(9) Diversion Capacity from Daule-Peripa to La Esperanza

The diversion capacity from Daule-Peripa to La Esperanza is fixed to be 18 m^3/s by the interinstitutional agreement between CEDEGE and CRM as discussed in 5.1 herein.

(10) Diversion Capacity from La Esperanza to Poza Honda

A diversion capacity of 16 m^3/s was proposed in the feasibility study under the following conditions.

- Reservoir storage curves before reservoir sedimentation were used.
- Dilution water requirement to dilute irrigation return flows was not considered.
- Interbasin flows were not taken into account.

The integrated reservoir operation study is repeated based on the conditions described from (1) to (12) hereof for a diversion capacity of 12 m^3/s, 14 m^3/s and 16 m^3/s.

(11) Diversion Capacity from Poza Honda to Mancha Grande

If the natural flow of the Chico river is neglected, water requirements are 1.9 m^3/s to supply the El Ceibal water treatment plant and 2.1 m^3/s to cover peak irrigation water requirement in September for the Chico irrigation system of 1,700 ha including 20% of the dilution water, totaling 4.0 m^3/s. The diversion capacity is, therefore, fixed at 4.0 m^3/s.

(12) Long-term Hydrological Series

Long-term hydrological series were simulated at important points in the Chone-Portoviejo river basins by the Tank Model method on a monthly basis for a period of 20 years from 1971 to 1990, in the feasibility study.

In the detailed design study, the long-term hydrological series are revised by a simulation study using the CIDIAT Model for a period of 29 years from 1964 to 1992. The results are shown in the Final Report, March 1995. The revised long-term hydrological series are used for the integrated reservoir operation study.

5.2.3 Integrated reservoir operation study

Based on the conditions described in 5.2.2, an integrated reservoir operation and water balance study is conducted. The results are shown in Figs. 5.1, 5.2 and 5.3 for a transbasin capacity of 16 m^3/s from La Esperanza to Poza Honda (Q_{Ep} = 16 m^3/s), in Figs.

5.4, 5.5 and 5.6 for Q_{Ep} = 14 m^3/s, and in Figs.5.7, 5.8 and 5.9 for Q_{Ep} = 12 m^3/s, and are summarized in the following table.

Summary of Integrated Reservoir Operation Study

Description	La Esperanza-Poza Honda Transbasin Capacity (m^3/s) 16	14	12
La Esperanza Reservoir			
Max.water level (EL.m)	66.0	66.0	66.0
Min. water level (EL.m)	39.8	40.4	40.0
Average water level (EL.m)	59.9	60.2	60.3
Average spillout (MCM/year)	118	115	118
Average evaporation (MCM/year)	21	21	21
Max.transbasin from Daule-Peripa (MCM/year)	500	500	500
Average transbasin from Daule-Peripa (MCM/year)	336	331	328
Max. transbasin to Poza Honda (MCM/year)	380	369	348
Average transbasin to Poza Honda (MCM/year)	213	212	205
Guarantee of water supply to Carrizal-Chone river basin (%)	100(100)	100(100)	100(100)
Guarantee of transbasin to Poza Honda (%)	95	96	96
Poza Honda Reservoir			
Max.water level (EL.m)	106.5	106.5	106.5
Min.water level (EL.m)	88.3	88.3	88.3
Average water level (EL.m)	103.2	102.2	101.5
Average spillout (MCM/year)	53	51	48
Average evaporation (MCM/year)	6	6	6
Max.transbasin from La Esperanza (MCM/year)	380	369	348
Average transbasin from La Esperanza (MCM/year)	213	212	205
Max.transbasin to Mancha Grande (MCM/year)	69	59	55
Average transbasin to Mancha Grande (MCM/year)	33	32	31
Guarantee of water supply to Portoviejo river basin (%)	97(83)	98(83)	98(86)
Guarantee of water supply to Chico river basin (%)	96(80)	94(72)	93(69)

(Note) Guarantee of water supply is on monthly basis. Figures in parenthesis are guarantee on annual basis which should be larger than 80% (water shortage is allowed once in 5 years).

The transbasin capacities of Q_{Ep} = 12 m^3/s and Q_{Ep} = 14 m^3/s are not recommendable because the guarantee of water supply to the Chico river basin including water supply to the El Ceibal treatment plant is lower than 80% on an annual basis.

The transbasin capacity from La Esperanza to Poza Honda has been decided to be 16 m^3/s, based on the result of the integrated reservoir operation study and also taking account of the following factors.

- Long term continuous operation of a pumping station at its full capacity will be difficult due to possible fault in power supply or some mechanical trouble. In case Q_{Ep} = 12 m^3/s, a continuous operation of sixteen months is required, while in case Q_{Ep} = 16 m^3/s it is only five months.

- A larger transbasin capacity will provide the whole transbasin schemes with more flexibility to cope with possible future changes in water demands.

The schematic water balance is shown in Fig. 5.10 for the proposed transbasin scheme with Q_{Ep} = 16 m^3/s.

6. THE PROJECT

6.1 General Description of the Project

The Project comprises three water transbasin schemes as presented below.

(1) Daule Peripa~La Esperanza Transbasin Scheme

Diversion tunnel	
Capacity	18 m^3/s, Free flow
Length	8.3 km
Section	3.7 m in diameter
	Standard horse-shoe section
Gradient	1/1,500

Access Roads	
Conguillo access road	22.6 km
Membrillo access road	0.4 km
El Guasmo access road	1.6 km

(2) La Esperanza~Poza Honda Transbasin Scheme

Severino pumping station	
Pumping capacity	16 m^3/s
Maximum head	70.0 m
Rated head	60.0 m
Nos.of pump unit	6 units (one for reserve)
Discharge of one unit	192 m^3/min. (3.2 m^3/s)
Type	Vertical shaft, single suction volute type

Penstock	
Length	173 m (through No.1 pump and No.1 penstock)
	170 m (through No.6 pump and No.2 penstock)
Nos. of lanes	2 lanes
Diameter	1,000 ~ 2,400 mm

Head tank	
Width	16.8 m ~ 8.8 m
Length	56.7 m

Open channel	
Capacity	16 m^3/s
Length	5.5 km
Gradient	1/3,000
Section	Trapezoidal

Syphons

Syphon No.	Length	Max.head	Remarks
1	72 m	8.7 m	Rectangular section
2	233 m	36.6 m	Rectangular & circular section
3	326 m	47.6 m	Rectangular & circular section
4	76 m	5.5 m	Rectangular section
5	174 m	17.5 m	Rectangular section

Diversion tunnel

Capacity	16 m^3/s, Free flow
Length	11.4 km
Section	3.5 m in diameter
	Standard horseshoe section
Gradient	1/1,500

Severino substation

Capacity	2 x 12.5 MVA
Voltage ratio	138/13.8 kV

Daule-Peripa ~ Severino transmission line

Length	32.6 km
Voltage	138 kV

Access roads

Severino access road	9.3 km
Caña Dulce inlet access road	2.7 km
Los Cuyuyes access road	14.8 km
La Seca access road	3.8 km

(3) Poza Honda~Mancha Grande Transbasin Schemes

Diversion tunnel

Capacity	4 m^3/s
Length	4.1 km
Section	2.5 m diameter
	Standard horseshoe section
Gradient	1/3,900

Access road

Poza Honda Inlet access road	0.7 km

6.2 Daule-Peripa ~ La Esperanza Transbasin

6.2.1 Conguillo inlet

(1) Present Site Conditions

A part of the tunnel inlet structure was constructed in 1990 at the Conguillo site with the bottom level of the open approach channel at EL. 66.0 m where the original riverbed level was EL. 69.0 m. Field survey in early 1994 revealed that the approach channel had already be sedimented up to around EL. 70 m in six years after creation of the reservoir.

Water hyacinths have densely covered the reservoir surface in and around the inlet site which may hamper a smooth water intake into the tunnel.

(2) Location of Tunnel Inlet and Intake Water Level

To avoid possible sedimentation problem, shifting of the inlet site to downstream of the Conguillo river was first studied and concluded that the shifting would increase the tunnel length and necessitate a large scale coffering for construction, and not economically feasible.

The next idea was to set the intake water level at higher level than the existing EL. 66.6 m, providing a barrier wall in front of the constructed tunnel inlet structure to protect sediment from blocking the tunnel inlet. This idea has also finally rejected because of the following considerations.

(i) It is almost impossible to reduce the Daule-Peripa water level down to EL. 66 m, which requires a large scale coffering for construction in front of the existing inlet structure or an under-water construction. Both are technically difficult and economically costly.

(ii) If the intake water level is elevated from the existing EL. 66.6 m, water transbasin from Daule-Peripa to La Esperanza is made more frequently impossible taking into account LWL of Daule-Peripa of EL. 60 m. It is of vital importance to secure water transbasin from Daule-Peripa as longer time as possible not to cause water deficit in the project area.

It is, therefore, decided finally to utilize the existing inlet structure as it is with the following countermeasures.

(i) To avoid sediment problem, the 36 m long approach channel is cleaned by dredging to the original bottom of EL. 66 m. The cleaned approach channel is to be kept by maintenance dredging.

(ii) If the Conguillo river course in front of the inlet is sedimented at a higher level than the Daule-Peripa water level and the water transbasin is still necessary, excavation or dredging should be done along the Conguillo river course to introduce Daule-Peripa water into the diversion tunnel.

(iii) To protect the tunnel inlet from water hyacinths, it is proposed to provide a trash-boom with net around the inlet. Water hyacinth entering over or under the trash-boom should be removed manually.

(3) Discharge Control Valves and Valve Chamber

Two steel pipes with the diameter of 1,400 mm are embedded at EL. 67.2 m and one steel pipe with the diameter of 800 mm is embedded at EL. 65.5 m in the constructed inlet structure with a butterfly valve at each pipe.

These three pipes are extended to lead water into a valve chamber where the discharge through the two larger pipes will be controlled by a sleeve valve. The valve chamber will have a general dimensions of 15.3 m in length, 9.0 m in width and 26.0 m in depth from the roof level of EL. 90.0 m. An oval shape is proposed as a horizontal section of the valve chamber to better withstand against rock pressure acting around it.

The design of the Conguillo inlet is shown on Drawings 6.1 and 6.2.

6.2.2 Daule-Peripa ~ La Esperanza diversion tunnel

(1) Hydraulic Design

Flow capacity of the tunnel was decided to be 18 m^3/s according to the interinstitutional agreement between CEDEGE and CRM. An open free flow is proposed to make the tunnel flow stable. A standard horse-shoe section is applied which is generally accepted as the most appropriate section for an open free flow.

A horizontal alignment of the tunnel should be straight as far as possible to minimize the tunnel length. Since the tunnel flow is planned by gravity, a steeper gradient is more economical because a smaller diameter tunnel can have the required flow capacity.

The tunnel alignment was studied with various alternatives and finally concluded as follows.

Section : Standard horse-shoe
Diameter : 3.7 m
Flow : Open free flow
Length : 8.3 km
Slope : 1/1,500
Capacity : 18 m^3/s at 80% water depth

Invert level
Inlet : 66.0 m
Outlet : 60.5 m

Target water level of La Esperanza: EL. 63.5 m
Plan and profile of the diversion tunnel are given on Drawing 6.3.

(2) Structural Design

Four types of tunnel sections are designed to be applied in the diversion tunnel as shown on Drawing 6.4 and as explained below.

	Type I	Type II	Type III	Type IV
Place		As shown on Drawings		
Distance applied (m)	0	7,666	0	610
Shotcrete thickness (cm)	10	10	15	10
Rock bolts	D25x5Nos.x2m (1.2m pitch)	D25x8Nos.x2m (1.2m pitch)	D25x8Nos.x2m (1.2m pitch)	D25x8Nos.x2m (1.2m pitch)
Concrete lining (cm)	30	30	30	30
Reinforcement	Nil	Nil	Nil	Nil
H-steel support	Nil	Nil	Nil	H125, 1.2m pitch

6.2.3 Membrillo outlet

The riverbed elevation at the Membrillo outlet site is around EL. 62 m, which is higher than the tunnel outlet invert level by about 1.5 m. Excavation of the river channel for a length of about 250 m is necessary from the outlet to downstream to secure a smooth flow out from the tunnel to the river or to the reservoir.

Average reservoir water level of La Esperanza is calculated to be EL. 59.9 m with the target water level of EL. 63.5 m. This means that the La Esperanza water level draws down below the riverbed elevation of EL. 62 m almost every year and sedimentation will be washed down during the low level period by the own basin flow as well as the diverted flow of 18 m^3/s.

The design of the Membrillo outlet is given on Drawing 6.5.

6.2.4 Work adits

The following three work adits are to be provided to facilitate tunnel construction.

Conguillo work adit	Tunnel inlet site, length: 183 m
El Guasmo work adit	About 3.4 km from tunnel inlet, length: 350 m
Membrillo work adit	Tunnel outlet site, length: 128 m

The work adit will have a semi-circular section, circular in upper half and rectangular in lower half, with a height of 4 m and a width of 4 m to arrange double track of trolley for tunnel mucking and other purposes. The surrounding bedrock of the work adit will be supported by shotcrete, rock bolts and steel supports except the bottom surface and lining concrete will be placed for the horizontal part. After completion of the tunnel construction, connection parts with main tunnel will be plugged by concrete to secure a smooth flow in the tunnel and to enhance the stability of structure at the connection parts.

6.3 La Esperanza ~ Poza Honda Transbasin

La Esperanza ~ Poza Honda Transbasin consists of Severino Pumping Station, Severino Penstock, Severino Head Tank, Severino Open Channel and La Esperanza ~ Poza Honda Diversion Tunnel. Optimum scale of the open channel and the tunnel as well as their formation level are interrelated to energy cost for pumping. A comparative study is conducted taking the transbasin facilities into consideration as an integrated system to define technical features of each facility.

The minimum operation level of the pumping station (EL. 47 m) and invert elevation at the diversion tunnel outlet (Los Cuyuyes Outlet) (EL. 102.5 m in water level) are set out based on the integrated reservoir operation study and the anticipated sediment level in La Esperanza reservoir as described in Chapter 5 herein.

6.3.1 Severino pumping station

(1) Basic conditions

Sedimentation in and around the pumping station on La Esperanza reservoir is a serious issue. A sediment level after 50 years is anticipated at about EL. 45 m. The minimum pumping operation level (MOL) is therefore set out at EL. 47 m, 2 m above EL. 45 m of the anticipated sediment level to prevent sediment from entering to pump suction.

La Esperanza dam is at present under construction and will be completed in 1996. The pumping station will be constructed after completion of the dam and impounding of the reservoir. On the other hand, water demand in the downstream of La Esperanza dam such as irrigation water and municipal water is not expected to increase rapidly. The irrigation project is at a feasibility study level at present and will not be completed before the year 2000. It is judged, therefore, that only a limited water requirement will have to be met by the La Esperanza reservoir during construction of the Severino pumping station.

Only a small scale coffering and dewatering will be required for the construction of the pumping station if a water level of La Esperanza reservoir is drawn below EL. 45 m. The crest elevation of the coffering is then determined at EL. 51 m to cope with a flood with 25-year return period.

The top elevation of the station is set out at EL. 70 m which is 2.3 m higher than the design flood water level of La Esperanza dam.

In accordance with the result of the integrated reservoir operation study, the design maximum discharge is determined at 16 m^3/sec and basic condition for a design of the pumping station are as follows:

- Water level and pump actual head

  Water level in pump suction pit

Flood water level	:	EL. 69.0 m
High water level	:	EL. 66.0 m
Weighted average water level	:	EL. 58.5 m
Minimum operation water level	:	EL. 47.0 m

  Water level in the head tank

Design water level	:	EL. 114.02 m

  Pump actual head

Maximum actual head	:	Hs max. = 67.02 m
Minimum actual head	:	Hs min. = 48.02 m
Design actual head	:	Hs = 55.52 m

- Intake structure sill level : EL. 42.00
- Elevation of pump center : EL. 46.00

The principal features of the Severino Pumping Station are summarized below and the design is shown on Drawings 6.6 to 6.8.

Pumps		
Type	:	vertical shaft, single suction volute type
Number of units	:	6 nos. (5 units on duty and 1 unit for stand-by)
Installed capacity	:	19.6 m^3/sec (3.2 m^3/sec for each)
Actual head	:	67.02 m
Electric Motors		
Type	:	vertical shaft, three phases, wound-rotor induction type
Output of each motor	:	2,400 kW, voltage 13.8 kV, frequency 60 Hz
Superstructure		
Length	:	65.0 m
Width	:	22.5 m
Height	:	13.5 m
Substructure		
Length	:	67.5 m
Width	:	29.0 m
Height	:	30.1 m

(2) Hydromechanical works

Considering the actual head of 67.3 m and the design discharge of 3.2 m^3/sec, two alternative types, i.e. (i) horizontal shaft double suction pump and (ii) vertical shaft single suction pump are conceivable. Out of the two types, a vertical shaft single suction pump is selected as a suitable type for the pumping station, from economic and constructional points of view, taking into account a cost of civil structures to resist high water pressure and uplift as well as pumping equipment cost.

The number of pump unit was decided on the basis that the design discharge could be dealt with on-duty pump units excluding a stand-by unit. One unit of stand-by pump is installed to ensure a stable operation against a trouble or long term repair of the on-duty pump units.

The number of on-duty pump unit is decided to be five through comparison of pumping station cost including civil works cost. Therefore, six pump units will be installed including one for reserve.

For a pumping discharge control method, the following methods are conceivable;

Control method of discharge	Feature
- Control by number of pump units	Simple, Escalation of discharge
- Control by discharge valve	Low operation efficiency, Limitation of operation range by type of pump and valve
- Control by revoluting speed	Continuous control, High construction cost

The method of discharge control by number of pump units is selected because of the following reasons,

- Poza Honda reservoir has a storage function to regulate the transbasin flow,
- A sensitive control is not required for the transbasin, and
- Both construction and running costs are lower because of its simple operation.

Rated total head for pump design is 60.0 m, which is the sum of 55.52 m of the design actual head and 4.48 m of head losses in the penstock.

Two sets of low speed overhead traveling crane are provided in pump house. One is set at the entrance platform for unloading and loading of pumping equipment. The other is set at the machine bay for installation and repair of pump equipment. Two 35/5-ton overhead traveling cranes are of the electrically operated, cab-controlled type, and equipped with a single trolley having both main and auxiliary hoists.

(3) Electrical works

(i) Electric motors

Vertical shaft, three-phase, wound-rotor induction type motor is selected for main pump, mainly in view of limiting starting current and of obtaining enough starting torque.

Design conditions of the motor are as follows:

- Voltage	13.8 kV
- Frequency	60 Hz
- Synchronous speed	600 rpm (12 poles)

The required power of each motor is estimated to be 2,400 kW based on the pump efficiency, design discharge and pumping head explained in the preceding section.

The motor is of totally-enclosed, self-ventilating and recirculating type with air coolers. This cooling system is adopted for this pump motor because of high cooling effect, low noise, compact size, clean cooling air and little influence to room temperature and room air flow compared with the open type, self-ventilating system. The cooling water of air coolers will be taken from the delivery pipe of main pump and discharged to the suction pipe.

The power factor and the efficiency of large induction motors like the proposed pump motors are generally expected to be more than 0.82 and 0.95, respectively. The above power factor can be raised up 0.90 to 0.96 by providing the 13.8 kV bus circuit with static condensers.

(ii) Indoor switchgear and control board

13.8 kV circuits for the main transformer, main pump motors, static condensers and station service transformers are arranged in the dead-front sheet steel cubicles with safety to the operator, and installed in the high-tension switch gear room. The single line diagram for Severino pumping station is shown in Figure 6.1.

Two three-phase, about 300 kVA station service transformers are installed in the low-tension switchgear room of pumping station to supply power for station use such as auxiliary machines for pumping equipment, overhead crane, drainage pumps, ventilation fans, lighting, etc. The transformer is of silicone-insulated, self-cooled, dry type enclosed with steel cabinet.

Control of the pumping equipment together with the substation facilities, are made by the control boards to be installed in the control room of the pumping station. The control boards consist of control desk and separated mimic board. The operation condition of water system, pumps, motors and electric equipment are indicated on the mimic board which is of vertical, self standing and steel sheet panel.

To supply power in emergency case of power failure, one diesel engine generator set is installed. The capacity of generator is adopted to be about 200 kVA to deliver power for essential load such as sump pump motor, ventilation fans, battery charger for control, etc. The power supply to main pumps is not taken into consideration.

(iii) Building facilities

The building facilities of the pumping station comprise the water supply system, sewerage and drainage system, air conditioning and ventilation system, and fire protection system.

The water supply system for the pumping station comprises the water supply for drinking water, sanitary use, and fire protection system of the pumping station. The water is obtained from cooling supply header installed at the pump room. The water filtering tanks, water storage tank, water supply pumps, water pressure tank, chemical feeder units and sterilization units are installed on the same room.

The drainage and sewerage system of the pump station is provided for drainage of waste water, roof rain water, seepage water and sewage of the pump station. The roof rain water will be collected and drained into the site drainage system. The sewage is collected into the septic tank and also be drained into the site drainage system. The waste water will be collected and drained into the sewage drain pipe line. The seepage water of the pumping station is collected into the drain gutters provided along the inside perimeter of the pumping station wall and drained into the sump pit.

The air conditioning system of pumping station is designed to provide the pumping station with a suitable environment. The air conditioning is effective for control room, office rooms and other administrative and relative areas where operation and maintenance personnels are commonly stationed.

Ventilation will be provided to the pumping station for the pump room, cubicle room and other rooms where machines and equipment are installed and also where air conditioning are not provided. Ventilation fans are provided to take in fresh air through ducts and distributing fresh air to each of the required rooms through ducts. The exhaust air will be exhausted through louvers provided in the ventilation fan room wall.

The fire protection system of the pumping station comprises the fire hydrant system. The fire hydrant system is provided to cover the entire pumping station floor area.

Lighting system is designed to obtain the functional and economical features as well as easy maintenance. From these points, locations of lighting fixtures and arrangement of circuits are determined adequately for both normal use system and the emergency lighting system required in the pumping station.

General earthing systems are provided at pumping station and substation outdoor switchyard for the following three main purpose.

- To safeguard operating personnel and public.
- To provide connections to the earth for transformer and other power equipment neutrals.
- To provide a discharge path to an earthing system for lightning arresters, overvoltage gape and similar device.

6.3.2 Severino penstock

Two lanes of penstock are provided in consideration of ensuring minimum operation against a risk of breakdown and inspection and/or repair under operation. The design conditions of the Severino Penstock are determined as shown below:

Total design discharge	:	16.0 m^3/sec
One lane discharge	:	9.6 m^3/sec each (3.2 m^3/sec x 3 pumping units)
Length of pipeline	:	170 m and 173 m

The above-ground type with the anchor blocks and saddle supports is selected because of lower cost and easy maintenance by visual inspection of pipes.

An optimal diameter of the penstock pipes is determined to be 2000 mm which minimizes the cost comprising (i) construction cost of penstock and (ii) pump operation cost.

Water hammer analysis was carried out for the longitudinal layout and the selected diameter of the penstock. As the results, a surge tank is required at the maximum negative pressure point on the penstock. One-way surge tank is selected in view of (i) low initial cost, (ii) low operation cost and (iii) easy maintenance.

The electromagnetic flowmeter is provided in the penstock to measure a pumping discharge.

The design of the Severino penstock is shown on Drawing 6.9.

6.3.3 Severino head tank

The Severino Head Tank is divided into two separate lanes by partition wall for maintenance.

A main function of the Severino Head Tank is to regulate water vein discharging from the penstock and to interconnect smoothly to the open channel. Other functions are to close off the open channel when the penstock is dewatered for inspection and maintenance, and to prevent backwater from the open channel when discharge valves do not work due to some troubles.

In due consideration of these functions, the overflow weir type head tank are designed, which is composed of outlet box, overflow weir and transition channel to the Open Channel. The weir is designed to have an enough height so that no backflow of water from the Open Channel will occur.

The principal features of the head tank are summarized as follows:

Length	:	56.7 m
Crest elevation of weir	:	EL. 113.3 m
Crest length of weir	:	14.64 m
Max. overflow depth	:	1.0 m

Design of the head tank is shown on Drawing 6.10.

6.3.4 Severino open channel

(1) Open Channel

The channel height is determined at 2.8 m adding a water depth of 2.5 m and a freeboard of 0.3 m. A trapezoidal section with a side slope of 1: 1.2 is selected considering a geological condition along the channel route. Concrete lining with a thickness of 150 mm is provided at the bottom and side slope of the channel and gravel bedding of 100 mm in thickness is provided under the bottom of the channel along the whole route.

The principal features of the open channel are as follows.

Design discharge	16 m^3/sec
Cross section	
Type	Trapezoidal, concrete lining
Bottom width	1.6 m
Side slope	1 : 1.2
Height	2.8 m including freeboard
Length	5.5 km
Bottom gradient	1 : 3,000
Water level at beginning point	EL. 113.3 m

Plan and profile of the open channel are shown on Drawings 6.11 and 6.12, and typical cross sections are shown on Drawing 6.13.

(2) Related Structures

i) Cross Drainage Facilities

There exist 25 rivulets along the open channel route in which the open channel traverses over with a cross drainage facility. The facility has a function to pass storm water under the open channel safely.

The facility consists of a reinforced concrete box culvert, base concrete and embankment forming the channel and connecting channel to a natural river course.

The design storm discharge of the culvert is determined based on Rational's formula with a rainfall intensity of 25-year probable rainfall. A runoff coefficient of 0.4 is applied in consideration of vegetation and topography in and around the facility site.

Standard design of the cross drainage facility is shown on Drawings 6.14 and 6.15.

ii) Inverted Syphon

Five locations are identified for the river crossing by syphon along the open channel route. Two types of syphon section are designed depending on the maximum pressure head; rectangular type for less than 20 m of working pressure and circular type for more than 20 m.

Typical design is shown on Drawings 6.16 and 6.17.

iii) Associated Works

- Slope protection

Sod facing is applied for embankment slope and excavation slope in common earth.

- Surface water drainage system

Arrangement of drain ditch is sited as shown in typical sections of the open channel (Drawing 6.13). Design capacity is also estimated by Rational's formula with a 10 minutes rainfall intensity of 175 mm/hour as 10-year probable rainfall. A runoff coefficient of 0.4 is applied. Storm water will be gathered by the drain ditch and discharged into river/rivulets at the syphon/cross drainage sites.

- Fence

Fence is provided at both side of the right of way for no admittance to the channel except an authorized person. Fence is of wooden stockade.

- Pedestrian bridge

One span reinforced concrete bridge is designed for pedestrians and constructed at 20 locations along the whole open channel route.

Details of the bridge is shown in Figure 6.2

6.3.5 Severino ~ Caña Dulce inspection road

Severino ~ Caña Dulce Inspection Road will be constructed on a mountain side along the open channel route. The road has functions of inspecting a condition of the open channel flow and of maintenance and repairing of the open channel facilities. Daily safety patrol will be done through the inspection road.

At river crossing points in which the open channel crosses river by syphon, any crossing road such as bridge/causeway is not considered. However, two (2) connection points between the inspection road and the Severino Access Road are provided to avoid separating the inspection road at the crossing points . The access road is utilized for the bypass of the crossing points in part. The connection points are provided at the head tank and siphon No.2 sites.

Pavement is provided by a layer of gravel wearing course of 15 cm in thickness. The longitudinal gradient is set out at 1/3,000 same as that of the open channel and crossfall is designed at 4 % toward a mountain side.

Roadway is designed at 3 m wide and 0.5 m of shoulder is provided along the open channel.

6.3.6 Caña Dulce inlet

The Caña Dulce inlet is a 3.5 m wide and 3.5 m high concrete structure without intake gate as shown in Drawings 6.18 and 6.19.

Sill elevation of the intake is set at EL. 107.3 m to assure a smooth flow from the open channel to La Esperanza ~ Poza Honda diversion tunnel.

The location of the inlet is set at sound and fresh bedrock, about 10 m deep from ground surface of mountain foot.

Cut slope of 1:0.5 is applied for fresh rock and 1:1.0 for weathered rock and soil. Slope protection is made by shotcrete and rock anchor on the fresh rock surface and sod facing on the weathered rock and soil surfaces.

Back water of Poza Honda reservoir at H.W.L. 106.5 m does not reach the inlet because its sill level is EL. 107.3 m, while at the time of F.W.L. 110.30 m, its backwater reaches the inlet and the open channel. Water supply to Poza Honda reservoir by pumping up at Severino pumping station is completely stopped when Poza Honda water level is higher than EL. 102.5 m.

6.3.7 La Esperanza ~ Poza Honda diversion tunnel

The diversion tunnel is a non pressure tunnel of 11,417 m long having a diameter of 3.5 m in standard horse-shoe section.

The diversion tunnel is connected with Severino open channel at Caña Dulce inlet to discharge the pumped up water of $16m^3/sec$ in maximum.

Plan and profile of the diversion tunnel are shown on Drawing 6.20. Slope of the tunnel invert is 1:1,500, and the tunnel bends at two points, about 250 m and 520 m from tunnel inlet and outlet, respectively, to smoothly connect to the inlet and outlet.

The maximum flow velocity in the tunnel is less than 1.4 m/s at the maximum discharge.

The following four types of the diversion tunnel section are designed and shown on Drawing 6.21.

	Type I	Type II	Type III	Type IV
Place		As shown on Drawings		
Distance applied (m)	0	4,627	6,300	470
Shotcrete thickness (cm)	10	10	15	10
Rock bolts	D25x5Nos.x2m (1.2m pitch)	D25x8Nos.x2m (1.2m pitch)	D25x8Nos.x2m (1.2m pitch)	D25x8Nos.x2m (1.2m pitch)
Concrete lining (cm)	30	30	30	30
Reinforcement	Nil	Nil	Nil	Nil
H-steel support	Nil	Nil	Nil	H125, 1.2m pitch

6.3.8 Los Cuyuyes outlet

Present sedimentation level at the tunnel outlet site reaches about EL. 98 m. An invert level of the tunnel outlet is set at EL. 99.7 m taking some allowance above the present sediment level and the proposed target water level of EL. 102.5 m of Poza Honda reservoir into account.

Plan and profile of the outlet are shown on Drawings 6.22 and 6.23.

The outlet structure is founded on the fresh rock, and the cut slope is protected by shotcrete and rock anchor on the rock portion. Concrete facing will be provided up to EL. 111.0 m. to protect the cut slope from erosion by waves in the reservoir.

An access road for construction and maintanance purpose is constructed to the outlet.

6.3.9 Work adit

Los Cuyuyes and La Seca work adits are provided at the outlet and about 4 km northeast of the outlet, respectively. The maximum slope of the work adit is designed as 25 %.

Los Cuyuyes work adit	Tunnel outlet site, length: 130 m
La Seca work adit	About 4 km from tunnel outlet, length: 519 m

6.3.10 Severino substation

(1) General

Electric power required for the pumping station is supplied from the planned Daule-Peripa power station. To receive power through a 138 kV transmission line to be constructed under the Project, Severino substation is constructed near the pumping station.

Since the operating number of pumps is widely changed, the capacity of the substation is determined with some allowance as two banks of 12.5 MVA. Secondary voltage of the transformer is adopted at 13.8 kV to be directly connected to the pump motors.

Arrangement of Severino Substation is shown in Figure 6.2.

(2) Main transformers

Two banks of 12.5 MVA main transformer is adopted. The main transformer will be of three-phase, oil immersed, forced-air-cooled/self-cooled, outdoor use type. Forced-air-cooled type is lower in price or simple in operation and maintenance for the transformer of such capacity. The voltage ratio of the transformer is selected at the no load ratio of 138/13.8 kV.

(3) 138 kV switchgear

Single bus system is adopted for 138 kV outdoor switchgear.

Two circuit breakers for 138 kV main transformer primary circuits will be of three-phase unit, high speed 3-cycle tripping and SF6 gas insulated type. The rupturing capacity of circuit breaker is selected as 25 kA which is one of standard capacity and to correspond to that of circuit breaker at the Daule-Peripa power station to be installed by Ecuador power company.

138 kV outgoing facilities at the outdoor switchyard of Daule-Peripa power station to be added for this Project will be provided in the similar way to the Severino substation switchgear equipment.

Layout of the outdoor switchyard is shown in Figure 6.3.

(4) Earthing system

General earthing systems are provided at the substation for the following three main purpose.

1) To safeguard operating personnel and public,

2) To provide connections to the earth for transformer and other power equipment neutrals, and

3) To provide a discharge path to an earthing system for lightning arresters, overvoltage gape and similar device.

6.3.11 Daule-Peripa ~ Severino transmission line

(1) General

Transmission line facilities are to be constructed between the Daule-Peripa hydropower station and the Severino pumping station.

Items discussed are route selection, selection of line voltage and power conductor as well as overhead earthwire, insulation and support to be applied for the Project.

(2) Design Features

The route is selected in consideration of easy and economical construction, operation and maintenance of the line. On the basis, the route between the power station and the pumping station is aligned on the possibly shortest distance and in close proximity to the existing roads as far as possible as shown in Figure 6.3 but diverting the CEDEGE ecological reservation area adjacent to the Daule-Peripa power station.

Plan and profile of the transmission line are shown on Drawing 6.24.

The line is to transmit power of 20 MW between the power station and the pumping station over a distance of about 32.6 km. Taking account of the project scale, either 138 kV or 69 kV is appropriate for the transmission line voltage. The Manabi Electrical Company suggests to apply the voltage of 138 kV for the Project in combination with the system voltage of the Daule-Peripa hydropower project. Therefore, 138 kV, one of the standard system voltage in the country will be applied for the transmission line of the Project.

The smallest conductor size for 138 kV system will be ACSR Oriole (outside diameter = 1.883 cm) from ASTM to avoid unacceptable corona disturbances.Aluminium Cable Steel Reinforced (ACSR) is economically and technically used for the overhead transmission lines and generally used in the country.

Current carrying capacity of the ACSR Oriole (Approximately 490 amperes) is sufficient for transmission of 20 MW. Power loss and voltage drop of the 138 kV ACSR Oriole line when 20 MW flows will be approximately 1 % and 2.5%, respectively. The values are adequate for operation of the trunk transmission line. From those points, ACSR Oriole is used for the line between the power station and the pumping station.

Number of circuit was studied either one circuit or two circuit. Water supply from Poza Honda is not affected even if the pumps are stopped for 2 or 3 days, because the dam has sufficient water storage. One circuit transmission line is judged sufficient for the Project.

6.4 Poza Honda ~ Mancha Grande Transbasin

6.4.1 Poza Honda inlet

The Poza Honda inlet will consist of an entrance, an inlet tunnel and a valve chamber. The minimum intake water level from Poza Honda reservoir should be low enough to allow continuous water transbasin to Mancha Grande, but should be high enough to enable a gravity flow to the tunnel outlet with EL. 89 m, to facilitate a coffering during construction of the tunnel entrance and to avoid possible sedimentation problem.

The minimum intake water level is decided to be EL. 94 m with the intake sill level of EL. 91.4 m. According to the water level duration curve of Poza Honda, the reservoir water level is lower than EL. 94 m only for 4 %, which is acceptable.

The proposed intake sill elevation of EL. 91.4 m is reasonably higher than the tunnel outlet sill level of EL. 89 m, to allow water transbasin by gravity. The Poza Honda reservoir has a capacity of 16 MCM between EL. 94 m and EL. 88.3 m (LWL) and of 10 MCM between EL. 92 m and EL. 88.3 m (LWL). In the later part of the dry season from September to November, the reservoir water level can be drawn down to EL. 92 m, securing water supply to Guarumo treatment plant of 0.5 m^3/s as well as the river maintenance flow of 0.25 m^3/s utilizing the reservoir capacity of 10 MCM for about 5 months even if no inflow to the reservoir is taken into account. It is suggested, therefore, to keep the reservoir water level lower than EL. 92 m for at least 3 months during which the tunnel entrance should be constructed with minor coffering work.

Original riverbed elevation in front of the tunnel inlet was EL. 77 m and the sediment level after 50 years is estimated to be EL. 82 m, which is far below the proposed intake sill level of EL. 91.4 m. No sediment problem will take place at the tunnel inlet.

The tunnel entrance is an open concrete structure equipped with stoplog slot and inclined trash racks. The width is 6 m at the upstream face and 4 m at the downstream and to be connected with the inlet tunnel.

The inlet tunnel connects the intake entrance with the valve chamber. Tunnel length is 38.5 m and the tunnel section is semi-circular with a height of 2.5 m and a width of 4.0 m.

In the valve chamber two steel pipes of 900 mm in diameter will be installed, equipped with a butterfly valve and a sleeve valve on each pipe to control discharge.

A horizontal section of the valve chamber is oval as in the case with the valve chamber at the Conguillo tunnel inlet. A roof level of the valve chamber is EL. 112 m in view of the flood water level of EL. 108.3 m of Poza Honda reservoir.

The design of the Poza Honda inlet is given on Drawings 6.25 and 6.26.

6.4.2 Poza Honda~Mancha Grande diversion tunnel

(1) Hydraulic Design

The capacity of the diversion tunnel is 4 m^3/s. The minimum tunnel diameter is considered to be 2.5 m to secure workability for tunnel construction. A tunnel section is standard horse-shoe and the flow type is an open free flow under the same consideration as to other diversion tunnels.

Tunnel length is 4,093 m and a slope of 1/3,900 is sufficient to discharge the capacity of 4 m^3/s with a tunnel of the minimum diameter of 2.5 m. This gentle slope will reduce the flow velocity in the tunnel and no specific facility for energy dissipation is required at the tunnel outlet.

Plan and profile of the diversion tunnel are given on Drawing 6.27.

(2) Structural Design

The same four types of the tunnel section are designed as in case of the other diversion tunnels. The distance for each type is tentatively decided as follows.

	Type I	Type II	Type III	Type IV
Distance (m)	0	473	3,500	100

The tunnel sections are given on Drawing 6.28.

6.4.3 Mancha Grande outlet

At the end of the diversion tunnel, the tunnel section is gradually changed from the standard horse-shoe to semi-circular. The tunnel flow is released into a trapezoidal open channel of 35 m in length and discharged into the Mancha Grande river. No specific energy dissipator is needed because the flow velocity in the tunnel is less than 1.0 m/s. Side slopes are protected with concrete facing wall for 60 m section to avoid erosion by water flow.

The design of the Mancha Grande outlet is given on Drawings 6.29.to 6.31.

6.4.4 Work adit

No work adit is needed at the tunnel outlet, but a work adit (Poza Honda Work Adit) is needed at the tunnel inlet to proceed with the tunnel construction from the inlet side in parallel with the construction of the valve chamber. The length of the Poza Honda Inlet work adit is 168 m.

6.5 Access Roads

6.5.1 General

Since the structures are spread in the Project area, 8 access roads were designed to connect the existing roads to the structure sites for construction and maintainance purposes. Locations of these access roads are shown in Figure 6.4.

Name of access roads and structures to be connected are shown below.

Name of Access Roads	Structures to be Connected
(A) Conguillo Access Road	Conguillo Inlet Conguillo Work Adit
(B) El Guasmo Access Road	El Guasmo Work Adit
(C) Membrillo Outlet Access Road	Membrillo Outlet Membrillo Work Adit
(D) Severino Access Road	Severino Pumping Station Severino Substation Severino Head Tank Severino Open Channel
(E) Caña Dulce Inlet Access Road	Caña Dulce Inlet
(F) Los Cuyuyes Access Road	Los Cuyuyes Outlet Los Cuyuyes Work Adit
(G) La Seca Access Road	La Seca Work Adit
(H) Poza Honda Inlet Access Road	Poza Honda Inlet Poza Honda Work Adit

6.5.2 Design of access roads

(1) Type of Road

All access roads are designed basically based on the Type 4 and 5, specified in the Design Manual for Roads of Ministry of Public Works-1984, Ecuador.

(2) Design Speed

Design speed is 30 km/h.

(3) Typical Cross Section

Typical cross section of the access roads are shown in Figure 6.5.

(4) Geometrical Design Standards

Geometrical design standards are shown below.

Geometric Design of Access Road

Road Standard	Class 4 and 5 (Mountainous region)	
Design Speed	30 km/h	
Element	**Standard**	**Remarks**
Horizontal Alignment		
Minimum radius of curve	30m	15 m in extreme case
Minimum curve length	40m	
Longitudinal Alignment		
Minimum longitudinal gradient	0.5%	
Maximum longitudinal gradient	7.0%	Up to 10% in extreme case
Vertical curve length	25m	
Minimum curve radius	250m	
Cross Section		
Standard crossfall	4.0%	
Maximum superelevation	8.0%	
Superelevation run-off	1/75 - 1/300	
Sight Distance		
Minimum sight distance	30m	

6.5.3 Study on the access road routes

(A) Conguillo Access Road

The access road has a function of connecting the Canuto Access Road at Buenaventura with the Conguillo Inlet passing through Membrillo village. A road is required to be newly constructed between Buenaventura and Membrillo village since there exist no roads. Between Membrillo village and Conguillo Inlet, there is an unpaved road with a width of about 2.5 m with maximum longitudinal gradient more than 20 %, which are not suitable for an access road.

The road is routed along left bank of Estero Cañales from the 5 km point to Conguillo Inlet via Cañales Grande village. The topographic condition along the route is gentle and the designed longitudinal gradient is not steep.

(B) El Guasmo Access Road

The road branches off from the Conguillo Access Road connecting to the El Guasmo Work Adit.

(C) Membrillo Outlet Access Road

Membrillo Outlet Access Road also branches off from the Conguillo Access Road and connects to the Membrillo Outlet.

(D) Severino Access Road

The road is for access from the existing Pichincha road to Severino Pumping Station or Caña Ducle Inlet to be newly constructed. A difference of 300 m in elevation should be overcomed.

(E) Caña Dulce Inlet Access Road

The road is constructed mainly in parallel with Severino Open Channel connecting the Severino Access Road with Caña Dulce Inlet. An alignment of the road is determined by making the most use of the existing road.

(F) Los Cuyuyes Access Road

The road connects Poza Honda dam with Los Cuyuyes Outlet via Mercedes No.1 and No.2 villages and Los Cuyuyes village. On the route between Poza Honda dam and Los Cuyuyes village, there is an existing road with a width of 3 m. A large number of inhabitants live on both sides of the existing road and their farm lands exist around the road gently sloping down to Poza Honda reservoir.

Accordingly, it is judged that a new construction of the access road should be avoided and the access road will be constructed by improving and widening the existing road in order to minimize a compensation for the inhabitants and an acquisition of the land on the route between Poza Honda dam and Rio Pata de Pájaro. Crossing point over Rio Pata de Pajaro is sited at the same location as the existing road and the route is selected to avoid passing through Los Cuyuyes village. A longitudinal gradient of 10% is used near the crossing point.

(G) La Seca Access Road

The access road connects to La Seca Work Adit for La Esperanza ~ Poza Honda Diversion Tunnel.

The road branches off from the Los Cuyuyes access road and passes through private farm land to La Seca Work Adit. In a part of the farm land there exists a road with a width of 2.5 m, which is required to be improved as an access road and a new road will be constructed in most of the section. There are lots of horizontal curve portions and steep longitudinal gradient sections on the route. A compensation and land acquisition should be made along the most of the route.

(H) Poza Honda Inlet Access Road

Poza Honda Inlet Access Road branches off from Los Cuyuyes Access Road connects to the Poza Honda Inlet and Poza Honda Work Adit. Length of the road is about 0.7km.

(I) Canuto Access Road

Macadam paved road with a width of about 4.0 m exists in a few kilometers from Canuto town and the rest are non-paved road with a width of about 2.5 m. The road passes through the valley along Rio Grande, one of the tributaries of Rio Canuto, upto Estero El Limon near Buenaventura which is accessible by vehicles. Rio Grande meanders through the valley and the road crosses the river about 20 times, where no crossing facilities such as bridges and culverts exist and it is impossible to pass through in high flow period.

Accordingly it is judged that an improvement of the road is required as an access road to Conguillo Inlet and Membrillo Outlet. The improvement works will be completed before commencement of construction for the Project.

7. CONSTRUCTION PLAN AND SCHEDULE

7.1 Construction Plan

7.1.1 Basic conditions

The construction method and sequence are planned on the basis of the mode of construction and the target schedule of construction. Availability of construction forces, weather condition, geological and topographic conditions at the site and the mechanized construction method are taken into consideration.

The commencement of the construction works is scheduled in June 1997 and the Project is planned to be ready for operation in November 2001, giving a construction period of 4.5 years (54 months).

With regard to the workable days, 240 days are assumed in a year for earthworks. Workable days for concrete and tunnel works are planned to be 252 days and 276 days per year, respectively. As for the daily working hours, one 8 hours shift per day is applied for earthwork and concrete work, and two 10 hours shift per day is applied for tunnel work.

The Construction works will be executed in the following three contract packages as discussed in 10.2 herein.

Package 1 : Civilworks for the Daule-Peripa ~ La Esperanza Transbasin

Package 2 : Civilworks for the La Esperanza ~ Poza Honda and the Poza Honda ~ Mancha Grande Transbasins

Package 3 : Electrical and Hydromechanical Works

7.1.2 Preparatory works and construction facilities

(1) Access Road

The road between Guayaquil and Portoviejo is about 200 km and the entire length is an asphalt pavement road. The access to the project site from Portoviejo is available for passing the existing pavement road for Rocafuerte-Tosagua, San Plácido-Pichincha and

Santa Ana-Poza Honda. However, the permanent access roads are required to connect the particular work sites from the existing roads.

The permanent access roads will be constructed at early stage of the construction as a temporary use and a haulage. For the Package 1 work, the access road of about 25 km long will be constructed from Buenaventura to Conguillo inlet, El Guasmo work adit and Membrillo outlet.

The Package 2 work requires about 31 km long access road in total, comprising of Severino access road, Caña Dulce inlet access road, La Seca access road, Los Cuyuyes access road and Poza Honda inlet access road.

(2) CRM Base Camp and Temporary Buildings

The CRM base camp is planned to be located 800 m apart from the pumping station along the Severino access road. The CRM base camp comprises main office, branch offices and housing for campground. The CRM base camp will be constructed at early stage of the construction to supervise and manage the project. The permanent resident quarters will be used for the operational and maintenance staff after the commissioning of pumping station.

The temporary buildings such as a contractor's office, quarters, a repair shop, a warehouse, labor quarters, etc. will be constructed at the Severino pumping station site, Poza Honda, Mancha Grande, Membrillo and Conguillo.

(3) Power Supply System

The electric power supply for the construction and camp use is planned to be done by diesel generator provided by each package contractor. The power supply system for the main base camp is planned to be 13.8 kV distribution line extended from the proposed transmission line connected to the Severino pumping station.

The diesel generator sets will be provided at each work adit and the Severino pumping station site. The distribution line covering on all project areas is not considered, since the electric demand sites are isolated each other.

(4) Water Supply System

The water supply system for the construction use and domestic use at base camp is planned for each contract package. The water sources and locations are as follows: Conguillo river, El Guasmo river, Membrillo river, Severino river, Pata de Pájaro river, Poza Honda reservoir and Mancha Grande river.

(5) Telecommunication System

The telecommunication systems consisting of radio communication system and wireless telephone system (micro wave) will be installed for construction use and operation and maintenance. These facilities will be provided by Package 2 contract.

The wireless radio communication system is planned to be VHF radio equipment and will be established for communications among the CRM's main office and the branch offices. The wireless telephone system will be installed between Calceta transmission station and CRM's main office at Severino.

The contractor may use the above telephone system as an emergency purpose. The radio communication system will be installed by each package contractor. The wired telephone facilities will be required within each tunnel work site including all work adit and open construction sites.

7.1.3 Major construction works

(1) Pumping Station

The pumping station is planned to be located at Severino, upstream of the La Esperanza reservoir. The La Esperanza dam impounding will be reached at the H.W.L 66.0 m before starting the pumping station construction. The lowering of reservoir water level is required to be at EL. 45.0 m and a temporary cofferdike will be provided in front of the inlet portion. The open construction work is necessary for the pumping station construction.

The first stage construction consists of open excavation, substructure concrete and embedded metal and pipe installation. The second stage construction consists of structural concrete for walls, piers and beams, encasement concrete of penstock, superstructure concrete and overhead crane installation. The architectural work will follow the structural concrete work and carried out in parallel with the superstructure work.

The inlet channel concrete work and the removal of cofferdike is scheduled to be made during two months from April to May 2001, by lowering again the La Esperanza dam reservoir level below EL. 45.0 m. The impounding level to EL. 58.5 m will be required for wet testing of pumps and the impounding-period is estimated at four months diverting water from the Daule-Peripa.

The excavation work will be carried out by 21 ton bulldozer and 32 ton bulldozer with ripper. The soft rock will be excavated by a combined method of low bench blasting and ripping. The excavated material will be loaded by 2.2 m^3 tractor shovel into 11 ton dump truck and hauled to the spoil area located along the open channel route.

The concrete plant will be installed near the head tank area or the beginning point of the open channel. The concrete will be transported by 3.0 m^3 agitator truck from the concrete plant of 0.75 m^3 x 2, and placed by 1.0 m^3 concrete bucket with 30 ton truck crane and 45 m^3/hr concrete pump car. Two nos. of fixed type tower crane with 1 ton lifting load and 30 m working radius will be provided for handling formwork material, reinforcement bars and so on.

The embedded pipes and penstock below EL. 70.0 m will be installed at the early stage of pumping station work, using 30 ton truck crane and fixed tower crane.

(2) Penstock

The penstock installation is divided in two stages. The penstock under backfilling of EL. 70.0 m will be installed for three months from July to September 1999. The remaining length to connect the head tank is scheduled to be installed from October 2000 to January 2001.

The open excavation work and concrete work are carried out by the same method applied for the pumping station. The saddle concrete slab will be placed before the installation of penstock. The steel pipe segment of 6 m long will be transported from the Guayaquil port to the stockyard. The steel pipe segments will be installed using inclined machine, dolly and 30 ton truck crane. And then the pipes will be set in position and adjusted to the correct alignment for joining by welding. As for the flat portion, the saddle concrete and anchor bars will be first provided. The ring girder will be set to the anchor bolt.

(3) Open Channel

Before starting the excavation work, the temporary access road will be constructed on the right side of open channel alignment. The haulage road to the spoil area will be branched from the above access road. This temporary access road will be also used for the La Esperanza - Poza Honda diversion tunnel work.

The excavation work above the planned inspection road level will be carried out using 21 ton bulldozer and 32 ton bulldozer with ripper. The material will be loaded by 2.2 m^3 tractor shovel into 11 ton dump truck for hauling to the spoil area. As for the channel section, the excavation work will be made by 11 ton bulldozer, 0.6 m^3 backhoe and rock breaker with 0.6 m^3 backhoe. The final stage excavation adjacent to the channel slope will be made using pick hammer and manpower trimming and finishing.

The embankment section will be first filled entirely, and then the channel section will be excavated. The embankment work will be made only during dry season from June to December.

The concrete placement is planned to be made by a conventional method using a portable metal form. The slab concrete will be first placed, and then the slope concrete will be placed at two lifts. The metal forms will be installed and removed by 20 ton truck crane with manpower. The concrete will be transported by 3.0 m^3 agitator truck and handled by 0.5 m^3 concrete bucket and one wheel buggy with manpower.

Before concrete placement, the underdrain of 50 mm dia., perforated pipe with sand and gravel is provided at the bottom. The sand and gravel layer of 100 mm thick will be filled and compacted by manpower.

Syphon concrete work will be made by a conventional method using 45 m^3/hr concrete pump car and 1.0 m^3 bucket with 30 ton truck crane.

(4) Inlet and Outlet Work

- Daule-Peripa ~ La Esperanza Diversion Tunnel

The Conguillo access road will be constructed to connect to the inlet structure. The common and weathered rock will be excavated by 21 ton bulldozer and 32 ton bulldozer with ripper. After the open excavation, the inlet shaft will be sinked downward. The rock excavation will be made by 7 m^3 crawler drill and 2.9 m^3/min sinker drill. The broken rock will be gathered by 0.4 m^3 tractor shovel and 0.3 m^3 backhoe and loaded into a deposit bucket. The deposit bucket will be pulled up by 30 ton truck crane and discharged into 11 ton dump truck bessel.

Succeeding to the shaft excavation, the inlet tunnel will be driven by blasting method and the broken rock will be loaded by 0.4 m^3 tractor shovel into deposit bucket handled with 30 ton truck crane. The concrete bulkhead will be demolished carefully after the confirmation of the interior water in the previous tunnel. The demolishing will be made by manpower with hand type concrete breaker and pick hammers.

The concrete will be discharged into 1.0 m^3 concrete bucket and handled to the concrete hopper by 30 ton truck crane and distributed into the placing spot through chutes from the hopper. The concrete lining of inlet tunnel will be carried out by means of concrete placer applied for the diversion tunnel lining work.

The dredging of inlet channel will be carried out by a 200 HP class dredger and the sand material will be delivered through 200 mm dia.delivery pipes. The delivered sand will be dried and then loaded by 0.6 m^3 backhoe into 11 ton dump truck for hauling to the spoil bank.

The outlet structures of tunnel portal are scheduled to be constructed from January 2001 after constructing temporary coffer dams. The remaining tunnel of 10 m long at the outlet will also be driven and concrete lined by the same method applied for the diversion tunnel work. However, the outlet channel construction will require the water lowering of La Esperanza dam reservoir. The lowering period is scheduled to be two months from March 2001. The recovery of La Esperanza reservoir will require four months for wet test of the mechanical equipment.

- La Esperanza ~ Poza Honda Diversion Tunnel

Caña Dulce inlet structures between the open channel and the diversion tunnel is scheduled to be constructed during dry season of 2000. The outlet structures are scheduled to be made for two months from July to August 2001, after lowering Poza Honda reservoir. The recovery of the reservoir water level will require one month for wet test of the mechanical equipment.

- Poza Honda ~ Mancha Grande Diversion Tunnel

The inlet facilities are designed to be similar with the Conguillo inlet facilities. The shaft excavation will be carried out by a sinking method as proposed for the Conguillo shaft.

The tunnel driving will be made by blasting method and the excavated material will be loaded by 0.4 m^3 tractor shovel into deposit bucket.

The inlet channel and a part of inlet tunnel are scheduled to be made for two months of July and August 2001, after lowering the Poza Honda reservoir. The recovery period of Poza Honda reservoir is one month in October 2001, after the completion of the inlet channel construction.

(5) Diversion Tunnel Work

A horse-shoe type tunnel with concrete lining is planned for all tunnel construction such as Daule-Peripa ~ La Esperanza tunnel (8,296 m long, 3.7 m dia.), La Esperanza ~ Poza Honda tunnel (11,417 m long, 3.5 m dia.) and Poza Honda ~ Río Mancha Grande tunnel (4,095 m long, 2.5 m dia.). Three tunnels are mainly aligned in massive and soft sandy mudstone with a compressive strength of about 100 kg/cm^2 and anticipated to encounter neither fault nor water problem. The tunnel construction will be a critical path of the construction work. In order to shorten the construction period, the following work adits are required for each tunnel considering the construction sequences:

(a) Daule-Peripa ~ La Esperanza tunnel:	Conguillo work adit (183 m), El Guasmo work adit (350 m) and Membrillo work adit (128 m)
(b) La Esperanza ~ Poza Honda tunnel:	La Seca work adit (519 m) and Los Cuyuyes work adit (130 m)
(c) Poza Honda ~ Río Mancha Grande tunnel:	Poza Honda work adit (168 m)

The work adit is designed to be a vertical wall and arch roof type, 4.0 m wide x 4.0 m high. The supporting system is to be a rock bolting and shotcrete method applied for the diversion tunnel supporting. The tunnel excavation is planned to be made by applying a full face attack method. The drilling rock will be carried out by 4 nos.leg drill with portable deck. The broken rock will be loaded by 0.4 m^3 inclined type muck loader into 2 nos. of 4.5 m^3 muck car, and then the muck cars will be pulled up outsite of tunnel portal by using 150 kW winch. The broken rock will be loaded by 1.2 m^3 tractor shovel into 8 ton dump truck. As for the Poza Honda work adit, 3.0 m^3 muck car and 100 kW winch will be used.

Typical tunnel cross section is planned to be four sections such as type I, II, III and IV according to the geological conditions and NATM tunnel supporting system is applied. A full-face attack method is applied for driving the tunnel, while hauling of broken rocks is to be by a rail haulage method. Three tunnel faces will be attacked simultaneously for La Esperanza~Poza Honda and Daule-Peripa~La Esperanza tunnels using three sets of tunnel equipment crew. As for the Poza Honda~Río Mancha Grande tunnel, two tunnel faces will be provided.

Tunnel excavation work will be carried out using an arm type mechanical tunneling machine with a cutting head, considering the geological conditions and the following supporting system comprising of rock bolting and shotcreting. Broken rocks will be loaded into 4.5 m^3 and 3 m^3 muck cars with the 8 ton and 6 ton battery locomotives for hauling respectively. The broken rocks carried to the open yard by those equipment will be loaded by 1.2 m3 tractor shovels into 8 ton dump trucks and will be hauled to the spoil bank.

Just after finishing one cycle excavating operation of 1.2 m progress, a primary shotcrete of 100 mm thick with 100 x 100 wire mesh and rock bolts of 2.0 m long will be provided. As for the lower compressive strength sections and fault zones, steel H beam ribs and additional shotcreting are provided.

A concrete lining thickness is designed to be 300 mm except for the shotcrete supporting thickness. The concrete lining work will be performed in parallel with the tunnel excavation works for La Esperanza - Poza Honda tunnel and Daule-Peripa~La Esperanza tunnel according to the NATM analysis. The concrete lining work of Poza Honda~Río Mancha Grande tunnel will be made after the completion of every 200 m long tunnel excavation work because of the limited tunnel internal working space area.

Lining concrete will be placed in the arch portion first and then placed in the invert portion. The concrete lining progress rate is planned to be the same progress rate of tunnel excavation to keep 200 m interval, with 12.0 m long concrete lining span. The lining progress rate of the Poza Honda~Río Mancha Grande tunnel is planned to be 276 m per month. The concrete will be transported by 3.0 m^3 agitator trucks from the concrete batcher plant, and then discharged into 6 m^3 and 4.5 m^3 concrete placer with 6 ton battery locomotive to transport to the placing spot in the tunnel. The concrete will be placed behind sliding forms of 12.0 m long by means of compressed air from the concrete placer. The invert concrete placing will be carried out using 3 m^3 agitator cars.

7.2 Construction Schedule

The construction period required for the proposed implementation program of the Project is planned to be 4.5 years including three contract packages. The construction works are scheduled to be commenced at the beginning of June 1997 and be completed by the end of November in 2001.

The financial arrangement of foreign loan is expected to take ten months period after the submission of loan application. The arrangement of foreign loan will be completed before starting the selection of consultant. The financial arrangement of national budget is expected to be completed at the same time of foreign loan arrangement.

The implementation schedule is shown in Fig. 7.1 and the construction schedule is shown in Fig. 7.2. The land acquisition and compensation for the Project will be settled by CRM prior to the commencement of the construction.

The following basic schedule is established in order to secure the commissioning target of the Project.

(a)	Financial arrangement for the construction work	:	10 months from April 1995 to January 1996
(b)	Selection of a consultant	:	3 months from February 1996 to April 1996
(c)	Tendering and contracts including prequalification		
	Package 1	:	13 months from May 1996 to May 1997.
	Package 2	:	13 months from May 1996 to May 1997
	Package 3	:	11 months from July 1997 to May 1998
(d)	Construction works	:	
	Package 1	:	54 months from June 1997 to November 2001
	Package 2	:	54 months from June 1997 to November 2001
	Package 3	:	42 months from June 1998 to November 2001
(e)	Commissioning of the Project	:	December 1, 2001

8. ENVIRONMENT

8.1 Environmental Impact Assessment

8.1.1 General

Environmental Impact Assessment (EIA) is conducted for the Project for the following 4 issues taken up for EIA based on the Project features and the results of the Initial Environmental Examination (IEE).

(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

8.1.2 Impacts on water quality of La Esperanza and Poza Honda reservoirs

The future water quality conditions of La Esperanza and Poza Honda reservoirs are predicted based on the existing water quality data. The future water quality in La Esperanza would be better than that of Daule-Peripa in BOD and COD, but worse in T-N and T-P. In Poza Honda, the water quality would basically remain the same except for a slightly increase in COD. No significant impacts are anticipated because no drastic water quality change would be expected in both reservoirs.

Based on the predicted water quality of T-P, the possibility of eutrophication of the reservoirs are assessed by using formulas for tropical lakes developed by CEPIS. The possibilities of eutrophication of La Esperanza and Poza Honda reservoirs would be rather high even though the transbasin project could improve retention time of the reservoirs. The result is shown in Fig. 8.1. Both Daule-Peripa reservoir (constructed in 1987) and Poza Honda reservoir (constructed in 1971) are considered to be under eutrophicated conditions. Therefore, La Esperanza reservoir would also be in the eutrophicated conditions. At present, effective and efficient countermeasures do not exist unfortunately to avoid eutrophication, so a long term management of the reservoir would be necessary under the appropriate EMMP for the Project.

8.1.3 Impact on river flow regime

The degree of the river flow change is estimated by the mathematical hydrologic model used in the water balance study for the Project. In the rainy season, the river flow discharge in the Chone river would be increased about 9 % at the river mouth area and 34 % at the Carrizal river. In the Carrizal river the mean discharge in the dry season could be increased from 140 MCM to 417 MCM, while the remarkable 100 % improvement of river flow discharge would be expected in the Prtoviejo river from 111 MCM to 221 MCM in the dry season. Consequently, the impacts caused by the river flow change would bring positive effects on the environment in the rivers and estuaries.

8.1.4 Impacts on water quality in rivers and estuaries

To clarify the impacts on water quality in the rivers, a qualitative approach is applied to reveal a degree of water quality deterioration in the Chone and Portoviejo rivers by using a concept of pollution load analysis. Based on the estimated pollution load change, the future water quality at four prediction points is assessed, and the result is summarized hereunder.

Result of Water Quality Prediction (unit: mg/l)

Prediction Point	BOD		COD		T-N		T-P	
	Exi't	Fut'e	Exi't	Fut'e	Exi't	Fut'e	Exi't	Fut'e
I. Lower reach of the Chone river								
a) Rainy	10.7	11.4	19.0	19.0	2.4	2.6	0.25	0.27
b) Dry	14.0	10.0	24.3	14.4	1.4	1.5	0.20	0.19
c) Annual	12.3	11.0	21.7	17.6	1.9	2.3	0.23	0.25
II. The Chone estuary								
a) Rainy	11.3	8.5	18.7	14.4	2.1	2.0	0.00	0.22
b) Dry	18.0	13.6	32.7	24.4	1.3	1.9	0.30	0.18
c) Annual	14.4	10.5	24.0	18.3	1.5	1.9	0.15	0.20
III. Lower reach of the Portoviejo river								
a) Rainy	13.3	15.0	20.0	18.7	1.9	2.4	0.24	0.33
b) Dry	14.3	18.1	23.7	21.8	1.3	2.6	0.40	0.53
c) Annual	13.8	16.1	21.9	19.8	1.6	2.4	0.32	0.40
IV. The Portoviejo estuary								
a) Rainy	12.0	15.6	17.3	19.4	2.2	2.6	0.43	0.35
b) Dry	19.0	19.1	33.7	22.9	0.9	2.9	0.30	0.55
c) Annual	15.5	16.8	25.5	20.7	1.5	2.7	0.37	0.42

Source: JICA Study Team

At the lower reach of the Chone river as well as at its estuary area, the future water quality would be better than that of the present conditions, mainly due to the river flow improvement in both rainy and dry seasons. Thus, positive impacts could be caused on the environment by the water quality change in the Chone river.

At the downstream of the confluence point with the Chico river and the lower reach of the Portoviejo river, the water quality deterioration could be serious mainly due to the wastewater discharge from Portoviejo city. Thus, the Portoviejo river will cause negative effects on the potable water treatment plant at El Ceibal. Improvement of the existing sewerage system is needed in Portoviejo city.

8.1.5 Impacts on ecosystem and fishery

At present, no national parks, nature conservation areas and game refuges exist in the Chone-Portoviejo river basins, and the existence of endangered species has not been reported because of broadly spread cultivation and pasture lands. Thus, the ecosystem to be protected in the basins are principally the estuary of the Chone river which provides high productive habitats for fauna and flora, and the indigenous species, namely "chame" a kind of goby, which contributes to the local economy. The ecological area to be protected is shown in Fig. 8.2.

Although the impacts caused by river flow change would be positive, the impacts caused by the water quality deterioration could be negative especially in the Portoviejo river. Therefore, the improvement of sewerage system in Portoviejo city is considered essential to mitigate the magnitude of impacts caused by the water quality deterioration.

The estuary in the Chone river which once had rich and wide mangrove forests, has been destroyed mainly due to shrimp pond construction. At present, only about 170 ha of mangrove remains. There are no room to expand shrimp ponds in the estuary area of the Portoviejo river, but about 450 ha of potential area still remains in the Chone river. Since the potential shrimp pond area is located outside the existing mangrove areas, any direct impacts would not be considered to mangrove ecosystem. However, uncontrolled expansion of shrimp ponds especially inland areas of the Chone river could cause serious problems not only on the ecosystem but also on the existing and future irrigation areas because of the discharge of saline water from ponds. Thus, strict regulation and control related to land use in the downstream area in the Chone river is recommended to protect the lands and ecosystem against the encroachment of overexploitation pressure.

The downstream area of the Chone river being prone to flood in the rainy season is considered the most important habitat of chame. In the rainy season, the river average flow discharge would be increased about 9 % at the river mouth area. Therefore, no serious impacts would be expected on the habitat of chame by the Project.

8.2 Environmental Management and Monitoring Plan (EMMP)

8.2.1 Institutional aspect

Basically, EMMP consists of three units, i.e., Environmental Management Unit (MAU), Environmental Monitoring Unit (MOU) and Laboratory (LAB). MAU has a function of overall management of EMMP including inter and inner institutional coordination and decision making for effective implementation of each plan and program. MOU has planning and executing functions of various kinds of study and monitoring plan and/or program in accordance with the policy decided by MAU. LAB has roles of the physical and chemical analysis or test of water and soil, and the research and development study for establishment of appropriate EMMP of the Project.

Taking the lessons from the case of Daule-Peripa dam being executed by CEDEGE into account, the following institutional arrangement will be made by CRM to attain the objectives of EMMP more effectively and successfully.

(1) Cost-benefit Analysis of EMMP

Needless to say, EMMP should cost. In order to justify the activities of EMMP, a cost-benefit analysis will be conducted before implementation of EMMP taking all environmental aspects into account. The analysis will also clarify the necessary power, cooperation and budget of EMMP.

(2) Executing System of Programs of EMMP

EMMP must be a headquarter related to environmental aspects, but it does not mean to keep all task forces in it. Considering tight and scarce resources in budgets and sophisticated personnel in Ecuador, a proper entrusting system will be essential for smooth and efficient execution of actual programs.

(3) Authorization of Activities of EMMP

The activities of EMMP will include inter-institutional matters. So, necessary right or power authorized by laws and ordinances of the nation will be given to EMMP to ensure not only effective execution of the activities but also appropriate collaboration system with the existing concerned agencies.

8.2.2 Technical aspects

Well managed EMMP is indispensable to the sustainability of the Project. In this connection, the following items are to be managed and monitored regarding to water quality, conservation of vicinity area of reservoirs and protection of ecosystem and fishery.

- Water Quality

a) Protection of quality deterioration of water to be used for municipal, agricultural and aquacultural water supply,

b) Solution of problems related to eutrophication of the reservoir water in La Esperanza and Poza Honda dams,

c) Conservation of water quality in the estuary area,

d) Setting up of water quality criteria and standards as the management goal and target.

- Conservation of Vicinity Area of Reservoirs

a) Protection of water quality contamination of the reservoirs and canals,

b) Protection of excessive sedimentation of reservoirs,

c) Promotion of reforestation and land use control around the reservoir area,

- Protection of Ecosystem and Fishery

a) Protection of mangrove areas,

b) Protection of habitats of indigenous species "chame",

c) Management and coordination of land use and exploitation of the downstream area of the Chone river,

d) Management of the tidal gate at Simbocal in the downstream of the Chone river.

The following programs are to be conducted in the EMMP to attain the objectives of EMMP efficiently.

The experience of on-going activities of EMMP for the Daule-Peripa dam should be duly taken into account.

- Water quality

a) Program for Establishment of Quality Standards

b) Program to Reduce the Effects of Agrochemicals

c) Program for Biomass Removed from La Esperanza Impoundment Area

d) Program for Aquatic Weed Control in the Reservoir Areas

- Conservation and Protection

a) Program for Reforestation and Land Use Control around the Reservoir Areas

b) Program for Reforestation and Conservation of the Chone River Estuary

c) Program for Conservation of the Portoviejo River Estuary

b) Program for Conservation of Wetlands and Chame Habitats.

- Operation of Simbocal Gate

a) Program for the Redesign, Implementation and Operation of the New Simbocal Tidal Gate

8.2.3 Indicative cost estimate

The annual cost for administration and operation for EMMP is estimated to be about US$207,000. The cost for programs to be conducted in the EMMP for the Project during a period of five to seven years from 1995 is estimated at US$2.7 million indicatively.

CRM will finance for administration for EMMP, the cost for programs has been arranged separately by the Government of Ecuador, through a loan from the Corporación Andina de Fomento (CAF).

8.3 Conclusion and CRM's Action Plan

8.3.1 Conclusion

Although several environmental impacts having certain effects on the environment are pointed out through EIA, these are not considered substantial for the Project because most of them could be mitigated by proper countermeasures. Therefore, the Project is judged acceptable from the environmental viewpoints conclusively if the following countermeasures are taken in future.

8.3.2 Action Plan

The following actions will be taken by CRM for the environmentally sound and sustainable development.

(1) To change Intake Site of El Ceibal Treatment Plant

CRM is currently constructing a new potable water treatment plant with production capacity of 90,000 m^3/day at El Ceibal site under the Poza Honda Water Supply System. It is planned to take raw water for this plant from the Portoviejo river near Rocafuerte town. However, problems related to potable water treatment could take place due to the expected future quality deterioration of raw water in the Portoviejo river. Thus, it is necessary to change the planned intake site from the Portoviejo river to other areas to take better quality raw water.

The Chico river will be the best option of raw water source. The future water quality at Río Chico, just upstream of the confluence point with the Portoviejo river, will be much better than that of the Portoviejo because the Chico river has less possibility of water quality deterioration in its basin. Therefore, CRM will use the Chico river as a new raw water source of the El Ceibal Treatment Plant upon completion of the Project.

(2) To improve Sewerage System

The degree of water quality deterioration of the rivers depends on the progress of wastewater treatment system. The future water quality at the lower reach of the Portoviejo river downstream of confluence point with the Chico river is predicted in four cases, namely no improvement of existing sewerage system, improvement in 30%, 50% and 70% of sewerage coverage ratio.

The results indicate that the sewerage system improvement is effective for conservation of the river water quality, but not enough. CRM will improve the sewerage system of Portoviejo city with the maximum effort. In the future also it is needed to implement a sort of pretreatment of the drainage water coming from the irrigation areas.

Result of Water Quality Prediction (unit: mg/l) at Lower Reach of the Portoviejo River

	BOD	COD	T-N	T-P
I. No Improvement in Sewerage System				
a) Rainy	15.0	18.7	2.40	0.33
b) Dry	18.1	21.8	2.60	0.53
c) Annual	16.1	19.8	2.40	0.40
II. 30% Sewerage Improvement				
a) Rainy	13.89	18.27	2.28	0.31
b) Dry	16.08	20.92	2.39	0.50
c) Annual	14.68	19.22	2.32	0.38
III. 50% Sewerage Improvement				
a) Rainy	13.07	17.91	2.21	0.30
b) Dry	14.57	20.28	2.27	0.48
c) Annual	13.61	18.76	2.23	0.36
IV. 70% Sewerage Improvement				
a) Rainy	12.23	17.56	2.15	0.29
b) Dry	13.07	19.64	2.16	0.46
c) Annual	12.53	18.31	2.15	0.35

Source: JICA Study Team

(3) To Control and Manage Land Use

The estuary area and the flood plain in the downstream area of the Chone river are considered important ecological zones. Uncontrolled expansion of shrimp ponds especially in flood plain of the Chone river could cause serious problems not only on the ecosystem but also on the existing and future irrigation areas because of the discharge of saline water from ponds. Thus, strict regulation and control related to land use in the estuary and flood plain in the Chone river will be done by CRM to protect the ecosystem against the encroachment of overexploitation pressures.

(4) To Improve the Operation of Simbocal Tidal Gate

The Simbocal tidal gate located in the downstream reach of the Chone river, is considered the focal point among beneficiaries such as shrimp culture, fish pond of chame and irrigation. Although CRM operates the gate at present, the gate is sometimes confronted difficulties mainly due to lack of sufficient technical and scientific information, and of management capability of coordination among beneficiaries.

A proper operation of the gate in accordance with the guideline provided during the EIA, is essential to conserve the habitat of chame and postlarvae of shrimp. Thus, the proper gate operation will be done by CRM including i) to operate the gate strategically, ii) to coordinate the management of the gate among CRM, shrimp pond owners and aquacultural farmers of chame.

(5) To Establish EMMP and Its Operation Unit

Even if the results of EIA conclude that the proposed project would be acceptable from the environmental viewpoint, it is not possible to eliminate all uncertainties related to environmental impacts caused by the project. Unexpected environmental problems might arise after implementation of the project. It is important to monitor the effectiveness and efficiency of the proposed mitigation measures, and EMMP will be conducted by CRM to attain environmentally sound and sustainable development of the Project.

9. THE EXECUTING AGENCY AND PROJECT ORGANIZATIONS

9.1 The Executing Agency

The executing agency of the Project is the Manabi Rehabilitation Center (CRM). CRM is responsible for development of water resources including potable water supply and irrigation in the province of Manabi as well as regional development of the Manabí province. Most of the water resources development projects in the Manabí province have been planned, designed, constructed, operated and maintained by CRM. Major projects handled and managed by CRM are the Poza Honda Multipurpose Project including the Poza Honda dam, Poza Honda water supply system and Poza Honda irrigation system; small irrigation schemes such as the La Estancilla irrigation system, the Chico river irrigation system, etc.; the Chone and the La Estancilla potable water supply systems; and the Carrizal-Chone Multipurpose Project including the La Esperanza dam under construction and the Carrizal-Chone irrigation system of 15,000 ha for which the study has been completed up to the feasibility level.

The cooperating agencies of the Project are the National Development Council (CONADE), the Ecuadorian Institute of Water Resources (INERHI), the Commission for Guayas River Basin Development (CEDEGE), the Jipijapa and Paján Board of Water Resources (JRH), the Ecuadorian Institute of Sanitary Works (IEOS), the Ecuadorian Institute of Electrification (INECEL), and the Ministry of Public Works (MOP).

CONADE is an institution for making a national development plan, and controls and guides sub-structures according to the national development plan as a council. CONADE is, therefore, the superstructure of CRM. INERHI is the institution for water resources development in Ecuador and owns all of the water right. The water resources of the Project area belong legally to INERHI. At present, however, the right of water management and utilization of the Manabi province has been transferred to CRM by means of concessions extended by INERHI. CEDEGE is the same kind of institution as CRM in charge of development in the Guayas river basin, including the Daule-Peripa dam. JRH is the institution to provide Jipijapa and Paján with potable water, irrigation water and sanitary sewerage for socio-economic development of Jipijapa and Pajan. As mentioned before, the Poza Honda water supply system now includes Jipijapa area.

The organization chart of the Executive Branch of the Government of Ecuador including the above mentioned agencies is given in Fig. 9.1.

CRM was established in 1962 motivated by the provincial people's strong request for a drastic countermeasure against the economic stagnation in Manabi province caused by a prolonged drought in 1962. CRM has been reformed and reorganized several times to better serve the people of Manabi province.

The new law of CRM established in 1994 describes as follows.

(Article 2)

CRM shall have the following objectives:

a) To attain entire socio-economic development of the Province of Manabi,

b) To prepare development plans, programs and projects in Manabi province in conformity with the national plan, in coordination with public and private institutions of the region to optimize the use of available resources,

c) To plan and execute water resources development project, especially the Daule-Peripa ~ La Esperanza ~ Poza Honda ~ Chico River transbasin project; environmental conservation including water supply and sewerage systems for wastewater and rain water, programs for control and management of the ecological systems especially the flora and fauna, toxic waste from industries, river cleaning and mangrove recovery; and urban planning and road paving in the province of Manabi,

d) To organize groups of provincial people for an efficient use of irrigation systems, control and care of the ecological system and water supply and sewerage system by zones, and to coordinate such activities with municipalities and other public and private institutions for centralized operation and administration avoiding duplication of bureaucracy and waste of economic resources, and

e) To advice municipalities on urban development.

(Article 4)

The directive structure of CRM shall be Board of Directors, General Manager and Technical and Administrative Departments.

(Article 5)

The Board of Directors of CRM is the top authority of Directory Level of the Institution and consists of the following members:

a) A representative of the Constitutional President of the Republic, who will lead the Board and shall be a resident of the province of Manabi,

b) The Secretary General of Planning of CONADE or his delegate, a citizen of Manabi with ample knowledge of National Development Planning,

c) The Governor of the province, or by delegation the Deputy Governor,

d) The Chairman of the Manabi Provincial Council or in his absence the Vice Chairman of the Council,

e) The representative of the Catholic Church of higher hierarchy with residence in Manabi,

f) A representative nominated by the municipalities of Manabi,

g) A representative elected by the Industries, Commerce and Construction Chambers,

h) A representative of the Provincial Agricultural Center,

i) A representative of the universities of Manabi, and

j) A representative of workers and farmers organizations.

One of the duties of the Board of Directors of CRM is to review, approve and authorize contracts or agreement for local or foreign loans (Article 9).

The administration of CRM shall be under charge of the General Manager to be nominated by the Board of Directors, top Executive Level, who will be a legal representative of CRM (Article 10).

One of the duties of the General Manager is to act as Secretary of the Board of Directors of CRM (Article 11).

The Technical and Administrative Departments are the Operating Level of CRM (Article 12).

CRM is authorized to enter into contract for local and foreign loans as well as to carry out any kind of financial transactions authorized by the laws. The National Government will guarantee loans directly contracted by CRM (Article 14).

CRM can enter into contracts or agreement for the execution of studies and works with natural and juridical persons of public and private right, national or international, in accordance with the provisions of the pertaining laws (Article 17).

The present organization of CRM is given in Fig. 9.2.

As of October 1994, CRM has 1,239 personnel: 743 in CRM headquarters, 274 in Poza Honda, 82 in Chone, 91 in La Estancilla and 49 others. The details of the CRM's workforce is given in Table 6.1

The CRM's financial situation is given in Table 6.2. The annual receipt of CRM was S/.14,749 million (US$13.8 million equivalent), while the annual expenditure of CRM was S/.14,537 million (US$.13.6 million equivalent) in 1992.

9.2 Project Organization

A transbasin project office is planned to be organized towards the construction of the Project. The planned organization of the transbasin project office during the construction is shown in Fig. 9.3. Project Manager will be appointed by the General Manager of CRM for the construction supervision of the Project.

The main project office is planned to be located at the Severino pumping station site and the branch offices are located at the Conguillo tunnel inlet site and the Poza Honda tunnel inlet site. These three offices are interconnected by a telecommunication system together with CRM's headquarters in Portoviejo. An international consultant as well as an Ecuadorian consultant will be employed by CRM to assist CRM in construction supervision of the Project. The consultants will work as a part of CRM.

Upon completion of the Project, CRM will hand over the transmission line between the Daule-Peripa substation and the Severino substation to INECEL for operation and maintenance. Also, the access roads will be handed over to the Ministry of Public Works (MOP) for maintenance. CRM will be responsible for operation and maintenance of the remaining Project facilities.

The operation and maintenance of the Project facilities will be made by CRM in the following manner.

The Severino Project office will become a Severino operation and maintenance center. Chief of the Severino O&M Center will be appointed by CRM. The Severino O&M Center is responsible for:

- Operation of the Severino pumping station in accordance with an operation manual based on such data as reservoir water levels at Daule-Peripa , La Esperanza and Poza Honda, discharge data at La Esperanza and Poza Honda including diversion discharge from Poza Honda to Mancha Grande, etc.

- Maintenance of the Severino pumping station, penstock lines, head tank, open channel with inspection road and the diversion tunnel to Poza Honda.

The Conguillo branch office for construction supervision will become a Conguillo O&M branch office, which is responsible for:

- Operation of the valve chamber at the inlet of the diversion tunnel to La Esperanza in accordance with instructions from the Severino O&M Center, informing daily the Daule-Peripa water level to the Severino O&M Center.

- Maintenance of the tunnel inlet areas by dredging, the valve chamber and the diversion tunnel to La Esperanza.

The Poza Honda branch office for construction supervision will become a Poza Honda O&M branch office, which is responsible for:

- Operation of the valve chamber at the inlet of the diversion tunnel to Mancha Grande according to water requirement instructed by the Severino O&M Center, informing daily the Poza Honda water level to the Severino O&M Center.

- Maintenance of the inlet, the valve chamber and the diversion tunnel to Mancha Grande including the outlet open channel to the Mancha Grande river.

The proposed organization of CRM for Project operation and maintenance is shown in Fig. 9.4.

10. PROCUREMENT PLAN

10.1 Engineering Services

10.1.1 Scope of works

To ensure a good engineering quality of construction and a target completion date, CRM intends to employ an international consulting firm in accordance with the regulations of the Government of Ecuador and also with guidelines of the financing institutions for engineering services during the implementation of the Project. The scope of works for the international consulting firm will be divided into two categories: (i) Pre-construction services during prequalification, tender, tender evaluation and contract award, and (ii) Construction supervision. Details of the services are described below.

(1) Pre-construction Services

The pre-construction services will include the following works:

- Assistance to CRM in prequalification calling, evaluation of application and selection of qualified applicants for tendering, and

- Assistance to CRM in tender procedures such as (i) answers to tenderers' questions during the tender period, (ii) pre-bid conference with site inspection trip by tenderers, (iii) opening of tenders, (iv) tender evaluation, (v) contract negotiation with the successful tenderer, (vi) preparation of contract documents, and (vii) contract signing.

(2) Construction Supervision

The construction supervision will include the following works:

- Preparation of construction drawings as necessary,

- Review and approval of the contractor's drawings for both permanent and temporary works including shop drawings for fabrication of mechanical and electrical works,

- Review and approval of the contractor's construction plan and time schedule,

- Site design changes and issuance of change order to the contractor,

- Quality control of the contractor's construction works and mechanical and electrical works to be supplied and erected by the contractor,
- Progress control of the contractor's construction works and mechanical and electrical works including issuance of hand-over certificate, completion certificate and maintenance certificate,
- Payment control to the contractor including issuance of payment certificate, and
- Settlement of contractor's claims for increase of the contract price or time extension for completion.

10.1.2 Work schedule and expertize requirement

(1) Work Schedule

As discussed in Chapter 7 herein, the engineering services for the pre-construction services and construction supervision for the Project will be required for a period of 62 months from May 1996 to November 2001; pre-construction services for 13 months from May 1996 to May 1997 and construction supervision services for 54 months from June 1997 to November 2001.

(2) Expertize Requirement

The following expertize requirements are proposed for each of the two categories.

Pre-construction Services

	(Expatriate Consultant)	
(a)	Project Manager to assist CRM in pre-qualification, tendering, tender evaluation and coordination with financing organizations.	4 M/M
(b)	Hydromechanical Engineer to assist CRM in tender evaluation of Package 3.	2 M/M
(c)	Electrical Engineer to assist CRM in tender evaluation of Package 3.	1 M/M
(d)	Transmission Line Engineer to assist CRM in tender evaluation of Package 3.	1 M/M
	Sub-total	8 M/M
	(Local Consultant)	
(e)	Contract Specialist to assist CRM in legal matters about contracting.	2 M/M

Total Expertize Input	10 M/M

Construction Supervision Services

(Expatriate Consultant)

(a)	Project Director, representing the consultant and taking responsibility of the contract.	2 M/M
(b)	Project Manager, responsible for management of the consultant's team and for coordination with CRM and financing organizations.	54 M/M
(c)	Civil Engineer-A, responsible for construction supervision of Daule-Peripa ~ La Esperanza transbasin.	40 M/M
(d)	Civil Engineer-B, responsible for construction supervision of La Esperanza ~ Poza Honda transbasin.	30 M/M
(e)	Civil Engineer-C, responsible for construction supervision of Poza Honda ~ Mancha Grande transbasin.	30 M/M
(f)	Civil Engineer-D, responsible for construction supervision of the open channel.	30 M/M
(g)	Civil Engineer-E, responsible for construction supervision of access roads.	22 M/M
(h)	Building/Utility Engineer, responsible for construction supervision of building and utility works of Severino pumping station.	15 M/M
(i)	Hydromechanical Engineer, responsible for hydro-mechanical works.	20 M/M
(j)	Electrical Engineer, responsible for electrical works	12 M/M
(k)	Transmission Line Engineer, responsible for transmission line and substations.	18 M/M
(l)	Geotechnical/Material Engineer, responsible for geotechnical works	25 M/M
	Sub-total	315 M/M

(Local Consultant)

(a)	Civil Engineer-A	40 M/M
(b)	Civil Engineer-B	47 M/M
(c)	Civil Engineer-C	30 M/M
(d)	Civil Engineer-D	30 M/M
(e)	Civil Engineer-E	22 M/M
(f)	Building/Utility Engineer	15 M/M

(g)	Hydromechanical Engineer	20 M/M
(h)	Electrical Engineer	12 M/M
(i)	Transmission Line Engineer	18 M/M
(j)	Geotechnical Engineer	25 M/M
(k)	Soil Mechanical Engineer	48 M/M
(l)	Concrete Engineer	48 M/M
(m)	Topographic Survey Engineer	48 M/M
	Sub-total	403 M/M
	Total Expertize Input	718 M/M

The required expertize inputs are summarized as follows.

Category	Expatriate	Local	Total
Pre-construction	8	2	10
Construction supervision	315	403	718
Total	323	405	728

10.2 Construction Works

The construction works of the Project are proposed to be divided into the following three contract packages and executed by contractors selected by an international competitive bidding including prequalification.

Package 1 : Civilworks for the Daule-Peripa ~ La Esperanza Transbasin including:

Conguillo inlet with valve chamber, Daule-Peripa ~ La Esperanza diversion tunnel, Membrillo outlet, Conguillo work adit, El Guasmo work adit, Membrillo work adit, Conguillo access road, El Guasmo access road, Membrillo outlet access road and CRM's site office and quarters.

Package 2 : Civilworks for the La Esperanza ~ Poza Honda and the Poza Honda~ Mancha Grande Transbasins including:

(La Esperanza ~ Poza Honda Transbasin)
Severino pumping station including building works, Severino penstock, Severino head tank, Severino open channel with inspection road, Caña Dulce inlet, La Esperanza ~ Poza Honda diversion tunnel, Los Cuyuyes outlet, La Seca work adit, Los

Cuyuyes work adit, Severino access road, La Seca access road, Los Cuyuyes access road and CRM's site office and quarters.

(Poza Honda ~ Mancha Grande Transbasin)
Poza Honda inlet with valve chamber, Poza Honda~Mancha Grande diversion tunnel, Mancha Grande outlet and Poza Honda work adit.

Package 3 : Electrical and hycromechanical works including:

(Electrical Works)
Electric motors, switchgears, transformers, supervisory and auxiliary equipment, etc.

(Hydromechanical Works)
Conguillo inlet valves and pipes, Severino pumping equipment and penstock, Poza Honda inlet valves and pipes, etc.

(Power Transmission Line)
138 kV transmission line, Severino substation and Daule-Peripa substation.

10.3 Project Administration

The project administration for the implementation of the Project will be done by a force-account of CRM. The Project Office to be established for the project administration will function as a project owner for any type of decision making and at the same time as a counterpart of the consultants to be employed by CRM to assist CRM in technical and administrative matters for a smooth implementation of the Project. The Project Office is also responsible for necessary training of the selected personnel of CRM for operation and maintenance of the Project facilities.

CRM is ready to appoint key personnel from its professional staff or by contracting with an individual engineers or administrators.

10.4 Land Acquisition and Compensation

In accordance with the Government regulation, CRM will enter into a contract with the National Directorate of Valuation and Cadastre (DINAC) for valuation of land and properties such as houses, trees, crops, etc. to be compensated for the implementation of the Project.

DINAC under the contract will send several experts to the Project site for valuation of land and properties and CRM will pay prices fixed by DINAC to land owners or property owners for compensation. Since DINAC is fully authorized to fix prices for land acquisition and compensation under the Government regulation, nobody can claim against the valuation of DINAC.

11. COST ESTIMATE

11.1 Basic Conditions

The basic conditions and assumptions applied for the cost estimate are presented below:

- The unit prices and rates are based on the current prices for labor, material and equipment as of August 1994.

- The estimated cost is composed of a foreign currency portion expressed in US Dollar and a local currency portion in Ecuadorian Sucre. The total amount is converted into Ecuadorian Sucre and in US Dollar as an equivalent price.

- The exchange rate is employed in consideration of the prevailing exchange rate in August 1994. The exchange rate used in this cost estimate is as follows:

  US $ 1.0 = Yen 100 = S/.2,250 (1 Yen = S/.22.5)

- The work quantities are calculated from the detailed design drawings and the technical specifications of the tender documents.

- The construction works will be carried out by contractors selected through an international competitive bidding in accordance with a guideline of the financial institution.

11.2 Constitution of Construction Cost

The construction cost consists of a direct cost and an indirect cost. The direct construction cost is estimated based on the work items and quantities derived from the detailed design. This cost includes the labor cost, material cost, equipment cost and contractor's indirect cost such as overhead and profit.

(1) Direct Construction Cost

- Package 1: Civil Works for Daule-Peripa~La Esperanza Transbasin

- Package 2: Civil Works for La Esperanza~Poza Honda Transbasin and Poza Honda~Mancha Grande Transbasin.

- Package 3: Electrical and Mechanical Works for Daule-Peripa ~ La Esperanza, La Esperanza ~ Poza Honda and Poza Honda ~ Mancha Grande Transbasin.

(2) Indirect Cost

- Land acquisition and compensation
- Administration expenses
- Engineering services
- Physical contingency
- Price escalation

11.3 Direct Construction Cost

(1) General Items

The cost for general items includes the cost for temporary buildings, water supply system, power supply system, telecommunication system, construction road and maintenance, laboratory equipment, exploratory borings, monument and memorial, camps for CRM and Supervision, office furnitures for CRM, first aid facilities, and vehicles for CRM and Supervision.

(2) Civil Works

The costs of civil works for Package 1 and Package 2 are estimated based on work quantities and unit rates which include labor cost, material cost, equipment cost and contractor's overhead expenses and profits.

(3) Electrical and Mechanical Works

The prices for main pumps, valves, motors, transformers, switchgears, 13.8 kV distribution lines, 138 kV transmission lines, trashracks, gates, discharge penstocks, etc. in the Package 3 are estimated on the basis of the recent international contract prices of similar equipment units. The cost of imported equipment and materials is estimated at CIF price at Guayaquil in foreign currency portion.

11.4 Indirect Cost

(1) Land Acquisition and Compensation

All required land acquisition and compensation shall be carried out by the CRM along the project implementation schedule. Those costs include the costs required for the acquisition of construction areas, transmission line routes, road alignment and the temporary land area.

(2) Administration Expenses

The administration expenses of CRM for project implementation are estimated to be 2% of the direct construction cost and allocated to the local currency portion.

(3) Engineering Services

The cost for engineering services is estimated based on the assumed man-month of foreign and local consultants to be employed during the implementation of the project. The assumed man-month is to be 323 M/M for foreign and 405 M/M for local consultants.

(4) Contingencies

Contingencies are provided to cope with unforeseen physical condition (physical contingency) and inflation (price contingency). The physical contingency is taken to be 10% of a sum of the Package 1 and Package 2 construction costs, land acquisition and compensation. The rate of 5% for administration expenses and engineering services is applied. As for the Package 3 work, 3% is to be applied for the physical contingency. The price contingency is estimated applying annual inflation rate of 3% for foreign currency portion. For local currency portion, actual annual inflation rate in recent years is more than 40% and it is almost impossible to predict future inflation rate of Ecuadorian Sucre. Therefore, the price contingency for the local currency portion is estimated by converting the local currency portion into US Dollars and applying the same inflation rate of 3% per annum in terms of US Dollars.

11.5 Construction Cost

The construction cost is estimated to be US$ 151.2 million in foreign currency portion and S/. 120.6 billion in local currency portion, totaling US$ 204.8 million equivalent, as smmarized in Table 11.1.

11.6 Annual Disbursement Schedule

The annual disbursement is estimated according to the construction schedule and summarized as follows. The disbursement schedule of the construction cost is tabulated in Table 11.2.

(US$ million)

	Foreign Currency	Local Currency	Total
1996	-	0.14	0.14
1997	27.43	14.48	41.91
1998	35.59	15.30	50.89
1999	30.27	14.13	44.40
2000	39.66	12.47	52.13
2001	10.59	4.75	15.34
Total	143.55	61.27	204.81

11.7 Operation and Maintenance Cost

The operation and maintenance cost of the Project is estimated as follows.

(US$ million)

Year	Energy Cost	O&M Cost except Energy Cost	Total O& M Cost
2002	1.55	0.82	2.37
2010	1.93	0.82	2.75
2015	2.28	0.82	3.10
2020	2.69	0.82	3.51

12. FINANCING PLAN

12.1 General Approach

The Project consists of three transbasin schemes, more or less independent one another. CRM intends to construct the Daule-Peripa~La Esperanza Transbasin first, utilizing the funds from CAF (Corporación Andina de Fomento), the Government fund and supplier's credit proposed by a tenderer.

The contract for construction of the abovementioned transbasin will be awarded in 1995 after an international competitive bidding with financing.

For the construction of the remaining two transbasins, CRM intends to apply for a soft loan to the Japanese government.

12.2 Financing Requirement for the Remaining Two Transbasins

The remaining two transbasins will be constructed under Package 2 for civilworks of the La Esperanza ~ Poza Honda, Poza Honda ~ Mancha Grande Transbasins and under Package 3 for electro-mechanical works including power transmission line. The Package 1 for civilworks of the Daule-Peripa ~ La Esperanza Transbasin, on the other hand, will be constructed under a separate financial arrangement as stated in 12.1 herein.

The total fund requirement for the construction of the remaining two transbasins is estimated to be US$145.16 million equivalent, consisting of a foreign currency portion of US$103.52 million and a local currency portion of US$41.64 million equivalent, as summarized below.

(Unit: US$ million)

	F.C.	L.C.	Total
1. Package 2	52.30	27.47	79.77
2. Package 3	25.05	2.64	27.69
Total 1 & 2 (Direct construction cost)	77.35	30.11	107.46
3. Land acquisition and compensation	-	0.19	0.19
4. Administration expenses	-	2.15	2.15
5. Engineering services	7.28	1.03	8.31
Total 3 to 5 (Indirect cost)	7.28	3.37	10.65
Total 1 to 5 (Base cost)	84.63	33.48	118.11
6. Price contingency	6.35	3.00	9.35
Total 1 to 6	90.98	36.48	127.46
7. Physical contingency	12.54	5.16	17.70
Grand Total 1 to 7	103.52	41.64	145.16

It is assumed that the OECF loan will cover 75% of the total project cost including interest during construction (IDC) with the loan terms of 3.0% in an annual interest rate and

30 years in repayment period including a grace period of 10 years, based on the OECF Guideline.

IDC may be calculated from the annual disbursement schedule as shown below.

Calculation of Interest During Construction

Year	1	2	3	4	5	Total
(1) Annual Disbursement of OECF Loan [1/]	19,441	30,148	19,877	31,220	8,181	108,867
(2) Total Disbursement as of Previous Year	-	20,024	51,677	73,701	108,069	
(3) Total Disbursement as of This Year [2/]	19,441	50,172	71,554	104,921	116,250	
(4) IDC for This Year [3/]	583	1,505	2,147	3,148	3,488	10,871
(5) Total Disbursement as of end This Year [4/]	20,024	51,677	73,701	108,069	119,738	

1/ : Assumed to be 75% of the total disbursement
2/ : (3) = (1) + (2)
3/ : (4) = (3) x 3.0%
4/ : (5) = (3) + (4) = (2) of next year

Then, the total project cost including IDC will be US$156.03 million equivalent, a sum of the foreign currency portion of US$114.38 million and the local currency portion of US$41.64 million equivalent. The total amount of the OECF loan will be US$117.02 mllion equivalent, as explained below.

US$156.03 million x 75% = US$ 117.02 million

The amount of the OECF loan will be utilized to cover the total foreign currency requirement of US$103.52 million equivalent, the total amount of IDC of US$10.87 million equivalent and a part of the local currency portion of US$2.63 million equivalent, totaling US$117.02 million as the total amount of the OECF loan.

The amount of US$39.01 million equivalent to cover the remaining local currency portion will be arranged by CRM and the Government of Ecuador.

13. PROJECT JUSTIFICATION

13.1 Economic Feasibility

13.1.1 Economic benefit of the project

(1) Definition of project benefit

In the water balance study, all the water to be supplied from the Daule-Peripa diversion, the La Esperanza dam, the La Esperanza~Poza Honda transbasin scheme, the Poza Honda dam and the Poza Honda ~ Mancha Grande transbasin scheme was compared with all the water demands for water supply, irrigation water, shrimp farming and river maintenance flows in the Chone and Portoviejo river basins as an integrated water supply scheme.

In order to quantify the benefit of the project consisting of three transbasin schemes and not including the La Esperanza dam nor the Poza Honda dam, it is necessary to define the benefit of the La Esperanza dam only and that of the Poza Honda dam only, and to define the benefit of the project as a balance of the total benefit of the integrated scheme and the benefits of the two dams.

The Poza Honda dam is capable of supplying 45 MCM/year for the Poza Honda Water Supply System which can meet the demand up to 1994, irrigation water of 25 MCM/year for 1,100 ha of the Santa Ana irrigation system and the river maintenance flow of 8 MCM/year.

The La Esperanza dam, on the other hand, is capable of supplying 40 MCM/year for the Chone-La Estancilla Water Supply System which can meet the demand up to 2017, irrigation water of 253 MCM/year for 15,000 ha of the Carrizal-Chone irrigation system and the river maintenance flow of 16 MCM/year.

The benefit of the project will be calculated by deducting the above stated benefits of the Poza Honda dam and the La Esperanza dam from the total water supply benefit to the Chone and Portoviejo river basins.

(2) Water supply benefit

Demand for water supply is shown in Table 13.1. The quantity of water supply by the project increases from 14.6 MCM/year in 2000 to 106.8 MCM/year in 2020 and is kept constant at 106.8 MCM/year afterward.

Unit economic value of water supply is difficult to be determined. A range of US$ 0.3/m^3 to US$ 0.5/m^3 is assumed as a unit economic value as one of the sensitivity tests on economic evaluation of the project.

(3) Irrigation benefit

The irrigation benefit of the project is calculated to be US$ 7.8 million/year in its maturity as shown in Table 13.2.

In the Portoviejo river basin where the irrigation benefit of the project is expected, farmers are more or less familiar with irrigated farming and the irrigation systems have already been provided in large areas though they have not been utilized in their full extent because of water shortage. Therefore, 64% of the total benefit in the first year, 80% of the total benefit in the second year and 100% of the total benefit from the third year are assumed.

(4) Shrimp farming benefit

The shrimp farming benefit of the project is calculated to be US$ 7.3 million/year in its maturity as shown in Table 13.3.

Shrimp farming in the project area is generally practiced in a scientific manner by large and medium enterprises. As far as beneficial to the shrimp farmers, they are assumed to willingly use fresh water with charge though they are not accustomed to apply fresh water. In this case, 50 % of the benefit is assumed to be generated in the first year, 75% in the second year and 100% from the third year.

13.1.2 Economic cost of the project

Conversion from financial cost to economic cost has been made in the following manners:

- Price inflation effect was not considered in the economic cost.

- Financial cost in foreign currency portion is estimated based on international prices at the border and, therefore, coincides with the economic cost.

- Labor cost and fuel cost in the local currency portion is converted to the economic cost by using conversion factors. Exchange rate of the local currency is changing day by day in the open money market and no shadow exchange rate exists.

- Shadow wage rate in the project area is assumed to be 70% based on the actual unemployment ratio of about 30%. Fuel cost in Ecuador is almost the same as the international price. Tax portion in the local procurement is about 10%.

- Out of the local currency portion, labor cost is assumed to be 30%. Then the conversion factor of the local currency portion is calculated to be 0.82.

13.1.3 Economic internal rate of return

Benefit and cost streams are prepared as shown in Table 13.4.

The economic internal rates of return (EIRR) were calculated for various unit water values for potable water supply as shown below.

Unit Raw Water Value (US$/m^3	Economic Internal Rate of Return (%)
0.3	11.4
0.4	12.8
0.5	13.9

The water unit cost of the existing water supply system is estimated to be about US$ 0.4/m^3 without counting the raw water cost, which may be compared with the assumed unit raw water values.

13.2 Financial Feasibility

13.2.1 Financial benefit of the project

(1) Water supply benefit

The current water tariff of CRM as of September 1994 is as follows. CRM has gradually increased the tariff in the past and will continue to increase the water tariff until it reaches a self-sufficient level.

Water Use per Customer (m^3/month)	Water Tariff (S/. per m^3)		
	Domestic	Commercial	Industrial
0 - 10	194	289	-
11 - 20	227	337	-
21 - 30	259	385	-
31 - 50	324	481	-
51 - 70	389	577	-
71 - 100	454	673	-
101 - 150	551	818	-
151 - 200	648	962	-
more than 201	810	1,203	-
0 - 40	-	-	1,374
41 - 100	-	-	1,511
101 - 150	-	-	1,786
151 - 250	-	-	2,061
251 - 350	-	-	2,336
351 - 500	-	-	2,748
501 - 700	-	-	3,160
701 - 1000	-	-	3,572
more than 1001	-	-	4,122

(Note) Exchange rate in September 1994: US$ 1.00 = S/.2,250

The average tariff is about US$ 0.29/m^3 which is still less than the current water production cost of US$ 0.39/m^3.

For the financial evaluation of the project, unit raw water price is assumed ranging from US$ 0.15/m^3 to US$ 0.25/m^3 as one of the sensibility tests for financial feasibility.

(2) Irrigation benefit

Irrigation water charge of CRM is currently S/.5,000/time/ha, which is equivalent to S/.5.0/m^3. This water charge, even if it was raised considerably, is still small.

If all the irrigation water supply benefit is charged to farmers, no benefit remains for farmers and they will lose their incentive for irrigated farming. It is assumed here that the irrigation benefit will be equally shared by the farmers and CRM. Then the irrigation water charge will be S/.33,190/time/ha, more than 6 times of the current water charge.

Average irrigation benefit	:	US$ 591/ha (US$ 7,772,000/13,150 ha, Refer to Table 13.2)
Assumed water charge	:	US$ 295/ha (0.5 x US$ 591/ha)
Times of irrigation	:	20 times/two crops in average a year
Water charge	:	US$14.8/time/ha (S/.33,190/time/ha) = US$ 0.015/m^3

(3) Shrimp farming benefit

The same philosophy as for the irrigation water charge is applied to the fresh water charge for shrimp farming. The water charge will be US$ 0.035/m^3 as explained below.

Average irrigation benefit	:	US$ 0.071/m^3 (US$ 7,271,000/102.6 MCM, Refer to Table 13.3)
Assumed water charge	:	US$ 0.035/m^3 (0.5 x US$ 0.071/m^3)

13.2.2 Financial internal rate of return

Financial benefit and cost streams are prepared as shown in Table 13.5.

The financial internal rates of return (FIRR) were calculated as follows for various raw water values for potable water supply.

Unit Raw Water Value (US$/$m^3$)	Financial Internal Rate of Return (%)
0.15	9.3
0.20	10.6
0.25	11.6

These FIRR may be compared with the current worldwide interest rate of loan of about 5%. It is, however, considered difficult to increase water tariff or water charges as discussed herein from the social point of view. It is absolutely necessary to introduce soft loans for the implementation of the project.

13.3 Socio-economic Impact of the Project

13.3.1 Socio-economic impact during construction of the Project

Local labor requirement will be about 36,000 M/M during the 4.5 year construction period, which means about 700 people will be hired at an average wage rate of about US$ 500/month. The total local labor cost will be in the order of US$ 18 million, which corresponds to about 30 % of the local currency component of the Project cost. About 700 people to meet the local labor requirement will be easily procured from local communities without much adverse impact on local socio-economy.

The local currency component of the Project cost is in the order of US$ 60 million including the local labor cost, locally procured material cost, cost of consumable such as fuels, etc. which is equivalent to two to three percent of the Regional Domestic Product of the Project area. In consideration of the linkage effect, annual expenditure of US$ 15 million equivalent will enhance local economy to a considerable extent.

13.3.2 Impacts on local commercial activities

The benefit cost analysis discussed in this Chapter is based on the farm gate prices of the agricultural and aquacultural products. These products should be marketed through local commercial channels. The enhanced commercial activities will activate local economy, offering more job opportunities to local people.

13.3.3 Industrial development

The belt zone along the highway Portoviejo to Manta via Montecristi has a great potential for industrial development if only water supply is ensured by the Project. The zone is favoured by abundant material and labor supply with transportation facilities such as the Manta international sea port, domestic airports at Portoviejo and Manta, and super highways from the zone to Quito and Guayaquil.

The zone is actually developed for industry with constraint of limited water supply. Once water supply is secured by the Project, the Portoviejo-Manta belt zone will be remarkably developed for not only agriculture-based industry such as food processing industry, textile industry, fertilizers, agrochemicals and farm machineries, but also other industries such as car manufacturing.

13.3.4 Improvement of sanitary condition

Expansion and improvement of potable water supply system with secured raw water sources will greatly contribute to the local people in sanitary conditions. It is prerequisite for a socio-economic development of the Project area for the local people to be able to access safe piped water. CRM, as stated in Chapter 8 herein, will at the same time improve the sewerage system with sewage treatment in large cities such as Portoviejo, Manta, Chone, etc.

13.3.5 Eco-tourism development

Current tourism centers of the Project area are coastal areas between Manta and Bahia de Caraquez. Eco-tourism will be developed in the estuary of the Chone river and forestal zones around the Poza Honda and La Esperanza reservoirs, which are carefully protected in their environmental values under the proposed EMMP.

The access roads to be constructed under the Project will contribute to enhance economy of communities in remote areas as well as to promote eco-tourism around the reservoirs.