社会開発調査部報告書

No. 42

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MUNICIPALITY OF LA PAZ
THE REPUBLIC OF BOLIVIA

THE STUDY ON
CONTROL OF WATER CONTAMINATION OF THE RIVERS
IN THE CITY OF LA PAZ

Summary

MAY 1993

PACIFIC CONSULTANTS INTERNATIONAL

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In this report, project cost is estimated in June 1992 prices at an exchange rate of 1 US$ = Bs. 3.87 (=¥127).

PREFACE

In response to a request from the Government of the Republic of Bolivia, the Government of Japan decided to conduct a master plan and feasibility study on Control of Water Contamination of the Rivers in the City of La Paz and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Bolivia a study team headed by Dr. Akira Uchida, Pacific Consultants International, three times between February 1992 and March 1993.

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

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

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

May 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

THE STUDY ON CONTROL OF WATER CONTAMINATION
OF THE RIVERS IN THE CITY OF LA PAZ

Mr. Kensuke YANAGIYA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "THE STUDY ON CONTROL OF WATER CONTAMINATION OF THE RIVERS IN THE CITY OF LA PAZ". This report has been prepared by the Study Team in accordance with the contract signed on 28 January 1992, 13 October 1992 and 27 April 1993 between the Japan International Cooperation Agency and Pacific Consultants International.

The report examines the existing conditions concerning river water pollution in La Paz, presents a basic plan for control of water pollution in La Paz and the results of a feasibility study on a priority project for sewerage development selected by the basic plan.

The report consists of the Summary, Main Report, and Supporting Report. The Summary summarizes the results of all studies. The Main Report presents the results of the whole study including background conditions, formulation of the basic plan for control of the river water pollution, selection of the priority project, and the feasibility study on the priority project. The Supporting Report describes in detail the same contents in the Main Report, and includes relevant appendices and a complete list of references. In addition, a Data Book has been prepared and is submitted herewith.

All members of the Study Team wish to express grateful acknowledgment to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Bolivia, and also to officials and individuals of the Municipality of La Paz and the Government of Bolivia 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 aquatic environment and the social and economic development in La Paz.

Yours faithfully,

内田顕

Akira UCHIDA
Team Leader

The Study on Control of Water Contamination of the Rivers in the City of La Paz

Summary

CONTENTS

1. INTRODUCTION

The City of La Paz is the largest city in Bolivia and the de facto capital of the country with a population of about 720,000. The Choqueyapu River and some of its tributaries have sufferd serious water pollution as the city has developed intensively along the Choqueyapu. Major causes of the river water pollution are domestic and industrial wastewaters that are discharged into the rivers directly or via sewer outlets without treatment.

This situation has brought about offensive odor and aesthetic deterioration along the rivers in the urban area, and damages to the use of the river water in the downstream farm lands. In order to improve the degraded quality of the aquatic environment of the city, development of a water pollution control plan has become necessary.

This Study on water pollution control of the rivers in La Paz (hereinafter referred to as "the Study") was conducted by the Study Team of the Japan International Cooperation Agency (JICA) in cooperation with the Municipality of La Paz (HAM-LP) and the Municipal Corporation of Potable Water and Sewerage in La Paz (SAMAPA) from February 1992 to May 1993.

The objectives of the Study are as follows:

- To prepare a basic plan for control of water pollution of the Choqueyapu River and its tributaries.
- To conduct a feasibility study on the first priority project to be selected from the components of the basic plan.

The study area is the catchment area of the Choqueyapu River above the Lipari bridge as shown in Fig. 1.1 with a total area of 535 km^2.

The study reports prepared are as follows:

(1) Main Report (English)
(2) Main Report (Spanish)
(3) Supporting Report (English)
(4) Summary Report (English)
(5) Summary Report (Spanish)
(6) Data Book (English)

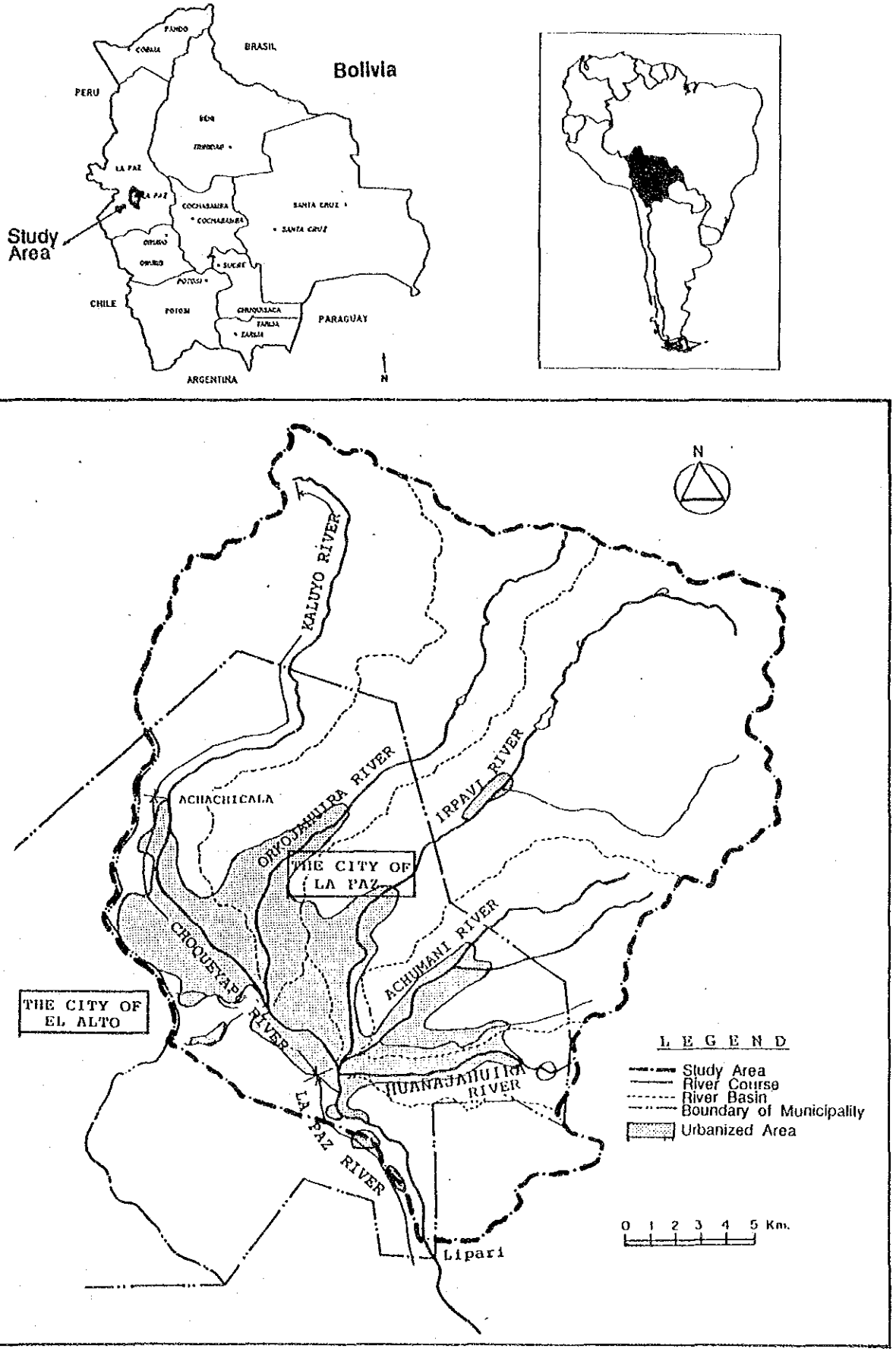
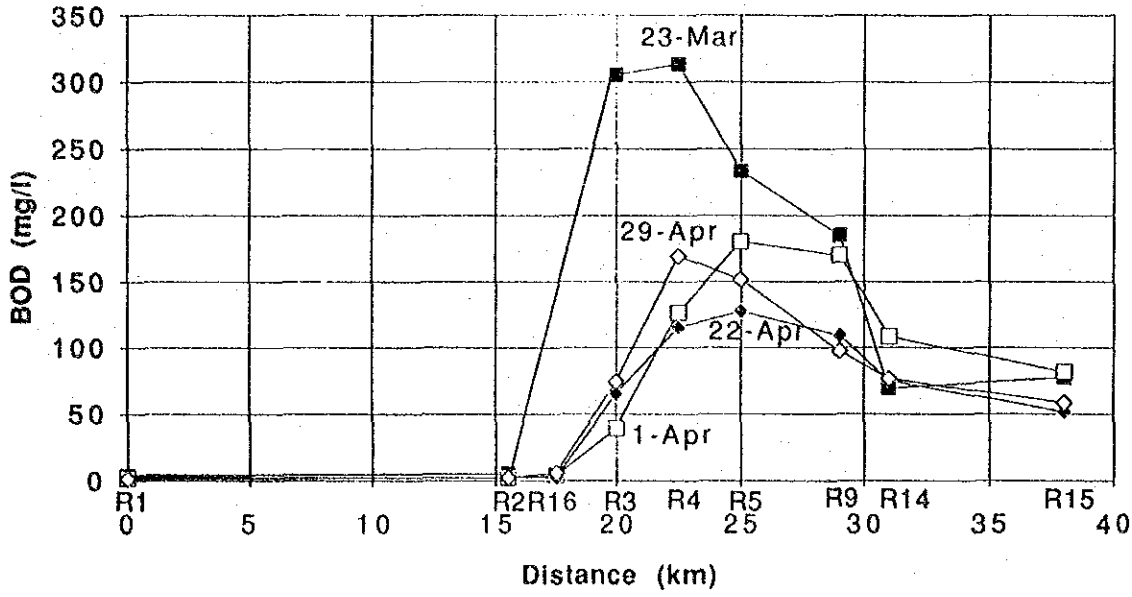


Fig. 1.1 Study Area

2. BASIC PLAN

2.1 Water Quality Conditions

The water quality survey for the Choqueyapu River was conducted at the locations shown in Fig. 2.1. The observed profiles of BOD along the main reach of the Choqueyapu River is shown in Fig. 2.2.



Note: During the survey of March 23, the Achachicala water treatment plant was taking river water from just below the point R16. This caused a reduction of the flow rate and therefore the high BOD concentration in the downstream, since there were factory wastewater discharges between R16 and R3 as usual.

Fig. 2.2 BOD Changes Along The Choqueyapu River

The BOD concentration of the Choqueyapu River sharply increases at the entrance to the urbanized area (No. R3). It is evident that the river water in the most parts of the urbanized area is polluted. However, since the Choqueyapu River in the Central Zone of the City is mostly covered and remaining open sections are deeply incised, the actual river water quality may not be widely recognized. Also, the steep flow of the river brings about vigorous aeration which reduces septic conditions. Still, many residents in the South zones of the City and the downstream areas are suffering from the obnoxious odors of the river. Moreover, such degraded river water presents

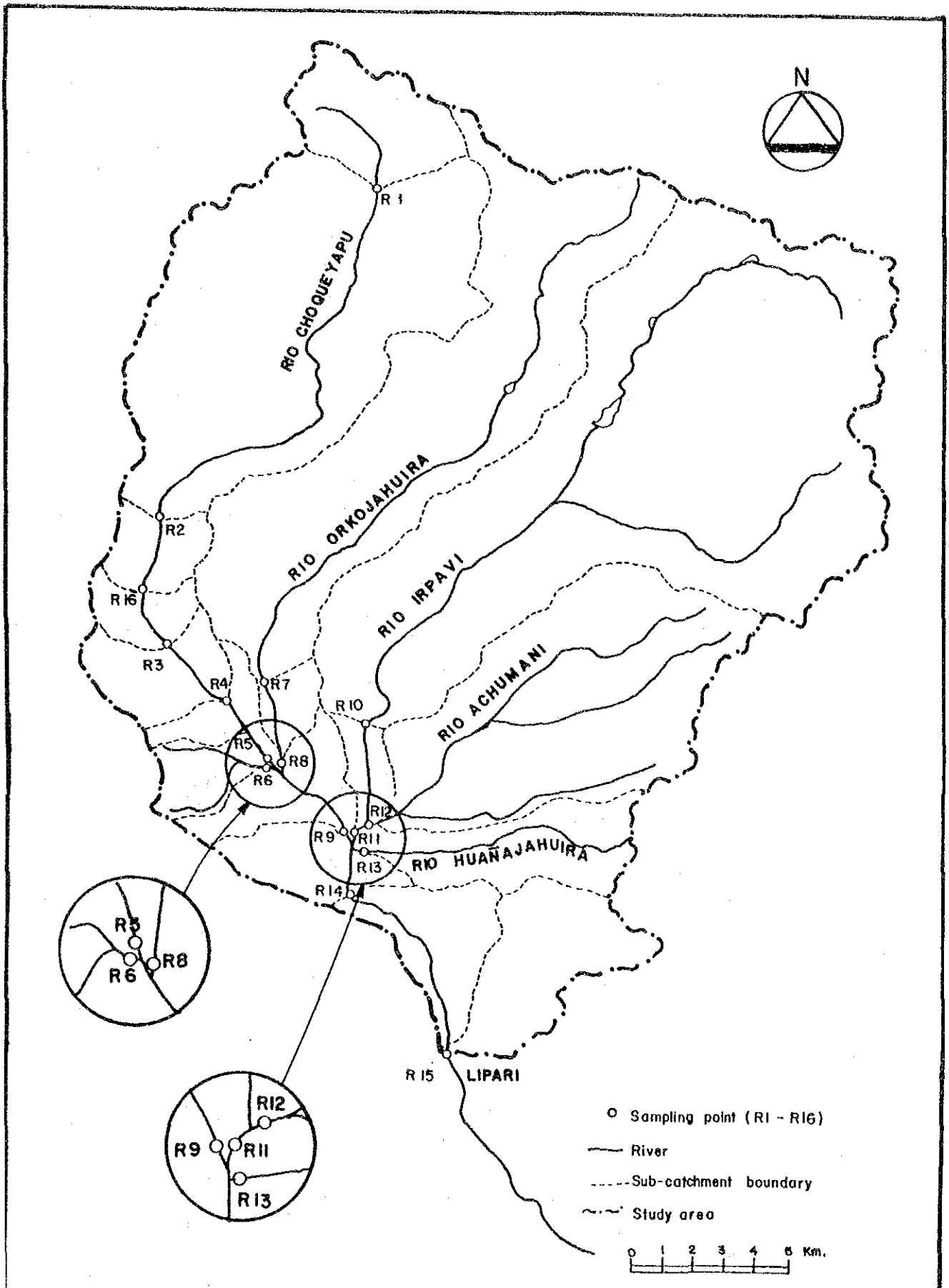


Fig. 2.1 Sampling Points for River Water Quality Survey

actual damages to the farmers in the downstream by unpopularity of their products in the markets since the river water is used for irrigating their farm lands.

The water quality of the tributaries in the urbanized area are similar to that of the Choqueyapu River. These tributaries also cause unpleasant living conditions.

Major sources of the river water pollution were found to be domestic and industrial wastewaters.

2.2 Planning Framework

The planning year for the Basic Plan was chosen to be 2010, but this is not necessarily the absolute target year for the implementation of the Basic Plan.

The water quality targets for the Basic plan were determined based on the Bolivian water quality standards as shown in Table 2.1, considering the expected water use at each evaluation point.

Table 2.1 Water Quality Targets

Evaluation Points*	Location	Required Water Conditions	Required Water Quality	
R2	Upstream of urbanized area of each river	Water quality which is suitable for conventional water treatment for potable water and/or which does not worsen natural environment.	BOD: DO: Coliform:	10 mg/l 60 % 10,000 MPN/100ml
R9, R8,R11,R12	In urbanized area	Water quality which does not generate obnoxious conditions along the stream.	BOD: DO: Coliform:	50 mg/l 50 % 20,000 MPN/100ml
R15	Downstream of urbanized area	Same as above. For the Choqueyapu river , water quality suitable for irrigation.	BOD: DO: Coliform:	50 mg/l 50 % 20,000 MPN/100ml

The planning area for formulation of the Basic Plan was determined to be the existing and future urbanized areas shown in Fig. 2.3.

The existing and estimated future population of the planning area is shown in Table 2.2.

Table 2.2 Present and Future Population

	year		
Zones	1992	2000	2010
Central Zone	631,000	640,000	650,000
South Zone	84,600	130,000	240,000
(Achocalla)	4,400	50,000	110,000
Total	720,000	820,000	1,000,000

2.3 Development of Alternatives for The Basic Plan

The water quality of the Choqueyapu River in the future was predicted using a water quality simulation model for the case that no pollution control measure would be taken. The result indicated that the river water pollution would further proceed downstream from the Calacoto area, and the BOD concentration at Lipari would increase from 54 mg/l at the present to 72 mg/l in 2010.

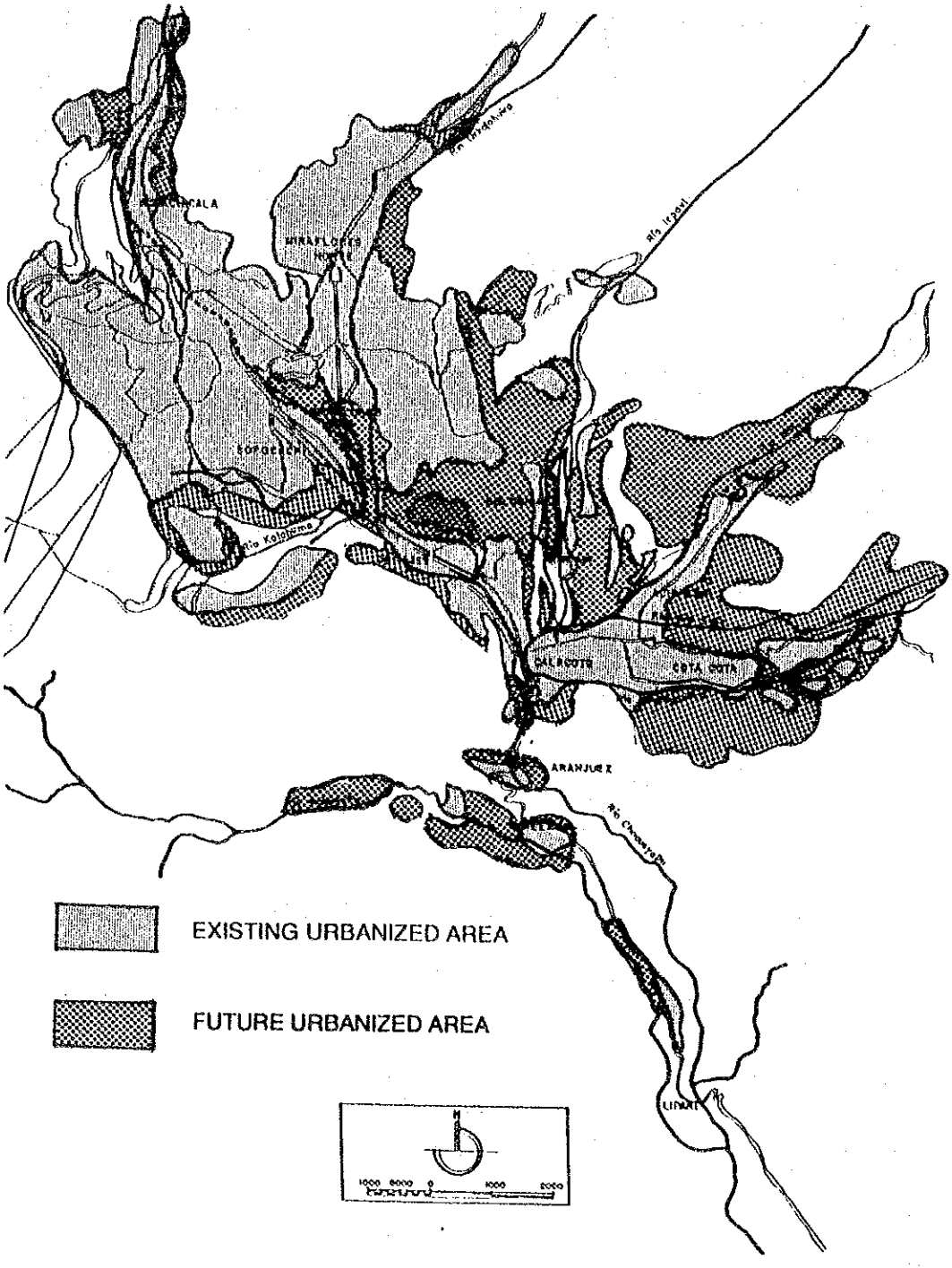


Fig. 2.3 Planning Area for Formulation of Basic Plans

In the formulation of the Basic Plan for control of the water pollution, preliminary screening was made considering the following conceivable control measures. Among them, last three measures were judged to be not applicable because of the reasons shown in parenthesis.

- Reducing pollutant loads to the rivers by wastewater treatment
- Dilution of river water (Sufficient water not available)
- Direct purification of river water (River water being too polluted for direct purification)
- Diversion (No waterbody to receive diverted water.)

As a result, it was concluded that the reduction of pollutant inflows by means of developing a wastewater treatment system is the most appropriate for the Basic Plan: this would be supplemented by 1) control of industrial wastewater discharges, and 2) control of domestic wastewater discharges in newly developing communities.

In planning the sewerage system, it was first considered that the planning area could be divided into appropriate sizes of zones each having a treatment plant, so that the whole systems could be developed step by step beginning from a highest priority zone.

However, studies revealed that such division was impractical because there are only limited area of lands available at reasonable cost for wastewater treatment plants in the Central Zone. Consequently, the most economical solution was to treat all wastewater from the Central Zone at one treatment plant in an appropriate site outside the Central Zone. Appropriate areas of lands for such centralized treatment plan are only available near the downstream end of the Irpavi River and in the flood plain of the Choqueyapu River near Lipari. These situations indicate that it is most economical to treat all the wastewater from both the Central and the South Zones of the City at one treatment plant at the Irpavi site (Irpavi option) or the Lipari site (Lipari option). In either case, the Basic Plan would consist of the following components.

i) to collect wastewater from the Central Zone (excluding the Orkojahuira catchment) by taking it directly from the Choqueyapu River at Kantutani

ii) to install a main sewer interceptor from the water intake point at Kantutani to the proposed wastewater treatment site

iii) to install sewer interceptors in the areas other than the Central Zone to collect wastewater through the existing sewer pipes, and to connect them to the main sewer interceptor

iv) to construct one centralized wastewater treatment plant to treat all wastewater collected

For the Irpavi option, the high-rate activated sludge method is the only applicable method for wastewater treatment because of area limitations. For the Lipari option, conventional activated sludge, aerated lagoons and trickling filters are applicable because adequate land area is available. Therefore, there are four alternatives for the Basic Plan as shown in Table 2.3.

Table 2.3 Alternatives for Basic Plan

Option	Alternative No.	Plant site	Treatment method	Main Sewer Interceptor
Irpavi	1	Left bank of the Irpavi River in the Calacoto area	High-Rate Activated Sludge	from Kantutani to Irpavi mainly along roads.
Lipari	2A	Near Lipari, #1	Conventional Activated Sludge	from Kantutani to Lipari along roads and river beds.
Lipari	2B	Near Lipari, #1	Trickling filters	same as above
Lipari	2C	Near Lipari, #1 and #2	Aerated Lagoons	same as above

Note : For location of plant sites, see Fig. 2.4.

2.4 Evaluation of the Alternatives

The estimated costs for four alternatives are shown in Table 2.4. Alternative 2C (Lipari/aerated lagoons) is far more advantageous than the other three in terms of cost.

Table 2.4 Comparison of Alternatives ($U.S. Million, 1992 Prices)

Costs	Alternatives 1	2A	2B	2C
Capital Costs				
Main sewer Interceptor	4.48	9.06	9.06	9.06
WWTP	49.82	49.82	45.53	19.12
Intake Facilities	1.15	1.15	1.15	1.15
Sewer interceptors	3.22	3.22	3.22	3.22
Sub-Total	58.67	63.25	58.96	32.55
Land and R.O.W.'s	17.25	2.94	2.94	5.34
Engineering	5.87	6.33	5.90	3.26
Contingency	8.80	9.49	8.84	4.88
Total	90.59	82.00	76.64	46.03
Annual Operation Costs	5.00	5.00	2.50	3.50

The four alternatives were also evaluated in terms of site availability, improvement effect on river water quality, technological adaptability, environmental impact and social impact. The evaluation of the four alternatives from various aspects are summarized as shown in Table 2.5.

Table 2.5 Summary of Evaluation of the Basic Plan Alternatives

Alternative No.	1	2A	2B	2C
Plant Site	Irpavi	Lipari	Lipari	Lipari
Treatment Method	High rate activated sludge	Conventional activated sludge	Trickling filters	Aerated lagoons
Initial Costs	x	x	x	xxx
Operation Costs	x	x	xxx	xx
Site Availability	x	xxx	xxx	xx
Improvement Effect on River Water Quality	xxx	xx	xx	xx
Technological Adaptability	x	x	xx	xxx
Degree of Environmental Impact	x	xxx	xxx	xx
Degree of Social Impact	x	xxx	xxx	xx

Note xxx : favorable (or easy) xx: average x : not favorable (or difficult)

By referring to Table 2.5, Alternative 2B and 2C are considered to be clearly advantageous over the other two. The most critical factor governing realization of the plan is considered to be the cost. Therefore, Alternative 2C is proposed as the Basic Plan for control of water pollution of the rivers in the City of La Paz.

2.5 Basic Plan

A general layout of principal facilities in the proposed Basic Plan is shown in Fig. 2.4.

Design wastewater flows for the Basic Plan are as follows.

(m^3/day)

	1992	1995	2000	2005	2010
River water	34,560	34,560	34,560	34,560	34,560
Central Zone	102,609	106,442	113,049	121,359	130,103
Orkojahuira	21,646	23,198	25,920	28,308	30,948
Irpavi	11,223	12,018	13,497	16,622	20,027
Calacoto	8,318	8,667	9,335	10,938	12,728
Total	178,356	184,885	196,361	211,787	228,366

Major structural components of the Basic Plan are as follows:

(1) Water Intake Facilities

Water intake facilities are to be installed in the Choqueyapu river at Kantutani to collect the wastewater from the Central Zone, where collection of wastewater by sewer interceptor separated from stormwater is considered to be difficult.

(2) Main Sewer Interceptor

The main sewer interceptor consists of the following sections:

Along main roads (with asphalt pavement)	3,630 m
Along secondary road (with stone pavement)	1,260 m
Passing through populated areas	485 m
Tunnel	260 m
In river bed	4,215 m

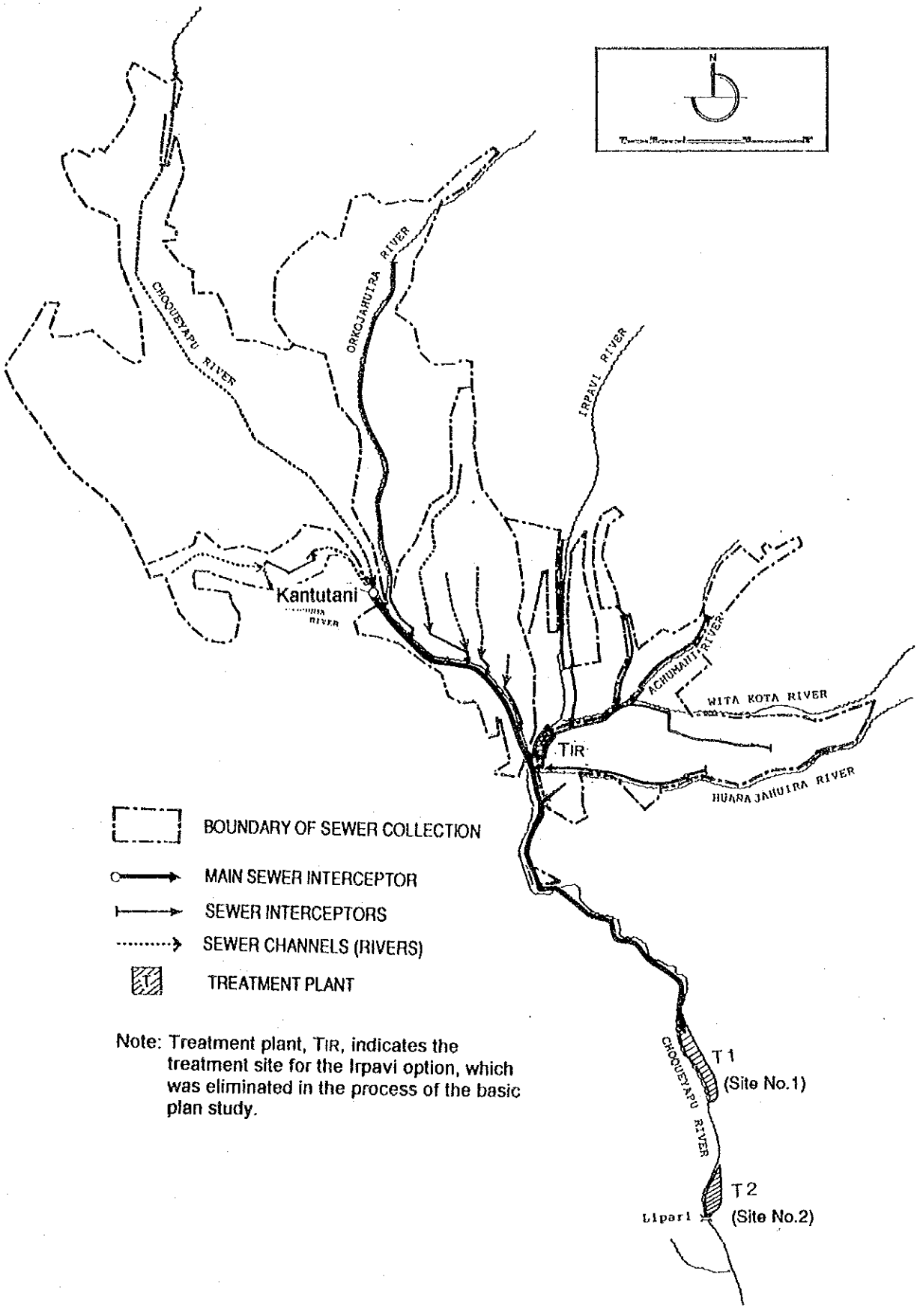


Fig. 2.4 General Layout of the Facilities in the Basic Plan

(3) Wastewater Treatment Plant

Site preparation:	Fill river bed and cultivated areas, Site #1 (20 ha) and Site #2 (12 ha).	
Preliminary treatment:	Bar screens	
	Grit chambers	
	Flow measuring:	Parshall flumes
Aerated lagoons:	Type,	Completely mixed by mechanical means or defused aerators.
	Volume,	690,000 m^3
	Surface area,	16 ha
	Max. depth,	6.0 m
	Detention time,	3 days
Solids separation basins:	Surface area,	11.5 ha
	Max. depth,	6.00 m
	Overflow rate,	2 m/day
	Sludge storage,	4 years

Implementation of the proposed structural measures for the Basic Plan should be supported by appropriate institutional provisions (non-structural measures). The following measures are recommended:

a) Reinforcement of the industrial effluent quality standards
b) Monitoring of industrial effluents and enforcement of the quality standards
c) Monitoring of river water quality
d) Control of solid wastes disposal into the rivers
e) Control of erosion and disorderly extraction of sand and gravel from the river beds
f) Reinforcement of organizations in charge of above tasks and development, operation and management of sewerage

In conclusion, the following structural and non-structural measures are proposed to be included in the Basic Plan.

1) Sewerage system development including wastewater treatment as described above.

2) Wastewater effluent control of the industries discharging over 100 m^3/day of wastewater, with an effluent BOD limit of 300 mg/l

3) Wastewater effluent control of newly developing communities with an effluent BOD limit at 50 mg/l

The overall effect of above measures is shown in Fig. 2.5.

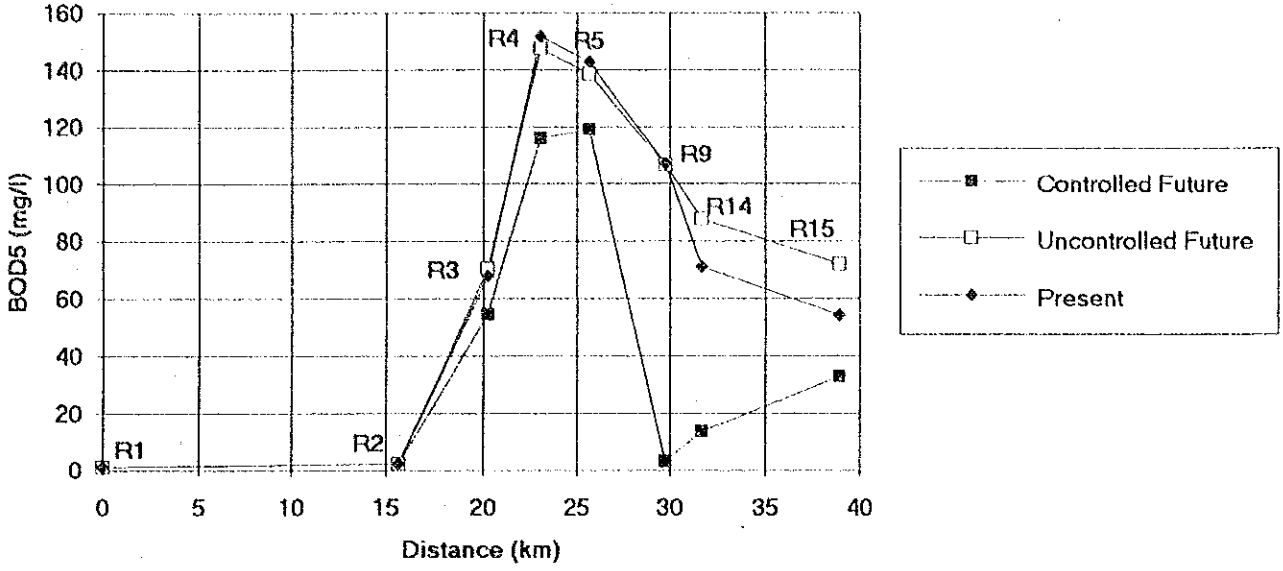


Fig. 2.5 Overall Effect of the Basic Plan

2.6 Implementation Program

An implementation program is proposed to be as shown in Table 2.6.

Table 2.6 Implementation Program

Implementation Period	Phase	Served areas	Treatment Capacity (m3/d)	Facilities to be Constructed
1993-1995	Phase 1	Central area	140,000 (partial mixed aerated lagoons)	Intake facilities Main sewer interceptor Site preparation - 20 Ha (site #1) Operations/other misc. buildings Aerated lagoons (12 Ha) Sedimentation basins (4 Ha)
1996-2000	Phase 2	Orkojahuira basin	170,000	Conversion of 4 Ha of sed. basins to aerated lagoons Conversion of 12 partially aerated lagoons to completely mixed lagoons Add aeration equipment Site preparation - 12 Ha (site #2) Sedimentation basins (11.5 Ha) Interceptor sewer for Orkojahuira basin
2001-2005	Phase 3	Irpavi basin	200,000	Add aeration equipment Interceptor sewer for Irpavi basin
2006-2010	Phase 4	Calacoto, etc	230,000	Interceptor sewer for Calacoto area

The phased project costs estimated according to the proposed implementation program are as follows in 1992 prices. In consideration of the phased construction, the required size of the WWTP site was reviewed and reduced to 32 ha from 40 ha which was estimated in comparison of the Alternatives (Table 2-4), resulting in reducing the total construction costs.

($U.S. million)

Phase	Construction Costs for each phase
1	23.83
2	8.19
3	0.15
4	1.15
Total	33.32

2.7 Priority Project

From the implementation program for the Basic Plan, the Phase 1 project (up to 1995) can be identified as the priority project. In the priority project, the wastewater from the Central Zone will be collected from the Choqueyapu River and treated at a wastewater treatment plant.

Facilities to be constructed in the priority project are as follows:

- Water intake facilities in the Choqueyapu River (at Kantutani)
- Main sewer interceptor (9.85 km)
- Aerated lagoons (12 ha, 140,000 m^3/day)
- Sedimentation basins (4 ha)
- Operations/miscellaneous buildings

The effect of water quality improvement by above measures of the priority project was predicted using the water quality simulation model for low flow conditions. It is shown in Fig. 2.6. While the BOD would exceed the target value of 50 mg/l in the downstream area when no control measure is taken by 1995, the implementation of the priority project would achieve the target BOD value of 50 mg/l: 40 mg/l at R14 and 47 mg/l at R15.

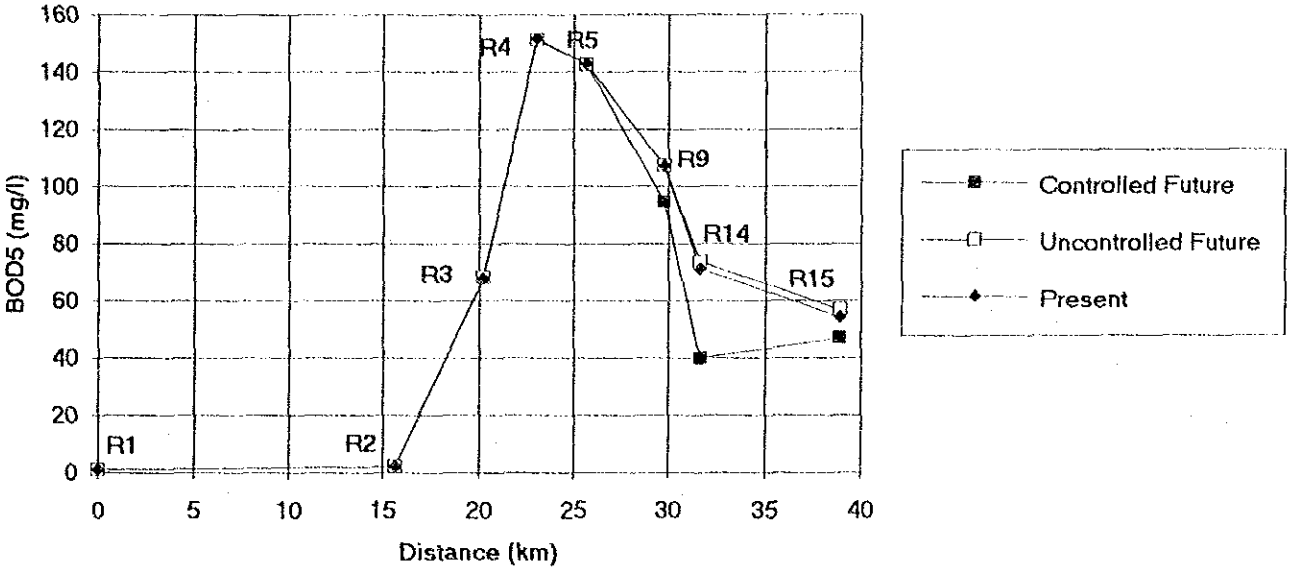


Fig. 2.6 Improvement of Water Quality by the Priority Project

3. FEASIBILITY STUDY

The priority project is planned to be implemented as a first stage of the Basic Plan from 1993 to 1995. It aims to treat the wastewater from the Central Zone, excluding the Orkojahuira basin, by diverting the Choqueyapu River water to the wastewater treatment plant.

3.1 Design Wastewater Flow

Design wastewater flows for the project facilities were determined as follows:

Component	Design wastewater	Remarks
Water intake facilities	170,000 m^3/day	River flow (0.4m^3/s) + Wastewater generation from the Central zone except the Orkojahuira basin in 2010.
Main sewer interceptor	230,000 m^3/day	Total wastewater generation from the area to be served in 2010
Wastewater treatment plant	140,000 m^3/day	River flow (0.4m^3/s) + Wastewater generation from the Central zone except the Orkojahuira basin in 1995.

3.2 Water Intake Facilities

The proposed location of the intake was determined to be at Kantutani; just above the confluence with the Cotahuma River, because the Cotahuma River is heavily laden with suspended solids of soil. However, the Kantutani River, which joints to the Cotahuma just upstream from the Choqueyapu confluence and carries wastewater from the Sopocachi area, would be diverted to the water intake facilities. The proposed location and structures of the facilities are shown in Fig. 3.1.

The water intake facilities comprise a fixed weir, a sluice gate for flow control, a connection pipe, an interface chamber to the main sewer interceptor, and miscellaneous works such as consolidation works for protection of the river bed.

The construction costs for the intake facilities are estimated to be as follows:

Civil works	US$49,000
Equipment/Materials	US$31,000
Total	US$80,000

3.3 Main Sewer Interceptor

The proposed route of the main sewer interceptor is shown in Fig. 3.2 and is divided into three sections:

Section A: In this section, major portion of the interceptor will be installed under the road. Two possible routes were considered, i.e., a route along the left bank and a route along the right bank. The right bank route was selected mainly because of lower construction costs.

Section B: The selected route follows the existing road mainly considering to reduce total length.

Section C: The route was selected in the river bed because there is no road or suitable terrain along the river. A tunnel section is included to avoid the steep narrow section and sharp meandering along the river at the downstream of Aranjuez.

The sizes and the design wastewater flow of the interceptor for each section are shown in Table 3.1.

Table 3.1 Sizes of the Interceptor

Section	No.	Design Wastewater (m^3/sec)	Size (mm x mm)	Gradient (%)	Velocity (m/sec)	Max. Capacity (m^3/sec)
	1	2.523	1200 dia	1.0	2.99	3.379
	2	2.523	1300, 1300	2.0	2.33	3.155
	3	2.523	1300, 1300	2.0	2.33	3.155
	4	2.553	1500, 1500	2.0	2.57	4.620
A	5	3.066	1500, 1950	2.0	2.57	4.620
	6	3.185	1500, 1950	2.0	2.57	4.620
	7	3.261	1500, 1950	2.0	2.57	4.620
	8	3.299	1500, 1950	2.0	2.57	4.620
	9	3.493	1500, 1950	1.8	2.44	4.383
B	10	3.502	1500, 1950	1.5	2.22	4.001
	11	3.504	1500, 1950	2.0	2.57	4.620
C	12	3.504	1500, 1950	2.0	2.57	4.620
	13	3.504	1500, 1950	3.0	3.14	5.659
	14	3.504	1500, 1500	1.8	3.14	4.383

Typical cross sections of the interceptor including manhole sections are shown in Fig. 3.3.

Groin works are proposed at the meandering sections to protect the buried interceptor in the river bed from exposures due to erosion.

The construction and operating costs are estimated as shown in Tables 3.2 and 3.3.

Table 3.2 Construction Cost for Main Sewer Interceptor

Work items	Amount (US$)
PC-pipe installation	36,320
Arched masonry	4,807,100
Tunnel	513,600
Road construction	38,470
Groin works	72,600
Total	4,954,490

Table 3.3 Operating Costs for Main Sewer Interceptor and Water Intake

Staff	Salary(US$/Year)
Engineers	4,950
Laborers	9,900
Night watch	1,650
Drivers	3,960
Total	20,460

3.4 Wastewater Treatment Plant

For the priority project, it is proposed to construct only a portion of the lagoons proposed in the Basic Plan and sedimentation basins at Site #1 as shown in Fig. 3.4. For this stage, the lagoons would be of the partially-mixed aerated type.

At Site #1 there is a total of about 20 Ha available. Since about 2 Ha are needed for roads, parking, berms, etc. there is about 18 Ha usable for process of facilities. For the priority project, it is proposed to provide the following facilities:

2 Ha	Preliminary (inlet) treatment works and buildings
16 Ha	Lagoons - partially-mixed aerated with sedimentation basins

Preliminary treatment works consist of bar screen, grit chambers, and Parshall Flume.

The lagoon system is composed of 2 parallel sets of cells, each set consisting of six 1 hectare cells plus one 2 hectare cell with a maximum depth of 6 meters. A profile of the lagoon system is shown in Fig. 3.5. The river bed at Site #1 will require fill to raise the plant site above flood levels. The system would have a 3.86 day retention time and BOD removal on the order of 60%.

The last cells of both sets of lagoons shown in Fig. 3.4, serving as sedimentation basins, would have an average depth of 4.7 meters with a total volume of 188,000 m^3. Of this volume, the top 2 meters would be reserved for sedimentation and the bottom

bottom portion for sludge storage and digestion. With this volume it is estimated that accumulated sludge can be stored for about four years.

The building requirements include an operations buildings with laboratory, office and meeting rooms, and storage/maintenance facilities for the aeration equipment.

The construction costs and operation costs are estimated as shown Tables 3.4 and 3.5.

Table 3.4 Construction Costs for Wastewater Treatment Plant

Items	Amount (million US$)
Site Preparation	1.68
Prelim. Treatment Works	0.38
Aerated Lagoons	3.75
Sedim. Basins (Site #1)	1.67
Buildings	0.40
Access Road	0.28
Electrical	0.11
Total Construction	*8.27*
Land Acquisition and R.O.W.	3.35
Total	*11.62*

Table 3.5 Operating Costs for Wastewater Treatment Plant

	(US$/year)
Staff salary	74,425
Equip/Material	13,000
Utilities	356,696
Total	444,121

3.5 Project Costs

The estimated construction costs for all components of the priority project are summarized as shown in Table 3.6. Operating costs for the priority project are summarized as shown in Table 3.7. The construction costs are considered lower than those estimated for Master Plan because the cost for interceptors and aerators are reviewed and reduced.

Table 3.6 Construction Costs for the Priority Project

(US$million)

Items	Local	Foreign	Total
Construction Costs	**11.49**	**1.82**	**13.31**
Water Intake Facilities	0.05	0.03	0.08
Main Sewer Interceptor	4.95		4.95
Wastewater Treatment Plant	6.49	1.79	8.28
Land Acquisition and ROW	**3.35**		**3.35**
Engineering	**1.15**	**0.18**	**1.33**
Contingency	**1.48**	**0.18**	**1.67**
Total	**17.47**	**2.18**	**19.66**

Table 3.7 Operating Costs for the Priority Project

		US$/Year
Wastewater collection/transmission		
	Personnel Expenses	20,460
Plant operations		
	Personnel Expenses	74,425
	Materials/Equipment	13,000
	Electricity	356,696
	Sub-Total	444,121
Total		464,581

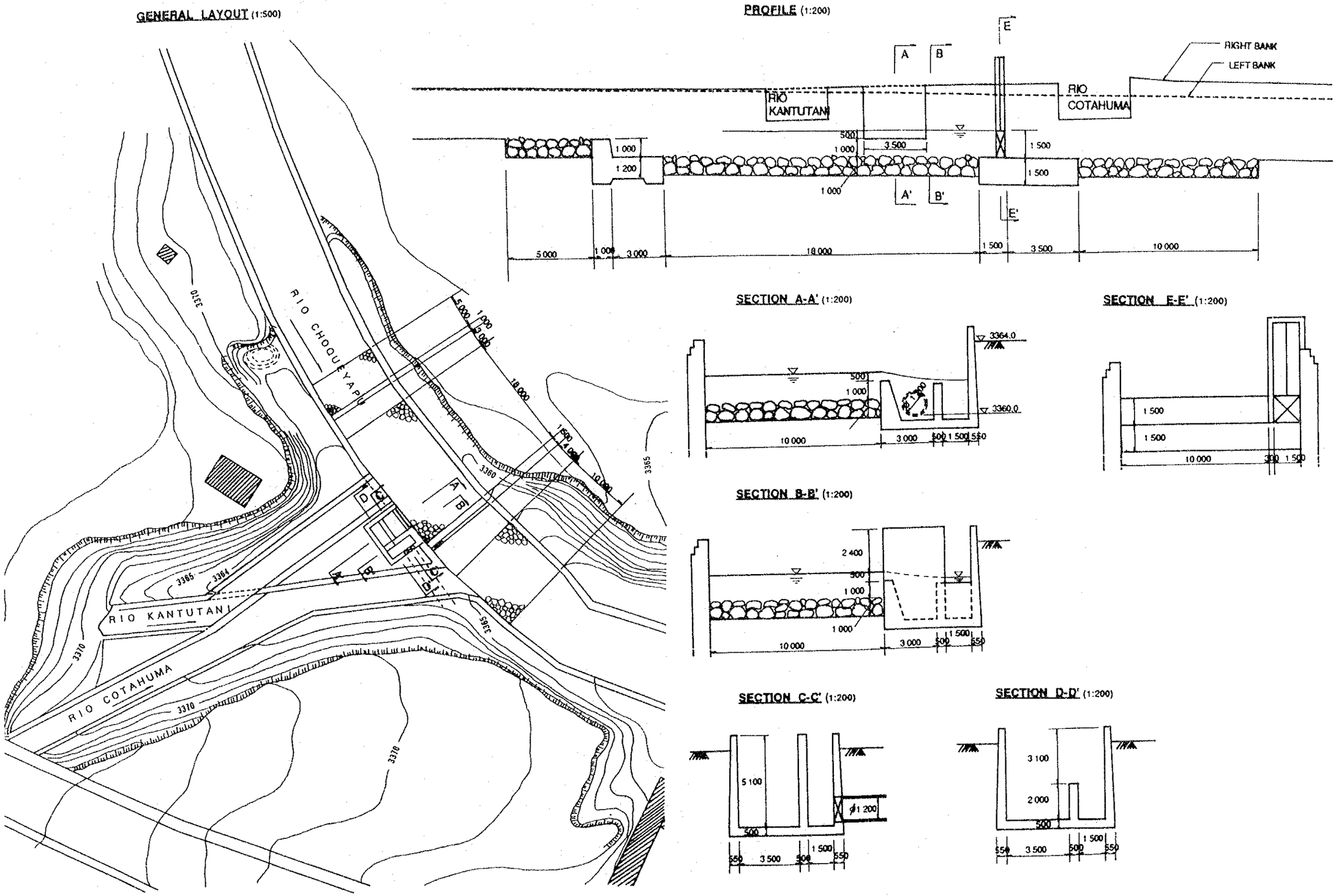


Fig. 3.1 General Layout and Profiles of Water Intake Facilities

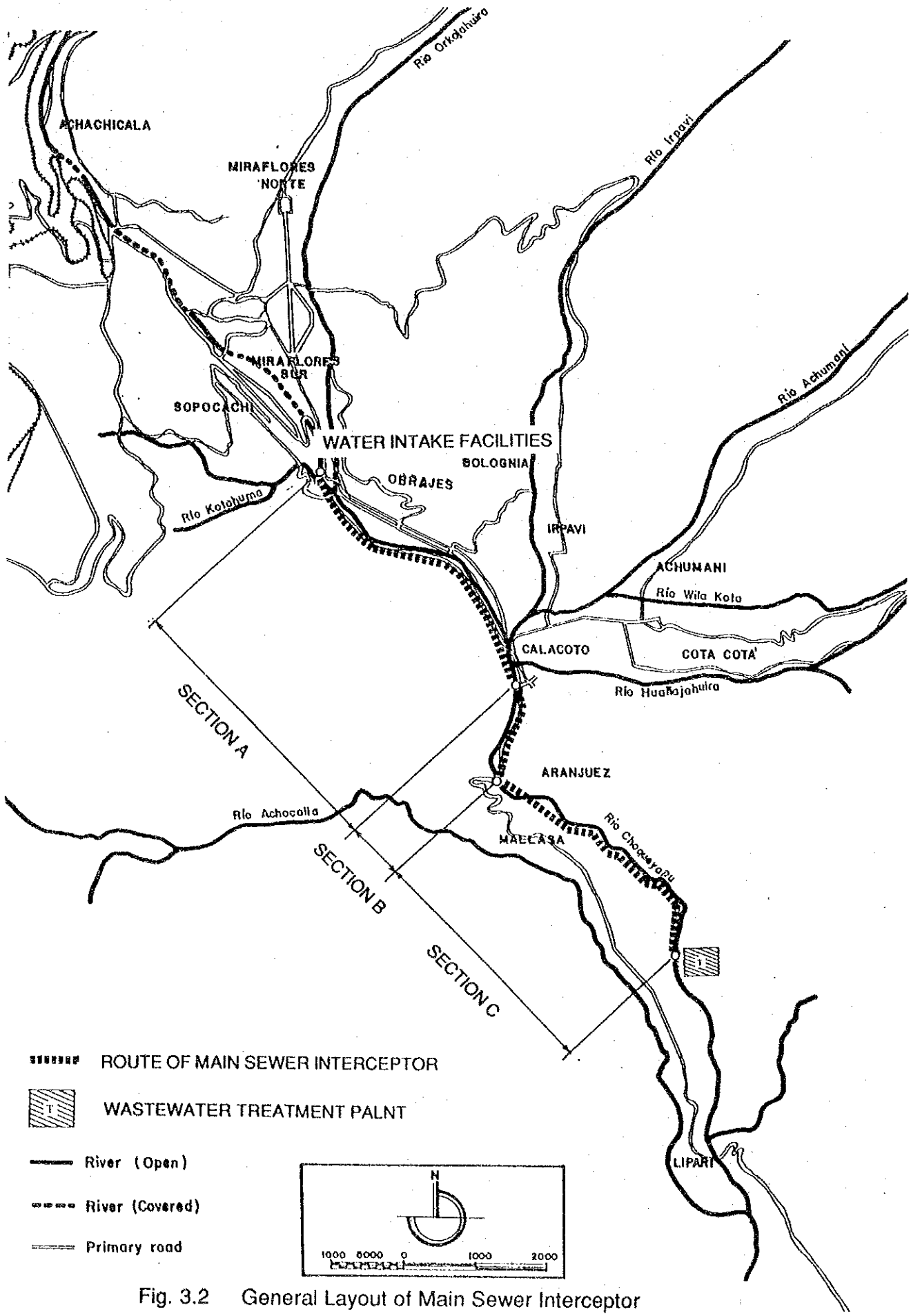


Fig. 3.2 General Layout of Main Sewer Interceptor

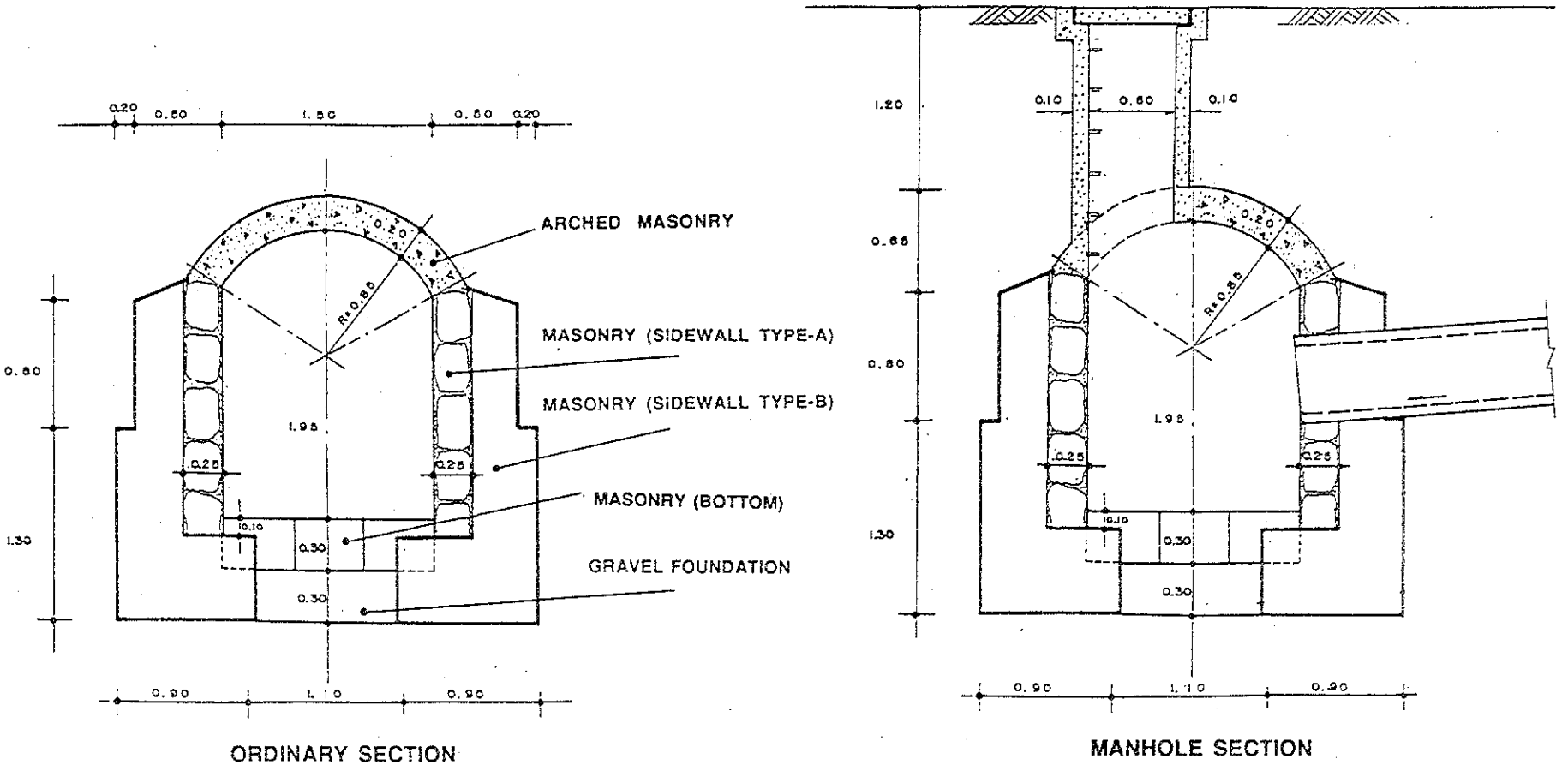


Fig. 3.3 Typical Cross Sections of Arched Masonry Interceptor

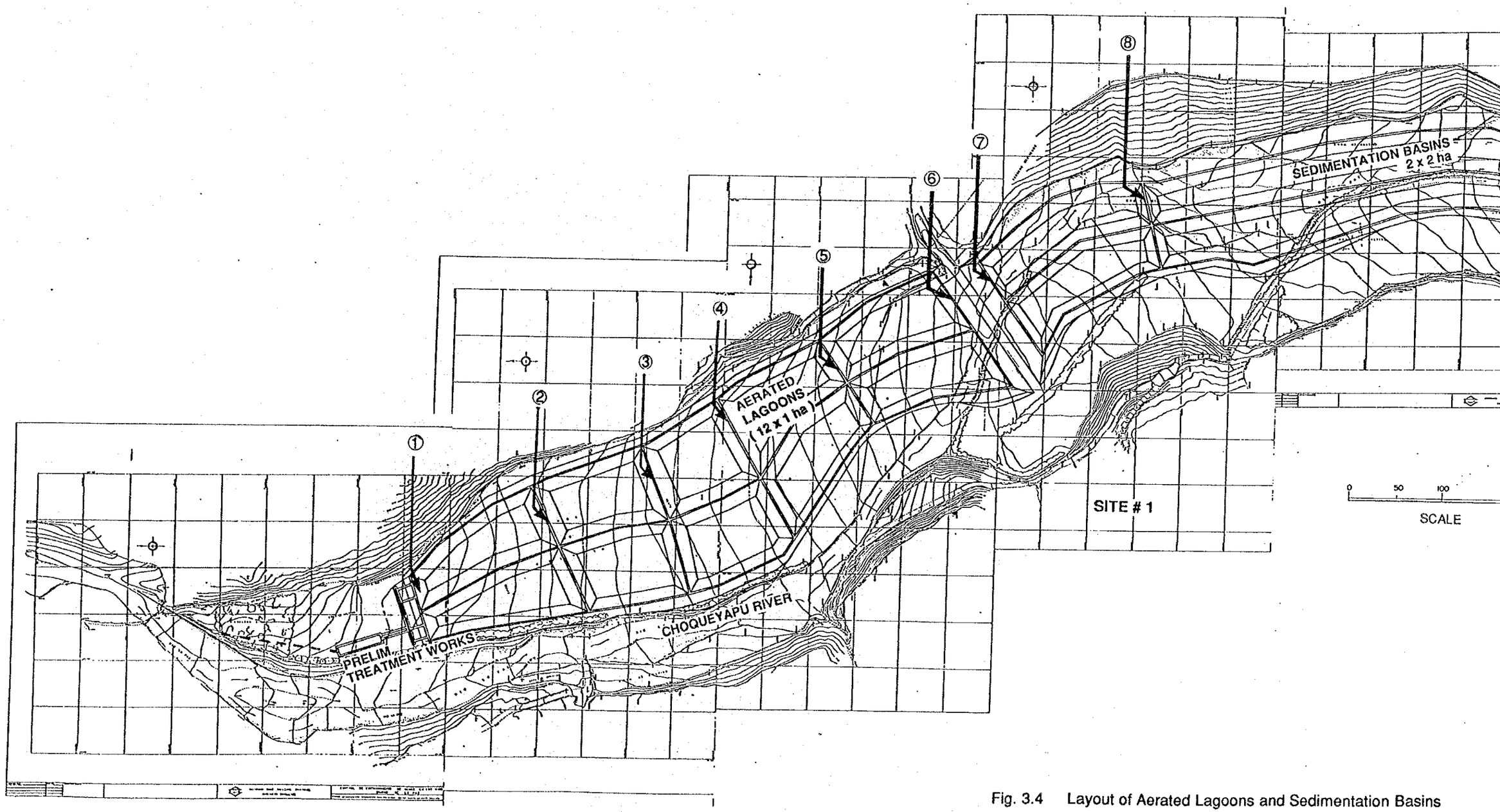


Fig. 3.4 Layout of Aerated Lagoons and Sedimentation Basins

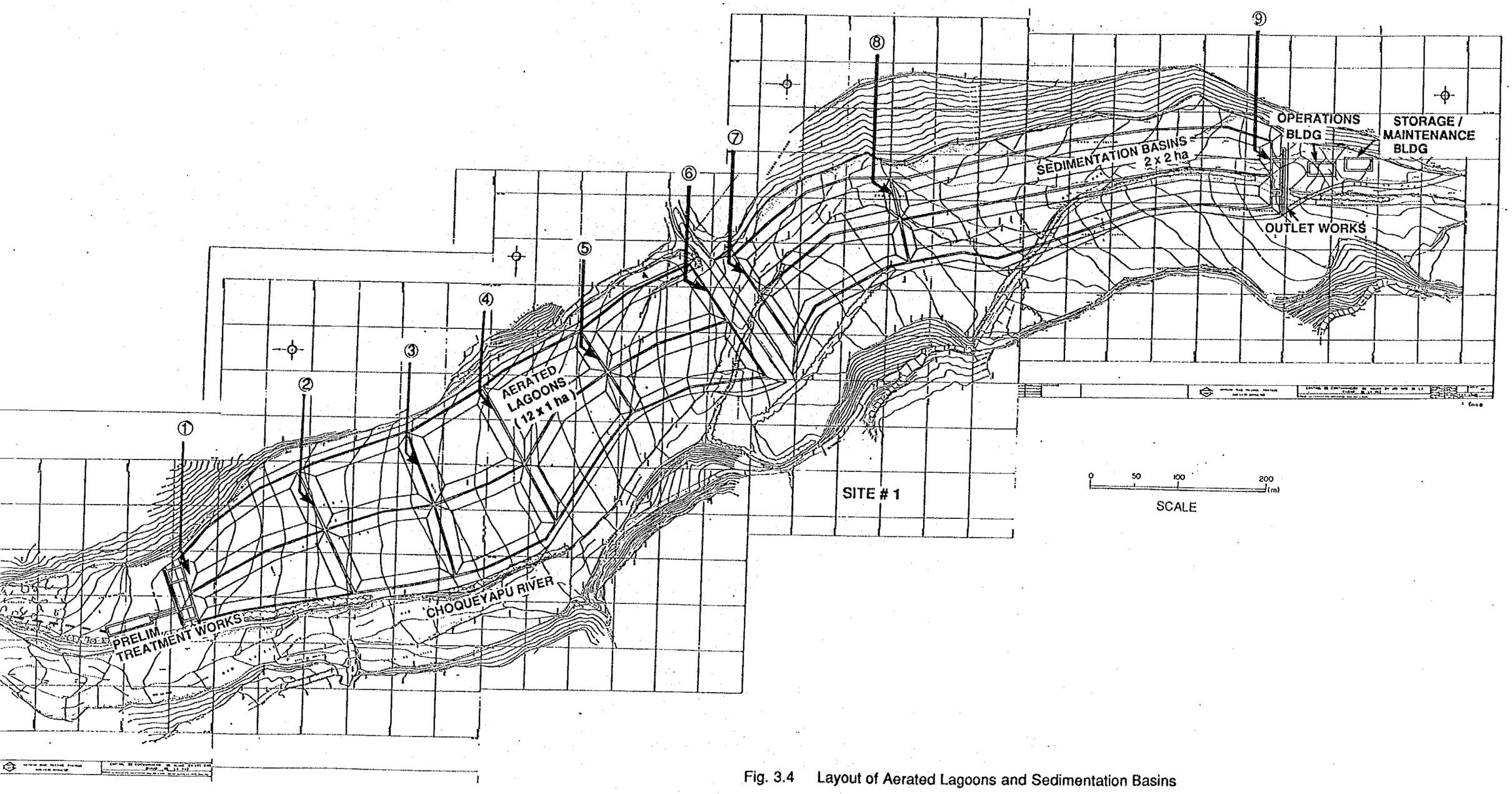
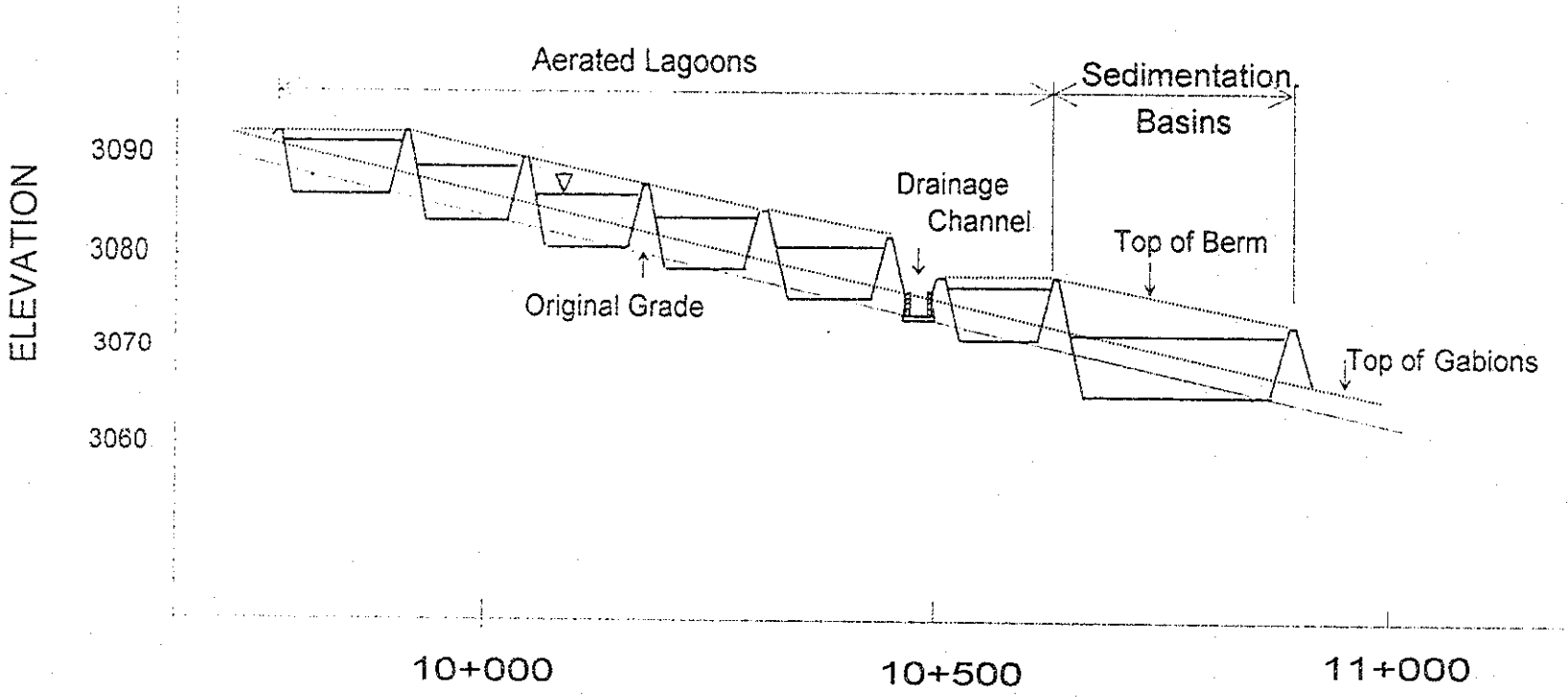


Fig. 3.4 Layout of Aerated Lagoons and Sedimentation Basins

Fig. 3.5 Profile of Lagoons Site 1 - Priority Project



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3.6 Project Scheduling

The time schedule of the priority project is proposed as shown in Fig. 3.6.

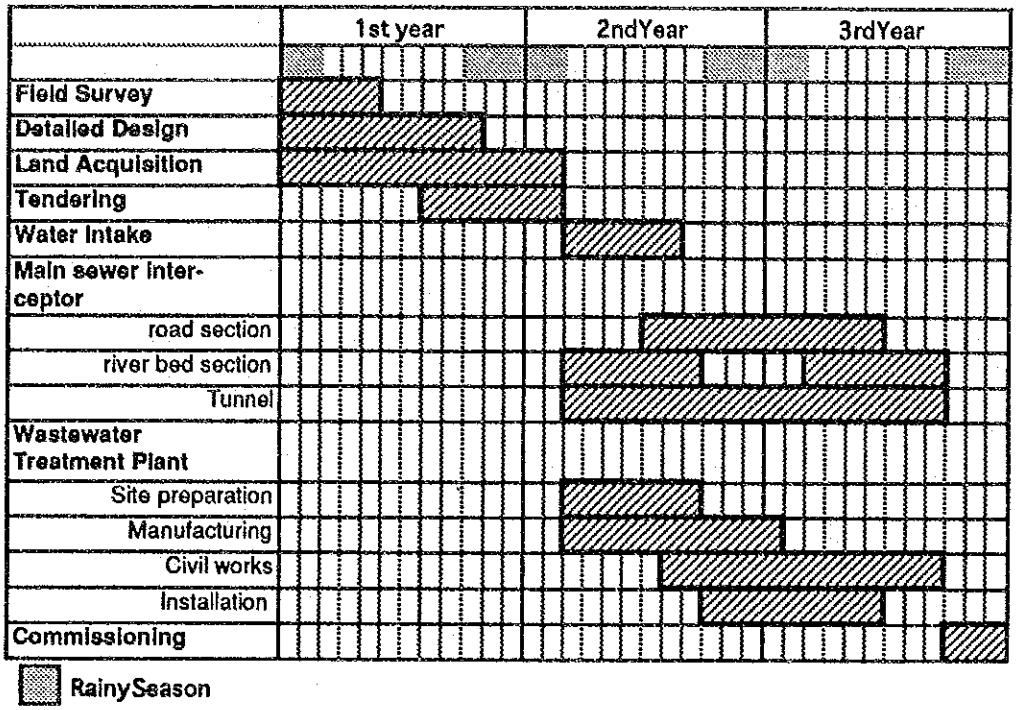

Fig. 3.6 Implementation Schedule for the Priority Project

3.7 Organizational Requirements

Among the four management units in SAMAPA, the Management of Engineering and Projects (GIP) would be responsible for the implementation stage of the priority project, and the Management of Operations and Maintenance (GOM) would be in charge of operations and maintenance of the developed sewerage system.

An increase of several personnel would be necessary in GIP for the project implementation stage. Within GOM, the Department of Sewerage Operations should be created for general management of operation and maintenance of the existing and newly developed sewerage facilities.

Training of personnel is essential since operations and maintenance of these facilities require certain skills. A training program should be prepared by the authority.

3.8 Social and Economic Evaluation

At present, the plant sites and their surrounding crop producing areas are functioning basically to supply vegetables and flowers. Therefore, after transformation of the lands at the plant site, the lower riverain areas might undertake the crop production for the markets as a substitute for the plant sites. These crop areas in the downstream basin might be promoted to work well as crop supplying zones.

The construction works of the priority project would stimulate the regional economy. When one monetary unit is invested in the construction sector, 2.06 units of the investment effects would be induced in the regional economy. This comprises one unit for construction sector as a direct economic effect and 1.06 units through other economic sectors as indirect effects.

An economic evaluation for the priority project was tried to be made by means of the economic internal rate of return (EIRR). Because of the difficulties in quantifying the economic benefits of improved environmental conditions, the benefit was calculated based on the result of questionnaire survey on people's willingness to pay for water quality improvement. The calculated EIRR worked out to be negative. Thus, the priority project might not be viable from the economic point of view. The project should be considered to fulfill basic human needs with regard to environmental conditions.

3.9 Environmental Evaluation

Environmental impacts after completion of the priority project are summarized as follows.

- Improvement of the river water quality below the treatment plant will contribute to the beneficial use of the river water for irrigation.

- Diversion of the polluted river water to the treatment plant and the reduced BOD concentration below the water intake point would result in the improved public health and sanitation, and improved aesthetic conditions.

- Several years after the start of operation of the treatment plant, hauling of sewage sludge accumulated in the sedimentation basin would have to begin. An ultimate sludge disposal site must be selected and prepared by that time.

- Although the water intake and other structures in the project were designed so as not to present obstacles to the flow of the river, they should be paid regular attention and maintained properly.

- Negative impacts to wild life is considered to be small.

- The negative effect of the wastewater treatment plant to the landscape would be minimum since there are only limited locations from where the plant can be viewed.

- Although the BOD concentration of the Choqueyapu River below the water diversion point will be reduced, the SS concentration would be increased unless control of SS in the Cotahuma and the Orkojahuira Rivers is made. Therefore, control of erosion and control of disorderly human activities in the rivers are recommended.

- Because of the diversion of polluted river water, obnoxious odors along the Choqueyapu in the South Zone of the City would be considerably reduced subject to proper control of solid waste dumping into the river.

3.10 Financial Evaluation

The capital investment for the priority project might be a burden on SAMAPA's financial management even in the case of low-interest loans.

In either case that the proposed projects would be implemented through foreign loans or grants, the present sewerage service charge would have to be increased considerably. To accomplish the sound revenue balance, the sewerage service rates might be about 220% more than the present rate in the case of loans, and about 52% more than the one in the case of grants. The increased charge might be a burden on low income citizens. To implement the project successfully, the authorities should make their best efforts to promote understandings of the beneficiaries as well as to obtain low-cost funds.

4. RECOMMENDATIONS

- Considering the required amount of investment, it is impracticable to implement the proposed projects by the SAMAPA's financial capacity alone. However, it may be possible that the national government could extend a strong support to SAMAPA. It is recommended that the national government consider this possibility.

- It is very important that the citizens understand the necessity of water pollution abatement and the need of fairly sharing the costs among the beneficiaries. Therefore, the relevant authorities should make their best to promote the understanding of the citizens as well as to obtain low-cost funds.

- It is recommended that the industrial wastewater discharge regulation be enforced as soon as possible especially for large wastewater dischargers and a new regulation be established to obligate newly developing communities to install their own wastewater treatment facilities. It is also recommended that the authority continue their efforts to control solid waste disposal.

- Implementation of the proposed projects would improve the river water quality considerably. However the improvement is not sufficient as irrigation water for production of freshly eaten vegetables in the downstream areas. If production of freshly eaten vegetables is intended in these areas, it is recommended to conduct a study to develop suitable water sources including groundwater.

- Since the organization for water pollution control in the City of La Paz is not adequate at present, its reinforcement is urgently needed. The capacities of relevant sections of the Municipality should be strengthened. A considerable degree of reinforcement of the organization of SAMAPA is recommended to execute sewerage development, operations and maintenance.

- It is recommended to rehabilitate the existing sewer system in the South Zone to collect the maximum amount of sewage into sewer lines by correcting malconnections between sewer lines and stormwater lines.

- It is considered worthwhile to study possibilities of other methods of mitigation being considered in La Paz such as providing dilution water from a dam.