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GOVERNMENT OF THE REPUBLIC OF ECUADOR

CENTRO DE REHABILITACION DE MANABI (CRM)

FEASIBILITY STUDY
ON
THE WATER RESOURCES DEVELOPMENT
FOR CHONE-PORTOVIEJO RIVER BASINS

FINAL REPORT
(SUMMARY)

DECEMBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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LIST OF REPORTS

PREFACE

In response to a request from the Government of the Republic of Ecuador, the Government of Japan decided to conduct a Feasibility Study on The Water Resources Development for Chone-Portoviejo River Basins and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Ecuador a study team headed by Mr. Osamu Takahashi, Nippon Koei Co., Ltd., four times between May 1991 and November 1992.

The team held discussions with the officials concerned of the Government of Ecuador, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

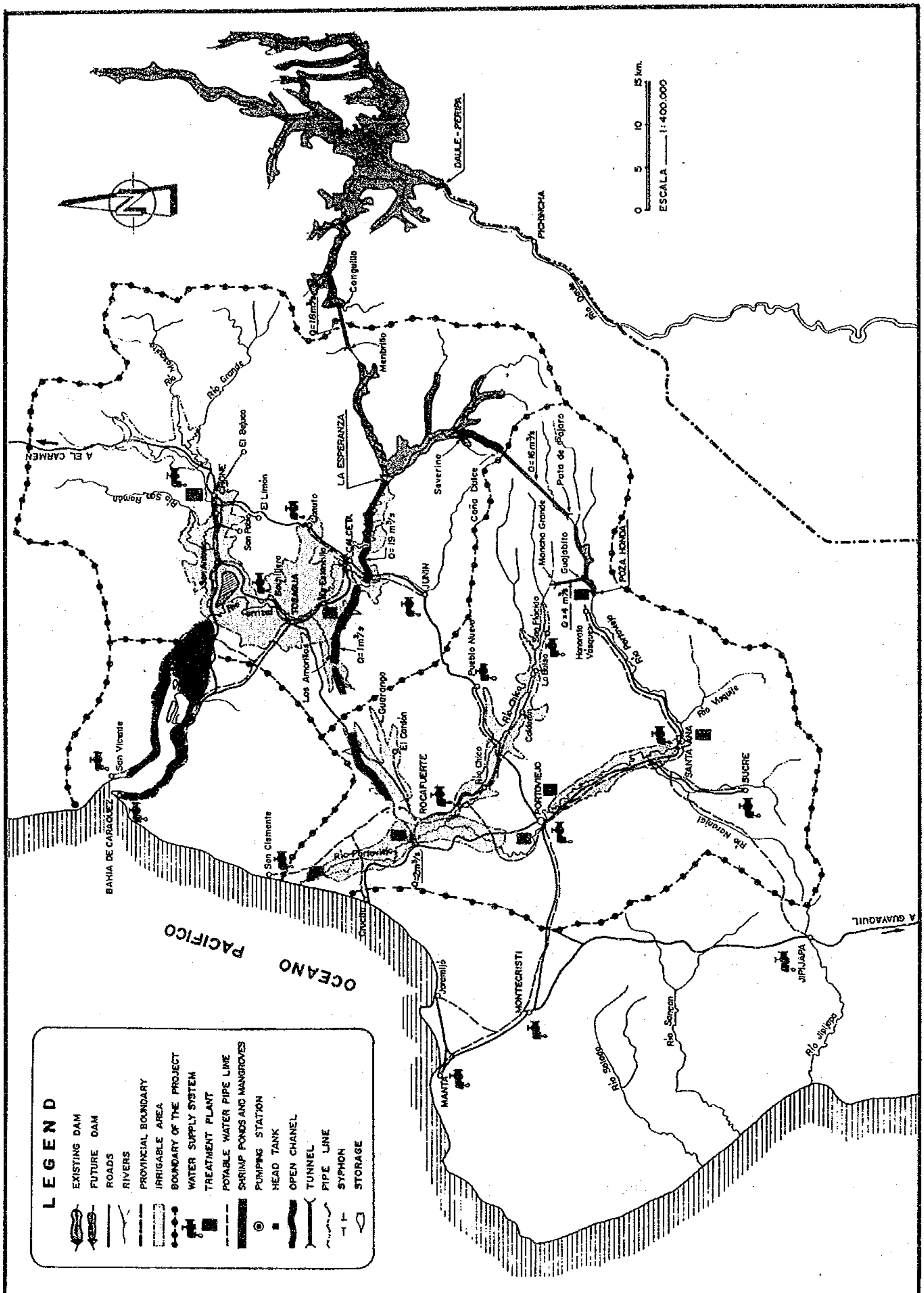
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Ecuador for their close cooperation extended to the team.

January 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation
Agency



LOCATION MAP

(Alternative -5 a)

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1. Introduction

In view of the urgent necessity of solving a habitual water shortage problem of Manabi province, the Manabi Rehabilitation Center (CRM) in cooperation with the National Development Council (CONADE) and the Ecuadorian Institute of Water Resources (INERHI) started a comprehensive study on the integrated water resources development of Manabi province (PHIMA) in late 1986. The Organization of American States (OAS) joined the PHIMA study in late 1987 and the Government of Japan also joined the PHIMA study in early 1989 through the Japan International Cooperation Agency (JICA).

The final report on the PHIMA study was prepared in January 1990 by JICA in collaboration with OAS and the Government of Ecuador (CONADE, INERHI, and CRM), which recommended to conduct a feasibility study on the water resources development in the Chone and Portoviejo river basins, more specifically on the water transbasin scheme from the existing Daule Peripa dam to the Chone-Portoviejo river basins (the Study). The PHIMA report identified six alternatives for the water transbasin scheme.

The Study was conducted by JICA in collaboration with CRM and other relevant organizations of the Government of Ecuador in two phases : Phase 1 from March 1991 to March 1992 for examination of various alternative transbasin schemes and selection of the best scheme and Phase 2 from May 1992 to December 1992 for elaboration of a feasibility study on the selected transbasin scheme.

2. The Study Area

The Study area is located in the central part of Manabi province facing to the Pacific Ocean and has an area of 4,870 km^2, accounting for 26 % of the total Manabi province. The population of the Study area was 484,500 in 1990, accounting for 47 % of the total Manabi population. More than 40 % of economically active population of Manabi province are engaged in the agriculture and livestock sector. Though the gross regional product (GRP) of Manabi province is about 7 % of the gross domestic product (GDP) of Ecuador, GRP of the agriculture and livestock sector of Manabi accounts for 14 % of the same sector of Ecuador and 42 % of the GRP of Manabi.

Major agricultural products are coffee, cocoa, maize, cotton, banana/platano and citrus. Livestock farming is also an important industry of Manabi, especially cattle and hog farming. The aquaculture of shrimp has been developed remarkably in several estuaries including lower reaches of the Chone and Portoviejo rivers. Main export products from Manabi were coffee (US$ 40 million), shrimp (US$ 32 million), fishes (US$ 28 million), cocoa (US$ 10 million), etc. in 1990.

The Study area is situated in the coastal region of Ecuador where younger geological layer of sedimentary rock of Tertiary makes gentle mountains. The annual mean rainfall is about 900 mm in the Portoviejo river basin and 1,200 mm in the Chone river basin. In both river basins, almost 90 % of the annual rainfall is concentrated in the rainy season from December to May.

3. Water Demands

Water demands in the Study area are as follows:

Municipal and Industrial Water Demands (MCM/year)

Year	Portoviejo Basin	Chone Basin	Total
1995	47	13	60
2000	60	18	78
2005	78	25	103
2010	97	31	128
2015	124	38	162
2020	152	45	197

Irrigation Water Demands (MCM/year)

Scheme	Net Area (ha) /1	Water Demand /2
Chone river basin		
Carrizal-Chone	15,000	253
Amarillos	1,000	19
Sub-total	16,000	272
Portoviejo river basin		
Guarango	1,500	36
Rio Chico	1,700	31
Pechiche-Pasaje	850	20
Santa Ana	3,300	73
Mejia	1,250	28
Ceibal-Guayaba	4,650	111
Sub-total	13,250	299
Total	**29,250**	**571**

Note : /1 ; Irrigation development areas including existing areas
/2 ; Water demand with 80 % guarantee

Fresh Water Demand for Shrimp Farming (MCM/year)

Year	Gross Area (ha)	Net Area(ha)	Water Demand
1995	5,280	3,170	98
2000	5,550	3,330	102
2020	5,550	3,330	102

River Maintenance Flow (MCM/year)

Scheme	Water Demand
Chone river (downstream of La Esperanza dam)	16
Portoviejo river (downstream of Poza Honda dam)	8

4. Water Resources Development in and around The Study Area

The Poza Honda dam was constructed by CRM in the upper reach of the Portoviejo river in 1971. The dam and reservoir regulates the annual mean inflow of 106 MCM from the catchment area of 175 km^2 with an effective reservoir capacity of 75 MCM and supplies the Poza Honda water supply system (45 MCM/year), the Santa Ana irrigation system (25 MCM/year for 1,100 ha) and the river maintenance flow (8 MCM/year).

The Daule Peripa dam was constructed by the Committee for Guayas River Basin Development (CEDEGE) in the upper reach of the Daule river in 1987. The dam and reservoir regulates the annual mean inflow of 5,000 MCM from the catchment area of 4,200 km^2 with an effective reservoir capacity of 4,000 MCM. The objectives of the dam are flood control, domestic water supply, irrigation water supply, hydroelectric power generation and water supply to Manabi province through water transbasin. According to the inter-institutional agreement between CEDEGE and CRM, CRM is entitled to divert up to 500 MCM/year with the maximum diversion of 18 m^3/s.

CRM started a study on water transbasin project from Daule Peripa dam to the central part of Manabi in 1984, when the Daule Peripa dam was under construction. The study was concluded in 1987 proposing that water of the Daule Peripa reservoir would be diverted to the La Esperanza reservoir through a 8.3 km tunnel by gravity with a transbasin capacity of 12 m^3/s and that water in the Daule Peripa river at about 30 km downstream of the Daule Peripa dam would be pumped up into the Poza Honda

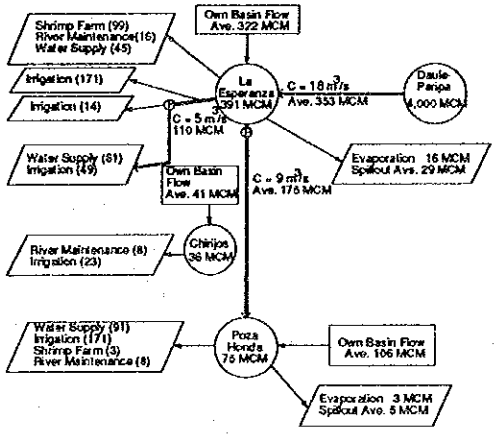
reservoir through a 13.3 km steel pipeline and a 11.2 km diversion tunnel with an initial capacity of 8 m^3/s and a final capacity of 12 m^3/s. This plan has been reviewed by JICA under the Study as Alternatives 2 and 6.

The La Esperanza dam construction was commenced in early 1992 by CRM with the target completion in early 1996. The dam is located in the upper reach of the Carrizal river, a major tributary of the Chone river. The dam and reservoir will regulate the annual mean inflow of 322 MCM from the catchment area of 445 km^2 with an effective reservoir capacity of 391 MCM and will supply irrigation water of 253 MCM/year to the proposed Carrizal-Chone irrigation system of 15,000 ha, domestic water up to 40 MCM/year to the Chone-La Estancilla water supply system and river maintenance flow of 16 MCM/year as well as flood control effect. Once the La Esperanza dam is constructed, the habitual inundation problem in the rainy season and the severe water shortage problem in the dry season will mostly be solved in the Chone river basin. The water shortage problem of the Portoviejo river basin will, however, still remain until the transbasin scheme is realized from Daule Peripa dam to Portoviejo river basin.

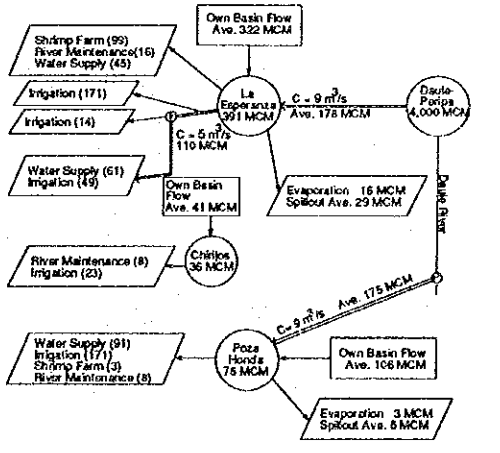
5. Six Alternatives for Water Transbasin

The following six alternatives are established as a combination of several transbasin schemes.

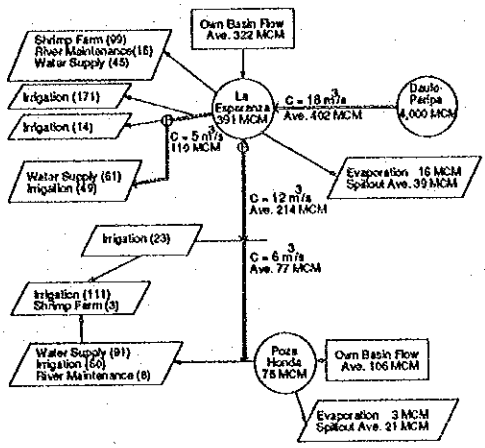
Alternative 1 : Daule Peripa dam - La Esperanza dam transbasin (18 m^3/s)
La Esperanza dam - Poza Honda dam transbasin (9 m^3/s)
La Esperanza dam - Guarango area transbasin (5 m^3/s)
Chirijos dam on upper Chico river



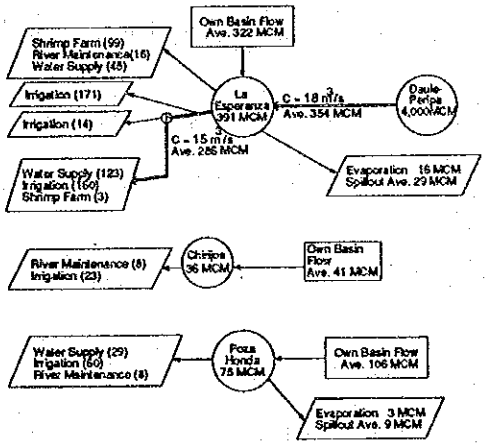
Alternative 2 : Daule Peripa dam - La Esperanza dam transbasin (9 m^3/s)
Daule river - Poza Honda dam transbasin (9 m^3/s)
La Esperanza dam - Guarango area transbasin (5 m^3/s)
Chirijos dam on upper Chico river



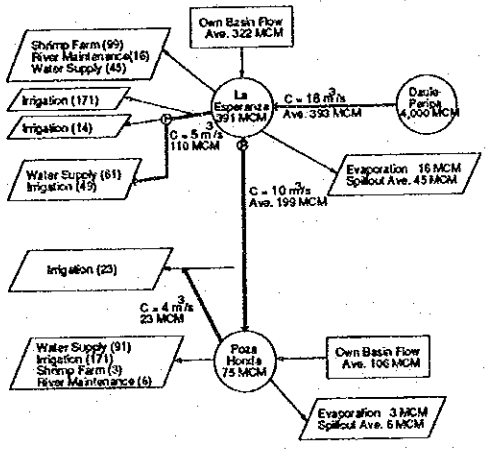
Alternative 3 : Daule Peripa dam - La Esperanza dam transbasin (18 m^3/s)
La Esperanza dam - Chico river transbasin (12 m^3/s)
Chico river - Portoviejo river transbasin (6 m^3/s)
La Esperanza dam - Guarango area transbasin (5 m^3/s)



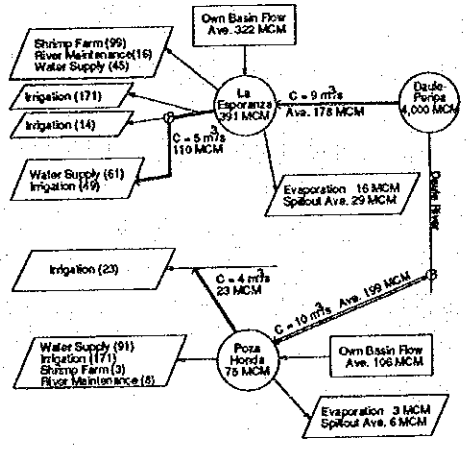
Alternative 4 : Daule Peripa dam - La Esperanza dam transbasin (18 m^3/s)
La Esperanza dam - Guarango area transbasin (15 m^3/s)
Chirijos dam on upper Chico river



Alternative 5 : Daule Peripa dam - La Esperanza dam transbasin (18 m^3/s)
La Esperanza dam - Poza Honda dam transbasin (10 m^3/s)
La Esperanza dam - Guarango area transbasin (5 m^3/s)
Poza Honda dam - Chico river transbain (4 m^3/s)



Alternative 6 : Daule Peripa dam - La Esperanza dam transbasin (9 m^3/s)
Daule river - Poza Honda dam transbasin (10 m^3/s)
La Esperanza dam - Guarango area transbasin (5 m^3/s)
Poza Honda dam - Chico river transbain (4 m^3/s)



6. Selection of Best Alternative

Based on the preliminary design, the costs are estimated for each alternative as follows.

(US$ million)

Cost	Alt.1	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6
Construction Cost	258.0	289.0	232.0	245.0	210.0	248.0
Annual O & M Cost	4.5	7.0	4.2	3.7	5.0	7.7
Total Annual Cost	25.1	30.1	22.8	23.3	21.8	27.5

Results of Initial Environmental Examination (IEE) such as effects on water environment of rivers and reservoirs, and social impacts of resettlement have proved that Alternatives 3, 5 and 6 are the most recommendable and the Alternative 4 is the least recommendable from the environmental point of view. The Alternative 5 is easier in its operation than the Alternative 3 because water from La Esperanza reservoir is received by the Poza Honda reservoir.

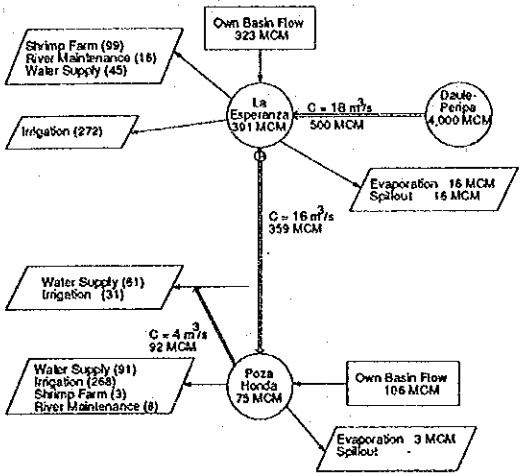
From the comparative study results of total project cost, initial investment cost, environmental impacts, O & M cost, etc., Alternative 5 is concluded as the best scheme to be taken up for further feasibility study.

7. Optimization of the Selected Alternative

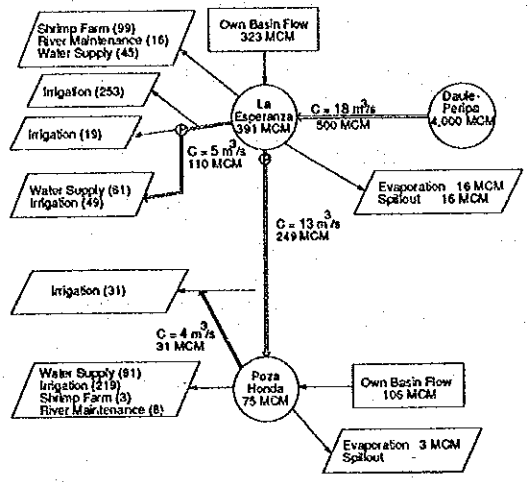
The transbasin capacities as determined in 5 above are based on irrigation water demand in average years. It is necessary to ensure water supply even in dry years. The La Esperanza dam - Poza Honda dam transbasin capacity should then be increased from 10 m^3/s to 13 m^3/s keeping the capacities of the other transbasin capacities, which is called as Alternative 5b.

Further, in view of possible technical difficulties in the construction of the Amarillos - Guarango tunnel included in the La Esperanza dam - Guarango area transbasin due to poor geological conditions containing swelling minerals, the capacity of the La Esperanza dam - Poza Honda dam transbasin scheme is proposed to further increase from 13 m^3/s to 16 m^3/s without the La Esperanza dam - Guarango area transbasin, which is called as Alternative 5a. Alternative 5a is judged to be the optimum scheme, because the cost of Alternative 5a is cheaper than that of Alternative

5b (about 80 %), and there are no disadvantages of environmental impacts comparing with Alternative 5b, if intake site of El.Ceibal treatment plant is changed. Feasibility study including the environmental impact analysis is concentrated on Alternative 5a.



Alternative 5a



Alternative 5b

8. Additional Geotechnical Investigations

Preliminary designs for comparison of six alternatives are prepared based on the geotechnical conditions assumed by surface geological survey, seismic refraction survey and data of previous geological investigations. Additional geotechnical investigations are carried out including test borings, test pittings, rock tests and soil mechanical tests for the preparation of feasibility designs of the optimum scheme of Altenative 5a.

Rocks through the proposed tunnel formation are mudstone with an unconfined compressive strength ranging from 60 kg/cm^2 to 100 kg/cm^2, which is classified into soft rocks. Permeability is generally low, in the order of 10^{-5} cm/sec. Soil mechanical tests have proved that the soil along the open channel route of the La Esperanza dam - Poza Honda dam transbasin are more or less expansive and that a careful design and construction will be required.

9. Feasibility Designs of Project Facilities

The technical features of the project are as follows.

(1) Daule Peripa Dam - La Esperanza Dam Transbasin Scheme

Tunnel	:	Capacity	18 m^3/s
		Length	8.3 km
		Gradient	1/1,500
		Diameter	3.7 m, Standard horse-shoe section, free flow type

(2) La Esperanza Dam - Poza Honda Dam Transbasin Scheme

Pumping Station	:	Total discharge	16 m^3/s
		Maximum head	76 m
		Type of pump	Double suction volute type
Pipeline	:	Length	250 m
		No. of lanes	2 lanes
		Diameter	2,100 mm
Head Tank	:	Width	12 m
		Length	18 m
Open Channel	:	Capacity	16 m^3/s
		Length	5.4 km
		Gradient	1/3,000
		Section	Trapezoidal
Syphon	:	Capacity	16 m^3/s
		No. of syphons	6 nos.
		Total length	906 m
		Max. head	7 m - 47 m
Tunnel	:	Capacity	16 m^3/s
		Length	10.7 km
		Gradient	1/1,500
		Diameter	3.5 m, Standard horse-shoe section, free flow type

(3) Poza Honda Dam - Mancha Grande Transbasin Scheme

Tunnel	:	Capacity	4 m^3/s
		Length	3.9 km
		Gradient	1/1,500
		Diameter	2.5 m, Standard horse-shoe section, free flow type

Judging from the geological conditions, New Austrian Tunnelling Method (NATM) is considered most suitable for tunnel construction. Load header is applied for tunnel excavation. Immediately after excavation, shotcrete will be provided on the excavated rock surface. Several rock bolts are to be driven depending on actual rock conditions. The tunnel construction will be completed by concrete lining for the whole stretches of the tunnel. Steel support is to be used for tunnelling in the colluvial and weathered rock zone near tunnel portals. Drain holes are also provided to relieve water pressure around the tunnel.

The open channel will be concrete lined and the channel foundation will be prepared by replacement with a selected filter material and if necessary with excavated tunnel rock fragments under the filter depending on the foundation condition.

10. Construction Schedule and Cost Estimates

The following construction schedule has been elaborated for the implementation of the project.

(1)	Financial arrangement	:	From January 1993 to October 1993
(2)	Selection of a consultant	:	From November 1993 to January 1994
(3)	Detailed design and preparation of tender documents	:	From February 1994 to January 1995
(4)	Tendering and contract award	:	From February 1995 to August 1995
(5)	Main construction works	:	From September 1995 to February 2000
(6)	Commissioning of the project	:	From March 2000

Construction costs are estimated as follows.

(1,000 US$)

	Description	Foreign Currency	Local Currency	Total
1.	Lot 1			
	La Esperanza dam - Poza Honda dam	58,537	19,384	77,921
	Poza Honda dam - Mancha Grande	8,667	3,237	11,904
	Sub-total (1)	67,204	22,621	89,825
2.	Lot 2			
	Daule Peripa dam - La Esperanza dam	31,780	13,031	44,811
	Total (1 and 2)	98,984	35,652	134,636
3.	Land acquisition	-	100	100
4.	Administration	-	2,693	2,693
5.	Engineering services	11,410	2,455	13,865
	Total (1 to 5)	110,394	40,900	151,294
6.	Physical contingency	11,039	4,090	15,129
	Total (1 to 6)	121,433	44,990	166,423
7.	Price contingency	20,022	7,230	27,252
	Grand total	141,455	52,220	193,675

Note: S./ 1,550 = US$ 1.0 = ¥ 128, as of July 1992

Annual disbursement of the construction cost is estimated as follows for the foreign and local currency portions based on the construction schedule.

(1,000 US$)

Year	Foreign Currency	Local Currency	Total
1994	4,233	275	4,508
1995	20,050	7,463	27,513
1996	23,503	11,332	34,835
1997	26,420	12,137	38,557
1998	31,723	11,839	43,562
1999	34,279	8,739	43,018
2000	1,247	435	1,682
Total	141,455	52,220	193,675

11. Environment

The environmental impact analysis (EIA) is conducted for the project and the following four issues are studied based on the project features and the results of the initial environmental examination (IEE) conducted for six alternatives.

(1) Impacts on water quality of La Esperanza and Poza Honda reservoirs
(2) Impacts on river flow regime
(3) Impacts on water quality in rivers and estuaries
(4) Impacts on eco-system and fishery

The project is judged acceptable from the environmental viewpoint if the following measures are taken.

(1) To consider a future shift of intake site of El Ceibal treatment plant from the Portoviejo river near Rocafuerte to the Chico river in order to obtain a good quality water

(2) To improve sewerage system in the Portoviejo river basin

(3) To control and manage land use of the estuary areas and the flood plain in the downstream area of the Chone river

(4) To improve the operation of Simbocal tidal gate

Even if the results of EIA conclude that the proposed project would be acceptable from the environmental viewpoint, it is impossible to eliminate all uncertainties related to environmental impacts caused by the project. It is, therefore, of vital importance to monitor the effectiveness and efficiency of the proposed mitigation measures, and the proper execution of environmental management and monitoring plan (EMMP) is essential to attain environmentally sound and sustainable development of the project.

12. Project Evaluation

The economic benefit for municipal and industrial water supply depends on the valuation of a unit raw water value as shown below.

Water Supply Benefit (US$ million/year)

Year	Unit raw water value (US$/m^3)		
	0.3	0.4	0.5
2000	4.4	5.8	7.3
2005	10.0	13.3	16.7
2010	15.6	20.8	26.0
2015	23.8	31.8	39.7
2020	33.6	44.8	56.0

The other economic benefits are estimated to be US$ 7.8 million/year for irrigation water supply and US$ 7.3 million/year for shrimp farming.

The economic internal rates of return (EIRR) of the project are calculated as follows.

Unit Raw Water Value for Water Supply (US$/m^3)	EIRR (%)
0.3	11.4
0.4	12.8
0.5	13.9

The financial benefit of water supply for irrigation and shrimp farming is assumed to be a half of the total benefit, leaving another half of the total benefit for farmers. The financial internal rates of return (FIRR) of the project are calculated as follows depending on pricing of unit raw water for water supply.

Unit Raw Water Price for Water Supply (US$/m^3)	FIRR (%)
0.15	9.3
0.20	10.6
0.25	11.6

13. Institutional Framework and Organization

The executing agency of the project is CRM under the Ministry of Agriculture and Livestock (MAG) of the Government of Ecuador. The cooperating agencies of the project are INERHI, CEDEGE and JRH under MAG and the Ecuadorian Institute of Sanitary Works (IEOS) under the Ministry of Public Health of the Government of Ecuador. CONADE will also play an important role in the project implementation in terms of project priority ranking, introduction of foreign loans, etc.

Most of the water resources development projects in Manabi province have been planned, studied, designed, constructed, operated and maintained by CRM. Major projects handled and managed by CRM are the Poza Honda multipurpose project and the Carrizal-Chone irrigation project including the La Esperanza dam under construction.

CRM is presently organized by the four levels such as Directive level, Advisor level, Auxiliary or Supporting level, and Operating level. The Operating level is formed by Directorate for Physical Infrastructure and Directorate for Socio-economic Development. Of these, the Operating level is proposed to be reinforced for more efficient management of projects including the proposed water transbasin project from Daule Peripa dam, in the following manner.

(1) The Directorate for Physical Infrastructure is to be devided into two directorates: Directorate for Study and Design to handle each project up to the detailed design stage, and Directorate for Construction and O&M to manage each project in construction and O&M stages by establishing a project office.

(2) An independent Department of Environment is proposed to be established under the existing Directorate for Socio-economic Development in view of increasing importance of environmental monitoring and management in infrastructural and socio-economic development.

The transbasin project office will be organized in the Directorate for Construction and O&M towards the construction stage of the project, and Project Manager will be appointed for the construction supervision of the project.