JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
NATIONAL INSTITUTE OF DEVELOPMENT (INADE)
THE REPUBLIC OF PERU

THE STUDY
ON
THE INTEGRATED WATER POLLUTION CONTROL
FOR
PUNO INTERIOR BAY OF LAKE TITICACA
IN
THE REPUBLIC OF PERU

SUMMARY

JANUARY 2000

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO
in association with
ENVIRONMENTAL TECHNOLOGIC CONSULTANT CO., LTD., TOKYO

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Estimate of Base Cost: as of 1998 price

Foreign Currency Exchange Rates:

Currency	Exchange Rate / US$
Peruvian Nuevo Sol (S/.)	3.15
Japanese Yen (¥)	116.70
Deutsche Mark (DM)	1.6710

(31 December, 1998)

Numerical Notation: Decimal marker : "." (period)
Digit separator : "," (comma)

PREFACE

In response to a request from the Government of the Republic of Peru, the Government of Japan decided to conduct a master plan and a feasibility study on The Integrated Water Pollution Control for Puno Interior Bay of Lake Titicaca in the Republic of Peru and entrusted the study to the Japan International Cooperation Agency (JICA).

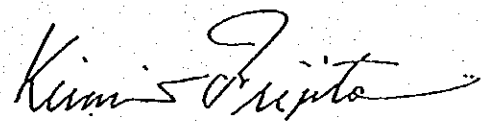
JICA selected and dispatched a study team headed by Mr. Tsutomu Kurihara of Pacific Consultants International (PCI) to Peru, three times between September 1998 and January 2000. In addition, JICA set up an advisory committee headed by Mr. Hidenori Aya, Professor of Musashi Institute of Technology, between September 1998 and January 2000, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Peru and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Peru for their close cooperation extended to the Team.

January, 2000



Kimio Fujita
President
Japan International Cooperation Agency

THE STUDY ON THE INTEGRATED WATER POLLUTION CONTROL
FOR
PUNO INTERIOR BAY OF LAKE TITICACA
IN
THE REPUBLIC OF PERU

January, 2000

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

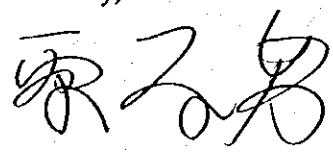
We are pleased to submit to you the final report entitled "The Study on The Integrated Water Pollution Control for Puno Interior Bay of Lake Titicaca in the Republic of Peru". This report has been prepared by the Study Team in accordance with the contracts signed on 16 September 1998 and 20 April 1999 between Japan International Cooperation Agency and Pacific Consultants International.

The report examines the existing conditions of Puno Interior Bay of Lake Titicaca and presents the results of master plan of the integrated water pollution control and feasibility study for priority project concluded in the master plan.

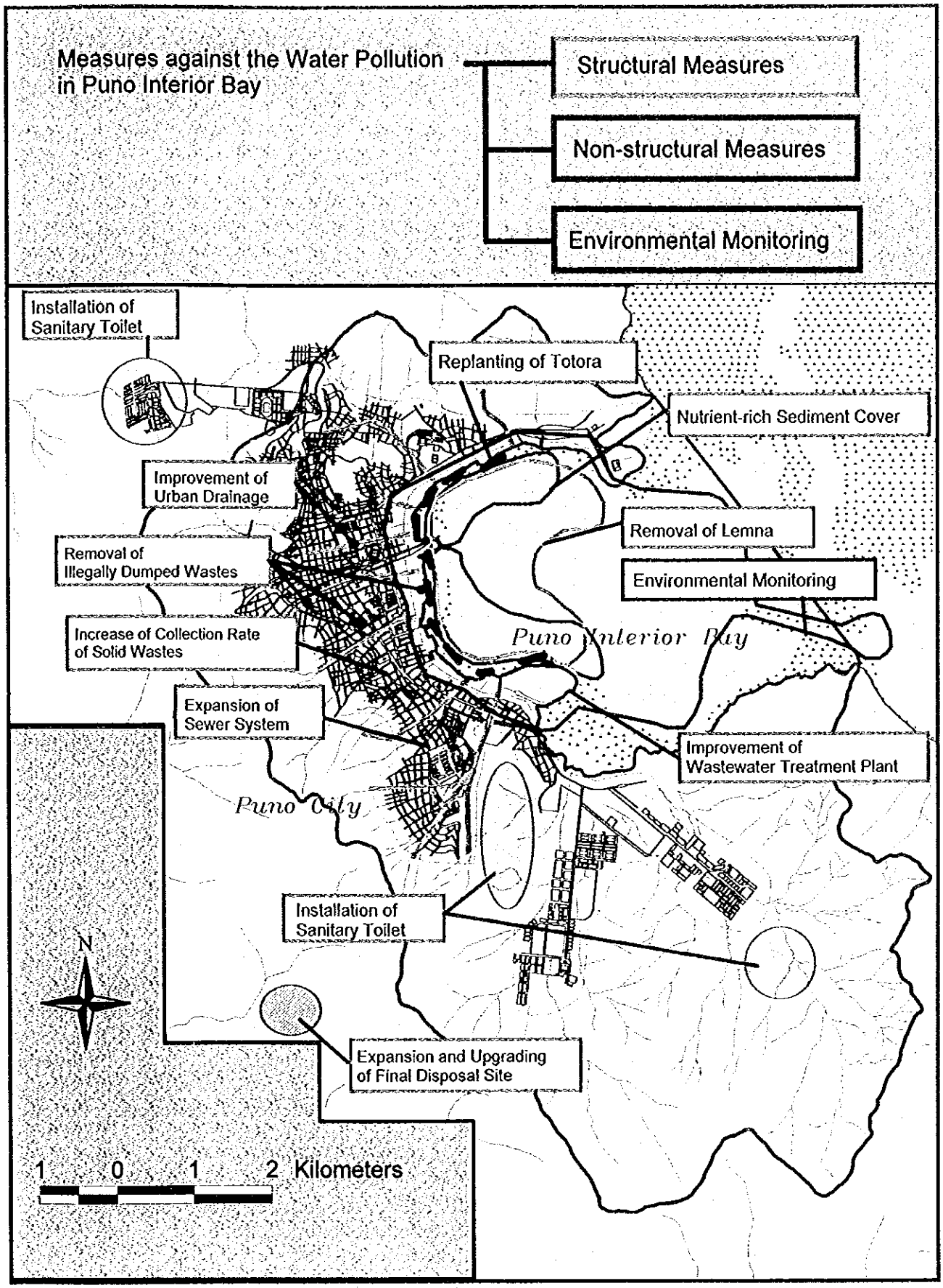
The report consists of the Summary, Main Report, Supporting Report and Data Book. The Summary summarizes the results of all studies. The Main Report contains the existing conditions, the master plan, the feasibility study, and conclusions and recommendations. The Supporting Report includes technical details of contents of the Main Report. In addition, Data Book has been prepared and is submitted herewith.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, Ministry of Health and Welfare, Environment Agency and Embassy of Japan in Peru, and also to officials and individuals of the Republic of Peru for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the improvement of water pollution of Lake Titicaca in the Republic of Peru and that friendly relations of both countries be promoted further by this occasion.

Yours faithfully,



Tsutomu Kurihara
Team Leader



Proposed Integrated Water Pollution Control Plan for Puno Interior Bay

ABSTRACT

1. BACKGROUND

Puno Interior Bay is suffering from progressive water pollution and eutrophication caused by inflow of sewage and other wastes from Puno city. As a typical feature, beneficial large hydrophyte such as Totora (reed) has been decreasing while floating *Lemna* (duckweed) have developed in large quantity and covers a wide lake surface.

Under these circumstances, this Study was conducted by the Study Team of the Japan International Cooperation Agency (JICA) in cooperation with the National Institute of Development (INADE) from September 1998 to January 2000.

The Study area covers Puno Interior Bay (about 17 km^2) and its surrounding catchment area (about 36 km^2).

2. INTEGRATED WATER POLLUTION CONTROL PLAN FOR PUNO INTERIOR BAY

2.1 FRAMEWORK OF THE INTEGRATED WATER POLLUTION CONTROL PLAN

(1) Targets

1) Water Quality of Puno Interior Bay

Recovery of the acceptable water quality as it used to be in the 1970's

2) Scenery of Puno Interior Bay

- Reduction of *Lemna* distribution
- Reduction of littered solid wastes to an insignificant level

3) Ecosystem of Puno Interior Bay

- Rehabilitation of Totora belt, fish, benthos and submerged macrophytes
- Conservation of habitats for wild birds

4) Public Health Conditions of Puno Interior Bay and Puno City

- Reduction of littered wastes in the watershed and the lake
- No bacterial and parasite contamination in the watershed and the lake

(2) Target Year

Short-term target year : the year 2008
Mid-term target year : the year 2015
Long-term target year : the year 2025

2.2 STRUCTURAL MEASURES

(1) Wastewater Control

1) Planning Conditions

	Year	1998	2008	2015	2025
Population of Puno City	Total	108,457	139,076	160,508	185,004
	Sewerage served	50,107 (46%)	97,631 (70%)	125,731 (78%)	157,253 (85%)
Daily Ave.	Wastewater Flow	77.2 l/s	128.6 l/s	170.0 l/s	224.0 l/s
Pollution Load (kg/day)	BOD_5	2,255	4,393	5,658	7,076
	T-N	551	1,074	1,383	1,730
	T-P	63	122	157	197

2) Proposed Plan

a. On-site system

On-site facility : Pit Latrine (0.7 W × 0.7 L × 1.5 H = 0.74 m^3)

Pit emptying : Small (vacuum) pit emptying machine (500 L/unit)

Sludge disposal : Truck (loading capacity: 2 ton)

b. Off-site system

Wastewater collection system

Sewer Total Length = 136,234 m

Phase 1 (1998-2008) Length = 23,396 m

Phase 2 (2009-2015) Length = 46,832 m

Phase 3 (2016-2025) Length = 66,007 m

Pump Station E.B. EL PUERTO

Submersible pump (5.25 l/s, 8.6 m, 1.2 kW, 1 set (+1))

Wastewater treatment plant

Pump station Submersible pump (200l/s, 8.6m, 30kW, 2 sets (+1))

Aerated lagoon 3 basins

Coagulant dosing equipment

Sedimentation pond 3 basins

Inlets for facultative lagoons

Primary lagoon 1 basin (existing facultative lagoon)

Secondary lagoon 1 basin (existing facultative lagoon)

Outlet facility for the second facultative lagoons

Constructed wetland (Totora) 34 basins (sub-surface flow type)

3) Project Cost

a. On-site system (for small pit emptying machine and truck)

Total investment cost : S/.1,248,000 Soles (not including IGV)

O/M cost : (not including IGV)

Year	2008	2015	2025
Cost (thousand S/./year)	237	195	171

b. Off-site system

Total investment cost : S/.91,189,800 Soles (not including IGV)

O/M cost : (not including IGV)

Year	2008	2015	2025
Cost (thousand S/./year)	757	1,109	1,447

(2) Solid Waste Management

1) Planning Conditions

	Year	1998	2008	2015	2025
Quantity of Solid Waste	Generated (t/day)	67.0	85.9	101.5	126.2
	Collected (t/day)	34.0 (51%)	58.3 (68%)	81.9 (81%)	126.2 (100%)

2) Proposed Plan

a. Collection and Transport

	Year	2008	2025
Required Number of Solid Waste Collection Vehicle	12 m^3 compactor	1	2
	4 m^3 compactor	7	15
	6.8 m^3 dump	1	5
	Tricycle	5	5
Manpower		153	204

b. Final Disposal Site

According to the technical guideline issued by DIGESA, 10 sanitary landfill sites having acreage of 20,000 m2 - 37,000 m2 are to be constructed stepwise. At the sites, heavy equipment will be also required.

3) Project Cost

Total investment cost : S/.89,232,800 Soles (not including IGV)

O/M cost : (not including IGV)

Year	2008	2025
Cost (thousand S/./year)	1,401	2,115

(3) Other Measures

1) Urban Drainage System

a. Proposed Plan

- enlargement and lining of existing channels
- construction of additional drainage ways
- construction of check dams and drop structures to control flow velocity and sediment
- separation of drainage ways and sanitary sewer system

b. Project Cost

Total cost : S/.8,543,200 Soles (not including IGV)

2) In-Lake Management

a. Removal of Duckweed (*Lemna*)

Proposed Plan

Regular removal of *Lemna* by a low-draft barge harvesting equipment (harvesting rate: 30~40 t/day) is proposed.

Project Cost

Total investment cost : S/.378,000 Soles (not including IGV)

O/M cost : S/.36,800 Soles/year (not including IGV)

b. Cover of Bottom Sediment

Proposed Plan

The areas for the sediment cover is the western part of Puno Interior Bay where the water depth is smaller than 3.5 m and the equipment can be operated. Possible covering material is silty sand which is distributed along the navigation channel of Puno Interior Bay.

- Sediment Covering Area :	2,400,000 m^2
- Covering thickness :	0.30 m
- Covering volume :	720,000 m^3

Project Cost

Total cost : S/.23,310,700 Soles (not including IGV)

c. Replanting of Reed (Totora)

Proposed Plan

Major processes of the rehabilitation of Totora are a multiplication of seedling Totora and a planting of multiplied Totora. The seedling Totora should be planted along the western shore of Puno Interior Bay.

-	Unit Totora belt :	length = 200 m, width = 40 m
-	Number of unit :	18 units
-	Total of planting area :	14.4 ha

Project Cost

Total cost : S/.158,300 Soles/year (not including IGV)

2.3 NON-STRUCTURAL MEASURES

(1) Proposed Plan

The following measures are proposed.

1) The **institutional consolidation plan;**

2) The **public education program;**

3) The **enlightenment campaign (installation of *the Clean Day)*;**

4) The **enforcement of environmental regulations.**

(2) Project Cost

Total investment cost : S/.579,600 Soles (not including IGV)

O/M cost : S/.516,300 Soles/year (not including IGV)

2.4 Environmental Monitoring

(1) Proposed Plan

1) Monitoring Program for Effluents

Food and processing industries (4 workshops)
Slaughter house (1 facility)
Espinar wastewater treatment plant (1 facility)

2) Monitoring Program for Water Bodies

a. Physical and Chemical Conditions

Lake water (7 main points, 5 supplementary points)
Drainage channels (5 points)
Lake sediment (12 points)

b. Biological Conditions

Lake water (Plankton,Benthos and Macrophytes)

(2) Project Cost

Total investment cost : S/.246,000 Soles (not including IGV)

O/M cost : S/.184,200 Soles/year (not including IGV)

2.5 Implementation Program

Implementation program for the Integrated Plan are summarized in *Table 1.* Among the proposed components, the sewerage systems improvement, the solid waste management and the environmental monitoring should be implemented as first priority projects in Puno.

The sediment cover should be implemented when the measures against the external pollution load does not produce the expected effects.

Besides the structural measures, no-structural measures should be started as early as possible in order to formulate citizen's awareness and understanding for the Integrated Plan. Citizen's awareness and understanding are indispensable to promote the structural measures.

3. FEASIBILITY STUDY

3.1 SELECTION OF PROJECT

In the Integrated Water Pollution Control Plan for Puno Interior Bay, each measure has been ranked considering its priority.

1st: Improvement/Upgrading of Sewerage Systems
2nd: Improvement/Upgrading of Solid Waste Management
3rd: Improvement of Urban Drainage Systems
4th: In-lake Measures (cover of the bottom sediment, removal of *Lemna*, rehabilitation of Totora)

With regard to sewerage network, the feasibility study has been already completed and the German Government will offer a financial assistance for the project as it is feasible. As a result, the improvement / upgrading of solid waste management by the year 2008 has been selected for the feasibility study.

3.2 DESIGNING

(1) Waste Collection

1) Proposed Plan

a. Necessary numbers of collection vehicles

			2002	2003	2004	2005	2006	2007	2008
2025-100%	Vehicle	12m3 Compactor	1	1	1	1	1	1	1
		Ditto(Existing)	1	1	1	1	-	-	-
		4m3 Compactor	1	2	2	2	4	4	5
		Ditto(Existing)	2	2	2	2	2	2	2
		6.8m³Dump Truck	1	1	1	1	1	1	1
		5 t Dump Truck	2	2	2	2	1	1	1
	Total (unit)		8	9	9	9	9	9	10
	Supplement Capacity(t/d)		22.6	28.0	28.0	33.4	38.8	38.8	44.2
	Existing Capacity(t/d)		34.4	34.4	34.4	17.2	17.2	17.2	17.2
	Total Capacity(t/d)		57.0	62.4	62.4	50.6	56.0	56.0	61.4
	Collection Quantity(t/d)		42.51	44.84	47.24	49.88	52.61	55.41	58.33
	Direct carried waste(t/d)		1.59	1.62	1.64	1.67	1.69	1.72	1.74

(2) Final Disposal Site

The following table shows the required capacity for waste in total.

	Waste Generation (Incl. Direc. carried in)	Wastes Hauled	Wastes Hauled	Volume of Wastes	Covering Soil	Necessary Volume	Volume Accumulated
	t/day	t/day	t/yr	m^3/yr	m^3/yr	m^3/yr	m^3
1998	68.41	35.49	12,954	18,506	4,626	23,131	23,131
2008	87.63	60.07	21,926	31,322	7,829	39,152	236,252

3) Necessary Equipment to be installed

Bulldozer, Backhoe, Dump Truck, Truck Scale, Generator are required for Sanitary Landfill.

3.3 IMPLEMENTATION PLAN

In order to construct a sanitary landfill, one year is necessary as a preparation year. Therefore, the construction work will start in 2001.

3.4 PROJECT COST

Construction cost	9,113,000 Soles
Equipment	3,738,000 Soles
Operation and Maintenance Cost	9,682,000 Soles
GRAND TOTAL	22,533,000 Soles (not including IGV)

3.5 PROJECT EVALUATION

Implementation of the project will have the social effects such as an improvement of sanitary conditions and an improvement of tourism development potential.

FIRR would exceed 7 % if revenue will be significantly increased by an increase of the waste handling charge or by an establishment of new funds such as environment fee, or if the state government will allocate subsidies or low-interest funds to Puno Provincial Municipality.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 EVALUATION OF THE INTEGRATED PLAN

The whole plan requires a large amount of investment even if reasonable techniques are applied to each component projects. However, the financial status of the local government in Puno is too serious to realize the Plan. Even if the local government of Puno succeed in increasing the revenue with a maximum effort, strong financial support by the state government will still be indispensable.

There will be various benefits accruing from this plan. If this plan can not start, the environment of Puno will become worse and worse. As the result, Lake Titicaca will be dirty and fishery activities will be damaged and the sightseeing business will be also diminished. The effects were estimated from current business volume. The value of EIRR is 15%, higher than the opportunity cost (the cost is assumed as 10% in Peru), and the cumulative profits is plus. So it can be said that the proposed Integrated Plan is viable from the economic point of view.

The Plan will essentially contribute to the environmental improvement of Puno Interior Bay. Organic pollution load will be reduced to the targeted level which used to be in/before the 1970's. Consequently, the target of the plan against the organic pollution in Puno Interior Bay will be achieved by the year 2008, and the favorable condition will last for a long period. Although the Plan will also produce negative effects through the phases of planning, construction and operation, it is evaluated that all impacts are minor or temporary and able to be mitigated within an acceptable level.

4.2 RECOMMENDATIONS

Puno Interior Bay is a part of Lake Titicaca. Not only the people who live there but also the Peruvian nation and foreign tourists have enjoyed the outstanding environment of the lake. Therefore they have to return the profits, in other word, provide the labor or the funds required for the environmental improvement of the lake. The economic benefit will surpass the total costs of the Plan. It means that the Plan is worthy to implement. However it is too hard for the local governments or residents to bear all costs when their financial difficulties are taken into account. The state government's financial assistance such as subsidies or low-interest funds are indispensable to realize the Plan. Furthermore, it is recommended to establish the system to raise the funds widely from the users or polluters of the lake environment.

Table 1 Implementation Schedule of The Integrated Water Pollution Control Plan for Puno Interior Bay

Proposed Plan			Priority	Year
Measures	Component			2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025
External Pollution Load Reduction	Sewerage Systems	Sewer Expansion	1	
		WWTS Improvement	1	
	Sanitary Toilet		2	
	Urban Drainage		3	
Solid Waste Management	Removal of Illegally Dumped Wastes		2	
	Increase of Collection Rate		1	
	Expansion/Upgrade of Final Disposal Site		1	
In-Lake Management	Removal of *Lemna*		2	
	Cover of Bottom Sediment		4	
	Replanting of Totora		3	
Non-Structural Measures	Environmental Education & Campaign		1	
	Citizen's Participation		1	
	Institutional Strengthening		1	
	Land Use Management		3	
	Livestock Farming Management		4	
	Regulation of Effluents		2	
Environmental Monitoring			1	

Construction

Operation

THE STUDY
ON THE INTEGRATED WATER POLLUTION CONTROL FOR PUNO INTERIOR BAY OF LAKE TITICACA IN THE REPUBLIC OF PERU

(SUMMARY)

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ABBREVIATIONS

1. Peruvian Organizations

ALT :	Binational Autonomous Authority of Lake Titicaca
APECO :	Peruvian Association of Conservation
CAPET :	Chamber of Fishery in Titicaca
CONAM :	National Environmental Council
DIGESA :	General Administration of Environmental Health, Ministry of Health
EMSAPUNO :	Municipal Enterprise for Potable Water and Sewerage
ENAFER :	National Railroad Company
GOP :	The Government of Peru
INADE :	National Institute of Development
INADUR :	National Institute of Urban Development
INEI :	National Institute of Statistics and Information
INRENA :	National Institute of Natural Resources
MITINCI :	Ministry of Industry, Tourism, Integration and International Trade Negotiations
MTCVC :	Ministry of Transport, Housing and Construction
PELT :	Special Binational Project for Lake Titicaca
PRONAA :	National Program of Nutrition Assistance
PRONAP :	National Program of Potable Water and Sewerage
SENAMHI :	National Service of Meteorology and Hidrology
SUNASS :	National Superintendence of Sanitation Service
SUNAT :	National Superintendence of Taxes
UNA :	National University of The Altiplano – Puno

2. Japanese/International Organizations

CEPIS :	Pan American Center for Sanitary Engineering and Environmental Sciences, WHO
GOJ :	The Government of Japan
IBRD :	International Bank for Reconstruction and Development (World Bank)
IDB :	Inter-American Development Bank
IMF :	International Monetary Fund
JICA :	Japan International Cooperation Agency
JST :	JICA Study Team
KfW :	German Bank for Reconstruction
OECD :	Organization for Economic Cooperation and Development
WHO :	World Health Organization

3. Measuring Units

1) Physical

mm	:	millimeter(s)
cm	:	centimeter(s)
m	:	meter(s)
km	:	kilometer(s)
ha(s)	:	hectare(s)
l, ltr	:	liter(s)
g, gr	:	gram(s)
kg	:	kilogram(s)
t, ton	:	tonnage(s)
s, sec	:	second(s)
min	:	minute(s)
h(hrs)	:	hour(s)
d(dys)	:	day(s)
y, yr(yrs)	:	year(s)

2) Chemical

mg/l	:	milligram(s)

3) Others

a.s.l.	:	above sea level
inh/ha	:	inhabitants per hectare
nos/l	:	numbers per liter

4. Monetary Terms

¥	:	Japanese Yen
US$	:	United States Dollar
S/.	:	Peruvian Nuevo Sol
DM	:	Deutsche Mark

5.Others

BOD	:	Biological Oxygen Demand
CIF	:	Cost, Insurance and Freight
COD	:	Chemical Oxygen Demand
Chl-a	:	Chlorophyll-a
D/D	:	Detailed Design
D/S	:	Definitive Study
DF/R	:	Draft Final Report
DID	:	Densely Inhabited District
DL	:	Datum Line

DO	:	Dissolved Oxygen
E/S	:	Engineering Service
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
F/R	:	Final Report
F/S	:	Feasibility Study
FDS	:	Final Disposal Site
FIRR	:	Financial Internal Rate of Return
FY	:	Fiscal Year
GDP	:	Gross Domestic Products
GNP	:	Gross National Products
IC/R	:	Inception Report
IEE	:	Initial Environmental Evaluation
IGV	:	General Sales Tax (Impuesto General a las Ventas)
IT/R	:	Interim Report
M/P	:	Master Plan
MSL	:	Mean Sea Level
N	:	Nitrogen
NGO	:	Nongovernmental Organization
P	:	Phosphorous
P/R	:	Progress Report
S/W	:	Scope of Work
SS	:	Suspended Solids
STP	:	Sewage Treatment Plant
SWM	:	Solid Waste Management
TDS	:	Total Dissolved Solids
VAT	:	Value Added Tax
WWTP	:	Wastewater Treatment Plant
WWTS	:	Wastewater Treatment System

CHAPTER – I INTRODUCTION

CHAPTER - I

INTRODUCTION

1. BACKGROUND OF THE STUDY

The City of Puno is expected to experience a substantial growth of population in the future due to newly emerging communities in the outskirts of the city in addition to population influx. However, improvement and expansion of urban infrastructure has fallen behind the rate of such population growth and most of the sewage is directly discharged into Puno Interior Bay without treatment. Besides, there are other problems, such as inflow of solid wastes into the interior bay during rainfall because of insufficient waste collection system.

The Bay is suffering from progressive water pollution and eutrophication caused by inflow of sewage and other wastes from Puno city. Beneficial large hydrophyte such as Totora (reed) has been decreasing while floating *Lemna* (duckweed) have developed in large quantity and covers a wide lake surface.

Under these circumstances, this Study was conducted by the Study Team of the Japan International Cooperation Agency (JICA) in cooperation with the National Institute of Development (INADE) from September 1998 to January 2000.

The objectives of the Study are as follows:

1) To formulate a Master Plan of integrated water quality improvement of Puno Interior Bay.
2) To conduct a feasibility study (F/S) on priority project identified from the Master Plan.
3) To transfer technology to counterpart personnel in the course of the Study.

The Study area covers Puno Interior Bay (about 17 km^2) and its surrounding catchment area (about 36 km^2), as shown in *Figure I.1*.

The Study reports prepared are as follows:

Main Report (English)

Main Report (Spanish)

Supporting Report

Summary Report (English)

Summary Report (Spanish)

Data Book

The Spanish versions of reports are prepared as reference.

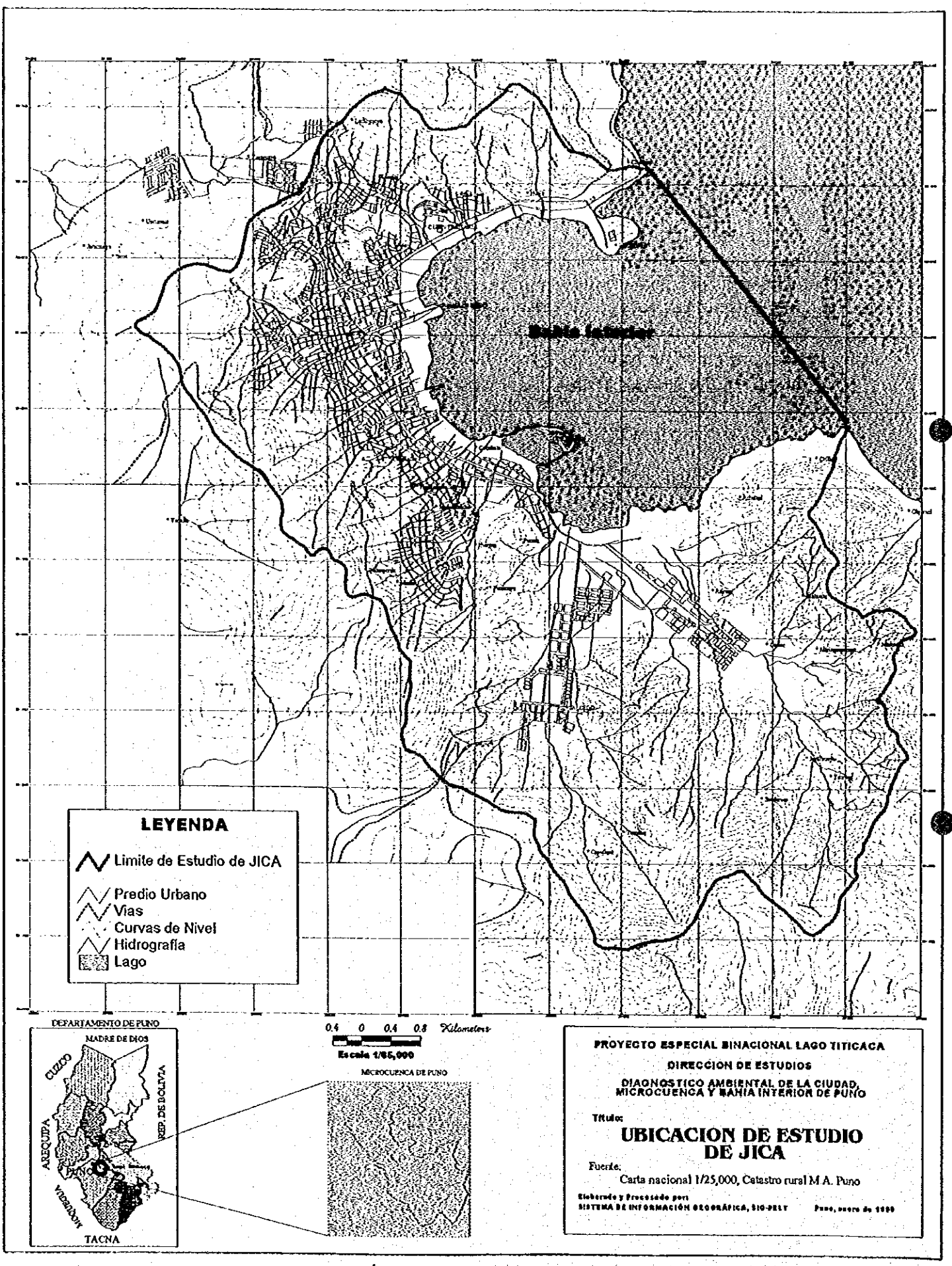


Figure I.1 Study Area

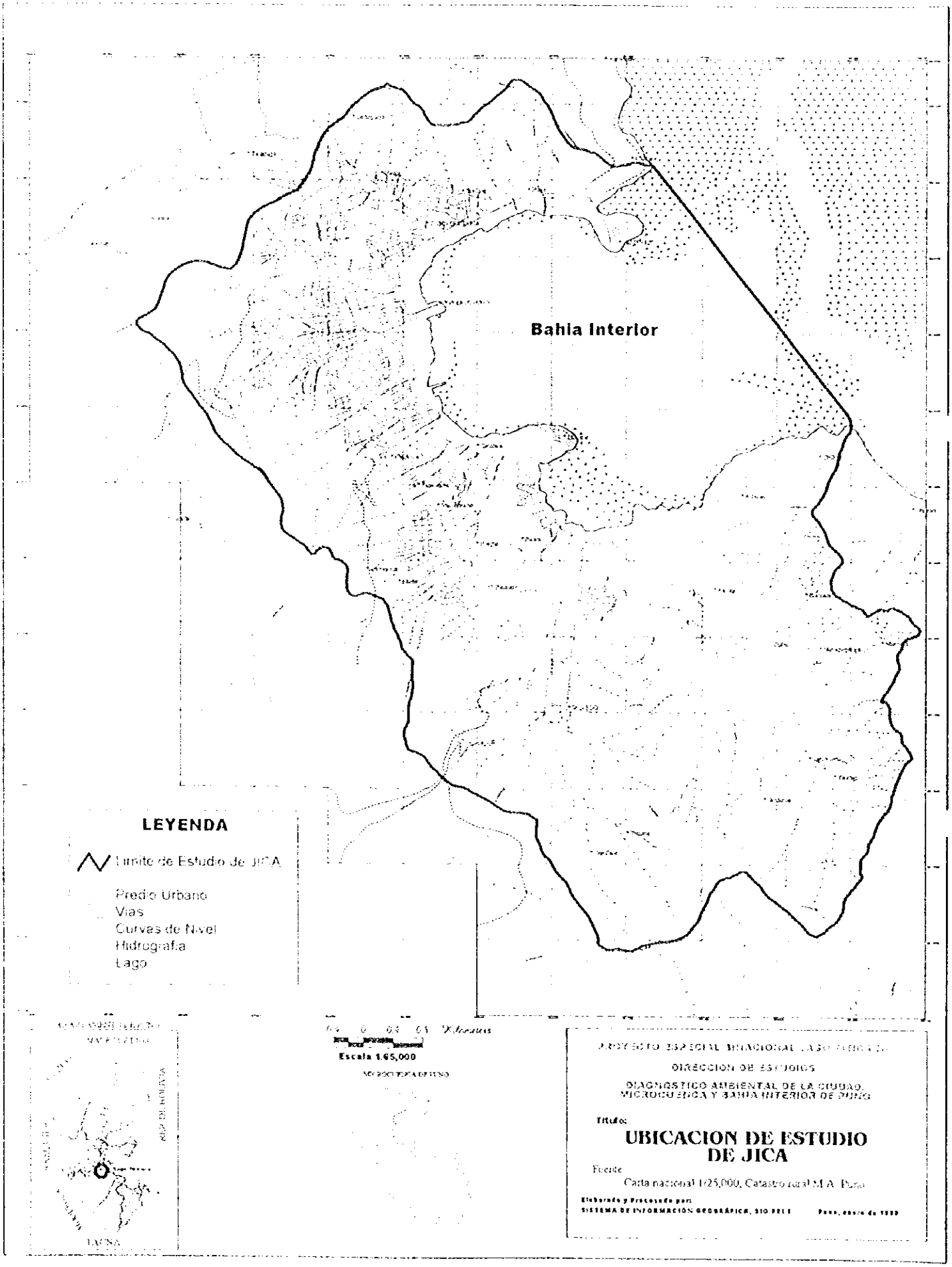


Figure I.1 Study Area

CHAPTER – II

THE INTEGRATED WATER POLLUTION CONTROL PLAN

FOR

PUNO INTERIOR BAY

CHAPTER – II

INTEGRATED WATER POLLUTION CONTROL PLAN FOR PUNO INTERIOR BAY

1. EXISTING PROBLEMS IN PUNO INTERIOR BAY

Figure II.1.1 summarizes of the last several decades records of environmental events, meteorological and hydrological observation, and development of sewerage systems. The figure also shows the transition of environmental conditions of Puno Interior Bay.

Water quality of Puno Interior Bay has been deteriorating since the 1970's or earlier. In particular, the western shoreline is affected mainly by domestic and commercial wastewater which is discharged from the urbanized area of Puno City.

The existing water environmental problems in Puno Interior Bay, which are identified by the field survey and interview, are described as below.

(1) Enclosed and shallow water body which is prone to be polluted

(2) Water use problems caused by significant eutrophication

(3) Depreciation of tourism resources

(4) Destruction of ecosystem

(5) Offensive odor

(6) Public health problems

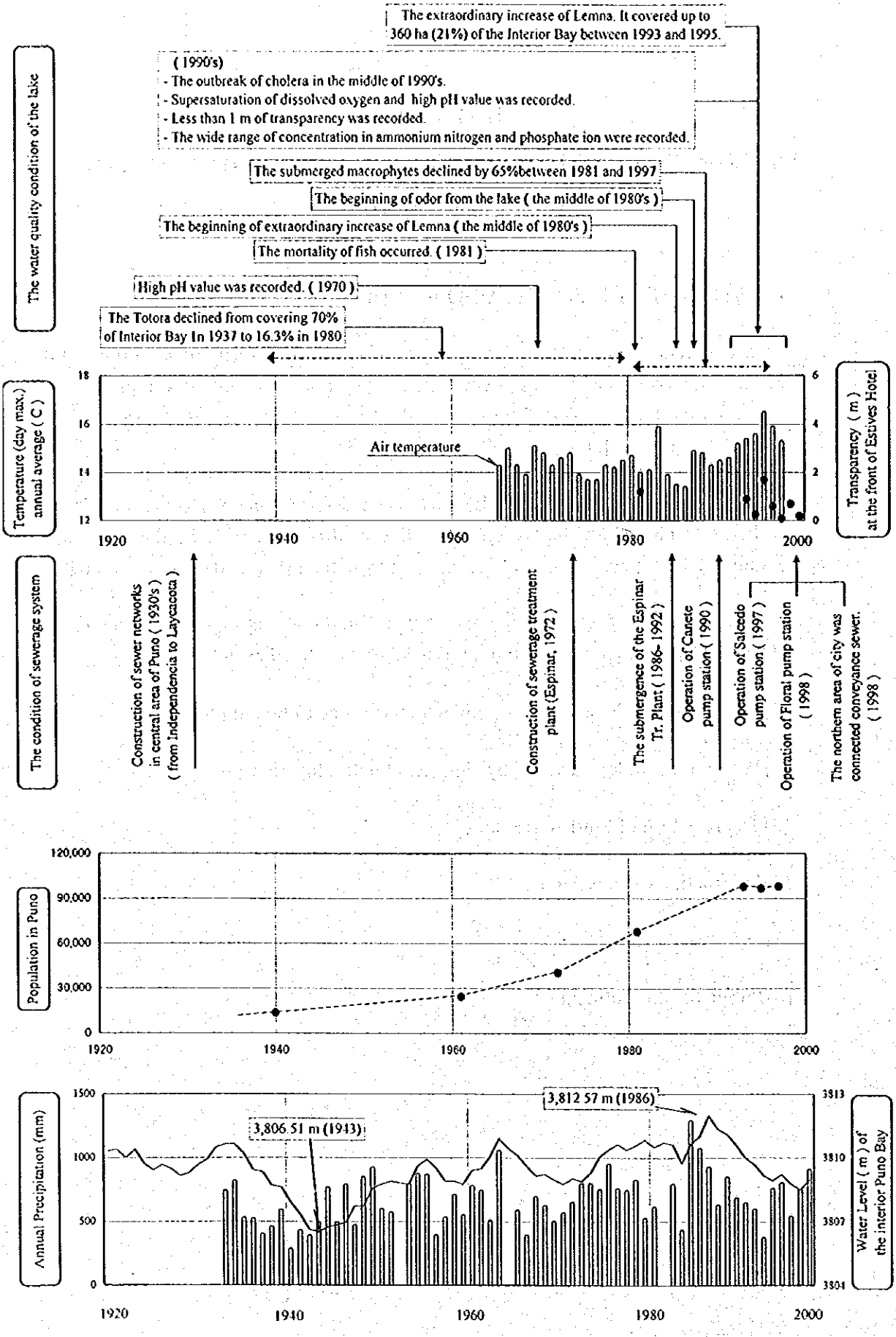


Figure II.1.1 The Transition of Puno Interior Bay and Its Background

2. FRAMEWORK OF THE INTEGRATED WATER POLLUTION CONTROL PLAN FOR PUNO INTERIOR BAY

2.1 CONCEPT OF THE INTEGRATED WATER POLLUTION CONTROL PLAN

(1) Goal

The Integrated Water Pollution Control Plan aims primarily to improve the water quality of Puno Interior Bay polluted by urbanization of Puno City, and consequently to contribute to the conservation of its unique natural environment and to the development of the regional economy and living conditions.

(2) Targets

1) Water Quality of Puno Interior Bay

Recovery of the acceptable water quality as it used to be in the 1970's

2) Scenery of Puno Interior Bay

- Reduction of *Lemna* distribution
- Reduction of littered solid wastes to an insignificant level

3) Ecosystem of Puno Interior Bay

- Rehabilitation of reed (Totora) belt
- Conservation of habitats for wild birds
- Recovery of fish and benthos
- Recovery of submerged macrophytes

4) Public Health Conditions of Puno Interior Bay and Puno City

- Reduction of littered wastes in the watershed and the lake
- No bacterial or parasite contamination in the watershed and the lake

(3) Target Year

Short-term target year : the year 2008
Mid-term target year : the year 2015
Long-term target year : the year 2025

(4) Methodology

In general, possible efforts to improve lake environment are classified into the following three categories:

- Structural Measures
- Non-structural Measures
- Environmental Monitoring

Structural measures are defined as the measures taken by administrative bodies to physically improve the environment of Lake Titicaca. Non-structural measures are defined as the measures which aim to motivate the state/local governments, private sectors or citizens to take some actions for environmental improvement. Environmental monitoring is defined as an environmental administration tool which detects/identifies environmental problems, assesses the effects/impacts caused by the implementation of structural measures, and rouses people's awareness. Although the structural measures must be the main category, the integrated plan will not fulfill its function unless all measures are systematically combined. The conceptual figure of "The Integrated Water Pollution Control Plan for Puno Interior Bay" is shown in *Figure II.2.1*.

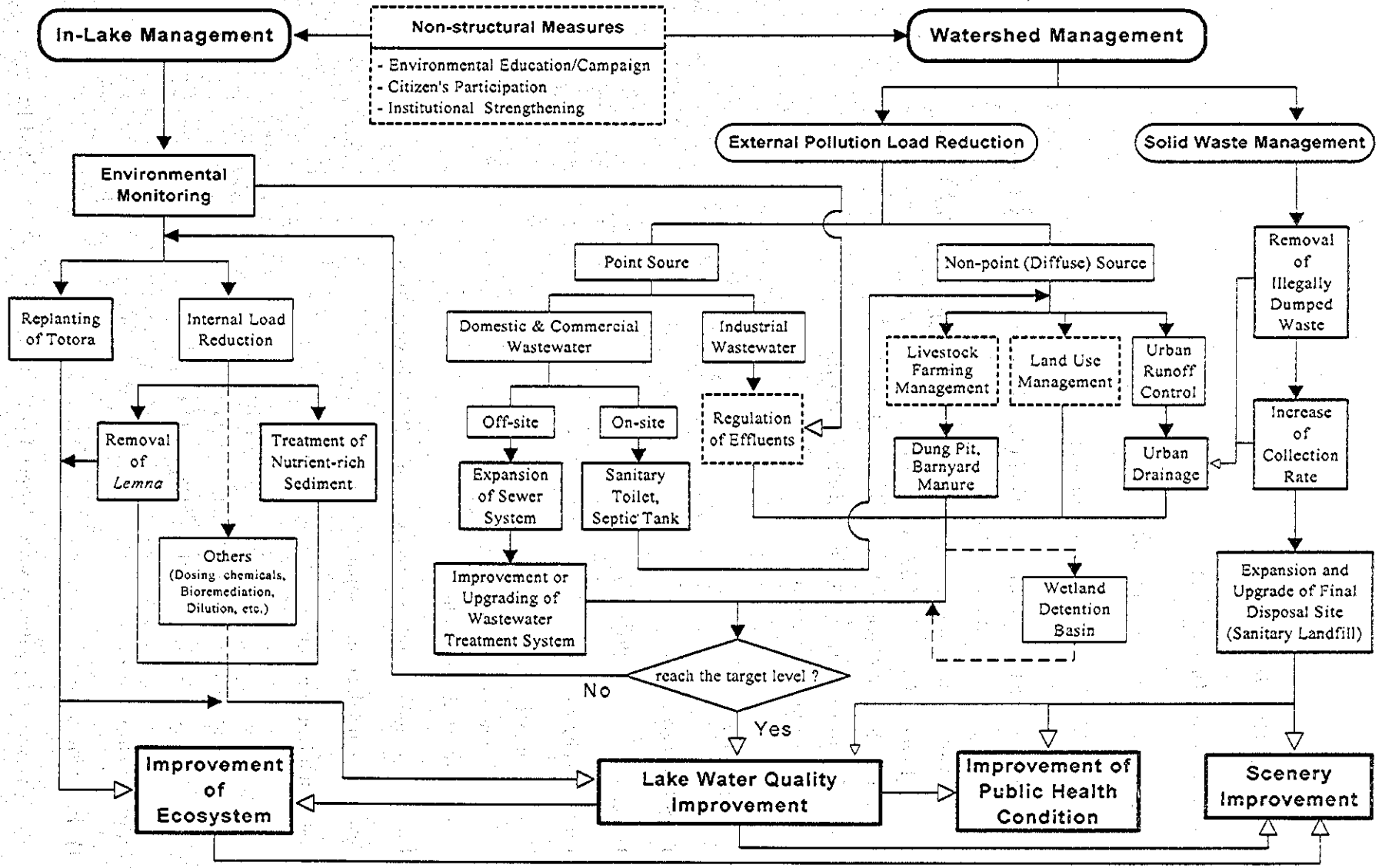


Figure II.2.1 Conceptual Figure of The Integrated Water Pollution Control Plan for Puno Interior Bay

3. STRUCTURAL MEASURES

3.1 WASTEWATER CONTROL SYSTEM

3.1.1 Evaluation of the Present Conditions

Existing problems are identified as follows:

- Low collection rate of wastewater (46% by sanitary sewer system)
- Broken covers of sewer pits
- Insufficient removal rate of nutrients at the Espinar stabilization lagoon (BOD5: 80%, T-N: 30%, T-P: 30%)
- Overload of Chanu Chanu treatment plant
- Inflow of rainwater to the collection network
- Lack of on-site systems

3.1.2 Master Plan

(1) Target and Strategy

Target year: 2025

Target wastewater:

- Domestic wastewater
- Commercial wastewater
- Industrial wastewater

Target coverage of sanitary sewer system: 85 % in year 2025

Sewer system selection: separate system

Staged implementation:

First stage	1998 – 2008	(Phase 1)
Second stage	2009 – 2015	(Phase 2)
Third stage	2016 – 2025	(Phase 3)

(2) Planning Conditions

1) Planning area

- Area served by sanitary sewer (zones 1 – 12, 14): 2831 ha
- Area served by on-site sanitation facilities (zones13, 15, 16): 539 ha

2) Sewerage service coverage

Table II.3.1 Target service coverage of sanitary sewer

	Year	1998	2008	2015	2025
Population of Puno City	Total	108,457	139,076	160,508	185,004
	Sewerage served	50,107 (46%)	97,631 (70%)	125,731 (78%)	157,253 (85%)
Daily Ave.	Wastewater Flow	77.2 l/s	128.6 l/s	170.0 l/s	224.0 l/s
Pollution Load (kg/day)	BOD_5	2,255	4,393	5,658	7,076
	T-N	551	1,074	1,383	1,730
	T-P	63	122	157	197

(3) Possible Plans for Structural Measures

1) On-site system

On-site facilities:

- Pit latrine
- Pour flush toilet

Pit emptying: small (vacuum) pit emptying machines + sludge trucks

Sludge disposal: land (forest) disposal

2) Off-site system

a. Wastewater collection system

Conventional sanitary sewer system in combination with simplified sewer system

b. Wastewater treatment system

Three Alternative plans for wastewater treatment and disposal processes exist, which include ones proposed by PRONAP (Alternative I, I-A) and INADE-PELT (Alternative II). Schematics of wastewater treatment processes for each alternative are shown below.

3) Cost estimation

The project cost is estimated based on the preliminary design for the Master Plan facilities. Unit prices and lump sum prices were determined considering local conditions, sub-contractors, equipment, available construction equipment and materials as well as suitability of the proposed construction method. The total costs for the alternatives are as shown in *Table II.3.2.*

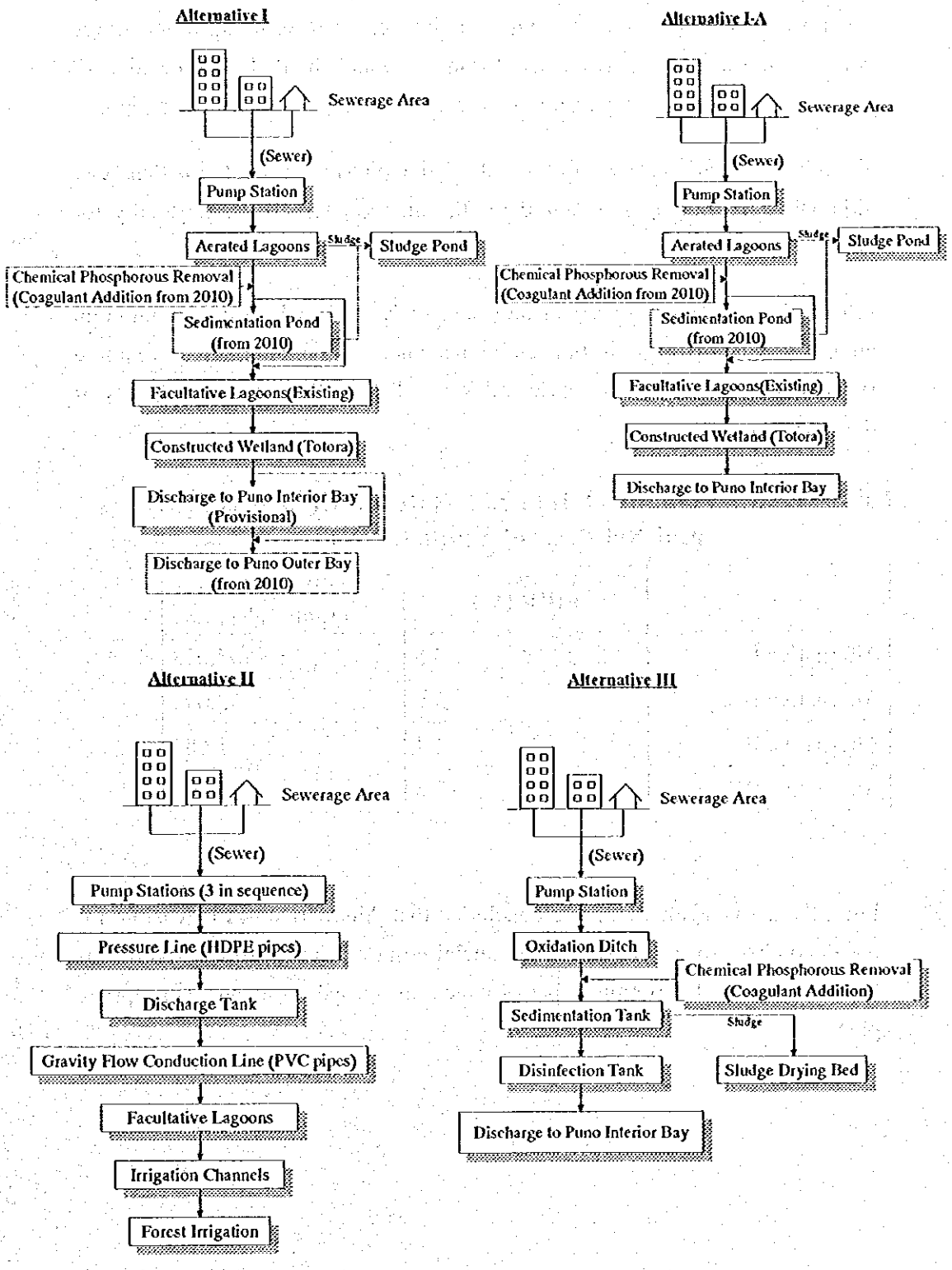
Table II.3.2 Total Project Costs (until the year 2025)

(S/.1000 (thousand Soles))

Item	Alternative			
	I	I-A	II	III
1. Land Acquisition	0	0	167	0
2. Administration	600	600	400	600
3. Construction Work	59,987	53,722	56,542	83,428
1) Sewer	31,639	31,639	31,639	31,639
2) Pump station	6,661	397	6,423	7,959
3) WWTP	21,687	21,687	18,480	43,829
4. Procurement of Maintenance Equipment	536	536	565	835
5. Engineering Service (10% of Item 3.)	5,999	5,372	5,655	8,343
6. Contingency (15% of Items 3,4,5)	9,979	8,945	9,414	13,890
7. IGV (18% of Items 3,4,5,6)	13,771	12,344	12,992	19,169
Total	90,870	81,519	85,734	126,266
8. Renewal of Equipment [1)]	28,567	26,939	12,969	72,044
9. O/M [2)]	27,640	23,896	40,597	31,323
Grand Total	147,077	132,354	139,300	229,633

Note : 1) Item "8." includes contingency and IGV.

2) Item "9." includes IGV.


Alternative I
Sewerage Area
(Sewer)
Pump Station
Aerated Lagoons
Sludge
Sludge Pond
Chemical Phosphorous Removal
(Coagulant Addition from 2010)
Sedimentation Pond
(from 2010)
Facultative Lagoons(Existing)
Constructed Wetland (Totora)
Discharge to Puno Interior Bay
(Provisional)
Discharge to Puno Outer Bay
(from 2010)
Alternative I-A
Sewerage Area
(Sewer)
Pump Station
Aerated Lagoons
Sludge
Sludge Pond
Chemical Phosphorous Removal
(Coagulant Addition from 2010)
Sedimentation Pond
(from 2010)
Facultative Lagoons(Existing)
Constructed Wetland (Totora)
Discharge to Puno Interior Bay
Alternative II
Sewerage Area
(Sewer)
Pump Stations (3 in sequence)
Pressure Line (HDPE pipes)
Discharge Tank
Gravity Flow Conduction Line (PVC pipes)
Facultative Lagoons
Irrigation Channels
Forest Irrigation
Alternative III
Sewerage Area
(Sewer)
Pump Station
Oxidation Ditch
Chemical Phosphorous Removal
(Coagulant Addition)
Sedimentation Tank
Sludge
Disinfection Tank
Sludge Drying Bed
Discharge to Puno Interior Bay

4) Evaluation of alternative plans

Alternative I discharges treated water to the Puno outer bay. Its discharge point is not so far from the drinking water intake. This drinking water source is most important for the residents of Puno City and should be protected at all cost. Failure for this may result in increased treatment cost for water supply.

Technical evaluation shows all four alternative plans are feasible for Puno city although staff training is required for the all the alternatives, especially for Alternative III.

Financial evaluation shows that only alternative I-A, which costs minimum among the alternatives, is financially feasible. Other alternatives required substantial rise in sewerage service rates or subsidies from the municipality or the government.

Table II.3.3 Financial Internal Rate of Return (FIRR) and Net Present Value (NPV)

	FIRR (%)	NPV (5%) (1,000 soles)
Alternative I	3.5	-4,018
Alternative I-A	5.9	2,094
Alternative II	4.4	-1,683
Alternative III	-3.5	-44,703

From the above evaluation, it is concluded that Alternative I-A is feasible for the Puno city, especially from the financial point of view. Alternative I-A is further analyzed for optimum performance and proposed as an appropriate plan.

(4) Proposed Plan

1) On-site system

a. Proposed on-site wastewater treatment/disposal system

Pit Latrine

- Pit Capacity : 0.7 W × 0.7 L × 1.5 H = 0.74 m^3
- Sludge Collection : Every 3 years
- Installation: Each house

Small Pit Emptying Machines

- Capacity : 500 L/unit
- Performance : 4.2 pits/day × 250days/year = 1,050 pits/year
- Economic Life : 4 years

Trucks for Sludge Transfer

- Loading Capacity : 2 ton
- Economic Life : 8 years

b. Sludge collection cost for on-site system

Total operation cost for sludge collection is calculated as S/.78 per collection (on average). Since it does not include administration cost and interests on capital cost, actual tariff may be set slightly higher.

2) Off-site system

a. Wastewater collection system

The summary of sewer and a pump station conducted in future plan are shown in the following tables.

Sewer

Table II.3.4 Summary of Sewer Plan

Phase	Pipe length (m)	Percent of sewered area (%)
Phase 1 (1998-2008)	23,396	36
Phase 2 (2009-2015)	46,832	57
Phase 3 (2016-2025)	66,007	72
Total	136,234	-

Pump Station

Table II.3.5 Summary of Pump Station Plan

Name	Specification
E.B. EL PUERTO	Submersible pump, 5.25 l/s, 8.6 m, 1.2 kW, 1 set (+1)

b. Wastewater treatment plant

- Possible improvement for Alternative I-A

Sedimentation lagoons

As required removal of accumulated solids from the facultative lagoons is quite difficult while continuous operation is required, installation of sedimentation lagoons is proposed. Two lagoons are to be constructed at Phase 2, which operate alternatively as a sedimentation lagoon and a sludge pond. Another lagoon is constructed at the start of Phase 3. Accumulated sludge in the aerated lagoons will be pumped to the sedimentation pond while it is used as a sludge pond.

Inlets for facultative lagoons

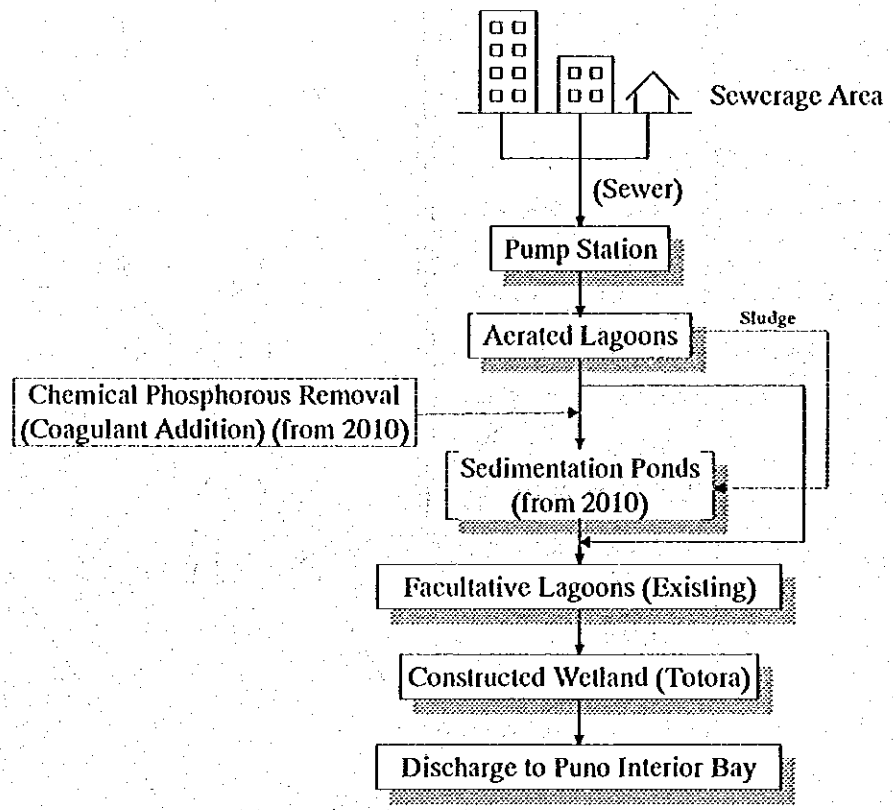
Inlets for the facultative lagoons are modified as shown in *Figure II.3.1* to maximize the average retention time of the lagoons.

Outlet facility for the second facultative lagoons

At present, a large amount algae is observed in the effluent of facultative lagoons. In order to minimize the release of algae into the effluent, outlet structure is to be installed.

- **Proposed wastewater treatment plant**

Schematic of the proposed wastewater treatment plant is shown below.



Layout for the proposed wastewater treatment plant is shown in *Figure II.3.1*. Specifications for major wastewater treatment facilities are shown in *Table II.3.6*.

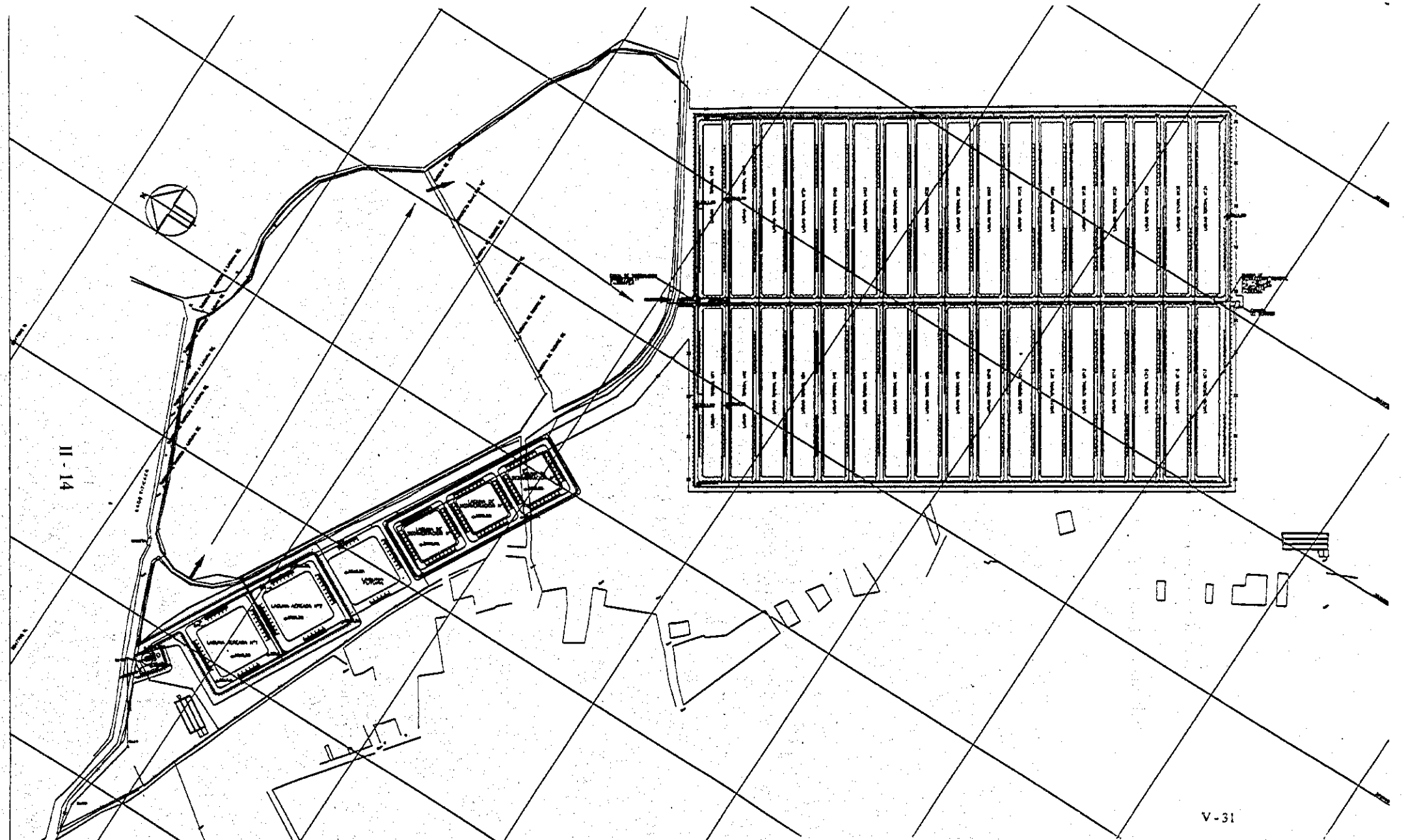


Figure II.3.1 Proposed wastewater treatment plant layout

Table II.3.6 Specifications of proposed wastewater treatment plant

Facilities	Specifications
1.Pump Station	
EB Puno	Submersible Pump, 200 l/s, 8.6 m, 30 kW, 2 sets (+1)
2. Aerated Lagoon	3 basins
Type	Rectangular Type
Dimension	64.0 m W x 80.0 m L x 4.0 m D
Aeration Power Level	22.35 kW (4 per Basin)
Retention Time	2.43 days
3. Existing Primary Lagoon	1 basin
Type	Facultative lagoon
Area	13.4 ha
Depth Average	1.5 m
Volume	204,600 m3
4. Existing Secondary Lagoon	1 basin
Type	Facultative lagoon
Area	7.9 ha
Depth Average	1.5 m
Volume	118,350 m3
5. Constructed Wetland	34 basins
Type	Sub-surface flow
Dimension	23.0 m W x 203.0 m L
Depth Average	0.3 - 0.5 m
6. Sedimentation ponds	3 basins
Type	Rectangular Type
Dimension	63.0 m W x 63.0 m L x 4.0 m D
Retention Time	2 days in year 2025

3) Non-structural measures

a. Institutional and operative capacity strengthening of EMSAPUNO

The staff training program shall be established to provide the existing and future staff to upgrade their knowledge and skills for organization management, operation & maintenance of the facilities.

b. Sanitation promotion

In order to achieve improvement of public health, sanitation promotion among the residents of Puno City is essential.

c. Control of sewerage system use

Sewerage systems are often damaged through public misuse. This results from a public misconception that a sewerage system can be used to carry away any unwanted object. Adequate regulations setting forth proper uses of the system and public cooperation are required to properly maintain and control the sewerage system.

(5) Implementation plan

Construction works according to the phases are as follows:

Facilities	Sewer Pipe	Pump Station	Wastewater Treatment Plant
Year	2000-2002	2000-2002	2000-2002
Phase 1	ϕ 150-900, L =25,223m	EB EL PUERTO	EB Puno Aerated Lagoon × 2 Constructed Wetland × 34
Phase 2	ϕ 150-300, L = 46,832m	-	<2009> Sedimentation Ponds × 2
Phase 3	ϕ 150-300, L = 66,007m	<2017> EB EL PUERTO (Pump equipment renewal)	<2016-2017> EB Puno (Pump equipment renewal) Aerated Lagoon × 1 Sedimentation Pond × 1

(6) Organization for Operation and Maintenance

Table II.3.7 Required number of staff for O&M of the proposed sewerage system

(Unit: person)

Field & Position		Phase 1	Phase 2	Phase 3	Duty
Manager		1	1	1	Responsible for wastewater system
Sewer and Pumping Station					
Sewer	Engineer	-	-	-	Responsible for cleaning of sewers
	Foreman	-	-	-	Responsible for site works
	Worker	2	4	6	2 workers/team
	Driver	1	1	1	2 workers/team
					*Vehicle maintenance shall be done by EMSAPUNO
Wastewater Treatment Plant					
Operation	Engineer	1	1	1	Responsible for technical matters
	Foreman	1	1	1	Responsible for operation of each shift
	Operator	1	1	2	1 (2) operator/shift
Maintenance	Technician	1	1	1	Responsible for site works
	Worker	-	-	-	Cleaning
W. Quality Analysis	Chemist	1	1	1	Water quality control
Total		7	9	14	

Administration staffs for EMSAPUNO are not included in the table. Temporary workers are hired for the operation, such as totora cutting and sludge removal.

(7) Project Cost

Construction cost for the proposed project is estimated as the same procedure explained in the previous section.

From the above study, overall implementation and disbursement schedule for the proposed plan is prepared as shown in *Table II.3.8.*

Table II.3.8 Project Implementation and Disbursement Schedule

Item \ Phase / Year		Phase 1											Phase 2							Phase 3									
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Implementation Schedule																													
1. Preparation of Project																													
2. Pre-Construction Stage																													
2.1 Detailed Design																													
2.2 Bidding																													
3. Construction																													
3.1 Collection System																													
3.2 Sewage Treatment Plant																													
- Civil Work																													
- Mechanical/Electrical Work																													
4. Procurement of Maintenance Equipment																													
5. Test Operation																													
Disbursement Schedule	**Total Cost** (Thousand S/.)	Phase 1 35,494											Phase 2 17,028							Phase 3 28,743									
1. Land Acquisition	0																												
2. Administration	600			22	22	22	22	22	22	22	22	22	29	29	29	29	29	29	29	20	20	20	20	20	20	20	20	20	20
3. Construction Work	53,553																												
(1) Sewer - civil works	31,639			2,586	2,586	2,586							1,447	1,447	1,447	1,447	1,447	1,447	1,447	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375
- mechanical/electorical	0																												
(2) Pump Station - civil works	34				34																								
- mechanical/electorical	363				181																181								
(2) Sewage Treatment Plant -civil	7,649				6,969								228								452								
- mechanical/electorical	13,868				8,489								817								4,562								
4. Maintenance Equipment	536					234							112									189							
5. Engineering Service	5,355		1,406		937								670		447					1,137		758							
6. Contingency	8,917		211	388	2,879	423	0	0	0	0	0	0	491	217	284	217	217	217	217	377	986	348	206	206	206	206	206	206	206
7. IGV (18 %) (for 3, 4, 5, 6)	12,305		291	535	3,974	584	0	0	0	0	0	0	678	299	392	299	299	299	299	520	1,360	481	285	285	285	285	285	285	285
Total Project Cost	81,265		1,908	3,531	26,072	3,849	22	22	22	22	22	22	4,471	1,992	2,598	1,992	1,992	1,992	1,992	3,429	8,936	3,172	1,886	1,886	1,886	1,886	1,886	1,886	1,886
8. Equip. Renewal (with IGV & contng.)	26,939			20			235	512						20		11,765	235	512				1,109	20		11,765	235	512		
9. Maintenance (with IGV)	23,896					550	574	599	623	659	696	735	778	913	945	978	1,012	1,046	1,081	1,114	1,149	1,181	1,219	1,256	1,289	1,322	1,357	1,391	1,427
Total Disbursement	132,100		1,908	3,552	26,072	4,400	831	1,133	646	681	718	757	5,249	2,925	3,544	14,735	3,238	3,549	3,072	4,544	10,085	4,354	4,214	3,163	3,175	14,974	3,478	3,790	3,313

(8) Project Evaluation

1) Social aspect

Expectation of improvement of sanitation and lake environment improvement by sewerage system development is very high in Puno City according to the public awareness survey carried out by JICA Study Team. Implementation of the Master Plan will have the following social effects:

- Improvement of sanitary conditions
- Improvement of tourism development potential by improving the water quality of Puno Interior Bay

The proposed Master Plan is considered socially feasible for Puno City. Social acceptance and effectiveness of the Master Plan will be enhanced through public awareness program.

2) Financial aspect

a. Financial Viability of Proposed Project

To calculate NPV of proposed plan, discount rate is supposed as 5%, because internal trade rate between banks in Peru was 5% in August 1999 (Banco Central De Reserva Del Peru, August 1999).

Table II.3.9 FIRR and NPV for the proposed Plan

	FIRR	NPV (S/.1000)
Proposed Plan	6.0%	S/. 2,277

Notice: Discount rate of NPV is 5%

FIRR and NPV are calculated by using the data of project cost, revenue, and donation.

FIRR (6.0%) is larger than discount rate (5%) and NPV (S/. 2,277) turns out positive, hence the proposed plan is estimated as feasible. However, the feasibility is based on the conditions mentioned in the previous section, so

finding sources of local loan with 5% interest and local fund without interest is crucial.

The change of cash balance is shown in the *Figure II.3.2*. The "cash flow out" will expand in 2001 and 2017, because the cost for construction work will swell in these years, and "cash flow out" will increase in 2012 and 2022, because the cost for procurement of equipment will expand in 2012 and 2022. While the "cash flow in" will increase in 2001, because of the donation of KfW. Moreover, "cash flow in" will swell in 2025, because it is supposed that all facilities and equipment will be sold out by EMSAPUNO at the remaining value.

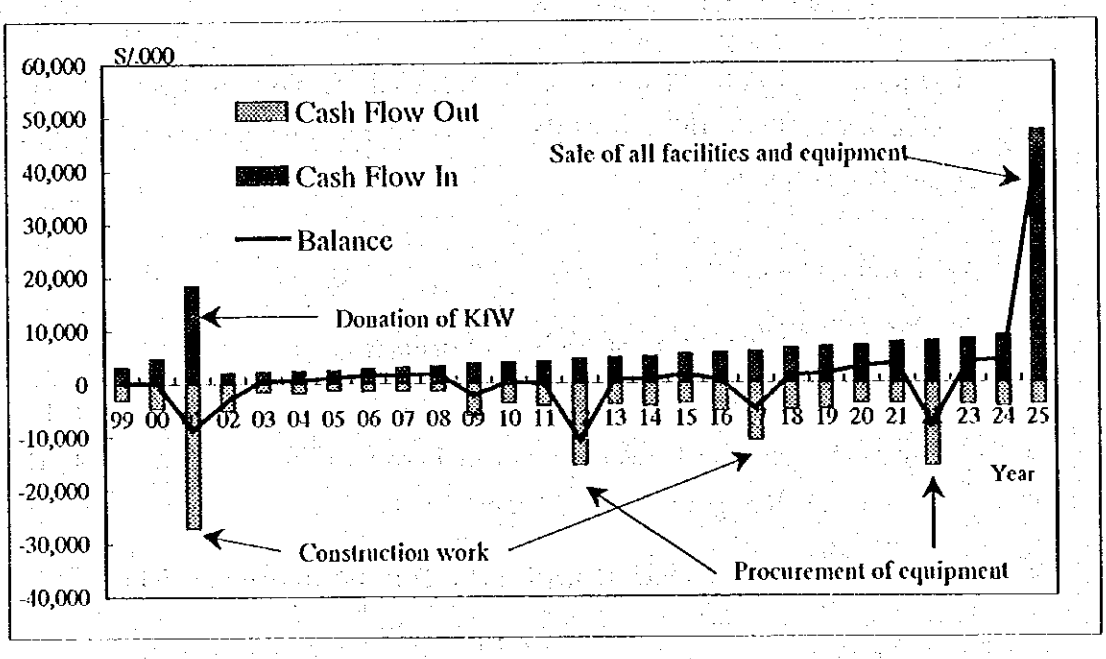


Figure II.3.2 Change of cash balance

b. Financial Plan

In order that the proposed plan reaches the financially viable level over 5% of FIRR, one of the most effective method is receipt of subsidy or grant. Moreover, not only the financial aspect of the proposed plan but also economic aspect should be considered, because the implementation of the proposed plan for improving water quality of Lake Titicaca will also influence

tourism and fish industry in Puno. To make the proposed plan feasible, the following measures must be taken into account.

(a) Finding a finance source of low interest lower than 5%.

(b) Finding a finance source of no interest.

(c) Increasing a charge collection rate. Present collection rate is approximately 76%.

(d) Increasing a sewerage service charge (5% increase every 3 years). The present sewerage service charge in Puno is approximately 97soles/family/year (EPS EMSAPUNO S.A. MEMORIA ANNUAL 1998). The raise must be regulated and informed well to Puno citizens from the preparation stage of the project.

(e) In order to mitigate the impact of the above raise in the sewerage charge on the lower-income households, a certain type of tariff structure could be considered. For example, progressive tariff system by metering block (usage) with a low basic charge will help lower-income households with small water usage.

(9) Recommendations

1) Immediate implementation of sewerage development plan

As eutrophic level of the Puno Interior Bay has reached hyper-eutrophic levels, immediate actions to reduce pollution load inflow to the bay are required.

2) Careful maintenance of constructed wetland

The wastewater treatment system contains the process of a subsurface-flow type artificial wetland respecting the design which the Peruvian authority is ambitious to construct. In general, the rate of pollution loads reduction by this facility is varied by several local conditions or a quality of maintenance. Therefore an experimental study is necessary to examine the efficiency and the proper maintenance of the facility. The study should also be carried out

for alternatives such as a surface-flow type wetland or a treatment system using *Lemna,* and the most suitable type should be decided by the results.

3) Inflow control for sanitary sewer system

Enforceable regulations shall be established to prevent devised connections of rainwater sources to the sanitary system.

4) Enhancement of environmental awareness

The lack of environmental awareness causes misuse of sanitary sewer system and use of drainage ways as toilet. Enhancement of environmental awareness is strongly recommended as a key factor for the environmental improvement.

3.2 SOLID WASTE MANAGEMENT

3.2.1 Evaluation of the Present Conditions

The following field surveys were conducted to exactly understand the present situation of the solid waste management (SWM) in Puno City.

- Time and Motion Study on the collection work
- Survey on the solid waste quantity transported into the final disposal site
- Survey on the illegal dumping of the waste (location and the quantity)
- Waste quantity and physical component.
- Measurement of the existing final disposal site

The city is divided into four areas; residential area (A), commercial area (B), new developing area (C) and mountain area (D).

From the results of the survey, the waste generation per capita and the average specific gravity are 0.33kg/person-day and 0.18kg/l respectively.

67 locations of illegal dumping were recognized and the total surface area and the quantity of the dumping sites were estimated as 5500m^2 and 180m^3 respectively. The areas to where collection vehicles are unable to access were counted as 50 locations and 20 of them are mountain slope areas, 10 are lakeside areas and the remaining 20 are other areas.

Figure II.3.3 shows the flow of solid waste treatment in 1998, which shows the waste generation and transported quantity of the waste to the final disposal site (FDS). The total collection rate of the waste in the city is 52% and rates of the collected waste for household and street cleansing are 35% and 75% respectively.

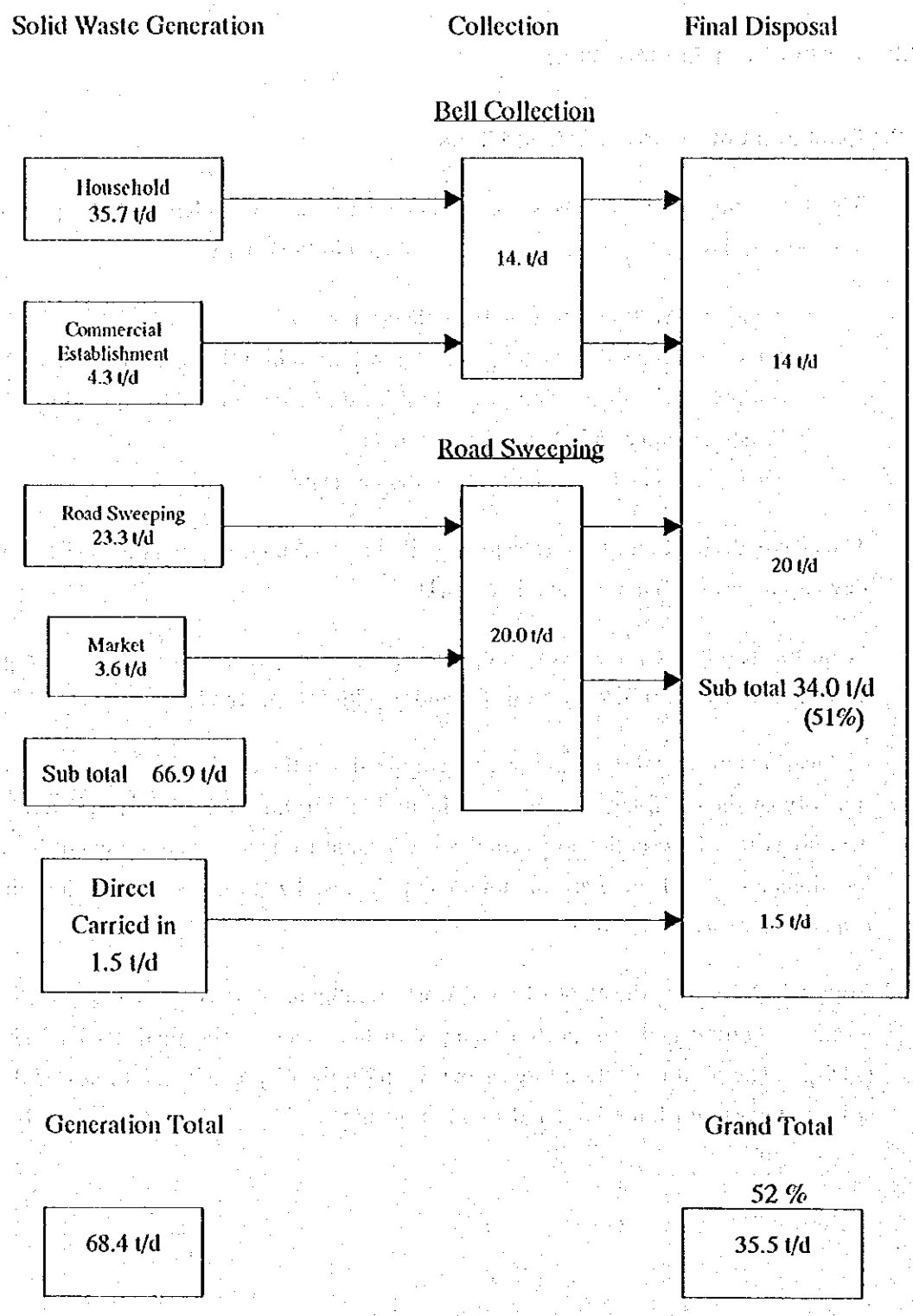


Figure II.3.3 Flow of Solid Wastes in Puno City (1998)

3.2.2 Master Plan

(1) Target and Strategy

Target :- Removal of the illegally dumped wastes (continuous removal of the illegally dumped wastes and elimination of illegal dumping)

- Improvement of the collection rate of the solid wastes (improvement of the collection system, purchase of additional collection vehicles, enhancement of the citizen's consciousness
- Improvement of the final disposal site (thoroughness of sanitary landfill method, acquisition of necessary space for final disposition)

Staged implementation :

the year 2008 : Implementation of sanitary landfill and increase of waste collection rate

the year 2025: Achievement of waste collection rate = 100 %

(2) Planning Conditions

1) Population

Population of Puno City is increasing every year and the population in 2025 is forecasted as 186,560 which corresponds to about 1.7 times as many as the present population in 1998. Population will decrease 10% in Zone A and that of Zone C will increase three times as many as the present population.

2) Solid waste quantity and characteristics

For the prediction of future waste generation in Puno City, the waste generation per capita is calculated based on the assumption that the annual economic growth ratio of the City is 1.5%. The generated waste will be 86 t/day in 2008, while it was 67 t/day in 1998. No yearly change of the waste characteristics is assumed, although the precise situation is not easy to predict. *Figure II.3.4* shows the predicted flow of solid waste treatment in 2025 in Puno City.

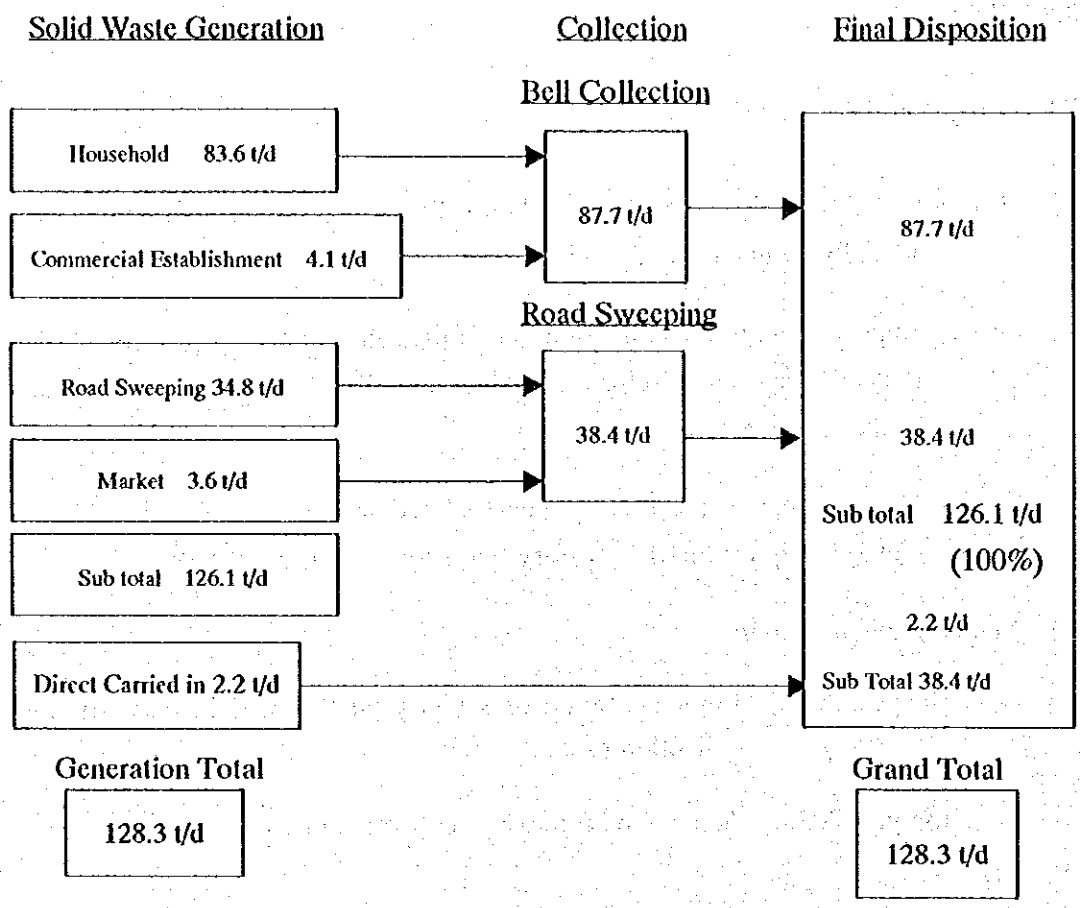


Figure II.3.4 Flow of Solid Waste in Puno City (2025)

(3) Possible Plans for Structural Measures

1) Improvement for Collection and Transportation

- Additional purchase of collection vehicles

Seven collection vehicles are owned by Puno City, but among them only four vehicles are available to work because of the deterioration of other vehicles. In order to improve the waste collection rate, more vehicles are required.

Table II.3.10 shows the present and the required numbers of the vehicles to achieve the collection rate of 100 % in 2008 and in 2025.

Table II.3.10 Required number of Vehicles for Collection

Vehicle	At present	Required Numbers in the target years	
	1999	2008	2025
12m^3 Compactor	1	2	2
6m^3 Garbage Truck	1	3	5
4.0m^3 Compactor	2	11	15
Total	4	16	22

2) Improvement of the final disposal site

- Procurement of heavy equipment

  For daily covering by soil, equipment such as bulldozer, excavator and dump truck is required.

- Acquisition of the new land for the expansion of landfill

  Present landfill site will be filled after a few years.

- Leachate treatment system

  Leachate treatment system should be newly installed according to the new regulation which will be enacted in near future.

3) Removal of the illegally dumped wastes

The removal work should be done through citizen's participation.

4) Alternative plans

a. Collection and transport

- Collection system

  Alternative 1 (A-1) : Adoption of the present Bell Collection System for the whole area of Zone A, B, C and D with collection frequency of twice a week

Alternative 2 (A-2) : For Zone A and Zone B the collection system which is used for A-1 is adopted and for Zone C and Zone D a new system based on the combination of container setting and introduction of special vehicles is adopted.

Alternative 3 (A-3) : Container is arranged for Zone C in the above A-2.

Among the above three alternatives, Alternative-3 is the most effective from the technical point of view. However, considering the overall cost, Alternative-1 is proposed as a practical one.

- Waste collection rate

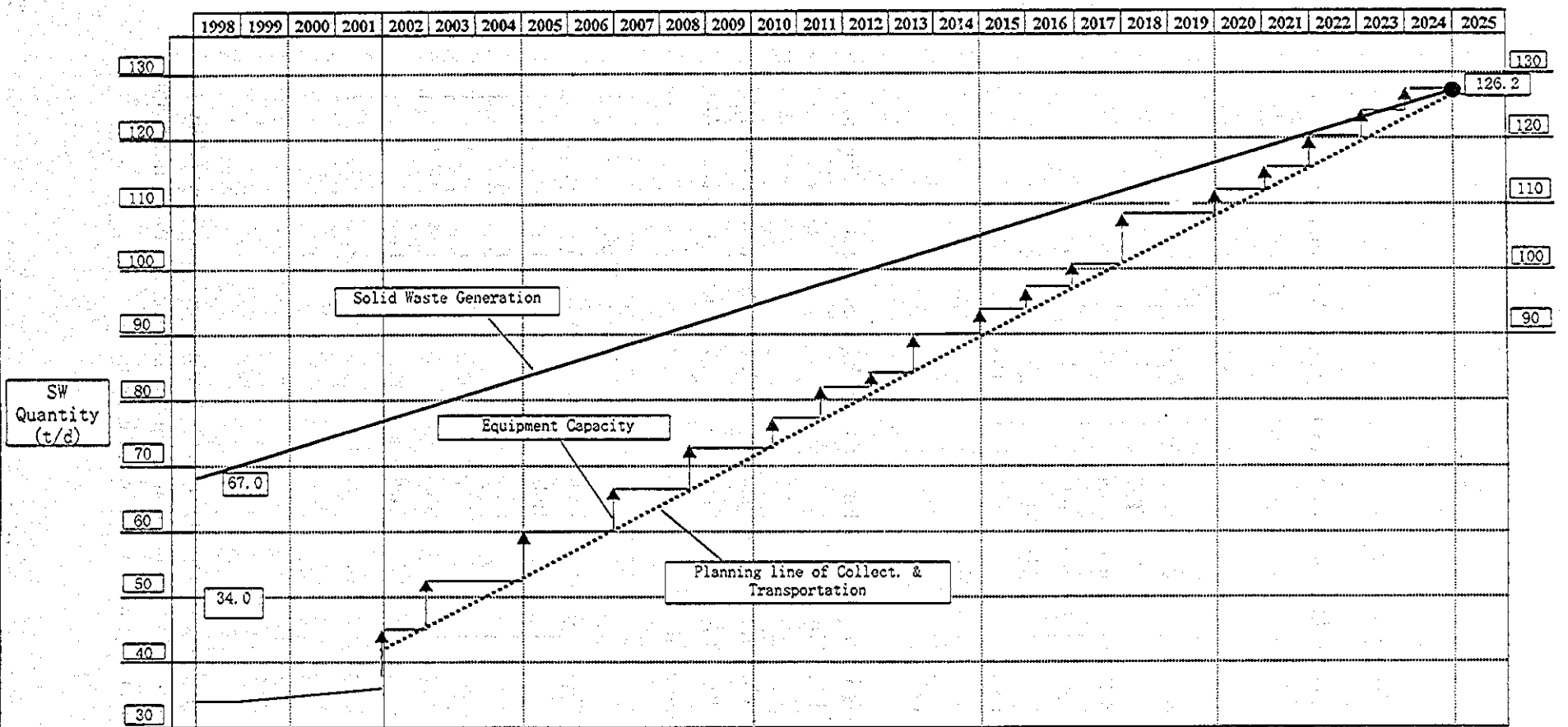
As the result of the case study for two alternatives that aim for a rapid or a moderate increase of collection rate, both will cost a large amount. Considering the financial difficulties of Puno Provincial Municipality, there is no way except selecting the moderate increase (see *Figure II.3.5*).

b. Final disposal site

Landfill site shall be designed in accordance with the technical guidelines of DIGESA (shortly to be enacted upon the approval of the National Congress)

Specifically, the following facilities should be considered for the sanitary landfill site in accordance with the technical guidelines:

- Retaining wall to prevent waste out flows.
- Drainage for superficial water due to rain.
- Leachate collector facility.
- Seepage control layer for leachate.
- Fence for preventing scattered waste due to wind blow.
- Access road.
- Leachate treatment facility.
- Site administration facility including weigh bridge.



Item		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
				-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
a	SW Generation t/d	67.0	68.6	70.4	72.2	74.0	75.8	77.6	79.6	81.7	83.8	85.9	88.0	90.0	92.3	94.6	96.9	99.3	101.5	103.9	106.3	108.8	111.2	113.7	116.2	118.7	121.2	123.7	126.2
b	SW Collection Quantity t/d	34.0	36.0	38.1	40.3	42.5	44.8	47.2	49.9	52.6	55.4	58.3	61.3	63.2	66.9	70.7	74.4	78.2	81.9	86.1	90.2	94.3	98.5	102.7	107.3	112.0	116.7	121.4	126.2
c	Collection Rate %	51%	52%	54%	56%	57%	59%	61%	63%	64%	66%	68%	70%	70%	73%	75%	77%	79%	81%	83%	85%	87%	89%	90%	92%	94%	96%	98%	100%

Figure II.3.5 Solid Waste Generation and Target Capacity to be Collected and Transported.
(Achievement of the collection rate 100% by 2025)

(4) Proposed Plan

1) Collection and transport

Considering the financial difficulties of Puno Provincial Municipality, the waste collection rate should be increased stepwise with the aim of achieving 100 % by the year 2025.

	Year	2008	2025
Required	12 m^3 compactor	1	2
Number of Solid	4 m^3 compactor	7	15
Waste Collection	6.8 m^3 dump truck	1	5
Vehicle	Tricycle	5	5
Manpower		153	204

2) Final Disposal Site

Sanitary landfill has been proposed for the final disposal site according to the technical guideline issued by DIGESA.

According to the technical guideline issued by DIGESA, 10 sanitary landfill sites having acreage of 20,000 m^2 - 37,000 m^2 are to be constructed stepwise. At the sites, heavy equipment will be also required.

	Year	2008	2025
Number of Sites	(to be constructed until the year)	3	10
Required Number of Heavy Equipment at the Final Disposal Site	Bulldozer	1	1
	Excavator	1	1
	Dump Truck	1	1
	Electric Generator	1	1
	Truck scale	1	1
Manpower		6	6

3) Non-Structural Measures

Basically the scattered wastes shall be removed using equipment owned by the provincial municipality, but other than ordinary service by the municipality voluntary involvement of citizens in this work is desirable.

(5) Implementation Plan

1) Removal of illegally dumped waste

10 to 20 working crew shall gather the scattered wastes to transport the materials to the final disposal site by collection vehicles owned by the provincial municipality on every weekend . It will take 6 months for the work to be completed.

2) Expansion of the final disposal site

Until the target year 2025, approximately 1,270,000m^3 of wastes including 254,000m^3 of covering soil is projected to be disposed of at the final disposal site. It is required to construct the final disposal site with the mentioned capacity.

Together with the construction, an access road, a truck scale, heavy machines, an electric generator and an administrative house shall be furnished for the site.

3) Supplement of the collection vehicles

Equipment shall be procured stepwise. One large compactor, one small compactors, five medium size dump tracks and a complete set of maintenance tools shall be procured by the year 2002 at latest.

4) Implementation schedule

- Commence the removal of the existing illegally dumped wastes from the year 2000 and complete the work within one year.
- Commence the construction of the final disposal site from the year 2001, and construct the 10 sites having 20,000m^2 – 37,000m^2 until the year 2025.

Implementation schedule is shown in *Figure II.3.6.*

(6) Project Cost

1) Condition

Conditions for cost calculations are summarized as follows,

- Most costs are expressed under the economic conditions that prevailed in 1998, and price escalation is not considered.
- The construction work is assumed to be contracted to Peruvian general contractors, and the operation and maintenance work is conducted by the staff of the municipality.
- For the estimation, the costs in Peru are used except that in Japan which is used for leachate collection pipe.
- The engineering service cost is assumed to be 5 % of the total of direct construction costs
- The physical contingency is assumed to be 15 % of the total of the direct construction costs and the engineering service costs.

2) Construction cost	**33,649,000 Soles**
3) Equipment	**12,913,000 Soles**
4) Operation and Maintenance Cost	**42,671,000 Soles**
Grand Total	**89,233,000 Soles (not including IGV)**

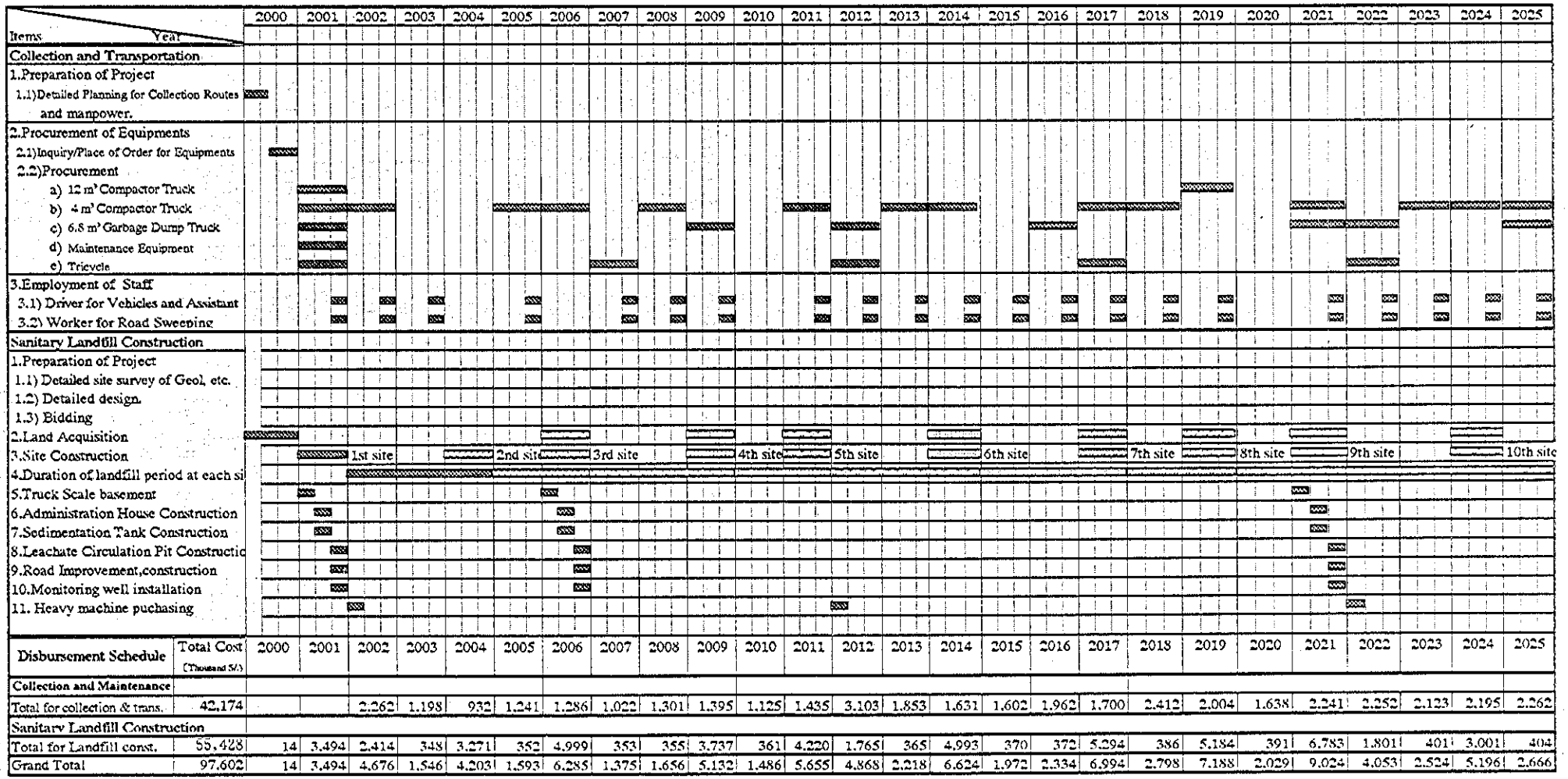
(7) Organization for Operation and Maintenance

1) Management of the Project

The Cleansing Department is in charge of operations for waste collection and disposal. However the maintenance of equipment or the task of charging are done by different regional departments of the maintenance of the equipment and the Department which in charge of the Tipping Fee Collection is required. Unification of these departments is required for efficient management.

2) Strengthening of the organization

It is desirable to educate of the staff to enhance their technical levels as well as to dispatch them to the technical training which is held by the state government or international organizations such as DIGESA or CEPIS.



Disbursement Schedule	Total Cost (Thousand $)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Collection and Maintenance																											
Total for collection & trans.	42.174			2.262	1.198	932	1.241	1.286	1.022	1.301	1.395	1.125	1.435	3.103	1.853	1.631	1.602	1.962	1.700	2.412	2.004	1.638	2.241	2.252	2.123	2.195	2.262
Sanitary Landfill Construction																											
Total for Landfill const.	55.428	14	3.494	2.414	348	3.271	352	4.999	353	355	3.737	361	4.220	1.765	365	4.993	370	372	5.294	386	5.184	391	6.783	1.801	401	3.001	404
Grand Total	97.602	14	3.494	4.676	1.546	4.203	1.593	6.285	1.375	1.656	5.132	1.486	5.655	4.868	2.218	6.624	1.972	2.334	6.994	2.798	7.188	2.029	9.024	4.053	2.524	5.196	2.666

Figure II.3.6 Project Implementation and Disbursement Schedule

(8) Project Evaluation

1) Calculation for Acceptable Financial Plan

In order to estimate the most suitable measure to make the proposed plan feasible, FIRRs of following 6 cases are calculated. In the *Table II.3.11*, combinations of a waste handling charge and an environment fee, and FIRRs (Financial Internal of Rate of Return) of each case are shown.

Case1: the present system of a waste handling charge(32 soles/household/yr as a handling charge and no environment fee).

Case4: O/M expenditure is supposed to be reduced by 30%.

Case1,4,6,7: the expenditure for engineering service is assumed to be covered by a contribution of Peru government.

Case5,8: the expenditure for engineering service, heavy machines, and vehicles is assumed to be covered by a contribution of Peru government.

Table II.3.11 Result of Financial Viability

	Waste Handling Charge	Environment Fee	O/M expend. cut	Subsidy by S.Gov.	FIRR	P/L	Revenue Balance
	soles/household/yr	$/day/person	(%)		%	1,000 soles	1,000 soles
Case 1	32	0	0	Eng.Ser.	-38.8	-60,781	-60,751
Case 4	32	0	30	Eng.Ser.	-32.6	-53,745	-53,715
Case 5	32	0	0	Eng.Ser.+ H.M+V	-27.1	-51,879	-51,849
Case 6	48	1.4	0	Eng.Ser.	8.1	273	303
Case 7	64	1.1	0	Eng.Ser.	8.7	1,553	1,583
Case 8	48	1.2	0	Eng.Ser.+ H.M+V	17.3	2,143	2,173

*1:P/L stands for Profit – Loss caused by the proposed project.

*2 S.Gov. is State Government.

*3 Eng.Ser. is Engineering Service

*4 H.M+V is Heavy Machines and Vehicles

The proposed plan is not feasible under Case1,4,5, because FIRRs of the cases are negative. On the other hand Case6,7, and 8 are viable, because FIRRs exceed 7% of an interest rate of soft loan and P/Ls and Revenue Balances are positive. Moreover, it can be said that the contribution for engineering service, heavy machines, and vehicles is more effective than the decrease of labor cost, because FIRR of Case 5 is higher than the one of Case4.

2) Financial Plan

Each case has a advantage under different situations. These advantages are cleared as follows:

Case 6: If the priority of citizens is higher than the one of tourist, and if heavy machines and vehicles are not covered by a contribution, Case6 is most suitable.

Case 7: If the priority of tourist is higher than the one of citizens, and if heavy machines and vehicles are not covered by a contribution, Case7 is most suitable.

Case 8: If the expenditure of engineering service, heavy machines, and vehicle is covered by a contribution of Peru government, Case8 is most suitable.

There are some crucial points to execute Case6,7,8 as follows:

Point1:The present collection rate of the waste handling charge must be increased from 48% to 70%. This method can be executed without a fundamental change of solid waste management in Puno.

Point2: The raise of the present waste handling charge must be regulated.

Point3: The raise of the present waste handling charge must be informed well to Puno citizens from the preparation stage of the project.

Point4: In order to mitigate the impact of the raise on the lower-income households, a certain type of mean could be considered. For example, Puno should be divided into higher income areas and lower income areas. Then, a higher increasing rate of waste handling charge should be applied at higher income areas.

Point5: Introduction of environment fee must be regulated and informed well to the hotels in Puno.

Point6: The state government should recognize that the value and benefit generated by the tourism at Lake Titicaca are worthy to provide a subsidy for an environmental improvement.

(9) Recommendations

- Adoption of the present Bell Collection System for the whole area with collection frequency of twice a week.
- Education on public health for citizens at church, chamber of commerce, and school to prevent illegal dumping of waste
- Use of media such as newspapers, television, and radio to educate citizens
- Execution of Seasonal clean-up campaigns