Part I

Phase 2-2: Integrated River Basin Management Plan

for the Kone River Basin

CHAPTER 1 SCOPE OF THE STUDY

1.1 Background of the Study

Water resources in Vietnam are characterized by severe water shortage in the dry season and, on the contrary, serious flood damages in the rainy season.

The water shortage in the dry season causes not only irrigation domestic and industrial water supply problems but also serious water pollution and saline water intrusion. Flood damages in the rainy season including agricultural production loss, human lives and important assets in densely populated urban areas are being accelerated due to recent remarkable urbanization.

As such, solution of the problems is of keen necessity of Vietnam, and several water resources development projects comprising mainly multipurpose dam based projects have been proposed by each province. However, since the proposed projects are not integrated as a basin-wide water resources development, the Ministry of Agriculture and Rural Development (MARD) has difficulty to determine the implementation sequence for these water resources developments. In order to overcome these constraints, the Government of Vietnam has come to conclusion that an integrated approach to water resources development and management is unavoidable, and had a strong intention to carry out a study on nationwide water resources development and management.

In order to materialize the study, the Government of Vietnam requested to the Government of Japan the technical assistance of the Study on Nationwide Water Resources Development and Management Master Plan (the Study). In response to request of the Government of Vietnam, the Government of Japan decided to conduct the Study within the general framework of the technical cooperation between the Government of Japan and the Government of Vietnam signed on October 20, 1998.

1.2 Objectives of the Study

The objectives of the Study are:

(1) To formulate a master plan for nationwide water resources development and management,

(2) To conduct a feasibility study for selected priority projects, and

(3) To pursue technology transfer to counterpart personnel in the course of the Study.

1.3 Study Area

The Study covers the following 14 major river basins:

1) Bang Giang and Ky Cung River basin
2) Red and Thai Binh River basin
3) Ma River basin
4) Ca River basin
5) Thach Han River basin
6) Huong River basin
7) Vu Gia-Thu Bon River basin
8) Tra Khuc River basin
9) Kone River basin
10) Ba River basin
11) Sesan River basin
12) Srepok River basin
13) Dong Nai River basin
14) Cuu Long River basin

Location map of the above 14 major river basins is shown in Figure 1.1.

1.4 Scope of the Study

The Study has been undertaken in the following manner in the two phases:

Phase I : [Basic Study and Formulation of Master Plan]

a) Formulation of a master plan for nationwide water resources development and management in 14 major river basins

Phase II : [Formulation of Integrated River Basin Management Plan(s) for the Selected River Basin(s) and Feasibility Study on Priority Projects]

a) Formulation of an integrated river basin management plan for the Huong River basin (Phase 2-1)
b) Formulation of an integrated river basin management plan for the priority river basin selected from 14 river basins (Kone River basin, Phase 2-2)
c) Feasibility study for the priority projects to be selected from the priority river basin (Phase 2-3)

1.5 Implementation Organization

Institute of Water Resources Planning, Ministry of Agriculture and Rural Development(MARD) act as the counterpart body to the JICA Study Team and also as the coordinating body in relation with other governmental and non-governmental organizations concerned in Vietnam for the smooth implementation of the Study.

The JICA Study Team is headed by the Team Leader who is responsible for maintaining a close liaison with the MARD, JICA and agencies concerned. He is also responsible for planning activities and monitoring the progress of the entire study for ensuring its timely and efficient completion. The members of the Study Team and the members of the Advisory Committee are presented in Table 1.1.

The Steering Committee was organized in February 2002, chaired by the Vice Minister of MARD. The Committee consists of MARD, Ministry of Planning and Investment(MPI), Vietnam National Mekong Committee(VNMC) and Peoples Committee(PC), Vietnam National Mekong Committee and Peoples Committee related to the Study. The Steering Committee members are shown is Table 1.2.

1.6 Study Schedule and Activities

(1) General Schedule

Phase I : Basic Study and Formulation of Master Plan during a period from September 2001 to July 2002,

Phase II-1 : Formulation of Integrated River Basin Management Plan for the Huong River Basin, during a period of October 2001 to July 2002.

Phase II-2, II-3:

Formulation of Integrated River Basin Management Plan for the Selected River Basin(Kone River basin) and Feasibility Study on Priority Projects during a period of August 2002 to September 2003, including

1) 2nd Works in Vietnam

2) 2nd Works in Japan

3) 3rd Works in Vietnam

4) 3rd Works in Japan

(2) Activities in the Works in Vietnam

In accordance with the objectives of the Study and schedule, the works in Vietnam were conducted in October 2001 through March 2002 for Phase I, and from August

2002 through March 2003 for the Phase II study. The third works in Vietnam was conducted from July to August 2003 for the discussion on the Final Report.

As a part of the works in Vietnam, the following field survey works have been carried out on sub-contract basis:

<u>Phase I</u>

(i) Inventory survey works

(ii) Hydro-meteorological observation

<u>Phase II-1</u>

(iii) Hydro-meteorological observation

(iv) Topographical survey

(v) Environmental Impact Assessment (EIA)

<u>Phase II-2</u>

(vi) Hydro-meteorological observation

Period	:	August 2002 to March 2003
Scope of Works	:	Hydro-meteorological observation in Kone River basin

(vii) River survey

Period	:	September to November 2002
Scope of Works	:	River cross section survey along the Kone River

(viii) Initial Environmental Examination (IEE)

Period	:	August to November 2002
Scope of Works	:	IEE in the Kone and Ha Thanh River basins

<u>Phase II-3</u>

(ix) Topographic survey

Period	:	December 2002 to January 2003
Scope of Works	:	Topographic survey including mesh survey and digitizing topographic maps for Dinh Binh dam site and Van Phong weir site

(x) Environmental Impact Assessment (EIA)

Period	:	December 2002 to March 2003
Scope of Works	:	EIA on the priority projects in the Kone River basin

(xi) Geological investigation

Period	:	December 2002 to February 2003
Scope of Works	:	Geological investigation in Dinh Binh dam site, Van Phong weir site and river improvement area in the Kone River basin

(3) Workshop, Technical Transfer Seminar and Presentation Seminar

Workshops and Seminars were held in the course of the Study in the following manner:

(a) Workshop

	Workshop	Subject	Date
(i)	Inception Workshop	Inception Report	November 2001
(ii)	1st Workshop	Progress Report (2)	March 2002
(iii)	2nd Workshop	Progress Report (3)	December 2002
(iv)	3rd Workshop	Interim Report(2)	March 2003

(b) Technical transfer seminar

	Seminar	Subject	Date
(i)	1st T.T.Seminar	- Formulation of flood control plan in the study - Application of computer software in runoff analysis - Application of computer software in irrigation planning/management - Alternative study in Huong river basin	September 2002
(ii)	2nd T.T.Seminar	- Achievement of Water Resources Development in Japan - River Plans in Japan - Planning Concept and Methodology on Multi-purpose Dam - Planning Methodology of Flood Control - Irrigation Planning for Better Operation and Maintenance	August 2003

(c) Presentation seminar

Seminar	Subject	Date
(i) Presentation Seminar	- Achievement of Water Resources Development in Japan - Recommendation and Overall Outcome of the Study - Formulated Water Resources Development and Management Plan - Planning Methodology of Flood Control - Formulated Agricultural Development Plan in the Study	August 2003

(4) Reports

In the course of the study, the following reports have been prepared and submitted to MARD to date:

	Report	Main Subject	Submission
(i)	Inception Report	Scope of works, work plan and work schedule	October 2001
(ii)	Progress Report (1)	Work progress of Phase I and Phase II-1	January 2002
(iii)	Progress Report (2)	Work progress of the formulation of the master plan for nationwide water resources development and management in 14 major river basins as well as the formulation of the integrated river basin management plan for the Huong River basin (Phase 2-1)	March 2002
(iv)	Interim Report (1)	Master plan for nationwide water resources development and management in 14 major river basins as well as the integrated river basin management plan for the Huong River basin (Phase 2-1)	August 2002
(v)	Progress Report (3)	Work progress on the formulation of the integrated river basin management plan for the Kone River basin (Phase 2-2)	December 2002
(vi)	Interim Report (2)	The integrated river basin management plan for the Kone River basin (Phase 2-2) and the Feasibility study for the priority projects in the Kone River basin (Phase 2-3)	March 2003
(vii)	Draft Final Report	All results of the Study	July 2003
(viii)	Final Report	All results of the Study incorporating the comments for the Draft Final Report	September 2003

This is the Main Report, as a part of the Final Report, covering the Integrated River Basin Management Plan for the Kone River Basin including the master plan study and the feasibility study for the priority projects (Phase 2-2 and 2-3).

1.7 Phase II-2 and II-3 Studies

The Phase II-2 Study has been conducted for the formulation of the integrated river basin management plan for the Kone River basin. The Feasibility Study, as Phase II-3 Study, comprises the studies on the Dinh Binh Multipurpose Reservoir Project, the Van Phong Weir and Irrigation and Drainage Project, and the Flood Control Project in the Downstream Reaches of the Kone River Basin.

CHAPTER 2 PRESENT CONDITION OF THE KONE RIVER BASIN

2.1 Socioeconomic Condition

2.1.1 Administration

Kone River Basin is located in the south central region of Vietnam and its basin area is 3,640km^2. The Kone River rises in the northeastern part of Gia Lai Province, in the Southern Truong Son Range, and it flows through Binh Dinh Province from the northwest to the southeast and pours into Thi Nai Swamp. Major part of Kone River Basin is situated in Binh Dinh Province (about 90%).

The 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.

2.1.2 Population and Labor Force

Average population of Binh Dinh Province is 1,504,700 in 2001. Urban population is 362,700 (24.1%) and rural population is 1,142,000 (75.9%), which are almost the same ratio as the national average. Average annual growth rate of the population is 1.3% during six years from 1995 to 2001. Rapid urbanization is underway in the province. Annual growth rate of urban population is 5.4% while that in rural population is 0.2% in the same period.

The Kone River Basin consists of 9 districts and 97 communes including irrigation extension areas. The total population of the Kone River Basin is 1,027,800 as of 2001 and its population density is 262 person/km^2. The most densely populated area is the capital city, Quy Nhon, and its population density is 1,150 people/km^2. If the average family size is still the same as that at 1999 Census, the number of households in the river basin is estimated to be 224,040. Summary of population in the river basin is shown below:

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./km^2)	No. of 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

The labor force population of Binh Dinh Province was 742,800 people according to 1999 Census. Out of this, the working population was 708,200 people (95.4%) and unemployment rate was 4.6%. In rural area, unemployment rate is low since agricultural sector absorb labor force. Conversely, in urban area like Quy Nhon, the rate is high at 10.8%. Agriculture and forestry sector employs 69% of working population, fishery, mining, manufacturing & construction, and other including service sector employ 4.4%, 1.1%, 9.7%, and 16%, respectively. In rural areas, the ratio of working population in agricultural sector is more dominant accounting for 77% of total working population.

2.1.3 Economic Condition

(1) 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.

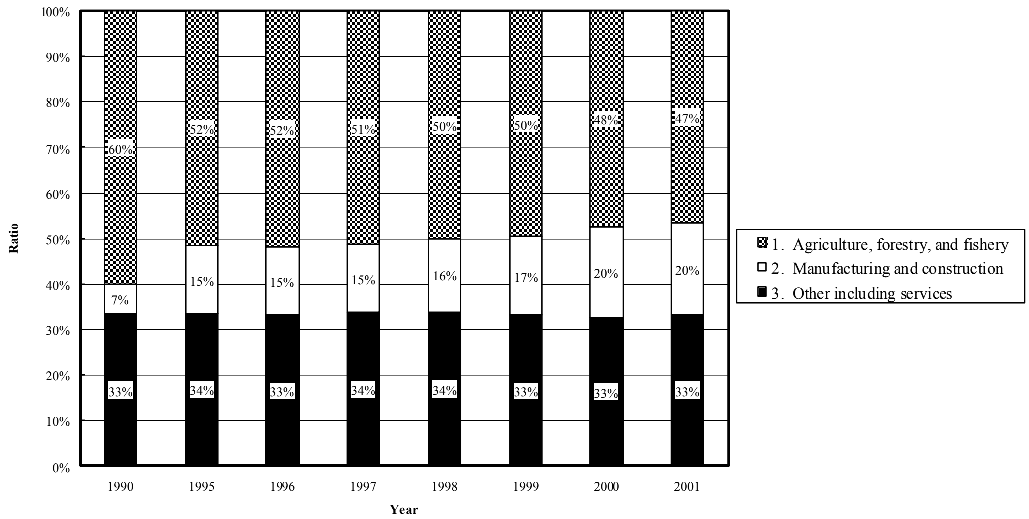
GRDP and Per Capita GRDP of Binh Dinh Province

	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
Real growth (%)		8.6%	7.8%	5.7%	8.0%	7.7%	4.5%

Source: Statistical Yearbook of Binh Dinh Province 2001

Per capita GDP of Binh Dinh Province in 2001 was VND3.27 million (US$217), which is almost the half of the national average. Similarly, average annual growth rate of the per capita GDP was high at 7% during the same period but that in 2001 dropped significantly to 4.5%.

Average growth rates for past six years of manufacturing and construction sector was the highest at 20%, fishing was 8.5%, agriculture was 6.5%, other including services was 8.3%. As a result, industrial structure of Binh Dinh Province has changed gradually as shown below:



Structure of GRDP of Binh Dinh Province (%)

(2) GRDP of Kone River Basin

Comparison of gross output of some sectors between the province and the districts in the Kone River Basin was made as shown below:

Comparison of Gross Output of Sectors between Province and Kone Basin in 2001

No.	Item	Unit	Province	Kone River Basin	Ratio of Kone Basin
1	Gross output of Agriculture	VND billion	1,861.7	1,469.6	79%
2	Gross output of Forestry	VND billion	108.6	69.0	64%
3	Gross output of Fishery	VND billion	696.1	455.4	65%
4	Gross output of Industry	VND billion	1,800.1	1,722.1	96%
	Weighed average (total)	VND billion	4,466.5	3,716.1	83%

Gross output of the Kone River Basin accounts for 79% in agriculture, 64% in forestry, 65% in fishery, and 96% in industry sectors of the province. Performance of the service and trade sector by district is not available but the sector deals with outputs of agriculture, forestry, fishery, and industry sectors. Therefore, weighted average value of these sectors can be used to estimate the ratio in the service sector (83%). Based on the above assumption, socioeconomic profile of the Kone River Basin is estimated as summarized below:

Socioeconomic Profile of Kone River Basin in 2001

Item	Unit	Province	Kone river basin	Ratio of Kone basin
Population	1,000 pers.	1,505	1,030	68%
Area	km2	6,026	3,927	65%
GRDP	VND bn	4,918	4,072	83%
- Agriculture, forestry & fishery	VND bn	2,007	1,505	75%
- Industry & construction	VND bn	1,160	1,114	96%
- Services & other	VND bn	1,750	1,453	83%

Comparing with the ratios of population and area, economic performance of Kone River Basin is higher. It means that Kone River Basin should play important roll as engine of economic development of the Province. Also Kone River Basin includes the provincial capital city, Quy Nhon, which will be commercial center of the region including Central Highlands.

(3) Foreign Trade

Total export turnover of Binh Dinh Province in 2001 was US$90.1 million, which increased more than four times of that in1995. Major export commodities are refined wood, logs, fish, rice, cashew nuts, footwear, and garments. Meanwhile total import of the province was US$61.1 million. Major import commodities are plastic materials, tires & tubes for vehicle, fertilizer, etc.

Export and Import of Binh Dinh Province (US$ million)

Commodity Groups	1995	1999	2000	2001
Export	21.5	71.2	103.9	90.1
Aquatic products	7.6	15.7	23.0	27.4
Agricultural products	1.0	7.2	7.1	7.2
Forest products	6.2	35.4	59.3	40.4
Industrial products	3.6	7.6	8.8	9.2
Mineral resources	3.0	5.4	5.6	6.0
Import	11.2	44.9	74.9	61.1
Machinery, equipment	0.4	3.5	1.9	3.0
Spare parts of vehicle	4.7	4.7	17.9	19.1
Half finished goods	6.0	34.4	51.5	36.3
Consumer goods	0.1	2.3	3.6	2.6

Source: Statistical Yearbook of Binh Dinh Province 2001

(4) Sectoral Economic Profile

(a) 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. Major livestock are cattle, milk caw, pig, and poultry.

(b) 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.

(c) Transport

Binh Dinh Province is located in one of the important transport point of the country. National Highway No.1 and railway connect Binh Dinh with northern provinces as well as southern provinces. National Highway No.19 joints the province with the provinces in Central Highlands. Phu Cat Airport links the province to Hanoi and Ho Chi Minh City. Quy Nhon Port is located at an attractive place for surrounding provinces as well as Northeastern Cambodia and Southern Laos for sea transportation of forest products, industrial products and minerals.

(d) Services

Service sector such as trade and social services of the province has achieved a high economic growth of 8.3% per annum for last six years. Total retail sales value in 2001 was VND4,797 billion (US$318 million), which was 77% increase from that in 1995. The total export turnover of Binh Dinh Province was US$90.1 million in 2001 and average annual growth was 27% on nominal basis. Out of this total turnover, forest product accounted for 45%, aquatic product 30%, manufacturing products 10%, agricultural products 8%, and mineral resources 7%. The commodities of the province have been exported to 32 foreign countries.

(5) Issues on Socioeconomic Development

Binh Dinh Province including the Kone River Basin has achieved remarkable developed during the last decade and is expected to maintain sustainable development.

The province put the greatest emphasis on agro-based industry like food and beverage, leather tanning & processing, wood processing etc., and it will be the engine of socioeconomic development of the area. This indicates that agriculture sector supports the growth of industrial sector through supplying the materials.

However, due to meteorological and geomorphologic conditions of the basin, water deficit in dry season and flood disaster in rainy season occurs quite frequently. The water deficit has caused not only irrigation, domestic and industrial water supply problems, but also serious water pollution and saline water intrusion. The flood disaster has ruined agricultural production, economic infrastructure, important assets, economic activities, and human lives. Such losses have hindered the socioeconomic development of the basin.

2.1.4 Land Use

The study area, covering the Kone, the Ha Thanh and south of the La Tinh River Basins, is about 388,000 ha, corresponding to 64% of the Binh Dinh province. The present land use is summarized below:

Present Land use of the Study Area (2000)

River Basin	Agriculture Land	Forest Land	Special Use Land	Residence Area	Unused Land	Total
Province	116,900 ha	193,700 ha	29,400 ha	6,400 ha	256,200 ha	602,600 ha
(Proportion)	19.4%	32.1%	4.9%	1.1%	42.5%	100.0%
Kone	54,900 ha	131,300 ha	13,300 ha	2,600 ha	98,900 ha	301,000 ha
Ha Thanh	11,000 ha	16,300 ha	4,300 ha	1,100 ha	30,300 ha	63,000 ha
La Tinh	10,200 ha	1,300 ha	2,200 ha	500 ha	10,000 ha	24,200 ha
Study Area	76,100 ha	148,900 ha	19,800 ha	4,200 ha	139,200 ha	388,200 ha
(Proportion)	19.6%	38.4%	5.1%	1.1%	35.9%	100.0%

Source: Estimation by the JICA Study Team based on the Data Set of Binh Dinh Land Use General Inventory in 2000, Land Office.

2.2 Topography and Geology

The project area lies along the Kone River, the largest river in Binh Dinh Province, Southern Central Vietnam, and involves almost half of the provincial area. 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. Scattered between the middle-low mountains and the plains are the hilly areas, which have an altitude of 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. In addition, the provincial area lies on a low seismic zone, which is characterized by occurrence of less and smaller earthquakes. After comparison of some estimated values by different criteria, the design seismic coefficients of 0.10 to 0.15 are recommended for the master plan.

2.3 Meteo-hydrology

2.3.1 Location and Basin Definition

The Kone River basin is situated in the south central Vietnam between 13°30' to 14°30' north latitude and 108°30' to 109°15' east longitude. The basin is almost entirely situated within the Binh Dinh Province. The Kone River basin is defined as the basin that discharges into the East Sea through the Quy Nhon Estuary. This basin is composed of the following sub-basins

- The upper and middle Kone basin, discharging at the Delta apex at Binh Thanh;
- The upper and middle Nui Mot basin located upstream of National Road No. 19;
- The upper and middle Ha Thanh basin located upstream of the National Road No.1;
- The upper and middle La Vi basin located upstream of Phu Cat and north of the Provincial Road 635;
- The lower basin or (flood prone) Delta area, located downstream of Binh Thanh and bordered by Road 635 in the north and Road 19 in the south.

The total basin area amounts to 3,640 km^2 and the sub-basin areas are as follows:

Kone sub-basin upstream Binh Thanh:	2,250 km^2
Nui Mot sub-basin:	180 km^2
Ha Thanh sub-basin:	590 km^2
La Vi sub-basin:	240 km^2
Delta area:	380 km^2
TOTAL BASIN	3,640 km^2

In addition to the division into sub-basins as indicated above, a further sub-division of the upper and middle Kone basin has been made in view of existing Vinh Son Dam and proposed Dinh Binh Dam site and Van Phong Weir site. This subdivision is as follows:

Kone sub-basin upstream Vinh Son:	214 km^2
Kone sub-basin upstream Dinh Binh:	1,040 km^2
Kone sub-basin upstream Cay Muong / Van Phong:	1,677 km^2

Measured along the axis of the Kone River, the distance from the river mouth to its source amounts to some 160 km, climbing from sea level to a maximum elevation of almost 920 m above sea level.

2.3.2 Hydro-meteorological Data

Historic runoff data are only available for the Kone sub-basin upstream of Cay

Muong (measured at Cay Muong). Runoff series for the other sub-basins are therefor to be generated on the basis of rainfall – runoff modelling in the respective basins. Such modelling requires an accurate assessment of the area rainfall and evaporation in the respective sub-basins. The collection of rainfall data has been focussed on an adequate coverage of all sub-basins. In fact, all available rainfall data over the period 1976 – 2001 with relevance for the estimate of the area rainfall in the respective sub-basins have been collected. Based on availability of data and the requirements of the study, it was decided to use a one-day time step for the runoff analysis. Only for the analysis of floods a shorter time step, i.e. one hour, has been used.

In addition to the runoff related data, also data have been collected related to the sediment loads corresponding with the basin runoff. This information is essential for the estimate of lifetime of proposed reservoirs and the morphological response of river works.

Finally, data on the occurrence of typhoons in or near the project area have been collected in order to analyse the relation between the incidence of this phenomenon and the occurrence of floods.

2.3.3 Climate

(1) Temperature

The climate in the Kone Basin is characterized by an equable temperature over the year, ranging, in the lower part of the basin, from 23 ^{o}C on the average in January to almost 30 on the average in the period June – August. The day-night fluctuation of the temperature is greatest (7-9 ^{o}C) during the June-August period and smallest (4-6 ^{o}C) during the cooler period December – February. In the upper part of the basin the temperature is, on the average, 1.5 ^{o}C lower than in the lower part.

(2) Humidity

The humidity is lowest in the months with highest temperature (about 70% in July).

(3) Evaporation

The annual evaporation in the lower basin, measured at Quy Nhon with “Piche”,over the period 1976 - 2000 amounts to 1041 mm on the average. A substantial variation in yearly evaporation has, however, been observed, from 776 mm in 1988 to 1319 mm in 1997. The monthly variation is on the average as shown in the figure below, with highest values in the dry and hot July-August period. During the “winter” months the monthly evaporation can be as low as half the monthly values during the “summer”months.

On the basis of the 24 year of rainfall-runoff simulation, that has been carried out in this study, it is found that the actual basin wide evapotranspiration amounts to some 565 mm per year on the average.

(4) Precipitation

The yearly basin rainfall, averaged over the last 25 years (1977 – 2001) amounts to 2120 mm. From this amount some 63%, or 1333 mm falls on the average in the period September – November.

The spatial distribution of the rainfall in the Kone basin indicates that the rainfall increases from the lower delta area to the upper area upstream of Binh Dinh. The yearly average precipitation in the Delta area amounts to 1857 mm, while in the upper catchment the rainfall is as high as 2590 mm per year on the average.

(5) Typhoons and tropical depressions

An inventory has been made of typhoons and tropical storms that made landfall during the period 1976 – 2000 at or near the Kone basin (between Na Trang and Da Nang or between 12^{o}N and 16^{o}N). A summary of this inventory is presented in the table overleaf. The inventory was made for the mentioned period in order to evaluate the coincidence of these storms with the occurrence of floods in the Kone basin.

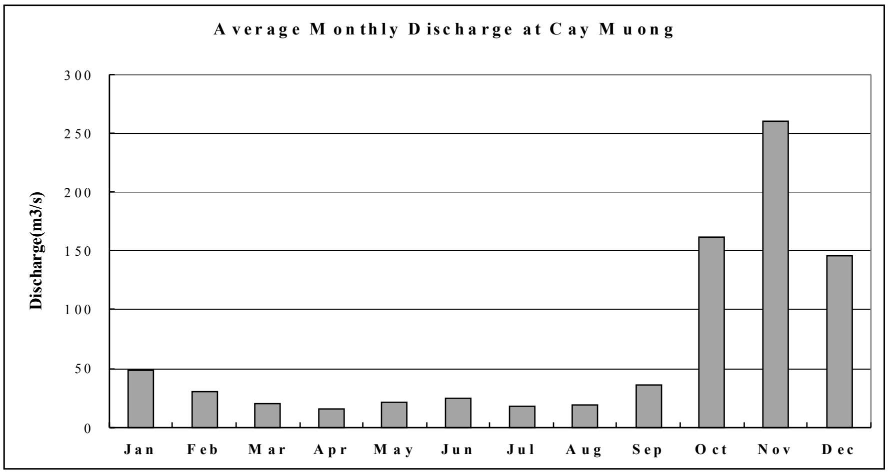
A total number of 34 relevant storms were identified, of which 28 toke place during October-November, two during the Minor flood season (May – June) and four during the Early flood season in September.

2.3.4 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. Moreover, the observed runoff at Cay Muong refers to the runoff of surface water only. It is estimated based on the results of the rainfall-runoff simulation in the basin that the surface runoff corresponds with about 70% of the total basin runoff including the subsurface flow.

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:



2.3.5 Flood Runoff

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 the result of tropical depressions, tropical storms or typhoons that land at the Vietnamese coast near the Kone Basin causing 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.

From the analysis of historical floods at Cay Muong, it is learned that the duration of the Main Floods varies between one and four days, and go together with area rainfalls in the order of some 300 mm in two days up to 500 mm in three days. The maximum yearly flood volumes (in the order of 200-400 Nm^3) correspond, on the average with about 65 % of the rainfall volumes. The floods have been a flashy character, reaching the peak discharge normally within 12 hours.

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

2.3.6 Sediments

The runoff of sediments is measured at Cay Muong only. Sediment concentrations at Cay Muong vary from practically zero in the low flow period to values of over 500 - 1000 gr/m^3 (ppm) during the floods in October – November. As a consequence most of the sediment load occurs during the flood season. The average suspended load is some 320,000 tonnes per year, of which almost 80% is transported during October – November.

2.4 Present River Condition

2.4.1 River System

The Kone River originates on the eastern slope of Truong Son Range in Binh Dinh Province, flows down to the southeastern direction in rather mountainous and hilly area, changes the river course to the east and 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 to the east 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 2.1.

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 longitudinal profile of the Kone River is shown in Figure 2.2. 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.

In its upstream reaches, the river narrows with a valley of 50 to 200 meters in width, and forms a V-shaped valley. Whereas the river becomes rather wide, respectively

200 to 500 meters wide in the middle reaches and 450 to 850 meters wide in the downstream reaches, and presents a U-shaped valley.

2.4.2 Related Structures

(1) River dyke

River dyke of the Kone River is constructed along the Dap Da River and the Tan An River along their downstream reaches. But the river dykes are not always connected longitudinally. The reasons are just because the land elevation is high enough to protect the flood flow at some locations.

(2) Weir

Along the Dap Da and the Tan An Rivers, there exist 10 weirs in the Kone River delta. The names and the locations of the weirs are shown schematically in Figure 2.3.

(3) Sea Dyke, Spillway and Sluice

Sea dyke is constructed along the Thi Nai swamp with the total length of about 40 km for the purpose to prevent the salinity intrusion into the inland area. Along the sea dyke there exist flood spillways at 20 locations with the total length of about 3 km for draining the overland floods. Sluice gates are constructed along the sea dyke at 34 locations for draining the inland water.

(4) Flood Spillway

A flood spillway along the river dyke is constructed just upstream of the Thach De Weir located upstream of the National Road No. 1 bridge over the Dap Da River. The spillway is provided on the right side dyke of the Dap Da River next to the irrigation intake of the said weir. During the rainy season, the flood water overflows the said spillway and flows into the irrigation channel and spreads over the low-lying Kone River delta. The overland flow finally discharges to the Thi Nai swamp through the above-mentioned sea dyke spillway.

2.4.3 Bank Erosion and Sedimentation

Bank erosion along the Dap Da and Tan An Rivers takes place at many locations and accordingly DARD of the Province has the construction plan and detailed design of the low water channel revetment. Sedimentation also takes place at many locations of the Dap Da and the Tan An Rivers. The sedimentation takes place along the Ha Thanh River too. In the dry season, the river-bed is seen at locations and some locations are utilized as the sand exploitation places. The Thi Nai swamp has become so shallow due to the sedimentation. The water transportation has almost disappeared now except some only during the high tide.

2.4.4 Flooding

Flooding in the Kone River delta takes place every year. 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
Qp	4,280	4,140	3,480	6,340	3,220	3,430	4,350	3,680

Qp : Peak discharge of flood at Cay Muong (m^3/s)

2.4.5 Tide Regime

Observation of tide in the Kone River basin has been conducted since 1959 at Quy Nhon marine hydro-meteorological station. The station is located at 109˚ 15́ east longitude and 13˚ 46́ north latitude at the southern tip of the Quy Nhon peninsula. The datum line of the tide record coincides with -1.56m to the datum plane of the national benchmark elevation network.

Tide record at Quy Nhon in the year 2001 is shown in Figure 2.4. As seen in Figure 2.4, the tide at Quy Nhon is basically diurnal tide. Monthly highest tide is shown below:

(unit : cm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
254	243	222	223	223	233	229	238	226	252	259	247

As seen, the higher tide took place in October to January, and the lower tide took place in March to September.

2.4.6 Present Flood Control System

In the Kone River basin, presently there exist three reservoirs: Vinh Son, Nui Mot, and Thuan Ninh reservoirs. But these are not for flood control purpose. Accordingly there is no flood control reservoir in the river basin. Floods just flow down to the Kone River delta, overflows into the river delta and discharge to the Thi Nai swamp through sluices or spillways along the sea dyke of the Thi Nai swamp. Houses are located on rather highly elevated land. Accordingly during the rainy season, people are often forced to transport by boats.

The flood warning system is established in the basin. During a flood, depending on the scale of the flood, a temporary organization for each flood is organized. Then from the flood prone area and the existing reservoir sites, information on hourly water level is transmitted to the provincial flood warning committee. And the committee will give necessary instructions to each district committee.

2.5 Agricultural Land Use and Irrigation

2.5.1 Present Agricultural Land Use

Land use of the whole study area of about 388,000 ha, covering the Kone, the Ha Thanh and south of the La Tinh River Basins, is summarized in Sub-section 2.1.4.

Agriculture land in the study area, extending 76,100 ha or 20% of the study area, comprises 55,700 ha of annual crops, 9,000 ha of miscellaneous land, 9,100 ha of perennial crops, 2,300 ha of aquaculture. Out of annual crop land, 35,800 ha is paddy field, 2,000 ha slash & burned (shifting cultivation) and 17,900 ha other land (upland field for subsidiary crops).

2.5.2 Present Condition of Agriculture

The agriculture sector, including crop & livestock, forestry and fishery sub-sectors, is characterized as the mainstay of economy in the Binh Dinh province, particularly in the rural area where more than 70% of provincial population is located. The sector produces 47% of GRDP in the province and provides 73% of total employment. Further, more than 40% of gross output value in the industry sector is accrued from manufacturing of agriculture products like food, beverage, leather and wood processing. This indicates that the agriculture sector sustains the industrial sector through supplying the materials.

The Kone River Basin has an important position in the agricultural sector of the province, as the about 65% of cultivated land is located and more than 60% of paddy and industrial crops have been produced in the study area. The average of planted area and crop production in the study area during the period of 3 years from 1999 to 2001 is estimated as shown along with those in the province in the following table:

Planted Area and Crop Production in the Study Area (Average 1999 to 2001)

	Planted Area			Production		
	Province	Study Area		Province	Study Area	
Annual Crops						
Paddy	127,300 ha	83,400 ha	66%	524,900 ton	351,800 ton	67%
Other Food Crops	14,100 ha	8,000 ha	56%	115,400 ton	63,200 ton	55%
Vegetables & Beans	9,400 ha	6,300 ha	67%	89,100 ton	64,000 ton	72%
Industrial Crops	19,700 ha	14,900 ha	76%	380,000 ton	249,500 ton	66%
Perennial Crops						
Industrial Tree Crops	24,800 ha	11,100 ha	44%	67,600 ton	22,100 ton	33%
Fruit Trees	4,100 ha	1,800 ha	63%	9,400 ton	4,300 ton	45%

Source: Estimation by the JICA Study Team based on the Statistical Yearbook 2001, Binh Dinh Province and districts.

2.5.3 Present Condition of Irrigation

Present condition of irrigation areas has been grasped with reference mainly to "Review and Supplementary Report on Agricultural and Rural Planning for Binh Dinh Province Towards 2010, Binh Dinh People's Committee, Department of Agriculture and Rural Development (DARD), 2002". The irrigation areas were put in order at first in accordance with the classification of the Review and Supplementary Report, and then areas in the JICA's Study Area have been selected.

Area in Review and Supple mentary Re port, Province

	Areas in River Basin	Area Initially Constructed	Area Presently Irrigated
		(ha)	(ha)
A.	North of La Tinh River	4,190	3,405
B.	South of La Tinh River and North of Kone River	7,813	5,169
C.	Tan An - Dap Da	14,020	12,413
D.	South of Kone River	6,700	4,530
E.	Ha Thanh River	960	800
F.	Van Canh	469	380
G.	Vinh Thanh	595	365
	Total	34,747	27,062

Study Area

	Areas in River Basin	Area Initially Constructed	Area Presently Irrigated
		(ha)	(ha)
A.	North of La Tinh River	1,614	1,614
B.	South of La Tinh River and North of Kone River	6,714	4,331
C.	Tan An - Dap Da	14,020	12,413
D.	South of Kone River	6,700	4,530
E.	Ha Thanh River	960	800
F.	Van Canh	469	380
G.	Vinh Thanh	595	365
	Total	31,072	24,433

From the above data, it is known that, as for the JICA Study Area, the area where the irrigation systems were initially constructed is 31,100 ha and the area where the irrigation systems are presently functioning is 24,400 ha. It means that the balance of 6,700 ha would be the area where the initially constructed irrigation systems have been deteriorated due to the superannuation and the water shortage and need the rehabilitation.

2.5.4 Irrigation Facilities

Existing irrigation facilities in the JICA Study Area are summarized as follows:

Major Irrigation Facilities in JICA Study Area

	Areas in River Basin	Dam	Weir	Pumping Station	Irrigation System
		(nos.)	(nos.)	(nos.)	(nos.)
A.	North of La Tinh River	0	2	0	2
B.	South of La Tinh River and North of Kone River	9	0	3	12
C.	Tan An - Dap Da	0	15	13	24
D.	South of Kone River	3	1	0	4
E.	Ha Thanh River	4	0	0	4
F.	Van Canh	2	0	0	2
G.	Vinh Thanh	1	0	0	1
	Total	19	18	16	49

Note. Some schemes have both of weir and pumping station or two pumping stations.
Including Van Moi temporary weir.

It has been examined through the field reconnaissance that existing dams for irrigation purpose are functioning rather well with occasional rehabilitation. As for the intake weirs, all the some existing weirs such as the Bay Yen Weir and the Thach De Weir have been rehabilitated. However, including those rehabilitated weirs, almost all weirs in the area are of the stop log type and they are being operated with manpower. It requires really heavy work seasonally, which are put down at the beginning of the dry season and taken off just before the flood season. In spite of such difficulty, those weirs are being well operated and maintained with effort of the authorities and persons concerned. Pumping stations are also being operated and maintained well. There are few dead pumping stations.

Majority of the irrigation systems are of the dual purpose canal for irrigation and drainage. It has a difficulty in drainage for the upper-stream area because of the check-up of water level for intake in the downstream area, while it has a merit in repeating use of water. In this situation, many drainage streams do not have enough capacity in the downstream reaches. As for the farm road, many communal roads are networked and used for faming operation as well as the canal inspection roads. It is to be noted that parts of the communal roads have been paved with concrete.

2.6 Water Uses

2.6.1 Agricultural Water Use

(1) Irrigation Water

Irrigation water is supplied for the fields through the water source facilities such as dams, weirs and pumping stations, and irrigation canal systems. There is little area irrigated with the groundwater. Present irrigation water use efficiency is recognized to be rather low due to the irrigation water losses caused in the irrigation systems that are composed of earth canals and no discharge measurement devices at diversion structures such as turnouts.

(2) Livestock Water

It has been confirmed that the almost all livestock farms are using the groundwater except the coastal area where the groundwater is salty and so the fresh water is to be taken from surface water sources.

(3) Aquaculture Water

(a) Coastal shrimp culture

All the coastal shrimp culture ponds along the Thi Nai Swamp are directly taking and using the brackish water from the swamp without any treatment such as salinity control with use of the fresh water. This water use is continued throughout the year at present. On the other hand, in some coastal shrimp ponds located in the south of Quy Nhon City, outside of the Thi Nai Swamp, the salty groundwater is used without salinity control.

In such conditions, the fresh water is not supplied for the coastal shrimp culture in the study area at present. However, it would be changed in future for more intensive culture.

(b) Inland fish culture

All the inland fish culture in the study area is being operated in the reservoirs. There is no fish pond in the field. Therefore, no particular water supply is done at present and such a way would continue also to the future in this area.

2.6.2 Domestic and Industrial Water Use

The Binh Dinh Water Supply & Drainage Company (WS&DC) is responsible for all urban domestic water supply in Binh Dinh Province. The Kone River basin catchment lies completely within this province and contains the capital Quy Nhon City in addition to the six major urban centres of Binh Dinh, Dap Da, Tuy Phuoc, Dieu Tri, Ngo May and Phu Phong towns.

Currently, the WS&DC provides only a piped water supply to Quy Nhon City.

Water is provided to Quy Nhon from the Ha Thanh groundwater well field, located 10km Northwest of the City through a water treatment plant (WTP) built in 1976 and located in the Southwest corner of the City. Currently there is less than 50% coverage and unaccounted for water (UFW) is 40%. Areas not connected to the system obtain their water supply from both protected and unprotected hand dug wells.

The Asian Development Bank (ADB) has invested $US17.45 million to improve the domestic water supply to Quy Nhon City and to increase it's capacity from 20,000 m^3/d to 45,000 m^3/d. The work is to be executed under four contract packages.

The first package is for the priority improvement of the old City network and was completed and brought into operation in mid October 2002. The second package, is for the improvement of the existing City network by the installation of new pipelines. Completion is anticipated in July 2003.

The third package was planned to commence in October 2002 and anticipated completion May 2004. It calls for the construction of nine tube wells and associated pumps on the left bank of the Tan An river in the vicinity of the National Highway 1 crossing and the existing Thanh Hoa weir. Eight of the wells are to be located upstream of the highway crossing and one well downstream. A pressure main is to be constructed under the contract from the well field to Quy Nhon City via a new WTP.

The final package under the ADB loan calls for the construction of a new water treatment plant (WTP) located 10km Northwest of the City at the intersection of National Highway 1 and the main road leading into Quy Nhon City. The initial treatment capacity of the plant will be 25,000 m^3/d.

Following the completion of the works under the four contract packages, it is estimated the water supply coverage to Quy Nhon City will increase to 60-70%.

In rural areas, the water sources such as dug wells, rain water, surface water and tubewells (or drilled wells) are used. Most of the dug wells are traditional ones, without cover slab and with a bucket used to retrieve the water from the well.

Some households have rain water tanks, while others collect and store the rain water in jars. This water is usually used for drinking and cooking.

Surface water such as springs, streams and irrigation canal are important sources of water. These are main sources in the mountainous districts where it is often the only available water sources.

On the other hand, piped-systems are expanding also in rural areas. The coverage of clean water is estimated at about 30% in rural areas.

2.6.3 Groundwater Resources

The Ha Thanh well field, located 10km Northwest of the City currently provides 20,000 m^3/day to Quy Nhon's domestic water supply. The well field consists of 11 river bank collector wells spread over a distance of some 5km along the left bank of the Ha Thanh river. The well field has been in operation since 1985 when 5 of the wells were originally constructed. The hydraulic properties of the aquifer of the well field have been assessed by the Binh Dinh Water Supply & Drainage Company (WS&DC) over the last 15 years using extensive pumping records and a safe yield of 20,000 m^3/day considered appropriate. By limiting abstraction to this rate, it is hoped that the average annual recharge rate of the aquifer is not exceeded and both pumping costs and intrusion of water of undesirable quality are kept to a minimum. Although this abstraction rate results in a reduction in the base flow component and a marked reduction in stream flow of the Ha Thanh River during the end of the dry summer months, both components of flow are restored following the onset of the rainy season.

In addition to this existing well field a new well field will be constructed under the Asian Development Bank (ADB). Designs for the new well field were completed based on geophysical surveys of the area carried out by the Geohydrological & Structural Geological Federation of South Vietnam on behalf of the WS&DC, to determine both the storage and yield of the aquifer. Pumping wells and observation wells were constructed and the resulting pumping test data analyzed to determine aquifer characteristics, including spacing of proposed wells. A safe yield of 30,000 m^3/day was subsequently approved by MARD.

The new well field is located approximately 17km Northwest of Quy Nhon and will provide 25,000 m^3/day to supplement the domestic water supply of the City. It will consist of 9 river bank collector wells, spread over a distance of 3km along the left bank of the Tan An river.

Notwithstanding the existence of the Ha Thanh and proposed Tan An well fields, with a combined abstraction rate of 45,000 m^3/day, any further exploitation of groundwater resources within the Kone River basin on any larger scale, than what is already taking place, would appear at this stage to be extremely limited. Careful consideration should be given to any future exploitation of groundwater in the downstream reaches of the Kone River to avoid upsetting the delicate balance between underground fresh water and salt water and to minimize the extent of salt water intrusion. As part of this, it is recommended that groundwater monitoring programs be implemented for both well fields, to monitor the effects of concentrated abstractions of groundwater for urban water supply. For the long term to meet the future water demands of Quy Nhon City over and above the 45,000 m^3/day and to meet the future water demands of the other major urban population centers within the river basin catchment, alternatives to groundwater will have to be found.

2.6.4 Hydropower Scheme

There are two hydropower schemes in or related to the Kone River basin comprising existing Vinh Son H/ P and proposed An Khe- Kanak H/P.

(1) Vinh Son H/P

The Vinh Son H/P is located at the most upstream reaches of the Kone River. As of early 2003, one hydropower plant with two reservoirs is in operation and one more reservoir is planned in the Ba River basin to increase the energy output. A general feature of the Vinh Son H/P is as described below:

Vinh Son H/P

- Location : Dak Kron Bung Riv.(Kone Riv.basin)
- Max.power discharge : 13.2 m^3/sec
- Max. power output : 66 MW
- Annual energy output : 228.5GWh (present), 318.5GWh (planned)

		Reservoir A	Reservoir B	Reservoir C
River	:	Dak Phan Riv. (Kone Riv.basin)	Dak Som Riv. (Kone Riv.basin)	Ba River
Max. waterlevel	:	El. 780.8 m	El. 832.1 m	El. 990.7 m
Catchment area	:	97 km^2	117 km^2	72 km^2
Gross storage	:	34 MCM	97 MCM	77.5 MCM
Effective Storage	:	22 MCM	80 MCM	102 MCM

(2) An Khe- Kanak H/P

The An Khe- Kanak H/P is the hydropower development plan substantially in the Ba River basin. The Kanak dam/reservoir/HP and An Khe dam/reservoir are to be located in the Ba River basin, while the An Khe H/P will be located at the Suoi Ca River in the Kone River basin, Tai Son District. Regulated water at the Kanak reservoir will be taken at the An Khe Dam and then conveyed to the An Khe H/P through waterway from the Ba River to the Kone River basins.

General feature of both schemes are presented as follows:

		Kanak H/P	An Khe H/P
Location	:	Ba River	Suoi Ca River (Kone Riv.basin)
Max.power discharge	:	36.8 m^3/sec	47.9 m^3/sec
Max.Head	:	59.2 m	377 m
Installed capacity	:	13 MW	150 MW
Annual energy output	:	56.8GWh	655GWh

		Kanak Reservoir	An Khe Reservoir
River	:	Ba River	Ba River
Normal waterlevel	:	El. 515 m	El. 427.5 m
Catchment area	:	833 km^2	1,246 km^2
Gross storage	:	314 MCM	13 MCM
Effective Storage	:	298 MCM	0 MCM

2.7 Current Conditions on Environment

2.7.1 Physical Environment

(1) Topography

The Kone and the Ha Thanh rivers basin consists of three distinguished topographic areas: 1) high and medium mountains, 2) hilly midland, and 3) coastal plain. High and medium mountains comprise the source of the Kone and Ha Thanh rivers, with an elevation less than 1,000 m in most of the area. Hilly midland runs along the midstream banks of the Kone river and the upstream of the Ha Thanh river with an average elevation less than 200 m in most of area. Coastal plains locate in the downstream of the Kone and the Ha Thanh rivers, of which the terrain is quite flat with the height of less than 30 m, sloping towards the sea. There is no precious or unique topography from the standpoint of natural science, landscape or tourism.

(2) Geology, mineral and soil

Geological Formation: Binh Dinh province has complicated geological structure. Northern half of it is mostly formed by metamorphic rocks with complicated fold, cresting blocks over the long distance. The rest in the south is formed by the Mesozoic, Cenozoic plutonic magma tectonics with Mesozoic faults filled with extrusive materials. The eastern edges are neo-tectonic depression to form Binh Dinh plain. There is no precious or unique geologic formation from the standpoint of natural science, landscape or tourism.

Mineral: Minerals are rich and diversified in the Kone river basin. There are many registered mines and ore points at present, belonging to three mineral types including fuel, metal and non-metal. Main minerals and/or materials being mined or recognized to deposit are the following: peat, gold, titan, kaolin, marsalit, feldspar/mica and construction materials, etc.

Soil: The Kone and the Ha Thanh rivers basin hold a variety of soil types. They can be categorized into four, namely 1) mountainous soils, 2) hilly soils, 3) plain soils and 4) coastal sandy soils, being classified in detail into more than 20 types. The soils are, as a whole, considered to be suitable for various plants to grow.

(3) Groundwater

There recognized at least three types of groundwater aquifer in the Kone and the Ha Thanh rivers basin, namely 1) aquifer in Holocene sediments, 2) aquifer in Pleistocene sediments and 3) fissured aquifer in Pliocene, Neogen and Paleo-Mezosoi formations. Groundwater potential for exploitation is not very promising. Besides, the groundwater in the downstream of the Kone river plain is suffering from salinity intrusion, so that the exploitation of the groundwater requires careful considerations.

(4) Air Quality

There is no ambient air pollution in the whole province, except for some locations close to Phu Tai industrial park located at the intersection of Routes 1 and 19, or Binh Dinh sugar mill factory situated along Route 19. The parameter which exceeds the Ambient Air Standard, TCVN 5937-1995, is dust, or suspended particulate matter. The monitoring results of other parameters such as NOx, SOx, CO and VOC, show no pollution, being far below the said standard.

(5) Water Quality

Kone river: Water quality of upstream reaches of the Kone river is quite good. Most of the parameters measured are within the Category A of Surface Water Quality Standard, TCVN 5942 - 1995, indicating that the water can be used for the source of domestic water supply. Water in the downstream of the Kone river shows the deterioration of water quality, for such parameters as BOD_5, COD and Coliform. The deterioration is attributed to the discharge of sewage water, industrial wastewater, and agrichemicals into the river.

Ha Thanh river: The results of water quality measurement show a sign of pollution for Coliform, exceeding the Category B of the said Quality Standard. Accordingly, the river water is not suitable even for irrigation or aquaculture supply. The main reason of the pollution can attribute to free-raising of duck, discharge of non-treated industrial wastewater from Phu Tai industrial park and solid waste dumping into the river.

Reservoir: Water quality of reservoirs is good as a whole according to the measurement results. Most of the parameters are within the allowable limits applied for the Category A of the Surface Water Standard, meaning the water can be used for irrigation, aquaculture as well as domestic supply.

Groundwater: Groundwater in Qui Nhon City is suffering from pollution. Coliform does not satisfy the allowable limit stipulated by the Groundwater Quality Standard, TCVN 5944-1995. Groundwater in rural areas is affected by bacteria. Poor hygiene condition results in the pollution of groundwater, especially in excrement pollution. In addition, there are some wells with high concentration of NO_3^-, or low pH value of less than 6.5. Furthermore, the groundwater in downstream delta of the Kone river is contaminated by saline water intruded from under Thi Nai Swamp.

Salinity condition

- Rivers: Downstream of the Kone river is protected from salinity intrusion with 47 km-De Dong dike system equipped along the Thi Nai Swamp. In addition, all river estuaries are equipped with salinity control dam; accordingly there is no evidence of salinity intrusion in rivers in dry season.
- Thi Nai Swamp: Flow regime and salinity feature are quite different in the dry season and in the rainy season. In the dry season, the tidal flow dominates the whole swamp while the river flows play an important role at the water surface in the rainy season. Depending on the flow regime, the salinity fluctuation in depth and in location in the swamp are almost negligible in the dry season, with the saline concentration ranging from 32.2 to 34.0 ‰, whereas that in rainy season severely fluctuates owing to the river water draining into the swamp, especially at the surface layer, with the salinity concentration of 0 to some 10 ‰.

Industrial wastewater: Industrial wastewater from the factories and the industrial park located in the Kone river basin is discharged with no proper treatment into surface water bodies, including the Kone river. However, Binh Dinh sugar mill factory was equipped with a wastewater treatment system in 2001 with a capacity of 1,500 m^3 per day.

(6) Noise and Vibration

Noise pollution is occurring near the intersections in Quy Nhon City, amounting to more than 70 dBA, which is far beyond the allowable standard of 60 dBA stipulated by TCVN 5949-1995. In most of the rural area, on the other hand, there is no noise pollution, except for locations close to the main roads where holding heavy traffic. Meanwhile, there is no available data on vibration.

2.7.2 Ecological Environment

(1) Forest and Vegetation

Forest area of the Kone and the Ha Thanh rivers basin is 135,360 ha, accounting for 61.4% of the total natural area of the basin of 220,400 ha. The forest is composed of Natural forest (129,670 ha) and Planted forest (5,690 ha). Forest types are classified as follows: 1) Closed, year-round green, semi-tropical rain, low mountain forest; 2) Monsoon semi-tropical large leaf trees mixed with acerose trees; 3) Closed, year-round green tropical rain forest; and 4) Grass plot, bushes and scattered timber trees.

The vegetation cover in the basin is strongly affected by uncontrolled exploitation, slash and burnt cultivation, causing forest fire and resulting in the reduction of timber resources, soil devastation and impoverishment. In order to cope with this problem, provincial People's Committee issued a Direction in 2001 aiming at forest fire fighting and prevention. An attention has been paid for forest protection and restoration in recent years. Forest restoration area has amounted to 166.4 ha in the past three years from 1999 through 2001.

(2) Terrestrial Ecology

<u>Terrestrial flora</u>: According to the statistic data of National Institute of Ecology, there are 664 flora species of 126 families identified in the Kone and the Ha Thanh rivers basin. Out of those identified, 18 species are listed in Vietnam Red Data Book, two of which are categorized as endangered, five are vulnerable, three are rare, one is threatened and seven are insufficiently known. Nine out of the 18 Red Data Book – listed are endemic species in Vietnam, inhabiting in Kon Chu Rang nature reserve located in the headwaters of the Kone river.

<u>Terrestrial fauna</u>: According to the statistic data of National Institute of Ecology, there identified 529 fauna species in the said two basins, including 63 mammal species, 221 bird species, 53 reptile species, 31 amphibian species, and 161 butterfly species. Out of the 63 mammal species, 17 species are listed in the Vietnam Red Data Book, and 14 bird species out of 221 species are listed in the book. Most of the precious species inhabit in the upstream of the Kone river basin, particularly in Kon Chu Rang nature reserve.

(3) Aquatic Ecology

Aquatic ecology in the Kone - Ha Thanh rivers basin comprises 2 systems; 1) river and 2) swamp, reservoir and lake:

- Aquatic flora: There are more than 136 species of seaweeds and higher-class flora found in the two rivers basin. The majority of river aquatic flora is high class with roots like water-grasses. Low class flora includes poorly-developed phytoplankton.
- Aquatic fauna: There are 116 species of fish recorded in the swamps and ponds, most of which are found in saline, fresh, brackish water swamps. There are some 100 mollusca species recorded in the coastal swamps and ponds. Fifteen (15) species of shrimp are also found in the swamp system. River fish inventory in the study area is comparatively poor, thought to be caused by extremely low flow in the dry season and quite large runoff discharge in rainy season.

(4) Thi Nai Swamp

Several studies on Thi Nai swamp ecosystem so far indicate that its aquatic resources are extremely abundant and diversified as listed below:

Category	Flora		Fauna		
	Phytoplankton	Phytobenthos	Zooplankton	Zoobenthos	Fish
No of species identified	185	136	58	181	116

Out of the 181 zoobenthos species, 100 are mollusca, 71 are arthropoda, 10 are Annellida and 10 is Coelentera. There are many commercially valuable species in phytobentos, zoobenthos and fish species, including some mollusca species, shrimps and many other edible fish.

(5) Protected Area

There is one nature reserve in the upstream of the Kone river basin: Kon Chu Rang nature reserve. It contains an extremely abundant biodiversity in both flora and fauna. The number of flora and fauna species listed in the Vietnam Red Data Book is 80, including globally threatened species.

2.7.3 Social Environment

(1) Demography

Out of total population of approximately 1.5 million in Binh Dinh province, the population in the Kone and the Ha Thanh river basins is approximately 0.9 million, of which rural population is accounting for more than 65 %. In the basins, Kinh group is much dominant especially in the districts which locate along the midstream of the Kone River or in the delta area. However, it is noted that Bana people inhabit in the upstream of the Kone River (Vinh Thanh district) and in the upstream of the Ha Thanh River (Van Canh district).

(2) Land Use

In the basins, more than 50% of the upstream areas of the Kone River and the Ha Thanh River are classified as forest land. Whereas in the delta area of the Kone River, i.e. An Nhon and Tuy Phuoc districts, approximately 40~50 % of the land are under cultivation.

(3) Economic Activities

Agriculture and forestry: Among GDP of about 5,000 billion VND in the province in 2001, the primary industry is accounting for approximately 40 % including fishery. Regarding the forestry, the artificial/planted forest generates 80~90 % of total forest products in the province.

Industrial sector: Although in 2001 the portion of labors engaged in the industrial sector is accounting only for about 7 % among the total labor force in the province, gross product in the sector reaches about 24 %. The growth rate of production value within recent 10 years has been more than 20 % annually on average.

Service sector: In the province, service sector is being developed with growth rate of approximately 8 % annually on average within recent 10 years, and produced value in the sector reaches about 36% in 2001.

(4) Fishery

According to the statistic data, the fishery production in Binh Dinh province is approximately 85,000 ton annually as of 2001. This figure shows about 40 % increase comparing with that as of 1995. Offshore and coastal fishing mainly contributed to the production increase. Whereas the fishery activities in fresh water are mainly done in the reservoirs and lakes by the local residents, and their production is limited.

(5) Fluvial Navigation and Other Transportation

Due to the topographical and hydrological condition and sedimentation, fluvial navigation (inland waterway transport) is not developed in the river systems of the province. Whereas Quy Nhon port located at the south end of Thi Nai swamp plays an important role in the region for inter-provincial and international transportation.

However, the inside of swamp has some constraints for usage as waterway transportation due to the shallow depth. Department of Transport of Binh Dinh has a plan for improvement of fluvial navigation in Thi Nai swamp area including the stretch of Tan An river downstream between Go Boi and the river mouth.

(6) Electricity Use/supply

The electric network service has already covered 100 % of communes in Binh Dinh province, and the power is supplied to more than 85 % of the households. The biggest power station in the basins is Vin Son hydropower plant located in uppermost Kone river, with power generation of 2x33 MW.

(7) Health and Sanitation

According to the statistical, dengue fever is found dispersedly in the Study Area, mostly from midstream of Kone River to the delta area although the disease succumb rate is less than the target of 50/100,000 people proposed by Ministry of Health. Malaria is still widespread in the province but its occurrence case has been decreased. The sanitary condition in the basin is still poor except Quy Nhon city.

(8) Historical and Cultural Heritage

As of July 2002, 39 historical/cultural heritages protected legally by PPC or the central ministry are located in the Kone and Ha Thanh river basins.

2.8 Issues of Flood Damage and Water Shortage

2.8.1 Flood Damage

Kone River Basin suffers from flood damage almost every year. Especially in the downstream areas from Thi Nai Swamp to 3.5km upstream side, the ground elevation is one meter or less and flood inundation occurs every year in the rainy season. Kone River Delta from that point up to Binh Thanh ,where Dap Da River and Tan An River separate, suffers from inundation every two or three years. Middle stream area from Binh Thanh to Tay Son Town suffers from flood damage every five years. Furthermore, Vinh Thanh area, which is located just downstream of the proposed Dinh Binh Reservoir site, also suffers from flood damage when big floods occur. Flood prone area of the Kone River Basin is shown in Figure 2.5.

Table 2.1 shows the record of major flood damages due to past floods in the Kone River Basin. The record shows that floods have occurred almost every year and have caused serious damages including losses of human lives.

The flood, which caused the most serious damage in this decade, is that in1999 as is the case with the other central provinces. The flood was evaluated as the magnitude between 5-year and 10-year return period (20-10% occurrence probability) in the Kone River Basin from the rainfall analysis. Results of flood damage survey in the districts in the Kone River Basin obtained from the provincial DARD is shown in Table 2.2 and summarized below:

Summary of Flood Damage in Kone River Basin in1999

Item	Qty	Unit	Damage (VND million)
1. Human life			-
- Dead	37	persons	
- Injured & sick	265	persons	
- Household needs assistance	7,930	households	
2. Houses	19,796	houses	15,960
3. Agriculture, aquaculture and grain & seed	6,059	ha	38,862
4. Irrigation system			16,711
5. Transport system	263,453	m	11,847
6. School and hospital			472
7. Electricity & telephone system			26
Total			83,877

Note: The damages in Phu Cat, An Nhon, Tuy Phuoc, Tay Son, Vinh Thanh are included.

As described in the table, the flood gave very serious damage to the people's properties, agricultural production, social and economic infrastructure, and people's lives. Such losses have hindered the socioeconomic development of the basin.

2.8.2 Water Shortage

Frequent droughts in the dry season are severely affecting the agricultural production as well as life of people.

Paddy production during the period of 12 years from 1990 to 2001 in the province and the Kone River Basin is illustrated in Figure 2.6. The production has been fluctuating due to the drought, particularly 1993, 1995 and 1998, though total production has been steadily increasing by 37% from 383,000 ton on average during the period of 3 years from 1990 to 1992 to 525,000 ton in 1999 to 2001.

CHAPTER 3 SOCIOECONOMIC FRAMEWORK PLAN

3.1 Regional Development Plans

3.1.1 Development Target

People's Committee of Binh Dinh Province approved "Modification and Supplement of Master Plan of Socioeconomic Development of Binh Dinh Province towards 2010" (Master Plan) on December 31, 2001. The Master Plan shows the following major development orientations:

- To enhance competitiveness of the province's economy and especially for export sector by promoting internal and external resources most efficiently,
- To achieve balanced economic development by giving priority to creation of job opportunities, poverty reduction, and hunger elimination, and
- To combine economic development with national defense and security

The following concrete development targets were set by the Master Plan:

Summary of Development Target of Binh Dinh Province

Item	2005	2010
Average growth rate of GDP	9.5%/year	
Per capita GDP (comparison with that in 2000)	1.5 times	2.3 times
Economic structure		
- Agriculture, forestry, and fishery	34-35%	26-28%
- Industry and construction	27-29%	33-35%
- Service	37-38%	38-40%
Economic growth		
- Agriculture, forestry, and fishery	5-5.5%	4.5-5%
- Industry and construction	18-19%	17-18%
- Service	12-13%	12-13%
Population of the province (1,000 people)	1,570.0	1,655.9
Working age population (1,000 people)	913.1	1,046.4
Unemployment rate	less than 5%	
Reduce malnutrition children	less than 15%	
Average live expectancy	the age of 75	
Forestry coverage ratio	43%	

3.1.2 Sectoral Development Program

Major points of the sectoral development program of the Socioeconomic Development Master Plan is summarized below:

(1) Agriculture, Forestry and Fishery

(a) Food Crop

- To reduce the areas of paddy field at some saline regions with low productivity to change into shrimp cultivation or other kinds of crop

cultivation,
- Intensive farming by increasing irrigation areas, utilizing new types of seeds, applying advanced technology into production,
- To produce high quality paddy in key zones, cultivating new varieties of rice with high productivity to be applied all over the regions,
- To increase production of corn and cassava

(b) Industrial Crop

- To establish key industrial zone specializing in short-term industrial crops in attachment with consumption and processing industry
- To increase production of sugarcane for supplying materials for Binh Dinh sugar factory
- To increase production of cotton, cashew-nuts, coconut, and other long-term industrial cops
- To grow fruits trees such as mango, pineapple, and other type of long-term fruits trees

(c) Breeding

Production of crossbred cattle, milk cows, lean pigs, and poultry with high productivity of meat and egg are enhanced.

(d) Forestry

- Areas of bare hill shall be replaced by agro-forestry area,
- Forest coverage is now 33.8% and it will be increased by 35% in 2005 and 43.5% in 2010.

(e) Aquaculture

- To enhance shrimp cultivation by semi-intensive and intensive farming and to expand the shrimp cultivation area to saline areas.
- To improve capability and quality of aquatic product processing.

(f) Rural Development

- To strengthen investment in construction of socioeconomic infrastructure in rural areas
- To increase ability of rural human resources, to settle unemployment issues, to deduct production cost, and to increase income and improve people's living standard in rural areas.

(2) Industry

- To develop industry, small-scale industry in diversified manner and appropriate with economic strength of the Province and suitable with market requirements.

- Agriculture, forestry, and aquaculture processing industry is ranked the first priority.
- To push up material source, increase capacity of supplying materials and trying to utilize all material sources produced in the province
- To increase timber fabrication, sugar processing, vegetable oil processing, caned products, beer, refreshments, manioc flour, and feed for poultry and cattle
- Strongly step up production of textile, footwear, and plastic products
- To increase and improve production of construction materials such as rock, cement, brick, tile, ceramic, reinforcement steel, etc.
- To enhance mining industry, mechanical industry, chemical production, electronic and software industry, and development of industrial zone

(3) Service and Tourism

- To promote retail trade and to develop Quy Nhon as commercial center of the region
- To enhance the regional economy, productivity, and competitiveness in order to increase export turnover
- To encourage internal and external economic sectors to invest in tourism sector and to improve tourist attraction in the Province
- To improve other services such as transport, seaport, postal, telecommunication, finance, banking, credit, insurance, etc.

(4) Infrastructure

(a) Irrigation

To implement Dinh Binh Water Resources Project and some large and medium reservoirs to ensure water supply for irrigation, domestic, industry, and aquaculture purposes

(b) Transport

To improve roads and pavement in provincial roads and most of major rural roads

(c) Power supply

To finalize electric network at the remaining communes by connecting to national electric network and striving for all of households in the province are electricity supplied.

(d) Water supply

- To improve and widen water supply system for Quy Nhon city.
- To establish water supply system for industrial zones, towns and districts. Economic sectors, individual households are encouraged to provide investment in construction of water supply and improvement of existing water source.
- Striving for 80% of households by 2005 and 95% of households by 2010 will be water supplied for domestic use

(e) Communication

- Modern telecommunication system will be developed with saturation level of 5-6 telephone sets/100 persons by 2005 and 12-25 sets/100 persons by 2010.

(5) Social - Cultural Sector

(a) Education and Vocational Training

- To universalize primary and secondary education in order to achieve national standard
- To renovate program, contents, and method of skill training in order to attain high-level labor force to serve various economic sectors

(b) Healthcare

- To heighten the quality of healthcare services in parallel with applying the policies on healthcare; developing health insurance, ensuring that every peoples to be received basic health services and equitable healthcare services.
- To strengthen facilities to serve for people's healthcare including rehabilitation of provincial and district polyclinic, special hospital at district and province levels.

(6) Environmental Protection

To prepare comprehensive plan on environmental protection and restoration including anti-pollution, natural landscape preservation, preservation of diversified biology, reasonable and economical use of natural resources

3.2 Socioeconomic Framework

Socio-economic framework plan for the target year 2020 has been set by the study team for estimation of the future water demand as well as the future flood damage potential. The socioeconomic framework includes the following items:

(i) Population projection (river basin, urban, rural, increasing rates)

(ii) Growth targets for GRDP (amount, sector component, and growth rate)

(iii) Per capita GRDP

3.2.1 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

3.2.2 Economic Growth Target

(1) Methodology

Three scenarios are conceived as follows:

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

Future GRDP of Binh Dinh Province is projected breaking down into three sectors; 1) agriculture, forestry, and fishery, 2) industry and construction, 3) service and other.

(a) Economic 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% : The lowest growth experienced last six years
8.4% : The average growth rate of last six years
9.5% : The target growth rate defined in the provincial Master Plan. After 2010, the same growth target as 2005-2010 has been applied until 2020.

(b) Growth of Agriculture and Forestry

For the Scenarios 2 and 3, the growth target defined in the Master Plan was assumed since it is one of the provincial policies to shift focus gradually from agriculture to industry. For the Scenario 1, the lowest experienced growth in agricultural sector was assumed.

(c) Growth of Services Sector

For the Scenario 1, the lowest experienced growth in service sector was assumed. For the Scenario 2, the average growth rate in service sector was assumed. For the Scenario 3, the provincial target defined in the Master Plan was assumed.

(d) Growth of Industry and Construction

For the Scenarios 1 and 2, the growth rates of industry and construction sector have been adjusted so that the total growth rates become the target growth rates. For the Scenario 3, the provincial target defined in the Master Plan was assumed.

(2) Results

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

The economic structure by each scenario is presented below:

Economic Structure by Scenario (%)

Sector	Scenario 1				Scenario 2				Scenario 3			
	2001	2005	2010	2020	2001	2005	2010	2020	2001	2005	2010	2020
Agriculture, forestry & fishery	47	44	40	33	47	42	36	24	47	39	32	18
Industry and construction	20	21	22	24	20	24	30	43	20	25	32	47
Service and other	33	35	38	43	33	34	34	33	33	35	36	34
Total	100	100	100	100	100	100	100	100	100	100	100	100

From the estimated future GRDP, the future per capita GDP has been estimated by scenario as shown below:

Future Per Capita GDP (1994 Constant Prince VND1,000)

Per Capita GDP	1994 Constant Price, VND1,000				Annual Growth Rate (%/year)		
	2001	2005	2010	2020	01-05	06-10	11-20
Scenario 1 (Low growth)	2,575	3,048	3,783	5,924	4.3	4.4	4.6
Scenario 2 (Medium growth)	2,575	3,333	4,656	9,738	6.7	6.9	7.7
Scenario 3 (High growth)	2,575	3,544	5,274	12,931	8.3	8.3	9.4

Out of the scenarios discussed above, Scenario 3 will be the most favorable scenario in line with the provincial Master Plan, although it will not be easy for the province to continue high economic performance under the ongoing worldwide recession and international competition. However, as discussed in Subsection 2.1.3 (3) relating to GRDP of Kone River Basin, economic performance of the Basin is higher than other areas of the Province. The basin has great potential for development if its resources are developed and utilized properly.

Therefore, in this study, Scenario 3 will be taken for future water demand estimation and/or estimation of flood damage potentials.

CHAPTER 4 METEO-HYDROLOGICAL ANALYSIS

4.1 Run-off Analysis

4.1.1 Objectives

The formulation of the integrated basin plan for the Kone Basin essentially considers only the availability of surface water resources within the basin. Two other potential sources that could be considered are: (i) groundwater and (ii) the import of surface water from neighbouring basins.

An estimated 20% of the rainfall volume on the basin runs off via groundwater flow. The potential use of this groundwater is limited as a consequence of the absence of subsurface aquifers from where this water could be subtracted in an economically acceptable way.

The transfer of water from the projected An Khe reservoir in the Ba basin is considered as a potential supplement to the available Kone basin waters, rather then as an alternative for the use of Kone basin waters. The basin plan will, therefore, primarily be based on the available resources in the Kone basin itself.

For the formulation of the integrated basin plan the natural flow regime of the Kone basin is taken as starting point. The plan will consider the construction of reservoirs for several purposes: (i) storage for satisfying demands under natural low flow conditions, (ii) retention of flood waves and (iii) hydro-power. The water balance will be the leading tool in the assessment of the need for such storage capacity.

The principal objective of the runoff analysis is to provide the input for detailed water balance studies and to allow the assessment in terms of time and location of the availability of surface water in the Kone basin.

4.1.2 Methodology

The water balance studies are carried out by simulation of water availability and demand in several control points in the basin with the help of historical series of runoff and climatological conditions. This approach gives a factual picture of the probability that a certain demand can be satisfied. This approach is preferred to the method in which the water balance is carried out on the basis of probabilities that in advance are assigned to the runoff.

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. Also the TANK model has been used in order to examine whether this model would give a better reproduction of the rainfall – runoff process in the Kone basin.

Since Cay Muong is the sole station with adequate discharge series, the model calibration could only be done for the catchment upstream of this station. A five year series (September 1982 – August 1987) with full coverage of discharge and rainfall data has been used for model calibration.

The calibration results of both the NAM and the TANK model are quite similar and no clear preference for the use of one of the models can be derived from these results. Both models describe satisfactorily the recession curve after the rainy season and give an acceptable reproduction of the low flow conditions. With reference to the greater familiarity that the MARD has with MIKE11-NAM model, it has been decided to use the results of this model in the further analysis.

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

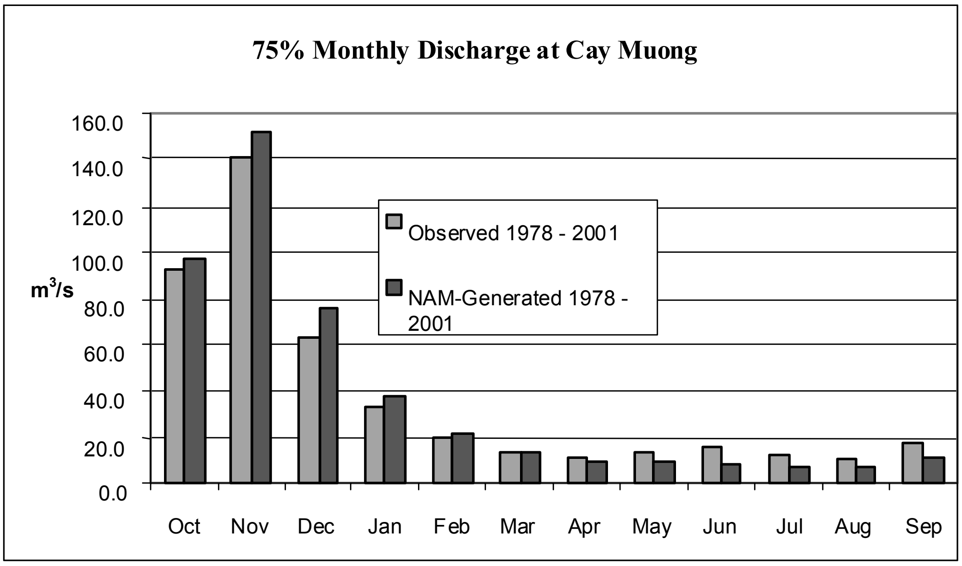
Average Yearly Runoff at Cay Muong (m^3/s)

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

It is noted that the minor floods that tend to occur in the May – June period are not well reproduced by neither of the models. This phenomena is most probably caused by the fact that in running the models, use has been made of the daily area rainfall data. These minor floods are likely to be the result local intensive storms of short duration. Spreading such short intensive rain over a full day hardly generates a noticeable peak runoff.

These minor floods, however, have a noticeable impact on the average monthly or 10-day runoff. This impact is not reproduced adequately in the models. As a consequence, the average monthly or decade discharges generated by the models show an underestimate of the natural runoff during especially the months May and

June. As such, the discharges generated for the months of May and June at other sub-catchments were adjusted on the basis of the deviation at Cay Muong between the generated runoff and the observed runoff. The deviation of the generated monthly low flows from the observed runoff at Cay Muong is presented in the figure brow.



In the absence of available runoff data and corresponding rainfall data of other (sub-) catchments in the Kone basin, it has not been possible to validate the calibration results of the Cay Muong catchment in other catchments. Therefore, the assumption that the Cay Muong calibration results can be used for the generation of runoff series in the different control points and sub-catchments could not be verified.

4.1.3 Results of the Runoff Analysis

With the help of the MIKE11-NAM model the discharge series have been generated at the respective control points for the period September 1977 – December 2001. These series have been used to compile the series of the 10-day runoff for all control point to be used in the water balance study.

The results are summarized for the relevant low flow months in the Figures 4.1 and 4.2. 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.

4.2 Flood Analysis

4.2.1 Objectives

Flood damage mitigation is one of the main subjects in the preparation of the integrated basin management plan for the Kone River basin. A proper description of the natural flood phenomena in the basin is essential for the formulation of measures for the mitigation of the flood damages. Moreover, regulation works for water management, like dams, weirs, dikes, etc, need to be designed in such a way that they are safe under most, if not all, flood conditions.

From the point of view of the mitigation of flood damages, it is essential that a flood protection level is adopted that is optimal from the socio-economic and environmental point of view.

Actually, the MARD is applying the following flood protection criteria for the Kone basin:

a) protection against the once in 10 years main flood, and

b) protection against the once in 100 years early flood occurring during August – September.

The Binh Dinh provincial authorities tend to accept the occurrence of the main flood, provided that the late floods occurring just after the October-November main flood season will not damage the newly planted winter-spring crop. A protection level of 5% (once in the 20 years on the average) is aimed at.

The present flood analysis aims at the assessment of peak discharges and the corresponding flood volumes for the flood events with return periods of 2 years, 5 years, 10 years, 20 years, 50 years and 100 years in the different flood periods. These flood events need to be estimated at the locations where the implementation of flood control measures are envisaged, as well just upstream of the flood prone area.

The implementation of flood control measures upstream of the flood prone area is envisaged at:

a) Dinh Binh (reservoir)

b) Cay Muong (retarding basin)

The flood prone area has been defined as follows:

The lower basin or Delta area, located downstream of Binh Thanh (Apex) and bordered by Road 635 in the north and Road 19 in the south.

Consequently, flood runoff of the following sub-basins is to be estimated:

a) The upper and middle Kone basin, discharging at the Delta apex at Binh Thanh;

b) The upper and middle Nui Mot basin located upstream of National Road No. 19;

c) The upper and middle Ha Thanh basin located upstream of the National Road No.1;

d) The upper and middle La Vi basin located upstream of Phu Cat and north of the Provincial Road 635;

Design floods are the floods to be used in designing the hydraulic works and that, therefor, include a certain safety margin as compared to the estimated probable floods. This distinction is made since the Vietnamese practice tend to assess the so-called probable floods with a safety margin included that is related to the length of the series and the standard deviation the observed extreme events.

4.2.2 Methodology

For the assessment of the flood runoff at the various locations in the Kone basin, two different approaches have been considered. Both based on the available historical hydro-meteorological data of the basin. The first method aims at a reliable and detailed description of rainfall-runoff relations, allowing the conversion of the (abundantly available) rainfall series into runoff series. The second method seeks the estimation of flood runoff from the statistical analysis of observed data and empirical methods for the conversion of the hydrograph from one sub-basin to another.

The rainfall series are generally available on a daily basis only. 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.

A number of historical floods observed at Cay Muong have been reproduced using the Mike11-NAM model. The basis for the calibration of this model is considered, however, rather weak. Verification of parameters found in the calibration process of one flood gives poor results in other flood events. The principle reason for these poor results is most probably related to the inaccurate reproduction of the distribution in time and space of the storm events that have caused the observed floods. It would be rather arbitrary to generate designs floods without a profound analysis of the probability of occurrence of certain storm events with certain time (hours) and spatial distribution. For such profound analysis, however, no adequate time series of hourly rainfall within the Kone basin and its respective sub-basins are available.

Following this conclusion it is considered more appropriate to derive from the historical observed flood events a suitable synthetic hydrograph that can be used for 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 principle: "a p% flood is generated by a p% (area) rainfall"

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 [m³/s]
	Q_p	=	Peak runoff [m³/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 [m³/s]
	A_p	=	Corresponding transpose factor [-]
	F_a	=	Gauged catchment area [km²]
	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.

The flood peak at the ungauged location is calculated using A_p derived from the analysis of historical Cay Muong floods.

4.2.3 Historical Floods

(1) Main Floods

The maximum yearly (instantaneous) peak discharges at Cay Muong have been analysed. The straightforward approach has been followed in which a number of distribution functions have been tried out to find the distribution function that best fits the series of 26 observed instantaneous peak discharges. That distribution function has subsequently been used to estimate the peak discharges with return periods up to 100 years.

The main flood is, according to the MARD definition, the flood that occurs in the months October – November. Out of the 26 years of observation three annual maximum discharges took place, however, in December and one in September. These "late and early floods" have been included in the analysis of the probability distribution of main floods.

Before the observed peak discharges were analysed, a brief validation exercise was carried out on the available data. No definite assessment can be made of the reliability of the "observed" peak discharges. The extrapolation of the1987 rating curve, leading to the maximum "observed" discharge of 6,340 m^3/s, seems not to be underpinned with measurements. The brief validation does not reveal, however, clear indication for the rejection of (part of) the collected data.

For the annual main flood peak discharge, a number of distribution functions have been examined. The results are summarised below:

Annual Peak Discharges Main Flood at Cay Muong (m^3/s)

Distribution Function	Probability (% per year)					
	50%	20%	10%	5%	2%	1%
GEV	2,526	3,704	4,409	5,035	5,777	6,286
Log Normal 3	2,541	3,698	4,384	5,020	5,739	6,269
Log Pearson 3	2,497	3,905	4,653	5,237	5,829	6,176
Pearson 3	2,536	3,706	4,396	5,007	5,738	6,253
Gumble	2,452	3,603	4,364	5,095	6,041	6,750
Raleigh	2,511	3,772	4,491	5,108	5,822	6,309
Goodrich	2,561	3,753	4,402	4,953	5,560	5,971

In addition to the analysis of the probability of peak discharges, also the shape and volume of the 10 major floods that have occurred in the period 1976 – 2001 have been examined. It is learned that the duration of the floods varies between one and four days. Taking respectively two and three days as typical duration of the floods, the following characterisation of the historical floods have been derived:

Historical Flood Characteristics, Considering 2-day Flood Duration

Year	1978	1980	1981	1984	1987	1992	1994	1996	1998	1999
Qp (m3/s)	1,475	4,280	4,140	3,480	6,340	3,220	2,330	3,430	4,350	3,680
Return Period (Qp-LN3) (yrs)	1.2	8.9	7.7	4.1	101.9	3.3	1.8	4.0	10	5
Corresponding 2-days area rain (mm)	166	292	312	190	313	380	267	314	331	354
Return Period rainfall (Pda-LN3) (yrs)	1.1	2.8	3.7	1.2	3.8	14.6	2.1	3.8	5.1	8.1
Volume of main peak (Mm3)	136	447	334	245	426	378	175	335	330	377
Return Period Volume (Vol-LN3) (yrs)	1.3	32.4	5.6	2.3	22.8	10.7	1.5	5.9	5.6	10.5
Overall Runoff Factor	0.5	0.9	0.6	0.8	0.8	0.6	0.4	0.6	0.6	0.6
Time to peak (hrs)	12	20	19	9	14	8	15	13	7	31
Average Overall Flood Runoff Factor	0.65									
Average Time to Peak (hrs)	14.8									

Historical Flood Characteristics, Considering 3-day Flood Duration

Year	1978	1980	1981	1984	1987	1992	1994	1996	1998	1999
Qp (m3/s)	1,475	4,280	4,140	3,480	6,340	3,220	2,330	3,430	4,350	3,680
Return Period (Qp-LN3) (yrs)	1.2	8.9	7.7	4.1	101.9	3.3	1.8	4.0	10	5
Corresponding 3-days area rain (mm)	357	359	329	191	358	511	280	380	456	520
Return Period rainfall (Pda-LN3) (yrs)	7	7	6	1.1	7	14	1.6	3.4	7	15
Volume of main peak (Mm3)	164	520	416	279	459	494	192	396	480	549
Return Period Volume (Vol-LN3) (yrs)	1.3	18.1	6	2.1	9.2	13.5	1.4	5	12	26
Overall Runoff Factor	0.3	0.9	0.8	0.9	0.8	0.6	0.4	0.6	0.6	0.6
Time to peak (hrs)	13	20	20	9	16	12	15	15	7	30
Average Overall Flood Runoff Factor	0.65									
Average Time to Peak (hrs)	15.7									

It is noted that the "Overall Runoff Factor" tends to be lower after the construction of Vinh Son reservoir (1988) than it was before. This points to the possibility that the fraction of the flood volume that is stored in the Vinh Son reservoir is substantial . It is recommended, however, not to reckon with the retarding effect of this reservoir. Neglecting the retarding effect would lead to an average overall runoff factor of about 0.7 during floods.

(2) Late Floods

Following the main floods that usually occur in the period October - November, preparations are made for planting the so-called winter-spring crop. Once land preparation and planting has started, agricultural damage can be caused by flooding. Floods that occur after the main flood season, and after the preparation for the winter-spring crop has started, are indicated as the so called Late Floods.

Frequency analyses have been carried out for different distribution functions. It is noted that for most functions a rather poor fit was achieved. The following results have been calculated:

Annual Late Flood Peak Discharges (m^3/s)

Distribution Funtion	Probability (% per year)					
	50%	20%	10%	5%	2%	1%
Log Normal 3	320	1,068	1,652	2,290	3,175	3,918
Log Pearson 3	221	695	1,250	2,045	3,657	5,499
Pearson 3	229	1,034	1,704	2,389	3,346	4,075
Gumble	407	1,217	1,752	2,266	2,931	3,430
Raleigh	452	1,314	1,805	2,227	2,716	3,048
Goodrich	235	798	1,523	2,064	3,131	4,036

In order to assess the allowable Dinh Binh reservoir level in the last two decades of December, an estimate has been made of the probable floods that may occur during the periods 11 December – 31 December and 21 December – 31 December.

The following probable maximum discharges at Cay Muong were found, estimating the instantaneous peak discharges at 1.5 times the daily peak discharges, in accordance with above mentioned relation between maximum daily and instantaneous peak discharges.

Probable maximum discharge at Cay Muong during late December (m^3/s)

Period	50%	20%	10%	5%	2%	1%
December 11–December 31	240	740	1,130	1,515	2,060	2,460
December 21–December 31	170	350	480	600	750	870

(3) Early Floods

The same distribution functions have been examined for the annual early flood peak discharges. These floods happen to occur during August-September and could potentially endanger the seasonal crops. The occurrence of these floods in terms of flood discharges and volumes has been analysed based on the historical early flood peak discharges, in order to assess the potential damage that can be caused by these floods under the present and future land use and water management conditions.

Annual Peak Discharges Early Flood (August – September) at Cay Muong (m^3/s)

Distribution Function	Probability (% per year)					
	50%	20%	10%	5%	2%	1%
GEV	171	338	483	654	935	1,200
Log Normal 3	187	375	511	647	839	991
Log Pearson 3	172	339	482	649	908	1,145
Pearson 3	176	373	519	664	858	1,006
Gumble	201	393	521	643	801	920
Raleigh	211	416	533	634	750	828
Goodrich	164	360	517	679	897	1,060

(4) Minor Floods

During the months May and June minor floods happen to occur that potentially could endanger the Summer-Autumn crop.

For the analysis of the minor floods it is considered appropriate to take into account the maximum discharges and corresponding rainfall that have been observed during the full Summer-Autumn crop period that spans the month April – July. Although the minor floods use to happen in May – June, also exceptional events that could occur in April or July are to be considered.

On the basis of the identified peak discharges, frequency analyses have been carried out for different distribution functions. The following results have been calculated:

Annual Peak Discharges Minor Flood (during Summer-Autumn Crop) at Cay Muong (m^3/s)

Distribution Funtion	Probability (% per year)					
	50%	20%	10%	5%	2%	1%
Log Normal 3	109	242	350	470	637	780
Log Pearson 3	104	211	312	427	652	862
Pearson 3	90	231	357	490	676	820
Gumble	127	275	373	467	588	680
Raleigh	135	293	383	460	549	610
Goodrich	130	270	357	434	531	597

4.2.4 Area Rainfall

(1) Main Flood Season

For the generation of the hydrographs with different probabilities and for the different sub-catchments, the area rainfall on these catchments has been estimated with the help of the daily rainfall data as explained in the Section 4.1.2.

The results of the frequency analysis of the yearly maximum rainfall are shown below for the respective sub-catchment areas for the 3-day, 2-day and 1-day rainfall. From the table it is learned that the area rainfall increases in the upstream direction.

The increase is sharper for the 3-rainfall (some 25% between Delta area and Dinh Binh area) than for the 1-day rainfall (10 – 20%).

Maximum 3-Day Catchment Rainfall (Gumbel Distribution)

Sub-catchment Area		P3da,50%	P3da,20%	P3da,10%	P3da,5%	P3da,2%	P3da,1%
	(km2)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Dinh Binh	1,040	349	474	557	636	739	816
Cay Muong	1,677	316	424	496	565	654	721
Intermediate area	637	268	348	401	452	518	567
Binh Thanh	2,250	299	397	461	524	604	665
Nui Mot	180	280	358	410	460	524	572
La Vi	240	312	428	505	579	674	745
Ha Tanh	590	283	368	423	477	546	598
Delta	380	282	378	441	502	581	640

Maximum 2-Day Catchment Rainfall (Gumbel Distribution)

Sub-catchment Area		P2da,50%	P2da,20%	P2da,10%	P2da,5%	P2da,2%	P2da,1%
	(km2)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Dinh Binh	1,040	289	382	444	503	580	637
Cay Muong	1677	262	345	399	451	519	570
Intermediate area	637	229	298	343	387	443	486
Binh Thanh	2,250	249	324	374	422	483	530
Nui Mot	180	238	300	340	380	430	468
La Vi	240	274	372	437	499	580	640
Ha Tanh	590	247	313	357	399	453	493
Delta	380	244	327	382	435	503	555

Maximum 1-Day Catchment Rainfall (Gumbel Distribution)

Sub-catchment Area		P1da,50%	P1da,20%	P1da,10%	P1da,5%	P1da,2%	P1da,1%
	(km2)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Dinh Binh	1,040	193	255	296	336	387	425
Cay Muong	1,677	176	231	267	302	348	382
Intermediate area	637	160	210	243	275	315	346
Binh Thanh	2,250	168	217	250	282	323	353
Nui Mot	180	170	224	260	295	339	373
La Vi	240	180	253	301	348	407	452
Ha Tanh	590	185	243	282	319	367	403
Delta	380	159	218	258	296	345	382

(2) Late Flood Season

For the estimate of the volumes of the late floods, the probable area rainfall during the month of December has been calculated (using the Log-Normal distribution) for different duration. The results are as follows:

Maximum Kone Basin Area Rainfall during December (mm)

	50%	20%	10%	5%	2%	1%
1-day rainfall	46	109	156	203	269	322
2-day rainfall	71	167	239	313	417	502
3-day rainfall	82	196	283	379	503	608

For the evaluation of future reservoir operation alternatives, the probability of the 2-day rainfall in the two last and the last decade of December has been calculated as follows:

Probable Kone Basin Area Rainfall u/s Dinh Binh during the later December Decades (mm)

Period	50%	20%	10%	5%	2%	1%
December 11 – December 31	48	102	142	184	243	291
December 21 – December 31	25	52	69	86	107	123

(3) Early Flood Season

The area rainfall in the early flood season has been estimated similarly for the entire basin as follows.

Maximum Kone Basin Area Rainfall during August- September (mm)

	50%	20%	10%	5%	2%	1%
1-day rainfall	40	70	90	100	130	160
2-day rainfall	70	110	140	180	220	270
3-day rainfall	80	120	160	200	250	300

(4) Minor Flood Season

For the estimate of the volumes of the minor floods, the probable area rainfall during the Summer – Autumn crop period has been calculated (using the Log-Normal distribution) for different duration. The results are as follows:

Maximum Kone Basin Area Rainfall during Summer-Autumn Crop Season (mm)

	50%	20%	10%	5%	2%	1%
1-day rainfall	50	60	70	80	90	100
2-day rainfall	60	80	90	100	120	130
3-day rainfall	70	90	100	120	130	140

(5) The Delta probable rainfall intensities in the delta region have been estimated for the main flood season under the sub-section (1) above. However, when (river) flooding is accepted during the main flood season and flood protection aims at the rest of the year, then also the drainage system in the delta area should be able to cope with the rainfall on this area during the rest of the year.

The delta area rainfall outside of the main October-November flood season has been estimated as follows:

Maximum Delta Area Rainfall Outside the Main Flood season (mm)

	50%	20%	10%	5%	2%	1%
1-day rainfall	77	109	134	157	190	216
2-day rainfall	109	155	185	216	254	284
3-day rainfall	129	184	222	259	306	342

4.2.5 Hydrographs for Flood Control Studies

Following the approach as described in Section 4.2.2 and based on the analysis of the historical floods and area rainfall, design hydrographs have been generated for the different sub-catchments of the Kone basin.

Comparison of the peak discharges and corresponding rainfall of the Minor (Summer-Autumn) floods with those of the Early floods indicate that the Summer-Autumn floods are both in peak and volume of the order of 70% of the Early floods. It is considered justified to use the 70% reduced design early floods for the evaluation of potential damages due to these floods under present and future water management and land use conditions.

For the estimate of the flood volumes the three(3) day rainfall volumes have been taken as starting point for the Main Floods. For the rainfall runoff factor a value of 0.7 has been adopted, in line with the recommendation made in Section 4.2.3.

For the Early Flood a lower rainfall-runoff factor is considered more appropriate: a value of 0.5 has been adopted, while the one-day probable rainfall has been assumed to produce the runoff volume of the corresponding probable flood.

For the Late Floods a rainfall runoff factor of 0.6 has been adopted, assuming that the catchment is still partly saturated after the main floods. For the Late Flood volumes the 2-day probable rainfall has been adopted as starting point, after comparing the calculated probable peak discharges with the historical late floods and corresponding rainfall data.

The times to peak of hydrographs generated in other sub-catchments are assumed to be in the ratio of the length of the respective catchments. The actual time to peak has been adjusted in the process of "calibration" of the synthetic hydrographs.

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 4.3 through 4.6.

Validation of the synthetic hydro-graphs has been carried out by comparison the generated hydro-graph of a catchment area with of the sum of generated hydrographs of the composing sub-catchments. An example of the result is shown in Figure 4.7.

4.2.6 Flood Hydrographs for Design Purposes

(1) Evaluation of Previous Results

The results of the present flood analysis are compared with the results of previous studies. The purpose of this comparison is to facilitate the selection of the appropriate approach for the development of flood protection measures in the Kone River basin.

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 can be summarized as:

Peak Discharges at Cay Muong Estimated from Frequency Analysis (m^3/s)

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

Observation: The IWRP and HEC-1 results 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”. Such margin is relevant in a risk (safety) analysis. A reasonable “Confidence margin” is analyzed in the subsequent paragraph (2) and is taken into consideration in the probable peak flood discharges.

Estimated Peak Discharges at Dinh Binh (m^3/s)

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

Observation: The transpose function used by IWRP to convert Cay Muong discharges into Dinh Binh discharges gives a more pronounced difference between these two stations, than a Creager approach does. The more conservative Creager approach is included in the present JICA analysis.

The approach followed by HEC-1 seems to aim at safety, rather than at the accuracy of the estimated peak flows.

Estimated Flood Volume at Dinh Binh

	Return Period	
	10 years	100 years
IWRP (3-day)	278 Mm^3	386 Mm^3
HEC-1		614 Mm^3
JICA (3-day)	405 Mm^3	590 Mm^3/s

Observation: It seems that the IWRP results are an underestimate, taking into account the area rainfall volumes on the sub-basin upstream of Dinh Binh. The 100-years three-day area rainfall has been calculated at 816 mm. The volume estimated by IWRP corresponds with only 45% of the rainfall volume. Historical data, however point at runoff coefficients of 0.65 on the average.

(2) Design Peak Discharges

The estimates of the probable peak discharges by IWRP and HEC-1 include a safety margin in line with the practice in Vietnam. It is not the usual practice to consider such a safety margin in a hydrological analysis. In the usual practice, such a safety margin is taken into consideration in the form of safety margin in the design of structures. However, the study followed the practice in Vietnam in consideration of the length of available data series to be used in the statistic analysis as follows:

In a probabilistic design approach, the risk should be estimated that the actual probable peak discharges are higher than the calculated values. Such risk depends, among other factors, on the length of the series that is used in the probability analysis and tends to increase when the series are shorter.

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.

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 4.8.

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	

(3) Design Hydro-graphs

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, in accordance with the methodology as presented under Section 4.2.5. (the 0.5% hydro-graph has been prepared for the Dinh Binh dam only).

For the design of the Dinh Binh dam, also design hydro-graphs with lower probabilities are to be considered. These exceptional floods are described in the following paragraph.

For the design of the flood control works the following flood characteristics have been assessed.

Design characteristics Main 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	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 0.5% Main Flood at Dinh Binh

Parameter	Area (km^2)	Q (m^3/s)	Vol (Mm^3)
Station : Dinh Binh	1,040	6,397	650

Design characteristics Late Floods

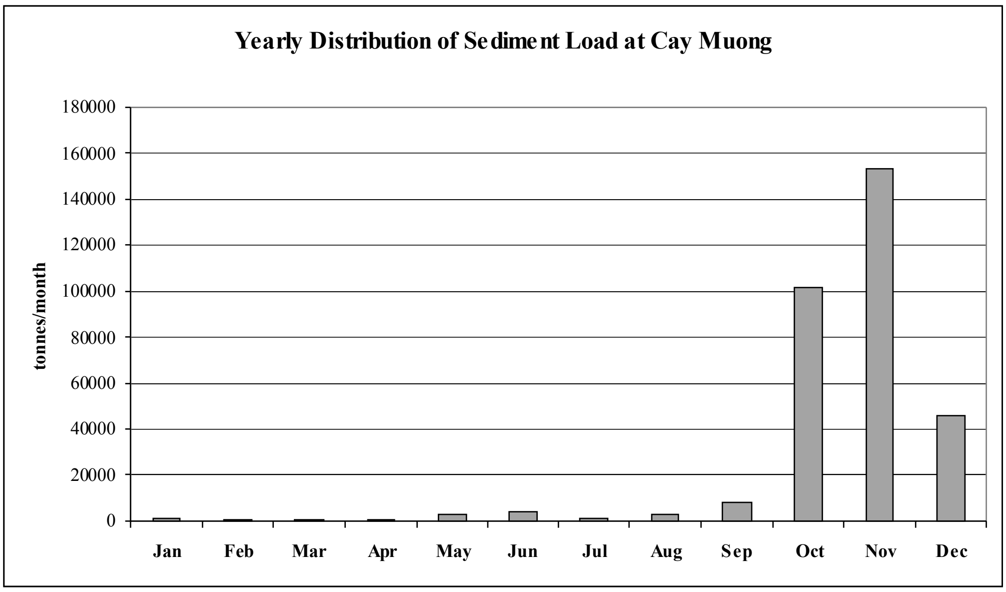
Probability		10%		5%		1%	
Parameter		Q (m^3/s)	Vol (Mm^3)	Q (m^3/s)	Vol (Mm^3)	Q (m^3/s)	Vol (Mm^3)
Station	Area (km^2)						
Dinh Binh	1,040	1,330	149	1,961	196	4075	313
Cay Muong	1,677	1,730	240	2,550	315	5,300	505
Binh Thanh	2,250	2,034	323	2,997	423	6,230	677
Nui Mot	180	507	26	747	34	1,553	54
La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

4.3 Sediment Analysis

4.3.1 Sediment Production

The concentration of suspended sediments is measured in Cay Muong. In the absence of the grain size distribution of the sediments, it is difficult to assess whether the measured sediment load refers to wash load only, or whether also bed material load is included. Here it is assumed that the measured sediment load consists practically entirely of wash load.

Sediment concentrations at Cay Muong vary from practically zero in the low flow period to values of over 500 – 1,000 gr/m^3 (ppm) during the floods in October – November. As a consequence most of the sediment load occurs during the flood season. The distribution of the average suspended load of some 320,000 tonnes per year is shown in the figure below:



Almost 80% of the transport of suspended sediments take place during October – November.

The yearly volume of sediments at Cay Muong corresponds with a sediment production of some 200 tonnes 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.

4.3.2 Reservoir Sedimentation in Dinh Binh Reservoir

It is anticipated that the trap efficiency of a future Dinh Binh reservoir will be relatively low. Most of the floodwaters that enter the reservoir in October – November will be discharged almost immediately, without allowing the wash load to settle. The volume of suspended load that enters the reservoir in December and the subsequent months (about 20% of the yearly volume on the average) could most likely settle in the reservoir.

It is assumed that in addition to the suspended sediments there will be some bed load with a volume corresponding with some 10% of the suspended load. Assuming that all these sediments will be trapped in the reservoir, then it is roughly estimated that on a yearly basis sedimentation could take place in the reservoir in the order of 100,000 m^3.

Regarding the above estimated sedimentation, the following is noted:

The sediment yield at the Dinh Binh damsite was estimated based on the actual measurement at Cay Muong, resulting in about 150,000 m^3/year or about 144 m^3/year/km^2. However, this value seems to be small compared with other similar river basins in which the sediment yield amounts to several hundreds cubic meter/year/km^2 or more. In the case of the Huong River basin, the sediment yield was estimated at about 670 m^3/year/km^2.

Such being the case, it is considered important to review the estimated sediment yield at the Dinh Binh damsite. To review the estimated sediment yield, it is considered effective to measure the actual sediment in the existing reservoirs. Although the Study Team tried to find such measurement data of actual sediment in the existing reservoirs, the data were not available, and therefore, it is strongly recommended to carry out the measurement of the actual sediment in the existing reservoirs at the earliest for confirmation or necessary correction, if any, of the estimated sedimentation at the Dinh Binh damsite

CHAPTER 5 WATER DEMAND FORECAST

5.1 Water Demand for Agriculture

Agricultural water demand for irrigation, livestock, aquaculture is summarized and tabulated as below. Processes and results of estimate for the respective components of agricultural water demand are briefly mentioned in the succeeding paragraphs hereinafter.

(1) Kone and Ha Thanh River Basins

Irrigation Area (ha)

River Basin	Present (2001)	Future (2010)	Future (2020)
Kone River Basin	20,200	25,100	43,900
Ha Thanh River Basin	1,200	2,400	4,300
Total	21,400	27,500	48,200

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

Item	Cropping Pattern		
	Present (2001)	Future (2010)	Future (2020)
Year	1995	1994	1992
Irrigation	19.18	20.03	32.75
Livestock	0.07	0.10	0.13
Aquaculture	0.00	0.36	0.36
Total	19.3	20.5	33.2

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

Item	Cropping Pattern		
	Present (2001)	Future (2010)	Future (2020)
Year	1986	1986	1997
Irrigation	19.85	20.73	34.00
Livestock	0.07	0.10	0.13
Aquaculture	0.00	0.36	0.36
Total	19.9	21.2	34.5

(2) La Tinh, Kone and Ha Thanh River Basins

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), Average Rainfall Year (m^3/sec)

Item	Cropping Pattern		
	Present (2001)	Future (2010)	Future (2020)
Year	1991	1991	1992
Irrigation	22.15	22.29	37.08
Livestock	0.07	0.10	0.13
Aquaculture	**0.00**	**0.36**	**0.36**
Total	**22.2**	**22.8**	**37.6**

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

Item	Cropping Pattern		
	Present (2001)	Future (2010)	Future (2020)
Year	1986	1986	1997
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

5.1.1 Methodology

(1) Irrigation Water Estimation Method

For estimation of irrigation water demand, future cropping pattern and crop planted area have been assumed according to the basic concept for agricultural development as described in the subsequent Sub-section 7.2.2. The basic concept is formulated based on policies mentioned in the agricultural and rural development plan of the province as well as the conceivable project works.

The main concept in the agricultural and rural development is i) Sustainable development in view of land, water and biological resources, ii) Increase of crop production through crop diversification to meet local food demand and support processing industry, iii) Raising of living standard in the rural area. Particularly, high priority has been given to the water resource development and management for flood mitigation, irrigation water and drainage improvement to facilitate diversification of crops and improved farming technologies in the crop production.

Under the conceivable project works, the future agriculture land will be provided with the following improvement under the project works:

(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.

The above conditions will enable to expand the cropped area, increase cropping intensity and better quality of products along with technical improvement of farming practices like introduction of improved varieties, efficient farming practices and proper input dosage.

Process and methodology for estimation of irrigation water demand adopted in this Study are as follows:

(i) Collection of data and information on present and future irrigation

(ii) Field investigation on present irrigation condition

(iii) Estimation of cultivated land area and planted area

(iv) Establishment of cropping pattern

(v) Estimation of irrigation area

(vi) Estimation of potential evapotranspiration (ETo) from cropped field

With reference to the Report "General Explanation No.444C-05-TM, Feasibility Study, Water Resources Project Dinh Binh Reservoir, HEC1, HDECE, May 2000, ETo has been estimated in accordance with FAO Irrigation and Drainage Papers No.24, No.46, No.56, etc.

(vii) Estimation of crop coefficient (Kc)

Kc has been estimated with reference to a past report of MARD and FAO Irrigation and Drainage Papers No.33 and No. 56.

(viii) Calculation of crop water requirement (CWR)

(ix) Calculation of consumptive use of water of crops (CUW)

(x) Estimation of effective rainfall (Peff)

Peff has been estimated with reference to FAO Irrigation and Drainage Papers No.25 and No. 46.

(xi) Calculation of net irrigation water requirement (NIR)

(xii) Estimation of irrigation efficiency (Ep)

Ep has been estimated as shown below with reference to FAO Irrigation and Drainage Papers No.24 and No. 46.

Item	Less-managed system (Year 2001)	Ordinary System (Year 2010)	Well-managed System (Year 2020)
Ep-paddy	0.60	0.65	0.70
Ep-upland	0.54	0.60	0.66

(xiii) Calculation of gross irrigation requirement (GIR)

(xiv) Calculation of irrigation water demand (IWD)

(2) Livestock Water Estimation Method

Process and methodology for estimation of livestock water demand adopted in this Study are as follows:

(i) Collection of data and information on present and future conditions of livestock

(ii) Estimation of unit water requirements (lit/day/head) of various kinds of livestock

With reference to "Guidelines for Preparation of National Master Water Plans, Water Resources Series No.65, ESCAP, 1989", the following has been estimated.

(Unit: lit/head/day)

Kind of livestock	Water requirement per head per day		
	Drinking	Others	Total
Pig	15	30	45
Ox	35	70	105
Buffalo	35	70	105
Poultry	0.25	0.50	0.75
Goat	25	50	75

(iii) Estimation of head numbers of various kinds of livestock

With reference to "Review and Supplementary Report on Agricultural and Rural Planning for Binh Dinh Province Towards 2010, Binh Dinh People's Committee, Department of Agriculture and Rural Development (DARD), 2002" and the statistics by districts of Binh Dinh Province, head numbers of the livestock have been estimated.

(iv) Calculation of water demand for each livestock

(v) Calculation of water demand for all kinds of livestock (LWD)

(3) Aquaculture Water Estimation Method

Process and methodology for estimation of aquaculture water demand (fresh water) adopted in this Study are as follows:

(i) Collection of data and information on present and future conditions of aquaculture

(ii) Estimation of unit water requirements (fresh water depth /year)

- Coastal brackish water shrimp culture: 0.46 m/year (fresh water)

(Brackish water 6.90 m/year)

"Standard on Fishery Industry in Vietnam, Ministry of Fishery, 2000" has been referred to for the above estimation.

- Note about inland fresh water fish culture

All the inland fresh water fish culture in the Study Area is being operated in the reservoirs. There is no fish pond in the field. Therefore, no particular water supply is done at present and such a way would continue also to the future in this area.

(iii) Estimation of areas for the coastal brackish water shrimp culture pond

"General Explanation No.444C-05-TM, Feasibility Study, Water Resources Project Dinh Binh Reservoir, HEC1, HDECE, May 2000, ETo has been referred to for estimation of the pond area for the coastal shrimp culture.

(iv) Calculation of fresh water demand for coastal shrimp culture

(v) Calculation of fresh water demand for the coastal shrimp culture

5.1.2 Forecast of Water Demand for Irrigation

(1) 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 from 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
Kone and Ha Thanh River Basins						
Year	1980	1995	1987	1994	1993	1992
Water Requirement	1.79	28,200	1.42	23,000	1.30	21,400
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.

It is noted that, 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),
Year with less than 1/4 of examined long period selected from 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
Kone and Ha Thanh River Basins						
Year	1987	1986	1983	1986	1996	1997
Water Requirement	1.89	29,200	1.45	23,800	1.32	22,300
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 in the both the average rainfall year and the year 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. The peak 10-day GIRs for the respective cropping patterns are shown in the Appendix-D.

(2) 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 calculated from 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
Kone and Ha Thanh River Basins						
Irrigation Area (ha)	21,400		27,500		48,200	
Water Demand	19.2	605	20.0	632	32.8	1,033
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),
Year with less than 1/4 of examined long period calculated from 10-day GIR (m^3/sec)

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
Kone and Ha Thanh River Basins						
Irrigation Area (ha)	21,400		27,500		48,200	
Water Demand	19.9	626	20.7	654	34.0	1,072
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

5.1.3 Forecast of Water Demand for Livestock

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)

Kind	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	19,600	2,060	32,000	3,360	41,000	4,300
Pig	71,000	3,200	90,000	4,050	117,000	5,260
Poultry	458,000	340	1,500,000	1,130	2,250,000	1,690
Goat	970	70	1,500	110	3,000	230
Total	-	5,670	-	8,650	-	11,480

5.1.4 Forecast of Water Demand for Aquaculture

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

5.2 Forecast of Domestic Water Demand

5.2.1 Methodology

The population figures in the Kone River basin were used to determine both present and future domestic water demands of the said basin in the Study. Out of 11 districts in Binh Dinh Province, only 7 districts are included in the Kone River basin as well as the Ha Thanh River basin which is regarded as a sub-catchment. An Lao, Hoai An, Hoai Nhon and Phu My districts of the Province are not included in the Kone River basin as shown in Figure 5.1.

The following urban centers, in addition to Quy Nhon, were identified for consideration and inclusion within a water utilization plan for the river basin:

- Quy Nhon City
- Ngo May Town
- Phu Phong Town
- Binh Dinh Town
- Dap Da Town
- Tuy Phuoc Town
- Dieu Tri Town
- Phu My Town

Note: Phu My Town, outside the Kone River basin, is especially considered to be supplied water from the Kone River basin.

Locations of the above major towns in the basin as well as districts are presented in Figure 5.1.

The population estimates for each of the above towns together with the corresponding rural areas in each of the respective districts, for the years 2010 and 2020 were made and are indicated in Table 5.1. The estimates are based on the 2001 population figures given in the Statistical Yearbook Binh Dinh Province 2001 and the percentage increases as determined by the socio-economic analysis for the Kone river basin given in Phase 1 of the Study.

Using these population figures and the assumptions indicated in Table 5.2 relating to per capita water consumption, service coverage, unaccounted for water (UFW) and institutional water use, the domestic water demand for the years 2001, 2010 and 2020, for the above 8 urban centers and rural areas lying within the catchment, were determined. The results of the exercise are given in Tables 5.2 and 5.3. Table 5.2 represents the water demand that will be connected to the water supply system as the service coverage area. Table 5.3 includes also for people not yet connected to the water supply system and as such could be considered as the total domestic water demand on the river basin.

In the above Tables 5.2 and 5.3, it is noted that water demand of 20,000 m^3/day for the new urban area (Nhon Hoi) located northeast of Quy Nhon city, which recently obtained Government approval, is additionally taken into account.

5.2.2 Result of Forecast for Domestic Water Demand

Based on the above analysis, the following table gives the projected increase of the domestic water demand in the river basin.

Domestic Water Demand (Excluding non-connected people)

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

Domestic Water Demand (Including non-connected people)

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

Urban domestic water demand in each urban center is shown in Figure 5.2.

5.3 Water Demand for Industrial Use

5.3.1 Rural Industrial Water Demand

The industrial water demand is divided into the rural industrial demand and the demand for industrial zone.

Water demand for the rural industrial use was investigated in the Feasibility Study of Dinh Binh Reservoir Project carried out by HEC-1 (Hydraulic Engineering Company No.1) in 2000. Based on the data provided by the provincial Department of Industry, the present demand was estimated at about 18.0 million m^3/year or 49,300 m^3/day, and this demand was analysed to increase to 30.12 million m^3/year or 82,525 m^3/day in 2010 in the Feasibility Study.

Reviewing the analysis in the Feasibility Study, the estimate of rural industrial water demand of 30.12 million m^3/year (or 82,525 m^3/day) in 2010 was considered reasonable and therefore, the water demand for 2020 was estimated on the basis of the above estimate for 2010 as follows:

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 5.4, 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)

5.3.2 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.

Phu Tai Industrial Zone is located at 9 km west of Quy Nhon City with the designed area of 250 ha. Long My Industrial Zone is planned in the south of Tuy Phuoc District with the designed area of 300 ha. Nhon Hoi Industrial Zone is planned in northeast of Quy Nhon City with the designed area of 1,000 ha.

Water demand is estimated based on 70 m^3/day per ha, and the total water demand is calculated at 108,500 m^3/day.

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 5.3.

5.4 Water Demand for Power Generation

The Dinh Binh Multipurpose Reservoir Project (D.B.R.P) is planned in the Kone River in Vinh Hao Commune, Vinh Thanh District, Binh Dinh Province.

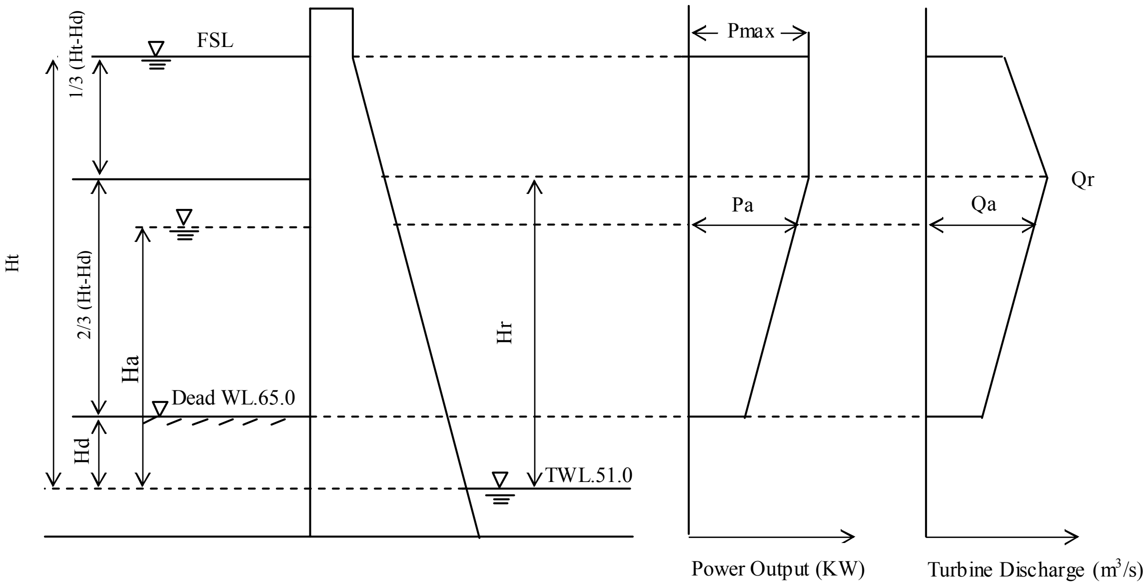
Objectives of D.B.R.P consist of flood control, water supply for irrigation, domestic and industrial water, power generation and improvement of river environment, etc. However, higher priority is put on the objectives of flood control and water supply, and the power generation is planned to be basically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

On the other hand, power generation of D.B.R.P is taken into account in the National Power Development Plan under the national power supply grid, and is expected to guarantee the following:

Installed capacity	:	6,600 KW
Guaranteed capacity (With 75% dependability)	:	2,200 KW
Guaranteed energy (With 75% dependability)	:	1,584 MWh/month

Therefore, if power generation by utilizing the water to be released for water supply purpose cannot meet the above guaranteed capacity and/or energy with 75% dependability, the water necessary to satisfy the guaranteed power generation should additionally be considered. This additional water for the power generation is considered the water demand for power generation.

The following is a schematic presentation of relation among the water head, turbine discharge and power output.



The power output and turbine discharge are calculated with the following formula:

Pmax = 9.8 x η x Hr x Qr

Qr = Pmax/9.8 x η x Hr = 6,600/ 9.8 x 0.87 x Hr = 774.1/ Hr

i) Above the rated head:

Pa = Pmax = 6,600

Qa = Pmax/9.8 x η x Ha = 6,600/ 9.8 x 0.87 x Ha = 774.1/ Ha

ii) Below the rated head:

$$Qa = Qr \text{ x } \sqrt{\frac{Ha}{Hr}} = \frac{774.1}{Hr} x \sqrt{\frac{Ha}{Hr}}$$

$$Pa = 9.8 \text{ x } \eta \text{ x Ha x Qa} = 9.8 \text{ x } 0.87 \text{ x Ha x} \frac{774.1}{Hr} x \sqrt{\frac{Ha}{Hr}}$$

$$= 6{,}600 \text{ x } \left(\frac{Ha}{Hr}\right)^{1.5}$$

where: Pmax : Installed capacity (6,600 KW)

η : Combined efficiency (0.87)

Hr : Rated head (m)

(The rated head is set around at the center of the effective storage volume as shown in the above schematic presentation)

Qr : Rated turbine discharge (m^3/s)

Ha : Head in accordance with variable reservoir water level (m)

Qa : Max. turbine discharge at Ha (m^3/s), and

Pa : Max. power output at Ha (KW)

The power generation of D.B.R.P is conducted by utilizing the water to be released for other prioritized water supply purposes. Therefore, it will happen that the actual discharge will be less than the turbine discharge (Qa) to be calculated by the above formula of power generation.

In this case, the power output will be forced to be lowered to the output to be calculated by the following formula:

Pi = 9.8 x 0.87 x Ha x Qi

where, Pi : Power output in the case that the actual discharge is less than the maximum turbine discharge (Qa) at Ha (KW),

Ha : Head in accordance with variable reservoir water level (m), and

Qi : Actual discharge to be released (m^3/s).

5.5 Water Demand for River Maintenance Flow

5.5.1 Introduction

In the Phase 1 study, the river maintenance flow of 14 river basins including the Kone river basin was examined from the following viewpoint:

- Prevention of saline water intrusion to secure necessary salinity for irrigation water,
- Prevention of water quality pollution due to waste water for ecological conservation and necessary water quality for domestic and industrial water, and
- Maintaining present activities in the river such as fluvial navigation.

For verification of the figure of the Kone river basin obtained in Phase 1 study, the maintenance flow is discussed and reexamined hereunder, based on the data and information collected additionally in the course of the Phase 2-2 study and analysis of them. The discussion and reexamination is done mainly on the following aspects:

1) Salinity intrusion,
2) Ecological conservation,
3) Water Quality, and
4) Fluvial navigation.

5.5.2 Prevention of Salinity Intrusion

Through the field reconnaissance and data collection of the Phase 2-2 study, it was found that the following structural countermeasures against salinity intrusion were already undertaken:

- Sea dyke (De Dong dyke) along the bank of Thi Nai swamp with approximately 47 km, and
- 5 weirs as shown in Figure 5.4, which contribute to the control of the salinity intrusion into the rivers although their main purposes are irrigation water intake for the nearby paddy fields.

There are no intake structures for taking fresh surface water in the downstream of five weirs. According to the officials of local authorities, the function of the above structures for prevention of salinity intrusion is satisfactorily fulfilled, and the constraint on the river water use for irrigation purpose is not popular from the salinity viewpoint.

The field survey of salinity measurement was conducted in the downstream of the Kone and Ha Thanh rivers on subcontract basis. The result of measurement in dry season (from 25th Aug. to 8th Sep., 2002) is shown in Table 5.5. This result also indicates that the salinity measured in the upstream from the said weirs in the Kone river is negligibly small from the viewpoint of irrigation use, and is suggestive that the said structures achieve salinity control function in the river systems.

Accordingly, it can be concluded that the allocation is unnecessary for the minimum discharge as counter flow against the salinity intrusion into the Kone and Ha Thanh river systems.

5.5.3 Ecological Conservation

Through the Phase 1 and 2-1 study, the minimum monthly discharge with P=90% is applicable as minimum discharge necessary for ecological conservation. This direction was proposed by Hanoi Water Resources University based on the past experiences of Vietnam in view of necessary minimum flow for maintaining the ecologically favorable condition in river systems. The maintenance flow for ecology was examined considering this direction, and the methodology are shown below:

i) The result of hydrological analysis revised on the daily basis from 1978 to 2001 (24 years) was employed for the examination,
ii) Three (3) points were selected for examination in due consideration of the river basins' characteristics; i.e. the case at Binh Thanh (the apex of the delta), the case of whole Kone river basin (the virtual river mouth of the Kone river), and the case of whole Ha Thanh river basin (the virtual river mouth of the Ha Thanh river), and
iii) The minimum monthly discharge with P=90% was calculated at each selected point, and converted into the cubic meter per second (m^3/s).

The examination on the above is shown in Table 5.6, and 6.6 m^3/s at Binh Thanh, 8.1 m^3/s for the Kone river basin, and 1.3 m^3/s for the Ha Thanh river basin are respectively obtained as minimum discharge for ecological conservation.

5.5.4 Prevention of Water Pollution

Water quality of the river depends on such conditions as discharge volume, pollution loads, water temperature and runoff velocity, etc. The discharge volume will determine the function of dilution, and temperature and runoff velocity will do the effectiveness of the capacity of self purification. Pollution loads include wastewater from domestic, industrial and agricultural use as well as the flush water from city ground. In the dry season, in general, water quality of river water is degraded, as the dilution capacity is low as far as the other conditions are the same.

The water pollution analysis on BOD is generally employed as quantitative examination for determination of river maintenance flow. However the data and information prerequisite for the analysis, such as original unit of pollutant load, pollution runoff ratio, and attenuation rate of the river, are not available in the Kone and Ha Thanh river basins. Therefore, the examination of maintenance flow was carried out based on the existing available data of water quality condition in the river basins.

Table 5.7 shows the available data on water quality condition in the Kone and Ha Thanh river basins. The data on BOD obtained through field work and laboratory analysis subcontracted to CWRET show that the water quality of the Kone and Ha Thanh rivers are good condition even in dry season generally. Most of these figures meet the Category A of the Surface Water Quality Standard (TCVN 5942-1995), except the figures of the water samples fetched near the section of river mouths and from the discharge point of hydropower plant. The data available in secondary information as shown in the table also indicate that the water pollution in the rivers is insignificant.

Therefore, it is suggestive that the decrement of existing low discharge be avoided by maintaining the hydrological regime of low water, in order to ensure the existing good condition of water quality of the Kone and Ha Thanh rivers. The maintenance flow for ecology as discussed in the previous section is considered to be sufficient to maintain the low water regime and to meet the necessary discharge for water quality control.

5.5.5 Maintaining Fluvial Navigation

It is considered that the condition for the fluvial navigation (inland waterway transport) in the Kone and Ha Thanh river systems can be mostly ensured by maintaining the existing hydrological regime of low water on the following grounds:

- Due to the topographical and hydrological condition and many obstacles such as hydraulic structures, fluvial navigation is not developed in the Kone and Ha Thanh river systems. The usage of small boats such as gravel transportation can be occasionally observed but much limited to the local area. According to the Department of Transport of the province (DOT), most of the transport of the cargo and passengers can be substituted by land in case of insufficiency of the depth and surface width of water.
- The standard for technical classification of inland waterways of Ministry of Transportation and Communication (TCVN 5664-1992) stipulates channel dimensions such as water depth and width for fluvial navigation in the rivers. This standard is applied to the Kone and Ha Thanh river systems. In relation to the maintenance flow for fluvial navigation, the applied standard is determined based on the frequency of plying service corresponding to P= 95% of natural hydrological regime in the dry season.

As mentioned in the Section 2.7 of the Chapter 2, DOT has a plan for improvement of fluvial navigation in the stretch of Tan An river downstream between Go Boi and the river mouth. Because the plan of this stretch intends to meet the target of navigability under P= 95% condition in dry season by means of dredging the riverbed, it is unnecessary to allot the additional discharge for navigation.

Through the above discussion, it can be concluded that the necessary maintenance flow for fluvial navigation in the river basins can be covered by the one for ecological conservation (P= 90 %).

5.5.6 Review of the Previous Study

In the previous study, the environmental minimum discharge of 3 m^3/s was proposed to be ensured during the months of February to August, in order to protect the ecological environment and salinity intrusion. However, the method of examination was unclear within the available information of the previous study, and the examination process for achieving this determination could not been identified and reviewed.

The discussion of the JICA Study on the river maintenance flow presented in this Chapter can be considered to be more applicable than that of the previous study from the technical viewpoint. Therefore, it is recommendable to adopt the conclusion of this Chapter as the river maintenance flow.

5.5.7 Set up of River Maintenance Flow

The outcomes for determination of the maintenance flow for the Kone and Ha Thanh rivers are summarized below, based on the above examination:

- It is unnecessary to allocate the minimum discharge for prevention of salinity intrusion into the river systems because the structures for salinity intrusion control are functional,
- The minimum discharge to ecological conservation is estimated at 6.6 m^3/s at Binh Thanh, 8.1 m^3/s for the Kone river basin, and 1.3 m^3/s for the Ha Thanh river basin, respectively, and,
- It is necessary to ensure the existing hydrological regime of low water from the view point of water quality control and fluvial navigation. This requirement will be mostly covered by the ecological minimum discharge.

The above discussion was done based on the detail information collected additionally in the course of Phase 2-2 study, including field measurement. Since the river maintenance flow for the Kone and Ha Thanh rivers is considered to be examined more deeply in this phase rather than that of Kone river case of the Phase 1, it is recommendable to apply the result of this phase to water balance analysis and formulation of the Master Plan for the Kone river basin.

As conclusion of the above analysis, 6.6 m^3/s at Binh Thanh (the apex of the delta), 8.1 m^3/s for Kone river basin, and 1.3 m^3/s for Ha Thanh river basin were obtained respectively as the river maintenance flow.

Besides, the relevancy between the river water quality and river maintenance flow determined hereinbefore will be discussed in the Phase 2-3 study.

CHAPTER 6 WATER BALANCE ANALYSIS

6.1 Water Balance Study

6.1.1 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.

6.1.2 Water Balance System

The analysis is made in the Kone River basin including Ha Thanh River, while only some irrigation water demand in the La Tinh River basin is incorporated in the analysis of the Kone River basin. The proposed Dinh Binh Reservoir is studied of its development scale to meet future water requirement in terms of necessary storage capacity as well as flood control capacity.

The analysis incorporates the following components:

(a) Water resources : river runoff in natural flow condition as well as existing and proposed reservoir storage

(b) Water demands : agriculture and fishery uses, domestic use, and industrial use, as well as hydropower generation use as subordinate requirement

(c) River maintenance flow.

Water balance is examined at each water intake location as water demanding point on the respective river course. Water balance of the whole basin taking actual river system into account is also evaluated in order to determine necessary water release of the multi-purpose dam (Dinh Binh Dam reservoir). Availability of the river maintenance flow is examined at the river mouth as a whole basin basis.

A schematic model for the analysis of the Kone River and Ha Thanh River basins are presented in Figure 6.1.

6.2 Basic Condition of Water Balance Analysis

6.2.1 Basic Condition

Water balance analysis is made in 10-day basis. Balance calculation was 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.

6.2.2 Water Resources

(1) Catchment Area

Principal catchment area of the basin applied in the analysis are as follows:

Kone River basin	:	3,010 km^2
Dinh Binh Dam	:	1,040 km^2
Van Phong Weir	:	1,677 km^2 (cumulative)
Binh Thanh	:	2,250 km^2 (cumulative)
Ha Thanh River basin	:	630 km^2

(2) Reservoirs

The following existing and proposed reservoirs are studied in the analysis:

Status	Reservoir	Main River System	Effective Storage Volume (MCM)		Main Purpose
			Existing	Proposed	
Existing	Vinh Son	Kone R.	102.0	132	Power
	Thuan Ninh	Kone R.	32.3		W/supply
	Nui Mot	Tan An R.	108.5		W/supply
	Hoi Son	La Tinh R.	43.7		W/supply
Proposed	Dinh Binh	Kone R.		279.5(1)	Multi-purpose
	Suoi Chiep	Ha Thanh R.		8.0	W/supply

Note: 1) Effective storage volume to be proposed in the Master Plan. Effective storage for water supply purpose was examined at 188.8, 209.9, 279.5 and 360.2 MCM.

Other than the above-listed reservoirs, several small scale reservoirs (1.0 million m^3<storage capacity<15.0 million m^3), both existing and proposed ones, are incorporated in the analysis. Such small scale reservoir is of the exclusive one to each irrigation scheme.

6.2.3 Water Demand

(1) Irrigation Water Demand

Irrigation water demand is the most major water requirement in the basin. The major irrigation schemes are individually incorporated in the analysis as shown in Figure 6.1, however small scale irrigation schemes are combined by area together with related small-scale reservoirs. Irrigation area considered in the study are shown as follows by river:

River	Irrigation Area (ha)			Note
	Present	2010	2020	
Kone River				
Upper Kone	1,510	5,417	20,020	until Binh Thanh
Dap Da	7,179	8,151	9,656	
Go Cham	3,866	6,006	6,160	
Tan An	7,818	8,040	10,097	
Ha Thanh	-	-	2,039	Water to be supplied from Kone River
La Tinh	-	-	6,297	Only related area to be supplied from Van Phong
Ha Thanh	1,180	2,394	3,928 – 2,246	Area in 2020 is adjusted according to water availability. Area in 2010 shows the decreased one following the 2020 adjustment.

Water supply to the irrigation system in the La Tinh River from the Kone River through Van Phong Weir is incorporated in the manner that only insufficient water supply capacity of the Hoi Son Reservoir is covered by the transferred water from the Kone River.

(2) Other Agricultural Water Requirement

In addition to the irrigation water requirement, other agricultural water requirement including the coastal shrimp culture and livestock are assumed in the water demand as follows:

Water Demand	Present (m^3/day)	2010 (m^3/day)	2020 (m^3/day)
Coastal shrimp culture			
Kone River basin	-	34,300	34,300
Ha Thanh River basin	-	51,400	51,400
Livestock			
Kone River basin	2,300	3,500	4,600
Ha Thanh River basin	3,400	5,200	6,900

(3) Domestic and Industrial Water Supply Requirement

Water requirement for the domestic and industrial demands estimated are incorporated in the analysis as well, which is summarized as follows:

(unit : m^3/day)

River	Present (2001)		2010		2020	
	Domestic	Industry	Domestic	Industry	Domestic	Industry
Kone River						
Upper Kone	2,382	49,300	7,419	82,525	12,385	195,367
Dap Da	7,585	0	24,114	0	41,715	0
Tan An	6,249	0	22,383	85,000	57,468	170,000
Ha Thanh	165	0	770	19,250	1,329	38,500

Remarks : Demand for river surface water only

(4) River Maintenance Flow

River maintenance flow is examined of its availability at the following predetermined points:

Kone River,	River mouth	:	0.70 million m^3/day (equiv.to 8.1 m^3/sec) (as total amount for a river basin)
	Binh Thanh	:	0.57 million m^3/day (equiv.to 6.6 m^3/sec) (diverging to Dap Da and Tan An Rivers)
Ha Thanh River,	River mouth	:	0.11 million m^3/day (equiv.to 1.3 m^3/sec)

6.3 Evaluation of Water Balance Analysis

Evaluation is made on the results of those in 2001, 2010 and 2020. 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	:	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)
(c)	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)

6.4 Present Water Balance Situation Against 2001 Demand

6.4.1 Kone River

In the Kone River basin at present, there are 3 existing reservoirs that have an effective storage capacity bigger than 30 million m^3, i.e. Nui Mot Dam and Thuan Nhin Dam as well as Vinh Son Dam which is of hydropower purpose.

Examination on the present water balance situation is made for the following water demands:

(i) Water demand that would be supplied by the aforesaid dams located upstream(deficit would be manageable by the upstream dams on the main stream).

(ii) Another demand is rather small-scale irrigation scheme with the exclusive small scale reservoir(s) on the tributaries(deficit is not manageable by the upstream dams on the main stream).

Water Demand on the Main Stream (deficit manageable)

Result of the water balance analysis on the present condition are summarized in the following manner:

(i) Water balance against agriculture and fishery water demands, as well as domestic and industry demands,

(ii) Demand in the upstream reaches between Dinh Binh Dam site and Binh Thanh, as well as downstream reaches between Binh Thanh and river mouth,

(iii) Water balance condition is examined by not considering river maintenance flow.

(iv) It is assumed in the analysis that the Nui Mot reservoir supplies its storage water exclusively to the irrigation scheme at downstream of the dam, but not cover water demand along the Tan An River.

(v) Water shortage condition is expressed in terms of rate of water deficit in respective year against a corresponding total water demands in the year.

(vi) Number of year to suffer water shortage(drought year) is defined as that rate is higher than 5%, tentatively.

Water Deficit Rate Against Annual Total Demands

(No Regulation by Release from Vinh Son Dam) (unit %)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Downstream	Irrigation	3.4	12.1	12.0	4.1	1.1	41.5	6.9	5.6	7.8	9.2	13.5

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Drought
Down-IR	6.1	18.6	5.3	9.7	17.4	2.0	11.9	1.2	-	10.9	-	-	1.5	15 years

According to the analysis result, no water shortage is found in the domestic and industrial water demands in the whole basin as well as in the irrigation demands in the upstream reaches.

While irrigation water demands in the downstream reaches encounters water deficit frequently, but which condition would be much improved by release from the Vinh Son Dam.

In both cases above, a part of water deficits to be caused by taking water from the Tan An River could be eased or eliminated by water release under adequate operation of the Nui Mot Dam.

Water Supply on the Tributaries (deficit not manageable)

Water balance condition in each irrigation scheme on the tributaries including the Nui Mot Dam is examined in the similar manner. Some of the existing small-scale irrigation schemes on the tributaries of the Kone River are found deficit every year. However, no deficit is observed in case of the Nui Mot and Thuan Ninh irrigation at all.

Water Deficit Rate Against Annual Demand (unit %)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Kone Riv.	Hon Lap Irrig.	-	-	-	-	-	10.6	-	-	-	-	-
	Hon Ga Irrig.	17.2	-	-	-	-	56.4	-	3.0	3.5	1.4	11.2
Dap Da Riv.	Suoi Chai Irrig.	28.0	47.0	39.6	46.2	30.1	67.6	13.2	42.4	41.9	46.7	43.6
Tan An	Thu Thien Irrig.	-	-	-	-	-	22.9	-	-	-	-	9.0

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Drought
Hon Lap	-	-	-	-	-	-	-	-	-	-	-	-	-	1 year
Hon Ga	-	-	7.0	8.4	18.5	-	7.4	-	-	13.1	-	-	1.9	8 years
Suoi Chai	13.5	50.0	38.3	45.9	53.1	41.0	42.9	34.5	34.2	51.7	15.7	5.0	43.9	24 years
Thu Thien	-	-	0.3	1.4	12.3	-	0.3	-	-	4.1	-	-	-	3 years

6.4.2 Ha Thanh River

In the present condition that there is no available reservoir for annual water regulating capacity to meet a certain water demand in the basin, water resources in the Ha Thanh River basin seems to be abundant against still low water requirement from the river surface water.

It is substantially observed that there is no water deficit in the basin except severe drought year that may occur only once or twice during examined 24 years series, as long as water balance evaluation is concerned.

Water balance condition in each existing irrigation scheme in the Ha Thanh River basin is examined in a similar manner as follows:

Water Deficit Rate Against Annual Demand (unit %)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Main Riv.	Ha Thanh Irrig.	0.5	1.3	-	3.3	-	12.8	0.8	-	-	0.7	-
Tributaries	Cay Da Irrigation	36.3	79.6	52.9	62.1	39.2	87.5	60.8	45.8	47.1	55.0	56.7

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Drought
Ha Thanh Ir.	-	-	-	-	5.1	-	1.8	-	-	-	-	-	-	2 years
Cay Da	35.8	60.0	45.0	56.7	76.3	35.4	70.4	55.8	30.2	80.4	21.3	22.9	46.3	24 years

No deficit is observed for the Ha Thanh domestic and industrial demands as well as Long My irrigation.

Water balance analysis on the present water demand by the existing demand schemes in the Ha Thanh River basin shows scarce water shortage conditions except

Cay Da irrigation schemes.

6.5 Future Water Balance Situation Against 2010 Demand

6.5.1 Kone River

In the Kone River basin of 2010 condition, there will be three existing reservoirs only. However, the storage capacity of the Vinh Son Dam is expected to increase to 132 million m^3.

Examination on the 2010 water balance situation is made for the water demands that some increase of water demands is expected in every water demand fields:

(1) Water Supply on the Main Stream (deficit manageable)

Result of the water balance analysis on the present condition are summarized in different condition from the preceding sections that water balance condition is examined by considering river maintenance flow.

(a) Water Deficit Rate Against Annual Total Demands
(No River Maintenance Flow is Considered)
(No Regulation by Release from Vinh Son Dam)

(unit %)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Downstream	Irrigation	5.0	11.9	12.3	3.7	3.4	47.0	7.2	11.8	14.6	15.8	21.1

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Drought.
Down-IR	8.4	19.9	13.0	14.4	24.8	6.8	11.7	1.2	0.7	11.7	-	-	6.7	18 years

(b) Water Deficit Rate Against Annual Total Demands
(River Maintenance Flow is Considered)
(No Regulation by Release from Vinh Son Dam)

(unit %)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Downstream	Irrigation	14.0	34.7	29.9	10.6	13.7	74.7	22.7	28.2	33.7	32.0	45.4

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Drought
Down-IR	21.7	39.3	29.6	34.2	50.9	21.6	34.0	7.9	3.4	26.6	1.3	-	18.6	21 years

No water deficit is found in water demands of the domestic and industrial uses in the whole basin as well as irrigation requirement in the upstream reaches in both cases above.

Water balance of all demands in the upstream area as well as whole domestic and industrial demands are still sufficient even in case of no water release from the Vinh Son Dam.

Due to remarkable increase of the irrigation area by 30 % towards year 2010, although it is expected that storage capacity of the Vinh Son Dam will be increased by 2010, it is obviously observed that drought condition of irrigation schemes in the downstream reaches would become more severe than the present condition in case of no availability of reservoir storage of the Vinh Son Dam. Furthermore, the water balance situation with a requirement of the river maintenance flow will not be satisfactory even if incorporation of the water release from the Vinh Son Dam was considered.

(2) Water Supply on the Tributaries (deficit not manageable)

Water balance condition in each irrigation scheme on the tributaries including the Nui Mot Dam is examined in the similar manner. Conceivable water balance situation in 2010 will be very diverse according to each irrigation scheme. Particularly, the Nui Mot reservoir seems to have enough space to supply its storage water to the irrigation schemes in the Tan An River basin since no deficit is expected as long as supplying for the Nui Mot irrigation scheme.

Water Deficit Rate Against Annual Total Demands (unit %)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Kone Riv.	Hon Lap Irrig.	-	-	-	-	-	11.8	-	-	-	-	-
	Hon Ga Irrig.	-	7.2	-	-	-	52.6	-	0.9	-	-	-
	Thuan Ninh Irrig.	-	41.3	3.0	-	0.3	74.7	1.9	10.2	9.5	6.9	16.3
Dap Da Riv.	Suoi Chai Irrig.	10.9	35.0	25.6	33.9	16.7	56.6	-	30.3	27.7	34.7	30.4
Tan An	Thu Thien Irrig.	-	-	-	-	-	20.4	-	-	-	-	6.3

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Def. yrs.
Hon Lap	-	-	-	-	1.2	-	-	-	-	-	-	-	-	1 year
Hon Ga	-	-	4.0	6.0	16.1	-	3.2	-	-	10.3	-	-	-	5 years
Thuan Ninh	-	19.1	13.3	13.6	23.1	4.9	19.0	4.4	-	17.9	-	-	10.4	13 years
Suoi Chai	-	30.0	23.9	34.3	39.4	29.5	29.7	21.4	23.0	40.7	-	0.8	31.8	20 years
Thu Thien	-	-	-	-	10.1	-	-	-	-	1.4	-	-	-	3 years

6.5.2 Ha Thanh River

Irrigation area is proposed to increase by 1,200 ha, which increased area would be double of the present one, while new reservoirs will be available by 2010, which total storage capacity will be 13 million m^3 only. Furthermore, the industrial water demands is projected being raised in 2010.

Due to such sharp increase of water demands, the water balance situation in the analysis is quite different from the present situation.

Water balance condition in each existing/proposed irrigation scheme in the Ha Thanh River basin is examined as follows:

Water Deficit Rate Against Annual Total Demands (unit %)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Main Riv.	Ha Thanh Irrig.	1.6	10.4	-	6.9	0.8	28.7	6.6	-	1.0	5.9	3.4
	Coastal Shrimp	-	8.7	-	2.7	-	21.6	4.7	-	0.4	0.8	1.1
River mouth with River Maintenance Flow		2.4	12.9	1.3	11.4	6.2	22.8	9.5	1.6	5.1	11.5	7.8
Tributaries	Suoi Chinh Irrig.	-	-	-	-	-	19.5	-	-	-	-	-
	Cay Da Irrig.	29.6	75.3	47.1	56.5	32.7	86.5	56.5	40.1	39.5	50.2	50.2
	Phu Tai Irrig.	-	-	-	-	-	2.2	-	-	-	-	-

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Def. yrs.
Ha Thanh Ir.	-	-	1.4	5.3	15.5	-	8.5	0.7	0.6	4.3	-	-	2.6	8 yrs.
Coastal Shrimp	-	-	-	1.2	17.2	-	11.0	-	-	4.1	-	-	1.7	4 yrs.
River Mouth	1.6	0.6	4.3	9.9	14.1	0.4	10.6	3.6	4.0	10.9	2.8	-	9.2	13 years
Suoi Chinh Ir	-	-	-	-	10.2	-	-	-	-	1.6	-	-	-	2 yrs.
Cay Da	25.6	52.0	38.1	51.1	70.9	30.9	65.5	51.1	27.4	75.8	14.8	15.2	41.3	24 yrs.
Phu Tai	-	-	-	-	-	-	-	-	-	-	-	-	-	

In Ha Thanh domestic and industry water demands case as well as Long My irrigation, water shortage condition is not observed.

As seen in the above, the drought condition in whole the basin with the river maintenance flow would occur almost every year, while every other year in case no river maintenance flow is considered. Similar situation is found for the Ha Thanh irrigation scheme. The other water demands except Cay Da irrigation scheme scarcely encounter water shortage condition.

6.6 Future Water Balance Situation Against 2020 Demand

6.6.1 Kone River

(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. Further, a small-scale reservoir as a part of the proposed irrigation system is also incorporated in the analysis as shown in Figure 6.1.

Firstly the water balance study is undertaken so as to find out the most appropriate reservoir development scale of the Dinh Binh Dam so as to meet the projected water demands in 2020.

(2) Effective Storage Alternatives

Effective storage volume of approx. 210 million m^3 available for water supply proposed by the previous feasibility study undertaken by MARD/HEC1 is assumed in the current study as minimum requirement to cope with 2020 water demand.

To cope with 2020 water demand, 210, 279 and 360 million m^3 in terms of the effective storage volume for water supply are examined, respectively.

(3) Flood Control Volume Alternatives

According to the flood control plan discussed in the succeeding Section 7.4, a certain amount of flood control space is expected to be secured in the reservoir storage during a flood season, as follows:

(a) Major flood season (September to November)

A flood control space of approx. 100 million m^3 to 375 million m^3 as well as the effective storage capacity in the flood season retaining 0.0 to 100 million m^3 according to the reservoir development scale.

(b) Late flood season (December).

In any development scale alternatives, 200, 120 and 55 million m^3 respectively in the first, second and third 10days.

(4) Examined Development Scale

In the study, the water transfer to the La Tinh River basin is included.

Examined alternatives with a combination of effective storage capacity and flood control space are summarized below:

Reservoir Development Scale Alternatives

(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) 1st-10th, 2) 11th to 20 th, 3) 21th to 31th.

(5) Reservoir Operation Rule Applied for the Analysis

In the present water balance analysis, preliminary reservoir operation procedure is predetermined to control reservoir storage volume in flood control aspect according to the three seasons a year as shown in the preceding Paragraph (4), i.e.: no-flood season (January to August), major flood season (September to November) and late flood season (December).

In addition to the above, a procedure on reservoir outflow control in the water supply aspect is predetermined as well. A concept of this rule is to discharge reservoir storage to meet water demand in the downstream reaches as long as storage water is available.

(a) Operation for Reservoir Storage Control

In annual operation for reservoir storage control, the highest priority is given to the following matter, respectively according to the flood seasons:

(i) Non-flood season : Securing effective storage capacity for water supply is prioritized provided that water supply demand is satisfied

(ii) Major flood season : Predetermined flood control space is to be secured

(iii) Late flood season : Predetermined flood control space is to be secured, while the effective storage capacity for water supply shall be restored towards the non-flood season.

(b) Operation for Reservoir Outflow Control

Reservoir outflow control is to be made in the following manner that current reservoir storage will not exceed the respective effective storage capacities according to the flood seasons:

(i) Current Reservoir Storage = Max .Effective Storage Capacity

- Qout = Qin when Qin > Qdemand
- Qout = Qdemand when Qin < Qdemand

(ii) Current Reservoir Storage < Effective Storage Capacity

- Qout = Qdemand until Current Reservoir Storage reaches to the Effective Storage Capacity, when Qin > Qdemand
- Qout = Qdemand until Current Reservoir Storage become the lowest, when Qin < Qdemand

(iii) Current Reservoir Storage = the lowest

- Qout = Qin when Qin < Qdemand
- Qout = Qdemand when Qin > Qdemand

In the above,

Qout : Necessary outflow volume from the reservoir

Qin : Inflow volume to the reservoir

Qdemand : Water demand in downstream reaches

(6) Water Balance Analysis by Development Scale

Water balance analysis is made for the several alternatives as shown above with the assumption that the reservoir storage of the Dinh Binh Dam and Vinh Son Dam is incorporated but storage capacity of the Nui Mot Damwill be considered later in the analysis.

Water balance condition in 2020 is shown below in terms of annual water deficit estimated by accumulating deficits per10day 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	209.9	-	75	-	-	-	641	-	-	20	61	196
I-2		-	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	-	110	13	115	290	-	160	-	-	88	-	-	-
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	-	-	-	-	-	-

(7) Detailed Examination

In the most of cases, minor difference is observed between comparative cases(such as I-1 and I-2) of flood control volume during major flood season, therefore only one case for each reservoir development scale, i.e. Alternative I-1, II-1 and III-1 are examined in detail as follows:

Annual Water Deficit by Area

(unit : million m^3)

		Alternative	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Whole Basin at River Mouth		I-1	-	75	-	-	-	640	-	-	20	61
(except demand in tributaries)		II-1	-	50	-	-	-	640	-	-	-	-
		III-1	-	50	-	-	-	640	-	-	-	-
Upstream Reaches	Irrigations (Water taken from main river only)	I-1	-	23	-	-	-	188	-	-	-	12
		II-1	-	10	-	-	-	188	-	-	-	-
		III-1	-	10	-	-	-	188	-	-	-	-
	Domestic&Industry	I-1	-	2.1	-	-	-	8.5	-	-	-	-
		II-1	-	**1.4**	-	-	-	8.5	-	-	-	-
		III-1	-	**1.4**	-	-	-	8.5	-	-	-	-
	Other Irrigations		-	22.1	-	-	-	53.6	-	3.6	1.8	0.9
Downstream Reaches	Main Rivers Area	I-1	-	50	-	-	-	444	-	-	20	39
		II-1	-	39	-	-	-	444	-	-	-	-
		III-1	-	39	-	-	-	444	-	-	-	-
	Nui Mot		-	-	-	-	-	-	-	-	-	-
	Other Tributaries		1.3	7.6	4.2	6.0	2.3	15	-	5.8	5.1	6.5

	Alt.	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Whole Basin	I-1	196	-	110	13	115	290	-	160	-	-	88	-	-	-
	II-1	119	-	76	-	40	209	-	88	-	-	20	-	-	-
	III-1	40	-	76	-	-	209	-	88	-	-	20	-	-	-
Up-irrigation	I-1	62	-	20	3.2	23.9	103	-	14	-	-	4.3	-	-	-
(Main)	II-1	51	-	11	-	6.8	80	-	6.9	-	-	-	-	-	-
	III-1	13	-	11	-	-	80	-	6.8	-	-	-	-	-	-
Up- D & I	I-1	5.0	-	1.9	0.8	2.8	5.9	-	1.5	-	-	0.3	-	-	-
	II-1	**3.3**	-	**0.6**	-	**1.3**	5.9	-	**1.1**	-	-	-	-	-	-
	III-1	**1.5**	-	**0.6**	-	-	5.9	-	**1.1**	-	-	-	-	-	-
Up-Other Irr		8.9	-	3.8	5.9	6.8	15	-	8.2	-	-	10	-	-	-
Down-Main	I-1	129	-	88	9.0	88	181	-	145	-	-	83	-	-	-
	II-1	65	-	64	-	32	123	-	80	-	-	20	-	-	-
	III-1	26	-	64	-	-	123	-	80	-	-	20	-	-	-
Nui Mot		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Down-Others		6.3	-	3.9	4.6	6.9	8.8	5.3	5.8	3.3	3.7	8.7	-	-	5.9

According to the result shown above, every alternative does not satisfy the evaluation criteria mentioned in preceding Section 6.3. Therefore, water shortage, which is not too severe, is examined if such condition could be improved by operation of the Dinh Binh Dam and the Nui Mot Dam.

In case of very severe drought such as those in 1983 case, which drought conditions are expressed in the shadowed column of the above table, such deficit can not be covered by the water storage of the Nui Mot Dam that storage capacity is 108 million m^3. In Alternative I-1 case, it is estimated to be 6 times(years) that severe drought condition will occur. Such severe condition could not be improved by such a way to in order to satisfy the predetermined criteria that water shortage for the irrigation demand should be 5 years or less out of the examined 24 years.

Possibility of Alternative II-1 if the situation would be improved to the satisfactory level is examined as follows:

i) Water shortage of the domestic and industrial demands is to be improved(figures of thick character), except in 1983 and 1993, by shifting deficits to the irrigation and fishery demands,

ii) Water shortage of the irrigation demands in upstream reaches for 1990, 1992 and 1998 (figures in double line column) is to be improved by appropriate operation of the Din Binh Dam.

iii) Water shortage of the irrigation demands in downstream reaches for 1990, 1992 and 1998(figures in double line column) is to be improved by the appropriate integrated operation of the Dinh Binh and Nui Mot Dams.

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

Consequently, 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&3 as well as Alternative III-1&3 will meet the requirement and conditions, while Alternatives I-1&3 will not have a sufficient storage capacity.

6.6.2 Ha Thanh River

(1) Water Balance on Original Development Plan

In the Ha Thanh River basin, the water demand projected in 2020 will be much increased comparing to the present one mainly due to the development of irrigation system as well as new development of industry zone which will take water from the Ha Thanh River.

The Suoi Chiep reservoir, which was previously planned to be an exclusive reservoir with an irrigation scheme, is currently proposed as a reservoir for water supply with regulating capacity.

Due to remarkable increase of water demands including irrigation, industry and fishery as well as river maintenance flow incorporated in the analysis, water deficit is estimated to occur almost every other year according to the analysis, as follows:

Water Deficit Rate Against Annual Total Demand (unit %)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Main Riv.	Ha Thanh Irrig.	-	12.4	-	9.8	-	38.8	6.7	-	-	6.7	4.5
	Coastal Shrimp	-	8.9	-	1.5	-	24.6	5.2	-	-	2.1	2.0
Tributaries	Suoi Chinh Irrig.	-	-	-	-	-	14.5	-	-	-	-	-
	Cay Da Irrig.	25.3	73.0	43.2	53.0	27.8	85.6	52.9	35.5	34.2	45.8	45.7
River mouth with River Maintenance Flow		-	8.9	-	8.6	2.3	20.9	4.5	-	-	6.7	3.8

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Def. yrs.
Ha Thanh Ir.	-	-	-	5.9	22.3	-	7.1	-	-	7.7	-	-	2.8	9 years
Coastal Shrimp	-	-	-	1.8	17.5	-	11.7	-	-	4.6	-	-	2.2	5 years
Suoi Chinh Ir	-	-	-	-	9.4	-	-	-	-	4.3	-	-	-	2 years
Cay Da	19.9	48.6	33.0	47.0	67.8	25.9	63.2	46.7	22.3	73.4	10.2	10.3	36.3	Every yr.
River mouth w/RMF	-	-	-	6.5	11.4	-	8.4	-	-	7.5	-	-	-	11 years

Ha Thanh domestic and industry water demands as well as irrigation demand on the tributaries including Da Mai, Long My and Phu Tai have no water deficit throughout examined 24 years.

(2) Water Balance on Alternative Plan

Improvement measure of severe drought condition foreseen in 2020 in order to meet the prescribed condition, an alternative plan as mentioned in (1) above was studied that the irrigation development area in 2020 is decreased as follows:

	Original Plan (ha)	Alternative Plan (ha)
Ha Thanh Irrigation	1,480	718
Da Mai Irrigation	700	0
Long My Irrigation	330	110

Examined water balance condition under the alternative plan decreasing development area is remarkably improved as follows even though the condition of tributaries has no change:

Water Deficit Rate Against Annual Total Demand (unit %)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Main Riv.	Ha Thanh Irrig.	-	1.0	-	-	-	19.9	-	-	-	-	-
	Ha Thanh D/I	-	-	-	-	-	-	-	-	-	-	-
	Coastal Shrimp	-	2.6	-	-	-	18.5	-	-	-	-	-
River mouth with River Maintenance Flow		-	4.0	-	2.0	-	17.7	-	-	-	-	-

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Def. yrs.
Ha Thanh Ir.	-	-	-	-	8.8	-	-	-	-	-	-	-	-	2 years
Ha Thanh D/I	-	-	-	-	-	-	-	-	-	-	-	-	-	No deficit
Coastal Shrimp	-	-	-	-	10.1	-	1.0	-	-	-	-	-	-	2 years
River mouth w/RMF	-	-	-	-	7.1	-	2.6	-	-	-	-	-	-	45 years

The alternative development plan satisfies the required condition of the development plan in 2020 of the Ha Thanh River basin.

CHAPTER 7 INTEGRATED RIVER BASIN MANAGEMENT

7.1 Basic Strategy for Integrated River Basin Management

7.1.1 Basic Strategy for Water Utilization

The goal of the integrated water resources development and management plan is to meet achievement of the macro-economic targets of the basin towards the year of 2020.

Therefore, formulation of the integrated water resources development and management plan to meet the water demand increase in accordance with the targeted economic growth of the basin is set as the basic strategy of water utilization plan.

The targeted economic growth of the basin is discussed and presented in the socio-economic framework plan of the foregoing Chapter 3.

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 Chapter 5.

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.

In order to improve the water management level, not only improvement of the facilities but also improvement of the operation skill should be achieved. Necessary projects so as to realize the improved water management skill of the year 2020 are considered as follows:

(a) Formulation of agricultural water use policy within the framework of water resources policy including all the other water-related sectors such as domestic water, industrial water, hydropower generation water, river maintenance flow

As FAO Irrigation and Drainage Paper No.52 "Performing Water Resources Policy - A guide to methods, processes and practices" presents the practical approach to the goal, it would be referred to as a guide in the course of the on-going water resources policy formulation in Vietnam.

(b) Capacity building and training, which are on-going in Vietnam, for
(i) central, provincial and district governments' water-related officials,
(ii) irrigation management companies' (IMCs') staff,

(iii) cooperatives' water management staff and

(iv) water users (farmers)

FAO Irrigation and Drainage Paper No.40 "Organization, Operation and Maintenance of Irrigation Schemes" would be used as a training material. No.40 presents also an important suggestion about the personnel training.

(c) Transfer of irrigation management services, which is on-going in Vietnam, from IMCs to cooperatives for efficient and effective operation and maintenance of irrigation schemes

FAO Irrigation and Drainage Paper No.58 "Transfer of irrigation management services - Guidelines" presents useful suggestions on all the steps from the mobilization to the implementation of the irrigation management transfer (IMT).

As projects related to the above are already on-going by the Provincial Government, the necessary measures to be taken from now on would be ones to improve the present methods so as to achieve the goal more efficiently and effectively in consideration of the Vietnam's or regional characteristics on the basis of the international standards mentioned above. To estimate the required period, staffing, and budget for the capacity building and training projects, the data of the on-going projects would be referred to. For example, according to the interview to the team leader of the AusAID Project made at the beginning of the Phase 1, the following were confirmed:

- Period : 32 months from October 2001
- Staffing : 3 foreign consultants with 124 M/M of local consultants

7.1.2 Basic Strategy of Flood Control

(1) Objective area

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

(2) Criteria

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

These criteria are decided in due consideration of the present agricultural activities in the said river delta. The river delta has been suffering from serious flood damage every year. Accordingly, no agricultural activities in the low-lying delta in the main flood season are presently conducted. But in early flood season, the spring-summer crops are nearly to be harvested. If these crops are inundated, the flood damage is too serious. Accordingly expectation of flood damage alleviation in early flood season is very high in the delta. On the other hand, after the main flood season is over, the farmers start planting in consideration that the flood would not come any more. But sometimes the late flood also attacks the delta. The flood damage in this season is not so serious compared with the early flood season. But re-planting due to late floods causes the change of annual cropping pattern in the delta resulting in the decrease of agricultural products. Accordingly the flood damage alleviation in late flood season is also important. In consideration of these, the said flood control criteria are proposed by the Government of Binh Dinh Province.

(3) 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.

(4) Flood discharge distribution

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

7.2 Agricultural Development Plan

7.2.1 National and Provincial Agriculture Development Policy

(1) Direction of Agricultural Development in South Central Coast Region

According to the agricultural development policy and strategy of the government, the direction given to the South Central Coast Region is i) Intensification of food production, ii) Increase and stabilization of annual industrial crop production, iii) Expansion of perennial industrial trees and fruits trees, iv) Promotion of livestock production, and v) Intensification of shrimp aquaculture for export.

(2) Socio-Economic Development Plan of Binh Dinh Province

In the socio-economic development plan in Binh Dinh Province 2001 – 2010, the development direction of agriculture sector is summarized as follow:

Development Direction of Agriculture Sector

Sub-Sector	Direction
Food Crops	Paddy: Low-productive paddy area to be shifted to shrimp aquaculture and other crops. Irrigation area to be expanded introduce new varieties and advanced cultivation technology. Maize: Expansion of production through increase of unit yield. Cassava: planted area to be stabilized and increase of unit yield
Industrial Crops	Expansion of planted area and increase of unit yield.
Livestock	Increase of cattle, pig and poultry by introducing farm models.
Fishery	Expansion of shrimp culture, development of cage culture, promotion of sustainable development according to environment and potential,

In addition, high priority in the industrial sector is given to processing industry for agriculture, forestry and fishery products.

(3) Agriculture and Rural Development Plan of Binh Dinh Province

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.

High priority is given to the water resource development to supply irrigation water for annual crops to facilitate diversification of crops along with improved farming technologies.

7.2.2 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.

Irrigation Condition in the Project Area

	Dinh Binh Reservoir			Other Water Sources	Total
	Van Phong	Other Schemes	Subtotal		
Irrigation Area	3,300 ha	12,400 ha	15,700 ha	8,700 ha	24,400 ha
Rainfed	13,800 ha	7,900 ha	21,700 ha	8,400 ha	30,100 ha
Total Land	17,100 ha	20,300 ha	37,400 ha	17,100 ha	54,500 ha

Note: Van Phong includes Van Phone proper area (10,800 ha), Extension in La Tinh (3,300 ha), and the command area of Hoi Son Reservoir (3,000 ha).

Other schemes includes such command area of Binh Dinh Reservoir as Tan An – Dap Da (14,500 ha), Tan An Extension in the lower reach of the Ha Thanh River (2,000 ha), and Vinh Thanh area etc. (3,700 ha).

Other water sources are command area of tributaries and other rivers like, upstream of the Ha Thanh River, command areas of Nui Mot, Thuan Ninh, etc.

Source: Estimation by the JICA Study Team based on the DARD information.

(2) Present Cropped Area in the Project Area

The flood condition is one of the serious constraints for crop cultivation. Therefore, the project area is classified into three categories according to the land position suffering from the floods, namely higher, middle and lower position, as below:

Land Position and Flood Condition in the Project Area

Position	Higher	Middle	Lower	Total
Area	37,700 ha	13,500 ha	3,300 ha	54,500 ha
Irrigated	11,800 ha	10,000 ha	2,600 ha	24,400 ha
Rainfed	25,900 ha	3,500 ha	700 ha	30,100 ha
Minor Flood	Not severe	Partially affected	Severely affected	-
Early Flood	Not severe	Partially affected	Severely affected	-
Major Flood	Not Severe	Severely affected	Severely affected	-
Late Flood	Not severe	Partially affected	Severely affected	-

Taking into account (i) the above flood condition, (ii) the agro-climatic condition, (iii) the statistical data at districts/ communes levels, and (iv) the previous studies, the present cropping patterns for each land position above are estimated, and summarized below:

Flood Condition and Cropping Pattern in the Project Area

Position	Higher	Middle	Lower	Total
Cropping Pattern presented in Figure 7.1	A	B	C	-
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 shown in Table 7.1 and 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.

In the project area, the present cropped area is estimated at about 95,700 ha in total. This corresponds to the average cropping intensity of 176%, consisting of 211% in 24,400 ha of the irrigation area and 133% in 30,100 ha of the rainfed and other land. The low cropping intensity in the rainfed area is mainly due to short supply of irrigation water, and irrigation and drainage improvement will improve crop production through expansion of cropped area and unit yield.

(3) Basic Concept for Agricultural Development

The agriculture development plan is formulated based on the irrigation and drainage development, taking into account the agricultural development policies at national and provincial levels, socio-economic scenario in 2020 assumed in this study. 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.

The above conditions will enable to expand the cropped area and increase cropping intensity along with technical improvement of farming practices like introduction of improved varieties, efficient farming practices and proper input dosage.

Regarding the crops, the following conditions are taken into account:

Crops	Conditions to be taken into account
- Paddy	- Main crops in order to secure stable farmers' income. - The present proportion of paddy cropped area is more than 80% against the total cropped area. The future proportion will not exceed the present level.
- Maize	- Main subsidiary crops for feed requirement and supply to feed processing industries to be established according to the province development plan.
- Sweet Potatoes, Cassava and Sesame	- These crops will not be cropped under irrigation condition, since these crops are rainfed crops in their nature.
- Groundnuts and Soybeans	- Main annual subsidiary crops, and crop rotation with other crops.
- Tobacco	- Cropped area is limited to small area due to the marketing situation.
- Sugarcane	- Cropped area within 70% of the future capacity of milling factory.

Although such other crops as vegetables and fruits trees are expected to be highly profitable in the future, the demand and marketing arrangement needs to be developed for stable production. Under the present condition, severe competition and high risks are expected for these crops. Therefore, these crops are excluded from the project.

At the present condition, the crops are conservatively selected in order to assure the project effect. Since paddy is the largest planted crop with the highest irrigation water requirement, if promising crops are found in future, paddy can be substituted with these crops in terms of water resource availability.

(4) Proposed Cropped Area under the Project

Based on the conditions mentioned above, the future cropping pattern and cropped area is formulated as shown Figure 7.1 and Table 7.2 and summarized 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	4,100 ha	600 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%

Incremental cropped area by the project is shown below:

Increment of Cropped Area

	Present	Project	Increment	Increase Rate
Irrigation Area	24,400 ha	54,500 ha	30,100 ha	123%
Non-Irrigation Area	30,100 ha	0 ha	-30,100 ha	-100%
Total	54,500 ha	54,500 ha	0 ha	0%
Paddy	65,000 ha	90,000 ha	+25,000 ha	+38%
Maize	10,900 ha	18,200 ha	+7,300 ha	+67%
Groundnuts/ Soybeans	7,300 ha	9,900 ha	+2,600 ha	+36%
Tobacco	400 ha	700 ha	+300 ha	+75%
Sugarcane	5,700 ha	5,600 ha	-100 ha	-2%
Pineapple	0 ha	300 ha	+300 ha	+100%
Cassava	6,300 ha	0 ha	-6,300 ha	-100%
Total Cropped Area	95,700 ha	124,700 ha	29,000 ha	+30%
Cropping Intensity	176%	229%	+53%	+30%

As shown in the above table, 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

7.3 Domestic and Industrial Water Supply Development Plan

7.3.1 Urban Domestic Water Supply Plan

(1) Water Supply Requirement

The domestic and industrial water demand in the basin was examined, and in due consideration of the existing water supply capacity, the water supply requirement for formulating the water supply plan was estimated in Tables 7.3 and 7.4.

The water supply requirement for the domestic and industrial water supply plan is summarized below:

Water Supply Requirement for Domestic and Industrial Water Supply Plan

(Unit: m^3/day)

Items		2010	2020
(1)	Domestic Water Requirement:		
1-a)	Urban Domestic Requirement	30,985	72,459
1-b)	Rural Domestic Requirement	18,622	35,815
	Sub – total	49,607	108,274
(2)	Industrial Water Requirement:		
2-a)	Industrial Zones Requirement	54,250	108,500
2-b)	Rural Industrial Requirement	33,225	146,067
2-c)	Proposed Paper Mill in An Nhon District	50,000	100,000
	Sub - total	137,475	354,567
Total		**181,157**	**448,167**

As seen above, the urban domestic water requirement for water supply plan in 2020 is assessed at 72,459 m^3/day. Requirement for each urban center is shown in Figure 7.2.

A schematic presentation of water requirement for rural domestic and industrial water supply plan is given in Figure 7.3.

(2) Proposed Urban Domestic Water Supply Plan

The urban domestic water supply plan was formulated in consideration of the urban domestic water supply requirement.

The plan considers the urban domestic water supply requirement of 72,459 m^3/day in the year of 2020 for the six (6) major urban centers lying within the river basin, in addition to the new urban area (Nhon Hoi) of Quy Nhon City and Phu My Town in Phu My district.

As a primary network, the plan will require duplication (with an increase in pipe diameter) of the proposed D 600 pipeline from the Tan An groundwater well field to Quy Nhon city, currently being constructed under the ADB contract package CW1B. It will include a D800 transmission pipeline and a D300 branch line to Tuy Phuoc Town and associated booster stations to deliver water from the Tan An tributary on the Kone river, adjacent to National Highway 1 crossing, to Quy Nhon City.

In addition, a D300 transmission pipeline from Dap Da to Ngo May with booster station will be required. Raw water intakes would be located at Phu Phong, Dap Da (Dap Da tributary), Binh Dinh (Tan An tributary) and Phu My towns. It is suggested the intakes be of a floating type with self – adjusting moorings and flexible pipes connecting them to the river bank, as these are generally trouble-free and considerably cheaper than fixed, permanent structures. Some form of pre-treatment (filtration/screening/pre-settlement/pre-chlorination), depending upon the level of suspended solids in the river water and actual water quality, may be required. If necessary this could take place on the river bank adjacent to these intakes.

Elevated storage reservoir would be provided in each of the seven urban centers and tertiary networks with pipe diameters ranging in size from D50 to D100 including metered house connections will be installed to full service coverage to each of the towns.

For Quy Nhon City the existing water reticulation pipe network will be improved to provide full service coverage to all existing areas. Secondary distribution mains and tertiary networks, including metered connections would also be provided for all new development areas, particularly the new urban area of Nhon Hoi located Northeast of the City, which recently obtained Government approval.

A layout design of the urban domestic water supply facilities is prepared and indicated in schematic form in Figure 7.4. The quantity of each facility is measured as follows:

Major Facilities for Urban Domestic Water supply plan

Facilities	Quantity
• Raw water Intakes and Pre – treatment Units	4 Nos.
• Booster Pumping stations and Ancillaries	4 Nos.
• Elevated storage Reservoir (1,000m^3)	7 Nos.
• Primary Transmission Mains (D300- D800)	25 km
• Tertiary Network (D50- D100)	90 km
• Metered House Connections	50,000 Nos.

For the above facilities, the construction cost is estimated at US$25.179 million as follows:

Construction Cost for Implementation of Urban Domestic Water Supply Plan

Facilities	Construction Cost (Million US$)
• Raw Water Intakes and Pre – treatment Units	1.940
• Booster Pumping stations and Ancillaries	7.287
• Elevated Storage Reservoirs	0.602
• Pipelines (Primary, secondary and Tertiary Mains)	8.867
• Metered House Connections	6.483
Total	25.179

Note: It should be noted this estimate does not take into account maintenance costs, rehabilitation works or replacement of old equipment at existing facilities.

7.3.2 Rural Domestic, Rural Industrial and Industrial Zones Water Supply Plan

(1) Water Source

Groundwater in the basin has been exploited such as the existing Ha Thanh well field and the proposed Tan An well field with a combined abstraction rate of 45,000 m^3/day. However, any further exploitation of groundwater resources on any larger scale, than what is already taking place, would appear to be extremely limited. Careful consideration should be given to any further exploitation of groundwater in the downstream reaches of the basin to avoid upsetting the delicate balance between underground fresh water and salt water and to minimize the extent of salt water intrusion.

Groundwater has been used also in rural areas. Some further utilization of groundwater will be made where groundwater is available. However, its potential is very limited for further exploitation, and therefore, the piped – system utilizing the surface water from the rivers and canal systems are basically considered for the future rural domestic, rural industrial and industrial zones water supply, similar to the urban domestic water supply plan as discussed in the preceding Section 9.1.

(2) Water Supply 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.

7.4 Flood Control Plan

7.4.1 Causes of Flood Disaster

Basic cause of the flood disaster in the Kone River delta is that the annual maximum peak flood discharge at Binh Thanh (apex of the Kone River delta) is much more than the present discharge carrying capacities of the branch rivers of the Kone River in the delta such as the Dap Da, the Nam Yang, the Go Cham, the Tan An, and the Cay My Rivers. According to the hydrological study in the present study, the probable flood peak discharge of major flood at Binh Thanh hydrological station is analyzed as follows:

Return Period (year)	1.01	2	3	4	5	10	20
Flood Peak Discharge (m^3/s)	800	2,970	3,600	4,000	4,350	5,170	5,900

The probable flood peak discharges for the return period less than 5 years are estimated by the extrapolation of the analyzed values.

On the other hand, the discharge carrying capacities of the said branch rivers are around 800 m^3/s in total in the upstream reaches, while less than 600 m^3/s in total in the downstream reaches. Accordingly the Kone River delta is inundated every year in the rainy season especially in its downstream area.

The causes of heavy rainfall in the basin are partly typhoons combined with reinforced cold fronts and partly tropical low pressures combined with reinforced cold fronts. Table 7.5 shows the causes of past major floods in 1977 to 2001.

7.4.2 Alternative Flood Control Plans

The conceivable structural measures of flood control plan in the Kone River basin are construction of reservoir(s) with flood control function in the upstream reaches, flood control retarding basin in the middle reaches, and the river improvement in the downstream reaches.

It was preliminarily studied that a proposed retarding basin near Tay Son Town with the river improvement of the downstream reaches was found not feasible due to its small effectiveness.

Therefore, some combinations of design discharge distribution among Dinh Binh reservoir and the branch rivers of the Dap Da, the Nam Yang, the Go Cham, the Tan An and the Cay My Rivers are studied as flood control alternatives. The locations of these measures are shown in Figure 7.5.

7.4.3 Examination on Alternative Flood Control Plans

(1) Basic Flood Control Concept

The basic criteria of flood control plan in the Study are predetermined as follows:

(a) Objective Flood

i) Objective flood : Late flood

ii) Return period : 20 years (the occurrence probability is 5%)

iii) Flood peak discharge : - 1,960 m^3/s at Dinh Binh

- 2,997 m^3/s at Binh Thanh

iv) Flood discharge hydrograph: as shown in Figure 7.6.

These are determined in comparison between 5% probable late flood and 1 % probable early flood.

(b) The Dinh Binh reservoir needs to fully reduce the above flood peak discharge at Dinh Binh Dam. The river improvement including dyke system in the downstream reaches aims at confinement of the remaining.

However, overflow from the side overflow weir is to be constructed and inundation on the delta will be allowed for floods of which the magnitude is over 5 % probable late flood.

(c) The designed dyke system should be sound for the excess flood up to 10 % probable major flood in structural aspect.

(d) The most effective flood control plan to mitigate the flood damage to be caused by the major flood should be identified among the combination of reservoir development and the proposed river improvement including the dyke system to 5 % probable late flood in terms of technical and economic aspects.

(2) Methodology

Promising flood control alternatives are examined in the following manner:

(a) It is viable that the design flood peak discharge of 5 % probable late flood at the Dinh Binh dam site is to be controlled fully by the Dinh Binh reservoir in view that required flood control volume is within the minimum reservoir capacity of presently proposed reservoir development scale.

Thus, the design discharge distribution to the downstream river channel is 1,743 m^3/s at Binh Thanh.

(b) This design discharge distribution to the downstream rivers are further distributed to the said 5 rivers, namely the Dap Da, the Nam Yang, the Go Cham, the Tan An, and the Cay My Rivers. In consideration of the present discharge carrying capacities of these rivers, two(2) alternatives of the design discharge distribution among these rivers are studied as follows:

(Alt-I) the design discharge will be distributed to the said 5 rivers in proportion to the present discharge carrying capacity of each river.

(Alt-II) the design discharges of the Nam Yang and the Cay My Rivers will be the present discharge carrying capacities and the remaining design discharge will be distributed to the remaining major branches, namely the Dap Da, the Go Cham and the Tan An Rivers, in proportion to the present discharge carrying capacities of the said rivers.

(c) River improvement plan is studied with two alternatives including:

(Alt-A) river improvement with the present alignment of the river dyke, and

(Alt-B) widening of the river channel.

(3) Alternative Study

(a) Alternative Study on Design Discharge Distribution

Unit : m^3/s

River Name	Design Discharge Distribution	
	Alternative I - Proportional distribution to the five rivers -	**Alternative II** - Distribution mainly to the main three rivers -
Dap Da River	601	627
Nam Yang River	41	20
Go Cham River	200	209
Tan An River	801	837
Cay My River	100	50

Note: the joining rivers of the La Vi and the Nui Mot Rivers are taken into consideration.

The water levels of the Dap Da River for the above two discharge alternatives are studied. The result is that the difference of the water level between the alternatives is less than 13 cm in the whole reaches of the Dap Da River with the same river width.

On the other hand, the river improvement plan of the Cay My River is studied for the alternatives. The result is that the river width of the Cay My River should be widened in case of Alternative I by 10 – 20 m for the present river width of 30-40 m, or design high water level should be raised by about 1.2 m.

This is to show that the land requirement and house resettlement would be needed more in the case of Alternative I than in the case of Alternative II.

In consideration of the above results, the design discharge distribution is determined to be the Alternative II that the design discharge is distributed mainly to major (3) rivers in the Kone River delta.

(b) Alternatives Study on River Improvement Feature

The longitudinal profiles of the calculated water levels of the Dap Da, the Tan An and the Go Cham Rivers for the alternatives of the river improvement plans for the determined discharge distribution alternative (Alternative II) are shown in Figures 7.7, 7.8, and 7.9, respectively. As shown in the figures, the water levels of the said rivers become very high in certain reaches of the rivers in the case of the present alignment of the river dyke (Alt. A).

It is conceivable that too high dyke has more risk of breach even though the dyke height itself is enough for the design high water levels. Regarding the Nam Yang River and the Cay My River, the flood high water levels are not high, since the design discharge distribution is just as much as the present discharge carrying capacities.

In due consideration of river improvement feature, the Alt.A is basically selected. However, the widening of the river channel shall be included in some reaches.

7.4.4 Proposed Flood Control Plan

Through examination in various aspects in flood control facilities, socio-economic conditions, environmental situations and others, the flood control plan is proposed as follows:

(1) Basic design flood peak discharge at Binh Thanh is 2,997 m^3/s (5 % probable late flood).

(2) The design flood peak discharge of the objective late flood should be mitigated to 1,691 m^3/s at Binh Thanh by the flood control effect of the Dinh Binh reservoir.

(3) The flood control volume of Dinh Binh reservoir should be kept at least at 293 MCM during the late flood period to attain the peak discharge mitigation of the objective flood.

(4) Flood control capacity of the Dinh Binh reservoir should be determined to attain the most effective and sound flood control plan to mitigate the flood damage.

(5) Design discharge distribution to the Dap Da, the Nam Yang, the Go Cham, the Tan An, and the Cay My Rivers should be as shown in the Figure 7.10. The basic concept herein introduced is that the design discharge distribution will be distributed mainly to major branch rivers, namely the Dap Da, the Go Cham and the Tan An Rivers. The major branch rivers should accept the design flood discharge proportional to their present discharge carrying capacities, while the Nam Yang and the Cay My Rivers should accept the design discharge same with the present discharge carrying capacities.

(6) The river improvement should be undertaken involving widening of river channel.

7.4.5 Flood Control Plan of the Ha Thanh River

(1) General

The Ha Thanh River flows in the Binh Dinh Province independently from the Kone River. But the downstream delta is adjacent to the Kone River downstream delta and the Ha Thanh River flows very closely to the Qui Nhon City, the capital city of the Binh Dinh Province. Flood control plan of the Ha Thanh River is studied herein consideration that the flood control plan of the Kone River is prepared mainly to protect the downstream delta of the Kone River which the Ha Thanh River shares partly in its downstream delta.

(2) Ha Thanh River

The Ha Thanh River originates on the northern slope of Mount Ba located in the southern part of the Binh Dinh Province, flows down to the north, turn to the east at the latitude of about 13 degrees 50 minutes north. The Ha Thanh River, after turning to the east, crosses the national road No.1 and branches to the Ha Thanh River -1 and the Ha Thanh River -2. The Ha Thanh River -1 flows rather to the northern direction and then branches to the Ha Thanh River -1 Left and the Ha Thanh River -1 Right, just about 2 km upstream of the Thi Nai Swamp. The both rivers then discharge to the Thi Nai Swamp. The Ha Thanh River -2 flows down to the east and discharges to the Thi Nai Swamp very close to the Quy Nhon City. The present discharge carrying capacities of the Ha Thanh River -1 and the Ha Thanh River -2 are estimated at about 100 – 200 m3/s and 100-300 m3/s respectively.

The catchment area of the Ha Thanh River is 590 km2. The location map of the Ha Thanh River is shown in Figure 7.11.

(3) Objective Area of Flood Control

The objective area of flood control of the Ha Thanh River is defined as the river delta downstream of the national road No.1.

(4) Design Discharge

The design discharge of the Ha Thanh River is determined based on the flood control criteria applied to the Kone River that the design discharge should be determined in consideration of 5% late flood or 1% early flood. Herein 5% late flood is estimated at 1,435 m3/s and 1% early flood is 728 m3/s. Accordingly the design discharge of the Ha Thanh River is determined to be 1,440 m3/s.

(5) Structural Flood Control Measures

Due to the characteristics of the river basin topography, flood control measures by reservoir are not adopted. Accordingly the flood control measures of the Ha Thanh River are limited only to river improvement as structural measures. In the Study, the river improvement is proposed to include excavation of river channel and construction of river dyke. The basic concept adopted in the Study is to keep the present river dyke alignment as much as possible.

(6) Design Discharge Distribution

The design discharge distribution between the Ha Thanh River -1 and the Ha Thanh River -2 is proposed to be the same, namely 720 m3/s for each river.

(7) Side Overflow Weir

In the same manner with the Kone River flood control plan, the side overflow weir is planned so that the proposed dyke against 5% late flood is safe against 10% major flood. The estimated 10% major flood is 2,796 m3/s. Design discharge distribution with side overflow weir is shown in Figure 7.12.

(8) Design Features of the River Improvement

The design longitudinal profiles and the typical design cross sections of the Ha Thanh River -1and Ha Thanh River -2 are shown in Figure 7.13 and Figure 7.14 respectively.

7.5 Drainage Plan

7.5.1 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 storm-water is drained to natural streams that are flowing in the city area. Those streams are partly improved with the concrete flume, etc. especially in areas where buildings and houses are crowded. Therefore, the partial inundations are caused in some hours at depressions scattered in the areas. The similar projects with it in Quy Nhon City would be implemented in those towns, too, soon in future.

7.5.2 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

Heavy inundation of the agricultural area causes the inundation of many roads passing through the area. Those roads should be designed taking into account the drainage plan of the 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. These streams would be separated from irrigation purpose and connected to the main rivers with enough capacity in other words the combination of cross-section and longitudinal gradient.

For this purpose, the excavation work of the existing streams and partial new drains to be connected to the existing ones would be implemented.

(iii) Drainage plan for paddy field

Downstream ends of such drains would connect to the drainage sluices to be constructed at the flood dike improvement or new construction. During the high water hours of the main rivers, the sluices should be closed to prevent the flood inflow to the agricultural area.

Therefore, 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)”.

Especially for the delta areas such as the Tan An – Dap Da and the downstream part of the Ha Thanh, the farm drainage would be considered for the period except the major flood time in relation to the flood protection plan. Therefore, the farm drainage design period for the delta areas has been determined to be 9.5 month from the middle of December to the end of September.

(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.

CHAPTER 8 INTEGRATED RIVER BASIN MANAGEMENT PLAN FOR THE KONE RIVER BASIN

8.1 Study on Alternative Basin Development Plans

8.1.1 Precondition of the Study on Alternative Basin Development Plans

The study on alternative basin development plans is conducted based on the following precondition:

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.

8.1.2 Water Supply Requirement

(1) General

The basin development plan aims at meeting the water supply requirement towards 2020, and thus, should consider to meet the water supply requirement.

The water supply requirement consists of the domestic and industrial water supply requirement, agricultural and fishery water supply requirement, and necessary river maintenance flow.

These water supply requirements have been examined in the foregoing chapters, and is summarized hereunder.

(2) Domestic and Industrial Water Supply

The water supply requirement for domestic and industrial water was examined in the foregoing Section 7.3. Those are summarized below:

Water Supply Requirement for Domestic and Industrial Water

Unit: m^3/day

Items	2010	2020
(1) Domestic Water Supply Requirement	49,607	108,274
(2) Industrial Water Supply Requirement	137,475	354,567
Total	181,157	448,167

As seen above, the domestic and industrial water supply requirement in 2020 which should be taken into account in the development plan is estimated at 448,167 m^3/day.

(3) Agricultural Water Supply

Agricultural water supply is composed of the irrigation water supply, aquaculture water supply and water supply for livestock.

The above agricultural water supply requirement is presented below.

(a) Irrigation Water Supply

The irrigation water supply which occupied major part of the water supply requirement was examined in the foregoing Sub-section 5.1.2. The basin development plan considers to meet the incremental water demand towards 2020, and the irrigation water supply requirement to be taken into account in the basin development plan is summarized below.

Irrigation Water Supply Requirement

Unit: m^3/day

Items	2001	2010	2020
I. Including La Tinh River Basin			
I-1) Irrigation Water Requirement (Average Rainfall Year)	1,913,414	1,926,080 (12,666)	3,203,260 (1,277,180)
I-2) Irrigation Water Requirement Year with less than 1/4 probability of examined long period	1,975,730	1,989,437 (13,707)	3,328,986 (1,339,549)
II. Excluding La Tinh River Basin			
II-1) Irrigation Water Requirement (Average Rainfall Year)	1,656,981	1,730,449 (73,468)	2,829,932 (1,099,483)
II-2) Irrigation Water Requirement Year with less than 1/4 probability of examined long period	1,715,020	1,791,313 (76,293)	2,937,557 (1,146,244)

Note: Figures in bracket indicate the incremental requirement which should be taken into account in the irrigation water supply plan.

(b) Aquaculture Water Supply

The aquaculture water supply requirement which was examined in Sub-section 5.1.4 and should be taken into account in the basin development plan is summarized below:

Water Supply Requirement for Aquaculture

(Unit: m^3/day)

Items	2001	2010	2020
Fresh surface water supply for coastal shrimp culture	0	31,507	31,507

(c) Water Supply for Livestock

The water supply requirement for livestock was examined in Sub-section 5.1.3. The water supply requirement for livestock to be taken into account in the basin development plan is as follows:

Water Supply Requirement for Livestock

Unit: m^3/day

Items	2001	2010	2020
Fresh surface water supply for livestock in coastal area	5,753	8,767 (3,014)	11,507 (5,754)

Note: Figures in bracket indicate the incremental requirement which should be taken into account in the water supply plan.

(4) River Maintenance Flow

Necessary river maintenance flow was examined in Section 5.5 in which the necessary river maintenance flow is found to be 6.6m^3/s at Binh Thanh, 8.1m^3/s for Kone River basin and 1.3m^3/s for Ha Thanh River basin.

(5) Requirement of Freshwater Production in Non-dam Schemes

Alternative basin development plans for examination take into consideration a non-dam scheme.

Since the non-dam scheme without the reservoir has no capability to meet the water supply requirement, production of freshwater is forced to be considered.

Considering that further exploitation of groundwater should basically be avoided, a technically possible way to produce fresh water without dam construction is to provide facilities to produce freshwater from sea water. Necessary production of freshwater should consider all water supply requirements including the domestic and industrial water, agricultural water and river maintenance flow, etc. However, in view of a big quantity of water requirement for agricultural water or river maintenance flow, freshwater production from sea water is limited to production for the domestic and industrial water requirement, although other water supply requirement cannot be satisfied.

The domestic and industrial water supply requirement in 2020 is assessed to be 448,167 m^3/day as mentioned in Section 8.1, resulting in the annual production of 163.6 million m^3/year. Necessary cost for fresh water production ranges approximately from US$1.5/ m^3 to US$2.5/m^3.

Assuming US$2.0/$m^3$ for he cost of freshwater production, the annual cost of freshwater production for the domestic and industrial water supply will approximately be US$327 million/year.

8.1.3 Flood Control Requirement

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

a) Downstream reaches of the basin should be protected from the 5 % probable (or 20-year recurrence) late flood.

b) The agricultural lands in the downstream reaches of the basin should be protected from 1% probable (or 100-year recurrence) early flood.

The 5 % probable major flood and 1% probable early flood are examined in Section 4.2 and are summarized as follows:

5 % -probable Late Flood

Description	Place		
	Dinh Binh	Cay Muong	Binh Thanh
Flood Peak Discharge (m^3/s)	1,960	2,550	2,997
Flood Volume (Million m^3)	196	316	423

1% - probable Early Flood

Description	Place		
	Dinh Binh	Cay Muong	Binh Thanh
Flood Peak Discharge (m^3/s)	994	1,300	1,521

8.1.4 Alternative Basin Development Plans

(1) Conceivable Facilities for Structural Measure

(a) Multipurpose Dam

One of the facilities for effective structural measure is multipurpose dam(s).

There are several prospective sites for medium scale of dam in the tributaries including Suoi Xem, Song Cut, Dong Sim, Thuan Ninh, Nui Mot and Hoi Son, etc.

However, the dams were already constructed at Thuan Ninh, Nui Mot and Hoi Son, etc. The Dong Sim dam is planned to be implemented as an exclusive reservoir for a proposed irrigation scheme. The dam sites such as Suoi Xem and Song Cut have difficulty for dam construction due to social environmental problems.

Only the Dinh Binh Dam site in the main stream is a promising site for construction of relatively large scale of dam, and the Dinh Binh Dam is taken up as an effective facility to meet the requirement of the basin.

The Dinh Binh Dam would be able to cut all the flood volume of the objective flood that is the 5 % probable (or 20-year recurrence) late flood with a peak discharge of 1,960 m^3/s and flood volume of 196 million m^3 at Dinh Binh Dam site. However, the flood control target of the basin cannot be fulfilled by only the Dinh Binh Dam since flood discharge from the remaining catchment basin is not controlled yet.

Therefore, the flood control target should be considered to attain in combination with the river improvement/ dyking system in the downstream reaches that will protect the downstream area from the objective flood.

The reservoir capacity with a flood control volume of over 196 million m^3 is the least requirement to receive all the flood volume of the objective flood. This capacity should allow overflow of flood discharge and flood inundation damages in the downstream area when a flood with a magnitude over 5 % probable late flood hits the basin. In order to find the most advantageous development scale of the proposed reservoir that would be able to regulate flood volume in technical and economic view points, three (3) alternative flood control volumes by different dam height are taken up for examination.

Furthermore, the multipurpose dam should consider to achieve the water supply purpose. The reservoir water level to be limited for flood control during the rainy season affects the water supply function and therefore, two (2) water levels to be limited during the major flood season are taken into consideration for examination.

As a result, six (6) comparative cases of scale for the Dinh Binh Dam as shown in Table 8.1 are considered for examination as shown below:

Dam Alternative	Dam Crest Elevation (EL., m)	Flood Control Volume (Million m^3)	Effective Storage for Water Supply (Million m^3)
Dam Alt. I-1	95.30	221.2	209.9
Dam Alt. I-2	95.30	121.2	209.9
Dam Alt. II-1	100.30	292.8	279.5
Dam Alt. II-2	100.30	192.8	279.5
Dam Alt. III-1	105.30	375.5	360.2
Dam Alt. III-2	105.30	275.5	360.2

(b) Dyking system

As explained in the preceding Paragraph (a), the flood control target has to be attained in combination with the flood control facilities in the downstream reaches.

Conceivable facilities for flood control in the downstream reaches are the dyking system along the Dap Da, the Tan An and the Go Cham Rivers with partial channel widening of the same rivers.

The flood control facilities in the downstream reaches should have a capacity to control the flood discharge at Binh Thanh of the objective late flood from the remaining catchment since the flood discharge from the catchment of the Dinh Binh Dam is fully controlled by the Dinh Binh Reservoir.

Other than the river dyking system to protect the target area from flooding, improvement of sea dyke system including new spillway on the sea dike will contribute to the earlier discharging of inundated water to the sea.

(c) Other Parameters to Compose Alternative Plans

i) Water supply to the La Tinh River basin

The La Tinh River basin is located in immediate north of the Kone River basin. Although the La Tinh River basin is not within the Kone River basin, irrigation water shortage in the La Tinh River basin is expected to be covered with water to be transferred from the Kone River.

Therefore, both the cases with and without considering the water supply to the La Tinh River basin are taken up in the alternative basin plans for examination.

ii) Non-dam scheme

In order to know the resulting state of the plan without the multipurpose dam, a non-dam scheme is also taken up as an alternative plan for examination. In this non-dam scheme, fresh water production from sea water for water supply purpose and flood control with river improvement/dyking system are considered as the conceivable measures.

(2) Alternative Basin Development Plan to be Examined

In due consideration of subjects which should be examined to find out the optimum basin development plan as discussed in the preceding Sub-section 8.1.3, the alternative basin development plans of 26 cases in total as shown in Table 8.2 are examined and evaluated from the technical, environmental and economic aspects.

8.1.5 Examination on Alternative Basin Development Plans

Outline of the process of examination on alternative basin development plans is described for selecting the optimum basin development plan.

(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 8.2.

(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 8.1.

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 8.2

(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) Cost Estimate

The cost estimate including the construction cost, resettlement and other indirect cost was made for the following:

a) For each of alternative scales of the Dinh Binh Dam,
b) For the dyking system that scale is determined by protection level of 5 % probable late flood, and sea dyke system,
c) For agricultural water supply and drainage facilities, and
d) For domestic and industrial water supply facilities.

The details of the above cost estimate are given in Section 9.2.

(5) Water Balance Analysis

Under the alternative scales of the effective storage, the water balance analysis is conducted in due consideration of the water supply requirements examined earlier. Such water requirement contains the agricultural and fishery water supplies, domestic and industrial water supplies, and river maintenance flow requirement, etc. and the flood control volume necessary to be secured during the major and late flood seasons.

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.

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.

8.1.6 Selection of Basin Development Plan

(1) Result of Examination on Alternative Basin Development Plans

Table 8.2 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:

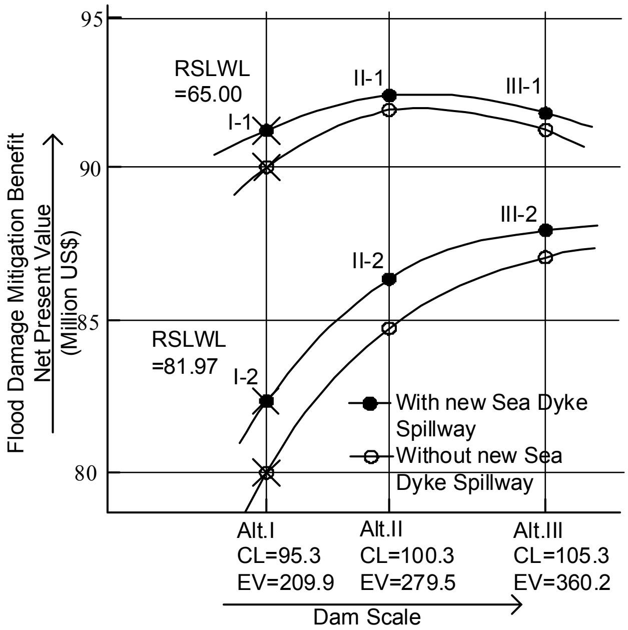
(a) Non- dam Plan

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

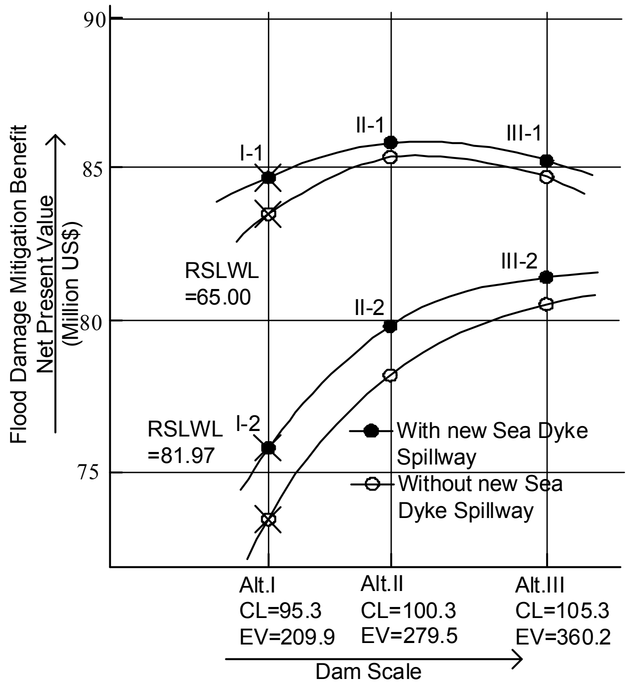
Alternative II-1 that the dam crest level is EL.100.3 m and flood control volume during major flood season is 293 million m^3 will maximize the economic viability in terms of flood damage mitigation effect for the downstream reaches of the Dinh Binh Dam both in upstream and downstream reaches of Binh 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.

(2) Examination of the Optimum Basin Development Plan

Among the promising alternative plans with higher economic viability, which satisfy water supply requirement, the following three alternatives are taken up for detailed comparative study. Both dam alternatives I-1 and I-2 do not satisfy water supply requirement.

Dam Alternatives	Alt. II-1	Alt. III-1	Alt. III-2
Dam Crest Level	EL.100.3 m	EL.105.3 m	EL.105.3 m
Flood Control Vol. for Major Flood Season	292.8 MCM	375.5 MCM	275.5 MCM
Flood Control Vol. for Late Flood Season	196.0 MCM	196.0 MCM	196.0 MCM
Effective Storage	279.5 MCM	360.2 MCM	360.2 MCM
Necessary Capacity of Downstream Dyking System	1,691 m^3/s	1,691 m^3/s	1,691 m^3/s

A detailed comparison for the above three (3) promising plans is made as follows:

	Alternative Plan	Flood Control Require-ment	Water Supply Require-ment	Environ-mental Evaluation	Economic Viability			Overall Evaluation
					EIRR(%)	B/C	NPV (M. US$)	
I. Incld.La Tinh								
A	No-New Sea Dyke Spillway							
	Dam II-1	Satisfied	Satisfied	Need appropriate consideration	15.0	1.51	91.9	(1)
	Dam III-1				14.8	1.50	91.3	(2)
	Dam III-2				14.6	1.48	87.1	(3)
B	New Sea Dyke Spillway							
	Dam II-1	Satisfied	Satisfied	Need appropriate consideration	15.1	1.52	92.4	(1)
	Dam III-1				14.9	1.50	91.7	(2)
	Dam III-2				14.7	1.48	88.0	(3)
II. Excld.La Tinh								
A	No-New Sea Dyke Spillway							
	Dam II-1	Satisfied	Satisfied	Need appropriate consideration	14.8	1.49	85.4	(1)
	Dam III-1				14.6	1.48	84.8	(2)
	Dam III-2				14.4	1.45	80.7	(3)
B	New Sea Dyke Spillway							
	Dam II-1	Satisfied	Satisfied	Need appropriate consideration	14.9	1.50	85.9	(1)
	Dam III-1				14.7	1.48	85.2	(2)
	Dam III-2				14.5	1.46	81.5	(3)

Remarks: B/C and NPV are worked out with discount rate at 10%.

The comparative study is evaluated below by each promising alternative:

(a) Dam Alt.II-1

Dam Alt.II-1 satisfies all requirements in any cases including or excluding the La Tinh River basin. Besides that, its economic viability will be highest in any cases as seen in the table above.

(b) Dam Alt.III-1

Dam Alt.III-1 also satisfies all requirements in any cases, similar to Dam Alt.II-1. However, its economic viability will be slightly less than those of Dam Alt.II-1 mainly due to the higher cost of higher dam compared with Dam Alt.II-1.

(c) Dam Alt.III-2

Dam Alt.III-2 also satisfies all requirements in any cases. However, its economic viability will be less than the other alternatives mainly due to the higher cost of higher dam and less benefit of less flood control volume compared with Dam Alt.II-1 and Dam Alt. III-1, respectively.

Based on the above comparative study, Dam Alt.II-1 is recommended to be selected.

i) Water Transfer to the La Tinh River basin

Among Dam Alt.II-1, the case to supply irrigation water to the La Tinh River basin will be of higher economic viability.

Thus, the water supply to the La Tinh River basin should be included.

ii) New Sea Dyke Spillway

Among the promising alternatives, inclusion of the new sea dyke spillway shows higher economic viability due to much effect to ease inundation situation by spill out of inundated water to the sea.

(iii) Selection of the Optimum Basin Development Plan

The optimum basin development plan which is finally selected and recommended through the examination as described herein and summarized as 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

8.2 Formulation of Integrated River Basin Management Plan

8.2.1 Water Resources Development Plan

(1) Dinh Binh Multi-purpose Dam

The Dinh Binh Multi-purpose Dam is one of the most important components composing the Integrated Basin Management Plan.

The dam will be of a concrete gravity type and be located at a narrow cross section of the Kone River main stream in Vinh Hao Commune, Vinh Thanh District.

Major dimensions of the dam which have been determined through a series of examinations are as follows:

Principal Feature of Dinh Binh Multi-purpose Dam/ Reservoir

a)	Dam Type	:	Concrete gravity dam with a gated spillway
b)	Dam Crest Level	:	EL. 100.3 m
c)	Dam Height	:	About 55 m
d)	Flood Control Volume of Reservoir	:	292.77 MCM
e)	Objective Flood for Flood Control	:	5 % probable (or 20-year recurrence) late flood with peak discharge of 1,960 m^3/s at dam site
f)	Effective Storage Volume of Reservoir	:	279.51 MCM
g)	Installed Capacity of Power Station	:	6,600 kW

The Dinh Binh Multi-purpose Dam will play a paramountly important role in the basin with the following functions:

Function of Dinh Binh Multi-purpose Dam/ Reservoir

(i) Flood control function together with the flood control facilities (the dyking system) in the downstream reaches to protect the basin from 5 % probable late flood and 1% probable early flood.

(ii) Water supply function with the effective storage volume of reservoir for the water requirement such as the agricultural water, domestic and industrial water and river maintenance flow, etc., solving the water shortage problem in the basin and contributing to socio-economic development of the basin.

(iii) Power generation of 37.84 GWh/year with the installed capacity of 6,600 KW.

Location of the Dinh Binh Multi-purpose Dam/ Reservoir is shown in Figure 8.3 together with other components of the Integrated Basin Management Plan.

(2) Van Phong Weir and Irrigation Water Supply Plan

The Van Phong Weir is one of the important components to supply water for the rain-fed area of 10,800 ha in net including some minor existing irrigation areas in left bank side of the Kone River and it of 3,300 ha in the both sides of the La Tinh River.

(a) Van Phong Weir

The proposed weir site by Hydraulic Engineering Consultants Corporation No.1 (HEC-1) in the Feasibility Study Report No.444C-05 is about 30 km downstream along the Kone River from the proposed Dinh Binh Multipurpose Dam site, which is located about 5 km upstream from Phu Phong Town in Tay Son District. The selected Site-I is near the Cay Muong Hydrological Monitoring Station and at foot of Nui Mot Hill.

The weir would be of a combination of the concrete overflow weir in almost part (470 m) and the earth non-overflow embankment in the remaining short parts (32 m) in the both sides, which total length is 502 m. Major dimensions of the weir, which have been determined through a series of examination, are as follows:

Major Dimensions of Van Phong Weir

a)	Weir Type	Concrete fixed weir with scouring sluice
b)	Weir Crest Level	EL. 25.00 m
c)	Weir Length	470 m
d)	River Bed Level	EL. 19.0 m at deepest
e)	Rock Foundation Level	EL. 7.0 m at deepest
f)	Weir Height	18.0 m at maximum
g)	Design Flood	7,380 m^3/sec (Probability P=1%)
h)	Flood Water Level	WL. 28.92 m
i)	Scouring Sluice	2 nos. x 2.75 m (B) x 2.75 m (H)

(b) Irrigation Water Supply Plan

With reference to "Complementary Report on General Explanation No.444B-06-T_1BS, Pre-Feasibility Study, Dinh Binh Control Project, Binh Dinh Province, Ministry of Agriculture and Rural Development, Construction Consultant Company No.1, September 1996" and the report of "General Explanation No.444C-05-TM, Feasibility Study, Water Resources Project Dinh Binh Reservoir, HEC1, HDECE, May 2000, it has been planned that the Van Phong Weir would supply irrigation water to the following 14,100 ha:

Commanding Areas by Van Phong Weir

a)	Van Phong Proper Area	10,800 ha
b)	Van Phong Extension Area (La Tinh)	3,300 ha
	Total	14,100 ha

On the other hand, the total proposed irrigation area would be 54,500 ha including 6,300 ha in the La Tinh. So, the areas of 40,400 ha other than it from the Van Phong Weir would be irrigated with use of water taken from the other water source facilities such as dams, weirs and pumping stations. Out of the area of 40,400 ha, the following 20,300 ha would be blessed with the water from the Dinh Binh Reservoir:

Commanding Areas of Other Systems under Dinh Binh Project

a)	Tan An - Dap Da	14,000 ha
b)	Lao Tam downstream new development	500 ha
c)	Vinh Thanh	1,000 ha
d)	Other systems along the Kone	2,700 ha
e)	Tan An Extension (Lower Ha Thanh)	2,100 ha
	Total	20,300 ha

So, the remaining 20,100 ha would be irrigated with the other water sources.

i) Systems of 2010

All the systems consisting of the existing schemes and the future projects to be functioned by 2010 have been arranged in accordance the classification of the Review and Supplementary Report, 2002, Binh Dinh Province. Two (2) major systems such as the Phu Tai and the Quang Hien would newly be added and the total number of the major schemes would become 51. All the major systems are listed in Table 8.3.

ii) Systems of 2020

All the systems under the Dinh Binh Reservoir Project are included in this group to become functioning by 2020, because the said project is planned to be completed in 2011. In addition to the two (2) schemes completed before 2010, 20 more major systems would newly be added and so the total number of the major schemes would become 71 in total. All the major systems are listed in Table 8.4. It is to be noted that the above are the number before integration that would be made for the systems in the Tan An - Dap Da Area, which is described in the succeeding Section 8.2.1. The number after the integration would become 56 in total.

iii) Thuan Phong irrigation scheme

Besides the above, the planned Thuan Phong irrigation scheme (700 ha) with a reservoir located in a tributary of the La Tinh River is specially considered as a new development project because of the serious water shortage in the area. It is noted in Table 8.6 and its location is shown in Figures 8.4 and 8.5.

(3) Domestic and Industrial Water Supply Plan

The domestic water supply requirement is composed of the urban domestic requirement and rural domestic requirement. The industrial water supply requirement is composed of the industrial zone requirement and rural industrial requirement.

Each of the above water supply requirements was examined and presented in the foregoing Section 7.3. Those are reproduced below:

Water Supply Requirement for Domestic and Industrial Water Supply Plan

(Unit: m^3/day)

Items		2010	2020
(1)	Domestic Water Requirement:		
1-a)	Urban Domestic Requirement	30,985	72,459
1-b)	Rural Domestic Requirement	18,622	35,815
	Sub – total	49,607	108,274
(2)	Industrial Water Requirement:		
2-a)	Industrial Zones Requirement	54,250	108,500
2-b)	Rural Industrial Requirement	33,225	146,067
2-c)	Proposed Paper Mill in An Nhon District	50,000	100,000
	Sub - total	137,475	354,567
Total		181,157	448,167

The urban domestic water supply considers the domestic water supply to the following eight (8) major urban centers in the basin:

a) Quy Nhon City
b) Ngo May Town
c) Phu Phong Town
d) Binh Dinh Town
e) Dap Da Town
f) Tuy Phuoc Town
g) Dieu Tri Town
h) Phu My Town

Exploitation of groundwater, including the existing supply capacity of 20,000 m^3/day and the committed capacity of 25,000 m^3/day, already reach 45,000 m^3/day. In view that the further exploitation of groundwater should be avoided, the urban domestic water supply is considered to be made with the surface water.

A layout design of the urban domestic water supply facilities was presented in Section 7.3 and was also indicated in Figure 7.4 and 8.3.

The following summarizes the major facilities for urban domestic water supply plan:

Major Facilities for Urban Domestic Water Supply Plan

Facilities	Quantity
- Raw Water Intake and Pre-treatment Units	4 Nos.
- Booster Pumping Station and Ancilliaries	4 Nos.
- Elevated Storage Reservoir (1,000 m^3)	7 Nos.
- Primary Transmission Mains (D300- D800)	25 km
- Tertiary Network (D50-D100)	90 km
Metered House Connections	50,000 Nos.

The construction cost for the above is estimated approximately at US$25.179 million.

The surface water is basically considered to be the water supply source for the rural domestic, rural industrial and industrial zones water supply requirements.

The demand areas for these water supply requirements will be scattered extensively in respective districts, and therefore, many piped-systems, each having a water intake in the rivers and/ or canal systems, are contemplated to be established.

The locations of the demand areas are not definitive at this stage. Therefore, the locations of facilities are not shown in Figure 8.3. The construction cost, which was estimated on the basis of construction cost for the urban domestic water supply facilities, is calculated at US$107.72 million.

(4) Flood Control and Bank Erosion Plan

In the proposed flood control plan of the Kone River delta, the late flood of 5 % probability is to be controlled by the construction of the Dinh Binh reservoir and the river improvement of the Dap Da, the Nam Yang, the Go Cham, the Tan An and the Cay My Rivers. The proposed design discharge distribution is that the design discharge of the Dap Da, the Go Cham and the Tan An rivers would be increased to about twice of the present discharge carrying capacities. And in the case of the Nam Yang and the Cay My Rivers, the flood flow velocity would be also increased since flood control river dyke would be constructed and design discharge would be confined in the river channel.

Accordingly much increase of the flood flow velocity would be expected in the all objective flood discharge distribution rivers. Accordingly the bank protection works against bank erosion need to be provided for the low water channel.

Present practice in the filed is that the bank protection works are provided with the rigid type wet masonry. But in consideration of the present situation of the river channel and the river water use by the local people, the flexible and durable type bank protection works are suggested. Japanese type gabion so called Kago Mat would be appropriate as the bank protection works since it is flexible and durable and suitable for protection of foot of the low water channel slope and the flood control dyke.

(5) Drainage Plan

(a) Urban Drainage

Urban drainage is now being executed in Quy Nhon City together with the road improvement work. The drainage works are the street drain, the street inlet and the underground drain to be connected to main drainage streams and rivers.

These works would be executed also in the other major towns such as Binh Dinh, Phu Phong, Ngo May, etc. in succession to Quy Nhon City in order to improve not only the living condition of inhabitants but also the industry and business circumstances.

(b) Rural Drainage

(i) Residential area

Similar drainage works with those for the urban drainage would be constructed at several important places. However, the major work in the other rural residential areas should be the same as those at present that is the improvement of natural drains in consideration of the required investment and the expected return.

(ii) Agricultural area

Drainage plan of the agricultural area has been established as follows:

i) Paddy field area

The drainage facilities such as drains and junction works should have the capacity required for the 5-day drainage of inundation. To prevent additional inundation at scattered low land areas due to runoff from upper stream fields, dikes would be required along the drains. Works such as flap gates should also be needed to expect the effectiveness of the works.

<u>Tan An – Dap Da Area</u>

Drainage plan of the Tan An – Dap Da would be as follows:

a. <u>Branching stream from main river</u>

Small streams branching from the main rivers such as the Tan An and the Dap Da for intake of irrigation water, etc. would be closed at the early and late floods except the major flood with the sluices to be constructed at the flood dike improvement or new construction. The sluices of the branching streams are as follows:

Sluices for Branching Streams

Code	Main River	Location	Present Major Irrigation Schemes under Branching Stream	Future Water Source for Irrigation
DU1	Dap Da	Nhon Hau	Ben Go (P)	Integrated to Thi Lua
TU1	Tan An	Nhon Khanh	-	-
TU2	Tan An	Nhon Hoa	Thanh Hoa II (CW)	Branching Stream
TU3	Tan An	Phuoc Hiep	-	-
HU1	Ha Thanh	Nhon Phu	-	-
HU2	Ha Thanh	Nhon	-	-

Note. P: Pump, CW: Check Weir

With such measures, the existing branching streams would in future function as follows:

- Early and late floods would not enter to branching streams.
- Water level could be kept at low level enough for drainage of the area.
- Domestic water being used at present would be secured with intake of river water through the sluice.
- Water supply for the pumping stations would be secured with intake of river water, too.

b. 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. These streams would be separated from irrigation purpose and connected to the main rivers with enough capacity in other words the combination of cross-section and longitudinal gradient.

For this purpose, the excavation work of the existing streams and partial new drains to be connected to the existing ones would be implemented. With such works, the drains would be well networked to meet the requirement. Downstream ends, namely beginning points, of the re-networked drains would be connected with the drainage sluices to be constructed as the related structures to the flood dikes. The proposed 34 major drains in the Tan An – Dap Da Area are listed together with the drainage sluices in Table 8.5.

ii) Upland field area

The drainage facilities should have the capacity to prevent inundation from the peak discharge from the catchment area.

iii) Works in agricultural area

Inundation in the paddy field area causes also inundation of many roads passing through the area. Those roads should be designed taking into account the drainage plan of the area. Any other public and private works, buildings and facilities would also be in the same condition. Necessary measures are to be taken accordingly under such condition.

(6) Rehabilitation in Irrigation Development Plan

(a) Existing Schemes outside Dinh Binh Reservoir Project

Rehabilitation works would be more effective than new development works of irrigation, drainage and farm road facilities to create the same production. Therefore, the rehabilitation works for non-function parts of the originally constructed area have been planned to be early implemented if conditions are favorable. Those areas are parts of almost all the existing irrigation schemes.

In actual, deteriorated and non-function facilities scatter all over the area. However, rehabilitation of some key works might recover the original function in the large areas where the initially constructed facilities are still in favorable condition. Table 8.6, Figures 8.4 and 8.5 are to be referred to.

(b) Existing Schemes under Dinh Binh Reservoir Project

Existing schemes such as those in the Tan An – Dap Da area under the Dinh Binh Reservoir Project should wait for timing of starting the rehabilitation projects. Result of the rehabilitation will become effective when the additional water to be supplied by the reservoir becomes available. Figures 8.6 and 8.7 are to be referred to.

(c) Integration of Existing Schemes in Tan An – Dap Da

As to the rehabilitation projects in the Tan An – Dap Da area, it is also to be noted that the presently separated schemes to up and downstream areas due to water shortage and deterioration of the facilities should have been integrated into one system. Such schemes concerned are as follows:

a) Binh Thanh Scheme: Ben Tranh, Thanh Danh
b) Bay Yen Scheme: An Thuan, An Hoa
c) Nui Mot Scheme: Long Quang
d) Thach De Scheme: Trung Ly, Ban Nui, Da Den, Part of Lao Tam, Van Kham, Bo Ngo
e) Thap Mao Scheme: Thanh Hoa Left
f) Thanh Hoa Scheme: Dap Cat, Nha Phu
g) Lao Tam Scheme: Van Moi

(d) Irrigation Schemes after Integration

With the above integration, the original 71 schemes would become 56 schemes in total including schemes under the other water sources.

i) Water source facilities after integration

Water source facilities for irrigation such as dams, weirs and pumping stations for the said 56 schemes are shown in Table 8.7.

It is noted that the existing weirs located in the downstream reaches in the coastal area such as Van Kham, Bo Ngo, Dap Cat, Nha Phu, etc. would function for the salinity intrusion control in future, too.

Other existing weirs and pumping stations would be used for intake of domestic water for the inhabitants. It means that the intake water level could be kept lower enough for the streams to function as drains.

ii) Major irrigation canals and related structures after integration

Irrigation canals and related structures after the integration would become similar to the original design.

(7) Rural Development Plan

Rural development would be executed in accordance with the plan described in "Review and Supplementary Report on Agricultural and Rural Planning for Binh Dinh Province Towards 2010, Binh Dinh People's Committee, Department of Agriculture and Rural Development (DARD), 2002".

(a) Rural Road Development

Total length of rural roads in Binh Dinh Province is 2,775 km at present. It is planned to improve some of those with concrete pavement. The target up to 2005 is 735 km in accumulation. 135 km have been already paved up to now. So, the remaining 600 km would be newly paved, of which 75% are inter-commune roads and trunk ones in communes.

Rural road development in the Study Area (about 60% in geographical area and about 65% including the La Tinh) would also be implemented in line with the above provincial plan.

(b) Rural Electrification

According to the forecast by Department of Electricity of Binh Dinh Province, the rural electrification would be completed by 2010. It means that 95% of households and 100% of communes would have access to the national electric grid and any other electric sources.

It is to be noted that about 4,000 units of solar batteries would be set up for 42 villages (4,000 households) in Quy Nhon City, Vinh Thanh District, Van Canh District, and two (2) other northern districts.

(c) Rural Domestic Water Supply

The rural domestic water supply plan is mentioned in Chapter 7.

(8) Power Generation

The Dinh Binh Multi-purpose Dam will be provided with the power station having an installed capacity of 6,600 KW. The power generation will be made by utilizing the water to be released for water supply purpose as well as the surplus water. The power station will generate the annual average power energy generation of 37.84 GWh/year and will ensure 24 hours operation with the power output of 2,200 KW with 75% dependability which is expected to be guaranteed in the national power development plan.

8.2.2 Water Resources Management Plan

(1) Basic Concept of Water Resources Management Plan

The water resources management plan as a part of the integrated basin management plan of the Kone River basin is formulated on the basis of the following basic concept:

(a) Water resources management in the Kone River basin will be carried out by an unified river basin management organization (authority) to be established that the Provincial Peoples Committee will be in charge of authority.

(b) Provincial government agencies and bodies presently related to the management of the Kone River basin will be the task force members of the organization as well as stakeholders of the basin water resources that will be the committee member

(c) Main tasks of the organization will be enumerated as follows:

- Water use management
- Flood control management
- River Environment management
- Dam operation management

(2) Water Use Management Plan

The water use management plan in the Kone River and Ha Thanh River basins is proposed that the priority activity is aiming at effective use of limited water resources taking priority of water use into account. For this purpose, the Water Use Management Committee will be established under the basin management authority.

(a) Proper Management of Water Demand

To make an updated estimate of water requirement every year at the beginning of dry season when water demand is to start increasing, the basin management authority will request the respective water users to submit expected monthly water requirement. The authority will be authorized to coordinate each requirement when it is deemed necessary and will prepare the water supply schedule that will be basis of a year's reservoir operation of available reservoirs. This schedule shall reflect the current reservoir storage, long-term weather forecast and long-term previous trend.

The authority will have an authority to monitor the actual water intake amount by respective water users.

(b) Latest Information Management of Water Resources Including River Flow and Reservoirs' Storage

The authority will monitor the current available water resources amount including river runoff and reservoir storage as well as actual water requirement. The committee may allow providing additional water when actual reservoir storage is more than scheduled one and as far as increase of production be expected by such additional water allotment.

(c) Proper Water Allotment Under Severe Drought Condition

Not only at the beginning of high demand period, but also when drought situation is foreseen, which may be at the peak period of water demand, the authority will coordinate all water users to cope with expected water deficit by adjusting water demands incorporating priority of water demands.

(d) Non-structural Measures

Non-structural measures for water saving such as,

- Enhancement of public awareness for water saving,
- Control of the water demand,
- Reduction of leakage, and
- Reduction of use of extra water by installing faucet aerator, etc.

are very important from the water utilization aspect, and the measures that are not so costly should be introduced at the earliest.

(3) Flood Control Management Plan

(a) Flood Warning and Communication System

Established present system is information system of hourly water level data from flood prone area/existing dam sites to the provincial flood warning committee. The provincial committee gives necessary instruction to each district committee concerned. The flood warning committee is temporarily organized when it is deemed necessary according to the scale of flood.

Present activities will be taken over to the Flood Control and Warning Committee under the basin management authority. The present system shall be sustained and to be upgraded being parallel with the Dinh Binh Multipurpose Reservoir Project.

The upgraded flood warning and communication system will cover the following organizations and facilities and others as required:

- PPC(Basin Management Authority)
- DARD, Dept. of Transportation
- Police Stations concerned
- Military Station (primary)
- District People's Committee concerned
- EVN Office in Qui Nhon
- Dinh Binh Dam Office
- Nui Mot Dam Office
- Van Phong Weir site
- Binh Son Dam Office

Several automatic water level stations along the Kone River as well as some automatic rainfall stations in the Din Binh Dam catchment will be installed to monitor the storm and water level information, but not for flood forecasting.

Installation and construction cost of the upgraded system is preliminarily estimated at about US$4.0 million for direct cost only.

(b) River Basin Conservation

River basin conservation is a key issue in flood control aspect of a river basin. The basic purpose of river basin conservation for flood control is to mitigate the flood water runoff and sediment discharge.

Deforestation and unregulated land development in the basin will cause the problems of land erosion and more sediment discharge to river channel. More sediment discharge will cause more serious sediment deposit in reservoirs as well as riverbed aggradations that lead to reduction of flood control capacity of the reservoir and discharge capacity of river channel. Deforestation, furthermore, will decrease the basin rainwater retention function due to less evapo-transpiration and less infiltration of rainfall in the basin.

In order to cope with the said issues, the river basin conservation with reforestation and land use control in the basin are essential as basin-wide flood control measure.

(c) Flood Hazard Map

Preparation of the flood hazard map is necessary by improvement of the existing flood-prone-area map with past flood water levels thereat.

To disclose the flood hazard information in terms of expected inundation area and depth is quite effective way to the local commune to aware of the flood risks in any rainy season.

(d) River Management

River area boundary should be clearly shown to the local commune and the area should be always kept as the expected situation. Any structure construction and hazardous activities should not be done in the river area without authorization.

The said activities and authorization should be managed by one river management organization.

(e) Non-structural Measures

Non-structural measures such as,

- Enhancement of public awareness for disaster prevention,
- Information transmitting system among resident people,
- Preparation of refuge, and
- Flood fighting activities, etc.

are very important and efficient for mitigating the flood damages, and should

be introduced as early as possible in advance of the structural measures such as dams or dyking system, etc.

Flood fighting is one of the important non-structural flood control measures. During floods, flood water level should be monitored continuously if the water level rises to the warning level, or higher than that. Even the water level would not rise higher than the warning level, flood embankment may become in danger. The piping phenomenon may happen. Leakage of water through the embankment body may happen. The intensive embankment erosion may take place. These phenomena may cause serious flood embankment breach resulting in the serious flood damage in the adjacent area.

But the flood embankment breach due to these phenomena may be avoided if the appropriate counter measures are timely taken. The activities to conduct the monitoring activities and to take those counter measures are called flood fighting.

Flood fighting is, accordingly, inevitable for flood control before and after the flood control project is implemented. Flood fighting should be conducted by every district level or village level. Here it is proposed that the resident people spontaneously establish the flood fighting body and the activity system.

(4) River Environment Management Plan

The river environment management plan is proposed to compose two issues on the river maintenance flow and the water quality control. It is recommended that the River Environment Management Committee will be established under the basin management authority to cope with the said issues.

(a) Management of the River Maintenance Flow:

It is recommended that the river environment management committee will collaborate with the proposed water use management committee to attain proper water distribution between the respective water demands and requirement of the river maintenance flow through well coordination with the related stakeholders.

(b) Water Quality Control

In order to cope with river water deterioration due to waste water discharge from domestic and industrial uses according to increasing water demand, the river water quality is to be maintained and/or improved by waste water control. It is recommended to establish regular monitoring activities of river water quality as well as proposed reservoirs including Dinh Binh Dam and Van Phong Weir.

(c) Thi Nai Swamp Monitoring

Thi Nai swamp can be recognized as a final receptor, which reflects the conditions of the Kone River and its basin. Thus, it is effective and essential to conduct a regular monitoring on the typical environmental parameters such as water quality and fishery catch, which indicate the soundness of the swamp.

(5) Dam Operation Management Plan

(a) Integrated Operation of the Existing and Proposed Dams in the Kone River Basin

In addition to the existing reservoirs in the Kone River basin, the Dinh Binh reservoir is proposed to be involved in the measures to cope with expected water deficit. With the Dinh Binh reservoir, the existing Nui Mot reservoir and reservoirs of the Vinh Son H/P would play as reservoirs to meet the downstream water demands. While, the Thuan Ninh reservoir will not have a capacity of water supply to the other demand's site according to the water balance study discussed in the preceding chapter.

According to the said water balance study, although the Dinh Binh reservoir will work as the most main one for water supply, the other two reservoirs are required to fulfill as the water supply function to the downstream demands, even it will be supplementary.

It is necessary to carry out integrated reservoir operation, which includes Vinh Son, Dinh Binh and Nui Mot reservoirs, that respective storage capacity could cover water deficits in the downstream area, through the effective use of storage water.

The integrated dam operation management will be handled by the water use management committee involving EVN-Binh Dinh and respective dam offices. Required communication measure is assumed to have been included in the proposed flood warning and communication system.

(b) Warning and Communication System of Dam Water Release

The flood control and warning committee needs to manage dam discharge information among each dam during flood season to prevent from causing unexpected flood by excess dam release. Based on the information from some of dam offices, the committee will coordinate with the other dam offices to control its dam release within possible extent. Dam release information needs to be disseminated to the downstream facilities such as Van Phong Weir as well as administrative units in downstream reaches and local government offices. The flood warning and communication system will be available for this activity.

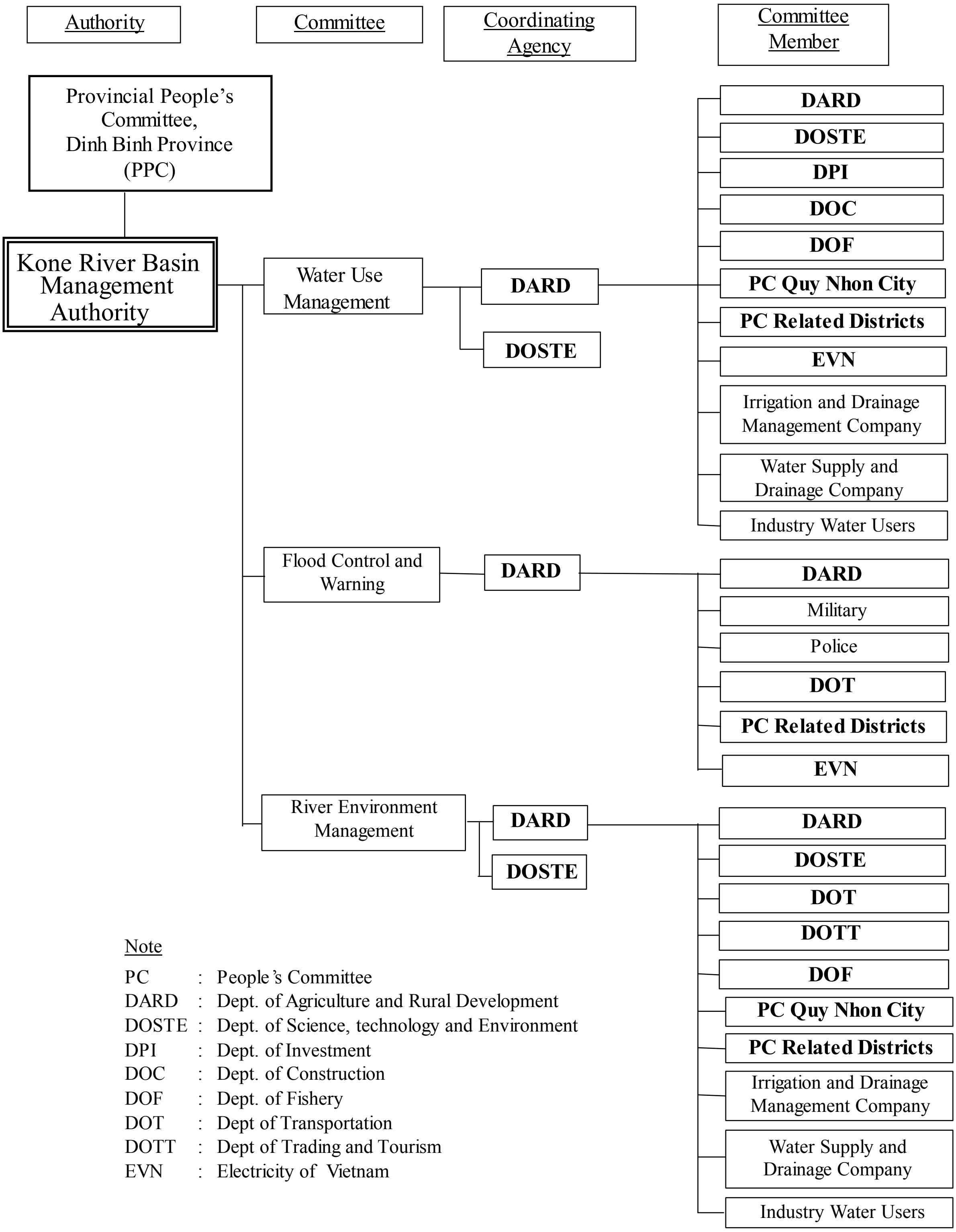
Dam release warning shall be disseminated to the downstream reaches of respective dams by each dam office when dam release through spillway would cause sudden raise of river water level at rather immediate downstream reaches. The warning range depends of river condition, inhabitants along the river and possibility of existence of people in the river course area.

In the Dinh Binh Dam case, it is assumed that the warning stations with siren will be needed at 10 locations with an installation cost of US$0.5 million including an operation console in the dam office.

(6) Administrative Management Plan

To accomplish the proposed river basin management plan, the river basin management authority with the water use management committee, flood control and warning committee and river environmental management committee is proposed to be established as a river basin organization (RBO). Involvement of this organization will be local government agencies as task force member and related organizations as committee member. A preliminary organization of the authority is proposed and organization chart is presented below:

Proposed Organization of Kone River Basin Management



Note

PC	:	People's Committee
DARD	:	Dept. of Agriculture and Rural Development
DOSTE	:	Dept. of Science, technology and Environment
DPI	:	Dept. of Investment
DOC	:	Dept. of Construction
DOF	:	Dept. of Fishery
DOT	:	Dept of Transportation
DOTT	:	Dept of Trading and Tourism
EVN	:	Electricity of Vietnam

8.2.3 Summary of the Integrated River Basin Management Plan

The Integrated River Basin Management Plan of the Kone River Basin has been studied and formulated as presented in the preceding Sub-sections 8.2.1 and 8.2.2.

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 as well as function and principal features of each component are summarized in Table 8.8.

CHAPTER 9 PRELIMINARY DESIGN, CONSTRUCTION SCHEDULE AND COST ESTIMATE

9.1 Preliminary Design of Major Facilities

9.1.1 Dinh Binh Dam

(1) Selection of Dam Site and Dam Type

There are two conceivable dam sites with a narrow cross section in Vinh Hao commune, Vinh Thanh district.

The downstream dam site is named to be Dam site I. The upstream dam site at about 600m from Dam site I is named to be Dam site II.

The Feasibility Study conducted by HEC-1 examined in detail the comparison of the dam sites as well as the most suitable dam type, and recommended to select Dam site I for the dam site and a concrete gravity dam with a gated spillway for the dam type.

Main reasons for the above selection are as follows:

1) Topographic conditions are more favorable in Dam site I having less valley width.
2) Geological conditions are also more favorable in Dam site I.
3) The thickness of coverage above the foundation rocks is relatively shallow.

Since the foundation rocks have strength to withstand the construction of a concrete gravity dam, the construction of a concrete gravity dam makes much more advantageous economically in comparison with a rockfill dam.

The examination in the Feasibility Study by HEC-1 indicates that the construction of a rockfill dam will require higher cost by about 50% than that of a concrete gravity dam.

Reviewal study on the Feasibility Study by HEC-1 fully agrees to the conclusion of the Feasibility Study.

Thus, the Dinh Binh Dam is planned at Dam site I with a concrete gravity dam.

(2) Development scale of the Dam

The optimum development scale of the Dinh Binh Dam was examined in combination with the flood control plan in downstream reaches in the preceding Section 8.1.

Based on the above examination, the development scale of the Dinh Binh Dam is determined as follows:

1)	Dam Crest Level	:	EL.100.30m
2)	Flood Water Level	:	EL.98.30m
3)	Surcharge Water Level	:	EL.97.80m
4)	Full Supply Level	:	EL.96.93m
5)	Rainy Season Limited Water Level	:	EL.65.00m
6)	Dead Storage Level	:	EL.65.00m

Location, Plan and Profile of the determined scale of dam are presented in Figures 9.1 to 9.4, respectively.

(3) Spillway Design

The design for spillway is made with consideration that,

1) the spillway should have a width generally equal to the original river width,
2) the spillway can be installed on the dam body in the case of concrete dam,
3) the spillway should be provided with a capacity to pass the spillway design flood peak discharge at the Flood Water Level, and
4) the spillway design flood peak discharge should consider 1% probable (or 100-year recurrence) flood for a concrete gravity dam.

The 1% probable flood peak discharge for spillway design is taken at 5,830 m^3/s which is provided with a safety allowance of 20% for 4,820 m^3/s estimated in the hydrological analysis and the following dimensions are provided for the spillway:

1)	Width	:	12^{m} x 7^{gates} = 84^{m} (115^{m} including pier width)
2)	Overflow Crest Level	:	EL.85.93 m
3)	Flood Water Level	:	EL.98.30 m

The spillway discharge capacity will be approximately 6,760m^3/s as follows:

$$Qc = C \times B \times H^{3/2}$$
$$= 1.85 \times 84 \times 12.37^{3/2}$$
$$= 6{,}760\ m^3/s$$

where: Qc : Spillway
C : Coefficient

B : Spillway width (m), and

H : Overflow depth (m)

As such, the spillway will have a sufficient capacity to pass the 1% probable flood peak discharge at the Flood Water Level so that the reservoir water level will not rise beyond the Flood Water Level in the event of occurrence of 1% probable flood.

(4) Freeboard

The following freeboards are provided in the preliminary design of the Dinh Binh Dam:

	Provided Freeboards
- Freeboard above the Flood Water Level (FWL)	2.00 m
- Freeboard above the Surcharge Water Level (SWL)	2.50 m
- Freeboard above the Full Supply Level (FSL)	3.37 m

Necessary freeboards are calculated as follows:

	Necessary Freeboards
- Freeboard above FWL	1.962 m
- Freeboard above SWL	2.184 m
- Freeboard above FSL	2.406 m

As seen above, freeboards more than the necessary freeboards are provided in the design. However, the following matter shall be noted:

The freeboard above the Full Supply Level should have a freeboard with which the Probable Maximum Flood (PMF) will not overtop the dam crest, taking into consideration the regulation effect of the reservoir.

The above check should be made, and if necessary, the dam crest level should be adjusted so as to meet the requirement. Review on the feasibility study following the formulation of the integrated river basin management plan shall examine the necessary freeboard above FSL for PMF.

(5) Dam Design near the Right Abutment

Near the right abutment of the dam, the dam foundation bedrock is situated with rather thick coverage of the light semi-clay of about 20 m in depth.

To save the cost, the dam design in the Feasibility Study is made by the reinforced concrete boxes filled with earth materials inside boxes and earth embankment with its surface protection of wet masonry put on the upstream side of the above concrete boxes.

The above structures are founded on the light semi-clay, grayish brown to yellowish brown, mixed with grit.

The review on the above structures suggested the following:

1) The structure of reinforced concrete boxes filled with earth materials is founded on the clayed layer of which shearing strength is considered insufficient for withstanding the water pressure which should be considered to act on the upstream surface.

2) Differential settlement will probably happen between the reinforced concrete boxes, or between the structure founded on the clayey layer and the adjacent concrete dam founded on the bedrock, making it difficult to ensure the water tightness and safety.

3) Stability of the structure should carefully be examined in due consideration of the above.

The preliminary design of the study tentatively indicates the idea proposed in the Feasibility Study by HEC-1. However, as discussed, a careful examination of stability of the dam structures designed near the right abutment is considered essential, which shall be conducted in the reviewal study on the Feasibility Study.

(6) Foundation Treatment

The proposed damsite is underlain mainly by granitic rocks, which have been subject to shallow weathering. Strongly weathered rocks (C_L～D class rock mass) are small and local. Below the depth of about 10 meters, the foundation rock consist mainly of C_M grade rock mass or more competent rocks.
The foundation rocks of C_M and C_H grad rock masses at damsite have small lugeon values, generally less than 5 at a depth of 20 meters. Although no groundwater level data around the abutments were available, groundwater level was considered to be rising in parallel to the ground surface. Groundwater level at damsite, 2 to 10 meters deep, is distributed between bedrock and the overlying soil layers, or locally above the strongly weathered rocks.
Consequently, the depth and extent of curtain grouting was determined to be 30 meters at deepest point and 10 meters at around fan-shaped rim in view of the dam height and geological conditions of dam foundation.

With the above in view, the dam foundation treatment is designed with the following curtain and consolidation grouting:

(a) Curtain grouting

Necessary depth of curtain grouting varies depending on the dam height, geological condition and ground water level. However, the depth of curtain grouting is generally given by the following formula:

Hc= Hd x 0.4 ~ 0.8

where, Hc : Depth of curtain grouting (m)

Hd : Height of dam (m)

At the dam height of 50m, the depth of curtain grouting is calculated at 20 to 40m.

The curtain grouting depth is designed, referring to the above.

The following standard curtain grout hole arrangement is made at this preliminary design stage:

- Two row at 1m interval, hole spacing of 2m on each row
- Hole arrangement to be made at zigzag.

(b) Consolidation Grouting

The dam foundation will be loosened by the excavation work of dam foundation by means of blasting, requiring improvement of the loosened dam foundation.

In order to improve by consolidating, the consolidation grouting is indispensable.

At this preliminary design, the following standard consolidation grouting is considered:

- Consolidation grout hole depth = 5 m
- Hole arrangement: At grid of 4 m interval

9.1.2 Van Phong Weir and Irrigation Facilities

(1) Van Phong Weir

(a) Site Selection

In the report of “General Explanation No.444C-05-TM, Feasibility Study, Water Resources Project Dinh Binh Reservoir, HEC1, HDECE, May 2000, two alternative sites were comparatively studied and Site-I has been selected with the following reasons:

i) River width at Site-I is narrower than Site-II (HEC-1) that is located at 2,300 m upstream point.

ii) Geological condition is the same each other, which is the granite rock.

iii) Sedimentation condition is the same, where 8 to 12 m thick river bed sand, boulder and gravel alluvium layer exists.

iv) Beginning section of the Van Phong Main Canal from Site-II (HEC-1) should pass the mountain skirt slope that would be unstable.

In addition to the above items, from the viewpoint of water route of the Kone River around the alternative weir sites, the relationship between the meandering curve course and the sedimentation occurring position requires to be reviewed in the Feasibility Study stage (Phase 2-3).

(b) Weir Type

The weir designed by HEC-1 in the report (No.444C-05-TM) is of the concrete fixed type as shown in Figure 9.5. Floods would flow over the crest of the concrete weir of 470 m in length. Downstream side of the weir has a shape to make the hydraulic jump for energy dissipation. As to the type of the downstream side, too, more study is required in the Feasibility Study stage (Phase 2-3).

(c) Crest Elevation

The crest elevation of the concrete weir has been determined at EL.25.00 m in the HEC-1 report. This might be enough high for the gravity irrigation in the all area of Van Phong Proper and the almost area of the Van Phong Extension (La Tinh) excluding its northern part. However, the crest elevation might have been determined without adopting the settling basin and the discharge measurement device. Adoption of those facilities and the necessary weir crest elevation including the required head loss should be studied in detail in the Feasibility Study stage (Phase 2-3). It is to be taken into account that the much increase of the weir crest should not be allowed, because it will cause the high elevation backwater due to the weir at floods.

(d) Design Flood and Inundation Area

The design flood has been set to be 7,380 m^3/sec (probability P=1%) in the report. The flood elevation is 28.92 m. The report points out the matter that the inundation of villages and a part of National Road No.19. The report mentions as follows:

- At the flood water level of 28.92 m, some villages and about 5 ~ 6 km of National Road No.19 would suffer from submergence. It should be taken into consideration during the design of works.

Alternative study to solve the matter will be conducted in the Feasibility Study stage (Phase 2-3) and the definite plan will be presented.

(e) Scouring Sluice

The scouring is of 2 nos. x 2.75 m (B) x 2.75 m (H) to be constructed in front of the intake sluice.

(f) Intake Sluice

As for the intake sluice, dimensions of 2 nos. x 2.75 m (B) x 2.75 m (H) has been proposed in the report for the design discharge of 19.65 m^3/sec for the commanding area of 10,815 ha. The required dimensions for the proposed irrigation will be examined in accordance with i) proposed cropping pattern, ii) proposed irrigation water requirement, and iii) proposed irrigation area in the Feasibility Study stage.

(2) Irrigation Facilities

Major points to have been considered in the design of irrigation canals, drains, farm roads and related structures are as follows:

(a) Irrigation Facilities

i) In canal layout design, the dual-purpose canal system for irrigation and drainage that is presently prevailing in the Study Area would be changed to it with independent setting of irrigation canals and drains.

ii) Presently scattered many irrigation systems would be integrated to the representative ones in accordance with the original layout designed initially. It has been confirmed through discussions with various central and provincial authorities concerned that not only the public organizations but also the present water users would agree to execute such integration of systems or unification of intake facilities such as weirs.

iii) Canal lining would be executed for water saving and efficient maintenance. It would be realized not only in the main system but also in the on-farm system in consideration of importance to improve the living standard or life style of the rural inhabitants concerned.

iv) Discharge measurement device would be equipped at every diversion point to prevent over-supply of water, or improvement of the irrigation efficiency with decrease of the water loss.

v) Capacity of canals and related structures would be designed with 10-day peak required discharge of 75% dependability.

With application of the above criteria, major irrigation facilities such as dams, weirs and pumping stations, canals and related structures have been designed at preliminary level.

i) Irrigation dams

Major 11 dams have been designed at preliminary level as shown in Table 9.1.

ii) Irrigation canals

Typical sections of irrigation canals have been designed at preliminary level as shown in Figure 9.6.

(b) Drainage Facilities

i) Drainage network would be established with construction of additional drainage canals so as to link the existing drains and the new ones.

ii) Capacity of drains in the paddy fields area would be determined with 5-day drainage of 3-day consecutive rainfall with 10% probability of occurrence. Specially for the Tan An – Dap Da area, 3-day consecutive rainfall during the period from the middle of December to the end of September would be applied in accordance with the flood protection plan in the area.

iii) Capacity of drains in the upland fields area would be enough for the peak discharge of 10% probability of occurrence.

(c) Farm Road Facilities

Following criteria would be applied:

i) Farm road network would be established with linking canal inspection roads, farm roads and commune roads.

ii) Gravel pavement with 3.0 m effective width would be adopted, which is the same width as it of the prevailing concrete pavement for commune roads.

The canal inspection roads for the above-mentioned proposed irrigation canals would be the main farm roads.

(d) Priority in Planning and Design

A priority has been put on the improvement of the existing functioning facilities and the rehabilitation and improvement of the presently non-functioning ones in the development plan and the canal system design in consideration of the efficiency of projects.

9.1.3 Flood Control and Drainage Facilities

(1) Flood Control Facilities

Proposed flood control facilities as the structural measures of the Kone River basin in the present study are the Dinh Binh reservoir, and the river improvement works. The necessary facilities for the river improvement works are as follows:

- flood control dyke
- diversion control groyne
- diversion control sluice
- diversion control fixed weir
- drainage sluice
- bank protection works

The diversion control sluices are needed at the bifurcation site of the Nam Yang River from the Dap Da River and that of the Cay My River from the Tan An River. The present situations at those sites are that flood would freely flow just depending on the site situation and the water levels of each river. But in the future situation of new flood control plan, the flood flow to the bifurcation should be controlled as planned by the flood control sluices.

The diversion control groyne is needed at the site of the bifurcation of the Dap Da from the Kone River.

The diversion control fixed weir is needed at the bifurcation site of the Go Cham river from the Tan An River.

The locations of the necessary diversion control facilities above-mentioned are shown in Figure 9.7.

Regarding the joining sites of the La Vi River and the An River, the backwater embankment along those tributaries are proposed.

Drainage sluices are also needed since the present conditions are that many small canals join the major branch rivers of the Kone River delta. Bu new flood control dyke needs to be constructed over those branch canals in the said delta. The locations of the drainage sluices necessary to be newly constructed are shown in the Figure 9.7.

Bank protection works against bank erosion need to be provided for the low water channel since the much flood flow is to be confined in the objective river channels and the flow velocity is expected to increase substantially in the present proposed flood control plan. As presented in Section 8.2.1, Kago Mat (Japanese type gabion) would be suggested as the bank protection works since it is flexible and durable and suitable for protection of foot of the low water channel slope and the flood control dyke.

(2) Drainage Facilities

(a) Urban drainage facilities

Urban drainage works in Quy Nhon City would consist of the street drain, the street inlet and the underground storm drain to be connected to main drainage streams and rivers.

Those in the other towns such as Binh Dinh, Phu Phong and Ngo May, would be partly constructed concrete flume, etc. especially in areas where buildings and houses are crowded.

For the future, the similar project with it in Quy Nhon City would be implemented in those towns, too.

Dimensions of the drainage facilities would be designed in consideration of the peak discharge to be drained.

(b) Rural drainage facilities

The rural drainage facilities would consist of those for the residential area and for the agricultural land. The following drainage facilities would be designed for the areas.

(i) Rural residential area

Improvement of natural drains to make storm-water flow smoothly would be major work in the other rural residential areas. Capacity of the drains would be designed for the peak discharge.

(ii) Agricultural area

Drainage facilities in the agricultural area would consist of the drains and the related structures as follows:

- Drains : combination of natural streams with necessary improvement and artificial drainage canals
- Dikes : dikes along drains in low land part
- Protection : lining works, flume works in weak parts, crowded parts, etc.
- Structures : structures related to drains such as junctions of two drains with protection if required, outlets to parent drains with flap gates at depressions if required, crossing structures with existing roads and canals.

Capacity of the drains would be designed as mentioned in the previous Sub-section 9.1.2 as follows:

- Paddy field : 5-day drainage of 3-day consecutive rainfall
- Upland field : Non-inundation drainage

9.2 Construction Schedule and Cost Estimate

9.2.1 Construction Schedule of Proposed Major Facilities

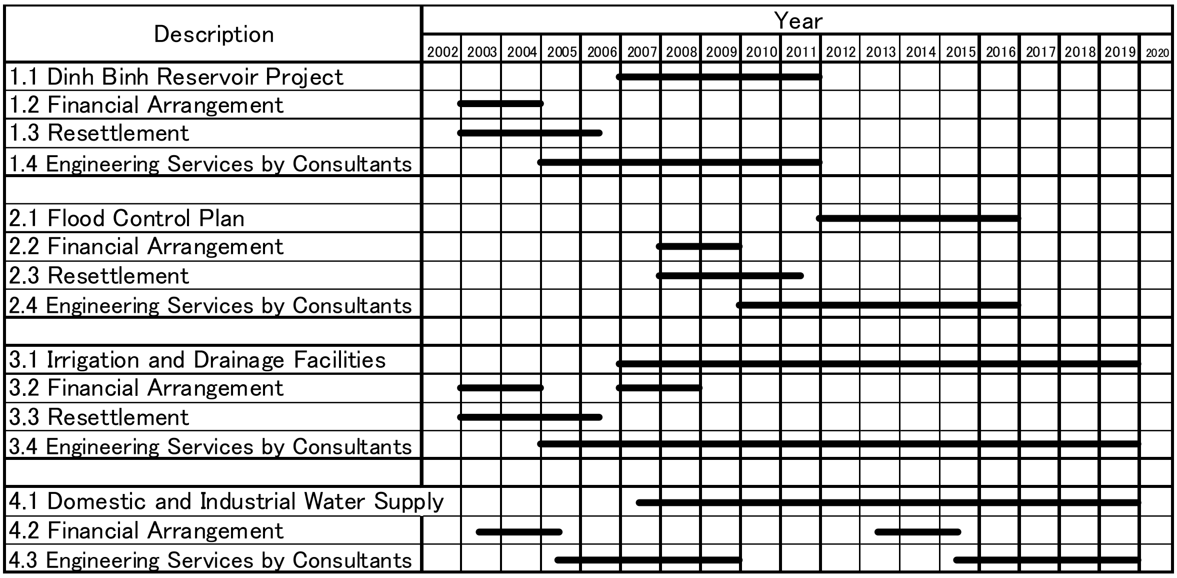
Based on the basic strategy for water utilization and flood control plan, the Integrated River Basin Management Plan has been examined and the following facilities are proposed for the Integrated River Basin Management Plan:

- Dinh Binh Reservoir Project including main dam, spillway, outlet works, intake, relocation road, switchgear and hydropower plant,
- Flood Control Facilities comprising Thi Nai Swamp, Dap Da River improvement, Go Cham River improvement, Tan An River improvement, Nam Yang River improvement and Ca My River improvement.
- Irrigation and Drainage Facilities consisting of Van Phong weir, rehabilitation of existing weirs, construction of new weirs, construction of new earthfill dams, existing reservoirs to be rehabilitated, construction of new pumping station, improvement of existing function, rehabilitation and improvement for non-functional area and construction for new development areas,
- Domestic and Industrial Water Supply including raw water intakes and pre-treatment units, booster pumping stations and ancillaries, elevated storage

reservoirs, primary transmission mains, tertiary network and metered house connection.

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

Kone River Basin
Overall Implementation Program of Proposed Major Facilities



9.2.2 Cost Estimate of Proposed Facilities

Various alternative basin development plans have been studied for finding the optimum basin development plan as presented in the foregoing Section 8.1, and the basin development plan consisting of the Dinh Binh Dam with its crest level at EL.100.3 m and flood control volume of 292.77 MCM, the river improvement/ dyking system for the Thi Nai Swamp, Dap Da River, Go Cham River, Tan An River, Nam Yang River and Ca My River to cope with the objective 5 % late flood together with the Dinh Binh Dam, irrigation and drainage facilities including the La Tinh River basin and domestic of industrial water supply facilities, etc. was selected as optimum.

The cost for the above proposed facilities is estimated in due consideration of the construction schedule as shown in Table 9.2, resulting in US$ 720.5 million.

CHAPTER 10 PROJECT EVALUATION

10.1 Technical Evaluation

10.1.1 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 as follows:

(1) Accessibility

The Dinh Binh Dam site is located on the middle reaches of the Kone River main stream, about 70 km northwest of Quy Nhon City. The national road No.637 passes the right bank of the dam site without any difficulty of the accessibility.

(2) Topographic conditions

The Kone River in its upstream stretches is narrow and steep both laterally and longitudinally and forms V-shaped valley, while in its mid and downstream stretches, the river becomes wide and gentle, and presents U-shaped valley. The Dinh Binh Dam site is selected on the middle stretches where the valley is narrower with 200 to 500 m in width. The topographic condition of the dam site is rather suitable for construction of a concrete gravity dam.

(3) Geological conditions

Geology of the damsite and its reservoir area consists mainly of granitic rocks and the overlying deposits. These granitic rocks have undergone weathering, locally down to 40 meters deep with varying degrees of weathering. Except the strongly weathered rock (C_L-D grade rock) that is thin and local, the bedrock (C_M grade rock) has a low permeability (Lugeon value less than 5 of over 75% sections) and a medium compressive strength (over 20,000 kN/m^2).

Neither active faults nor large earthquake records have been found around the Project area. No landslides and potential unstable slopes have been observed along the bank slopes. Because the overlying soil layers are thin, there is no or less possibility that large landslides occur along the bank slopes due to impounding or earthquake, or both after the completion of the dam.

Around the right abutment, the thick deposit of 10 to 20 m in thickness remains unclear in terms of its distribution and engineering properties. Geological investigations indicated the presence of a shear zone beneath the thick deposit. As such, further geological investigations were proposed to define these issues.

Technical solution will be possible although the best way for solution should be examined.

(4) Construction Materials

Within 10 km downstream of the dam site, some borrow areas comprising mainly medium sand to coarse gravel of granite, provide a suitable sources for the construction of the gravity concrete dam.

10.1.2 Van Phong Weir

The proposed Van Phong Weir also has no particular technical problems as follows:

The Van Phong Weir is located on the bottlenecked valley in the downstream course of the Kone River, about 38 km downstream of the Dinh Binh damsite. The backwater area, about 450 to 850 meters wide and 5,000 meters long at maximum water level, forms U-shaped valley with a riverbed slope of about 0.5/1000.

At the weir site proposed by HEC-1, the Nui Mot hill on the right side starts to elevation with a slope of 20 to 25 degrees, while on the left side, the Hanh Son range joins the riverbed through a narrow and rather flat river shelf, with a slope of 10 to 15 degrees. The riverbed at the weir site is about 420 m wide at elevation of 20 meters.

The site and its backwater area are underlain by granitic rocks and the overlying deposits. The granitic rocks, although strongly weathered locally, have a low permeability (Lugeon value less than 5 of over 75% sections) and a medium strength (over 20,000 kN/m^2), and thus provides a good foundation for the construction of the weir. Furthermore, near the weir site, some borrow areas have been investigated to be suitable in quantity and durability for the construction of the concrete weir.

No geological investigation results were available to evaluate the weathering conditions and strength properties of the foundation rocks more precisely, therefore, in feasibility study (Phase 2-3), further geological investigations were proposed to obtain the necessary geological conditions and the geotechnical parameters for the weir design..

10.2 Initial Environmental Examination (IEE)

Among the components of the Master Plan, 7 projects/components, 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, were selected as those necessary for IEE. Other components were screened out from the examination since no or negligibly negative impacts on environment were expected to occur.

The IEE was conducted on the various elements of physical, ecological, and social aspects. The results of the examination of conceivable impacts caused by the selected projects/components are summarized as the table below:

Summary of Results of IEE

Environmental Elements \ Selected Projects/Components	Dinh Binh Reservoir	Quarry	River Improvement	Irrigation System	Agriculture Input	Domestic/ Industrial Water Plant	Water Supply System
I. NATURAL ENVIRONMENT							
I-1. Physical Environment							
Topography incl. sedimentation	?O/Δ	?O/Δ	O	?O/Δ			
Geology incl. mineral and soil	?O/Δ	?O/Δ					
Groundwater	?O/Δ		?O/Δ	?O/Δ	?O/Δ		
Air quality	Δ	Δ	Δ	Δ	Δ		
Water quality incl. eutrophication	O	?O/Δ	O	O	?O/Δ		
Noise and vibration	Δ	Δ	Δ	Δ			
I-2. Ecological Environment							
Forest and vegetation	Δ	Δ	Δ	Δ			
Terrestrial ecology	?O/Δ	?O/Δ		Δ			
Aquatic ecology	O	?O/Δ	O	O	?O/Δ		
Ecology of Thi Nai swamp	?O/Δ		?O/Δ	?O/Δ	?O/Δ		
Protected area							
II. SOCIAL ENVIRONMENT							
Land acquisition and resettlement	O	?O/Δ	O	O		Δ	Δ
Ethnic minority	O						
Change of split of communities	O						
Economic activities incl. inland fishery							
Fishery in Thi Nai swamp	?O/Δ		?O/Δ	?O/Δ	?O/Δ		
Transportation system incl. fluvial navigation	Δ		Δ	Δ			
Cultural/historical heritage			?O/Δ				
Landscape	O	Δ	O	Δ		Δ	Δ
Health, sanitation and construction waste	Δ	Δ	Δ	Δ	Δ		

1. The table above indicates the impacts with the following classification, excluding the impact with "positive" direction. Detailed examination is described in Appendix-I.
2. The item marked with O in the above means that negative impact with major magnitude is conceivable.
3. The item marked with Δ in the above means that negative impact with minor magnitude is conceivable.
4. The item marked with ?O/Δ in the above means that the occurrence and/or magnitude of negative impact is not clear due to the lack/limitation of information regarding existing environmental condition and/or project feature.
5. The item non-marked in the above means that i) magnitude of conceivable impact is negligible, or ii) impact is not conceivable.

Based on the results of the environmental evaluation, the items marked with "O" or "?O/Δ" are to be examined in the further EIA study in Phase 2-3. The main issues to be identified and discussed in the EIA study 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.

Besides, the projects on Domestic/Industrial Water Plant and Water Supply System will be excluded for the further EIA study since these are not to be nominated as the priority projects.

10.3 Economic and Financial Evaluation

10.3.1 Economic Evaluation

Economic analysis has been examined for 26 alternative schemes including without dam alternatives. The following direct benefits were taken into consideration for the economic analysis of the alternatives:

- Incremental agricultural benefit including crop, livestock, and aquaculture,
- Hydropower generation,
- Domestic and industrial water supply, and
- Flood damage mitigation

Based on the estimated benefits and costs of the alternatives, economic viability was examined by cost-benefit analysis applying the discounted cash flow method. The results of the economic analysis of the alternatives are shown in Table 10.1. As a result of the analysis, almost all the alternatives except "without dam alternatives" indicated sufficient economic efficiency with EIRR of more than 14%. Among the alternatives, I-1.3B indicated the largest Net Present Value (NPV) of US$92.4 million and can be evaluated as the most effective scheme from the economical point of view. Economic benefits of the alternative are summarized below:

Annual Economic Benefit of Alternative I-1.3B

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 economic cash flow of the alternative is presented in Table 10.2 and the results of the economic analysis of the alternative is summarized blow:

Results of Economic Analysis of Alternative I-1.3B

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%.

Sensitivity analysis has been examined for the alternative I-1.3B in several cases of increase in costs and decrease in benefits. The results of the analysis are shown below:

Sensitivity Analysis for Alternative I-1.3B

Case	EIRR (%)	B/C ratio	NPV (US$ m)
a) Base estimate	15.1	1.52	92.4
b) Cost increase of 10%	13.8	1.38	74.6
c) Cost increase of 20%	12.7	1.27	56.7
d) Benefit decrease of 10%	13.7	1.37	65.3
e) Benefit decrease of 20%	12.2	1.21	38.2
f) Combination of c) and e)	10.1	1.01	2.6

The alternative indicated sufficient economic efficiency even under the conditions of increase in costs and decrease in benefits by 20%. Therefore, the project is viable from the economic point of view.

Other than benefits discussed above, various effects are expected by implementation of the project as listed below:

- Creation of new job opportunity during construction: 5,400,000 man-days,
- Contribution to national food security,
- Reduction of food import and saving foreign exchange holdings,
- Improvement of self-sufficiency and nutritional level of rural farmers,
- To narrow the earnings differentials among regions,
- Convenience of rural population by improvement of access roads to the dam sites and the roads may reduce the cost of moving produce from the farm to the consumer,

- Improvement of public health and quality-of-life by supplying better quality water including decrease of water-related disease,
- To ease the water carrying works,
- Groundwater recharge, and
- Stabilization of rural farmers' livelihood and prevention of influx of rural population into urban areas.

The benefits listed above are very valuable, they are nevertheless virtually impossible to value satisfactory in monetary terms.

10.3.2 Financial Evaluation

Financial evaluation has been conducted for the alternative I-1.3B. The financial feasibility of the alternative is evaluated by examining repayment capability of the capital cost, coverage capability of O&M and replacement costs for the projects based on a financial cash flow statement using the anticipated project revenue and fund requirement.

(1) Basic Conditions of Financial Evaluation

The basic conditions of estimation is summarized below:

- 2001 constant price is used for all the cash outflow and inflow,
- 85% of the capital costs are assumed to be financed by international or bilateral financial institution as far as the costs are eligible items. The non-eligible items are costs for land acquisition, house compensation, administration, and any types of taxes and duties.
- Assumed condition of finance is with an interest rate of 1.8% per annum for repayment period of 30 years including a grace period of 10 years
- Required operation and maintenance (O & M) cost are assumed as follows based experience of similar projects:

Financial O & M Cost

Item	Rate for capital cost
- Civil construction for dam, irrigation, and flood control	0.5%
- Mechanical facilities for irrigation	1.5%
- Hydropower facilities	1.5%
- Domestic and industrial water supply	5.0%

- The following replacement costs are assumed for replacement of facilities after their lifetimes:

Financial Replacement Cost

Item	Replacement
- Mechanical and electrical facilities for dam and hydropower generation	after 25 years
- Pumps and gates for irrigation	after 25 years
- Mechanical facilities for flood control	after 25 years
- Wooden gate for flood control	after 10 years
- Water supply facilities	after 30 years

- As irrigation fee, weighted average fee of the latest tariff in Binh Dinh Province, VND274,488/ha/crop, has been used,
- As electric charge, EVN's tariff for domestic firm, 5.2 US Cents/kWh has been used.
- As domestic and industrial water charge, VND2,000/m^3 for domestic use and VND3,500/m^3 for industrial use are applied.

(2) Results of Financial Evaluation

The financial cash flow statement of the project based on the above basic conditions is presented in Table 10.3. From the financial cash flow statement, the following matter became evident:

- Irrigation water charge 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 for dam, irrigation, and flood control after their lifetime, government financial support will be necessary.

If a soft loan is available, implementation of the project is financially possible.

10.4 Priority Projects for Feasibility Study

10.4.1 Implementation Schedule

A realistic implementation schedule in due consideration of the importance and urgency of each facility, a reasonable fund arrangement, necessary preconstruction procedures and necessary time for construction work, etc. is examined and proposed as shown in Figures 10.1 and 10.2.

The Dinh Binh Dam is the most important and urgent facility for the mitigation of flood damages and solution of water shortage problems in the basin, and is proposed to be implemented at the earliest. However, its realistic time of completion will be in 2011, considering the necessary process as shown in Figure 10.1.

The river improvement/ dyking system is proposed to be implemented, following the completion of the Dinh Binh Dam in consideration of fund arrangement.

Although the irrigation and drainage facilities as well as the domestic and industrial water supply facilities are considered to be executed in a long span up to the year of 2020, the important structures or works such as the Van Phong Weir, rehabilitation and improvement of the existing function, etc. are proposed to be put into execution in the earlier stage.

10.4.2 Priority Projects for the Feasibility Study in Phase 2-3

Following formulation of the Integrated River Basin Management Plan, the Feasibility Study is to be conducted in early part of 2003 for the priority projects to be selected.

Considering the keen requirement for the flood control and agricultural development of the basin, the following three (3) projects are proposed to be selected as the priority projects for the Feasibility Study in Phase 2-3:

(i) Dinh Binh Multipurpose Reservoir Project,

(ii) Flood Control Project in the Downstream Reaches of the Kone River Basin, and

(iii) Van Phong Weir as well as Irrigation and Drainage Systems

(1) Dinh Binh Multipurpose Reservoir Project

A feasibility study was already conducted for the Dinh Binh Multipurpose Project by HEC-1. Its feasibility report was prepared in 2000. However, it did not consider the full protection of the objective flood in combination with the flood control measures in the downstream reaches of the basin.

The Study for the Integrated River Basin Management Plan which considered the optimum development of the whole basin revealed that the Dinh Binh Dam with a scale larger than the presently proposed scale would be more justifiable as the whole river basin plan in combination with the downstream flood control facilities and also from the aspect of water supply purpose. Thus, a full review on the present feasibility study is considered indispensable.

(2) Flood Control Project in the Downstream Reaches of the Kone River Basin

The Dinh Binh Dam will greatly contribute to the flood control purpose. However, the objective flood for flood control purpose, which is 5 % probable late flood with the flood peak discharge of 1,960 m^3/s at Dinh Binh Dam site of 1,040 km^2 in catchment area and 2,997 m^3/s at Binh Thanh of 2,250 km^2 in catchment area, respectively, is not possible to be fully controlled with only the Dinh Binh Dam, requiring to consider the full protection of the objective flood in combination with the flood control measures in the downstream reaches. The Study for the Integrated River Basin Management Plan examined the optimum combination of the downstream flood control plan with the Dinh Binh Dam. Following the said study, a feasibility study to further materialize the downstream flood control plan should be conducted towards fulfillment of the flood control target of the basin.

(3) Van Phong Weir as well as Irrigation and Drainage Systems

Irrigation development is one of the most important targets together with the flood control of the basin.

The basin's economic development target aims at the irrigation development from the present 24,400 ha to 54,500 ha in total in the year of 2020. The above irrigation development additionally includes the irrigation development of the adjacent La Tinh River basin.

Under the above development target of the basin, the irrigation system to meet the target should be studied in detailed including the Van Phong Weir which will play an important role in the irrigation system of the basin.

CHAPTER 11 CONCLUSIONS AND RECOMMENDATIONS

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.