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FINAL REPORT

VOLUME V

MAIN REPORT

(ANNEX 3)

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JAPAN INTERNATIONAL COOPERATION AGENCY

CENTRO DE REHABILITACION DE MANABI (CRM)
THE REPUBLIC OF ECUADOR

THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE - PORTOVIEJO RIVER BASINS

FINAL REPORT
VOLUME V
MAIN REPORT

(ANNEX 3)

5.ENVIRONMENTAL STUDY

MARCH 1995

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FINAL REPORT

LIST OF REPORTS

Volume	Title
I.	MAIN REPORT (SUMMARY)
II.	MAIN REPORT
III.	MAIN REPORT (ANNEX 1)
	1. DESIGN CRITERIA
	2. HYDROLOGICAL STUDY
	3. WATER TRANSBASIN PLAN
IV.	MAIN REPORT (ANNEX 2)
	4. GEOLOGY AND CONSTRUCTION MATERIALS
V.	MAIN REPORT (ANNEX 3)
	5. ENVIRONMENTAL STUDY
VI.	DESIGN CALCULATION REPORT
VII.	QUANTITY CALCULATION REPORT
VIII.	CONSTRUCTION PLAN AND SCHEDULE
IX.	COST ESTIMATE
X.	IMPLEMENTATION PROGRAM
XI.	DESIGN DRAWINGS

FINAL REPORT

MAIN REPORT - GENERAL CONTENTS

Volume I. MAIN REPORT SUMMARY

Volume II. MAIN REPORT

PREFACE
LETTER OF TRANSMITTAL
TABLE OF CONTENTS
LIST OF TABLES
LIST OF FIGURES
LIST OF DRAWINGS
ABBREVIATION

Chapter 1 GENERAL
Chapter 2 REVIEW OF PREVIOUS STUDIES
Chapter 3 STUDIES AND INVESTIGATIONS
Chapter 4 DESIGN
Chapter 5 CONSTRUCTION PLAN AND SCHEDULE

TABLES
FIGURES
DRAWINGS

Volume III. MAIN REPORT ANNEX 1

1. DESIGN CRITERIA
2. HYDROLOGICAL STUDY
3. WATER TRANSBASIN PLAN

Volume IV. MAIN REPORT ANNEX 2

4. GEOLOGY AND CONSTRUCTION MATERIALS

Volume V. MAIN REPORT ANNEX 3

5. ENVIRONMENTAL STUDY

ANNEX 3

ENVIRONMENTAL STUDY

TABLE OF CONTENTS

Page

1. EXECUTIVE SUMMARY ---- 1-1

1.1 Objectives and Approach ---- 1-1

1.1.1 Summary of project actions recognaissance ---- 1-1

1.2 Water Quality Analysis ---- 1-2

1.2.1 Sampling ---- 1-2

1.3 Water Quality in Reservoirs ---- 1-3

1.3.1 Eutrophication ---- 1-4

1.3.2 Suitability of reservoir water for various uses ---- 1-6

1.4 Water Quality in Rivers and Estuaries ---- 1-8

1.4.1 River flow regime ---- 1-8

1.4.2 Pollution load analysis ---- 1-9

1.4.3 Pesticides and fecal pollution ---- 1-12

1.4.4 Salinity measurements ---- 1-13

1.5 Environmental Management and Conservation Programs ---- 1-14

1.5.1 Program for prevention of water quality deterioration in reservoirs ---- 1-19

1.5.2 Basic program for conservation of mangrove habitat ---- 1-21

1.5.3 Basic program for the conservation of Chame and wetland habitat ---- 1-22

1.5.4 Operation program for Simbocal tidal gate ---- 1-27

1.6 Recommendations ---- 1-28

1.7 Environmental management and monitoring plan ---- 1-30

1.7.1 Management and operational costs ---- 1-30

1.7.2 Cost per program ---- 1-32

2. PROJECT ACTIONS RECONNAISSANCE ---- 2-1

2.1 Introduction ---- 2-1

2.2 Project Actions ---- 2-1

2.2.1 Daule Peripa-La Esperanza diversion tunnel ---- 2-1

2.2.2 Severino pumping station ---- 2-2

2.2.3 Severino open channel ---- 2-2

2.2.4 La Esperanza-Poza Honda diversion tunnel ---- 2-2

2.2.5 Poza Honda-Mancha Grande diversion tunnel ---- 2-3

2.2.6 Daule Peripa-Severino transmission line ---- 2-3

Page

2.2.7 Access roads ---- 2-3
2.3 Existing Conditions ---- 2-4
2.3.1 Daule Peripa-La Esperanza diversion tunnel ---- 2-4
2.3.2 Severino pumping station ---- 2-4
2.3.3 Severino open channel ---- 2-5
2.3.4 La Esperanza-Poza Honda diversion tunnel ---- 2-5
2.3.5 Poza Honda-Mancha Grande diversion tunnel ---- 2-5
2.3.6 Daule Peripa-Severino transmission line ---- 2-5
2.3.7 Access roads ---- 2-6
2.4 Possible Impacts ---- 2-7
2.4.1 Daule Peripa-La Esperanza diversion tunnel ---- 2-7
2.4.2 Severino pumping station ---- 2-9
2.4.3 Severino open channel ---- 2-9
2.4.4 La Esperanza-Poza Honda diversion tunnel ---- 2-10
2.4.5 Poza Honda-Mancha Grande diversion tunnel ---- 2-10
2.4.6 Daule Peripa-Severino transmission line ---- 2-10
2.4.7 Access roads ---- 2-11
2.5 Recommended Actions ---- 2-12
2.5.1 Daule Peripa-La Esperanza diversion tunnel ---- 2-12
2.5.2 Severino pumping station ---- 2-13
2.5.3 Severino open channel ---- 2-13
2.5.4 La Esperanza-Poza Honda diversion tunnel ---- 2-14
2.5.5 Poza Honda-Mancha Grande diversion tunnel ---- 2-14
2.5.6 Daule Peripa-Severino transmission line ---- 2-15
2.5.7 Access roads ---- 2-15

3. WATER QUALITY ANALYSIS AND PREDICTION ---- 3-1

3.1 Introduction ---- 3-1
3.2 Water Quality Sampling ---- 3-1
3.3 Water Quality in the Reservoirs ---- 3-1
3.3.1 Concept ---- 3-1
3.3.2 Prediction ---- 3-2
3.3.3 Possibility of eutrophication in reservoirs ---- 3-2
3.3.4 Suitability of reservoirs water for various uses ---- 3-4
3.4 Water Quality Prediction in Rivers & Estuaries ---- 3-11
3.4.1 Introduction ---- 3-11

Page

3.4.2 River flow regimes---- 3-12
3.4.3 River flow change---- 3-12
3.4.4 Estimation of pollution load---- 3-14
3.4.5 Volume of waste water ---- 3-15
3.4.6 Estimation of pollution load change---- 3-15
3.4.7 Prediction of Water Quality Change ---- 3-16
3.4.8 Microbiological Analysis---- 3-23
3.4.9 Pesticide Analysis---- 3-24
3.5 Salinity study in the Chone river estuary---- 3-27
3.5.1 Reommendations---- 3-27
3.5.2 Salinity measurement in june (at the end of the rainy season) --- 3-28
3.5.3 Salinity measurement in august (at the end of the rainy season)---- 3-29
3.6 Recommendations---- 3.29

4. PROGRAM FOR ESTABLISHMENT of WATER QUALITY STANDARD---4-1

4.1 Introduction---4-1
4.2 Water Quality Criteria---4-2
4.3 Ecosystems Approach ---4-2
4.4 Classification of Polluted Waters---4-3
4.4.1 Classification system ---4-3
4.4.2 Classification graphs---4-4
4.5 Data Acquisition---4-4
4.5.1 Parameters to be measured---4-5
4.6 Assessment of Water Resources ---4-7
4.6.1 Reference resources---4-7
4.7 Polluted Water Classification and Water Resource Use ---4-7
4.7.1 Eutrophication ---4-8
4.8 Conclusions---4-8

5. BASIC PROGRAM FOR PREVENTION OF WATER QUALITY DETERIORATION IN POZA HONDA & LA ESPERANZA RESERVOIRS ---5-1

5.1 Introduction---5-1
5.2 Immediate Area of Influence---5-2
5.2.1 Poza Honda---5-2
5.2.2 La Esperanza---5-3
5.3 Actual Use of the Land ---5-4

Page

5.3.1 Poza Honda-zone A ---- 5-4
5.3.2 Poza Honda-zone B ---- 5-5
5.3.3 Poza Honda-zone C ---- 5-6
5.3.4 La Esperanza-zone A ---- 5-6
5.3.5 La Esperanza-zone B ---- 5-7
5.3.6 La Esperanza-zone C ---- 5-7
5.4 Potential Use of the Land ---- 5-8
5.5 Proposed Use of the Land ---- 5-9
5.5.1 Zone A-Poza Honda & La Esperanza ---- 5-9
5.5.2 Zone B-Poza Honda & La Esperanza ---- 5-12
5.5.3 Zone C-Poza Honda & La Esperanza ---- 5-23
5.6 Impounded Area Before Submergence ---- 5-24
5.6.1 Plant biomass clearing ---- 5-24
5.7 Impounded Area After Submergence ---- 5-25
5.7.1 Aquatic plant infestation ---- 5-26
5.8 Plant Nursery Implementation ---- 5-29
5.9 Credit Availability for Farmers ---- 5-29

6. BASIC PROGRAM FOR CONSERVATION OF MANGROVE AND CHAME HABITAT ---- 6-1

6-1 Estuary Importance ---- 6-1
6.2 Chone Estuary ---- 6-3
6.2.1 Existing situation ---- 6-3
6.2.2 Existing management efforts ---- 6-6
6.2.3 Proposed conservation program ---- 6-7
6.2.4 Permits and controls for shrimp farm development ---- 6-21
6.2.5 Legal elements for mangrove conservation ---- 6-23
6.3 Portoviejo River Estuary ---- 6-24
6.3.1 Introduction ---- 6-24
6.3.2 Existing situation ---- 6-25
6.3.3 Proposed conservation program ---- 6-26
6.4 Wetland Habitat for Chame ---- 6-27
6.4.1 Introduction ---- 6-27
6.4.2 Importance of wetlands ---- 6-28
6.4.3 Significant areas ---- 6-32
6.4.4 Water dynamics ---- 6-32

Page

6.4.5 Existing uses ---- 6-33
6.4.6 Existing conflicts ---- 6-34
6.4.7 Existing conservation efforts ---- 6-34
6.4.8 Proposed conservation plan ---- 6-35

7. OPERATION PROGRAM FOR SIMBOCAL TIDAL GATE ---- 7-1

7.1 Simbocal Tidal Gate ---- 7-1
7.2 Main Functions of the Tidal Gate ---- 7-1
7.3 Tidal Measurements ---- 7-2
7.4 Salinity Measurements ---- 7-2
7.5 Flooded Area Upstream Simbocal Tidal Gate ---- 7-3

8. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN (EMMP) ---- 8-1

8.1 Introduction ---- 8-1
8.2 Institutinal Aspect ---- 8-1
8.3 EMMP Management and Operational Costs ---- 8-1
8.4 Technical Aspect ---- 8-2
8.4.1 Program for etabblishment of water quality standard ---- 8-2
8.4.2 Program for prevention of detrimental effects of agrichemicals ---- 8-5
8.4.3 Program for plant biomass removal from La Esperanza mpounded area ---- 8-9
8.4.4 Program for aquatic weed control in reservoir area ---- 8-10
8.4.5 Program for reforestation and land use control around reservoir areas 8-12
8.4.6 Program for reforestation and conservation of the Chone river estuary 8-22
8.4.7 Program for conservation of the Portoviejo river etuary ---- 8-26
8.4.8 Program for conservation of wetland and Chame habitat ---- 8-28
8.4.9 Program for the re-design, implementation and operation of the new Simbocal tide gate ---- 8-30

TABLES

FIGURES

REFERENCES

LIST OF TABLES

Table	Description	Page
Table 3.1	Water Quality Conditions in the Study Area	T-1
Table 3.2	Estimation of Water Quality of La Esperanza and Poza Honda Dams	T-8
Table 3.3	Possibility of Eutrophication in the Reservoirs of La Esperanza Dam and Poza Honda Dam	T-9
Table 3.4	Existing and Future River Flow Conditions in the Study Area	T-10
Table 3.5	Per Capita Polution Load Unit and Sewage Water Quality	T-12
Table 3.6	Change of Load from Water Supply for Aquaculture	T-13
Table 3.7(1/6)	Pollution Load from Irrigation Water	T-14
Table 3.7(2/6)	Incremental Pollution Load by Land Use Change	T-15
Table 3.7(3/6)	Incremental Pollution Load by Land Use Change	T-16
Table 3.7(4/6)	Incremental Pollution Load by Land Use Change	T-17
Table 3.7(5/6)	Incremental Pollution Load by Land Use Change	T-18
Table 3.7(6/6)	Decrease of Pollution Load by Change of Cattle Heads	T-19
Table 3.8	Estimation of Incremental Pollution Load by the Project	T-20
Table 3.9(1/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-21
Table 3.9(2/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-22
Table 3.9(3/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-23
Table 3.9(4/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-24
Table 3.9(5/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-25
Table 3.9(6/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-26
Table 3.9(7/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-27
Table 3.9(8/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-28
Table 3.9(9/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-29
Table 3.9(10/10)	Prediction of River Flow Discharge and Water Quality in 2020	T-30
Table 3.10(1/2)	Summary on Average Salinity, Surface and Bottom	T-31
Table 3.10(2/2)	Summary on Average Salinity, Surface and Bottom	T-32
Table 3.11(1/2)	Prediction of River Water Flow Discharge and water Quality in 2020 in Chico River	T-33
Table 3.11(2/2)	Prediction of River Water Flow Discharge and water Quality in 2020 in Chico River	T-34
Table 7.1(1/2)	Tidal Measurements in Chone River Estuary (December 17, 18 and 19, 1993)	T-35

Table | Description | Page

Table 7.1(2/2) Tidal Measurements in Chone River Estuary
(January 28, 29 and 30, 1994)) ---------- T-36
Table 7.2(1/2) Tidal Measurement in Chone River Estuary
(June 03, 04 and 05, 1994) ---------- T-37
Table 7.2(2/2) Tidal Measurement in Chone River Estuary
(August 12, 13 and 14, 1994) ---------- T-38

LIST OF FIGURES

Figure	Description	Page
Figure 2.1	Location of Project Actions	F-1
Figure 3.1	Location of Water Quality sampling stations	F-2
Figure 3.2	Eutrophic tendency in Poza Honda and La Esperanza	F-3
Figure 3.3	Schematic Diagram of Polution Load Analysis	F-5
Figure 3.4	Location of Tidal and Salinity Gauge Stations	F-6
Figure 3.5	Longitudinal variation of Salinity in the Chone river estuary	F-7
Figure 5.1	Conservation and Special Management Zone, Poza Honda	F-8
Figure 5.2	Conservation and Special Management Zone, La Esperanza Reservoir	F-9
Figure 5.3	Land Use Map, Poza Honda Reservoir	F-11
Figure 5.4	Land Use Map, La Esperanza Reservoir	F-12
Figure 6.1	Chone River Estuary, Delimination of Protection and Conservation Areas	F-13
Figure 6.2	Portoviejo River Estuary, Delimination of Conservation Areas	F-14
Figure 6.3	Chame Habitat and Wetland Area, Delimination of Conservation Area and Flood Elevations	F-15
Figure 7.1	Tidal Measurement at Chone River Estuary referred to IGM levels (December/93)	F-16
Figure 7.2	Tidal Measurement at Chone River Estuary referred to IGM levels (January/94)	F-17
Figure 7.3	Tidal Measurement at Chone River Estuary referred to IGM levels (June/94)	F-18
Figure 7.4	Tidal Measurement at Chone River Estuary referred to IGM levels (August/94)	F-19
Figure 8.1	Organization Chart for the Environmental Management and Monitoring Plan (EMMP)	F-20

ABBREVIATION

Ecuadorian Institutions

CEDEGE	:	Committee for Guayas River Basin Development
CETUR	:	Ecuadorian Corporation for Tourism
CLIRSEN	:	Integrated Center for Remote Sensing Survey
CONADE	:	National Development Council
CPC	:	Chamber of Shrimp Producer
CRM	:	Manabi Rehabilitation Center
DIGMER	:	Directorate General of Merchant Marine
DINAC	:	National Directorate of Valuation and Cadastre
DINAF	:	National Directorate of Forestry
DITURIS	:	Directorate of Tourism
EMAPAM	:	Municipal Enterprise of Potable Water and Sewerage of Manta
ESPOL	:	Polytechnic Littoral College
GOE	:	Government of Ecuador
IEOS	:	Ecuadorian Institute of Sanitary Works
IERAC	:	Ecuadorian Institute for Agrarian Reform
IGM	:	Geographic Military Institute
INAMHI	:	National Institute of Meteorology and Hydrology
INEC	:	National Institute of Statistics and Census
INECEL	:	Ecuadorian Institute for Electrification
INEFAN	:	Ecuadorian Institute of Forestry and Natural Areas
INEN	:	Ecuadorian Institute of Standards
INERHI	:	Ecuadorian Institute of Water Resources
INIAP	:	Institute of Agricultural Investigations
INOCAR	:	Military Oceanographic Institute
JRH	:	Jipijapa and Pajan Board of Water Resources
MAG	:	Ministry of Agriculture and Livestock
MICIP	:	Ministry of Industry, Commerce, Integration and Fishery
MOP	:	Ministry of Public Works and Communications
PFI	:	Institutional Reinforcement Planning Unit of CRM

PHIMA	:	Integrated Water Resources Development Plan of Manabi
PMRC	:	Management Program of Coastal Resources

International or Foreign Institutions

ACI	:	American Concrete Institute
ASCE	:	American Society of Civil Engineers
ASTM	:	American Society for Testing and Materials
CAF	:	Corporación Andina de Fomento
CEPIS	:	Panamerican Center for Sanitary Engineering and the Environment
CIDIAT	:	Interamerican Center for Integrated Development of Water and Land
FAO	:	Food and Agriculture Organization of the United Nations
IDB/BID	:	Interamerican Development Bank
IEC	:	International Electrotechnical Commission
JEC	:	Japanese Electrotechnical Committee
JICA	:	Japan International Cooperation Agency
JIS	:	Japanese Industrial Standards
OAS/OEA	:	Organization of American States
OECF	:	Overseas Economic Cooperation Fund of Japan
SCS	:	Soil Conservation Service of USDA
UNDP	:	United Nations Development Program
USA	:	United States of America
USAID	:	United States Agency for International Development
USDA	:	United States Department of Agriculture
WHO	:	World Health Organization of the United Nations

Technical Terms

A.C.	:	Alternating Current
ACSR	:	Aluminum Cable Steel Reinforced
BOD	:	Biochemical Oxygen Demand
COD	:	Chemical Oxygen Demand

D.C.	:	Direct Current
DO	:	Dissolved Oxygen
EC/CE	:	Electrical Conductivity
EIA	:	Environmental Impact Assessment
EMMP	:	Environmental Management and Monitoring Plan
FEM	:	Finite Element Method
F.M.	:	Finess Modulus
F/S	:	Feasibility Study
FWL	:	Flood Water Level
GPS	:	Global Positioning System
H	:	Horizontal
HWL	:	High Water Level
IEE	:	Initial Environmental Examination
IPM	:	Integrated Pest Management
LACAT	:	Program for Warm Tropical Lakes
LWL	:	Low Water Level
MOL	:	Minimum Operating Level
NATM	:	New Austrian Tunneling Method
PLC	:	Power Line Carrier
RWL	:	Reservoir Water Level
SPT	:	Standard Penetration Test
ST	:	Station
T-N	:	Total Nitrogen
T-P	:	Total Phosphorus
TRMS	:	Transbasin and Reservoir Management System
TSS	:	Total Suspended Solid
V	:	Vertical
ZEM	:	Special Zone for Management

Economic Terms and Others

CIF	:	Cost Insurance and Freight

EIRR	:	Economic Internal Rate of Return
FC	:	Foreign Currency
FIRR	:	Financial Internal Rate of Return
FOB	:	Free on Board
GDP	:	Gross Domestic Product
GRP	:	Gross Regional Product
IVA	:	Sales Tax or Value Added Tax
LC	:	Local Currency
NGO/ONG	:	Non Governmental Organization

ABBREVIATION OF MEASURES

Length

mm	=	millimetre
cm	=	centimetre
m	=	metre
km	=	kilometre
masl	=	metre above sea level
EL.	=	elevation

Area

ha	=	hectare
m^2	=	square metre
km^2	=	square kilometre

Volume

l, lit	=	litre
Kl, Klit	=	kilolitre
l/s	=	litre per second
m^3	=	cubic metre
m^3/s, cms	=	cubic metre per second
m^3/min	=	cubic metre per minute
m^3/hr	=	cubic metre per hour
MCM, mcm	=	million cubic metre
m^3/d, cmd	=	cubic metre per day

Weight

mg	=	milligram
mg/l	=	milligram per litre
meq/l	=	milli-equivalent per litre
g	=	gram
kg	=	kilogram
t, ton	=	ton
t/y	=	ton per year
MT	=	metric ton

Time

sec	=	second
min	=	minute
hr, HR	=	hour
d	=	day
yr	=	year

Money

S/.	=	Ecuadorian Sucres
¥	=	Japanese Yen
US$	=	U. S. Dollars

Energy

Kcal	=	Kilocalorie
KW, Kw	=	kilowatt
MW, Mw	=	megawatt
KWh, Kwh	=	kilowatt-hour
GWh, Gwh	=	gigawatt-hour
V	=	volt
KV	=	kilovolt
KVA	=	kilovolt ampere
MVA	=	megavolt ampere
Hz	=	Hertz

Others

%	=	percent
°	=	degree
'	=	minute
"	=	second
°C	=	degree Celsius
MD, md	=	man-day
mil.	=	million
NO. Nos	=	number
pers.	=	person
Umho	=	micromho
ppt	=	parts per thousand
ppm	=	parts per million
ppb	=	parts per billion
l/h/d	=	litre per person per day
g/c/d	=	gram per capita per day
LS	=	lump sum
MPN	=	most probable numbers
O&M	=	Operation and Maintenance
p.a.	=	per annum
rpm	=	revolutions per minutes

1. EXECUTIVE SUMMARY

1.1 Objectives and Approach

The objectives of this environmental study are:

i) to review the existing environmental information,

ii) to evaluate the existing and predictable water quality conditions in the study area based on new water quality analysis,

iii) to establish the guidelines for a prevention of the water quality deterioration in the reservoirs,

iv) to establish the guidelines for a conservation and management plan in the vicinity areas of the reservoirs,

v) to establish the guidelines for the protection of the mangrove and Chame habitat in the Chone and Portoviejo estuaries and in the permanent inundation wetland areas,

vi) to establish a program for the Simbocal tidal gate operation.

Based on the existing environmental information, the project actions reconnaissance, field trips, generation of new data and interviews with authorities and personnel related to this context, the above objectives are developed for the purpose of generating a document which will be the basis for the development and implementation of the management and monitoring plan by CRM.

1.1.1 Summary of project actions reconnaissance

During the present study a general reconnaissance of project actions was undertaken, including the following:

- Daule Peripa-La Esperanza diversion tunnel
- Severino pumping station
- Severino open channel

- La Esperanza-Poza Honda diversion tunnel
- Daule Peripa-Severino transmission line
- Access roads

No major environmental impacts are expected in the tunnel constructions since they will be excavated underground. In the location of the pumping station and open channel no mayor impacts are expected. The area in general is highly deforested and with a low population density.

At the end of the transmission line, on the right bank of the Daule river, immediately downstream of the Daule-Peripa dam, there is an ecological reservation of CEDEGE with an area of about 200 ha. This area is actually under a sustained reforestation process and environmental management, thus it is recommended that the transmission line does not transect this area.

Access roads could incentivate new colonization to adjacent areas, and could enhance the value of the land. Although in general, opening or improving rural roads could incentivate deforestation in the areas adjacent to the access roads, deforestation is already accentuated, and the actual condition of the existing roads has not stopped the massive deforestation process, so a significant impact on the further deforestation of the area is not foreseen with the improvement of the access roads.

The implementation of the environmental management plans for the reservoirs should act as a control for new colonization of the areas adjacent to the reservoirs that could be incentivated with the improvement of the access roads, especially in Poza Honda.

The population of Membrillo, adjacent to the Membrillo outlet in La Esperanza could become more dependent on inland water transportation. Preventive measures to avoid point source pollution into the reservoir because of an inland port situation should be considered.

1.2 Water Quality Analysis

1.2.1 Sampling for Water Quality Analysis

Water analysis 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). Twenty six (26) physical-chemical parameters were evaluated in each station, and results in BOD, COD, T-N, and T-P are

used as evaluation parameters for pollution load analysis. Although no mayor industries as point source pollution are present in the area, tests on heavy metals were also made.

1.3 Water Quality in Reservoirs

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:

$$C2=(L0 + L1)/(Q0 + Q1)=(Q0 \text{ X } C0 + Q1 \text{ X } C1)/(Q0 + Q1)$$

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

The water quality at Poza Honda reservoir 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 1.3.2 of this subsection.

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.

1.3.1 Eutrophication

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/m^3)	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/m^3)	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.

1.3.2 Suitability of reservoir water for various uses

The following basic parameters established by the Official Register of Ecuador, June 5/1989 as suitable raw water for drinking purpose are taken into account.

Parameter	Unit	Type of Treatment	
		Conventional	Disinfection
		Maximum allowable values	
BOD-5	mg/l	2	2
Fecal Coliforms	MPN/100 ml	600	20
Total Coliforms	MPN/100 ml	3,000	100
DO	mg/l	more than 4	more than 6
PH	Unit	6-9 (Range)	6-9 (Range)
Color	Units	100	20
Chlorides	mg/l	250	250
Turbidity	Units	100	10

Except for BOD in all reservoirs and DO in 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 are related to the massive infestation of aquatic plant (Eichornia crassipes).

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

RAS* (meq/l)	Electrical conductivity (Umohs/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 present in the reservoir water

Indicator	Unit	Daule - Peripa	La Esperanza	Poza Honda
Conductivity	Umhos/cm	149.50	516.66	335.37
Sodium as Na	mg/l	11.30	32.83	23.50
	meq/l	0.49	1.43	1.01
Calcium as Ca	mg/l	14.38	46.17	28.67
	meq/l	0.72	2.30	1.43
Magnesium	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.

1.4 Water Quality in Rivers and Estuaries

1.4.1 River flow regime

Table 3.4 show 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 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 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	(1) Chone River Mouth	(2) Chone Upst'm	(3) Carr'l River	(4) Porto. Downst.	(5) Porto. Upst'm	(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	(1) Chone River Mouth	(2) Chone Upst'm	(3) Carr'l River	(4) Porto. Downst.	(5) Porto. Upst'm	(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) Dario Guevara (ST-16)
(5) Potoviejo (ST-14)
(6) Rio Chico (ST-11)

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

1.4.2 Pollution load analysis

The water quality in rivers and estuaries is evaluated by using the concept of pollution load analysis, based on the existing information and water quality surveys. Four prediction points are assessed with and without dilution flow conditions:

P-1) Lower reach of Chone river (st-6), at Simbocal
P-2) Estuary area of the Chone river (st-8), at Punta Prieta
P-3) Middle reach of the Portoviejo river, at the downstream confluence point with the Chico river (st-15),Guayaba.
P-4) Estuary area of the Portoviejo river (st-17)

Results obtained are summarized as follows:

Result of Water Quality Prediction "Without" dilution flow

(unit: 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	29.3	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 "With" dilution flow

(unit: 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	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	24.8	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	0.9	2.6	0.13	0.53
c) Average	13.8	16.1	21.9	19.8	1.4	2.4	0.19	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	0.55
c) Average	15.5	16.8	25.5	20.7	1.5	2.7	0.37	0.42

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 and 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 increased 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:

$$C3'' = C3' \times \exp(-Kt)$$

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)

1.4.3 Pesticides and fecal pollution

Pesticide analysis was carried out by CRM during the dry season on December 12, 1993 and June 3 and 6 and August 16 and 30 of 1994, when agricultural runoff and agrochemical application in the field is minimal or non existent. Concentrations of Cis-Heptachlor was detected in a range below the maximum residue limit (MRL) established by the Codex Alimentarius FAO/WHO, 1990, as reported by MAG, Sanidad Vegetal, Ecuador, 1993-1994.

Concentrations of Heptachlor were detected in the second sampling campaign, August 30/94, in the areas of Simbocal (St-6); upstream and at the middle reach of Portoviejo river (St-14 and 15).

Pesticide analysis was also carried out by CRM during the rainy season on January 1994, that is after the application of pesticides in dry season and just when the first rain came, in this case the concentrations of Heptachlor were beyond the maximum residue limit (MRL) at the three stations mentioned above.

It is assumed that the reported values will increase in the future, when the irrigation area is increased with the project condition as shown in the following table.

Agricultural Area

Area	Existing Agricultural Area (ha)	Net Potential Irrigation Area (ha) JICA-CRM
	Reference→1988 Data (Except Amarillos-Guarango Systems)	
Carrizal-Chone System	1,516	15,000
Poza Honda System	4,518	10,050
Rio Chico System	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 Ceibal treatment plant rather than the Portoviejo river.

Microbiological analysis carried out by CRM during the months of December/93 and January, June and August/94, shows 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 13) and downstream (st-14 and 15) Portoviejo river.

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

1.4.4 Salinity measurements

Salinity measurements were conducted during the months of June and August of 1994, at the same sampling sites as for tidal measurements. Surface and bottom samplings, 20 cm and 50 cm below the water surface respectively, were made at every sampling site.

Salinity changes with the height of the tide, being greater at the highest tide. Average salinity concentration is greater in the estuary at stations 1 and 2, and it decreases upstream from the estuary as shown in Figure 3.5.

1.5 Environmental Management and Conservation Programs

1.5.1 Program for prevention of water quality deterioration in reservoirs

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 possible eutrophication is derived from the agricultural, cattle raising, and other human activities, these activities are to comply with sound management and planning practices.

(1) Area of influence

The following 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.

Zone A: This zone is 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.

Zone B: This zone is associated with agriculture practices, cattle raising and human settlement.

Zone C: This zone is associated with steep slopes, where the isolated patches of altered forest are capable of regeneration if left untouched.

Zoning around Poza Honda and La Esperanza reservoirs is defined in Figure 5.1 and Figure 5.2, respectively, and their areas are as follows.

	Area (km^2)		
Resorvior	Zone A	Zone B	Zone C
Poza Honda	8.23	11.06	12.17
La Esperanza	32.89	124.02	48.26

The actual land use of the defined areas around Poza Honda and La Esperanza is as follows :

Actual Use of the Land

Land Use	Poza Honda Zone			La Esperanza Zone		
	A (ha)	B (ha)	C (ha)	A (ha)	B (ha)	C (ha)
Dense Forest	295	560	658	386	3,619	2,008.4
Low Dens.Forest	123	94	190	130	577.2	300
Total Forest	(418)	(654)	(848)	(516)	(4,196)	(2,308.4)
Pasture land	291	250	354	2,769	8,132	2,477.6
Annual Crops	43	60	11	-	54.2	12.2
Permanent Crops	71	128	2	3.3	20	17.2
Ponds	-	6.00	-	-	-	-
Populated Centers	-	7.00	-	ND	ND	ND
Nude Soil	-	0.62	2.5	-	-	10.3

(2) Proposed use of the land

The following strategies have been considered adequate to enhance soil conservation, reduce soil erosion, and increase land productivity for local farmers. 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.

(i) Zone A

- Establishment of this area as a protection buffer belt between water body and human activity.

- Reforestation with flowering and fruit bearing species to attract local fauna.

- Prohibition of animal husbandry, soaps, oil, liquid and solid waste disposal into the reservoir.

Proposed Use of the Land
Zone A-Reforestation Area

	Area Type	Poza Honda	La Esperanza
(1)	Total Area (ha)	823	3,289
(2)	Forested Area (ha)	418	516
(3)	Grassland Area (ha)	291	2,769
(4)	Area (ha) to be Reforested= 80% of (3) @ 300 trees/ha	233	2,215

(ii) Zone B

This zone is to be considered to be a protected area of multiple use with restrictions. Since this area is settled by people deriving a living as farmers and cattle raisers, the absolute preservation of the Zone is not recommendable (although desireable) to avoid excessive social impact to be caused by resettlement. None the less, the activities derived from the population must be regulated and restricted in several uses to gain control over the erosion, deforestation and non point pollution sources originated in this area.

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

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

Item	Land Use	%	# of Plants per ha.	Poza Honda (ha)	La Esperanza (ha)
Total Area Zone B				1,106	12,402
(A)	Agroforestry in Slopes < 70%				
(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	325
(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
(B)	Forestry Plantations and Grazing in Slopes < 70%				
(1)	Pasture Area	100	-	250	8,132
(2)	Proposed Area	80	100	200	6,506

(iii) Zone C

For Poza Honda and La Esperanza, this zone 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.

(3) Impounded areas

(i) Plant biomass control

- Before inundation of 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, and reducing the possibility of an eutrophied water quality condition.

- The existing water quality conditions in Daule Peripa reservoir have promoted the infestation of the aquatic plant, Eichoniae crassipes. This aquatic plant is considered the most problematic plant in the world for reservoirs and impoundments.

- The aquatic plant in the Daule Peripa reservoir, by April 1991, had covered an estimated 12,000 ha, with an estimated growth rate of 4,000 ha/year. It is assumed that by December 1993 the coverage area is around 22,000 ha, due to the reduced extraction and/or control implemented at the Daule Peripa reservoir.

- According to the water quality prediction discussed in 1.3, 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 the same except for COD which could slightly increase.

- The physical characters of the reservoirs are summarized as follows:

Item	Daule Peripa	La Esperanza	Poza Honda
Impoundment			
Area (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 branched 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.

Recommended actions for control include the following:

1- Short term strategy: Physical isolation of an area adjacent to the Conguillo inlet by a trash boom, to avoid masses of plants to enter into the tunnel while operating.

2- Medium term strategy: Mechanical and hydraulic control actually being carried out by CEDEGE in the Daule-Peripa reservoir. The control may be necessary in Poza Honda and La Esperanza reservoir:

- To prevent the blockage of navigation channel
- To eliminate the substratum for vector of diseases
- To reduce the organic matter effluents that my cause euthrophication problems
- To avoid excessive evapotranspiration from the reservoirs
- To lessen the risks of physical deterioration of the dam works

1.5.2 Basic program for conservation of mangrove habitat

(1) Chone Estuary

The Chone river estuary is so deteriorated that it is considered an estuary in great danger of suffering an ecological collapse by a massive degradation of the environmental quality and the loss of the ecosystem functions.

The proposed conservation program is prepared in support of the existing efforts, and intends to implement corrective measures in the different components of the system. The following components are included in the management and conservation program:

- Mangrove forest management

Reforestation of the areas adjacent to the estuary located below EL. 100 m and to prepare the integrated management plan for the Chone river which is the main producer of sediments directed towards the estuary. Reforestation of drainage and inflow channels at the shrimp farms is also suggested as a contribution from the shrimp farms to the community, when receiving a surplus fresh water flow during the dry season by the project operation.

Declare as protected areas, Isla Corazon and the existing mangrove patch in the upper reach of the estuary left margin as shown in Figure 6.1, in an estimated area of 40 ha for Isla Corazon and 123 ha in Calle Larga. Isla Corazon is already considered as a forestry research area by DIGMER, and a zone of tourist interest by CETUR.

Promote the culture and seeding of bivalves such as Anadara sp., in an effort to establish a sustainable use of the forest, and educate the local people in the proper use and importance of the mangrove ecosystem, while deriving an economic benefit out of it.

- Mariculture industry management

The only areas for the shrimp farming industry to expand are a few existing mangrove patches, especially in the upper reaches of the estuary, and the lands adjacent to the wetlands, also in the upper reaches of the estuary. CRM must take measures so that the existing legislation is applied and the infractors are sanctioned, CRM must cooperate with the PMRC efforts in this respect and coordinate actions for the implementation of the law.

- Water quality management

Implementation of the new design for Simbocal tidal gate is proposed. The existing tidal gate at Simbocal is deteriorated, and its operational capacity diminishes with the highest tides of the lunar cycle, because the wooden gate floats and allows the intrusion of salt water.

Regulation, control and implementation of management strategies for pesticide, herbicide and fertilizer use in the agricultural areas upstream from the estuary are discussed in this study, as well as the guidelines for an integrated pest management implementation program.

Implementation of sewerage disposal systems according to sound sanitary engineering practices for the population adjacent to the estuary channels is advised for the reduction of the raw sewage effluent discharge into the estuary.

- Erosion management

Erosion problems derived from the agricultural practices in the adjacent hills has already been reported. The adjacent area of influence generating erosion and sediment deposition in the estuary will be defined as an area which is characterized by steep slopes and deforestation with high risk of erosion. Joining efforts with PMRC in the following strategies to control erosion is recommended.

- Agricultural runoff control

The Chone river estuary will receive the drainage waters from 15,000 hectares of agricultural land to be abilitated for year round farming when the project is placed to service, and the impact on the estuary by the increase in agrichemical runoff could be significant, although the increase in fresh water flow during the dry season will have positive effects in the ecosystem and fisheries of the area, by reducing the salinity, especially in the upper areas of the estuary, where eutrophic conditions have been already detected by PMRC.

The implementation of 15,000 ha for year round farming will inevitably promote the use of pesticides, herbicides and inorganic fertilizers. The concentration of pesticides and agrochemicals leaching from the agricultural area into the estuary will have a detrimental effect in the ecosystem and fisheries. Shrimp post-larvae are one of the most sensitive organisms to be affected.

(2) Portoviejo river estuary

The mangrove area in Las Gilces in the Portoviejo river estuary is estimated to be 81.3 ha for 1984 and 1987, with no reduction in the covered area, while the shrimp farm expansion is reported in 103.1 ha for 1984 and 128.5 in 1987, with an increment of 25.3 ha.

The Portoviejo river is the recipient of point source pollution loads from the cities of Portoviejo, Roca Fuerte, Mejia, Sosote, El Higueron and Salinas. Only in Portoviejo, there is a sewerage treatment plant to cover 18% of the urban population.

No conservation efforts are reported for the Portoviejo river estuary. The proposed conservation area includes the area of mangrove forest and the intermediate sandy beach belt existing between the mangrove area and the ocean.

The basic concept is to declare this area as protected with controled use as a public recreational area for the population of Portoviejo city.

The proposed conservation program includes the following actions:

1-Declaration of a protected area according to the existing legislation for mangrove areas, stressing the reasons for the need of a public recreational area, mangrove conservation and bird sanctuary condition of the existing vegetation.

2-Stopping of further shrimp farm development in the area, through the existing legal entities in charge.

3-Declaration of the beach area as of public interest for recreational purposes, and not adequate for constructions such as hotels, resorts and the like.

4-Improvement of the sewerage system for Portoviejo city which is highly recommended to maintain adequate water quality conditions for recreation and ecosystem.

5-Promotion of nature oriented tourism for bird watching, mangrove ecology education and leisure. Tourism oriented towards shore fishing (casting) is already a popular activity in the area.

6-Implementation of an Integrated Pest Management Program for the agricultural area to be implemented with the project, including control of the types of pesticide used.

1.5.3 Basic program for the conservation of Chame and wetland habitat

In the area where the Carrizal and Chone rivers converge, between Simbocal and La Margarita, there are 21 permanent lagoons, some of which are about 350 ha in extension, and 57 wetlands, with an average area of 60 ha/each, which dry out during the dry season. Traditionally, these areas have been used for the small scale culture of Chame (Dormitator latifrons), and fresh water prawns (Machrobrachium sp).

The culture of Chame is an extensive practice carried out by local farmers, which derive a significant income to the farmers. A total estimated of 1,380 ha of permanently inundated areas in Chone have been identified in previous studies.

A permanently inundated area is an area which retains water even during the dry season, and the main objective of the present program is to protect and maintain the areas permanently inundated, to ensure the continuation of this ecosystem and the local Chame production.

(1) Ecological importance

Wetlands as well as mangroves serve as biological filters for the improvement of water quality flowing through them. These are fragile ecosystems, and should be managed carefully. The wetlands also provide feeding grounds for migratory and endemic fauna, flood control areas, and are utilized by their landscape and aesthetic value for tourism and recreation.

(2) Socio-economic importance

The most important permanently inundated area within the estimated 1,380 ha (between Simbocal and San Antonio), is La Sabana with an estimated area of 400 ha, where 90-100 families derive an income through the culture of Chame.

The estimated Chame production for La Sabana, per family per year for an average area of 5 cuadras/family (1 cuadra= 0.75 ha) is 30 Chame boxes/year, which means a production of 30 boxes for 3.75 ha/family.

The annual income from Chame production (2'998,800 sucres/family/year) corresponds to an average monthly income of 249,900 sucres/family/month.

The above data shows how the Chame producing families can enjoy an income from the Chame production as a secondary activity, since the culture of Chame is done in an extensive and artisanal mode of production, where operational costs and maintenance are minimum, ie. no feeding or pumping costs involved.

This condition allows the Chame producer to dedicate most of his time to other activities such as farming, commerce or cattle raising, and thus derive a second income which will allocate this families in the 301,000-400,000 sucres/ month income, approaching the highest average income/family in the area.

From the nutritional viewpoint, Chame is an excellent protein supplement for the local population, and well accepted as a regular food by the population. Chame is a hardy animal, capable of withstanding more than 24 hours outside the water if maintained humid, facilitating the transportation and storage, in an area where refrigeration and electricity is scarce.

From the socio-cultural viewpoint , this is a traditional activity practiced in the area for more than 30 years, and 92% of the existing culture area is located in the Chone and Tosagua areas, with an estimated area of 914 ha.

(3) Significant Areas

The following areas have been reported as subject to inundation in the province of Manabi:

Type of Inundation	Area of Inundation (ha)	
	Chone	Portoviejo
Permanent	1,380	120
Seasonal	5,320	4,680
Occasional	8,010	590

The permanent inundation areas are areas which retain water even during the dry season. The seasonal inundation area is an area subject to inundation during the rainy season, and occasional inundation area is the area inundated in periods of extraordinary floods.

(4) Water dynamics

The water inflow to the permanently inundated areas has several sources:

1- Precipitation during the rainy season, the annual average precipitation for the area is 1,000-1,200 mm; and the annual average evapotranspiration is estimated in 1,000-1,100 mm.

2- Runoff from adjacent hills located north-east(NE) of la Sabana, and north, north-west (N-NW) of La Pampa de Vellis.

3- Floods caused by the Carrizal river for la Sabana, and floods caused by the Chone river for La Pampa de Vellis and adjacent areas between La Margarita and Simbocal.

The partial drainage of these areas occurs during the dry season, because of the difference in elevation existing between La Sabana and Simbocal, and eventually the Chone river estuary. The magnitude of the drained volume is dependent on the surface water elevation maintained at Simbocal during the dry season by means of the artificial handling of the Simbocal tidal gate.

In the situation with project, where the flood condition of the Carrizal river is to be regulated, the remaining sources of water inflow will be the runoff and the rainfall, and the water supply scheme to be proposed in the conservation program for the area of La Sabana. It is considered that the adequate management of the Simbocal tidal gate is of vital importance to maintain the water level in this area during the dry season, and a detailed program for the operation of the Simbocal tidal gate is discussed further in this report.

The condition for the areas located between Simbocal and La Margarita are similar, except for the fact that the Chone river is not subject to flood control with the project condition, so these areas will still have the possibility of inundation by floods of the Chone river because the maximum flow in La Segua for a 50 year return period is 720 m^3/sec and 580 m^3/sec for a 25 year return period, and the carrying capacity of the Chone river in this area is only 150 m^3/sec.

(5) Existing conflicts

1- The agricultural activities adjacent to the inundated area are carried out during the dry season, and are expected to be done year round with the project condition. Conflicts arising between the agricultural practices and the wetland ecology and its human use are the following:

i) Pesticide and agrochemical runoff from the agricultural area towards the inundated area could affect the trophic chain through bioaccumulation.

ii) Maintaining an adequate surface water elevation at Simbocal during the dry season for the conservation of the inundated area promotes excessive soil humidity and development of diseases such as fungus to agricultural crops in the adjacent areas.

2- Shrimp farm expansion is exerting a pressure to move upstream of Simbocal in view of the lack of space to expand in the estuary area, and the existing legislation forbidding the cutting of mangrove.

3- Technified Chame farms are colonizing adjacent areas of the wetlands with massive dirt movement, invading potentially floodable areas, and eventually generating effluent high in BOD and nutrients that could affect the wetland.

(6) Proposed conservation plan

The proposed conservation plan is mainly directed towards implementing strategies for the preservation of La Sabana, since this area is the one to be directly affected by the project through the regulation of flow in La Esperanza. As previously stated, the area of La Pampa de Vellis and adjacent areas between Simbocal and La Margarita will still be subject to inundation by floodflows of the Chone river.

The successful implementation of the conservation program is directly related to the declaration of the wetland area as a protected area of restricted use, based on its ecological and socio-economical importance. CRM should in cooperation with PMRC and the ZEM Bahia-San Vicente-Canoa approach the legal authorities related to this purpose.

(i) Hydrology

The proposed limit for the wetland conservation area is elevation EL. 6 m above sea level, which will allow for the adequate hectarage and water depth for the artisanal culture of Chame. The stored volume in the wetland area at this elevation is estimated to be 16 MCM.

The maximum storage water capacity at Simbocal is 3 MCM, covering 120 ha of wetlands during the dry season.

(ii) Agrochemical runoff

The water quality management scheme is basically directed towards the reduction of the toxic pesticide runoff coming from the adjacent agricultural areas. The integrated pest management program could be a positive approach for the reduction of agrochemicals from the irrigation area adjacent to the wetlands.

(iii) Use of adjacent land

The existing conflict between farmers and Chame culturists due to the water saturation of the soil when the water level at Simbocal is adequate to prevent wetland drainage can be attenuated if the farmers in the adjacent areas will grow

water resistant plants, such as rice, which under inundated conditions will generate better yields than in a non inundated condition.

(iv) Colonizing of aquaculture farms

The change in the use of the land adjacent to the wetlands to the establishment of shrimp and/or Chame technified farms must be stopped with the declaration of the wetland as protected area.

1.5.4 Operational program for Simbocal tidal gate

In the case of the Chone River estuary, the shrimp farming activity has covered an area of 4,967 ha, accounting for 41 % of the shrimp farms of the Manabi province. It is estimated that the shrimp ponds in this area store approximately 33.5-55.2 MCM, which is equivalent to the storage capacity of the estuary at low tide. The daily water exchange of the shrimp farms is estimated in 3.3-5.5 MCM/day, or approximately 10% of the stored volume.

The water quality of the estuary is a result of the uncontrolled agricultural, maricultural and ecological mismanagement of the system. It is considered that the Chone River estuary is about to suffer an ecological collapse, due to the massive deforestation of mangrove forest, and the effluent discharge from the agriculture, mariculture and urban development.

The artisanal Chame production in the wetland area of La Sabana and La Segua is dependent on the fresh water level at Simbocal to maintain an adequate water level and avoid drainage of the wetland area to a level which makes the culture of Chame unfeasible during the dry season. At the same time, the agricultural farmers adjacent to the wetland areas require to lower the water level at Simbocal, to avoid excessive water saturation of the soil at the farming area, which tends to the development of fungus and diseases in the agricultural crops during the dry season. This situation has been discussed before in the Basic Program for the Conservation of Chame Habitat.

The abovementioned situation originates the existing conflicts centered in the operation of the Simbocal tidal gate, and provides the need for an operational program of the tidal gate.

The following requirements are expected from the proper management program for the tidal gate at Simbocal:

1- During the dry season (July-December), the tidal gate must allow for the inflow into the estuary of 99 MCM of fresh water allocated for the improvement of the shrimp farming production and the lowering of the salinity content in the estuary water.

2- Also, in this season, the gate must allow the inflow of fresh water into the estuary, during the low tide at Simbocal, for about one hour two times a day and working at 35 % of its full capacity. The remaining time the gate must be closed to maintain the wtaer level and to avoid teh salinity intrusion.

3- During this season, the operation of the gate must allow to keep enough quantity of water to avoid the drainage of the Chame farms, and also to preserve the wetlands. At the same time, the retained water level at Simbocal must allow the upstream farmers to draw water out from the Carrizal River for irrigation purposes.

4- During the rainy season, the operation of the tidal gate must allow for the discharge of flood flows of 25,50 and 100 years of return period,

Results of the hydrological analysis show that the volume generated by a 25 and 50 year return period floods a considerable agricultural area, mainly due to the fact that the existing Simbocal tidal gate is insufficient to discharge the mentioned volumes.

To achieve the above mentioned requirements, it is necessary to implement a new design for the Simbocal tidal gate structure taking into account the recommendations previously stated.

1.6 Recommendations

1) Future studies are recommended to evaluate the socio-economic impact of the project during construction and operation, such as employment, development of the economy, relocation and resettlement of households and structures, and land aquisition and compensation.

2) Development and implementation of the EMMP is recommended for the adjacent areas of the reservoirs, based on the present and existing environmental studies.

3) Total coliforms determination and bacteria count is recommended to be done in all reservoirs, and in a periodic schedule, as proposed in the program for establishing a

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

4) Pesticide analysis is recommended in all the reservoirs, and in a regular schedule, to evaluate the possible danger of pesticide polluted water entering the intake of the treatment plants for human consumption. Special attention should be paid to Cis-heptachlor, which already appears in concentrations of greather than the maximum allowed.

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

6) Implementation of aquatic plant control mechanisms such as described in this report and the coordination with CEDEGE are recommendable to improve water quality conditions at Conguillo inlet, and avoid further colonization of the plant into the other reservoirs.

7) The implementation of the sewarage system for Portoviejo city should be considered as a priority to avoid the serious future deterioration expected for the Portoviejo river.

8) Design of the proposed new Simbiocal dike is recommendable to allow the stored water elevation to reach 6 m above sea level.

9) A new Simbocal tidal gate operation manual should be established based on the present study, to achieve efficiency and coordination of the operation for the existing users, and the conservation of the wetland area.

10) Periodic tidal measurements should be made in a monitoring program, during 2 consecutive days of each month, and for a one year period, to adjust the existing operational program. At the same time, salinity measurements of top and bottom samples are recommnendable to be taken during the same period and in the same tidal measurement stations, to evaluate tide mixing patterns and fresh water requirements of the estuary.

11) An Integrated Pest Management Program (IPM) should be implemented as outlined in this study, for the irrigation area in an effort to reduce the use of pesticides and inorganic fertilizers, and through this mechanism improve the water quality conditions in rivers, estuaries and wetlands.

1.7 Environmental Management and Monitoring Plan

The present study is conceived as a first step of a management and monitoring plan, and should be understood as such. Programs and basic studies are well detailed in the different sections of the study, and the present section acts as a summary, with the objective of clarifying the environmental aspects to be managed and monitored, and to delineate a framework through the technical and financial viewpoints.

The JICA study team proposed in 1992 a structural organization consisting of three units, namely Environmental Management Unit (MAU), Environmental Monitoring Unit (MOU), and Laboratory (LAB). MAU has the function of overall management of the EMMP, including inter and inner institutional implementation of each plan and program. MOU has the planning and execution functions of the various kinds of studies and monitoring plans or programs in accordance with the policies decided by MAU. LAB has the roles of the physical, chemical, bacteriological and pesticide analysis for water and soil, and the research and development study for the establishment of appropriate EMMP of the project. The organizational chart is shown in Figure 8.1.

1.7.1 Cost for Impremention of EMMP

Several programs are to be conducted in EMMP for the Project during a period of five to seven years from 1995. The cost for these program is estimated at US$ 2.7 million indicatively, as shown hereunder.

EMMP Indicative Cost for Implementation

Program	Item	Indicative Cost in (US$)	
		Foreign Currency	Local Currency
A- Water Quality:			
• Program for Establishment of Water Quality Standard	Local Personnel	–	73,000
	Equipment	101,500	
• Program to Reduce Effects of Agrochemical	Local Personnel	–	84,000
	International Consultant	50,000	
	Equipment	170,300	
• Program for Biomass Removal from La Esperanza Impoundment Area	Local Personnel	–	24,000
	Equipment	1,800	
• Program for Aquatic Weed Control in Reservoirs	Local Personnel	–	150,000
B- Protection and Conservation			
B-1 Reservoir area			
• Program for Reforestation and Land Use Control around Reservoirs area	Local Personnel	–	156,800
	International Consultant & Local Experts	206,000	
	Equipment	523,200	
	Civil Works	420,000	
B-2 Estuary and Alluvial Areas			
• Program for Reforestation and Conservation of the Chone River Estuary	Local Personnel		327,000
	International Consultant & Local Experts	140,000	
	Equipment	127,800	
• Program for Conservation of the Portoviejo river Estuary	Local Personnel	–	5,600
	Equipment	24,200	
• Program for Conservation of Wetlands and Chame Habitats	Local Personnel	–	43,200
	International Consultant	72,000	
	Equipment	29,200	
C- Operation of Simbocal Tidal Gate			
• Program for Redesign, Implementation and Operation of the New Simbocal Gate	Local Personnel	–	7,200
	Equipment	3,200	
Total Estimated EMMP Cost		1,869,200	870,800

1.7.2 Cost for Administration of EMMP

The annual cost for administration by CRM for EMMP has been estimated in US$ 207,000 as shown below.

Administrative Cost for EMMP

Item	Unit Cost/Year (US$)	No.	Total Cost/Year (US$)
i) Personnel			
- Professional staff	5,000	5	25,000
- Assistants	4,000	10	40,000
- Others	3,000	6	18,000
ii) Office Cost			
- Vehicles	6,000	4	24,000
- LAB equipment	–	1	50,000
- Others	–	1	50,000
Total:			207,000

Note: Do not include overhead because they are government offices

2. PROJECT ACTIONS RECONNAISSANCE

2.1 Introduction

The objective is to identify the main possible environmental conflicts arising from the project actions defined. A general project activity reconnaissance is carried out to assess key issues related to the project actions.

In the area of influence of the project there are two reservoirs in operation: Poza Honda (1973), and Daule-Peripa (1988), with useful volumes estimated in 85 MCM and 4,000 MCM respectively, and one reservoir under construction, La Esperanza with a useful volume of 391 MCM.

The purpose of the project is the water transbasin of 336 MCM in average and 500 MCM as maximum from the Daule-Peripa reservoir to La Esperanza reservoir through a tunnel of 8.3 km long to conduct a 18 m^3/sec flow by gravity, and from la Esperanza reservoir to Poza Honda reservoir, through a pumping station located at the Severino site and discharging in a trapezoidal open concrete channel of 6.4 km long, and connecting with a tunnel 11.4 km long, to finally deliver a 16 m^3/sec flow in Poza Honda reservoir at the Los Cuyuyes site. A third tunnel, 4.1 km long, is to be constructed between Poza Honda and Mancha Grande river, to deliver a maximum flow of 4 m^3/sec into Mancha Grande river by gravity.

The project also includes a single circuit transmission line of 33 km long, 138 kV, a subestation and 2 transformer units of 10 MVA.

Permanent and temporary access roads to the different sectors of the area of influence are to be improved or newly constructed in sectors. Four main access roads have been identified for this purpose.

Refer to Figure 2.1 for location of project actions.

2.2 Project Actions

2.2.1 Daule-Peripa -La Esperanza diversion tunnel

The tunnel is 8.3 km long, with a horse shoe section and a designed diameter of 3.7 m, tunnel inlet and outlet and work adits are located at the Conguillo inlet, at the Membrillo outlet, and Conguillo, El Guasmo and Membrillo work adits.

The tunnel is designed to have a gradient of 1/1,500, concrete lining of 30 cm without reinforcement bars and shotcrete , 10 to 15 cm in thickness, and it will be excavated in rock to communicate the Daule-Peripa reservoir with La Esperanza reservoir.

2.2.2 Severino pumping station

The pumping station at Severino will have the intake adjacent to La Esperanza reservoir, with a maximum pumping height of 67 m, and will allocate five pumps of 3,2 m^3/s in capacity each, for a total flow of 16 m^3/sec, including an emergency unit.

Two penstock lanes of steel, 173 m and 170 m long respectively, with an inside diameter of 2,000 mm for each pipe. Access road will have to be improved and constructed in sectors to reach the Severino pumping station and service it.

2.2.3 Severino open channel

The proposed open channel has a longitudinal gradient of 1/3,000, 6.4 km long including syphons, trapezoidal in its transversal section, with its bottom width of 1.6 m, and it is designed for a discharge of 16 m^3/sec. The open channel will be fed by the pumping station at Severino, and will discharge at La Esperanza-Poza Honda diversion tunnel.

The channel will have a concrete lining, and will cross three (3) streams on its route.

2.2.4 La Esperanza-Poza Honda diversion tunnel

This tunnel is located between the outlet of the Severino open channel at Ca~a Dulce and Poza Honda reservoir. The tunnel is 11.4 km long, with a 3.5 m horseshoe type diameter and a longitudinal gradient of 1/1,500, lining is similar than for Daule-Peripa ~ La Esperanza tunnel.

Part of the excavated material is to be used in the Severino open channel construction, and the rest is to be disposed of in spoil banks.

The tunnel is to be excavated in rock and will connect La Esperanza reservoir with Poza Honda reservoir.

2.2.5 Poza Honda~Mancha Grande diversion tunnel

The tunnel is 4.1 km long, it has a horse shoe section 2.5 m in diameter, a gradient 1/3,900 and a concrete lining similar than the one for Daule-Peripa ~ La Esperanza. It will have a maximum discharge of 4 m^3/s and its purpose is to communicate Poza Honda reservoir with Mancha Grande river. The Poza Honda inlet has a control structure to regulate the flow for the water level fluctuation at Poza Honda reservoir. The outlet is a concrete open channel 250 m long.

2.2.6 Daule-Peripa -Severino transmission line

The proposed transmission line is 33 km long, and will carry a voltage of 138 kV in a single circuit. The line connects the Severino substation with the Daule-Peripa Hydropower plant.

2.2.7 Access roads

(1) Severino access road

This road has to be constructed to access Severino pumping Station. It will have a gravel subbase , with approximately 9.2 km long, and will intersect three (3) streams, Estero Conguillo, Limon, and Estero El Sambo. The road to Caña Dulce inlet, branches off from Severino access road, it is 2.7 km long and with similar technical characteristics than Severino's road.

(2) Los Cuyuyes access road

This is an existing road on the right bank of Poza Honda reservoir that must be improved with a subbase of gravel, to access La Esperanza~Poza Honda diversion tunnel at Los Cuyuyes outlet. The road is approximately 14.8 km long and has been constructed more than 20 years ago, the road intersects four (4) main streams. A branch of this road, 0.7 km long, connects to Poza Honda ~ Mancha Grande inlet portal

(3) Conguillo access road

This road has to be newly constructed in a length of approximately 22.3 km, consisting of a subbase of gravel and will serve for the transportation of construction materials to the Conguillo inlet. Two branches connect this road to the El Guasmo work adit and to the Membrillo outlet of the Daule-Peripa ~ La Esperanza tunnel, with a length of 1.50 km and 0.9 km , respectively.

(4) La Seca access road

The proposed access road to be constructed is 3.8 km long, with a subbase of gravel, and will serve to access La Seca work adit through the Los Cuyuyes main road.

2.3 Existing Conditions

2.3.1 Daule-Peripa -La Esperanza diversion tunnel

This tunnel is designed to communicate Conguillo river at the Daule-Peripa reservoir with Membrillo river at La Esperanza reservoir. The tunnel route is located in a mountain area with pronounced slopes. The inlet portal at Conguillo is 18 m below the HWL of the reservoir.

The immediate water areas around Conguillo inlet are completely covered by water hyacinth (Eichornia crassipes). The aquatic plant had covered an estimated 12,000 ha by April 1991, with an estimated growth rate of 4,000 ha/year (18). It is assumed that by August 1993 the coverage area was around 22,000 ha, due to the reduced extraction and control implemented at the Daule-Peripa reservoir. The immediate areas surveyed (3 km upstream) are 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.

Membrillo tunnel outlet site is on the Membrillo river adjacent to the community of Membrillo, with approximately 40 houses of permanent dwellers. The permanent water level expected at this point with the project condition will enable the population of Membrillo to mobilize themselves by boat.

2.3.2 Severino pumping station

The pumping station at Severino is located in an open field disposed for extensive cattle raising, at some 700 m wide band along the river. The adjacent area in general is highly deforested, and populated by isolated individual houses of local permanent-subsistence farmers. No vegetation of interest or dense population settlements exist.

The geological investigation indicates an adequate condition and fresh rock in the subsoil to provide a good foundation.

2.3.3. Severino open channel

The proposed open channel route is located in a colluvial area adjacent to the mountain area. The area at the channel route has a moderate slope, alternating with gulches. The use of the land is dedicated to extensive cattle raising, and subsistence agriculture of the scattered permanent dwellers of the area. In general, the landscape is deforested, consisting of pasture lands, with scattered patches of altered secondary forest. No flora or fauna of interest is reported or evident in the area.

2.3.4 La Esperanza~Poza Honda diversion tunnel

The tunnel route is located in a mountain area, with steep slopes alternating with gulches. Elevations in this area are between 200 and 400 m.a.s.l. The area is highly deforested, and isolated patches of altered forest are the only remanent of the original vegetation. The use of the land is mainly dedicated to extensive cattle raising and subsistence agriculture.

The topography at Los Cuyuyes outlet and Ca–a Dulce inlet has moderate slopes, where the fresh rock is covered with colluvial deposits, and a highly meteorized rock.

The proposed location for Los Cuyuyes outlet at Poza Honda shows extensive deposition of sediment on the left margin of the Mineral river outlet.

2.3.5 Poza Honda~Mancha Grande diversion tunnel

The tunnel route runs through a mountain area, with elevations between 200-400 m.a.s.l., at the Poza Honda inlet and Mancha Grande outlet the slope is moderate, and the topsoil is composed of colluvial deposits and a layer of highly meteorized rock.

In the route from Poza Honda to Mancha Grande, the proposed tunnel is aligned passing through and under a forested area located between two hills. Vegetation in this area is secondary and altered, although thick. The proposed outlet portal at Poza Honda is adjacent to a cacao plantation area.

2.3.6 Daule-Peripa ~Severino transmission line

The proposed transmission line route is through mountain areas, alternating with gulches, through open fields dedicated to subsistence agriculture and extensive cattle raising.

The area is highly deforested, with scattered patches of altered secondary forest, and with a very low density of population.

At the end of the transmision line, that is, the left bank of Daule river next and downstream the Daule-Peripa dam, there is an ecological reserve declared by CEDEGE, with aproximately 200 ha. This area is undergoing in a sustained reforestation process and sound environmental management, therefore, it is recommended to avoid passing the transmision line through this area.

2.3.7 Access roads

(1) Severino access road

The area is of undulated topography, highly deforested with isolated patches of altered secondary forest.

The use of the land is restricted to extensive cattle raising and subsistence agriculture.

The road will pass close to several (21) isolated houses of permanent dwellers which in the actual situation have restricted access specially during the rainy season, where secondary adjacent roads are not adequate for vehicles.

(2) Los Cuyuyes access road

The existing road that has to improved was built more than 20 years ago, it transect 4 esteros and 9 gulches, and it is actually used by the population of the area for the transportation of agricultural produce, specially during the dry season, since during the rainy season, the road is not accessible.

The area adjacent to the road has been highly deforested, alternating with isolated patches of altered tropical dry forest. Areas above the road elevation still have important patches of dry forest alternating with cleared areas for agriculture in very steep slopes.

The actual use of the land is dedicated to extensive cattle raising and agriculture of cacao, and fruit trees, mixed with subsistence short cycle produce. The human settlement is scattered in a linear fashion along the existing road, and two defined settlements are located in the eastern end of the road, namely Las Mercedes I and Las Mercedes II.

The topography of the existing road is moderate, with alternating crossing of rivulets and esteros, and is adjacent to the steeper slopes of the mountain side at the northern side of the road.

A detailed analysis of the existing situation in this area is discussed in the Conservation Program for the Vicinity Area of Poza Honda further in this report.

(3) Conguillo access road

The adjacent area of the proposed and existing road is a mountain area, with elevations of 200-400 m or more, the area is highly deforested, with scattered patches of altered forest alternating with clear land dedicated to subsistence agriculture and extensive cattle raising.

Agricultural areas have been implemented in slopes of 70% or more, favoring deforestation in the higher elevations and pronounced slopes.

The settlement of Membrillo has approximately 40 houses, and is located half way between Buenaventura and Conguillo, at some 200 m from the water access in the Membrillo river at La Esperanza reservoir. People in this settlement are isolated during the rainy season from vehicle access, given the bad road condition. The population is not used to a heavy traffic situation in the vicinity of the settlement.

(4) La Seca access road

The area is of steep topography, alternating with hills. The use of the land is dedicated to extensive cattle raising and subsistence agriculture, the human settlement is aligned linearly along the main road. The area is adjacent to the main road, and highly deforested.

2.4 Possible Impacts

2.4.1 Daule-Peripa -La Esperanza diversion tunnel

No mayor impacts are expected because of the construction of the tunnel itself, since it is excavated in rock and below the land surface, without any effect on the ecosystem or human activities occurring in the surface.

The Conguillo inlet at Daule-Peripa is surrounded by a heavy growth of the aquatic plant Eichornia crassipes, 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
- Substrate for disease vectors such as mosquitoes, rats, and mollusks, etc.
- Limiting light penetration and promoting anoxic conditions, and limiting water quality conditions for fish.
- Enhancement of excessive evapotranspiration and 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 particulate matter in water.

The Membrillo outlet at Membrillo river in La Esperanza, is adjacent to the population of Membrillo (approximately 40 houses), this condition will favor the transportation by boat of the population of Membrillo, improving their communication means. On the other hand, the population of Membrillo becomes a pollution source to the water body. Possible impacts arising from this possibility are mentioned:

- Disposal of fuels and oils at the docking site
- Solid waste disposal in the water body
- Domestic sewerage effluent disposal into the water body
- Use of the water body as water source for cattle, pigs etc.

- Sewerage disposal of eventual poultry and/or hog production facilities.

- Soap residue disposal due to clothing washing in the water body.

2.4.2 Severino pumping station

No mayor impacts are foreseen with the location and installation of the pumping station at Severino, the area is a low density populated area, and no natural resources of importance are to be perturbed.

The main issue regarding the pumping station is the noise that the facility will generate, perturbing the natural quietness of the area, it's dwellers, and the still existing fauna of the place.

People accessing the pump intake at the water side could indulge in swimming, cloth washing or approaching the intake and suction end, favoring accidents.

2.4.3 Severino open channel

No mayor impacts are foreseen in the flora, fauna or cultural components of the open channel route, the area is highly deforested and no species of commercial, scientific or cultural value are reported or found.

The existence of a water channel transecting through arid lands where water is scarce will inevitably attract animals and people to it, some expected activities generated by the existence of the new channel are:

- Cattle accessing the channel for drinking water, some animals might fall in and drown, deteriorating the water quality.

- Use of the channel as effluent disposal for poultry and/or hog raising.

- Human settlement allocation in the perimeter of the channel with the consequent sewerage and/or solid waste disposal.

- Washing of pesticide equipment

- People swimming in the channel

- Allocation of aquaculture facility with water intake and water effluent disposal in the channel.

The open channel route will transect several existing properties, and some of them could become isolated from the rest of the property or from access roads because of the channel.

Runoff from adjacent hills during the rainy season in a highly deforested area could deposit important sediment loads in the channel, reducing it's capacity and/or transporting this sediment to the reservoir.

2.4.4 La Esperanza~Poza Honda diversion tunnel

No mayor impacts are expected because of the construction of the tunnel itself, since it is excavated below the land surface.

Part of the excavated rock will be used in the construction of the open channel, the remaining volume is to be disposed of in spoil banks.

2.4.5 Poza Honda~Mancha Grande diversion tunnel

No mayor impacts are expected because of the construction of the tunnel itself, since it is excavated below the land surface.

Los Poza Honda inlet is adjacent to a cacao plantation located between the existing road and the reservoir, this area is private property an must be purchased in part to allocate the outlet and access the area.

2.4.6 Daule-Peripa~Severino transmission line

The transmission line route transect through a low density populated area, through pasture lands and open fields surrounded by scattered patches of altered secondary forest growth, no major impact is expected by the transmission line route.

Transmission line towers are to be erected in several points of the route, in open agricultural or cattle raising fields, the existence of this towers could induce persons or children to climb the towers which are designed for easy access for repair. The high voltage of the lines could cause accidents to unauthorized people trying to climb these structures.

The final lenght of the transmision line rute passes through an ecological reserve, thus the layout of the rute must be changed to avoid passing through the protected area.

2.4.7 Access roads

(1) Severino access road

This is a new road to be constructed, and will favor the access to the adjacent areas, appreciation of the land and probably the new colonization trends will be incentivated by the adequate access to the area.

In general, the area is highly deforested and altered, and the difficulties in the accessing of this area have not stopped the massive deforestation process, so no significant impact is expected from this project action in regards to deforestation.

The road will improve the process of extraction of agricultural produce and cattle, and it is foreseen that the land value will be appreciated, the planned road will be adjacent to at least 21 isolated houses which will have an immediate improvement in their communication means.

The road is to transect 3 esteros, and sound engineering measures are to be taken not to obstruct the water flow in these esteros, and in areas of steep slopes, erosion control measures must be considered.

(2) Los Cuyuyes access road

This road has been built more than 20 years ago, it is not accessible by car during the rainy season, and there is a linear disposition of housing, schools and installations along the road.

It is assumed that the improvement of the road will induce further colonization of the area, non the less, the area is highly deforested, and the inaccessibility of the road during the rainy season has not stopped the deforestation process, so no mayor impact in deforestation is expected because of the road improvement, specially if the environmental program outlined further in this report is implemented by CRM.

The road will favor tourism, and the extraction of agricultural produce year round, and will allow for the relocation of the existing docking facility to the tail end of the reservoir, reducing the pollution source generated by the docking facility located in front and at some

100 m from the potable water intake in Guarumo. This situation is discussed in detail in the conservation program for the immediate areas of the reservoir further in this report.

The existing road located in a very steep band between the hills and the water level of the reservoir acts as a barrier against erosion or land sliding, and will remain doing so with the road improvement.

(3) Conguillo access road

The population of Membrillo settlement is not used to heavy traffic in the area, with the road improvement and the project constructions a heavy traffic is expected with the construction material transportation, this action could cause traffic accidents among the population of Membrillo, specially children and elderly.

The new road will enhance the communication possibilities of the community of Membrillo, facilitating produce export, and appreciating the value of the existing land. It will probably induce new colonization and a mayor number of vehicles passing through the area.

The adjacent area to the road is a mountain area with slopes 200-400 m, highly deforested, alternating with isolated patches of altered forest, for this reason the impact on future deforestation is considered of medium importance, since most of the area has been already deforested with the actual road conditions.

(4) La Seca access road

This is a short access road (3.8 km), through a deforested area alternating with scattered patches of altered forest, and no mayor impact is expected because of the new road. Slopes on the road route are steep, and accidents with heavy equipment and loaded trucks are bound to occur. Erosion in this road is expected to be high, given the steep slopes.

2.5 Recommended Actions

2.5.1 Daule-Peripa -La Esperanza diversion tunnel

At the Conguillo inlet, the aquatic plant infestation of Eichornia crassipes could be approached by two complimentary strategies: