PART 1

Phase 1 : WATER RESOURCES DEVELOPMENT AND MANAGEMENT PLAN FOR 14 MAJOR RIVER BASINS

1.1 Present Condition of Study Area

1.1.1 River and Flood Control

Objective 14 river basins have been suffering flood damage in recent decades in varying degrees depending on the locations and availability of flood control facilities in the basin. Especially a flood in November 1999 caused huge damage in central region of Vietnam.

Basically river basins in central region of Vietnam do not have any flood control facilities nor the flood control master plans.

Among objective 14 river basins, Red and Thai Binh River basin, Dong Nai River basin, and Cuu Long River basin have already the master plan on flood control of the river basin. Other river basins do not have a master plan on flood control.

Among the said river basins, the Red and Thai Binh River basin, the Ma River basin, and Ca River basin are provided with the dyke system. But the dyke systems are long, high and old, and accordingly the deterioration of the dyke system has been causing huge maintenance cost. Besides, the dyke systems are not yet in an enough level for the required flood control level of each river basin. Additional construction of upstream reservoir(s) and/or upgrading of the existing dyke system are urgently needed.

Some river basins are already provided with some non-structural flood control measures in such a form of flood warning system and evacuation facilities. But these are still far from the required level.

Bank erosion of river is one of the serious problems in each river basin. Every year much land along the river is being lost causing the serious economic and social damage in the river basin. Some measures against the bank erosion have been provided in some river basins, but the required level is far beyond the present practice due to financial issues.

1.1.2 Agriculture

In the 1990s, in addition to far-reaching reforms in agriculture involving de-collectivization, allocation of land to farmers and liberalization of prices and

markets, there was also major investment in rural infrastructure. Consequently, agriculture, forestry and fishery sector growth averaged 4% over the period 1991-1997. Performance in 1998 was disappointing with 2.8% growth due mainly to drought-affected low harvests, and partially to the effect of Asian economic crisis. A bumper rice crop, as well as growth in fisheries and livestock in 1999, boosted agricultural growth to 5.2%. Agricultural growth is estimated to have grown by around 4% in 2000.

The agriculture, forestry and fishery sector (agriculture sector) accounts for about 23.8% of GDP in 1999 at constant price of 1994, of which agriculture sub-sector accounts for about 81.8%, forestry for 4.4%, and Fishery for 13.8% as shown in the following table.

Gross Output of Agriculture, Forestry &Fishery at Constant Price of 1994

(Unit : Billion Dong)

	1990			1999			1999/1990
	Output	%	%	Output	%	%	Increment (%)
1. Agriculture	**61,818**	**82.5**	100.0	**102,933**	**81.8**	100.0	66.5
Cultivation	49,604		80.2	82,946		80.6	67.2
Food Crops	(33,290)		(53.9)	(52,738)		(51.2)	58.4
Industrial Crops	(6,692)		(10.8)	(16,977)		(16.5)	153.7
Fruit Crops	(5,029)		(8.1)	(6,193)		(6.0)	23.2
Vegetables & Beans	(3,477)		(5.6)	(5,947)		(5.8)	71.0
Livestock	10,283		16.6	17,337		16.8	68.6
Service	1,930		3.1	2,650		2.6	37.3
2. Forestry	**4,969**	**6.6**		**5,415**	**4.4**		9.0
3. Fishery	**8,135**	**10.9**		**17,425**	**13.8**		114.2
Total of 1. to 3.	**74,922**	**100.0**		**125,773**	**100.0**		67.9

Source: Statistical Data of Vietnam; Agriculture, Forestry and Fishery 1975-2000

The production structure of agriculture in Vietnam is dominated by rice, which accounts for half the gross value of agricultural output.

In 1985, Vietnam cultivated only 5,718.3 thousand ha of paddy with an average yield of 2.77 ton/ha and an output of 15,859.3 thousand tons, then in 1999, these figures are 7,648.1 thousand ha, 4.10 ton/ha, and 31,393.8 thousand tons.

Planted Area and Production Volume in 1999 by Regions

(Unit: 1,000ha;1,000tons)

	Paddy			Other cereals			Industrial Crops			
							Annual**		Permanent***	
	Area	%	Output	Area	%	Output*	Area	%	Area	%
Red River Delta	1,048	13.7	5,693	142	11.6	427	67	7.5	4	0.3
Northeast	690	9.0	2,574	319	26.1	710	109	12.2	50	4.0
Northwest	133	1.7	379	136	11.1	258	36.7	4.1	10	0.8
North Central Coast	678	8.9	2,653	233	19.1	477	148	16.5	48	3.9
South Central Coast	435	5.7	1,704	88	7.2	172	101.3	11.3	52	4.2
Central Highlands	134	1.8	414	100	8.2	279	75	8.4	337	27.0
Southeast	543	7.1	1,696	164	13.4	488.4	221	24.8	615	49.3
Cuu Long Delta	3,987	52.1	16,281	39	3.2	50	136	15.2	132	10.6
Whole Country	7,648	100.0	31,394	1,220	100.0	2,860	893	100.0	1,248	100.0

Note: * =Paddy equivalent

** Includes cotton, jute, rush, sugarcane, soybean, and tobacco etc.

*** Includes tea, coffee, rubber, pepper, coconut, and cashew, etc

Source: Statistical Data of Vietnam; Agriculture, Forestry and Fishery 1975-2000

While rice and other cereals (mainly maize) remain the most important component of agricultural production, there has been some diversification to industrial crops in recent years as shown in the following table.

Gross Output of Agricultural Crops (At constant price of 1994)

(Unit : Bill. Dongs)

	Total		Food Crops		Vegetable and Beans		Industrial Crops		Fruit Crops	
	Value	%	Value	%	Value	%	Value	%	Value	%
1985	41,951	100.0	28,080	66.9	2,853	6.8	5,718	13.6	4,180	10.0
1990	49,604	100.0	33,290	67.1	3,477	7.0	6,692	13.5	5,029	10.1
1999	82,946	100.0	52,738	63.6	5,947	7.2	16,977	20.5	6,193	7.5
1999/1985	2.0		1.9		2.1		3.0		1.5	
1999/1990	1.7		1.6		1.7		2.5		1.2	

Source: Statistical Data of Vietnam; Agriculture, Forestry and Fishery 1975-2000

The major producing areas of specific crops at present are: the Cuu Long Delta and the Red River Delta for rice, the Central Highlands and Southeast regions for coffee; northern mountains and midland areas for tea; Southeast region for rubber, Southeast, the Cuu Long Delta and some northern provinces for fruits, and Lam Dong Province in Southeast region and the Red River Delta region for vegetables.

1.1.3 Domestic and Industrial Water Use

(1) Domestic Water Use

Domestic water supply is to cover for the water needs of individual households, institutions (e.g. offices, hospitals and schools), and commercial enterprises (e.g. business, hotels, restaurants and shops).

Water demands are usually prescribed by government regulations, which reflect the government's ideas and aspirations to what level of service they want to serve the population. These guidelines form a basis for design of new or extended water supply systems and can be used for water demand forecast.

The guideline values for domestic water demand are set by the Ministry of Construction (MOC) and are as follows:

Urban water demand = 150 lpcd (liter/capita/day)

Rural water demand = 45 lpcd (liter/capita/day)

(2) Industrial Water Use

It is found that almost all of the industrial activity in the country takes place in the Red River Basin and around Ho Chi Minh City. The Dong Nai river basin, with Ho Chi Minh City at the centre, accounts for approximately 85% of all industrial production. The industrial centres in the North adding another 10%. The rest of the country only represents approximately 5% of the countries industrial output.

1.1.4 River Environment

(1) Natural Environment

Precious Species: A total of 359 species of precious animals and of 344 species of precious plants are listed "Red Data Book of Vietnam." In comparison by basin, the Huong river and the Thach Han river basins have the higher density of precious species of both flora and fauna per unit surface area, indicating that in spite of relatively small surface area, these two basins have a variety of natural environment. On the other hand, relatively larger basins such as Red and Thai Binh rivers basin, Cuu Long river basin and Dong Nai river basin have smaller density of precious species.

Nature Conservation Areas: There are several categories with regard to the nature conservation areas: Protected Area, Wetlands, and those related to International Convention such as Ramsar Sites and World Heritage Sites. Surface area of all the nature conservation areas in Vietnam amount to 1,953,860 ha and it covers 7.07 %

of all the land. Among the 14 river basins, Red and Thai Binh Rivers basin leads both in number (39 in total) and the surface area (801,377 ha), and as for the coverage rate of nature conservation areas for the total surface area of each river basin, Huong River basin leads with 27.42 %.

River Water Quality: As a whole, there is no seriously polluted river with organic materials or heavy metals, except for some reaches near highly populated cities or industrial estates. Remarkable and significant features of water quality of these rivers are that they show the turbid appearance, or high suspended solids, and relatively high concentrations of Biochemical Oxygen Demand (BOD_5) or Chemical Oxygen Demand (COD), exceeding the Limitation Value A of Surface Water Quality Standard of Vietnam (TCVN 5942, 1995), although they are consistent with the Limitation Value B.

Salinity Intrusion: Salinity intrusion is a serious problem of major rivers of Vietnam in dry seasons. It can intrude up to deeper than 50 km in such rivers as the Dong Nai and the Cuu Long. Low land areas near river mouth are suffering from the high salinity concentration in not only surface water but also groundwater, which affects to domestic water use and irrigation over crop lands seriously. It lasts during dry season for several months, or sometimes, up to 10 months.

(2) Social Environment

Inland Waterways: Vietnam has 2,360 rivers with a total length of 41,900 km. Of this, the total navigable inland waterways are about 19,500 km, and about 8,000 km are currently used as navigation. The main inland waterways comprise about 2,500 km in the north mainly in Red River system and 4,500 km in the south mainly in Cuu Long River system including Dong Nai and Saigon rivers.

Cultural and Historical Heritage: Among 33 Cultural and Historical Environmental Sites (CHESs) in all Vietnam, which are designated as one of nature conservation areas, 28 CHESs are located in 14 river basins on provincial basis. The greater part of 28 CHESs is designated in order to protect their historical sites or unique landscapes.

Ethnic Minorities: Kinh is much predominant in the greater part of 14 river basins. However, the portion of Kinh group is low in Ban Giang & Ky Cung Rivers basin, Thai Binh River basin, upper area of Red River basin, and Sesan River basin. Especially in Bang Giang & Ky Cung Rivers basin, the portion of Kinh group is estimated only at 12 %, and Tay and Nung groups are predominant.

1.1.5 Activities on Water Resources Development and Management

(1) In accordance with the development of industrialization and urbanization in Vietnam, establishment of widely well-controlled and integrated management of water resources becomes essential. Under such a situation, the new law on water resources has been prepared. The new law was approved by the National Assembly in May 1998 and enforced in January 1999.

(2) Noteworthy points of the new law are as follows:

1) Responsibility on water resources management of the Government including MARD, other ministries, and People's committees is made clear.
2) The National Water Resources Council (NWRC) has been established. NWRC is composed of the Deputy Prime Minister for the Council's Chairman, the Minister of MARD for the standing member, representatives from ministries and some experts and scientists, and will function as the advisor to the Government.
3) The River Basin Organization (RBO) has been established as the government organization belonging to MARD to manage basin-level water resources development planning.
4) Development, conservation and utilization of water resources are stipulated to be made based on a river basin- not based on the administrative boundaries.
5) It is stipulated that organizations and individuals that will exploit and use water resources must apply for a license from the State authorized agencies.

1.2 Establishment of Socio-Economic Frame Work Plan

Socio-economic framework plan for the target year 2020 has been set by the study team for estimation of the future water demand and flood damages.

The economic development targets of provinces are collected by the questionnaire survey with assistance of IWRP. Economic development plans of the 14 river basins in this study are basically established based on those provincial targets.

The established socio-economic targets are summarized below:

Socio-economic Targets

River Basin	Population (1,000)		GRDP (VND billion)		Per capita GRDP (VND 1,000)	
	2001	2020	2001	2020	2001	2020
Bang Giang & Ky Cung	1,234	1,530	3,821	17,488	3,096	11,430
Red River Delta	17,360	21,649	82,229	369,605	4,737	17,073
Red & Thai Bin outside delta	10,228	14,077	29,139	128,673	2,849	9,141
Ma	3,605	4,396	8,498	68,664	2,357	15,620
Ca	4,394	5,575	12,405	48,500	2,823	8,700
Thach Han	598	746	1,813	7,100	3,032	9,517
Huong	1,083	1,403	3,875	22,896	3,578	16,319
Vu Gia-Thu Bon	2,133	2,619	7,660	45,341	3,591	17,312
Tra Khuc	1,214	1,501	3,618	14,597	2,980	9,725
Kone	1,503	1,910	5,010	21,939	3,333	11,486
Ba	1,834	2,507	6,272	29,396	3,420	11,726
Se San	338	550	876	3,529	2,592	6,416
Srepok	1,940	3,325	5,460	22,552	2,814	6,783
Dong Nai	11,966	17,381	88,571	224,911	7,402	12,940
Cuu Long	16,832	21,509	73,071	418,777	4,341	19,470

Note: GRDP and per capita GRDP are in 2000 constant price.

1.3 Meteo-hydrological Analysis

1.3.1 Run-off Analysis

(1) Approach to the Natural Runoff Analysis

The natural runoff has been defined as the volume of water that would pass through the base point of the basin in the absence of the withdrawal of water for agricultural, domestic or industrial purposes and assuming that no artificial storage is taken place in the catchment. The natural runoff has been estimated for the present land use and vegetation conditions in the basins.

For the assessment of the natural runoff of the basins, use has been made, to the extent possible, of historic runoff information in the form of discharge data. Only in case the historic discharge data gave insufficient information, rainfall data have been used either to generate or to complete runoff series.

Over the last years comprehensive water resources development studies have been carried out for a number of basins. If in the framework of those studies relevant runoff series were compiled, these series have been used with due care in the present analysis. This approach is found more appropriate than generating new series in the limited timeframe of the present analysis, that, moreover, has a broader scope than the mentioned specific basin studies. This approach has been followed for the following basins:

- The Red River basin (used source: 1994 Red River Delta Master Plan, Binnie & Partners et al.)
- Se San basin (used source: 1999 National Hydropower Plan Study, SWECO et al.)
- Dong Nai basin (used source 1996 Master Plan study on Dong Nai river and surrounding basins water resources development, JICA, Nippon Koei)
- Mekong Delta basin (used source: 1993 Mekong Delta Master Plan, NEDECO)

(2) Runoff Analysis and Water Availability for 14 River Basins

The results of the analysis in terms of volumes of water that is potentially available each month at 75% of dependability are summarized in the Table S1.1.

1.3.2 High Flow Analysis

(1) Approach to the High Flow Analysis

Flood discharges and volumes have, in principle, been estimated on the basis of a frequency analysis of available historic peak discharge and rainfall data. The latter data have merely been used for the estimate of flood volumes. Only in the basins in which the availability of historic discharge information is considered inadequate for such approach, a rainfall-runoff approach has been used, or use has been made of the results of the high flow analysis in an adjacent catchment.

For the estimate of the flood runoff of the Huong basin, rainfall – runoff modeling has been carried out with the Mike11-NAM model as well as with the Sacramento model. The modeling is described separately in the Main Report. The results obtained with the Sacramento model have been included in the following section.

(2) Summary of the results of the High Flow Analysis

Validation of the discharge data requires substantial effort in analyzing the methodology and quality of the data collection. Especially in the central region, where the floods have an extremely flashy character, the measurement of peak discharges is very complicated and may bring inaccuracies in the data. Besides the quality of the data of peak discharges, it is also the limited length of the available series of such discharges, that makes it necessary to use the results of the present analysis with due care. It is inevitable that in further planning stages, more attention is given to checking and eventually improving the data sets on peak discharges. The results of the analysis are presented in the Tables S1.2 to S1.4.

1.4 Water Demand Forecast

1.4.1 Water Demand for Agriculture

Agricultural water demand is composed of irrigation, livestock and aquaculture. The agricultural water demand varies depending on the rainfall. The present and future agricultural water demands are analyzed on the monthly basis for 25 years for the use in water balance analysis. The agricultural water demand in the average rainfall year is shown in Table S1.5 and summarized below:

Agricultural Water Demand (AWD), Average Rainfall Year (m^3/sec)

River Basin	Present(2001)	Future (2010)	Future (2020)
01. Bang Giang	9.5	13.1	14.5
02. Red	510.1	595.5	602.8
03. Ma	55.4	69.0	72.8
04. Ca	44.9	55.9	62.9
05. Thach Han	3.0	5.3	5.9
06. Huong	11.1	13.1	15.5
07. Thu Bon	15.5	24.3	24.3
08. Tra Khuc	13.1	13.4	13.5
09. Kone	22.5	27.8	31.7
10. Ba	27.5	56.8	70.4
11. Sesan	6.3	10.2	13.4
12. Srepok	15.1	15.3	33.1
13. Dong Nai	109.1	137.1	158.0
14. Cuu Long Delta	1,110.7	1,325.5	1,463.9

1.4.2 Water Demand for Domestic and Industrial Use

(1) Water Demand for Domestic Use

If the population growth figures of the Vietnamese General Statistical Office are taken as the basis for the calculations and assuming that the Vietnamese government will continue to give priority to the water supply sector, the following water use projections are found:

Summary of Domestic Water Use Projections (M. m3/year)

Water Use Category	2001	2005	2010	2015	2020
Urban domestic	684	1,038	1,420	1,861	2,325
Rural	535	553	613	701	807
Total	**1,219**	**1,591**	**2,033**	**2,562**	**3,132**

(2) Water Demand for Industrial Use

It is assumed that the industrial water use including urban and rural areas will increase in proportion to the economic growth of the sector in each river basin, which is assessed in the economic framework plan.

Besides the above, since the Government has designated seven future Export Processing Zones (EPZ) and Industrial Estates (IE) of which plans are informed to be ambitious and to certainly be realized in the next 10 to 20 years, it is assumed that these EPZ and IE will take place there. The industrial water use for other planned EPZ and / or IE are considered to be included in the above water use projection based on the economic growth.

Summary of Industrial Water Use Projection is given below.

Summary of Industrial Water Use Projections (M·m^3/year)

2001	2005	2010	2015	2020
715	1,042	1,381	1,732	2,114

1.4.3 Water Demand for Power Generation

Hydropower projects and multipurpose projects which are incorporated in the national power development plan are expected to ensure the planned firm power output of each project. Therefore, the water discharge necessary for the planned firm power output is considered the minimum requirement for the power generation of hydropower or multipurpose projects.

The main role of multipurpose projects which are not considered in the national power development plan is the water supply for the water demands such as irrigation, domestic & industrial water and river maintenance flow, etc. and therefore, power generation of these projects are assumed to be basically conducted by utilizing the discharge for the said water supply.

Table S1.6 calculates the minimum water requirement for power generation of the hydropower and multi-purpose reservoir projects which are incorporated in the national power development plan.

1.4.4 Water Demand for River Maintenance Flow

River maintenance flow for 14 river basins is examined from the viewpoint of i) prevention of saline water intrusion (only for 11 river basins which have river mouth in Vietnam), ii) prevention of water pollution and conservation of ecological condition, and iii) prevention of adverse effects on the present activities such as

fluvial navigation. Through the above examination, the maintenance flow of respective river is determined as follows:

Required River Maintenance Flow (Unit: m^3/s)

River	Discharge	River	Discharge
Ban Giang & Ky Cung Rivers	29.3	Tra Khuc River	52.0
Red & Thai Binh Rivers	867.0	Kone River	13.5
Ma River	114.7	Ba River	28.7
Ca River	173.0	Dong Nai River	97.5
Thach Han River	10.9	Sesan River	96.1
Huong River	31.0	Srepok River	40.5
Vu Gia-Thu Bon River	147.1	Cuu Long River	2,074.6

1.5 Water Balance Analysis

1.5.1 Water Balance System

Water balance analysis is made in monthly basis. Water resources and water demand data be given as monthly basis for a duration of 13-25 years.

Water balance point is predetermined at a water demanding point of each sub-basin and river mouth for the maintenance flow in a whole basin basis.

Return flow rate is assumed to be 10 % for irrigation water and not considered (0 %)of demand for domestic and industrial waters.

1.5.2 Water Balance System of 14 River Basins

(1) River Basin and Reservoirs Considered

The natural flow of each river basin is applied for the analysis as monthly runoff series with certain duration. In addition to the natural flow as basin runoff, reservoir storage is also considered as water resources during drought period. General feature of reservoirs is summarized in the succeeding table.

(2) Water Demands

Water demands incorporated in the analysis are for the agriculture including irrigation, fishery and livestock as well as domestic and industrial uses. Water release for hydropower generation incorporated in the national power development plan is considered as minimum water release from the reservoir. In case of several reservoirs, the flood control volume is assumed during a certain months as a restriction of water availability in the analysis.

River maintenance flow requirement is not a water demand but incorporated in the evaluation of the water balance analysis.

1.5.3 Results of Water Balance Analysis

(1) The following table shows the result of the water balance analysis as well as the proposed new reservoir schemes in the 14 basins, respectively.

Water Balance Analysis for 14 River Basins

River Basin	Year	Water Demand: Agriculture: Irrigation (1,000 ha)	Water Demand: Agriculture: Fishery/ Livestocks (MCM/month)	Water Demand: Urban: Domestic Water (MCM/month)	Water Demand: Urban: Industrial Water (MCM/month)	Maintenance Flow Requirement: Saline Water Intrusion (m^3/sec)	Maintenance Flow Requirement: River Ecology (m^3/sec)	Water Resources Development: Dam	Status	River	Available Volume for Water Supply (MCM)	Hydropower: Minimum Release (MCM/month)	Required Flood Control Space (MCM)	Water Balance Analysis and Evaliation: Duration of Runoff Series (Year)	Case	Drought Years: Water deficit in the year (Nos. of year(s) (No M.flow case))	Design Drought Year: Rank from the most severe drought	Design Drought Year: Lowest Reservoir Storage in the Year (MCM)
1 **Bang Giang & Ky Cung**	Present	25.5	1.38	0.88	0.04			**Ban Lai**	**Plan**	Ky Cung	310.5	–	96.2	15	Present	12 (0)	–	–
	2010	54.5	2.01	1.42	0.04	0.04	29.3								2010	12 (2)	–	–
	2020	67.5	2.42	2.21	0.10										2020 with Dam	0 (0)	12/15	100.5
															2020 - No Dam	14 (5)	–	–
2 **Red River & Thai Binh**	Present	1008.0	117.0	22.0	25.8			Son La	Plan	Da	14,900	1,306		20	Present	0 (0)	–	–
	2010	1197.0	173.9	45.0	25.8	(-)	**867.0**	Hoa Binh	Exist	Da	5,650	–			2010	3 (0)	–	–
	2020	1291.0	193.3	79.4	46.8			Bac Me	Plan	Gam	1,055	233.4			2020 with Dam	0 (0)	–	
								Dai Thi	Plan	Gam	1,091	261			2020 - No Dam	3 (0)	–	–
								Thac Ba	Exist	Thao	1,055	–						
3 **Ma**	Present	112.0	18.1	1.93	0.34			**Cua Dat**	**Plan**	Chu	1,210	80.9	105.6	20	Present	19 (1)	–	–
	2010	177.6	22.1	5.40	0.34	61.0	**114.7**								2010	19 (5)	–	–
	2020	199.5	23.9	8.42	1.63										2020 with Dam	3 (1)	16/20	122.0
															2020 - No Dam	20 (6)	–	–
4 **Ca**	Present	9.30	12.7	2.10	0.04			**Ban La**	**Plan**	Nam Non	1,244	140.1	216.0	25	Present	24 (7)	–	–
	2010	150.0	17.9	4.60	0.04	72.3	**173.0**	Ban Mai	Plan	Ca	3,140	–			2010	23 (4)	–	–
	2020	203.0	19.6	7.78	0.13										2020 with Dam	1 (0)	19/25	595.0
															2020 - No Dam	22 (1)	–	–
5 **Thach Han**	Present	5.00	0.96	0.57	0.01			**Rao Quan**	**Plan**	Rao Quan	291.0	6.6	104.7	24	Present	13 (1)	–	–
	2010	12.3	1.30	0.89	0.01	(-)	**10.9**								2010	17 (6)	–	–
	2020	15.4	1.52	1.40	0.02										2020 with Dam	5 (5)	19/24	0.0
															2020 - No Dam	17 (8)	–	–
6 **Huong**	Present	21.2	1.55	1.19	0.53			**Ta Trach**	**Plan**	Ta Trach	460.0	–	390.0	24	Present	24 (9)	–	–
	2010	21.2	4.28	2.03	0.53	**61.0**	**31.0**	Huu Trach	Plan	Huu Trach		–	(105.0)		2010	23 (9)	–	–
	2020	21.2	5.90	3.62	1.96			Co Bi	Plan	Bo		–	(44.0)		2020 with Dam	5 (2)	19/24	0.0
															2020 - No Dam	23 (13)	–	–
7 **Vu Gia -Thu Bon**	Present	30.9	6.49	2.83	8.58			**Ho Song Tran**	**Plan**	Thu Bon	945.0	200	800.0	17	Present	12 (10)	–	–
	2010	69.0	5.87	4.76	8.58	28.9	**147.1**	**Song Cai**	**Plan**	Vu Gia		–	(550.0)		2010	13 (12)	–	–
	2020	77.0	6.04	7.34	17.0										2020 with Dam	3 (3)	13/17	0.0
															2020 - No Dam	13 (13)	–	–

River Basin	Year	Water Demand: Agriculture: Irrigation	Water Demand: Agriculture: Fishery/ Livestocks	Water Demand: Urban: Domestic Water	Water Demand: Urban: Industrial Water	Maintenance Flow Requirement: Saline Water Intrusion	Maintenance Flow Requirement: River Ecology	Water Resources Development: Dam	Status	River	Available Volume for Water Supply	Hydropower Minimum Release	Required Flood Control Space	Water Balance Analysis and Evaliation: Duration of Runoff Series	Case	Drought Years: Water deficit in the year	Design Drought Year: Rank from the most severe drought	Design Drought Year: Lowest Reservoir Storage in the Year
		1,000 ha	MCM/month	MCM/month	MCM/month	m^3/sec	m^3/sec				MCM	MCM/month	MCM	Year		Nos. of year(s) (No M.flow case)		(MCM)
8 **Tra Khuc**	Present	33.0	0.60	0.70	0.18			**Nuoc Trong**	**Plan**	Thach Nham	185.8	–	184.2	20	Present	15 (1)	–	–
	2010	42.0	0.73	1.13	0.18	24.1	**52.0**								2010	15 (1)	–	–
	2020	54.0	0.95	1.85	0.46										2020 with Dam	3 (0)	16/20	31.0
															2020 - No Dam	15 (2)	–	–
9 **Kone**	Present	25.0	1.52	1.42	0.17			**Dinh Binh**	**Plan**	Kone	209.0	–	97.2	25	Present	11 (10)	–	–
	2010	36.5	1.80	2.35	0.17	**15.3**	13.5	Vinh Son	Exist		102.0				2010	17 (15)	–	–
	2020	49.0	2.09	3.95	3.94			Thuan Ninh	Exist		32.3				2020 with Dam	4 (4)	20/25	0.0
								Nui Mot	Exist		90.0				2020 - No Dam	17 (15)	–	–
10 **Ba**	Present	41.0	1.75	1.67	0.04			**Song Ba Ha ***	**Plan**	Ba	484.4	148.2	38.1	13	Present	0 (0)	–	–
	2010	129.0	2.20	3.32	0.04	17.1	**28.7**	La Yun	Exist	Dak la Yun	201.0	–			2010	2 (1)	–	–
	2020	186.0	2.72	5.19	0.11			Hinh	Exist	Hinh	323.0	–			2020 with Dam	2 (2)	10/13	0.0
								An Khe - Kanak *[2]	Plan	Ba		–			2020 - No Dam	5 (5)	–	–
11 **Sesan**	Present	22.5	0.72	0.75	0.05			**Dak Bla**	**Plan**	Dak Bla	873.0	–	78.0	22	Present	7 (0)	–	–
	2010	35.4	0.95	1.19	0.05	(-)	**96.1**	Plei Krong	Plan	Krong Poko	1,131				2010	6 (0)	–	–
	2020	50.0	1.24	1.92	0.13										2020 with Dam	0 (0)	18/22	790.0
															2020 - No Dam	7 (0)	–	–
12 **Srepok**	Present	29.0	2.66	1.66	0.05			**Buon Kuop**	**Plan**	Srepok	315.0	116.1	–	24	Present	22 (17)	–	–
	2010	35.0	3.10	3.37	0.05	(-)	**40.5**	**Krong Boung**	**Plan**	Krong Boung	21.6	–	21.4		2010	22 (19)	–	–
	2020	91.0	3.64	6.86	0.14			**Upper Krong Pach**	**Plan**	Krong Pach	72.0	–	26.2		2020 with Dam	22 (5)	19/24	0.0
								Upper Krong Buk	**Plan**	Krong Buk	83.4	–	–		2020 - No Dam	23 (20)	–	–
								Lower Krong Buk	Exist	Krong Buk	45.0	–	33.3					
13 **Dong Nai**	Present	115.0	39.8	18.9	77.0			Dau Tieng	Exist	Sai Gon					Present		–	–
	2010	224.0	45.9	36.8	77.0	(-)	**97.5**	Thac Mo	Exist	Be					2010		–	–
	2020	362.0	51.0	59.9	102.9			Tri An	Exist	Dong Nai					2020 with Dam			
								Ham Thuan /Da Mi	Exist	Dong Nai					2020 - No Dam		–	–
14 **Cuu Long**	Present	1,487.0	307.2	12.8	0.64										Present		–	–
	2010	1,891.0	475.4	26.8	0.64	(-)	**2,075.0**								2010		–	–
	2020	2,242.0	612.3	42.2	1.97										2020 with Dam			
															2020 - No Dam		–	–

Evaluation by Basin

River	Evaluation
Ban Giang and Ky Cung Rivers	Implementation of Ban Lai Dam would eliminate deficit to be caused by projected 2020 demand completely.
Red River and Thai Binh	Projected 2020 demand would be completely satisfied by additional three dams under planning.
Ma River	Serious water deficit is observed in the present condition. Construction of one dam which is assumed to be Cua Dat Dam is quite necessary to cope with the projected 2020 demand.
Ca River	Ban La Dam could satisfy the water supply demand in 2020 and it would have rather sufficient capacity exceeding estimated 2020 requirement.
Thach Han River	The proposed Rao Quan Dam would satisfy the projected 2020 demand only but no spare capacity against demand exceeding 2020.
Huong River	Ta Trach Dam would satisfy the projected 2020 demand only and no spare capacity is anticipated to cope with demand exceeding 2020.
Vu Gia and Thu Bon Rivers	Vu Gia and Thu Bon Rivers; Ho Song Tran II Dam would satisfy the projected 2020 demand only and no spare capacity to cope with demand exceeding 2020. Song Cai Dam may not be required for water supply purpose until 2020.
Tra Khuc River	Nuoc Trong would satisfy the future demand even though water deficit would be anticipated for a few years.
Kone River	Present condition of water deficit will be more serious to meet increasing water requirement. Dinh Binh Dam will meet such demand in 2020. However another water resource development might be necessary in case water demand after 2020 will be still increasing.
Ba River	No water deficit is observed at present owing to the existing two dams. To improve increasing water deficit due to sharply increasing water demand in 2020, Song Ba Ha Dam would be additionally necessary.
Sesan River	Water supply will be covered yet even in 2020 by the river runoff itself. However minimum flow to be secured for Cambodia requires additional discharge, so that, Dak Bla Dam is proposed, which storage capacity would have much surplus against the projected 2020demand.
Srepok River	Due to irrigation water requirement out of benefit area of the proposed Buon Kuop Dam, very severe water deficit is anticipated including present and future conditions.

1.6 Basic Strategy of Water Resources Development and Management Master Plan

(1) Basic Strategy for Water Utilization Plan

The goal of the Water Resources Development and Management Master Plan is to meet achievement of the macro-economic targets by river basin toward the year 2020.

Therefore, formulation of the water resources development and management master plan to meet the water demand increase in accordance with the targeted economic growth of each sector is set as the basic strategy of the water utilization plan. The water demand increase in accordance with the targeted economic growth of each sector is detailed in the main text.

(2) Basic Strategy for Flood Control

1) Objective Area: Objective area of flood control of each river basin is defined in consideration of socio-economic and political conditions in the basin, flood prone and/or flood susceptible area, topographical conditions and others. The flood control objective area of each river basin is shown in Main Report.

2) Flood Protection Level: Flood protection level of each river basin is basically defined based on the request of each river basin. The flood protection level of each river basin is shown in Table S1.7.

3) Flood Control Measures: Flood control measures consist of structural measures and non-structural measures. Structural measures consist of river improvement including construction of river dike system, construction of upstream reservoirs, flood diversion channel, flood retarding basin. Non-structural measures consist of forestation in the upstream basin, establishment of flood forecasting and warning systems, flood evacuation system, flood fighting system and others. These measures should be taken into consideration in view of comprehensiveness, consistency, social equity, operation and management, and other socio-economic situations in the basin.

1.7 Formulation of Water Resources Development and Management Master Plan for 14 River Basins

1.7.1 Flood Control Plan

Flood control plan of each river basin is prepared based on the flood control criteria applied in accordance with the requirement of each river basin and is summarized in Table S1.8.

1.7.2 Irrigation Water Utilization Plan

(1) Establishment of standard for future facilities level

Irrigation facilities level of the year 2020 should be one that the irrigation efficiency of 0.70 can be realized with the well water management to be made by skillful operators who use the facilities.

(2) Necessary projects so as to realize the facilities level of the year 2020

Irrigation projects formulated to realize the required irrigation area estimated based on the agricultural development strategy and examined by the water balance calculation are as follows:

Irrigation Projects (required for agriculture development) (ha)

River Basin		Present (2000)	Future (2010)	Future (2020)
01. Bang Giang	Irri. Area	25,500	54,500	67,500
Rehabilitation /Improvement Area		11,500/ 37,000		0/ 0
New Development Works		17,500		13,0000
02. Red	Irri. Area	1,008,000	1,197,000	1,291,000
Rehabilitation /Improvement Area		189,000/ 1,197,000		94,000/ 94,000
03. Ma	Irri. Area	112,000	176,000	199,500
Rehabilitation /Improvement Area		64,000/ 176,000		22,400/ 22,400
New Development works		0		1,100
04. Ca	Irri. Area (ha)	93,000	150,000	203,000
Rehabilitation/ Improvement		57,000/ 150,000		53,000/ 53,000
05. Thach Han	Irri. Area (ha)	5,000	12,300	15,400
Rehabilitation/ Improvement		7,300/ 12,300		3,100/ 3,100
06. Huong	Irri. Area (ha)	25,900	25,900	25,900
Rehabilitation/ Improvement		0/ 3,900		0/ 22,000
07. Thu Bon	Irri. Area (ha)	30,900	69,000	77,000
Rehabilitation/ Improvement		38,100/ 69,000		5,900/ 5,900
New Development		0		2,100
08. Tra Khuc	Irri. Area (ha)	33,000	42,000	54,000
Rehabilitation/ Improvement		9,000/ 42,000		12,000/ 12,000
09. Kone	Irri. Area	25,000	36,500	49,000
Rehabilitation/ Improvement		10,400/ 35,400		3,400/ 3,400
New Development		1,100		9,100
Van Phone Weir	River Width (m)	700		-
Two Pumping Stations	Comm. Area	0		5,200
10. Ba	Irri. Area	41,000	129,000	186,000
Rehabilitation/ Improvement		88,000/ 129,000		50,400/ 50,400
New Development		0		6,600
11. Sesan	Irri. Area	22,500	35,400	50,000
Rehabilitation/ Improvement		12,900/ 35,400		14,600/ 14,600
12. Srepok	Irri. Area	29,000	35,000	91,000
Rehabilitation/ Improvement		600/ 29,600		30,700/ 30,700
New Development		5,400		25,300
Upper Krong Buk Weir	River Width (m)	200		-
13. Dong Nai	Irri. Area	115,000	224,000	362,000
Rehabilitation/ Improvement		100,000/ 215,000		38,000/ 38,000
New Development		9,000		100,000
New Weir	River Width (m)	-		200 x 3 nos.
Pumping Stations	Comm. Area	9,000		70,000
14. Cuu Long Delta	Irri. Area	1,487,000	1,891,000	2,242,000
Rehabilitation/ Improvement		34,000/ 1,791,000		101,000/ 101,000
New Development		100,000		250,000
Pumping Stations	Comm. Area	100,000		250,000

1.7.3 Projects to Compose the Master Plan

(1) Dam/reservoir Projects in Each River Basin

The major dam/reservoir projects which have been planned in each river basin were found from the following documents and information:

(i) dam/reservoir projects listed as priority projects in "Water Resources Development Strategy to the year 2010, MARD, August 1999",

(ii) dam/reservoir projects listed as proposed development projects in "Water Resources Sector Review, 1996, WB, ADB, FAO, UNDP, NGO's Water Resources Group in cooperation with IWRP" and

(iii) information on dam/reservoir projects with high priority in each province.

(2) Summary of Master Plan Formulated for 14 River Basins

Proposed projects including the flood control plan, the water utilization plan as well as dam reservoir projects are summarized in the following table, which locations are shown in Main Report (Figures 9.9 to 9.22)

Proposed Major Projects in Each River Basin

	River Basin	Project			River	CA (km2)	Purpose			Gross (10^6 m^3)	Available Storage		Flood Control	Irrigation		Hydropower
		Type	Status	Name			WS	FC	HP		Water Supply (10^6 m^3)	Flood Control (10^6 m^3)	Structural Measure (excld. Dam)	Irrigation Area in 2000 (1,000 ha)	Irrigation Area in 2020 (1,000 ha)	Minimum Guaranteed Discharge (mil m^3/M)
1	**Bang Giang & Ky Cung**	**Dam**	**Plan**	**Ban Lai**	Ky Cung	550	X	X	X		310.5	96.2				
		Flood C.											-			
		Irrigation/Drainage	**Extension**											25.5	67.5	
2	**Red River & Thai Binh**	Dam	Plan	Son La	Da	43,760	X		X	30850.0	14,900					1,306.3
		Dam	Exist	Hoa Binh	Da	9,140/ (52,900)	X			9500.0	5,650					
		Dam	Plan	Bac Me	Gam	5,000	X		X	1,830	1,055					233.3
		Dam	Plan	Dai Thi	Gam	7,690/ (12,690)	X		X	1,626	1,091					261.0
		Dam	Exist	Thac Ba	Thao	10,980	X			1,830	1,055					
		Flood C.														
		Irrigation/Drainage	Extension	Red River Delta										1,008	1,291	
3	**Ma**	**Dam**	**Plan**	**Cua Dat**	Chu	5,700	X	X	X	1,531	1,210	105.6				80.9
		Flood C.											-			
		Irrigation/Drainage	**Extension**											112.0	199.5	
4	**Ca**	**Dam**	**Plan**	**Ban La**	Nam Non	8,700	X	X	X	1,800	1,244	216.0				140
		Dam	Plan	Ban Mai	Ca	13,272				4,200	3,140					
		Flood C.											Heightening of the existing dyke crown			
		Irrigation/Drainage	**Extension**											93.0	203.0	
5	**Thach Han**	**Dam**	**Plan**	**Rao Quan**	Rao Quan	159	X	X	X		291.0	104.7				6.6
		Flood C.											Dyke heightening & River improvement			
		Irrigation/Drainage	**Extension**											5.0	15.4	
6	**Huong**	**Dam**	**Plan**	**Ta Trach**	Ta Trach	717	X	X	X	610.0	460.0	383.0				
		Dam	Plan	Huu Trach	Huu Trach	570				230.0						
		Dam	Plan	Co Bi	Bo	712				242.0						
		Flood C.											-			
		Irrigation/Drainage	**Rehabili..**											21.2	21.2	
7	**Vu Gia -Thu Bon**	**Dam**	**Plan**	**Ho Song Tranh II**	Thu Bon	1,441	X	X	X	1,067	945.0	507.0				200.4
		Dam	**Plan**	**Song Cai**	Vu Gia	1,763		X		870	-	543.0				
		Flood C.											River improvement / Dyke system : 35 km			
		Irrigation/Drainage	**Extension**											30.9	77.0	
8	**Tra Khuc**	**Dam**	**Plan**	**Nuoc Trong**	Thach Nham	446	X	X	X	222.6	185.8	185.8				
		Flood C.											Heightening of the existing dyke crown			
		Irrigation/Drainage	**Extension**											33.0	54.0	
9	**Kone**	**Dam**	**Plan**	**Dinh Binh**	Kone	1,040	X	X	X	226.0	209.0	120.0				
		Dam	Existing	Vinh Son		97	X		X		102.0					
		Dam	Existing	Thuan Ninh		35	X				32.3					
		Dam	Existing	Nui Mot		120	X				90.0					
		Flood C.											River improvement / Dyke system : 62 km			
		Irrigation/Drainage	**Extension**											25.0	49.0	
10	**Ba**	**Dam**	**Plan**	**Song Ba Ha** *1	Ba	11,115	X	X	X	740.6	484.4	38.1				148.2
		Dam	Exist	La Yun	Dak la Yun	1,670	X				201.0					
		Dam	Exist	Hinh	Hinh	722	X				323.0					
		Dam	Plan	An Khe - Kanak *2	Ba	1,222/ 833										
		Flood C.											Heightening of the existing dyke crown			
		Irrigation/Drainage	**Extension**											41.0	186.0	
11	**Sesan**	**Dam**	**Plan**	**Dak Bla**	Dak Bla	2,780	X	X	X		873.0	78.0				
		Dam	Plan	Plei Krong	Krong Poko	3,224					1,131					94.5
		Flood C.											-			
		Irrigation/Drainage	**Extension**											22.5	50.0	
12	**Srepok**	**Dam**	**Plan**	**Buon Kuop**	Srepok	3,860	X	X	X	350.9	315.0					116.1
		Dam	**Plan**	**Krong Boung**	Krong Boung	790	X	X			21.6	21.4				
		Dam	**Plan**	**Upper Krong Pach**	Krong Pach	490	X				72.0					
		Dam	**Plan**	**Upper Krong Buk**	Krong Buk	149	X	X			83.4	26.2				
		Dam	Exist	Lower Krong Buk	Krong Buk	118	X	X			45.0	33.3				
		Flood C.											-			
		Irrigation/Drainage	**Extension**											29.0	91.0	
13	**Dong Nai**	Dam	Plan	Dong Nai No.3	Dong Nai	4,361				1,764	1,186					89.4
		Dam	Plan	Dong Nai No.4	Dong Nai	4,530				117.5	30.2					96.0
		Dam	Plan	Fu Mieng	Be	4,110					462.0					
		Dam	Existing	Dai Ninh	Da Nhim											
		Dam	Existing	Dau Tieng	Sai Gon											
		Dam	Existing	Tri An	Dong Nai											
		Irrigation/Drainage	Resevoirs & Extension	Eight Irrigation Projects										115	362	
		Water supply	Plan	Water Supply Project along Highway No.51									Pipeline			
14	**Cuu Long**	Irrigation/Drainage	Extension/Re-habilitation	-	-	-				-	-			1,487	2,242	
		Flood C.											Dyke embankment for shallow&deep protection			

1.7.4 Preliminary Cost Estimate for Projects

80,079,217 million VND equivalent to 5,315 million US$ is estimated to be required in total for the implementation of the recommended projects and measures for the 11 river basins from 2002 to 2020, excluding 3 river basins of the Red & Thai Binh, Dong nai and Cuu Long with the authorized Master Plan.

The reason why 3 river basins having the authorized Master Plan are excluded herein is presented in Section 1.8.2. The financial requirement for each river basin is summarized below:

Project Cost

River Basin	Million VND	Equivalent to Million US$
Bang Giang & KY Cung	3,580,717	238
Red & Thai Binh	-	-
Ma	11,111,689	737
Ca	12,838,780	852
Thach Han	3,419,005	227
Huong	3,717,229	247
Vu Gia-Thu Bon	14,881,578	988
Tra Khuc	2,068,870	137
Kone	3,825,525	254
Ba	10,630,547	706
Sesan	5,218,115	346
Srepok	8,787,162	583
Dong Nai	-	-
Cuu Long Delta	-	-
Total	80,079,217	5,315

1.7.5 Economic Viability of the Projects

Economic analyses of the projects have been examined for the 11 river basins, excluding 3 river basins having the authorized Master Plan. Economic indicators are calculated and summarized below:

Economic Indicators

River basin projects	EIRR (%)	B/C Ratio	NPV (Million US$)
Bang Giang & Ky Cung	14.1	1.27	24.8
Ma	11.7	0.97	-7.5
Ca	12.5	1.06	16.2
Thach Han	11.2	0.91	-8.6
Huong	17.4	1.70	59.5
Vu Gia-Thu Bon	9.6	0.78	-81.8
Tra Khuc	19.8	2.12	60.5
Kone	15.4	1.40	35.3
Ba	15.6	1.44	103.9
Se San	9.9	0.79	-24.7
Srepok	13.5	1.16	33.9

Note: B/C and NPV are calculated with a discount rate of 12%.

1.8 Evaluation of Basins and Projects

1.8.1 Evaluation Methodology

The evaluation of projects and river basins is conducted through evaluation on the following items which are considered important factors in the water resources development and management of Vietnam.

(i) Domestic water supply
(ii) Industrial water supply
(iii) Irrigation water supply
(iv) Power generation
(v) Flood control effect
(vi) River maintenance flow
(vii) Degree of poverty in river basin
(viii) Investment cost (Degree of financing difficulty)
(ix) Resettlement (Adverse impact on social environment)

The government's policy is also an important factor in evaluation which is incorporated in weight to be given to each evaluation item.

1.8.2 Projects and Rivers Basins to be Evaluated

(1) Eleven River Basins without Master Plan

The socio-economic framework plan (the macro-economic targets of each river basin) has been established in Section 1.2 in line with the government's development policy. Then, the basic strategy for formulating the Water Resources Development and Management Master Plan which would meet achievement of the

above goal have been set out in the Study as mentioned in Section 1.6.

Projects in each of eleven (11) river basins which have no basin master plan yet are examined and taken up out of the planned projects along the said basic strategy, and evaluation is made on these projects which compose the basin master plan. Evaluation for river basin is made on the basis of evaluation on the projects in each of the eleven (11) river basins.

(2) Three River Basins with Master Plan

Three (3) river basins of the Red&Thai Binh, Dong Nai and Cuu Long already have the respective Master Plan for water resources development and management of the basin. The Master Plan and projects taken up in the Master Plan have been authorized and officially recognized as the most important projects and/or basins.

Therefore, the Study treats projects in these three (3) basins as "authorized" and these three (3) river basins are excluded in the examination to select the priority river basin.

1.8.3 Result of Evaluation of Projects & River Basins

(1) Evaluation Result on Each Evaluation Item

Projects are evaluated for each evaluation item in line with the said evaluation methodology. Its result is summarized in Table S1.9.

(2) Overall Evaluation /Scoring of Projects and River Basins

11 River Basins and Selection of Priority Basin

Overall evaluation and scoring of projects and river basins is made in Table S1.10.

The overall evaluation and scoring of projects and river basins indicated the following ranking and classification.

Ranking of 11 River Basins

Ranking	River Basin	Basin's Score	Classification
1	Huong	30.3	Group A
2	Kone	24.0	
3	Sesan	20.0	
4	Ma	14.0	
5	Tra Khuc	10.0	
6	Vu Gia-Thu Bon	0.0	Group B
7	Ba	0.0	
8	Srepok	-9.84	
9	Thach Han	-14.0	Group C
10	Bang Giang and Ky Cung	-16.0	
11	Ca	-26.0	

Ranking of Projects(11 River Basins)

Ranking	Name of Basin	Name of Project	Score	Classification
1	Huong	Ta Trach	32	Group A
2	Kone	Dinh Binh	24	
3	Sesan	Dak Bla	20	
4	Ma	Cua Dat	14	
5	Tra Khuc	Nuoc Trong	10	
6	Huong	Huu Trach	6	
7	Ba	Song Ba Ha	0	
8	Vu Gia-Thu Bon	Song Cai	-8	Group B
9	Srepok	Buon Kuop-Chupong Kron	-10	
10	Srepok	Krong Buong	-12	
11	Srepok	Upper Krong Pach	-12	
12	Srepok	Upper Krong Buk	-12	
13	Thach Han	Rao Quan	-14	Group C
14	Bang Giang and Ky Cung	Ban Lai	-16	
15	Ca	Ban La	-26	
16	Vu Gia-Thu Bon	Ho Son Thanh II	-26	

River basins and projects classified into Group A are considered to have relatively higher necessity and urgency for implementation, and can be an index for selection of the priority river basin, and/or priority projects, since the ranking is made through due evaluation on conceivable important factors such as the water shortage, flood, social and natural environment, poverty, and financing, etc.

The study recommends to select the Kone River basin as the priority river basin for Phase 2-2, based on the result of the study.

1.9 Conclusion

(1) The master plan consists of development component of the multipurpose dams, river improvement/dyking systems, agricultural development including irrigation/drainage systems and water supply for aquaculture and livestock, and domestic and industrial water supply in each river basin as well as the water resources management component.

(2) Socio-economic framework plan for the target year 2020 has been set for estimation of the future water demand and flood damages. Economic development plans of the 14 river basins in the Study are basically established based on the economic development targets of provinces collected in the Study. The established socio-economic targets are summarized below:

Socio-economic Targets

River Basin	Population (1,000)		GRDP (VND billion)		Per capita GRDP (VND 1,000)	
	2001	2020	2001	2020	2001	2020
Bang Giang & Ky Cung	1,234	1,530	3,821	17,488	3,096	11,430
Red River Delta	17,360	21,649	82,229	369,605	4,737	17,073
Red & Thai Bin outside delta	10,228	14,077	29,139	128,673	2,849	9,141
Ma	3,605	4,396	8,498	68,664	2,357	15,620
Ca	4,394	5,575	12,405	48,500	2,823	8,700
Thach Han	598	746	1,813	7,100	3,032	9,517
Huong	1,083	1,403	3,875	22,896	3,578	16,319
Vu Gia-Thu Bon	2,133	2,619	7,660	45,341	3,591	17,312
Tra Khuc	1,214	1,501	3,618	14,597	2,980	9,725
Kone	1,503	1,910	5,010	21,939	3,333	11,486
Ba	1,834	2,507	6,272	29,396	3,420	11,726
Se San	338	550	876	3,529	2,592	6,416
Srepok	1,940	3,325	5,460	22,552	2,814	6,783
Dong Nai	11,966	17,381	88,571	224,911	7,402	12,940
Cuu Long	16,832	21,509	73,071	418,777	4,341	19,470

Note: GRDP and per capita GRDP are in 2000 constant price.

(3) The water resources development plan is formulated in accordance with the major water supply requirement in terms of agricultural water demand, domestic and industrial water demand, water use for power generation and requirement for river maintenance flow.

(4) The water resources development plan is also formulated for the flood control purpose in the Study except for the Red River/Thai Binh River basin, Dong Nai River Basin and Cuu Long River basin for which the flood control master plan have been formulated and authorized already.

(5) Water resources development to meet water demand is a development of the multi-purpose dam(reservoir) at 1-2 locations in each river basin in addition to the existing reservoirs.

Flood control measures in the formulated plan in the Study includes mainly the multi-purpose reservoir with a flood control space, as well as river improvement, dyking system and heightening of the existing dykes.

(6) The proposed major projects in each river basin are presented in Section 1.7.3.

Implementation Cost of Each River Basin

River Basin	Project Cost	
	Million VND	Equivalent to Million US$
Bang Giang & KY Cung	3,580,717	238
Red & Thai Binh	-	-
Ma	11,111,689	737
Ca	12,838,780	852
Thach Han	3,419,005	227
Huong	3,717,229	247
Vu Gia-Thu Bon	14,881,578	988
Tra Khuc	2,068,870	137
Kone	3,825,525	254
Ba	10,630,547	706
Sesan	5,218,115	346
Srepok	8,787,162	583
Dong Nai	-	-
Cuu Long Delta	-	-
Total	**80,079,217**	**5,315**

(7) Economic indicators estimated by the economic analysis for the 11 river basins excluding 3 river basins with the authorized river basin master plan river basin master plan are shown as follows:

Economic Indicators

River basin projects	EIRR (%)	B/C Ratio	NPV Million US$)
Bang Giang & Ky Cung	14.1	1.27	24.8
Ma	11.7	0.97	-7.5
Ca	12.5	1.06	16.2
Thach Han	11.2	0.91	-8.6
Huong	17.4	1.70	59.5
Vu Gia-Thu Bon	9.6	0.78	-81.8
Tra Khuc	19.8	2.12	60.5
Kone	15.4	1.40	35.3
Ba	15.6	1.44	103.9
Se San	9.9	0.79	-24.7
Srepok	13.5	1.16	33.9

Note: B/C and NPV are calculated with a discount rate of 12 %.

(8) Priority river basins have been selected out of 11 river basins excluding Red River basin, Dong Nai River basin and Cuu Long River Delta. Priority projects have been also selected out of projects in the said 11 river basins. The 11 river basins as well as projects have been examined in various aspects

and evaluated as shown in Section 1.8.

(9) The Huong River basin and the Kone River basin are selected as the most river basins and the Study recommends selecting the Kone River basin as the priority river basin for the Phase 2-2 study.

It is noted that the result of ranking is considered just a reference for the Government's decision, since the ranking will be changeable in accordance with conditions of evaluation.

1.10 Recommendations

(1) It is recommended that the Huong River basin and the Kone River basin are selected as the most priority river basins to proceed to the Phase 2-1 and Phase 2-2 studies, respectively to formulate the integrated river basin management plan.

(2) Flood Warning and Communication System is to be established as an urgent measure for flood damage mitigation in the respective river basins especially in the central coastal region so that the information of storm in the upstream reaches and/or waterlevel rising be informed to the related agencies and broadcast to the public.

(3) Flood Hazard Map is to be prepared with the past flood water levels thereat to disclose the flood hazard information in terms of expected inundation area, depth, flood flow direction and evacuation is quite effective way to the local commune to aware of the flood risks in any rainy season.

(4) In order to cope with the issues in terms of erosion, much sediment discharge and creation of bare land , a river basin management plan shall be established incorporating (i) Land use management (control) and (ii) Forestation.

(5) As a measure for the river bank protection, it is recommended that a flexible and durable type bank protection works so called Kago Mat works be used widely for bank protection works for the rivers in Vietnam in view that it is flexible, durable, less costly, and suitable for protection of foot of the low water channel slope.

(6) The water intake control for the proper water demand management in order to decrease excessive water consumption shall be introduced:

1) Proper intake control by appropriate intake water measurement

2) Integration and coordination of water demand by an authority

A river basin organization (an authority) which shall be independent from the

water-use stakeholders will be the one to execute the water use management activities.

(7) In order to improve salinity water intrusion as well as the deterioration of water quality due to waste water discharge from domestic and industrial uses, the following measure and activities are recommended:

(i) To establish / strengthen / maintain waste water management system

(ii) Monitoring system of river water quality

(iii) Management (control) system of required minimum river flow.

(8) In the present situation that there are several reservoirs under the different operators and purposes including hydropower, water supply and flood control, the dam operating purpose and procedure are mutually different since that each of operators aims at the most appropriate operation in accordance with the own purposes.

However, such individual operating system is recommended to be improved to the integrated dam operating system in a main river basin under the coordination of an authorized water resources management body. Such integrated operation is particularly necessary when flood is occurring and a river basin is in severe drought situation.

(9) The authorized river basin organization shall be strengthened (Red River, Dong Nai River and Cuu Long River basins where RBOs have established; Huong River basin where the Board of management has established) or established early (for the other river basins) in the respective river basins to implement necessary water resources management as follows:

1) Identification of individual key issues in each river basin,

2) Definition of primary tasks of the organization in accordance with the present situation of the respective river basins,

3) Formulation of a specific action plan to execute the tasks, and

4) Capacity building of the organization and training of the personnel.

(10) It is recommended that specialists be dispatched with the following categories and tasks:

(a) Water resources management and coordination

Effective utilization of water resources through appropriate coordination between different sectors concerned, and between the central government

and the local governments and authorities.

(b) Capacity building in the engineering and the institutional aspects

For smooth establishment of an organization or strengthening of the existing RBOs having been established recently, institutional capacity building of the organization as well as engineering capacity building of the personnel are to be executed by some experienced specialists.

PART 2

Phase 2-1 : INTEGRATED RIVER BASIN MANAGEMENT PLAN FOR HUONG RIVER BASIN

2.1 Introduction

2.1.1 Background of the Study

Floods and inundation have caused serious damages in Hue City and downstream parts of the Huong River basin. The flood in November 1999 caused very severe casualties in which 89 people reportedly died and huge assets were damaged.

In view of high urgency for countermeasure, both the Government of Vietnam and Japan agreed that an Integrated River Basin Management Plan should be formulated for the Huong River basin at the earliest. Thus, the formulation of the Integrated River Basin Management Plan for the Huong River basin was conducted in parallel with Phase 1 study.

A feasibility study was executed by the Government of Vietnam for major projects in the Huong River basin, and the major projects are intended to proceed to the implementation stage after the formulation of the Integrated River Basin Management Plan for the Huong river basin.

2.1.2 Study Area

The study area is the Huong River basin located in the south central coast region of Vietnam. The Huong River basin has a catchment area of 3,300 km^2, belonging to the Thua Thien Hue Province. A location map is shown in Figure S2.1.

2.2 Present Situation of the Basin

(1) Local Administration

The Thua Thien Hue Province administratively consists of a capital city of Hue and eight districts. Under these districts and city, there are 122 communes and 28 towns, as summarized below:

Area and Administrative Units in Thua Thien Hue Province

City & District	Area (sq. km)	Towns	Communes	Communes in the Project
1. City Hue	71	5	20	5
2. District. Phong Dien	954	15	1	6
3. District. Quang Dien	163	10	1	6
4. District. Huong Tra	521	15	1	15
5. District. Phu Vang	280	19	1	6
6. District. Huong Thuy	457	11	1	8
7. District. Phu Loc	728	17	1	2
8. District. A Luoi	1,229	20	1	0
9. District. Nam Dong	651	10	1	0
Total	5,054	122	28	48

*1: preliminary basis, subject to change after confirmation.

Source: Statistical Yearbook 2000, Hue Province

Two districts of A Luoi and Nam Dong are totally outside the project area. It is estimated that 48 communes of 1 city and 6 districts entirely or partially falls under the project area.

(2) Population

The total population of the province is 1,066,200 in 2000, consisting of 316,200 (29.7%) in urban area and 750,000 (70.3%) in rural area. Population density is 211 person per km^2, ranging from the lowest density of 21 persons per km^2 in Nam Dong district and the highest of 4,201 in Hue City.

Average population growth rate during the period from 1995 to 2000 is estimated at 1.56% per annum in total, composed of 4.11% in the urban area, and 0.61% in the rural area.

(3) Gross Regional Domestic Product(GRDP)

The area has achieved an economic growth at a rate of 6.3% per annum from 1995 to 2000. The future economic growth rates of the river basin have been targeted at 13.5% from 2000 to 2005, 10.3% from 2005 to 2010, and 8.0% from 2010 to 2020 per annum. The share of agriculture, forestry, and fishery will drop gradually from the present 23% to 11% in 2020. The share of service sector will also drop from 45% to 39%, while that of industrial sector will increase from 32% and 50%.

Per capita GRDP of the basin was estimated to be VND3,251 thousand in 2000, which was lower than national average of VND5,717 thousand. During the period from 2001 to 2020, it is forecasted that per capita.

GRDP will become about four times of the present amount.

(4) Agriculture

Total land of the province is 505,400 ha, of which 61,200 ha or 12% is agricultural land. Paddy field is 27,400 ha, producing 47% of agricultural gross output as well as 196,300 ton of paddy on average for 5 years from 1996 to 2000.

About 25,900 ha including 18,000 ha of paddy field is located on gross area of 40,000 ha of the flood plain extending over the lower reaches of the Huong River. Irrigation scheme in the Huong River basin is as seen in Figure S2.2.

The present crop production in the project area of 29,500 ha is shown below:

Production in the Project Area

Crop	Win – Spr	Sum – Aut	Total	Unit Yield	Production
Win – Spr Paddy	18,022 ha	-	18,022 ha	2.8 ton/ha	50,500 ton
Sum – Aut Paddy	-	15,197 ha	15,197 ha	3.0 ton/ha	45,600 ton
Subsidiary Crop	5,622 ha	1,033 ha	6,655 ha		25,400 ton
(Maize)	(79 ha)	(78 ha)	(157 ha)	1.2 ton/ha	200 ton
(Sweet Potatoes)	(4,838 ha)	(0 ha)	(4,838 ha)	4.8 ton/ha	23,200 ton
(Groundnuts)	(705 ha)	(955 ha)	(1,660 ha)	1.2 ton/ha	2,000 ton
Vegetables	2,256 ha	2,256	4,512 ha	6.0 ton/ha	27,100 ton
Total	25,900 ha	18,486 ha	44,386 ha	-	148,600 ton

The crop production is presently constrained due to (i) early flood occur in May to June damaging summer – autumn crop, (ii) salt water intrusion suffering spring and autumn crops along the irrigation canal in the dry season , and (iii) short supply of irrigation water in the dry season.

(5) River and Flooding

a) River

The Ta Trach River originates on the northern slope of Bach Ma Range in Vietnam, flows to the north direction, changes the name to the Huong River after the joining of the Huu Trach River in the upstream of Hue City, flows in the midst of Hue City, and after the joining of the Bo River in the downstream of Hue City, discharges into the Tam Giang Lagoon that is the biggest lagoon in Vietnam. The catchment area of the Huong River is 3,300 km^2. The length of the Huong River is 102 km including the Ta Trach River.

The elevation of the river ranges from 500 m above mean seal level to 0 m. The river slope is very steep in its upstream basin ranging from 1/100 to 1/700. The river slope becomes rather gentle with some 1/2,500 in the reaches from the river-mouth to the proposed dam site of Ta Trach reservoir.

Tão Long Barrage is located about 4 km upstream of the river-mouth of the

Huong River. This was constructed in 1973 for the purpose to stop the salinity intrusion along the Huong River. But since the barrage was so much deteriorated, the reconstruction of the barrage was planned and a new barrage is now under construction at about 40 m downstream of the present location.

Along the lagoon, the sea dike has been constructed with the crown elevation of about 1.2 m above mean sea level to protect the agricultural land from wave intrusion.

Along the Huong River, there exist no river dike system to protect the Hue City and the agricultural land from flooding.

b) Flooding

The downstream basin of the Huong River has been flooded 3 to 7 times every year. During the flooding, a wide area is inundated and even the wheeled traffic becomes interrupted. In Hue City, there exist the world cultural heritages of Nguyen Dynasty. The heritages are wooden buildings and easy to be damaged when inundated. During a flood, sea dikes are often overtopped by about 1.5 m and collapse.

The flood in November 1999 seriously damaged this basin. This flood was the biggest one since the flood in 1953. Recorded 24-hour rainfall on November 2, 1999 was 1,422mm. This was never recorded before. The number of death and missing due to this flood was 373. The number of houses washed away by the flood was 25,000. The total damage was estimated at US$ 160 million. The sand bar of the lagoon was washed away at 3 locations. Accordingly the number of the opening of the lagoon to the sea became 5 together with the previous 2 openings. The new 2 openings were closed by the littoral drift afterwards. The remaining one opening located at Hoa Duan District was closed by the construction of road by using concrete blocks by the local government for restoring the local traffic since there exist many settlements on the sand bar.

2.3 Hydrological Analysis

2.3.1 Low Flow Analysis

The MIKE 11-NAM model, mathematical model for the estimate of runoff, are used for the estimate of the Huong basin runoff, since the results of the NAM model are verified to be conservative and reasonable under low flow conditions.

The results are summarized as follows:

Dependable Monthly Runoff at Tuan in Mm^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	210	109	71	52	68	69	53	57	148	589	726	498
75%	144	79	53	35	40	40	32	36	84	370	497	354
90%	102	59	40	24	26	24	20	23	51	243	353	260

Dependable Monthly Runoff at Co Bi in Mm^3

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
50%	95	48	33	32	45	41	32	32	85	298	363	251
75%	58	30	22	21	32	27	21	22	52	205	254	181
90%	38	20	16	14	23	18	15	15	33	147	185	135

2.3.2 High Flow Analysis

As for the analysis of the low flows in the Huong basin, it has been inevitable also for the estimate of peak flows and corresponding volumes to make use of an appropriate rainfall – runoff modelling. As called for in the Terms of Reference, use has been made of the Mike11-NAM model, while as second modelling tool the Sacramento model has been used.

The calibration and validation of the flood runoff model is carried out for the three sub-basins Bo (at Co Bi), Huu Trach (at Binh Dien) and Ta Trach (at Thuong Nhat) separately with the help of, on the average, three historical storms per sub-basin.

Calibration of the Mike11-NAM model is done with the help of the auto-calibration option. This calibration gave reasonable results for the three sub-basins. Subsequent simulations were carried out with the probable storms, with the following results:

Mike11-NAM	Peak Discharges Main Flood Season (m^3/s)			
	10 years	20 years	50 years	100 years
Bo at Co Bi	5,100	6,200	7,400	8,800
Huu Trach at Binh Dien	4,700	5,500	6,400	7,300

Intensive calibration and validation efforts have been made to achieve an acceptable reproduction of the historical floods with the help of the Sacramento model. Both the land-phase (runoff generation) and the channel-phase (flood routing) are included in the calibration process. The following peak discharges are generated:

Sacramento	Peak Discharges Main Flood Season (m^3/s)			
	10 years	20 years	50 years	100 years
Bo at Co Bi	3,900	5,100	6,700	7,800
Huu Trach at Binh Dien	3,600	4,200	5,000	5,800
Ta Trach at dam site	5,500	6,400	7,500	8,200

In earlier studies, the following flood discharges have been presented for the different sub-catchments:

Sacramento	Peak Discharges Main Flood Season (m^3/s)			
	10 years	20 years	50 years	100 years
Bo at Co Bi[1)]	4,100		6,400	7,200
Bo at Co Bi[2)]	2,558	2,850		
Huu Trach at Binh Dien[2)]	3,450	3,848		
Ta Trach at dam site[3)]	4,240	5,570		9,400

1): Feasibility Study of Four Dams, WAPCOS, India, 1982
2): Feasibility Study on Ta Trach Project, Interim Report, HEC-1, 1999
3): Ta Trach Reservoir Project, Supplemental Report, HEC-1, 2000

It is observed that the peak discharges as generated with the help of the Sacramento model tend to be higher than peak discharges presented in previous studies. The peak discharges generated with the Mike11-NAM are again substantially higher than the Sacramento results. It is anticipated that the Mike11 results give an overestimate of the peak flows and that further detailed calibration of this model may give a more attenuated reproduction of the runoff of the basins.

For the present study the results of the Sacramento model have been selected for the formulation of flood mitigation measures in the Huong basin.

2.4 Water Demand Forecast

(1) Domestic and Industrial Water Demand

Domestic and industrial water demands in the Huong River basin are projected to increase as follows:

(Unit: m^3/day)

	Present(2001)	2010	2020
Domestic Water Demand	36,545	67,800	118,660
Industrial Water Demand	5,000	17,734	65,743
Total	41,545	85,534	184,403

(2) Water Demand for Power Generation

To meet the power demand growth forecast in the EVN's Master plan,, the Master Plan considers to additionally provide various power plants including hydropower plants of multipurpose reservoir projects.

However, relatively small scale of power generation like the multipurpose reservoir projects in the Huong River basin was not taken into account in the national power supply plan. Therefore, it is assumed that the multipurpose reservoirs in the Huong River basin will primarily serve the water supply such as the domestic and industrial water supply, agricultural water supply and river maintenance flow, etc. and that the power generation will utilize the water to be used for the said water supply purpose and any surplus water.

Thus, the multipurpose reservoirs projects in the Huong River basin will have no particular water demand for power generation.

(3) Irrigation Water Demand (IWD)

Taking the irrigation area into the calculation, the irrigation water demands IWD (m^3/sec) have been estimated for the present (2001) and the future (2010, 2020). The irrigation water demand is variable depending on the rainfall, and thus, the demand is analyzed on the monthly basis for 24 years for use in the water balance analysis.

The irrigation water demands IWD (m^3/sec) in the Huong River Basin under the average year rainfall condition are shown as follows:

Monthly Irrigation Water Demand (IWD), Average Year, Huong (Unit: m^3/sec)

(Irri. Area)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
2001 (25,900 ha)	2.3	12.7	16.1	10.1	23.3	18.4	23.8	7.8	0.0	0.0	0.0	4.7	9.9
2010 (25,900 ha)	2.3	11.9	15.0	9.6	22.8	18.1	23.3	7.5	0.0	0.0	0.0	4.4	9.6
2020 (25,900 ha)	2.3	11.7	14.8	9.6	26.7	21.5	28.2	9.1	0.0	0.0	0.0	4.4	10.7

(4) Forecast Demand for Livestock

With reference to the Agriculture in Vietnam - 61 Provinces and Cities, MARD, NIAAP, 2001, numbers of various kinds of livestock are taken for estimation of water demands of livestock. The water demands for the present (2001) and future(2010,2020) are estimated as follows:

Water Demand for Livestock (Huong River Basin)

River Basin	Pig (10^3 heads)	Ox (10^3 heads)	Buffalo (10^3 heads)	Poultry (10^3 heads)	Goat (10^3 heads)	Daily Consumption (m^3/day)	Required Intake Discharge (m^3/sec)
Present (2001)	227	33	35	1,790	-	6,200	0.07
2010	305	49	38	2,261	-	8,200	0.10
2020	666	68	42	2,872	-	14,600	0.17

(5) Water Demand for Aquaculture

With use of the unit water requirement, which is expressed in the water depth (m/year), and the estimated aquaculture pond area (ha), the water demand for aquaculture has been estimated for the present(2001) and future(2010,2020) as follows:

Water Demand for Aquaculture (Huong River Basin)

River Basin	Coastal Shrimp Culture		Inland Fish Culture		Total	
	Pond Area (ha)	Fresh Water Demand (10^3 m^3)	Pond Area (ha)	Fresh Water Demand (10^3 m^3)	Fresh Water Demand (10^3 m^3)	Average Intake Discharge (m^3/sec)
Present(2001)	1,010	4,646	920	31,280	35,926	1.1
2010	3,290	15,147	2,730	92,643	107,790	3.4
2020	4,510	20,762	3,690	125,545	146,307	4.6

(6) River Maintenance Flow

River maintenance flow for the Huong River which is considered one of the water demand is examined from the viewpoint of i) saline water intrusion, ii) water pollution, iii) river mouth clogging, iv) fluvial navigation, and v) ecological conservation.

The outcomes of the examination for determination of maintenance flow are summarized below:

- 61 m^3/s at Phu Cam from the view point of prevention of the saline water intrusion,
- Ensuring the existing hydrological regime of low water from the view point of water quality, river mouth clogging and fluvial navigation, and
- 31 m^3/s at the river mouth from the ecological view point.

Among these, it is expected that the problem of the saline water intrusion will be solved apparently after completion of the new Thao Long barrage. As conclusion, 31 m^3/s at the river mouth was obtained as the river maintenance flow of the Huong River.

2.5 Water Balance Analysis

2.5.1 Water Balance System

Water balance analysis is made in monthly basis. Water resources and water demand data are given as monthly basis for a duration of 24 years.

Water balance point is predetermined at each water demanding point for water demand and river mouth for the maintenance flow in a whole basin basis.

Return flow rate is assumed to be 10 % for irrigation water and not considered (0 %)of demand for domestic and industrial waters.

In the Huong River basin, no existing reservoir and three planned reservoir are

considered in the analysis model. The said dam reservoirs are as follows:

i) Ta Trach : 460 MCM (considered as effective storage for water supply)
ii) Huu Trach : (not considered as water supply purpose)
iii) Co Bi : (not considered as water supply purpose)

Irrigation water demand is the most major water requirement in the basin. There are six(6) irrigation areas in the basin, which total service area in 2000(present) is 25,900 ha which was projected being no change towards 2020. Water demands for domestic and industrial uses in Hue City and its vicinity are considered. Its present demand of surface water is 41,545 m^3/day, while future projection in 2020 is 184,403 m^3/day. Required maintenance flow considered at the balance point is presumed to 31 m^3/sec based on the previous study.

2.5.2 Evaluation of Water Balance Analysis

Water deficits are presently observed in both cases with / without consideration of the maintenance flow. In the case of maintenance flow considered, much deficits are found every year for analyzed 24 years.

In future condition of 2020, available reservoir storage is at 460 million m^3 in terms of effective storage capacity for water supply in the Ta Trach reservoir. Flood control space is considered in the month of September, October and November. A full capacity of 460 million m^3 is available during month except those three months, while only 145 million m^3 is expected during those months as the effective storage for water supply.

In case of maintenance flow of 31 m^3/sec taking into consideration, deficits are seen in five years. And storage water would be fully released to eliminate any water deficit in the whole basin in case of another year.

Water deficit would be caused for 5 years out of 24 years even after the Ta Trach Reservoir is available. The sixth drought year could be covered by the Ta Trach Dam with a storage capacity of 460 million m^3 for water supply. Water deficit to be occurred is estimated as below according to the water balance analysis:

	(1)	(2)	(3)	(4)	(5)	(6)
Annual Deficit Volume (MCM)	275	199	185	164	149	0
(corresponding year)	1977	1990	1988	1980	1978	1983

It is concluded that the water supply capacity with the Ta Trach reservoir will just meet water demands in 2020 by incorporating the Thao Long Barrage and the river maintenance flow.

2.6 Formulation of Integrated River Basin Management Plan

2.6.1 Alternative Basin Development Plans

(1) Water Supply Requirement

The water balance analysis conducted on the basis of the water demand has found that reservoirs to be planned should have a storage capacity of 460 million m^3 to meet the water supply requirement.

In the case of non-reservoir scheme, freshwater supply to meet the water supply requirement has to be considered. Necessary freshwater supply in the case of non-reservoir scheme is assessed to be 219 million m^3/annum.

(2) Flood Control Requirement

Flood control requirement of the Huong River basin which is targeted by MARD is as follows:

a) Hue City should be protected from the same flood peak discharge as that in 1999.
   Flood water level at Kim Long due to 1999 flood with the peak discharge of 13,670m^3/s was EL. 5.84m which should be lowered to EL. 3.7m at Kim Long, corresponding to the river discharge of 2,000m^3/s. Flood hydrographs of the above objective flood are seen in Figure S2.3.

b) The agricultural lands extending in downstream reaches should be protected from 10-year (or 10%) probable early flood, of which flood hydrographs are seen in Figure S2.3.

c) Flood water level of the Bo River at Phu Oc due to 1999 year flood with the peak discharge of 3,050m^3/s was measured to be EL. 4.89m. This flood water level of EL. 4.89m should be lowered to EL. 4.50m, corresponding to the river discharge of 1,410m^3/s.

The target area is shown in Figure S2.4.

(3) Alternative Structural Measures for Water Supply and Flood Control

To find the optimum plan, the study was made on conceivable alternatives.

Facilities which are conceivable and taken up for examination of structural measure are as mentioned hereinafter. Location of each facility is shown in Figure S2.5. Storage-capacity curves of three (3) dams taken into consideration are presented in Figure S2.6 to S2.8, respectively.

a) Maximum Ta Trach Dam with the crest level at EL.55.0 m

b) Minimum Ta Trach Dam with crest level at EL.53.0 m

c) Maximum Huu Trach Dam with crest level at EL.61.0 m

d) Minimum Huu Trach Dam with crest level at EL.56.0 m

e) Maximum Co Bi Dam with crest level at EL.46.0 m

f) Minimum Co Bi Dam with crest level at EL.38.0 m

g) Non-dam Facilities

Non-dam facilities for water supply

Freshwater production plants from sea water with production capacity of 600,000m^3/day are considered as an alternative measure for necessary water supply without dam.

Necessary cost for freshwater production ranges approximately from US$ 1.5/m^3 to US$ 2.5/m^3. Assuming US$ 2.0/m^3 for the cost of freshwater production from sea water, the cost for necessary water supply in the basin will approximately be US$ 438 million/annum (219 million m^3/annum x US$ 2.0 /m^3 = US$ 438 million/annum)

Non-dam facilities for flood control

The following combination is considered as conceivable non-dam flood control facilities:

Non-dam Facilities for Flood Control	Flood Control Capacity
- Diversion Channel	3,000 m^3/s
- Parapet Wall	2,000 m^3/s (*)
- Retarding Basin	400 m^3/s (**)
- Diversion Tunnel	350 m^3/s

Note(*): Parapet wall capacity of 2,000 means that Hue City to be enclosed with a parapet wall of 1.0 m in height can withstand further increase of flood discharge.

(**): Capacity of retarding basin of 400 m^3/s is determined by assuming the retarding basin area of 3 million m^2, its depth of 5.0 m and flood cutting of 10 hours(3 million m^3x 5.0 / 10 hours = approx. 400 m^3/s)

2.6.2 Examination on Alternatives

To find the optimum basin plan, thirty-three (33) alternatives in total, consisting of the above conceivable measures, are taken up for examination.

As shown in Table S2.1, the combination of the maximum Ta Trach Dam and the maximum Huu Trach Dam (Case No. I-B.2) indicates the highest economic viability out of alternatives which can achieve the target of the basin plan in 2020.

The above two dams are also judged acceptable from the environmental aspects as evaluated in Table S2.1, and the overall evaluation recommends to select the above two dams (Case No.I-B.2) as the optimum basin plan towards the target in 2020.

2.6.3 Recommended Basin Development Plan

As discussed, the basin development plan consisting of the maximum Ta Trach Dam and the maximum Huu Trach Dam was evaluated to be the most favorable scheme through the overall evaluation. Based on the above, the basin plan was recommended and proposed as follows:

Recommended Basin Plan

	Ta Trach Dam	Huu Trach Dam
Crest level	EL. 55.0m	EL. 61.0m
Effective storage volume	460 million m^3	182 million m^3
Flood control volume	392.6 million m^3	105 million m^3

2.6.4 Recommendation for Implementation of Basin Development Plan

As examined and discussed above, two dams of Ta Trach Dam and Huu Trach Dam will be required to completely satisfy the flood control requirement as explained, while project effectiveness of Ta Trach Dam only is high as discussed in the Main Report.

Considering this high effectiveness as well as the financial constraints, implementation of only Ta Tach Dam is considered sufficient for the time being. It is considered possible that Huu Trach Dam can wait until the financial conditions allow its implementation.

2.6.5 Examination on Effectiveness of Dams in Upstream Reaches of Ta Trach Dam

(1) General

The optimum development plan of the Huong River basin has been examined and development scale of the Ta Trach Dam has been optimized in this Huong River basin development planning.

The proposed damsite of the Ta Trach Dam is considered most effective topographically for achieving both flood control and water supply targets of the basin. For confirming the above, effectiveness of possible dams in the upstream reaches of the proposed Ta Trach damsite is preliminarily examined.

(2) Possible Damsites in the Upstream Reaches

There are three conceivable damsites in the upstream reaches of the proposed Ta

Trach damsites. The location map of the conceivable damsites is shown in the Figure S2.9. These three damsites are named as T-1, T-2 and T-3, respectively as seen in the figure.

Principal features of these three upstream dams which will accommodate the objective flood for control are as shown below:

Principal Features of Upstream Dams

Upstream Dams	Dead Storage Volume (MCM)	Effective Storage		Flood Control Space		Dam		
		Volume (MCM)	F.S.L (El, m)	Volume (MCM)	S.W.L	Height (m)	Volume ($1,000m^3$)	Cost (Mil. US.$)
T-1	7.7	37.3	102	42.1	105	60	2,870	31.6
T-2	11.5	55.5	141	62.8	144	61	2,700	29.7
T-3	16.7	83.3	134	90.9	137	55	1,950	21.5

Note: S.W.L: Surcharge Water Level F.S.L: Full Supply Level

(3) Conclusion

As a result of examination, findings are summarized as follows:

1) The examination found that the upstream dams cannot achieve the flood control target of the basin without a dam at the proposed Ta Trach damsite due to the flood from the catchment basin which is not covered with the three upstream dams. The possible flood control effect with upstream dams will approximately be a half of that of the proposed Ta Trach Dam, while the cost of the three upstream dams amounts to about 80% of the cost of the proposed Ta Trach Dam.

2) The cost of the Ta Trach dam to attain the flood control target of the basin with upstream dams will be lessened from 100.6 Mil.US$ to 82.5 Mil.US$. However, since the cost of upstream dams will amount to 82.72 Mil.US$, the combined total cost will result in 165.22 Mil.US$ which is much more expensive compared with the cost of 100.6 Mil.US$ in the plan of the Ta Trach Dam without upstream dams.

3) As stated above, dams in upstream reaches of the Ta Trach river have been found much less effective.

4) Besides that, adverse impacts on the natural environment due to upstream dams will become larger than those of the proposed Ta Trach Dam. Especially, the T-3 dam will largely submerge the Bach Ma National Park, and its implementation will encounter difficult environmental issues.

   The area(about 18.3 km^2) to be submerged by the upstream three dams will

be larger than the area(about 11.5 km^2) to be reduced by the smaller dam at the proposed Ta Trach damsite.

5) The decrease of necessary resettlement by the smaller dam at the proposed Ta Trach damsite is estimated to be very small.

6) Thus, the study confirmed that the dam planning of the Ta Trach river should be made at the proposed Ta Trach Damsite.

2.6.6 Domestic and Industrial Water Supply Plan

(1) Domestic Water Supply

The present situation can be summarised as follows:

Production facility	Year	Capacity (m^3/day)	Actual Production (m^3/day)	Supply to	Remarks
Quang Te-1 (old)	1926	40,000	20,000	Hue City	To be decommissioned
Quang Te-2 (new)	1997	20,000	15,000	Hue City	Phase 1 project
Quang Te-2 (ph-2)	-	20,000	-	Hue City	Phase 2, planned
Da Vien	1952	12,000	10,000	Hue City	Salt intrusion problem
Tu ha	1968	4,000	350	Tu Ha & Hue	
Chan May dong	(2000)	6,000	300	Phuoc Hai	
Nam Dong	(2000)	1,000	300	Nam Dong	Under construction
A Luoi	-	4,000		A Luoi	Under construction
Phu Bai	-	5,000		Phu Bai, Hue	Under construction
Phong Dien	-	6,000		Phng Dien	planned

The future development plan for Hue and surrounding urban centres will have to focus on keeping up with the population growth in Hue and reaching full service coverage in the smaller towns. Apart from the present projects in Phu Bai and A Luoi, the future investments will probably concentrate on the following required facilities:

- Construction of Phase 2 of Quang Te 2
- Additional pipelines to connect new development areas in Hue, 50 to 100 km of primary and secondary pipelines
- Approximately 45,000 house connection to cover the population growth until 2020 and maintain full coverage

(2) Industrial Water Supply

Presently, the main industrial water users are a beer factory, cement industry, glass and garment factories. The largest user by far is the beer factory, producing 33 million litres per year, which amounts to a water demand of approximately 4,500 m^3/day. Although the government's policy strongly supports industrial development, the future plans do not foresee any new large-scale industries for Thua Thien province. It can therefore be concluded that any industrial activity will receive its

water from the Hue urban water supply scheme in limited quantities.

(3) Approximate Investment Costs

A layout design of domestic and industrial water supply facilities is prepared as shown in Figure S2.10.

Depending on priorities and urgency of facilities, the investment costs required in the water supply sector of Thua Thien Province may vary from 30 to 40 Million US dollars over the next 20 years, which cost does not include maintenance costs, rehabilitation works or replacement of old equipment at existing facilities.

2.6.7 Agricultural Water Supply Plan

(1) Agricultural Development Plan

1) According to the agriculture development policy and strategy of the government, the direction given to the North Central Coast Region is i) acceleration of commodity-based production, ii) expansion of livestock and agro-processing, iii) improvement of rural living standard through increase of farmers' income and enhancement of rural services.

   Along with this direction, the agricultural policy of the province put their emphasis on i) food security and poverty alleviation, ii) enhancement of living standard through income generation, iii) increase of export earning, and iv) expansion of vegetation cover on slopes for environmental conservation.

2) Taking the present status of the above projects into account, the first priority for agricultural development is given to the irrigation rehabilitation and drainage improvement of 25,900 ha surrounding the Hue City. Irrigation rehabilitation and drainage improvement will provide i) irrigation water supply, ii) drainage improvement, iii) mitigation of the early flood during May to June, iv) prevention of salt water intrusion into irrigation water, v) protection from tidal wave during storm.

3) The present irrigation condition of 25,900 ha of agriculture land will change in the following manner after completion of the project:

Change in Land Use

Land Use	Condition	Present	Future	Balance
Paddy Field	Irrigated	18,022 ha	19,912 ha	+1,890 ha
Upland Crop Filed	Irrigated	0 ha	5,988 ha	+5,988 ha
Upland Crop Filed	Rainfed	7,878 ha	0 ha	-7,878 ha
Total		25,900 ha	25,900 ha	0 ha

Based on cropped area and anticipated unit yield, future agricultural production is estimated at about 200,000 ton of paddy, 3,700 ton of maize, 24,000 ton of sweet potatoes, 5,400 ton of groundnuts and 40,000 ton of vegetables, as shown below:

Future Production in the Project Area (2020)

Crop	Win – Spr	Sum – Aut	Total	Unit Yield	Production
Win – Spr Paddy	19,922 ha	-	19,022 ha	5.0 ton/ha	99,610 ton
Sum – Aut Paddy	-	19,922 ha	19,022 ha	5.0 ton/ha	99,610 ton
Sub-Total	19,922 ha	19,922 ha	39,844 ha		199,220 ton
Subsidiary Crop	3,988 ha	3,988 ha	6,655 ha		33,272 ton
(Maize)	(460ha)	(460 ha)	(920 ha)	4.0 ton/ha	3,680 ton
(Sweet Potatoes)	(3,456 ha)	(0 ha)	(3,456 ha)	7.0 ton/ha	24,192 ton
(Groundnuts)	(72 ha)	(3,528 ha)	(3,600 ha)	1.5 ton/ha	5,400 ton
Vegetables	2,000 ha	2,000 ha	4,000 ha	10.0 ton/ha	40,000 ton
Total	25,900 ha	18,486 ha	44,386 ha	-	272,492 ton

(2) Irrigation Water Supply Plan

1) The irrigation water supply plan includes irrigation, drainage and inundation protection. The present layout of the irrigation scheme should remain unchanged. Huong, Bo and Truoi Rivers will be the main sources of irrigation water. Improvements are required on inundation protection and drainage. Rehabilitation and delayed maintenance has to be carried out. Main works under construction are: Truoi Dam (2002), Thao Long Barrage (2004), Phu Bai Dam (rehabilitation 2002). Main works planned are: Ta Trach Dam, Cong Quan Outlet (additional), Khe Nuoc Dam.

2) The peak supplies are worked out as follows based on the above water demands and command areas:

Estimated Peak Supply

Intake	Command area (ha)	Peak supply (m^3/s)
Bo River (pump)	10,883	1.56
Nham Bieu	1,676	2.42
Total Huong North	12,559	18.03
Huong River (pump)	168	0.24
Phu Cam	8,460 - 7,153	12.24 – 10.35
La Y	0 - 1,307	0 - 1.84
Truoi	4,713	6.81
Total Huong South	13,341	19.23

3) Early flooding takes place in Huong North: areas adjacent to Bo and Huong Rivers, near the lagoon and in Huong South: whole southeastern part, in

particular reclaimed lagoon lands.

The drainage system should (a) prevent early flooding and (b) timely discharge after major flooding. Part of the rainfall is intercepted or temporary stored. From the rainfall on the agricultural lands 65% and from the hilly uplands 60% has to be drained. Most of the rainfall on sandy areas will infiltrate. The delay in runoff from the hills will be short (only a few hours). The water should be drained off within three days (72 hrs).

2.6.8 Water Resources Management Plan

As part of the integrated river basin management plan, the water resources management plan is formulated for the Huong River basin:

(1) Water Use Management Plan

1) Proper management of water demand
2) Latest information management of water resources
3) Proper water allotment under severe drought condition
4) Water saving measure

(2) Flood control Management Plan

1) National & provincial disaster warning systems
2) Disaster preparedness
3) Flood inundation mapping
4) Field benchmark network
5) Public awareness program
6) Reforestation

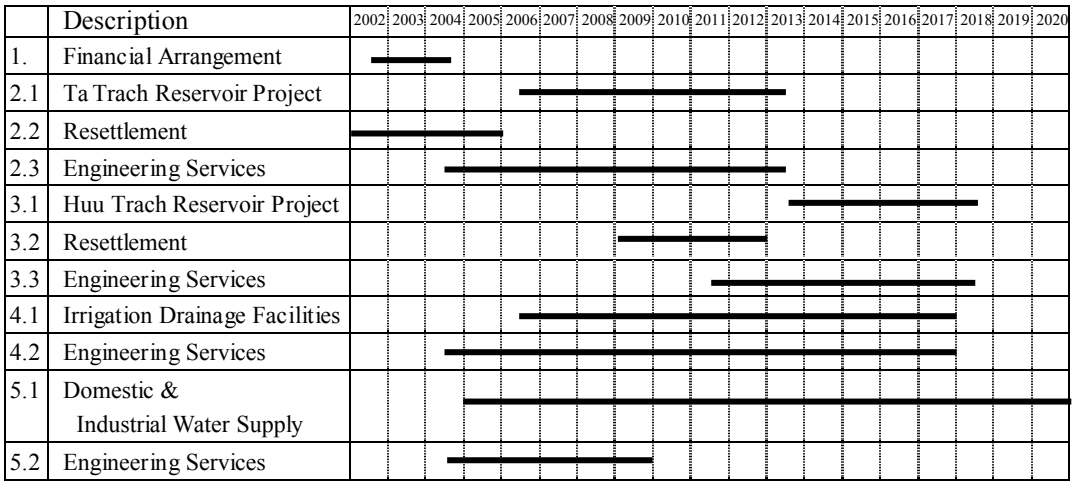
(3) River Environment Management Plan

1) Management of the river maintenance flow
2) Water quality control
3) Environmental monitoring

(4) Administrative Management Plan including proposed organization of the Board of Management of the Huong River Projects

2.7 Preliminary Implementation Program of Proposed Major Facilities

An overall implementation program of the proposed major facilities is shown below:



2.8 Preliminary Project Cost Estimate

The project costs for the proposed major facilities are estimated as follows:

Description	Project Cost	
	million VND	million US$ Equivalent
Ta Trach Reservoir Project (Earthfill type Dam with Hydropower)	2,512,381	166.7
Huu Trach Reservoir Project (Earthfill type Dam)	738,061	49.0
Irrigation and Drainage Facilities	1,600,868	106.2
Domestic and Industrial Water Supply	1,147,030	76.0
Total	5,998,340	398.1
Value Added Tax (VAT)	260,341	17.3
Grand Total	6,258,681	415.4

2.9 Project Evaluation

2.9.1 Technical Evaluation

The following is the most major point from the technical aspect which is found through a review on the Ta Trach Dam design conducted in the feasibility study.

1) Two concrete culverts as well as intake towers are installed within the dam body of fill type dam. The international dam design criteria do not allow this design, since piping may occur through insufficient contact between concrete structures and dam embankment materials. The insufficient contact between concrete structures and dam embankment materials will easily be caused due

to differential settlement of concrete structures and dam embankment materials, or due to earthquake if it will happen, thus requiring a careful design review.

2) The present dam construction schedule considers the river diversion system by using the two concrete culverts to be embedded in the dam body, and the schedule is too tight. In the event that dam embankment can not reach necessary level before the rainy season, artificial calamity may happen. Careful review of the construction schedule as well as dam design will be required.

3) Based on the design criteria for the fill type dam, river diversion system having a capacity to discharge 20-year probable flood should be introduced. However, in the case of Ta Trach river, 20-year probable flood magnitude is estimated at approximately 8,000 m^3/sec requiring several diversion tunnels of 10 m in its diameter, which are considered unrealistic. Therefore, a concrete dam (RCC dam) or concrete facing rockfill dam, which allows overtopping during construction, should be taken into consideration in the review of dam design and construction schedule. As such, detailed investigation for strength of the foundation rock will be important.

4) The thickness of mountain at the left abutment in the present dam design does not seems sufficient, requiring a careful examination.

It is strongly recommended that all of these problems should be clarified for the final design in the subsequent stage.

2.9.2 Economic Evaluation

Economic analysis has been examined for 10 alternative schemes for water resources development and management of the Huong River Basin. As a result of the analysis, all the alternatives have sufficient economic efficiency with EIRRs of more than 15%, which are higher than the opportunity cost of capital in Vietnam. The alternative I-B.2 (Max. Ta Trach + Max. Huu Trach Reservoirs) showed the largest NPV of USD 49.5 million and EIRR of 16.5%.

The economic analyses based on practical implementation schedule (stage construction) have been examined for the optimum alternative I-B.2. The results also indicated the alternative has sufficient economic efficiency with EIRR of 16.5%, which is higher than the opportunity cost of capital. The alternative can be rated as being economically feasible.

Alternative	EIRR (%)	B/C Ratio	NPV (Million US$)
I-B.2 (Max. Ta Trach + Max. Huu Trach)	16.5	1.56	47.5

2.9.3 Financial Evaluation

Financial evaluation has been conducted for the optimum alternative, I-B.2: Maximum Ta Trach + Maximum Huu Trach Reservoirs.

The financial feasibility of the projects is evaluated by examining the repayment capability of the capital cost for the projects based on a financial cash flow statement using the anticipated project revenue and fund requirement.

From the financial cash flow statement, the following matter became evident:

- Irrigation water charge cannot fully cover O & M cost of irrigation but shortage is very small and can be covered by small adjustment of water charge.
- Hydropower produces large benefit for the project.
- Water supply also can cover O & M cost of the water supply.
- In 2019 and afterward, government subsidy will not become necessary except during the replacement work of major mechanical and electrical facilities.

If soft loan is available, implementation of the projects will be financially possible.

2.9.4 Environmental Evaluation

Among the components of the Master Plan, 3 projects, namely i) Ta Trach Dam, ii) Huu Trach Dam, and iii) Domestic/industrial Water Supply, are selected as those necessary for environmental evaluation.

The environmental evaluation is conducted on the various elements of both social and natural aspects. As a result, most of the negative impacts by implementation of the Master plan will be caused by Ta Trach Dam project. It is expected that the major negative impacts by Ta Trach Dam, on which the adequate consideration should be given, are land acquisition and resettlement, and split of the communities. The mitigation measures or monitoring system to cope with or identify these impacts should be developed and provided. Besides, the magnitude of impacts on river degradation/aggradation, and ecology of lagoon caused by Ta Trach and Huu Trach Dam is unclear. The monitoring in these regards after completion of Ta Trach Dam is recommendable to identify whether the significant impacts appear or not.

2.9.5 Undertakings of Vietnamese Side

The project evaluation pointed out that the following undertakings or attentions of

Vietnamese side are important.

(1) The provisional flood control measure as mentioned in the Main Report should be kept in mind: that is, the present condition of the left side river branch located just upstream of the Hue City should be maintained until the completion of the Huu Trach Dam.

(2) The non-structural measures for flood damage mitigation or water saving as discussed in Section 8.3 of the Main Report which will be efficient both before and after the completion of upstream dam(s) should be implemented at the earliest.

PART 3
Phase 2-2 : INTEGRATED RIVER BASIN MANAGEMENT PLAN FOR KONE RIVER BASIN

3.1 Kone River Basin

The Phase 1 study has examined the water resources development and management plan for 14 major basins and selected the Kone River basin as a priority river basin for which an integrated river basin management plan would be formulated in Phase 2-2.

The Kone River basin is almost entirely situated within the Binh Dinh Province, southern central Vietnam, and the largest river in the province. The river originates on the eastern slope of Truong Son Range in Binh Dinh Province and discharges into the East Sea through the Quy Nhon Estuary.

The catchment area of the Kone River is 3,640 km^2 including that of the Ha Thanh River and the river length of the Kone River is about 160 km.

The location and study area are shown in Figure S3.1.

3.1.1 Natural Condition

(1) Topography and Geology

The provincial area, located between the Southern Truong Son Range and the East Sea, has been geo-morphologically divided into middle-low mountains, hills and plains from the west to the east. The middle-low mountains stretch nearly north-south with an altitude of 500 to 1,000 meters. The alluvial plains are mostly below 10 meters in elevation. The hilly area are scattered between the middle-low mountains and the plains. The hilly areas have an altitude less than 200 meters.

The provincial area is dominated by metamorphic rocks and igneous rocks, which are unconformably overlain by the Quaternary deposits originating mostly from alluvium and deluvium. Geo-structurally, the provincial area is located in the central part of the Kon Tum Geoblock, a micro-continent of Precambrian crystalline rocks. In the area, three sets of faults have been observed, but they have been evaluated to be inactive.

(2) Climate

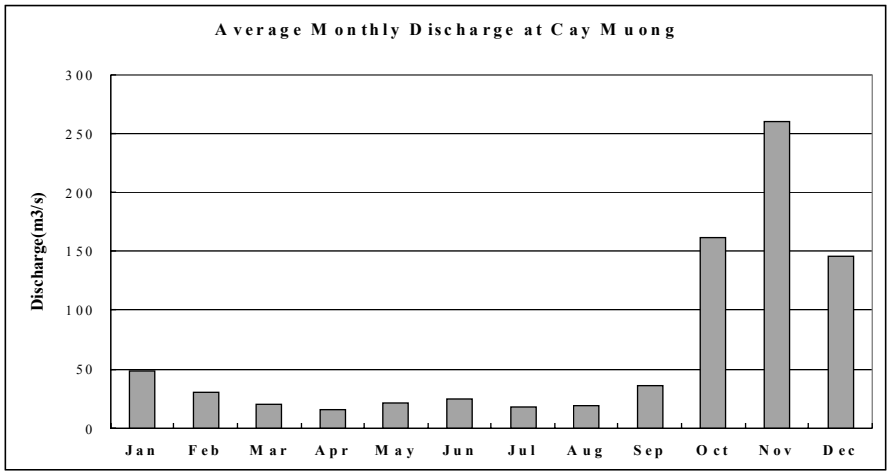
The rainfall pattern is much less equable. The yearly basin rainfall, averaged over the last 25 years (1977 – 2001) amounts to 2,120 mm. From this amount some 63%, or 1,333 mm falls on the average in the period September – November.

(3) Natural Runoff

Long series of discharge observations are available at Cay Muong only. This hydrological station covers 1,677 km2, or 46% of the total basin area.

From the 1976 – 2001 daily discharge data at Cay Muong, it is derived that the average runoff at that location amounts to 68.2 m^3/s. This corresponds to 1,283 mm on a yearly basis or 54% of the average yearly rainfall, calculated at 2,368 mm for the area upstream of Cay Muong.

The average monthly discharges at Cay Muong are as follows:



(4) Flood

During the 25 years in the past from 1977 to 2001, there occurred floods in 21 years and only three of them took place in December and the others took place in October or November. Among the floods in the past in the year 1977 to 2001, the major floods in the delta are as follows:

Year	1980	1981	1984	1987	1992	1996	1998	1999
Peak discharge of flood at Cay Muong (m^3/s)	4,280	4,140	3,480	6,340	3,220	3,430	4,350	3,680

In the Kone basin a distinction is made between the Main Floods, Early Floods, Minor Floods and Late Floods.

Main floods occur in the period October-November or, exceptionally, in December. These floods are often cause high rainfall intensities in the order of 200 – 400 mm in one day.

An early arrival of storms, generally with lower intensities in the order of 50 – 100 mm in one day may cause the so-called Early Floods during the months August - September.

Minor Floods may occur in the months May – June, corresponding with rainfall that is similar to the Early Flood rainfall.

Late floods are floods that may occur in December after the main floods have passed, these floods tend to go together with rainfall intensities in the order of 200 mm in one day.

The highest discharge at Cay Muong has been observed in 1987 and amounted to 6,340 m^3/s. This peak discharge has an estimated return period of about 100 years. The estimated probable peak discharges of the various floods are indicated below:

Annual Peak Discharges at Cay Muong

(m^3/s)

	Probability (% per year)					
	50%	20%	10%	5%	2%	1%
Main Flood Peak Discharge	2,530	3,700	4,400	5,020	5,750	6,270
Late Flood Peak Discharge (December)	250	900	1,530	2,200	3,330	4,380
Minor Flood Peak Discharge (May – June)	120	250	360	460	610	720
Early Flood Peak Discharge (August –September)	180	360	500	660	880	1,070

(5) River System

The Kone River originates on the eastern slope of Truong Son Range in Binh Dinh Province, flows down in rather mountainous and hilly area, reaches the apex of the Kone River delta about 35 km upstream of the river mouth, and bifurcates there to the Dap Da and the Tan An Rivers. About 2 km downstream of the bifurcation, the Go Cham River bifurcates from the Tan An River. These rivers flow down in the Kone River delta and finally discharge to the Thi Nai swamp.

Quy Nhon City, the capital city of the Binh Dinh Province, is located at the outlet of the Thi Nai swamp to the East Sea. The river system of the Kone River basin is shown in Figure S3.2.

The longitudinal slope of the Kone River is very steep in its upstream reaches ranging from 1/20 to 1/80. The longitudinal slope of the Kone River in its downstream reaches is about 1/2,480, being not so gentle like those of other rivers in the south central coast rivers in the downstream reaches.

3.1.2 Socioeconomic Condition

(1) Administration

Binh Dinh Province has an area of 6,026km^2 and consists of the capital city, Qui Nhon, and other 10 districts of An Lao, Hoai An, Hoai Nhon, Phu My, Phu Cat, Vinh Thanh, Tay Son, An Nhon, Tuy Phuoc, and Van Canh. The city and districts

are further divided into 126 communes.

(2) Population

Average Population and Number of Households in Kone River Basin

No.	District	No. of commune	Area (km^2)	Population in 2001 (1,000)	Population density (pers./km2)	No. of household (household)	Family size (pers/hh)
1.	Quy Nhon city	19	213.0	244.9	1,150	52,410	4.7
2.	An Lao	1	260.4	0.5	2	90	5.8
3.	Phu My	6	170.4	73.1	429	16,080	4.5
4.	Phu Cat	14	549.6	156.6	285	34,240	4.6
5.	Vinh Thanh	7	700.8	26.4	38	5,610	4.7
6.	Tay Son	15	708.0	133.2	188	29,160	4.6
7.	An Nhon	15	242.2	184.9	763	41,670	4.4
8.	Tuy Phuoc	14	284.9	186.1	653	39,980	4.7
9.	Van Canh	6	798.0	22.1	28	4,810	4.6
	Total	97	3,927.1	1,027.8	262	224,040	4.6

Source: Statistical yearbook of each district 2001

The annual population growth rates of the districts are 1.4% for Quy Nhon, Phu Cat, Vinh Thanh, and Van Canh, 1.3% for An Lao, Phu My, Tay Son, and Tuy Phuoc, and 1.1% for An Nhon during six years from 1995 to 2001

(3) Gross Regional Domestic Product (GRDP) of Province

Gross regional domestic product (GRDP) of Binh Dinh Province was VND4.9 trillion（US$326.4 million) in 2001, which accounted for 1.0% of the country's GDP. Average annual growth rate of GRDP was high at 8.4% on constant price basis during six years from 1995 to 2001. However, the growth rate in 2001 was 5.7%, which is the lowest during the same period, due to influence of the current worldwide recession. GRDP and Per Capita GRDP of Binh Dinh Province are shown below:

GRDP and Per Capita GRDP of Binh Dinh Province

	1995	1996	1997	1998	1999	2000	2001
GRDP Total (VND bn)							
At current prices	2,717.7	3,122.4	3,435.2	3,856.0	4,181.3	4,591.9	4,917.5
At 1994 constant prices	2,388.7	2,627.6	2,869.8	3,071.4	3,359.3	3,661.3	3,874.0
Real growth (%)		10.0%	9.2%	7.0%	9.4%	9.0%	5.8%
Per capita GRDP (VND1,000)							
At current prices	1,949.1	2,209.9	2,399.9	2,659.7	2,848.3	3,091.0	3,268.1
At 1994 constant prices	1,713.2	1,859.7	2,004.9	2,118.5	2,288.4	2,464.6	2,574.6

Source: Statistical Yearbook of Binh Dinh Province 2001

(4) Agriculture, Forestry and Fishery

From the socioeconomic viewpoints, agriculture including crop & livestock, forestry, and fishery sectors are characterized as the mainstay of economy in Binh Dinh Province, producing 47% of Gross Regional Domestic Products (GRDP), 73% of employment. Furthermore, about 90% of the population is categorized

as rural habitants and their living is largely depending on agriculture. Many positive changes have occurred in agricultural sector, from a self-supplying to commodity agriculture gradually.

Paddy cultivation is the main agricultural activity in the province. The average paddy production during the period from 1999 to 2001 is presented below:

Paddy Production of the Province (average during 1999 to 2001)

Cropping Season	Winter-Spring	Summer-Autumn	3rd Crop	Total
Planted Area (ha)	46,700 ha	40,600 ha	40,000 ha	127,300 ha
Unit Yield (ton/ha)	4.71 ton/ha	4.25 ton/ha	3.30 ton/ha	4.12 ton/ha
Production (ton)	220,100 ton	172,700 ton	132,100 ton	524,900 ton

Source: Statistical Yearbook 2001, Binh Dinh Province.

Other major crops are maize, cassava, sweet potato, vegetables, groundnut, soybean, sesame, sugarcane, and tobacco. Livestock farming is also practiced in the province.

(5) Industry

Although the industrial sector shows the higher growth rate of 14.0% since 1995, more than 40% of industrial gross output was produced by agro-based manufacturing like food and beverage, leather tanning & processing, wood processing etc. This indicates that the agriculture sector supports the growth of industrial sector through supplying the materials. Other major industrial products of the province are furniture, electricity, non-metallic mineral products, and transport equipment.

3.2 Socio-economic Framework Plan

(1) Population Projection

Future population in the Kone River Basin is projected based on the population growth target defined in socioeconomic framework in the Phase-1 study. The annual growth rates are slightly higher than the population growth target in the provincial Master Plan but the difference is small and it is safe side for estimation of future domestic water demand. The estimated future population is summarized below:

Population Projection for Kone River Basin

	Population (1,000)			Annual Growth (%)	
	2001	2010	2020	01-10	10-20
Total (river basin)	1,001.1	1,130.7	1,293.6	1.36	1.36
- Urban	324.0	390.1	475.8	2.08	2.01
- Rural	677.1	740.7	817.9	1.00	1.00

(2) Economic Growth Target

Three scenarios are conceived and examined as follows:

Scenario 1 : "Low growth"
Scenario 2 : "Average growth"
Scenario 3 : "High growth"

GRDP growth rates are assumed at 5.6%, 8.4%, and 9.5% per year for Scenario 1 (low growth), Scenario 2 (average growth), and Scenario 3 (high growth). Each growth rates are decided from the following consideration:

5.6% : Lowest growth experienced last six years
8.4% : Average growth rate of last six years
9.5% : Target growth rate defined in the provincial Master Plan. After 2010, the same growth target as 2005-2010 has been applied until 2020.

The economic growth target of each sector is assumed as summarized below according the development scenarios discussed above:

Economic Growth Target by Scenario

	GRDP (1994 Constant Price, VND bn)				Annual Growth Rate (%/year)		
	2001	2005	2010	2020	01-05	06-10	11-20
Scenario 1 (Low growth)							
Agriculture, forestry & fishery	1,806	2,088	2,504	3,601	3.7	3.7	3.7
Industry and construction	777	1,005	1,387	2,640	6.7	6.7	6.6
Service and other	1,291	1,693	2,374	4,670	7.0	7.0	7.0
Total	3,874	4,786	6,265	10,912	5.4	5.5	5.7
Scenario 2 (Medium growth)							
Agriculture, forestry & fishery	1,806	2,197	2,759	4,351	5.0	4.7	4.7
Industry and construction	777	1,260	2,304	7,712	12.8	12.8	12.8
Service and other	1,291	1,777	2,647	5,875	8.3	8.3	8.3
Total	3,874	5,233	7,710	17,938	7.8	8.1	8.8
Scenario 3 (High growth)							
Agriculture, forestry & fishery	1,806	2,197	2,759	4,351	5.0	4.7	4.7
Industry and construction	777	1,409	2,816	11,255	16.0	14.9	14.9
Service and other	1,291	1,958	3,158	8,214	11.0	10.0	10.0
Total	3,874	5,564	8,733	23,820	9.5	9.5	9.5

In the Study, Scenario 3 is taken for future water demand estimation and/or estimation of flood damage potentials.

3.3 Meteo-hydrological Analysis

3.3.1 Run-off Analysis

Cay Muong is the only station in the Kone basin with a sufficiently long record of discharge data. On the other hand, a full picture of the rainfall in the Kone basin can be obtained from 9 rainfall stations in and near the basin. The assessment of the runoff in locations different from Cay Muong has, therefore, been made with the help of rainfall – runoff modelling, using rainfall data of the period September 1977 – December 2001. Sufficient information is available for an adequate modelling, calibration and verification of the rainfall – runoff process in the basin upstream of Cay Muong. In the present study the NAM module of this system is used for the generation of runoff series. The reproduction of the runoff at Cay Muong on a yearly basis is quite accurate, as is shown below:

Average Yearly Runoff at Cay Muong (m^3/s)

Probability of Exceeding (assuming LN3 distribution)	50%	75%	90%
Historic Series 1978 - 2001	66.4	46.5	31.0
Generated Series 1978 - 2001	65.4	45.6	29.3

The results are summarized for the relevant low flow months in the Figures S3.3 and S3.4. The figures show the "probable runoff" as normally used in water balance studies in Vietnam in order to allow the comparison of these results with the results of previous studies.

3.3.2 Flood Analysis

(1) Methodology

The absence of sufficient hourly rainfall information hampers seriously an accurate calibration of rainfall-runoff relations under flood conditions. The very rapid response of the various sub-basins on the occurrence of storms, (in the order of a few hours) requires very accurate hourly area rainfall information for calibration and verification of rainfall-runoff models for the simulation of flood runoff of the different sub-catchments.

Consequently, the following approach has been followed for the generation of the flood hydrographs to be used in the formulation and subsequent design of the flood protection measures.

Basic (single peak) synthetic hydrograph is given by: $Q_t = Q_p \left(\frac{t}{T_p} \right)^m * e^{m(1-t/T_p)}$

where:
- Q_t = Runoff at time t [m^3/s]
- Q_p = Peak runoff [m^3/s], at time T_p
- t = time elapsed [h]
- T_p = time to peak of hydrograph [h]
- m = determines the shape of the hydrograph. For m = 3, this hydrograph matches the USDA SCS dimensionless hydrograph closely.(In physical terms, m = the number of reservoirs in the so-called Nash reservoir cascade)

The transposing of flood peaks and base flows from the gauged (Cay Muong) catchment to the ungauged catchment is carried out as follows, with the associated catchment rainfall being derived using the Thiessen method:

$$Q_{\max,p} = A_p F_a^{(1-n)}$$

where,
- $Q_{max,p}$ = Flood peak with an associated probability of p%, including baseflow [m^3/s]
- A_p = Corresponding transpose factor [-]
- F_a = Gauged catchment area [km^2]
- n = Regionalised factor determined by experience, for Southern Central Region of Vietnam, n = 0.35
  A "n" value of 0.55 would give similar results as the Creager Formula (giving the envelop for maximum peak discharges).
  A "n" value of 0.45 has been applied in the present study.

(2) Hydrographs for Flood Control Studies

The probable flood hydro-graphs have been generated for several types of flood and several probabilities. Several probable main, early and late floods are presented in the Figures S3.5 through S3.8.

(3) Flood Hydrographs for Design Purposes

In case the designs are made on the basis of a deterministic approach, then it is important to make an estimate of the "possible underestimate" of the calculated probable peak discharges, considering the length of data series that was used in the probability analysis.

The "possible underestimate" of the calculated probable peak discharges was considered the difference between the upper confidence limit and the regression line as shown in Figure S3.9.

For the 1976 -2001 series of the yearly instantaneous peak discharges in Cay Muong, the above approach led to safety factors of,

- 1.13 for 10% probable peak discharge
- 1.16 for 5% probable peak discharge, and
- 1.21 for 1% probable peak discharge.

Under application of these safety factors, for all types of floods, the design peak discharges have been assessed as follows (for the 5% probable peak a safety factor of 1.16 has been applied):

Design Discharges at Cay Muong m^3/s

Type of Flood	Return Period			
	10 years	20 years	100 years	200 years
Main Flood	4,970	5,820	7,590	8,320
Late Flood	1,730	2,550	5,300	
Early Flood	570	770	1,300	
Minor Flood	410	540	870	

For the design of proposed structures in the Study, the respective probable peak discharges and hydro-graphs need to be estimated. The design hydro-graphs have been prepared for the 10%, 5% 1% and 0.5% estimated design peak discharges.

Design Characteristics Main Floods

Parameter / Probability		10%		5%		1%	
Station	Area (km^2)	Q (m^3/s)	Vol (Mm^3)	Q (m^3/s)	Vol (Mm^3)	Q (m^3/s)	Vol (Mm^3)
Dinh Binh	1,040	3821	405	4,475	463	5,836	594
Cay Muong	1,677	4,970	583	5,820	665	7,590	847
Binh Thanh	2,250	5,842	726	6,841	825	8,922	1,047
Nui Mot	180	1,456	52	1,705	58	2,224	72
La Vi	240	1,706	85	1,998	98	2,605	125
Ha Tanh	590	2,798	175	3,276	197	4,273	248

Design Characteristics Late Floods

Probability		10%		5%		1%	
Parameter		Q (m^3/s)	Vol (Mm^3)	Q (m^3/s)	Vol (Mm^3)	Q (m^3/s)	Vol (Mm^3)
Station	Area (km^2)						
Dinh Binh	1,040	1,330	149	1,961	196	4075	313
Cay Muong	1,677	1,730	240	2,550	315	5,300	505
Binh Thanh	2,250	2,034	323	2,997	423	6,230	677
Nui Mot	180	507	26	747	34	1,553	54
La Vi	240	594	34	875	45	1,819	72
Ha Tanh	590	974	85	1,436	111	2,984	178

3.3.3 Sediment Analysis

The concentration of suspended sediments is measured in Cay Muong. The yearly volume of sediments at Cay Muong corresponds with a sediment production of some 200 tons per km^2 per year. If this production is assumed to be representative

for the entire basin, then it can be estimated that the sediment load that is passing yearly the Dinh Binh dam site will be of the order of 220,000 tonnes, or some 150,000 m^3 at a density of 1,400 kg/m^3.

3.4 Water Demand Forecast

3.4.1 Water Demand for Agriculture

(1) Irrigation Water Demand Forecast

Gross Unit Irrigation Requirements (GIR)

GIRs estimated based on the present and future conditions of cropping patterns are as follows:

Gross Unit Irrigation Water Requirement (GIR), Average Rainfall Year, 10-day GIR

Item	Cropping Pattern					
	Present (2001)		Future (2010)		Future (2020)	
	Peak 10-day lit/sec/ha	Annual Total m^3/year/ha	Peak 10-day lit/sec/ha	Annual Total m^3/year/ha	Peak 10-day lit/sec/ha	Annual Total m^3/year/ha
La Tinh, Kone and Ha Thanh River Basins						
Year	1995	1991	1978	1991	1992	1992
Water Requirement	1.78	28,600	1.41	23,100	1.30	21,500

The above GIRs in the average rainfall year are to be used to roughly grasp the water demand condition.

Besides the above, 10-day basis GIRs for the 24 years from 1978 to 2001 have been calculated for the water balance calculation to judge if the planned irrigation development would be possible or not.

Gross Unit Irrigation Water Requirement (GIR),

Less than 1/4 of examined long period, 10-day GIR

Item	Cropping Pattern					
	Present (2001)		Future (2010)		Future (2020)	
	Peak 10-day lit/sec/ha	Annual Total m^3/year/ha	Peak 10-day lit/sec/ha	Annual Total m^3/year/ha	Peak 10-day lit/sec/ha	Annual Total m^3/year/ha
La Tinh, Kone and Ha Thanh River Basins						
Year	1987	1986	1983	1986	1991	1997
Water Requirement	1.88	29,500	1.45	23,800	1.32	22,300

The above peak 10-day GIRs with less than 1/4 of examined long period have been calculated as a weighted average of the respective cropping patterns adopted for the respective areas, and are presented here just for reference. The peak 10-day GIRs at the probable drought year for the respective cropping patterns are to be used for the

design discharge calculation to determine the capacity of canals and related structures of the irrigation systems.

Irrigation Water Demand (IWD)

IWDs estimated based on the present and future conditions of cropping patterns and irrigation areas are as follows:

Irrigation Water Demand (IWD), Average rainfall Year, 10-day GIR

Item	Cropping Pattern					
	Present (2001)		Future (2010)		Future (2020)	
	Annual Average m^3/sec	Annual Total 10^6 m^3 / year	Annual Average m^3/sec	Annual Total 10^6 m^3 / year	Annual Average m^3/sec	Annual Total 10^6 m^3 / year
La Tinh, Kone and Ha Thanh River Basins						
Irrigation Area (ha)	24,400		30,500		54,500	
Water Demand	22.2	698	22.3	703	37.1	1,169

Irrigation Water Demand (IWD), Less than 1/4 of examined long period, 10-day GIR

Item	Cropping Pattern					
	Present (2001)		Future (2010)		Future (2020)	
	Annual Average m^3/sec	Annual Total 10^6 m^3 / year	Annual Average m^3/sec	Annual Total 10^6 m^3 / year	Annual Average m^3/sec	Annual Total 10^6 m^3 / year
La Tinh, Kone and Ha Thanh River Basins						
Irrigation Area (ha)	24,400		30,500		54,500	
Water Demand	22.9	721	23.0	726	38.5	1,215

(2) Livestock Water Demand Forecast

Water demand for livestock (LWD) estimated based on the present and future numbers of various kinds of livestock in the coastal area where the groundwater is salty is as follows:

Livestock Water Demand (LWD)

	Present (2001)		Future (2010)		Future (2020)	
	Heads (nos.)	Demand (m^3/day)	Heads (nos.)	Demand (m^3/day)	Heads (nos.)	Demand (m^3/day)
Cattle&Buffalo, Pig, Poultry, Goat	549,570	5,670	1,623,500	8,650	2,411,000	11,480

(3) Aquaculture Water Demand Forecast

Gross water demands (required fresh water) for the coastal shrimp culture (AWDs) estimated based on the present and future areas of the pond are as follows:

Coastal Shrimp Culture Water Demand (AWD)

Kind	Present (2001)		Future (2010)		Future (2020)	
	Area (ha)	Demand (10^3 m^3/year)	Area (ha)	Demand (10^3 m^3/year)	Area (ha)	Demand (10^3 m^3/year)
Coastal Shrimp	1,600	7,360	2,500	11,150	2,500	11,150

(4) Summary of Agricultural Water Demand

Irrigation Area (ha)

River Basin	Present (2001)	Future (2010)	Future (2020)
La Tinh River Bain	3,000	3,000	6,300
Kone River Bain	20,200	25,100	43,900
Ha Thanh River Basin	1,200	2,400	4,300
Total	24,400	30,500	54,500

Agricultural Water Demand (AWD),
Less than 1/4 of examined long period, (m^3/sec)

Item	Cropping Pattern		
	Present (2001)	Future (2010)	Future (2020)
Year	1991	1991	1992
Irrigation	22.87	23.03	38.53
Livestock	0.07	0.10	0.13
Aquaculture	0.00	0.36	0.36
Total	22.9	23.5	39.0

3.4.2 Water Demand for Domestic and Industrial Water Use

(1) Domestic Water Demand Forecast

The projected increase of the domestic water demand in the river basin are given as follows:

Domestic Water Demand (Excluding non-connected people) (m^3/d)

	2001	2010	2020
Urban Area	31,301	75,985	117,459
Rural Area	5,078	23,701	40,894
Total	36,379	99,686	158,353
	(1.09 M m^3/m)	(2.99 M m^3/m)	(4.75 M m^3/m)

Domestic Water Demand (Including non-connected people)

	2001	2010	2020
Urban Area	34,541	78,318	119,572
Rural Area	16,928	59,251	81,784
Total	51,469 m^3/d	137,569 m^3/d	201,356 m^3/d
	(1.54 M m^3/m)	(3.68 M m^3/m)	(6.04 M m^3/m)

Urban domestic water demand in each urban center is shown in Figure S3.10.

(2) Industrial Water Demand Forecast

Rural Industrial Water Demand

The socio-economic development target in the industrial sector of the basin sets the annual growth rate of 9.0% during 2010 to 2020, and the water demand was assumed to increase in accordance with this targeted growth rate.

Calculation is made in Table S3.3, resulting in the following:

Year	Rural Industrial Water Demand
2010	82,525 m^3/day (2.48 Million m^3/month)
2020	195,367 m^3/day (5.86 Million m^3/month)

Industrial Water Demand for Industrial Zones

The following development of industrial zone is planned by the Department of Industry:

Industrial zone	Location	Status	Designed area (ha)	Water demand (m^3/day)
Phu Tai	Quy Nhon City	Under construction	250	17,500
Long My	Tuy Phuoc District	Planned	300	21,000
Nhon Hoi	Quy Nhon City	Planned	1,000	70,000
Total				108,500

Source: Feasibility Study Report of Dinh Binh Reservoir Project.

In addition to the water demands by the industrial zones, a paper pulp mill is expected in operation by 2005 at Nhon Hoa, An Nhon District, according to the information of DARD. Water demand is expected to be 50,000 m^3/day in the first phase and 100,000 m^3/day as long-term plan.

A schematic presentation of the industrial water demand as well as rural domestic water demand in 2020 is given in Figure S3.11.

3.4.3 Water Demand for Power Generation

Objectives of the Dinh Binh Multipurpose Reservoir Project consist of flood control, water supply for irrigation, domestic and industrial water, power generation and improvement of river environment, etc. However, higher priority is put on the objectives of flood control and water supply. The power generation is planned to be basically conducted by utilizing the water to be released for the water supply purpose as well as surplus water.

3.4.4 Water Demand for River Maintenance Flow

The river maintenance flow of the Kone and the Ha Thanh river basins was discussed and reexamined for verification of effectiveness and adequacy of the figure obtained by Phase 1 study. The discussion and reexamination was done from the viewpoint of i) salinity intrusion, ii) water pollution, iii) fluvial navigation, and iv) ecological conservation, based on the data and information collected additionally in the course of the Phase 2-2 study and analysis of them. As a conclusion of the analysis, 6.6 m^3/s at Binh Thanh (the apex of the delta), 8.1 m^3/s for the Kone river basin, and 1.3 m^3/s for the Ha Thanh river basin were obtained respectively as the river maintenance flow.

3.5 Water Balance Analysis

3.5.1 Water Balance Study

(1) Objectives of the Study

The water balance analysis is made to evaluate water balance of the present situation as well as future conditions of the target year 2020 and year 2010 as an intermediate year. Proposed Dinh Binh Reservoir is studied of its necessary development scale to meet future water requirement in terms of necessary storage capacity as well as flood control capacity.

(2) Water Balance System

The analysis is made in the Kone River basin with a catchment area of 3,010 km^2 and Ha Thanh River basin with a catchment area of 630 km^2, while only some irrigation water demand in the La Tinh River basin is incorporated in the analysis of the Kone River basin. A schematic model for the analysis of the Kone River and Ha Thanh River basins are presented in Figure S3.12.

The existing and proposed reservoirs are studied in the analysis including Vinh Son, Thuan Ninh and Nui Mot reservoirs as well as Dinh Binh and Suoi Chiep reservoirs.

3.5.2 Basic Condition of Water Balance Analysis

(1) Basic Condition

Balance calculation has been carried out every ten days by giving water resources and water demand data as 10-day basis for duration of 24 years. Natural flow of a series of 1978 to 2001 was applied for the analysis as water resources.

Return flow rate is assumed to be 10 % for irrigation water and not considered (0 %)of demand for domestic and industrial waters.

(2) Water Demand

(a) Agricultural Water Demand

Total irrigation areas considered in the study are shown as follows by river:

River	Irrigation Area (ha)			Note
	Present	2010	2020	
Kone River	20,373	27,614	47,972	Including demand of Ha Thanh to be supplied from the Kone River.
La Tinh	-	-	6,297	Only insufficient water supply capacity of the Hoi Son Reservoir is covered by the transferred water from the Kone River.
Ha Thanh	1,180	2,394	3,928 – 2,246	

Other than the irrigation water demand, the water demand for the coastal shrimp culture and livestock are incorporated in the analysis as the agricultural water demand.

(b) Domestic and Industrial Water Supply Requirement

(unit : m^3/day)

River	Present(2001)		2010		2020	
	Domestic	Industry	Domestic	Industry	Domestic	Industry
Kone River	16,216	49,300	53,916	167,525	111,568	365,367
Ha Thanh	165	0	770	19,250	1,329	38,500

Remarks : Demand for river surface water only

(c) River Maintenance Flow

River maintenance flow is examined of its availability at the river mouth as total amount for a river basin. Requirement for the Kone River and Ha Thanh River basins are 0.70 million m^3/day (equiv.to 8.1 m^3/sec) 0.11 million m^3/day (equiv.to 1.3 m^3/sec), respectively.

3.5.3 Evaluation of Water Balance Analysis

Water supply condition against water demand is evaluated of its tightness in accordance with the applicable criteria for 2020 set out as follows:

Water demand		Allowable probability or years that insufficient water supply (water shortage) condition will occur
(a) Agriculture, Fishery, River maintenance flow	:	Less than 1/4 probability of the examined 24 years or Less than 6 years (5 years in 24 years at the most)

(b) Domestic use, Industry: Less than 1/10 probability of the examined 24 years or 2 years in 24 years at the most)

3.5.4 Future Water Balance Situation Against 2020 Demand

(1) Development Scale of Dinh Binh Reservoir

In the 2020 case, the proposed Dinh Binh Dam is integrated in the analysis in addition to the existing reservoirs.

Development Scale Alternatives of Dinh Binh Reservoir

(unit : million m^3)

	Gross Storage Volume	Effective Storage Capacity for Water Supply			Expected Flood Control Space	
		Non-flood season	Major flood season	Late flood season	Major flood season	Late flood season
		Jan.-Aug.	Sep.-Nov.	Dec.	Sep.-Nov.	Dec.
I-1	237.5	209.9	0.0	1) 21.2 2) 101.2 3) 166.2	221.2	1) 200.0 2) 120.0 3) 55.0
I-2			100.0		121.2	
II-1	309.1	279.5	0.0	1) 92.8 2) 172.8 3) 237.8	292.8	
II-2			100.0		192.8	
III-1	391.8	360.2	0.0	1) 175.5 2) 255.5 3) 320.5	375.5	
III-2			100.0		275.5	

Remarks: In Late Flood season (December), the effective storage volume and the flood control space will be gradually increased and decreased every 10 days, respectively; 1) 1^{st}-10^{th}, 2) 11^{th} to 20 th, 3) 21th to 31th.

(2) Reservoir Operation Rule Applied for the Analysis

Preliminary reservoir operation procedure is predetermined to control reservoir storage volume in flood control aspect according to the three seasons, i.e.: no-flood season (January to August), major flood season (September to November) and late flood season (December). A procedure on reservoir outflow control in the water supply aspect is predetermined as well. A concept is to discharge reservoir storage to meet water demand in the downstream reaches as long as storage water is available.

(3) Water Balance Analysis by Development Scale

Water balance condition in 2020 is shown below in terms of annual water deficit estimated by accumulating deficits per 10 day calculation interval:

Annual Water Deficit in Whole Basin by Development Alternatives

(unit : million m^3)

Alternatives	Eff. Storage	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
I-1/I-2	209.9	-	75	-	-	-	641	-	-	20	61	196
II-1	279.5	-	50	-	-	-	638	-	-	-	-	119
II-2		-	-	-	-	-	566	-	-	-	-	119
III-1	360.2	-	50	-	-	-	638	-	-	-	-	40
III-2		-	-	-	-	-	542	-	-	-	-	40

Alternatives	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
I-1/I-2	-	110	13	115	290	-	160	-	-	88	-	-	-
II-1	-	76	-	40	209	-	88	-	-	20	-	-	-
II-2	-	40	-	40	209	-	88	-	-	20	-	-	-
III-1	-	76	-	40	209	-	88	-	-	20	-	-	-
III-2	-	-	-	-	131	-	72	-	-	-	-	-	-

(4) Result of Water Balance Analysis in Kone River Basin

The water balance situation of the Alternative II-1 would meet the predetermined condition except some irrigation schemes on the tributaries as follows:

Water Demand		Water Shortage in 24 years
Domestic and Industry in whole basin	:	2 years
Irrigation and Fishery related to the Main Rivers	:	5 years
Nui Mot	:	1 year
Hon Lap, Hon Ga	:	1 to 2 years
Thuan Ninh, Dong Sim	:	9 years
Tui Thien	:	12 years
Suoi Chai	:	20 years

In water supply capacity aspect, Alternative II-1&2 as well as Alternative III-1&2 will meet the requirement and conditions, while Alternatives I-1&2 will not have a sufficient storage capacity.

3.6 Basic Strategy for Integrated River Basin Management

(1) Basic Strategy for Water Utilization

The targeted economic growth of the basin is discussed and presented in the socio-economic framework plan of the foregoing Section 3.2.

The water demand consists of the agricultural water demand, domestic and industrial water demand, demand for power generation and river maintenance flow, etc. The increase of these water demands in line with the target economic growth of the basin is examined in Section 3.4.

The formulation of the water utilization plan of the basin envisages, as the basic strategy, to meet these water demand increase towards the year 2020.

(2) Basic Strategy of Flood Control

Objective area

Objective area of flood control of the Kone River basin is the Kone River delta.

Criteria

Flood control criteria of the Kone River delta are to protect the objective area from 5% probable late flood and 1% early flood.

Flood control measures

Flood control measures should consist of structural measures and non-structural measures. Structural measures considered are construction of reservoir in the upstream basin, construction of retarding basin in the middle stream basin, and river improvement in the downstream basin.

Non-structural measures considered are forestation in the upstream basin, establishment of flood forecasting and warning system, evacuation system, flood fighting system, regulation of land use, regulation of activities in the river area, public education, construction of high-floor building, and regulation of land fill of swamp and ponds or low-lying areas.

Flood discharge distribution

In consideration of the present river conditions in the Kone River delta, the design flood discharge should be distributed to the Dap Da, the Nam Yang, the Go Cham, the Tan An, and the Cay My Rivers.

3.7 Agricultural Development Plan

3.7.1 National and Provincial Agriculture Development Policy

In line with the national agricultural development policies,the agriculture and rural development plan in Binh Dinh province for the period from 2001 to 2010 puts its focus on the following points:

1) Sustainable development in view of land, water and biological resources,
2) Increase of crop production through crop diversification to meet local food demand and support processing industry,
3) Raising of living standard in the rural area.

3.7.2 Agricultural Development Plan

(1) Project Area

The project area for irrigation development is demarcated to 54,500 ha through the water balance study within the existing development plan of DARD. The project area is consisting of 24,400 ha of the present irrigation area and 30,100 ha of the rain-fed and other area including unused land.

(2) Present Cropped Area in the Project Area

The present cropping patterns for each land position are estimated, and summarized below:

Flood Condition and Cropping Pattern in the Project Area

Position / Area / Cropping Pattern	Higher A	Middle B	Lower C	Total -
Van Phone Area	16,800 ha	300 ha	0 ha	17,100 ha
Other Schemes under Dinh Binh Dam	3,800 ha	13,200 ha	3,300 ha	20,300 ha
Other Water Resources	17,100 ha	0 ha	0 ha	17,100 ha
Total	37,700 ha	13,500 ha	3,300 ha	54,500 ha

The present cropped area is summarized below:

Present Cropped Area in the Project Area

Land Position	Higher	Middle	Lower	Total
Cropping Pattern	A	B	C	Combined
Total Land	37,700 ha	13,500 ha	3,300 ha	54,500 ha
Irrigation Area	11,800 ha	10,000 ha	2,600 ha	24,400 ha
Paddy	39,400 ha	20,000 ha	5,600 ha	65,000 ha
Maize	7,800 ha	2,700 ha	200 ha	10,900 ha
Groundnuts/ Soybeans	6,100 ha	1,700 ha	200 ha	7,300 ha
Tobacco	400 ha	0 ha	0 ha	400 ha
Sugarcane	5,700 ha	0 ha	0 ha	5,700 ha
Cassava	4,900 ha	1,400 ha	0 ha	6,300 ha
Total Cropped Area	64,300 ha	25,100 ha	6,300 ha	95,700 ha
Cropping Intensity	172%	182%	191%	176%

Source: Estimation by the JICA Study Team based on the Statistics and previous studies.

(3) Basic Concept for Agricultural Development

In the agricultural development plan, the future agriculture land is assumed to be provided with the following conditions under the project:

(i) Irrigation water will be adequately supplied.

(ii) Cultivated land will be protected from the minor, early and late floods except major floods.

(iii) Drainage condition will be improved to remove internal excessive water.

(4) Proposed Cropped Area under the Project

Based on the conditions mentioned above, the future cropping pattern and cropped area is formulated as shown below:

Proposed Cropped Area in the Project Area

Land Position	Higher	Middle	Lower	Total
Cropping Pattern	A	B	C	Combined
Future Irrigation Area	37,700 ha	13,500 ha	3,300 ha	54,500 ha
Paddy	63,900 ha	20,800 ha	5,300 ha	90,000 ha
Maize	12,000 ha	5,500 ha	700 ha	18,200 ha
Groundnuts/ Soybeans	5,200 ha	4,1000 ha	6000 ha	9,900 ha
Tobacco	700 ha	0 ha	0 ha	700 ha
Sugarcane	5,600 ha	0 ha	0 ha	5,600 ha
Pineapple	300 ha	0 ha	0 ha	300 ha
Total Cropped Area	87,700 ha	30,400 ha	6,600 ha	124,700 ha
Cropping Intensity	234%	220%	200%	229%

The future cropped area increase to 124,700 ha from the present cropped area of 95,700 ha. Based on the future cropping area and the anticipated unit yields, the crop production is estimated as shown below:

Production Increment in the Project Area

	Present			Project under Project			Increment (ton)
	Area (ha)	Unit Yield (ton/ha)	Production (ton)	Area (ha)	Unit Yield (ton/ha)	Production (ton)	
Paddy	65,000	2.2-4.3	246,700	90,000	4.7	426,600	179,900
Maize	10,900	1.4-3.3	17,300	18,200	4.5	81,900	64,700
Groundnuts/Soybeans	7,400	0.7-1.5	6,800	9,900	1.9	18,800	12,000
Tobacco	400	0.9-1.5	400	700	1.7	1,200	800
Sugarcane	5,700	34.1-49.7	194,400	5,600	60.0	336,000	141,600
Pineapple	0	-	0	300	20.0	6,000	6,000
Cassava	6,300	6.5	41,000	0	-	0	-41,000
Total Cropped Area	95,700		506,500	124,700		870,500	364,000

3.8 Domestic and Industrial Water Supply Development Plan

The demand areas will be scattered extensively in respective districts, and its locations are not definitive at this stage. Therefore, the plan considers that many piped – systems, each having a water intake in the rivers and/or canal systems, will be established.

The unit construction cost for the facilities is assumed to be generally the same as that of the urban domestic water supply facilities. With this assumption, the construction cost is calculated as shown below:

- Urban Domestic Water supply Quantity 72,459 m^3/day
- Estimated Construction Cost of Urban Domestic Water supply Facilities US$ 25.179 million
- Unit Construction Cost for Urban Domestic Water supply Facilities US$ 381.72 /m^3/day
- Unit Construction cost for Rural Domestic, Rural Industrial and Industrial Zones Water supply Facilities US$ 381.72 /m^3/day

Total water supply requirement for the rural domestic, rural industrial and industrial water in 2020 is assessed to be 375,708 m^3/day.

Thus, the total construction cost except the urban domestic water supply facilities amounts to US$107.72 million.

The whole construction cost including the urban domestic water supply facilities amounts to US$ 132.90 million.

3.9 Flood Control Plan

3.9.1 Major Features of Objective Design Flood

The peak flood discharge of 5% probable late flood at Binh Thanh is 2,997 m^3/s. Since flood peak discharge of 1% probable early flood is 1,521 m^3/s, being much smaller than 5% probable late flood, the design flood peak discharge is defined as the flood peak discharge of 5% probable late flood. Objective design flood hydrograph is shown in Figure S3.13.

3.9.2 Alternative Flood Control Plans

Flood control measures considered in the present study are the Dinh Binh reservoir, a flood retarding basin near the Tyson Town and improvement of the branch rivers in the delta. The combinations of these three measures are studied in the present study for flood control plan.

As a result of the preliminary study, it is found that the flood control plan with the retarding basin and the branch rivers improvement is infeasible due to the small effectiveness. Accordingly the combinations of the Dinh Binh reservoir and the branch rivers improvement are further studied for the optimum flood control measures. The locations of above mentioned measures are shown in Figure S3.14.

3.9.3 Examination on Alternative Flood Control Plans

(1) The flood control volume of the Dinh Binh reservoir is decided from the most economic viable aspect in consideration of the cost of flood control volume and the cost of river improvement in downstream reaches. The flood control volume of the Dinh Binh reservoir thus calculated is 293 MCM. The design discharge distribution to the downstream reaches is, accordingly 1691 m^3/s.

(2) The design discharge distribution thus calculated to the downstream reaches is further distributed to the Dap Da, the Nam Yang, the Go Cham, the Tan An, and the Cay My Rivers. The design discharge distribution among these branches of the Kone River is studied among two alternatives of 1) design discharge distribution proportional to the present discharge carrying capacities and 2) the distribution in increase of discharge carrying capacities of major three branches. Here the alternative 2) is selected from the view point of least work quantities.

3.9.4 Proposed Flood Control Plan

(1) Basic design flood discharge at Binh Thanh is 2,997 m^3/s.

(2) Design flood peak discharge should be decreased to 1,691 m^3/s at Binh Thanh by Dinh Binh reservoir.

(3) The flood control volume of Dinh Binh reservoir should be 293 MCM.

(4) The design flood discharge should be distributed to the Dap Da, the Nam Yang, the Go Cham, the Tan An, and the Cay My Rivers.

(5) The design discharge distribution is shown in Figure S3.15.

3.10 Drainage Plan

3.10.1 Urban Drainage

At present, the urban drainage work is being constructed together with the city road improvement work in Quy Nhon City. The works are the street drain, the street inlet and the underground storm drain to be connected to main drainage streams and rivers.

In the other towns such as Binh Dinh, Phu Phong and Ngo May, the similar projects with it in Quy Nhon City would be implemented soon in future.

3.10.2 Rural Drainage

The rural drainage consists of the drainage for the residential area and it for the agricultural land.

(1) Residential Area

As for the rural residential area, the similar way with the urban drainage would be applied to some limited important places and the improvement of natural drains to make storm-water flow smoothly would be major work in the other rural residential areas.

(2) Agricultural Area

(a) Paddy field area

Drainage plan of the paddy field area such as Tan An – Dap Da would be as follows:

(i) Branching stream from main river

Branching small streams from the main rivers such as the Tan An and the Dap Da for intake of irrigation water, etc. would be closed with the sluices to be constructed at the flood dike improvement or new construction.

(ii) Drainage stream in field

Many drainage streams originating in the area become smaller in the downstream reaches than in the middle stream reaches or some ones disappear in the downstream area because of irrigation water is being taken from those streams. The excavation work for such existing streams would be implemented and partial new drains would be connected to the existing ones. Downstream ends of such drains would connect to the drainage sluices to be constructed at the flood dike improvement or new construction.

(iii) Drainage plan for paddy field

The drainage plan for the paddy field area has been formulated so that the inundation should be solved during the design drainage duration including the high water hours of the main rivers. The design drainage duration has been set at 5 days for drainage of 3-day consecutive rainfall with 10% of probability of occurrence with reference to "Drainage Coefficient for Paddy Fields – Design Criteria (14TCN.60-88)".

(b) Upland Field Area

Drainage of the upland field area would be planned so that inundation might not be caused. Therefore, the peak discharge should be drained without inundation on the field. The design drainage discharge of drains should be determined for the peak runoff from the catchment area caused by 1-day rainfall with 10% of probability of occurrence.

3.11 Study on Alternative Basin Development Plans

3.11.1 Precondition of the Study on Alternative Basin Development Plans

The study on alternative basin development plans is conducted based on the precondition stated hereinafter.

There is information that the power sector of Vietnam contemplates a hydropower development (An Khe-Kanak Hydropower Project) which will transfer the water from the adjacent Ba River basin to the Kone River basin. However, the investigation and study for the project is still rather premature and its realization is considered not definitive yet. Therefore, the study is conducted without considering the water transfer from Ba River basin which is presently contemplated in the power sector.

3.11.2 Examination on Alternative Basin Development Plans

The optimum basin development plan is found through examination on alternative basin development plans.

The process of examination on alternative basin development plans is outlined herein.

(1) Alternative Dam Scales

Alternative dam scales (dam height, effective storage and flood control volume) of the Dinh Binh Dam were set up to find out the most effective dam plan to mitigate flooding damage in the downstream reaches in technical and economic view points as seen in Table S3.4.

(2) Examination of Flood Damage Mitigation Effect of Dinh Binh Dam

Following setting up the alternative dam scales and flood control volumes, the flood control effect of the Dinh Binh Dam for the assumed flood control volume is examined by using the probable major flood hydrograph at the Dinh Binh Dam site.

Relationship between the flood control volume of the Dinh Binh Dam and probable major flood peak discharge at Binh Thanh after regulation by the Dinh Binh reservoir is obtained as shown in Figure S3.16.

Expected flood damage in the downstream basin will depend on the regulated discharge from the Dinh Binh Dam and the flood discharge of the remaining catchment area. Therefore, flood control benefit to be expected by the flood mitigation in the downstream area depends on the flood control capacity of the reservoir, which relationship is obtained as shown in Figure S3.17.

(3) Flood Control Capacity of Dyking System

The objective 5 % probable late flood with the flood peak discharge of 1,960 m^3/s at Dinh Binh Dam site will be fully regulated by the Dinh Binh Reservoir. However, the remaining discharge has to be controlled by the dyking system. As such, the dyking system was provided with the capacity to accommodate the 5 % probable late flood after fully regulated by the Dinh Binh Dam.

(4) Water Balance Analysis

The water balance analysis confirmed whether or not, the respective alternative plans will satisfy the water supply requirement for more than 3/4 period in years out of examined long period for agriculture and fishery demands as well as the river maintenance flow, while 1/10 period in years out of examined long period for the domestic and industry demands.

If the alternative plan cannot meet the water supply requirement with predetermined dependability, the alternative plan dropped in this screening, and further evaluation on this plan is omitted.

(5) Non-dam Plan

In the case of non-dam plan, the water supply source considers freshwater production from sea water which is only the way for water source in the case that the further exploitation of ground water should basically be avoided.

The freshwater production from sea water is considered only for the domestic and industrial water supply requirement, i.e. the agricultural water supply is not considered in view that the freshwater production from sea water for a large quantity of agricultural water requirement would be unrealistic, although the agricultural development target of the basin is disregarded in this case.

(6) Environmental Evaluation

Alternative basin development plans which satisfies the water supply requirement are subject to the environmental evaluation from both the natural and social environmental aspects.

The natural environmental aspects focused on factors such as the precious species, impact on protected areas, impact on lagoon and water quality. The social environmental aspects focused on the impact on resettlement and the important infrastructures such as the national road and railway.

(7) Economic Viability and Overall Evaluation

Alternative basin development plans which were accepted from the environmental aspects are evaluated from the economic aspect.

Economic viability is assessed for the above alternative plans and then, the most recommendable basin development plan is selected through an overall evaluation.

3.11.3 Selection of Basin Development Plan

Table S3.5 summarizes the result of examination on all alternative basin development plans of 26 cases, which were taken up for selection of the optimum one.

Main points of the examination result are specified below:

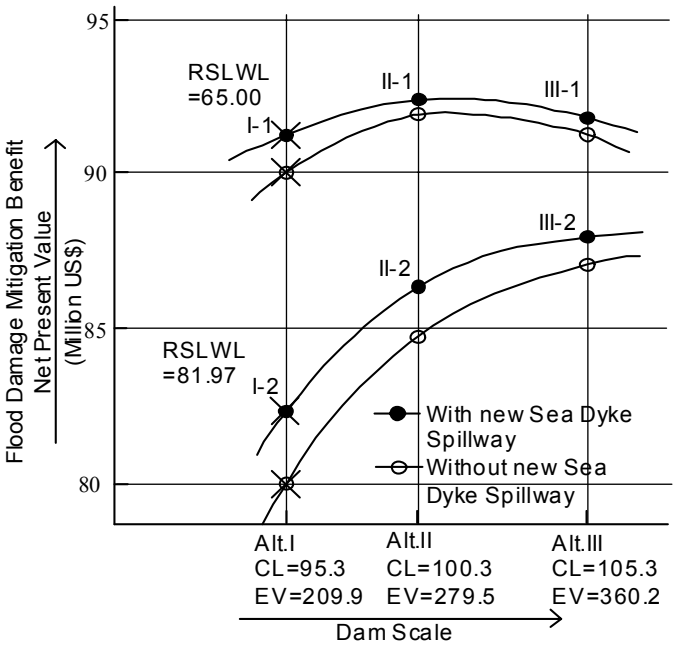
(a) Non- dam Plan

The non-dam plan will not be able to meet the agricultural water supply requirement. Besides that, the non-dam plan will not be feasible economically.

(b) Development scale of Dinh Binh Dam

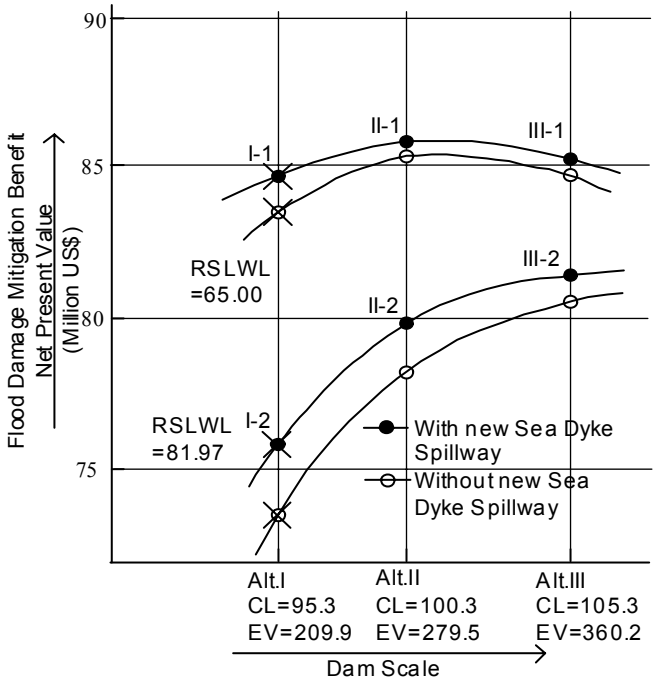
Alternative II-1 that the dam crest level is EL.100.3 m and flood control volume during major flood season is 293 million m^3 will maximize the economic viability in terms of flood damage mitigation effect for the downstream reaches of the Dinh Binh Dam both in upstream and downstream reaches of Binh Thanh. The study indicates that the Dinh Binh Dam with scale smaller or larger than the above development scale, i.e.Dam Alt. II with a maximized flood control volume (Dam Alt II-1), will lessen the economic viability in flood damage mitigation effect. Economic viability calculated for alternative plans are shown below:

(i) Water Transfer to La Tinh River Basin



RSWL: Rainy Season Limited Water Level
CL : Dam Crest Level
EV : Effective Storage (million m ^{3})

(ii) No Water Transfer to La Tinh River Basin



RSWL: Rainy Season Limited Water Level
CL : Dam Crest Level
EV : Effective Storage (million m ^{3})

(c) Effect of Irrigation Water Supply to the La Tinh River Basin

The water supply requirement targeted in 2020 covering the La Tinh River basin will be fulfilled by examined Dam Alternatives II and III, and higher economic viability could be expected when water transfer to the La Tinh basin is included in the plan.

Further detailed evaluation is presented in the Main Report.

The optimum basin development plan which is finally selected and recommended through the examination is summarized below:

Recommended Basin Development Plan

• Alternative Dinh Binh Dam Scale No	:	Dam Alt.II-1
• Dinh Binh Dam Crest Level	:	EL.100.3 m
• Dinh Binh Dam Flood Control Volume	:	292.8 MCM
• Dinh Binh Dam Effective Storage	:	279.5 MCM
• Necessary Capacity of Downstream Dyking System	:	1,691 m^3/s
• New Sea Dyke Spillway	:	To be provided
• La Tinh River Basin	:	Water supply to La Tinh River basin should be included

3.12 Integrated River Basin Management Plan for the Kone River Basin

The Integrated River Basin Management Plan is composed of the water resources development plan and the water resources management plan. Components of the formulated Integrated River Basin Management Plan are shown in Figure S3.18 and function and principal features of each component are summarized in Table S3.6.

3.13 Construction Schedule and Cost Estimate

3.13.1 Construction Schedule of Proposed Major Facilities

An overall implementation program of the major facilities is shown below:

Kone River Basin
Overall Implementation Program of Proposed Major Facilities

Description	Year																		
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1.1 Dinh Binh Reservoir Project																			
1.2 Financial Arrangement																			
1.3 Resettlement																			
1.4 Engineering Services by Consultants																			
2.1 Flood Control Plan																			
2.2 Financial Arrangement																			
2.3 Resettlement																			
2.4 Engineering Services by Consultants																			
3.1 Irrigation and Drainage Facilities																			
3.2 Financial Arrangement																			
3.3 Resettlement																			
3.4 Engineering Services by Consultants																			
4.1 Domestic and Industrial Water Supply																			
4.2 Financial Arrangement																			
4.3 Engineering Services by Consultants																			

3.13.2 Cost Estimate of Proposed Facilities

The cost for the proposed facilities is estimated in due consideration of the construction schedule as shown in Table S3.7, resulting in US$ 720.5 million.

3.14 Evaluation

3.14.1 Technical Evaluation

(1) Dinh Binh Dam

The Dinh Binh Dam planned with a concrete gravity dam of about 55 m in height has no particular technical problems and difficulties, including Accessibility,

Topographic conditions, Geological conditions, and Construction Materials.

(2) Van Phong Weir

The proposed site of Van Phong Weir by HEC-1 is located on the bottlenecked valley in the downstream course of the Kone River, about 38 km downstream of the Dinh Binh damsite. The Van Phong Weir is proposed with a fixed concrete type and has no particular technical problems or difficulties similar to the Dinh Binh Dam.

3.14.2 Environmental Evaluation

Regarding 7 projects/components of the Integrated River Basin Management Plan, namely i) Dinh Binh Reservoir Development, ii) Quarry Site Development for Dam Construction, iii) River Improvement, iv) Irrigation System Development, v) Agriculture Input, vi) Domestic/Industrial Water Plant Installation, and vii) Water Supply System Development, the environmental evaluation was conducted on the various elements of physical, ecological, and social aspects. The conceivable impacts and their magnitude, caused by the selected projects/components, were preliminarily examined. And the main issues to be identified and discussed in the further EIA study in Phase 2-3 are pointed out below:

- Water pollution (turbid/alkaline discharge) mainly due to the construction works of Dinh Binh dam and Van Phong weir,
- Issues concerning Thi Nai swamp and possibility of environmental change of swamp due to the implementation of the priority projects,
- Issues concerning the vulnerable species and likely impacts on forest and terrestrial and aquatic biota due to the implementation of the priority projects,
- Land acquisition, resettlement, and related social impacts mainly due to Dinh Binh reservoir, Van Phong irrigation system, River improvement, etc., and
- Identification of conceivable impacts and their magnitude regarding i) Quarry site development, and ii) Agricultural input (possibility of increment of agro-chemicals and fertilizer), after determining the features of these plans.

In the course of further EIA study including the above, the environmental mitigation measures and monitoring plan are to be developed and proposed.

3.14.3 Economic and Financial Evaluation

(1) Economic Viability

Economic benefits of the project have been estimated as summarized below:

Annual Economic Benefit of Integrated River Basin Management Plan

Benefit item	Qty		US$ m
Agriculture incl. livestock and aquaculture	54,500	ha	23.59
Hydropower generation	37.8	GWh	1.89
Domestic and industrial water supply (2020)	448,000	m3/day	37.52
Flood damage mitigation	5	districts	13.39
Total			76.38

The results of the economic analysis for the Integrated River Basin Management Plan is summarized below:

Results of Economic Analysis for the Integrated River Basin Management Plan

Alternative	EIRR(%)	B/C Ratio	NPV(US$ m)
I-1.3B	15.1	1.52	92.4

Note: B/C and NPV are calculated with a discount rate of 10%.

The results indicate that the Integrated River Basin Management Plan has sufficient economic efficiency with EIRR of 15.1% and Net Present Value (NPV) of US$92.4 million.

Sensitivity analysis also indicates that the Integrated River Basin Management Plan maintains EIRR of more than 10% even under the conditions that 20% increase in costs and 20% decrease in benefits occur simultaneously. Therefore, the project is evaluated viable from the economic point of view.

(2) Financial Evaluation

Financial feasibility of the Integrated River Basin Management Plan is evaluated by examining repayment capability of the capital cost and coverage capability of O&M and replacement costs based on a financial cash flow statement using the anticipated project revenue and fund requirement.

From the financial analysis, the following matters become evident:

- Irrigation fee can fully cover O & M cost of irrigation and dam,
- The revenue from hydropower generation and the domestic & industrial water supply can cover their O & M cost and generate profits,
- For repayment of the loan capital, interest payment, and replacement of major mechanical and electrical facilities after their lifetime, government financial support will be necessary, and

- If a soft ODA loan is applicable for construction of dam, irrigation, and flood control facilities, the annual required fund for the construction and O&M will not be a burden of the Central and Local Governments.

From the above consideration, if a soft loan is applicable, implementation of the project will be financially feasible.

3.15 Conclusion and Recommendation

Major conclusions and recommendations as a result of the study are summarized herein.

(1) The Kone River Basin Plan with the Dinh Binh Multipurpose Reservoir will independently meet the water requirement in 2020 including the La Tinh River Basin.

(2) As a measure for the flood control of the Kone River basin, a dyking system was examined for the downstream reaches of the basin. The examination found that the flood control capacity with the downstream dyking system has a limitation especially due to social impacts in the downstream reaches.

Hence, the flood control target of the Kone River basin requires considering a dam in upstream (the Dinh Binh Dam) in combination with the downstream dyking system.

(3) The optimum combination of the downstream flood control plan and the Dinh Binh Multipurpose Reservoir which also meet the water supply requirement is as follows:

a) The Dinh Binh Dam of a concrete gravity type with,

- dam crest level at EL.100.3 m which is higher by 5 m than the presently planned dam,
- flood control volume of 292.8 MCM, and
- effective storage volume of 279.5 MCM

b) The downstream dyking system with a capacity to accommodate the flood discharge of 1,691 m^3/s.

(4) The formulated Integrated River Basin Management Plan will be justifiable economically.

(5) There are no particular technical difficulties and problems in construction of the Dinh Binh Dam, downstream dyking system or Van Phong Weir, etc.

(6) Some environmental adverse impact will be expected to a certain extent that needs proper basin management plan involving environmental aspect.

(7) The following resettlement is estimated to be required:

a)	Dinh Binh Multipurpose Reservoir	:	616 households
b)	Downstream Dyking System	:	248 households
c)	Van Phong Weir and Canal System	:	713 households
	Total	:	1,577 households

The impact of resettlement is conceivable, however it seems to be inevitable to realize this important and essential project.

(8) A non-dam scheme will not be realistic.

(9) The following three (3) projects are recommended to be selected as the priority projects for which the Feasibility Study is to be conducted in Phase 2-3.

a) Dinh Binh Multipurpose Reservoir Project,
b) Flood Control Project in the Downstream Reaches of the Kone River Basin, and
c) Van Phong Weir as well as Irrigation and Drainage System.

(10) The following the water resources management plan is recommended

(A) Water Use Management Plan

1) Proper management of water demand
2) Latest information management of water resources
3) Proper water allotment under severe drought condition
4) Non-structural measure

(B) Flood control Management Plan

1) Flood warning and communication systems
2) River basin conservation
3) Flood hazard map
4) River management
5) Non-structural measure

(C) River Environment Management Plan

1) Management of the river maintenance flow
2) Water quality control
3) Thi Nai Swamp monitoring

(D) Dam Operation Management Plan

1) Integrated operation of the existing and proposed dams in the Kone River basin

2) Warning and communication system of dam water release

(E) Administrative Management Plan including proposed organization of the Kone River basin management

The non-structural measures incorporated in the management plans, which can be executed at a less cost, are recommended to be implemented at the earliest.

PART 4

Phase 2-3: FEASIBILITY STUDY FOR THE PRIORITY PROJECTS

4.1 Dinh Binh Multipurpose Reservoir Project

4.1.1 Introduction

Based on the Phase 2-2 study which formulates the Integrated River Basin Management Plan for the Kone River basin as presented in PART 3, the following three(3) priority projects have been selected for the Feasibility Study :

a) Dinh Binh Multipurpose Reservoir Project,

b) Van Phong Weir and Irrigation & Drainage System, and

c) Flood Control Project in the Downstream Reaches of the Kone River Basin.

The feasibility study in the Study (JICA Feasibility Study) is carried out for the Dinh Binh Multipurpose Reservoir Project which has selected as one of the priority projects in the Kone River basin.

On the other hand, a feasibility study have already been conducted by HEC1 (existing Feasibility Study (F/S)) as well as the Technical Design (T/D) following the existing Feasibility Study. As such, the JICA Feasibility Study makes a review study on the existing Feasibility Study, duly referring to the Technical Design. Further, it is noted that the JICA Feasibility Study aims at reviewing the existing Feasibility Study and/or the Technical Design in the light of the internationally widely accepted standard.

4.1.2 Necessity and Development Scale of the Dinh Binh Dam

(1) Necessity of the Dinh Binh Dam

The Kone River basin is located in the south central region of Vietnam with a basin area of 3,640km^2. Major part of Kone River Basin is situated in Binh Dinh Province (about 90%).

Floods, which are caused due to heavy rains concentrated in October and November, often attack the downstream areas of the Kone River basin and threaten lives and properties of people as well as the agricultural production. The steep slope and short length of the river seriously increase the damages. Annual losses reportedly amount to tens of billions VND.

On the other hand, despite the significant necessity of water supply for water

demand, including the agricultural water, domestic water, industrial water and environmental flow, etc., the basin suffers from serious drought during the dry season.

Solution of the problems as mentioned above is of keen necessity of the province, and measure for solution is only construction of the Dinh Binh Dam which will mitigate the flood damages during the rainy season and meet the water demand during the dry season.

(2) Development Scale of the Dam

Recommended development scheme through Phase 2-2 study is as follows:

Recommended Development Scheme for the Dinh Binh Dam

a)	Dam type	Concrete gravity dam with gated spillway
b)	Dam crest level	EL. 100.3 m
c)	Flood water level	EL. 98.3 m
d)	Surcharge water level	EL. 97.8 m
e)	Full supply level	EL. 96.93 m
f)	Flood control volume of reservoir	292.77 MCM
g)	Effective storage volume of reservoir	279.51 MCM

4.1.3 Comparative Study and Selection of Damsite and Dam Type

The existing Feasibility Study executed a comparative study on the conceivable alternative damsites and dam types for the Dinh Binh Dam, and recommended to select the alternative Damsite-I and a concrete gravity dam with gated spillway. Locations of alternative sites are shown in Figure S4.1.

The JICA Feasibility Study conducts a review study on this comparative study through his own examination. Result of the review study is presented herein.

A comparative study to review the selection of damsite and dam type is conducted.

The direct construction cost estimated for each case is summarized as follows:

Summary of Estimated Direct Construction Cost

Alternative Damsites	Alternative Dam Types	Dam Crest Level	Direct Construction Cost (million VND)
Damsite I	Concrete Gravity	EL. 100.3 m	392,342
Damsite I	Rockfill	EL. 101.3 m	887,559
Damsite II	Concrete Gravity	EL. 100.9 m	528,052
Damsite II	Rockfill	EL. 101.9 m	916,754

As seen in the table above, the alternative Damsite II makes the construction cost higher due to its wider valley. The rockfill dam is evidently disadvantageous due to the cost necessary for the diversion tunnels. Thus, the review on selection of the damsite and dam type by the JICA Feasibility Study comes to the same conclusion as the existing Feasibility Study and Technical Design; that is, selection of Damsite I and concrete gravity type of dam.

4.1.4 Geological Condition of Damsite

The overburden, 2 to 20 meters and alluvial to residual origin, is subdivided, in terms of the sedimentary processes, origins and compose, into the following 3 layers:

- **Layer 1**: Coarse to medium SAND (SP), loose and pervious, occurring mostly on the riverbed in thickness of 1.0 to 5.0 meters.
- **Layer 2**: Medium-grained clayey SAND (SC), 2 to 3 meters thick, overlying merely on the river terrace.
- **Layer 3**: Gravelly CLAY (CG), soft to firm, covering mainly on the natural slope with a thickness varying from 2 to 20 meters.

The bedrock is dominantly Mesozoic granite with various degrees of weathering. The completely weathered and strongly weathered rocks generally occur in thickness of 2 to 5 meters. The moderately and slightly weathered rocks, fewer joints, have a medium compressive strength and low permeability.

4.1.5 Hydrological Condition of Damsite

(1) General

The hydrological analysis are performed for the whole Kone River basin, including those of respective sub-catchment areas such as Dinh Binh Dam site, Cay Muong, intermediate area, Binh Thanh, Nui Mot, La Vi, Ha Thanh, and delta area, and details of the analysis are presented in PART 3.

(2) Runoff Analysis

Previous water balance studies that have been carried out for the Kone basin (IWRP, 1997-1998 and HEC-1, 2000) made use of the observed runoff series. After a statistical analysis of the runoff characteristics ("flow modules" in $m^3/s/km^2$) of this series, these characteristics were used for the assessment of the probable runoff of other sub-catchments in the basin. The yearly flow distribution, either in months or decades was, derived from the "typical" distribution at Cay Muong station. In this way, typical (synthetic) runoff years with a certain probability of occurrence (50%, 75%, 80%, 85%, 90%) were generated and used in the water balance analysis.

Sufficient information is available for an adequate modelling, calibration and verification of the rainfall – runoff process in the Cay Muong sub-basin. With the help of such model, the runoff series can be generated. For the estimate of the area rainfall, the Thiessen method is applied.

The reproduction of the runoff at Cay Muong on a yearly basis is quite accurate, as is shown in the following table:

Average Yearly Runoff at Cay Muong (m^3/s)

Probability of Exceeding (assuming LN3 distribution)	50%	75%	90%
Historic Series 1978 - 2001	66.4	46.5	31.0
Generated Series 1978 - 2001	65.4	45.6	29.3

In the Study, the water balance in the respective sub-catchment areas is analysed on the basis of the 25 years of historic 10-days runoff series. These series have been generated in accordance with the methodology described above and presented in PART 3.

(3) Flood Analysis

Flood Peak Discharge for Design

As explained in Flood Analysis of Phase 2-2, the "possible underestimate" of the calculated probable peak discharges is considered the difference between the upper confidence limit and the regression line which is taken as the safety margin.

For the 1976 – 2001 series of the yearly instantaneous peak discharges in Cay Muong, the safety factors resulted in the flowing:

- 1.13 for 10% probable peak discharge
- 1.16 for 5% probable peak discharge, and
- 1.21 for 1% probable peak discharge.

Under application of these safety factors, for all types of floods, the flood peak discharges for design at the Dinh Binh Dam site have been assessed. Those are summarized as well as the analyzed flood peak discharge as shown below:

Probability of Flood	Flood peak discharge(m^3/s)		Flood volume(Mm^3)	
	Analyzed	For design	Analyzed	For design
(Major flood)				
10 %	3,380	(3,821)	405	(405)
5 %	3,860	(4,475)	463	(463)
1 %	4,820	(5,832)	594	(594)
0.5 %	5,180	(6,397)	650	(650)
0.1 %	7,068	(7,718)	729	(729)
0.01 %	8,882	(9,578)	907	(907)
PMF	13,900	(15,000)	1,490	(1,490)
(Late flood)				
10 %	1,180	(1,330)	149	(149)
5 %	1,690	(1,961)	196	(196)
1 %	3,370	(4,075)	313	(313)
(Early flood)				
10 %	380	(430)		
5 %	510	(592)		
1 %	820	(992)		

Review on Results of the Previous Flood Analysis

The results of the present flood analysis are compared with the results of previous studies for the review on them.

Earlier studies have, among others, been carried out by IWRP (1997) for the Water Use Planning in the basin, and by HEC-1 (2000) in the framework of the feasibility study of the Dinh Binh Reservoir.

The results of these studies at Cay Muong and Dinh Binh Dam site are summarized in comparison with the present analysis in the Study results as follows:

Peak Discharges at Cay Muong Estimated from Frequency analysis

		Return Period		
		10 years	100 years	200years
IWRP	(series 1976 – 1996, distribution function Pearson-3)	4,917 m^3/s	7,778 m^3/s	
HEC-1	(series 1976 – 1998, distribution function Pearson-3)	4,860 m^3/s	7,860 m^3/s	8,720 m^3/s
JICA	(series 1976 – 2001, several distribution functions)	4,400 m^3/s (4,972 m^3/s)	6,270 m^3/s (7,587 m^3/s)	6,740 m^3/s (8,320 m^3/s)

Estimated Peak Discharges at Dinh Binh

	Return Period		
	10 years	100 years	200 years
IWRP (Flow Cutting Module)	3,604 m^3/s	5,702 m^3/s	
HEC-1 (Integrated Water Concentration Model)		7,300 m^3/s	8,080 m^3/s
JICA (Flow Cutting – Creager))	3,380 m^3/s (3,821 m^3/s)	4,820 m^3/s (5,832 m^3/s)	5,180 m^3/s (6,397 m^3/s)

Note : Figures in bracket show the discharge with the safety factor.

The IWRP and HEC-1 results at Cay Muong are quite similar, certainly when the different length of the observation period is taken into account. The present analysis, however, produces much lower values. It is anticipated that the values calculated by both IWRP and HEC-1 already include a “confidence margin” or "safety factor", in view that the values of the present study with the reasonable safety factor result in quite similar values to those of IWRP and HEC-1.

At the Dinh Binh Dam site, the approach followed by HEC-1 seems to aim at safety, rather than at the accuracy of the estimated peak flows.

(4) Sediment Analysis

It is roughly estimated that on a yearly basis, sedimentation could take place in the reservoir in the order of maximum 100,000 m^3 in average. Thus, the sedimentation in the reservoir for 100 years will approximately be 10,000,000 m^3.

On the other hand, the existing HEC-1's F/S sets the sediment level or the dead storage level at EL. 65.0 m at which the dead storage volume of the reservoir is measured to be 16,300,000 m^3, having a sufficient allowance for sedimentation for 100 years, and the dead storage level of EL. 65.0 m is considered to be properly planned.

The following, however, is noted in connection of the estimate of the sedimentation:

Although the estimate of sediment yield is based on the actual measurement data at Cay Muong, the estimated volume seems to be small compared with other similar river basins, and it is recommended that the actual sediment volume in the existing reservoirs is measured for confirmation of the estimated sediment yield.

4.1.6 Design of Major Structures

The dam design has been thoroughly reviewed in the light of the widely accepted design standard. Details of the review are presented in the Main Report. The review found that the dam design conducted by HEC-1 is almost reasonable. However, the following rearrangement is necessary:

1) Revision of the dam downstream slope from 1 to 0.75 to 1 to 0.80 is required to meet all requirements for dam stability.

2) The usual concrete gravity dam should be considered for the dam structure proposed to be constructed with concrete boxes filled with compacted earth materials in both the abutment portions, since the concrete box structure will not result in less cost and will not have any merits.

3) The dam block arrangement which is made with a large width of 24m to 37m should be rearranged with the standard width of 15m to avoid trouble/inconvenience to be caused by a large block width.

4) Rearrangement of the spillway and the bottom outlets, resulting from the dam block rearrangement, becomes necessary.

5) A slight adjustment for alignment of power intake and waterway is necessary to avoid the negative pressure to be caused due to water hammer.

The Dinh Binh Dam design proposed through the review in the Study is shown in Figures S4.2 to S4.5

4.1.7 Construction Time Schedule

(1) Original Schedule

The construction period of civil works including hydropower plant is estimated at 5.0 years in the existing Feasibility Study Report. While examination found that the construction period of 5.0 years for the proposed Dinh Binh Multipurpose Reservoir would be reasonable.

The proposed construction time schedule for Dinh Binh Multipurpose Reservoir is shown in Figure S4.6.

As seen in the figure, the mobilization will be at the beginning of F/Y 2007 and the completion of the Dinh Binh Dam will be at the end of F/Y 2011.

(2) Accelerated Schedule

The completion of the Dinh Binh Dam based on the ordinary construction time schedule will be at the end of the F/Y 2011 as shown in Figure S4.6, while its earlier completion is strongly requested in view of extremely high urgency of the Dinh Binh Dam. Therefore, an accelerated time schedule is examined by considering a physically possible squeeze of time schedule hereunder.

The period from the mobilization of the contractor to the completion of the whole Dinh Binh Dam construction work is shortened from 5.0 years in the ordinary

schedule to 2.50 years in the accelerated schedule. Major arrangement for shortening the construction period is reduction of river diversion work from 3 times in the ordinary schedule to 2 times in the accelerated schedule. Further,

the following arrangement was taken into consideration in the accelerated schedule:

1) The working hours of 12 hours ×2 shifts/day were employed for the dam work, while 8 hours × 2 shifts/day was considered in the original schedule.

2) The work was assumed to be executed without holidays.

The accelerated schedule is shown in Figure S4.7(1) and S4.7(2). The completion of the Dinh Binh Dam in the accelerated schedule is facilitated by 2.5 years from the end of F/Y 2011 in the ordinary schedule to the middle of June, 2009. The above accelerated schedule is based on the assumption that all necessary process such as 1) financing process, 2) government's approval on bid evaluation report, 3) donor's concurrence on bid evaluation report, 4) contract negotiation, 5) government's approval on the contract, and 6) donor's concurrence on the contract, etc. will be handled smoothly without any problems, comments, time loss and repetition, etc. However, referring to the past examples, each process should have some allowance, and it is considered reasonable to consider the ordinary schedule in the planning stage.

4.1.8 Project Cost

The total project cost is estimated at 520,910 million VND equivalent to 34.6 million US$ in foreign currency portion and 928,504 million VND equivalent to 61.6 million US$ in local currency portion, in total 1,449,414 million VND equivalent to 96.2 million US$.

Disbursement of the project cost is shown in Table S4.1.

4.1.9 Examination on Two- Step Implementation of Dinh Binh Multipurpose Reservoir Project

(1) General

The Study has examined the optimum development scale of the Dinh Binh Dam and determined its development scale with the crest level at E.L 100.3 m which is higher by 5.0 m than the dam height proposed in the existing Feasibility Study.

In implementing the Dinh Binh Dam with the above optimum development scale, the Government of Vietnam wished to know how the resultant project viability would be, if the project will be implemented by two steps by some reasons such as difficulty in financial arrangement, etc.

In response to the request, the project viability is examined for the case of the following two-step implementation:

1) First step : Construction of the Dinh Binh Dam with the crest level at E.L 95.3 m

2) Second step : Heightening the dam up to the crest level of E.L 100.3 m

(2) Comparison of Cost between Non-stepwise and Stepwise Implementation

The total project cost including the indirect cost of two-step implementation will be 116.1 Mil.US$ against 96.2 Mil.US$ for the non-stepwise implementation, indicating an increase of about 20.7 %.

(3) Economic Evaluation

The result of the economic analysis is summarized in comparison with the economic viability of those of the non-stepwise implementation below.

Economic Indicators	Non-stepwise Implementation	Stepwise Implementation
EIRR	11.9 %	11.7 %
B/C	1.22	1.19
NPV(Million US$)	21.7	19.0

As seen in the above table, the economic viability in the stepwise implementation will considerably become less compared with the non-stepwise implementation due to the cost increase and delay of accrual of the benefits, and therefore, it is recommendable for enhancing the effect of the project to make arrangement so as to execute the project without phasing.

4.2 Van Phong Weir and Irrigation & Drainage System

4.2.1 General

(1) Project Area for Irrigation Development

The project area is selected in the master plan as the irrigation development area under the Binh Dinh reservoir, as shown below:

Irrigation Schemes under Feasibility Study

Name of Schemes	Total Area	Irrigated	Rainfed
1. Van Phong Weir	17,112 ha	3,299 ha	13,813 ha
2. Other Schemes under Binh Dinh Reservoir	20,245 ha	12,413 ha	7,912 ha
Total	37,357 ha	15,712 ha	21,725 ha

(2) Demographic Condition of the Project Area

Administratively, the project area falls under 57 units of wards, sub-towns and communes in Qui Nhon City and 6 districts of Phu My, Vinh Thanh, Phu Cat, Tay Son, An Nhon, Tuy Phuoc, where the total administrative area is about 1,630 km^2.

Population in 1999 in the project area is 665,100 at average family size of 4.6 members. Average population density is 409 persons/km^2.

(3) Present Land Use

Agricultural land extending over the project is 56,700 ha, as presented below:

Present Land of the Project Area (2000)

Agriculture Land	Forest Land	Special Use Land	Residence Area	Unused Land	Total
56,700 ha	31,200 ha	14,100 ha	3,000 ha	58,300 ha	163,100 ha
34.8%	19.0%	8.7%	1.8%	35.7%	100.0%

Source: Data Set of Binh Dinh Land Use General Inventory in 2000, Land Office.

Annual crop land is 41,300 ha, of which paddy field is 29,400 ha and upland crops fields is 11,300 ha, as shown below:

Agriculture Land of the Project Area (2000)

	Annual Crops	Misc. Garden	Perennial Crops	Aqua-culture	Total
Total	41,300 ha	7,100 ha	6,400 ha	1,900 ha	56,700 ha
(Proportion)	72.8%	12.5%	11.3%	3.4%	100.0%

Source: Data Set of Binh Dinh Land Use General Inventory in 2000, Land Office.

(4) Agricultural Development Plan

Basic Concept of Agricultural Development Plan

The agricultural development plan follows the basic concept of irrigation development formulated in the master plan.

Present Cropped Area in the Project Area

The present cropping patterns in each land position are assumed and the cropped area is estimated as shown below:

Present Cropped Area in the Project Area

Land Position	Higher	Middle	Lower	Total
Cropping Pattern	A	B	C	Combined
Total Land	20,500 ha	13,600 ha	3,300 ha	37,400 ha
Paddy	14,700 ha	20,000 ha	5,600 ha	40,300 ha
Other annual crops	8,700 ha	3,500 ha	700 ha	13,000 ha
Sugarcane & Cassava	7,300 ha	1,300 ha	0 ha	8,600 ha
Total Cropped Area	30,700 ha	24,800 ha	6,300 ha	61,800 ha
Cropping Intensity	150%	182%	191%	165%

Source: Estimation by the JICA Study Team based on the Statistics and previous studies.

Future Production under the Project

After implementation of the project, the irrigation area will expand 37,400 ha from the existing 15,700 ha, and the future cropping pattern and cropped area are formulated as shown in below:

Proposed Cropped Area in the Project Area

Land Position	Higher	Middle	Lower	Total
Cropping Pattern	A	B	C	Combined
Future Irrigation Area	20,500 ha	13,600 ha	3,300 ha	37,400 ha
Paddy	35,000 ha	20,500 ha	5,300 ha	60,800 ha
Other annual crop	9,900 ha	9,500 ha	6,700 ha	20,700 ha
Sugarcane & Pineapple	3,300 ha	0 ha	0 ha	3,300 ha
Total Cropped Area	48,200 ha	30,400 ha	6,600 ha	84,800 ha
Cropping Intensity	235%	220%	200%	227%

Incremental Cropped Area under the Project

The future cropped area increase to 84,800 ha from the present cropped area of 61,800 ha. Based on the future cropping area and the anticipated unit yields, the crop production is estimated as shown below:

Production Increment in the Project Area

	Present			Project under Project			Incre-men t
	Area (ha)	Yield (ton/ha)	Prod. (ton)	Area (ha)	Yield (ton/ha)	Prod. (ton)	(ton)
Paddy	40,300	2.6-6.5	152,700	60,800	5.0	305,300	130,200
Other Annual Crops	12,900	0.7-3.3	18,300	20,700	1.7-4.5	72,300	54,000
Sugarcane/ Pineapple	4,000	34.1-49.7	136,300	3,300	60 / 20	186,000	43,700
Cassava	4,600	7.0	32,200	0	-	0	-32,200
Total Cropped Area	61,800		361,900	84,800		563,600	201,700

4.2.2 Comparative Study and Selection of Weir Site and Weir Type

(1) Alternative Weir Sites

The comparative study about the alternative weir sites has been made for the following two (2) alternative sites.

Site-I (HEC-1)

Site-I in this Study is the same as Site-I proposed by HEC-1 in the Feasibility Study report (No.444C-05-TT2, June 2000). It is located about 5 km upstream from Phu Phong Town in Tay Son District. The site is near the Cay Muong Hydrological Monitoring Station and at foot of Nui Mot Hill.

The curve of meandering around Site-I is leftwards and the peak of the curve is positioned about 500 m upstream from Site-I. The curve changing point to the right side is about 200 m downstream from Site-I. It means that the intake structure is to be positioned at inside of the curve where the sedimentation of sand has been caused in about 200 m width.

Therefore, the common design criteria prescribe that the intake facilities site should be selected at the outside of meandering curve and at a little downstream point of the peak of the curve.

It would be better to shift the weir site to avoid the sedimentation to be caused in front of the intake facilities.

Site-II (JICA Team)

Site-II (JICA Team) used in this Study is located between Site-I and Site-II proposed by HEC-1 in the Feasibility Study report. It is located about 1 km upstream from Site-I and about 1.3 km downstream from Site-II (HEC-1).

The curve of meandering around Site-II (JICA Team) is rightwards and the peak of the curve is positioned about 200 m upstream from Site-II (JICA Team). The curve changing point to the left side is about 400 m downstream from Site-II (JICA Team).

(2) Selection of Weir Site

Site-II (JICA Team) was regarded as the optimum site and selected for the site of the Van Phong Weir on the basis of the sediment distribution in the present river valley.

(3) Alternative Weir Types

The following four (4) alternative types at Site-II (JICA Team) have been selected for the comparative study.

(i) Concrete fixed spread foundation type

(ii) Concrete fixed floating type

(iii) Concrete spread foundation type with rubber weir

(iv) Concrete floating type with rubber weir

(4) Comparative Study and Selection

The result of the cost comparison is summarized in the following table, in which the concrete fixed spread foundation weir (2A) shows the lowest cost.

Cost Comparison by Weir Type

(unit: million VND)

Work Item	1A. Fixed, Spread Foundation	1B. Fixed, Floating	2A. Rubber, Spread Foundation	2B. Rubber, Floating
Earth works	5,328	6,045	5,575	6,069
Concrete works	97,108	149,615	93,068	144,408
Sheet pile works	0	8,377	0	8,377
Foundation pile works	0	3,746	0	3,370
Foundation grouting works	7,081	0	7,081	0
Rubber weir	0	0	13,448	13,448
River dike works	5,885	5,885	4,059	4,059
Total	115,402	173,668	123,231	179,731

Through the above comparative study, the concrete fixed spread foundation type weir has finally been selected from the technical and economical viewpoints.

4.2.3 Design of Major Structures

General features of the major structures including the weir body, the scouring sluice, the apron and the intake facilities are described below and shown in Figure S4.8.

(1) Weir Body

The weir body is made of the concrete. The cross-section is the trapezoid-shape with the vertical upstream surface, 3.0 m crest length with overflow stream line and the inclined downstream surface with a slope of 1:0.7. The bottom is the spread foundation on the base rock. The downstream slope toe forms the bucket to smoothly connect with the downstream apron. The weir height would vary from 18.5 m to 7.5 m depending upon the base rock depth.

(2) Scouring Sluice

The scouring sluice would be constructed at the left side end in connection with the fixed weir. The scouring sluice part would be separated from the fixed weir part with the guide wall.

The scouring sluice gates would be two (2) steel slide gates of B 2.75 m x H 2.75 m with the four-side water tightness.

(3) Apron

The upstream apron would not be considered. The downstream apron would be constructed on the base rock foundation in connection with the bucket at the downstream slope toe of the weir body. The floor level of the apron would be the same as the downstream base rock surface level. The length of the apron would be 5.0 m and the thickness 1.0 m. The same concept would be applied for the apron of the scouring sluice.

(4) Intake Facilities

The intake facilities would be constructed through the left side wall at just upstream point of the scouring sluice gate. The intake surface would be set on the same surface as the side wall so that the unnecessary space might not be made, where the sediments would remain even after the scouring activity. The intake flow direction would be perpendicular to it of the scouring sluice.

(a) Intake Gate

The intake gates would be two (2) steel slide gates of B 3.00 m x H 3.00 m with the four-side water tightness.

(b) Settling Basin

The settling basin of natural flushing type would be constructed with required dimensions in connection with the downstream end of the intake box culvert after the intake gates.

(c) Discharge Measurement Device

The discharge measurement device would be constructed between the end of the settling basin and the beginning point of the Van Phong Main Canal. The broad-crested overflow measuring weir would be installed in the rectangular concrete flume portion.

4.2.4 Geological Conditions and Geotechnical Parameters for Weir Design

The geological conditions and the geotechnical parameters for the Van Phong weir are summarized as follows:

- Strongly to moderately weathered granite (C_L to C_M) as the foundation rock.
- Lugeon value less than 10 (of over 80%).
- Compressive strength over 20,000 kN/m^2.
- Cohesion c = 10 kgf/cm^2=1,000 kN/m^2 (C_L grade rock).
- Internal friction angle ϕ = 30 degrees.
- Horizontal seismic coefficient K_h = 0.12.

4.2.5 Irrigation and Drainage System

(1) General

The objective area of irrigation, drainage and farm road system development in this Feasibility Study has been selected through the Master Plan Study. The selected area has in principle been limited to the irrigable area with the water from the proposed Dinh Binh Reservoir. The following irrigation systems would receive the water from the Dinh Binh.

Irrigation Systems under Dinh Binh Reservoir (Unit: ha)

	Irrigation System	Category	Net Area
(i)	Van Phong Proper	R&I, N	10,815
(ii)	Van Phong Extension (La Tinh)	N	3,297
(iii)	Tan An - Dap Da	R&I, I, N	14,532
(iv)	Tan An Extension (Lower Ha Thanh)	I, N	2,039
(v)	Vinh Thanh	R&I, N	1,017
(vi)	South West Kone	N	2,657
	Total		34,357

Note. R: Rehabilitation, I: Improvement, N: New Development

The Van Phong Extension (La Tinh) System would partly use the existing canals of the Cay Gai System and the Cay Ke System in the La Tinh area. Therefore, the existing La Tinh areas of 3,000 ha, which are irrigated with the water from the Hoi Son Reservoir, would be added to the above as the rehabilitation and improvement area. Including this, the total project area becomes about 37,400 ha in net.

Objective of Irrigation Development

The major objectives of the irrigation development would be summarized as follows:

(i) Improvement of irrigation efficiency to save the water
(ii) Improvement of efficiency in operation and maintenance to create the time for improvement of the living standard

Premise of Project

The major premise of the irrigation development project would be the realization of the proposed Dinh Binh Reservoir because of the present water shortage in the existing irrigation schemes of the Tan An – Dap Da.

Development Concept

The development concept has been formulated with the three (3) categories in consideration of the economical effectiveness of the project as follows:

Irrigation System's Area by Category (Unit: ha)

	Category	Net Area
(i)	Improvement of existing functioning systems	16,200
(ii)	Rehabilitation and improvement of non-functioning systems	3,400
(iii)	Development of new systems	17,800
	Total	37,400

Note. Above areas are based on the on-farm system's level including 500 ha in Tan An Extension area, where on-farm systems could be used only with improvement and without rehabilitation.

(2) Irrigation System

The following six (6) irrigation systems (34,400 ha) would be executed in the direct relation to the proposed Dinh Binh Reservoir.

(i) Van Phong Proper Irrigation System
(ii) Van Phong Extension (La Tinh) Irrigation System
(iii) Tan An – Dap Da Irrigation System
(iv) Tan An Extension (Lower Ha Thanh) Irrigation System
(v) Vinh Thanh Irrigation System

(vi) Southwest Kone Irrigation System

In addition to the above, the existing irrigation systems under the Hoi Son Reservoir (3,000 ha) in La Tinh would be improved for convenience in execution of the Van Phong Extension (La Tinh) System.

General features of the respective projects for the above-mentioned irrigation systems are as follows:

Van Phong Irrigation System

The proposed Van Phong Irrigation System of 10,815 ha would be grouped into two (2) areas. One is the area of 10,484 ha to be irrigated by gravity with the water from the proposed Van Phong Weir. The other is the area of 331 ha to be irrigated by the existing three (3) pumping stations namely the Dai Binh (45 ha), the Thi Lua (226 ha) and the Ngai Chanh (60 ha).

Van Phong Extension (La Tinh) Irrigation System

The Van Phong N1 Canal would function like a main canal for the Van Phong Extension (La Tinh) System. Therefore, for discussion of the Van Phong Extension (La Tinh) System, the point of the boundary that is positioned at 4.1 km from BP. of the N1 Canal would be considered to be BP. of the portion in the Extension System of the N1 Canal (Van Phong N1 Extension Canal).

(a) Water supply to Cay Gai Right Main Canal

The N1 Canal would cross under the Cay Gai Right Main Canal at 1.3 km point from the boundary (BP. of Van Phong N1 Extension Canal). A supply canal would branch at just upstream point of the siphon to the right bank side (eastwards) to connect the Cay Gai Main Canal at 1.5 km downstream where the water level of the Cay Gai Main Canal becomes low enough to receive the water from the N1 Canal.

(b) Water Supply to La Tinh River

The Van Phong N1 Extension Canal would cross under the La Tinh River at 2.3 km point with a siphon. A diversion structure from the Van Phong N1 Extension Canal to the La Tinh River would be constructed at just upstream point of the siphon.

(c) Pumping Station for Phu My Irrigation Area

After crossing the La Tinh, the Van Phong N1 Extension Canal would run northeastwards. Then, it would reach a proposed pumping station for the Phu My irrigation area at 8.4 km point.

Tan An – Dap Da Irrigation System

The Tan An – Dap Da Irrigation System would be composed of 10 irrigation systems after the project or after the integration. Out of the 10 systems, five (5) systems would take the water from the Dap Da River, three (3) are from the Go Cham River and two (2) are from the Tan An River. Major systems are as follows:

Major Irrigation Systems in Tan An - Da Da after Projec (Unit: ha)

	Irrigation System	Net Area
(i)	Tach De Right (Gravity) from Dap Da River	3,800
(ii)	Lao Tam Left from Dap Da River	750
(iii)	Thap Mao Right (Gravity) from Go Cham River	1,670
(iv)	Thanh Hoa Right from Tan An with Thanh Hoa I & II	6,650

Details of the integration or the intake unification are shown in Figures S4.9 and S4.10.

Tan An Extension (Lower Ha Thanh) Irrigation System

The Tan An Extension (Lower Ha Thanh) Irrigation system would be composed of two (2) irrigation systems. The canals would be connected with downstream ends of the Thanh Hoa I canal and Thanh Hoa II canal, respectively.

Irrigation Systems in Tan An Extension (lower Ha Thanh (Unit: ha)

	Irrigation System	Net Area
(i)	Thanh Hoa I Right from Tan An River	1,580
(ii)	Than Hoa II from Tan An River	460
	Total	2,040

Vinh Thanh Irrigation System

The Vinh Thanh Irrigation System would receive the water directly from the proposed Din Binh Reservoir. The irrigation area would be the sloping right bank field of the Kone River. The irrigation area would be 1,020 ha.

Southwest Kone Irrigation System

The Southwest Kone Irrigation System would be composed of six (6) pumping irrigation systems along the Kone River.

Irrigation Systems of Southwest Kone (Unit: ha)

	Irrigation System	Net Area
(i)	Huu Giang	350
(ii)	Huong Giang	310
(iii)	Binh Hoa	350
(iv)	Binh Ke	1,320
(v)	Hoa Lac	150
(vi)	Hon Gach	180
	Total	2,660

Only the Hon Gach Irrigation System would be located on the left bank side of the Kone River and others be on the right side.

Irrigation Facilities Design

Preliminary design of the irrigation facilities such as canals and related structures has been made with reference to "Irrigation Canal Scheme – Design Criteria (TCVN 4118-85)" and HEC-1's design drawings.

The design gross unit irrigation water requirement to determine the capacity of the irrigation facilities has been estimated to be 1.62 l/s/ha that is the peak requirement with 75% dependability for the cropping pattern B and at 2010 year irrigation efficiency level.

Consequently, taking a safety allowance for the future condition into account, this 1.62 l/s/ha has finally been selected to be applied for all the areas of this feasibility study.

4.2.6 Construction Time Schedule for Van Phong Weir and Irrigation and Drainage System

The construction period for Van Phong weir and irrigation and drainage system is estimated at 5.0 years.

The construction time schedule includes mobilization, preparatory works, civil and building works.

The proposed construction time schedule for Van Phong weir and irrigation and drainage system is shown in Figure S4.11.

4.2.7 Project Cost of Van Phong Weir and Irrigation and Drainage System

The total project cost is estimated at 740,893 million VND equivalent to 49.2 million US$ in foreign currency portion and 1,174,439 million VND equivalent to 77.9 million US$ in local currency portion, in total 1,915,332 million VND equivalent to 127.1 million US$. Disbursement of the project cost are shown in Table S4.2.

4.3 Downstream Flood Control Plan

4.3.1 Thi Nai Swamp

Based on the design discharge distribution shown in Figure S4.12, the design high water level and design dyke elevation are calculated and the proposed design longitudinal profile of the swamp is shown in Figure S4.13.

No excavation nor the width widening is proposed in the Thi Nai swamp since the influence of those plans are very limited in the whole reaches of the objective five rivers. At the same time, the widening of the swamp is not considered in consideration of the intensive shrimp culture along the swamp.

4.3.2 River Improvement Plan

In planning the river improvement plan of the Dap Da, the Go Cham, and the Tan An Rivers, two alternatives are studied: 1) to keep the present river dyke alignment to avoid the people's resettlement as much as possible, 2) to widen the present river width to lower the design high water level to moderate level. According to the result, the design high water level should be heightened too much with the alternative 1 in some reaches. But in some reaches, the design high water levels are not much different between said two alternatives. Accordingly the compromise plan with the said two alternatives is adopted. Namely the river widening is planned in some special reaches and the present river alignment is kept in the other reaches.

Regarding the Nam Yang River and the Cay My River, the river improvement plans are prepared with the case of keeping the present river dyke alignment since the design discharge distribution is planned basically with the present river channel discharge carrying capacities.

4.3.3 Side Overflow Weir

(1) General

One of the basic requirements of the river improvement plan is that the river dyke to be constructed against the design discharge distribution of 5 % late flood should be safe against 10 % major flood by providing the side overflow weir along the

objective rivers.

The side overflow weir is studied and planned for the Dap Da, the Go Cham and the Tan An Rivers, since the excess flood water is to be distributed to these major branch rivers.

(2) Design Discharge Distribution

The proposed design discharge distribution is shown in Figure S4.12.

(3) Features of Overflow Weir

The proposed locations of the overflow sites are shown in Figure S4.14. The length of the overflow weirs are as follows:

1) The Dap Da : 210m and 185m
2) The Go Cham : 50m and 60m
3) The Tan An : 115m, 96m and 190m

The crown elevation of the overflow weirs are generally the elevation of deign high water level at the site.

(4) River Profiles

Based on the new discharge distribution for the safety of the river dyke against 10% major flood, the height of the river dyke should be raised from the proposed river dyke height for 5% late flood. The necessary heightening of dyke is about 30cm in average. Thus prepared design longitudinal profiles and design cross-sections of the objective 5 branch rivers are shown in Figures S4.15 – S4.24.

(5) Drainage of Kone River Delta

The present situation of inundation in the Kone River delta would change after completion of the proposed flood control plan of the Kone River delta. The inundation condition would change to rather severe one with floods bigger than the 5% late flood.

Accordingly it is proposed to construct additional spillways to letdown the inundation situation with the flood control plan. Presently the total length of the spillways along the Thi Nai swamp on the objective river area from the Cay My River to the Dap Da River side is about 1,230m. Here it is proposed to construct additional spillway with the same total length of the spillways at around 12 locations.

4.3.4 Construction Plan

The construction period for the proposed downstream flood control plan is assumed to be 5.0 years.

The proposed construction schedule for downstream flood control plan is shown in Figure S4.25.

4.3.5 Cost Estimate of Downstream Flood Control Plan

The total project cost is estimated at 518,395 million VND equivalent to 34.4 million US$ in foreign currency portion and 907,690 million VND equivalent to 60.2 million US$ in local currency portion, in total 1,426,085 million VND equivalent to 94.6 million US$.

Breakdown of the project cost is shown in Table S4.3.

4.4 Environmental Impact Assessment

4.4.1 Impact Prediction and Assessment

As the results of the examination and prediction of environmental impacts, the following are enumerated as un-negligible adverse effects to occur:

- Turbid/alkali water flow from construction sites: In construction stage, turbid water flow may occur from construction sites according to earthworks. High alkali water may flow due to concrete works as well.
- The possibility of eutrophication in the Dinh Binh reservoir: The occurrence of eutrophication in Dinh Binh reservoir cannot be denied completely judging from the current water quality and runoff discharge in the Kone river.
- Water quality degradation in the Kone river: The increase of agricultural input as well as wastewater from domestic and industrial water use will bring about the degradation of water quality in the Kone river unless any appropriate countermeasures are undertaken.
- Habitat disturbance on aquatic ecology in the Kone river: The construction of Dinh Binh dam and Van Phong weir may cause the habitat disturbance of aquatic biota, including the disconnection of longitudinal connectivity, which may adversely impact on the ecology of migratory fish such as eels (*Anguilla marmorata*).
- Reduction of nutrient supply to Thi Nai swamp: Due to the existence of Dinh Binh dam and Van Phong weir, the deposition of sediment load and nutrients

supplied from upstream reaches will occur. This may adversely impact on aquatic ecology, including the fish production and aquaculture in the swamp.

- Land acquisition and resettlement: The expected households to be resettled due to Dinh Binh dam, river improvement, and irrigation system will amount to approximately 600, 250, and 700, respectively. The lands under cultivation will be also acquired by the projects' implementation. These impacts are inevitable, and to be managed properly.
- Social and communal issues: There is a possibility that the priority projects would induce social negative impacts such as the communal conflict in the resettlement sites, difficulty of livelihood restoration, etc.
- Impact on fishery conditions and resources in Thi Nai swamp: Due to the priority projects' implementation, there is a possibility of the physical and ecological changes in Thi Nai swamp. This would bring about the negative impacts on fishery conditions and resources in the swamp.

4.4.2 Environment Management Plan

(1) Environmental Mitigation and Monitoring Plan

Mitigation measures and monitoring activities are to be undertaken properly especially for the un-negligible adverse effects to occur. The following are the possible mitigation measures and monitoring activities proposed:

- Turbid/alkali water flow from construction sites: Afforestation, planting grasses, installation of deposition pond should be carried out as required. The phenomenon of turbid/alkali water flow from construction sites are to be monitored.
- Eutrophication in the Dinh Binh reservoir: Thorough clearance of existing trees, bushes and others on the reservoir bed should be executed before the water storage to minimize the possibility of eutrophication. The water quality in the Dinh Binh reservoir is to be monitored in O/M stage.
- Water quality degradation in the Kone river: Water quality control including wastewater treatment for domestic and industrial water use should be introduced. Consideration in agricultural input based on Integrated Pest Management (IPM) is also effective for minimizing the degradation of water quality. The water quality in the Kone river is to be monitored in O/M stage.
- Habitat disturbance on aquatic ecology in the Kone river: Due consideration in design of dam, weir and river improvement, especially for the creation of

favorable condition for aquatic biota is essential. Inventory of aquatic biota is to be conducted in O/M stage. Migratory fish, especially eels (Angulla marmorata) should be focused on in the inventory.

- Reduction of nutrient supply to Thi Nai swamp: This impact is inevitable to some extent as far as the project is implemented. Monitoring of aquatic biota for further information is to be carried out in the swamp for the effective countermeasure.
- Land acquisition and resettlement: Regarding Dinh Binh dam project, it is essential to implement the resettlement action plan prepared already by PPC, in parallel with the public consultation before and after the resettlement action. Regarding the river improvement and irrigation system, it is necessary to prepare and implement a plan in the same manner as Dinh Binh dam case.
- Social and communal issues: It is essential to cope with solution of social/communal conflicts and stabilization of affected households' livelihood, which would be caused through the resettlement action.
- Impact on fishery conditions and resources in Thi Nai swamp: This impact is inevitable to some extent as far as the project is implemented. Monitoring of catch amount and production in the swamp is to be carried out together with the monitoring on natural environment.

(2) Proposed Direction of Management on Social Impact

Dinh Binh dam: Resettlement action plan for Dinh Binh dam project has been already prepared by the Resettlement and Relocation Management Board (RMMB) and authorized by the provincial people's committee. It can be said that the prepared plan presents enough schemes especially on the physical layouts and support for the resettlement action itself. Public hearing/consultation on the project was also held many times since 1999. However, it is proposed to give more consideration on i) definition of cut-off date for avoiding confusion of eligibility, ii) necessary support for minimizing social conflicts including the ethnic minority issues, and iii) monitoring activities on resettlement action and stabilization of livelihood. RRMB is considered to be a key body and is proposed to cover the scopes on i) monitoring and evaluation activities, ii) direct support and assistance to the households who are severely faced with difficulty on restoration and stabilization, and iii) liaison and/or coordination work function.

Irrigation system development and river improvement: Irrigation system development and river improvement work have a characteristic basically as

linear-shape development. This means that the set-back type shifting is a preferable resettlement manner since i) the communal society will not be suffered from the serious social conflicts or destruction, and ii) the local people does not have an expectation to move a far area. Based on the above understandings, such direction is proposed to be integrated into the resettlement action plan, as i) basic application of cash-compensation manner, ii) support/assistance for restoration of living condition of affected households, and iii) due consideration to be paid on the experiences of Dinh Binh dam case including public hearing, monitoring/evaluation, and establishment of a board for managing resettlement action.

4.4.3 Environmental Evaluation and Recommendations

Considering the environmental evaluation in the Study, the following recommendations are presented for the environmental sustainability of the projects:

(1) The environment mitigation measures and monitoring activities proposed in environmental management plan should be certainly followed. A project executing body is to be under responsibility on it.

(2) The project executing body will require the cooperation and instruction from relevant organizations/agencies in order to accomplish the above.

(3) The directions of management on social issues should be followed in order to promote the socially acceptable resettlement and livelihood stabilization of the affected households. Public consultation and monitoring are also essential.

(4) According to the legal EIA procedure mentioned in Circular No. 490/1998/TT-BKHCNMT, the EIA report(s) on Dinh Binh dam project and irrigation development project should be prepared by MARD, and be submitted to and reviewed by MOSTE (new MONRE) before the projects' implementation.

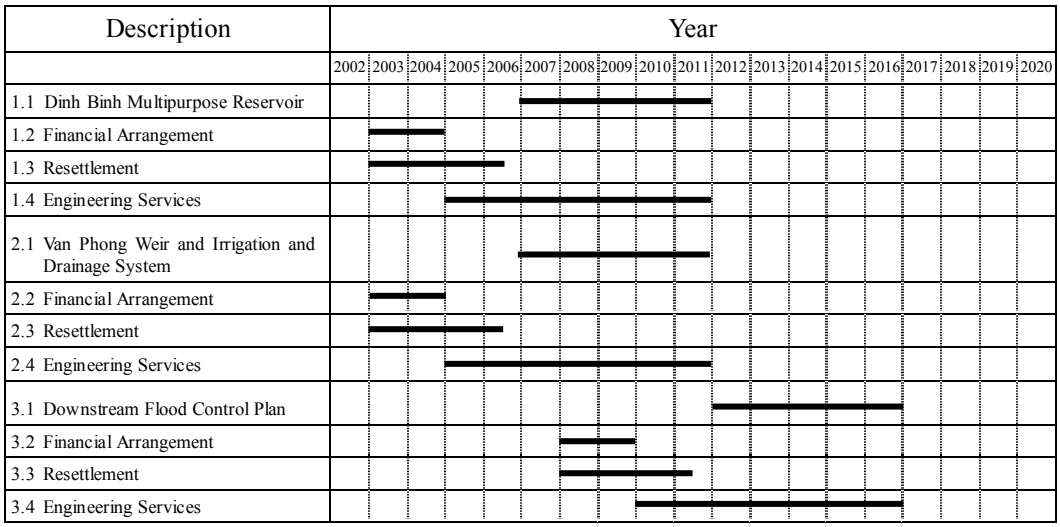
4.5 Overall Project Implementation Plan and Cost Estimate

(1) Overall Project Implementation Plan

The overall project implementation schedule for all sectors including financial arrangement, employment of consultants, land acquisition and compensation including resettlement, survey and investigation, detailed design works, prequalification of bidders, bidding and construction works is shown in Figures S4.26 and S4.27.

An overall implementation program of the proposed major facilities is shown below:

Overall Implementation Program of Proposed Major Facilities



(2) Cost Estimate

The project cost consists of direct construction cost and indirect construction cost. The direct construction cost comprises the general items, civil works, building works and mechanical and electrical works. The indirect construction cost includes the resettlement, engineering service, administration, price escalation contingency and physical contingency. The project cost for all sectors is estimated as shown in Table S4.4 and summarized as follows:

		Project Cost (million VND,US$)		
		Foreign Currency	Local Currency	Total
1.Dinh Binh Multipurpose Reservoir	(VND)	520,910	928,504	1,449,414
	(US$)	34.6	61.6	96.2
2.Van Phong Weir & Irrigation / Drainage System	(VND)	740,893	1,174,439	1,915,332
	(US$)	49.2	77.9	127.1
3.Downstream Flood Control Plan	(VND)	518,395	907,690	1,426,085
	(US$)	34.4	60.2	94.6
Total	(VND)	1,780,198	3,010,633	4,790,831
	(US$)	118.1	199.8	317.9

Note : The above project costs indicate the case that the water supply to the La Tinh River basin is included.

4.6 Economic and Financial Evaluation

(1) Economic Evaluation

Economic benefit of the priority project is estimated as summarized below:

Annual Economic Benefit of Priority Project

Benefit item	Qty	US$ million
Agriculture incl. livestock and aquaculture	37,400 ha	17.12
Hydropower generation	37.8 GWh	1.89
Flood damage mitigation	5 Districts	13.39
Total		32.40

The results of the economic analysis of the priority projects are summarized below.

Results of Economic Analysis of Priority Project

	EIRR (%)	B/C Ratio	NPV (US$ m)
Priority Project	12.0	1.23	22.6

Note: B/C and NPV are calculated with a discount rate of 10%.

The results indicate that the priority project has sufficient economic efficiency with EIRR of 12% and Net Present Value (NPV) of US$22.6 million.

Sensitivity analysis also indicates that the priority project has sufficient economic viability with EIRR of more than 10% even under the conditions of cost increase of 20% or benefit decrease of 15%. Therefore, the project is evaluated viable from the economic point of view.

(2) Financial Evaluation

Financial feasibility of the priority project is evaluated by examining repayment capability of the capital cost and coverage capability of O&M and replacement costs based on a financial cash flow statement using the anticipated project revenue and fund requirement.

From the financial analysis, the following matters become evident:

- Irrigation fee can fully cover O & M cost of irrigation as well as that of dam,
- The revenue from hydropower generation can fully cover its O & M cost and generate profits,
- For repayment of the loan capital, interest payment, and replacement of major mechanical facilities after their lifetime, government subsidy will be necessary, and
- If a soft ODA loan is applicable for construction of dam, irrigation, and flood

control facilities, the annual required fund for the construction and O&M will not be a burden of the Central and Local Governments.

From the above consideration, if a soft loan is applicable, implementation of the project will be financially feasible.

4.7 Conclusion and Recommendation

4.7.1 General

The JICA Feasibility Study is carried out for,

1) The Dinh Binh Multipurpose Reservoir Project,
2) Van Phong Weir and Irrigation & Drainage System, and
3) Downstream Flood Control Plan.

As a result of the JICA Feasibility, the conclusion and recommendation are summarized herein.

4.7.2 Dinh Binh Multipurpose Reservoir Project

(1) The comparative study on the alternative damsites as well as the dam types revealed that the alternative Damsite I, which is located at about 600 m downstream of the alternative Damsite II, should be selected for the Dinh Binh Dam site as concluded in the previous studies conducted by HEC-1(the existing Feasibility Study and Technical Design).

(2) The dam type of the Dinh Binh Dam should be of the concrete gravity dam with gated spillway. The geological conditions of the dam site will be satisfactory for construction of the proposed concrete gravity dam.

(3) The dam should be founded on the moderately weathered, slightly weathered or fresh rock which will withstand the construction of the proposed concrete gravity dam.

(4) The dam downstream slope should be revised from 1.0 to 0.7 proposed in the previous studies by HEC-1 to 1.0 to 0.8, so that the dam can satisfy the condition of the "Middle Third" under the condition of the normal Full Supply Water Level.

(5) The previous studies proposed concrete boxes filled with compacted earth materials for the dam structure in both the banks. The review in the Study found that this dam structure will be safe, provided that the concrete be properly reinforced to withstand the bending moment and that the sectional area of the structure be increased so as to satisfy the condition of the "Middle

Third" under the condition of the normal Full Supply Water Level.

However, cost estimate found that the dam structure with the concrete boxes will not lessen the cost. In view that the dam structure with the concrete boxes has no merits from both the technical and economic aspects, the usual concrete gravity dam is recommended to be employed by withdrawing the idea of concrete boxes.

(6) The dam block arrangement in the previous studies by HEC-1 is made with a large dam block of 24m to 37m in width which will not be acceptable from the aspect of international standard, causing several troubles such as the crack occurrence in dam concrete, costly large scale of facilities for concreting and waste of time for concreting due to shortage of number of dam blocks, etc.

Hence, the dam block arrangement is proposed to be made with the standard dam block width of 15m.

(7) Dimensions and number of the spillway which were concluded in the previous studies by HEC-1 are considered proper, having a capacity to pass the spillway design flood peak of 5,832 m^3/s at the Flood Water Level.

However, the spillway gate arrangement should be reconsidered in accordance with the dam block rearrangement. In due consideration of the dam block rearrangement, the spillway design is made as follows:

- Width of spillway 12 m x 7 gates = 84 m
  (108 m in total incl. pier)

The spillway will have the same capacity as those proposed in the previous studies shown below:

- Width of spillway 14 m x 6 gates = 84 m
  (108 m in total incl. pier)
- Overflow crest level EL. 85.93 m
- Flood water level(FWL) EL. 98.30 m
- Overflow depth 12.37 m
- Spillway discharge at FWL 6,769 m^3/s

(8) The previous studies employed the ski-jump type for spillway energy dissipater of which technical soundness was confirmed by a model test. However, since any comparative study with other types has not been conducted, a comparative study is executed in the Study with the stilling basin type which is the most typical type of energy dissipater. Its result indicated that the ski-jump type would be more advantageous economically, and

therefore, the application of the ski-jump type energy dissipater is considered justifiable.

(9) The bottom outlets should be provided for the flood control purpose before the reservoir water level reaches the Surcharge Water Level. The dimensions and number of the bottom outlets provided in the Technical Design by HEC-1 are considered proper. However, in connection with the dam block rearrangement, arrangement of the bottom outlets is made so that one dam block accommodates one conduit of bottom outlets, requiring 6 dam blocks to install 6 conduits of bottom outlets.

Principal features of the proposed bottom outlets are as follows:

- Height of bottom outlet conduit 6.0 m
- Width of bottom outlet conduit 5.0 m
- Sill level of bottom outlet conduit EL. 59.50 m
- Number of bottom outlet conduit 6 Nos.
- Maximum discharge capacity $5^{m} \times 6^{m} \times 12^{m/s} \times 6^{nos.} = 2{,}160\ m^3/s$

(10) In order to confirm the dam safety for floodings, flood routings are carried out for various cases of floodings, including occurrence of 10,000- year probable flood with the peak discharge of 9,578 m^3/s which is taken as the flood for checking of dam safety. The flood routing confirms for both dams crest levels at EL. 95.3 m and EL.100.3 m that:

a) All floods not more than the objective 10%(or 10-year) probable flood will be accommodated within the flood control volume of reservoir below the Surcharge Water Level,

b) The reservoir water level rise at occurrence of the spillway design flood (1% or 100-year probable flood with the peak discharge of 5,832 m^3/s) will be controlled below the Flood Water Level, and

c) Overtopping over the dam crest will not occur at occurrence of 10,000-year probable flood.

As such, the dam safety for flooding is confirmed to be ensured with the provided freeboard.

(11) The power waterway will be subject to the water hammer due to closing and opening of turbine guidevanes, causing fluctuation of water pressure in the waterway conduit. Negative pressure which may damage the conduit will be caused due to fluctuation of water pressure at the downstream end of horizontal portion of the power waterway designed in the previous study, and

therefore, alignment of the waterway should be rearranged so that the horizontal part of waterway conduit is lowered immediately after the transition.

(12) The construction plan and schedule proposed in the previous studies is reviewed through examination of the river diversion process, available workable days and necessary construction equipment, etc. The review finds that the dam could be constructed with the proposed river diversion process and construction equipment during the total construction period of 5 years as proposed in the previous studies. The mobilization will be at the beginning of F/Y 2007 and the completion of the Dinh Binh Dam will be at the end of F/Y 2011.

The above construction plan and schedule proposed in the previous studies by HEC-1 are considered reasonable and realistic. However, in view that the Dinh Binh Dam is of extremely high urgency, an accelerated schedule is examined by considering a physically possible squeeze of time schedule. The examination finds that the schedule will physically be possible to be shortened by 2.5 years, provided that every process will be handled smoothly without any delay in preconstruction and construction stages.

(13) In implementing the Dinh Binh Dam, the Government of Vietnam wished to know how the resultant project viability would be, if the project will be implemented by two steps by some reasons such as difficulty in financial arrangement, etc.

In response to the request, the project viability is examined for the case of the following two-step implementation:

1) First step : Construction of the Dinh Binh Dam with the crest level at E.L 95.3 m
2) Second step : Heightening the dam up to the crest level of E.L 100.3 m.

The examination finds that although the two-step implementation will technically be possible without particular difficult problems, the cost will increase by about 20% in terms of the project cost.

The economic viability in comparison with those of the non-stepwise implementation is as shown below:

Economic Indicators	Non-stepwise Implementation	Stepwise Implementation
EIRR	11.9 %	11.7 %
B/C	1.22	1.19
NPV(Million US$)	21.7	19.0

As seen in the above table, the economic viability in the stepwise implementation is considerably become less compared with the non-stepwise implementation due to the cost increase and delay of accrual of the benefits, and therefore, it is recommendable for enhancing the effect of the project to make arrangement so as to execute the project without phasing.

4.7.3 Van Phong Weir and Irrigation & Drainage System

(1) The proposed site of the Van Phong Weir is selected between the alternative Site-I and Site-II presented in the previous Feasibility Study report (June 2000). This proposed site is located about 1.0 km upstream from Site-I and it is named to be Site-II (JICA Team). This site is selected from the viewpoint of no sedimentation in front of the intake gate.

(2) The type of the proposed Van Phone Weir is selected to be the concrete fixed spread foundation one through the technical comparative study such as for i) the fixed or the rubber and ii) the spread foundation or the floating as well as the cost comparison. The fixed type is selected mainly from a point of less operation and maintenance, and the spread foundation type to be placed directly on the base rock be selected mainly from the lower cost.

(3) Major features of the Proposed Van Phone Weir are as follows:

a) Weir body

- Weir width (overflow section) : 525 m
- Crest elevation : EL.25.50 m
- Weir cross-section : trapezoid-shape
  - Crest ; 3.0 m in length (overflow stream line shape)
  - Side slope ; vertical on front side, 1:0.7 on rear side
- Weir height : 18.5 m to 7.5 m

b) Scouring sluice

Steel slide gate : B 2.75 m x H 2.75 m x 2 nos.

c) Apron

Downstream apron only : 5.0 m in length on base rock

d) Intake facilities

Intake gate	:	perpendicular intake B 3.00 m x H 3.00 m x 2 nos.
Settling basin	:	natural flushing type (gravity)
Discharge measurement device	:	broad-crested overflow weir

(4) The river flood dike against the backwater due to the proposed Van Phong Weir is preliminarily studied, and the required locations and the crown elevation are determined for the flood at the probability of occurrence P=1% under the condition after the construction of the proposed Dinh Binh Dam. The dike required portion would be about 11 km along the river course from the proposed weir site.

(5) Irrigation system is in principle limited to the irrigable area with the water from the proposed Dinh Binh Reservoir. The following irrigation systems would receive the water from the Dinh Binh.Dam:

Irrigation Systems under Dinh Binh Reservoir (Unit: ha)

	Irrigation System	Category	Net Area
(i)	Van Phong Proper	R&I, N	10,815
(ii)	Van Phong Extension (La Tinh)	N	3,297
(iii)	Tan An - Dap Da	R&I, I, N	14,532
(iv)	Tan An Extension (Lower Ha Thanh)	I, N	2,039
(v)	Vinh Thanh	R&I, N	1,017
(vi)	South West Kone	N	2,657
	Total		34,357

Note. R: Rehabilitation, I: Improvement, N: New Development

The Van Phong Extension (La Tinh) System would partly use the existing canals of the Cay Gai System and the Cay Ke System in the La Tinh area.

(6) The development concept is formulated with the three (3) categories in consideration of the economical effectiveness of the project. Priority is put on i) improvement of existing function system and ii) rehabilitation and improvement of existing non-function system. The respective areas are as follows:

Irrigation System's Area by Category (Unit: ha)

	Category	Net Area
(i)	Improvement of existing function systems	16,200
(ii)	Rehabilitation and improvement of non-function systems	3,400
(iii)	Development of new systems	17,800
	Total	37,400

Note. Above areas are based on the on-farm system's level.

(7) Several existing irrigation systems in the Tan An – Dap Da have the supplementary water sources such as weirs or pumping stations. Those systems such as the Van Kham, the Bo Ngo, the Dap Cat, the Nha Phu, etc. would in principle be returned to the original parent irrigation systems to save the operation and maintenance cost.

(8) The Van Phong N1 Canal branching from the Van Phong Main Canal would function like a main canal for the Van Phong Extension (La Tinh) System. The point of the boundary between the Van Phong Proper System and the Van Phong Extension System (La Tinh) is positioned at 4.1 km from BP. of the N1 Canal.

(9) The drainage system in the Tan An – Dap Da and the Lower Ha Thanh would be closely related to the flood protection system in those areas. A period of the major floods that is set to be two (2) and half months from the beginning of September to the middle of December have been excluded for the agricultural field drainage plan and design.

4.7.4 Downstream Flood Control Plan

(1) Design Discharge Distribution

The design discharge distribution among 5 objective rivers here proposed needs to be reviewed in the detailed design stage, since the river cross-sections used in the present study is very limited. The better discharge distribution might be found with more river cross-sections of those objective 5 rivers. This idea is confirmed in the steering committee of the present study.

(2) Thi Nai Swamp

The sea dyke surrounding the Thi Nai Swamp is proposed to be raised for flood control plan since the flood control plan aims to confine the floods up to 5% probable late flood in the river and the all floods discharge to the swamp. The sea dyke crown elevation is to be raised from the present elevation of 1.5 m to 2.9 m at maximum. But neither widening nor the excavation of the swamp is proposed in consideration of intensive shrimp aquaculture along the swamp.

(3) River Improvement Plan

River improvement plan includes the river widening, river excavation and dyke construction. In the river widening, widening is basically limited to avoid people's resettlement as much as possible. The river widening is planned in some special reaches to avoid too much high dyke.

The reaches to widen the Dap Da River is about 7,120 m long against the whole reaches of 28,870m. Those of the Go Cham River is about 7,270 m long against the whole reaches of 25,830m. Those of the Tan An River is about 4,180m long against the whole reaches of 28,660m.

Regarding the Nam Yang River and the Cay My River, no river widening is planned since the design discharge distribution to those rivers is basically the present discharge carrying capacities.

(4) Design Discharge Distribution Structure

Design discharge distribution could be attained with some diversion structures. The basic dimensions of those structures need to be confirmed with model test in the detailed design stage.

(5) Side Overflow Weir

Excess flood water more than the design discharge of 5% probable late flood up to the scale of 10% major flood is planned to be spread in the Kone River delta. Here the proposed dimensions of the side overflow weir should be further studied in the detailed design stage by using the model test. The locations of the side overflow weir should be also reviewed in due consideration of the social conditions including the public participation of the project in the detailed design stage.

(6) Sea Dyke Spillway

Sea dyke spillway surrounding the Thi Nai Swamp is proposed to be doubled in its length and numbers to improve the inundation situation in the Kone River delta after the river improvement project. This feature should also be reviewed in the detailed

design stage since the calculation is conducted in the present study based on the very limited information of the delta features.

(7) Implementation Schedule

The river improvement should be started after the completion of the Dinh Binh reservoir since the flood discharge distribution to the downstream rivers are decided based on the flood absorption by the said reservoir. Without the reservoir, the improved rivers may suffer a severe damage every year.

(8) Public Education

After the implementation of the flood control project, people living in the Kone River delta may think that their area is free from flooding. But the present flood control plan aims at flood damage alleviation up to 5% probable late flood. The area is still not free from flooding to the severer floods. Accordingly it is proposed that the provincial government may conduct the social education on this situation.

4.7.5 Environmental Impact Assessment

1) Environmental Impacts due to the implementation of the priority projects was examined on the various components, and the results of examination reveal that some negative impacts are to be brought out. Among others, it is noted that the following components are recognized as ones to which a special consideration is to be given:

   - Possibility of water quality degradation in the Kone river system including Dinh Binh dam reservoir,
   - Possibility of environmental change of Thi Nai swamp resulting in the impacts on ecology and fishery, and
   - Considerable magnitude of impact of land acquisition and resettlement.

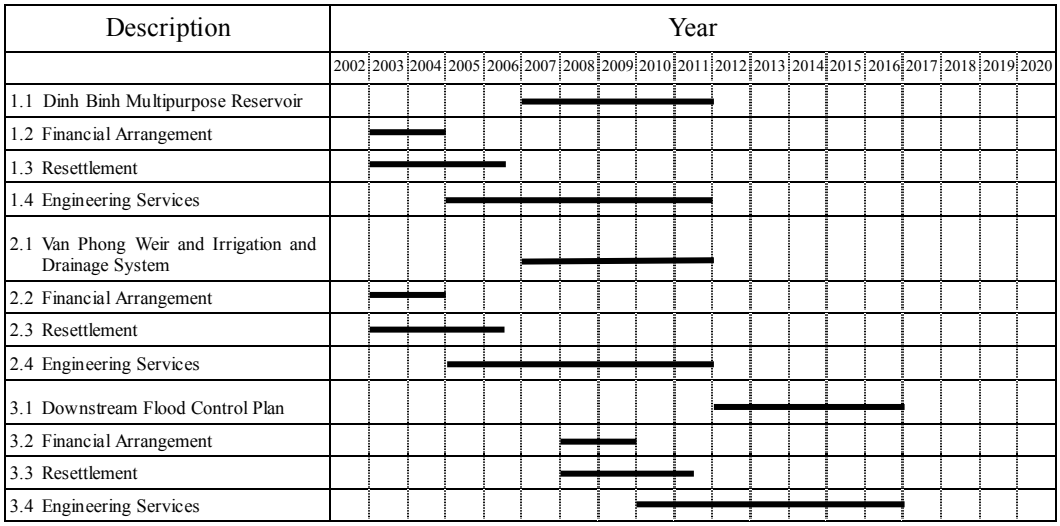
2) The predicted negative impacts including the above are to be managed properly for the successful completion of the priority projects. The following is essential for environmental management to be integrated into the priority projects' implementation.

   - Water quality control and monitoring in the Kone river system and Dinh Binh dam reservoir,
   - Monitoring on environmental change in Thi Nai swamp, regarding water quality, salinity, aquatic biota, and catch amount and production of fishery, and

- Implementation of the ready resettlement action plan for Dinh Binh dam project, and preparation of a resettlement action plans for irrigation development and river improvement, together with conducting public consultation and monitoring activities

4.7.6 Overall Project Implementation Plan and Cost Estimate

(1) The proposed overall implementation program of the proposed major facilities is shown below:



(2) The total project cost for all sectors is estimated at 4,790,831 million VND or 317.9 million US$ as follows:

		Project Cost (million VND,US$)		
		Foreign Currency	Local Currency	Total
1.Dinh Binh Multipurpose Reservoir	(VND)	520,910	928,504	1,449,414
	(US$)	34.6	61.6	96.2
2.Van Phong Weir & Irrigation / Drainage System	(VND)	740,893	1,174,439	1,915,332
	(US$)	49.2	77.9	127.1
3.Downstream Flood Control Plan	(VND)	518,395	907,690	1,426,085
	(US$)	34.4	60.2	94.6
Total	(VND)	1,780,198	3,010,633	4,790,831
	(US$)	118.1	199.8	317.9

Note : The above project costs indicate the case that the water supply to the La Tinh River basin is included.

4.7.7 Economic and Financial Evaluation

The results of the economic analysis indicate that the priority project has sufficient economic efficiency with EIRR of 12% and Net Present Value (NPV) of US$22.6 million.

Also the financial analysis shows if a soft loan is applicable, implementation of the project will be financially feasible.

4.7.8 Recommendation

It is found through the Study that the project would be feasible from the technical, economic, and social aspects. Thus, realization of the project is important. However, since the realization of the project is forced to take some long time, it is recommended that the non-structural measures for mitigating the flood damages and for water saving, which were presented in Sub-section 8.2.2 and are considered effective with less cost, should be implemented at the earliest.

Tables

Table S1.1 Result of the Runoff Analysis

Basin	Estimated Area		75% of Dependable Monthly Natural Runoff in MCM												Generated period
	Location	(km2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Bang Giang & Ky Cung	International boundary	11,250	96	85	87	117	208	550	837	1,031	650	314	181	118	1960-1974
Red & ThauBinh[1]	Son Tay	144,000	2,870 3,803*	2,245 3,368*	2,027 3,482*	2,173 3,732*	3,326 4,875*	8,371	15,763	19,107	13,448	9,183	5,342	3,595 4,071*	1957-1986 *[2]
Ma	Entire basin	31,060	451	342	345	342	556	851	1,382	1,824	1,880	1,306	739	561	1981-2000
Ca	Entire basin	29,850	605	482	464	472	694	895	1,187	1,924	2,916	2,914	1,258	775	1976-2000
Thach Han[3]	Entire basin	2,550	191	107	75	47	50	48	43	68	189	612	587	384	1977-2000
Huong[3]	Entire basin	3,300	220	118	81	56	76	71	55	61	243	976	1,153	691	1977-2000
Vu Gia & Thu Bon	Entire basin	10,380	1,169	682	522	387	523	464	409	428	777	2,768	3,832	2,760	1984-2000
Tra Khuc	Entire basin	5,200	573	305	215	150	203	201	170	161	332	1,304	2,141	1,142	1976-2000
Kone	Entire basin	3,640	165	106	85	69	83	86	76	72	104	463	659	288	1976-2000 (exclude1977)
Ba	Entire basin	14,030	302	168	113	79	140	200	244	388	709	956	1,454	532	1977-1989
Sesan[4]	International boundary	11,530	489	343	320	295	404	589	939	1,632	1,621	1,504	1,033	710	1976-1997
Srepok	International boundary	12,030	306	185	149	139	242	369	591	794	1,103	1,360	849	564	1977-2000
DongNai[5]	confluence with Saigon River	29,120	700	318	245	256	501	1,576	3,022	4,036	4,747	5,254	3,026	1,410	1964-1984
Cuu Long Delta	Cuu Long Delta	795,000 (37,870)	15,895	8,233	6,500	5,636	7,304	20,746	37,718	67,990	76,089	64,509	47,561	29,721	1960-1984

Note

1: used source / 1994 Red River Delta Master Plan, Binnie & Partners et all.

2: consideration of reservoirs effect (contribution to the low flows during the period December - May)

3: runoff data was generated by rainfall-runoff modelling

4: used source / 1999 National Hydropower Plan Study, SWECO et all.

5: used source / 1996 Master Plan study on DongNai river and surrounding basins water resources development, JICA, Nippon Koei.

Table S1.2 Result of the High Flow Analysis (Northern Basins)

Northern basins flood runoff							
Basin	Main Flood season	Location	Catchment Area (km^2)	Peak Discharges Main Flood Season (m^3/s)/($l/s/km^2$)			
				10 years	20 years	50 years	100 years
Bang Giang & Ky Cung	June-Sept.	Lang Son	1,560	2,450 / 1,600	2,950 / 1,900	3,650 / 2,350	4,200 / 2,700
Red River & Thai Binh basin	July-Sept.	Son Tay	144,000	23,500 / 163	27,000 / 188	32,050 / 223	35,730 / 248
		Hanoi		16,150 / n.a.	18,020 / n.a.	20,540 / n.a.	22,230 / n.a.
Ma Basin	July–Oct.	Cua Dat	6,170	3,600 / 583	4,200 / 681	4,700 / 762	5,200 / 843
		Cam Thuy	17,500	4,100 / 234	4,800 / 274	5,500 / 314	6,100 / 349
		Ma – Buoi conf.	19,820	4,300 / 217	5,000 / 252	5,800 / 293	6,400 / 323
Ca Basin	July-Oct.	Dua	20,800	6,800 / 326	8,200 / 394	10,300 / 495	11,900 / 572
		Yen Thuong	23,000	6,200 / n.a.	7,100 / n.a.	8,300 / n.a.	9,200 / n.a.

Northern basins n-day storms								
Basin	Main flood season	Location	Catchment area (km^2)	n-day	Area rainfall in mm			
					10 years	20 years	50 years	100 years
Bang Giang & Ky Cung	June-Sept.	Ky Cung sub basin	6,790	1 day	114	128	148	162
				2 day	148	165	188	204
		Bang Giang sub basin	4,460	1 day	131	142	157	167
				2 day	157	168	182	192
Ma Basin	July–Oct.	Cua Dat	6,170	1 day	179	202	229	250
				2 day	267	304	347	381
				3 day	315	357	415	457
		Cam Thuy	17,500	1 day	141	159	180	196
				2 day	213	239	276	303
				3 day	253	290	333	368
Ca Basin	July- Oct.	Dua	20,800	1 day	141	162	188	209
				2 day	200	229	268	296
				3 day	223	257	300	333

Table S1.3 Result of the High Flow Analysis (Central Basins 1/3)

Central basins flood runoff "early" flood season							
Basin	Early Flood season	Location	Catchment Area (km^2)	Peak Discharges Main Flood Season (m^3/s)/($l/s/km^2$)			
				10 years	20 years	50 years	100 years
Thach Han	Jan.- Aug.	Thach Han weir	1,390	1,800 / 1,300	2,300 / 1,700	3,000	3,500
Huong	Jan.- Aug.	Tra Trach dam site	717	1,900 / 2,600	2,600 / 3,600	4,000	5,200
		Bien Dinh	570	1,100 / 1,900	1,600 / 2,800	2,200	3,000
		Tuan confluence	1,460	3,100 / 2,100	4,400 / 3,000	6,400	8,400
		Co Bi	720	1,000 / 1,400	1,200 / 1,700	1,600	2,000
Thu Bon	Jan.- Aug.	Nong Son	3,130	2,000 / 640	2,600 / 830	3,400	4,000
		Thanh My	1,850	1,400 / 760	1,900 / 1,030	2,500	3,100
Tra Khuc	Jan.- Aug.	Son Giang	2,440	1,300 / 530	1,700 / 700	2,400	3,000
Kone	Jan.- Aug.	Cay Muong	1,677	430 / 260	580 / 350	810	1,010
Ba	Jan.- Aug.	Cung Son	12,800	1,450 / 110	1,750 / 140	2,150	2,500

Central basins one day storms "early" flood season							
Basin	Main Flood season	Location	Catchment Area (km^2)	One day area rainfall in mm			
				10 years	20 years	50 years	100 years
Thach Han	Jan.- Aug.	Upper/middle basin	2,180	170	200	245	275
Huong	Jan.- Aug.	Tra Trach dam site	717	260	330	420	495
		Bien Dinh	570	210	260	335	400
		Tuan confluence	1,460	225	285	365	430
		Co Bi	720	165	195	235	270
Thu Bon	Jan.- Aug.	Nong Son	3,130	140	165	200	225
		Thanh My	1,850	135	165	205	235
Tra Khuc	Jan.- Aug.	Son Giang	2,440	120	145	175	200
Kone	Jan.- Aug.	Cay Muong	1,677	130	150	180	200
Ba	Jan.- Aug.	Cung Son	12,800	75	85	100	110
			Two day area rainfall Ba basin	95	105	125	135
			Three day area rainfall Ba basin	115	130	150	165

Table S1.3 Result of the High Flow Analysis (Central Basins 2/3)

Central basins flood runoff main flood season							
Basin	Main Flood season	Location	Catchment Area (km^2)	Peak Discharges Main Flood Season (m^3/s)/($l/s/km^2$)			
				10 years	20 years	50 years	100 years
Thach Han	Sept.-Nov.	Thach Han weir	1,390	3,500 / 2,500	4,300 / 3,000	5,200 / 3,700	6,100 / 4,400
Huong	Sept.-Nov	Tra Trach dam site	717	5,500 / 7,700	6,400 / 8,900	7,500 / 10,500	8,200 / 11,400
		Bien Dinh	570	3,600 / 6,300	4,200 / 7,400	5,000 / 8,800	5,800 / 10,200
		Tuan confluence	1,460	9,800 / 6,700	11,400 / 7,800	13,400 / 9,200	15,000 / 10,300
		Co Bi	720	3,900 / 5,400	5,100 / 7,100	6,700 / 9,300	7,800 / 10,800
Thu Bon	Oct.-Dec.	Nong Son	3,130	8,900 / 2,800	10,300 / 3,300	12,100 / 3,900	13,400 / 4,300
		Thanh My	1,850	6,000 / 3,200	7,000 / 3,800	8,600 / 4,600	9,800 / 5,300
Tra Khuc	Oct.-Dec.	Son Giang	2,440	10,000 / 4,100	11,500 / 4,700	13,500 / 5,500	15,000 / 6,100
Kone	Oct.-Dec.	Cay Muong	1,677	4,500 / 2,700	5,200 / 3,100	6,000 / 3,600	6,700 / 4,000
Ba	Sept.-Nov.	Cung Son	12,800	13,500 / 1,100	17,000 / 1,300	21,000 / 1,600	24,000 / 1,900
Sesan	Aug.-Nov.	Kon Tum	3,056	2,500 / 800	2,900 / 950	3,400 / 1,100	3,750 / 1,250
Srepok	Aug.-Nov.	Ban Don	10,700	2,550 / 240	2,950 / 280	3,500 / 330	4,100 / 380

Table S1.3 Result of the High Flow Analysis (Central Basins 3/3)

Central basins n-day storms main flood season								
Basin	Main Flood season	Location	Catchment Area (km^2)	n-day	Area rainfall in mm			
					10 years	20 years	50 years	100 years
Thach Han	Sept.-Nov.	Upper/middle basin	2,180	1 day	275	315	370	410
Huong	Sept.-Nov	Tra Trach dam site	717	1 day	475	525	590	635
		Bien Dinh	570	1 day	400	450	500	550
		Tuan confluence	1,460	1 day	400	440	490	525
		Co Bi	720	1 day	440	505	600	665
Thu Bon	Oct.-Dec.	Nong Son	3,130	1 day	330	370	425	465
		Thanh My	1,850	1 day	305	350	410	450
Tra Khuc	Oct.-Dec.	Son Giang	2,440	1 day	370	425	495	550
Kone	Oct.-Dec.	Cay Muong	1,677	1 day	260	295	340	370
Ba	Sept.-Nov.	Cung Son	12,800	1 day	180	210	250	275
				2 day	265	310	370	420
				3 day	290	340	405	455
Sesan	Aug.-Nov.	Dak Bla sub basin	3,410	1 day	130	145		
Srepok	Aug.-Nov	Srepok basin	12,030	1 day	150	175	205	229
				2 day	222	268	326	373

Table S1.4 Result of the High Flow Analysis (Southern Basins)

Southern basins flood runoff							
Basin	Main Flood season	Location	Catchment Area (km^2)	Peak Discharges Main Flood Season (m^3/s)/($l/s/km^2$)			
				10 years	20 years	50 years	100 years
Dong Nai	Aug.-Oct.	Tri An	14,025		6,459 / 460		8,265 / 590
		Dau Tieng	2,700		2,351 / 870		3,197 / 1,180

Table S1.5 Agricultural Water Demand (AWD), Average Rainfall Year

(m^3/sec)

River Basin		Present (2001)	Future (2010)	Future (2020)
01. Bang Giang	Total	9.5	13.1	14.5
	Irrigation	8.5	11.8	13.0
	Livestock	0.2	0.3	0.5
	Aquaculture	0.8	1.0	1.0
02. Red	Total	510.1	595.5	602.8
	Irrigation	419.0	459.9	453.9
	Livestock	2.8	4.1	6.1
	Aquaculture	88.3	131.5	142.8
03. Ma	Total	55.4	69.0	72.8
	Irrigation	42.0	52.6	55.4
	Livestock	0.6	0.8	1.1
	Aquaculture	12.8	15.6	16.3
04. Ca	Total	44.9	55.9	62.9
	Irrigation	35.2	42.3	48.2
	Livestock	0.5	0.6	0.8
	Aquaculture	9.2	13.0	13.9
05. Thach Han	Total	3.0	5.3	5.9
	Irrigation	2.3	4.4	4.9
	Livestock	0.1	0.1	0.1
	Aquaculture	0.6	0.8	0.9
06. Huong	Total	11.1	13.1	15.5
	Irrigation	9.9	9.6	10.7
	Livestock	0.1	0.1	0.2
	Aquaculture	1.1	3.4	4.6
07. Thu Bon	Total	15.5	24.3	24.3
	Irrigation	11.4	20.1	19.9
	Livestock	0.2	0.2	0.3
	Aquaculture	3.9	4.0	4.1
08. Tra Khuc	Total	13.1	13.4	13.5
	Irrigation	12.8	13.1	13.1
	Livestock	0.2	0.2	0.3
	Aquaculture	0.1	0.1	0.1
09. Kone	Total	22.5	27.8	31.7
	Irrigation	21.5	26.6	30.4
	Livestock	0.1	0.2	0.3
	Aquaculture	0.9	1.0	1.0
10. Ba	Total	27.5	56.8	70.4
	Irrigation	26.4	55.4	68.9
	Livestock	0.2	0.3	0.4
	Aquaculture	0.9	1.1	1.1
11. Sesan	Total	6.3	10.2	13.4
	Irrigation	5.8	9.6	12.6
	Livestock	0.1	0.2	0.3
	Aquaculture	0.4	0.4	0.4
12. Srepok	Total	15.1	15.3	33.1
	Irrigation	13.0	12.9	30.5
	Livestock	0.1	0.2	0.4
	Aquaculture	2.0	2.2	2.2
13. Dong Nai	Total	109.1	137.1	158.0
	Irrigation	78.5	101.7	119.2
	Livestock	0.5	0.8	1.4
	Aquaculture	30.1	34.6	37.4
14. Cuu Long Delta	Total	1,110.7	1,325.5	1,463.9
	Irrigation	923.9	1,023.8	1,075.9
	Livestock	0.7	1.2	2.4
	Aquaculture	186.1	300.5	385.6

Table S1.6 : Minimum Water Demand for Hydropower Generation in National Power Development Plan

	Power Stations	Installed Capacity (MW)	Rated Head (m)	Expected Energy Generation (GWh/yr.)	Expected Energy Generation (GWh/day)	Expected Operation Hours (Hrs./day)	Average Power Output (MW)	Planned Firm Output (MW)	Required Turbine Discharge for Firm Output (m3/s)	Daily Discharge Volume for Firm Output (1000 M3)	Monthly Discharge Volume for Firm Output (Mil. M3)
1	Song Hinh	**70**	**140.0**	**404**	**1.108**	**15.8**	**70.0**	**31.5**	**26.4**	**1406.1**	**42.2**
2	Yaly 3,4	**360**	**190.0**	**1,825**	**5.000**	**14.8**	**337.8**	**90.0**	**55.6**	**2960.1**	**88.8**
3	Ham Thuan	**300**	**250.0**	**1,291**	**3.537**	**14.8**	**239.0**	**80.0**	**37.5**	**1999.7**	**60.0**
4	Dami	**177**	**142.9**	**789**	**2.163**	**14.8**	**146.1**	**45.0**	**36.9**	**1967.9**	**59.0**
5	Can Don	**72**	**51.0**	**280**	**0.767**	**14.8**	**51.8**	**18.0**	**41.4**	**2205.6**	**66.2**
6	Dai Ninh	**300**	**635.0**	**1,314**	**3.600**	**14.8**	**243.2**	**98.5**	**18.2**	**969.4**	**29.1**
7	Rao Quan	**70**	**499.0**	**207**	**0.566**	**14.8**	**38.2**	**17.5**	**4.1**	**219.2**	**6.6**
7	Cua Dat	**120**	**69.5**	**486**	**1.332**	**14.8**	**90.0**	**30.0**	**50.6**	**2697.5**	**80.9**
9	Se San 3	**273**	**62.6**	**1,127**	**3.088**	**14.8**	**208.6**	**68.3**	**127.9**	**6813.1**	**204.4**
10	Na Hang(Dai Thi)	**300**	**58.2**	**986**	**2.700**	**14.8**	**182.4**	**81.0**	**163.2**	**8697.2**	**260.9**
11	A Vuong 1	**170**	**102.0**	**760**	**2.082**	**14.8**	**140.7**	**53.8**	**61.9**	**3297.9**	**98.9**
12	Ban May(Ban La)	**260**	**87.0**	**996**	**2.729**	**14.8**	**184.4**	**65.0**	**87.6**	**4668.9**	**140.1**
13	Dong Nai 3	**250**	**131.0**	**784**	**2.148**	**14.8**	**145.1**	**62.5**	**56.0**	**2981.5**	**89.4**
14	Dong Nai 4	**260**	**127.0**	**916**	**2.510**	**14.8**	**169.6**	**65.0**	**60.0**	**3198.4**	**96.0**
15	An Khe - Ka Nak	**155**	**360.0**	**712**	**1.950**	**14.8**	**131.8**	**43.3**	**14.1**	**751.6**	**22.6**
16	Buon Kuop	**280**	**113.0**	**1,346**	**3.688**	**14.8**	**263.4**	**70.0**	**72.7**	**3871.1**	**116.1**
17	Song Ba Ha	**200**	**63.0**	**944**	**2.586**	**14.8**	**174.8**	**49.8**	**92.7**	**4939.8**	**148.2**
18	Plei Krong	**120**	**59.5**	**629**	**1.723**	**14.8**	**116.4**	**30.0**	**59.1**	**3150.8**	**94.5**
19	Se San 4	**330**	**54.0**	**1,348**	**3.693**	**14.8**	**249.5**	**82.5**	**179.2**	**9547.3**	**286.4**
20	Son La Units 1to 10	**3,600**	**127.5**	**15,856**	**43.440**	**22.0**	**1974.6**	**600.0**	**549.8**	**43543.3**	**1306.3**
21	Song Tranh 2	**160**	**32.0**	**497**	**1.362**	**14.8**	**92.0**	**34.2**	**125.4**	**6678.8**	**200.4**
22	Se San 3A	**100**	**23.0**	**478**	**1.310**	**14.8**	**88.5**	**25.0**	**127.5**	**6792.5**	**203.8**
23	Srok Phu Mien	**70**	**25.0**	**261**	**0.715**	**14.8**	**48.3**	**17.5**	**89.4**	**4763.2**	**142.9**
24	Dong Nai 2	**100**	**86.9**	**389**	**1.066**	**14.8**	**72.0**	**25.0**	**33.7**	**1797.8**	**53.9**
25	Dak My 4	**200**	**170.0**	**768**	**2.104**	**14.8**	**142.2**	**65.0**	**44.9**	**2389.4**	**71.7**
26	Hua Na	**275**	**105.0**	**689**	**1.888**	**14.8**	**127.6**	**64.0**	**71.5**	**3809.0**	**114.3**
27	Srepok 3	**190**	**50.0**	**598**	**1.638**	**14.8**	**110.7**	**47.5**	**121.3**	**6464.4**	**193.9**
28	Ban Uon	**250**	**64.0**	**1,015**	**2.781**	**14.8**	**187.9**	**55.0**	**100.8**	**5370.3**	**161.1**
29	Huoi Quang	**500**	**149.0**	**1,920**	**5.260**	**14.8**	**355.4**	**130.0**	**102.3**	**5452.3**	**163.6**

Table S1.7 Flood Control Criteria for River Basin

River	Location	Occurred floods		Flood control criteria				Remarks
	Name	H (m)	Q (m^3/s)	Year	H (m)	Q (m3/s)	Frequencies (%)	
Bang Giang - Ky Cung	Lang Son town	20.00	4,520	7/1986	17.00	2,800	2.5	
		17.00	2,800	8/1980				
Ma	Xuan Khanh	13.90	8,500	1962	13.90		0.6	
	Giang	7.50	NA	1927	7.50		1	
	Len Bridge	6.80	2,050	1973	6.80		1	
	Tao Bridge	5.60	1,250	1973	5.60		1	
	Kim Tan	13.50	NA	1996	13.50		5	
Ca	Do Luong	20.49(upstream)	8,350	1978	20.49		2	
		20.33(downstream)			20.33			
	Yen Thuong	12.95	13,060	1978	12.95		1.5	
	Nam Dan	10.16	13,160	1978	10.16		1	
	Cho Trang	7.28	16,000	1978	7.28		1	
	Linh Cam	7.88	5,970	1978	7.88		1	
	Ben Thuy	6.28	17,660	1978	6.28		1	
Thach Han	Quang Tri Citadel	7.64	NA	1999	6.50			Main flood
	Quang Tri Citadel	4.25	NA	1983	3.85			Summer-autumn flood
Huong	Kim Long	5.84	13,670	1999	3.71			Main flood
	Phu Oc	4.89	3,050	1999	4.50			
	Kim Long	4.23	42,43	1989	2.50		10	Summer-autumn flood
	Phu Oc	4.50	1,410	1989	3.50			
Vu Gia - Thu Bon	Nog Son		10,600	11/1998		9,100	10	Mail flood
	Nog Son		4,500	10/1986		4,766	5	Early floods
	Ai Nghia	10.56		1946	9.50		10	Main flood
	Giao Thuy	9.41		20/11/1998	8.40		10	Main flood
Tra Khuc	Song Giang		18,400	12/1986		10,200	10	Main flood
	Song Giang		6,560	9/1997			5	Early flood
	Tra Khuc	7.72		11/1998	6.20		10	Main flood
Kone	Cay Moung		6,340	1987		10,200	10	Main flood
	Cay Moung		978	9/1977		1,780	1	Eary flood
	Tan An	8.92		1987	7.60		10	Main flood
Ba	Cung Son		20,700	11/1993		13,675	10	Main flood
	Cung Son		4,500	9/1977		4,500	10	Early flood
	Phu Lam	5.20		11/1993	4.39		10	Main flood
Sesan	Kontum		3,620	11/1996		3,600	3	Main flood
	Kontum		2,540	9/1994		2,900	5	Early flood
	Dakbla Bridge	520.70		11/1996	517.00		3	Main flood
Srepok	Giang Son		990	10/1992			10	Main flood
	Giang Son	426.70		10/1992	425.00		10	Main flood
	Duc Xuyen	431.85	1,920	10/1992	431.00		10	Main flood
Dong Nai	Tri An			1978			10	early floods
	Bien Hoa	1.89			2.45			
	Nha Be	1.19			1.46			
	Binh Duong	1.28			1.35			
	Phu An	1.33			1.45			
				1952			1	main flood
	Bien Hoa	4.80			4.87			P=1% for Ho Chi
	Nha Be	1.52			1.54			Minh city.
	Binh Duong	1.69			1.70			P=3-5% for oter
	Phu An	1.48			1.54			cities.
Cuu Long (Mekong)	Tan Chau	4.880		30/8/1978	4.37	23,950	10	early floods
	Chau Doc	4.040		31/8/1978	3.57	7,910	10	early floods
	Tan Chau	5.280		12/10/1961	5.50	28,820	1	main floods
	Chau Doc	5.060		13/10/1961	5.17	9,220	1	main floods
								P=2-5% for towns
	Tan Chau			11/1994				Late floods and
								11/1994 flood

Table S1.8 Major Features of Flood Control Plans of 14 Rivers

No.	River Name	Design Scale	Basic Design Discharge	Design High Waer Level	Flood Control Facilities	Flood Control Volume of Reservoir (MCM)	Design Discharge Distribution
1	Ky Cung	2.5% Major Flood	Qp=4,520 m^3/s at Lang Son Town	Hp=17.0m at Lang Son Town	Ban Lai Reservoir	96.2	Qp=2,800 m^3/s at Lang Son Town
2-1	Red River *1)	EMP(Hanoi) Present : 0.8%, Medium : 0.4 % Long Term-1 : 0.2 % Long Term-2 : <0.2 %	Present : Qp=37,800m^3/s Medium : Qp=42,600 m^3/s Long Term-1 : Qp=48,500 m^3/s, Long Term-2 : Qp>48,500 m^3/s at Son Tay	Hp=13.4 m at Hanoi	1) Existing reservoirs for present, 2) Additional Dai Thi reservoir for Medium Term, 3) Additional Son La reservoir for Long Term-1(Da River FCV=7,000MCM) 4) Ditto for Long Term-2 (Da River FCV>7,000MCM)		
2-2	Other Rivers in Red & Thai Binh River Basin *1)	EMP(Hanoi) Present : 0.8%, Medium :0.67 % Long Term-1:0.33 % Long Term-2:<0.33 %	Present : Qp=37,800m^3/s Medium : Qp=40,500 m^3/s Long Term-1: Qp=44,500 m^3/s, Long Term-2: Qp>44,500 m^3/s at Son Tay	Hp=13.1 m at Hanoifor I, II, III Dyke Class Hp=7.2 m at Pha Lai	1) Existing reservoirs for present, 2) Additional Dai Thi reservoir for Medium Term, 3) Additional Son La reservoir for Long Term-1(Da River FCV=7,000MCM) 4) Ditto for Long Term-2 (Da River FCV>7,000MCM)		
3	Ma	1% Major Flood	Qp=7,000 m^3/s at Tao Bridge	H=5.6 m at Tao Bridge	Cua Dat Reservoir	105.6	Qp=5,000 m^3/s at Tao Bridge
4	Ca	1% Major Flood	Qp=11,900 m^3/s at Ben Thuy Bridge	H=6. 28 m at Ben Thuy Bridge	Ban La Reservoir and River Improvement	216.0	Qp=10,000 m^3/s at Ben Thuy Bridge
5	Thac Han	1.9% Major Flood	Qp=13,670 m^3/s at Quang Tri Citadel	H=6.5 m at Quang Tri Citadel	Rao Quan Reservoir and River Improvement	104.7	Qp=9,210 m^3/s at Quang Tri Citadel
6	Huong	5.9% Major Flood	Qp=13,670 m^3/s at Kim Long, Qp=3,500 m^3/s at Phu Oc	H=3.71 m at Kim Long, H=4.5m at Phu Oc	Ta Trach, Huu Trach, and Co Bi Reservoirs	390.0 105.0 44.0	Qp=2,000 m^3/s at Kim Long, Qp=1,400m^3/s at Phu Oc
7-1	Vu Gia	10% Major Flood	Qp=10,870 m^3/s at Ai Nghia	H=9.5 m at Ai Nghia	Song Cai Reservoir and River Improvement	550.0	Qp=6,510 m^3/s at Ai Nghia
7-2	Thu Bon	10% Major Flood	Qp=9,610 m^3/s at Nong Son	H=8.4 m at Giao Thuy	Ho Song Tranch II Reservoirs	800.0	Qp=4,595 m^3/s at Nong Son
8	Tra Khuc	10% Major Flood	Qp=10,690 m^3/s at Son Giang	H=6.2m at Tra Khuc	Nuoc Trong Reservoir and River Improvement	184.2	Qp=6,033 m^3/s at Tra Khuc
9	Kone	5% Late Flood	Qp= 2,997 m^3/s at Bin Thanh	-	Dinh Bin Reservoir and River Improvement	292.8	Qp=1,691 m^3/s at Bin Thanh
10	Ba	10% Major Flood	Qp=13,560 m^3/s at Cung Son	H=4.39m at Phu Lam	Song Ba Ha Reservoir and River Improvement	38.1	Qp=11,000 m^3/s at Phu Lam
11	Sesan	1.4% Major Flood	Qp=3,600 m^3/s at Kon Tum	H=517.0 m at Dakbla Bridge	Dak Bla Reservoir	78.0	Qp=642 m^3/s at Dakbla Bridge
12	Srepok	10% Major Flood	Qp=1,633 m^3/s at Giang Son	Hp=425 m at Giang Son	Lower Krong Buk Reservoir Upp Krong Buk Reservoir Krong Buong Reservoir	33.3 26.2 21.4	Qp=573 m^3/s at Giang Son Bridge
13	Dong Nai *2)	EMP 1) 10% major flood on Saigon River, 2) 7% major flood on Dong Nai River	1) Lower Dong Nai River : existing reservoir and proposed two reservoirs, 2) Saigon River : existing reservoirs				Qp=6,200 m^3/s on Dong Nai River, Qp=2,200 m^3/s on Saigon River
14	Cuu Long *3)	EMP 1) 10% major flood for shallow-flood area, 2) 4% major flood for human resettlemetns and infrastructure	* short to medium term plan 1) full flood protection at primary level of the shallow-flood area, 2) controlled flooding of the deep-flood area		1) dikes and embankment along the main rivers and primary canals, 2) enlargement of primary canals		–

*) EMP : Existing Master Plan

*1) IWRP Documents approved by the Government of Vietnam 2003

*2) THE MASTER PLAN STUDY ON DONG NAI RIVER AND SURROUNDING BASINS WATER RESOURCES DEVELOPMENT AUGUST 1996

*3) MEKONG DELTA MASTER PLAN THEMATIC STUDY ON MANAGEMENT OF WATER RESOURCES DECEMBER 1993

Table S1.9 Evaluation Results on Each Evaluation Item

Item		Domestic Water Supply			Industrial Water Supply			Agriculture Water Supply			Power Generation			Flood Control Effect		
Project Name		Contribution (%)	Grade	Score	Contribution (%)	Grade	Score	Contribution (%)	Grade	Score	Power Energy Generation (GWh)	Grade	Score	Damage Reduction (Mil.VND)	Grade	Score
Ban Lai		47.0	V	20	85.5	IV	40	34.4	III	60	39	V	20	27,720	III	60
Cua Dat		62.4	I	100	94.5	I	100	23.9	III	60	465	II	80	510	IV	40
Ban La		56.0	III	60	88.3	III	60	28.7	III	60	996	I	100	0	V	20
Rao Quan		49.8	V	20	86.1	III	60	50.2	II	80	292	III	60	102,642	II	80
Ta Trach		59.6	II	80	89.1	II	80	28.1	III	60	70	IV	40	425,176	I	100
Huu Trach		0.0	V	20	0.0	V	20	0.0	V	20	71	IV	40	47,242	II	80
Ho Song Tranh II		55.3	III	60	98.9	I	100	36.4	II	80	615	II	80	36,625	III	60
Song Cai		0.0	V	20	0.0	V	20	0.0	V	20	775	II	80	21,316	III	60
Nuoe Trong		46.0	V	20	83.5	IV	40	3.3	V	20	64	IV	40	252,368	I	100
Dinh Binh		54.9	IV	40	84.8	IV	40	28.9	III	60	38	V	20	262,571	I	100
Song Ba Ha		58.9	III	60	86.5	III	60	61.0	I	100	1,044	I	100	10,085	IV	40
Dak Bla		60.0	II	80	88.2	III	60	52.7	II	80	346	III	60	948	IV	40
Buon Kuop-Chupong Krong		44.4	V	20	58.1	IV	40	35.4	II	80	1,025	I	100	227	IV	40
Krong Buong		2.7	V	20	3.6	V	20	2.2	V	20	0	V	20	15	V	20
Upper Krong Pach		9.6	V	20	12.5	V	20	7.7	V	20	0	V	20	50	V	20
Upper Krong Buk		11.6	V	20	15.3	V	20	8.7	V	20	0	V	20	58	V	20
Bac Me		3.8	V	20	5.3	V	20	1.0	V	20	993	I	100	0	V	20
Dai Thi		4.0	V	20	5.5	V	20	1.0	V	20	985	I	100	0	V	20
Son La		54.2	IV	40	74.5	IV	40	13.4	IV	40	14,895	I	100	0	V	20
Dong Nai Basin Development		64.5	I	100	50.6	IV	40	30.9	III	60	1,700	I	100	43,018	III	60
Cuu Long Delta Development		58.4	III	60	90.8	II	80	24.1	III	60	0	V	20	621,389	I	100
Grading	Grade I	More Than		60	More Than		92	More Than		55	More Than		900	More Than		180,000
	Grade II	60	----	59	92	----	89	55	----	35	900	----	400	180,000	----	45,000
	Grade III	59	----	55	89	----	86	35	----	20	400	----	100	45,000	----	20,000
	Grade IV	55	----	50	86	----	20	20	----	10	100	----	60	20,000	----	100
	Grade V	Less than		50	Less than		20	Less than		10	Less than		60	Less than		100

Item		River Maintenance Flow			Degree of Poverty			Investment Cost			Resettlement		
Project Name		Increase Rate	Grade	Score	Rate	Grade	Score	Amount (Mil. US$)	Grade	Score	Affected People	Grade	Score
Ban Lai		1.6	IV	40	32.8	I	100	238	IV	-40	20,000	I	-100
Cua Dat		2.9	II	80	21.3	III	60	737	II	-80	8,324	IV	-40
Ban La		2.6	II	80	21.3	III	60	852	II	-80	12,000	II	-80
Rao Quan		1.5	IV	40	21.3	III	60	355	III	-60	36,000	I	-100
Ta Trach		3.7	II	80	15.3	IV	40	184	IV	-40	5,000	IV	-40
Huu Trach		1.5	IV	40	6.0	IV	40	63	IV	-40	3,500	IV	-40
Ho Song Tranh II		1.0	IV	40	13.5	IV	40	540	II	-80	25,000	I	-100
Song Cai		0.6	IV	40	8.0	IV	40	448	III	-60	7,100	IV	-40
Nuoe Trong		1.8	IV	40	21.5	III	60	137	IV	-40	10,000	III	-60
Dinh Binh		2.2	III	60	21.5	III	60	254	IV	-40	2,930	IV	-40
Song Ba Ha		3.2	II	80	21.5	III	60	706	II	-80	7,390	IV	-40
Dak Bla		1.7	IV	40	31.5	II	80	346	III	-60	2,500	V	-20
Buon Kuop-Chupong Krong		1.5	IV	40	20.5	III	60	460	II	-80	6,000	IV	-40
Krong Buong		0.1	V	20	1.3	V	20	15	IV	-40	2,200	V	-20
Upper Krong Pach		0.3	V	20	4.4	V	20	48	IV	-40	1,000	V	-20
Upper Krong Buk		0.4	V	20	5.4	V	20	65	IV	-40	2,700	V	-20
Bac Me		0.2	V	20	18.0	IV	40	559	II	-80	10,000	III	-60
Dai Thi		0.2	V	20	18.0	IV	40	513	II	-80	14,000	II	-80
Son La		3.0	II	80	18.0	IV	40	5,150	I	-100	110,000	I	-100
Dong Nai Basin Development		1.1	IV	40	3.1	V	20	2,744	I	-100	1,130	V	-20
Cuu Long Delta Development		0.0	V	20	12.8	IV	40	1,790	I	-100	0	V	-20
Grading	Grade I	More Than		5.00	More Than		32	More Than		1,000	More Than		20,000
	Grade II	5.00	----	2.50	32	----	25	1,000	----	450	20,000	----	12,000
	Grade III	2.50	----	2.00	25	----	20	450	----	300	12,000	----	8,500
	Grade IV	2.00	----	0.50	20	----	6	300	----	10	8,500	----	2,900
	Grade V	Less than		0.50	Less than		6	Less than		10	Less than		2,900

Table S1.10 Overall Evaluation on River Basins and Projects

Evaluation Items		River Basin	Bang Giang and Ky Cong	Ma	Ca	Thach Han	Huong			Vu Gia-Thu Bon			Tra Khuc	Kone	Ba	Sesan	Srepok				
		Project	Ban Lai	Cua Dat	Ban La	Rao Quan	Ta Trach	Huu Trach		Ho Song Tranh II	Song Cai		Nuoe Trong	Dinh Binh	Song Ba Ha	Dak Bla	Buon Kuop-Chupong Krong	Krong Buong	Upper Krong Pach	Upper Krong Buk	
Domestic Water Supply	Contribution Degree of Project(%)		47.00	62.41	55.95	49.84	59.64	0.00		55.31	0.00		45.99	54.86	58.88	59.99	44.37	2.73	9.56	11.60	
	Score of Project for Evaluation Item		20	100	60	20	80	20		60	20		20	40	60	80	20	20	20	20	
	Weight on Evaluation Item Given in each basin		0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Weighted score of Project for Evaluation Item		2	10	6	2	8	2		6	2		2	4	6	8	2	2	2	2	
	Weight of Project in Basin		1	1	1	1	1.00	0.00		1.00	0.00		1	1	1	1	0.65	0.04	0.14	0.17	
	Score of Basin for Evaluation Item		2.0	10.0	6.0	2.0	8.0	0.0	8.0	6.0	0.0	6.0	2.0	4.0	6.0	8.0	1.3	0.1	0.3	0.3	2.0
Industrial Water Supply	Contribution Degree of Project(%)		85.45	94.47	88.34	86.11	89.13	0.00		98.92	0.00		83.53	84.77	86.52	88.17	58.14	3.58	12.52	15.31	
	Score of Project for Evaluation Item		40	100	60	60	80	20		100	20		40	40	60	60	40	20	20	20	
	Weight on Evaluation Item Given in each basin		0.3	0.3	0.1	0.1	0.1	0.1		0.1	0.1		0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.3	
	Weighted score of Project for Evaluation Item		12	30	6	6	8	2		10	2		4	4	6	18	12	6	6	6	
	Weight of Project in Basin		1	1	1	1	1.00	0.00		1.00	0.00		1	1	1	1	0.65	0.04	0.14	0.17	
	Score of Basin for Evaluation Item		12.0	30.0	6.0	6.0	8.0	0.0	8.0	10.0	0.0	10.0	4.0	4.0	6.0	18.0	7.8	0.2	0.8	1.0	9.9
Agriculture Water Supply	Contribution Degree of Project(%)		34.38	23.88	28.66	50.20	28.06	0.00		36.42	0.00		3.25	28.92	60.99	52.65	35.40	2.20	7.70	8.70	
	Score of Project for Evaluation Item		60	60	60	80	60	20		80	20		20	60	100	80	80	20	20	20	
	Weight on Evaluation Item Given in each basin		0.2	0.2	0.1	0.1	0.1	0.1		0.1	0.1		0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	
	Weighted score of Project for Evaluation Item		12	12	6	8	6	2		8	2		2	6	10	16	16	4	4	4	
	Weight of Project in Basin		1	1	1	1	1.00	0.00		1.00	0.00		1	1.00	1	1	0.66	0.04	0.14	0.16	
	Score of Basin for Evaluation Item		12.0	12.0	6.0	8.0	6.0	0.0	6.0	8.0	0.0	8.0	2.0	6.0	10.0	16.0	10.5	0.2	0.6	0.6	11.9
Power Generation	Power Energy Generation of Project(GWh)		39.40	465.00	996.00	292.00	70.00	71.00		615.00	775.30		63.50	38.30	1044.00	346.00	1025.00	0.00	0.00	0.00	
	Score of Project for Evaluation Item		20	80	100	60	40	40		80	80		40	20	100	60	100	20	20	20	
	Weight on Evaluation Item Given in each basin		0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Weighted score of Project for Evaluation Item		2	8	10	6	4	4		8	8		4	2	10	6	10	2	2	2	
	Weight of Project in Basin		1	1	1	1	0.50	0.50		0.44	0.56		1	1.00	1	1	1.00	0.00	0.00	0.00	
	Score of Basin for Evaluation Item		2.0	8.0	10.0	6.0	2.0	2.0	4.0	3.5	4.5	8.0	4.0	2.0	10.0	6.0	10.0	0.0	0.0	0.0	10.0
Flood Control Effect	Flood Damage Reduction by Project(Mil.USD)		27720	510	0	102642	425176	47242		36625	21316		252368	262571	10085	948	227	15	50	58	
	Score of Project for Evaluation Item		60	40	20	80	100	80		60	60		100	100	40	40	40	20	20	20	
	Weight on Evaluation Item Given in each basin		0.1	0.1	0.3	0.3	0.3	0.3		0.3	0.3		0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	
	Weighted score of Project for Evaluation Item		6	4	6	24	30	24		18	18		30	30	12	4	4	2	2	2	
	Weight of Project in Basin		1	1	1	1	0.90	0.10		0.63	0.37		1	1.00	1	1	0.65	0.04	0.14	0.17	
	Score of Basin for Evaluation Item		6.0	4.0	6.0	24.0	27.0	2.4	29.4	11.4	6.6	18.0	30.0	30.0	12.0	4.0	2.6	0.1	0.3	0.3	3.3
River Maintenance Flow (Improvement of River Environment)	Discharge Increase Rate in the Driest Month		1.56	2.88	2.56	1.50	3.65	1.45		1.01	0.60		1.82	2.22	3.23	1.70	1.46	0.09	0.32	0.38	
	Score of Project for Evaluation Item		40	80	80	40	80	40		40	40		40	60	80	40	40	20	20	20	
	Weight on Evaluation Item Given in each basin		0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	Weighted score of Project for Evaluation Item		4	8	8	4	8	4		4	4		4	6	8	4	4	2	2	2	
	Weight of Project in Basin		1	1	1	1	0.72	0.28		0.63	0.37		1	1.00	1	1	0.65	0.04	0.14	0.17	
	Score of Basin for Evaluation Item		4.0	8.0	8.0	4.0	5.7	1.1	6.9	2.5	1.5	4.0	4.0	6.0	8.0	4.0	2.6	0.1	0.3	0.3	3.3
Degree of Poverty in River basin	Population below Poverty line (%)		32.83	21.30	21.30	21.30	15.30	6.00		13.54	7.95		21.49	21.49	21.49	31.48	20.46	1.26	4.41	5.35	
	Score of Project for Evaluation Item		100	60	60	60	40	40		40	40		60	60	60	80	60	20	20	20	
	Weight on Evaluation Item Given in each basin		0.1	0.1	0.2	0.2	0.2	0.2		0.2	0.2		0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	
	Weighted score of Project for Evaluation Item		10	6	12	12	8	8		8	8		12	12	12	8	6	2	2	2	
	Weight of Project in Basin		1	1	1	1	0.72	0.28		0.63	0.37		1	1.00	1	1	0.65	0.04	0.14	0.17	
	Score of Basin for Evaluation Item		10.0	6.0	12.0	12.0	5.7	2.3	8.0	5.0	3.0	8.0	12.0	12.0	12.0	8.0	3.9	0.1	0.3	0.3	4.6
	Sub-total of score (i)		48.0	78.0	54.0	62.0			70.3			62.0	58.0	64.0	64.0	64.0					45.0
Investment Cost (Degree of Financing Difficulty)	Investment cost of Project (Mil.USD)		237.6	737.4	852.1	354.8	183.8	62.9		540.2	447.5		137.3	253.9	705.5	346.3	459.6	15.1	47.8	65.4	
	Score of Project for Evaluation Item		-40	-80	-80	-60	-40	-40		-80	-60		-40	-40	-80	-60	-80	-40	-40	-40	
	Weight on Evaluation Item Given in each basin		0.6	0.6	0.6	0.6	0.6	0.6		0.6	0.6		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
	Weighted score of Project for Evaluation Item		-24	-48	-48	-36	-24	-24		-48	-36		-24	-24	-48	-36	-48	-24	-24	-24	
	Weight of Project in Basin		1	1	1	1	0.75	0.25		0.55	0.45		1	1.00	1	1	0.78	0.03	0.08	0.11	
	Score of Basin for Evaluation Item		-24.0	-48.0	-48.0	-36.0	-17.9	-6.1	-24.0	-26.3	-16.3	-42.6	-24.0	-24.0	-48.0	-36.0	-37.5	-0.6	-2.0	-2.7	-42.8
Resettlement (Adverse Impact on Social Environment)	Number of people to be resettled by Project (Nos		20000	8324	12000	36000	5000	3500		25000	7100		10000	2930	7390	2500	6000	2200	1000	2700	
	Score of Project for Evaluation Item		-100	-40	-80	-100	-40	-40		-100	-40		-60	-40	-40	-20	-40	-20	-20	-20	
	Weight on Evaluation Item Given in each basin		0.4	0.4	0.4	0.4	0.4	0.4		0.4	0.4		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	
	Weighted score of Project for Evaluation Item		-40	-16	-32	-40	-16	-16		-40	-16		-24	-16	-16	-8	-16	-8	-8	-8	
	Weight of Project in Basin		1	1	1	1	0.59	0.41		0.78	0.22		1	1.00	1	1	0.50	0.18	0.08	0.23	
	Score of Basin for Evaluation Item		-40.0	-16.0	-32.0	-40.0	-9.4	-6.6	-16.0	-31.2	-3.5	-34.7	-24.0	-16.0	-16.0	-8.0	-8.1	-1.5	-0.7	-1.8	-12.0
	Sub-total of score (ii)		-64.0	-64.0	-80.0	-76.0			-40.0			-77.3	-48.0	-40.0	-64.0	-44.0					-54.8
Score of Each Project	Grand Total of Score		-16	14	-26	-14	32	6		-26	-8		10	24	0	20	-10	-12	-12	-12	
	Ranking in 11 River Basins		14	4	15	13	1	6		15	8		5	2	7	3	9	10	10	10	
Score of Eaach Rvier Basin	Grand Total of Score ((i)+(ii))		-16.0	14.0	-26.0	-14.0			30.3			-15.3	10.0	24.0	0.0	20.0					-9.8
	Ranking in 11 River Basins		10	4	11	8			1			9	5	2	6	3					7

Table S2.1 Comparison of Alternative Plans (1/2)

	Capacity of Facilities			Technical Aspect				Environmental Aspect		Economic Aspect		Overall Evaluation
	Storage capacity	Flood Control Capacity for Hue City		Water Utilization Plan (IR, WS, HY = 460 mil. m^3) */	Major Flood Control for Hue City (Requirement = 13,670 - 2,000 = 11,670 m^3/s) */	10-yr. Probable Early Flood Control for Agriculture Lands (Requirement = less than 1,400 m^3/s in D/S reaches) */	Bo River Flood Control (Requirement = 3,050 - 1,410 = 1,640 m^3/s)	Natural Environment Indicators: 1) Impact on protected area 2) Impact on landscape of Hue 3) Impact on lagoon	Social Environment Indicators: 4) Impact of resettlement 5) Impact on important infrastructure such as national road and railway 6) Impact on regional economy regarding tourism	Construction Cost	Economic Viability EIRR, % (B/C)	
	(mil, m^3)	(mil, m^3)	(m^3/s)							(Mil, US$)		
I. With Dam												
I-A without Ta Trach Dam												
I-A.1 Huu Trach Dam (F.S.L = EL. 55.0)	182	182	4,720	Not Satisfied	Not Satisfied	Huong: 1,904m^3/s Bo : 1,005m^3/s Total : 2,909m^3/s Not Satisfied	Not Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-A-2 Huu Trach Dam (F.S.L = EL. 55.0) + Diversion Channel + Parapet Wall + Retarding Basin + Diversion Tunnel	182	182	4,720 5,000 400 350	Not Satisfied	Not Satisfied	Huong: 0m^3/s Bo : 1,005m^3/s Total : 1,005m^3/s Satisfied	Not Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-A.3 Huu Trach Dam (F.S.L = EL. 55.0) + Diversion Channel X 2 + Parapet Wall	182	182	4,720 8,000	Not Satisfied	Satisfied	- Ditto - Satisfied	Not Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-A.4 Huu Trach Dam (F.S.L = EL. 55.0) + Co Bi Dam (F.S.L = EL.40.0)	182 167	182 -	4,720 -	Satisfied	Not Satisfied	Huong: 1,904m^3/s Bo : 0m^3/s Total : 1,904m^3/s Not Satisfied	Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-A.5 Huu Trach Dam (F.S.L = EL. 55.0) + Co Bi Dam (F.S.L = EL.40.0) + Diversion Channel X 2 + Parapet Wall	182 167	182 -	4,720 - 8,000	Satisfied	Satisfied	Huong: 0m^3/s Bo : 0m^3/s Total : 0m^3/s Satisfied	Satisfied	1) Slight (Phong Dien) by Co Bi 2) Medium by parapet wall 3) Slight ~ medium by 2 div. channels Acceptable	4) Unclear by Huu Trach & Co Bi but less than Ta Trach 4) Very large by 2 div. channels (20~40 thou. or more) 5) Large by 2 div. channels 6) Medium by parapet wall Not Acceptable	(Screened out due to "Not Acceptable" from social environmental aspect)		
I-A.6 Co Bi Dam (F.S.L = EL. 40.0)	167	-	-	Not Satisfied	Not Satisfied	Huong: 2,998m^3/s Bo : 0m^3/s Total : 2,998m^3/s Not Satisfied	Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-A.7 Co Bi Dam (F.S.L = EL. 40.0) + Diversion Channel X 2 + Parapet Wall + Retarding Basin + Diversion Tunnel	167	-	- 8,000 400 350	Not Satisfied	Not Satisfied	Huong: 0m^3/s Bo : 0m^3/s Total : 0m^3/s Satisfied	Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-B With Max. Ta Trach Dam												
I-B.1 Max Ta Trach Dam (S.W.L = EL. 52.0)	460	392.6	8,070	Satisfied	Not Satisfied	Huong: 1,094m^3/s Bo : 1,005m^3/s Total : 2,099m^3/s Not Satisfied	Not Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)			16.6% (B/C=1.58)	
I-B.2 Max Ta Trach Dam (S.W.L = EL. 52.0) + Huu Trach Dam (F.S.L = EL.55.0)	460 182	392.6 105	8,070 3,600	Satisfied	Satisfied	Huong: 0m^3/s Bo : 1,005m^3/s Total : 1,005m^3/s Satisfied	Not Satisfied	1) Slight (Bach Ma) by Ta Trach 2) None 3) Unclear on negative/positive direction by Ta Trach and Huu Trach Acceptable	4) Medium by Ta Trach (4~5 thou. population) 4) Unclear by Huu Trach but less than Ta Trach 5)6) None Acceptable	100.6 30.0 130.6	16.5% (B/C=1.55)	- Essential technical requirements are satisfied. - Acceptable from environmental aspects. - Economic viability is highest. Recommendable
I-B.3 Max Ta Trach Dam (S.W.L = EL. 52.0) + Min. Huu Trach Dam (F.S.L = EL.50.0)	460 105	392.6 105	8,070 3,600	Satisfied	Satisfied	- Ditto - Satisfied	Not Satisfied	-Ditto- Acceptable	-Ditto- Acceptable	100.6 22.0 122.6	16.4% (B/C=1.55)	- Essential technical requirements are satisfied. - Acceptable from environmental aspects. - Economic viability is slightly less than case I-B.2. Not Better than Case I-B.2
I-B.4 Max Ta Trach Dam (S.W.L = EL. 52.0) + Co Bi Dam (F.S.L = EL40.0)	460 167	392.6 -	8,070 -	Satisfied	Not Satisfied	Huong: 1,094m^3/s Bo : 0m^3/s Total : 1,094m^3/s Satisfied	Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-B.5 Max Ta Trach Dam (S.W.L = EL. 52.0) + Min. Co Bi Dam (F.S.L = EL32.0)	460 45	392.6 -	8,070 -	Satisfied	Not Satisfied	- Ditto - Satisfied	Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-B.6 Max Ta Trach Dam (S.W.L = EL. 52.0) + Huu Trach Dam (F.S.L = EL.55.0) + Co Bi Dam (F.S.L = EL.40.0)	460 182 167	392.6 105 -	8,070 3,600 -	Satisfied	Satisfied	Huong: 0m^3/s Bo : 0m^3/s Total : 0m^3/s Satisfied	Satisfied	1) Slight (Bach Ma & Phong Dien) by Ta Trach & Co Bi 2) None 3) Unclear on negative/positive direction by Ta Trach, Huu Trach & Co Bi Acceptable	4) Medium by Ta Trach (4~5 thou. population) 4) Unclear by Huu Trach & Co Bi but less than Ta Trach 5) None 6) None Acceptable	100.6 30.0 15.0 145.6	15.8% (B/C=1.46)	- All technical requirements are satisfied. - Acceptable from environmental aspects. - Economic viability becomes less than Case I-B.2. Not Better than Case I-B.2
I-B.7 Max Ta Trach Dam (S.W.L = EL. 52.0) + Huu Trach Dam (F.S.L = EL.55.0) + Min. Co Bi Dam (F.S.L = EL 32.0)	460 182 45	392.6 105 -	8,070 3,600 -	Satisfied	Satisfied	- Ditto - Satisfied	Satisfied	-Ditto- Acceptable	-Ditto- Acceptable	100.6 30.0 10.0 140.6	16.0% (B/C=1.48)	- All technical requirements are satisfied. - Acceptable from environmental aspects. - Economic viability becomes less than Case I-B.2. Not Better than Case I-B.2
I-B.8 Max Ta Trach Dam (S.W.L = EL. 52.0) + Min. Huu Trach Dam (F.S.L = EL.50.0) + Co Bi Dam (F.S.L = EL.40.0)	460 105 167	392.6 105 -	8,070 3,600 -	Satisfied	Satisfied	- Ditto - Satisfied	Satisfied	-Ditto- Acceptable	-Ditto- Acceptable	100.6 22.0 15.0 137.6	15.8% (B/C=1.46)	- All technical requirements are satisfied. - Acceptable from environmental aspects. - Economic viability becomes less than Case I-B.2. Not Better than Case I-B.2
I-B.9 Max Ta Trach Dam (S.W.L = EL. 52.0) + Min. Huu Trach Dam (F.S.L = EL.50.0) + Min. Co Bi Dam (F.S.L = EL 32.0)	460 105 45	392.6 105 -	8,070 3,600 -	Satisfied	Satisfied	- Ditto - Satisfied	Satisfied	-Ditto- Acceptable	-Ditto- Acceptable	100.6 22.0 10.0 132.6	16.0% (B/C=1.48)	- All technical requirements are satisfied. - Acceptable from environmental aspects. - Economic viability becomes less than Case I-B.2. Not Better than Case I-B.2
I-B.10 Max Ta Trach Dam (S.W.L = EL. 52.0) + Diversion Channel + Parapet Wall	460 - -	392.6 - -	8,070 3,000 2,000	Satisfied	Satisfied	Huong: 0m^3/s Bo : 1,005m^3/s Total : 1,005m^3/s Satisfied	Not Satisfied	1) Slight (Bach Ma) by Ta Trach 2) Medium by parapet wall 3) Unclear on negative/positive direction by Ta Trach 3) Slight by div. channel Acceptable	4) Medium by Ta Trach (4~5 thou. population) 4) Large by div. channel (20 thou. population at least) 5) Large by div. channel 6) Medium by parapet wall Not Acceptable	(Screened out due to "Not Acceptable" from social environmental aspect)		

Note: - */: Essential requirements from technical aspects '- IR: Irrigation, WS: Water supply, HY: Hydropower, D/S: Downstream

Table S2.1 Comparison of Alternative Plans (2/2)

	Capacity of Facilities			Technical Aspect				Environmental Aspect		Economic Aspect		Overall Evaluation
	Storage capacity	Flood Control Capacity for Hue City		Water Utilization Plan (IR, WS, HY = 460 mil. m^3) */	Major Flood Control for Hue City (Requirement = 13,670 - 2,000 = 11,670 m^3/s) */	10-yr. Probable Early Flood Control for Agriculture Lands (Requirement = less than 1,400 m^3/s in D/S reaches) */	Bo River Flood Control (Requirement = 3,050 - 1,410 = 1,640 m^3/s)	Natural Environment Indicators: 1) Impact on protected area 2) Impact on landscape of Hue 3) Impact on lagoon	Social Environment Indicators: 4) Impact of resettlement 5) Impact on important infrastructure such as national road and railway 6) Impact on regional economy regarding tourism	Construction Cost (Mil, US$)	Economic Viability EIRR, % (B/C)	
	(mil, m^3)	(mil, m^3)	(m^3/s)									
I-B.11 Max Ta Trach Dam (S.W.L = EL. 52.0) + Diversion Channel + Parapet Wall + Co Bi Dam (F.S.L = EL.40.0)	460 - - 167	392.6 - - -	8,070 3,000 2,000 -	Satisfied	Satisfied	Huong: 0 m^3/s Bo : 0 m^3/s Total : 0 m^3/s Satisfied	Satisfied	1) Slight (Bach Ma & Phong Dien) by Ta Trach & Co Bi 2) Medium by parapet wall 3) Unclear on negative/positive direction by Ta Trach & Co Bi 3) Slight by div. channel Acceptable	4) Medium by Ta Trach (4~5 thou. population) 4) Unclear by Co Bi but less than Ta Trach 4) Large by div. channel (20 thou. population at least) 5) Large by div. channel 6) Medium by parapet wall Not Acceptable	(Screened out due to "Not Acceptable" from social environmental aspect)		
I-B.12 Max Ta Trach Dam (S.W.L = EL. 52.0) + Diversion Channel + Parapet Wall + Min. Co Bi Dam (F.S.L = EL 32.0)	460 - - 45	392.6 - - -	8,070 3,000 2,000 -	Satisfied	Satisfied	Huong: 0 m^3/s Bo : 0 m^3/s Total : 0 m^3/s Satisfied	Satisfied	-Ditto- Acceptable	-Ditto- Not Acceptable	(Screened out due to "Not Acceptable" from social environmental aspect)		
I-C With Min. Ta Trach Dam												
I-C.1 Min. Ta Trach Dam (S.W.L = EL. 50.0)	460	312	6,951	Satisfied	Not Satisfied	Huong: 1,094 m^3/s Bo : 1,005 m^3/s Total : 2,099 m^3/s Not Satisfied	Not Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-C.2 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Huu Trach Dam (F.S.L = EL.55.0)	460 182	312 182	6,951 4,720	Satisfied	Satisfied	Huong: 0 m^3/s Bo : 1,005 m^3/s Total : 1,005 m^3/s Satisfied	Not Satisfied	1) Slight (Bach Ma) by Ta Trach 2) None 3) Unclear on negative/positive direction by Ta Trach & Huu Trach Acceptable	4) Medium by Ta Trach (4~5 thou. population or less) 4) Unclear by Huu Trach but less than Ta Trach 5)6) None Acceptable	97.0 30.0 127.0	16.4% (B/C=1.55)	- Essential technical requirements are satisfied. - Acceptable from environmental aspects. - Economic viability is slightly less than case I-B.2. Not Better than Case I-B.2
I-C.3 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Min. Huu Trach Dam (F.S.L = EL.50.0)	460 105	312 105	6,951 3,600	Satisfied	Not Satisfied	- Ditto - Satisfied	Not Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-C.4 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Co Bi Dam (F.S.L = EL40.0)	460 167	312 -	6,951 -	Satisfied	Not Satisfied	Huong: 1,094 m^3/s Bo : 0 m^3/s Total : 1,094 m^3/s Satisfied	Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-C.5 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Min. Co Bi Dam (F.S.L = EL32.0)	460 45	312 -	6,951 -	Satisfied	Not Satisfied	- Ditto - Satisfied	Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-C.6 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Huu Trach Dam (F.S.L = EL.55.0) + Co Bi Dam (F.S.L = EL.40.0)	460 182 167	312 182 -	6,951 4,720 -	Satisfied	Satisfied	Huong: 0 m^3/s Bo : 0 m^3/s Total : 0 m^3/s Satisfied	Satisfied	1) Slight (Bach Ma & Phong Dien) by Ta Trach & Co Bi 2) None 3) Unclear on negative/positive direction by Ta Trach, Huu Trach & Co Bi Acceptable	4) Medium by Ta Trach (4~5 thou. population or less) 4) Unclear by Huu Trach & Co Bi but less than Ta Trach 5)6) None Acceptable	97.0 30.0 15.0 142.0	15.7% (B/C=1.45)	- All technical requirements are satisfied. - Acceptable from environmental aspects. - Economic viability becomes less than Case I-B.2. Not Better than Case I-B.2
I-C.7 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Huu Trach Dam (F.S.L = EL.55.0) + Min. Co Bi Dam (F.S.L = EL 32.0)	460 182 45	312 182 -	6,951 4,720 -	Satisfied	Satisfied	- Ditto - Satisfied	Satisfied	-Ditto- Acceptable	-Ditto- Acceptable	97.0 30.0 10.0 137.0	15.9% (B/C=1.48)	- All technical requirements are satisfied. - Acceptable from environmental aspects. - Economic viability becomes less than Case I-B.2. Not Better than Case I-B.2
I-C.8 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Min. Huu Trach Dam (F.S.L = EL.50.0) + Co Bi Dam (F.S.L = EL.40.0)	460 105 167	312 105 -	6,951 3,600 -	Satisfied	Not Satisfied	- Ditto - Satisfied	Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-C.9 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Min. Huu Trach Dam (F.S.L = EL.50.0) + Min. Co Bi Dam (F.S.L = EL 32.0)	460 105 45	312 105 -	6,951 3,600 -	Satisfied	Not Satisfied	- Ditto - Satisfied	Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
I-C.10 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Diversion Channel + Parapet Wall	460 - -	312 - -	6,951 3,000 2,000	Satisfied	Satisfied	Huong: 0 m^3/s Bo : 1,005 m^3/s Total : 1,005 m^3/s Satisfied	Not Satisfied	1) Slight (Bach Ma) by Ta Trach 2) Medium by parapet wall 3) Unclear on negative/positive direction by Ta Trach 3) Slight by div. channel Acceptable	4) Medium by Ta Trach (4~5 thou. population or less) 4) Large by div. channel (20 thou. population at least) 5) Large by div. channel 6) Medium by parapet wall Not Acceptable	(Screened out due to "Not Acceptable" from social environmental aspect)		
I-C.11 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Diversion Channel + Parapet Wall + Co Bi Dam (F.S.L = EL.40.0)	460 - - 167	312 - - -	6,951 3,000 2,000 -	Satisfied	Satisfied	Huong: 0 m^3/s Bo : 0 m^3/s Total : 0 m^3/s Satisfied	Satisfied	1) Slight (Bach Ma & Phong Dien) by Ta Trach & Co Bi 2) Medium by parapet wall 3) Unclear on negative/positive direction by Ta Trach & Co Bi 3) Slight by div. channel Acceptable	4) Medium by Ta Trach (4~5 thou. population or less) 4) Unclear by Co Bi but less than Ta Trach 4) Large by div. channel (20 thou. population at least) 5) Large by div. channel 6) Medium by parapet wall Not Acceptable	(Screened out due to "Not Acceptable" from social environmental aspect)		
I-C.12 Min. Ta Trach Dam (S.W.L = EL. 50.0) + Diversion Channel + Parapet Wall + Min. Co Bi Dam (F.S.L = EL 32.0)	460 - - 45	312 - - -	6,951 3,000 2,000 -	Satisfied	Satisfied	- Ditto - Satisfied	Satisfied	-Ditto- Acceptable	-Ditto- Not Acceptable	(Screened out due to "Not Acceptable" from social environmental aspect)		
II. Without Dam												
II-1 Diversion Channel x 2 + Parapet Wall + Retarding Basin + Diversion Tunnel	- - - -	- - - -	6,000 2,000 400 350	Not Satisfied	Not Satisfied	Huong: 0 m^3/s Bo : 1,005 m^3/s Total : 1,005 m^3/s Satisfied	Not Satisfied	(Screened out due to "Not Satisfied" for essential technical requirements)				
II-2 Diversion Channel x 3 + Parapet Wall + Retarding Basin + Diversion Tunnel + Freshwater Production Facilities (219 MCM/annum in average)	- - - - -	- - - - -	9,000 2,000 400 350 -	Satisfied	Satisfied	Huong: 0 m^3/s Bo : 1,005 m^3/s Total : 1,005 m^3/s Satisfied	Not Satisfied	1) None 2) Medium by parapet wall 3) Medium by 3 div. channels Acceptable	4) Very large by 3 div. chanels (60 thou. population at least) 5) Large by 3 div. channels 6) Medium by parapet wall Not Acceptable	52.0 x 3 1.3 13.0 68.9 239.2 US$438 mil/yr (Freshwater production cost)	(B/C=0.1)	- Essential technical requirements are satisfied. - Not acceptable from environmental aspects. - Economic viability is extremely low. Not Justifiable Economically

Note: - */: Essential requirements from technical aspects '- IR: Irrigation, WS: Water supply, HY: Hydropower, D/S: Downstream

Table S3.1 Probable Domestic Water Demands 2001 to 2020 to be Connected to the Water Supply System

District	Urban Centre	Domestic Water Demand (m^3/day)					
		2001 Urban Water Use: 100 lpcd, UFW=40%, Coverage=60%, Institutional Use = 15%. Rural Water Use: 25 lpcd, No UFW, Coverage = 30%.		2010 Urban Water Use: 120 lpcd, UFW=30%, Coverage=80%, Institutional Use = 15%. Rural Water Use: 80 lpcd, No UFW, Coverage = 40%.		2020 Urban Water Use: 150 lpcd, UFW=25%, Coverage=95% Institutional Use = 15%. Rural Water Use: 100 lpcd, No UFW, Coverage = 50%.	
		Urban	Rural	Urban	Rural	Urban	Rural
Quy Nhon	Quy Nhon City New Urban Area (Nhon Hoi)	21,957	152	39,272 20,000	707	68,366 20,000	1,220
Vinh Thanh	-	-	198	-	924	-	1,594
Phu Cat	Ngo May Town	1,082	1,339	1,935	6,248	3,369	10,781
Tay Son	Phu Phong Town	1,285	899	2,298	4,197	4,000	7,241
An Nhon	Binh Dinh Town	1,744	1,116	3,119	5,209	5,429	8,987
	Dap Da Town	1,744		3,119		5,429	
Tuy Phuoc	Tuy Phuoc Town	1,677	1,210	2,999	5,646	5,221	9,742
	Dieu Tri Town	719		1,286		2,238	
Van Canh	-	-	165	-	770	-	1,329
Phu My	Phu My Town	1,094		1,957		3,407	
Sub-Total :		31,301	5,078	75,985	23,701	117,459	40,894
Total :		36,379 m^3/d (1.09 Mm^3/m)		99,686 m^3/d (2.99 Mm^3/m)		158,353 m^3/d (4.75 Mm^3/m)	

Table S3.2 Probable Domestic Water Demand 2001 to 2020 Including for Non-Connected People

District	Urban Centre	Domestic Water Demand (m^3/day)					
		2001		2010		2020	
		Urban	Rural	Urban	Rural	Urban	Rural
Quy Nhon	Quy Nhon City	24,230	505	41,360	1,768	69,851	2,440
	New Urban Area (Nhon Hoi)			20,000		20,000	
Vinh Thanh	-	-	660	-	2,310	-	3,188
Phu Cat	Ngo May Town	1,194	4,463	1,954	15,620	3,441	21,561
Tay Son	Phu Phong Town	1,418	2,998	2,320	10,492	4,087	14,482
An Nhon	Binh Dinh Town	1,924	3,720	3,149	13,021	5,546	17,973
	Dap Da Town	1,924		3,149		5,546	-
Tuy Phuoc	Tuy Phuoc Town	1,851	4,033	3,028	14,115	5,334	19,483
	Dieu Tri Town	793		1,298		2,286	
Van Canh	Van Canh Town	-	550	-	1,925	-	2,657
Phu My	Phu My Town	1,207		2,061		3,481	
Sub-Total :		34,541	16,928	78,318	59,251	119,572	81,784
Total :		51,469 m^3/d (1.54 Mm^3/m)		137,569 m^3/d (4.13 Mm^3/m)		201,356 m^3/d (6.04 Mm^3/m)	

Table S3.3 Probable Rural Industrial Water Demand

(Unit: m^3/day)

Area	Demand 2001	Demand 2010	Growth factor 2010-2020	Demand 2020
- Downstream area of Binh Thanh	11,410	19,100	9%	45,217
- Area between Van Phong and Binh Thanh	25,370	42,465	9%	100,530
- Area between Dinh Binh and Van Phong	12,520	20,960	9%	49,620
Total	49,300 (1.48 Mm^3/m) (18.0 Mm^3/yr.)	82,525 (2.48 Mm^3/m) (30.12 Mm^3/yr.)		195,367 (5.86 Mm^3/m) (71.3 Mm^3/yr.)

Table S3.4 Alternative Scales of Dinh Binh Dam

Items		Alt.I		Alt.II		Alt.III		Remarks
		Alt.I-1	Alt.I-2	Alt.II-1	Alt.II-2	Alt.III-1	Alt.III-2	
Dam Crest Level		EL.95.3	EL.95.3	EL.100.3	EL.100.3	EL.105.3	EL.105.3	
F.W.L (Gross Vol., MCM)		EL. 93.3 (242.78)	EL.93.3 (242.78)	EL.98.3	EL.98.3	EL.103.3	EL.103.3	Flood Water Level
S.W.L (Gross Vol., MCM)		EL.92.8 (237.52)	EL. 92.8 (237.52)	EL.97.8 (309.07)	EL.97.8 (309.07)	EL.102.8 (391.82)	EL.102.8 (391.82)	Surcharge Water Level
F.S.L (Gross Vol., MCM)		EL.91.9 (226.18)	EL.91.9 (226.18)	EL.96.9 (295.81)	EL.96.9 (295.81)	EL.101.9 (376.53)	EL.101.9 (376.53)	Full Supply Level
Rainy Season Limited W.L (Gross Vol., MCM)		EL.65.0 (16.3)	EL.82.0 (116.3)	EL.65.0 (16.3)	EL.82.0 (116.3)	EL.65.0 (16.3)	EL.82.0 (116.3)	Sep. to Nov.
Dead W.L (Gross Vol., MCM)		EL.65.0 (16.3)	EL.65.0 (16.3)	EL.65.0 (16.3)	EL.65.0 (16.3)	EL.65.0 (16.3)	EL.65.0 (16.3)	
F/C Vol. (MCM) -Major Flood-		221.22	121.22	292.77	192.77	375.52	275.52	Flood Control Volume
F/C Vol. (MCM) -Late Flood-	(Dec. 1-10)	200.0	200.0	200.0	200.0	200.0	200.0	Flood Control Volume
	(Dec. 11-20)	120.0	120.0	120.0	120.0	120.0	120.0	
	(Dec. 21-31)	50.0	50.0	50.0	50.0	50.0	50.0	
Effective Storage Vol.	(MCM)	209.88	209.88	279.51	279.51	360.23	360.23	
D/S River Discharge at Binh Thanh for Probable Major Flood (m^3/s)	10 % flood	5,037	5,037	4,450	4,450	3,887	3,887	
	5 % flood	4,018	4,018	3,494	3,494	3,021	3,021	
	2 % flood	3,264	3,264	2,807	2,807	2,277	2,277	
Resettlement (by D/B Dam) - Households (Nos.)		587	587	616	616	646	646	

Table S3.5 : Examination on Conceivable Alternative Basin Development Plans (1/2)

Alternative Basin Development Plans	Flood Control (F/C) Aspect											Water Utilization Aspect							Environmental Aspect		Economic Aspect		Overall Evaluation
	Dinh Binh Dam				Dyke System			New Sea Dyke Spillway			F/C Requirement (1,960 m3/s)	Effective Storage of Dam (MCM)	Power Generation (GWh/yr)	Cost			Resettlement (Households)	W/S Requirement /3	Natural Environment Indicators: 1) Precious species 2) Impact on protected area 3) Impact on lagoon 4) Water quality	Social Environment Indicators: 5) Impact of resettlement 6) Impact on important infrastructures such as national road and railway	Total construction cost (M.US$) /4	Economic Viability, EIRR(%) NPV (Mil.US$)	
	F/C Vol. of Dam (MCM)	F/C Capacity (m3/s) /1	Resettlement (Households)	Cost (M. US$) /4	F/C Capacity (m3/s)	Resettlement (Households)	Cost (M. US$) /4	Mitigation of Inundation (km^2) /2	Resettlement (Households)	Cost (M. US$) /4				Dam & weir (M. US$) /4	Irr.& Drainage System (M.US$) /4	D&I W/S Facilities (M. US$) /4							
I. Including La Tinh River Basin																							
I.-1 With Dam																							
A. Without New Sea Dyke Spillway																							
I.-1.1A Dam Alt.I-1	221.7	2,886	587	81.7	1,691	248	107.1	-	0	0	Satisfied	209.9	36.5	50.1	144.3	294.4	713	Not satisfied	-	-	-	-	
I.-1.2A Dam Alt.I-2	121.2	2,130	587	81.7	1,691	248	107.1	-	0	0	Satisfied	209.9	42.0	50.1	144.3	294.4	713	Not satisfied	-	-	-	-	
I.-1.3A Dam Alt.II-1	292.8	3,343	616	94.3	1,691	248	107.1	-	0	0	Satisfied	279.5	37.8	50.1	144.3	294.4	713	Satisfied	- No impact for 1) & 2) - Not clear but minor for 3) & 4) ; Need appropriate consideration	-Medium impact for 5) -Relatively larger for 6) Need appropriate consideration	690.2	15.0 % 91.9	Optimum with La Tinh and without new sea dyke spillway
I.-1.4A Dam Alt.II-2	192.8	2,660	616	94.3	1,691	248	107.1	-	0	0	Satisfied	279.5	44.6	50.1	144.3	294.4	713	Satisfied	- Ditto-	- Ditto-	690.2	14.7 % 84.9	
I.-1.5A Dam Alt.III-1	375.5	3,711	646	107.1	1,691	248	107.1	-	0	0	Satisfied	360.2	37.2	50.1	144.3	294.4	713	Satisfied	- Ditto-	- Ditto-	703.0	14.8 % 91.3	
I.-1.6A Dam Alt.III-2	275.5	3,220	646	107.1	1,691	248	107.1	-	0	0	Satisfied	360.2	44.7	50.1	144.3	294.4	713	Satisfied	- Ditto-	- Ditto-	703.0	14.6 % 87.1	
B. With New Sea Dyke Spillway																							
I.-1.1B Dam Alt.I-1	221.72	2,886	587	81.7	1,691	248	107.1	17.0	0	0.3	Satisfied	209.9	36.5	50.1	144.3	294.4	713	Not satisfied	-	-	-	-	
I.-1.2B Dam Alt.I-2	121.22	2,130	587	81.7	1,691	248	107.1	17.0	0	0.3	Satisfied	209.9	42.0	50.1	144.3	294.4	713	Not satisfied	-	-	-	-	
I.-1.3B Dam Alt.II-1	292.77	3,343	616	94.3	1,691	248	107.1	17.0	0	0.3	Satisfied	279.5	37.8	50.1	144.3	294.4	713	Satisfied	- No impact for 1) & 2) - Not clear but minor for 3) & 4) Need appropriate consideration	-Medium impact for 5) -Relatively larger for 6) Need appropriate consideration	690.5	15.1 % 92.4	Optimum with La Tinh and with new sea dyke spillway
I.-1.4B Dam Alt.II-2	192.77	2,660	616	94.3	1,691	248	107.1	17.0	0	0.3	Satisfied	279.5	44.6	50.1	144.3	294.4	713	Satisfied	- Ditto-	- Ditto-	690.5	14.8 % 86.3	
I.-1.5B Dam Alt.III-1	375.52	3,711	646	107.1	1,691	248	107.1	17.0	0	0.3	Satisfied	360.2	37.2	50.1	144.3	294.4	713	Satisfied	- Ditto-	- Ditto-	703.3	14.9 % 91.7	
I.-1.6B Dam Alt.III-2	275.52	3,220	646	107.1	1,691	248	107.1	17.0	0	0.3	Satisfied	360.2	44.7	50.1	144.3	294.4	713	Satisfied	- Ditto-	- Ditto-	703.3	14.7 % 88.0	
I.-2 Without Dam	0	0	0	0	1,691	248	107.1	17.0	0	0.3	Not Satisfied	0	0	0	0	294.4	0	Satisfied for D & I water supply	- Ditto-	- Ditto-	401.8	Negative -1,114.7	-Not feasible economically -No agricultural water supply
														Cost of Freshwater Production: =448,167 m3/d*365d*US$2.0/m3 =US$327million/year									

Note
F/C: Flood Control
Irr.: Irrigation
D&I W/S: Domestic and Industrial Water Supply
NPV Net Present Value in million US$

Remarks
/1 In case of 10 % probable major flood
/2 Area that inundating water level lowering is expected by more than 1.0 m.
/3 75 % dependability for irrigation and fishery
90 % dependability for domestic/industrial water supply
/4 Excluding VAT.

Table S3.5 : Examination on Conceivable Alternative Basin Development Plans (2/2)

Alternative Basin Development Plans	Flood Control (F/C) Aspect											Water Utilization Aspect							Environmental Aspect		Economic Aspect		Overall Evaluation
	Dinh Binh Dam				Dyke System			New Sea Dyke Spillway			F/C Requirement (1,960 m3/s)	Effective Storage of Dam (MCM)	Power Generation (GWh/yr)	Cost			Resettlement (Households)	W/S Requirement /3	Natural Environment Indicators: 1) Precious species 2) Impact on protected area 3) Impact on lagoon 4) Water quality	Social Environment Indicators: 5) Impact of resettlement 6) Impact on important infrastructures such as national road and railway	Total construction cost (M.US$) /4	Economic Viability, EIRR(%) NPV (Mil.US$)	
	F/C Vol. of Dam (MCM)	F/C Capacity (m3/s) /1	Resettlement (Households)	Cost (M. US$) /4	F/C Capacity (m3/s)	Resettlement (Households)	Cost (M. US$) /4	Mitigation of Inundation (km^2) /2	Resettlement (Households)	Cost (M. US$) /4				Dam & weir (M. US$) /4	Irr.& Drainage System (M.US$) /4	D&I W/S Facilities (M. US$) /4							
II. Excluding La Tinh River Basin																							
II.-1 With Dam																							
A. Without New Sea Dyke Spillway																							
II-1.1A Dam Alt.I-1	221.7	2,886	587	81.7	1,691	248	107.1	-	0	0	Satisfied	209.9	36.5	48.5	127.4	294.4	713	Not satisfied	-	-	-	-	
II-1.2A Dam Alt.I-2	121.2	2,130	587	81.7	1,691	248	107.1	-	0	0	Satisfied	209.9	42.0	48.5	127.4	294.4	713	Not satisfied	-	-	-	-	
II-1.3A Dam Alt.II-1	292.8	3,343	616	94.3	1,691	248	107.1	-	0	0	Satisfied	279.5	37.8	48.5	127.4	294.4	713	Satisfied	- No impact for 1) & 2) - Not clear but minor for 3) & 4) ; Need appropriate consideration	-Medium impact for 5) -Relatively larger for 6) Need appropriate consideration	671.7	14.8 % 85.4	Optimum without La Tinh and without new sea dyke spillway
II-1.4A Dam Alt.II-2	192.8	2,660	616	94.3	1,691	248	107.1	-	0	0	Satisfied	279.5	44.6	48.5	127.4	294.4	713	Satisfied	- Ditto-	- Ditto-	671.7	14.5 % 78.4	
II-1.5A Dam Alt.III-1	375.5	3,711	646	107.1	1,691	248	107.1	-	0	0	Satisfied	360.2	37.2	48.5	127.4	294.4	713	Satisfied	- Ditto-	- Ditto-	684.5	14.6 % 84.8	
II-1.6A Dam Alt.III-2	275.5	3,220	646	107.1	1,691	248	107.1	-	0	0	Satisfied	360.2	44.7	48.5	127.4	294.4	713	Satisfied	- Ditto-	- Ditto-	684.5	14.4 % 80.7	
B. With New Sea Dyke Spillway																							
II-1.1B Dam Alt.I-1	221.72	2,886	587	81.7	1,691	248	107.1	17.0	0	0.3	Satisfied	209.9	36.5	48.5	127.4	294.4	713	Not satisfied	-	-	-	-	
II-1.2B Dam Alt.I-2	121.22	2,130	587	81.7	1,691	248	107.1	17.0	0	0.3	Satisfied	209.9	42.0	48.5	127.4	294.4	713	Not satisfied	-	-	-	-	
II-1.3B Dam Alt.II-1	292.77	3,343	616	94.3	1,691	248	107.1	17.0	0	0.3	Satisfied	279.5	37.8	48.5	127.4	294.4	713	Satisfied	- No impact for 1) & 2) - Not clear but minor for 3) & 4) Need appropriate consideration	-Medium impact for 5) -Relatively larger for 6) Need appropriate consideration	672.0	14.9 % 85.9	Optimum without La Tinh and with new sea dyke spillway
II-1.4B Dam Alt.II-2	192.77	2,660	616	94.3	1,691	248	107.1	17.0	0	0.3	Satisfied	279.5	44.6	48.5	127.4	294.4	713	Satisfied	- Ditto-	- Ditto-	672.0	14.6 % 79.8	
II-1.5B Dam Alt.III-1	375.52	3,711	646	107.1	1,691	248	107.1	17.0	0	0.3	Satisfied	360.2	37.2	48.5	127.4	294.4	713	Satisfied	- Ditto-	- Ditto-	684.8	14.7 % 85.2	
II-1.6B Dam Alt.III-2	275.52	3,220	646	107.1	1,691	248	107.1	17.0	0	0.3	Satisfied	360.2	44.7	48.5	127.4	294.4	713	Satisfied	- Ditto-	- Ditto-	684.4	14.5 % 81.5	
II.-2 Without Dam	0	0	0	0	1,691	248	107.1	17.0	0	0.3	Not Satisfied	0	0	0	0	294.4	0	Satisfied for D & I water supply	- Ditto-	- Ditto-	401.8	Negative -1,114.7	-Not feasible economically -No agricultural water supply
														Cost of Freshwater Production: =448,167 m3/d*365d*US$2.0/m3 =US$327million/year									

Note

F/C: Flood Control
Irr.: Irrigation
D&I W/S: Domestic and Industrial Water Supply
NPV Net Present Value in million US$

Remarks

/1 In case of 10 % probable major flood
/2 Area that inundating water level lowering is expected by more than 1.0 m.
/3 75 % dependability for irrigation and fishery
90 % dependability for domestic/industrial water supply
/4 Excluding VAT.

Table S3.6 Summary of Integrated River Basin Management Plan for the Kone River Basin (1/3)

	Sub-project	Major Functions	Principal Feature	Financial Cost (including VAT) /EIRR
1.	**Dinh Binh Multipurpose Reservoir**	- Flood control of 5 % probable late flood and 1% probable early flood - Flood damage mitigation by flood regulation of the floods over the objective flood. - Water supply (including La Tinh River basin) for agricultural water, domestic&industrial water and river maintenance flow - Power generation	- Dam type: Concrete gravity dam with a gated spillway - Dam height: about 55 m - Dam crest level: EL.100.3 m - Flood control volume: 292.77 MCM - Effective storage volume: 279.51 MCM - Power installed capacity: 6,600 kW - Annual average energy generation: 37.84 GWh - Resettlement: 616 households	**US$98.0 mil.**
2.	**Agricultural Development Plan**			**US$202.6 mil.**
	2.1 Van Phong Weir	- Irrigation water supply for 14,100 ha of Van Phong and La Tinh , etc.	- Weir type: Concrete fixed type - Weir length: 470 m - Crest level: EL.25m - Weir Height: 18 m	
	2.2 Irrigation and Drainage Plan consisting of: - Improvement of the existing functional facilities, - Rehabilitation of the existing non-functional facilities, and - New development	- Irrigation for 54,500 ha of Van Phong, Tan An, Dap Da, Ha Thanh and La Tinh, etc.	- Improvement of the existing functional facilities: 24,400 ha - Rehabilitation of the existing non-functional facilities: 6,700 ha - New development: 23,400 ha - Weirs to be rehabilitated: 8 nos. - New weirs: 1 no. - New reservoirs: 11 nos. - Resettlement: 713 households	
3.	**Domestic and Industrial Water Supply Plan**	- Urban and rural domestic water supply, - Industrial zones and rural industrial water supply	- Urban domestic water supply: 72,459 m^3/day - Rural domestic water supply: 35,815 m^3/day - Industrial zones water supply: 108,500 m^3/day - Rural industrial water supply: 146,067 m^3/day - Water Supply for Paper Mill in An Nhon: 100,000 m^3/day	**US$307.8 mil.** Remarks 1)

Table S3.6 Summary of Integrated River Basin Management Plan for the Kone River Basin (2/3)

	Sub-project	Major Functions	Principal Feature	Financial Cost (including VAT) /EIRR
4.	**Flood Control and Bank Erosion Protection Plan**			**US$112.2 mil.**
	4.1 Thi Nai Swamp Improvement Work	- Increase of discharge carrying capacity to 627 to 1,743 m^3/s for flood control of the objective 5 % probable late flood together with the Dinh Binh Dam	- Construction/heightening of sea dyke: 7.8 km - Construction/improvement of drainage sluice: 21 nos. - Construction of sea dyke spillway: 12 sites	
	4.2 Dap Da River Improvement Work	- Increase of discharge carrying capacity to 597 to 627 m^3/s for flood control of the objective 5 % probable late flood together with the Dinh Binh Dam	- Construction/ heightening of flood control dyke: 28.9 km - Excavation of river channel: 28.9 km - Construction of side overflow weir: 2 sites - Construction of flood diversion groyne: 5 nos. - Construction/improvement of bridges: 4 nos. - Construction/improvement of drainage sluice: 21 nos. - Construction of flood diversion sluice: 1 no. - Construction/ improvement of bank protection work: 9.7 km - Resettlement: 88 households	
	4.3 Nam Yang River Improvement Work	- Increase of discharge carrying capacity to 20 m3/s for flood control of the objective 5% probable late flood together with the Dinh Binh Dam	- Construction/heightening of flood control dyke : 15.9km - Excavation of river channel: 15.9 km - Construction/improvement of drainage sluice: 1 no - Construction/improvement of bank protection works: 5.3 km	
	4.4 Go Cham River Improvement Works	- Increase of discharge carrying capacity to 209 m3/s for flood control of the objective 5% probable late flood together with the Dinh Binh Dam	- Construction/heightening of flood control dyke : 25.8 km - Excavation of river channel: 25.8 km - Construction of side overflow weir: 2 sites - Construction of flood diversion weir: 1 no. - Construction/improvement of bank protection works: 8.7 km - Resettlement: 58 households	
	4.5 Tan An River Improvement Work	- Increase of discharge carrying capacity to 837 m3/s ~ 1,077 m3/s for flood control of the objective 5% probable late flood together with the Dinh Binh Dam	- Construction/heightening of flood control dyke : 28.6 km - Excavation of river channel: 28.6 km - Construction of side overflow weir: 3 sites - Construction/improvement of drainage sluice: 10 nos - Construction of flood diversion sluice: 1 no. - Construction/improvement of bank protection works: 9.6 km - Resettlement: 102 households	
	4.6 Cay May River Improvement Works	- Increase of discharge carrying capacity to 50 m3/s for flood control of the objective 5% probable late flood together with the Dinh Binh Dam	- Construction/heightening of flood control dyke : km: 8.5 km - Excavation of river channel: 8.5 km - Construction/improvement of bank protection works: 2.8 km	

Table S3.6 Summary of Integrated River Basin Management Plan for the Kone River Basin (3/3)

	Sub-project	Major Functions	Principal Feature	Financial Cost (including VAT) /EIRR
5.	**Rural development Plan**			
	5.1 Rural Roads Development Plan	- Inter commune and in-commune transportation	- Road length: 735 km	- Remarks 1)
	5.2 Rural Electrification	- Access to the national grid or other sources	- Coverage: 95 % of households 100% of communes	- Remarks 1)
	5.3 Rural domestic Water Supply	- Access to fresh water	- Coverage: 50 % connection to piped-system	- Remarks 2)
6.	**Water Resources Management Plan**			Remarks 1)
	6.1 Water Use Management Plan	- Proper management of water demand - Latest information management of water resources including river flow and reservoir's storage - Proper water allotment in drought year	- Management of current water demand and water supply - Preparation of annual water use plan prior to the dry season - Preparation of water demand restriction plan prior to the drought season	
	6.2 Flood Control Management Plan	- Mitigation of flood damage - River basin conservation	- Flood warning and communication system - Reforestation for watershed conservation - Preparation and disclosure of hazard map	US$4.0 mil. Remarks 1)
	6.3 River Environment Management Plan	- Management of river maintenance flow - Water quality control - Thi Nai swamp monitoring	- Proper water distribution between respective water demands and river maintenance flow requirement. - Establishment of regular monitoring of river water quality as well as proposed reservoirs including Dinh Binh Dam and Van Phong Weir.	
	6.4 Dam Operation Management	- Integrated operation of the existing and proposed dams including Vinh Son Dam, Dinh Binh Dam and Nui Mot Dam - Warning and communication system of dam water release	- Integrated reservoir operation for effective water supply including Vinh Son, Dinh Binh and Nui Mot Dams. - Warning dissemination of dam water release	US$0.5 mil. Remarks 1)
	6.5 Administrative Management Plan	- Establishment of the Kone River Basin Management Authority - Committees will act as task force under the authority to carry out activities: - Water use management - Flood control management - River environment management - Dam operation management	- Establishment of water use management committee with DARD as coordinating agency - Establishment of flood control and warning committee that will take over tasks of the existing provincial committee. DARD will act as coordinating agency. - Establishment of River Environment Management Committee with DOSTE as coordinating agency.	
	TOTAL COST /EIRR			**US$720.5 million /15.1 %**

Remarks 1) : This cost is not considered in the cost estimate for the Integrated River Basin Management Plan.

2) : This cost was taken into account in the rural domestic water supply plan.

Table S3.7 Summary of Disbursement Schedule for Kone River Basin

Alternative II-1 & II-2

Unit: Million VND, Million US$

Description	Total	Year																		
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1. Dinh Binh Reservoir Project																				
(1) Direct Construction Cost	722,854				38,588	38,588	142,392	103,038	113,660	145,270	141,316									
(2) Indirect Construction Cost	697,309		47,268	49,584	78,803	52,619	79,772	69,504	83,938	115,517	120,304									
Sub-total	1,420,163		47,268	49,584	117,392	91,207	222,164	172,542	197,598	260,787	261,620									
Equivalent to US$	94.3		3.1	3.3	7.8	6.1	14.7	11.5	13.1	17.3	17.4									
(3) VAT	56,972		0	0	2,972	3,034	10,098	7,843	9,006	11,878	12,141									
Equivalent to US$	4.0		0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0									
Total	**1,477,135**		**47,268**	**49,584**	**120,363**	**94,241**	**232,262**	**180,385**	**206,604**	**272,665**	**273,761**									
Equivalent to US$	98.0		3.1	3.3	8.0	6.3	15.4	12.0	13.7	18.1	18.2									
2. Flood Control Project																				
(1) Direct Construction Cost	699,931											216,696	215,892	117,018	76,641	73,684				
(2) Indirect Construction Cost	918,595							16,324	16,772	36,541	28,016	209,452	229,567	147,708	114,284	119,930				
Sub-total	1,618,525							16,324	16,772	36,541	28,016	426,148	445,459	264,725	190,925	193,615				
Equivalent to US$	107.4							1.1	1.1	2.4	1.9	28.3	29.6	17.6	12.7	12.8				
(3) VAT	71,520							183	176	1,046	984	19,370	20,248	12,033	8,678	8,801				
Equivalent to US$	4.7							0.0	0.0	0.1	0.1	1.3	1.3	0.8	0.6	0.6				
Total	**1,690,045**							**16,507**	**16,948**	**37,587**	**29,000**	**445,518**	**465,707**	**276,758**	**199,603**	**202,415**				
Equivalent to US$	112.2							1.1	1.1	2.5	1.9	29.6	30.9	18.4	13.2	13.4				
3. Irrigation and Drainage Facilities																				
(1) Direct Construction Cost	1,472,538						329,915	284,446	287,740	194,322	205,820	21,048	21,048	21,048	21,048	21,048	21,048	21,048	22,961	
(2) Indirect Construction Cost	1,451,320		31,148	32,674	47,358	31,951	172,050	172,206	196,601	155,698	181,758	41,520	44,586	47,802	51,176	54,715	58,427	62,321	69,329	
Sub-total	2,923,858		31,148	32,674	47,358	31,951	501,965	456,652	484,340	350,020	387,578	62,568	65,634	68,850	72,224	75,763	79,475	83,369	92,290	
Equivalent to US$	194.0		2.1	2.2	3.1	2.1	33.3	30.3	32.1	23.2	25.7	4.2	4.4	4.6	4.8	5.0	5.3	5.5	6.1	
(3) VAT	128,263		151	158	760	798	22,817	20,757	22,015	15,910	17,617	2,844	2,983	3,130	3,283	3,444	3,612	3,790	4,195	
Equivalent to US$	8.5		0.0	0.0	0.1	0.1	1.5	1.4	1.5	1.1	1.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	
Total	**3,052,121**		**31,298**	**32,832**	**48,118**	**32,749**	**524,781**	**477,409**	**506,356**	**365,930**	**405,195**	**65,412**	**68,617**	**71,980**	**75,507**	**79,206**	**83,087**	**87,159**	**96,485**	
Equivalent to US$	202.6		2.1	2.2	3.2	2.2	34.8	31.7	33.6	24.3	26.9	4.3	4.6	4.8	5.0	5.3	5.5	5.8	6.4	
4. Domestic and Industrial water Supply																				
(1) Direct Construction Cost	2,001,996						69,177	385,732	385,732	39,849	39,849	39,849	39,849	39,849	39,849	39,849	109,026	385,732	387,652	
(2) Indirect Construction Cost	2,433,851				14,374	27,644	61,214	237,758	268,309	27,571	30,875	34,341	37,976	41,789	68,981	94,587	195,589	620,237	672,606	
Sub-total	4,435,847				14,374	27,644	130,390	623,490	654,041	67,421	70,724	74,190	77,825	81,639	108,831	134,437	304,615	1,005,968	1,060,258	
Equivalent to US$	294.4				1.0	1.8	8.7	41.4	43.4	4.5	4.7	4.9	5.2	5.4	7.2	8.9	20.2	66.8	70.4	
(3) VAT	201,629				653	1,257	5,927	28,340	29,729	3,065	3,215	3,372	3,538	3,711	4,947	6,111	13,846	45,726	48,194	
Equivalent to US$	13.4				0.0	0.1	0.4	1.9	2.0	0.2	0.2	0.2	0.2	0.2	0.3	0.4	0.9	3.0	3.2	
Total	**4,637,477**				**15,027**	**28,900**	**136,317**	**651,830**	**683,770**	**70,485**	**73,939**	**77,562**	**81,363**	**85,350**	**113,778**	**140,548**	**318,461**	**1,051,694**	**1,108,452**	
Equivalent to US$	307.8				1.0	1.9	9.0	43.3	45.4	4.7	4.9	5.1	5.4	5.7	7.6	9.3	21.1	69.8	73.6	
5. Total																				
(1) Direct Construction Cost	4,897,319		0	0	38,588	38,588	541,484	773,216	787,132	379,441	386,985	277,593	276,789	177,915	137,538	134,581	130,074	406,780	410,613	
(2) Indirect Construction Cost	5,501,075		78,416	82,258	140,535	112,214	313,036	495,792	565,620	335,327	360,953	285,313	312,129	237,299	234,441	269,232	254,016	682,558	741,935	
Sub-total of 1 to 4	**10,398,393**		**78,416**	**82,258**	**179,124**	**150,802**	**854,519**	**1,269,008**	**1,352,751**	**714,769**	**747,938**	**562,906**	**588,918**	**415,214**	**371,980**	**403,815**	**384,090**	**1,089,337**	**1,152,548**	
Equivalent to US$	690.1		5.2	5.5	11.9	10.0	56.7	84.2	89.8	47.4	49.6	37.4	39.1	27.6	24.7	26.8	25.5	72.3	76.5	
(3) VAT of 1 to 4	458,384		151	158	4,385	5,089	38,842	57,123	60,926	31,899	33,957	25,586	26,769	18,874	16,908	18,356	17,458	49,516	52,389	
Equivalent to US$	30.4		0.0	0.0	0.3	0.3	2.6	3.8	4.0	2.1	2.3	1.7	1.8	1.3	1.1	1.2	1.2	3.3	3.5	
Total of 1 to 4	**10,856,777**		**78,567**	**82,416**	**183,509**	**155,891**	**893,361**	**1,326,131**	**1,413,677**	**746,668**	**781,895**	**588,492**	**615,687**	**434,088**	**388,888**	**422,171**	**401,548**	**1,138,853**	**1,204,937**	
Equivalent to US$	720.5		5.2	5.5	12.2	10.3	59.3	88.0	93.8	49.6	51.9	39.1	40.9	28.8	25.8	28.0	26.6	75.6	80.0	

TableS4.1 Disbursement Schedule for Dinh Binh Multipurpose Reservoir

Dam Crest EL.. 100.3 m, Alternatives II-1 & II-2

Unit: Million VND, Million US$

Description	Total(VND)			2003		2004		2005		2006		2007		2008		2009		2010		2011	
	F.C(VND)	L.C(VND)	Total(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)
1. Direct Construction Cost																					
1.1 General Items	34,881	34,465	69,346									34,881	34,465								
1.2 Main Dam Works																					
1.2.1 Overflow	61,719	60,983	122,702									15,430	15,246	15,430	15,246	15,430	15,246	15,430	15,246		
1.2.2 Non-overflow	139,436	137,773	277,209									34,859	34,443	34,859	34,443	34,859	34,443	34,859	34,443		
1.2.3 Dam Shoulder Embankment	2,318	2,290	4,608									580	573	580	573	580	573	580	573		
1.2.4 Related Works	16,716	16,516	33,232									3,343	3,303	3,343	3,303	3,343	3,303	3,343	3,303	3,343	3,303
1.2.5 Hydromechanical and Hydroelectrical Plant	16,191	15,998	32,189													5,505	5,439	5,343	5,279	5,343	5,279
Sub-total	236,380	233,561	469,941									54,212	53,565	54,212	53,565	59,717	59,004	59,555	58,844	8,686	8,583
1.3 Hydropower Plant																					
1.3.1 Main Civil Works	6,056	5,983	12,039															3,028	2,992	3,028	2,992
1.3.2 Related Works	25,542	25,237	50,779															12,771	12,618	12,771	12,618
1.3.3 Hydropower Plant, 3,300 kw x 2	34,602	34,189	68,790																	34,602	34,189
Sub-total	66,199	65,409	131,608															15,799	15,610	50,400	49,799
1.4 Transmission Line, 22 kv x 25 km	15,076	14,896	29,971																	15,076	14,896
1.5 Relocation Road	31,156	30,785	61,941					15,578	15,392	15,578	15,392										
Total of 1	**383,692**	**379,115**	**762,808**					**15,578**	**15,392**	**15,578**	**15,392**	**89,093**	**88,030**	**54,212**	**53,565**	**59,717**	**59,004**	**75,353**	**74,454**	**74,162**	**73,277**
Equivalent to US$	25.5	25.2	50.6					1.0	1.0	1.0	1.0	5.9	5.8	3.6	3.6	4.0	3.9	5.0	4.9	4.9	4.9
2. Indirect Construction Cost																					
2.1 Resettlement Cost	0	134,656	134,656		39,050		39,050		39,050		17,505										
2.2 Engineering Cost	38,369	37,912	76,281					6,139	6,066	5,372	5,308	5,372	5,308	5,372	5,308	5,372	5,308	5,372	5,308	5,372	5,308
2.3 Administration	0	26,924	26,924		3,231		2,962		2,962		2,962		2,962		2,962		2,962		2,962		2,962
2.4 Price Escalation (F.C:1.6% , L.C:4.9%)	54,487	217,749	272,236	0	4,245	0	6,483	1,424	13,385	1,730	11,124	9,439	32,015	7,002	24,594	8,813	31,365	12,397	44,512	13,682	50,025
2.5 Physical Contingency (Civil:10%, Plant:5%)	44,361	76,381	120,743	0	4,653	0	4,850	2,314	7,685	2,268	5,229	10,390	12,831	6,659	8,643	7,115	9,592	9,045	12,460	6,571	10,439
Total of 2	**137,218**	**493,621**	**630,839**	**0**	**51,179**	**0**	**53,345**	**9,877**	**69,148**	**9,370**	**42,128**	**25,201**	**53,116**	**19,033**	**41,506**	**21,300**	**49,226**	**26,814**	**65,241**	**25,624**	**68,733**
Equivalent to US$	9.1	32.8	41.9	0.0	3.4	0.0	3.5	0.7	4.6	0.6	2.8	1.7	3.5	1.3	2.8	1.4	3.3	1.8	4.3	1.7	4.6
Total of 1 & 2	**520,910**	**872,737**	**1,393,647**	**0**	**51,179**	**0**	**53,345**	**25,455**	**84,540**	**24,948**	**57,520**	**114,294**	**141,146**	**73,244**	**95,071**	**81,016**	**108,231**	**102,167**	**139,695**	**99,786**	**142,010**
Equivalent to US$	34.6	57.9	92.5	0.0	3.4	0.0	3.5	1.7	5.6	1.7	3.8	7.6	9.4	4.9	6.3	5.4	7.2	6.8	9.3	6.6	9.4
3. VAT (5 %)	**0**	**55,767**	**55,767**		**178**		**171**		**2,636**		**2,637**		**11,611**		**7,651**		**8,627**		**11,018**		**11,239**
Equivalent to US$	0.0	3.7	3.7		0.0		0.0		0.2		0.2		0.8		0.5		0.6		0.7		0.7
Total of 1 to 3	**520,910**	**928,504**	**1,449,414**	**0**	**51,357**	**0**	**53,516**	**25,455**	**87,176**	**24,948**	**60,157**	**114,294**	**152,757**	**73,244**	**102,722**	**81,016**	**116,858**	**102,167**	**150,713**	**99,786**	**153,250**
Equivalent to US$	34.6	61.6	96.2	0.0	3.4	0.0	3.6	1.7	5.8	1.7	4.0	7.6	10.1	4.9	6.8	5.4	7.8	6.8	10.0	6.6	10.2

Note:

(1) Cost data sources; Feasibility study report, executive summary, Stage 2, No. 444C-05-TT2, General Explanation, No.444C-05-TM (HEC-1) and Supplementary Study, No.444C-10-T1(HEC-1)

(2) Price level; As of Year 2001

(3) Exchange rate; US$ 1.0 = VND 15,068 = ¥ 123.39

(4) Price escalation; F.C : 1.6 % and L.C : 4.9 %

Table S4.2 Disbursement Schedule for Van Phong Weir and Irrigation and Drainage System

Unit: Million VND, Million US$

Description	Total(VND)			2003		2004		2005		2006		2007		2008		2009		2010		2011	
	F.C(VND)	L.C(VND)	Total(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)
1. Direct Construction Cost																					
1.1 General Items	25,741	25,434	51,175									25,741	25,434								
1.2 Van Phong Weir																					
1.2.1 Weir	83,171	82,179	165,350									18,298	18,079	18,298	18,079	18,298	18,079	18,298	18,079	9,981	9,861
1.2.2 Scouring Sluice	2,021	1,997	4,018											2,021	1,997						
1.2.3 Intake Facilities	3,838	3,792	7,631											3,838	3,792						
1.2.4 Flood Dike	4,939	4,880	9,819									4,939	4,880								
Sub-total	93,969	92,848	186,817									23,236	22,959	24,157	23,869	18,298	18,079	18,298	18,079	9,981	9,861
1.3 Rehabilitation Works of Existing Weirs	36,544	36,108	72,652									5,847	5,777	7,674	7,583	7,674	7,583	7,674	7,583	7,674	7,583
1.4 New Pumping Station	14,746	14,570	29,316									2,359	2,331	3,097	3,060	3,097	3,060	3,097	3,060	3,097	3,060
1.5 Main Irrigation System	153,914	152,078	305,992									24,626	24,333	32,322	31,936	32,322	31,936	32,322	31,936	32,322	31,936
1.6 Primary and Secondary Irrigation Systen	142,656	140,955	283,611									22,825	22,553	29,958	29,600	29,958	29,600	29,958	29,600	29,958	29,600
1.7 Drainage System	34,177	33,769	67,946									5,468	5,403	7,177	7,092	7,177	7,092	7,177	7,092	7,177	7,092
1.8 Farm Road Network	4,147	4,097	8,244									663	656	871	860	871	860	871	860	871	860
1.9 On-farm System (Irrigation, Drainage and Farm Road Facilities)	34,668	34,254	68,923									5,547	5,481	7,280	7,193	7,280	7,193	7,280	7,193	7,280	7,193
Total of 1	**540,562**	**534,114**	**1,074,676**									**116,314**	**114,926**	**112,536**	**111,193**	**106,677**	**105,404**	**106,677**	**105,404**	**98,359**	**97,186**
Equivalent to US$	35.9	35.4	71.3									7.7	7.6	7.5	7.4	7.1	7.0	7.1	7.0	6.5	6.4
2. Indirect Construction Cost																					
2.1 Resettlement Cost	0	79,294	79,294		22,995		22,995		22,995		10,308										
2.2 Engineering Cost	54,056	53,411	107,468					8,649	8,546	7,568	7,478	7,568	7,478	7,568	7,478	7,568	7,478	7,568	7,478	7,568	7,478
2.3 Administration	0	34,619	34,619		4,154		3,808		3,808		3,808		3,808		3,808		3,808		3,808		3,808
2.4 Price Escalation (F.C:1.6%, L.C:4.9%)	78,921	294,563	373,484	0	2,726	0	4,136	567	7,455	625	5,835	12,379	41,960	14,115	48,716	15,469	54,405	17,544	62,789	18,222	66,542
2.5 Physical Contingency (10%)	67,354	99,600	166,954	0	2,988	0	3,094	922	4,280	819	2,743	13,626	16,817	13,422	17,119	12,971	17,109	13,179	17,948	12,415	17,501
Total of 2	**200,331**	**561,487**	**761,818**	**0**	**32,863**	**0**	**34,034**	**10,138**	**47,084**	**9,012**	**30,172**	**33,573**	**70,063**	**35,105**	**77,121**	**36,008**	**82,800**	**38,291**	**92,022**	**38,205**	**95,329**
Equivalent to US$	13.3	37.3	50.6	0.0	2.2	0.0	2.3	0.7	3.1	0.6	2.0	2.2	4.6	2.3	5.1	2.4	5.5	2.5	6.1	2.5	6.3
Total of 1 & 2	**740,893**	**1,095,601**	**1,836,494**	**0**	**32,863**	**0**	**34,034**	**10,138**	**47,084**	**9,012**	**30,172**	**149,886**	**184,989**	**147,640**	**188,314**	**142,685**	**188,204**	**144,968**	**197,426**	**136,564**	**192,515**
Equivalent to US$	49.2	72.7	121.9	0.0	2.2	0.0	2.3	0.7	3.1	0.6	2.0	9.9	12.3	9.8	12.5	9.5	12.5	9.6	13.1	9.1	12.8
3. VAT (5 %)	**0**	**78,838**	**78,838**		**229**		**220**		**1,209**		**1,126**		**15,222**		**15,271**		**15,040**		**15,563**		**14,958**
Equivalent to US$	0.0	5.2	5.2		0.0		0.0		0.1		0.1		1.0		1.0		1.0		1.0		1.0
Total of 1 to 3	**740,893**	**1,174,439**	**1,915,332**	**0**	**33,091**	**0**	**34,253**	**10,138**	**48,293**	**9,012**	**31,298**	**149,886**	**200,211**	**147,640**	**203,585**	**142,685**	**203,245**	**144,968**	**212,990**	**136,564**	**207,473**
Equivalent to US$	49.2	77.9	127.1	0.0	2.2	0.0	2.3	0.7	3.2	0.6	2.1	9.9	13.3	9.8	13.5	9.5	13.5	9.6	14.1	9.1	13.8

Note:

(1) Cost data sources; Feasibility study report, executive summary, Stage 2, No. 444C-05-TT2, General Explanation, No.444C-05-TM (HEC-1) and Supplementary Study, No.444C-10-T1(HEC-1)

(2) Price level; As of Year 2001

(3) Exchange rate; US$ 1.0 = VND 15,068 = ￥ 123.39

(4) Price escalation; F.C 1.6 % and L.C 4.9 %

Table S4.3 Disbursement Schedule for Downstream Flood Control Plan

Unit: Million VND, Million US$

Description	Total(VND)			2008		2009		2010		2011		2012		2013		2014		2015		2016	
	F.C(VND)	L.C(VND)	Total(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)	F.C(VND)	L.C(VND)
1. Direct Construction Cost																					
1.1 General Items	16,765	16,565	33,330									16,765	16,565								
1.2 Thi Nai Swamp																					
1.2.1 Sea Dyke	14,824	14,647	29,471									5,559	5,493	7,412	7,324	1,853	1,831				
1.2.2 Improvement of Sluice Gates	55,494	54,832	110,326									20,810	20,562	27,747	27,416	6,937	6,854				
1.2.3 Improvement of spillway	1,012	1,000	2,011									379	375	506	500	126	125				
1.2.4 New Construction of Spillway	843	833	1,677									316	313	422	417	105	104				
Sub-total	72,173	71,312	143,485									27,065	26,742	36,087	35,656	9,022	8,914				
1.3 Dap Da River																					
1.3.1 Dyke	24,445	24,154	48,599									3,911	3,865	5,133	5,072	5,133	5,072	5,133	5,072	5,133	5,072
1.3.2 Bridges	22,249	21,984	44,233									3,560	3,517	4,672	4,617	4,672	4,617	4,672	4,617	4,672	4,617
1.3.3 Side Overflow Spillway	3,446	3,405	6,852									3,446	3,405								
1.3.4 New Construction of Sluice Gates	21,880	21,619	43,499									3,501	3,459	4,595	4,540	4,595	4,540	4,595	4,540	4,595	4,540
1.3.5 Bank Protection Works	5,656	5,589	11,245									905	894	1,188	1,174	1,188	1,174	1,188	1,174	1,188	1,174
1.3.6 Reconstruction of Irrigation Weir	20,500	20,256	40,756									7,688	7,596	10,250	10,128	2,563	2,532				
Sub-total	98,178	97,007	195,184									23,011	22,736	25,839	25,530	18,151	17,935	15,589	15,403	15,589	15,403
1.4 Go Cham River																					
1.4.1 Dyke	4,296	4,244	8,540									1,074	1,061	1,418	1,401	1,418	1,401	387	382		
1.4.2 Bridges	7,198	7,112	14,311									1,800	1,778	2,375	2,347	2,375	2,347	648	640		
1.4.3 Side Overflow Spillway	960	949	1,909									960	949								
1.4.4 New Construction of Fixed Weir	6,239	6,165	12,404									2,340	2,312	3,120	3,082	780	771				
1.4.5 Reconstruction of Irrigation Weir	3,120	3,082	6,202									1,170	1,156	1,560	1,541	390	385				
1.4.6 Bank Protection Works	5,031	4,971	10,003									1,258	1,243	1,660	1,641	1,660	1,641	453	447		
Sub-total	26,845	26,524	53,369									8,601	8,499	10,133	10,012	6,623	6,544	1,487	1,470		
1.5 Tan An River																					
1.5.1 Dyke	34,532	34,120	68,651									5,525	5,459	7,252	7,165	7,252	7,165	7,252	7,165	7,252	7,165
1.5.2 Bridges	18,977	18,751	37,729									3,036	3,000	3,985	3,938	3,985	3,938	3,985	3,938	3,985	3,938
1.5.3 Side Overflow Spillway	3,440	3,399	6,839									3,440	3,399								
1.5.4 New Construction of Sluice Gate	42,391	41,885	84,277									6,783	6,702	8,902	8,796	8,902	8,796	8,902	8,796	8,902	8,796
1.5.5 Improvement of Irrigation Weir	17,826	17,614	35,440									6,685	6,605	8,913	8,807	2,228	2,202				
1.5.6 Bank Protection Works	6,360	6,284	12,644									1,018	1,005	1,336	1,320	1,336	1,320	1,336	1,320	1,336	1,320
Sub-total	123,527	122,054	245,580									26,487	26,171	30,388	30,025	23,703	23,420	21,475	21,219	21,475	21,219
1.6 Nam Yang River																					
1.6.1 Dyke	3,375	3,334	6,709									1,265	1,250	1,687	1,667	422	417				
1.6.2 Bridges	4,417	4,364	8,782									1,656	1,637	2,209	2,182	552	546				
1.6.3 New Construction of Sluice Gate	875	864	1,739									875	864								
1.6.4 Bank Protection Works	3,096	3,059	6,155									1,161	1,147	1,548	1,530	387	382				
Sub-total	11,763	11,622	23,385									4,958	4,899	5,444	5,379	1,361	1,345				
1.7 Ca My River																					
1.7.1 Dyke	522	516	1,039									392	387	131	129						
1.7.2 Bank Protection Works	1,645	1,625	3,270									1,234	1,219	411	406						
Sub-total	2,167	2,141	4,309									1,625	1,606	542	535						
1.8 Kone River																					
1.8.1 Groyne	648	640	1,288									486	480	162	160						
Sub-total	648	640	1,288									486	480	162	160						
Total of 1	**352,065**	**347,866**	**699,931**									**108,998**	**107,698**	**108,594**	**107,298**	**58,860**	**58,158**	**38,550**	**38,091**	**37,063**	**36,621**
Equivalent to US$	23.4	23.1	46.5									7.2	7.1	7.2	7.1	3.9	3.9	2.6	2.5	2.5	2.4
2. Indirect Construction Cost																					
2.1 Resettlement Cost	0	27,580	27,580		7,998		7,998		7,998		3,585										
2.2 Engineering Cost	35,207	34,787	69,993					5,633	5,566	4,929	4,870	4,929	4,870	4,929	4,870	4,929	4,870	4,929	4,870	4,929	4,870
2.3 Administration	0	21,825	21,825		2,619		2,401		2,401		2,401		2,401		2,401		2,401		2,401		2,401
2.4 Price Escalation (F.C: 1.6%, L.C: 4.9%)	83,997	338,530	422,527	0	4,223	0	4,848	865	8,590	848	6,660	21,735	79,617	23,820	88,841	14,620	56,428	10,820	43,261	11,289	46,061
2.5 Physical Contingency (10%)	47,127	77,059	124,186	0	1,484	0	1,525	650	2,456	578	1,752	13,566	19,459	13,734	20,341	7,841	12,186	5,430	8,862	5,328	8,995
Total of 2	**166,330**	**499,781**	**666,112**	**0**	**16,324**	**0**	**16,772**	**7,148**	**27,011**	**6,354**	**19,268**	**40,230**	**106,346**	**42,484**	**116,453**	**27,389**	**75,885**	**21,179**	**59,394**	**21,546**	**62,328**
Equivalent to US$	11.0	33.2	44.2	0.0	1.1	0.0	1.1	0.5	1.8	0.4	1.3	2.7	7.1	2.8	7.7	1.8	5.0	1.4	3.9	1.4	4.1
Total of 1 & 2	**518,395**	**847,647**	**1,366,042**	**0**	**16,324**	**0**	**16,772**	**7,148**	**27,011**	**6,354**	**19,268**	**149,228**	**214,044**	**151,077**	**223,752**	**86,249**	**134,042**	**59,729**	**97,485**	**58,609**	**98,949**
Equivalent to US$	34.4	56.3	90.7	0.0	1.1	0.0	1.1	0.5	1.8	0.4	1.3	9.9	14.2	10.0	14.8	5.7	8.9	4.0	6.5	3.9	6.6
3. VAT (5 %)	**0**	**60,043**	**60,043**	**0**	**183**	**0**	**176**	**0**	**938**	**0**	**875**	**0**	**16,512**	**0**	**17,038**	**0**	**10,013**	**0**	**7,146**	**0**	**7,162**
Equivalent to US$	0.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	1.1	0.0	1.1	0.0	0.7	0.0	0.5	0.0	0.5
Total of 1 to 3	**518,395**	**907,690**	**1,426,085**	**0**	**16,507**	**0**	**16,948**	**7,148**	**27,949**	**6,354**	**20,143**	**149,228**	**230,556**	**151,077**	**240,789**	**86,249**	**144,056**	**59,729**	**104,631**	**58,609**	**106,111**
Equivalent to US$	34.4	60.2	94.6	0.0	1.1	0.0	1.1	0.5	1.9	0.4	1.3	9.9	15.3	10.0	16.0	5.7	9.6	4.0	6.9	3.9	7.0

Note:
(1) Cost data sources; Feasibility study report, executive summary, Stage 2, No. 444C-05-TT2, General Explanation, No.444C-05-TM (HEC-1) and Supplementary Study, No.444C-10-T1(HEC-1)
(2) Price level; As of Year 2001 (3) Exchange rate; US$ 1.0 = VND 15,068 = ¥ 123.39 (4) Price escalation; F.C 1.6 % and L.C 4.9 %

Table S4.4 Summary of Disbursement Schedule for Kone River Basin

Alternative II-1 & II-2, Feasibility Study

Unit: Million VND, Million US$

Description	Total(VND)			2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
	F.C (VND)	L.C (VND)	Total (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)	F.C (VND)	L.C (VND)
1. Dinh Binh Multipurpose Reservoir																															
(1) Direct Construction Cost		379,115	762,808					15,578	15,392	15,578	15,392	89,093	88,030	54,212	53,565	59,717	59,004	75,353	74,454	74,162	73,277										
(2) Indirect Construction Cost	137,218	493,621	630,839	0	51,179	0	53,345	9,877	69,148	9,370	42,128	25,201	53,116	19,033	41,506	21,300	49,226	26,814	65,241	25,624	68,733										
Sub-total	520,910	872,737	1,393,647	0	51,179	0	53,345	25,455	84,540	24,948	57,520	114,294	141,146	73,244	95,071	81,016	108,231	102,167	139,695	99,786	142,010										
Equivalent to US$	34.6	57.9	92.5	0.0	3.4	0.0	3.5	1.7	5.6	1.7	3.8	7.6	9.4	4.9	6.3	5.4	7.2	6.8	9.3	6.6	9.4										
(3) VAT	0	55,767	55,767		178		171		2,636		2,637		11,611		7,651		8,627		11,018		11,239										
Equivalent to US$	0.0	3.7	3.7	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.8	0.0	0.5	0.0	0.6	0.0	0.7	0.0	0.7										
Total	**520,910**	**928,504**	**1,449,414**	**0**	**51,357**	**0**	**53,516**	**25,455**	**87,176**	**24,948**	**60,157**	**114,294**	**152,757**	**73,244**	**102,722**	**81,016**	**116,858**	**102,167**	**150,713**	**99,786**	**153,250**										
Equivalent to US$	34.6	61.6	96.2	0.0	3.4	0.0	3.6	1.7	5.8	1.7	4.0	7.6	10.1	4.9	6.8	5.4	7.8	6.8	10.0	6.6	10.2										
2. Van Phong Weir and Irrigation and Drainage System																															
(1) Direct Construction Cost	540,562	534,114	1,074,676									116,314	114,926	112,536	111,193	106,677	105,404	106,677	105,404	98,359	97,186										
(2) Indirect Construction Cost	200,331	561,487	761,818	0	32,863	0	34,034	10,138	47,084	9,012	30,172	33,573	70,063	35,105	77,121	36,008	82,800	38,291	92,022	38,205	95,329										
Sub-total	740,893	1,095,601	1,836,494	0	32,863	0	34,034	10,138	47,084	9,012	30,172	149,886	184,989	147,640	188,314	142,685	188,204	144,968	197,426	136,564	192,515										
Equivalent to US$	49.2	72.7	121.9	0.0	2.2	0.0	2.3	0.7	3.1	0.6	2.0	9.9	12.3	9.8	12.5	9.5	12.5	9.6	13.1	9.1	12.8										
(3) VAT	0	78,838	78,838		229		220		1,209		1,126		15,222		15,271		15,040		15,563		14,958										
Equivalent to US$	0.0	5.2	5.2		0.0		0.0		0.1		0.1		1.0		1.0		1.0		1.0		1.0										
Total	**740,893**	**1,174,439**	**1,915,332**	**0**	**33,091**	**0**	**34,253**	**10,138**	**48,293**	**9,012**	**31,298**	**149,886**	**200,211**	**147,640**	**203,585**	**142,685**	**203,245**	**144,968**	**212,990**	**136,564**	**207,473**										
Equivalent to US$	49.2	77.9	127.1	0.0	2.2	0.0	2.3	0.7	3.2	0.6	2.1	9.9	13.3	9.8	13.5	9.5	13.5	9.6	14.1	9.1	13.8										
3. Downstream Flood Control Plan																															
(1) Direct Construction Cost	352,065	347,866	699,931																			108,998	107,698	108,594	107,298	58,860	58,158	38,550	38,091	37,063	36,621
(2) Indirect Construction Cost	166,330	499,781	666,112											0	16,324	0	16,772	7,148	27,011	6,354	19,268	40,230	106,346	42,484	116,453	27,389	75,885	21,179	59,394	21,546	62,328
Sub-total	518,395	847,647	1,366,042											0	16,324	0	16,772	7,148	27,011	6,354	19,268	149,228	214,044	151,077	223,752	86,249	134,042	59,729	97,485	58,609	98,949
Equivalent to US$	34.4	56.3	90.7											0.0	1.1	0.0	1.1	0.5	1.8	0.4	1.3	9.9	14.2	10.0	14.8	5.7	8.9	4.0	6.5	3.9	6.6
(3) VAT	0	60,043	60,043											0	183	0	176	0	938	0	875	0	16,512	0	17,038	0	10,013	0	7,146	0	7,162
Equivalent to US$	0.0	4.0	4.0											0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	1.1	0.0	1.1	0.0	0.7	0.0	0.5	0.0	0.5
Total	**518,395**	**907,690**	**1,426,085**											**0**	**16,507**	**0**	**16,948**	**7,148**	**27,949**	**6,354**	**20,143**	**149,228**	**230,556**	**151,077**	**240,789**	**86,249**	**144,056**	**59,729**	**104,631**	**58,609**	**106,111**
Equivalent to US$	34.4	60.2	94.6											0.0	1.1	0.0	1.1	0.5	1.9	0.4	1.3	9.9	15.3	10.0	16.0	5.7	9.6	4.0	6.9	3.9	7.0
4. Total																															
(1) Direct Construction Cost	892,627	1,261,095	2,153,722	0	0	0	0	15,578	15,392	15,578	15,392	205,407	202,956	166,748	164,758	166,394	164,408	182,030	179,858	172,521	170,463	108,998	107,698	108,594	107,298	58,860	58,158	38,550	38,091	37,063	36,621
(2) Indirect Construction Cost	503,879	1,554,889	2,058,768	0	84,042	0	87,379	20,015	116,232	18,382	72,300	58,774	123,179	54,138	134,951	57,308	148,798	72,253	184,274	70,183	183,330	40,230	106,346	42,484	116,453	27,389	75,885	21,179	59,394	21,546	62,328
Sub-total of 1 to 3	1,780,198	2,815,985	4,596,183	0	84,042	0	87,379	35,593	131,624	33,960	87,692	264,180	326,135	220,884	299,709	223,701	313,207	254,283	364,132	242,704	353,793	149,228	214,044	151,077	223,752	86,249	134,042	59,729	97,485	58,609	98,949
Equivalent to US$	118.1	186.9	305.0	0.0	5.6	0.0	5.8	2.4	8.7	2.3	5.8	17.5	21.6	14.7	19.9	14.8	20.8	16.9	24.2	16.1	23.5	9.9	14.2	10.0	14.8	5.7	8.9	4.0	6.5	3.9	6.6
(3) VAT of 1 to 3	0	194,648	194,648		407		391		3,845		3,763		26,833		23,105		23,843		27,519		27,072		16,512		17,038		10,013		7,146		7,162
Equivalent to US$	0.0	12.9	12.9	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.0	1.8	0.0	1.5	0.0	1.6	0.0	1.8	0.0	1.8	0.0	1.1	0.0	1.1	0.0	0.7	0.0	0.5	0.0	0.5
Total of 1 to 3	**1,780,198**	**3,010,633**	**4,790,831**	**0**	**84,449**	**0**	**87,770**	**35,593**	**135,469**	**33,960**	**91,455**	**264,180**	**352,968**	**220,884**	**322,814**	**223,701**	**337,050**	**254,283**	**391,651**	**242,704**	**380,865**	**149,228**	**230,556**	**151,077**	**240,790**	**86,249**	**144,055**	**59,729**	**104,631**	**58,609**	**106,111**
Equivalent to US$	118.1	199.8	317.9	0.0	5.6	0.0	5.8	2.4	9.0	2.3	6.1	17.5	23.4	14.7	21.4	14.8	22.4	16.9	26.0	16.1	25.3	9.9	15.3	10.0	16.0	5.7	9.6	4.0	6.9	3.9	7.0

Note:

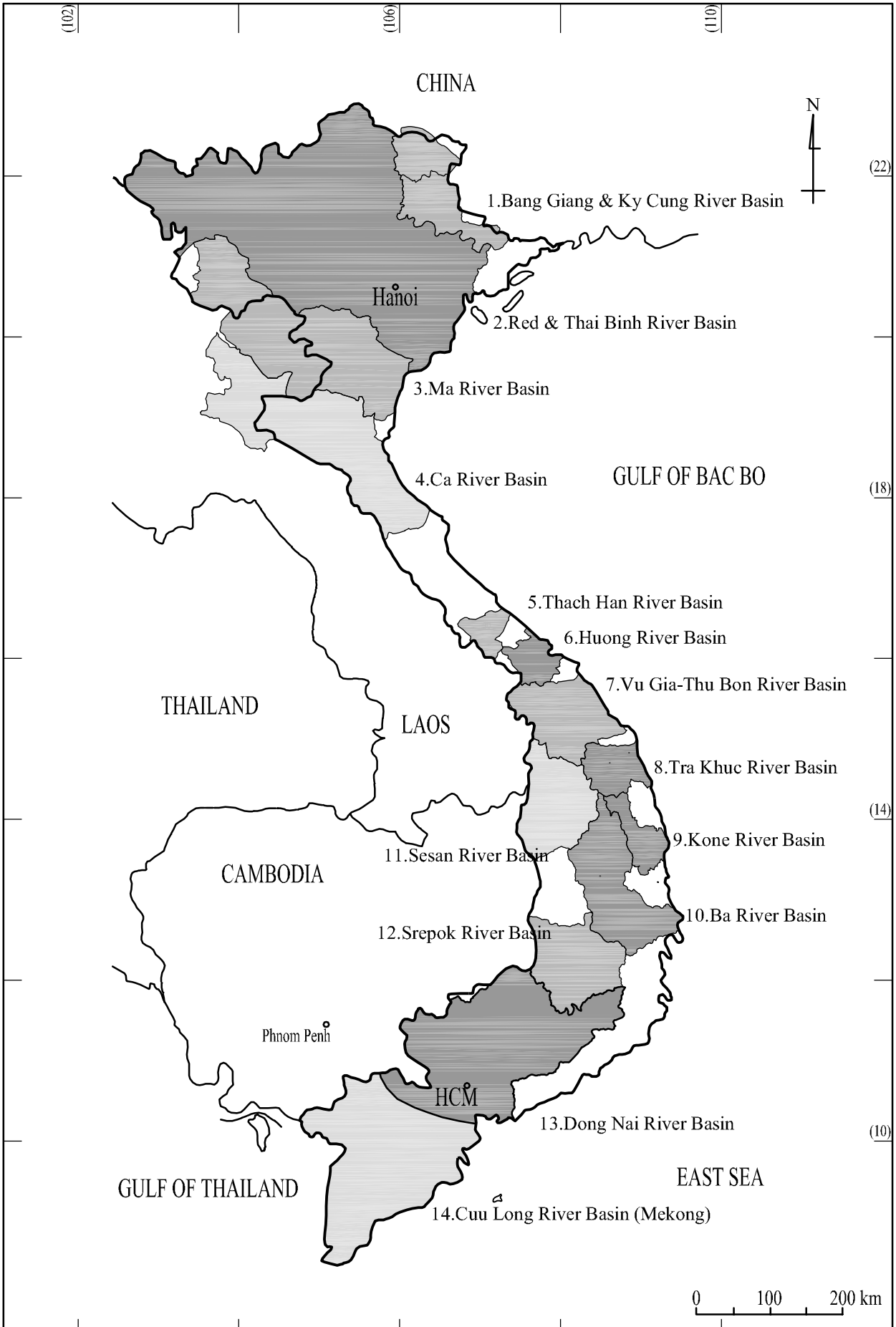
(1) Cost data sources; Feasibility study report, executive summary, Stage 2, No. 444C-05-TT2, General Explanation, No.444C-05-TM (HEC-1) and Supplementary Study, No.444C-10-T1(HEC-1)

(2) Price level; As of Year 2001

(3) Exchange rate; US$ 1.0 = VND 15,068 = ¥ 123.39

(4) Price escalation; F.C : 1.6 % and L.C : 4.9 %

Figures



The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam	**Figure S1.1**
JAPAN INTERNATIONAL COOPERATION AGENCY	**Location Map of 14 River Basins**

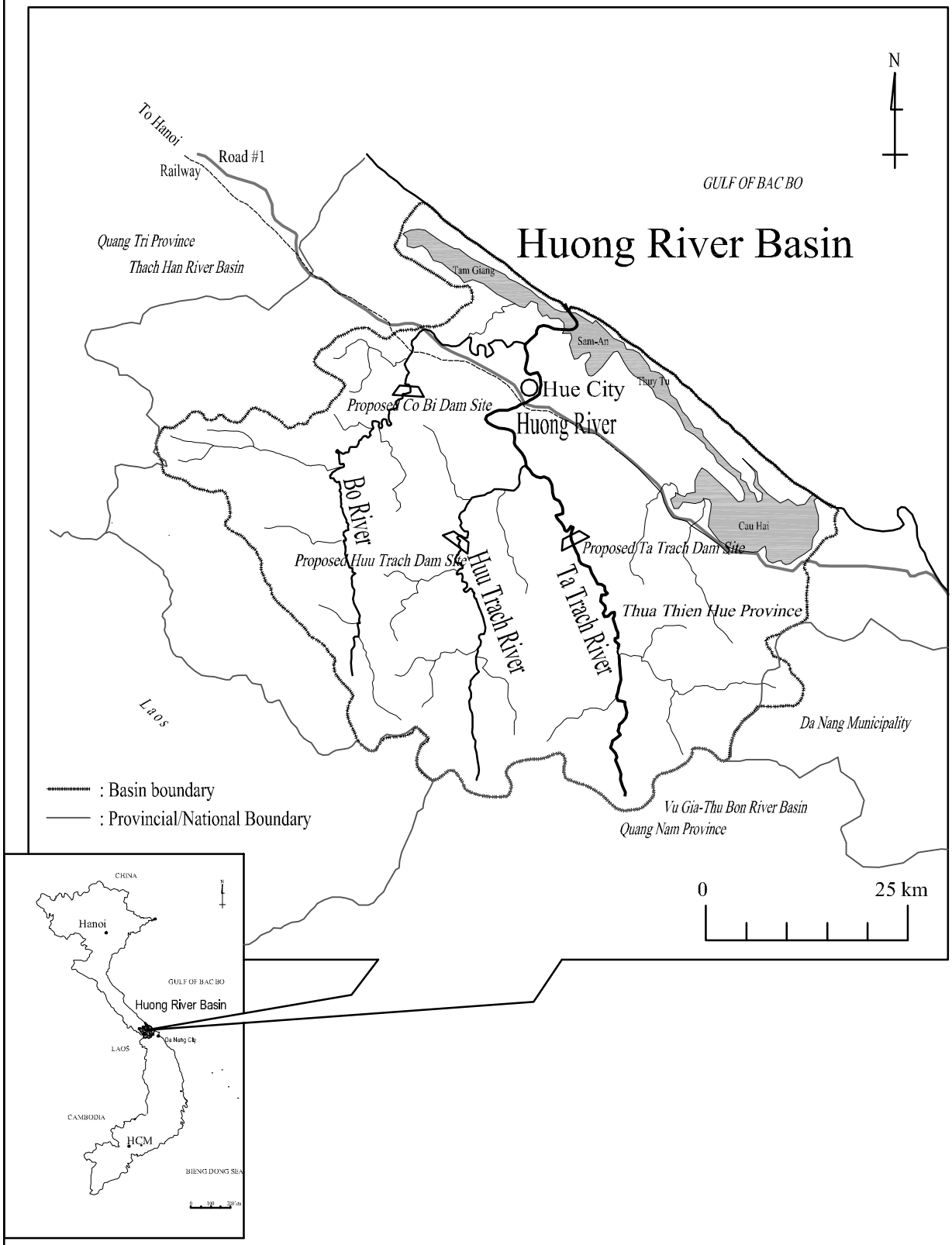
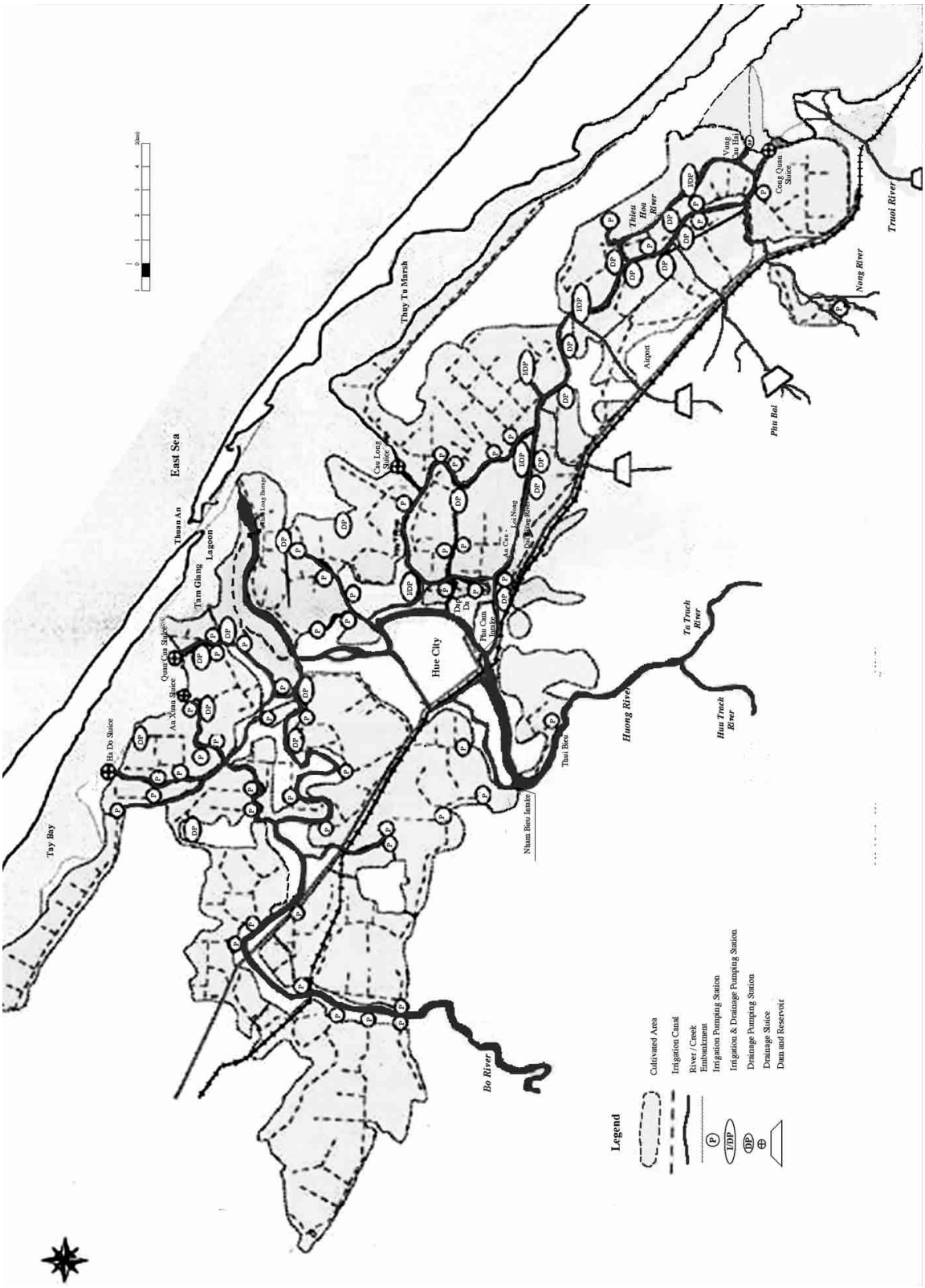


Figure S2.1 Location Map of Study Area



The Study on Nationwide Water Resources Development and Management in the Socialist Republic of Vietnam	**Figure S2.2** **Huong River Irrigation Scheme**
JAPAN INTERNATIONAL COOPERATION AGENCY	