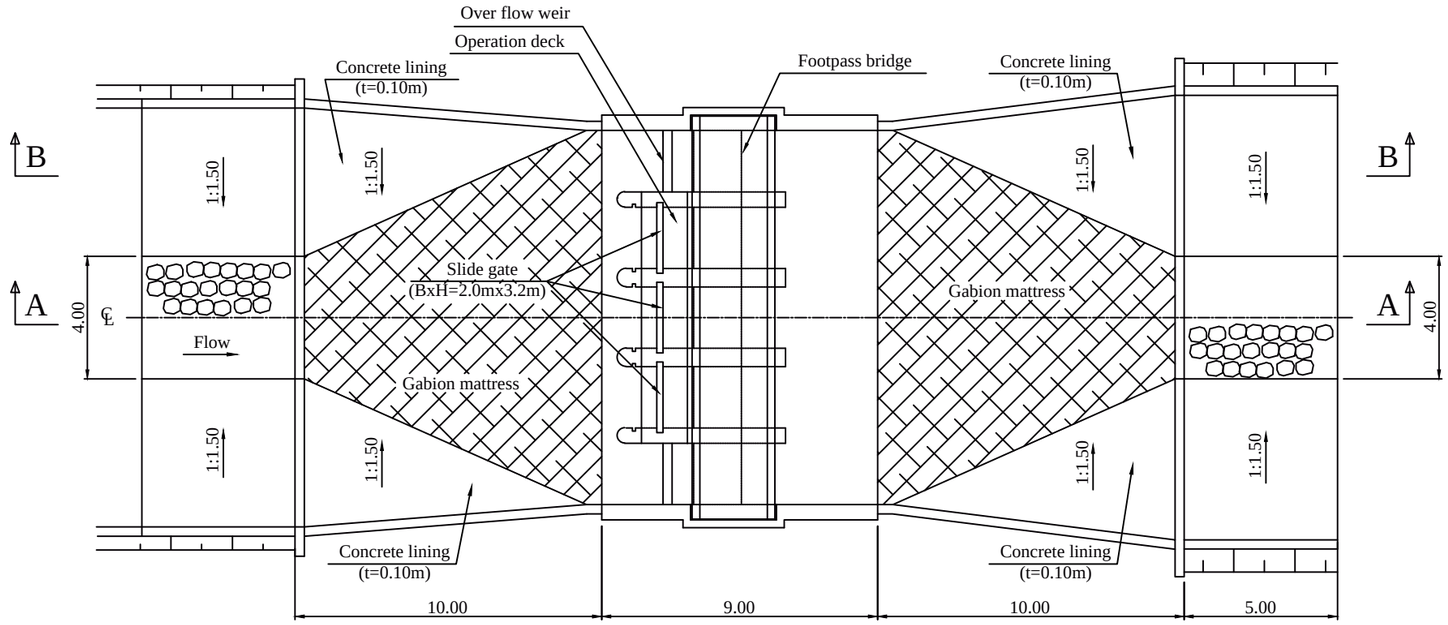
Station No.	Distance (m)	Accumulated distance (m)	Design: Canal Bank elevation (m)	Design: Water surface (m)	Design: Canal bed elevation (m)	Existing: Right bank elevation (m)	Existing: Left bank elevation (m)	Existing: Canal bed elevation (m)
NO.0	0.00		36.00	35.70	32.31	36.88	36.20	31.51
+286.892	286.89					36.53	36.80	34.27
+613.182	326.29					36.60	37.16	32.51
+985.123	371.94		35.95	35.65	32.26	37.38	37.43	34.08
NO.1	14.88		35.95	35.65	32.26			
+314.496	314.50					37.33	37.81	33.35
+569.255	254.76	0.00	35.90	35.60	32.21	37.55	38.02	32.83
+737.395	168.14	168.14	35.87	35.57	32.60	37.17	37.59	33.34
NO.2	262.60	430.74						
+94.206	94.21	524.95	35.82	35.52	32.55			
+484.633	390.43	915.38	35.78	35.48	32.51	36.54	36.54	33.25
+790	305.37	1220.75	35.75	35.45	32.48	35.85	36.26	32.73
+929.702	139.70	1360.45	35.74	35.44	32.48	36.28	36.28	32.81
NO.3	70.30	1430.75	35.73	35.43	32.47			
+25.00	25.00	1455.75	35.72	35.42	32.46	33.59	36.02	33.59
+181.965	156.96	1612.71	35.70	35.40	32.48	36.37	36.37	32.93
+293.112	111.15	1723.86	35.69	35.39	32.47	34.07	36.35	32.90
+517.757	224.64	1948.5				35.25	35.91	32.93
+820.517	302.76	2251.76	35.64	35.34	32.42	35.86	35.86	32.95
+920	99.48	2350.74						
NO.4	80.00	2430.74	35.62	35.32	32.40			
+194.651	194.65	2625.39				36.05	35.53	32.72
+533.055	338.40	2963.79	35.57	35.27	32.35	36.42	36.42	33.41
+791.484	258.43	3222.22				35.55	35.54	32.52
NO.5	208.52	3430.74	35.52	35.22	32.30			
+64.37	64.37	3495.11				35.421	35.68	33.00
+545	480.63	3975.74	35.47	35.17	32.25			
+584.205	39.20	4014.94	35.36	35.16	32.24	35.158	35.16	32.33
+778.572	194.37	4209.31	35.44	35.14	32.22	35.200	35.20	32.10
NO.6	221.43	4430.74	35.42	35.12	32.20			
+142.765	142.76	4573.5	35.40	35.10	32.18	35.06	35.06	32.53
+191.337	48.57	4622.07	34.62	34.32	31.40	34.52	34.51	31.78
+394.402	203.06	4825.13	34.60	34.30	31.38	34.43	34.35	31.68
+594.481	200.08	5025.21	34.58	34.28	31.37	34.20	34.20	31.75
+735.698	141.22	5166.43	34.56	34.26	31.35	34.55	34.07	31.54
NO.7	264.30	5430.73	34.54	34.24	31.33			
+182.539	182.54	5613.27				34.15	33.90	31.17
+580.777	398.24	6011.51				33.66	33.40	30.29
+761.737	197.26	6208.77	34.46	34.16	31.25	33.58	33.58	31.65
P0	180.96	6389.73	33.90	33.50	30.70	34.18	34.29	30.95
P1	100.00	6489.73	33.88	33.48	30.68	34.00	33.94	31.08
P2	100.00	6589.73	33.86	33.46	30.66	33.88	33.95	31.02
P3	100.00	6689.73	33.84	33.44	30.64	33.90	34.05	30.82
P4	100.00	6789.73	33.82	33.42	30.62	33.93	34.12	31.42
P5	100.00	6889.73	33.80	33.40	30.60	33.93	33.89	31.50
P6	100.00	6989.73	33.78	33.38	30.58	33.79	34.06	31.45
P7	100.00	7089.73	33.76	33.36	30.56	33.77	33.72	31.17
P8	100.00	7189.73	33.74	33.34	30.54	33.88	34.35	31.30
P9	100.00	7289.73	33.72	33.32	30.52	34.02	34.20	31.34
P10	100.00	7389.73	33.70	33.30	30.50	34.06	34.40	31.35
P11	100.00	7489.73	33.68	33.28	30.48	34.08	34.33	31.40
P12	100.00	7589.73	33.66	33.26	30.46	34.03	34.15	31.32
P13	100.00	7689.73	33.64	33.24	30.44	34.13	34.22	31.22
P14	100.00	7789.73	33.62	33.22	30.42	34.44	34.22	31.14
P0			33.62	33.22	30.42	33.95	35.00	31.34
P1	100.00	7889.73	33.60	33.20	30.40	32.76	34.55	30.88
P2	100.00	7989.73	33.58	33.18	30.38	32.37	34.48	30.91
P3	100.00	8089.73	33.56	33.16	30.36	32.35	34.35	30.97
P4	100.00	8189.73	33.54	33.14	30.34	32.48	34.33	31.13
P5	100.00	8289.73	33.52	33.12	30.32	32.60	34.51	30.79
P6	100.00	8389.73	33.50	33.10	30.30	32.83	34.48	30.88
P7	100.00	8489.73	33.48	33.08	30.28	33.04	34.46	30.83
P8	100.00	8589.73	33.46	33.06	30.26	32.74	34.48	30.83
P9	100.00	8689.73	33.44	33.04	30.24	32.61	34.22	31.10
P10	100.00	8789.73	33.42	33.02	30.22	32.92	34.47	31.31
P11	100.00	8889.73	33.40	33.00	30.20	32.98	34.24	31.20
P12	100.00	8989.73	33.38	32.98	30.18	32.97	34.08	31.30
P13	100.00	9089.73	33.36	32.96	30.16	32.05	34.21	31.12
P14	100.00	9189.73	33.34	32.94	30.14	30.07	34.24	31.27
P15	100.00	9289.73	33.32	32.92	30.12	30.68	34.07	31.07
P16	100.00	9389.73	33.30	32.90	30.10	32.01	34.23	31.30
P17	100.00	9489.73	33.28	32.88	30.08	32.31	34.22	31.01
P18	100.00	9589.73	33.26	32.86	30.06	32.61	34.01	30.60
P19	100.00	9689.73	33.24	32.84	30.04	33.92	34.34	30.44
P20	100.00	9789.73	33.22	32.82	30.02	34.52	35.21	30.64

PROFILE

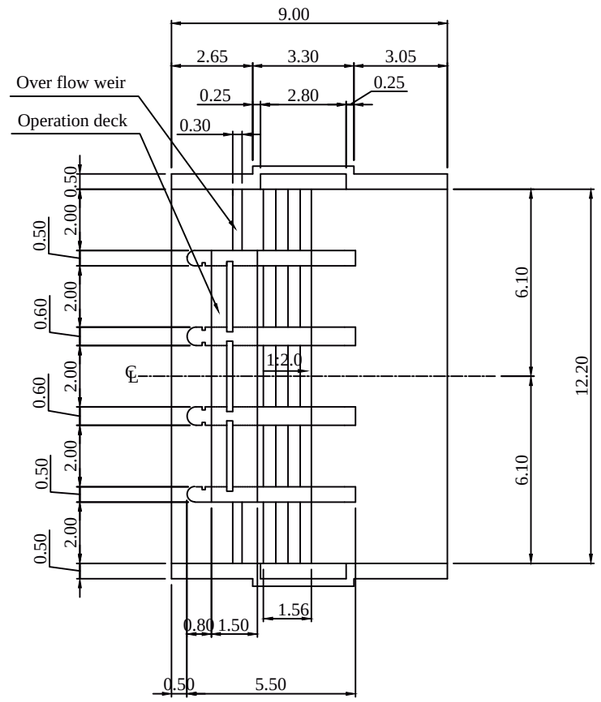
Dimensions
Q=Design discharge (m^3/sec)
i=Canal bed gradient
h=Design water depth (m)
V=Flow velocity (m/sec)
B=Width of canal bed (m)
H=Height of canal (m)
Canal slope (horizontal to vertical) m=1.50

Source : Prepared by JICA Survey Team

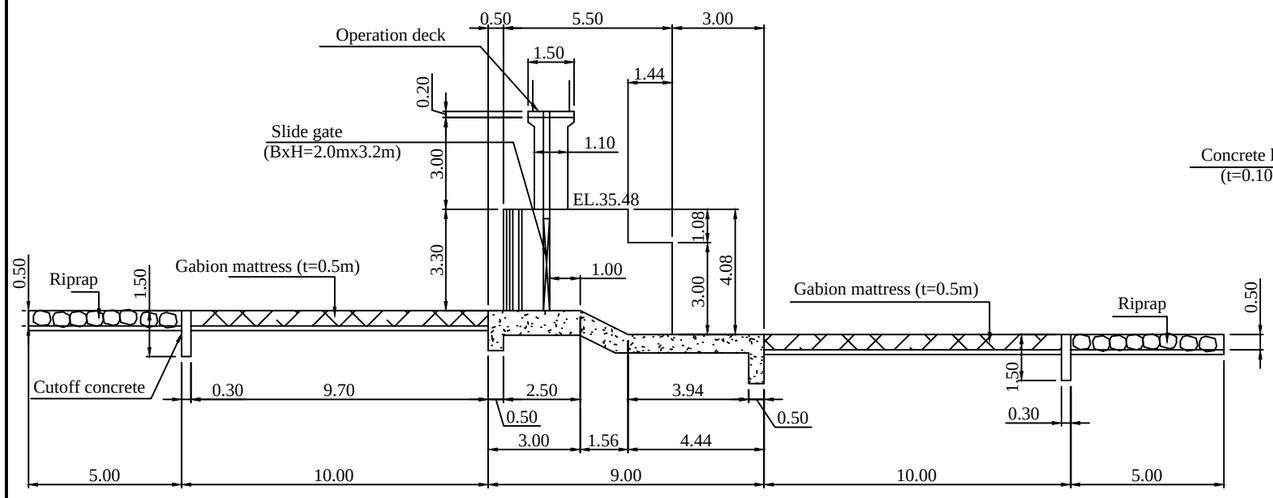
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date: Sept. 2011
Japan International Cooperation Agency (**JICA**)	**Longitudinal Profile of SMC (Upstream)**	DWG. No.: RCH - 12



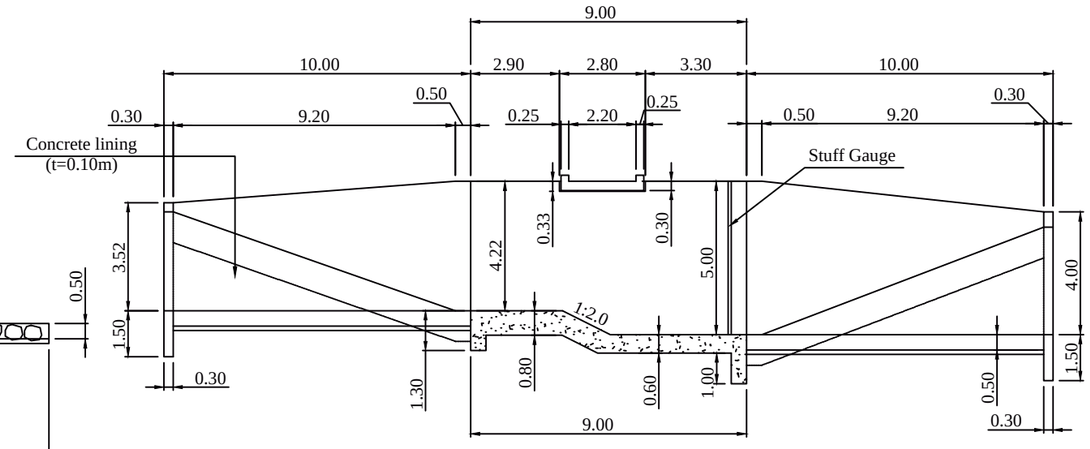
PLAN



PLAN



SECTION A-A



SECTION B-B

0 5 10

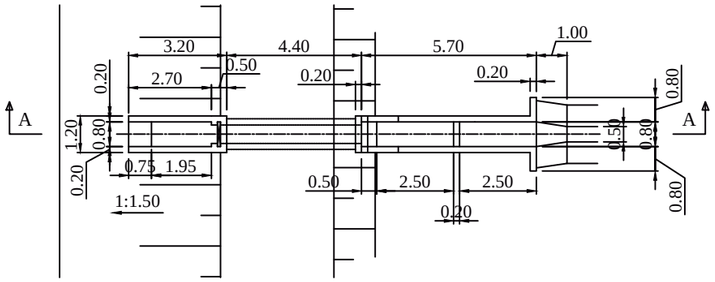
Scale 5:1

Source: The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008

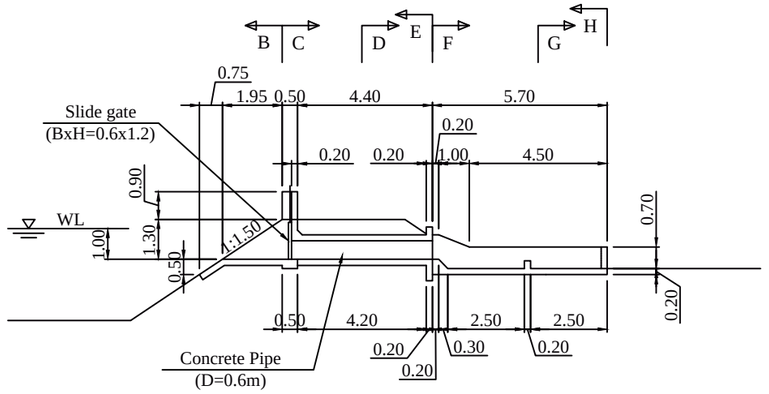
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Check Structure on Main Canal**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH-13

TYPE-1

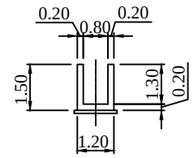
(to Secondary Canal)



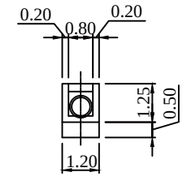
PLAN



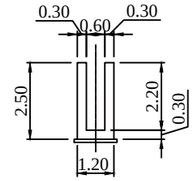
SECTION A-A



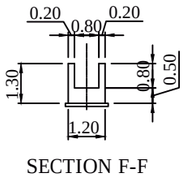
SECTION B-B



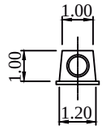
SECTION E-E



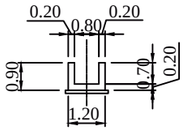
SECTION C-C



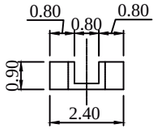
SECTION F-F



SECTION D-D



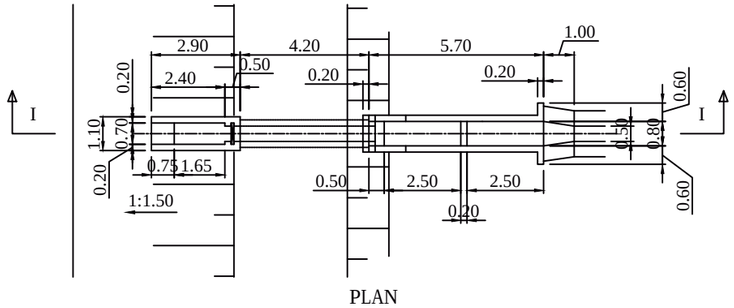
SECTION G-G



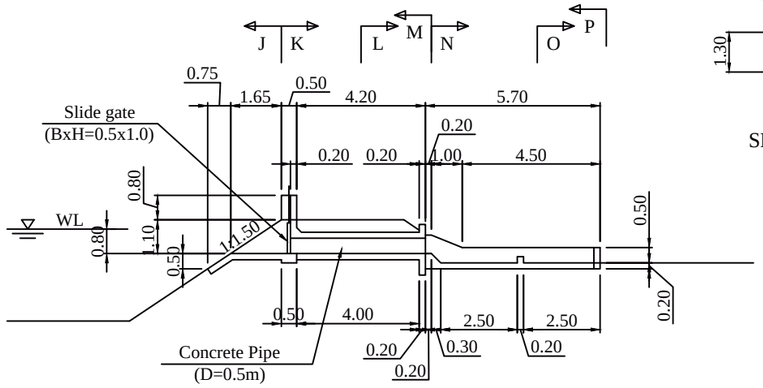
SECTION H-H

TYPE-2

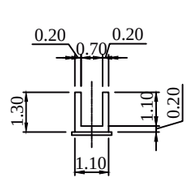
(to Tertiary Canal)



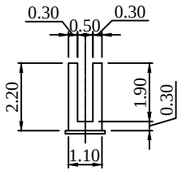
PLAN



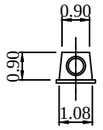
SECTION I-I



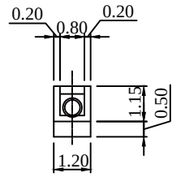
SECTION J-J



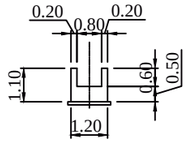
SECTION K-K



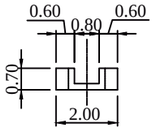
SECTION L-L



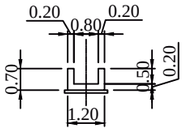
SECTION M-M



SECTION N-N



SECTION P-P



SECTION O-O

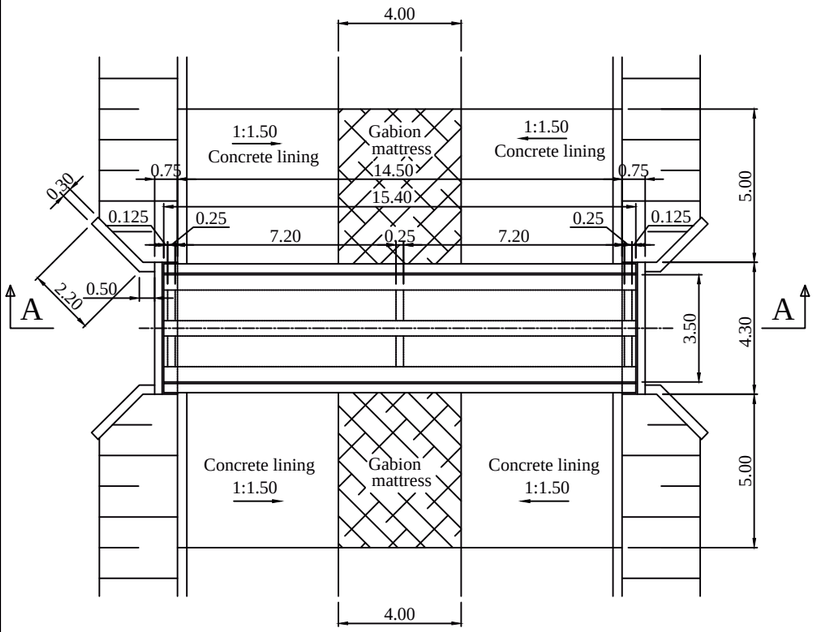
0 5 10

Scale 5:1

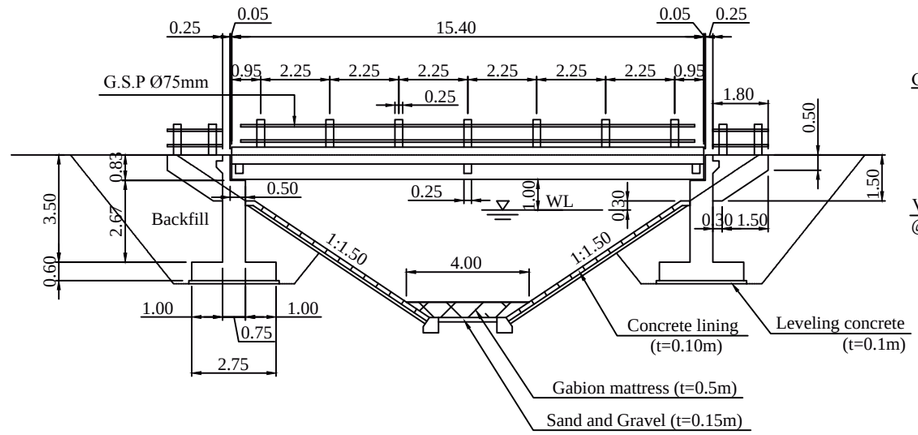
Source: The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Turnout on Main Canal**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH-14

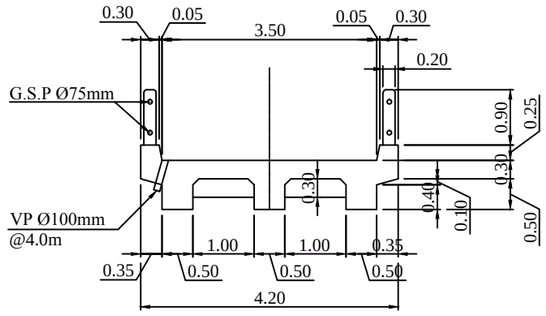
BRIDGE



PLAN Scale A

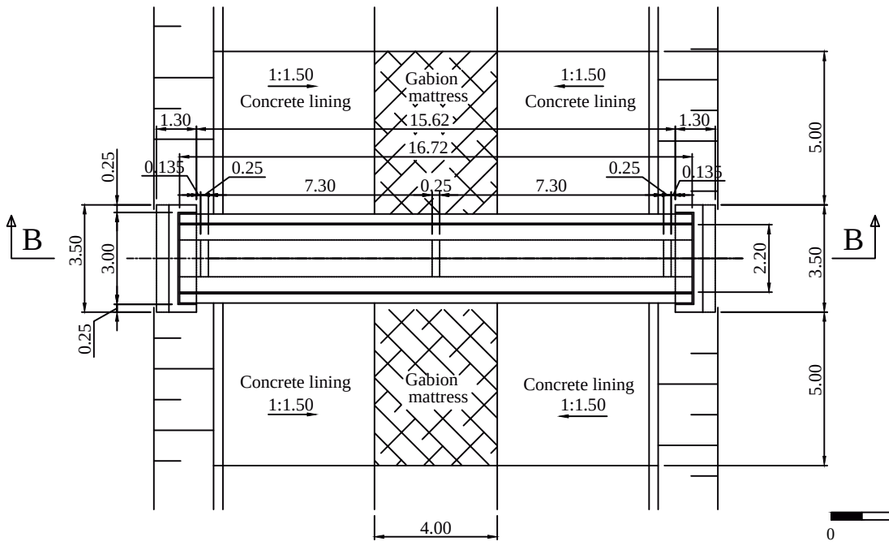


SECTION A-A Scale A

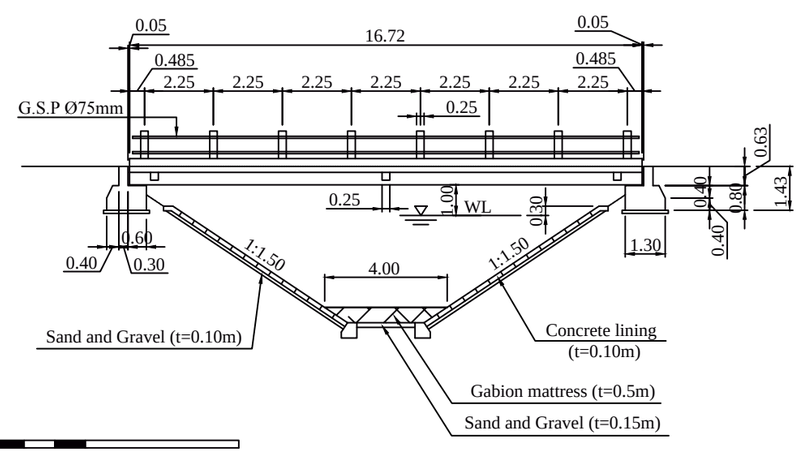


BRIDGE Scale B

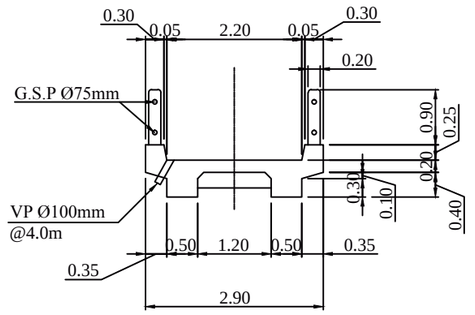
FOOT PATH BRIDGE



PLAN Scale A



SECTION B-B Scale A



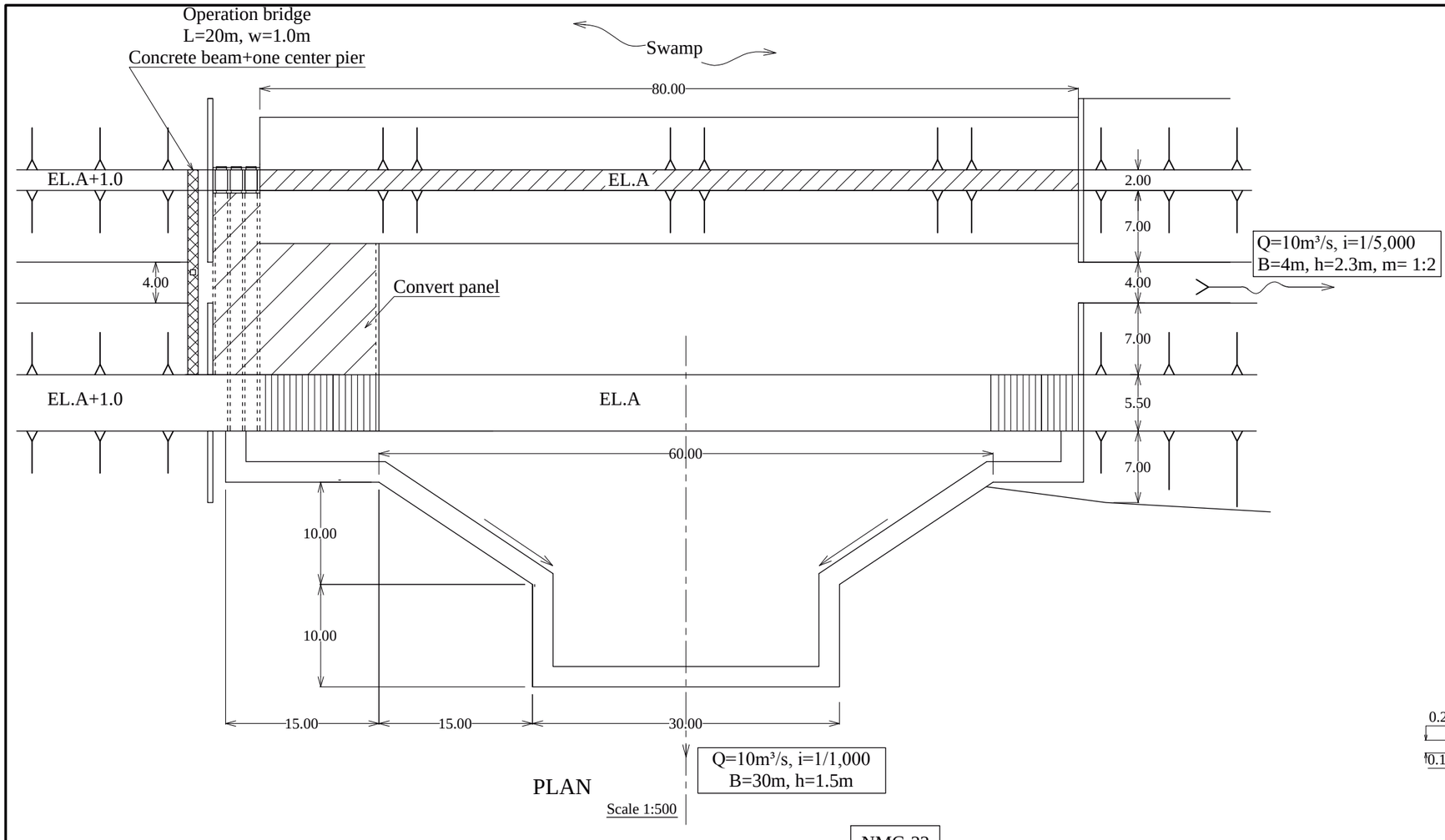
FOOT PATH Scale B

0 5 10
Scale A (5:1)

0 2.5 5
Scale B (10:1)

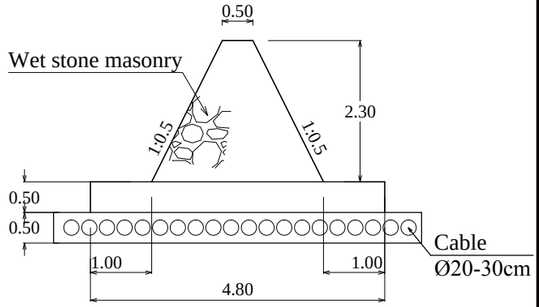
Source: The Study on Comprehensive Agricultural Development of Prek Thnot River Basin in the Kingdom of Cambodia, JICA, 2008

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Bridge and Foot Path Bridge of Main Canal**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. RCH-15

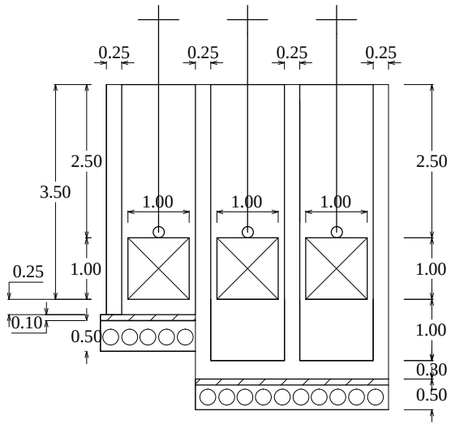


PLAN

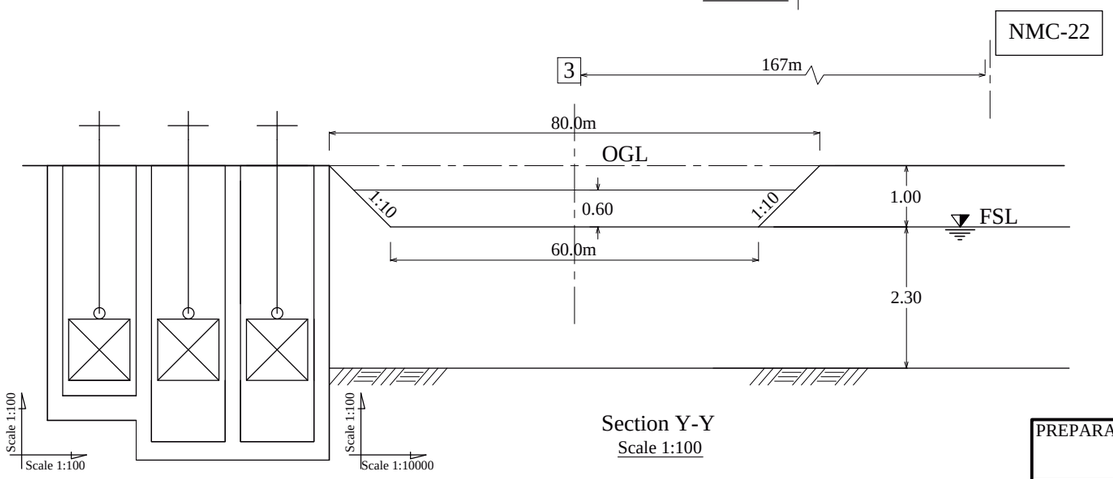
Scale 1:500



Scale 1:100

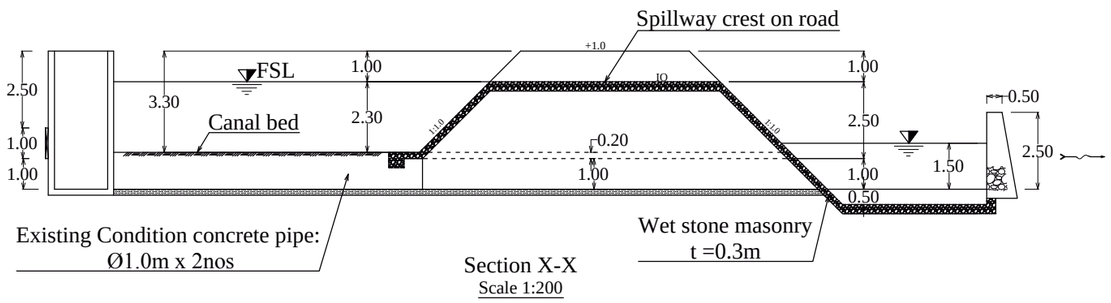


Scale 1:100



Section Y-Y

Scale 1:100



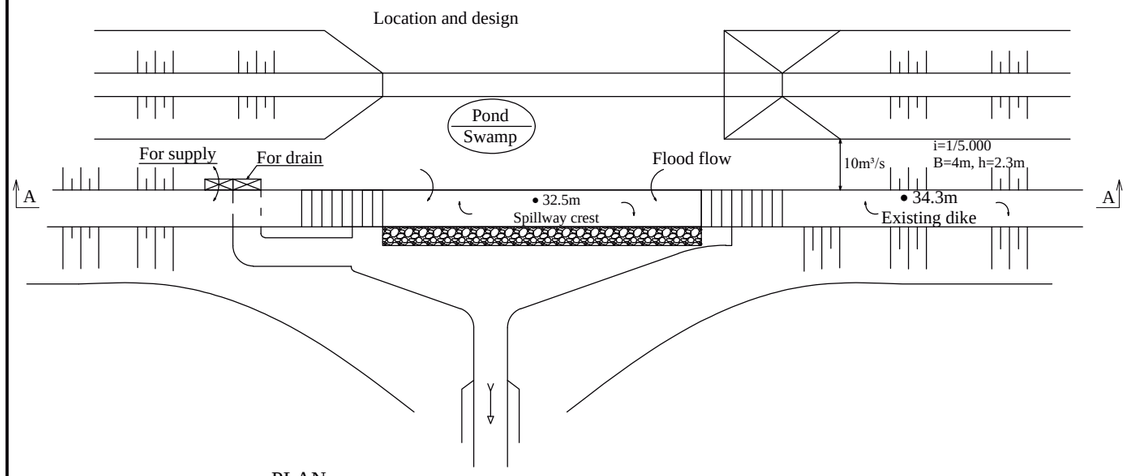
Section X-X

Scale 1:200

Source: Prepared by JICA Survey Team

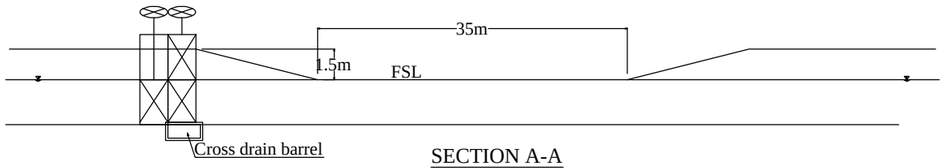
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Spillway at Level Crossing Reservoir, NMC-22**	Date Sept. 2011
Japan International Cooperation Agency **(JICA)**		DWG. No. RCH-16

CONSTRUCTION OF CROSSWAY AT SPILLWAY

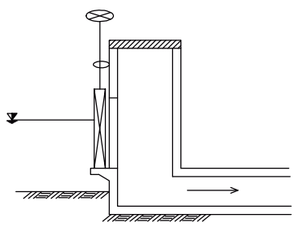


PLAN

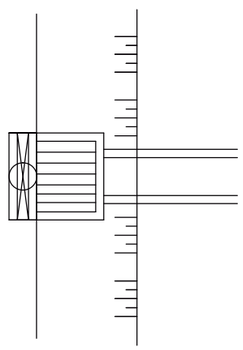
: To the estimated based on Flood discharge = 70m³/s
(20years)_12hours outlet



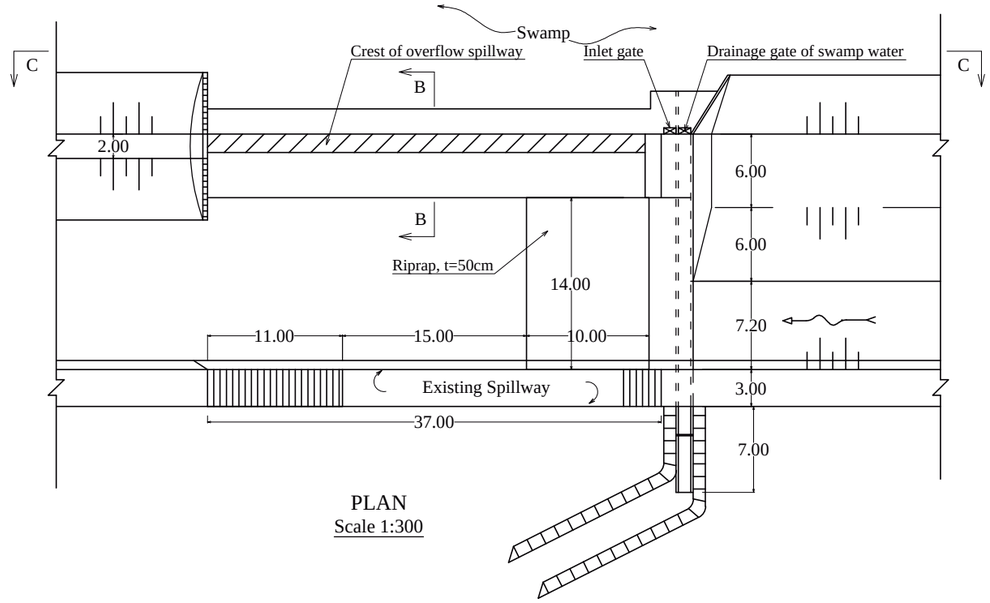
SECTION A-A
Scale 1:300



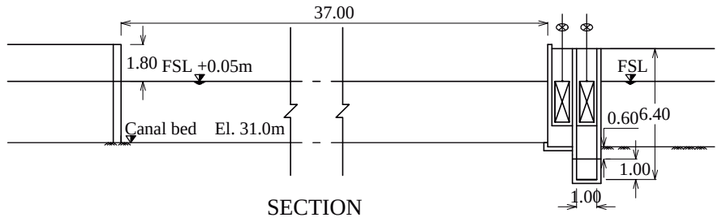
Scale 1:150



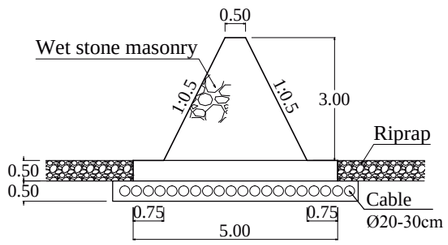
Scale 1:150



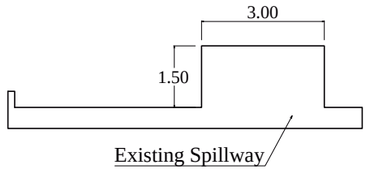
PLAN
Scale 1:300



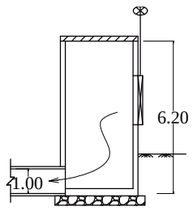
SECTION
C-C
Scale 1:300



SECTION
B-B
Scale 1:150



Scale 1:150



Scale 1:150

Gate single	Drain gate

Swamp area
A~200m x 400m
~80,000m²
Ave. water depots
= 1.0m
Storage volume
V= 80,000m³
for 1week drain
= 7 x 86,400sec
Q = 0.13m³/s
Assume, V = 0.5m
A= 0.26m²

∴ 1.0m x 1.0m x 1

- It is recommending to construct spillway as show above.
- The swamp/pond was created before construction of NMC. The pond has function as storage pond and buffer to the food flows. It is better to maintain the condition as it is, with re-installation of intake gates.

Source : Prepared by JICA Survey Team

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

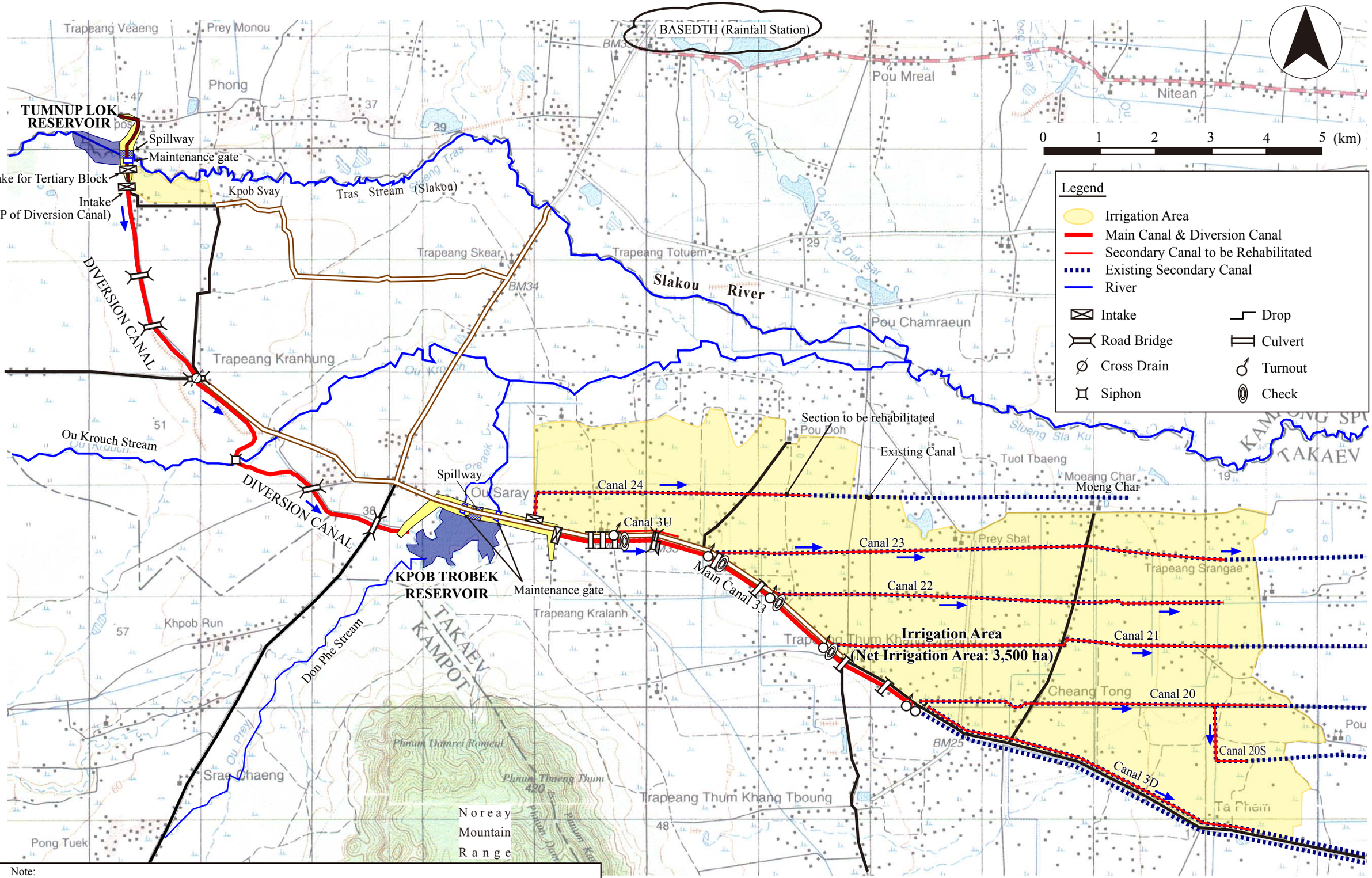
Japan International Cooperation Agency
(**JICA**)

Title of Drawing

Spillway at Level Crossing Reservoir, SMC - 18 and 24

Date
Sept. 2011

DWG. No.
RCH - 17



Note:

1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified portions by the Survey Team are marked by clouds as follows:
3. Other than the above modefications, the following information are deleted, which are not related to USISRSP:
   (1) Location of O Saray Reservoir, proposed DEPOTS, Ang 160 SRP,
   (2) Information of proposed road rehabilitation works

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

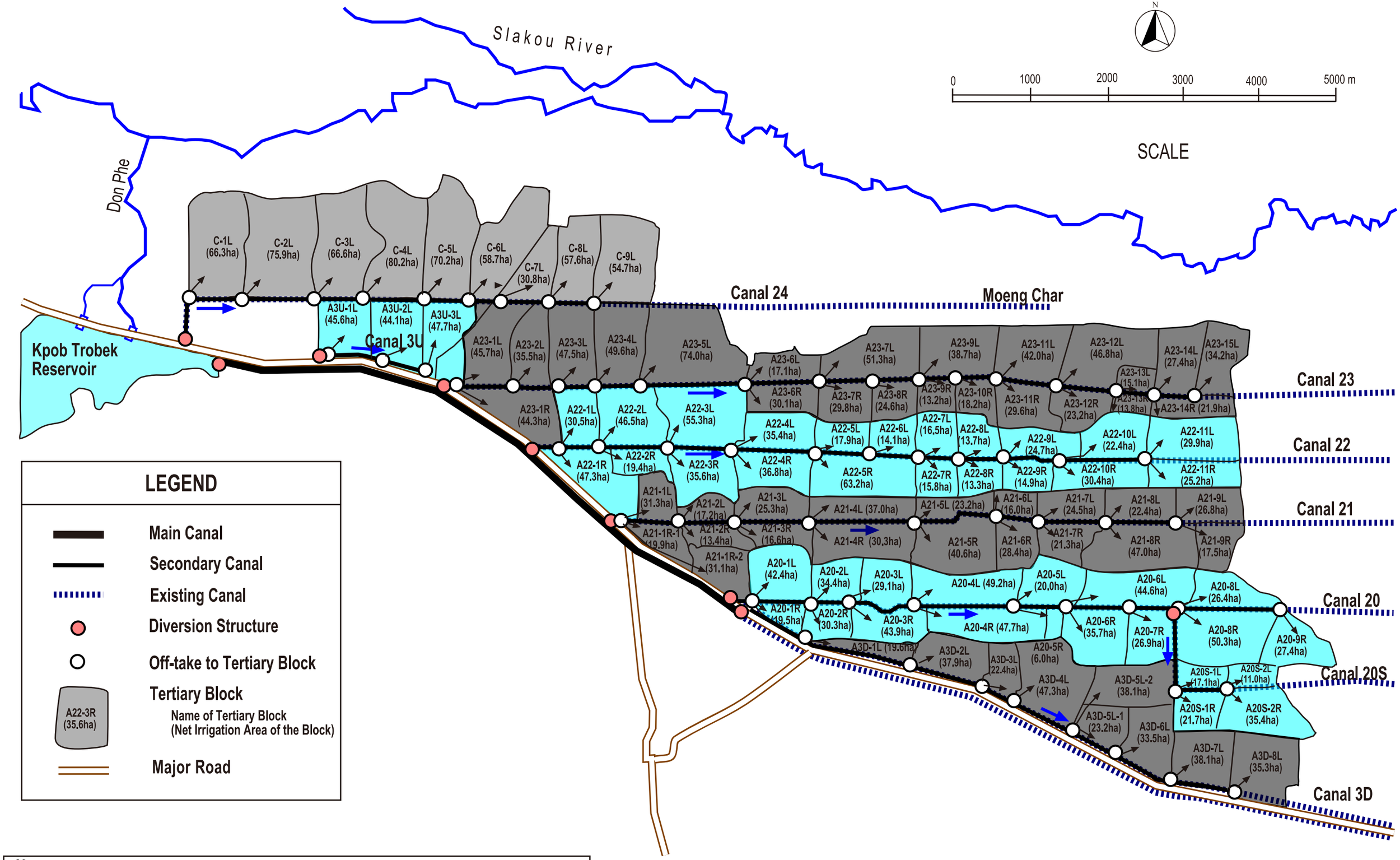
Japan International Cooperate Agency
(JICA)

Title of Drawing

General Layout of Upper Slakou Irrigation System Rehabilitation Sub-project

Date
Sept. 2011

DWG. No.
USS-01



LEGEND

- Main Canal
- Secondary Canal
- Existing Canal
- Diversion Structure
- Off-take to Tertiary Block
- Tertiary Block
  - Name of Tertiary Block
  - (Net Irrigation Area of the Block)
  - Example: A22-3R (35.6ha)
- Major Road

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. The following information are deleted, which are not related to USISRSP:
   (1) Information of proposed road rehabilitation works

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

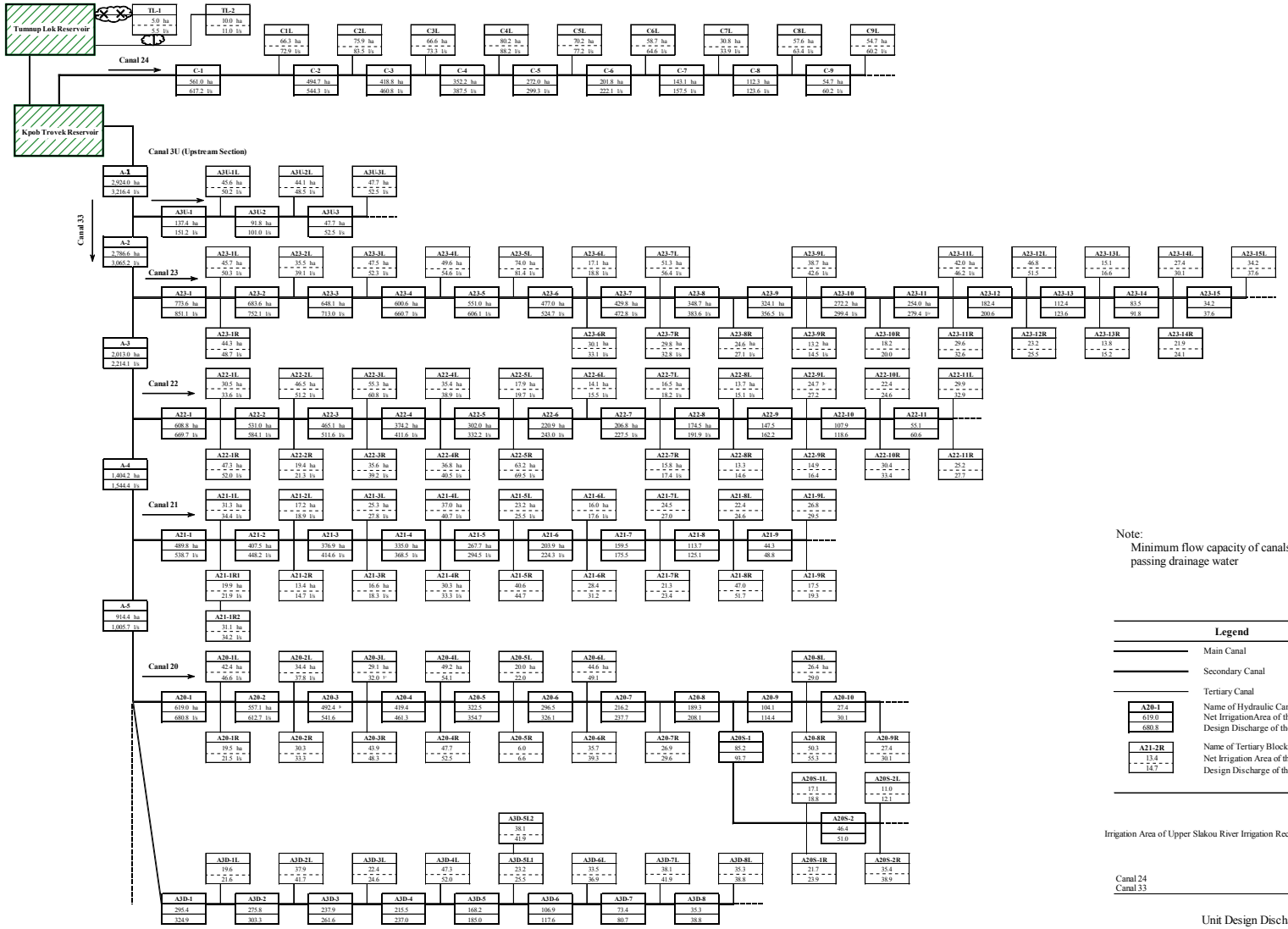
Japan International Cooperate Agency
(JICA)

Title of Drawing

Layout of Tertiary Blocks

Date
Sept. 2011

DWG. No.
USS-02



Note:
Minimum flow capacity of canals is to be 200 l/sec passing drainage water

Legend

- Main Canal
- Secondary Canal
- Tertiary Canal
- A20-1 / 619.0 / 680.8 — Name of Hydraulic Canal Section; Net IrrigationArea of the Section; Design Discharge of the Section
- A21-2R / 13.4 / 14.7 — Name of Tertiary Block; Net Irrigation Area of the Block; Design Discharge of the Block

Irrigation Area of Upper Slakou River Irrigation Reconstruction Plan (USP)

	15.0
Canal 24	561.0
Canal 33	2,924.0 ha
	3,500.0 ha

Unit Design Discharge: 1.1 l

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Prouction System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified portions by the Survey Team are marked by clouds as follows:

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

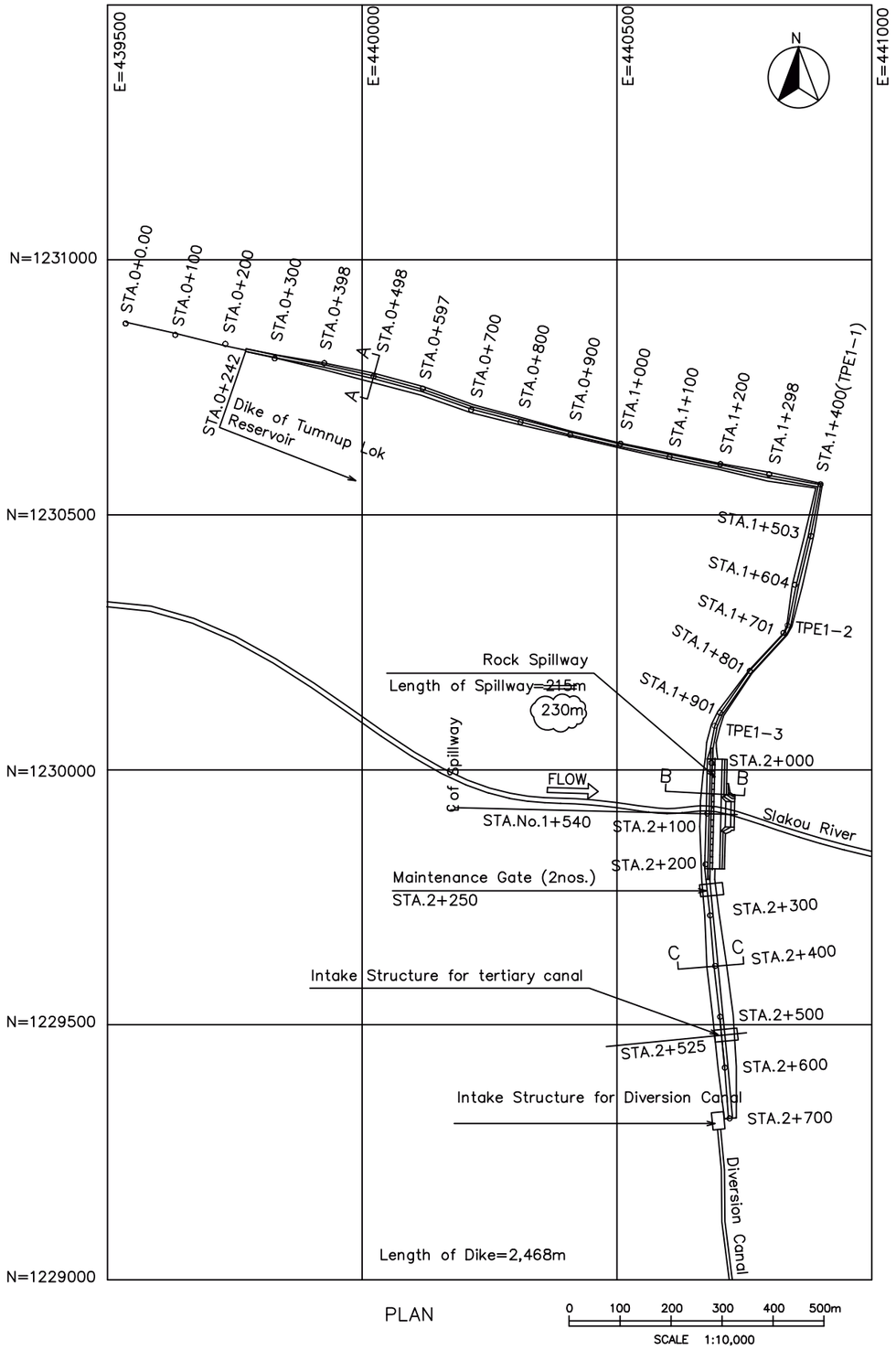
Japan International Cooperation Agency **(JICA)**

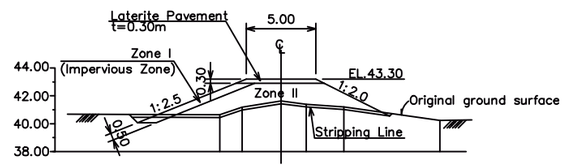
Title of Drawing

Irrigation Flow Diagram

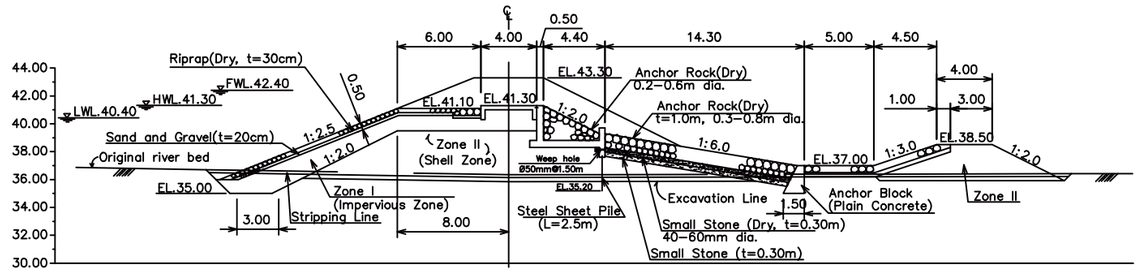
Date
Sept. 2011

DWG. No.
USS-03

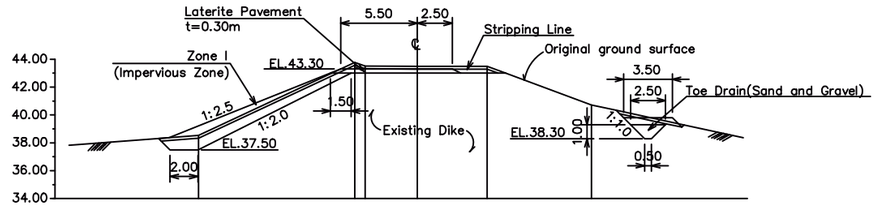




SECTION A–A (STA. 0+498) SCALE 1:400



SECTION B–B (STA.2+060) SCALE 1:400



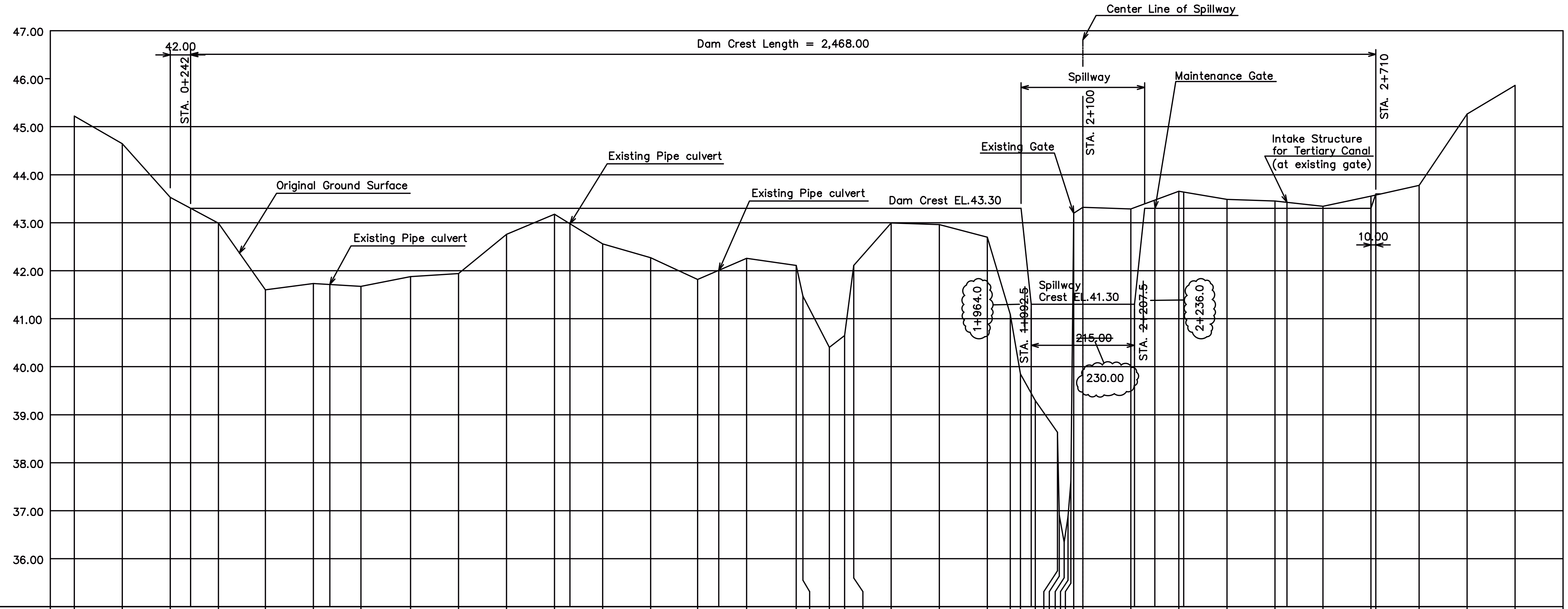
SECTION C–C (STA. 2+400) SCALE 1:400

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified portion by the Survey Team are marked by cloud as follow:

0 5 10 15 20m
SCALE 1:400

Note;Zone I(Impervious Zone); Mixed Soil Material of Laterite, Clayey Gravel and Excavated Soil at Reservoir Area
Zone II(Shell Zone); Excavated Soil at Reservoir Area(CL, SC, SM)

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Tumnup Lok Reservoir** **General Plan**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. USS-04



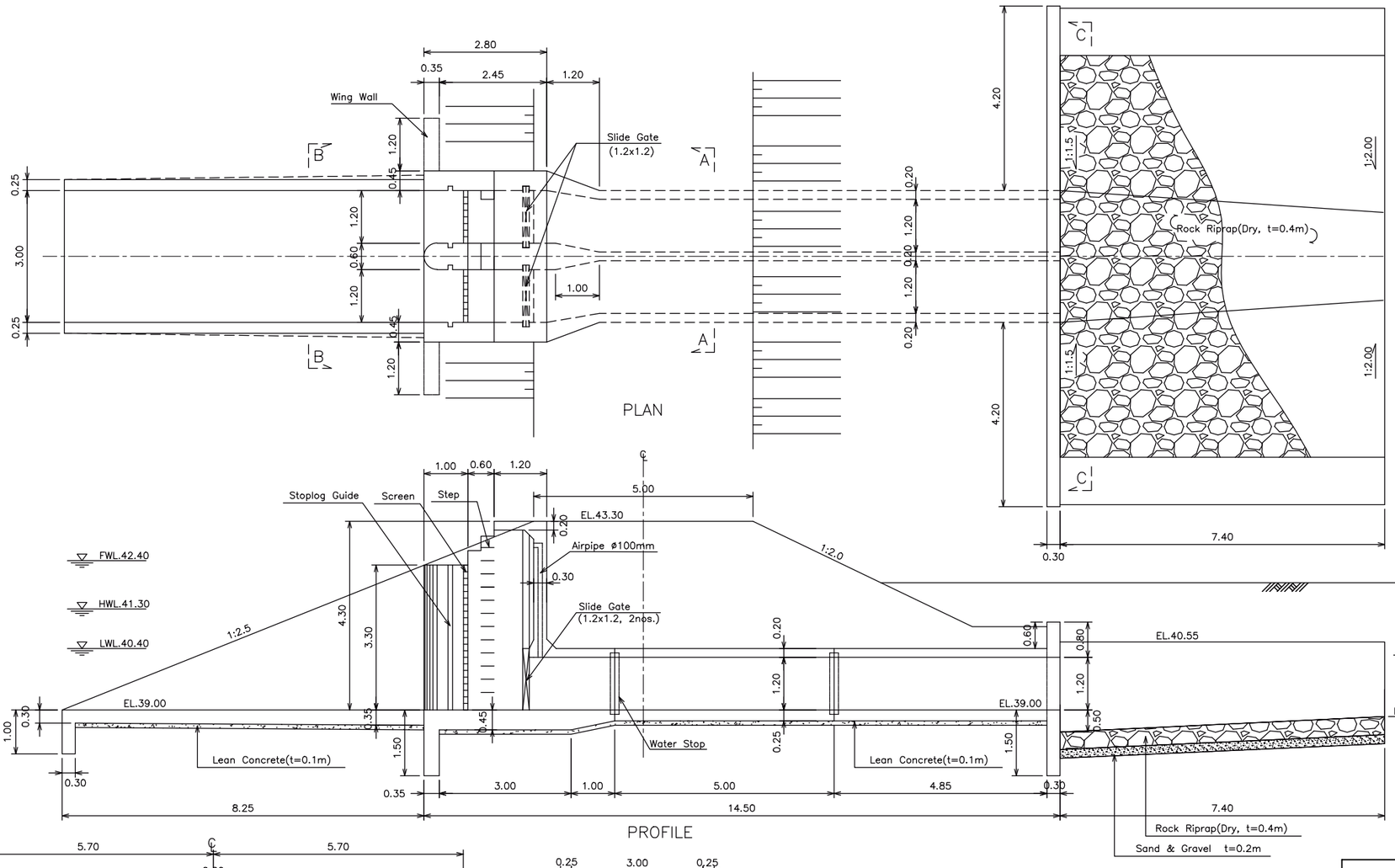
STATION No.		EXISTING GROUND LEVEL(m)	ELEVATION at CREST of DIKE(m)	ACCUMULATED DISTANCE (m)	DISTANCE (m)
0+000	CRE1-0	45.224		-242.0	0.0
0+100	CRE1-1	44.646		-142.0	100.0
0+200	CRE1-2	43.527		-42.0	100.0
0+242			43.3	0.0	42.0
0+300	CRE1-3	42.991	43.3	58.0	58.0
0+398	CRE1-4	41.602	43.3	156.0	98.0
0+498	CRE1-5	41.734	43.3	256.0	100.0
0+532				290.0	34.0
0+597	CRE1-6	41.676	43.3	355.0	65.0
0+700	CRE1-7	41.879	43.3	458.0	103.0
0+800	CRE1-8	41.942	43.3	558.0	100.0
0+900	CRE1-9	42.760	43.3	658.0	100.0
1+000	CRE1-10	43.178	43.3	758.0	100.0
1+032				790.0	32.0
1+100	CRE1-11	42.559	43.3	858.0	68.0
1+200	CRE1-12	42.273	43.3	958.0	100.0
1+298	CRE1-13	41.818	43.3	1056.0	98.0
1+342				1100.0	44.0
1+400	CRE1-14	42.259	43.3	1158.0	58.0
1+503	CRE1-15	42.112	43.3	1261.0	103.0
1+517		41.472		1275.0	14.0
1+572		40.405		1330.0	55.0
1+604	CRE1-16	40.651	43.3	1362.0	32.0
1+627		42.112		1385.0	23.0
1+701	CRE1-17	42.995	43.3	1459.0	74.0
1+801	CRE1-18	42.962	43.3	1559.0	100.0
1+901	CRE1-19	42.699	43.3	1659.0	100.0
1+949		41.090			
1+969		39.850			
1+971.5			43.3	1729.5	70.5
1+992.5			41.3	1750.5	21.0
2+000	CRE1-20	39.295	41.3	1758.0	7.5
2+047		38.634			
2+051		36.908			
2+061		36.342			
2+069		36.883			
2+075		37.610			
2+081		43.197			
2+100	CRE1-21	43.323	41.3	1858.0	100.0
2+200	CRE1-22	43.287	41.3	1958.0	100.0
2+207.5			41.3	1965.5	7.5
2+228.5			43.3	1986.5	21.0
2+250			43.3	2008.0	21.5
2+300	CRE1-23	43.657	43.3	2058.0	50.0
2+310				2068.0	10.0
2+400	CRE1-24	43.486	43.3	2158.0	90.0
2+500	CRE1-25	43.453	43.3	2258.0	100.0
2+525				2283.0	25.0
2+600	CRE1-26	43.342	43.3	2358.0	75.0
2+700	CRE1-27	43.556	43.3	2458.0	100.0
2+710				2468.0	10.0
2+800	CRE1-28	43.777			
2+900	CRE1-29	45.266			
3+000	CRE1-30	45.860			

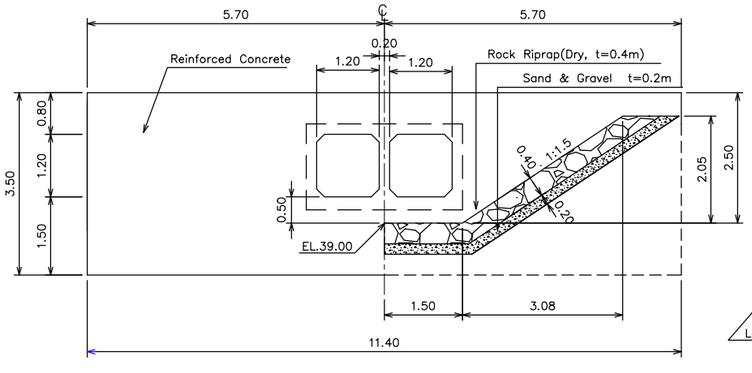
V=1/100 H=1/10,000

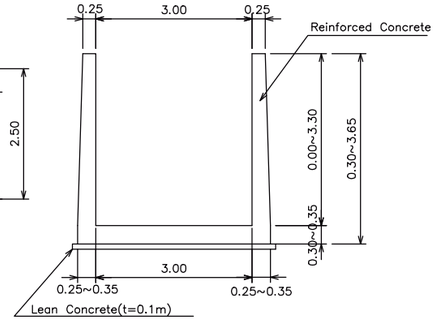
0 100 200 300 400 500m

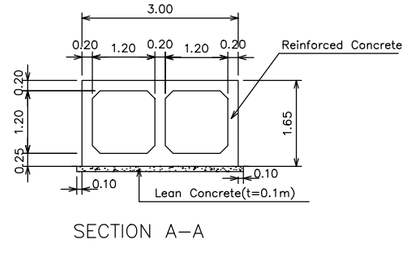
Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified portion by the Survey Team are marked by cloud as follow:

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Tumnup Lok Reservoir**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)	**Profile of Dike**	DWG. No. USS-05





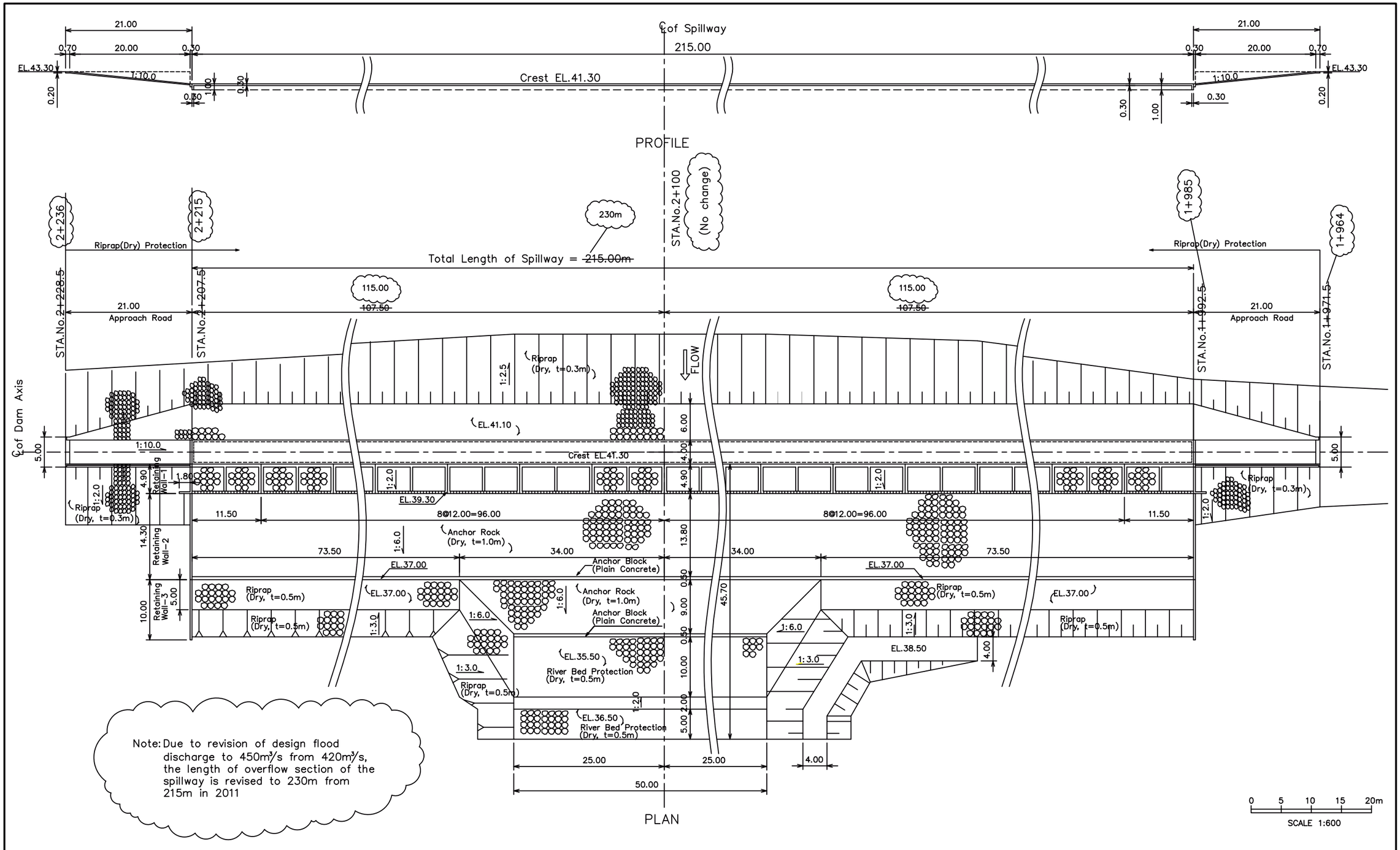




Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basn" by JICA Study Team in January 2002.
2. No modification is made by the Survey Team in 2011.

0 1 2 3 4 5m
SCALE 1:100

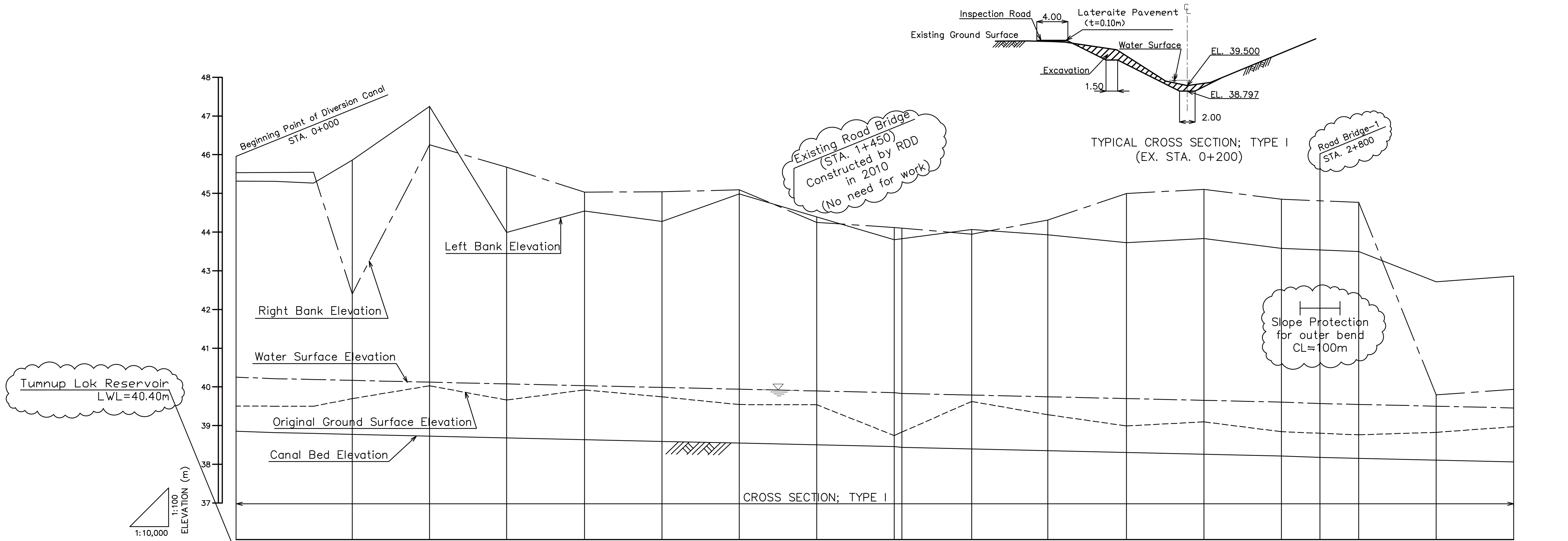
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Tumnup Lok Reservoir** **Intake Structure for Diversion Canal**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. USS-06



Note: Due to revision of design flood discharge to 450m³/s from 420m³/s, the length of overflow section of the spillway is revised to 230m from 215m in 2011

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified portion by the Survey Team are marked by cloud as follow:

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date
	Tumnup Lok Reservoir	Sept. 2011
Japan International Cooperation Agency (**JICA**)	**Plan of Spillway**	DWG. No. USS-07



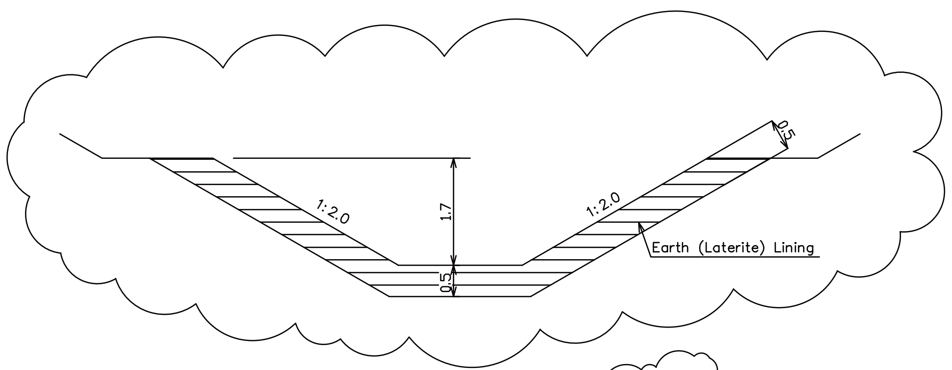
WATER SURFACE ELEVATION	40.250	40.213	40.191	40.168	40.122	40.077	40.031	39.986	39.941	39.895	39.850 39.830	39.789	39.744	39.698	39.653	39.607	39.570	39.547	39.501	39.456
HYDRAULIC CANAL BED ELEVATION	38.856	38.819	38.797	38.774	38.728	38.683	38.637	38.592	38.547	38.501	38.456 38.456	38.395	38.350	38.304	38.259	38.213	38.176	38.153	38.107	38.062
ORIGINAL GROUND SURFACE ELEVATION	39.506	39.501	39.500	39.696	40.029	39.660	39.921	39.743	39.543	39.538	38.744 38.832	39.623	39.280	38.991	39.096	38.842	38.801	38.761	38.826	38.970
LEFT BANK ELEVATION	45.315	45.311	45.266	45.860	47.249	43.992	44.560	44.274	44.984	44.390	43.803	44.066	43.932	43.728	43.833	43.579		43.498	42.717	42.861
RIGHT BANK ELEVATION	45.595	45.541	45.545	42.400	46.255	45.676	45.032	45.041	45.093	44.250	44.118	43.947	44.310	44.998	45.103	44.849		44.768	39.792	39.936
ACCUMULATED DISTANCE	0	100	200	300	500	699	900	1,100	1,300	1,500	1,700 1,720	1,900	2,097	2,300	2,500	2,700	2,800	2,900	3,100	3,300
DISTANCE	0	100	100	100	200	199	201	200	200	200	200 20	180	197	203	200	200	100	100	200	200
STATION NO.	0+000	0+100	0+200	0+300	0+500	0+699	0+900	1+100	1+300	1+500	1+700 1+720	1+900	2+097	2+300	2+500	2+700	2+800	2+900	3+100	3+300

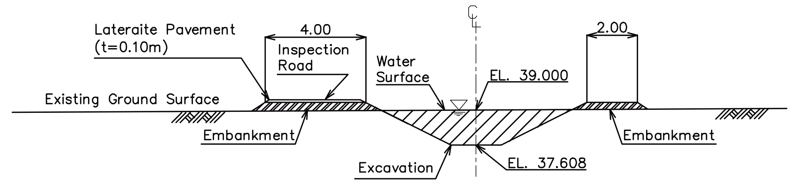
Hydraulic Parameters

Discharge (m^3/s)	Canal Bed Width(m)	Velocity (m/s)	Gradient	Roughness Coefficient	Canal Inside Slope	Design Water Depth(m)	Outside Slope
3.500	2.00	0.524	1: 4,400	0.025	1: 2.0	1.39	1: 1.5

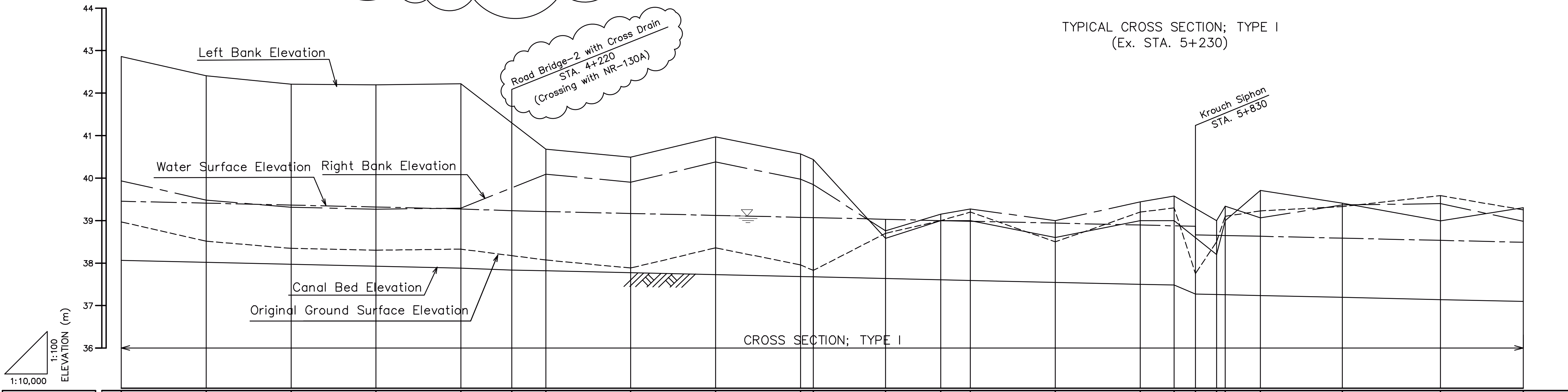
Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified and/or added portion by the Survey Team are marked by cloud as follow:

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Diversion Canal**	Date Sept. 2011
Japan International Cooperation Agency **(JICA)**	**Profile of Diversion Canal (1/3)**	DWG. No. USS-08





TYPICAL CROSS SECTION; TYPE I
(Ex. STA. 5+230)



WATER SURFACE ELEVATION	39.456	39.411	39.365	39.320	39.274	39.232	39.214	39.168	39.123	39.077	39.071	39.032
HYDRAULIC CANAL BED ELEVATION	38.062	38.017	37.971	37.926	37.880	37.838	37.820	37.774	37.729	37.683	37.677	37.638
ORIGINAL GROUND SURFACE ELEVATION	38.970	38.516	38.347	38.304	38.329	38.175	38.073	37.884	38.360	37.957	37.828	38.700
LEFT BANK ELEVATION	42.861	42.407	42.238	42.195	42.220		40.683	40.494	40.970	40.567	40.438	38.580
RIGHT BANK ELEVATION	39.936	39.482	39.313	39.270	39.295		40.092	39.903	40.379	39.976	39.847	38.760
ACCUMULATED DISTANCE	3,300	3,500	3,700	3,900	4,100	4,220	4,300	4,500	4,700	4,900	4,930	5,100
DISTANCE	200	200	200	200	200	120	80	200	200	200	30	170
STATION NO.	3+300	3+500	3+700	3+900	4+100	4+220	4+300	4+500	4+700	4+900	4+930	5+100

WATER SURFACE ELEVATION	39.002	38.986	38.941	38.896	38.877	38.666	38.655	38.650	38.631	38.587	38.535	38.491
HYDRAULIC CANAL BED ELEVATION	37.608	37.592	37.547	37.502	37.483	37.272	37.261	37.256	37.237	37.193	37.141	37.097
ORIGINAL GROUND SURFACE ELEVATION	39.000	39.200	38.500	39.200	39.300	37.755	38.500	39.100	39.229	39.330	39.588	39.253
LEFT BANK ELEVATION	38.850	39.000	38.605	39.000	39.000		38.200	39.000	39.709	39.413	38.995	39.306
RIGHT BANK ELEVATION	39.150	39.275	39.000	39.440	39.580		39.000	39.340	39.066	39.369	39.399	38.986
ACCUMULATED DISTANCE	5,230	5,300	5,500	5,700	5,780	5,830	5,880	5,900	5,983	6,176	6,407	6,602
DISTANCE	130	70	200	200	80	50	50	20	83	193	231	195
STATION NO.	5+230	5+300	5+500	5+700	5+780	5+830	5+880	5+900	5+983	6+176	6+407	6+602

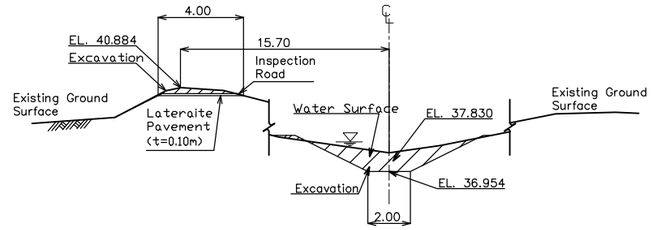
Hydraulic Parameters

Discharge (m^3/s)	Canal Bed Width(m)	Velocity (m/s)	Gradient	Roughness Coefficient	Canal Inside Slope	Design Water Depth(m)	Outside Slope
3.500	2.00	0.524	1:4,400	0.025	1:2.0	1.39	1:1.5

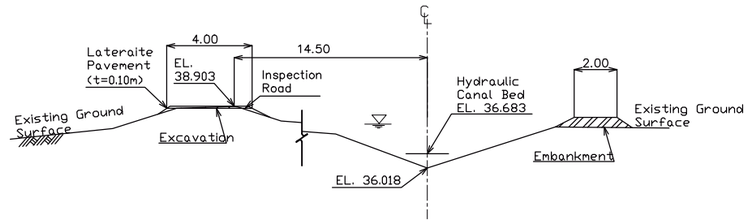
Note ; Stripping shall be given to the original ground on which embankment will be made.

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified and/or added portion by the Survey Team are marked by cloud as follow:

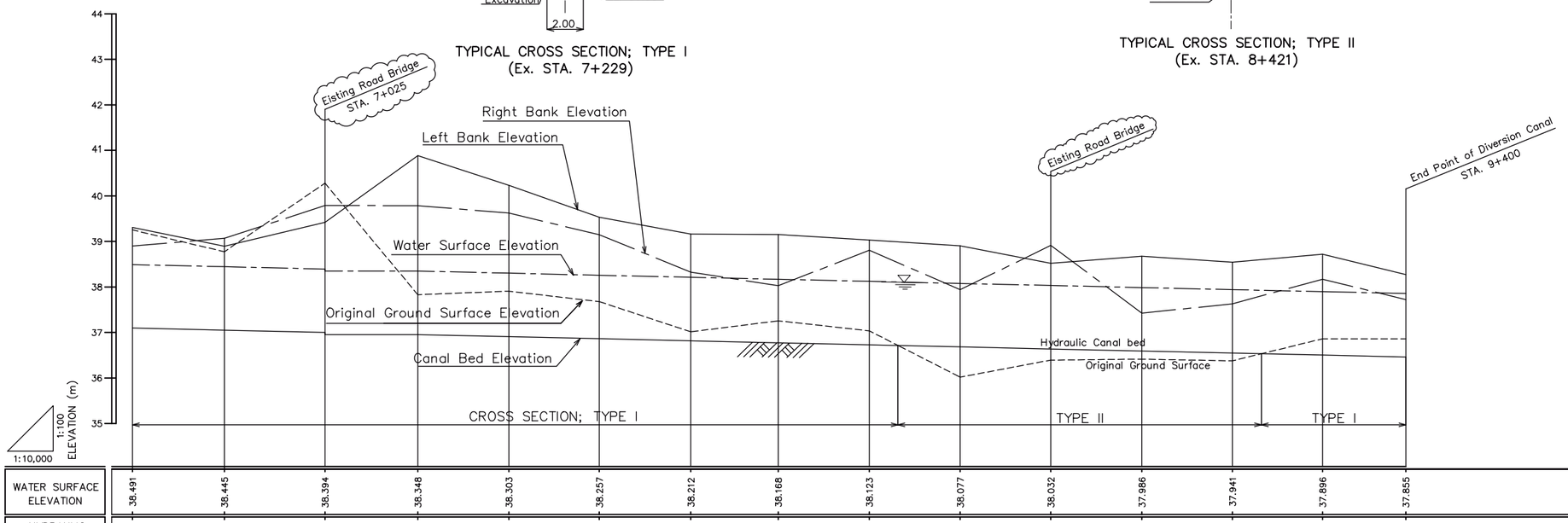
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Diversion Canal**	Date Sept. 2011
Japan International Cooperation Agency (JICA)	**Profile of Diversion Canal (2/3)**	DWG. No. USS-09



TYPICAL CROSS SECTION; TYPE I
(Ex. STA. 7+229)



TYPICAL CROSS SECTION; TYPE II
(Ex. STA. 8+421)



WATER SURFACE ELEVATION	38.491	38.445	38.394	38.348	38.303	38.257	38.212	38.168	38.123	38.077	38.032	37.986	37.941	37.896	37.855		
HYDRAULIC CANAL BED ELEVATION	37.097	37.051	37.000	36.954	36.909	36.863	36.818	36.774	36.729	36.683	36.638	36.592	36.547	36.502	36.461		
ORIGINAL GROUND SURFACE ELEVATION	39.253	38.774	40.279	37.830	37.907	37.677	37.014	37.256	37.036	36.018	36.393	36.414	36.376	36.861	36.861		
LEFT BANK ELEVATION	39.306	38.894	39.419	40.884	40.232	39.530	39.161	39.151	39.029	38.903	38.518	38.676	38.545	38.720	38.272		
RIGHT BANK ELEVATION	38.986	39.068	39.789	39.786	39.622	39.147	38.325	38.026	38.807	37.938	38.915	37.426	37.628	38.171	37.723		
ACCUMULATED DISTANCE	6,602	6,804	7,025	7,229	7,429	7,628	7,829	8,021	8,221	8,421	8,620	8,820	9,019	9,217	9,400		
DISTANCE	195	202	221	204	200	199	201	192	200	200	199	200	199	198	183		
STATION NO.	6+602	6+804	7+025	7+229	7+429	7+628	7+829	8+021	8+221	8+421	8+620	8+820	9+019	9+217	9+400		

Hydraulic Parameters

Discharge (m^3/s)	Canal Bed Width(m)	Velocity (m/s)	Gradient	Roughness Coefficient	Canal Inside Slope	Design Water Depth(m)	Outside Slope
3.500	2.00	0.524	1:4,400	0.025	1:2.0	1.39	1:1.5

Note ; Stripping shall be given to the original ground on which embankment will be made.

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified and/or added portion by the Survey Team are marked by cloud as follow:

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (**JICA**)

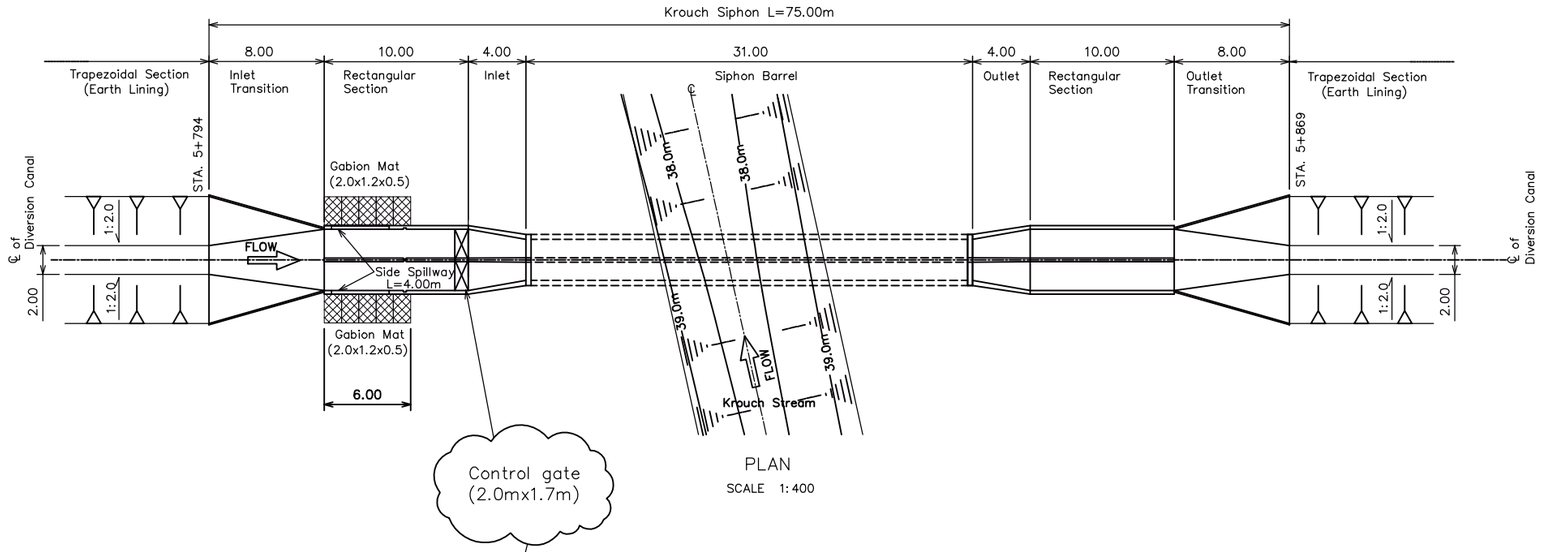
Title of Drawing

Diversion Canal

Profile of Diversion Canal (3/3)

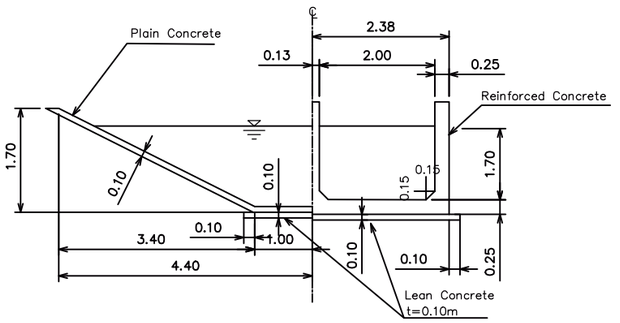
Date
Sept. 2011

DWG. No.
USS-10



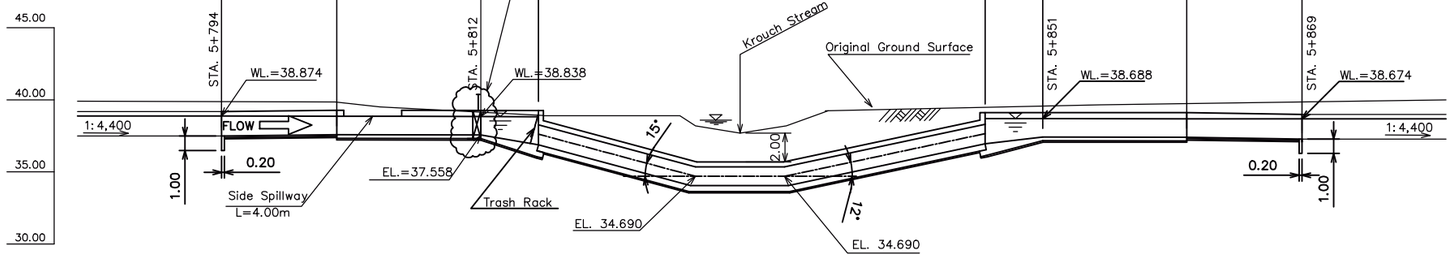
PLAN

SCALE 1:400



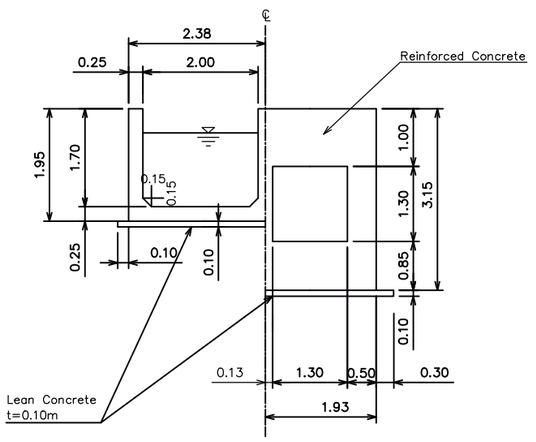
INLET TRANSITION

SCALE 1:100



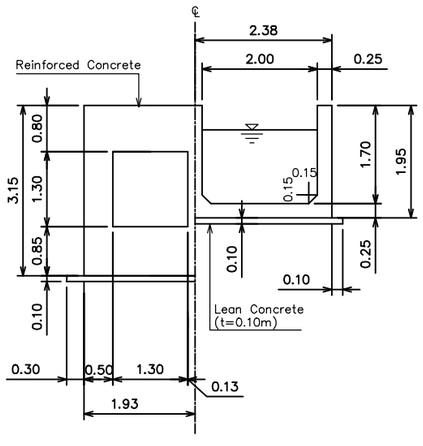
PROFILE

SCALE 1:400



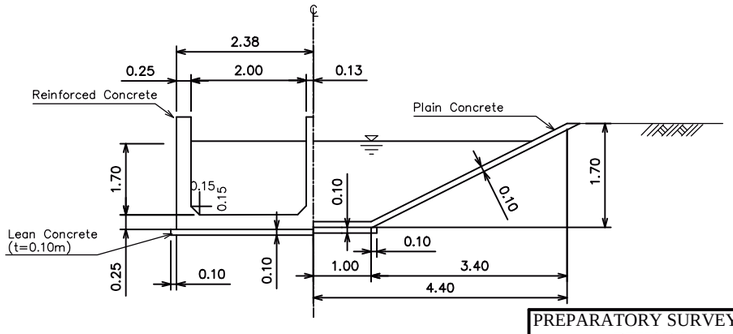
INLET

SCALE 1:100



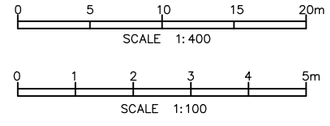
OUTLET

SCALE 1:100



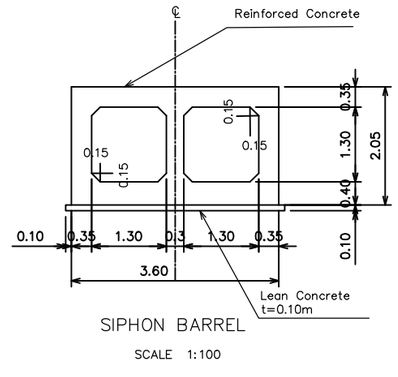
OUTLET TRANSITION

SCALE 1:100



Note:

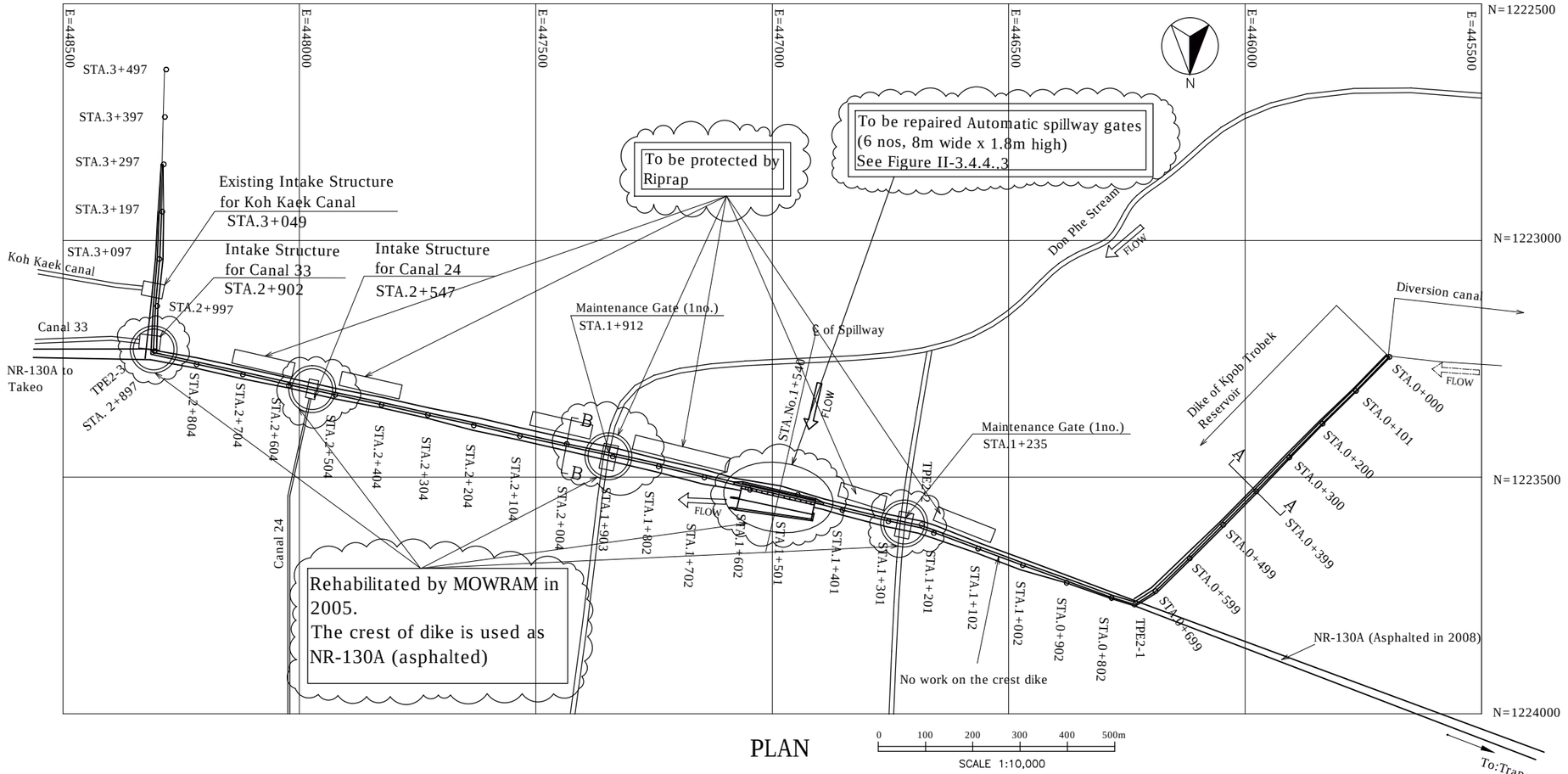
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified portion by the Survey Team are marked by cloud as follow:



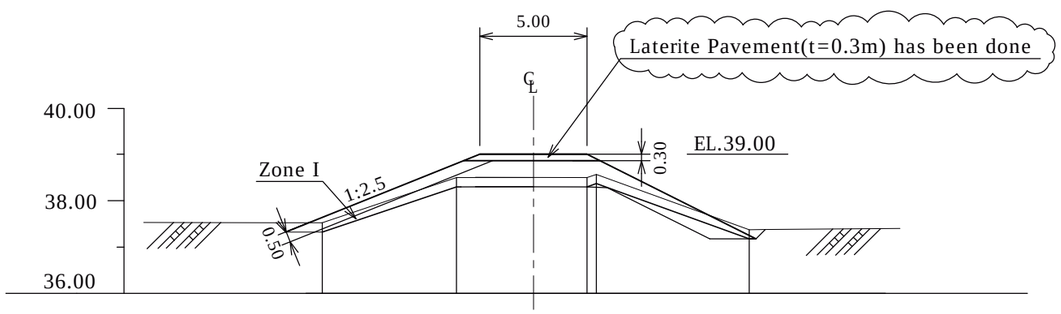
SIPHON BARREL

SCALE 1:100

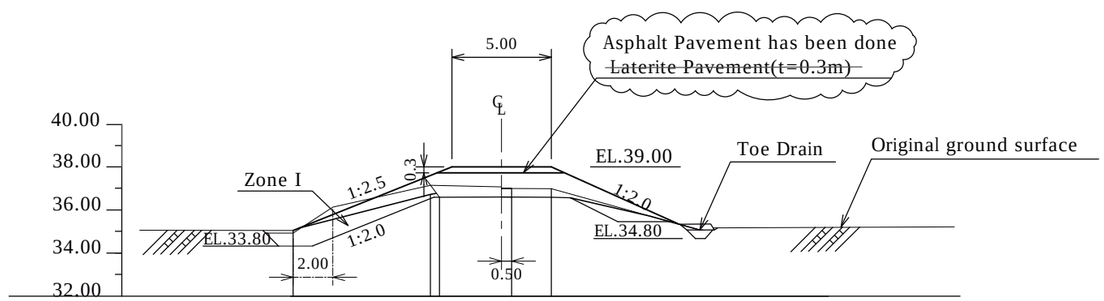
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Diversion Canal** **Krouch Siphon**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. USS-11



PLAN



SECTION A-A (STA.0+399) SCALE 1:400



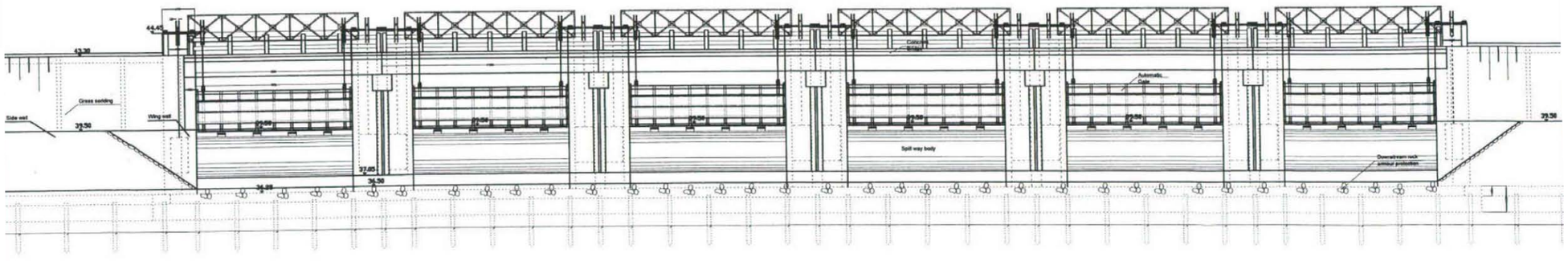
SECTION B-B (STA.2+004) SCALE 1:400

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified and/or added portion by the Survey Team are marked by cloud as follow:

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Kpob Trobek Reservoir**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)	**General Plan**	DWG. No. USS-12

DOWNSTREAM SIDE

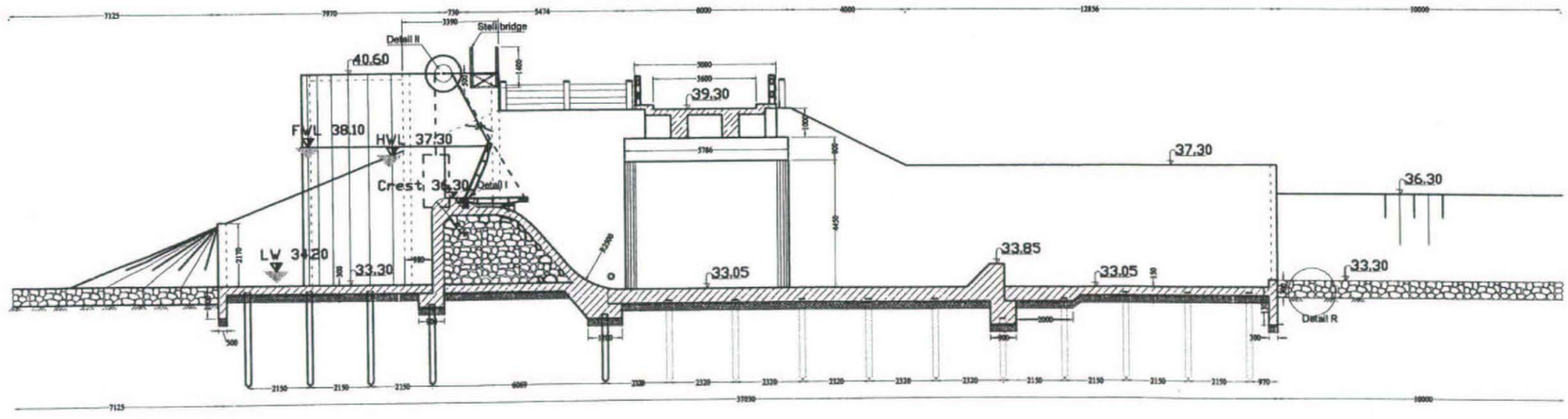
SCALE 1:100



PROFILE

~~CROSS SECTION A-A~~

SCALE 1:200

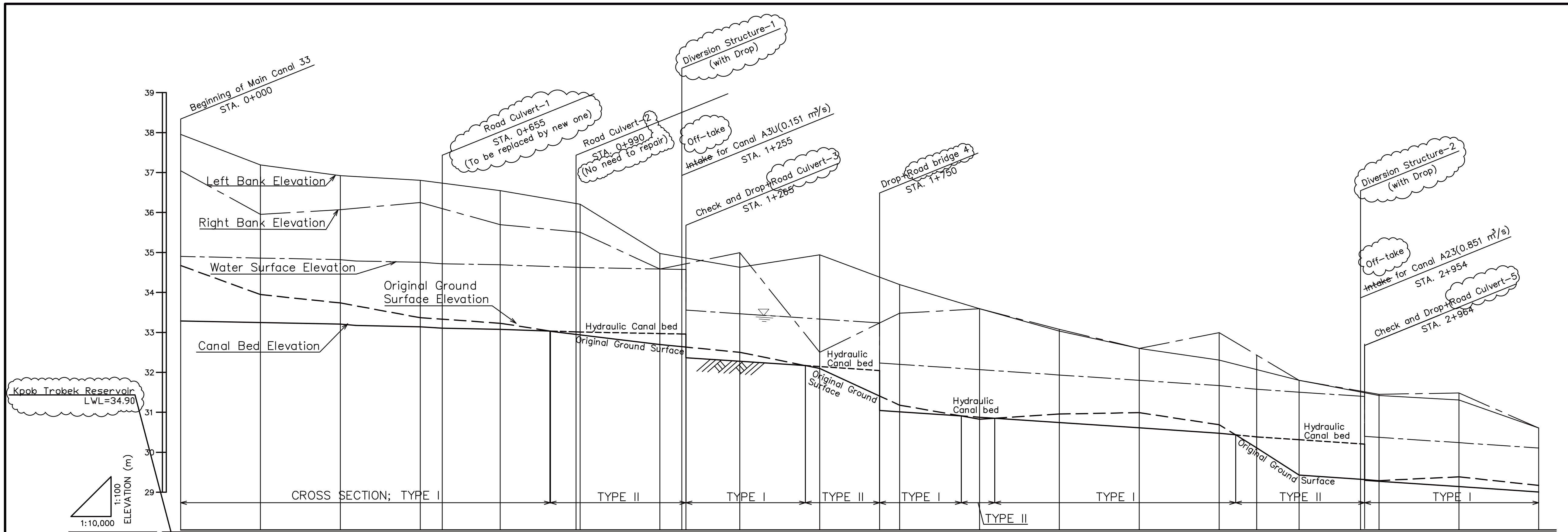


0 1 2 3 4 5m

SCALE 1:100

Note:
1. Original of this drawing was prepared for the rehabilitation of the Kpob Trobek Reservoir by MORAM in 2005.

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Kpob Trobek Reservoir**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)	**Existing Gated Spillway (Reference only)**	DWG. No. USS-13



HYDRAULIC SECTION	Type A-1												Type A-2	
WATER SURFACE ELEVATION	34.900	34.860	34.820	34.787	34.755	34.719	34.690	34.627	34.625	34.585	34.574	33.557	33.467	33.334
HYDRAULIC CANAL BED ELEVATION	33.285	33.245	33.205	33.172	33.140	33.104	33.075	33.012	33.010	32.970	32.959	32.367	32.277	32.144
ORIGINAL GROUND SURFACE ELEVATION	34.674	33.945	33.736		33.367		33.229		32.917	32.694			32.501	32.095
LEFT BANK ELEVATION	37.955	37.191	36.926		36.805		36.549		36.207	34.975			34.630	34.942
RIGHT BANK ELEVATION	37.046	35.952	36.070		36.248		35.697		35.504	34.598			34.995	32.503
ACCUMULATED DISTANCE	0	200	400	440	600	655	800	990	1,000	1,200	1,255	1,265	1,400	1,600
DISTANCE	0	200	200	40	160	55	145	190	10	200	55	10	135	200
STATION NO.	0+000 (BP)	0+200	0+400		0+600		0+800		1+000	1+200			1+400	1+600

HYDRAULIC SECTION	Type A-2										Type A-3		
WATER SURFACE ELEVATION	32.234	32.200	32.067	31.934	31.800	31.667	31.574	31.504	31.401	30.397	30.373	30.240	30.106
HYDRAULIC CANAL BED ELEVATION	31.044	31.010	30.877	30.744	30.610	30.477	30.384	30.314	30.211	29.297	29.273	29.140	29.006
ORIGINAL GROUND SURFACE ELEVATION		31.179	30.827	30.957	30.992	30.688	30.113	29.428			29.290	29.385	29.170
LEFT BANK ELEVATION		34.197	33.592	33.031	32.600	32.307		31.798			31.421	31.306	30.607
RIGHT BANK ELEVATION		33.479	33.550	33.075	32.594	32.994		31.703			31.452	31.482	30.507
ACCUMULATED DISTANCE	1,750	1,800	2,000	2,200	2,400	2,600	2,694	2,800	2,954	2,964	3,000	3,200	3,400
DISTANCE	150	50	200	200	200	200	94	106	154	10	36	200	200
STATION NO.		1+800	2+000	2+200	2+400	2+600		2+800			3+000	3+200	3+400

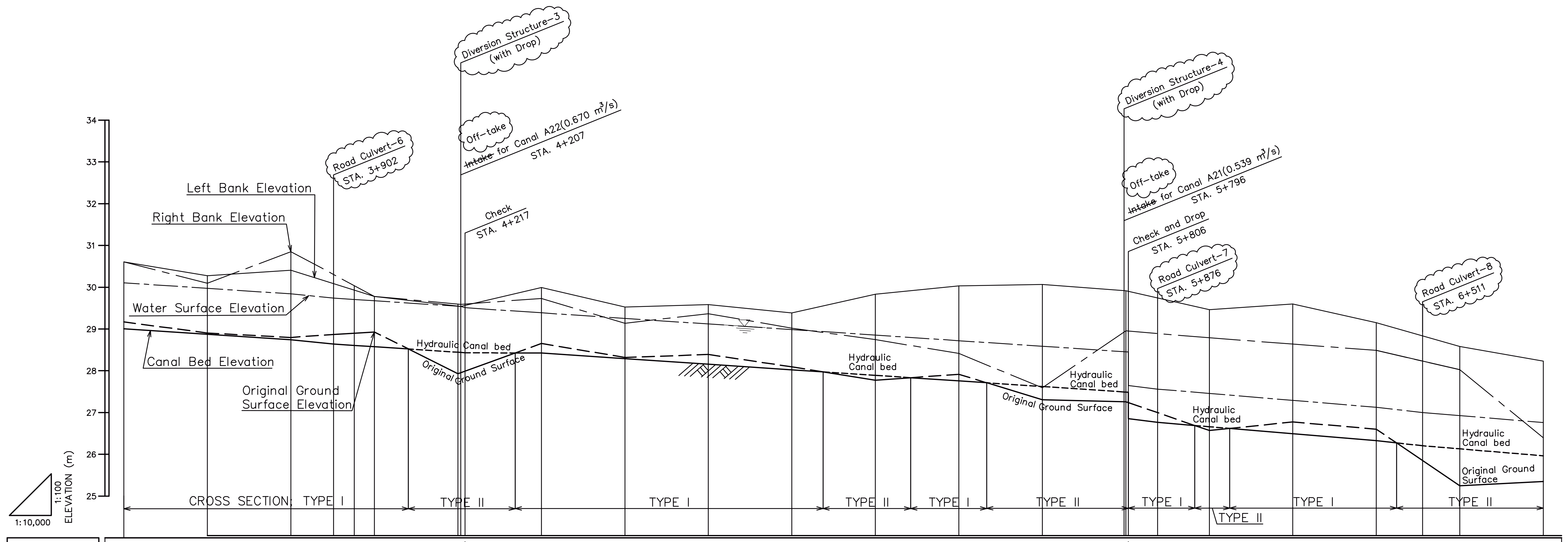
Hydraulic Parameters

Hydraulic Section	Discharge (m^3/s)	Canal Bed Width(m)	Velocity (m/s)	Gradient	Roughness Coefficient	Canal Inside Slope	Design Water Depth(m)	Outside Slope
Type A-1	3.216	2.00	0.381	1:5000	0.035	1:2.0	1.615	1:1.5
Type A-2	3.065	2.00	0.588	1:1500	0.035	1:2.0	1.190	1:1.5
Type A-3	2.214	1.50	0.544	1:1500	0.035	1:2.0	1.100	1:1.5
Type A-4	1.544	1.30	0.498	1:1500	0.035	1:2.0	0.963	1:1.5
Type A-5	1.006	1.00	0.486	1:1500	0.035	1:2.0	0.797	1:1.5

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified and/or added portion by the Survey Team are marked by cloud as follow:

Note ; Typical Cross Sections for Type I and II are given in Drawing No. "32 of 62".

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Irrigation Canal System**	Date Sept. 2011
Japan International Cooperation Agency (JICA)	**Profile of Main Canal 33 (1/3)**	DWG. No. USS-14



HYDRAULIC SECTION	STATION NO.	ACCUMULATED DISTANCE	DISTANCE	WATER SURFACE ELEVATION	HYDRAULIC CANAL BED ELEVATION	ORIGINAL GROUND SURFACE ELEVATION	LEFT BANK ELEVATION	RIGHT BANK ELEVATION
Type A-3	3+400	3,400	200	30.106	29.006	29.170	30.607	30.507
	3+600	3,600	200	29.973	28.873	28.903	30.275	30.094
	3+800	3,800	200	29.840	28.740	28.798	30.407	30.852
		3,902	102	29.742	28.642	28.857		
		3,952	50	29.708	28.608			
	4+000	4,000	48	29.676	28.576	28.929	29.781	29.774
	4+200	4,200	200	29.543	28.443	27.932	29.540	29.596
		4,207	7	29.538	28.438			
Type A-4		4,217	10	29.509	28.431			
	4+400	4,400	183	29.387	28.424	28.653	29.993	29.732
	4+600	4,600	200	29.254	28.291	28.319	29.526	29.137
	4+800	4,800	200	29.120	28.157	28.390	29.585	29.365
	5+000	5,000	200	28.987	28.024	28.093	29.384	29.020
	5+200	5,200	200	28.854	27.891	27.775	29.834	28.746
	5+400	5,400	200	28.720	27.757	27.915	30.034	28.414
	5+600	5,600	200	28.587	27.624	27.308	30.068	27.593
		5,796	196	28.456	27.493	27.259	29.913	28.957
	5+800	5,800	4	28.454	27.491			
Type A-5		5,806	6	27.649	26.852			
		5,876	70	27.561	26.764			
	6+000	6,000	124	27.458	26.661	26.570	29.464	28.789
	6+200	6,200	200	27.291	26.494	26.775	29.600	28.639
	6+400	6,400	200	27.124	26.327	26.637	29.150	28.487
		6,511	111	27.002	26.205			
	6+600	6,600	89	26.928	26.131	25.245	28.582	28.027
	6+800	6,800	200	26.761	25.964	25.349	28.233	26.394

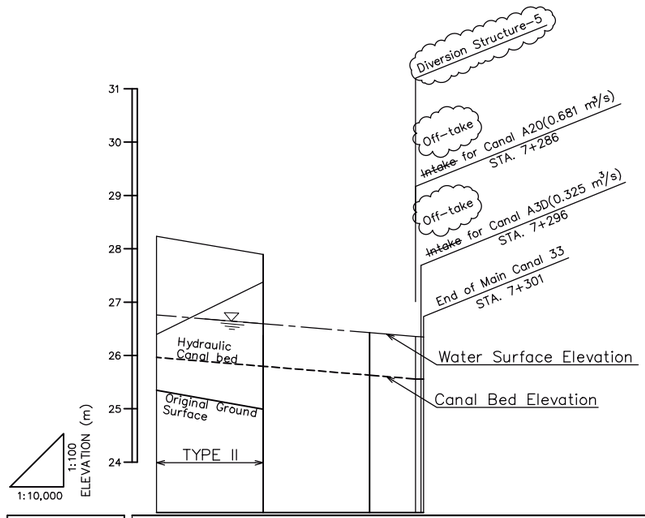
Hydraulic Parameters

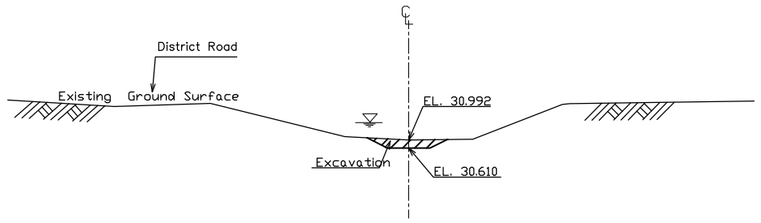
Hydraulic Section	Discharge (m^3/s)	Canal Bed Width(m)	Velocity (m/s)	Gradient	Roughness Coefficient	Canal Inside Slope	Design Water Depth(m)	Outside Slope
Type A-1	3.216	2.00	0.381	1:5000	0.035	1:2.0	1.615	1:1.5
Type A-2	3.065	2.00	0.588	1:1500	0.035	1:2.0	1.190	1:1.5
Type A-3	2.214	1.50	0.544	1:1500	0.035	1:2.0	1.100	1:1.5
Type A-4	1.544	1.30	0.498	1:1500	0.035	1:2.0	0.963	1:1.5
Type A-5	1.006	1.00	0.486	1:1500	0.035	1:2.0	0.797	1:1.5

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified and/or added portion by the Survey Team are marked by cloud as follow:

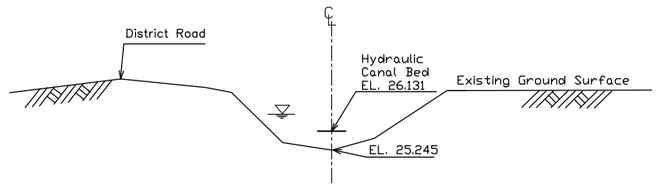
Note ; Typical Cross Sections for Type I and II are given in Drawing No. "32 of 62".

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Irrigation Canal System**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)	**Profile of Main Canal 33 (2/3)**	DWG. No. USS-15





TYPICAL CROSS SECTION-TYPE I
(Ex. STA No.2+400)



TYPICAL CROSS SECTION-TYPE II
(Ex. STA No.6+600)

HYDRAULIC SECTION	Type A-5							
WATER SURFACE ELEVATION	26.761	26.594	26.428	26.356	26.349	26.346		
HYDRAULIC CANAL BED ELEVATION	25.964	25.797	25.631	25.559	25.559	25.559		
ORIGINAL GROUND SURFACE ELEVATION	25.349	24.993		24.518				
LEFT BANK ELEVATION	28.233	27.896						
RIGHT BANK ELEVATION	26.394	27.378						
ACCUMULATED DISTANCE	6,800	7,000	7,200	7,286	7,296	7,301		
DISTANCE	200	200	200	86	10	5		
STATION NO.	6+800	7+000		7+301 (EP)				

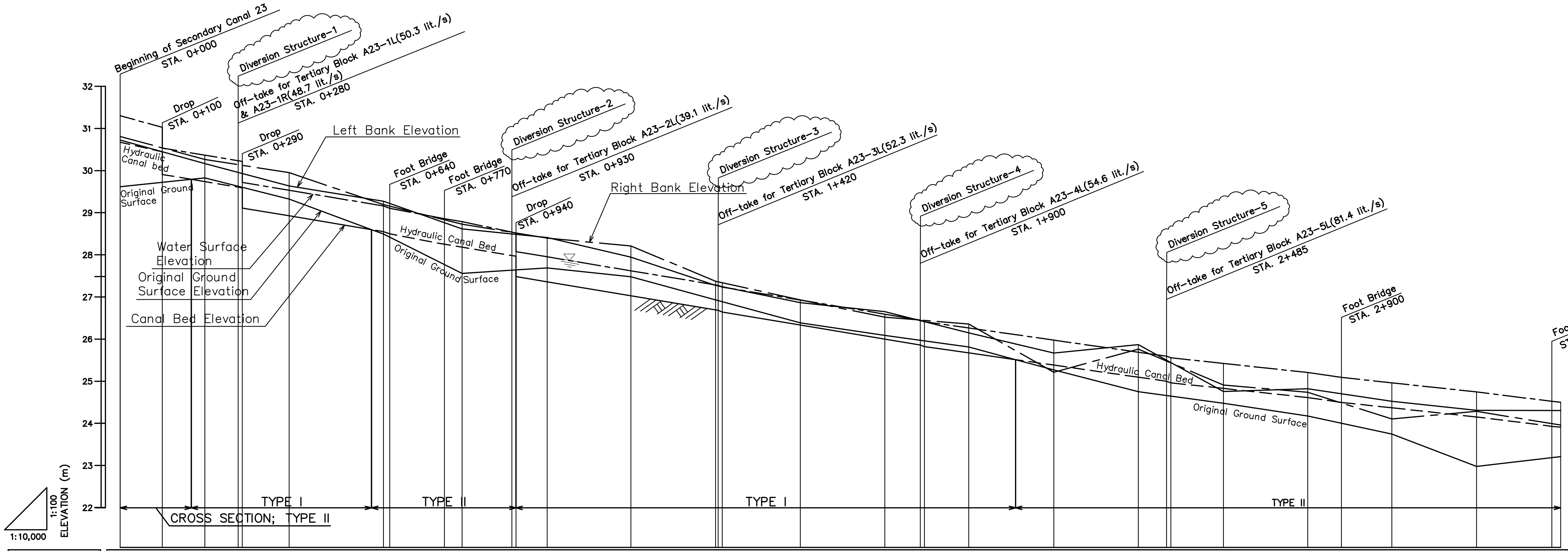
Hydraulic Parameters

Hydraulic Section	Discharge (m^3/s)	Canal Bed Width(m)	Velocity (m/s)	Gradient	Roughness Coefficient	Canal Inside Slope	Design Water Depth(m)	Outside Slope
Type A-1	3.216	2.00	0.381	1:5000	0.035	1:2.0	1.615	1:1.5
Type A-2	3.065	2.00	0.588	1:1500	0.035	1:2.0	1.190	1:1.5
Type A-3	2.214	1.50	0.544	1:1500	0.035	1:2.0	1.100	1:1.5
Type A-4	1.544	1.30	0.498	1:1500	0.035	1:2.0	0.963	1:1.5
Type A-5	1.006	1.00	0.486	1:1500	0.035	1:2.0	0.797	1:1.5

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified and/or added portion by the Survey Team are marked by cloud as follow:

Note; Survey Results for the lower stretch are not available and Profile of the stretch(Station No. 7+000 to the end) is not included in this drawing.

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Irrigation Canal System** **Profile of Main Canal 33 (3/3)**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. USS-16



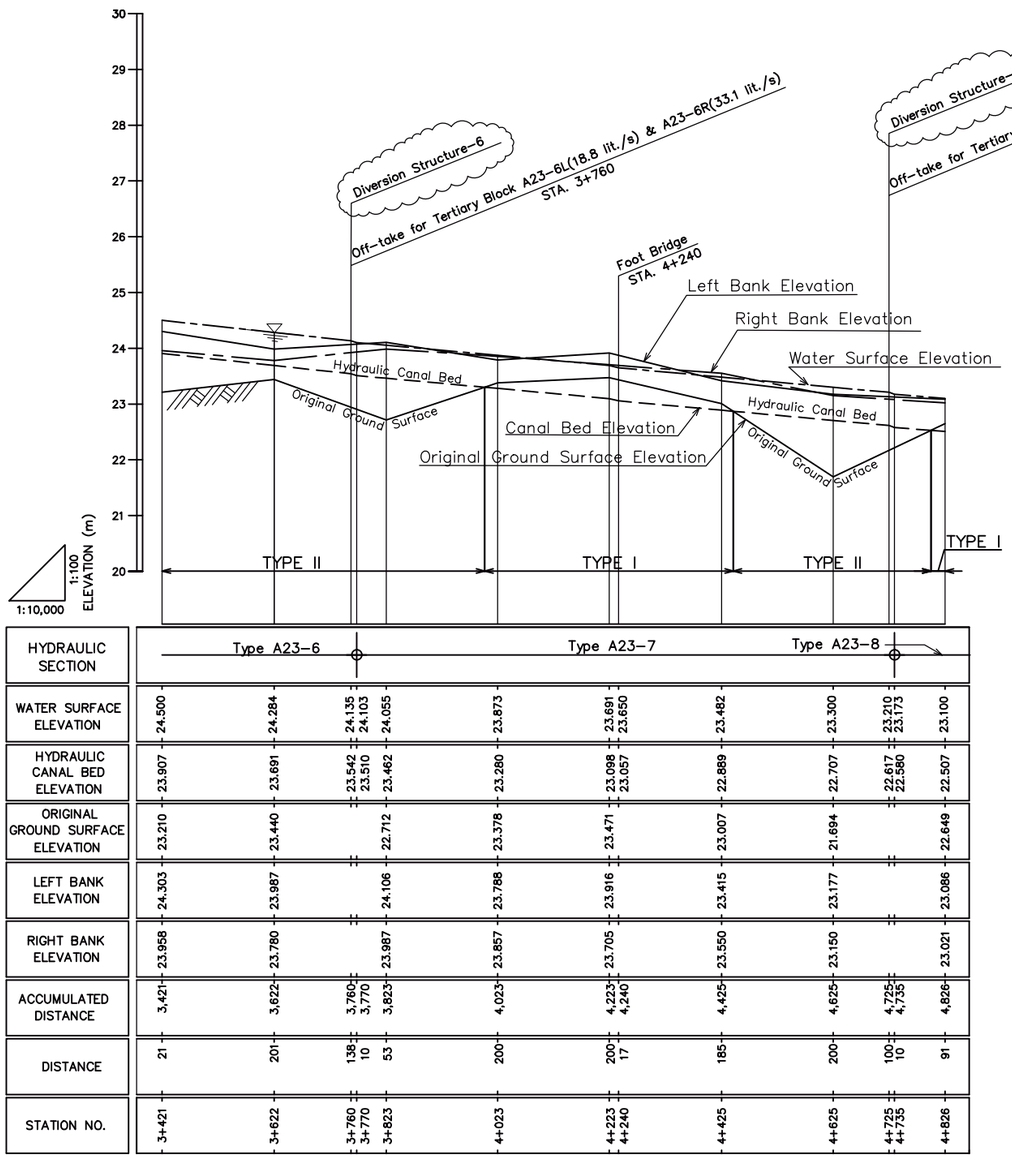
STATION NO.	HYDRAULIC SECTION	WATER SURFACE ELEVATION	HYDRAULIC CANAL BED ELEVATION	ORIGINAL GROUND SURFACE ELEVATION	LEFT BANK ELEVATION	RIGHT BANK ELEVATION	ACCUMULATED DISTANCE	DISTANCE
0+000	Type A23-1	31.300	30.673	29.616	30.722	30.809	0	0
0+100		30.534	29.907				100	100
0+201		30.365	29.738	29.825	30.167	30.264	201	101
0+280	Type A23-2	30.234	29.607				280	79
0+290		29.718	29.110				290	10
0+401		29.533	28.925	29.323	29.634	29.950	401	111
0+625		29.160	28.552	28.495	29.271	29.191	625	224
0+640		29.105	28.497				640	15
0+770		28.858	28.250				770	130
0+812		28.788	28.180	27.558	28.613	28.728	812	42
0+930	Type A23-3	28.592	27.984				930	118
0+940		28.075	27.842				940	10
1+014		27.952	27.359	27.689	28.408	28.396	1,014	74
1+213		27.620	27.027	27.478	27.947	28.209	1,213	199
1+414		27.285	26.692	26.929	27.275	27.373	1,414	201
1+420	Type A23-4	27.275	26.682				1,420	6
1+430		27.234	26.641				1,430	10
1+615		26.926	26.333	26.387	26.863	26.929	1,615	185
1+816		26.591	25.998	26.085	26.651	26.518	1,816	201
1+900	Type A23-5	26.451	25.858				1,900	84
1+910		26.414	25.821				1,910	10
2+015		26.264	25.671	25.811	26.146	26.357	2,015	105
2+217		25.975	25.382	25.268	25.667	25.212	2,217	202
2+418		25.688	25.095	24.753	25.869	25.763	2,418	201
2+485	Type A23-6	25.593	25.000				2,485	67
2+495		25.555	24.962				2,495	10
2+620		25.421	24.828	24.478	24.757	24.908	2,620	125
2+820		25.206	24.613	24.174	24.823	24.737	2,820	200
2+900		25.090	24.497				2,900	80
3+020		24.961	24.368	23.747	24.523	24.103	3,020	120
3+221		24.745	24.152	22.978	24.307	24.286	3,221	201
3+400		24.522	23.929				3,400	179
3+421		24.500	23.907	23.210	24.303	23.958	3,421	21

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified and/or added portion by the Survey Team are marked by cloud as follow:

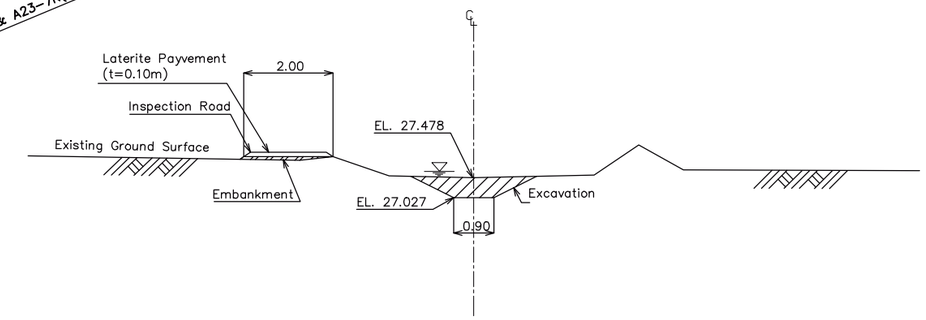
Note 1; Length of Canal 23 is 9,245m in total.
Survey Results for the lower stretch are not available and Profile of the stretch(Station No. 4+826 to the end) is not included in this drawing.

Note 2; Typical Cross Sections for Type I and II are given in Drawing No. "35 of 62".

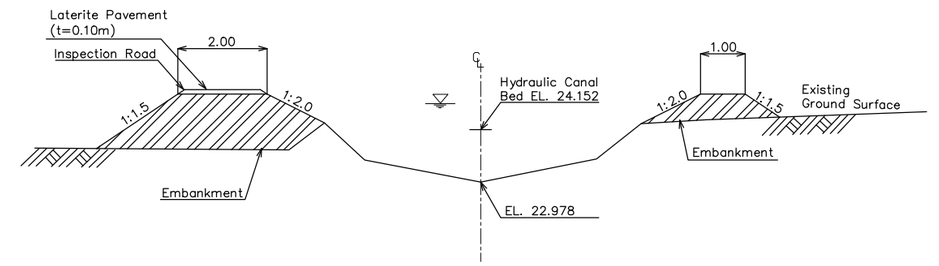
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Irrigation Canal System**	Date Sept. 2011	
Japan International Cooperation Agency (**JICA**)	**Profile of Secondary Canal 23 (1/2)**	DWG. No. USS-17	



HYDRAULIC SECTION	Type A23-6							Type A23-7									Type A23-8						
WATER SURFACE ELEVATION	24.500	24.284	24.135	24.103	24.055	23.873	23.691	23.650	23.482	23.300	23.210	23.173	23.100										
HYDRAULIC CANAL BED ELEVATION	23.907	23.691	23.542	23.510	23.462	23.280	23.098	23.057	22.889	22.707	22.617	22.580	22.507										
ORIGINAL GROUND SURFACE ELEVATION	23.210	23.440			22.712	23.378	23.471		23.007	21.694			22.649										
LEFT BANK ELEVATION	24.303	23.987			24.106	23.788	23.916		23.415	23.177			23.086										
RIGHT BANK ELEVATION	23.958	23.780			23.987	23.857	23.705		23.550	23.150			23.021										
ACCUMULATED DISTANCE	3,421	3,622	3,760	3,770	3,823	4,023	4,223	4,240	4,425	4,625	4,725	4,735	4,826										
DISTANCE	21	201	138	10	53	200	200	17	185	200	100	10	91										
STATION NO.	3+421	3+622	3+760	3+770	3+823	4+023	4+223	4+240	4+425	4+625	4+725	4+735	4+826										



TYPICAL CROSS SECTION; TYPE I
(Ex. STA No.1+213)



TYPICAL CROSS SECTION; TYPE II
(Ex. STA No.3+221)

Hydraulic Parameters

Hydraulic Section	Discharge (m^3/s)	Canal Bed Width(m)	Velocity (m/s)	Gradient	Roughness Coefficient	Canal Inside Slope	Design Water Depth(m)	Outside Slope
Type A23-1	0.851	1.00	0.60	1:600	0.035	1:2.0	0.62	1:1.5
Type A23-2	0.752	0.90	0.58	1:600	0.035	1:2.0	0.60	1:1.5
Type A23-3	0.713	0.90	0.57	1:600	0.035	1:2.0	0.59	1:1.5
Type A23-4	0.661	0.80	0.56	1:600	0.035	1:2.0	0.58	1:1.5
Type A23-5	0.606	0.80	0.52	1:700	0.035	1:2.0	0.58	1:1.5
Type A23-6	0.525	0.80	0.45	1:930	0.035	1:2.0	0.58	1:1.5
Type A23-7	0.473	0.80	0.41	1:1,100	0.035	1:2.0	0.58	1:1.5
Type A23-8	0.384	0.80.	0.37	1:1,250	0.035	1:2.0	0.54	1:1.5

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. Modified and/or added portion by the Survey Team are marked by cloud as follow:

Note 1; Length of Canal 23 is 9,245m in total.
Survey Results for the lower stretch are not available and Profile of the stretch(Station No. 4+826 to the end) is not included in this drawing.

Note 2; Stripping shall be given to the original ground on which embankment will be made.

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (**JICA**)

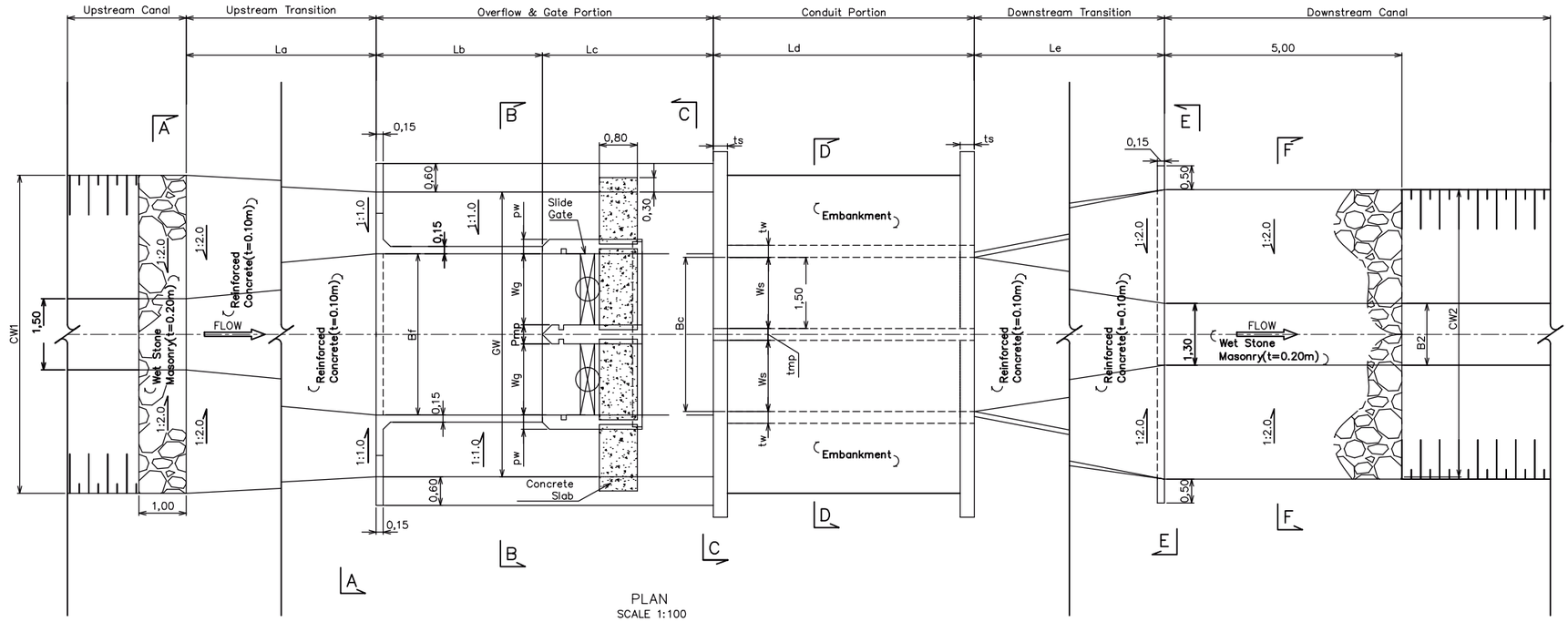
Title of Drawing

Irrigation Canal System

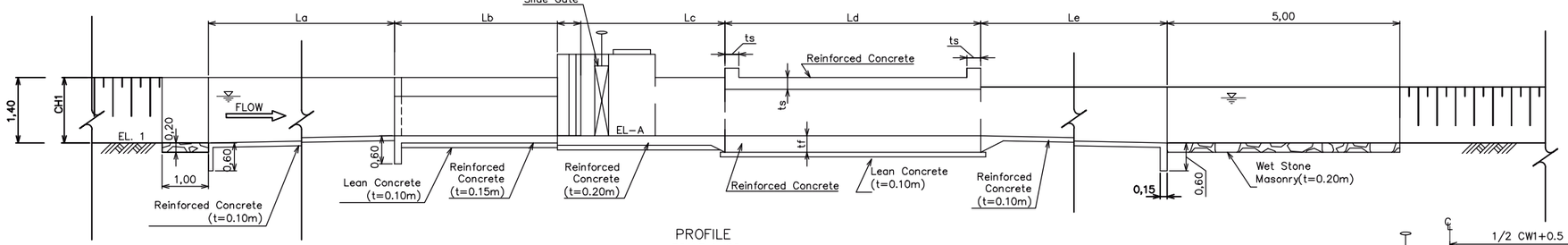
Profile of Secondary Canal 23 (2/2)

Date
Sept. 2011

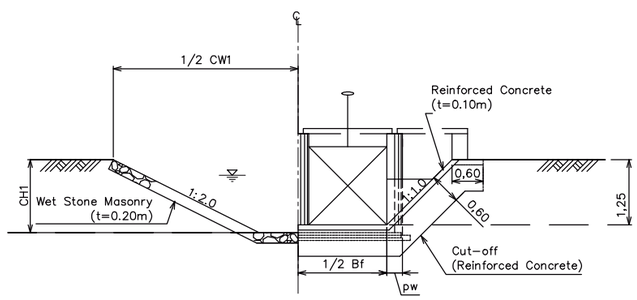
DWG. No.
USS-18



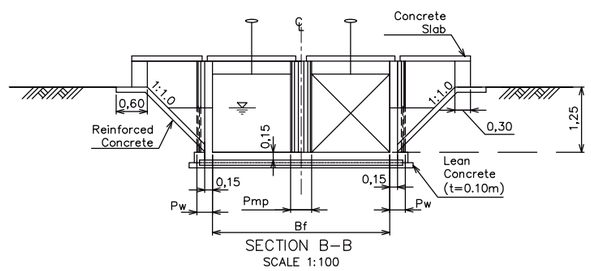
PLAN
SCALE 1:100



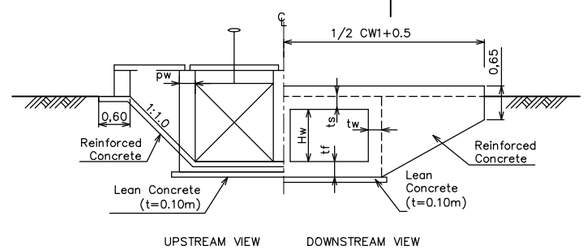
PROFILE
SCALE 1:100



SECTION A–A
SCALE 1:100



SECTION B–B
SCALE 1:100



UPSTREAM VIEW DOWNSTREAM VIEW

SECTION C–C
SCALE 1:100

0 1.0 2.0 3.0 4.0 5.0m
SCALE 1:100

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. No modification is made by the Survey Team in 2011

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (**JICA**)

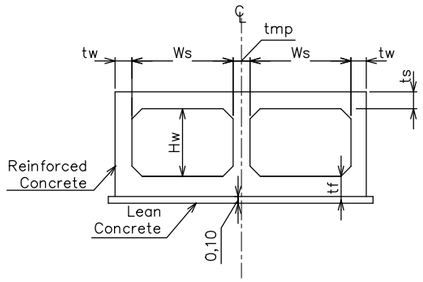
Title of Drawing

Related Structures

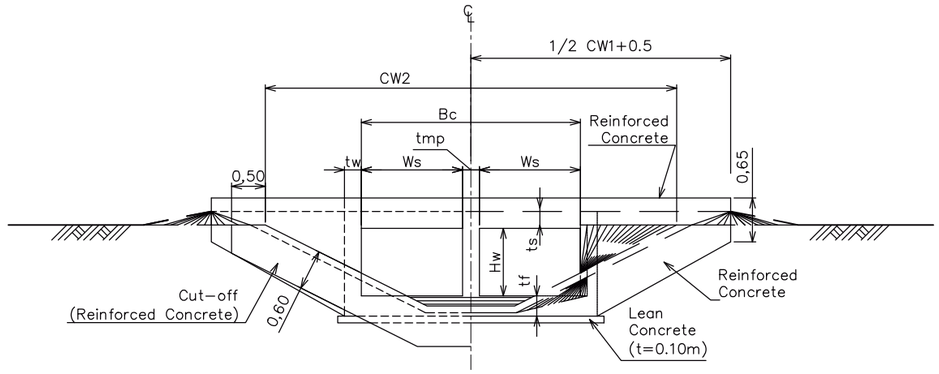
Diversion Structure without Drop (1/2)

Date
Sept. 2011

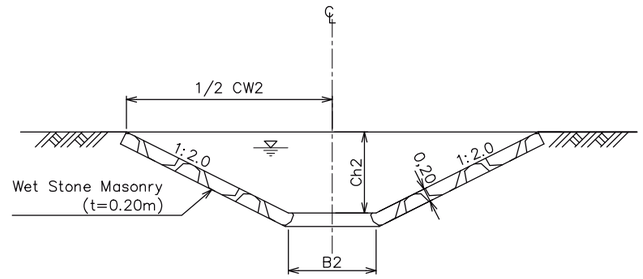
DWG. No.
USS-19



SECTION D–D
SCALE 1:100



SECTION E–E
SCALE 1:100



SECTION F–F
SCALE 1:100

Code No.	Upstream Canal			Upstream Transition	Overflow and Gate Portion							
	Canal Bed Width	Total Height	Total Width		Overflow Portion	Gate Portion	Inlet Width at Overflow	Total Width at Overflow	Center Pier Width at Gate	Side Pier Width at Gate	Gate Size	Gate Nos.
(m³/s)	B–1	CH1	CW1	La	Lb	Lc	Bf	Gw	Pmp	Pw		
Main Canal												
Q=2.0	1.50	1.40	6.70	7.00	3.50	3.60	3.40	7.30	0.40	0.30	1.50x1.50	2
Secondary Canal												
Q<0.25	0.50–0.60	0.50–0.60	2.50–3.00	2.00–3.00	1.00	2.60	0.60	2.10–2.40	0.40	0.30	0.60x0.60	1
0.25<Q=or<0.40	0.60–0.75	0.60–0.70	3.00–3.55	3.00–4.00	1.50	2.60	0.80	2.60–2.90	0.40	0.30	0.80x0.80	1
0.40<Q=or<0.50	0.70–0.80	0.70–0.80	3.50–4.00	4.00–5.00	2.00	2.85	1.60	3.70–4.00	0.40	0.30	0.60x0.60	2
0.50<Q=or<0.90	0.75–1.00	0.70–0.90	3.55–4.60	4.00–6.00	2.50	3.10	2.00	4.10–4.70	0.40	0.30	0.80x0.80	2

Code No.	Conduit Portion								Down–stream Transition	Downstream Canal			Total Structure Length
	Conduit Portion	Inlet Width of Conduit	Conduit Size	Conduit Nos.	Box Side Wall Thick	Box Top Slab Thick	Box Bottom Slab Thick	Box Centre Wall Thick		Canal Bed Width	Total Height	Total Width	
(m³/s)	Le	Bc	Ws x Hw	––	tw	ts	tf	tmp	Le	B2	Ch2	CW2	Lt
Main Canal													
Q=2.0	3.00or6.00	3.25	1.50x1.0	2	0.25	0.25	0.30	0.25	7.00	1.30	1.20	6.10	30.1–33.10
Secondary Canal													
Q<0.25	3.00or6.00	0.60	0.60x0.60	1	0.15	0.15	0.15	–	2.00–3.00	0.50–0.60	0.50–0.60	2.50–3.00	16.60–21.60
0.25<Q=or<0.40	3.00or6.00	0.80	0.80x0.80	1	0.15	0.15	0.15	–	3.00–4.00	0.60–0.75	0.60–0.70	3.00–3.55	19.10–24.10
0.40<Q=or<0.50	3.00or6.00	1.60	0.60x0.60	2	0.20	0.20	0.25	0.20	4.00–5.00	0.70–0.80	0.70–0.80	3.50–4.00	21.85–26.85
0.50<Q=or<0.90	3.00or6.00	2.00	0.80x0.80	2	0.20	0.20	0.25	0.20	4.00–6.00	0.70–1.00	0.70–0.90	3.55–4.60	22.60–29.60

0 1.0 2.0 3.0 4.0 5.0m
SCALE 1:100

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. No modification is made by the Survey Team in 2011

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (**JICA**)

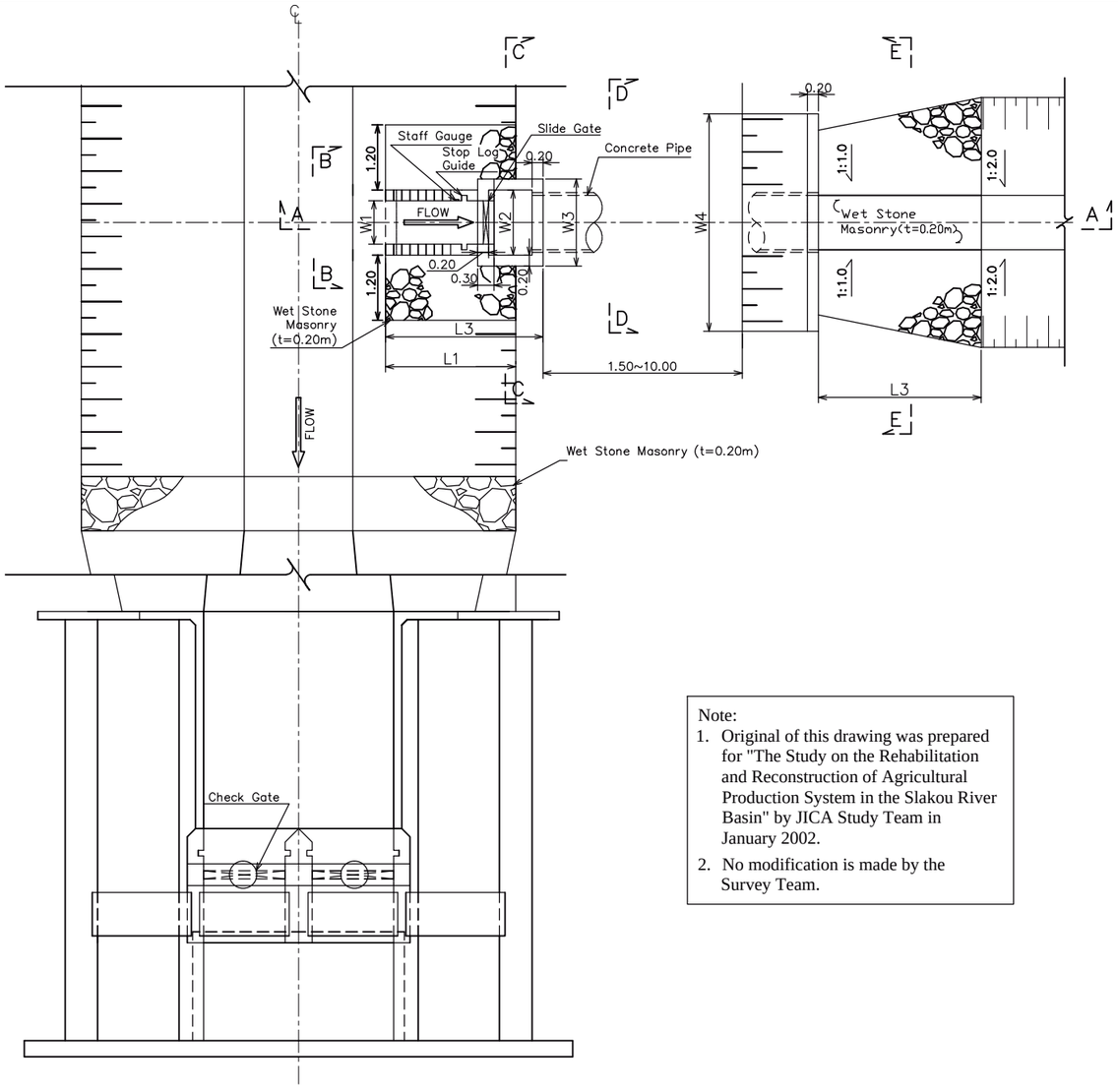
Title of Drawing

Related Structures

Diversion Structure without Drop (2/2)

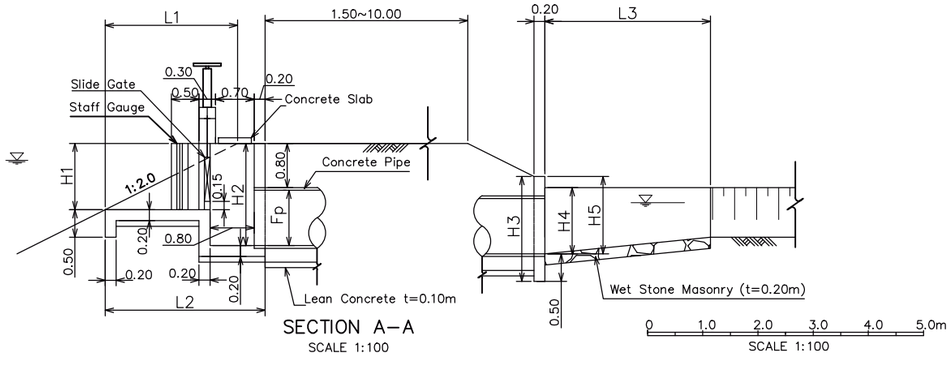
Date: Sept. 2011

DWG. No. USS-20



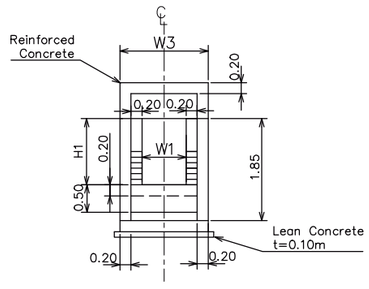
Dimension Box of Diversion and Off-take				
	Q<0.06m³/s	0.06≦Q<0.2m³/s	0.2≦Q<0.4m³/s	0.4≦Q<0.9m³/s
L1	1.60	1.80	2.00	2.40
L2	2.10	2.30	2.50	2.90
L3	3.00	3.00	5.00	5.00
H1	0.80	1.00	1.00	1.20
H2	1.45	1.45	1.65	1.85
H3	1.30	1.50	1.80	1.90
H4	0.60	0.80	1.10	1.20
H5	0.80	1.00	1.30	1.40
Fp	0.40	0.60	0.80	1.00
Gate Size	0.60 x 0.60	0.60 x 0.60	0.80 x 0.80	0.80 x 0.80
W1	0.60	0.60	0.80	0.80
W2	0.60	0.80	1.00	1.20
W3	1.00	1.20	1.40	1.60
W4	2.20	2.80	3.40	4.00
W5	0.40	0.60	0.80	1.00
Bw	0.70	0.90	1.10	1.30
Bt	0.15	0.20	0.25	0.25

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. No modification is made by the Survey Team.

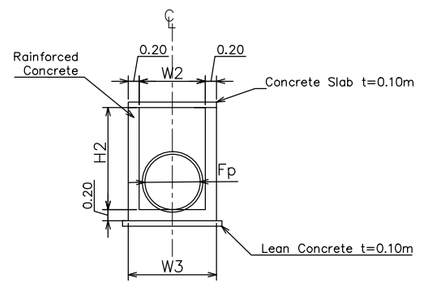


SECTION A–A
SCALE 1:100

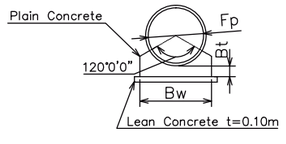
SCALE 1:100



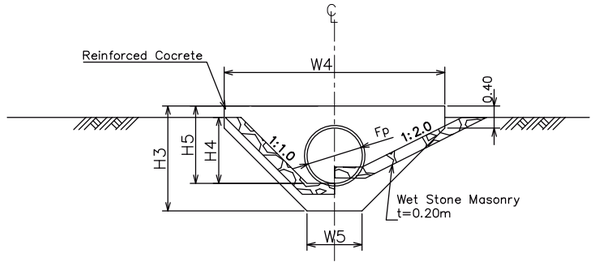
SECTION B–B
SCALE 1:100



SECTION C–C
SCALE 1:100

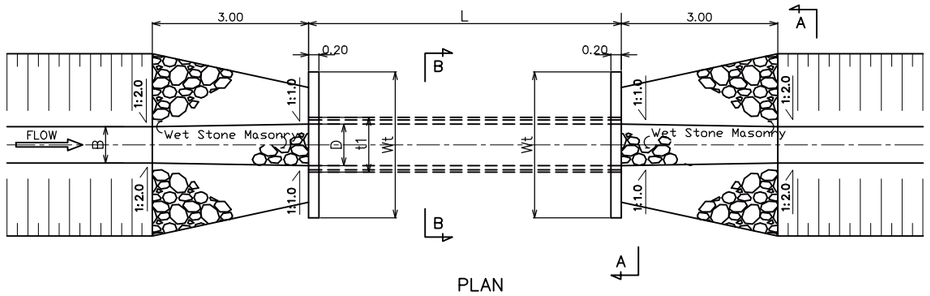


SECTION D–D
SCALE 1:100

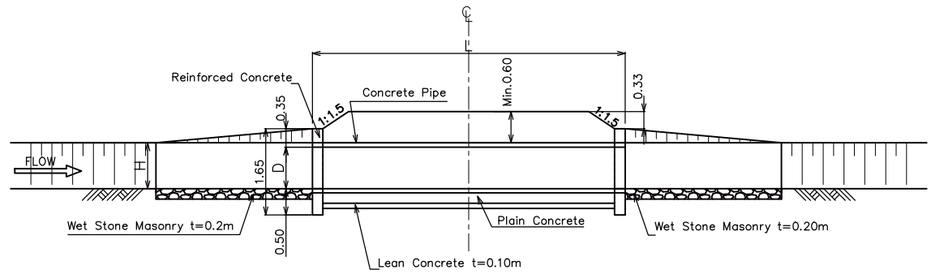


SECTION E–E
(OUTLET WALL)
SCALE 1:100

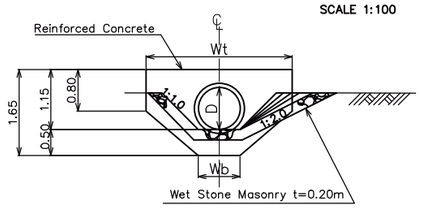
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Related Structures** **Off-Take**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. USS-21



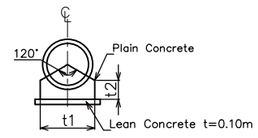
PLAN
SCALE 1:100



PROFILE
SCALE 1:100



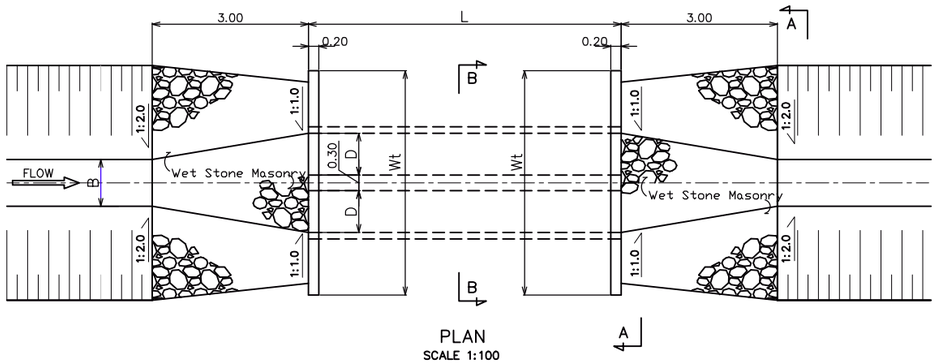
SECTION A–A
SCALE 1:100



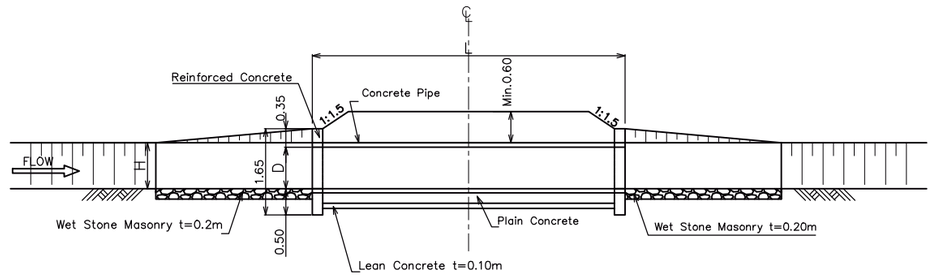
SECTION B–B
SCALE 1:100

For Foot Bridge

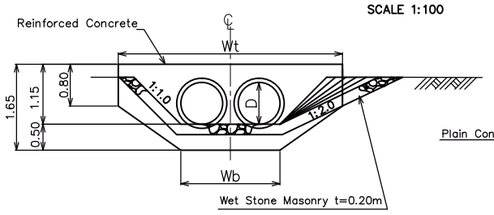
Canal Type		Pipe Culvert Type						
B(m)	H(m)	L(m)	D(mm)		Wt(m)	Wb(m)	t1(m)	t2(m)
1.00	0.80	3.00	ø800	Double	4.10	1.90	2.15	0.36
0.90	0.90	3.00	ø800	Double	4.30	1.90	2.15	0.36
0.80	0.90	3.00	ø800	Double	4.30	1.90	2.15	0.36
0.80	0.80	3.00	ø800	Double	4.10	1.90	2.15	0.36
0.80	0.80	3.00	ø800	Double	4.10	1.90	2.15	0.36
0.75	0.70	3.00	ø800	Double	3.90	1.90	2.15	0.36
0.75	0.60	3.00	ø800	Double	3.70	1.90	2.15	0.36
0.70	0.80	3.00	ø800	Double	4.10	1.90	2.15	0.36
0.70	0.70	3.00	ø600	Double	3.50	1.50	1.70	0.27
0.50	0.60	3.00	ø600	Single	2.40	0.60	0.80	0.27
0.50	0.50	3.00	ø800	Single	2.40	0.80	1.05	0.36
0.50	0.50	3.00	ø600	Single	2.20	0.60	0.80	0.27



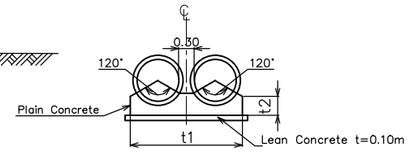
PLAN
SCALE 1:100



PROFILE
SCALE 1:100



SECTION A–A
SCALE 1:100



SECTION B–B
SCALE 1:100

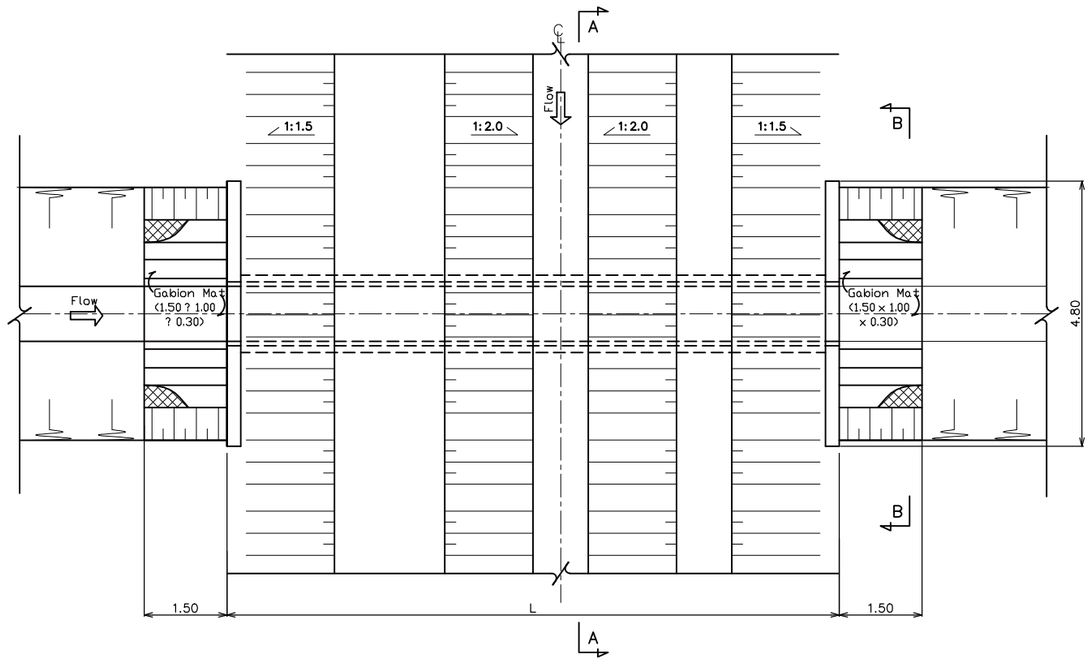
0 1.0 2.0 3.0 4.0 5.0m
SCALE 1:100

For Road Brigde

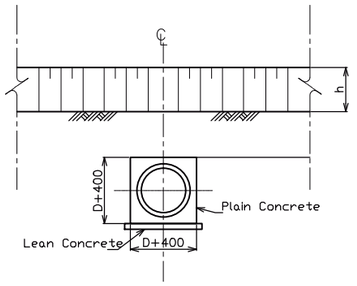
Canal Type		Pipe Culvert Type						
B(m)	H(m)	L(m)	D(mm)		Wt(m)	Wb(m)	t1(m)	t2(m)
0.80	0.80	6.00	ø800	Double	4.10	1.90	2.15	0.36
0.75	0.70	6.00	ø600	Double	3.50	1.50	1.70	0.27
0.70	0.70	6.00	ø800	Single	2.80	0.80	1.05	0.36
0.60	0.60	6.00	ø600	Single	2.40	0.60	0.80	0.27
0.50	0.50	6.00	ø800	Single	2.40	0.80	1.05	0.36
0.50	0.40	6.00	ø600	Single	2.00	0.60	0.80	0.27

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. No modification is made by the Survey Team in 2011

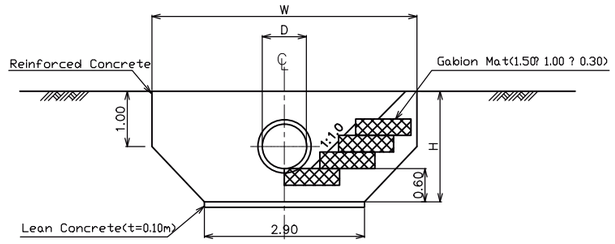
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Related Structures** **Pipe Culverts**	Date Sept. 2011
Japan International Cooperation Agency (**JICA**)		DWG. No. USS-22



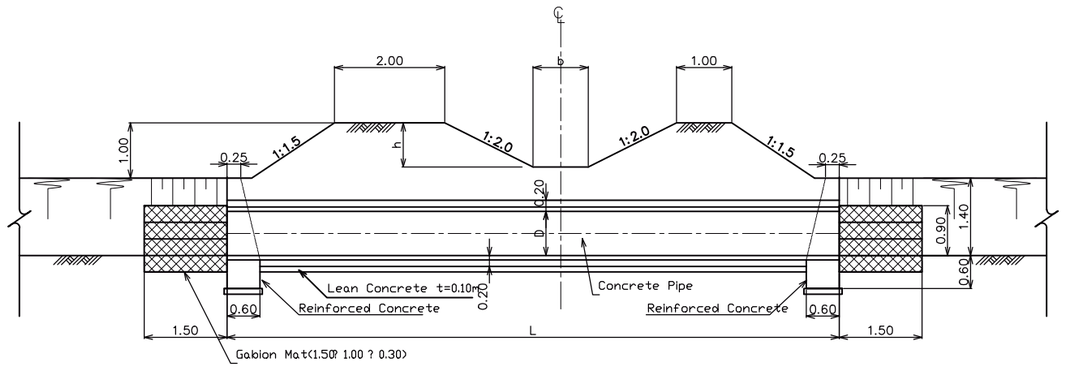
PLAN
SCALE 1:100



SECTION A–A
SCALE 1:100



SECTION B–B
SCALE 1:100



PROFILE
SCALE 1:100

Canal Type Crossing		Type of Cross Drain Culvert				
Bed Width b(m)	Hieght h(m)	Length L(m)	D=ø600		D=ø800	
			Width W(m)	Height H(m)	Width W(m)	Height H(m)
1.00	0.90	12.00	4.60	1.90	4.80	2.00
1.00	0.80	12.00	4.60	1.90	4.80	2.00
0.90	0.90	12.00	4.60	1.90	4.80	2.00
0.90	0.80	11.00	4.60	1.90	4.80	2.00
0.80	0.90	12.00	4.60	1.90	4.80	2.00
0.80	0.80	11.00	4.60	1.90	4.80	2.00
0.75	0.80	11.00	4.60	1.90	4.80	2.00
0.75	0.70	11.00	4.60	1.90	4.80	2.00
0.75	0.60	11.00	4.60	1.90	4.80	2.00
0.70	0.80	11.00	4.60	1.90	4.80	2.00
0.70	0.70	11.00	4.60	1.90	4.80	2.00
0.70	0.60	10.00	4.60	1.90	4.80	2.00
0.60	0.70	11.00	4.60	1.90	4.80	2.00
0.60	0.60	10.00	4.60	1.90	4.80	2.00
0.50	0.60	10.00	4.60	1.90	4.80	2.00
0.50	0.50	10.00	4.60	1.90	4.80	2.00
0.50	0.40	9.00	4.60	1.90	4.80	2.00

0 1.0 2.0 3.0 4.0 5.0m
SCALE 1:100

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. No modification is made by the Survey Team in 2011.

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (**JICA**)

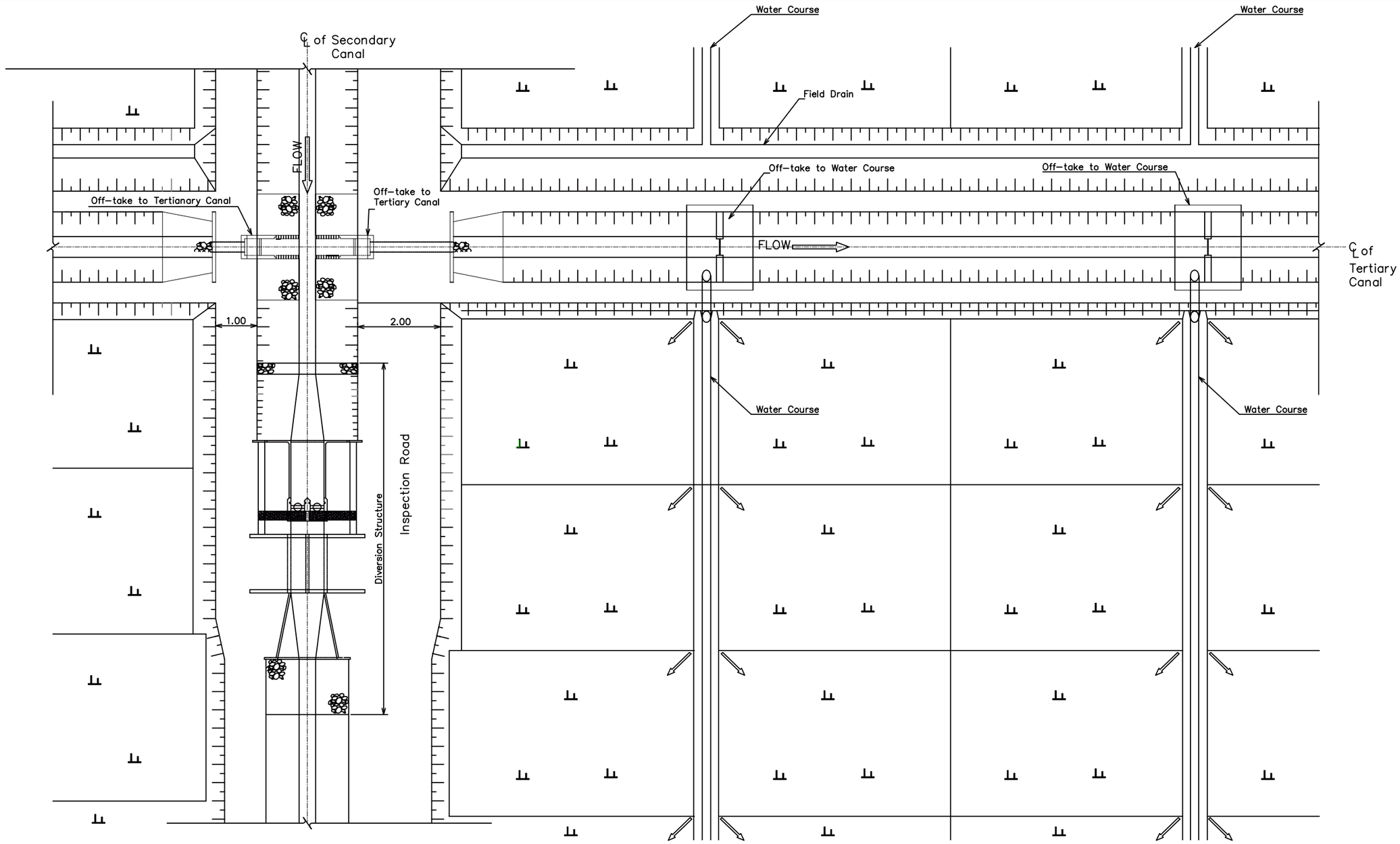
Title of Drawing

Related Structures

Cross Drain

Date
Sept. 2011

DWG. No.
USS-23



PLAN
NOT SCALED

Note:
1. Original of this drawing was prepared for "The Study on the Rehabilitation and Reconstruction of Agricultural Production System in the Slakou River Basin" by JICA Study Team in January 2002.
2. No modification is made by the Survey Team in 2011

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (**JICA**)

Title of Drawing

Irrigation Canal System

Standard Layout of Tertiary System

Date
Sept. 2011

DWG. No.
USS-24

0.0 0.5 1.0 2.0 (km)

LEGEND

- Main Irrigation Canal
- Existing Canal
- Tertiary Canal
- Existing Canal Used for Drainage
- Dike
- River
- Irrigation Area
- Weir
- Regulator

Daeum Rues Regulator

NS-78

Existing Weir

New Weir

(50ha)

NS-82
KC-4

(150ha)

Intake/Pump Station

Flood Protection Dike

KC-41

Swamp

First Priority Area
(1.950ha, Implemented in 2005-2007)

EW-61

EW-60 (6.6Km)

EW-59

EW-58 (4.7Km)

EW-57

(450ha)

(700ha)

KC-3-1

KC-311

KC-2

EW-63

Kampong Daungkar Regulator
(Spillway)

Bati Area

MD-1 (MC-2)

MR-1

MR-3

MD-3

L3

L4

L5

L6

L7

L8

(1,600ha)

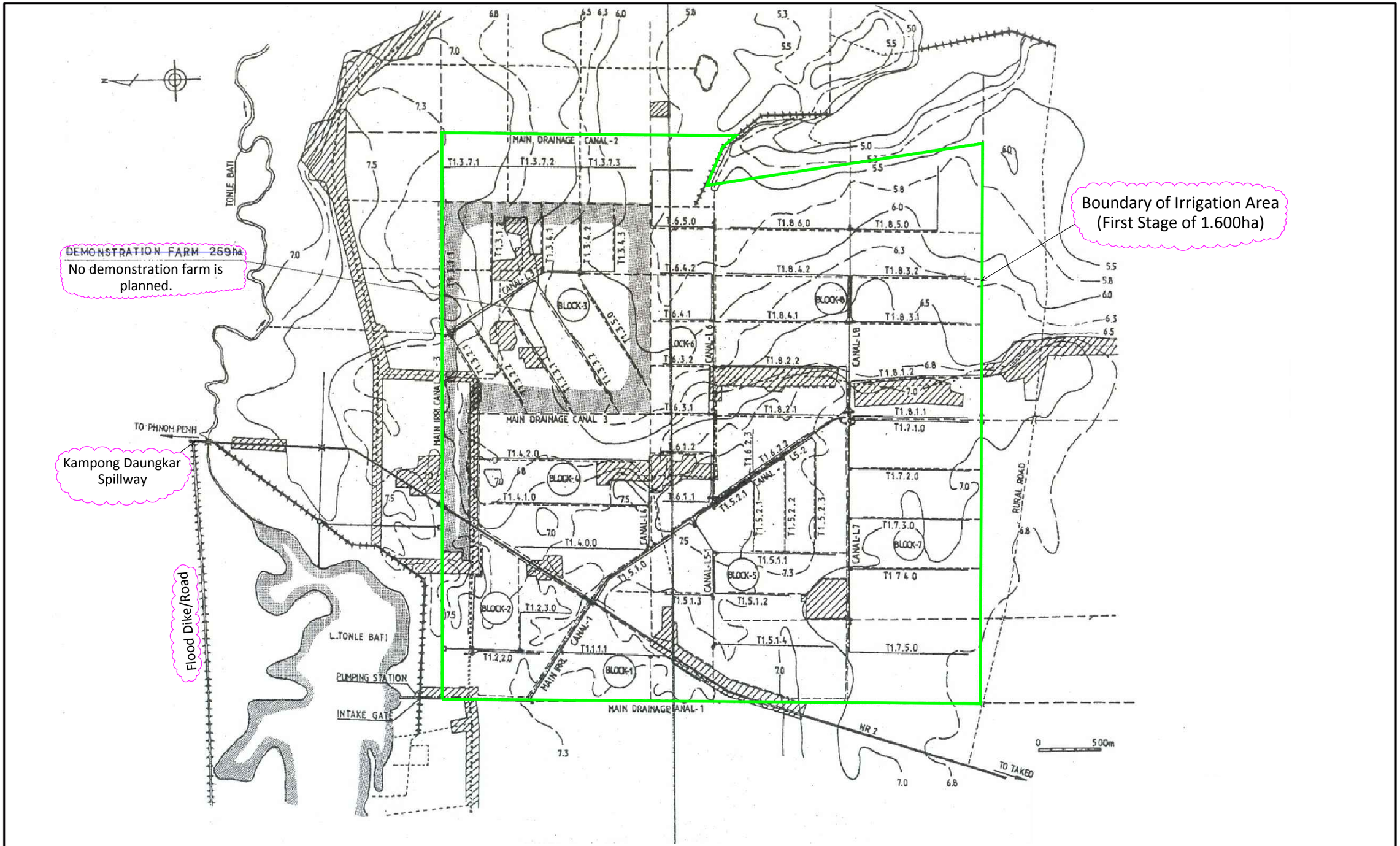
Kandal Stung Area

(200ha)

(200ha)

Drain

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA Japan International Cooperate Agency (JICA)	Title of Drawing **General Layout of Kandal Stung-Bati Irrigation System Rehabilitation Sub-project**	Date Mar. 2012 DWG. No. KSB-01



~~DEMONSTRATION FARM 259ha~~
No demonstration farm is planned.

Boundary of Irrigation Area
(First Stage of 1.600ha)

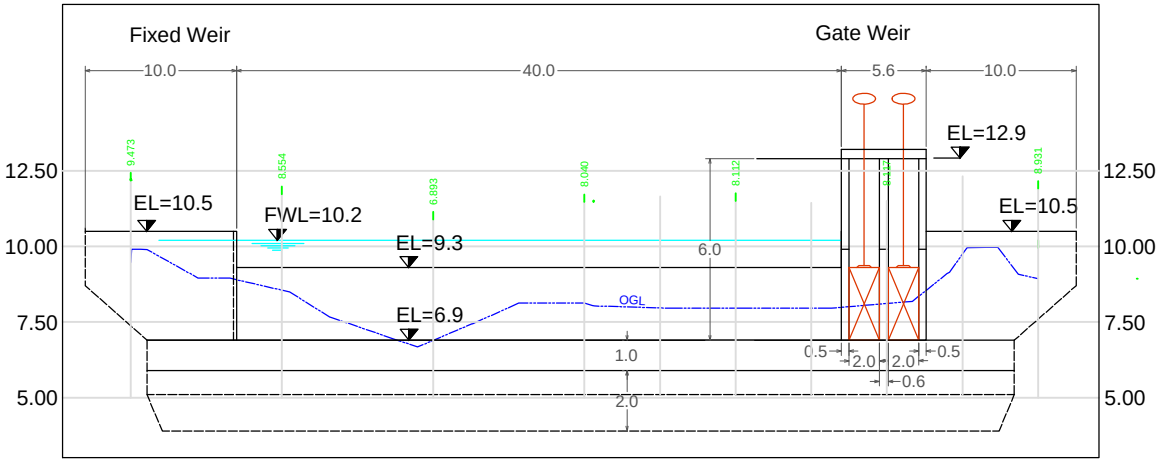
Kampong Daungkar Spillway

Flood Dike/Road

Note:
1. Original of this drawing was prepared for "Master Plan Study on the Integrated Agricultureal and Rural Development Project in the Suburbs of Phnom Penh" by JICA Study Team in February 1995.
2. Modified portion by the Survey Team are marked by cloud as follow:

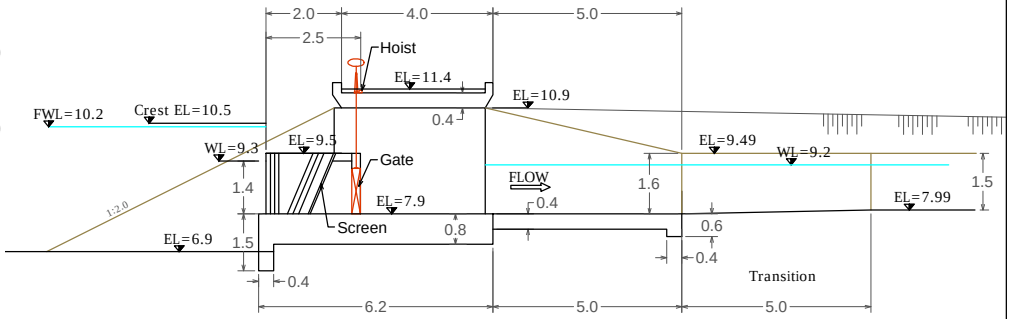
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Canal Layout of Tonle Bati Area**	Date: Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. KSB-02

Diversion Weir

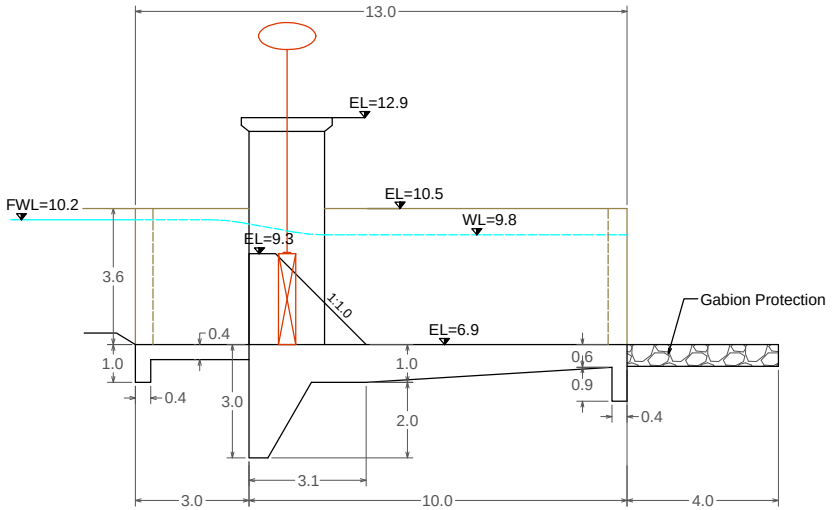


Front Elevation
Scale H=1:500; V=1:250

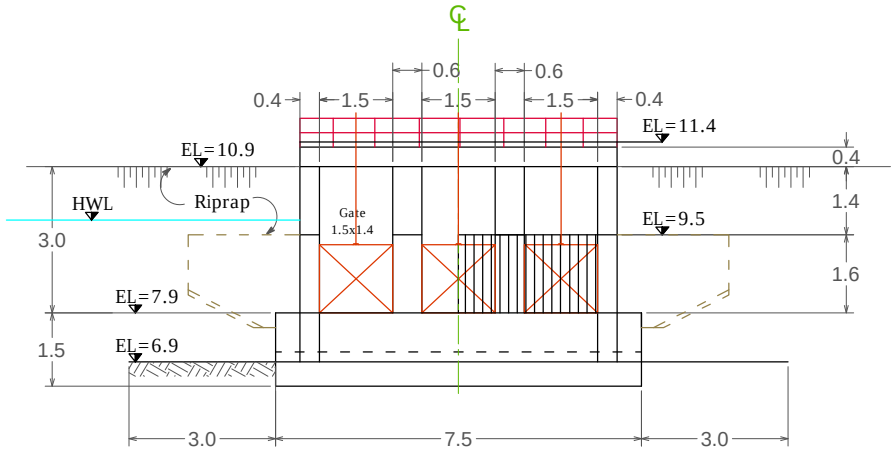
Intake Gate for Connection Canal



Profile
Scale 1:200

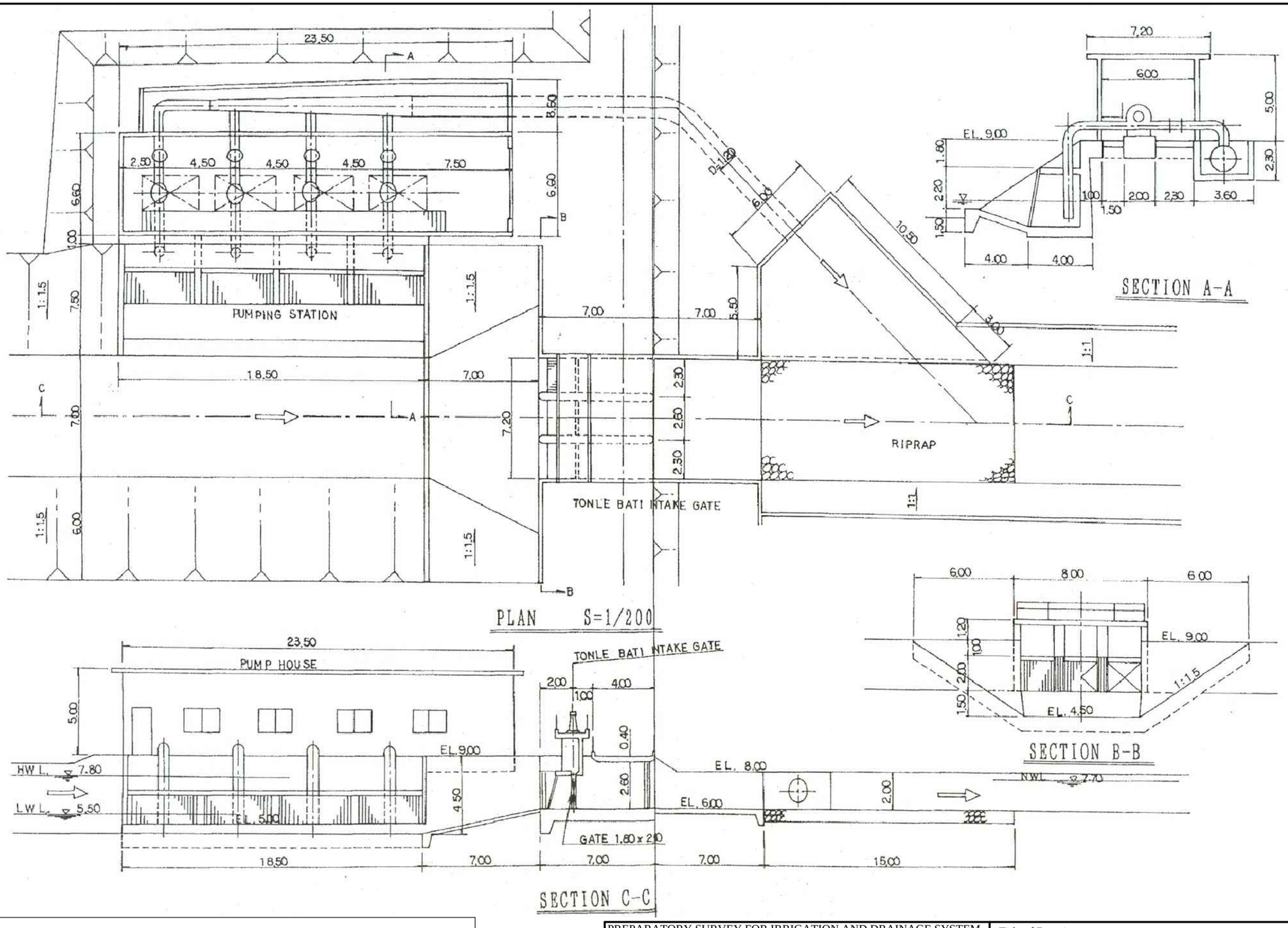


Profile
Scale 1:200



Front Section
Scale 1:200

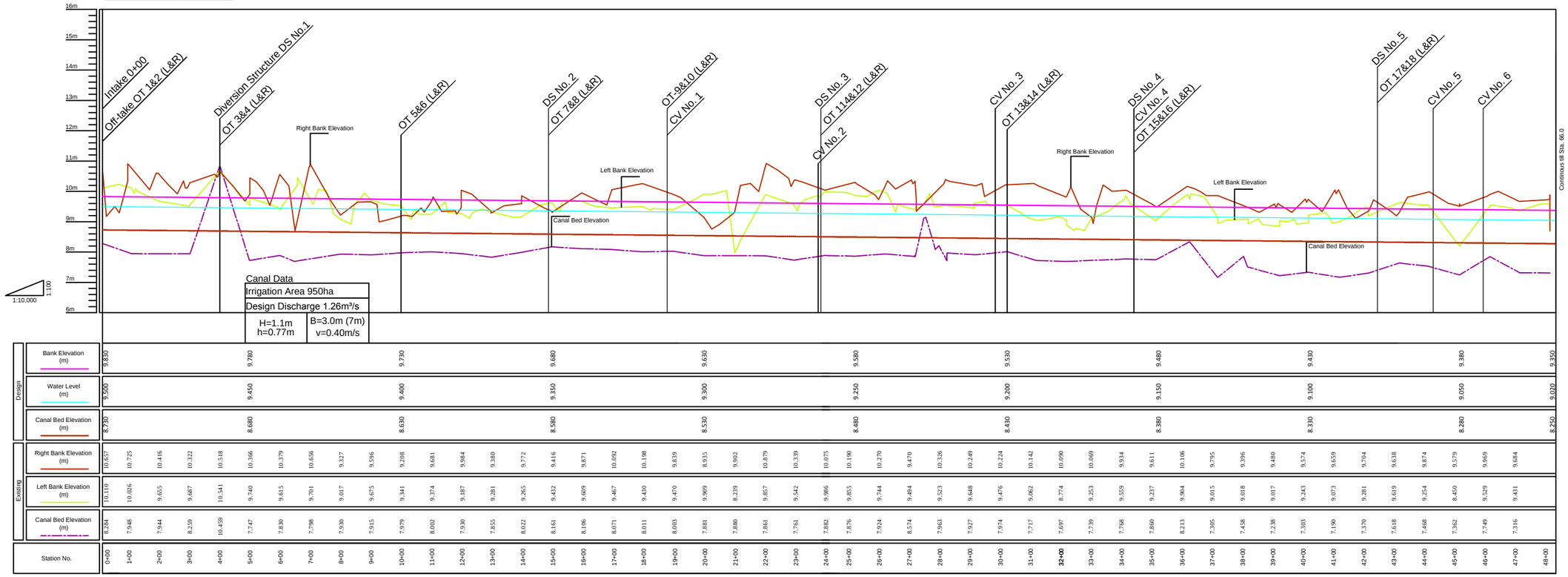
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHALIBITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **New Diversion Weir and Intake for Connection Canal on Stung Touch River**	Date: Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. KSB-03



Note:
1. Original of this drawing was prepared for "Master Plan Study on the Integrated Agricultureal and Rural Development Project in the Suburbs of Phnom Penh" by JICA Study Team in February 1995.
2. Modified portion by the Survey Team are marked by cloud as follow:

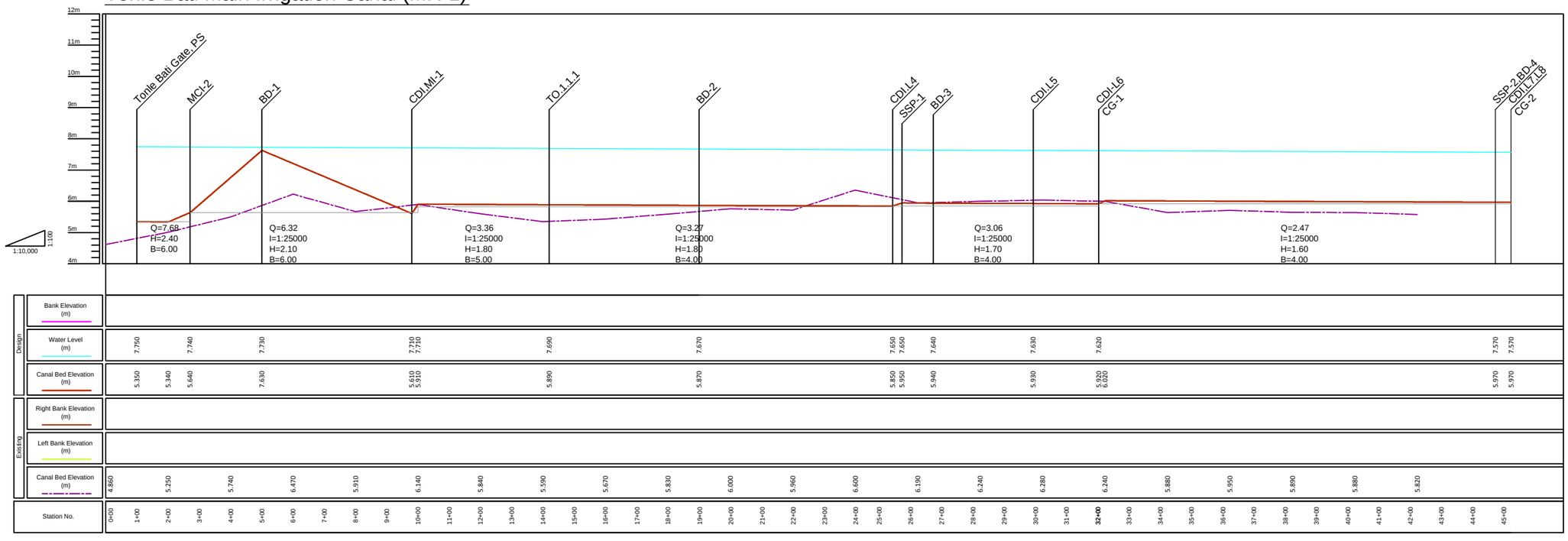
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **New Tonle Bati Pumping Station and Intake Gate**	Date: Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. KSB-04

EW-60 (KC-2)



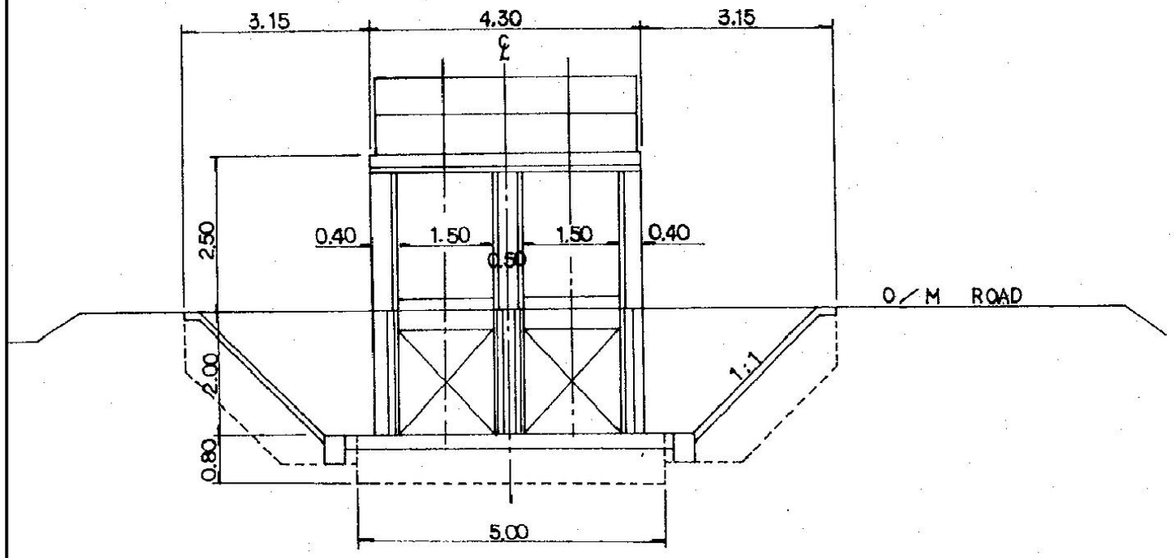
Source: JICA Survey Team.

Tonle Bati Main Irrigation Canal (MR-1)

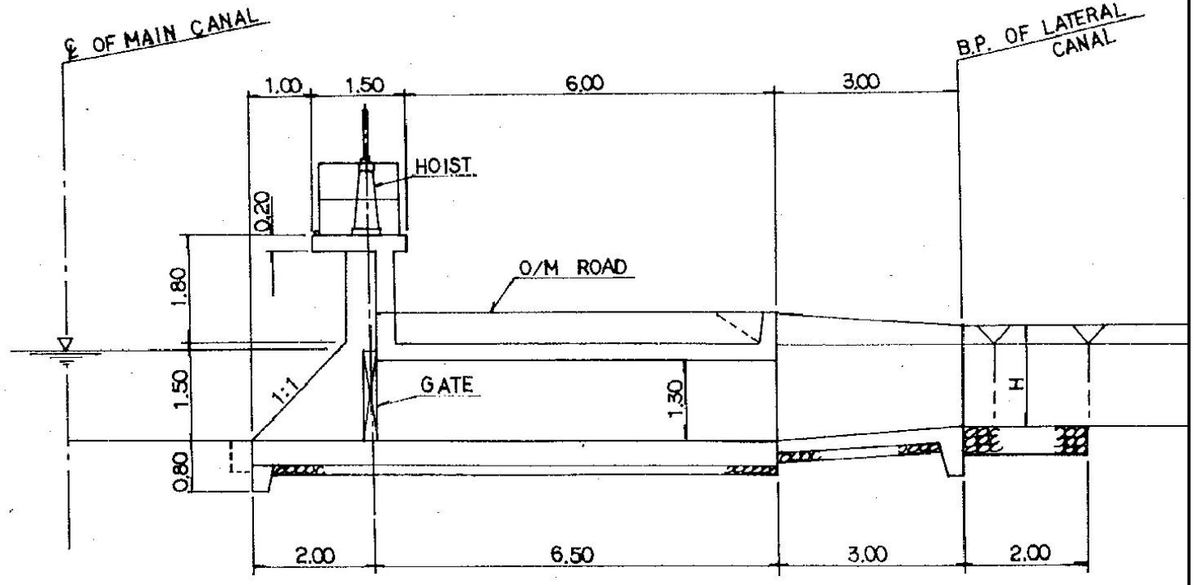


Note:
1. Original of this drawing was prepared for "Master Plan Study on the Integrated Agricultural and Rural Development Project in the Suburbs of Phnom Penh" by JICA Study Team in February 1995.

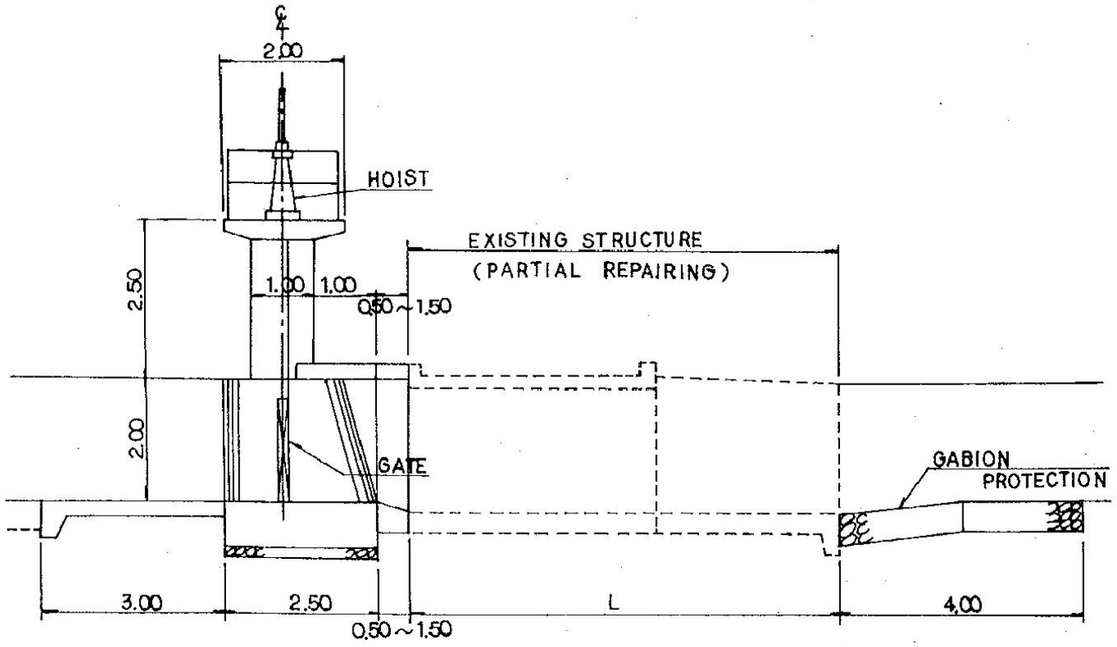
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHALIBITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date: Mar. 2012
Japan International Cooperation Agency (**JICA**)	**Longitudinal Profile of EW-60 (KC2) and MR-1**	DWG. No. KSB-05



FRONT ELEVATION



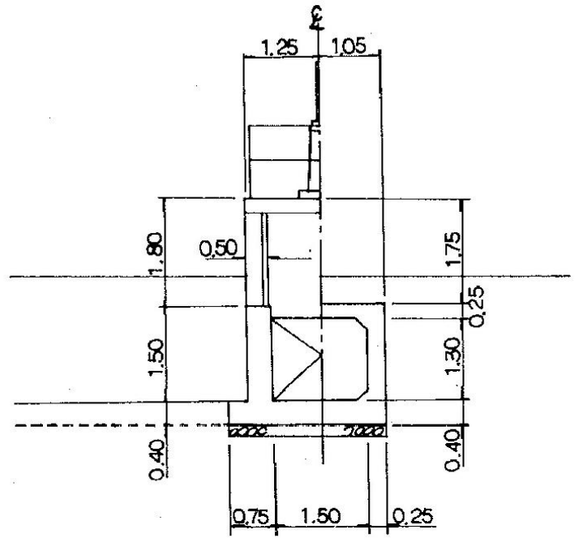
PROFILE



PROFILE

CHECK GATE S=1/100

DIVERSION STRUCTURE



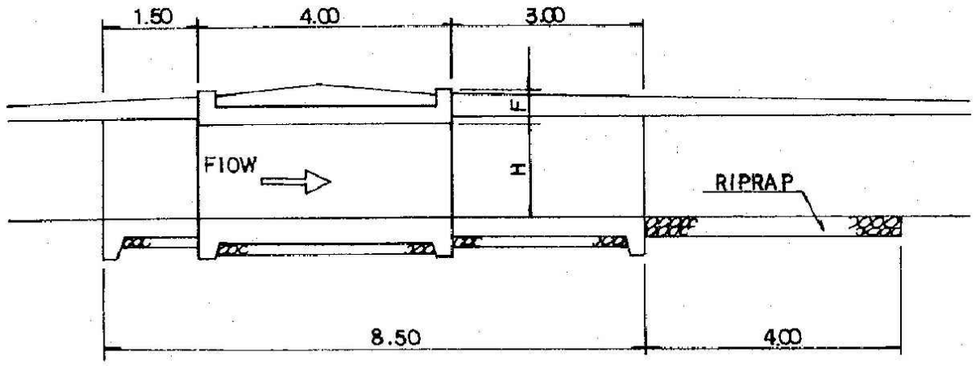
SECTIONS

LATERAL TURNOUT S=1/100

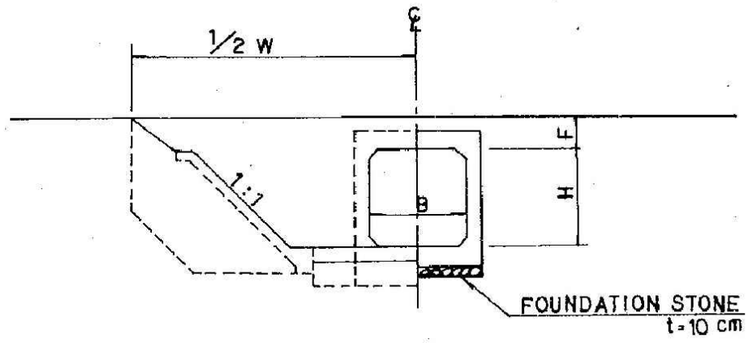
OFF-TAKE

Note:
1. Original of this drawing was prepared for "Master Plan Study on the Integrated Agricultureal and Rural Development Project in the Suburbs of Phnom Penh" by JICA Study Team in February 1995.
2. Modified portions by the Survey Team are marked by cloud as follow:

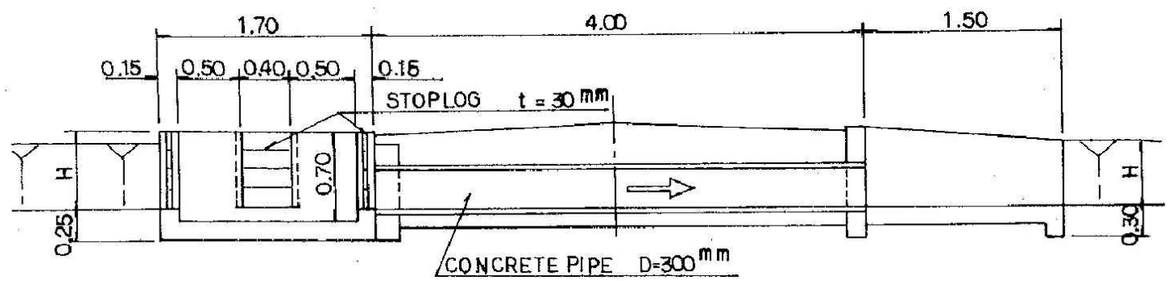
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date: Mar. 2012
Japan International Cooperation Agency (**JICA**)	**Typical Section of Diversion Structure and Off-take**	DWG. No. KSB-06



PROFILE

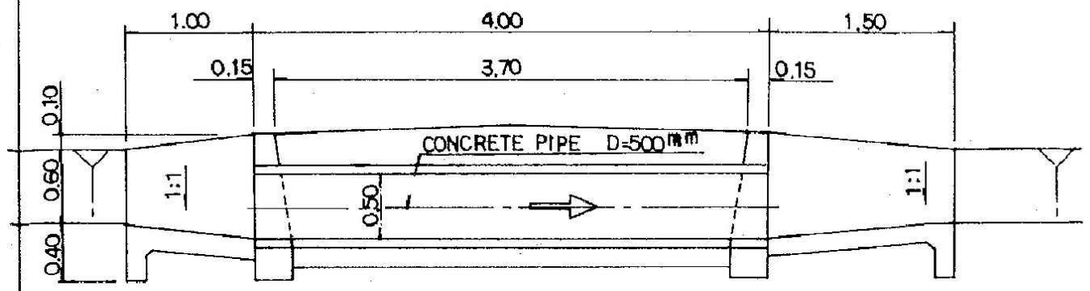


BOX CULVERT S=1/100

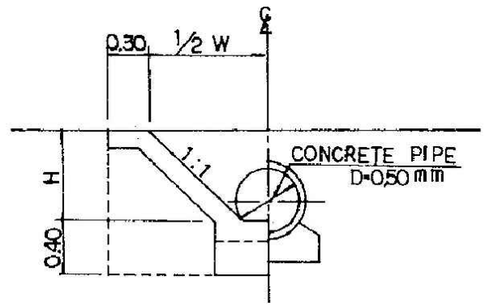


PROFILE

DIVISION BOX S=1/50

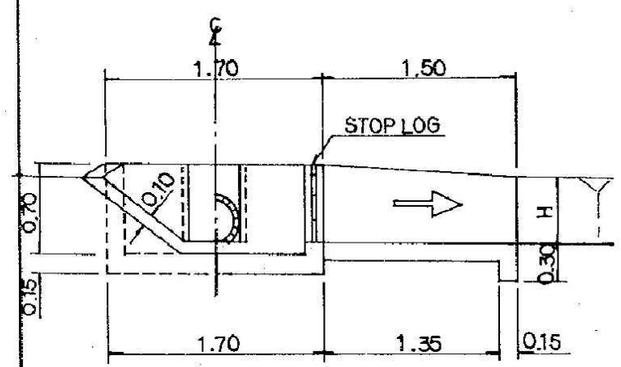


PROFILE



SECTIONS

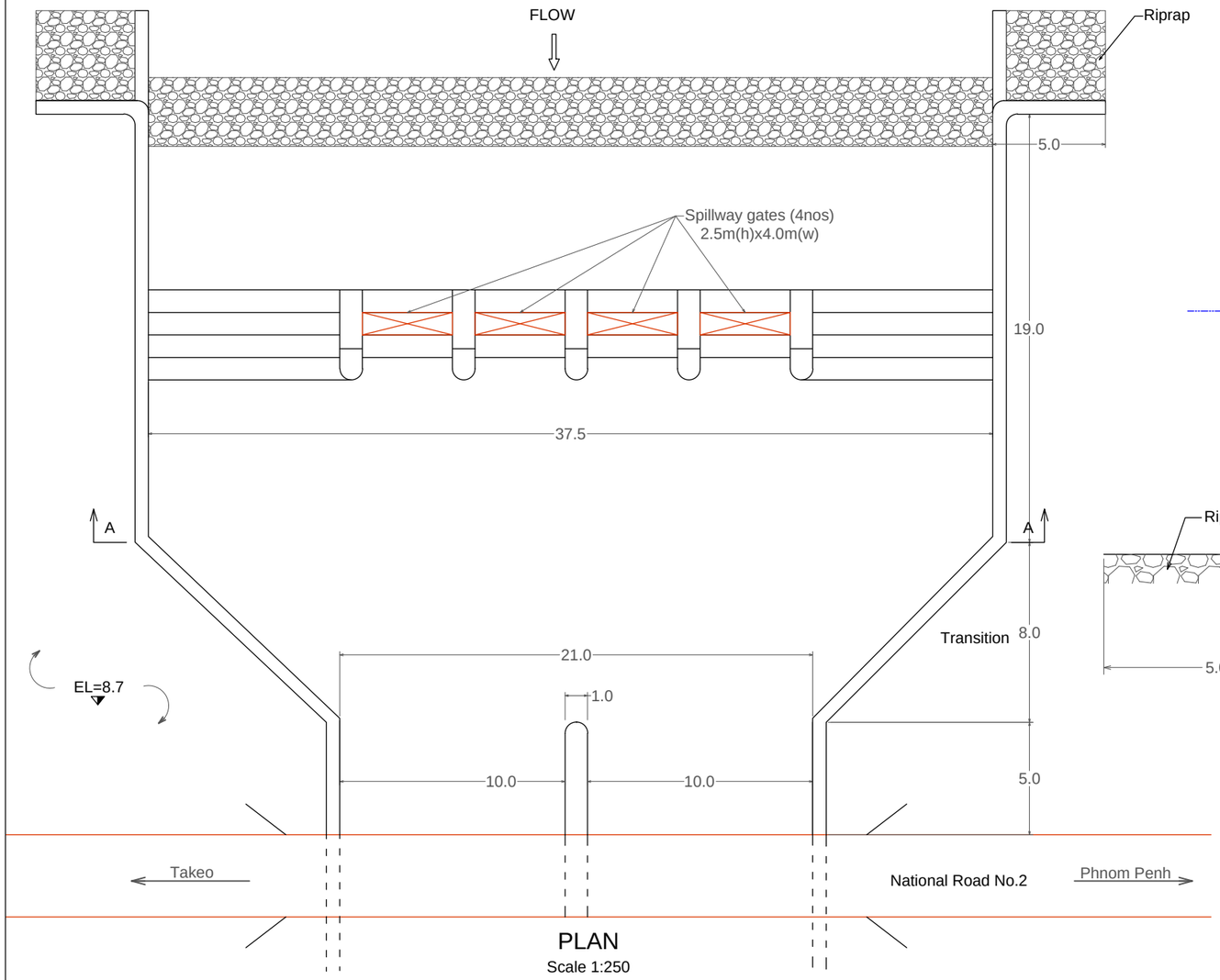
PIPE CULVERT S=1/50



SECTIONS

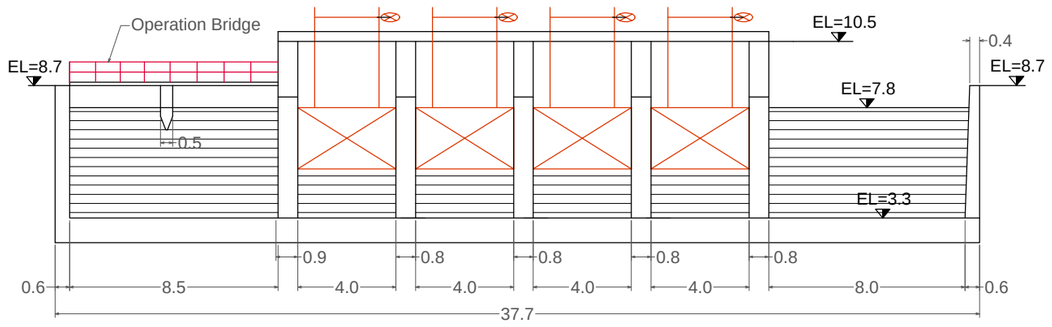
Note:
1. Original of this drawing was prepared for "Master Plan Study on the Integrated Agricultureal and Rural Development Project in the Suburbs of Phnom Penh" by JICA Study Team in February 1995.

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA Japan International Cooperation Agency (**JICA**)	Title of Drawing **Typical Section of Culverts and Division-Box**	Date: Mar. 2012 DWG. No. KSB-07



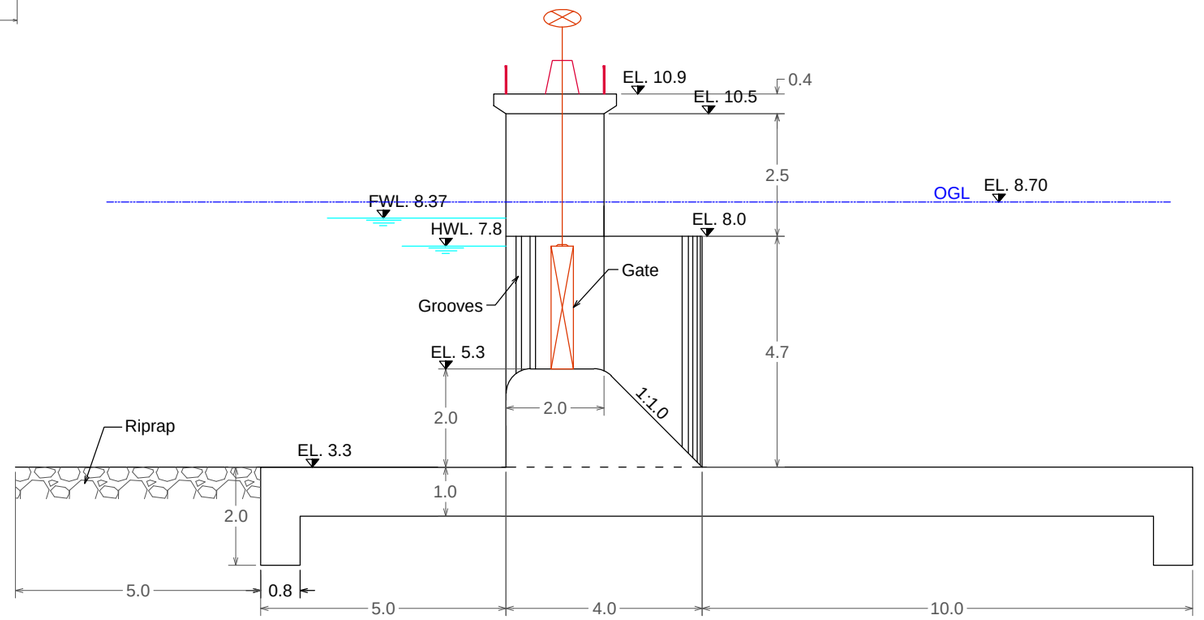
PLAN

Scale 1:250



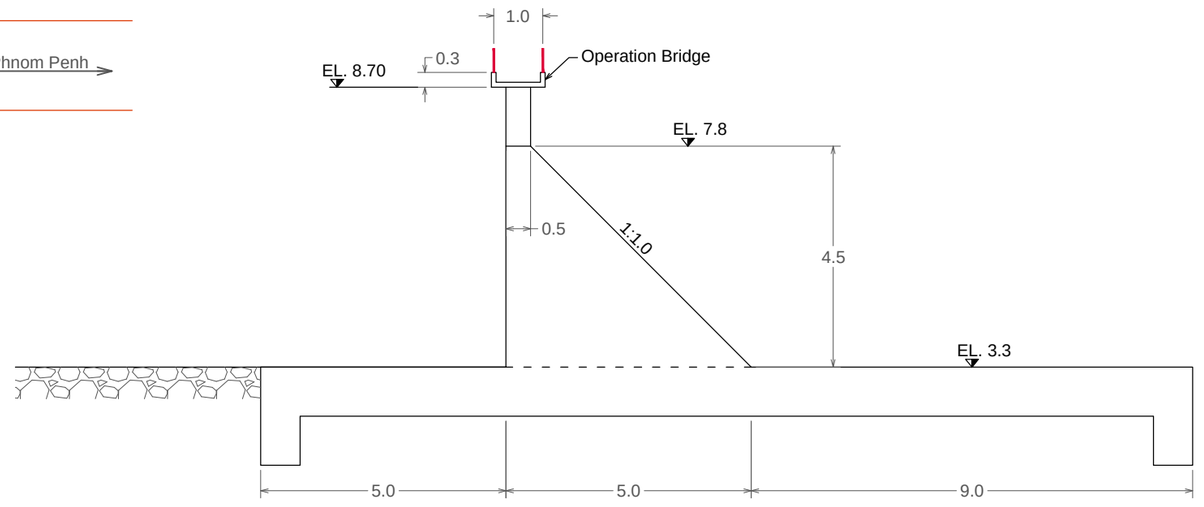
SECTION A-A

Scale 1:250



Gate Weir Profile

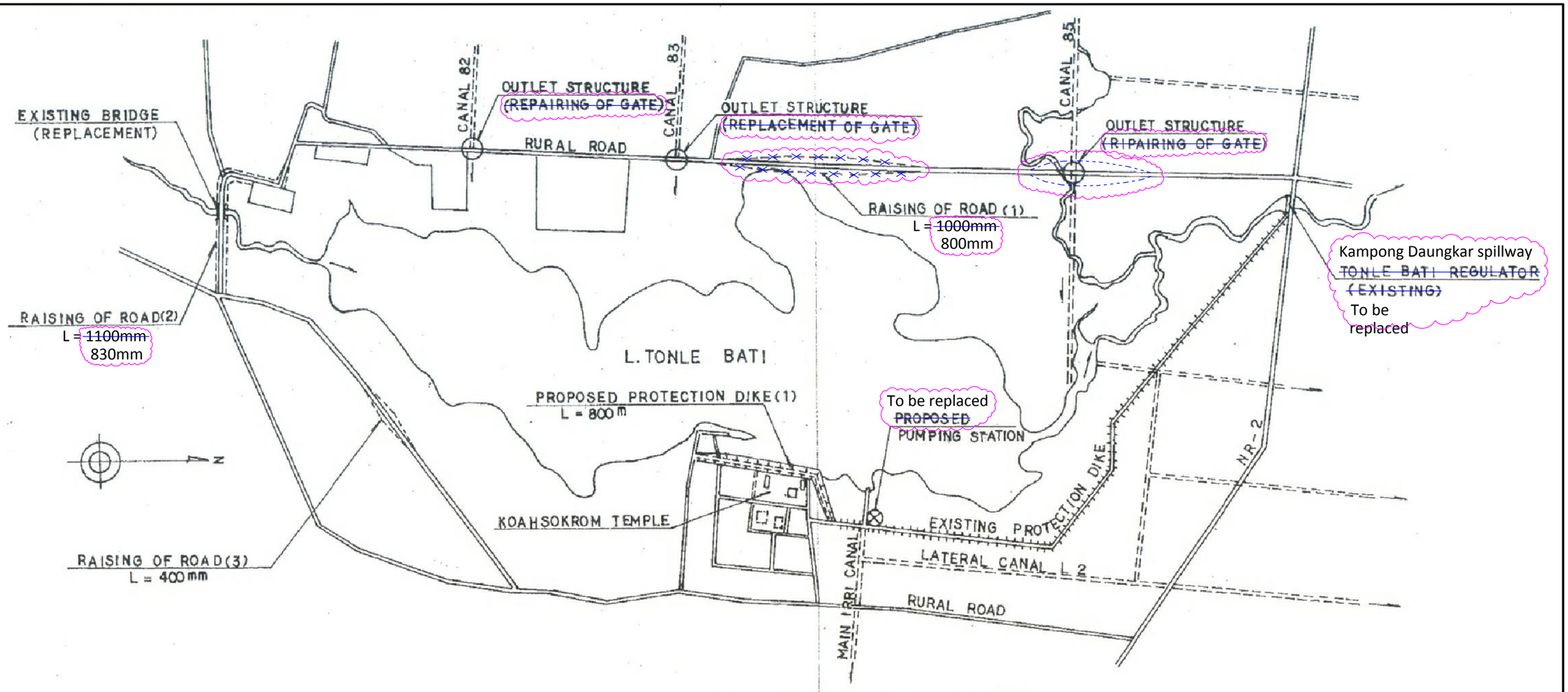
Scale : 1:125



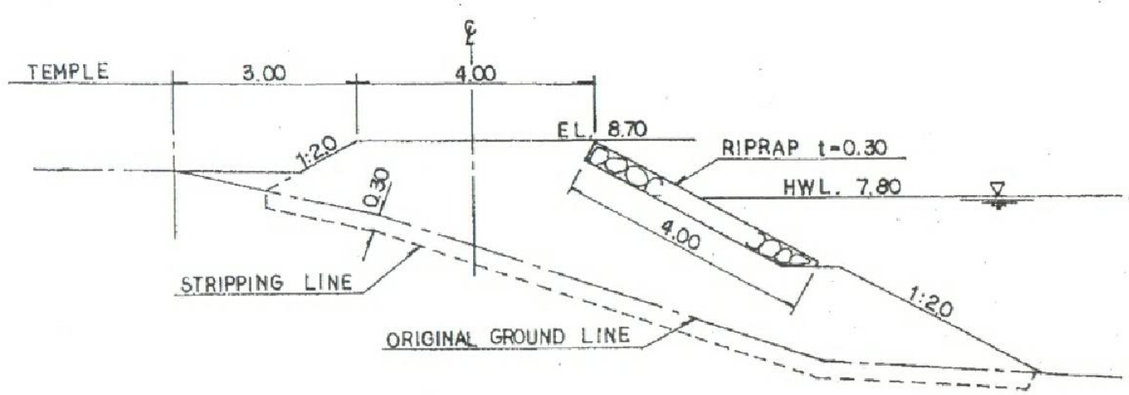
Fixed Weir

Scale : 1:125

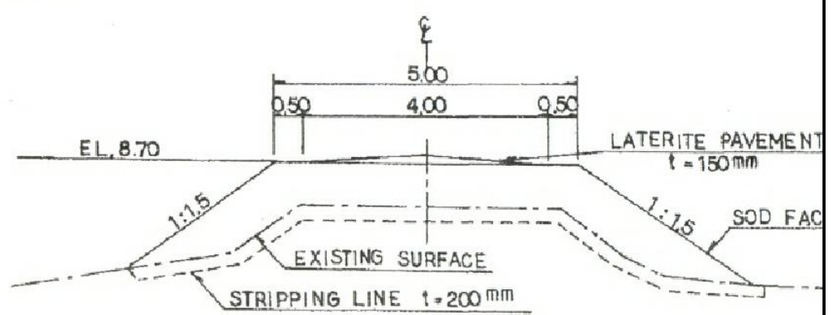
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHALIBITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **New Kampong Daungkar Spillway on Tonle Bati Lake**	Date: Mar-2012
Japan International Cooperation Agency (**JICA**)		DWG. No. KSB-08



PLAN OF REHABILITATION S=1/20,000



TYPICAL SECTION OF PROTECTION DIKE S=1/100



TYPICAL SECTION OF ROAD S=1/100

Note:
1. Original of this drawing was prepared for "Master Plan Study on the Integrated Agricultureal and Rural Development Project in the Suburbs of Phnom Penh" by JICA Study Team in February 1995.
2. Modified portion by the Survey Team are marked by cloud as follow:

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

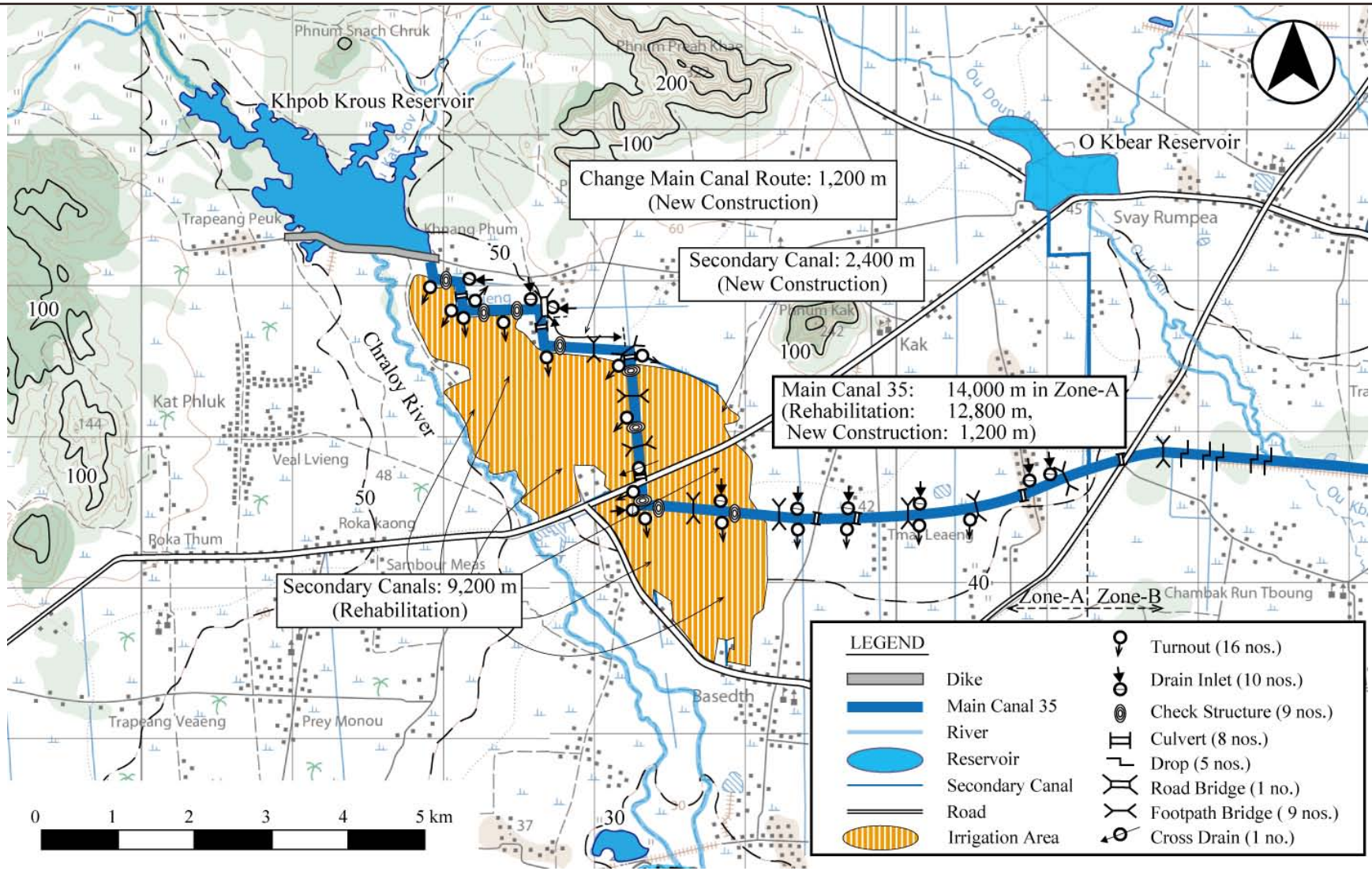
Japan International Cooperation Agency (**JICA**)

Title of Drawing

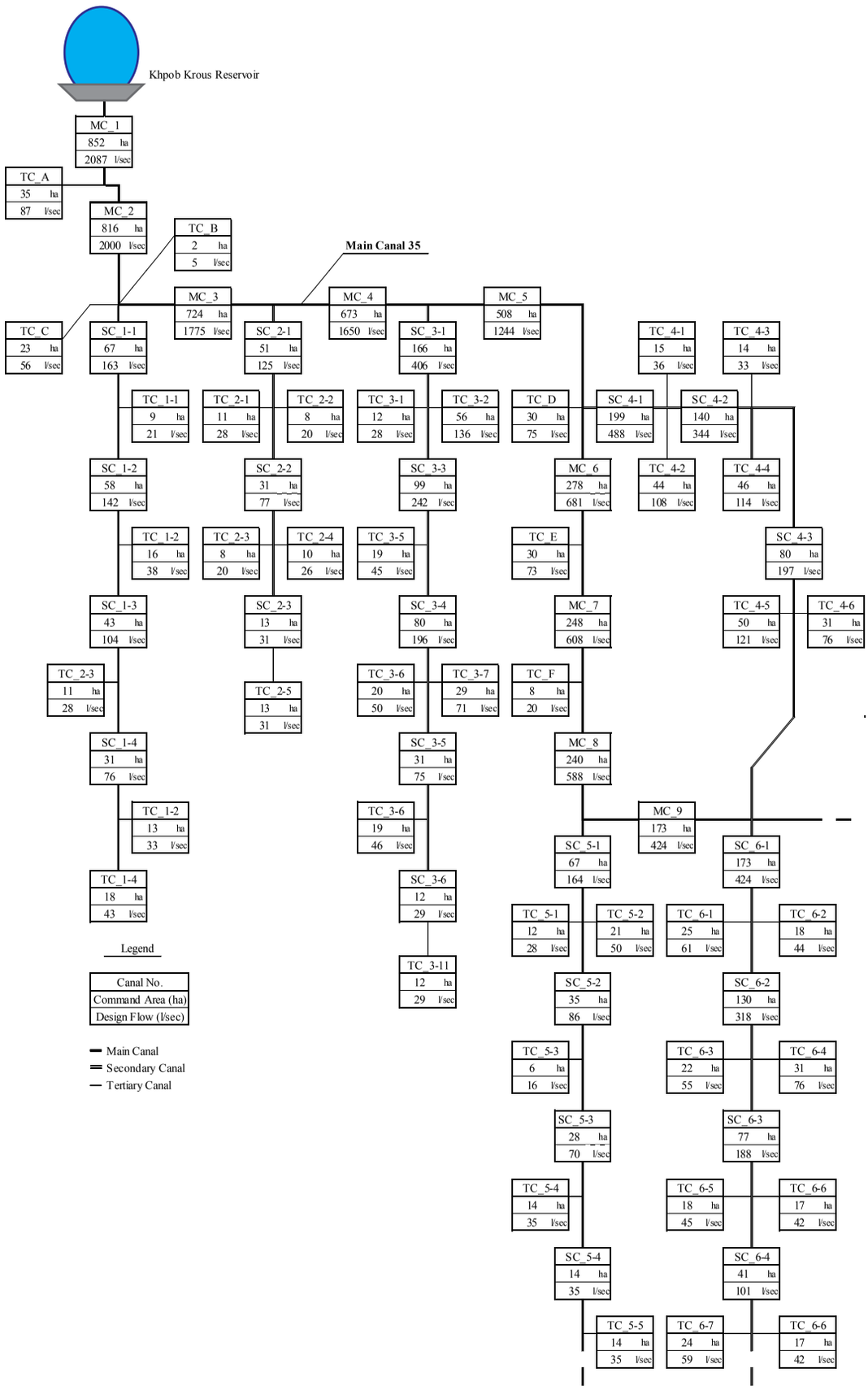
Related Works Surrounding Tonle Bati Lake

Date: Mar. 2012

DWG. No. KSB-09



PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVENMENT PROJECT IN THE KIMDOM OF CAMBODIA	Title of Drawing	Date: Mar. 2012
Japan International Cooperation Agency (JICA)	**General Layout of MC35RSP**	DWG. No. MC-01



Date: Mar. 2012

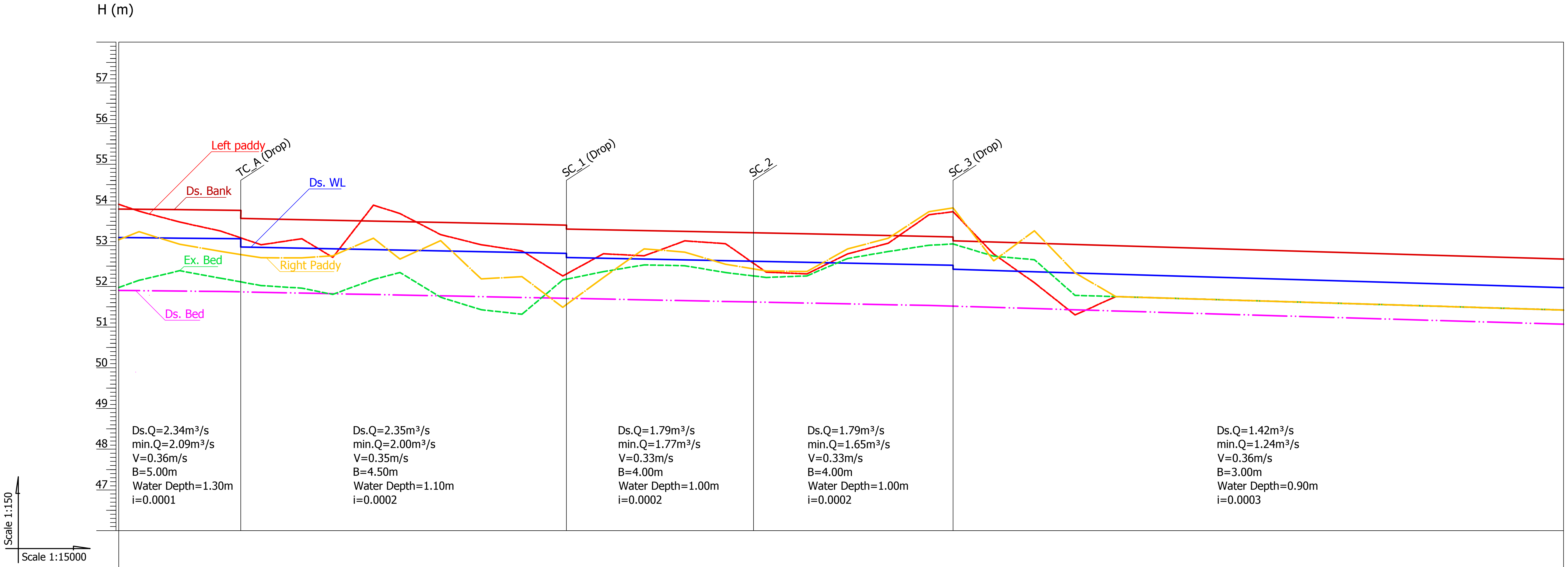
DWG. No. MC-02

Title of Drawing

Irrigation Flow Diagram of Main Canal 35
Rehabilitation Sub-project

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

Japan International Cooperation Agency (JICA)



Point	Accum. Distance	Distance	Existing: Right Field	Existing: Left Field	Existing: Bed Canal	Design: Water Level	Design: Canal Bank	Design: Bed Canal
P0	0		53.15	54.02	51.97	53.20	53.90	51.90
P1	50	50	53.34	53.85	52.15	53.20	53.90	51.90
P2	150	100	53.03	53.58	52.39	53.19	53.89	51.89
P3	250	100	52.86	53.36	52.20	53.18	53.88	51.88
TC_A	300	50	52.78	53.19	52.11	52.97	53.67	51.87
P4	350	50	52.71	53.02	52.02	52.96	53.66	51.86
P5	450	100	52.70	53.17	51.96	52.94	53.64	51.84
P6	526	76	52.75	52.71	51.80	52.92	53.62	51.82
P7	626	100	53.18	54.00	52.17	52.90	53.60	51.80
P8	691	65	52.67	53.79	52.34	52.89	53.59	51.79
P9	791	100	53.12	53.27	51.73	52.87	53.57	51.77
P10	891	100	52.18	53.02	51.43	52.85	53.55	51.75
P11	991	100	52.24	52.87	51.32	52.83	53.53	51.73
P12	1091	100	51.49	52.26	52.16	52.81	53.51	51.71
SC_1	1100	9	51.55	52.31	52.18	52.71	53.41	51.71
P13	1191	91	52.22	52.80	52.36	52.69	53.39	51.69
P14	1291	100	52.92	52.75	52.53	52.67	53.37	51.67
P15	1391	100	52.84	53.12	52.51	52.65	53.35	51.65
P16	1491	100	52.54	53.05	52.34	52.63	53.33	51.63
SC_2	1560	69	52.43	52.57	52.26	52.62	53.32	51.62
P17	1591	31	52.38	52.35	52.22	52.61	53.31	51.61
P18	1691	100	52.37	52.31	52.26	52.59	53.29	51.59
P19	1791	100	52.92	52.80	52.69	52.57	53.27	51.57
P20	1891	100	53.19	53.06	52.86	52.55	53.25	51.55
P21	1991	100	53.84	53.76	53.01	52.53	53.23	51.53
SC_3	2050	59	53.93	53.84	53.04	52.42	53.12	51.52
P22	2150	100	52.63	52.79	52.74	52.39	53.09	51.49
P23	2250	100	53.37	52.09	52.66	52.36	53.06	51.46
P24	2350	100	52.33	51.30	51.78	52.33	53.03	51.43
P25	2450	100	51.75	51.75	51.75	52.30	53.00	51.40
P26	2550	100	51.72	51.72	51.72	52.27	52.97	51.37
P27	2650	100	51.69	51.69	51.69	52.24	52.94	51.34
P28	2750	100	51.66	51.66	51.66	52.21	52.91	51.31
P29	2850	100	51.63	51.63	51.63	52.18	52.88	51.28
P30	2950	100	51.60	51.60	51.60	52.15	52.85	51.25
P31	3050	100	51.57	51.57	51.57	52.12	52.82	51.22
P32	3150	100	51.54	51.54	51.54	52.09	52.79	51.19
P33	3250	100	51.51	51.51	51.51	52.06	52.76	51.16
P34	3350	100	51.48	51.48	51.48	52.03	52.73	51.13
P35	3450	100	51.45	51.45	51.45	52.00	52.70	51.10
P36	3550	100	51.42	51.42	51.42	51.97	52.67	51.07

Ds.Q : Design Discharge

DWR : Diversion Water Reguirement

V : Flow Velocity

B : Canal Bed Width

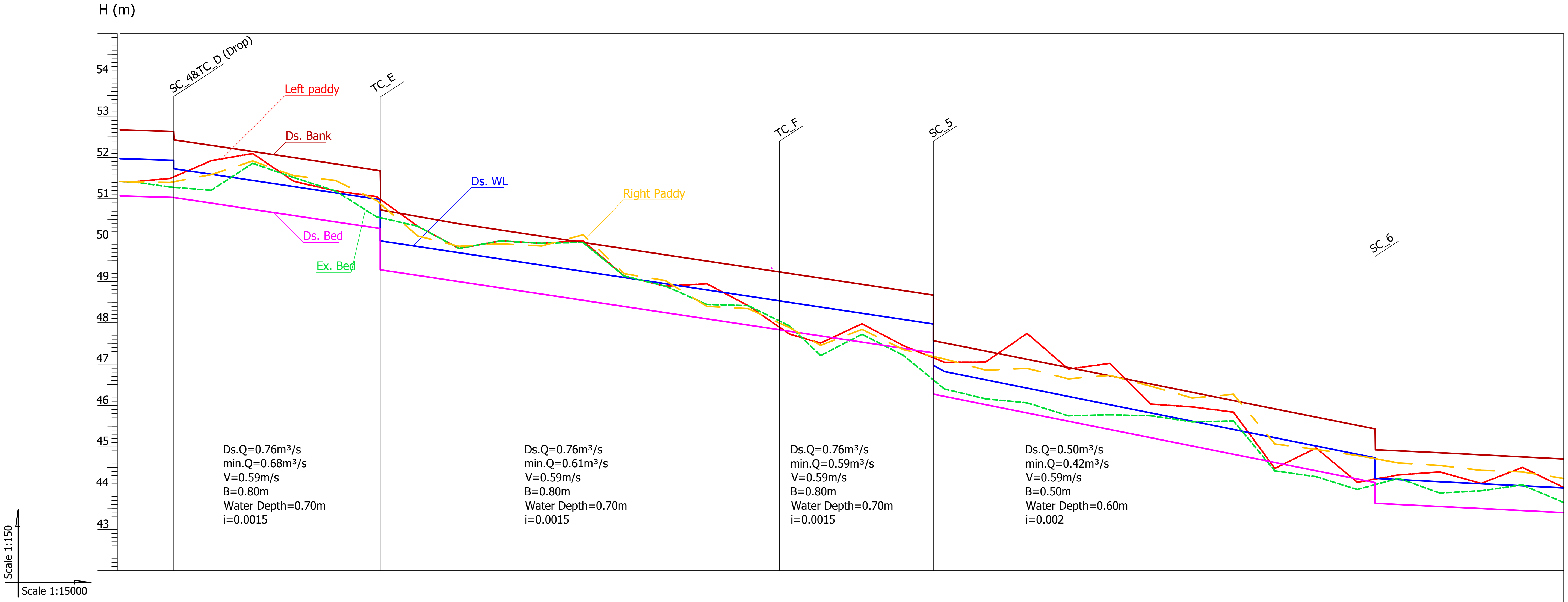
h: Design Water Depth

i: Canal Bed Gradient

Free board : 0.70m

Canal slope (horizontal to vertical)=1.50

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date: Mar. 2012
Japan International Cooperation Agency **(JICA)**	**Profile of Main Canal 35 (1/4)**	DWG. No. MC-03



Point	Accum. Distance	Existing: Right Field	Existing: Left Field	Existing: Bed Canal	Design: Water Level	Design: Canal Bank	Design: Bed Canal
P36	3550	51.42	51.42	51.42	51.97	52.67	51.07
P37	3580	51.41	51.41	51.41	51.96	52.66	51.06
P38	3671	51.40	51.49	51.29	51.93	52.63	51.03
SC_4 &TC_D	3680	51.41	51.53	51.28	51.73	52.43	51.03
P39	3771	51.59	51.92	51.21	51.59	52.29	50.89
P40	3871	51.91	52.10	51.86	51.44	52.14	50.74
P41	3971	51.56	51.42	51.51	51.29	51.99	50.59
P42	4071	51.45	51.19	51.19	51.14	51.84	50.44
P43	4171	50.96	51.05	50.57	50.99	51.69	50.29
TC_E	4180	50.88	50.99	50.55	50.98	51.68	50.28
P44	4271	50.10	50.34	50.34	50.84	51.54	50.14
P45	4371	49.85	49.80	49.80	49.69	50.39	48.99
P46	4471	49.91	49.98	49.98	49.54	50.24	48.84
P47	4571	49.86	49.92	49.92	49.39	50.09	48.69
P48	4671	50.13	49.99	49.94	49.24	49.94	48.54
P49	4721	49.66	49.56	49.54	50.17	50.87	49.47
P50	4771	49.19	49.13	49.13	49.09	49.79	48.39
P51	4871	49.02	48.89	48.89	48.94	49.64	48.24
P52	4971	48.40	48.95	48.45	48.79	49.49	48.09
P53	5071	48.34	48.42	48.42	48.64	49.34	47.94
P54	5171	47.89	47.73	47.93	48.49	49.19	47.79
TC_F	5180	47.83	47.70	47.84	48.48	49.18	47.78
P55	5247	47.45	47.51	47.21	48.38	49.08	47.68
P56	5347	47.84	47.98	47.72	48.23	48.93	47.53
P57	5447	47.35	47.45	47.21	48.08	48.78	47.38
SC_5	5520	47.18	47.15	46.62	47.87	48.57	47.27
P58	5547	47.12	47.04	46.40	47.82	48.52	47.22
P59	5647	46.85	47.05	46.16	46.62	47.32	46.02
P60	5747	46.90	47.74	46.06	46.42	47.12	45.82
P61	5847	46.64	46.88	45.75	46.22	46.92	45.62
P62	5947	46.73	47.02	45.78	46.02	46.72	45.42
P63	6047	46.46	46.03	45.75	45.82	46.52	45.22
P64	6147	46.18	45.96	45.60	45.62	46.32	45.02
P65	6247	46.27	45.84	45.63	45.42	46.12	44.82
P66	6347	45.07	44.47	44.42	45.22	45.92	44.62
P67	6447	44.94	44.97	44.27	45.02	45.72	44.42
P68	6547	44.79	44.14	43.97	44.82	45.52	44.22
SC_6	6590	44.71	44.22	44.08	44.73	45.43	44.13
P69	6647	44.61	44.32	44.23	44.62	45.32	44.02
P70	6747	44.55	44.39	43.88	44.54	45.24	43.94
P71	6847	44.43	44.11	43.93	44.46	45.16	43.86
P72	6947	44.39	44.50	44.08	44.38	45.08	43.78
P73	7047	44.23	44.01	43.65	44.30	45.00	43.70

Distance: 30, 91, 9, 91, 100, 100, 100, 9, 91, 100, 100, 100, 100, 50, 50, 100, 100, 100, 9, 67, 100, 100, 73, 27, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 43, 57, 100, 100, 100, 100, 100

Ds.Q : Design Discharge

DWR : Diversion Water Requirement

V : Flow Velocity

B : Canal Bed Width

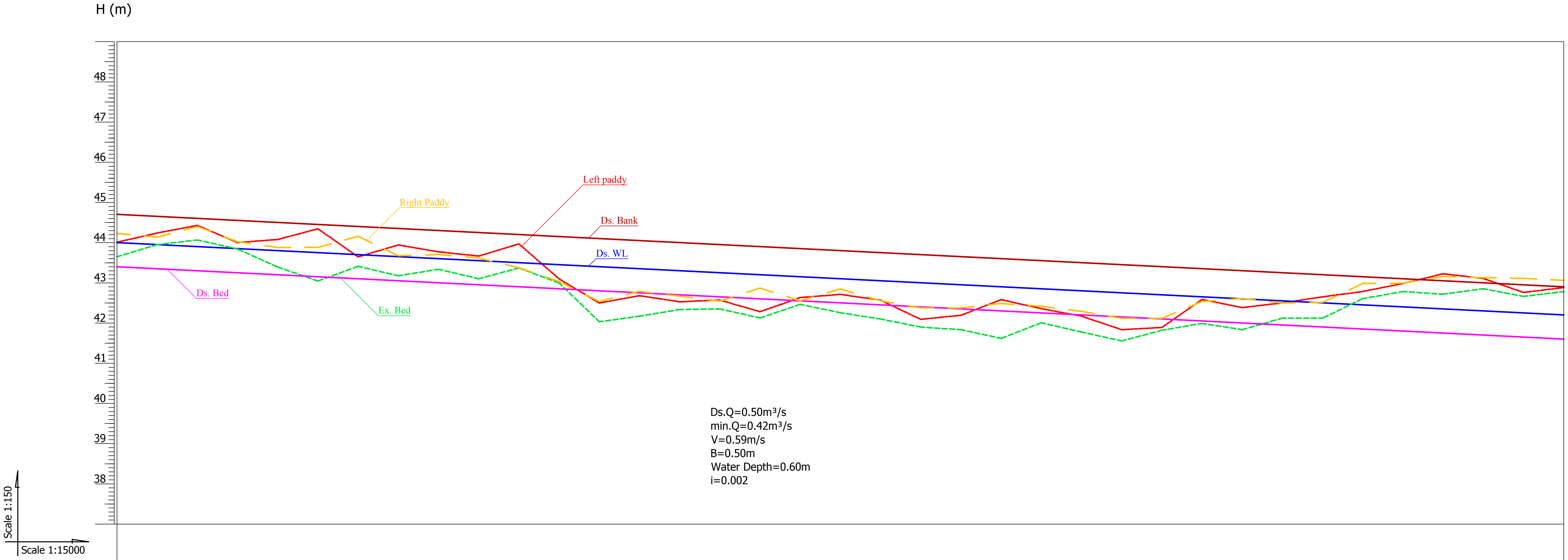
h: Design Water Depth

i: Canal Bed Gradient

Free board : 0.70m

Canal slope (horizontal to vertical)=1.50

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date: Mar. 2012
Japan International Cooperation Agency **(JICA)**	**Profile of Main Canal 35 (2/4)**	DWG. No. MC-04



Point	Accum. Distance	Distance	Existing Right Field	Existing Left Field	Existing Bed Canal	Design Canal Bank	Design Water Level	Design Bed Canal
P73	7047		44.23	44.01	43.65	44.30	45.00	43.70
P74	7147	100	44.14	44.24	43.95	44.22	44.92	43.62
P75	7247	100	44.40	44.43	44.07	44.14	44.84	43.54
P76	7347	100	44.03	44.00	43.84	44.06	44.76	43.46
P77	7447	100	43.88	44.08	43.39	43.98	44.68	43.38
P78	7547	100	43.88	44.35	43.05	43.90	44.60	43.30
P79	7647	100	44.16	43.65	43.41	43.82	44.52	43.22
P80	7747	100	43.67	43.94	43.18	43.74	44.44	43.14
P81	7847	100	43.70	43.77	43.34	43.66	44.36	43.06
P82	7947	100	43.62	43.67	43.10	43.58	44.28	42.98
P83	8047	100	43.38	43.97	43.37	43.50	44.20	42.90
P84	8147	100	43.03	43.10	43.00	43.42	44.12	42.82
P85	8247	100	42.54	42.50	42.03	43.37	44.07	42.77
P86	8347	100	42.79	42.68	42.17	43.32	44.02	42.72
P87	8447	100	42.67	42.53	42.34	43.27	43.97	42.67
P88	8547	100	42.55	42.57	42.35	43.22	43.92	42.62
P89	8647	100	42.87	42.28	42.13	43.17	43.87	42.57
P90	8747	100	42.56	42.63	42.46	43.12	43.82	42.52
P91	8847	100	42.85	42.71	42.26	43.07	43.77	42.47
P92	8947	100	42.56	42.57	42.10	43.02	43.72	42.42
P93	9047	100	42.38	42.09	41.90	42.97	43.67	42.37
P94	9147	100	42.38	42.19	41.84	42.92	43.62	42.32
P95	9247	100	42.49	42.58	41.62	42.87	43.57	42.27
P96	9347	100	42.42	42.36	42.01	42.82	43.52	42.22
P97	9447	100	42.29	42.17	41.78	42.77	43.47	42.17
P98	9547	100	42.12	41.84	41.56	42.72	43.42	42.12
P99	9647	100	42.12	41.89	41.82	42.70	43.40	42.10
P100	9747	100	42.54	42.59	41.99	42.68	43.38	42.08
P101	9847	100	42.61	42.38	41.84	42.66	43.36	42.06
P102	9947	100	42.50	42.50	42.12	42.64	43.34	42.04
P103	10047	100	42.51	42.65	42.12	42.62	43.32	42.02
P104	10147	100	42.99	42.79	42.61	42.60	43.30	42.00
P105	10247	100	42.99	42.98	42.78	42.58	43.28	41.98
P106	10347	100	43.16	43.23	42.72	42.56	43.26	41.96
P107	10447	100	43.13	43.11	42.85	42.54	43.24	41.94
P108	10547	100	43.11	42.76	42.66	42.52	43.22	41.92
P109	10647	100	43.06	42.88	42.78	42.50	43.20	41.90

Ds.Q : Design Discharge

DWR : Diversion Water Requirements

V : Flow Velocity

B : Canal Bed Width

h: Design Water Depth

i: Canal Bed Gradient

Free board : 0.70m

Canal slope (horizontal to vertical)=1.50

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

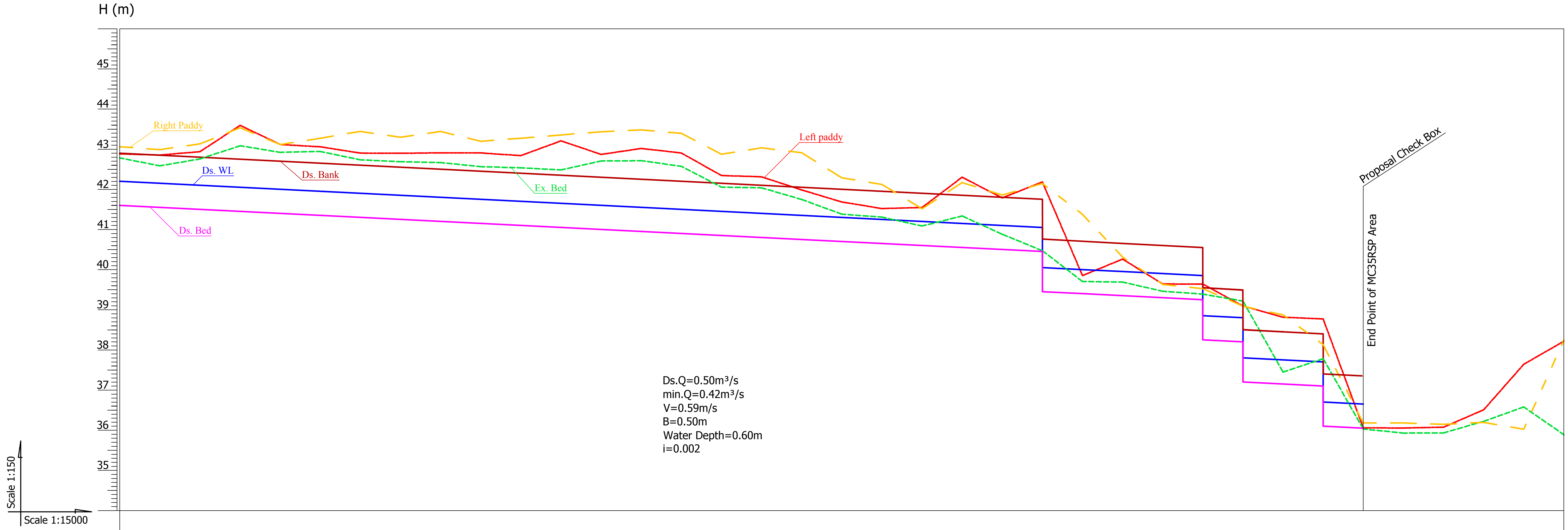
Japan International Cooperation Agency
(JICA)

Title of Drawing

Profile of Main Canal 35 (3/4)

Date: Mar. 2012

DWG. No. MC-05



Accum. Distance	Distance	Existing Right Field	Existing Left Field	Existing Bed Canal	Design Water Level	Design Canal Bank	Design Bed Canal	Point
10647	100	43.06	42.88	42.78	42.50	43.20	41.90	P109
10747	100	42.99	42.86	42.59	42.48	43.18	41.88	P110
10847	100	43.13	42.94	42.76	42.46	43.16	41.86	P111
10947	100	43.54	43.60	43.09	42.44	43.14	41.84	P112
11047	100	43.12	43.12	42.92	42.42	43.12	41.82	P113
11147	100	43.28	43.06	42.95	42.40	43.10	41.80	P114
11247	100	43.45	42.90	42.74	42.38	43.08	41.78	P115
11347	100	43.30	42.90	42.69	42.36	43.06	41.76	P116
11447	100	43.44	42.91	42.67	42.34	43.04	41.74	P117
11547	100	43.20	42.91	42.57	42.32	43.02	41.72	P118
11647	100	43.28	42.84	42.54	42.30	43.00	41.70	P119
11747	100	43.36	43.21	42.49	42.28	42.98	41.68	P120
11847	100	43.44	42.87	42.71	42.26	42.96	41.66	P121
11947	100	43.48	43.02	42.71	42.24	42.94	41.64	P122
12047	100	43.40	42.91	42.58	42.22	42.92	41.62	P123
12147	100	42.88	42.35	42.06	42.17	42.87	41.57	P124
12247	100	43.04	42.31	42.04	42.12	42.82	41.52	P125
12347	100	42.91	41.99	41.75	42.07	42.77	41.47	P126
12447	100	42.29	41.69	41.38	42.02	42.72	41.42	P127
12547	100	42.12	41.52	41.31	41.97	42.67	41.37	P128
12647	100	41.52	41.55	41.09	41.92	42.62	41.32	P129
12747	100	42.17	42.30	41.34	41.87	42.57	41.27	P130
12847	100	41.86	41.79	40.88	41.82	42.52	41.22	P131
12947	100	42.15	42.19	40.47	41.77	42.47	41.17	P132
13047	100	41.38	39.85	39.71	40.72	41.42	40.12	P133
13147	100	40.32	40.26	39.69	40.67	41.37	40.07	P134
13247	100	39.63	39.64	39.46	40.62	41.32	40.02	P135
13347	100	39.53	39.64	39.39	40.57	41.27	39.97	P136
13447	100	39.09	39.10	39.22	39.52	40.22	38.92	P137
13547	100	38.87	38.82	37.45	38.47	39.17	37.87	P138
13647	100	38.14	38.77	37.78	38.42	39.12	37.82	P139
13747	100	36.18	36.06	36.03	37.37	38.07	36.77	Proposal Check Box
13847	100	36.18	36.06	35.93				P140
13947	100	36.15	36.08	35.93				P141
14047	100	36.20	36.51	36.22				Proposal Spillway &Check Box
14147	100	36.03	37.64	36.58				P142
14247		38.24	38.22	35.89				

Ds.Q : Design Discharge

DWR : Diversion Water Requirement

V : Flow Velocity

B : Canal Bed Width

h: Design Water Depth

i: Canal Bed Gradient

Free board : 0.70m

Canal slope (horizontal to vertical)=1.50

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA

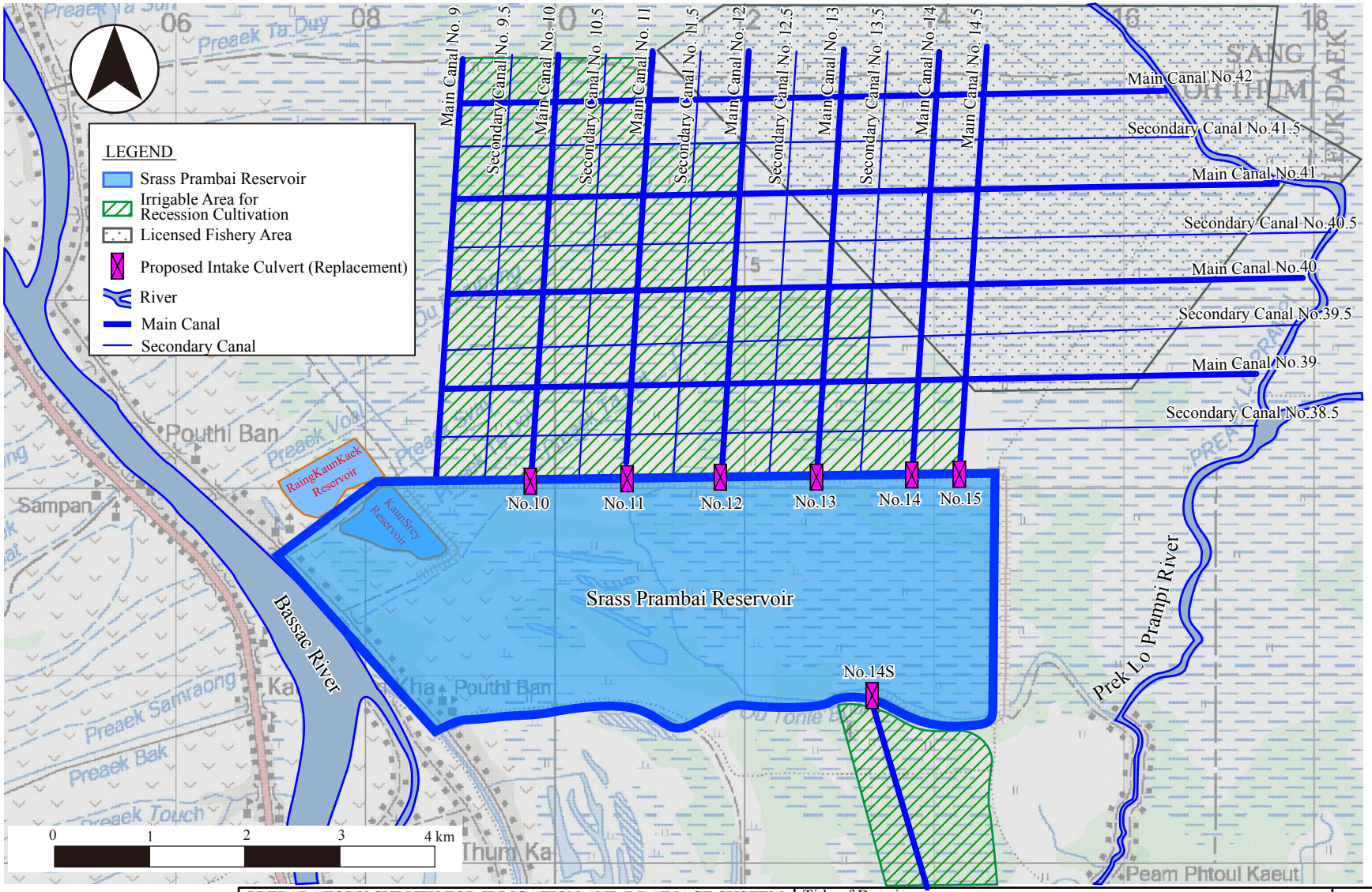
Japan International Cooperation Agency (**JICA**)

Title of Drawing

Profile of Main Canal 35 (4/4)

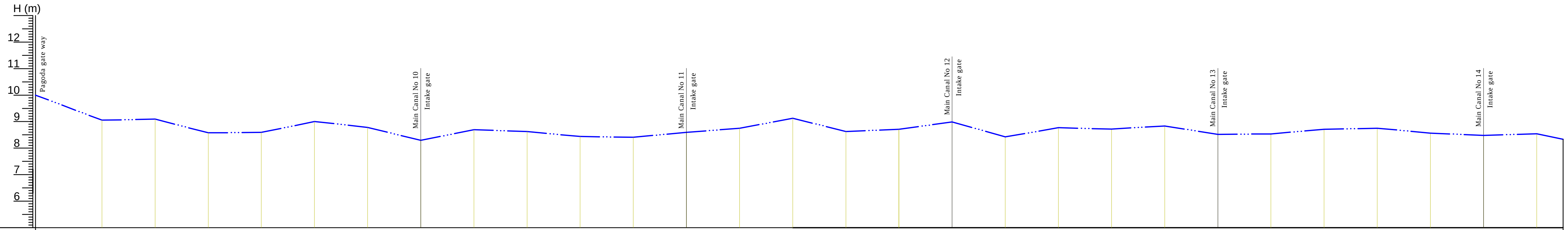
Date: Mar. 2012

DWG. No. MC-06

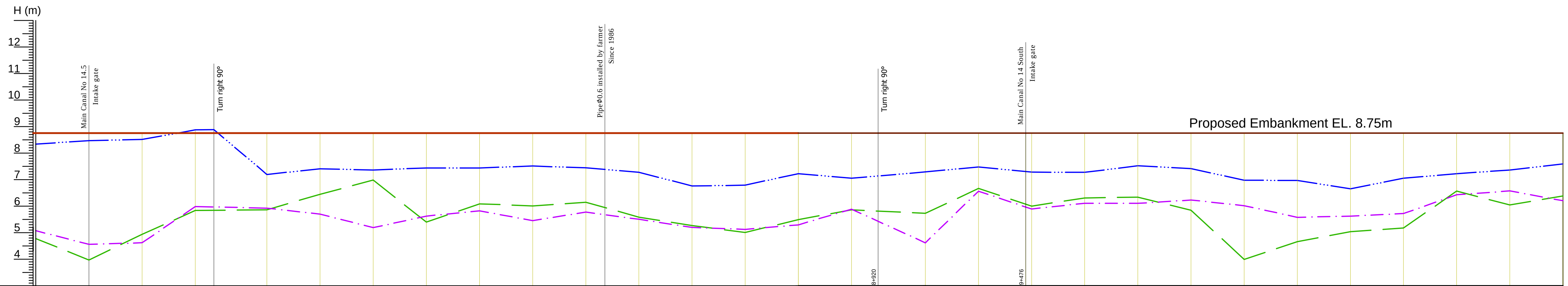


PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **General Layout of Srass Prambai Water Recession Rehabilitation Sub-project**	Date: Mar. 2012
Japan International Cooperation Agency **(JICA)**		DWG. No. SP-01

Source: JICA Survey Team



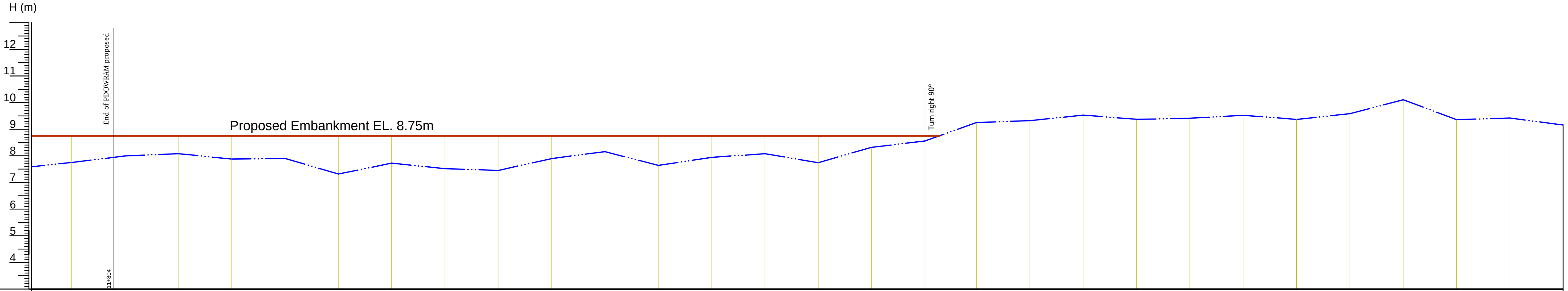
Chainage (m)	Distance (m)	Existing Left Field Level	Existing Bottom Level	Existing Right Field Level	Proposed Reservoir Embankment Level
0+000	250		10.000		
0+250	200		9.054		
0+450	200		9.094		
0+650	200		8.578		
0+850	200		8.593		
1+050	200		9.004		
1+250	200		8.782		
1+450	200		8.292		
1+650	200		8.695		
1+850	200		8.625		
2+050	200		8.439		
2+250	200		8.410		
2+450	200		8.597		
2+650	200		8.747		
2+850	200		9.128		
3+050	200		8.630		
3+250	200		8.711		
3+450	200		8.989		
3+650	200		8.427		
3+850	200		8.769		
4+050	200		8.719		
4+250	200		8.838		
4+450	200		8.521		
4+650	200		8.536		
4+850	200		8.714		
5+050	200		8.751		
5+250	200		8.568		
5+450	200		8.484		
5+650	100		8.539		
5+750			8.338		



Chainage (m)	Distance (m)	Existing Left Field Level	Existing Bottom Level	Existing Right Field Level	Proposed Reservoir Embankment Level
5+750	200	4.777	8.338	5.072	8.750
5+950	200	3.967	8.471	4.557	8.750
6+150	200	4.937	8.511	4.617	8.750
6+350	70	5.833	8.873	5.983	8.750
6+420	200		8.882		
6+620	200	5.859	7.194	5.924	8.750
6+820	200	6.447	7.407	5.698	8.750
7+020	200	6.979	7.363	5.187	8.750
7+220	200	5.394	7.440	5.624	8.750
7+420	200	6.086	7.438	5.820	8.750
7+620	200	6.009	7.511	5.451	8.750
7+820	200	6.144	7.442	5.774	8.750
8+020	200	5.583	7.274	5.502	8.750
8+220	200	5.270	6.759	5.197	8.750
8+420	200	5.006	6.788	5.123	8.750
8+620	200	5.488	7.225	5.293	8.750
8+820	278	5.860	7.049	5.886	8.750
9+098	200	5.729	7.290	4.616	8.750
9+298	200	6.666	7.476	6.563	8.750
9+498	200	6.000	7.282	5.890	8.750
9+698	200	6.306	7.272	6.108	8.750
9+898	200	6.337	7.521	6.104	8.750
10+098	200	5.845	7.411	6.229	8.750
10+298	200	3.991	6.977	6.017	8.750
10+498	200	4.661	6.964	5.577	8.750
10+698	200	5.034	6.652	5.623	8.750
10+898	200	5.177	7.052	5.720	8.750
11+098	200	6.564	7.221	6.427	8.750
11+298	200	6.045	7.362	6.572	8.750
11+498		6.381	7.589	6.202	8.750

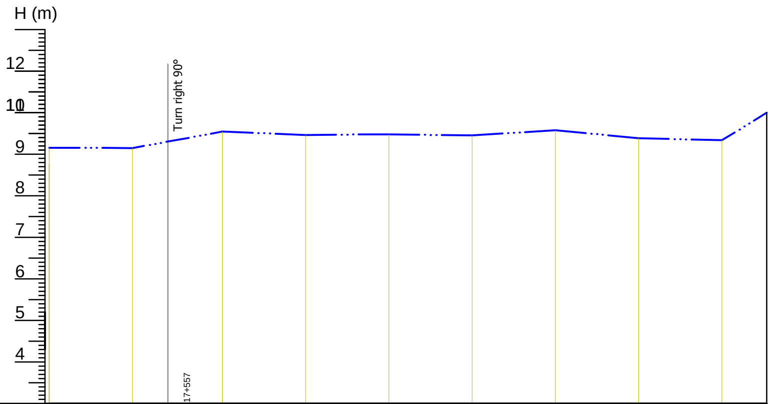
Remark: EL. is based on local benchmark.

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KIMDOM OF CAMBODIA Japan International Cooperation Agency **(JICA)**	Title of Drawing **Longitudinal Profile of Srass Prambai Reservoir Dike** **(1/2)**	Date: Mar. 2012 DWG. No. SP-02



Chainage (m)	11+498	11+648	11+848	12+048	12+248	12+448	12+648	12+848	13+048	13+248	13+448	13+648	13+848	14+048	14+248	14+448	14+648	14+848	15+041	15+241	15+441	15+641	15+841	16+041	16+241	16+441	16+641	16+841	17+041	17+241
Existing: Left Field Level																														
Existing: Bottom Level	7.589	7.753	7.996	8.084	7.878	7.905	7.316	7.724	7.519	7.453	7.899	8.158	7.642	7.944	8.079	7.745	8.320	8.558	9.250	9.322	9.529	9.370	9.411	9.522	9.369	9.581	10.102	9.359	9.416	9.155
Existing Right Field Level																														
Proposed Reservoir Embankment Level	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750	8.750

Distance (m)																												
	150	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	193	200	200	200	200	200	200	200	200	200	200



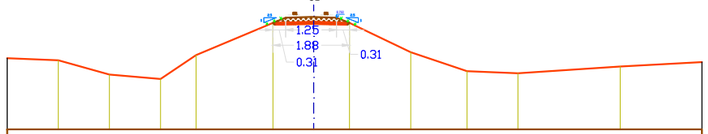
Chainage	17+241	17+441	17+657	17+857	18+057	18+257	18+457	18+657	18+857	18+965
Existing: Left Field Level										
Existing: Bottom Level	9.155	9.148	9.544	9.465	9.480	9.451	9.579	9.384	9.337	9.998
Existing Right Field Level										
Proposed Reservoir Embankment Level										

Distance									
	200	216	200	200	200	200	200	200	108

Remark: EL. is based on local benchmark.

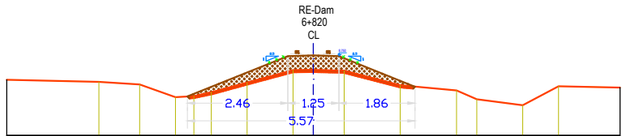
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVENMENT PROJECT IN THE KIMDOM OF CAMBODIA	Title of Drawing	Date: Mar. 2012
Japan International Cooperation Agency **(JICA)**	**Longitudinal Profile of Srass Prambai Reservoir Dike (2/2)**	DWG. No. SP-03

RE-Dam
5+750
CL



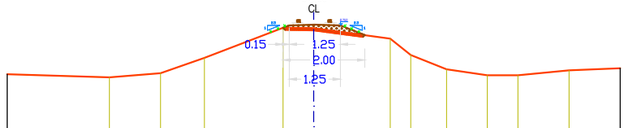
4.777	4.577	3.187	2.752	5.092	8.250	8.338	8.248	5.372	3.512	3.322	3.962	4.410
5.0	5.0	5.0	3.5	7.5	4.0	3.5	6.0	5.5	5.0	10.0	8

RE-Dam
6+820
CL



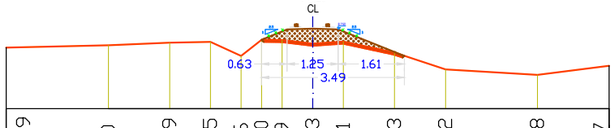
6.447	6.242	5.987	4.747	4.859	5.222	6.176	7.395	7.407	7.336	5.906	5.399	4.535	3.967	5.812	5.698
9.0	4.0	3.5	1.8	1.7	3.5	4.5	2.0	3.0	5.5	5.5	2.0	4.5	3.5	6.0

RE-Dam
5+950
CL



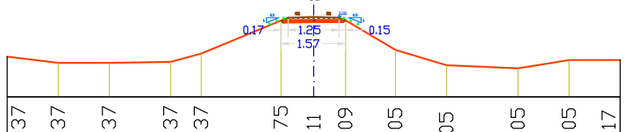
3.967	3.667	4.067	5.567	8.506	8.471	7.455	5.857	4.457	3.857	3.857	4.357	4.557
10.0	5.0	4.3	7.7	3.0	7.5	2.0	3.5	4.0	3.0	5.0	5.0

RE-Dam
7+020
CL



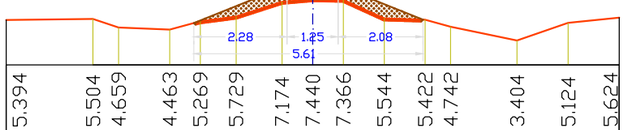
6.979	7.210	7.449	7.535	6.176	7.750	7.719	7.363	7.571	6.483	4.832	4.298	5.187
10.0	6.0	4.0	3.0	2.0	2.0	3.0	3.0	5.0	5.0	9.0	7.0

RE-Dam
6+150
CL



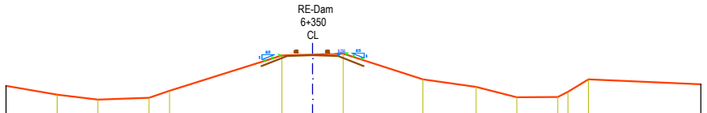
4.937	4.337	4.337	4.437	5.237	8.475	8.511	8.509	5.605	4.105	3.805	4.605	4.617
5.0	5.0	6.0	3.0	7.81	3.19	3.12	4.88	5.0	7.0	5.0	5.0

RE-Dam
7+220
CL



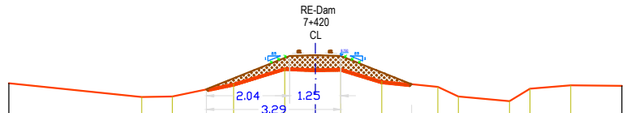
5.394	5.504	4.659	4.463	5.269	5.729	7.174	7.440	7.366	5.544	5.422	4.742	3.404	5.124	5.624
8.5	2.5	5.0	3.0	3.5	4.5	3.0	3.0	4.0	4.0	2.5	6.5	5.0	5.0

RE-Dam
6+350
CL



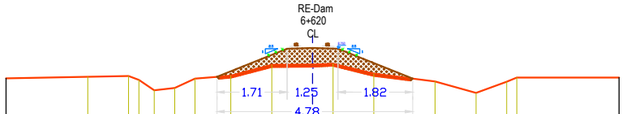
5.833	4.963	4.483	4.653	5.336	8.790	8.873	8.972	6.447	5.728	4.713	4.723	5.243	6.460	5.983
5.0	4.0	5.0	2.0	11.0	3.0	3.0	7.8	5.2	4.0	4.0	1	2.0	11

RE-Dam
7+420
CL



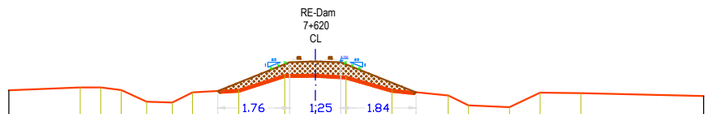
6.086	4.737	4.790	6.040	7.564	7.438	7.490	6.275	5.718	4.772	4.337	5.544	5.884	5.820
13.0	3.0	6.0	5.0	3.0	2.5	4.0	5.5	2.0	5.0	2.0	4.0	5.0

RE-Dam
6+620
CL



5.859	6.004	6.099	5.718	4.700	4.930	5.831	6.125	7.185	7.194	7.293	6.304	5.559	4.434	5.533	5.928	5.924
8.0	4.0	1.5	2.0	2.0	3.5	4.0	4.0	2.0	4.0	6.0	4.0	3.0	1	10.0

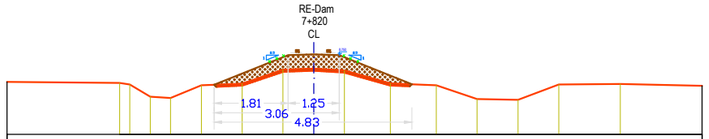
RE-Dam
7+620
CL



6.009	6.269	6.274	6.030	4.891	4.806	5.792	6.049	7.485	7.511	7.345	6.045	5.481	4.518	4.347	5.766	5.725	5.451
7.0	2.0	2.0	2.5	2.5	2.0	4.5	4.5	3.0	3.0	4.5	5.5	2.0	4.0	3.0	4.0	12

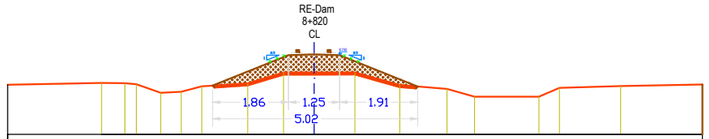
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Cross Section of Srass Prambai Reservoir Dike (1/4)**	Date Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. SP-04

RE-Dam
7+820
CL



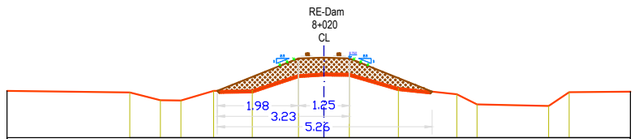
6.144	6.044	5.889	4.696	4.572	5.802	5.974	7.331	7.442	7.267	5.991	5.817	4.474	4.388	5.885	5.929	5.774
11.0	1	2.0	2.0	3.0	4.0	4.0	3.0	3.0	4.5	4.5	4.0	4.0	4.0	6.0	8.0	

RE-Dam
8+820
CL



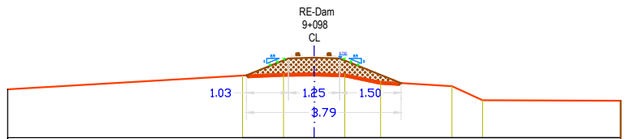
5.860	6.046	6.012	5.909	5.086	5.184	5.709	6.003	7.067	7.049	7.069	5.834	5.456	4.684	4.694	5.567	5.738	5.886
9.2	2.3	1.1	2.4	2.0	2.0	4.5	3.5	3.0	4.0	4.4	4.6	2.7	6.3	2.0	6.0	8.0	

RE-Dam
8+020
CL



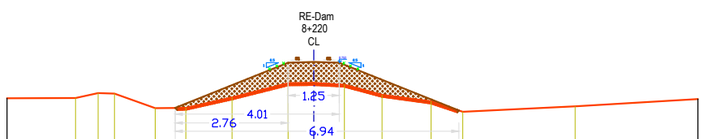
5.583	5.440	4.677	4.632	5.573	5.635	7.123	7.274	7.249	5.861	5.252	4.263	4.117	5.450	5.502
12.0	3.0	2.0	3.2	3.8	4.5	2.5	2.5	4.8	5.7	2.0	7.0	2.0	6.0	

RE-Dam
9+098
CL



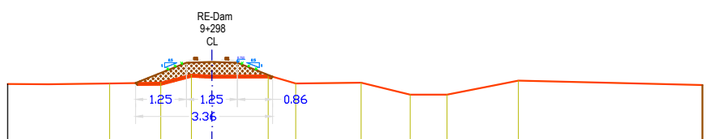
5.729	7.083	7.252	7.290	7.195	6.470	6.036	4.675	4.616
23.0	4.0	3.0	3.0	3.5	7.0	3.0	13.5	

RE-Dam
8+220
CL



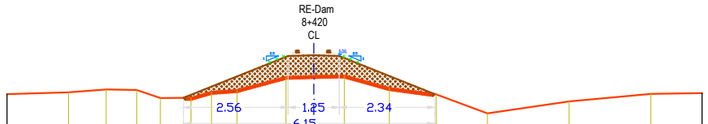
5.270	5.304	5.777	5.737	4.303	4.342	5.355	6.732	6.759	6.603	5.608	4.959	3.937	4.474	5.197
6.7	2.2	1.6	4.0	3.0	4.5	5.5	2.5	3.0	3.7	4.8	3.1	11.0	12	

RE-Dam
9+298
CL



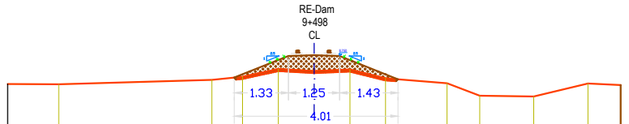
6.666	6.715	6.799	6.576	7.476	7.499	6.722	6.786	5.621	5.636	6.991	6.563
4.0	5.0	3.0	2.0	5.5	2.7	6.4	4.8	3.6	7.0	18	

RE-Dam
8+420
CL



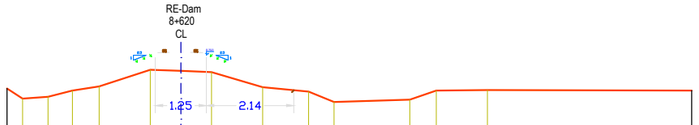
5.006	5.188	5.458	5.408	4.623	4.662	5.230	5.412	6.698	6.788	6.848	5.614	4.988	3.123	4.290	5.034	5.123
6.0	3.7	3.0	2.3	3.0	2.0	2.5	4.8	2.7	3.0	4.4	4.6	5.0	8.0	8.0	5	

RE-Dam
9+498
CL



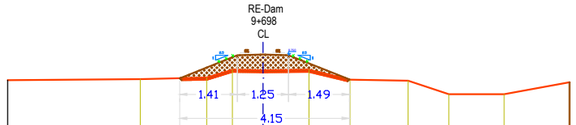
6.000	5.985	6.420	6.701	7.463	7.282	7.420	6.558	6.087	4.867	4.773	6.045	5.890
5.0	15.0	3.0	3.5	3.5	3.5	3.5	6.0	3.2	5.3	5.3	3.2	

RE-Dam
8+620
CL



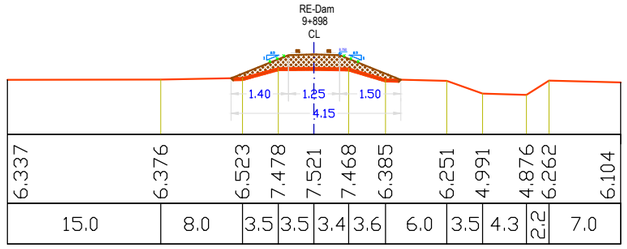
5.488	5.488	4.683	5.298	5.695	7.314	7.225	7.085	5.608	5.190	4.174	4.385	5.293	5.325	5.293
15	2.5	2.6	2.4	5.0	3.0	3.0	5.0	4.5	2.5	7.4	2.6	5.0	20.0	

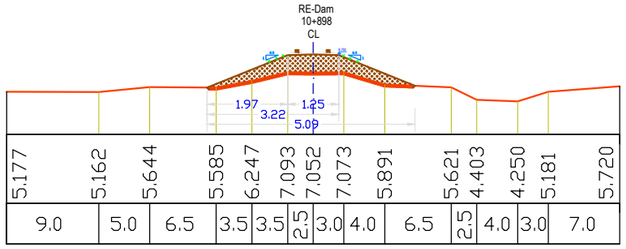
RE-Dam
9+698
CL

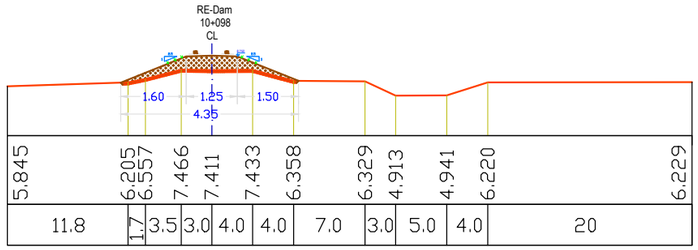


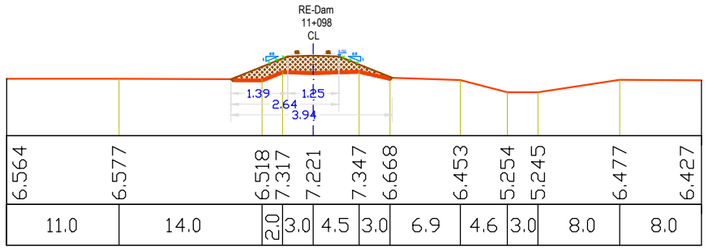
6.306	6.408	6.546	7.310	7.272	7.323	6.358	6.249	4.925	4.922	6.108
13.0	6.5	2.5	3.0	4.5	4.0	5.7	4.0	5.4	6.4	

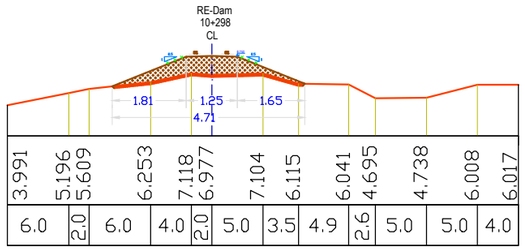
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Cross Section of Srass Prambai Reservoir Dike (2/4)**	Date Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. SP-05

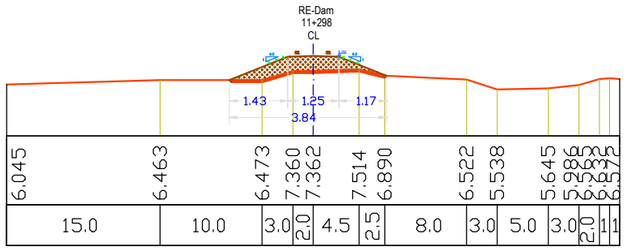


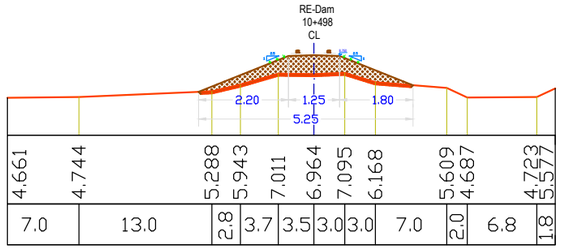


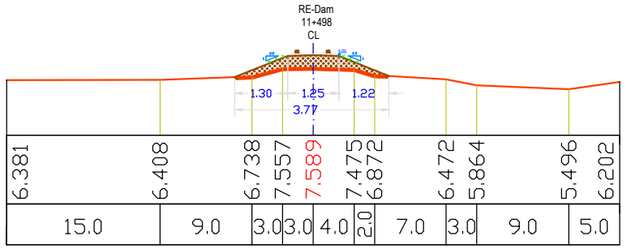


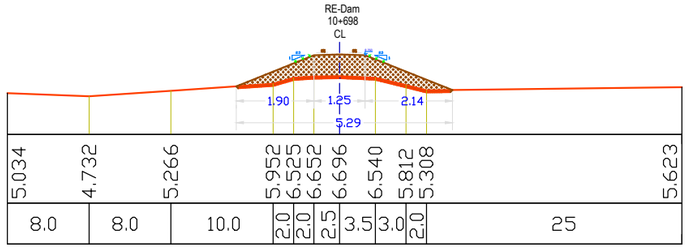


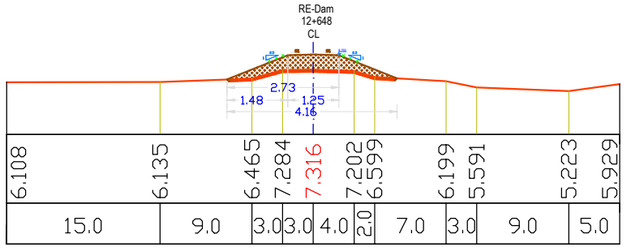




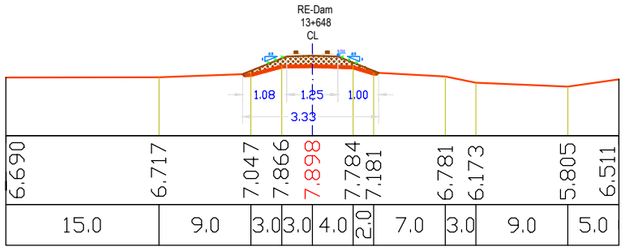


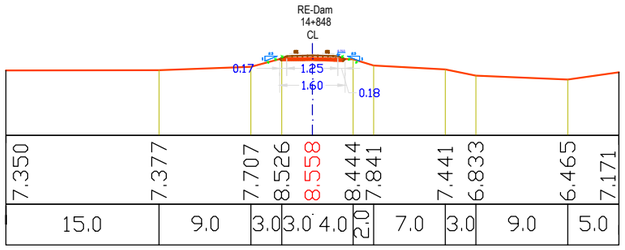




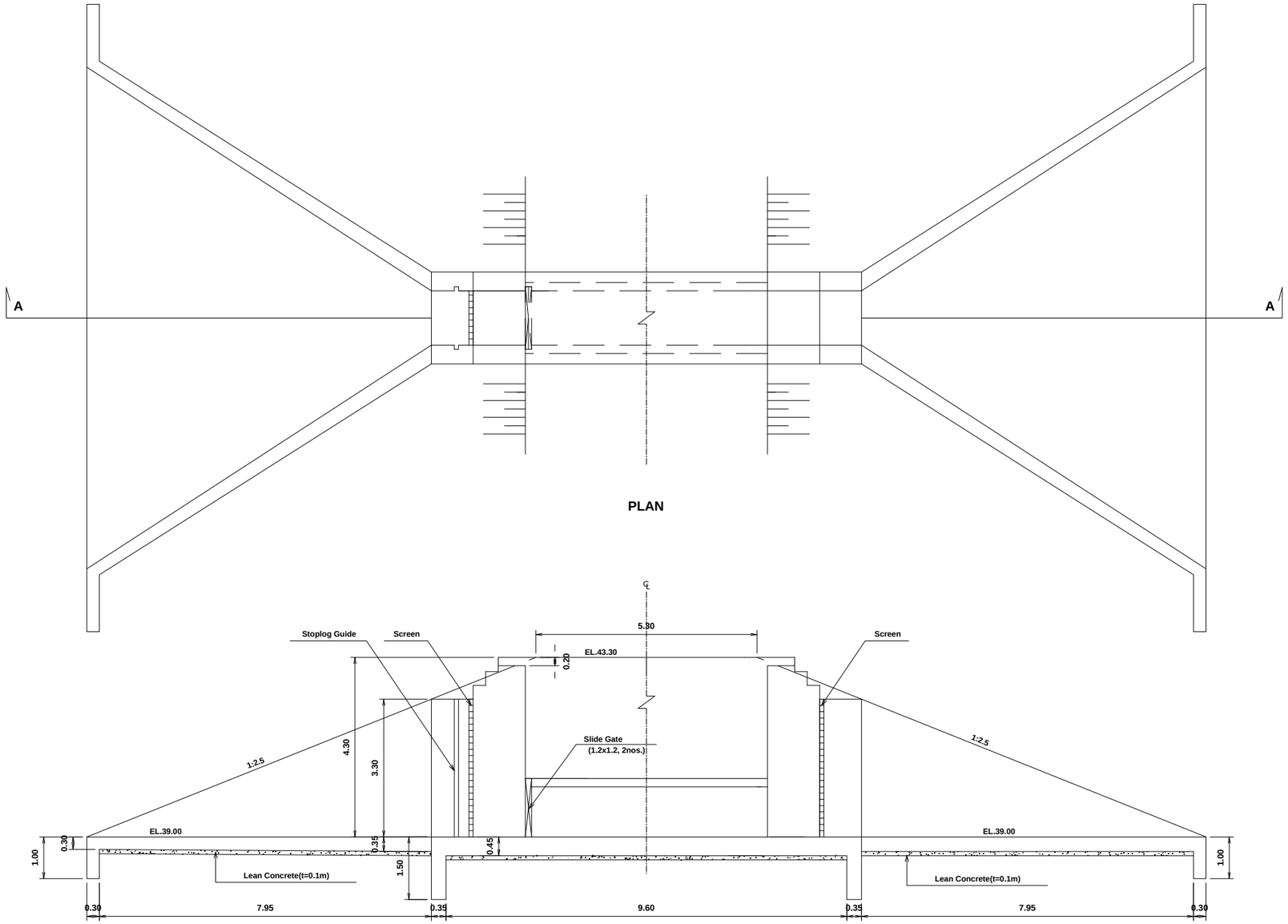


PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Cross Section of Srass Prambai Reservoir Dike (3/4)**	Date Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. SP-06

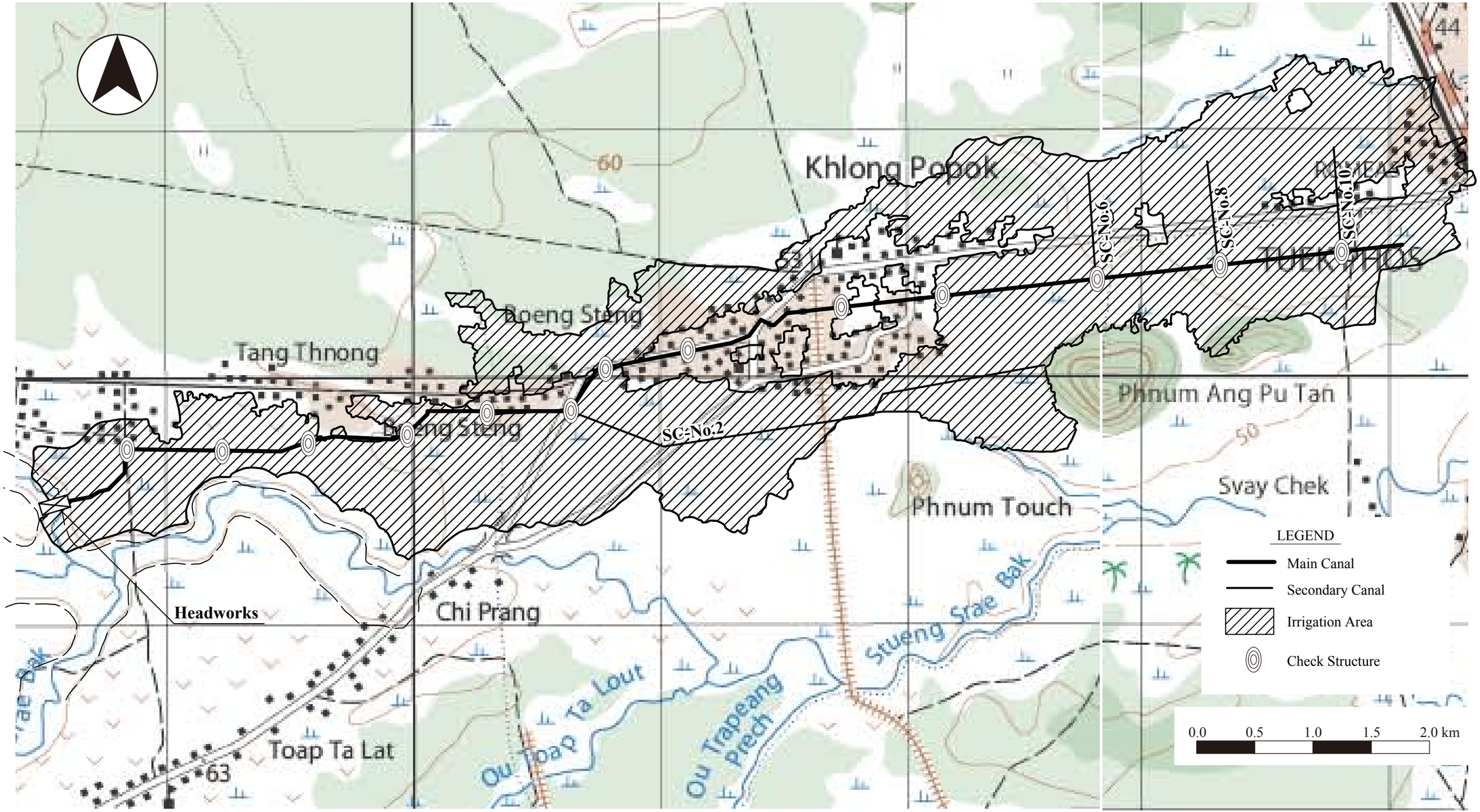




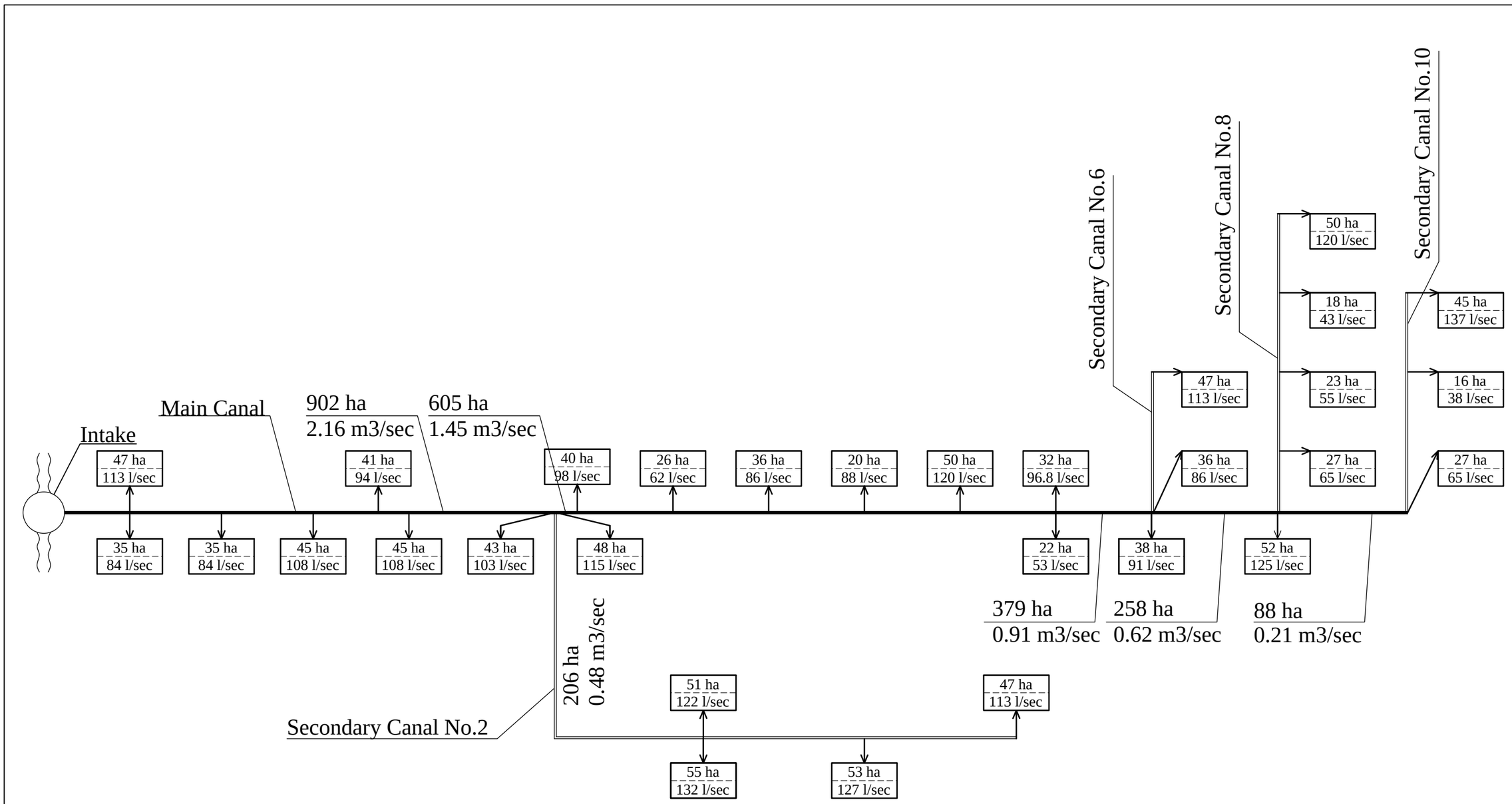
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **Cross Section of Srass Prambai Reservoir Dike (4/4)**	Date Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. SP-07



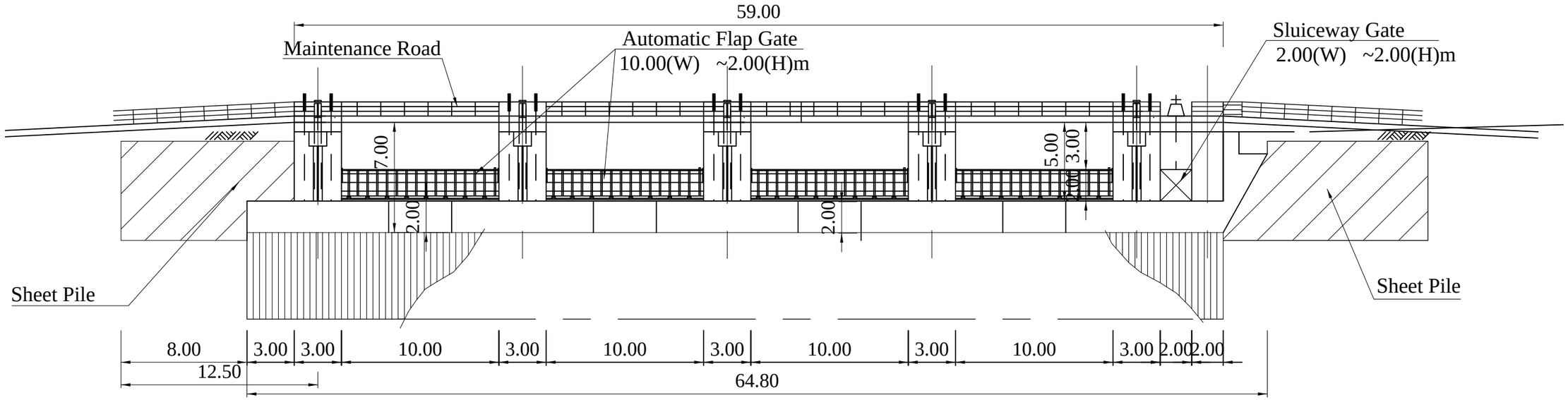
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing	Date
	Intake Culvert	Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. SP-08



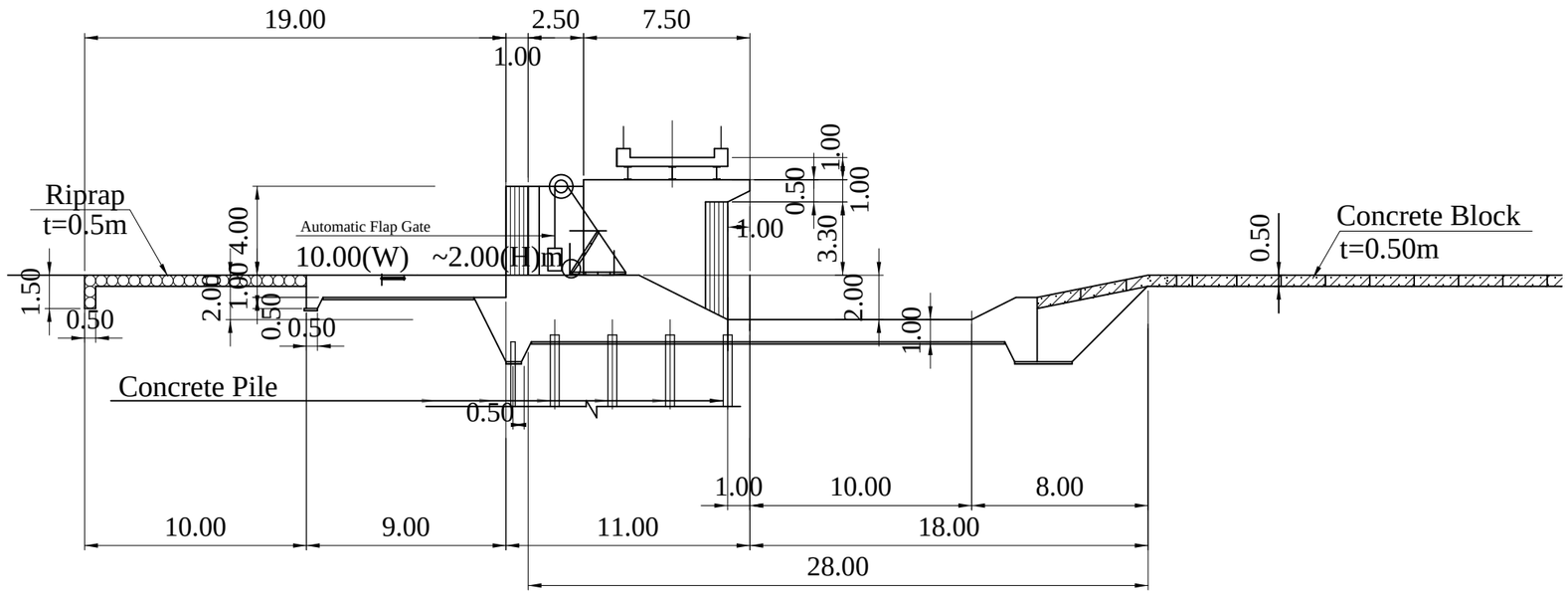
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing **General Layout of Daun Pue Irrigation System Rehabilitation Sub-project**	Date Mar. 2012
Japan International Cooperate Agency **(JICA)**		DWG. No. DP-01



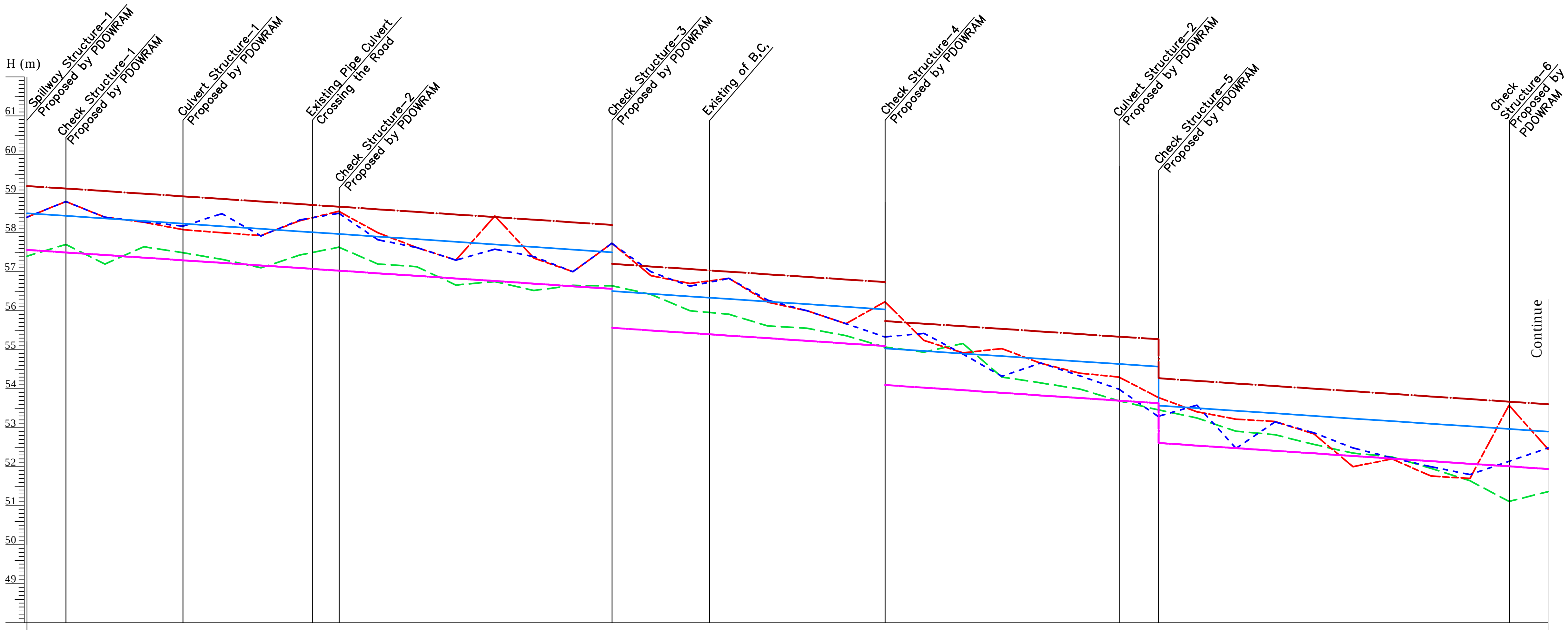
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVENMENT PROJECT IN THE KIMDOM OF CAMBODIA	Title of Drawing	Date: Mar. 2012
Japan International Cooperation Agency **(JICA)**	Irrigation Flow Diagram	DWG. No. DP-02



Scale 1:400



PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing Preliminary Design of Daun Pue Regulator	Date Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. DP-03



Point	Accum. Distance (m)	Distance (m)	Existing: Left Field	Existing: Bed Canal	Existing: Right Field	Design: Water Level	Design: Canal Bank	Design: Bed Canal
P0	0	100	58.40	57.40	58.40	58.50	59.20	57.56
P1	100	100	58.80	57.70	58.80	58.44	59.14	57.50
P2	200	100	58.40	57.20	58.40	58.37	59.07	57.43
P3	300	100	58.27	57.64	58.28	58.30	59.00	57.36
P4	400	100	58.08	57.49	58.17	58.24	58.94	57.30
P5	500	100	58.00	57.32	58.49	58.17	58.87	57.23
P6	600	100	57.93	57.10	57.92	58.10	58.80	57.16
P7	700	100	58.31	57.43	58.33	58.04	58.74	57.10
P8	800	100	58.55	57.63	58.50	57.97	58.67	57.03
P9	900	100	58.00	57.20	57.82	57.90	58.60	56.96
P10	1000	100	57.62	57.13	57.62	57.84	58.54	56.90
P11	1100	100	57.30	56.66	57.30	57.77	58.47	56.83
P12	1200	100	58.43	56.75	57.58	57.70	58.40	56.76
P13	1300	100	57.35	56.52	57.39	57.64	58.34	56.70
P14	1400	100	57.00	56.65	57.00	57.57	58.27	56.63
P15	1500	100	57.73	56.64	57.73	57.50	58.20	56.56
P16	1600	100	56.90	56.42	57.00	56.44	57.14	55.50
P17	1700	100	56.70	56.00	56.63	56.37	57.07	55.43
P18	1800	100	56.83	55.91	56.83	56.30	57.00	55.36
P19	1900	100	56.22	55.61	56.27	56.24	56.94	55.30
P20	2000	100	56.00	55.55	56.00	56.17	56.87	55.23
P21	2100	100	55.67	55.36	55.67	56.10	56.80	55.16
P22	2200	100	56.23	55.07	55.33	56.04	56.74	55.10
P23	2300	100	55.24	54.94	55.42	54.97	55.67	54.03
P24	2400	100	54.92	55.16	54.89	54.90	55.60	53.96
P25	2500	100	55.03	54.30	54.32	54.84	55.54	53.90
P26	2600	100	54.65	54.15	54.66	54.77	55.47	53.83
P27	2700	100	54.40	53.99	54.33	54.70	55.40	53.76
P28	2800	100	54.30	53.69	53.99	54.64	55.34	53.70
P29	2900	100	53.78	53.46	53.29	54.57	55.27	53.63
P30	3000	100	53.41	53.25	53.58	53.50	54.20	52.54
P31	3100	100	53.22	52.91	52.47	53.44	54.14	52.48
P32	3200	100	53.16	52.82	53.15	53.37	54.07	52.41
P33	3300	100	52.84	52.57	52.87	53.30	54.00	52.34
P34	3400	100	52.00	52.35	52.48	53.24	53.94	52.28
P35	3500	100	52.20	52.25	52.23	53.17	53.87	52.21
P36	3600	100	51.76	51.96	52.00	53.10	53.80	52.14
P37	3700	100	51.70	51.64	51.80	53.04	53.74	52.08
P38	3800	100	53.58	51.11	52.14	52.97	53.67	52.01
P39	3900		52.45	51.36	52.48	52.90	53.60	51.94

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KIMDOM OF CAMBODIA

Japan International Cooperation Agency

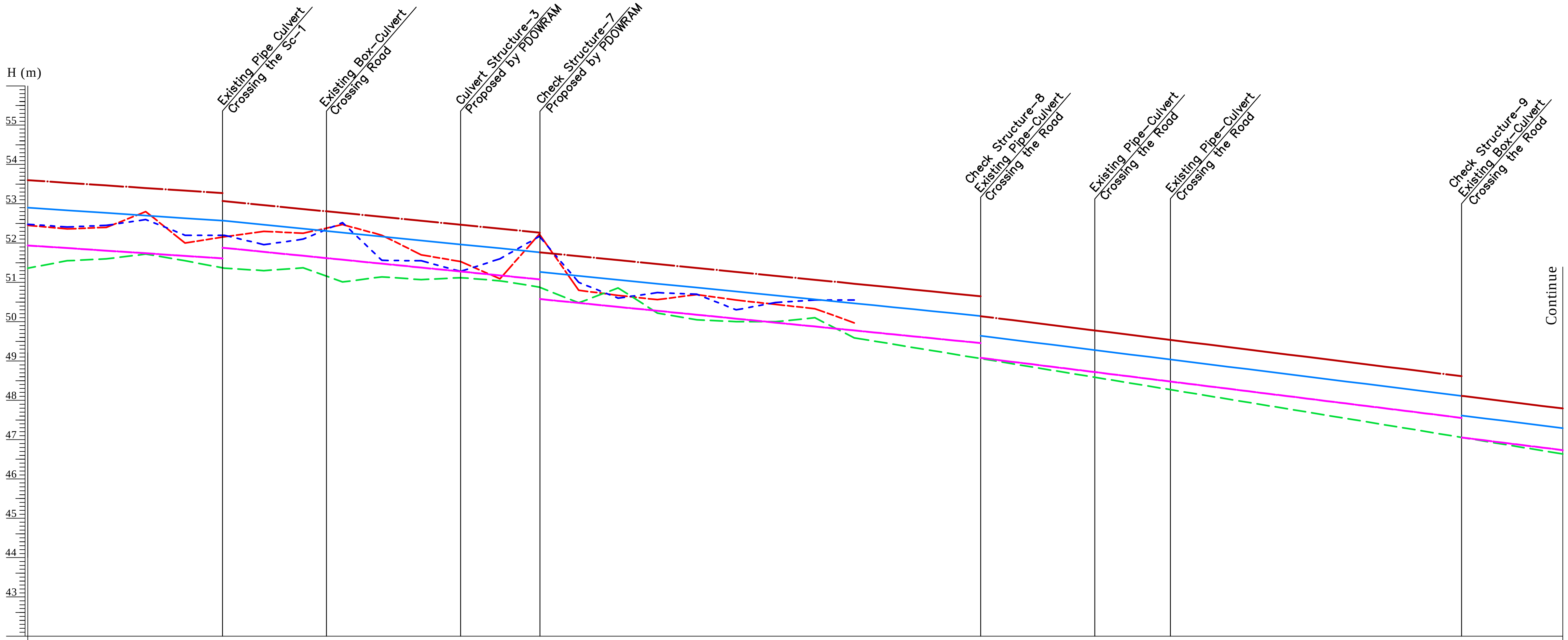
(JICA)

Title of Drawing

Longitudinal Profile of Daun Pue Main Canal (1/3)

Date: Mar. 2012

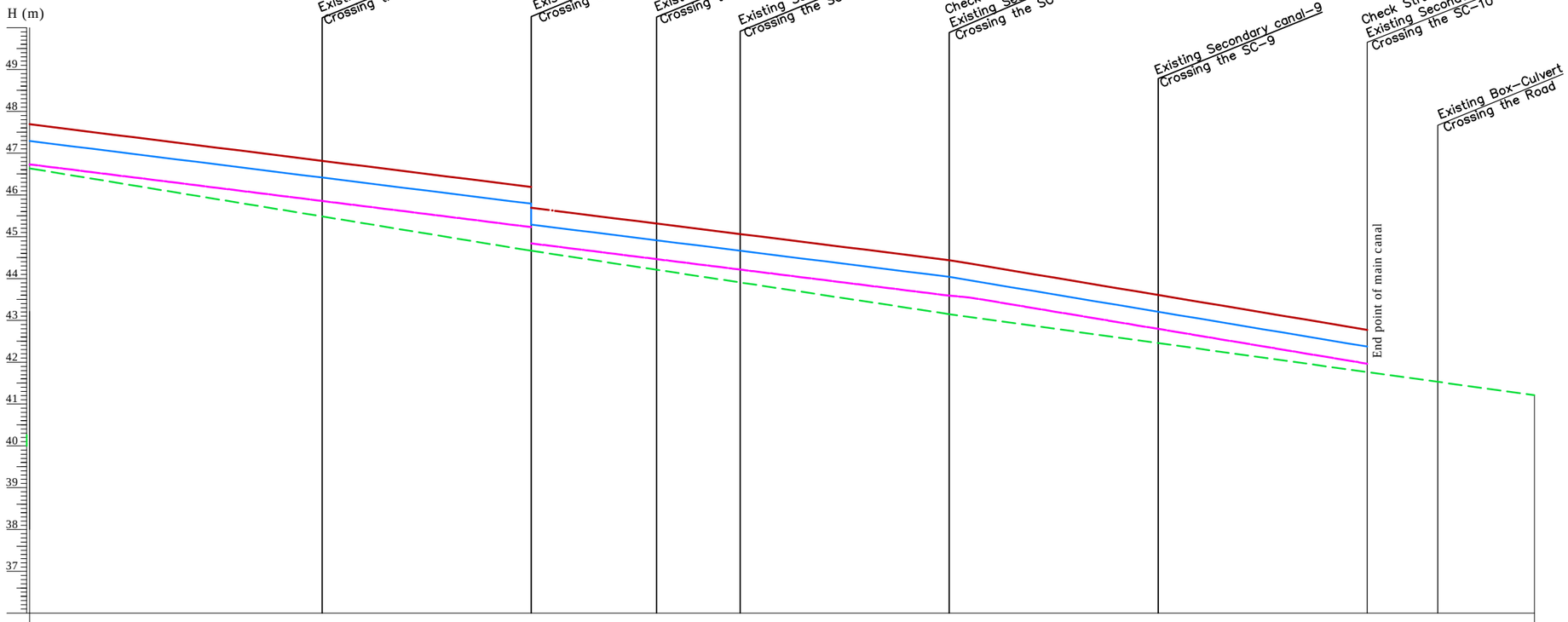
DWG. No. DP-04



Accum. Distance (m)	3900	4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	5500	5600	5700	5800
Distance (m)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Existing – Left Field	52.45	52.36	52.40	52.80	52.00	52.16	52.30	52.25	52.47	52.20	51.70	51.53	51.09	52.23	50.80	50.67	50.56	50.69	50.55	50.44
Existing – Bed Canal	51.36	51.55	51.60	51.72	51.55	51.36	51.30	51.37	51.01	51.14	51.07	51.12	51.04	50.88	50.48	50.86	50.22	50.05	50.00	50.00
Existing – Right Field	52.48	52.41	52.45	52.60	52.20	52.20	51.96	52.10	52.52	51.56	51.55	51.28	51.60	52.17	51.00	50.60	50.74	50.70	50.30	50.49
Design – Water Level	52.90	52.84	52.77	52.70	52.64	52.57	52.47	52.37	52.27	52.17	52.07	51.97	51.87	51.77	51.17	51.07	50.97	50.87	50.77	50.67
Design – Canal Bank	53.60	53.54	53.47	53.40	53.34	53.27	52.97	52.87	52.77	52.67	52.57	52.47	52.37	52.27	51.67	51.57	51.47	51.37	51.27	51.17
Design – Bed Canal	51.94	51.88	51.81	51.74	51.68	51.61	51.78	51.68	51.58	51.48	51.38	51.28	51.18	51.08	50.48	50.38	50.28	50.18	50.08	49.98
Point	P39	P40	P41	P42	P43	P44	P45	P46	P47	P48	P49	P50	P51	P52	P53	P54	P55	P56	P57	P58

Accum. Distance (m)	5900	6000	6100	6200	6300	6400	6500	6600	6700	6800	6900	7000	7100	7200	7300	7400	7500	7600	7700	7800
Distance (m)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Existing – Left Field	50.33	49.97																		
Existing – Bed Canal	50.10	49.59	49.42	49.25	49.09	48.92	48.75	48.58	48.41	48.25	48.08	47.91	47.74	47.57	47.41	47.23	47.07	46.90	46.73	46.57
Existing – Right Field	50.55	50.55																		
Design – Water Level	50.57	50.47	50.42	50.37	50.27	50.17	49.54	49.42	49.29	49.17	49.04	48.92	48.79	48.67	48.54	48.42	48.29	48.17	47.54	47.42
Design – Canal Bank	51.07	50.97	50.92	50.87	50.77	50.67	50.04	49.92	49.79	49.67	49.54	49.42	49.29	49.17	49.04	48.92	48.79	48.67	48.04	47.92
Design – Bed Canal	49.88	49.78	49.73	49.68	49.58	49.48	48.98	48.86	48.73	48.61	48.48	48.36	48.23	48.11	47.98	47.86	47.73	47.61	46.98	46.86
Point	P59	P60	P61	P62	P63	P64	P65	P66	P67	P68	P69	P70	P71	P72	P73	P74	P74	P76	P77	P78

PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVENMENT PROJECT IN THE KIMDOM OF CAMBODIA	Title of Drawing	Date: Mar. 2012
Japan International Cooperation Agency **(JICA)**	**Longitudinal Profile of Daun Pue Main Canal (2/3)**	DWG. No. DP-05

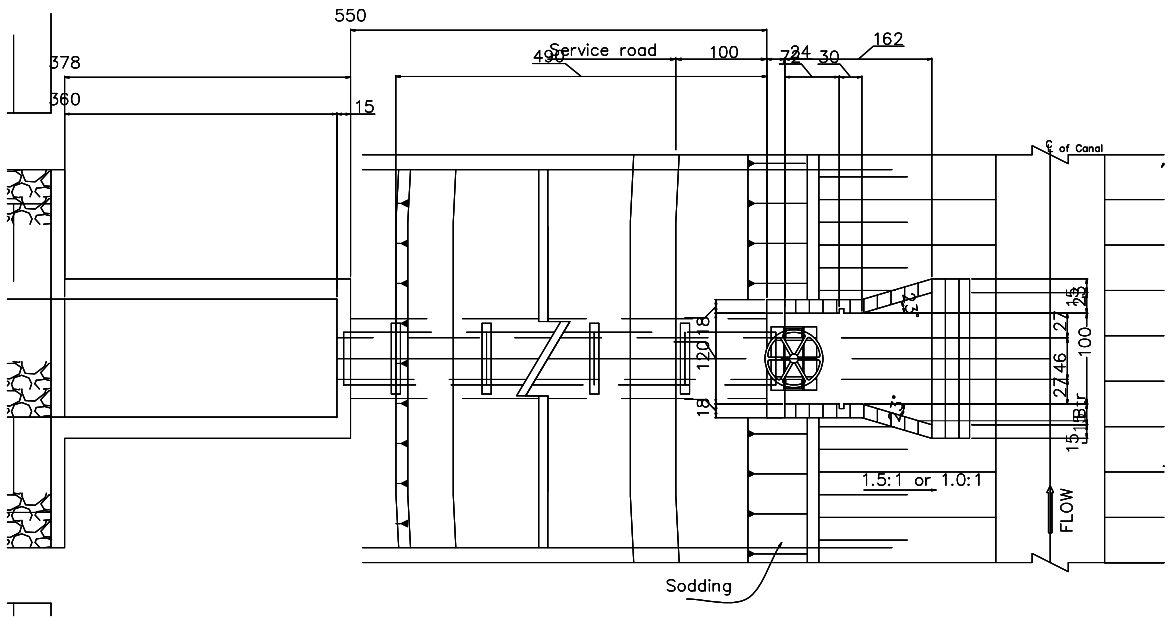


Accum. Distance (m)	7800	7900	8000	8100	8200	8300	8400	8500	8600	8700	8800	8900	9000	9100	9200	9300	9400	9500	9600	9700	9800	9900	10000	10100	10200	10300	10400	10500	10600	10700	10800	10900	11000	11100	11200	11300	11400
Distance (m)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Existing – Left Field																																					
Existing – Bed Canal	46.57	46.40	46.23	46.06	45.89	45.73	45.56	45.39	45.22	45.05	44.89	44.72	44.55	44.47	44.39	44.31	44.23	44.16	44.08	44.00	43.92	43.84	43.76	43.58	43.30	43.21	43.03	42.85	42.67	42.49	42.30	42.12	41.94	41.76	41.58	41.39	41.21
Existing – Right Field																																					
Design – Water Level	47.29	47.17	47.04	46.92	46.79	46.67	46.54	46.42	46.29	46.17	46.04	45.92	45.79	45.17	45.04	44.92	44.79	44.67	44.54	44.42	44.29	44.17	44.04	43.88	43.71	43.54	43.38	43.21	43.04	42.88	42.71	42.54	42.38				
Design – Canal Bank	47.79	47.67	47.54	47.42	47.29	47.17	47.04	46.92	46.79	46.67	46.54	46.42	46.29	45.67	45.54	45.42	45.29	45.17	45.04	44.92	44.79	44.67	44.54	44.38	44.21	44.04	43.88	43.71	43.54	43.38	43.21	43.04	42.88				
Design – Bed Canal	46.73	46.61	46.48	46.36	46.23	46.11	45.98	45.86	45.73	45.61	45.48	45.36	45.23	44.72	44.59	44.47	44.34	44.22	44.09	43.97	43.84	43.72	43.59	43.47	43.30	43.13	42.97	42.80	42.63	42.47	42.30	42.13	41.97				
Point	P78	P79	P80	P81	P82	P83	P84	P85	P86	P87	P88	P89	P90	P91	P92	P93	P94	P95	P96	P97	P98	P99	P100	P101	P102	P103	P104	P105	P106	P107	P108	P109	P110	P111	P112	P113	P114

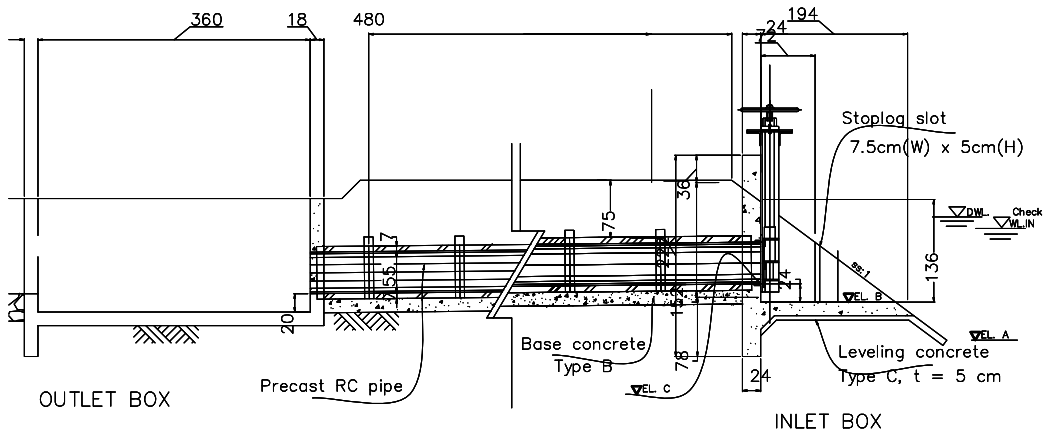
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVENMENT PROJECT IN THE KIMDOM OF CAMBODIA	Title of Drawing **Longitudinal Profile of Daun Pue Main Canal (3/3)**	Date: Mar. 2012
Japan International Cooperation Agency **(JICA)**		DWG. No. DP-06

Turnout

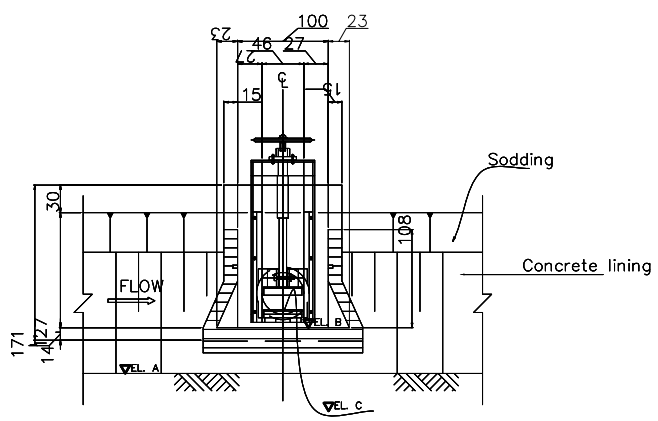
SCALE 1 : 100



PLAN (INTAKE SILL IS HIGHER THAN CANAL BED)



PROFILE (SECTION A–A)

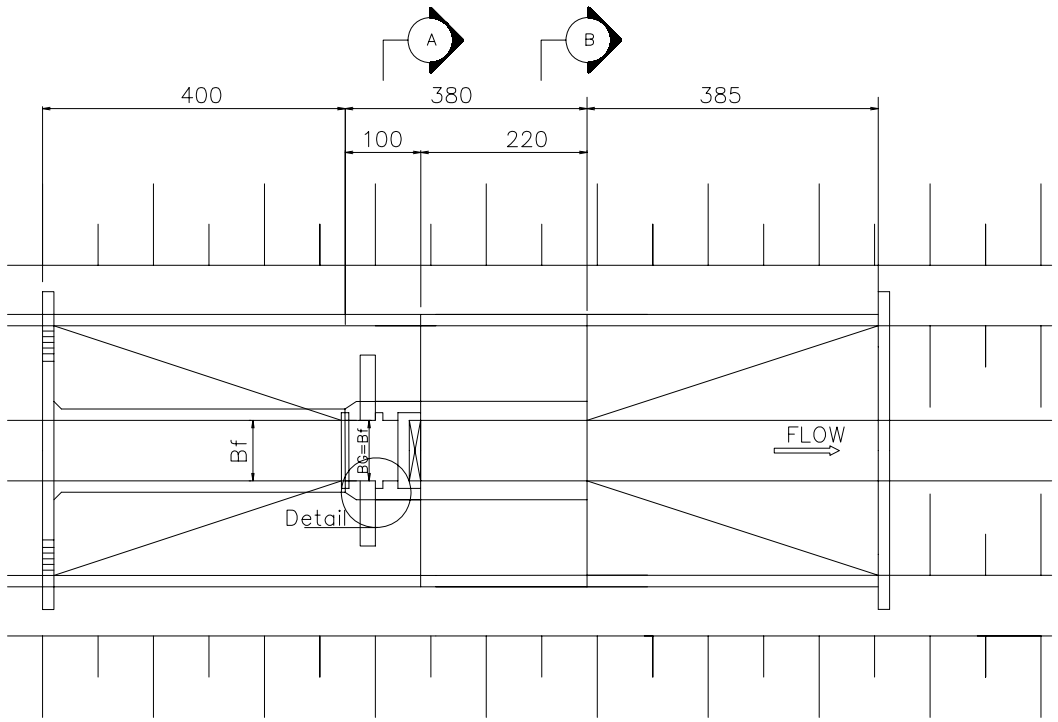


SECTION II–II
INLET BOX TYPE B

Check Structure

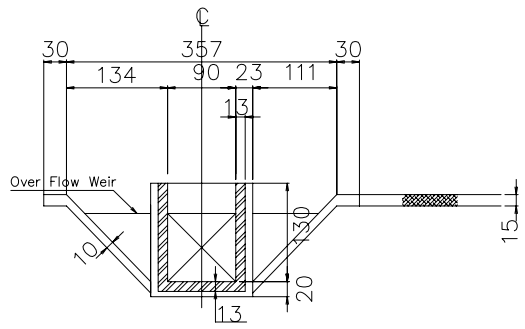
SCALE 1 : 100

(TYPE A)



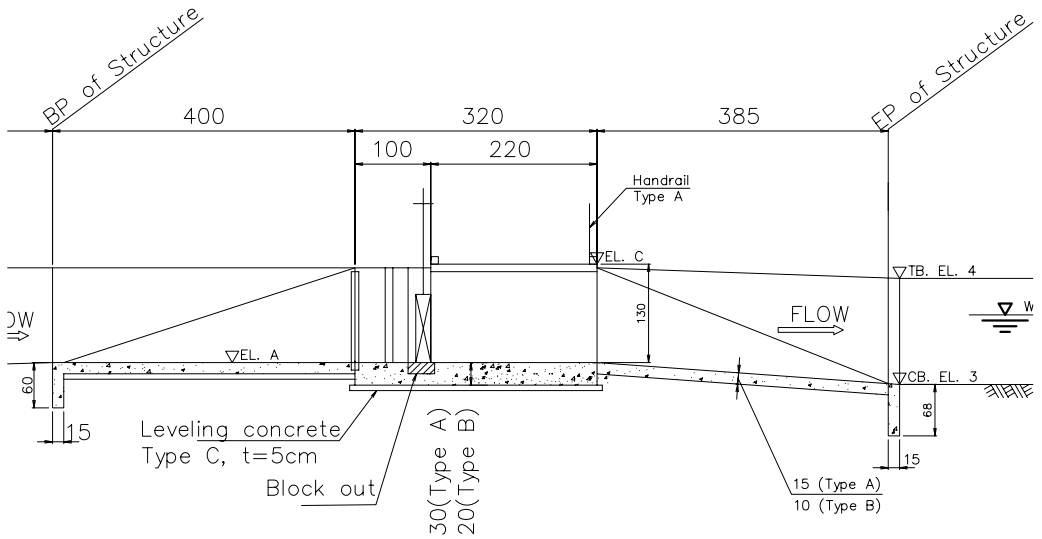
(TYPE B)

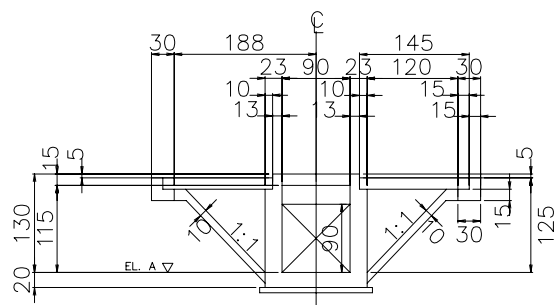
PLAN



(TYPE B)

SECTION A–A



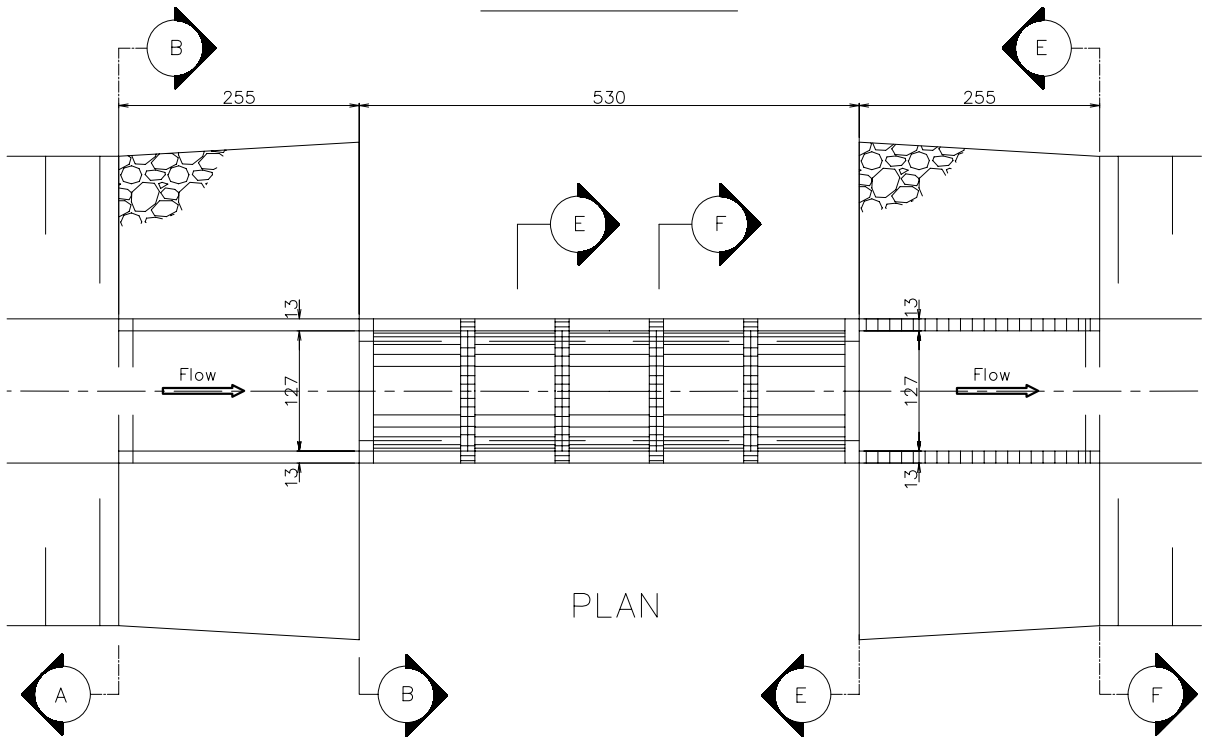


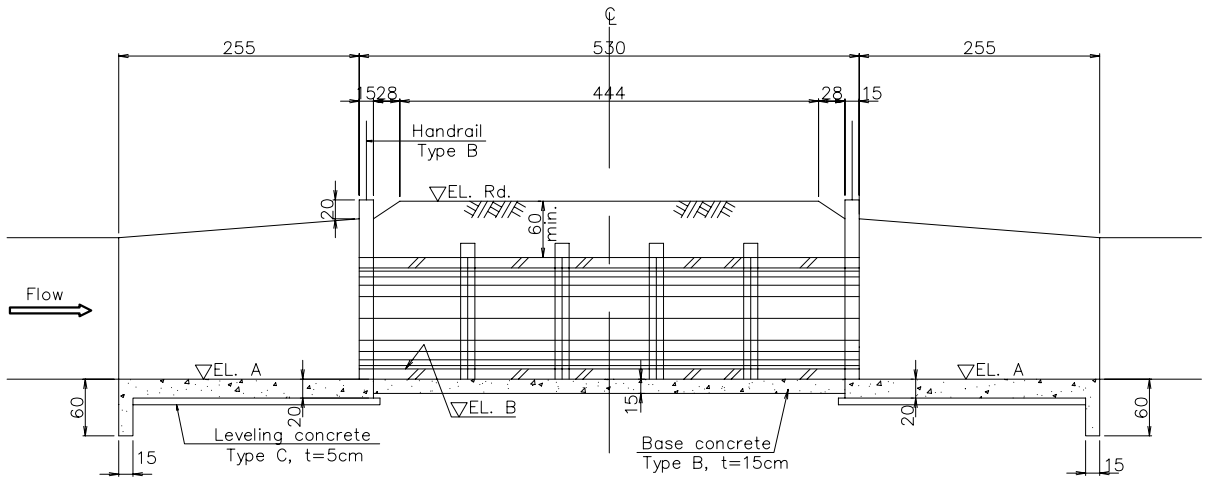
(TYPE B)

SECTION B–B

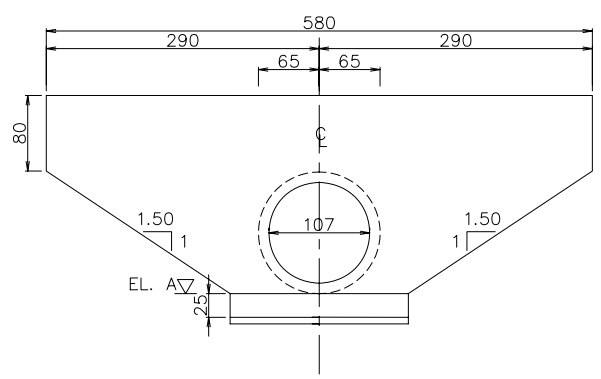
PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA Japan International Cooperation Agency **(JICA)**	Title of Drawing Check Structure and Turnout	Date Mar. 2012 DWG. No. SS-01

CULVERT





PROFILE

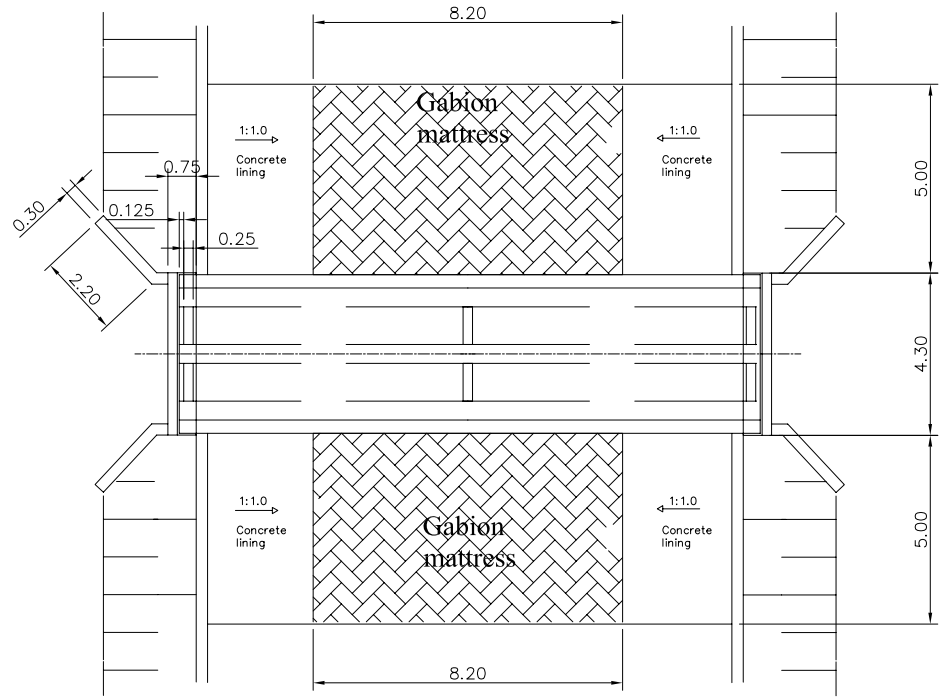


(TYPE B)

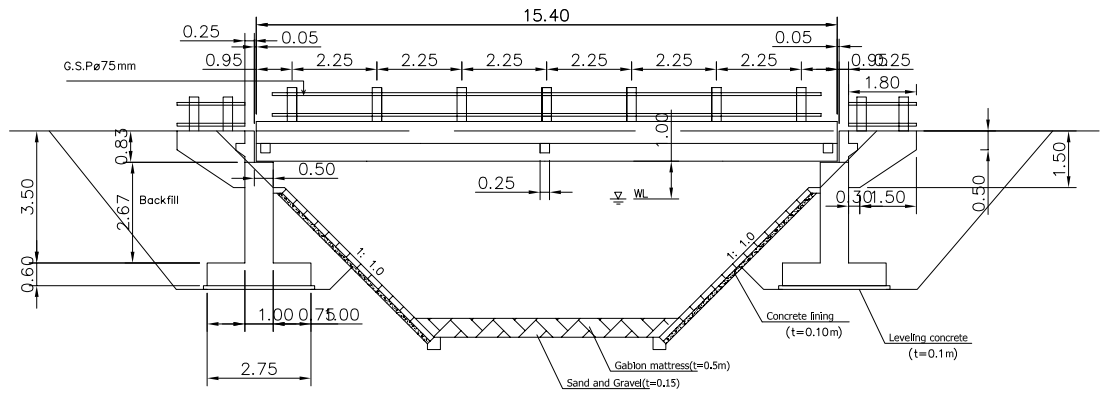
SECTION B–B

SCHALE 1 : 100

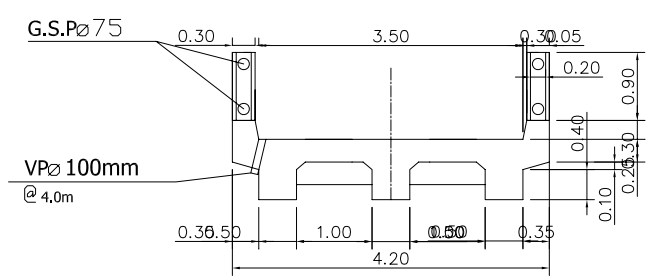
BRIDGE



PLAN



SECTION A–A



PREPARATORY SURVEY FOR IRRIGATION AND DRAINAGE SYSTEM REHABILITATION AND IMPROVEMENT PROJECT IN THE KINGDOM OF CAMBODIA	Title of Drawing Culvert and Bridge	Date Mar. 2012
Japan International Cooperation Agency (**JICA**)		DWG. No. SS-02