Appendix D

Environment

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1 ADDITIONAL DATA COLLECTION AND ANALYSES

1.1 Collected Data and Information

The status of data collection in relation to environment is summarised below:

Data and Information on Environment Collected

Category		Contents collected
Natural Environment	Existing EIA Study	Environmental Impact Assessment for the Ta Trach Reservoir Project in Thua Thien Hue Province conducted by MARD
	Ecology	Study on Stabilisation and Restoration of Thuan An – Tu Hien Estuaries Inventory of flora and fauna with description on characteristics by province List of precious species in Huong river basin
	Protected Area	Description on current conditions of Bach Ma National Park
	Water Quality	Current conditions (physical, chemical and biological conditions) of Huong river system Current conditions (physical, chemical and biological conditions) of Tam Gian – Cau Hai Lagoons
	Saline Water Intrusion	Current condition of saline water intrusion on Huong river with seasonal expansion
Social Environment	Land Acquisition and Resettlement	Resettlement action plan on Ta Trach Reservoir project
	Fishery	Current conditions on fishery and aquaculture in fresh and brackish water in Huong River basin
	Inland Waterways	Overview of inland waterway aspects in Huong River basin
	Forestry	Current conditions on forest and forestry product
	Health and Sanitation	Current conditions on health and sanitation
	Cultural and Historical Heritage	List of cultural and historical environmental sites in Huong River basin
	Ethnic Minorities	Current conditions on ethnic minorities
	Others	Current conditions on noise and ambient air

1.2 Major Analyses

Analyses were made aiming at the understanding of the current situations of both natural and social environments as well as the identification of current issues/problems based on the collected data/information. The following are the environmental fields focused on for the analyses.

(1) Natural Environment

- Environmental policy/strategy of Thua Thien Hue Province.
- Review of existing Study, including EIA study and study on lagoon ecology.
- Precious Species, including endangered, vulnerable, threatened and rare

species
- Bach Ma National Park, including current conditions of forests, flora and fauna
- Water Quality, including physical, chemical and biological conditions
- Saline Water Intrusion
- Maintenance Flow

(2) Social Environment

- Review of resettlement action plan on Ta Trach Reservoir project
- Inland fishery and aquaculture
- Inland waterways, including network and transportation status
- Forestry, including usage of forest resources/product
- Health and sanitation, including the conditions on water-borne diseases and safe-water accessibility
- Cultural and historical heritage such as protected sites
- Ethnic minorities, including their distribution and living status

Besides, major laws and regulations related to environment are enumerated in Table D.1.

2 REVIEW OF LAGOON ECOLOGY SURVEY

2.1 General

Tam Giang-Cau Hai lagoon covers a surface water area of 22,000 ha, the largest one in Southeast Asia, extending along Thua Thien Hue coastline with the total length of 60 km (Refer to Figure D.1). The lagoon system consists of Tam Giang-Cau Hai lagoon system and Lang Co swamp. Tam Giang-Cau Hai lagoon system is often divided into 3 main areas: Tam Giang lagoon in the north, Sam-An Truyen swamp and Thuy Tu swamp in the middle, and Cau Hai swamp in the south.

The Tam Giang-Cau Hai lagoon has two mouths at the moment: Thuan An mouth and Tu Hien mouth. These mouths have been repeatedly closed and opened over the past years. During the flood in November 1999, Hoa Duan mouth was newly opened as the result of the destruction of the sandbar located between the East Sea and the Sam- An Truyen swamp.

The Vietnamese Government conducted "the Study on Restoration and Stabilization of Thuan An - Tu Hien Estuary (RSTATHE Study)." The study was conducted from May 2000 through May 2001. The objective of the study was to predict the positive and negative impacts of the closure of the Hoa Duan mouth,

and to formulate the countermeasures for the negative impacts brought about by the closure. However, the former MOSTE had decided to close the Hoa Duan mouth in August 2000 before the study has completed. The objective of the study, therefore, was changed to obtain a scientific foundation of comprehensive solution for this area where there is a sequence of river, lagoon/swamp and the sea, including such natural condition/phenomenon as flooding, the development of lagoon and marine hydro-dynamics, aquatic ecosystem and socio-economic conditions.

The report is composed of one master plan and 13 thematic reports, including history of lagoon development, geography, geology, ecology, marine hydrodynamics, flood and mathematical models, coastal line development, coastal line emergency countermeasures, socio-economic condition, survey on hydro-topography and so on.

The study is the first scientific study reviewing and summarising all the previous researches, and at the same time, it is the first formulation of systematic report on environment of this area. The members of the study team were composed of dozens of scientists from 5 ministries and 15 scientific institutes.

Amongst the thematic study, the lagoon ecology is included as one of the 13 themes. The scope of work includes: environmental condition, biological inventory, fisheries and socio-economic conditions.

2.2 Review Result

2.2.1 Lagoon Environment

In order to figure out proper measures for conservation and stabilization of Tam Giang - Cau Hai lagoon system, impacts of unstable estuaries on the lagoon environment and natural resources have been researched and analyzed as one of RSTATHE Study. A thematic report, "Impacts of the Destabilization of Lagoon Estuary on Tam Giang – Cau Hai Environment and Resources", was prepared in April, 2000. The study results are summarized in Table D.2 and presented below:

(1) Environmental and Nutrient Factors

Temperature

The average water temperature in the cold season and the rainy season is 20.5 ^{0}C with the fluctuation ranging from 15.1^{0}C to 24.1^{0}C, and 29.1^{0}C with the fluctuation ranging from 26.2^{0}C to 30.0^{0}C. Temperature differences in the lagoon were observed at boundaries of the currents, namely, at the conjunction of river flows and tides with the maximum differences up to 3-4 ^{0}C, specifically at

the areas from O Lau river estuary to Thuan An estuary, from Hoa Duan estuary to Vinh Hung and adjacent to Tu Hien estuary.

pH and DO

Lower pH is often observed in the area from O Lau river estuary to An Gia with the range from 6.5 to 7.5, whereas other areas have the pH value ranging from 7.6 to 8.2. This indicates that the lagoon has fairly strong interactions of tides from the sea except for the area from O Lau river estuary to An Gia (The value of pH of seawater is noticed as 8.1±0.2 globally).

DO in the lagoon in 1999 and 2000 ranged from 5.3 to 8.4 mg/l and 4.9 to 8.0 mg/l, respectively. This DO concentration, on the whole, satisfies the requirement of aquaculture breeding.

COD and BOD_5

The average COD in the whole region varies from 6-12 mg/l, whereas the average BOD_5 about 0.5-1.0 mg/l. Because of the low COD and BOD_5 in the whole lagoon, environmental pollution by organic matter is not worth worrying. However, there are some locations with high COD concentration up to 25 mg/l.

Salinity

Salinity before the 1999 Flood: When Tu Hien estuary was silted up in March 1979, only Thuan An estuary affected the saline concentration in the lagoon. The Tu Hien estuary which was then dredged to open to Chan May Tay Strait, the salinity went up, but the impacts on Cau Hai area were not so powerful that the salinity near Tu Hien estuary was not as high as in the area near Thuan An estuary.

Tam Giang – Cau Hai lagoon system was able to be divided into sub-regions on the basis of salinity as follows (This division is basically applicable even at present.):

- Sub-region I: the part near O Lau river mouth where the environment shifted from fresh brackish (salinity less than 0.5 ‰) to moderately brackish (salinity from 5 to 18 ‰),
- Sub-region II: the part from Dam market to An Gia where the environment shifted from fresh brackish to softly brackish (salinity from 0.5 to 5 ‰), moderately brackish, and
- Sub-region III: the part from Tu An Xuan to Thuan An estuary, from Sam-An Truyen to Tu Hien estuary where the environment shifted from fresh brackish to softly brackish, moderately brackish, heavily brackish (salinity from 18 to 30 ‰).

Tam Giang – Cau Hai lagoon environment changed in the rainy and dry seasons, showing the two corresponding periods: de-salinity (dilution) and salinity intrusion. De-salinity period lasted longer than the salinity intrusion. The lagoon was drastically affected by freshwater intrusion in October and November and then the seawater began to intrude and affected on the lagoon in January and February, resulting in the highest level of salinity from April to August or September.

Salinity after the 1999 Flood: The disastrous flood in November 1999 destroyed the estuary bank, forming new lagoon mouths, of which Hoa Duan and Tu Hien estuaries at the foot of Linh Thai Mountain are remarkable. As a result of the combined effects of Hoa Duan and Thuan An estuaries, the salinity of Sam-An Truyen rose. However, its salinity difference before and after the opening of the estuaries is not significant; its highest salinity did not exceed 28 ‰. It is obvious that the Huong river still considerably dominates this area.

In the north of Thuan An estuary, the interactions of tides through Thuan An and Hoa Duan estuaries did not create a remarkable increase in salinity, varying from 20 to 24 ‰. The O Lau river mouth and neighbouring area still keep the salinity stage unchanged. This is the unique part of the lagoon where the salinity stage is low and stable over years with small difference between rainy and dry seasons.

Cau Hai area was affected by the sea through Tu Hien and by intakes of freshwater from rivers in the north west of the swamp. As a result, salinity is very low, but unlike O Lau river mouth, it undergoes huge impacts from the sea through Tu Hien estuary; the salinity surges up to or over 10 ‰. Thuy Tu area was notably affected by the appearance of Hoa Duan estuary, particularly in the area from Vinh Xuan to Vinh Hung.

In conclusion, in respond to the 1999 flood, Hoa Duan mouth was newly opened. The appearance of Hoa Duan mouth, however, has not converted Tam Giang – Cau Hai lagoon into a heavy brackish water body in whole, but it has brought about some changes. On the basis of salinity change affected by Hoa Duan and Tu Hien lagoon mouth, the lagoon can be divided into the following three sub-regions:

- The area with nearly unchanged salinity despite the appearance of newly opened Hoa Duan mouth: stretching from An Gia to O Lau river mouth.
- The area of slightly changed salinity to be affected by Hoa Duan mouth: stretching from the north of Thuan An estuary to An Xuan.
- The area of greatly changed salinity as a result of Hoa Duan and Tu Hien mouths: the large area including Sam-An Truyen, Thuy Tu and the whole Cau

Hai area.

(2) Biological inventory

Inventories of Some Biological Groups

A total of 438 species of major biological groups have been identified in Tam Giang – Cau Hai swamp as divided in the following:

- Phytoplankton: 357 species in 6 divisions, namely:
  + Cyanophyta (Cyanobacteria) division: 19 species;
  + Heterokontophyta division: 241 species;
  + Chromophyta division: 3 species;
  + Dinophyta division: 72 species;
  + Euglenophyta division: 2 species; and
  + Chlorophyta division: 20 species.
- Aquatic plants and sea grasses: Magnoliophyta division; 16 species.
- Zooplankton: 43 species in 2 divisions, namely:
  + Arthropoda division: 33 species and
  + Asthlminthes division: 10 species.
- Benthic macrofauna: 21 species in 3 divisions, namely:
  + Annelida division: 13 species;
  + Aethropoda division: 6 species; and
  + Mollusca division: 2 species.

Changes in Biological Inventories Made by New Estuaries

After the Tu Hien estuary was silted up in 1979, the whole Cau Hai environment was strongly desalinated, causing a rapid change of inventories of flora and fauna. Creatures of sea origin have vanished and have been substituted by fresh water and by some softly brackish ones. In this respect, the most dominant phenomenon was the fast growth of *Cyrimus centralus* and aquatic grasses. The aquatic grasses with fresh and brackish water origin became abundant throughout Cau Hai area. They had grown to such big size that was an obstacle to navigation.

Consequently, a string of *Penaeus monodon* and *gracilaria* breeding ponds at Vinh Hien and Vinh Giang had become not to be suitable for aquaculture, which resulted in a stop of the operation of some aquatic activities. This indicate that if the sea influence on the lagoon was weakened and the salinity dropped below 12 ‰, it would make a water body poor in biodiversity, rich in the living mass of high-class aquatic grasses and unsuitable for *Penaeus monodon*, *gracilaria* and crab breeding.

The 1999 flood and the formation of new estuaries has triggered the increase in the average lagoon salinity. Under the newly created environment by the estuaries, biological composition has undergone many changes as summarized below:

Phytoplankton: There exist a quite obvious difference in the number of phytoplankton species and density before and after the 1999 flood. With regard to the number of species, the major components in the lagoon are *Bacillariphyceae* and *Dinophyceae*. The number of *Dinophyceae* climbed by 5, 12 and 13 species at the mouth of the Truoi river, near Thuy Tu and Tu Hien estuary, respectively. The number of *Bacillariphyceae* also went up by 27 species, but concentrated only at Tu Hien estuary. In Thuy Tu area, the dominant species shifted to *Chaetoceros*.

Before the flood, Cau Hai area was considered poor in phytoplankton in terms of species and density, except a limited area at Tu Hien estuary. After the creation of Hoa Duan and expanded Tu Hien estuary, its density soared up largely due to the dominant growth of *Prorocetrum*, a kind of *Dinophyceae*.

To conclude, the change in the lagoon environment brought about by the 1999 flood has affected to the growth and distribution of phytoplankton: *Dinophyceae*, especially *Chaetoceros* at Thuy Tu and *Prorocentrum* at Cau Hai have expanded its distribution area and have higher average density.

Aquatic Grasses: The distribution of aquatic grasses at Tam Giang – Cau Hai lagoon indicates that it strongly depends on salinity values; the number of species shrinks from river mouths to sea estuaries. The lagoon can be divided into three regions:

- Regions affected by fresh water: river mouths of O Lau and Truoi rivers where *Valisneria spiralis, Najas indica* diperse from the banks to the middle of lagoons.
- Regions affected by the sea: the area near Tuan An and Tu Hien estuaries where *Cymmodocea rotundata, Halophylla ovalis* disperse from the banks to the point with the depth of 1.5 m.
- Intermediary regions between the above ones: *Halophylla beccari* flourishes along the banks to the point with the depth of 2 m and *Najas indica, Ruppia maritaima* distribute at the middle of the lagoon.

Dominant species observed by the area and its characteristics are as follows:

- Even after the 1999 flood, there remained those species: *Valisneria spiralis, Potamogeton malaianus, Hydrilla verticula* and *Ceratophyllum demresum* from O Lau to An Gia, and *Cymmodocea rotundata* from An Xuan to Thuan An estuary.

- Thuy Tu has similar characteristics, but *Halophylla beccari, Najas indica, Valisneria spiralis* are prevailing in the north area from Vien Trinh to Vinh Hung. However, these species have vanished due to the higher salinity.
- Cau Hai area has almost no aquatic grass cover but *Valisneria, Najas, Halophila* and *Potamogeton* are seen. Currently, they survive only in the form of limited bands near Truoi and Cong Quan river mouths.

Meanwhile, the noticeable changes in the sea grasses are recognized at Cau Hai area, reflecting the higher salinity brought about by the appearance of new lagoon mouths.

Zooplankton: No significant changes in the species composition have been found before and after the 1999 flood. Its density and distribution areas have experienced some changes: the most densely populated area was formerly stretching from An Gia to Thuan An, but now it tends to move to the south, from An Xuan to Thuan An. The remaining areas, from Hoa Duan to Cau Hai swamp, have lower density.

Copepoda is the dominant species in the lagoon, accounting for a large ratio after the formation of the new estuaries.

Benthic Macrofauna: Thirteen species identified are in annelid group, six in crustacean, and two in mollusk group. *Dendronereis arborifera, Ceratonereis mirabilis* are recognized to appear at Thuan An in the new environment after the 1999 flood. Besides, *Anomura* was seen for several times at Thuan An and Hoa Duan estuaries. *Dendronereis arborifera, Caratonereis mirabilis* are widely distributed over the whole Cau Hai swamp.

With the formation of the estuaries, the density of benthic macrofauna has multiplied from hundreds of individuals/m^3 to thousands of individuals/m^3, i.e. 30 to 50 times higher.

(3) Fisheries

Fish Catch

According to an expert of Department of Fishery, Thua Thien Hue province, current fish catch is on the increase compared to that before the 1999 flood, particularly that of *Metapenaeus ensis, Mugil spp., Scylla serrata, Penaeus semisulcatus, Siganus spp., Penaeus monodon, Epinepelus spp., Meretrix meretrix, Mactra quadragularis* shown in the table below. However, there are some species of which fish catch has fallen, including *Cyprinus centralus* and *Caridina sp.*.

It is asserted that the formation of new lagoon mouths has increased the aquatic

fish breeds within the lagoon as the new lagoon environment with higher salinity facilitates their growth, bringing about bigger catch outputs.

Table: Comparisons of catch outputs at Tam Giang - Cau Hai lagoon before and after the presence of new estuaries (in 1999 and 2000)

Caught items	1999		2000	
	Catch output (kg/month)	Percentage (%)	Catch output (kg/month)	Percentage (%)
Cyprinus centralus	5,120	16.63	1,570	2.17
Metapenaeus ensis	1,375	4.47	9,167	12.66
Mugil spp.	640	2.08	5,114	7.07
Scylla serrata	576	1.87	3,589	4.96
Metapenaeus ensis	533	1.73	3,735	5.16
Siganus spp.	478	1.55	3,332	4.60
Penaeus monodon	171	0.56	12,495	17.26
Epinepelus spp.	110	0.36	835	1.15

Source: Impacts of the destabilization of lagoon estuary on Tam Giang-Cau Hai Environment and Resources, April 2001.

Aquaculture

With the appearance of Hoa Duan and Tu Hien estuaries, the salinity stage in the lagoon system has been lifted up on an extensive scale although its values did not rise up to the sea level. Additionally, the time for the restoration of salinity values after the rainy season has been significantly shortened. In light of aquaculture, therefore, the new environment characteristics have provided for great positive impacts even though there are some adverse effects raised, including direct impacts of waves, wind and tides through the Hoa Duan estuaries on aquaculture activities and its production loss.

Based on the current situation of aquaculture activities comparing those before and after the formation of new estuaries, the impacts of the formation are summarized below:

Table: Some impacts of the opening of Hoa Duan and Tu Hien estuaries on major aquaculture areas in Tam Giang – Cau Hai lagoon

Affected areas, communes	Negative impacts	Positive impacts
O Lau	—	—
An Gia – An Xuan	The appearance of 6-whinsker shrimps scrambling food with bred species.	Prompt restoration of salinity values after the rainy season may help increase the number of crops (production time) a year.
Phu Thuan	High salinity triggers difficulties in the culture of shrimps for food.	Suitable for culture of young shrimp breeds.
Sam-An Truyen	Powerful waves, wind and flows destroy outward rounded up ponds. Increased occurrence of unsuitable water quality in breeding ground. Difficulties in the culture of gracilaria have resulted in difficulties in dorab culture. Appearance of 6-whinsker shrimps.	Greater water exchange in culture ponds.
Vinh Hung – Vinh Giang	Amplified.	Greater salinity is suitable for the culture of Penaeus monodon, no need to intake saline water from drilled boreholes.

Source: Impacts of the destabilization of lagoon estuary on Tam Giang-Cau Hai Environment and Resources, April 2001.

(3) Summary of the Impacts of Unstable Estuaries on the Lagoon Ecology.

As results of the study on the impacts of unstable estuaries on Tam Giang – Cau Hai lagoon system, the following conclusions were obtained:

- Although the presence of Hoa Duan and Tu Hien estuaries does not lead to a higher peak in the lagoon, the salinity stage of 15 ‰ or more over an extensive scale and shorter periods for restoration of salinity after the rainy season have been brought about, which have resulted in more favourable condition for fisheries, particularly aquaculture activities.
- The southern part of Thuan An estuary, including Sam-An Truyen and north of Thuy Tu area are clearly affected by Hoa Duan estuary whereas Cau Hai area is strongly dominated by Tu Hien estuary. Areas to the north of Thuan An estuary is almost stable in the face of the newly formed Hoa Duan estuary.
- The southern part of the lagoon tends to shift from a system characterized by the production of aquatic grasses to that of marine phytoplankton and small-sized benthic macrofauna, and from a system characterized by creature preferring soft brackish water to that completely composed of moderately or heavily brackish water ones.

2.2.2 Fishery Activities in Lagoon Area

The socio-economic survey and research were conducted as one of RSTATHE

Study. A thematic report, "Some Issues on Socio-economic Development in Thuan-An – Tu Hien Estuarine Area and Tam Giang – Cau Hai Lagoon (the lagoon socio-economic report)", was prepared in April, 2001. The survey and research focused mainly on the fishery activities in lagoon area, and the outline of results is presented below.

(1) Social Background in Lagoon Area

Tam Giang - Cau Hai lagoon, together with the external coastal area, consists of 5 districts, namely Phong Dien, Quang Dien, Phu Vang, Phu Loc districts, and a part of Huong Tra district. Of those 5 districts, the area relating to coastal and lagoon area is more than 94,000 ha, in which gross agricultural land area is 49,000 ha, and that of sand dunes is 19,000 ha. Its population is approximate 300,000 people accounting for 30% of total provincial population and 50% of population in 5 districts.

The lagoon socio-economic report classified the living standard of the households as the following tables, both on the related district basis and on the economic sector basis.

Table: Living Standard of Households in 5 Districts in Lagoon Area

Unit: %

District	Very high	High	Medium	Low
1. Phong Dien	0.5	19.6	63.6	16.3
2. Quang Dien	0.7	15.0	67.1	17.2
3. Huong Tra	0.5	20.0	65.5	14.0
4. Phu Vang	4.8	26.1	50.6	18.5
5. Phu Loc	2.6	27.0	51.1	19.3
Average of 5 districts	1.8	21.5	59.6	17.1
Total of TT-Hue prov.	2.7	22.3	58.8	16.9

Source: Some Issues on Socio-economic Development in Thuan-An – Tu Hien Estuarine Area and Tam Giang – Cau Hai Lagoon, April 2001.

Note: "Very high" is equivalent to the monthly income of more than 300,000 VND per capita.
"High" is equivalent to the monthly income of 180,000 - 300,000 VND per capita.
"Medium" is equivalent to the monthly income of 70,000 - 180,000 per capita.
"Low" is equivalent to the monthly income of less than 70,000 per capita.

*: The reason is unclear, why the total in this row exceeds 100 %.

Table: Living Standard of Households by Economic Sectors

Unit: %

Sector	Very high	High	Medium	Low
Households mainly engaged in agriculture *	0.6	16.8	66.4	17.2
Households mainly engaged in fishery	4.5	21.3	59.6	14.6
Others	1.8	27.4	56.7	14.1
Average of above sectors	2.3	21.8	60.9	15.3

Source: Some Issues on Socio-economic Development in Thuan-An – Tu Hien Estuarine Area and Tam Giang – Cau Hai Lagoon, April 2001.

Note: The criteria on "Very high", "High", "Medium", and "Low" is same as the former table.

*: The reason is unclear, why the total in this row exceeds 100 %.

(2) Fishery Activities in Lagoon Area

Due to the difficulties, such as saline intruded water/land, in agriculture, fishery sector has been promoted and is the mainstay of economy at present in the coastal and lagoon area. The total households engaged in fishery in lagoon and coastal area amount to approximate 12,000, of which 10,000 - 11,000 are working within the lagoons.

There are three main types of fishery activities, namely fishing within the lagoons, aquaculture within or around the lagoons, and fishing in the coastal/offshore area.

1) Fishing within the lagoons

The following table shows the trend of the number of boats for fishing and its density within the lagoons.

Table Number and Density of Boats within the Lagoons

Unit: nos., nos./ha

	1975	1986	1990	1991	1992	1993	1995	1999
Total boats	2,614	2,723	3,110	3,524	3,862	4,359	4,694	5,665
(w/ engine)	(973)	(842)	(1,014)	(1,166)	(1,243)	(1,383)	(1,528)	(2,797)
(w/o engine)	(1,641)	(1,881)	(2,096)	(2,358)	(2,629)	(2,976)	(3,166)	(2,868)
Density of boats	0.12	0.12	0.14	0.16*	0.18*	0.20*	0.21	0.25

Source: Some Issues on Socio-economic Development in Thuan-An – Tu Hien Estuarine Area and Tam Giang - Cau Hai Lagoon, April 2001.

*: The density was calculated as whole lagoon area of 22,000 ha since no data is available in above report.

The above table shows that, for recent 25 years, the fishing boasts with engine has increased approximately three times, and that the density has been doubled. This indicates that the load or pressure of fishing activities to natural resources of the lagoons goes up remarkably.

The following table shows the trend of catch amount of fishing within the lagoons. The considerable increment of fishing catch amount cannot be recognized in spite of a rise of fishing capability, and the catch per boat seems to decline.

Table Amount of Fishing Catch within the Lagoons

Unit: ton, ton/boat

Year	1966	1973	1979	1985	1990	1991	1992	1993	1995	1996	1997	1998	1999
Amount	4042	4517	2575	2937	2100	2650	2830	2500	2600	2927	2700	2500	2500
Catch per boat	-	-	0.99[1)]	1.08[2)]	0.68	0.75	0.74	0.57	0.55	-	-	-	0.44

Source: Some Issues on Socio-economic Development in Thuan-An – Tu Hien Estuarine Area and Tam Giang - Cau Hai Lagoon, April 2001. ("Catch per boat" is calculated by JICA Study Team.)
1): The number of boats for calculation is as of 1975.
2): The number of boats for calculation is as of 1986.

The fishing in the lagoon was being enhanced for more than 10 years under the motivation of market economy, although total catch stagnated or followed a decrease trend. According to the lagoon socio-economic report, the followings are reasons why the investment (i.e. the number of boats) is increasing in spite of decreasing the productivity (catch per boat) within the lagoons:

- The unit price of fishing product has been boosted up due to the open-door policy of the country.
- The economic activities in other sectors are less effective than that in fishing, as the survey of RSTATHE study shows that the households working in fishery sector gain higher income than those working in agricultural sector.
- It is considered that a re-distribution of benefits among fishermen is in progress, and that investment for fishing still brings about higher benefit.

The number of the households who live on the boats within the lagoons is about 1,400 or more, equivalent to more than 10,000 people. They are engaged mainly in the fishing within lagoon, and their living standard and literacy level remain considerably low. They can meet the catch amount of fishing equivalent to 10,000 – 40,000 VND/boat/day, and the income per capita of them meets approximate 100,000 VND or less per month

2) Aquaculture within/around the Lagoons

Aquaculture within/around the lagoons has been started with planting seaweed since 1977. And at present, shrimp breeding becomes flourishing in addition to seaweed planting. The situation of aquaculture is shown in the table below.

Table Situation of Aquaculture in Tam Giang- Cau Hai lagoon

Year	1993	1995	1996	1997	1998	1999
Shrimp/fish breeding area (ha)	437	830	1,102	1,162	1,298	1,628
Seaweed area (ha)	357	396	437	437	437	437
Total product of aquaculture (ton)	800	1,043	1,208	1,248	1,239	1,400

Source: Some Issues on Socio-economic Development in Thuan-An – Tu Hien Estuarine Area and Tam Giang - Cau Hai Lagoon, April 2001.

The increase rate of the total product is approximate 8 % annually from 1993 to

1999, and 2,700 – 3,000 households are engaged in the aquaculture within/around the lagoons.

There are mainly two types for aquaculture. One is to utilize the water surface within the lagoons by fencing physically, and the other is to utilize the area adjacent to the lagoons which was used for planting paddy originally. According to the lagoon socio-economic report, the first method can generate the income of 280,000 VND/month/labor at maximum. However the benefit/income generated the second method is unclear in the report.

3) Fishing in Coastal/offshore Area

The following table shows the trend of the number of boats and catch amount regarding the coastal/offshore fishing.

Table Number of Boats (w/ engine) for Coastal/offshore Fishing

	1995	1996	1997	1998	1999
Total boats (nos.)	1,884	1,924	2,003	2,208	2,250
Total catch amount (ton)	9,117	9,907	11,110	12,800	14,000
Catch per boat (ton/boat)	4.8	5.2	5.6	5.8	6.2

Source: Some Issues on Socio-economic Development in Thuan-An – Tu Hien Estuarine Area and Tam Giang - Cau Hai Lagoon, April 2001. ("Catch per boat" is calculated by JICA Study Team.)

The increase rate of the total catch amount is approximate 11 % annually from 1995 to 1999. The rapid development is mainly brought about by the enhancement and promotion of offshore fishing. And the offshore fishing is also lessening the coastal fishing density and is expanding the employment. The lagoon socio-economic report shows the financial situation of 46 offshore fishing boats in 1999 based on the field survey; i) catch amount of 46 boats is 2,830 ton, ii) revenue is 8,890 mill. VND, iii) fishing cost is 6,330 mill. VND, and iv) profit is 2,060 mill. VND. The report judged the offshore fishing to be much attractive and to be a key economic activity in fishery.

(3) Processing Sector on Fishery

In line with fishery development, processing is also following increased tendency as shown in the table below.

Table Trend of Processing Sector on Fishery

Unit: ton

Year	1995	1996	1997	1998	1999	2000
Total processing product	1,328	1,376	1,959	1,550	1,956	2,000
(Frozen products)	(1,159)	(1,045)	(1,636)	(1,200)	(1,529)	(1,550)
(Dried products)	(169)	(331)	(322)	(350)	(427)	(450)

Source: Some Issues on Socio-economic Development in Thuan-An – Tu Hien Estuarine Area and Tam Giang - Cau Hai Lagoon, April 2001.

The increase rate of the total product is more than 8 % annually from 1995 to 1999.

The approximate 500 households take part in the processing activities for domestic demand, and they generate a rather high income, ranging from 15 million to above 140 million VND annually on a household basis.

The data and information on service sector related to fishery is not available, since there has been neither statistic survey nor researches done.

(4) Disadvantage of Agricultural Activities around Lagoon Area

The lagoon socio-economic report briefly touches on the disadvantage of agriculture sector in the area near lagoon.

The report points out 3 reasons why the difficulties are brought about on the agricultural activities, namely, i) saline intruded water/land, ii) flood damage on summer crop and drought damage on winter-spring crop, and iii) poor irrigation system. Agricultural product per capita around the lagoon area has been below 200 kg, including paddy of about 170 kg, on an annual average, which meets equivalence to 25 % of that in Mekong river area and to 60 % of that in Red river. The report suggests that the potential of agricultural activities is rather low around the lagoon, and that this sector would consequently decline.

(5) Conclusion of the Lagoon Socio-economic Report

The main conclusion of the report is summarized as follows from the viewpoint of socio-economic development with sustainability.

- The scale and magnitude of existing fishing activities within the lagoons should be reduced drastically, since the exploitation of natural resources has reached or exceeded the maximum re-productivity of the lagoons. About 50 % of the current fishing load on the resources within the lagoons is to be released for restoration of lagoon re-productivity.
- The aquaculture within the lagoons does not contribute to the common economic growth on the whole fishery sector, since it only redistributes the benefit among the fishermen generated from the potential of natural resources in the lagoons. And the conflict will be introduced between monopolistic fishermen (aquaculture) and free fishermen (fishing). Thus, enhancement of aquaculture within the lagoons is not much prospective.
- It is preferable and acceptable to convert saline intruded paddy field near the lagoons into aquaculture/breeding area, since much higher productivity and advantage is expected. This direction will also contribute to releasing the fishing load on the lagoons.

- The processing/services sector should be enhanced, both through the transformed aquaculture/breeding mentioned above, and through the promotion of coastal/offshore fishing.

2.2.3 Interview Result

An interview to Professor Tran Dinh Hoi, Deputy Director of Vietnam Institute for Water Resources Research, MARD, and at the same time one of the members of the said study, was also carried out in Hanoi on December, 27th, 2001. The key issues of the interview are as follows:

The biggest difference between before and after the 1999 flood is that the formation of the new mouth, Hoa Duan mouth, has brought about the salinity increase. The existence of Hoa Duan mouth is considered to have the following advantages: flood mitigation, good condition for aquaculture and ecological environment.

The Ministry of Fisheries is against to close the mouth for the reason of aquaculture. The Ministry of Transport, on the contrary, agreed with the closure of the mouth, because there was a road over the Hoa Duan mouth formerly, which is essential for local people and economic activity. People's Committee of Thua Thien Hue Province also agreed with the closure of the mouth, because if the Hoa Duan was remained open, Thuan An, a important port for local transportation, and other mouths might be closed naturally. As a consequence, it is likely to cause a serious damage to local transportation activities.

Current problems of the lagoon system comprise of the two: salinity variation and environmental degradation caused by human activities. Regarding the salinity variation, during the dry season in particular, sea water intrudes the lagoon, which makes the salinity higher. On the other hand, during the rainy season or after a heavy storm, flooding spawns the low salinity in the lagoon. This low salinity and the higher variation discourages the potential of aquaculture and constraints its products.

The content of nitrogen and/or phosphorous is increasing gradually although it has not reached a critical range nor the eutrophication has not been recognized yet at this moment. The phenomenon of red tide has been recognized recently.

2.2.4 Review Result of Other Study

A document on the lagoon environment was collected from DOSTE, Thua Thien Hue Province during a field reconnaissance, conducted during December 23rd through 26th, 2001. The review results of it were summarized below:

(1) Biodiversity of Lagoons and Coastal Areas

In the Tam Giang - Cau Hai lagoon system, 620 species of flora and fauna groups have been recorded as of late 1998. In comparison with other ecosystems of the same kind in Vietnam, the ecosystem in the Tam Giang - Cau Hai lagoons is rather abundant in number of species recorded.

(2) Benefits of Aquatic Flora and Fauna

Many creatures in the lagoon are of economic value for natural exploitation, fishery, breeding and processing. The 4 basic groups are seaweed, prawn and crab, mollusc and fish. For example, it was discovered that there are 12 kinds of prawn, 18 that of crabs with highly nutritious and economic value in the Tam Giang – Cau Hai lagoon system. Prawns and crabs are naturally exploited or breeding in ponds, cages. Prawns/crabs breeding is a new way of earning money appearing since the beginning of this decade with 71.4 ha in 1991, by the early 1999 the total prawns/crabs breeding area was multiplied by 20 times, reaching up to nearly 1500 ha. The output of breeding prawns/crabs from ponds has also increased rapidly.

However, the above benefits of aquatic flora and fauna are so seriously decreasing that some are running the risks of extinction. According to local fisher folks, fish catch of each household every night is 100 times fall in this 2 decades. It is clear that besides the advantages of aquaculture exploitation and processing, the daily pressure has pushed exploitation excessive its natural recovery. The number of means of catching and laborers has rapidly increased in the last years: For instance, in 1984 there were 450 fish traps, but in 1997 the figure expanded up to 2078. Furthermore, the means of exterminating catching, such as thick nets, dynamites, potential pulse are still being used publicly or secretly. According to the statistics of Thua Thien Hue branch office for the preservation of aquatic flora and fauna benefits, in 30 villages near the lagoon, there have been 2,159 sets to catch fish by potential pulse. Although the branch office has tried to stop this situation but the result is not desirable.

(3) Water Quality

The Tam Giang- Cau Hai lagoon system is open to 2 mouths, they are Thuan An and Tu Hien. They are all unstable mouths with tendencies of shrinkage, occlusion or transformation. Due to this characteristic, the water quality of it is unstable.

Temperature

The temperature of the water in the lagoon is changing between 20-30 ^{0}C. In the

sunshine season, the temperature of water in the bottom level is lower than that of the surface water, however, since the depth of water in the lagoon is not high (often ranging from 1-2 m, in the deepest place in Thuan An mouth, it is only more than 10 m), so the temperature stratification is not remarkable.

Suspended Solid

Suspended solid of the lagoon varies in a wide range from 0 to 34 mg/l. The turbidity of water depends on many different things, such as wind, wave, depth, etc. Generally speaking, suspended solid is on the increase in the rain season and down in the dry season.

pH

The value of pH of water in the Tam Giang- Cau Hai lagoon varies in the range of 5.6- 9.3. The range of pH in the rainy season is higher than that in the dry season. It is high and comparatively stable in Lang Co swamp and Thuan An and Tu Hien swamp. In general, it changes in accordance with salinity change and therefore the salinity stratification (Salinity in the surface area is lower than that in the bottom area) occurs in some areas in the lagoon.

Salinity

Salinity in the lagoon system depends on many things such as season, location and water level, ranging from 0 to 32.2 ‰. The highest salinity was in Lang Co mouth (32.2‰) and Thuan An mouth (27.4‰). Salinity decreases gradually when coming into the lagoon.

The seasonal vibration of salinity is as follows: In the dry season, average salinity vibration range is 5 to 10‰ in every location. In the rainy season, desalination occurs in almost all the lagoons except for Lang Co swamp. The average salinity in the whole region, except for Lang Co swamp is very low, about 0- 6‰. In Tam Giang lagoon and Cau Hai swamp, salinity stratification is remarkable. On the other hand, especially after heavy rain, or storms, the salinity in the Lang Co swamp is 20- 22‰.

Dissolved oxygen (DO)

DO of the lagoon varies in a range from 5 to 10 mg/l. Sometimes, however, DO below 2.5 mg/l was recorded in Cau Hai swamp. In general, DO of the water in Cau Hai swamp is slightly lower than that in the Tam Giang and Thuy Tu area. However, according to the standards of coastal water quality, TCVN 5943- 1995, there is no shortage of DO in the water of the lagoon, and the water can be used completely for the purpose of aquaculture (limited DO is 5 mg/l).

The demand of chemical oxygen (COD) and biochemical oxygen (BOD_5)

COD in the lagoon ranges from 2.7 to 24.0 mg/l, and BOD_5 ranges from 0.1 to 7.3 mg/l. According to the research results, the following conclusions were obtained:

- The average COD and BOD_5 obtained in 1995 was higher than that obtained in 1993, suggesting that there is a tendency of organic pollutants increase in the lagoon.
- COD in the lagoon tends to increase in the estuaries (it is noticeable in Huong river), and coastal regions (especially in Thuy Tu swamp).
- According to the research results in November, 1995, the water bodies can be arranged in a descending order of COD and BOD_5: Thuy Tu (COD = 4.01 mg/l; BOD_5 = 2.14 mg/l) > Cau Hai (3.82 mg/l; 1.85 mg/l) > Tam Giang (2.89 mg/l; 1.23 mg/l).

Content of N- NO_3 and P- PO_4

The average low concentration of N-NO_3 and P-PO_4 shows little possibility of fertile substances in the water source. The research results show that after floods and rains the content of N-NO_3 and P-PO_4 in the water of the Tam Giang- Cau Hai swamp area suddenly increases remarkably, indicating that there contained some nutrients in water from cultivated fields. Further, this implies the possibility that a remarkable amount of more dangerous pollutants can be brought into the lagoon through the water from the cultivated area, such as insecticides and fertilizers.

2.2.5 Evaluation and Recommendations

(1) Evaluation of Lagoon Ecology

Tam-Giang – Cau Hai lagoon covers a surface water area of 22,000 ha, the largest one in Southeast Asia, extending along Thua Thien Hue coastline with the total length of 60 km. The lagoon can be divided into three areas: Tam – Giang Lagoon in the north, Sam – An Truyen swamp and Thuy Tu swamp in the middle and Cau Hai swamp in the south. Reflecting its variety of natural environment, the ecosystem in the lagoon is rather wealthy in the number of species recorded in comparison with other lagoon system in Vietnam.

The lagoon is currently open to the sea through two mouths: Thuan An and Tu Hien. Both of them are unstable and have been repeatedly incurring the shrinkage, occlusion or transformation. In addition, during the destructive flood in November in 1999, Tu Hien mouth was extended and the new mouth was created at Hoa Duan located south of Tuan An estuary, although the Hoa Duan estuary is closed again currently.

The lagoon system has the characteristics that the water quality varies with location and is easily affected by the fluctuation of river discharge and tide. Water quality in the lagoon is suitable for aquatic organisms at present and satisfies the requirements of aquaculture breeding in terms of such indicators as pH, DO, COD and BOD. According to the interview to local fishermen, however, water quality has been degraded caused by human activities and there was the presence of red tides in 2000, which shows a sign of threatening the aquatic ecology and reducing the fish catch.

Salinity is one of the determinants of the distribution and growth of salty water flora and fauna in the lagoon where the environment constantly changes under the process of river and sea interaction. On the basis of the salinity data, the lagoon can be divided into the following three sub-regions: 1) the area with almost unchanged salinity (the area from An Gia to O Lau river mouth), 2) the area of slightly changed salinity (the area from the north of Thuan An estuary to An Xuan) and 3) the area of greatly changed salinity (the area including Sam-An Truyen, Thuy Tu and the whole Cau Hai swamp).

The appearance of Hoa Duan mouth and expanded Tu Hien mouth has not converted the whole Tam Giang – Cau Hai lagoon into a heavily brackish water body. However, the impacts on salinity were observed in some area, e.g. the salinity of Cau Hai swamp was partly raised by Tu Hien mouth.

With respect to the impacts on fisheries, due to the newly created mouth of Hoa Duan and expanded Tu Hien, most of the aquaculture production has increased. This fact indicates that the presence of the lagoon mouth/estuary, or intrusion of sea water, provide positive impacts on the aquatic production and tend to increase the biodiversity in the lagoon.

As for the socio-economic aspect, fishery is the mainstay of economy in the lagoon area. There are three main types of fishery in the area; i.e. fishing within the lagoons, aquaculture within the lagoons, and fishing in the coastal/offshore area. Fishing and aquaculture in the lagoon and coastal/offshore area have been increasing remarkably over the past years.

The scale and magnitude of existing fishing activities are considered to have reached or exceeded the maximum re-productivity of the lagoon system as pointed out by the former MOSTE. For the sustainable development of socio-economy in the area, it was recommended that the reduction of fishing and aquaculture activities, conversion of saline intruded paddy fields near the lagoon into aquaculture/breeding area.

(2) Recommendations

As described above, the major problems in the lagoon are enumerated as below:

- There is a symptom of degradation of water quality caused by human activities, which has reached the level on which the red tide is identified.
- Salinity in the lagoon is unstable which is largely due to the fragile estuaries, especially Tu Hien mouth.
- Fishing and/or aquaculture activities are considered to have reached to or exceeded the re-productive capacity in the lagoon system including the adjacent coastal area.

In order to cope with these problems, the following actions/measures should be taken:

1. Environmental monitoring should be conducted in order to obtain benchmark data/information and to evaluate the change of lagoon environment. Parameters and/or indicators of the monitoring include 1) physico-chemical parameter; temperatures, pH, DO, BOD, COD, Salinity, Nitrogen and Phosphorous, 2) biological inventories; not only aquatic organisms including phytoplankton, zooplankton, aquatic grasses, benthic organisms but also fishes (not limited edible fishes) and waterfowl. The monitoring should be done regularly, preferably yearly at the same points as those made by the former MOSTE for the comparison. In addition, the data on fish catch and aquaculture production by breeding should be monitored monthly or at least yearly, because the fish catch amount is strongly reflecting the lagoon ecology.
2. Salinity is the most important and influential factor for the lagoon ecology and for the fisheries. Salinity is affected by the shrinkage or expansion of lagoon estuaries, especially by unstable Tu Hien at present. Therefore, adaptive management of Tu Hien mouth is essential as pointed out by the former MOSTE in the research report. Specifically, the maintaining of Tu Hien mouth in proper size should be required.
3. As indicated in the research report prepared by the former MOSTE, some control of fishing and aquaculture activities is needed. The excessive fishing activities will cause not only the exhaustion of aquatic resources but also the environmental load to the lagoon water quality. Considering the fact that red tide has observed in recent year, water quality in the lagoon is to be evaluated as at the entrance stage of eutrophication, although the current water quality is satisfactory level for aquaculture.

Thus, the environmental monitoring and the proper management of the Tam Giang – Cau Hai lagoon system are the most essential for the sustainability of lagoon

ecology as well as the socio-economy of the surrounding area.

3 EXAMINATION OF MAINTENANCE FLOW

3.1 Items to be Considered for Examination of River Maintenance Discharge

River maintenance discharge, which is needed for preventing saline water intrusion, water quality degradation, river mouth clogging, maintaining fluvial navigation, and ecological conservation is to be studied from the following view points:

1) Saline water intrusion: necessary discharge for allowable salinity at objective area is to be examined from correlation between discharge of the objective area from river mouth and salinity. Effect of the proposed river mouth barrage is to be taken into consideration.
2) Water pollution: necessary discharge is to be examined from correlation between river flow and allowable water quality standard.
3) River mouth clogging: necessary discharge is to be estimated from past clogging conditions.
4) Fluvial navigation: necessary discharge is to be examined from correlation among draft of ships, discharge and depth.
5) Ecological conservation: necessary discharge is to be examined from the viewpoint of ecological conservation in the river system.

Comparing these 5 discharge figures obtained as a result of the examination, the maximum figure should be adopted as the river maintenance discharge of Huong river.

3.2 Maintenance Discharge Proposed in EIA Study

In the report on the EIA for the Ta Trach Reservoir Project in Thua Thien Hue Province, a couple of examinations were undertaken. Firstly, it was examined and calculated from the stand point of the water use for irrigation.

Salinity depends on various factors such as discharges from upstream and tributaries, tidal level, and distance from the sea. In general, the further from the sea, the less salinity contents in river water. Based on the actual data on salinity at several points on the Huong River, the relationship of the salinity level and the distance from East Sea were identified.

Currently, there is an intake for irrigation to South Huong River irrigation area at Phu Cam, at a distance of 14.2 km from the East Sea. Taking into consideration the water use as irrigation water, the salinity of the Huong River at the intake must meet the condition of less than 1 ‰ as maximum salinity content for crops, and it

was concluded that the discharge must be more than 61 m^3/s at Phu Cam. Excluding the inflow from tributaries of approximately 16.9 m^3/s, the maintenance discharge from upstream must be more than 45 m^3/s.

3.3 Maintenance Flow Based on Water Quality

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 analysis, such as original unit of pollutant load, pollution runoff ratio, and attenuation rate of the river, are not available in the Huong River Basin. Therefore, the examination of maintenance flow was carried out based on the existing data of water quality condition in the river and other relevant information.

Some water quality data measured in February to April, 1997, show that the water quality of Huong river is good condition even in most of dry season, meeting the Surface Water Quality Standard (TCVN 5942-1995) except for coliform bacteria.

The table below shows the water quality (BOD) measured in June to December, 1998, at 6 locations in the section between river mouth to confluence of Ta Trach and Huu Trach rivers. This also indicates that the water pollution in Houng river, even in the drought season, is insignificant.

Table Water Quality (BOD) in Huong River (measured Jun-Dec, 1998)

Unit: mg/l

Location of measurement	Average	Minimum Value	Maximum Value
River mouth (Thao Long Barrage)	0.8	0.4	1.1
Sinh (Confluence of Bo and Huong rivers)	0.9	0.5	1.6
Downstream of Hue city	0.9	0.3	1.7
Upstream of Hue city	0.6	0.2	3.4
Van Nien	0.5	0.2	0.7
Tuan (Confluence of Huu Trach and Ta Trach rivers)	0.5	0.0	1.1

Source: Report on Current Situation of Water Quality of Thua Thien Hue Lagoon System and Tentative Culture Ponds (Vietnam-French Lagoon Project, 1999)

Besides, according to the scientists of the Department of Environmental Science, Hue University of Sciences, when the discharge volume of the Huong river becomes less than 10 m^3/s at the confluence of Ta Trach and Huu Trach rivers, water quality of the Huong river degrades. However, they have no suggestion on the discharge volume at the river mouth.

Accordingly, it is recommended that, in order to ensure the existing good condition of water quality of the Huong river, the decrement of existing low discharge be avoided through maintaining the hydrological regime of low water. The hydrological analysis of monthly availability water at the river mouth shows 86 MCM as the minimum monthly discharge during the term of the above water quality measurement. This corresponds to approximate 30 m^3/s on a trial of calculation of the average.

3.4 River Mouth Clogging

According to the available information, any problems and constraints on river mouth clogging were not reported so far at the mouth of the Huong river. This suggests that, although the effectiveness of the flood for flushing the sediment at the mouth is unknown, the existing low discharge is almost enough for prevention of river mouth against clogging. Therefore, the river mouth clogging can be avoided by maintaining the existing hydrological regime of low water.

3.5 Fluvial Navigation

Usage of inland waterways in the Huong River Basin is a relatively small scale.

The freight transport of waterways accounts for less than 5 % of the total transport in the region.

The small boats for sightseeing, fishery, and transportation of gravel and local passengers were observed in the field reconnaissance. According to the People's Committee of Hue province, in addition, the fluvial navigation in the Huong river is only locally important, and most of the transport of the freight and passengers can be substituted for the other transport such as roads in case of insufficiency of the depth and surface width of water. Therefore, it is considered that the condition for the fluvial navigation can be mostly ensured by maintaining the existing hydrological regime of low water.

3.6 Minimum Discharge for Ecological Conservation Proposed in EIA Study

In the EIA study for the Ta Trach Reservoir Project in Thua Thien Hue Province, the minimum discharge for ecological conservation was also examined and proposed. The ecologically minimum discharge of the Huong river was determined as equal to minimum monthly discharge at the inlet of river mouth corresponding to P =90%. Data on monthly and annual flow were calculated and restored based on rain intensity data using TANK model. As a conclusion, river maintenance discharge for ecological conservation was obtained as 31.0 m^3/s at the river mouth.

3.7 Set up of River Maintenance Flow

Based on the above examination, the outcomes for determination of the maintenance flow of the Huong river are summarized below:

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

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

4 ENVIRONMENTAL IMPACT ASSESSMENT

4.1 Significant Environmental Aspects Based on Review of MARD's Investigation

4.1.1 Project Description

Environmental Impact Assessment (EIA) for the Ta Trach Reservoir Project in Thua Thien Hue Province was conducted and the report on the EIA was prepared in May 2000 by MARD. The project proponent is MARD and the Ta Trach Reservoir Project is composed of the following (Sizes are the ones shown in F/S):

- Reservoir with a capacity corresponding to maximum storage elevation is 610,000,000 m^3.
- Dam with a crest elevation of 56m.
- Spillway with a flood flow of 11,400 m^3/s.
- Inlet sluice with a maximum flow of 100 m^3/s.
- Hydropower plant with a capacity of 19,500 kW.

The result of the EIA Study is described as follows:

4.1.2 Present Situation of Environment

(1) Natural Environment

a. Water Quality

The water quality of Huong River system was investigated in October 1999 (rainy season) and March 2000 (dry season), indicating the following characteristics:

Rainy season:

- Biological content: Every sample is affected by micro-organism (coliform), which must be treated before using as domestic water.
- Major chemical content: The river water level rises high, the current is strong, the salinity, pH and electric conductivity are decided by rain water.
- Other contents: All the samples satisfy the requirement of domestic and irrigation water.
- In general, Ta Trach river water can be exploited for domestic use, irrigation, husbandry and industry after treatment.

Dry season:

- Biological content: All the samples must be treated before using as domestic water.
- There some samples with relatively high salinity (brackish water) which cannot be used as domestic water.

b. Vegetation Cover

Due to the weather distinction mainly caused by the topographic conditions, the vegetation cover of the project area clearly reflects its distribution corresponding to the elevation belt. Based on published documents and the findings in the field survey, it is possible to divide the vegetation cover corresponding to the two elevation belts as follows:

- Elevation belt with the height of less than 900m is covered by thick tropical rain forest with main composition of D*ipterocarpaceae, Fabaceae, Sapindaceae* and *Guttiferae* species, etc.
- Elevation belt with the height of more than 900m is mainly the thick semi-tropical rain forest. Major plants species include *Fabaceae, Lauraceae* and *Theaceae.*

However, the vegetation cover in the project area has been drastically changed due to great impacts to the forest area. The thick tropical rain forests on the 900m belt upward still remain but account for only a very small portion, distributed in remote area, far from transportation roads. More common is the secondary forests which are being restored with bushes intervened with wood trees or grazing areas.

c. Flora and Fauna

In order to make a comprehensive biological assessment of the project area, a list of flora species has been built up. According to the list, there are 585 species of flora. Particularly, there are 96 species of herbs and 216 species of timber trees in the upstream area.

The number of birds, mammals and reptiles in the upstream area of the project site is plentiful. The list of in-land fauna, aquatic fauna of Ta Trach upstream area has been built up. According to the list, there were 45 species of mammals, 149 species of birds, 35 species of reptiles and 12 species of amphibians.

Although the upstream area of the project has been affected by human activities negatively, it is still considered as a diversified biological area, which has some precious genes. Among these genes, there were 8 species of flora and 11 species of fauna being listed in Red Data Book of Vietnam.

(2) Social Environment

The project area is basically located in Nam Dong and Huong Thuy districts of Thua Thien Hue province according to the EIA report on Ta Trach reservoir project. In the course of the EIA study conducted by HEC-1, the survey on social environment was focused on 2 districts. The present situation of social environment of the 2 districts are summarised and concluded in the EIA report, as follows:

a. Nam Dong District

Advantages on present socio-economic situation

In general, the land in Nam Dong district has relatively high potential, which is suitable for forestry development (afforestation) and some industrial trees such as rubber, coffee and tea. The soil and climate in the district also allow the development of fruit trees such as pineapple, orange, lemon, mandarin and grape-fruit. With the abundant rainfall volume, the forestry coverage rate is rather high. Nam Dong does not have to face with water shortage in dry season as other districts, possible for the development of trees species requiring much water.

The grazing area in Nam Dong at present is relatively large, allowing the development of buffaloes and cows. Besides grazing area, it is possible to take the advantages of forest land for raising these buffaloes and cows. The development of buffalo and cow raising will not only ease the immediate and long-term local food consumption need of Hue City but also provide food for the Ta Trach Reservoir construction with thousands of workers and staff working at the site.

Although being mountainous, the district established rather good infrastructure with asphalt roads to each village. Nine out of 10 villages are supplied with electricity from the national gridline, and over 50% of households are supplied with treated water. Every village is equipped with brick primary school and medical station capable for treating common diseases. The spiritual life of local people is also somehow improved by the fact that there are televisions in every village and over 20% of households possess radio sets.

Difficulties

- Many households do not have enough capital for development of agricultural production.
- The adaptability of the local people to modern technology is limited mainly because of low education level.
- In rainy season, some of villages in the district are inaccessible by vehicle due to the poor condition of the roads.

b. Huong Thuy District

Advantages on present socio-economic situation

Natural condition of Huong Thuy district is favourable comprising both plain and mountainous areas. Plain ensures to supply grain food sufficiently. There is the largest area of two main paddy harvest in the district. If intensive farming, fertilizer and new genes as well as irrigation work were applied properly, farming

practice would be shifted to two paddy harvest cultivation and self-supplied grain food would be realised.

Presently, remote mountainous area of the district has not yet been exploited, and hilly area near the residential area is used for plantation of fruit or other industrial trees.

The district has also the potential to develop livestock farming of buffaloes or cows by using grazing land under forest canopy or natural grass area.

Difficulties

- Many households do not have enough capital for development of agricultural production.
- The adaptability of the local people to modern technology is limited mainly because of low education level.
- There are few asphalt roads in the district and the accessibility of inter-village is very tough in rainy season.
- Due to the lack of the marketability awareness, the local farmers can earn the limited monetary benefit from the product of agriculture and agroforestry.

(3) Issues on Land Acquisition and Resettlement

According to the EIA report prepared by HEC-1, Ta Trach reservoir project will cause the resettlement whose magnitude would be estimated at 815 households with about 5,000 of affected people. Among all the affected people, nearly 90 % are the residents of Huong Thuy and Na Dong districts, of which 95 % are made up of Kinh group. It is expected, in the EIA report, that the number of households to be resettled will increase to 875 up to the year 2003 (target year of completion of resettlement activities).

The loss of property such as land and agricultural production to be compensated amounts to approximate 55,000 million VND, although the magnitude of loss such as size of acquired land is unclear in the EIA report. Total amount necessary for activities on resettlement and compensation is expected to reach approximately 160,000 million VND.

4.1.3 Environmental Impacts of the Ta Trach Reservoir Project

The environmental impacts caused by Ta Trach reservoir project and possible mitigation methods were analyzed and the levels of each impact were evaluated. The summary of the EIA study is shown in Table D.3.

In the study conducted by MARD, the most significant negative impacts include the following components:

- Inundation, emigration away from reservoir bed and resettlement.
- Erosion and mud flow
- Diversion of downstream flow

The first item may have the impacts/issues such as inappropriate compensation, relocation(s) of affected (submerged) households and livelihood problems after emigration. The second item is the impacts of mud flow and turbid flow in the downstream area during construction stage when raining. The third item means the impacts caused by the change of water regime in operation stage, including the impacts on fluvial transport, irrigation, water quality and riverside and riverbed erosion. Other conceivable impacts are as listed in the table.

4.1.4 Review of the EIA Study Conducted by MARD

In the EIA Study, environmental impacts were examined, predicted and evaluated from ecological, physico-chemical and socio-economic points of view at the three stages: preparation stage (planning or designing stage), construction stage and operation stage. Conceivable impacts caused by the implementation of the Project was evaluated and described in detail, both qualitatively and quantitatively. In addition, mitigation measures are enumerated and environment management plan was described (but the environmental monitoring plan was not proposed).

However, considering the current conditions of the Project site that holds a wealthy biodiversity, and the magnitude of the project that has a submerged area of 23.5km^2 (at average storage elevation), the following points should be studied more in detail and sufficiently:

- Impacts on terrestrial flora and fauna, including precious species
- Identification on social conditions especially in inland fishery, health condition and cultural/historical heritage

In addition, the environmental monitoring plan is to be prepared during both construction and operation stages. Taking into account these items to be studied and identified in detail, the Environmental Impact Assessment (EIA) Study was undertaken by the JICA Study Team, covering the scopes listed in the next section.

4.2 Scope of Environmental Impact Assessment

Environmental Impact Assessment (EIA) Research was subcontracted to the Center of Water Resources and Environment Technology (CWRET). The items which were examined and evaluated in the EIA Study are enumerated as follows:

Items of EIA Study to be Subcontracted

1) Currect situation of and impacts on physical environment	- Water sampling and quality analysis including saline water intrusion in the Huong River basin. (The sampling points and the parameters to be analyzed will be given by the Study Team.) - Sanitary condition in the lower reach of the Huong River focusing on water pollution being aggravated by human and industrial activities - Current situation of soil erosion, bank erosion and land subsidence along the Huong River - Current conditions of soil and vegetation in the Huong River basin - Current conditions of sedimentation, siltation and/or river bed degradation - Others to be required in the course of the study
2) Current situtaiton and impacts on ecology	- Current land use of the area to be affected by the Project - Inventory of aquatic flora and fauna, and impacts on them by the Project - Inventory of terrestrial flora and fauna in terms of existing species, including vulnerable, rare, and endangered ones as well as its habitat - Conceivable impacts on Back Ma National Park - Conceivable impacts on existing lagoons and swamps over the river mouth - Others to be required in the course of the study
3) Current situtaiton and impacts on socio-economic and cultural environment	- Location and the surface area of land acquisition, the number of households to be relocated accompanied by the Project implementation - Conceivable social issues of and/or impacts on land acquisition, resettlement, and local economy caused by the Project implementation - Location and the surface area of existing farm lands to be affected by the Project implementation including its cropping pattern and annual products - Farm lands and forest conservation areas to be affected by access road construction - Current situation of fishery in the Huong River basin including the annual fish catch, fishing practices and kinds of fish being caught - Environmental health and sanitary conditions of the area to be affected by the Project implementation - Social impacts of noise and dust to be caused by construction works focusing on living environment - Current situation of minority tribes to be affected by the Project implementation including its name, location, the number of households and population, cultures and customs and so on by tribe, as well as possible measures for sustainability and/or improvement of their living condition - Locations of historical and cultural heritage including recreational spots as well as local crematories - Others to be required in the course of the study

The environmental impacts on physical, natural and social environment were examined and evaluated based on the environmental standards in Vietnam, if applicable and appropriate to assess the proposed project. Otherwise, other adequate standards were introduced for the evaluation. The Study report also includes the mitigation measures, environmental management and monitoring plans.

4.3 Preliminary Survey of the Work

4.3.1 Field Reconnaissance

The EIA Study has commenced on 21st of December, 2001, and the Inception

Report was submitted on 28th of the same month. A field reconnaissance was conducted during 23rd through 26th of December, aiming to grasp the current environmental situations of the project sites, resettlement areas, and river environment in the Huong River as well as to give detailed instructions on sampling points for water quality measurements and on saline water investigation.

(1) Natural Environment

As a result of the field reconnaissance, the water sampling points were determined as listed in Table D.4. The parameters to be analyzed were selected from those given by the standards of surface water quality as listed in Table D.5.

Additionally, the investigation of saline water intrusion, with the parameter of salt content, were determined at the following points:

- The upstream Thao Long barrage (Huong river)
- The downstream Thao Long barrage (Huong river)
- Sinh fork intersection (Huong river)
- Thanh Ha (Bo river)
- Phu Cam (Phu Cam sewer/culvert – Huong river)
- Nguyet Cam (Huong river)

The sampling work and field measurement were conducted from the latter half of February to the beginning of March, 2002, and the analytical values are under processing.

(2) Social Environment

The outline of the following issues on social environment were grasped through the field reconnaissance and meeting with officials of local authorities:

- Summary of the impact on and countermeasures for land acquisition and resettlement caused by Ta Trach reservoir project
- Current condition and general plan of the proposed resettlement area in Ben Van area in Phu Loc district
- Overview on inland fishery and waterways in Huong River basin
- Items researched/investigated by Hue University of Science regarding the social issues along the Huong river

4.3.2 Data Collections

The following data/information was collected in the field reconnaissance on December, 2002:

- Documents on "Study on Stabilization and Restoration of Thuan An – Tu Hien estuaries"

- Report on Environmental Impact Assessment, Ta Trach Reservoir Project, Thua Tien Hue Province
- Document on current condition of coastal areas and lagoons environment
- Document on Forestry resources and current conditions
- Some documents on water quality of Huong river system and lagoons
- Resettlement area development plan (layout map) of Ben Van area
- Resettlement action plan on Ta Trach Reservoir Project

In addition, the various data/information on the current condition of environment in the Huong river basin was collected by the sub-contractor (CWRET) in the course of the study, and was integrated into the EIA report.

4.3.3 Interview Survey

Interview surveys were undertaken in order to grasp the current situation of environment of the project areas and to know the availability of data/information on the environment. Two interviews were done: 1) Hue University of Sciences and 2) BirdLife International, an Environmental NGO. The results of the interviews were as follows:

(1) Interview to Hue University of Sciences:

- Date: December 26th, 2001
- Interviewee:
  - Mr. Le Van Thang, Ph.D., Director of Center for Resources, Environment and Biodiversity, Hue University of Sciences.
  - Mr. Pham Khac Lieu, Vice Head of Department of Environmental Sciences, Hue University of Sciences.
- Information items obtained:
  - Current condition of water quality of the Huong River and Tam Giang-Cau Hai Lagoon
  - The outlines of researches conducted so far on water quality, ecology and socio-economy.

(2) Interview to Birdlife International (Environmental NGO):

- Date: December 28th, 2001
- Interviewee:
  - Mr. Jack Tordoff, Project Coordinator, Birdlife International Vietnam Programme.
- Information items obtained:
  - Protected areas system in Vietnam
  - The outline of studies conducted so far in Vietnam.

- The activity of other environmental NGO.
- The availability of data on natural environment including biodiversity and natural forest.

4.4 Results of the EIA Study

4.4.1 Introduction

The target development project for the EIA Study is the Huong River Development Project, including the following components:

- Ta Trach Reservoir development
- Thao Long Barrage

The approach and methodology for the EIA study are mainly i) collection of existing data or information, ii) literature review, iii) field measurement and laboratory analysis of water quality, and iv) interview to the informant including local people. The draft report was submitted on March 6, 2002. The mitigation measures and monitoring plan was proposed in the final report submitted in the middle of March, 2002.

Besides, prerequisite conditions such as the scale and dimension of the target projects for EIA study are obtained from the following reports:

- Feasibility Study for Ta Trach Dam prepared by HEC-I
- Feasibility Study for Thao Long Barrage prepared by SAFEGE

4.4.2 Current Situation of Environment

(1) Physical Environment

a. Salinity Intrusion

Current situation based on the existing data: The Huong river is affected by irregular semi-diurnal tidal regime, and the highest tidal amplitude may achieve up to 60 to 80 cm. Accordingly, salinity intrusion is measured in the river and it can rise over Gia Vien water factory which is located at approximately 19 km upstream from the estuary. The average salinity in locations on the Huong river gradually increases in dry season and reaches to the maximum value in August as shown in the table below:

Table: Relationship between salinity and time in the Huong river

Location	Average salinity (‰)					
	June/98	July/98	Aug./98	Sept./98	Nov./98	Dec./98
Tuan influence	0.03	0.03	0.03	0.00	0.02	0.02
Van Nien	0.03	0.03	0.03	0.00	0.02	0.02
Gia Vien	0.04	0.27	1.47	0.00	0.02	0.02
Company of Huong seafood import-export	0.14	2.10	4.95	0.03	0.02	0.03
Sinh influence	0.35	1.93	6.55	0.07	0.02	0.03
Thao Long upstream	0.73	2.90	6.74	0.20	0.05	0.20

Data source: Current Environment status in Thua Thien -Hue province 1994-1998, DOSTE

Salinity intrusion is alleviated by the existing Thao Long Barrage but it is old and its function is not enough at the moment. The new Thao Long Barrage is now under construction just below the existing one on the Huong river.

The results of on-site measurement in the course of this study: The Salinity measurement as well as the water level measurement was conducted for 24 hours on 21st through 22nd, February, 2002. The measurement was done at the following 6 stations:

- ***Tan My Station:*** right bank of Huong river, and 0.2 km from the sea.
- ***Thao Long Station:*** on the left bank of Huong river at Thao Long barrage, and 2.0 km far from the sea.
- ***Sinh Station:*** on the left bank of Huong river at Sinh confluence, and 8.0 km far from the sea.
- ***Lai Y Station:*** on the right bank of Huong river, and 13.0 km far from the sea.
- ***Phu Cam Station:*** on the right bank of Huong river, and 18.0 km far from the sea.
- ***Kim Long Station:*** on the left bank of Huong river, and 20.0 km far from the sea.

Salinity samples were taken at vertical line in mid-stream, and on each vertical line, the salinity sample was taken at 3 points: surface point, middle point and bottom point. The samples were taken 12 times a day in odd hours. Salinity was identified by a salinity meter for each sample taken. The time to take samples was simultaneous with the time to measure the water level at the station.

The measurement results of the salinity concentration are summarised in the table below. At Lai Y station, the average salinity only reached to 0.178 ‰, but when the tide was high, the salinity varied from 1-1.4 ‰, which indicates taking water for production and domestic use should be ensured its safety by the measurement and prediction of salinity concentration. From Phu Cam and upstream reach of the Huong river, the salinity is diluted this time of the year so it is possible to use the

river water for domestic and production use.

Table: Average salinity concentration on the Huong river

Unit: ‰

No	Station	Distance from the sea	Mean salinity	Surface salinity	Middle salinity	Bottom salinity
1	Kim Long	20.0 km	0.042	0.041	0.042	0.042
2	Phu cam	18.0 km	0.066	0.065	0.066	0.067
3	Lai y	13.0 km	0.177	0.160	0.178	0.195
4	Sinh	8.0 km	1.45	1.33	1.45	1.86
5	Thao Long	2.0 km	7.9	5.25	8.24	10.2
6	Tan My	0.2 km	10.9	7.32	10.9	14.5

Date of measurement: February 21 to 22, 2002.
Sources: "the Report on Environmental Impact Assessment in Huong River Basin, Annex 1" 2002.

b. Water Quality

Current situation based on the existing data: According to the secondary data, the water quality of the Huong river is summarized as Tables D.6 and D.7. The feature of water quality of the Huong river main stream is as follows:

- Most of the parameters are consistent with the Limitation Value A of Surface Water Quality Standard of Vietnam, except for Coliform.
- Coliform concentration does not meet the Limitation Value A, or even Value B, which indicate the pollution caused by untreated municipal wastewater, direct defecation and other activities form residents living along river banks and from "floating communities using boats" in the river.
- BOD_5 is lower than 2.0 mg/l and COD is lower than 9.0 mg/l, indicating the pollution caused by organic substances is quite slim. These concentrations, however, increase as river water flows to downstream, especially at downstream of Hue City. This shows that Hue city is the origin of water pollution by organic substances.
- The DO concentration is higher than 6.0 mg/l, mostly higher than 7.0 mg/l, which indicates the river water is suitable environment in terms of the habitat for aquatic organisms and, hence, of the aqua culture production.
- The concentrations of heavy metals such as Mercury, Arsenic, Cadmium, Lead, Copper, Nickel and Zinc are quite low. There is no problem on contamination by heavy metals at all.

In dry seasons, however, when discharge of the Huong river reduces remarkably, the phenomenon of "alga flower" is reported to occur in many sections. High concentration of phosphorus is considered to be one of its causes. This phenomenon makes the river water specific green, causing un-preferable condition in terms of scenery, aquatic organisms and so on.

Water Quality Analysis conducted in the course of this Study: Water quality analysis was conducted and its results were summarized in Table D.8.

Comparing the results with the secondary data mentioned above, the concentration of BOD_5 and COD have changed to be polluted far beyond the Limitation Value A. Suspended Solid (SS) also showed the concentration not met the Limitation Value A. In addition, the average lead concentration has not met the Limitation Value A. On the contrary, there are similar tendency that high concentrations of Dissolved Oxygen (DO) and Coliform.

As for BOD_5 and COD, the cause of the relatively high concentrations is unclear at the moment. It is also not identified whether or not the high concentrations lasts from now on. The on-site ocular observation has not recognized such a high concentration of BOD_5 and COD.

Regarding the high average concentration of lead, this is brought about by the result of only one sampling point with very high lead concentration. The remaining points met the Limitation Value A.

In conclusion, water quality of the Huong river is characterized by high concentration of SS and is being affected by domestic effluent and direct defecation, reflecting the high concentration of Coliform and the tendency of high BOD_5 and COD. Additionally, it is featured of high DO value, which indicates the good condition for aquatic organisms and aquaculture production.

(2) Ecological Environment

a. Vegetation

According to 1998 statistics of Thua Thien Hue forestry resources, the vegetation and forest land cover the area of 347,653 ha and are divided into the following seven categories:

Table: Vegetation cover of Thua Thien Hue Province

Categories	Area and coverage rate
1. Evergreen closed trivially affected forests.	37,437 ha (10.8 %)
2. Evergreen closed considerably affected forests.	113,182 ha (32.6 %)
3. Rehabilitation sapling forests.	19,624 ha (5.6 %)
4. Scattered lumber plots mixed with secondary big-sized lumber bushes.	51,800 (14.9 %)
5. Perennial afforested and cash crop forests.	43,910 ha (12.6 %)
6. Bushes mixed with small-sized lumber trees and some secondary kinds.	59,040 ha (16.7 %)
7. Grass-plot mixed with some light-favored fast growing species.	23,630 ha (6.8 %)

Source: "1998 statistics of Thua Thien Hue forestry resources."

Bush areas comprise of typical plant species such as Cratoxylum polyanthum,

Hubasoi Macarenga denticulata, Grewia paniculata, Melastoma Candium, Uepatorium Odoratum, Sacchrrum spontaneum, Thysanoleona maxima, Imprerata cylindrrica, Miscarthust sinesit, Barbus spp, etc.

Grass covers a large area, including such main plants as *Imperata Cylindrica, Themeda giganntea, Apluda mutica* and *Uepatorium Odoratum*. The planted layer is dominated with perennial industrial trees, short-term industrial trees, fruit trees and food plants.

b. Flora

The present reservoir bed is covered with some area of forests including natural timber forest, bamboo forest, planted young forest and on-rock forest, of which the vegetation cover is mainly of bushes, grass and agricultural plants.

According to the document of Natural Conservation Division under Forest Management Department, MARD, the flora in and around the Ta Trach Dam Project Site has 585 species, 363 members, 177 families belonging to 7 high-ranked plants. However, these numbers are supposed to be still smaller than the actual numbers in reality.

The flora is badly affected and some rare and precious species listed in Red Data Book of Vietnam. They are mostly seen in upstream area of Bo and Ta Trach rivers, especially, an area in Bach Ma National Park with elevation of 600 to 1,200 m. The following table shows the list of the 12 rare and precious species:

Table: List of rare and precious species listed in Red Data Book, Vietnam 1, Plant Species

No	Vietnamese name	Scientific name
1	Thong tre	*Podocarpus neriitolius*
2	Tram huong	*Aquilaria crassna*
3	Cam lai ba ria	*Dalbergia bariaensis*
4	Gu mat	*Sindora cochinchinensis*
5	Gu lau	*Sindora tonkinensis Acher*
6	Trac	*Dalbergia cochinchinensis*
7	Po mu	*Fokienia hodginsii*
8	Sen mat	*Madhuca pasquieri*
9	Lim xanh	*Erythrophloeum toridii*
10	Kim giao	*Padocarpus fleuryi*
11	Com Bach Ma	*Elaeo carpus bachmaensis Gaguep*
12	Chia voi	*Sissus bachmaensis*

c. Fauna

According to "Actual Environmental Situation Report of 5 years (1994 to 1998) in Thua Thien Hue province, 1998," the following numbers of terrestrial fauna inhabit in and around the Project Site. They include:

- 8 assemblages, 20 families and 45 species of mammals;

- 13 assemblages, 36 families and 146 species of birds;
- 2 assemblages, 11 families and 35 species of reptiles and 35 species of amphibians; and
- 1 assemblage, 4 families and 12 species of fishes.

The total number of species identified is 273, of which 25 species of rare and precious ones are listed in the Vietnam Red Data Book, Volume 2: Animals, as listed table below:

Table: List of rare and precious species listed in Red Data Book, Vietnam 2, Animal Species

No	Vietnamese name	English name	Scientific name
1	Voi	Elephant	*Elephas maximus*
2	Ho	Tiger	*Panthera tigris*
3	Bao hoa mai	Leopard / Panther	*Panthera pardus*
4	Bao gam	Clouded Leopard	*Neotaliss nebulosa*
5	Gau cho	Malayan Sun Bear	*Helaretos malayanus*
6	Gau ngua	Aiatic Black Bear	*Selenaritos thibetanus*
7	Vooc va	Douc Monkey	*Pygathrix nemaneus*
8	Vooc ha tinh	Hatinh's Langur	*Presleytis francoisi hatinhensis*
9	Vuon den bac ma	White-cheeked Gibbon	*Hylobates concolor leucogenis*
10	Cay muc	Binturong	*Arctictis binturong*
11	Cu li nho	Common Slow Loris	*Nycticebus pygmaeus*
12	Soi Do	Dhole	*Cuon alpinus*
13	Cong	Green Peafowl	*Pavo muticus imperater*
14	Ca loi hong tia	Pheasant	*Lophura diardi*
15	Ca loi lam mao den	Imperial Pheasant	*Lophura imperialis*
16	Ca loi lam duoi trang	Vietnamese Pheasant	*Lophura hatinhensis*
17	Tri sao	Crested Argus	*Rheinartia ocellata ocellata*
18	Khi moc	Assamese Macaque	*Macaca assamensis*
19	Khi vung	Yellow Macaque	*Macaca malatta*
20	Khi duoi lon	Pig-tailed Macaque	*Macaca nemestrina*
21	Son duong	Chamois	*Capricornis sumatraensis*
22	Meo rung	Lynx	*Felis bengalensis*
23	Rai ca thuong	Otter	*Lutra lutra*
24	Sao la	Ox	*Psendorux nghetinhesis*
25	Mang lon	Giant muntfae	*Megamuntiacus vuquangensis*

Source: "Current Environment Status in Thua Thien Hue province," 2002

d. Bach Ma National Park

Bach Ma national Park is located 45 km far in the south of Hue city. Geographically, it occupies 16°05'- 16°06', north latitude and 107°43'- 107°53', east longitude, with the total area of 22,030 ha. There are mainly two 2 types of forests in the park:

- Closed, year-round green, rain semi-tropical forest in the elevation of more than 900 m with the majority of *Podocarpaceae*, *Fagaceae*, and *Theaceae*; and
- Closed, year-round green, rain tropical forest in the elevation of less than 900

m with the majority of *Dipterocarpaceae* and *Fabacea*e.

A total of 1,286 plant species are recorded, of which the mostly seen are Euphorbiaceae: 22 species, Lauraceae: 18 species, Orchidaceae: 20 species, Palmae: 18 species, Moraceae: 16 species, Asteraceae: 16 species, Theaceae: 13 species. Among them, there are many endemic species and precious species identified.

A total of 459 animal species are recorded, of which 55 mammal species, 135 bird species, 31 reptile species, 20 amphibian species and 218 butterfly species are identified. Bach Ma national park has some endemic animal species representing for the animals in the south region of Vietnam.

(3) Social Environment

a. Population

In 2000 the Thua Thien Hue province has an estimated population of 1,066,200. The population is evenly distributed in the province with its densely-populated areas mostly in the city, towns and along rivers and coastal zones. The labour force in 2000 totals 576,000 persons, covering 54% of the total population. The labour participating in the national economic sector totaled 495,500 persons, accounting for 86% of the total laborers of the whole province.

Thua Thien Hue province is the home of 25 ethnic groups who live friendly in a harmonious community, comprised of Kinh, Ban Na, Ede, Ngai, Giao, Nung, Muong, Khome, Tay, Thai, Hoa, San Chay, Co Ho, Cham, Hore, Monong, Bru, Tho, Day, Ca Tu, Ta Oi, Lao, Chut and Van Kieu.

b. Major Economic Activities

Agriculture: According to the socio-economic development plan of the province, the agricultural produces are estimated at 683 billion VND in 2000 (in 1994 price). The average growth in 1996-2000 is slow as estimated about 1.6%. In the production value structure, the husbandry proportion accounts for 22-23%, and the contribution from the services varies from 6-7%. In 1994 price, the proportion of agricultural production in recent years are presented below:

Unit: %

Items/Year	1995	1997	1999	2000
Agricultural production values	100	100	100	100
- Cultivation	71.2	71.7	75.8	69.0
- Husbandry	22.8	22.1	15.6	23.4
- Services	6.0	6.2	8.6	7.6

Forestry: In 5 years of 1996-2000, through the mobilization of funds from various

sources, a total of 19,267 ha of forests and 25.9 million trees have been planted in the province (Hai Van north area, Phu Loc district, Phong Dien district, etc.), according to .the socio-economic development plan of the province. The forest covering increases approximately from 34% in 1995 to 44% in 2000. The natural forest timber are exploited with the capacity of 5000 m^3 in 2000, substantially lower than the previous years due to the policy on exploitation restriction and closure of the forests in critical locations. The majority of timber capacity of 25.000 m^3 is mature trees of planted forests for wood pulps.

Fishery: According to the socio-economic development plan of the province, the fishery production gains approximately 182,3 billion VND in 2000 (in 1994 price), and the average annual growth rate in 1996-2000 is 12.9%. The internal structure of fishery has been rightly shifted; i.e. exploiting the fishery resources of lagoon and swamps, and increasing the proportion of aquaculture. The exploitation of fishery has a remarkable growth, especially offshore fishing. In addition, the aquaculture is developed rapidly in the lagoon and swamps in the coastal area recently, focusing on shrimp, crab, and fish in brackish water. Fresh water fish culture is somewhat popular in ponds, swamps, streams, rivers and reservoirs for local/household consumption.

Industries: The garment industry plays an important role in Thua Thien Hue. The production value of garment industry makes up 20% of the total industrial production in the basin, and it attracts 25% of total industrial labours. In addition, the construction materials production is one of industries that have a fast growth rate. In 2000, a total of 430,000 tons of cement and 41.5 million bricks are produced, and this industry attracts 12% of total labours over the province. Besides, food and drinking processing, such as beer and frozen aquatic products, is also major industry in the province.

Tourism: Huong river basin has a lot of well-known places such as Ngu Mountain, Hai Van mountain pass, Bach Ma, lagoon and many beaches. Hue ancient capital city with many masterpieces of imperial palace architect, cultural structures and royal mausoleums was ranked by UNESCO as a world cultural heritage on December 11, 1993. The ancient Hue city is a key for the enhancement of tourism sector. And also, the province has hundreds of pagodas with unique traditional architectures such as Thien Mu, Bao Quoc, etc.

Targeting the tourism for key-economic sector, the physical infrastructures of the tourism increase notably from early 1990s. For example, the rooms of hotels totaled 509 in 1991 but in 2000 a total 2,153 rooms are accounted, responding to the increasing requirement and demand of customers. In the last10 years, the

international customers to Hue increase 29.8% per year in average, and the national customers increase to 12.8% annually. The incomes from tourism increase 7 times, and contribute to the GDP growth from 2% in 1990 to 7.7% in 1999.

c. Health and Sanitary Condition

In recent years, the heath care system from province to district, commune, village and hamlet is improved and strengthened. The basin has a total of 10 hospitals, 23 general clinic offices, of which Hue Central hospital are equipped with 1,100 hospital beds.

The annual national health programs are always launched, including open vaccination program, cholera and typhoid preventive program, and other environmental sanitation and diseases preventive programs. These programs are effectively implemented and help eliminate a certain social diseases and cease the diseases spreading. However, the poor quality of domestic water affects negatively to the health of the people especially in the rural area. According to the available data, the morbidity and mortality of water-borne diseases are reported as follows:

Disease	Year	1993	1994	1995	1996	1997	1998	1999	2000
Diarrhea	Case	-	-	-	-	12,767	10,422	13,004	11,624
Cholera	Case/death	1827/3	3/0	47/0	38/0	0	0	1/0	0
Typhoid	Case	307	149	167	250	32	123	10	16

Source: Report on review of cholera and typhoid preventive program in TT-Hue, 2001

The absence of toilets or unhygienic toilets is a pressing problem in the rural area of the province. In accordance with report on "Agriculture and rural environment status in Thua Thien Hue province in 1994-1998", in 5 years, the proportion of the hygiene toilets increased insignificantly, from 22% to 34%, and the situation of non-toilets or unhygienic toilets tended to reduce but not much. The communes in highland area in Nam Dong and A Luoi, as much as 95% of total households do not have toilets or even if so the toilets are not hygienic.

Besides, from the living environmental point of view, the air pollution caused by the large cement factories is considered to be somewhat significant, although the actual measured data is not available.

4.4.3 Impacts on Physical Environment

(1) Meteorology

The existence of Ta Trach reservoir may increase the humidity in the surrounding area due to the evaporation from it especially in dry season. In addition, the groundwater table would rise in the vicinity of the reservoir. The soil humidity

would, therefore, increase remarkably, providing a good condition of the development of forests and vegetation cover around the reservoir.

Thao Long barrage will cause no impacts on the climate conditions because it will not produce a new water body or raise the groundwater level along the Huong river significantly.

(2) Saline water intrusion

After the construction of Thao Long barrage, the sea tide will not enter deeper than the barrage in the Huong river any longer, which will solve the problem on water use for paddy fields and domestic water caused by saline water intrusion along the Huong river.

(3) Geology

Based on the study results on earthquake aroused of big reservoirs, the necessary and sufficient conditions for an earthquake acceleration that can harm the reservoir and dams area are summarised as follows:

- Capacity of reservoir is over one billion m^3;
- Depth of reservoir exceeds 90 m; and
- Reservoir locates in a complex geological condition especially in a tectonic destroyable zone which is still active.

Given the size of Ta Trach Dam of the height of 56 m and a total volume of 610 million m^3, the possibility of seismic acceleration is considered to be quite slim.

(4) Impacts on Water Environment

In the reservoir, temperature stratification will be created after the water has been accumulated. Considering other case of reservoir in Vietnam, e.g. Hoa Binh Dam reservoir, the temperature difference between the surface and the bottom is estimated to be less than 6 ℃ even in dry season, and the water temperature at the bottom is estimated at around 20 ℃. This level of water temperature would not cause significant adverse effect on water use for irrigation, domestic, or industrial one in the downstream area.

As to Dissolved Oxygen (DO), the stratification, or the difference of DO between surface and the bottom, will also be created in the reservoir. DO concentration will temporality become less than 2 mg/l at the bottom layer since DO in the bottom layer will be consumed for biological decomposition of submerged organic matter such as trees and grasses formerly growing on the reservoir bed.

The circulation of the reservoir water would not fully occur because of the climate in Vietnam because due to the warm climate, water temperature of surface layer

does not go down or last enough to boost the vertical circulation. With respect to this condition, the reservoir might have a possibility of occurrence of eutrophication. However, based on other cases of major dams in Vietnam, e.g. Hoa Binh Dam reservoir, the occurrence of eutrophication is considered to be rare. In addition, taking into account the water quality of the Huong river that water pollution of organic substance or high concentration of nitrogen or phosphorus is not recognized on an upstream reach, the possibility of eutrophication is considered to be slim.

After the construction of Ta Trach Dam, sediment contents from upstream will be stored in the reservoir. The reduction of sedimentation in the lagoon would contribute to prolong the life of the lagoon system taking into account the fact that its depth has been getting shallower historically.

When Thao Long barrage is completed, saline water intrusion shall be controlled at the barrage in the Huong river, thus the water quality shall be improved and suitable for the agricultural development and fresh water fishery development along the river.

In contrast to the improvement of water quality in the Huong river, Thao Long saline control barrage makes the water environment in Tam Giang lagoon more brackish or fully saline water in dry season unless discharge from Ta Trach Dam is adequately controlled.

(5) Erosion and Sedimentation

During the construction stage, mud flow and turbid flow from the construction site of Ta Trach Dam to downstream would be spawned, which in turn causes the sedimentation in the lower reach. In addition, concrete placement for the dam body would cause the alkaline water discharge, in case that gravity type dam by concrete would be applied to Ta Trach Dam, although fill type was planned in F/S of Vietnam. These negative impacts can be mitigated on site by the set up of sedimentation basin and/or alkaline treatment facilities depending on the discharge volume when necessary.

During the operation stage, as a result of discharge from Ta Trach Dam and Thao Long barrage, erosion would occur especially at the foot of the dam and barrage. This phenomenon of the deep erosion transmitted by discharged water is likely to happen and results in degradation or further erosion of banks in downstream. This impact should be minimised by the consideration of structural design.

4.4.4 Impacts on Ecological Environment

(1) Impacts on Vegetation and Flora

Responding to the normal water level of 45 m, the natural forest area to be submerged is estimated as 437 ha, of which grass dominate, bushes and secondary forests do not so much with the biomass of 5 tons per ha on average. On the other hand, the planted forest to be submerged is estimated as 1,267.5 ha with that of 20 tons per ha on average. The biomasses to be submerged responding to normal water level of 45.0 m is estimated as 27,500 tons in total.

Thus, the present vegetation cover is mainly comprised of grass, bushes and agricultural plants. Besides, majority of planted forests are eucalyptus and bamboo, where the natural degree of vegetation is considered to be low. Therefore, the impacts caused by Ta Trach reservoir on the vegetation cover and forest resources are not considered to be significant.

As listed in the table in the precious section, there are 12 rare and precious plant species identified in the headwater area of the Huong river. The most of them are seen in the area in Bach Ma National park, especially that with elevation of 600 – 1,200 m. Impacts on these species, therefore, are not significant because even the maximum water level of Ta Trach reservoir, approximately 52.0 m, is far below the area where these species grow.

(2) Impacts on Wild Animals

In and around the Ta Trach Dam Project Site, the wild animals have been extensively affected due to the uncontrolled hunting, forest cutting for cultivation, and flash and burn shifting cultivation. Thus, even if without the Ta Trach reservoir, wild animals in the Huong river basin are affected by human activities.

According to the mobilization of large number of construction workers during construction period, wild animals would be affected in the form of the disturbance and/or the loss of their habitat, including illegal hunting.

As listed in the table in the precious section, there are 25 rare and precious wild animals identified in and around the Project Site. Of which otters (*Lutra lutra*) and green peafowls (*Pavo muticus imperater*) would be affected because they are riparian species and their primary habitat would be lost. In addition, as for the other precious species, except for birds, there would be some adverse effects in terms of migration for foods, hiding or breeding.

(3) Fishes in the Huong river

Due to the existence of Ta Trach reservoir, the sediment content shall reduce in

downstream in the river, which would cause the reduction of the nutrition for the phytoplankton and results in affecting to its development. The decreased quantity of phytoplankton affects the food sources of fishes in the Huong river. The existence of the dam and reservoir also impedes the migration of fishes to upstream and vice verse.

On the other hand, the freshwater fish production in the reservoir and its upstream area is expected to increase due to the formation of the water body, i.e. Ta Trach reservoir, and the increase of phytoplankton, humus and residues in it, being combined with the increased potential of fishery development.

(4) Impacts on lagoon ecological system

a. Salinity condition and Nutrition

After the construction of Ta Trach Dam and Thao Long Barrage, the discharge from the dam is regulated and maintained at more than 25m^3/s even in dry season. During the flood season, all the valve gate of Thao Long Barrage will be open for a fast flush of floodwater. Thus, the constructions of the dam and barrage will form a stable discharge flowing into the lagoon and more stable salinity condition during non-flood season and yet will not reduce the nutrition supply excessively from the upstream because of the remaining of fast flush of floodwater.

b. Phytoplankton

Phytoplankton in the lagoon has two kinds: fresh water phytoplankton and sea water phytoplankton. The freshwater phytoplankton only appears in lagoon in rainy season when the flood flows into the lagoon.

The change of phytoplankton in Tam Giang lagoon is the alternate of the typical compositions of fresh water phytoplankton and sea water phytoplankton. With Ta Trach reservoir, floodwater shall be restored and then regulates the discharge to downstream and Tam Giang lagoon, thus the freshwater phytoplankton will be reduced in rainy season. On the contrary, the sea water phytoplankton will increase relatively even in rainy season.

c. Zooplankton and benthic macro-organism

The composition of the freshwater zooplankton and benthic macro-organisms usually appear in Thuan An estuary where receiving the Huong river water. However, it will gradually decrease and be replaced with brackish and sea water ones.

d. Fishes

A total of 163 species of fishes identified in Tam Giang – Cau Hai Lagoon can be divided into four groups:

- Fresh water fishes
- Brackish water fishes;
- Saline water fishes; and
- Migratory fishes.

The impacts of the construction of Ta Trach Dam and Thao Long Barrage on fishes will differ depending on these groups.

Fresh water fishes

The construction of the dam and the barrage will regulate the freshwater supply from upstream as a whole. Therefore, the habitat will be limited near the estuaries of the Huong river mainstream and its branches and of other rivers flowing into the Lagoon. However, even during period of water shortage, the maintenance flow will contribute to improve the living conditions near the estuary of the Huong river for fresh water fishes. During flood season, the living conditions for fresh water fishes will be almost the same as present due to the full open for a fast flush of floodwater. In conclusion, the change of water regime caused by the project implementation will not bring about a negative effect significantly on fresh water ecology in the lagoon.

Brackish water fishes

The brackish water fishes are able to live in a large amplitude of salinity varying from 5 ‰ to 18 ‰, and account for the largest number in the lagoon. Therefore, the impact on the brackish water fishes will be small, and the fish catch will be maintained.

Saline water fishes

Salinity in the lagoon water varies over time and space, depending on the river water supply and sea tides. But, all in all, the magnitude of salinity fluctuation will be reduced and stabilized due to the discharge regulation from the dam as mentioned above. Therefore, living conditions for saline water fishes will be improved, not be damaged, and fishery production will be estimated to increase than the present status.

Migratory fishes

There considered to be two types of migratory fishes in Tam Giang - Cau Hai lagoon and Huong river system. One is those species of feeding migration and the other is those of delivery migration.

The feeding migratory fishes migrate for food and their migration is considered to depend on the abundance of food in coastal sea, the lagoon system and the Huong river channel. The food and nutritious condition in the lagoon and the Huong river will not change significantly. Therefore, the impact on the feeding migratory fishes is considered to be slim.

With respect to delivery migratory fishes, on the other hand, there are several species categorized in it. They include the following two groups: 1) eels (*Anguilliformes*), *Mugil* and *Ephinephelus*, which migrate in river or lagoon to live and grow, and to spawn in the sea, and 2) *Lutianus*, *Stolenphorus* and *Theropn*, which migrate to lagoon to live and grow, and to river to spawn. Among the latter category, there are such migratory fishes that go deeply upstream to river headwaters to spawn, including *Chupanodon* and *Marura*.

Thus, the construction of Ta Trach Dam and Thao Long Barrage shall affect the migratory fishes migrating between the sea and river, including *Chupanodon* and *Marura* because they migrate deeply into river. The impacts may also fall on eels (*Anguilliformes*), *Lutianus*, *Stolenphorus* and *Theropn* because they migrate between the sea and river. Magnitude of the impacts, however, is not clear because the information on the number of these species is not available.

4.4.5 Impacts on Bach Ma National Park

The construction of Ta Trach Dam and the formation of reservoir will submerge a certain area of the park. However, the area to be submerged does not affect the forest zoning for the strict protection in order to keep the ecosystem unchanged and the habitat of the precious species in good condition. It does not affect either the resort and tourism area where there exist hundreds of villas and road systems connecting such villas.

Thus, although the construction of Ta Trach reservoir shall submerge a part of forest in the transition area of Bach Ma National Park, the impact is not considered to be significant because the area to be submerged is not ecologically important forest lands.

4.4.6 Impacts on Social Environment

(1) Magnitude of Land Acquisition

Ta Trach reservoir responding to SWL of EL 52 m will submerge about 35 km2 including the agricultural land of 5 km2 and forest of 17 km2. Whereas Thao Long barrage will acquire about 2 ha for constructing of 2 ends of the bridge, and management area temporarily occupies about 5 ha for borrowing area such as

material stockpiling and layout of the works. These impacts are negative and indispensable.

(2) Resettlement and Change of Social Issues

The construction of Ta Trach reservoir in the case of SWL of 52 m will directly affect 4,300 people (predicted to year 2003) in 855 households, of which 383 people are Van Kien ethnic minority in 73 households. In addition the host communities will be indirectly affected because they have to share the natural resources and will be suffered from the disorder of social and cultural activities.

The area to be submerged accompanies with houses, gardens, paddy field, vegetable area and planted forest of the local people and other public infrastructures such as school, clinic, office buildings, Commune's People's committee, assets, tombs, etc.

Van Kieu group is almost civilized, and at present they live with Kinh in the reservoir bed. The structure of their houses is similar to Kinh's. Thus, it will be acceptable for Van Kieu group to resettle in the same manner of the Kinh.

(3) Health and Sanitary Condition

The national and regional programs for health care including the prevention of water-born diseases have been implemented, and contributed to elimination of diseases. However, water-born diseases such as diarrhea and cholera are still observed somewhat in the areas along the rivers and canals under the probable infectious risk. In addition, the resources of domestic water use are currently suffered from the saline water intrusion caused by the low river flow. Saline water intrudes to Phu Cam annually, even to Van Nien in 2001.

Ta Trach reservoir and Thao Long barrage will improve these situations together with the enhancement of distribution of domestic water, and will introduce a great positive effect on the water use in daily life of the people living along the river. This means that the people in Huong river basin have convenient conditions to take care of their health, and that the community health/sanitary condition will be significantly improved.

On the other hand, the due consideration should be paid on the following issues:

- Probable deterioration of health and sanitary condition caused by mobilization of large number of labour force, and
- Increment of potential risk of diseases such as malaria in the areas adjacent to the new water bodies.

(4) Cultural or Historical Heritage

Both Ta Trach reservoir and Thao Long barrage will not cause negative impacts on the historical monuments and cultural structures or landscapes.

One of remarkable positive effects by Ta Trach reservoir is that it releases flood water to protect the Hue ancient capital city including citadels, ramparts, and royal tombs from inundation. At present the Citadel of Hue ancient capital city is under reparation and upgrading to attract both national and international. Ta Trach reservoir will decrease the risk of floodwater damage on the restored Citadel remarkably

(5) Noise and Dust

A huge amount of earthwork is planned for the construction both of Ta Trach reservoir and of Thao Long barrage. The construction sites and the vicinity will be affected by nuisance of noise and dust, and by chemical use if any.

(6) Impact on Forestry

Total forestland to be lost by Ta Trach reservoir will be about 1,300 ha of planted forest and about 400 ha of natural forest. The natural forest in reservoir bed mainly comprises of bamboo and timber with low capacity, and the vegetation cover mainly comprises of grasses and bushes. Thus the impact on the natural is minor. Regarding the planted forest, the loss of eucalyptus is estimated at about 500 million VND whereas that of bamboo is at about 50 million VND.

According to the proposed land-use plan for production land in the resettlement area, the planted forestland of about 1,200 ha is planned. The scale of this reforestation plan will approximately meet the magnitude of loss by the reservoir. In addition, the reforestation plan in the resettlement area includes the enhancement of recovering forestry and planting perennial fruit trees. Thus the negative impact on the existing forestry is considered to be reduced to the extent possible.

(7) Impact on Fishery

Inland Fishery

Ta Trach reservoir would affect the temporary migration of some fishes in Huong river to Ta Trach branch and vice verse. And also Thao Long barrage would affect the migration of some fishes in river and lagoon that go deeply to upstream for spawning. Although the change of condition for fish migration will probably reduce the productivity of fishery, the impact on annual fish production will not be significant because the migratory fish species are not considered to be economic ones.

Lagoon Fishery

The catch amount of lagoon fishery after 1999 flood increased remarkably, i.e. more than five times as much as that in 1980's and 1990's. It is considered that i) the appearance of the new lagoon estuaries by flood helped increase the migration species into the lagoon, and ii) the higher saline environment over the large area of the lagoon facilitates the development of the fish species in the lagoon. This suggests that the water exchange among river, lagoon, and sea plays an important role to the lagoon ecological environment, affects the catch amount of fishery in the lagoon.

Ta Trach reservoir has a function to regulate the river flow, and will, especially in dry season, contribute to stabilization of supplying the fresh water to the downstream and lagoon. From the experience mentioned above, this might have a tendency of decreasing the product of fish dependent on high saline water.

4.5 Environmental Management Plan

4.5.1 Mitigation and Enhancement Measures

The conceivable impacts by the constructions of the Ta Trach Dam and Tao Long Barrage on natural and social environment were predicted and described in detail in the previous section. The mitigation and/or enhancement measures to cope with the impacts are listed in Table D.9.

4.5.2 Environmental Monitoring Plan

In the previous section, the impacts by the implementation of both Ta Trach dam and Tao Long Barrage construction projects were predicted, and its mitigation and/or enhancement measures were described in detail. In order to manage both natural and social environment and to keep them in favourable condition, the existing environment and its change is to be monitored properly before and after the project implementation.

Table D.10 shows the necessary monitoring plan to follow-up the physical,

ecological, and social environment in and around the project sites.

5 ENVIRONMENTAL EVALUATION ON THE MASTER PLAN

5.1 Introduction

This section preliminarily examines the likely negative impacts on environment caused by the projects composing the Master Plan, and proposes the approach to cope with the impacts. The environmental evaluation was carried out in

accordance with the JICA Environmental Consideration Guideline.

Among the components of the Master Plan shown in Table D.11, the following projects were selected as those necessary for discussion in this section, in due consideration of characteristics of each project:

- Ta Trach Dam (Structural Flood Control Plan)
- Huu Trach Dam (Structural Flood Control Plan)
- Domestic/industrial Water Supply (Water Utilization Plan)

The components of the Master Plan such as i) Non-structural Flood Control Plan, ii) Agricultural Development and Irrigation Water Supply (Water Utilization Plan), iii) Other Management Plan, were screened out from the discussion, because it is expected that the negative impacts on environment will be insignificant as shown in Table D.12.

The matrix on the results of environmental evaluation is shown in Table D.13.

5.2 Social Environmental Aspect

(1) Land Acquisition and Resettlement

Land acquisition and resettlement are considered as one of the major negative impacts caused by Ta Trach Dam project. According to the existing studies in case of SWL of about EL 52 m, it is expected that more than 800 households will be compelled to resettle, of which about 600 are located within the proposed reservoir area and others are located at the dam site or stockpile. Out of the total affected households, approximate 5 % is Van Kieu group (one of the ethnic minorities in Vietnam). The existing studies also estimate the affected land to be approximate 35 km^2 including the agricultural land of 6 km^2.

Implementing Ta Trach Dam project, the above impact is inevitable. Therefore, it is, firstly, recommended that the program prepared for compensation and resettlement be carried out securely. Secondly, the consultation with the stakeholders, including the recipient communities of resettles, should be done during all the stages not only of preparation and implementation of the program, but also of stabilization of living condition after program completion.

Although the construction of Huu Trach Dam would cause the land acquisition and resettlement, the concrete and actual magnitude is unclear due to no availability of the existing data and information. The proposed site and reservoir area of the dam is located at the steep valley, and, therefore, the magnitude of impact does not seem to be serious due to the limited inundated area of approximate 11 km^2. However, the more survey is necessary, in order i) to identify

the magnitude of impact on land acquisition and resettlement, and ii) to prepare the proper program for resettlement action if the significant impact is expected. In addition, it should be also clarified, whether or not i) the ethnic minorities exist, and ii) impact on them is expected.

Regarding the domestic/industrial water supply plant, the magnitude of land acquisition and resettlement is not considered so significant since the required area for plant will be considerably small. However, the plan for compensation and resettlement should be prepared and implemented.

(2) Change or Split of Communities

According to the existing studies in case of SWL of about EL 52 m of Ta Trach Dam, approximate 60 % of the affected households will be compelled to resettle to other communes/districts, whereas on-site resettlement will be done for remaining affected households. This would cause the change or split of the existing communities. In addition, some conflict between new and old villagers would be introduced especially in the recipient communities. Thus, the close consultation with stakeholders is recommendable for mitigating the communal society as much as possible and additional support should be given if necessary.

It is unclear whether or not the change or split of the existing communities will be caused by the construction of Huu Trach Dam. As well as the issues on land acquisition and resettlement, the more survey is necessary.

(3) Traffic and Public Facilities

Especially on the fluvial navigation, the transportation by small boats for gravel is observed at Ta Trach Dam site, although the frequency of passing through the dam site is unknown. The proper support, such as preparation of small port connecting alternate roads, should be given against the inconvenience during and after dam construction. Regarding Huu Trach Dam, the same consideration as Ta Trach will be preferable.

(4) Health and Sanitary Condition

Large number of labour forces will be mobilized for the construction of Ta Trach Dam and Huu Trach Dam. In order to avoid deterioration of health and sanitary status in and around the project areas of 2 dams, it is recommended that construction workers be given basic education and preliminary aid, and also that public medical services be improved.

The risk of water-borne diseases might increase due to the appearance of new water bodies by Ta Trach Dam and Huu Trach Dam. According to the Ministry of

Health, malaria and dengue fever are not so common in T. T. Hue province at present. However, the ministry also suggests that the new dam reservoirs might make a potential risk of malaria high in the areas adjacent to the new water bodies. Therefore, monitoring of indicators such as out-patients will be required around the new reservoirs' area.

(5) Noise and Dust

Although the detail of construction plan and schedule of Ta Trach Dam and Huu Trach Dam is unknown, the construction activities are likely to increase the nuisance of dust and noise. Since these affect will be inevitable, the following measures is to be planned and implemented to the extent possible, namely i) the construction road and operation of heavy equipment should be away from settlement area, ii) the work hours should be restricted to the daytime hours, and iii) water spraying should be done on the construction road.

5.3 Natural Environmental Aspect

(1) Topography

The construction of Ta Trach Dam and Huu Trach Dam will cause the topographic change. However, there are no precious topography nor tourism spots relied on the unique topography. Thus the topographic change due to the dams construction will be acceptable.

After completion of Ta Trach Dam and Huu Trach Dam, the change of lagoon topography might occur due to the reduction of the sediment load from the upstream. The preliminary examination shows that the reduction of sedimentation rate in lagoon is estimated at about 26 cm/100years (average depth of lagoons is 1.5 – 2.0 m). According to the Study on Restoration and Stabilization of Thuan An - Tu Hien Estuary (May, 2001), the history of the lagoon system indicates that bed siltation on lagoon occurred together with the contraction of water surface. It is, therefore, considered that the reduction of sediment load to lagoon would make the progress of bed siltation slow somewhat.

Ta Trach Dam and Huu Trach Dam will improve the hydrological regime of the Huong river than the current status. Simultaneously, the composition of sediment, sediment transport pattern, and the tractive force will be also changed in the downstream. At present, it is unclear whether degradation/aggradation of river bed will occur or not.

(2) Water Quality

During the construction stage of Ta Trach Dam and Huu Trach Dam, there will be

a risk of pollution to their downstream by blasting or earthwork that will increase sediment load. In addition, the concrete placement of 2 dams' bodies would adversely affect the river water quality due to the alkaline discharge in case that gravity type dam by concrete would be applied to Ta Trach and Huu Trach dams although fill type was planned in F/S of Vietnam. It is therefore necessary, i) to provide the silting/sedimentation basin for reduction of sediment load, ii) to develop sediment control measures against soil erosion of exposed area, and iii) to provide treatment facilities of alkaline discharge if necessary.

Large number of labor forces will be employed for construction work of Ta Trach Dam and Huu Trach Dam. In order to avoid organic pollution to their downstream, the wastewater from campsites should be treated on sites. Moreover, emergency measures should be developed in the event of an accidental spillage of oil and other chemicals from the construction sites.

The proposed gross storage of Ta Trach Dam is 610 MCM, whereas the average annual inflow to the dam is estimated at 1,626 MCM by the hydrological analysis. The annual turn-over rate of the reservoir is obtained as about 2.7 times on an average. This means that there would be a possibility of occurrence of water temperature stratification in the reservoir. However, the difference of water temperature between surface and bottom will be 5 ℃ according to the experience of the existing dams in Vietnam. Therefore, the problem of cold water will be insignificant. In case of Huu Trach Dam, The annual turn-over rate of the reservoir is obtained as about 5.0 times on an average (gross storage of 230 MCM, average annual inflow of 1,154 MCM). This means that a possibility of occurrence of water temperature stratification in the reservoir would be small. And in the same manner as Ta Trach Dam, the problem of cold water will be insignificant.

Regarding eutrophication of the reservoir of Ta Trach Dam, the nutrient load to the reservoir will not be significant, since, i) the agricultural land as the major source of nutrient occupies less than 10 % of the catchment area of the dam based on the available information on land use, and ii) there are no developed urban area in the catchment area of the dam. And eutrophication phenomena is not so common according to the experience of the existing dams in Vietnam. Therefore, it is enough to check continuously whether or not the water bloom appears in the reservoir during the dam operation stage. In case of Huu Trach Dam, the problem of eutrophication will be insignificant in the same manner as Ta Trach Dam.

The storage and operation of Ta Trach Dam and Huu Trach Dam will ensure the discharge of the maintenance flow in Huong river. Therefore, the degradation of water quality of the downstream will be insignificant on the whole in the

condition that new other pollutant load in the watershed will be adequately managed.

(3) Flora, Fauna, and Ecology

A part of the Bach Ma National Park will be included within the reservoir area of Ta Trach Dam. However, the area to be submerged does not affect the forest zone which is strictly protected in order to keep the ecosystem unchanged and the habitat of the precious species in good condition. Therefore, from the ecological view point, the negative impact on the national park is considered slim. For the ecological conservation of the park, it is enough to check whether or not the negative impacts occur by Ta Trach Dam through the ordinary inspection result of MARD that is responsible for the management of the park.

The existing studies so far reported that some of flora/fauna listed in the red book as endangered or rare species were found in the upstream area of Ta Trach Dam. However, the impacts, such as whether or not the habitats of endangered/rare species would be damaged by the dam, are unclear in the existing studies. Therefore, it is recommended that the magnitude of impacts be clarified, and that mitigation measures be developed if practical.

Huu Trach Dam will not directly affect any designated areas such as national park and nature reserve. However, the existing condition on distribution and habits of endangered/rare species of flora/fauna is unclear. It is, therefore, recommendable that the more survey be carried out to grasp the existing condition, and that adequate consideration be given if the impact on endangered/rare species is expected significant.

According to the existing studies, the major species of fresh-water fish in the Huong river are carp, catfish, and eel. Since the eel is a migratory fish species, obstruction of migration might be caused by the dam structures. Therefore, adequate consideration such as fishway should be considered in case that the eel is catadromous for spawning in the sea by passing through the dam sites.

Any components of the Master plan of Huong river basin will not directly change or affect the existing conditions of the lagoons. However, the lagoons have an ecologically fragile system. So the ecological system of lagoons might be affected indirectly due to the change of river hydrology and reduction of sediment load by Ta Trach Dam and Huu Trach Dam, although the magnitude and positive/negative direction are unclear. In the case that the change of ecological condition in the lagoons would be significant, economic activities especially on lagoon fishery would be also affected considerably. The change of fishery condition in lagoon

can be considered as one of the most important indicators of ecological deterioration/enhancement of lagoon. It is, therefore, recommendable that the monitoring of fishery activities in lagoon, such as the change and trend of catch amount and fish/shellfish kinds, be carried out continuously and frequently.

(4) Landscape

The existing landscape will be changed drastically due to the construction of Ta Trach Dam and Huu Trach Dam. After the completion of the dams, however, appearance of vast water areas will also create the new landscape spot and have a potential for enhancement of regional economic activities such as tourism.

In the case that the domestic/industrial water supply plant would be constructed near the Hue city, the consideration in harmony with the existing landscape nearby is preferable because of the designation of the city as World Heritage.

Table D.1 List of Law and Regulation Related to Environment

(1) Fundamental Legislation, Guideline, etc.
- Environmental Protection Law 1994
- Decree on Guiding Implementation for Environmental Protection Law (Gov. Decree No. 175-CP, 1994)
- Decree on Sanction for Administrative Violations for Environmental Protection Law (Gov. Decree No. 26-CP, 1996)
- Decree No. 22/CP on Responsibilities, Authority and Organization of the Ministry of Science, Technology and Environment (22 May, 1993)
- National Plan on Biological Diversity (MOSTE, 1995)
- Biodiversity Action Plan, Decision Approving (PM Decision No. 845/TTg, 1995)
- Law on Land, 1993
- Decree No. 22/1998/ND-CP (Compensation for lost property by State's expropriation)
- Circulation No. 145/1998/TT-BTC, Guidelines on the Implementation of the Decree 22/1998/ND-CP, Ministry of Finance (Extracts)
- Master Guidelines and Policies to Utilize Unoccupied Land, "Barren", Hilly Areas, Forests, Denuded, Beaches and Waterfront (COM Decree No. 327, 1992)
- Law on Forest Protection and Development (12 August 1991)
- Law on Minerals (20 March 1996)

(2) Regulations Related to Environmental Impact Assessment (EIA)
- EIA and Licensing, Decision on Regulations and Appraisal Council (MOSTE Decision No. 1806/QD-MTg, 1994)
- EIA and Licensing, Regulations and Appraisal Council (MOSTE Decision No. 1807/QD-MTg, 1994)
- EIA Instruction for Guiding Operating Units (MOSTE Instr. No.1420/QD-MTg, 1994)
- EIA Instruction for Report to the Direct Foreign Investment Project (MOSTE Instr. No. 715/QD-MTg, 1995)
- Temporary Guidance for Environmental Impact Assessment of Technical-Economic Project, No.1485/MTg, 1993
- Circulation No. 490/1998/TT-BKHCNMT, MOSTE, Guiding the Preparation and Evaluation of AEI (EIA) Reports for Investment Projects

(3) Environment-related Standards
- Air Quality, Ambient Standards (TCVN 5937, 1995)
- Air Quality, Hazardous Substance Standards (TCVN 5938, 1995)
- Air Quality, Industrial Standards for Inorganic Substances (TCVN 5939, 1995)
- Air Quality, Industrial Standards for Organic Substances (TCVN 5940, 1995)
- Standards for Noise in Public and Residential Areas (TCVN5945, 1995)
- Standards for Noise on Road Motor Vehicle (TCVN5948, 1995)
- Soil Quality Standards on Pesticide Residue Limits (TCVN5941, 1995)
- Industrial Waste Water Discharge Standards (TCVN5945, 1995)
- Water Quality Standards; Coastal Water (TCVN5943, 1995)
- Water Quality Standards; Groundwater (TCVN5944, 1995)
- Water Quality Standards; Surface Water (TCVN5942, 1995)

Table D.2 Summary of Water Quality of Tam Giang - Cau Hai Lagoon

Parameter	Water Sampling Location	Year	Results of Analysis		Unit
			Range of average	Overall range	
Temperature	The whole area	1999	20.5	15.1－24.1	ºC
		2000	29.1	26.2－30.0	
pH	O Lau River estuary to An Gia	1999-2000	6.5-7.5	Not described	-
	The rest area	Ditto	7.6-8.2	Not described	
DO	Tam Giang and Thuy Tu lagoon	1999-2000	5.3-8.4	Not described	mg/l
	Cau Hai Swamp	Ditto	4.9-8.0	Not described	
COD	The whole area	1999-2000	6-12	5-25	mg/l
BOD_5	The whole area	Ditto	0.5-1.0	Not described	mg/l
Salinity	Near O Lau River Mouth	1999	Not described	0-18	‰
	Dam market to An Gia	1999	Not described	0-18	
	Tu An Xuan To Thuan An estuary	1999	Not described	0-30	
	Sam-An Truyen to Tu Hien	1999	Not described	0-30	

Source : "Study on stabilization and restoration of Thuan An - Tu Hien estuaries and Tam Giang - Cau Hai lagoon," May 2001, MOSTE

Table D.3 Inventory of impacts on environment caused by Ta Trach reservoir and mitigation methods

Project's activities and impacts on natural resources	Loss of natural resources	Level of impact				Mitigation methods
		Much	Medium	Little	No	
I. Environment issues raised by selection of route						
1. Inundation, emigration away from reservoir bed and resettlement	Much impact to social stability	√				Provision of proper finance plan for settlement
2. Destroy the rare ecosystem	Lose of gene resources				√	Provision of appropriate planning and mitigation methods
3. Destroy the cultural and historic values	Lose of cultural and historic values				√	Appropriate planning and mitigation methods
4. Basin erosion, deposit of mud and soil in the riverbed	Shorten the Works' life-span					Provision of basin management program particularly covering vegetation
5. Underground water, mineral resources	Lose of reservoir water causing a swampy ground and lose of mineral resources .		√			Provision of mitigation method. Exploration the mineral mine before reservoir overflowed.
6. Seismic threatening	Variation of frequency and seismic level			√		Provision of a careful alignment design
7. Others	Depend on each loss					Cautious selection of alignment
II. Environmental issues relating to inappropriate design						
1. Erosion due to access road and reservoir clearance	Change of water quality and nutritious regime of reservoir		√			Provision of careful design and construction. Preparation of proper plan and restoration.
2. Advantage of water supply and fish feeding	Rise the social conflict			√		Develop the knowledge of people
III. Environment issues in construction stage						
1. Flow stop for dam construction	Prevent ships from traffic and fish from transition			√		Change of transport means. Preserve the rare and valuable fish
2. Erosion and mud flow	Lessen the water and soil quality	√				Provision of suitable construction plan as well as careful supervision
3. Hygiene, heal care, and labor safety	Transmit the diseases. Weaken the worker and local people		√			Provision of appropriate health-care program
4. Construction supervision	The Contractor will ignore the construction requirement if no supervision is required		√			Supervise the construction progress to minimize the adverse impacts
IV. Environment issues in operation stage						
1. Diversion of downstream flow	Influence on river transport, irrigation structure, water quality, riverside and riverbed erosion	√				Change to transport means used for dry season. Consolidate the important section. Minimize the adverse impacts.
2. Alter the estuarine ecosystem	Lose of food resources. Salted condition in dry season				√	Provision of convenient regulation of water
3. Basin and reservoir erosion	Increase the deposit in the reservoir. Decrease the operation.		√			Provision of suitable cultivation and protection forest
4. Supervise the operation stage	Lose and inappropriate use of water due to lack of supervision		√			Manage and supervise the operation stage
V. Environment issues relating to flood protection and electric generation						
1. Conflict between flood protection and electric generation. Prevention from designed and annual flood	Difficult flood protection. Lose electricity		√			Provision of suitable operation procedure and equipment
2. Electric wire and transformer	Affect to natural resources where passing by			√		Provision of accurate planning and construction
3. Supply of urban electricity	Raise the living standard but also increase the unexpected accident			√		Develop the knowledge of people in using electricity

Source: Report on Environmental Impact Assessment on Ta Trach Reservoir Project in Thua Thien Hue Province, 2000

Table D.4 Water Sampling Locations in Huong River Basin in EIA Study

N⁰	Locations	River	Number of water samples		
			Chemic - Physical criteria, microogranisim	Heavy mental	Pesticide
Surface water:					
1.	*Upstream of the Thanh Long dam*	Huong	3	1	1
2.	*Sinh confluence (Huong and Bo rivers)*	Huong and Bo	3		1
3.	*Da Dam (3km to thedownstream)*	Huong	3	1	1
4.	*Kim Long water-level station (1km down to Hue city)*	Huong	3	1	
5.	*Thien Mu domestic water supply station*	Huong	3	1	1
6.	*Tuan confluence (Huong and Ta Trach rivers)*	Huong and Ta Trach	3	1	
7.	*Phu Cam*	Huong	3		
8.	*Van Nien*	Huong	3		
9.	*The mouth of Huong river in Thuan An*	Huong	3		1
10.	*Duong Sat bridge*	Bo	3	1	
11.	*An Lo bridge*	Bo	3		
12.	*Thanh Ha*	Bo	3	1	
13.	*Niem Pho*	Bo	3	1	
14.	*Thuy Chau*	Nong	3		
15.	*The below 1km of Da dam*	Nong	3	1	
16.	*The below of La Y dam*	Nong	3		
Waste water and drainage water:					
17.	*Waste water canals of Hue city (3 locations)*		9	3	
18.	*Agricultural drainage canals (3 locations)*		9		3
Groundwater:					
19.	*Hue urban areas (3 locations)*		15	2	
20.	*Hue environs and adjacent areas (3 locations)*		9	1	
21.	*Coastal area (3 locations)*		15	1	
Sum			***105***	***16***	***7***

Table D.5 Parameters to be Analyzed in EIA Study

N⁰	Chemic - Physical criteria, microorganism	Heavy mental	Pesticide
1	Temperature	Cu	HCB
2	pH	As	Diedrin
3	Ca_2^+	Cd	Monitor
4	Mg_2^+	F	Lindan
5	Total Solid	-	-
6	SO_4^{2-}	-	-
7	Total Alkaline	-	-
8	Cl^-	-	-
9	Total Fe	-	-
10	NH_4 as N	-	-
11	NO_2 as N	-	-
12	NO_3^-	-	-
13	PO_4^{3-}	-	-
14	DO	-	-
15	COD	-	-
16	BOD_5	-	-
17	Suspended Solid	-	-
18	Conductivity	-	-
19	Turbidity	-	-
20	Coliform	-	-
21	Fecal.coliform	-	-
22	Cl.ferfrigens	-	-
23	TDS	-	-

Table D.6 Water Quality of Huong River (Average figure of data from 1996 to 1999)

Parameter and Substance	Unit	Surface Water Quality Standard*		Tuan Confluence	Van Nien Intake	Gia Vien Intake	La Y Dam	Sinh confluence	Thao Long Barrage
		A	B						
pH value	--	6 – 8.5	5.5 - 9	7.03	7.16	7.16	7.05	7.13	7.19
Electric conductivity (EC)	uS/cm	-	-	0.06	0.05	1.38	4.59	5.29	5.93
Salinity	‰	-	-	0.02	0.02	0.44	1.72	1.12	2.09
Suspended solids (SS)	mg/l	20	80	3.8	4.6	3.9	4.3	6.9	4.7
Turbidity	FTU	-	-	7.8	8.2	8.2	8.5	9.1	9.2
Dissolved oxygen (DO)	mg/l	6	2	7.00	7.29	7.4	6.97	6.87	7.27
COD	mg/l	<10	<35	3.7	3.6	4.5	6.1	6.2	8.8
BOD_5 (20ºC)	mg/l	<4	<25	0.5	0.5	0.6	0.9	0.9	0.8
Nitrate (as N)	mg/l	10	15	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Phosphoric acid (PO_4^{3-})	mg/l	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury (Hg)	mg/l	0.001	0.002	-	0.0003	0.0003	0.0002	-	-
Arsenic (As)	mg/l	0.05	0.1	-	0.0115	0.0113	0.0140	-	-
Cadmium (Cd)	mg/l	0.01	0.02	-	0.0008	0.0006	0.0009	-	-
Lead (Pb)	mg/l	0.05	0.1	-	0.0052	0.0041	0.0068	-	-
Copper (Cu)	mg/l	0.1	1	-	0.0042	0.0045	0.0049	-	-
Nickel (Ni)	mg/l	0.1	1	-	0.0005	0.0005	0.0005	-	-
Zinc (Zn)	mg/l	1	2	-	0.0109	0.0105	-	-	-
Coliform	MPN/ 100ml	5,000	10,000	-	6,860	12,340	12,940	-	-

* Note: Surface Water Quality Standard of Vietnam (TCVN 5942, 1995). Values in the column A are applied to the surface water using for source of domestic water supply with appropriate treatments.
Values in the column B are applied to the surface water using for the purposes other than domestic water supply. Quality criteria of water for aquatic life are specified in a separate standard.

Data Source: "Current Environmental Status 1994 – 1998," DOSTE, Thua Thien Hue Province

Table D.7 Water Quality of Huong River

Parameter and Substance	Unit	Surface Water Quality Standard*		Van Nien Intake	Gia Vien Intake	Hue City (1)	Hue City (2)	Sea Food Processing Co.	Bao Vinh Confluence
		A	B						
Temperature	℃	-	-	24.4	25.2	24.8	25.1	24.9	25.4
pH value	-	6 – 8.5	5.5 - 9	7.02	7.06	7.03	7.08	6.98	7.02
Dissolved oxygen (DO)	mg/l	≥6	≥2	7.27	7.11	7.25	7.06	6.91	6.78
BOD_5 (20ºC)	mg/l	<4	<25	1.2	1.3	1.3	1.6	1.7	1.6
COD	mg/l	<10	<35	4.7	4.5	6.0	7.3	7.2	7.4
EC	mS/cm	-	-	50.2	55.5	52.5	57.6	60.0	72.4
Suspended solids (SS)	mg/l	20	80	11.5	11.6	15.0	14.1	14.1	14.2
Cl	mg/l	-	-	4.3	4.9	4.7	5.8	8.3	10.1
Hardness	mg/l as $CaCO_3$	-	-	21.1	20.8	21.2	22.2	23.0	25.2
Nitrate (as N)	mg/l	10	15	0.24	0.26	0.18	0.21	0.23	0.20
TKN-N	mg/l	-	-	0.35	0.48	0.70	0.66	0.48	0.45
Fecal Coliform	MPN/ 100ml	-	-	1,275	1,283	3,025	3,703	3,653	5,620
Coliform	MPN/ 100ml	5,000	10,000	5,875	17,825	9,805	15,920	10,120	17,623

* Note: Surface Water Quality Standard of Vietnam (TCVN 5942, 1995). Values in the column A are applied to the surface water using for source of domestic water supply with appropriate treatments.
Values in the column B are applied to the surface water using for the purposes other than domestic water supply. Quality criteria of water for aquatic life are specified in a separate standard.

Data Source: "River Water Quality Management Using Water Quality Indices and Tools From Impact Assessment: A Case Study from Vietnam," October, 1997.

Table D.8 The Summary of Water Quality Analysis for the Huong River

No	Parameter	Unit	Surface Water Quality Standard*		Water Quality**		
			A	B	Average	Min.	Max.
1	Temperature	℃	-	-	21.1	20.2	22.3
2	pH	-	6 – 8.5	5.5 - 9	7.6	7.4	7.8
3	Conductivity	MicroS/cm	-	-	2853.9	45.2	24200
4	Turbidity	NTU	-	-	17.5	12.0	28.0
5	DO	mg/l	≥ 6	≥ 2	6.78	5.1	8.1
6	BOD5	mg/l	<4	<25	13.1	4.9	79.0
7	COD	mg/l	<10	<35	10.5	7.2	18.7
8	Hardness (CaCO3)	mg/l	-	-	128	80	250
9	Alkalinity (HCO3-)	mg/l	-	-	35.6	12.2	109.8
10	Calcium	mg/l	-	-	30.8	14	70
11	Magnecium	mg/l	-	-	9.4	3.0	17.4
12	Chlorine	mg/l	-	-	2362.6	14.2	20376.0
13	Ammonium	mg/l	0.05	1	0.13	0.06	0.17
14	Nitrite	mg/l	0.01	0.05	0.020	0.005	0.048
15	Nitrate	mg/l	10	15	2.635	0.016	8.090
16	Suspend Solid (SS)	mg/l	20	80	43	25	70
17	Dissolved Solid	mg/l	-	-	449	234	950
18	Phosphaste	mg/l	-	-	0.040	0.008	0.190
19	Total Iron	mg/l	1	2	0.067	0.002	0.287
20	Coliform	Coli/100ml	5000	10000	3705	760	11000
21	Fecal.coliform	F.c/100ml	-	-	1653	240	4500
22	Cl.ferfrigens	10 ml	-	-	6.4	2	15
23	Copper	mg/l	0.1	1	0.004087	0.001470	0.011941
24	Lead	mg/l	0.05	0.1	0.47252	0.00591	0.93913
25	Cadmium	mg/l	0.01	0.02	0.00418	0.00003	0.01748
26	Zinc	mg/l	1	2	0.01217	0.00405	0.02069
27	As	mg/l	0.05	0.1	0.00005	0.00002	0.00007
28	F-	mg/l	1	1.5	0.91685	0.85100	1.02580
29	Lin dan	MicroG/l	-	-	0.00510	0.00114	0.00761
30	Monitor	MicroG/l	-	-	0.01434	0.00704	0.02246
31	Metylparathion	MicroG/l	-	-	0.01022	0.00898	0.01141
32	HCB	MicroG/l	-	-	0.00028	0.00010	0.00041
33	Diedrin	MicroG/l	-	-	0.00199	0.00084	0.00363

* Note: Surface Water Quality Standard of Vietnam (TCVN 5942, 1995). Values in the column A are applied to the surface water using for source of domestic water supply with appropriate treatments.
Values in the column B are applied to the surface water using for the purposes other than domestic water supply. Quality criteria of water for aquatic life are specified in a separate standard.

**Note: Date of Water Sampling: 26 through 28, January, 2002.

Data Source: "Final Report on Environmental Impact Assessment in Huong River Basin, Annex 2," JICA, March, 2002.

Table D.9 Possible mitigation/enhancement measures for the conceivable impacts

	Conceivable impacts on environment	Possible mitigation/enhancement measures
Physical environment	· Humidity increase in both air and soil. · Lift up of groundwater level.	· Reforestation/plantation in headwater areas and reservoir embankments
	· Mud flow and turbid flow from construction site.	· Establishment of sedimentation basin just below the construction site.
	· Erosion at immediately below the Ta Trach dam or Thao Long barrage by scouring.	· Due consideration of structural design.
	· Discharge of alkaline water while concrete placement works.	· Establishment of alkaline water treatment facility.
	· Possibility of cold water intake for downstream irrigation and the damage to agricultural crops.	· Establishment of several intake points, i.e. sluices, at the dam weir and the mixture of the water taken for discharging.
	· Water pollution in the reservoir. · Decomposition of submerged trees and plants. · Contamination by residual substances such as wastes, chemicals and/or fuels.	· Clearance of existing plants, trees, houses and other residual substances on the reservoir bed before the submersion.
	· Possibility of eutrophication.	· Clearance of existing substances mentioned above and reforestation in headwater areas.
	· Nutrient loss in downstream area in Huong river and Tam Giang – Cau Hai lagoon.	· Proper regulation of flush water to release downstream deliberately at Ta Trach dam during rainy season.
Ecological Environment	· Loss of vegetation cover and accompanying habitat loss for terrestrial wild animals.	· Reforestation/plantation in headwater area and reservoir embankments in order to recover and enhance the ecological functions, such as supplying hiding places, foods and breeding areas.
	· Impacts on aquatic organisms and aquaculture in Huong river and Tam Giang – Cau Hai lagoon.	· The execution of the mitigation measure for nutrient loss mentioned above and establishment of bio-path at Ta Trach dam and at Tao Long barrage for the mitigation of impacts on migratory fish.
	· Threatening of the extinction of the precious and/or endemic species.	· Implementation of on-site investigation for the identification of the precious and/or endemic animals/plants and consideration of practical method for their transplantation.
	· Impacts on Bach Ma National Park.	· Reforestation/plantation in headwater area of Ta Trach river in Bach Ma National Park for limiting erosion and washing and the formation of habitat of wild animals.
Social Environment	· Impact of resettlement by Ta Trach Dam.	· Due implementation of resettlement action plan in parallel with consultation with stakeholders.
	· Conflict between new comers and recipient communities of resettlers.	· Preparation of communal society development program for stabilizing life conditions.
	· Deterioration of health and sanitary condition due to mobilization of workers during construction stage.	· Provision of basic education and primary aid, and improvement of public medical services.
	· Impact of noise and dust during construction stage.	· Due consideration to residential area on locating construction road and operating heavy equipment, restriction of work hours to daytimes, and water spraying on the road.

Table D.10 Environmental Monitoring and Management Plan

	Area/Target		Locations	Monitoring parameters	Frequency	Methodology
Physical Environment	Water regime	Huong river basin	Existing hydrological station(s)	Rainfall, water level, run-off velocity and discharge.	Continuously.	Same as on going method.
	Water quality	Ta Trach reservoir	One station: representative point in the reservoir.	Physical, chemical and biological parameters in Surface Water Quality Standard of Vietnam (TCVN 5942, 1995).	Monthly (12 times a year)	Water sampling and laboratory tests.
		Huong river	Four stations: 1) Van Nien water supply factory. 2) Gia Vien water supply factory. 3) Down stream of sewage discharge from Hue city. 4) Sinh confluence.	Ditto	Monthly (12 times a year) for sampling station 1) and 2). Dry season and rainy season (2 times a year) for sampling station 3) and 4).	Ditto
		Tam Giang – Cau Hai lagoon	One station: representative point in the lagoon near Thuan An estuary.	Physical, chemical and biological parameters in Surface Water Quality Standard of Vietnam (TCVN 5942, 1995) and Coastal Water Quality Standard of Vietnam (TCVN 5945, 1995)	Monthly (12 times a year)	Ditto
	Erosion and sedimentation	Ta Trach reservoir	Surrounding areas of Ta Trach reservoir and inflow point of Ta Trach river into the reservoir	The magnitude of erosion, sedimentation and other risks of other earth related disaster.	Yearly, and when necessary, e.g. after flooding.	Ocular observation and on-site survey if necessary.
		Huong river including Ta Trach river	River banks	The magnitude of erosion along the river.	Ditto	Ditto
		Tam Giang – Cau Hai logoon	Tuan An estuary	The change of erosion/sedimentation caused by the existences of Ta Trah dam and Tao Long barrage.	Ditto	Ditto
Ecological Environment	Flora	Terrestrial flora	Reservoir bed (area to be submerged) prior to the construction work. If the transplantation of precious species executed, the transplantation site.	Higher level plants and trees including precious species	Once at pre-construction period. If the transplantation of precious species executed, twice a year (dry season and rainy season) .	On-site identification and description on community and population and interview to local residents.
	Fauna	Terrestrial fauna	Reservoir bed (area to be submerged) prior to the construction work. If the transplantation of precious species executed, the transplantation site.	Mammals, birds, reptiles and amphibians	Ditto	On-site identification and description on breeding grounds and population and interview to local residents.
		Aquatic organisms	Ta Trach reservoir, Huong river and Tam Giang – Cau Hai lagoon	1) Composition and quantity of natural fishes including migratory fishes, phytoplankton, zooplankton and benthic organisms. 2) Composition, quantity, growth rate and production of raised fishes.	Once at pre-construction period and twice at operation period a year (dry season and rainy season).	On-site identification by net-catching and interview to local fisher forks and officials working at relevant organizations.
Social Environment	Resettlement	Effectiveness of action plan	Ta Trach dam, resettlement areas	Actual progress of and compliance with the plan. Socio-economic conditions and requirement of stakeholders.	Once at pre-construction stage, and continuously after construction work starts until achievement to self-sustenance.	Field observation, interview or inquiry, consultation with stakeholders.
	Health and sanitation	Construction workers, residents near reservoir	Ta Trach dam	Health condition of construction workers and sanitary condition of campsites during construction stage. Number of out-patients and morbidity trend after completion.	Twice a year during construction stage (dry season and rainy season). Once a year after completion.	Field observation, interview or inquiry, recording file review.
	Noise and dust	Dam construction	Residential areas near dam construction site	Nuisance status of noise and dust, Noise level and dust concentration if necessary.	Once a month during construction stage for qualitative confirmation, Field measurement when necessary.	Field observation, interview or inquiry, field measurement if necessary.

Table D.11 Summarized Description of Master Plan and Screening

Major Components	Type		Outline of Features		Screening
	New	Improv. /Rehab.	Scale, etc.	Characteristic	
a. Flood control plan (structural)					
a-1 Ta Trach Dam (multipurpose)	○		610 MCM (Gross)	Active storage of 538 MCM, reservoir area of approx. 35 km^2 at SWL of EL 52.0 m, FWL of EL 49.2 m.	to be evaluated
a-2 Huu Trach Dam (multipurpose)	○		230 MCM (Gross)	Active storage of 182 MCM, FWL of EL 55 m, reservoir area of approx. 11 km^2.	to be evaluated
b. Flood control plan (non-structural)	○	○	Basinwide	Establishment of Disaster Mitigation Management Center, improvement of existing measures such as warning system,flood prone area maps, public awareness, etc.	screen out
c. Water utilization plan					
c-1 Domestic/industrial water supply	○		20,000 m^3/day	Development of domestic water supply plant	to be evaluated
c-2 Agricultural development		○	25,900ha	Stabilization of agricultural production through protection from i) early flood, and ii) saline water intrusion.	screen out
c-3 Irrigation water supply		○	25,900ha	Improvement or rehabilitation of existing facilities for irrigation and drainage	screen out
d. Other management plan					
d-1. Soft component for flood control	○	○	Basinwide	O&M of facilities, development or improvement of flood forecasting system, watershed management, etc.	screen out
d-2. Soft component for water utilization	○	○	Basinwide	O&M of facilities, development of system for proper water distribution, etc.	screen out
d-3. River environment management	○	○	Basinwide	Development or improvement of monitoring system for river water quality and for lagoon environment, etc.	screen out
d-4. Administration		○	Basinwide	Strengthening of legal control and administration, strengthening of the institution related to water utilization, etc.	screen out

Table D.12 Description on the Components Screened Out from Evaluation

Components [1/]	Description of Basis to be Screened Out
b. Flood control plan (non-structural)	- The non-structural measures for flood control proposed in the Master Plan are; i) disaster preparedness, ii) public awareness programs, iii) upgrading existing flood inundation mapping, and iv) improvement of field benchmark networks. - Establishment of Disaster Mitigation Management Center is also proposed in the Master Plan. - No environmental impact by the above programs/activities is expected.
c. Water utilization plan c-2. Agricultural development	- The purposes of the plan are to stabilize the agricultural protection through control of i) early flood, and ii) saline water intrusion. - The expansion of the target area for the development is not proposed in the Master Plan (existing agricultural land of 25,900 ha). - Enhancement of agricultural input such as chemicals and fertilizer is not proposed in the Master Plan. - The rate of increment of cropping intensity is considerably low; about 16.7%. - The environmental impact by the above is expected to be negligibly small.
c-3. Irrigation water supply	- The development of new irrigation and drainage system is not proposed in the Master Plan. - The main programs of the plan are i) to rehabilitate the existing canals for irrigation and drainage, and ii) to improve or replace the existing pumps for irrigation and drainage. - The environmental impact by the above is expected to be negligibly small.
d. Other management plan	- Other management plan is mainly composed of i) soft component for flood control such as O&M of the facilities, ii) soft component for water utilization, iii) river environment management such as improvement of monitoring system on water quality, and iv) administrative strengthening. - No environmental impact by the above programs/activities is expected.

1/: Components screened out in Table D.11.

Table D.13 Environmental Evaluation

Components [1/] / Environmental Elements [3/]	Environmental Evaluation [2/]					
	Ta Trach Dam		Huu Trach Dam		Domestic/industrial water supply	
	Construction Stage	Operation Stage	Construction Stage	Operation Stage	Construction Stage	Operation Stage
1. Social Aspects						
Land acquisition and resettlement	-/○	-/△	?	?	-/△	×
Economic activities	+-/○	+/△	+-/○	+/△	+-/△	×
Traffic and public facilities	-/○	-/○	-/○	-/○	×	×
Change or split of communities	-/○	-/△	?	?	×	×
Water rights and fishing rights	×	×	×	×	×	×
Health and sanitary condition	-/△	-/△	-/△	-/△	×	×
Cultural/historical heritage	×	×	×	×	×	×
Noise and dust	?	×	?	×	×	×
2. Natural Aspects						
Topography	-/△	?	-/△	?	×	×
Hydrology	×	+/○	×	+/○	×	×
Coastal area	×	×	×	×	×	×
Water quality	-/△	-/△	-/△	-/△	×	×
Flora, fauna, and ecology	-/△	?	?	?	×	×
Landscape	-/○	+-/○	-/○	+-/○	-/△	-/△

1/: Major components of the Master Plan to be examined (See Table D.11).

2/: Each applicable item is marked with the following classifications.

+/○: Upper part shows the direction of impacts and lower part shows the magnitude of impacts.

○: Major △: Minor ×: None ? : Not Clear

+: Positive -: Negative +-: Neutral

3/: Environmental Elements were selected based on JICA Environmental Consideration Guideline

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Figure D.1
Geographical Extent of Tam Giang - Cau Hai Lagoon