1- Short term strategy: Physical isolation of an area adjacent to the inlet, to avoid masses of plants to access the tunnel while operating it in the immediate future, as illustrated in the design works for the Daule-Peripa ~La Esperanza tunnel inlet .

2- Medium term strategy: Mechanic and Hydraulic Control and coordinate with what CEDEGE is currently carrying out at the Daule-Peripa reservoir and which objetive will consist in decreasing the excesive growth of water hyacinth, to:

1. To prevent the hampering of boats for navigation
2. To prevent the creation of substrate for disease vectors
3. To lower the pollution load by organic matter into the water body that could increase the eutophication problem
4. To avoid the excess in evapotranspiration from the water surface
5. To decrease the risk of physical deterioration of the dam works

2.5.2 Severino pumping station

To avoid excessive and continuos noise generated by the pumping station setup, it is advisable to use noise insulation material on the walls and roof of the enclosing structure of the pumping station. This will reduce the disturbing noise for adjacent dwellers.

To avoid possible accidents at the suction pipes of the pumping station it is advisable to fence out the entrance of the suction pipe and allocate preventive signs, to avoid people swimming in the vicinity, specially children.

2.5.3 Severino open channel

To avoid animals and people approaching or installing themselves in the margins of the open channel, it is suggested that a buffer area of 10 m on each side of the channel be established, and fenced out with galvanized mesh along the total length of the channel. Access bridges have to be defined in order to allow animal and human transit from one margin to the other, in areas were access roads are to be reached, or were existing farms are dissected by the channel.

In areas adjacent to steep slopes, erosion barriers are to be implemented, to avoid having the channel act as a sediment trap.

To avoid erosion of the side slopes, a berm should be left on it in the channel route as when building a road. Recommendations to avoid slides reported for the access roads should be followed also for the open channel route.

2.5.4 La Esperanza-Poza Honda diversion tunnel

Some of the measures to consider when allocating spoil banks are the following:

- Spoil banks should not be allocated in stream gulches, rivulets or esteros, since the material disposed could block the natural water flow during the rainy season.

- Spoil banks should not be allocated in areas covered by natural vegetation, since these are scarce in the area and will eventually serve as natural seed banks for reforestation.

- Spoil banks in the best case should appreciate the land value by filling ditches and leveling the landscape, i.e. making it suitable for housing construction or other purposes.

- Spoil banks should not interfere with the landscape, and should be recovered with a layer of soil for the existing vegetation to emerge during the rainy season.

- Spoil banks should be located away from existing villages and houses, to avoid disturbance of the population with dust and noise from the continuos truck traffic.

- Spoil banks should be allocated as close as possible from the extraction point, to reduce the use of access roads and the possibility of accidents.

- Material to be disposed of should not be deposited in running rivers or next to roads or access roads.

2.5.5 Poza Honda-Mancha Grande diversion tunnel

Expropriation of an area of the adjacent cacao plantation becomes necessary for the installment of the inlet portal at Poza Honda reservoir. The existing farm is between the access road and the portal site, access to the portal will also require trespassing the existing farm.

2.5.6 Daule-Peripa ~Severino transmission line

To avoid people accessing the transmission line towers, it is recommended that a 5 m buffer area is left around the perimeter of the tower, and that this area be fenced with galvanized mesh. Proper signs alerting the danger of accessing the towers should be placed on visible places at the tower site.

The route of the transmission line must avoid to pass through the ecological reserve of CEDEGE.

2.5.7 Access roads

(1) General Considerations

The following measures and suggestions are applicable to all roads to be improved and/or constructed with the project.

To avoid erosion in steep slopes it is advisable to implement control mechanisms such as:

- Proper drainage along the sides of the road.
- Energy dissipators to reduce the drainage flow velocity along the slope.
- Cut slopes should have proper inclinations to avoid land slides.
- Adequate road pavement should be applied, specially in areas of steep gradient.
- The road should have side slopes to favor surface runoff.
- When adjacent hills have pronounced slopes, terracing of the slope is recommended.
- Maximizing the use of excavated material in the cuts (cut & fill) will diminish the volume of disposable material and the need for spoil banks.

For the adequate crossing of gulches, rivulets and esteros, a sound engineering structure like bridge or aqueduct should allow the natural flow of the stream in the rainy season, erosion control structures like aprons along the sides of the bridge or aqueduct base in the river margin are advisable to avoid erosion of the foundation.

(2) Specific Considerations

(i) Los Cuyuyes Access Road

To avoid accidents in the existing population linearly oriented along the existing road, the following actions are recommended:

- Traffic signs must be allocated along the road alerting of the expected heavy traffic, curves, speed reduction, school, etc.

- Traffic education workshop through the existing schools allocated in the right bank of Poza Honda reservoir. The local teachers should be instructed to alert the student population of the new traffic conditions expected with the project actions.

- To regulate the possible new colonization of settlers, when the new road is in operation, the implementation of the environmental management plan for the adjacent areas of Poza Honda reservoir is required. Since it is impossible to prohibit new colonization, the eventual new colonization must comply with the environmental management plans to avoid further deterioration of the area.

An environmental management plan is outlined further in this report.

Erosion control mechanisms at the road elevation are particularly important in this road, since it is located at an elevation where the steep slopes and the runoff from them reaches the road before reaching the reservoir, for this reason, the existing road location acts as an erosion barrier for the reservoir.

(ii) Conguillo Access Road

This route is considered the most adequate from the environmental point of view, since the route transect the least pronounced slopes, and the road does not pass directly through the community of Membrillo. It is non the less advisable to alert traffic with traffic signs allocated in the vicinity of Membrillo, pronounced curves etc., since a heavy traffic of vehicles related to the project, and to the extraction of local produce is expected in this area.

(iii) La Seca Access Road

An adequate access road route should be considered for this Access road.

3. WATER QUALITY ANALYSIS AND PREDICTION

3.1 Introduction

The objective of the Chone-Portoviejo transbasin project is to divert water from Daule-Peripa reservoir to La Esperanza reservoir, and provide water for the downstream area of Chone and Carrizal rivers for municipal, agricultural, and aquaculture purposes. Water transbasin is also expected to the Poza Honda reservoir, which in turn will provide water to the Portoviejo and Chico rivers for municipal and agriculture purposes.

For these reasons, water quality prediction at La Esperanza, Poza Honda and the downstream areas is important.

3.2 Water Quality Sampling

Water sampling was carried out in 17 predetermined stations throughout the project area as shown in Figure 3.1. Sampling was carried out during the dry season (November 18-December 3, 1993, May 30 - June 13 and August 15-29, 1994) and during the rainy season (January 10-28, 1994), results are summarized on Tables 3.1. Twenty six (26) physical-chemical parameters were evaluated in each station, and results in BOD, COD, T-N, and T-P were used in the polution load analysis. Although no mayor industries as point source pollution are present in the area, tests on heavy metals were also made.

3.3 Water Quality in the Reservoirs

3.3.1 Concept

The water quality of the Daule-Peripa reservoir will determine the water quality conditions at La Esperanza reservoir, together with the water quality of the inflow to the reservoir.

The water quality of la Esperanza reservoir (C2) will be estimated by the following equation:

$$C2=(L0 + L1)/(Q0 + Q1)=(Q0 \times C0 + Q1 \times C1)/(Q0 + Q1)$$

where:

C2 = water quality at La Esperanza reservoir

L0 = load from Daule-Peripa reservoir

Q0 = volume from Daule-Peripa reservoir

C0 = quality of diverted water

L1 = annual load to la Esperanza reservoir from its own basin

Q1 = annual inflow to La Esperanza reservoir from its own basin

C1 = quality of own basin flow to La Esperanza

For Poza Honda reservoir, water quality is calculated by the same method, in this case L0, Q0, and C0 must be the La Esperanza reservoir's. The suitability of Daule-Peripa, La Esperanza, and Poza Honda water for irrigation, source of raw water for treatment plant and domestic uses is further evaluated in section 3.3.4.

3.3.2 Prediction

By using the above mentioned equation and the existing water quality data in Daule-Peripa, La Esperanza, and Poza Honda as shown in Table 3.1, the future water quality is predicted, and the results are shown in Table 3.2.

The future water quality at La Esperanza would be better than those of Daule-Peripa in BOD and COD, but worse in T-N, and T-P.

In Poza Honda reservoir the water quality basically remain same except for COD. No significant impact is expected from the COD increment in 1.58 mg/l.

3.3.3 Possibility of eutrophication of the reservoirs

The past, present and future water quality condition at Poza Honda is evaluated using the information available (1981-1994), and the Program for Warm Tropical Lakes (LACAT) developed by the Panamerican Center for Sanitary Engineering and the Environment (CEPIS) and using the concept of multiple regression for total phosphorus:

$$[T\text{-}P] = 0.290\ L(p)^{0.891}\ T_w^{0.676}/Z^{0.934}$$

where,

[T-P] = total phosphorus (mg/l) for assessment of trophic condition
L(p) = annual phosphorus surface load (g/m^2/year)= L/A
T_w = retention time (years) = V/Q
Z = reservoir depth in (m) = V/A
L = annual inflow of phosphorus load (t/year) = Q•P

Q	=	annual inflow of water (MCM/year)
P	=	phosphorus concentration of inflow water (mg/l)
A	=	surface area of reservoir (km^2)
V	=	total storage volume of reservoir (MCM)

Additionally, the CEPIS formula for tropical lakes was used in this study (Salas & Limón, 1985)

$$P(f) = \left(\frac{L(p)}{Z}\right)\left(\frac{Tw^{3/4}}{3}\right)$$

where,

P(f) = Resulting phosphorous concentration, in g/m^3

Eutrophication ranges for both cases are:

Trophic level	[T-P] (mg/l) or P(f) (g/m^3)
Oligotrophic	≤0.01
Mesotrophic	0.01 - 0.03
Eutrophic	0.03 - 0.1
Hipereutrophic	≥0.1

The trophic condition of the Poza Honda reservoir is assessed by the abovementioned procedure as follows:

Trophic Condition of Poza Honda Reservoir

Year	[T-P] (mg/l)	P(f) (g/m³)	Most probable trophic condition	Reference of input data
1981	0.218	0.41	Hipereutrophic	Vásconez
1982	0.278	0.39	Hipereutrophic	Vásconez
1987	0.078	0.066	Eutrophic	PHIMA-OEA
1992	0.048	0.052	Eutrophic	CRM-JICA
1994	0.06	0.065	Eutrophic	JICA
Future estimated	0.070	0.082	Eutrophic	JICA

The trophic study PHIMA/OEA detected that by 1983 the major factors affecting eutrophication were the agricultural and cattle raising practices accounting for 74% of the phosphorus load, and the watershed deforestation and pronounced slopes favoring erosion, sedimentation process, and the consequent nutrient leaching into the reservoir. The eutrophic condition will become serious in the future unless an efficient program for prevention of water quality deterioration is implemented together with the conservation of the areas adjacent to the reservoir.

Water quality at La Esperanza is also evaluated by the same procedure and its trophic condition is assessed as follows:

Trophic Condition of La Esperanza Reservoir

Year	[T-P] (mg/l)	P(f) (g/m³)	Most probable trophic condition	Reference of input data
1992	0.061	0.069	Eutrophic	CRM/JICA
1994	0.063	0.068	Eutrophic	JICA
Future estimated	0.066	0.072	Eutrophic	JICA

No drastic changes in the trophic condition of La Esperanza reservoir are expected if the plant biomass existing in the impoundment area is removed before inundation, and if the environmental management plan is implemented as a long term control measure. In Figures 3.2 it can be observed the eutrophic condition shown by the reservoirs during the considered years.

3.3.4 Suitability of the reservoirs water for various uses

The following table shows the different water quality parameters, updated, in Daule-Peripa, La Esperanza and Poza Honda reservoirs.

Existing Water Quality Parameters in the Reservoirs

Parameter	Unit	Daule Peripa	La Esperanza	Poza Honda
Total Coliforms	MPN/100 ml	2,400	2,400	144
Fecal Coliforms	MPN/100 ml	+	+	+
BOD	mg/l	13.95	8.53	10.56
Dissolved Oxygen	mg/l	1.86	6.98	5.85
PH	unit	7.43	7.40	7.65
Chlorides	mg/l	19.17	21.67	17.33
Fluorides	mg/l	0.0	0.0	0.0
Color	units	5.00	10.80	6.67
Turbidity	units	12.33	31.67	11.67
Tot. dis. solid.	mg/l	107.60	228.97	211.19
Total hardness	mg/l	71.33	177.83	111.50
Borum Total	mg/	-	-	-
Manganese Total	mg/l	0.0	0.0	0.0
Iron as Fe	mg/l	0.54	0.38	0.24
Sodium	mg/l	11.30	32.83	23.50
Sulphate	mg/l	0.0	29.00	14.33
Nitrate	mg/l	1.02	1.25	1.19
Cadmium	mg/l	0.0	0.0	0.0
Calcium	mg/l	14.38	46.17	28.67
Potasium	mg/l	0.0	0.66	2.00
Magnesium	mg/l	8.82	15.50	8.00
Conductivity	Umohs/cm	149.50	516.66	335.37

The following basic parameters established by the Oficial Register of june 5, 1989, has been summarized as a reference to assess the water quality of the reservoirs for various uses. The main uses established for this project are potable water and irrigation water.

Summary of raw water quality parameters for various uses

1) Human consumption and domestic (need conventional treatment)

PARAMETER	EXPRESSED AS	UNIT	MAXIMUM ALLOWABLE
Temperature		°C	Natural condition ± 3°C
Hidrogen potential	pH		6 - 9
Dissolved Oxygen	D.O.	mg/l	80% of saturation oxygen,non less than 6mg/l
Biochemical Oxygen	B.O.D.	mg/l	10% DBO5 allowable and 2 mg/l as Demand maximum
Coliforms	MPN/100cm^3	Coll. Tot.	3,000
		Coll.Fecal	600
Oil and Greases	visible film		Negative
Dissolved Solids		mg/l	1,000
Turbidity		UTF	100
Color	Real-Color	Unidades de color	100
Odor and flavor			Odor and flavor that can be removed by conventional methods only allowed
Floating matter			Negative
Ammonia	$N-NH_3$	mg/l	1.0
Arsenic	As	mg/l	0.05
Barium	Ba	mg/l	1.0
Cadmium	Cd	mg/l	0.01
Hardness		mg/l	450
Cianide	CN^-	mg/l	0.2
Zinc	Zn	mg/l	5.0
Chlorides	Cl	mg/l	250.0
Copper	Cu	mg/l	1.0
Phenolic compounds	Phenol	mg/l	0.002
Chromium	Cr^{+6}	mg/l	0.05
Difenil Polichlorides	Concentratión of active agent		Non detectable
Mercury	Hg	mg/l	0.002
Nitrates	N-nitrates	mg/l	10.00
Nitrites	N-nitrites	mg/l	1.0
Silver	Ag	mg/l	0.05
Lead	Pb	mg/l	0.05
Selenium	Se	mg/l	0.01
Sulphates	$(SO_4)^{-2}$	mg/l	400.0
Tensoactives	Active sustances to blue of Methylene	mg/l	0.5

2) For human consumption and domestic, (only disinfection needed)

PARAMETER	EXPRESSED AS	UNIT	MAXIMUM ALLOWABLE
Temperature		°C	Natural condition ± 3°C
Hidrogen potential	pH		6 - 9
Dissolved Oxygen	D.O.	mg/l	80% of oxygen of saturation and not less than 6 mg/l
Biochemical Oxygen	B.O.D.	mg/l	10% BOD5 allowable and
Demand			maximum 2 mg/l of Oxygen
Coliforms	MPN/100cm^3	Coll. Tot.	100
		Coll.Fecal	20
Oil and Greases	Visible film		Negative
Dissolved solids		mg/l	1,000
Turbidity		UTF	10
Color	Color Real	Color units	20
Odor and flavor			Negative
Floating matter			Negative
Ammonia	$N-NH_3$	mg/l	1.0
Arsenic	As	mg/l	0.05
Barium	Ba	mg/l	1.0
Cadmium	Cd	mg/l	0.01
Cianide	CN^-	mg/l	0.2
Zinc	Zn	mg/l	5.0
Chlorides	Cl	mg/l	250.0
Copper	Cu	mg/l	1.0
Phenolic compounds	Phenol	mg/l	0.002
Chromium	Cr^{+6}	mg/l	0.05
Difenil Policlorates	Concentration of		
	active agent		Non detectable
Mercury	Hg	mg/l	0.002
Nitrates	N-nitrates	mg/l	10.00
Nitrites	N-nitrites	mg/l	1.0
Silver	Ag	mg/l	0.05
Lead	Pb	mg/l	0.05
Selenium	Se	mg/l	0.01
Sulphates	$(SO_4)^{-2}$	mg/l	400.0
Tensoactives	Active substances to the		
	Methylene blue	mg/l	0.5
Hardness		mg/l	450

3) For irrigation purposes

PARAMETER	EXPRESSED AS	UNIT	MAXIMUM ALLOWABLE
Aluminum	Al	mg/l	5.0
Arsenic	As	mg/l	0.1
Berilium	Be	mg/l	0.1
Borum	B	mg/l	1.0
Cadmium	Cd	mg/l	0.01
Zinc	Zn	mg/l	2.00
Cobalt	Co	mg/l	0.05
Copper	Cu	mg/l	2.00
		mg/l	0.2
Chromium	Cr^{+6}	mg/l	0.1
Fluor	F	mg/l	1.0
Iron	Fe	mg/l	5.0
Litium	Li	mg/l	2.5
Manganese	Mn	mg/l	0.2
Molibdenum	Mo	mg/l	0.01
Niquel	Ni	mg/l	0.2
Hidrogen potential	pH		6 - 9
Lead	Pb	mg/l	0.05
Selenium	Se	mg/l	0.02
Vanadium	V	mg/l	0.1
Colliforms bacterias	MPN/100 cm^3	Coll. total	1,000
Parasite eggs			Negative
Oil, greases	Visible film		Negative
Floating matter			Negative

Apart from the above referred parameters, the following will be used for the interpretation of the water quality for irrigation uses.

	RESTRICTION DEGREE			
POTENTIAL PROBLEM	UNITS	None	Low-Moderate	Severe
Salinity: (1)				
CE (2)	Milimhos/cm	<0.7	0.7 - 3	> 3.0
SDT (3)	mg/l	<450	450 - 2,000	>2,000
Infiltration: (4)				
RAS = 0 - 3 y CE =		<0.7	0.2 - 0.7	>0.7
3 - 6 =		<1.2	0.3 - 1.2	>1.2
6-12 =		<1.9	0.5 - 1.9	>1.9
12-20 =		<2.9	1.3 - 2.9	>2.9
20-40 =		<5.0	2.9 - 5.0	>5.0
Toxicity per specific ion (5)				
Sodium, RAS(6)				
Surface irrigation	meq/l	3.0	3 - 9	>9
Sprinkling	meq/l	3.0	3	
Chlorides				
Surface irrigation	meq/l	4.0	4 - 10	>10
Sprinkling	meq/l	3.0	3	
Borum	mg/l	0.7	0.7 - 3.0	>3
Miscelaneous effects (7)				
Nitrogen (N-NO3-)	mg/l	5	5 30	>30
Bicarbonate (HCO3-)	meq/l	1.5	1.5 - 8.5	>8.5
pH	normal range	6.5 - 8.4		

(1) Affecting the water availability for cropping.

(2) Irrigation water conductivity

(3) milimhos/cm = 1,000 micromhos/cm

(3) Total dissolved solids

(4) Affecting the water infiltration rate in the soil

(5) Afecting the soils sensibility

(6) RAS, adjusted sodium absortion rate

(7) Affecting susceptible crops

Except for BOD in all reservoirs, and DO in the Daule-Peripa reservoir, the parameters show a good suitability of water as source of raw water for treatment plants. Low values of DO of Daule-Peripa at the site of the Conguillo inlet are related to the massive infestation of aquatic plant (Eichornia sp.).

According to the analysis effectuated by CEDEGE in June 2 of 1993, heavy metals were found in the Conguillo river at its confluence with the Daule river, although the water quality sampling effectuated by JICA in august of 1994 didn't find the prescence of heavy metal in the Conguillo river at the site of the inlet portal of the Project, that is 20 km upstream the sampling site of CEDEGE. The following table summarizes those data:

Total Heavy Metals (mg/l)	Sampling site				
	JICA			CEDEGE	
	Conguillo Inlet at Daule Peripa			June/93	
	Ag. 15/94	Ag. 22/94	Ag. 29/94	Surface	Bottom
Copper	ND	ND	ND	0.06	0.2
Lead	ND	ND	ND	ND	ND
Zinc	ND	ND	ND	0.4	0.2

ND: Non detected

According to the previous table, there can be confirmed the non existense of heavy metals in the Daule-Peripa reservoir in the water intake site of the Project (Conguillo inlet), whereas downstream this site according to CEDEGE, there is a little presence of heavy metals, below the allowed limits, which possibly are carried by the Peripa river, an important affluent of the reservoir.

No heavy metals were detected in the La Esperanza, and Poza Honda reservoirs, in accordance to the water quality sampling conducted by JICA in June and August of 1994.

Values of Nitrates, Fluorides, Magnesium, and Sodium are within the maximum allowable limits for the raw water.

Although the total coliform count is slightly superior than the maximum alowable value, it is recommended that a fecal coliform count (not only detection of the presence) is done to assess the bacteriological suitability for irrigation purposes.

PH, total dissolved solids, and conductivity values are below the no restriction value for irrigation water.

Suitability of the water as source for irrigation use was evaluated based on the electrical conductivity and salinity ranges in the reservoirs as follows.

RAS (*) (meq/l)	Electrical Conductivity (Umhos/cm) Restriction Degree		
	None	Low - Moderate	Severe
0 - 3	< 200	200 - 700	> 700
3 - 6	< 300	300 - 1,200	> 1,200
6 - 12	< 500	500 - 1,900	> 1,900
12 - 20	< 1,300	1,300 - 2,900	> 2,900
20 - 40	< 2,900	2,900 - 5,000	> 5,000

Salts presents in the reservoir water

Parameter	Unit	Daule-Peripa	La Esperanza	Poza Honda
Conductivity	Umhos/cm	149.50	516.66	335.37
Sodium (Na)	mg/l	11.30	32.83	23.50
	meq/l	0.49	1.43	1.01
Calcium (Ca)	mg/l	14.38	46.17	28.67
	meq/l	0.72	2.30	1.43
Magnesium (Ma)	mg/l	8.82	15.50	8.00
	meq/l	0.72	1.28	0.66
RAS(*)	meq/l	0.58	1.07	0.70

(*) Relative Absorption of Sodium = $\frac{Na}{\sqrt{(Ca + Mg)/2}}$ (meq/l)

In conclusion, the water from the Daule-Peripa reservoir are without restriction for irrigation purpose. La Esperanza and Poza Honda have a little restriction. They can be used for crops with moderate tolerance to salts or for soils with a moderate to high infiltration rate.

3.4 Water Quality Prediction in Rivers and Estuaries

3.4.1 Introduction

Using the concept of pollution load analysis to clarify the impacts on water quality deterioration in the Chone and Portoviejo rivers, a qualitative approach is applied.

The Chone river is divided into 2 regions, namely: 1) middle reach of the Chone river (by the confluence point of the Chone and Carrizal rivers), and 2) estuary area of the Chone river. While, the Portoviejo river is also divided into 2 regions, namely 3) middle reach of Portoviejo river (by the confluence point of the Portoviejo and Chico rivers), and 4) estuary of the Portoviejo river. Taking the location of the water bodies mentioned above, the following 4 points are selected as the water quality prediction points. Figure 3.3. shows the location of the 4 prediction points and the schematic diagram of water quality analysis.

- P-1: Simbocal (downstream confluence point of the Chone and Carrizal rivers, ST-6)

- P-2: Punta Prieta (middle reach of estuary area of the Chone river, ST-8)

- P-3: Guayaba (downstream of the confluence point of the Portoviejo and Chico rivers, ST-15)

- P-4: Estuary (estuary area of Portoviejo river, ST-17)

3.4.2 River flow regime

The project plans to divert 336 MCM from Daule-Peripa to La Esperanza and 213 MCM of water from La Esperanza to Poza Honda. The Portoviejo River will receive 223 MCM, which means that the flow conditions of the Portoviejo river will be considerably improved.

3.4.3 River flow change

Table 3.4. shows the existing and future river flow calculated by the mathematical hydrological model used in the water balance in this project, for the situations with and without added dilution flow. The condition "with" dilution flow is recommended to dilute pollutants in the river course.

The mentioned study estimates that in the rainy season, the river flow discharge in the Chone River would be increased in 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 in the Portoviejo river, a remarkable (100%) improvement of river flow discharge would be expected from 111 MCM to 221 MCM as indicated in the following table.

Change of River Flow Regime (%)

"without" Dilution Flow Condition

Period	Chone River (1) River mouth	(2) Upstream	Portoviejo River (3) Carrizal River	(4) Portoviejo River Downst'm	(5) Portoviejo River Up'stm	(6) Chico River
a)Rainy	+9	0	+29	+16	+34	+28
b)Dry	+88	0	+147	+16	+65	+151
c)Annual	+22	0	+47	+16	+42	+61

Change of River Flow Regime (%)

"with" Dilution Flow Condition

Period	Chone River (1) River mouth.	(2) Upstream	Portoviejo River (3) Carrizal River	(4) Portoviejo River dow'stm	(5) Portoviejo River Up'stm	(6) Chico River
a)Rainy	+9	0	+34	+29	+43	+31
b)Dry	+132	0	+197	+49	+100	+165
c)Annual	+29	0	+59	+36	+58	+67

Remarks : (1) Simbocal (ST-6)

(2) H. Saida (ST-5)

(3) Bachillero (ST-4)

(4) Darío Guevara (ST-16)

(5) Portoviejo (ST-14)

(6) Río Chico (ST-11)

The condition "with" dilution flow assures an additional flow of 20% of the irrigation flow demand, or equivalent to the estimated return flow from the agricultural area.

3.4.4 Estimation of pollution load

(1) Pollution load unit

Four water quality items, namely BOD, COD, T-P, and T-N are selected as the indexes for the assessment of water quality change caused by the project, because they are the most important ones. Besides, there are no major industries which could cause water pollution by hazardous substances in the study area, according to the sampling made.

(2) Municipal water supply

Per capita pollution load unit and quality of sewage of BOD, COD, T-P, and T-N is estimated by previous studies (51), and based on the data obtained from "A Guideline for Integrated Basin-Wide Sewerage System Development", 1983, Ministry of Construction, Japan.(adjusted to local conditions), as shown on the Table 3.5.

(3) Irrigation water use

No data related to pollution load unit is available in Ecuador, and the following load units commonly used in Japan, and considered in previous studies (51) are applied in this study.

Land Use	BOD	COD	T-N	T-P
1) Paddy	82	102	32	3.2
2) Pasture	59	106	14	1.6
3) Perennial crop	14	18	73	0.7
4) Upland	20	26	28	0.9
5) Others (Forests, etc.)	12	15	2	0.4

Source: Integrated Water Quality Control in Lakes, Ministry of Construction, Japan, 1987.

The setup of unit pollution load by land use is needed to calculate pollution load change caused by the project. At present, cattle grazing is a common farm type and a lot of cattle is being raised in the proposed irrigation area. The existing pastures in the project area are to be converted into irrigation land, so the pollution load of the cattle will be decreased by the project. The load derived from the cattle has been estimated in previous studies (51), and the unit is commonly used in Japan.

Pollution Load Unit (Kg/head/yr)

Item	BOD	COD	T-N	T-P
Cattle	243	193	138	20

Source: Guidelines for Integrated Basin-Wide Sewerage System, Ministry of Construction, Japan, 1986

(4) Aquaculture water supply

Semi extensive and semi-intensive shrimp farming is being conducted in the estuaries of the Chone and Portoviejo rivers. The expanding potential is estimated in 450 ha for the Chone river and no hectares for the Portoviejo river. Although it has been recommended to stop the shrimp farming activity in the Chone river estuary, a load unit has been estimated for the existing and possible future pollution loads from shrimp ponds. Since the data related to unit load of shrimp pond is not available in Ecuador, the actual data obtained by water quality survey shown in Table 3.1 is applied for calculation of pollution load in this study.

3.4.5 Volume of waste water

(1) Domestic waste water

The volume of domestic waste water is calculated by multiplying the unit sewage discharge and the population in the water served area both in 1990 and 2020. Calculations have been estimated in previous reports (51) by JICA team.

(2) Drained water from irrigation area

By considering the evapotranspiration area and soil permeability in the study area, the volume of drained water from irrigation area (return flow) is assumed to be 20% of the water requirement of each irrigation area (51).

(3) Drained water from shrimp pond

The drained water volume from shrimp ponds at an estimated (51) exchange rate of 10% is estimated, and the results are shown in Table 3.6.

3.4.6 Estimation of pollution load change

(1) Load change by municipal water supply

Load from treated sewage and load from untreated sewage have been considered for the estimation of pollution load from municipal water supply (51). There are no sewerage improvement plans in the project area, and the load is estimated in the same condition of the existing sewerage system. Most cities do not have sufficient canals and drainage for sewerage collection, thus 70% of the load from untreated sewage is assumed to be discharged directly to the public water bodies. The incremental pollution load from municipal water supply, from 1990 to 2020 was estimated in this study.

(2) Load change by agricultural water supply

Three pollution sources, namely load from irrigation water, load from land use change, and load from cattle are to be considered for calculation of incremental pollution load. The load from irrigation water depends on the water quality of the water source, such as La Esperanza and Poza Honda reservoirs. So the predicted water quality data in this study is used as the quality of irrigation water for load estimation.Results are shown in Tables 3.7.

(3) Load change by aquacultural water supply

Although an estimated volume of 99 MCM of fresh water has been allocated for the shrimp farms (51) with the project condition, the total load from existing shrimp ponds is expected to be the same, because the total amount of nutrients applied now will not be changed after receiving the fresh water from the project. Therefore, only the load derived from the potential shrimp pond areas is considered as the source causing an additional pollution load. Thus, the load from 450 ha of potential shrimp ponds in the Chone river estuary is calculated in this study.Results are shown in Table 3.6.

(4) Total incremental load caused by the project

The total incremental pollution load caused by the project is estimated by summing up the results mentioned above, and summarized in Table 3.8.

3.4.7 Prediction of water quality change

January and June are the months considered as representatives for the rainy season and dry season respectively for predicting the quality of water in the following sites:

(1) Simbocal (P-1)

The future water quality at Simbocal (P-1) in the middle reach of the Chone river (C3') in 2020 can be estimated by the following equation, and the result is shown in Table 3.9.

$$C3' = (L3+L1+L2) / Q3' = (L3+L3') / Q3'$$

where:

L1,L2	: incremental load from irrigation and municipal water supply,
L3	: existing load of river flow
L3'	: additional future load of river flow (L1+L2),
Q3'	: volume of future river flow

(2) Punta Prieta (P-2)

The future water quality at P-2 (C5') can be predicted by the following equation, and the result is shown in Table 3.9.

$$C5'=(L3'+L4+Ls) / (Q3'+Q4+Qs)$$

where:

L3'	: future load of river flow
L4	: load from potential shrimp ponds,
Ls,Qs	: load and volume by tidal action

(3) Guayaba (P-3)

The water quality at Guayaba (P-3) in the middle reach of the Portoviejo river (C8') in 2020 can be estimated by the following equation, and the results are shown in Table 3.9.

$$C8'=(L8+L6+L7) / Q8'$$

where:

L6,L7	: incremental load from irrigation and municipal water supply,
L8	: existing load of river flow
L8'	: additional future load of river flow (L6+L7)
Q8'	: volume of future river flow

(4) Estuary (P-4)

The future water quality at the Portoviejo river estuary (C11') can be predicted by the following equation, and the result is shown in Table 3.9.

$$C11'=(L8'+L9+L10)/(Q8'+Q9+Q10)$$

where:

L9,L10 : incremental load from irrigation and municipal water supply,

Q9,Q10 : incremental discharge from irrigation and municipal water supply,

L8' : additional future load of river flow (L6+L7)

Q8' : volume of future river flow.

(1) Evaluation

The results of water quality prediction are summarized hereunder.

Result of Water Quality Prediction
"without" dilutión flow

(mg/l)

Prediction	BOD		COD		T-N		T-P	
Point	act.	fut	act.	fut.	act	fut.	act.	fut.
I.P-1								
a)Rainy season	10.7	11.4	19.0	19.0	2.4	2.6	0.25	0.27
b)Dry season	14.0	12.4	24.3	17.8	1.4	1.9	0.20	0.23
c)Average	12.3	11.7	21.7	18.7	1.9	2.4	0.23	0.26
II.P-2								
a)Rainy season	11.3	8.5	18.7	14.4	2.1	2.0	0.00	0.22
b)Dry season	18.0	14.7	32.7	26.5	1.3	2.1	0.30	0.19
c)Average	14.7	10.8	24.8	18.9	1.5	2.0	0.15	0.21
III-P-3								
a)Rainy season	13.3	16.7	20.0	20.9	1.9	2.6	0.24	0.37
b)Dry season	14.3	23.3	23.7	28.1	1.3	3.3	0.40	0.68
c)Average	13.8	18.9	21.9	23.2	1.6	2.9	0.32	0.47
IV-P-4								
a)Rainy season	12.0	17.4	17.3	21.6	2.2	2.8	0.43	0.39
b)Dry season	19.0	24.4	33.7	23.9	0.9	3.7	0.30	0.70
c)Average	15.5	19.6	25.5	24.1	1.5	3.1	0.37	0.49

Result of Water Quality Prediction
"without" dilutión flow

(mg/l)

Prediction Point	BOD act.	BOD fut	COD act.	COD fut.	T-N act	T-N fut.	T-P act.	T-P fut.
I.P-1								
a)Rainy season	10.7	11.4	19.0	19.0	2.4	2.6	0.25	0.27
b)Dry season	14.0	10.0	24.3	14.4	1.4	1.5	0.20	0.19
c)Average	12.3	11.0	21.7	17.6	1.9	2.3	0.23	0.25
II.P-2								
a)Rainy season	11.3	8.5	18.7	14.4	2.1	2.0	0.00	0.22
b)Dry season	18.0	13.6	32.7	24.4	1.3	1.9	0.30	0.18
c)Average	14.4	10.5	25.7	18.3	1.7	1.9	0.15	0.20
III-P-3								
a)Rainy season	13.3	15.0	20.0	18.7	1.9	2.4	0.24	0.33
b)Dry season	14.3	18.1	23.7	21.8	1.3	2.6	0.40	0.53
c)Average	13.8	16.1	21.9	19.8	1.6	2.4	0.32	0.40
IV-P-4								
a)Rainy season	12.0	15.6	17.3	19.4	2.2	2.6	0.43	0.35
b)Dry season	19.0	19.1	33.7	22.9	0.9	2.9	0.30	0.58
c)Average	15.5	16.8	25.5	20.7	1.5	2.7	0.37	0.42

The results of the existing and future water quality conditions are evaluated with the results of the water quality analysis presented in Tables 3.9

The results in the situation with dilution show that at the lower reach of the Chone river at Simbocal (P-1) the future water quality during the dry season would be improved in BOD and COD.

At the estuary area of the Chone river, Punta Prieta (P-2), the future water quality would be improved for BOD amd COD while T-N and T-P will slightly increase.

At the middle reach of the Portoviejo river, downstream confluence point with the Chico river at Guayaba (P-3), and at the Portoviejo estuary area (P-4), the water quality deterioration could be serious, mainly due to the waste water discharge from Portoviejo city.

When a self purification coefficient of 0.1 is assumed between P-1 and P-2, the future water quality of BOD at P-2 could be reduced as much as 50% of the predicted value by the following Streeter-Phelph's equation:

$$C3'' = C3' x\ e^{(-Kt)}$$

where:

C3" = future quality with self-purification capacity,

C3' = predicted future water quality

K = self-purification coefficient
(K= 0.1 in this study)

t = time (hour) to reach P-2 from P-1
(t=5 km/0.2 (m/s)/3,600=7 hours)

(2) Necessary actions to be taken

As previously mentioned, water quality deterioration for the Portoviejo river, after its confluence with the Chico river would be serious in the future. The following actions shall be carry out by CRM to mitigate the environmental impact and to avoid problems with the water use in the future.

i) To change the water intake for the Ceibal Treatment Plant

CRM is actually constructing a new potable water treatment plant with a capacity of 90,000 m3/d, known as El Ceibal Treatment Plant and belonging to the Poza Honda System. Raw water from the Portoviejo river is to be taken near the town of Rocafuerte.

However, problems related to the water treatment could occur due to the serious deterioration of the water quality for the Portoviejo river. Thus, it may be necessary to relocate the planned water intake from the Portoviejo river to another site where a best source of water can be taken.

The Chico river is the best option for the water intake, and the water quality of the Chico river, upstream its confluence with the Portoviejo river, would be better than the water quality of the Portoviejo river (Table 3.11). Moreover, the Chico river has a minor posibility of deterioration in its basin. That is the reason why CRM will have to use the Chico river as a new water source for the El Ceibal Treatment Plant over the end of the Project.

Results on Water Quality Prediction
"with dilution flow"

(mg/l)

Chico River	BOD		COD		T-N		T-P	
	Actual	Future	Actual	Future	Actual	Future	Actual	Future
a) Rainy season	9.33	9.24	16.33	13.98	2.58	2.38	0.21	0.22
b) Dry season	14.30	8.27	23.00	10.73	0.70	0.82	0.23	0.17
c) Average	11.82	8.83	19.67	12.60	1.64	1.71	0.22	0.20

ii) To improve the sewerage system

Water quality deterioration of the rivers depends on the development of the sewerage treatment system. The future water quality in the lower reach of the Portoviejo river downstream the confluence point with the Chico river, site P-3, is predicted in four cases, namely: no improvement of the coverage rate, improvement of 30%, 50% and 70% of the sewerage coverage rate.

Results show that an improvement of the sewerage system is effective for the preservation of water quality but not enough. CRM must conduct its best efforts to improve the sewerage treatment system in the city of Portoviejo. However in the future also it will be necessary to look for a sort of pretreatment of the drainage water coming from the irrigation areas.

Result on the water quality prediction (unit:mg/l)

P-3	DBO	DQO	T-N	T-P
I. Without improvement of sewerage system				
a) Rainy	15.0	18.7	2.4	0.33
b) Dry	18.1	21.8	2.6	0.53
c) Annual	16.1	19.8	2.4	0.40
II. 30% of 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% of 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% of 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

3.4.8 Bacteriological Analysis

Bacteriological analysis carried out by JICA during December, 1993, January, June and August of 1994, showed the following results:

Bacteriological Analysis

Station	Total Coliforms MPN/100ml		Fecal Coliforms		Standard Bact. Count	
	Dec.	Jan.	Dec.	Jan.	Dec.	Jan
ST-1	2,240	2,400	+	+	9,637	177
ST-2	240	2,400	+	+	8,807	177
ST-3	800	nd	+	nd	38	nd
ST-6	240	2,400	+	+	5,003	180
ST-9	144	nd	+	nd	5,233	nd
ST-10	600	nd	+	nd	15	nd
ST-12	700	nd	+	nd	15	nd
ST-13	96	2,400	+	+	6,200	17
ST-14	42	240,000	+	+	3,433	UC
ST-15	13	2,400	+	+	3,068	150
ST-17	1,300	nd	+	nd	38	nd

nd = No Data
UC=Uncountable

Bacteriological Analysis

Station	Total Coliforms MPN/100ml		Fecal Coliforms		Standard Bact. Count	
	August	June	August	June	August	June
ST-1	2,240	2,400	+	+	226.66	197
ST-2	2,400	2,400	+	+	83.33	56.6
ST-3	nd	nd	+	nd	nd	nd
ST-6	2,400	2,400	+	+	110	53.3
ST-9	nd	nd	+	nd	nd	nd
ST-10	nd	nd	+	nd	nd	nd
ST-12	nd	nd	+	nd	nd	nd
ST-13	2,400	2,400	+	+	83.33	106.6
ST-14	2,400	2,400	+	+	200	200
ST-15	2,400	2,400	+	+	123.33	150
ST-17	nd	nd	+	nd	nd	nd

nd = No data

Results show a generalized fecal contamination from the Daule-Peripa reservoir at Conguillo inlet (ST-1) to Simbocal (ST-6), including La Esperanza (ST-2) and Tosagua (ST-3). Fecal contamination is also present from Poza Honda (ST-9) to the Portoviejo river estuary (ST-17), including Mancha Grande (ST-10), and upstream (ST-12 and ST-13) and downstream of the Portoviejo river (ST-14 and ST-15).

Higher concentrations of coliforms and total bacteria count at the Conguillo outlet are probably related to the reduced water exchange rate at the end of the dry season for this part of the reservoir. The high total coliform count for the Portoviejo river estuary reflects the raw sewarage coming mainly from Portoviejo city, and recalls the need for a proper sewarage treatment system at Portoviejo city to avoid future increases in coliform counts.

Microbiological water quality of the stations surveyed is not considered adequate for drinking or swimming, but it is considered as a source with a moderate restriction value to be used as raw water source for treatment.For irrigation purposes it is considered adequate when the total coliform count is 1,000/100 ml or less.

3.4.9 Pesticide Analysis

Water analysis carried out by CRM in December of 1993 and January, June and August of 1994 respectively show the following results;

Pesticide Residues in ppb

Pesticide	STATION								
	(ST-6)		(ST-14)		(ST-15)		(ST-16)		MRL
	Dec.	Jan	Dec.	Jan	Dec.	Jan	Dec.	Jan	
Lindane	-	0.01	0.011	0.03		Nd	-	0.01	5
Cis-Heptaclor	0.03	0.25	0.06	0.18	0.04	0.08	0.04	0.08	0.1
Transclordane	0.013	0.04	Nd	0.03	Nd	0.03	Nd	0.01	3
pp' DDE	0.03	0.02	0.03	0.03	0.01	Nd	0.07	0.02	50
pp' DDD	Nd	Nd	Nd	Nd	0.01	0.02	0.05	0.03	
op' DDT	0.02	Nd	0.02	Nd	0.05	Nd	0.04	Nd	
pp' DDT	0.02	0.02	0.02	Nd	Nd	0.03	Nd	0.04	100
Clorpyrifos	1.2		Nd		Nd		4.10		
Dimetoato	Nd		Nd		Nd		1.26		

Nd = Non detected

Pesticide	STATION								
	(ST-6)		(ST-14)		(ST-15)		(ST-16)		MRL
	August	June	August	June	August	June	August	June	
Lindane	Nd	0.027	0.011	0.04	0.011	0.0015	0.027	0.0025	5
Heptachlor	0.027	Nd	0.007	Nd	0.008	Nd	Nd	Nd	0.1
Cis-Heptachlor	Nd	Nd	Nd	Nd	Nd	Nd	Nd	0.011	0.1
Transclordane	Nd	Nd	Nd	Nd	Nd	Nd	Nd	0.011	3
pp' DDE	Nd	Nd	Nd	Nd	Nd	Nd	Nd	0.011	50
pp' DDD	Nd	Nd	Nd	Nd	Nd	Nd	Nd	0.011	50
op' DDT	Nd	0.12	Nd	Nd	Nd	Nd	Nd	0.011	50
pp' DDT	Nd	0.024	Nd	0.027	Nd	0.046	Nd	0.03	50
Clorpyrifos	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	100
Dimetoato	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	100

Nd = Non detected

Results during December, 12/93, June 3, 6 and August 16 and 30/94 when no aplication of pesticides is done or no agrochemical runoff is present, detected concentrations of Cis-Heptachlor for a range less than the Maximum Residue Limit (MRL) established by the Codex Alimentarius FAO/WHO, 1990, as reported by MAG, Sanidad Vegetal, Ecuador, 1993-1994.

During January, when the aplication of pesticides and agrochemicals is evident, the concentration of Cis-Heptachlor went beyond the Maximum Residue Limit (0.18 and 0.25 ppb).

Concentration of Heptachlor were detected in the second sampling, on August 30/94 in Simbocal (ST-6) and upstream and middle reach of the Portoviejo river (ST-14, ST-15).

In summary, the sampling conducted by the MAG, give some values of organochorides and chlorides pesticides, as well as phosphorous residues, which is a bad signal if it is assumed that the detected values are to be increased in the future when the irrigation area is implemented by the project. The following increment in the agricultural area reflects this possibility:

Agricultural Area

Area	Existing Agricultural Area (ha) Reference, 1988 Data	Net Potential Irrigation Area (ha) JICA-CRM (51) (Except Amarillos - Guarango systems)
Carrizal-Chone	1.516	15,000
Sistema Poza-Honda	4.518	10,050
Sistema Rio-Chico	1.383	1,700

It is evident from the above data that the Chico river irrigation area will be the least affected by an increment in the irrigation area, and with an added 4 m^3/sec flow with the project condition. Water quality condition in the Chico river will be a more suitable source for the El Ceibal treatment plant rather than the Portoviejo river.

The Government of Ecuador has forbidden the use of the following pesticides according to decree # 2332, published in the Official Register #649 from December 28, 1983:

Aldrin

Amitrole

BHC

DDT

Camphechlor

Captan

Chlordane

Chlorobencilate

Mercurial compounds

Chlordimeform

DBCP

Dieldrin

Methyl Parathion

Heptachlor

Mirex

Carbon Tetrachloride

Endrin

Arsenic compounds

Penta chlorophenol

It is important to comply with this law, since by March 1989, already residues of Lindane, DDT, Aldrin, Heptachlor, and Chlordane were detected in nursing mothers milk, and this residues were being transmitted to infants at breast feeding. Mitigating meassures for this situation include the implementation of an integrated pest management program in the agricultural area (IPM), which will be discussed further in this report.

3.5 Salinity study in the Chone river estuary

In the Chone river estuary, fresh water is scarce, especially during the dry season, where this source of water , coming from the Carrizal and Chone rivers, is used mainly for potable and irrigation uses, whereas it is used for aquacultural purposes in the estuary area.

Salinity changes seasonally, nevertheless, due to the high volume of return flow coming from the shrimp ponds for about 3.3 to 5.5 MCM per day, the agrochemical runoff and other efluents around the area, the salinity content rises considerably. This provokes the deterioration of aquatic life quality and imposes a high risk on the ecologic and socioeconomical system.

Being the salinity concentration a key parameter to determine the water quality condition for varios uses, namely, the shrimp farm activities and the irrigation and drainage practices, in the crop selection, and to a certain degree in other soil practices upstream of the estuary area, there was necessary to conduct a salinity survey during the design stage of the project, in the estuary of the Chone river, due to its direct influence in and upstream of the estuary, in regard to irrigation and potable water uses.

For irrigation purposes, there must be pointed out that unless the salinity is not controled, the agricultural yields will decrease, the value of the land will fall down, and, in extreme cases, the land will be abandoned.

3.5.1 Salinity measurements

Salinity measurements were conducted in seven (7) points along the Chone river estuary, at the same sampling sites of the tide measurements, Figure 3.4. This ocurred in

June, 3 to 5, and August, 12 to 14/94. Top samplings were made at 20 cm below the water surface and bottom sampling at 50 cm of it.

3.5.2 Salinity measurement in June (at the end of the rainy season)

i) Salinity decreases as the tide moves away from Bahía de Caraquez, upstream the estuary

ii) Mean salinity levels, according to the analysis, Tables 3.10 and Figure 3.5., show a great variation from Bahía de Caraquez to the ST.2 (Quiroga). This is mainly due to the direct influence of the sea water in that length of the estuary,of about 18 Km

From the last station up to the ST.5 and ST.5-A (Simbocal), the variation is minimal for the two samples made, and it can be assumed as an almost constant salinity level for a length of about 9.5 Km, and it may be due to the fresh water flowing from the Chone river during this period of the year.

There is a minor increment of salinity at the ST.5-A, which is not detrimental for irrigation purposes, but so do is for potable water, this is a consequence of the less mixing property found in that point, because of the less exposure to the Chone river flow and also due to the major retention time of sea water caused by the dyke proposed by CRM and other geographical features of the areas.

iii) In June, the profile of Figure 3.5 shows a higher longitudinal gradient of salinity (ds/dx), that is 1.55 ppm/km, between Bahía de Caraquez and Salinas.

iv) The salinity analysis at every station during the sampling period, stablished a variation to higher value of salinity as the samplings goes deeper, for the surface and bottom samplings, specially in the high tide, and being more obvious in stations # 1 and 2, due to the direct inflow of the sea water into the estuary. This tendency reverses for other stations, meaning that, the deeper the water level of sampling, the lower the salinity levels, and in certain cases, as in stations # 4 and 5, the surface and bottom salinity levels remain constant at different levels of water. This particularity is mainly due to the great fresh water inflow from the Chone river in the rainy season.

On the other hand, being the actual structure of flow control not enough to stop the extraordinary flows of the Chone river during the rainy season, provoking the flooding of vast agricultural areas and affecting also their flora and fauna, it is necessary to implement the tidal gate of control at Nuevo Simbocal to evacuate these extraordinary floods. Its cost will be weighted against the benefits for the incorporation of temporary and permanent flooded areas into agricultural lands.

3.5.3 Salinity measurements in August (during the dry season)

i) Salinity is relatively higher than in the rainy season, increasing during the high tide and decreasing during the low tide, for both the surface and bottom samplings.

ii) The mean salinity levels through all the estuary, Table 3.10 and Figure 3.5, show that, departing from Bahía de Caraquez to Station 3 (Ariaga) there is a great variation of such levels. This is due to the lower mixing effect of the Chone river flow during this time of the year.

From this last station up to Simbocal (5 and 5A), the salinity level decreases drastically, being the station # 5 the lowest in salinity level, this is due to the influence of the Chone river when the gates are opened and there is not artificial dike downstrem of them.

A representative increment of salinity, between 5.5 and 7 ppm, is found at Station 5A, higher than the salinity obtained in the rainy season. This is due to the minor mixing degree of the Chone river flow.

However, the salinity concentration in the estuary at Simbocal stations 5 and 5A is generally higher (0.8 to 5 ppm) and is higher than the allowable limit criteria for domestic and irrigation uses, therefore this water may be used with restrictions.

iii) The salinity profile in Figure 3.5. shows that for the month of august, the maximum salinity gradient of salinity (ds/dx) moves upstrem the estuary, between Ariaga and Barquero it has a value of 2.76 ppm/km.

iv) From the salinity analysis in all the sampling stations, there can be demonstrated that for Bahía de Caraquez the salinity is almost constant relative to the water depth, which means a total mixing of water in this site. For other stations, there is a change of salinity in regard to the water depth, that is, as greater the depth the greater the salinity, with a few exceptions as in the stations 5 and 5A, in the surface sampling, where the salinity is almost constant.

Finally, to avoid the potential salinization of the flatlands in the Carrizal-Chone valley, it is necessary the implementation of the new tidal control gate, i.e. the control gate at Nuevo Simbocal, ST 5A, moreover if the expected salinities at this point will goes beyond the 5 ppm, and being greater during or near the high tide.

3.6 Recommendations

1) Fecal coliform determination and counting is recommended to be done in all reservoirs, in a periodic schedule as proposed in the program for the establishment of the water

quality criteria. This analysis will provide criteria to evaluate suitability of the water for the different uses, from the microbiological point of view.

2) Pesticide analysis is recommended to be done in all reservoirs, in a regular schedule, to evaluate the possible danger of pesticide polluted water entering the distibution system for human consumption. Special attention should be paid to Cis Heptachlor, which already exist and in some cases is higher than the maximum limit allowed.

3) Erradication of the plant biomass in La Esperanza impoundment area before inundation is of critical importance to avoid future deterioration of the water quality.

4) Implementation of aquatic plant control mechanisms such as the described in this report are recommendable to improve water quality conditions at Conguillo inlet.

5) To consider the location of water intake for El Ceibal at the Chico river, where a lesser pesticide load is expected.

6) To implement the Integrated Pest Management Program in the agricultural areas, as outlined in this study, in an effort to reduce the use of pesticides and the future expected increment of these products.

7) Due to a higher salinity concentration of the water upstream of Simbocal in the dry season, ST 5A , the water resource should be used with restrictions, for both domestic and irrigation uses. In the rainy season there are not restrictions.

8) To re-design and construct the tidal gate and dyke at Nuevo Simbocal, ST 5A, which will allow the spillover of the extraordinary floods of the Chone river, of 25 ,50 and 100 years of return period, and, in the dry season, to control the tide fluctuations and impede the salinization of agricultural lands upstream Simbocal, also to maintain and improve the ecological conditions of this area.

4. PROGRAM FOR THE ESTABLISHMENT OF WATER QUALITY STANDARD

4.1 Introduction

A water quality standard is considered as a rule or law related to the use or uses to be made of the water body, and the water quality criteria are necessary to protect that use or uses. Water quality standards are to protect the public health and enhance the water quality.

Standards serve the dual purpose of establishing the water quality goals for a specific water body, and serve as the regulatory basis for the establishment of water quality based treatment controls and/or strategies and programs for the prevention of water quality deterioration.

Water quality should, whenever possible, provide for the protection and sustainment of fish, mollusks, and wildlife and recreation in the water. In the management of the water quality standard program, improvements in the following regulations will be attainable:

Regulations for the control of pesticides and toxic pollutants

Regulations for mandatory upgrading of water quality standards, especially in the water treatment plants for human consumption

Regulations for the protection of natural forests, especially those existing in the watersheds of the water sources, and the required reforestation programs to be implemented in the areas adjacent to the reservoirs.

Regulations for the creation of national parks, forest reserves and protected areas and recreational areas.

The scientific basis for the eventual establishment of water quality standards is the data to be obtained in a regular and adequate manner, and through a preset methodology. CRM must ensure, through cooperation with the government offices related to this matter, that the process and procedures used to revise standards will result in sufficient data to support a decision, especially in relation to water treatment plants for human consumption, forestry regulations, pesticide use control and enforcement of the law in these areas.

Water quality standards are the foundation of a water quality management program. Standards establish water quality goals and requirements for specific water bodies, serve as the basis for regulating and enforcing municipal and industrial pollutants, drive the planning and implementation of pollution control programs, and provide a measure of the effectiveness of pollution control programs through attainment of water quality standards.

It is very important that CRM will assure that decisions on standards are adequately supported by scientific and technical evidence collected on a regular basis. For this reason, the program for establishing a water quality standard should be implemented as part of the Environmental Management and Monitoring Plan.

4.2 Water Quality Criteria

Criteria are elements of water quality standards expressed as concentrations or levels, that represent a quality of water that supports a particular use. When criteria is properly selected, it is presumed that water quality will protect the designated use.

Criteria may be established by employing bioassay, biological criteria, or numerical values. Site specific criteria can be developed in cases where background water quality or aquatic organisms differ from preset ones, such as those used in other latitudes. Criteria should be a guidance, and should be based on the latest scientific information available on the effect of a pollutant on human health and aquatic life.

4.3 Ecosystems Approach

The basis for this system is the natural water quality without any form of influence from human activities. The influence of pollution on the water quality, or the difference between the natural water quality and the water quality of today is the outstanding character for the classification of polluted water.

The system for assessment of water quality for various uses is based both on the existing water quality and some physical properties of the environment (i.e. calcareous deposits will enhance water hardness).

The need for monitoring biological parameters such as fish status, chlorophyll concentration, and microalgae composition and growth besides physical and chemical parameters is evident when dealing with base conditions of eutrophication in the reservoirs, where biological indicators will determine the level of deterioration of the system. As mentioned before, the assessment of the water quality and pollution level will give the basis for the management programs to be implemented in the ecosystem related to the water body.

4.4 Classification of Polluted Water

The system is based on the quality of natural water existing in the watershed in which the reservoirs are located. Nearby water courses to the reservoirs which are not influenced by man should be selected as a reference. Pollution is defined here as any human influence. If we can reconstruct the natural situation as best possible, and we know the present water quality, then we can assess the influence of pollution. The system will then give information on the present process of alteration, and what may happen in the future.

The fact that we are dealing with an impounded body of water is to be considered in the classification as a main distinction when we correlate the reference natural water quality obtained from an unpolluted river system with the impoundment.

Because of the fact that the water quality in Daule-Peripa reservoir will be the starting reference value for the water quality in La Esperanza and Poza Honda, it is recommended that the quality of the water at Daule-Peripa be used as a parallel reference to that of a natural body of water from an unpolluted source. We will then have two basis of comparison to establish criteria, the water quality at Daule-Peripa, and the water quality from an unpolluted source.

4.4.1 Classification system

The effects of pollution load in the water course may be characterized by the magnitude and type of polluted water being discharged. The classification of water quality could be divided in the following effects of pollution loads:

Effects of nutrients
Effects of organic matter
Toxic effects (agrochemicals and other toxics)
Effects of particular materials
Microbiological effects

The various effects of pollution could be classified in the following categories:

Category A: Effects of pollution are hardly detectable (almost natural water quality)
Category B: Reasonable deviation from natural water quality
Category C: Distinct variation from natural water quality
Category D: Great deviation from natural water quality

The following traits describe the different categories:

A: The pristine natural ecosystem is intact. The flora and fauna are almost what we can expect in natural water ecosystems.

B: The original biological community is to some extent affected by pollution. Some species have disappeared and other species have become dominant. The algal production has increased, and the bottom communities have changed to some degree. Fish species exist in the water.

C: Both the composition of flora and fauna and production are essentially changed with respect to the natural conditions. Hardy flora and fauna species dominate. Heterotrophic organisms may be present. Water quality is considerably deteriorated.

D: The ecosystem is completely out of balance. Species of blue-green algae dominate the algal community. Anaerobic conditions, high concentration of toxic substances, possible fish kills will take place.

4.4.2 Classification graphs

Every water quality parameter can be classified by means of graphs or diagrams, where the natural water quality reference condition could be correlated to the existing condition on a given time.

The plotting of the existing condition on the same scale graph will show the points (values) that differ from the natural water, and/or from those at Daule-Peripa, and subsequent plotting will show how the present water quality condition at that time differs from the previous situation.

The deviation between natural and present water quality on the graph will illustrate the degree of pollution and the deviation between the previous water quality and the last water quality, and the degree to which the water quality is improving or deteriorating as related to the last evaluation.

The confidence of the valuation will increase with the number of parameters used.

4.5 Data Acquisition

Data acquisition is expensive and should be planned in detail, and executed carefully to avoid sampling errors.

Monitoring stations to be surveyed should be the same ones as the ones surveyed during the present study to give continuity and to take advantage of the baseline data generated in this study. Location of the sampling stations (17 stations) is detailed in the schematic map presented in Figure 3.1.

Biological parameters to be monitored are stated only for the reservoir impoundment areas. These parameters will contribute to the evaluation of the trophic condition of the reservoirs.

4.5.1 Parameters to be measured

As a minimum, but not restricted to them, the following parameters should be measured:

(1) Physical-chemical

1- pH
2- BOD
3- COD
4- Ammonia Nitrogen (as N)
5- Total kjeldahl Nitrogen (as N)
6- Nitrate Nitrogen (as N)
7- Chloride (as Cl^-)
8- Fluoride (as F)
9- Sulfate (as SO_4^{2-})
10- Phosphate (as P)
11- Total Solids dried at 105C
12- Suspended Solids dried at 105C
13- Dissolved Solids
14- Salinity
15- Conductivity (µmhos/cm)
16- Borum (as Bo)
17- Iron (as Fe)
18- Color (Hazen units)
19- Turbidity (FTU)
20- Total hardness (as $CaCo_3$)
21- Cadmium (as Cd)
22- Sodium (as Na)
23- Potassium (as K)
24- Calcium (as Ca)
25- Magnesium (as Mg)

26- Cooper (Cu)
27- Lead (Pb)
28- Zinc (Zn)
29- Dissolved oxygen
30- Manganese (Mn)
31- Bottom/Surface temperature
32- Transparency (Secchi disc)
33- Temperature top/bottom

(2) Bacteriological

1- Total Coliforms / 100 ml
2- Fecal Coliforms / 100 ml
3- Fecal Streptococcus / 100 ml
4- Standard bacteria count colonies / ml
5- Salmonella

(3) Biological

1- A Type Chlorophyll
2- Primary Productivity
3- Dominant microalgae species
4- Benthic biota (macroinvertebrates)
5- Cell count/ml

Biological parameters should be measured any time besides the above mentioned schedule, when conditions indicate a deviation towards a higher eutrophication stage. These biological parameters will provide an indication of such stage.

(4) Pesticides

1- Aldrin
2- Dieldrin
3- Chlordane
4- DDT and metabolites
5- Heptachlor
6- Lindane
7- HCH

Other pesticides eventually being used in the area can be incorporated if they are bound to affect public health. Attention should be paid to the use of organochlorine pesticides, relatively insoluble in water, but absorbed by particular matter and easily transported by rivers. Some chlorine pesticides like Dieldrin stay active for 8 years average, and are usually applied at doses of 1-3 kg/ha/yr.

(5) Sampling locations

The sampling locations in Fig 3.1 are suggested as the minimum for the data acquisition. These locations could be modified or increased by CRM according to new observations.

4.6 Assessment of Water Resource Uses

The water in La Esperanza and Poza Honda will be used for a series of activities including potable water and crop irrigation . Different water resource uses have different requirements, and the objective is to make possible an assessment of the water resource suitability for the different uses. For this objective, the water quality in the body of water should be expressed according to a determined scale in order to evaluate the suitability of use.

The final determination of the suitability for different uses can be established in the following classes:

Class 1:	The water body is excellent for the specific use
Class 2:	The water body is satisfactory for the specific use.
Class 3:	The water body is doubtfully suitable for the specific use.
Class 4:	The water body is not satisfactory for the specific use.

4.6.1 Raw water quality reference criteria

Various reference sources for the suitability of the water quality for different water uses can be consulted. However, the raw water quality criteria in use in Ecuador according to the final use of water, which were published in the Official Register on June 5, 1989 shall be identified in the course of the monitoring in Poza Honda and La Esperanza. Those parameters have been defined previously in Chapter 3.3.4.

4.7 Polluted Water Classification and the Water Resource Use

By relating the classification for polluted water and the assessment for water resource use, the water quality could be divided into the following types of condition:

1-Eutrophication
2-Saprophication (organic materials)
3-Acidification
4-Effects of toxic substances
5-Effects of particular materials
6-Microbiological effects

The present condition of the water quality is then compared with the class of suitability for the actual use, and for each water resource use an assessment form is developed, and all related parameters are listed in the form where the evaluation system and classes are shown. Based on the collected data the assessment form is filled out and the determination of suitability is done by comparison, according to evaluation criteria to be used.

Eutrophication has been the most evident problem related to water quality in Poza Honda. Several studies have been carried out by FAO (31) and CRM-INERHI-CONADE-OEA (32). The available information is already in the hands of CRM, and the implementation of the monitoring program for the trophic condition of the reservoirs is explicit in the studies (38 &39).

4.7.1 Eutrophication

The concentration of phosphorus is the common denominator throughout the different methods for determining the trophic level of a body of water. Formulas stated in Chapter 3.3.3 should be used for the assessment of the eutrophication of the body waters involved in this project.

4.8 Conclusions

The program for establishing a water quality standard comprising the system for classification of polluted water and the system for assessment of water resource uses will provide CRM with a useful tool to evaluate the status of the aquatic ecosystem and its usability for different purposes. The criteria will serve to integrate two separate but interrelated activities i.e. pollution assessment and the possibility of control, and water quality evaluation for different uses.

The information derived from monitoring and organized into this system or a similar one would provide a feedback on the status of the environmental management plan, as related to the program of prevention of the water quality deterioration.

The information derived from this program will show, when compared with water analysis done at the inlet of the water treatment plants, the degree of pollution generated between the reservoir and the inlet to the treatment plant, suggesting that corrective measures are to be located in this sector to improve the quality of the water entering the treatment plant.

Finally, the program for establishing water quality standards in the reservoirs is intimately related to a control mechanism with the program for prevention of the water quality deterioration and the program for environmental conservation in the vicinity of the reservoirs.

5. BASIC PROGRAM FOR PREVENTION OF WATER QUALITY DETERIORATION IN POZA HONDA AND LA ESPERANZA RESERVOIRS

5.1 Introduction

Based on the existing water quality data in Daule-Peripa , La Esperanza, and Poza Honda reservoirs as shown in Table 3.1, the future water quality is predicted, and the results are shown in Table 3.2.

The future water quality at La Esperanza would be better than those of Daule-Peripa in BOD and COD, but worse in T-N, and T-P.

In the condition with project, the water quality at La Esperanza would be improved in T-N, and T-P, but worse in BOD and COD if compared with the "without project" condition of La Esperanza.

In Poza Honda reservoir the water quality will be the same except for COD, which will have a low increment of 1.58 mg/l, so no significant impact is expected.

The eutrophication study carried out by CRM-INERHI-CONADE-OEA (32) determines that by 1983 already the mayor factors affecting the eutrophication process were the agricultural and cattle raising activities, which provide for 74% of the phosphorus load, and for the total watershed, approximately 40% was already deforested, and 60% showed pronounced slopes.

Based on the previous findings, the present program for prevention of the deterioration of the water quality will address the immediate sectors of the reservoir, in order to give the guidelines for the implementation of the management and monitoring plan to be implemented in such areas.

The present program is interrelated to the basic study for the delineation of the conservation area, and to the program for establishing a water quality standard. The former will define the area for implementing the plan, and the latter will provide a monitoring tool to evaluate the results derived from the EMMP on the medium and long term.

At present, CEDEGE is conducting a succcefully environmental management plan for the Daule-Peripa reservoir, thus this report recommends the coordination between CRM and CEDEGE, to see the posibility of implementing the same policies, procedures and experiences of the Daule-Peripa environmental management plan to the La Esperanza and Poza Honda reservoirs, and, in general to fulfill the following objectives:.

(1) Improving the quality of life for the inhabitants in the watersheds

(2) Erosion control in the watersheds and reservoir sedimentation

(3) Stablishing a reforestation program at the margin of the reservoirs and critical areas of the watersheds

(4) Zoning the adjacent reservoir areas, for reforestation

(5) To implement training and diffusion programs in areas such as silviculture, agriculture and cattle raising practices

(6) To implement dinamic research programs to stablish and manage the various forestry species

(7) Training programs at different levels

5.2 Immediate Area of Influence

5.2.1 Poza Honda

The immediate area of influence has been defined in Figure 5.1. Three basic zones have been defined in the area of influence, considering the actual use of the land, the potential use of the land, the risk of erosion and the reservoir as a public interest component.

Based on this consideration, the objective is to lower the sediment load and nutrient leaching into the reservoir, which affect the quality of the water body. So it is very important to implement this program.

Zone A: This zone is directly surrounding and limiting the impoundment. It is the area where variations in the level of the water directly affect the land, and where human activities are directly related to the use of the water resource. Given the steep slopes descending directly to the impoundment in some sectors, and the existence of the access road as a settled land mark, and the increased density of human activity from the road up, the extension of Zone A has been set at the access road elevation throughout the perimeter of the impoundment. The upper limit elevation for Zone A is elevation 160 m above sea level, the lower limit is the water level at the reservoir.

Zone B: This zone is directly associated with agriculture practices, cattle raising and human settlement, and is limited in its lower end by the access road elevation, 160 m a.s.l. and in its upper end by the presence of steep slopes inadequate for agriculture or cattle raising, with a strong forest vocation, and with existing altered forest patches isolated from one another by deforested land. The upper limit of this zone was set at elevation: 260 m and 200 m above sea level, for the left and right banks respectively.

Zone C: This zone is directly associated with steep slopes, and the presence of isolated and altered forest patches capable of regeneration if left untouched. The area is apt for forest regeneration or reforestation and presents a high risk of erosion. The agricultural use in some of these areas is in conflict with the land aptitude, and deforestation is a common practice. The upper limit of this zone was set at elevation 360 m and 300 m above sea level, for the left and right banks respectively.

Total Areas for Zones A - B - C
Poza Honda

Area	Zone A	Zone B	Zone C
Km^2	8.23	11.06	12.17
ha	823	1,106	1,217

5.2.2 La Esperanza

The immediate area of influence has been defined in Figure 5.2, and three zones have been defined, considering the actual use of the land, the potential use of the land, the risk of erosion and the reservoir as a public interest component.

Zone A: This zone is directly adjacent to the water body and limits it. In this area the variation of the water level directly affects the land, and the human activities in the land directly affect the water body. This zone is considered for protection with restricted use, and as a protection buffer area immediately adjacent to the water body. The lower elevation limit of the area is the low water level of the reservoir, and the upper limit is elevation 100 m above sea level. Zone A is characterized by flat areas alternating with undulated landscape.

Zone B: This zone is directly associated with agriculture practices, cattle raising and human settlement, and is limited in its lower elevation by Zone A elevation, and in its upper elevation by Zone C, with steep slopes inadequate for agriculture or cattle raising, a strong forest vocation, and existing altered forest patches isolated from one another by deforested land. The upper limit of this zone was set at elevation 200 m above sea level.

Zone C: The limit elevations Zone C are considered elastic, depending on the slopes, erosion risk and land vocation at different sectors, as visualized in the map, at the dam site and covering a cone on the left and right banks. Zone C extends from the water level up to elevation 300 m above sea level, given the pronounced slopes in this sector, and then gradually descends to meet elevation 200 m above sea level as the upper limit of Zone C circumscribing the area.

Total Areas for Zones A - B - C
La Esperanza

Area	Zone A	Zone B	Zone C
Km^2	32.89	124.02	48.26
ha	3,289	12,402	4,826

5.3 Actual Use of the Land

5.3.1 Poza Honda-zone A

The actual use of the land in Zone A is defined by the human use of the water resource:

- Cattle herds drinking water
- Bathing of hogs
- Docking for public transportation outboard motor boats.
- Accessing of scattered farmers to boats for transportation of produce. There are about 50 stop points for accessing people to the boats in the perimeter of the

reservoir.

- Washing clothing
- Swimming/recreation for local children, and for adjacent population during weekends
- Public bus stop associated with the docking of boats and unloading of produce from the surroundings.
- Public stand selling food and beverage at the docking site
- Solid waste disposal into the reservoir, derived from human activity in the surroundings.

The area is covered with grasses and scattered trees, as shown in Figure 5.3. Some people have already started to put fences in the water, trying to delimit an area for their own use, such as animal husbandry.

5.3.2 Poza Honda-zone B

The area is characterized by the existence of artificial grasslands, non-differentiated fruit trees, mainly oranges and citrics, and the association of coffee/cacao/bananas/citrics, as referred to Figure 5.3.

By interviewing different local dwellers, it is estimated that between 500-600 people inhabit the adjacent areas of the reservoir in this zone.The most significant human settlement is Las Mercedes, located at some 1.5 km from the eastern end of the reservoir, on the right side of the impoundment, and at some 0.5 km from the impounded water.

Estimated Number of Houses

	Las Mercedes I	Las Mercedes II
Number of Houses	40	38

The agricultural activities are carried out in slopes 30-70% or more, with the consequent erosion problems. The local practice of planting along the gradient of the slope increases the risk of erosion in the hilly areas.

Burning the brush down to the bare land is a common practice to "prepare" the land for planting.

5.3.3 Poza Honda-zone C

The area is characterized by steep slopes, in some cases higher than 70%, with the existence of isolated patches of tropical dry forest that have been altered by partial deforestation, and are alternating with totally deforested patches.

The land clearing for the expansion of the agricultural activities is an ongoing practice through the burning of brush before the rainy season starts.

Human settlement is reduced in this area, although a reduced number of scattered houses can be found along the extension of the reservoir length.

Actual Use of the Land
Poza Honda

Land Use	Zone A (ha)	Zone B (ha)	Zone C (ha)
Dense Forest	295	560	658
Low Dens.Forest	123	94	190
Total Forest	(418)	(654)	(848)
Pastureland	291	250	354
Annual Crops	43	60	11
Permanent Crops	71	128	2
Ponds	-	6.00	-
Populated Centers	-	7.00	-
Nude Soil	-	0.62	2.5

5.3.4 La Esperanza-zone A

Since La Esperanza reservoir is not operating yet, the use of the land in this area is not evident. None the less, people allocated in the area are culturally oriented to the use of the water resource, especially during the rainy season, when roads are inaccessible.

Similar uses as in Poza Honda are expected once the reservoir is in operation. The area is covered with grasses and scattered patches of forest. Adjacent to the dam site, slopes are very steep, and will immediately limit the water once the reservoir is full. This area has been considered as Zone C, or of forest reserve vocation although it limits the water. Erosion risk in this area is considered high, as indicated in Figures 5.2 and 5.4.

5.3.5 La Esperanza-zone B

This area will allocate most of the displaced dwellers from the reservoir inundation area. The area is characterized by steep slopes alternating with moderate slope areas, especially in the northern and southern branches of the reservoir.

The traditional activities are extensive cattle raising, and subsistence agriculture of plantain, corn, coffee and fruit trees, as shown Figure 5.4.

5.3.6 La Esperanza-zone C

The area is characterized by steep slopes, in some cases higher than 70%, with the existence of isolated patches of tropical dry forest that have been altered by partial deforestation, and are alternating with totally deforested patches, as shown in Figures 5.2 and 5.4.

The land clearing for the expansion of the agricultural activities is an ongoing practice through the burning of brush before the rainy season starts.

Human settlement is reduced in this area, although a reduced number of scattered houses can be found along the extension of the reservoir length.

Actual Use of the Land
La Esperanza

Land Use	Zone A (ha)	Zone B (ha)	Zone C (ha)
Dense Forest	386	3,619	2,008.4
Low Dens.Forest	130	4,196.2	300
Total Forest	(516)	(4,196.2)	(2,308.4)
Pastureland	2,769.4	8,132.2	2,477.6
Annual Crops	-	54.2	12.2
Permanent Crops	3.3	20	17.2
Ponds	-	-	-
Populated Centers	nd	nd	nd
Nude Soil	-	-	10.3

- Actual use of the land in La Esperanza was estimated based on the existing map and aereal photo information consisting of 37%, 20%, and 36% of the total area for zones A, B, and C respectively. Data for total area use was extrapolated from these figures with the aid of photography taken by satellite in February 1990 and October.1991

5.4 Potential Use of the Land

For Poza Honda, previous studies(17) determined that the adjacent areas of the reservoir are adequate for forest growth. The pronounced slopes in the area, and the high to very high erosion risk (50-200 Ton/ha/year to 2,200 Ton/ha/yr) estimated for this area in 1988 confirm this potential use.

For La Esperanza, the existing erosion in 1988 was considered moderate for most of the adjacent areas (10-50 Ton/ha/year), and high for the dam site adjacent cone located in both margins of the reservoir (50-200 Ton/ha/year). The risk of erosion was also considered high (50-200 Ton/ha/year). The recommended conservation practices are forestry plantations, forestry and grazing, and management for maintenance. In a lesser scale, the existence of soil types adequate for intensive agriculture (17).

Considering this potential use of the land, agroforestry and forestry plantations appear as the more adequate use for the areas adjacent to the reservoirs. None the less, considering the existing population in the area and their economic activity derived from agricultural and cattle raising practices, several strategies are to be considered to reduce the impact on soil erosion from these activities.

The following strategies have been considered as adequate to enhance soil conservation, reduce soil erosion, and increase land productivity for the local farmer. When improving the productivity of the land, the farmer will tend to follow the strategies proposed, which in turn will promote the conservation of the soil and eventually improve the conditions of water quality in the reservoirs.

The conservation strategies considered are the following:

Improvement of pasture areas
Agroforestry
Forestry and pasture land
Agroforestry and pasture land
Forestry plantations
Row plantations as sediment barriers
Construction of erosion ditches

5.5 Proposed Use of the Land

The program for prevention of the deterioration of the water quality is basically oriented towards an adequate use of the adjacent areas of the reservoirs, and the establishment of protection zones.

Since it is estimated that the mayor contribution to the eutrophied condition is derived from the agricultural, cattle raising, and human activities, these activities are to comply with sound management and planning practices such as the above mentioned.

5.5.1 Zone A-Poza Honda & La Esperanza

Zone A is the immediate land belt around the reservoir and must act as a buffer strip between human activity and the impoundment. This area is to be considered as a protected area with absolute restriction of any activity involving, but not restricted to, the following:

- Disposal of solid waste
- Disposal of liquid effluent
- Disposal of oils, lubricants and fuels
- Use of soaps and detergents
- Animal husbandry and water provision
- Washing of agrochemical equipment
- Installment of any type of commercial activity related to food, beverage, hotels, recreational houses, recreational boating facilities, etc.
- Urban development
- Deforestation

(1) Short term actions

The following activities already occurring should be organized and/or relocated in this zone without any delay.

(i) Docking facility at Poza Honda

The docking facility for outboard motor boats used for public transportation, located at some 100 m from the water intake of the treatment plant must be relocated to the tail end of the reservoir, on the right bank.

The future rehabilitation of the road will provide for proper access year round (dry and rainy season), eliminating the need for the docking site to be at the dam site end of the reservoir.

Operators of the public boat transportation business are to comply with regulations, such as:

1- Provide adequate toilets and sewage disposal through sesspits designed according to sound sanitary engineering practices and approved by competitive authorities.

2- Disposal of fuels, oils and lubricants is to be done in drums, and carried out of the area for proper disposal in a gasoline station or any other suitable disposable area.

3- Location of recipients for solid waste disposal in areas where human activity is occurring, and extraction of the waste outside of the reservoir area.

4- Limit the operational area of the "port" to that designated by CRM, where catwalks are to be installed to avoid people and produce transit in the bare soil.

5- The area utilized for the loading and unloading of trucks, and people transit is to be paved or asphalted, to provide adequate conditions for the activity.

6- The flow of boat users towards the reservoir coming from different points (50 points) is to be assessed in order to centralize the flow of users to a minimum number of landing spots, where a rustic roofing could be provided to shelter users, and to landmark the spots. This measure will ensure that the daily traffic of people through the restricted zone is predetermined, and open access is available for this purpose.

Further evaluation by CRM concerning the minimum number of boats for public and produce transportation is suggested. To minimize the number of boats circulating in the reservoir, dispositions and regulations should be issued and enforced.

(ii) Animal husbandry

All activities involving access of animals to the reservoir for bathing, drinking or others is to be stopped by fencing Zone A at the preestablished elevation. Other measures suggested are the installment of signs alerting the people to keep out the animals, which should be set every 1 km throughout the perimeter of the Zone, in visible areas for people to see.

All fences and land divisions existing in this area are to be removed, to regain control over the area, and people insisting to this activity should be sanctioned according to the law.

The above measure is in accord with Article 1 of the Ministry agreement for the conservation and maintenance of reservoirs and impoundments, Official register # 549, March 20, 1978.

Strategically located water wells and water tanks for cattle is a suggestion to be further analyzed, in order to detour the animal flow from the reservoir during the dry season. This infrastructure is to be promoted by CRM by providing assessment of best area for drilling, manpower, drilling, casing, and water tank for cattle, and the farmer could provide the pump and maintenance.

(iii) Washing clothing

Direct use of soaps and effluent disposal of soaps in the reservoir must be stopped. CRM should promote the drilling of strategically located wells, where people with difficult access to water could supply themselves without accessing the impoundment.

The alternative of establishing "washing areas" for clothing in Zone B, where women could come instead of accessing the impoundment is to be evaluated. Proper design for the disposal of soaps is to be considered in this option.

(2) Medium term actions

(i) Reforestation

Zone A is to be reforested with native species for the multiple purpose of soil protection, enhancement of the environment for tourism purposes, and attraction of birds and other fauna in order to recreate the biodiversity of the environment.

Proposed Use of the Land
Zone A-Proposed Reforestation Area

Area Type	%	Poza Honda	La Esperanza
(1) Total Area (ha)	100	823	3,289
(2) Forested Area (ha)	51	418	516
(3) Grassland Area (ha)	35	291	2,769.4
(4) Area (ha) to beReforested= 80%of (3) @ 300 trees/ha	28.3	233	2,215.5

It is suggested that local species existing in the upper slopes of the area be considered for the purpose, especially those bearing fruits edible to the local animal species. This will attract fauna and contribute to the tourist attraction of the area in the future.

Seedlings and newborn trees could be found in the vicinity of the existing forest patches in the upper slopes, and local people could derive an extra income by collecting the seeds and selling them to the program. These newborn plants are to be transported to nurseries, and nourished until they acquire an adequate size for direct planting into the ground.

Some species of trees suggested for Zone A are listed below:

COMMON NAME	SCIENTIFIC NAME
Mara–on	Anacardium excelsium
Guayacan	Tabebuia sp.
Caimito	Ponteria caimito
Guaba	Inga educis
Arbol de pan	Antocargus edulis
Mamey	Mamea americana
Zapote	Copposis sp.
Algarrobo	Prosopis juliflora
Laurel blanco	Cordia alliodora
Roble	Tabebuia pallida

5.5.2 Zone B-Poza Honda & La Esperanza

This area is to be considered as a protected area of multiple use with restrictions. Since this area is occupied by 500-600 people living as farmers and cattle raisers, the absolute preservation of the Zone is not recommendable given the social impact to be caused. None the less, the activities derived from the population must be regulated and restricted in several uses to gain control over erosion, deforestation and non punctual pollution sources originated in this area.

The following activities should be prohibited:

- Deforestation and use change of the forested area
- Mining and/or installation of any kind of industry
- Installation of massive animal husbandry industries such as poultry, hogs or others
- Installation of hotels and massive tourist facilities
- Burning practices to clear the land for planting without proper control mechanisms to avoid forest fires.

(1) Short term actions

The following activities already occurring must be put to an end and the pertinent legislation is to be enforced without delay.

(i) Deforestation and burning

The expansion of the agricultural area is evident in the upper slopes of this Zone. Cleared patches of deforested land, isolate sectors of altered tropical dry forest throughout the landscape, and planting of crops is done on steep slopes, sometimes exceeding 70%, in rows parallel to the slope of the hill. The area is considered as of medium to high risk of erosion, with a moderate erosion rate of 10-50 Ton/ha/year by 1988.

It is very urgent that CRM put a stop to the actual deforestation practices occurring in this area, and that CRM puts in effect the existing legislation to this matter. A suggested mechanism to enforce the legislation is to coordinate with the regional office of INEFAN in the Manab' province and allocate at least 2 forest guards in Zone B.

(2) Medium term actions

Reforestation of degraded areas with slopes more than 70% have been recommended in previous studies (17). A significant change in the use of the land, oriented towards the elimination of the forested areas and the increment of the cleared land for agriculture and cattle raising has taken place in the adjacent areas of the reservoirs, including areas with slopes higher than 70%, which are exclusive areas for forest growth, accelerating the erosive process.

The actual situation demands that soil conservation practices be implemented in the area, such as the strategies previously mentioned.

(i) Agroforestry

A mixture of reforestation and agriculture on areas with 40-70% slope have been proposed by previous studies (17).

The system aims to combine annual crops and permanent crops with reforestation of endemic trees, to improve the soil coverage.

Some species adequate for this purpose are the following:

Common Name	Scientific Name
Laurel	Cordia alliodora
Pachaco	Chizolobium parahibum
Guachipeli	Albisinia guachapele
Cedro	Cedrella odorata
Leucaena	Leucaena leucocephala
Roble	Tabebuia pentaphylla

Permanent crops, such as cofee and cacao, are to be intermixed with the above species of trees. Pasture lands existing in high slope areas should be converted into crops such as cacao and coffee.

It is recommended that a demonstrative area be implemented with improved varieties of cacao and coffee, and appropriate management practices such as higher plant density, erosion ditches, erosion interceptor plant barriers, trimming of plants, etc. to demonstrate the local farmers the benefits of such system.

The estimated area to be covered by this strategy is:

Proposed Use of the Land
Zone B-Agroforestry for Pasture Land

Item	Land Use	%	# of Plants per ha.	Poza Honda (ha)	La Esperanza (ha)
(A)	Agroforestry in Slopes < 70%				
Total Area Zone B				1,106	12,402
(1)	Pasture Area	100	-	250	8,132
(2)	Proposed Agroforestry Area = (3) + (4)	20	-	50	1,626
(3)	Agroforestry,& Annual Crops = (3.1) + (3.2)	10	-	25	813
(3.1)	Forestry Plantation	6	1,110	15	488
(3.2)	Annual Crops	4	200	10	253
(4)	Agroforestry & Permanent Crops = (4.1) + (4.2)	10	-	25	813
(4.1)	Permanent Crops	6	200	15	488
(4.2)	Forestry Plantation	4	1,110	10	325

(ii) Forestry plantations and grazing

The main purpose of this strategy is to plant trees following given elevations in areas covered with pasture. Through this strategy it is expected that the erosive process will be diminished, and that the use of specific areas of pasture be used in a rotative schedule, to avoid their degradation.

Forestry plantation and trees to be planted under this strategy will serve for soil retention and will also provide supplemental feeding to cattle. Previous studies (17) have identified pasture land areas with slopes between 40 and 70% as the ones to be implemented with this strategy.

Species suggested to be planted in these areas are the following:

Common Name	Scientific Name
Algarrobo	Prosopis sp.
Leucaena	Leucaena sp.
Cracol	Eytricia sp.
Yuca de Raton	Glericidia sp.
Faique	Acacia macracanta
Caoba	Switenia machrophylla
Cedro	Cedrella odorata
Guayacan	Tectoma crysantha
Guachipeli	Pseudosamanea guchapele
Feman Sanchez	Triplaris guayaquilensis

The use of Teak (Tectona grandis) and Saman (Samanea saman) is not recommended for pasture areas because of the plentiful leaf drop covering the ground, and inhibiting grass survival.

The use of Faique (Acacia macracanta) has given good results when used for reforestation and grazing purposes (36). The legumes serve as supplemental food for cattle, branches are good for firewood, and the wood is commercialized for the aggregate type floors industry

The establishment of live fences contributes to the reforestation while serving a fence purpose. Trees planted for shade purpose are scattered throughout the pasture land and initially protected by small fences to avoid cattle stepping on them.

Trees planted by following specific elevations will serve to retain erosion. These are planted in high densities, perpendicularly oriented to the slope direction. When planted for barriers, trees could be planted at high densities. Best experiences have been reported with Leucaena, and it is considered that double rows of this plant separated from each other by 10 m, and with 2.5 m between plants provide the best barrier for erosion control.

The distance between 2 barriers of Leucaena should vary according to the slope of the land, closer barriers are recommended for higher slopes, ie. 25 m for 10% slope, and 6 m for 35% slopes. The approximate amount of Leucaena seed required is 1 kg/100 m.

It is also recommended to establish a demonstrative farm where improvement of pastures by seeding roughage legumes, fencing and sectioning of the land for rotational use, live fences, etc. will allow for the demonstration of a higher carrying capacity of the area.

The possibility of introducing the local cattle breed Criollo or Runa, a hardy species very resistant to parasites and diseases should be evaluated to be a compliment of the demonstrative farm and as an alternative for the local producers.

The estimated number of hectares to be implemented with this strategy in Zone B is summarized in the following table

Proposed Use of the Land
Zone B-Forestry & Grazing

Item	Land Use	%	# of Plants per ha.	Poza Honda (ha)	La Esperanza (ha)
(B)	Forestry Plantations and Grazing in Slopes < 70%				
	Total Area Zone B			1,106	12,402
(1)	Pasture Area	100	-	250	8,132
(2)	Proposed Area	80	-	200	6,506

(iii) Agroforestry and grazing

This strategy includes a mixture of the above mentioned methods, and it is to be implemented with the previously mentioned species. The combined system aims at a multiple use of the productive area, and it is to be applied where socio-cultural practices determine that this mixed system is the most recommended, and/or where terrain conditions dictate it.

(iv) Forestry Plantations

Areas with slopes higher than 70%, actually covered with pasture land are adequate for forestry plantations. Plantations with an estimated 20% exploitation rate for the production of firewood and charcoal, with a rapid natural regeneration time could use the following species:

Common Name	Scientific Name
Leucaena	Leucaena sp.
Jasmin	Melia arederach
Fernan Sanchez	Tryplaris guayaquilensis

Plantation forests with an estimated 50% exploitation rate for the production of commercial wood of high value in the market will use the following species:

Common Name	Scientific Name
Caoba	Switenia macrophila
Cedro	Cedrella odorata
Laurel	Cordia alliodora
Balsa	Ochroma lagopus
Amarillo, Lagarto	Centrolobium patinense
Gomelina	Gmelina arborea

The proposed density is of 1,100 plants/ha, with a resulting planting distance of 3x3 m. This density is considered high, and the purpose is to provide maximum coverage area to protect areas with high erosion risk.

Areas with high risk of fire will be adequate for Teak (Tectona grandis). In view of its adaptability to fires, experience with teak (36) has proven that a density of 625 trees/ha is recommendable.

Proposed Use of the Land
Zone B-Forestry Plantations

Item	Land Use	%	# of Plants per ha.	Poza Honda (ha)	La Esperanza (ha)
(C)	Forestry Plantations in Slopes > 70%				
	Total Area Zone B			1,106	12,402
(1)	Area of Slope > 70%	100	1,100	48	3,112
(2)	Proposed Area	100	1,100	48	3,112

(v) Improvement of pasture lands

Most of the existing cattle raising farms in the area are extensive, with an average of

0.7 animals/ha, because of absence of rotational pasture areas, grazing in inadequate areas, and using natural grasses with low nutritional value (17).

With a program aiming at the improvement of the productive activity, which at the same time will minimize the erosive effects of the actual practice, the following activities are to be implemented:

- Fencing out of specific areas to allow rotation of grazing areas and a more efficient use of the pasture area.
- Disease and parasite control
- Identification and marking of the animals
- Identification of mating stage
- Eradication of weeds
- Introduction of new breeds for the improvement of the genetic pool
- Implementation of erosion ditches as energy reducers to reduce soil loss
- Maintenance of the pasture growth at a certain height

It is recommended that the Saboya type grass is maintained, given its adaptability to the area and its resistance to drought. With the implementation of the above mentioned measures, it is estimated that the carrying capacity of the pasture land should be increased at least to 1 animal/ha. Experiences with the local Runa breed have good results with 2 animals/ha at Daule-Peripa (36).

Legumes are considered as plants that will improve soil in nitrogen content, organic carbon, available phosphorus and others. The compatibility of legumes and grasses increases when the grasses used grow in bundles, such as the Saboya grass used in the area. It is desireable then to introduce legumes by spreading the seed before the rainy season. Legume seeds such as roughage soy and centrosema are recommendable for the improvement of pasture areas in amounts of 1 and 4 kg/ha (19).

The estimated area at Zone B to be implemented with this strategy is summarized as follows:

Proposed Use of the Land
Zone B-Grassland Areas

Area/Slope	Poza Honda (ha)	La Esperanza (ha)
Total Grassland Area	250	8,132
Grassland Area with >70% slope	48	3,112
Grassland Area with <70% slope	202	5,020

(vi) Bamboo planting

For the protection of gulches carrying runoff from the higher areas, and to reduce the erosive effect of the water flow on the margins of these gulches, the planting of Bamboo is suggested.

Bamboo favors the development of thick growths, is a fast growing plant, and has deep roots, fixing unstable areas and stabilizing slopes, avoiding slides and reducing erosion, and it is widely used for construction purposes throughout the province. Its availability will reduce the pressure over the existing forest for construction material.

Species that have been reproduced in nurseries at CEDEGE are the following:

Guadua aculeata Repretech
Guadua angustifolia kunth
Bambusa vulgaris Nakai
Bambusa vulgaris var.Striata Nakai
Bambusa tulda Roxb
Bambusa tulda c.v. Stripe
Dendrocalamus giganteus Munro
Phyllostachys bambusoides Steb & Zucc
Phyllostachys aurea A. et C. Riviere
Dendrocalamus asper Backer
Bambusa edulis Keng
Bambusa textiles Mc. Clure
Bambusa polymorpha Munro
Bambusa tuldoides munro
Bambusa multiplex Raenschel
Melocanna baccifera (Roxb.)Skeels

Best results have been obtained using Bambusa vulgaris (striata), given its resistance to drought and floods.

It is also recommended to plant bamboo along the upper elevation mark of Zone A, to act as a barrier for erosion runoff coming from the upper slopes. The bamboo band is to go around parallel to the reservoir perimeter and around it. The estimated length of this band is 41 Km.

(vii) Road drainage in Poza Honda

The existing access road is to be improved as an access road to accomplish the construction of the tunnel portal at the tail end of Poza Honda reservoir. This access road is located at the lower limit of the defined Zone B, and the runoff from the above slopes eventually meets the road. At the same time the unprotected surface of the road exposed during the rainy season is a source of sediment and an erosive exposed area itself.

It is recommendable that the improvement of the road for the project purposes includes adequate lateral drainage structures, with energy dissipators in areas of pronounced slope, and adequate sediment collectors throughout the length of the road, according to sound road engineering practices.

The sediment collectors can be cleaned and maintained periodically, especially at the beginning of the rainy season, and the water channelized by the lateral drainage can be disposed off with a reduced sediment load.

(viii) Sewage and waste disposal in Poza Honda

According to local interviews, the estimated population living in the area is between 500-600 people. Most of the people are scattered throughout the area, and two settlements appear as the areas of mayor concentration of people in one place: Las Mercedes I and Las Mercedes II. These settlements have incipient sewerage disposal systems that could be improved.

The urban area at las Mercedes has streets of bare soil, favoring erosion during rainy season, and the runoff of the area located at a higher elevation in respect to the reservoir eventually ends up in the reservoir through the existing gulches. Solid waste disposal is done in the vicinity areas of the settlement, causing disease spreading. It is also assumed that some of the waste eventually finds its way down to the reservoir or its immediate vicinity.

The following are recommendations for Las Mercedes settlements, in an effort to reduce the output of sediment and sewage, and to enhance their quality of life:

Construct adequate lateral drainage ditches along both sides of the existing roads at Las Mercedes, according to sound road engineering practices, including energy dissipators and sediment collectors along the slope.

Provide road bed coverage, such as asphalt to reduce erosion of the bear soil road bed.

Promote the coverage of areas adjacent to the road with grasses, and promote the planting of trees along the road and throughout the neighborhood. Incentives to landscape the residential areas in the settlements can be related to the creation of the nurseries for reforestation. These nurseries could be an economic activity carried out by the locals with proper technical advise, and at the same time the entrance door for the environmental education program to be implemented among the population.

Implement for the proper disposal of sewage effluent through design and construction of adequate sesspits and sewage disposal systems for rural areas.

Allocate landfill for the proper disposal of solid waste for the community. The landfill is to be associated with an area for recycling of organic matter to generate compost that will be purchased from the community for the plant nursery. This program is to be integrated with the environmental education program and with the plant nursery, while at the same time will provide an improvement in quality of life and an extra income for the community.

Other activities associated with the production of compost through organic matter disposal is the culture of earth worms. These will be sold to the tourists interested in fishing, and to the nursery project for soil enhancement. Eventually, through the environmental education program, these will be sold to the local farmers to enhance the nitrogen content and aeration of the planting soil, which in turn will reduce the need for nitrogenous fertilizers.

The participation of IEOS, Instituto Ecuatoriano de Obras Sanitarias, as the official institution dealing with sanitary works is advisable for the design and implementation of proper sanitary disposal of sewage.

(ix) Involuntary resettlement-La Esperanza

In La Esperanza, the existing settlements will be inundated with the reservoir, and the relocation process is an ongoing process today. Most of the people will be relocated in adjacent lands located at higher elevations, and it has been established that the established buffer zone (Zone A) must not have inhabitants allocated. So it is important to relocate these people in Zone B.

The relocation plan should follow the general guidelines appended to this report for involuntary resettlement, and the sanitary and waste disposal considerations established for the human settlements in Zone B- Poza Honda are applicable also for La Esperanza and must be considered in the resettlement planning process.

5.5.3 Zone C-Poza Honda & La Esperanza

This area is considered for absolute protection, where no human activity should be allowed. The area is partially covered with isolated patches of altered forest between cleared areas with varying degrees of deforestation.

The area has the possibility of regeneration if left untouched, and in the areas where the isolation between forested patches is large, reforestation by human intervention will accelerate the process.

The following activities should be prohibited:

- Deforestation and use change of the forested area
- Burning practices to clear the land for planting

(1) Short term actions

The following activities already occurring must be put to an end and the pertinent legislation is to be enforced with no delay.

(i) Deforestation and burning practices

The expansion of the agricultural area is evident in this Zone. Cleared patches of deforested land isolate sectors of altered tropical dry forest throughout the landscape, and planting of crops is done on steep slopes, sometimes exceeding 70%, in rows parallel to the slope of the hill. The area is considered as of high risk of erosion.

Actual Use of the Land
Zone C-Deforested Area

	Poza Honda (ha)	La Esperanza (ha)
Total Area Zone C	1,217	4,826
Densely forested Area	658	2,008
Low Density Forested Area	190	300
Grassland Area	354	2,478
Permanent Crops	2	17
Annual Crops	11	12
Nude Soil	2.5	10.3

It is urgent that CRM implements the periodic vigilance of this area with forest rangers, and that the existing legislation be applied by prohibiting the ongoing deforestation and the confiscation of saws and axes from the infractor, as well as with the issuing of fines. The implementation of forest rangers in the area is outlined in the vigilance section of this report.

(2) Medium term actions

Medium term actions foresee the continuation of the vigilance program with forest rangers, the implementation of the existing forestry law and the environmental education of the farmers through the technical assistance program, and the establishment of forestry plantations in Zone B as a medium term alternative for wood extraction.

The previously mentioned strategies and activities for Zone B will enhance the income and quality of life along with a continuous environmental education process to bear fruit in the mid and long term basis.

Alternatives for deriving an income from the forest are through the nature tourism oriented visitor. Activities such as bird watching, forest walks, etc. will be an alternative that requires the forest knowledge and preservation by the community, while deriving an income as guides and from the tourist expenditures in the area.

5.6 Impounded Area Before Submergence

5.6.1 Plant biomass clearing

Before filling up La Esperanza reservoir, the vegetation such as trees, brush and crops should be removed from the reservoir area by extraction or by burning the brush and remaining plant cover. The purpose is to avoid future organic matter decomposition in the impoundment, reducing the risk of eutrophication in the water body.

The following requirements are to be considered for the proper elimination of the biomass:

One or more companies are to be contracted for the extraction of the vegetable material existing in the impoundment area.

The companies should do the work during the dry season, to avoid access problems and plugging of river channels with branches and other vegetable materials resulting from the cutting in rainy season.

One or more forestry professionals are to be hired to supervise the cutting and extraction. Supervision must consider:

- That the maximum elevation of the deforestation should not be exceeded by the loggers.
- That all vegetable material must be extracted, not only the valuable wood.
- That the work is scheduled to be finished in anticipation of the rainy season and the filling.
- That the remaining vegetable matter is burned.
- That the loggers fulfill the contract.

5.7 Impounded Area After Submergence

On the reservoir itself it is advisable to prevent the spreading of the water hyacinth to uncontrollable situations.

The plant cover provides abnoxious smell, coloring matter and suspended particular matter in water. Floating mats provide excellent habitat for rats, and the evapotranspiration rate from water hyacinth cover is very high, and the plants provide habitat and food for vectors of disease like malaria, encephalitis, schisostomiasis etc. The production of biomass is estimated at 350-450 ton/ha at 26-30 C, (35).

The following species of aquatic plants have been identified at Daule-Peripa reservoir:

Common Name	Scientific Name
Jacinto de agua	Eichornia crassipes
Lechuga de agua	Pistia stratiotes
Salvinia	Salvinia sp.
Sombrerito de agua	Hydrocotile sp.
Hoja de buitre	Limocharis flava

Eichornia crassipes is the most abundant, between 1987 and April 1991 the surface area coverage has increased from 20 ha to 12,000 ha, estimated growth rate is 4,000 ha/year (18).

5.7.1 Aquatic plant infestation

The immediate water areas around the Conguillo tunnel inlet are completely covered by water hyacinth. The aquatic plant is in good health and it is assumed that by August 1994 the coverage area is around 22,000 ha, due to the reduced extraction and/or control implemented at the Daule-Peripa reservoir. The immediate areas surveyed (3 km upstream) is completely covered with the plant. The water quality condition of the reservoir and its tendency towards eutrophication is an adequate medium for the plant growth.

(1) Possible impacts

Since the transbasin operation conveys the lowering of the water level at this point, it is expected that massive volumes of Eichornia could access the tunnel, and will be transported to La Esperanza reservoir where they will reproduce and infest the reservoir at an expected growth rate similar to that occurring at the Daule-Peripa .

Some problems associated with the massive growth of this plant include:

- Hampering of boat accessibility.
- Reduction of dissolved oxygen in the water.
- Sustenance for disease vectors such as mosquitos, rats, and mollusks, etc.
- Limiting light penetration and promoting anoxic conditions limiting water quality conditions for fish.
- Enhancement of excessive evapotranspiration. Water loss has been estimated in 3.5 times that of a free water surface (52).
- Blockage of valves and water control structures.
- Abnoxious smell, colouring matter and suspended particular matter in water.

According to Table 3.2 the future water quality at La Esperanza would be better in BOD and COD, but worse in T-N and T-P. In Poza Honda, the water quality could be improved except for COD.

The physical characters of the reservoirs are summarized as follows:

Item	Daule-Peripa	La Esperanza	Poza Honda
Impoundment Are (Km^2)	270	29	6.1
Reservoir Fetch (Km)	100	22	14
Configuration	Branched	Branched	Non Branched

Colonization of La Esperanza is considered high since the water quality conditions are predicted to be worse in T-N and T-P, and the configuration of the reservoir is of a brancked type, with channels that will favor the enclosure of the plant, as is the case in the Daule-Peripa .

In Poza Honda the possibility of colonization is considered low, since the T-P condition is to improve, and the reservoir fetch combined with the non-branched configuration allows an efficient discharge of the plant over the spillway during the rainy season, when river flows are maximized towards the dam site.

(2) Recommended actions

At the inlet portal area at Conguillo, the problem of aquatic plant infestation of Eichomia crassipes could be resolved by two complementary strategies:

1-Short term strategy: Physical isolation of an area adjacent to the inlet, to avoid masses of plants to access the tunnel while operating in the immediate future, as explained in the design works for the Daule-Peripa ~ La Esperanza tunnel inlet.

2-Medium term strategy: To coordinate with CEDEGE for the implementation of the same control mechanism.

(3) Short term strategy

In the design of the civil works for the Daule-Peripa ~La Esperanza tunnel inlet there is proposed a control system for the aquatic plant. Its implementation must follow the specifications set for this system.

(4) Medium term strategy

To coordinate with CEDEGE the actions to be developed for the control of the aquatic plant, whose objective would consist in eliminate the excessive growth of the plant, by using, speciphically the hydraulic control. The control may be necessary in Poza Honda and La Espenraza reservoirs.

1.- To prevent the blockage of navigation channel
2.- To eliminate the substratum for vector of diseases
3.- To reduce the organic matter efluents that may cause euthrophication problems
4.- To avoid excessive evapotranspiration from the reservoirs
5.- To lessen the risks of physical deterioration of the dam works

As a reference, two methods actually employed by CEDEGE for the control of aquatic plant in the Daule-Peripa reservoir is herewith explained:

(i) Mechanical control methods

Using floating platforms, the method is based on the accumulation of plants in floating platforms made of bamboo, where the load is left during 24 hours to reduce the water content, and then the weeds are pulled to the edge to be disposed of. This method, common in Taiwan, has been adopted at Daule-Peripa , and the cheapest in cost.

Pulling and extraction methods consist of the enclosing of floating mats with bamboo, and pulling with a motor boat to the edge, where mechanized equipment such as backhoe can pull it out. This method has achieved an efficiency of 6,000 m^2/8 hour period, and it is efficient when the backhoe can access the load.

Pulling and releasing through the dam overflow is the cheapest, most practical and efficient method being used at the Daule-Peripa reservoir.

(ii) Chemical control methods

Successful results were obtained by CEDEGE using 2-4D Amina herbicide at a doses of 5 l/ha with spraying devices. This is the most economical method proven. The product is considered biodegradable, but it is advisable to use it only in critical conditions, and not as a routine practice.

The negative aspect of this method is that the dead plants will sink to the bottom in massive amounts at one time, and will release large amounts of nutrients accelerating eutrophication conditions. For this reason it is not advisable to rely on this method.

5.8 Plant Nursery Implementation

Existing efforts by the Portoviejo church and the Finland embassy in Quito have implemented a tree nursery project for reforestation purposes. Technology and implementation is carried out by Enso Forest Development Ltd. of Finland, and in an effort to make use of the existing experience in Portoviejo, Enso Forest Development appears as a viable alternative for the implementation of tree nurseries required for this project.

A description of a prototype forest tree nursery prepared by Enso is appended to this report. The proposal for 2 nurseries should supply 3,000 ha of reforested land, and each nursery will require an estimated 2 ha area, one nursery expert, an Ecuadorean counterpart, one mechanic and 12 workers.

5.9 Credit availability for farmers

Credit availability for farmers interested in reforestation has to be an incentive for the farmer. Interest rates should be low and payment term should be in accord with the growth and harvest period of the specie to be utilized. Present interest rate at 34% per year and 1-2 years repayment period for agriculture and cattle raising are not attractive for reforestation.

Some sources of credit to be approached are the following:

1- Ministry of Agriculture (MAG), through INEFAN department has a program (PLANFOR) for reforestation, presently enough to cover 1,000 ha in the Manab' province. Future expectations include the expansion of this fund through injection of international resources. The refund of 70% of the cost of reforestation can be expected because previous inspection of the plantation assured that 70% survival had been achieved.

2- The Banco de Fomento will be in disposition of participating in a joint program with MAG, INEFAN or other agencies capable of backing up a subsidy for such loans.

   The Bank could also implement a series of requirements for farmer approaching the bank, related to the execution of environmental management practices as a condition to receive a traditional loan for farming or cattle raising.

3- Other sources to be approached are international funds for forestry oriented projects, such as debt for nature swaps, Interamerican Development Bank (IDB) special funds for reforestation, and the foreign aid programs of the Finland embassy in cooperation with ENSO Forest Development Ltd., a company in Finland already operating a nursery for trees in Portoviejo, through the Portoviejo church. Other embassies to approach are suggested: Holland, Switzerland, Norway, Denmark and Germany, which are interested in these areas.

CRM should research the available mechanisms and assist the farmer in the bureaucratic paperwork, expediting and simplifying the procedure, in an effort to make the credit simple to obtain for the farmer.

6. BASIC PROGRAM FOR CONSERVATION OF MANGROVE AND CHAME HABITAT

6.1 Estuary Importance

The mangrove ecosystem has an intrinsic value as recipient of living systems. The products of the mangrove system have important commercial, scientific and recreational value, and they are an important part of the overall equilibrium of the coastal ecosystem.

The functions associated with the mangrove ecosystem are related to the production of plant biomass, nutrient recycling, detritus production, protection of channel margins, preservation of water quality, habitat and nursery for commercially important species and coastal erosion protection.

Significant commercial activities for the country such as shrimp culture depend on this ecosystem for the provision of post-larvae and water supply of adequate quality. Local economies depend heavily on the ecosystem through the capture of crabs, fish, mollusks and crustaceans, and emerging economic activities of importance such as ecotourism are starting to approach this type of ecosystem with an educational interest throughout the tropical world and Ecuador in particular.

Some of the fauna of aesthetic, scientific and commercial value associated with the mangrove habitat in Ecuador has been identified by PMRC (39):

Birds

Pluvialis squatorola	(migratory)
Numenius phaeopus	(migratory)
Catoptrophorus semipalmatus	(migratory)
Tinga sp.	(migratory)
Pelecanus occidendalis	(resident)
Columbina sp.	(nesting)
Fregatta magnificens	(resident)
Eudocimus albus	(frequent)
Mycteria americana	(frequent)
Casmerodius albus	(frequent)
Egretta sp.	(frequent)
Nycticorax sp	(frequent)
Phalacrocorax olivaceus	(frequent)
Pandion haliaetus	(migratory)
Rostrhamus sociabilis	(migratory)

Other birds identified by Ortiz, 1991:
Nycticoraz nycticoraz
Nyctanassa violaceale
Egretta alba
Egretta thula
Ardea herodias
Phalacrocorax olivaceus
Eudocimus albus
Ajaja ajaja
Mycteria americana
Bistoridis striatus
Pandion haliaetus
Chlorocervle amazona

Mollusks

Anadara tuberculosa	(resident, commercial)
Anadara similis	(resident, commercial)
Crassostrea columbiensis	(resident, commercial)
Mytella guyanensis	(resident, commercial)
Littorina sp.	(resident)

Crustanceans

Penaeus occidentalis	(resident, commercial)
Penaeus vannamei	(resident, commercial)
Penaeus stylirrostris	(resident, commercial)
Ucides occidentalis	(resident, commercial)
Goniapsis pulchra	(resident)
Callinectes arcuatus	(resident, commercial)
Cardisoma crasum	(resident, commercial)

Fish

Mugil sp	(resident, commercial)
Dormitator sp	(resident, commercial)
Isopisthus sp	(resident)
Aequides rivulotus	(resident, commercial)
Hoplios microlepis	(resident, commercial)
Gobionous maculatus	(resident, commercial)
Rhamdia sp.	(resident)
Centropomus sp.	(resident, commercial)
Brycon sp.	(resident)
Poecilia sphenops	(resident)
Plectostomus sp.	(resident)