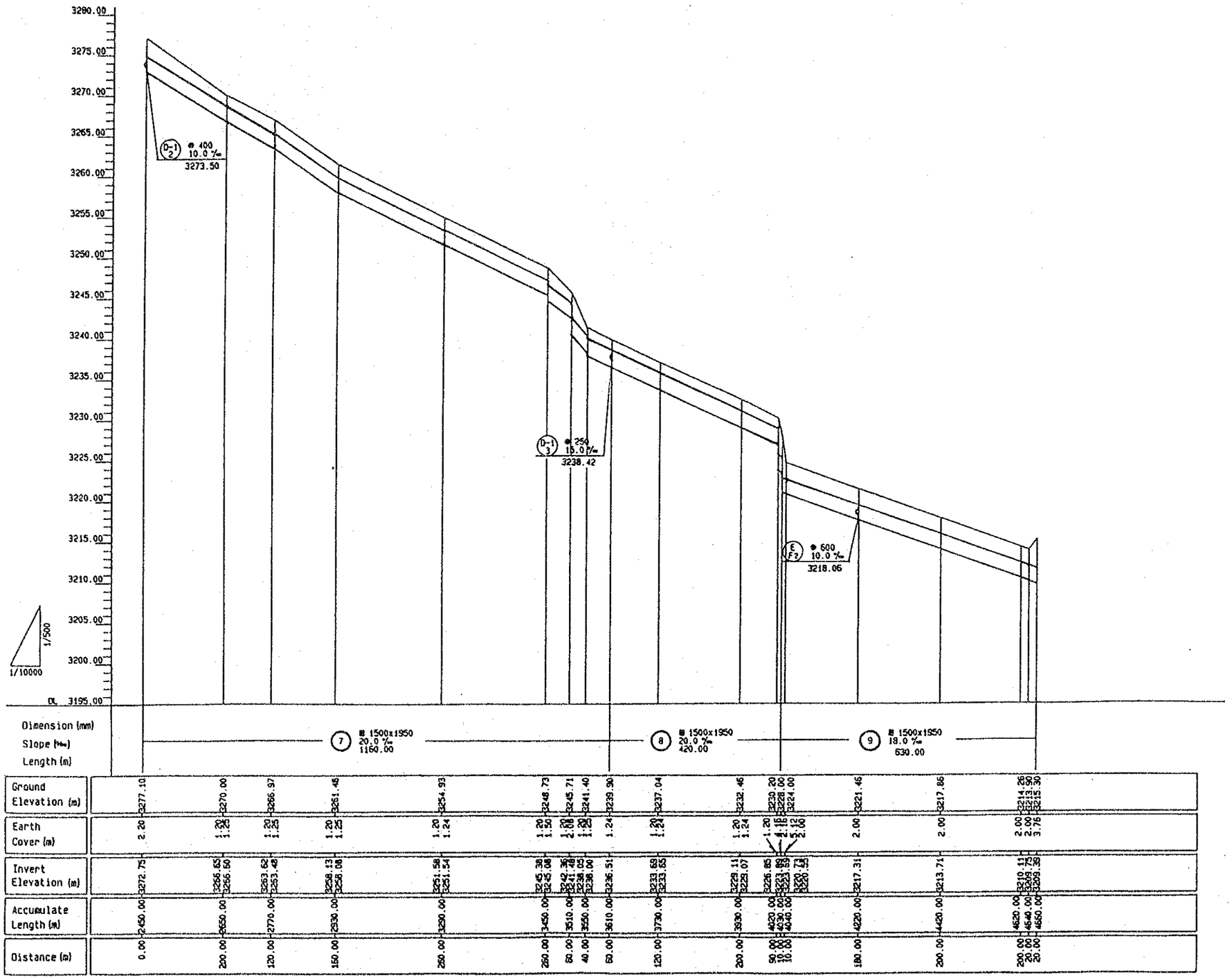


Fig. 7.3.4 LONGITUDINAL PROFILE OF PROPOSED MAIN SEWER INTERCEPTOR (2/4)

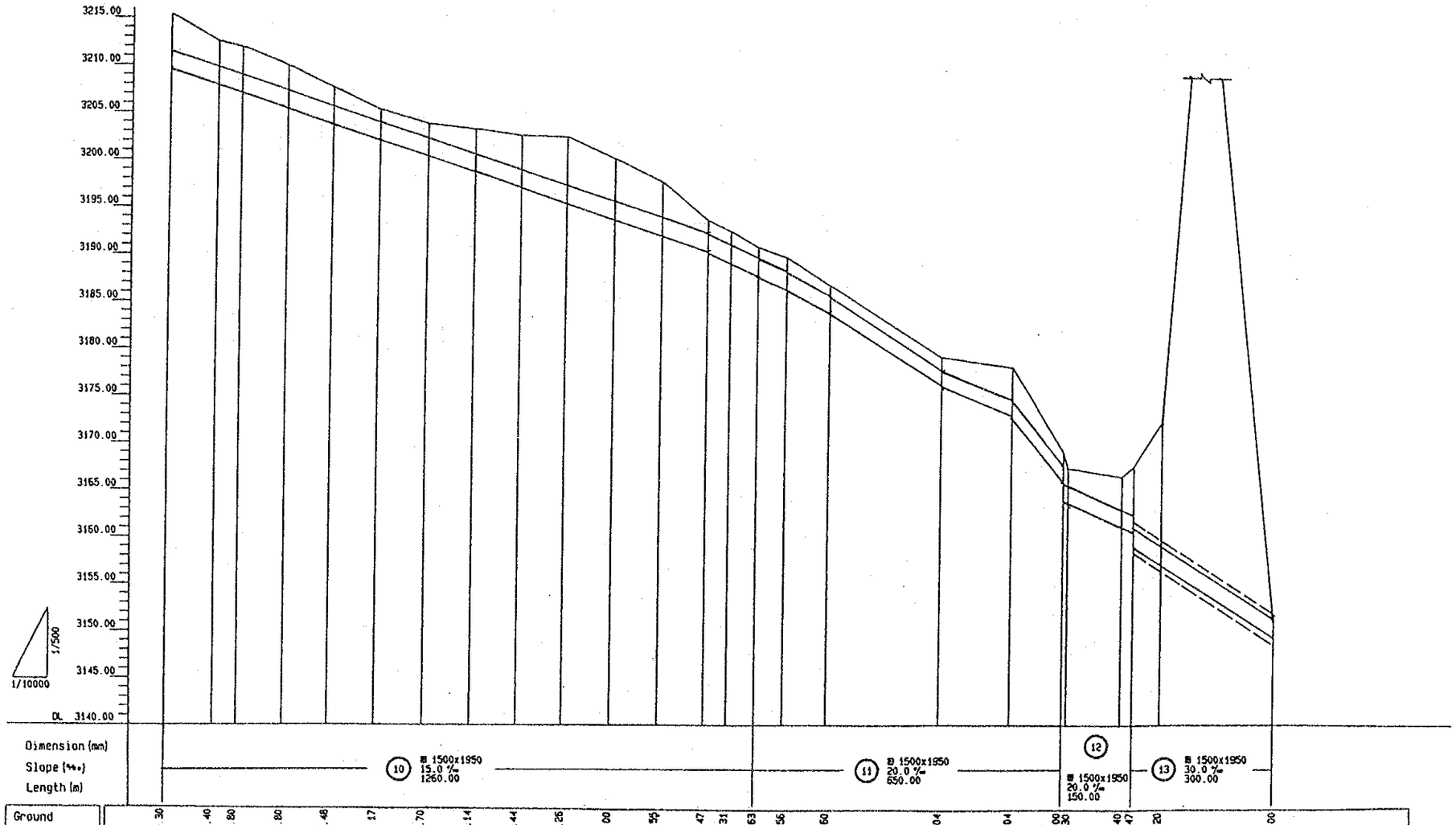


Fig. 7.3.4 LONGITUDINAL PROFILE OF PROPOSED MAIN SEWER INTERCEPTOR (3/4)

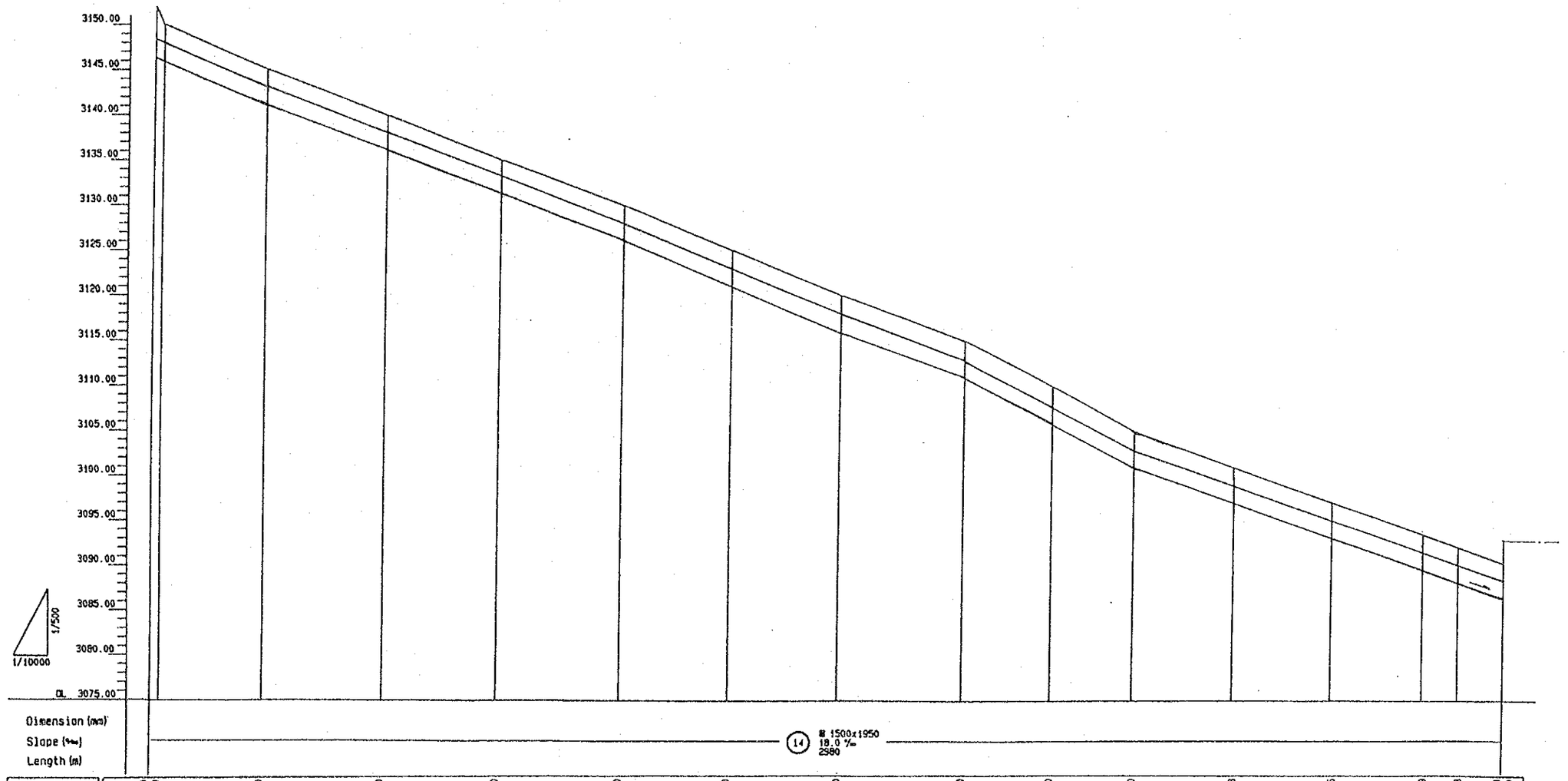
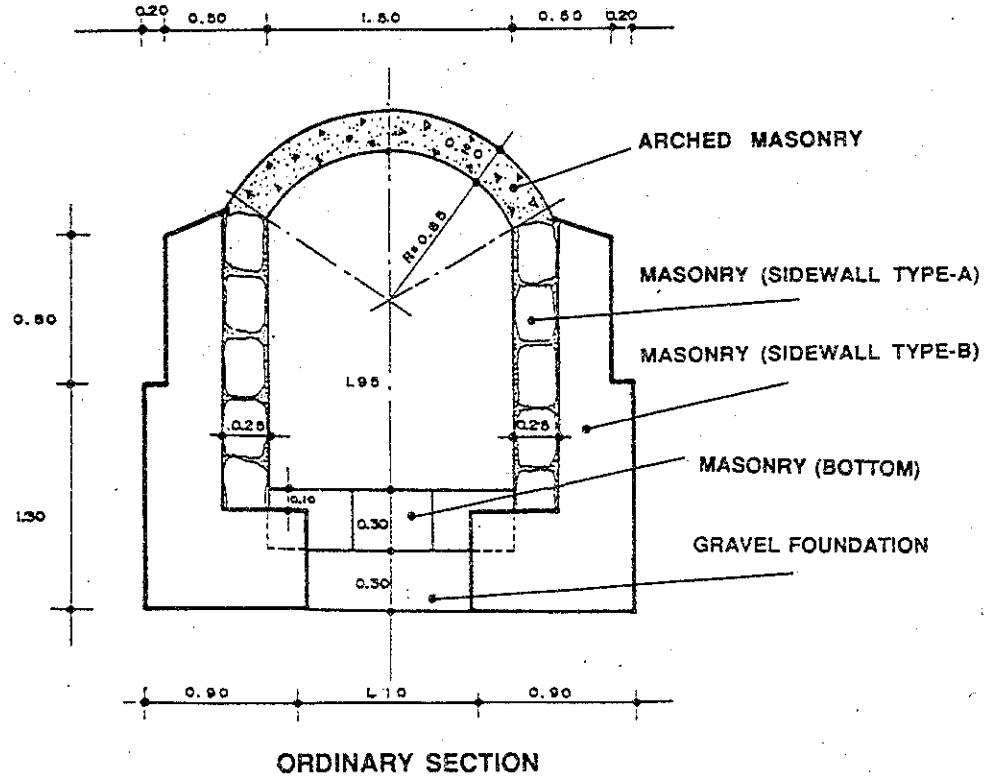
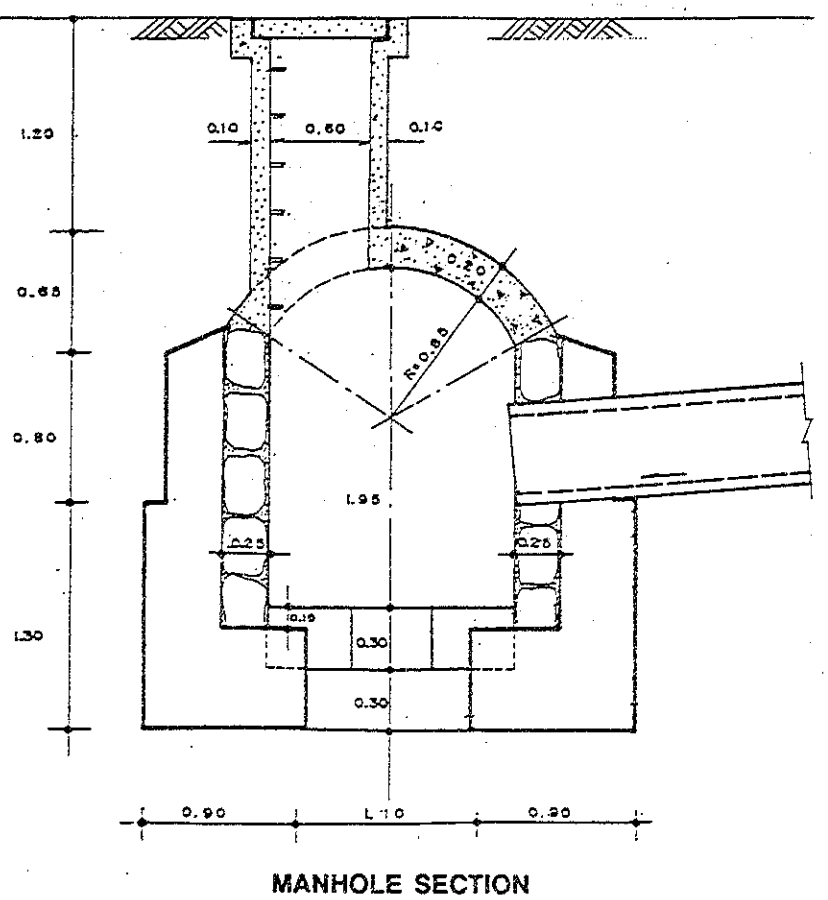


Fig. 7.3.4 LONGITUDINAL PROFILE OF PROPOSED MAIN SEWER INTERCEPTOR (4/4)

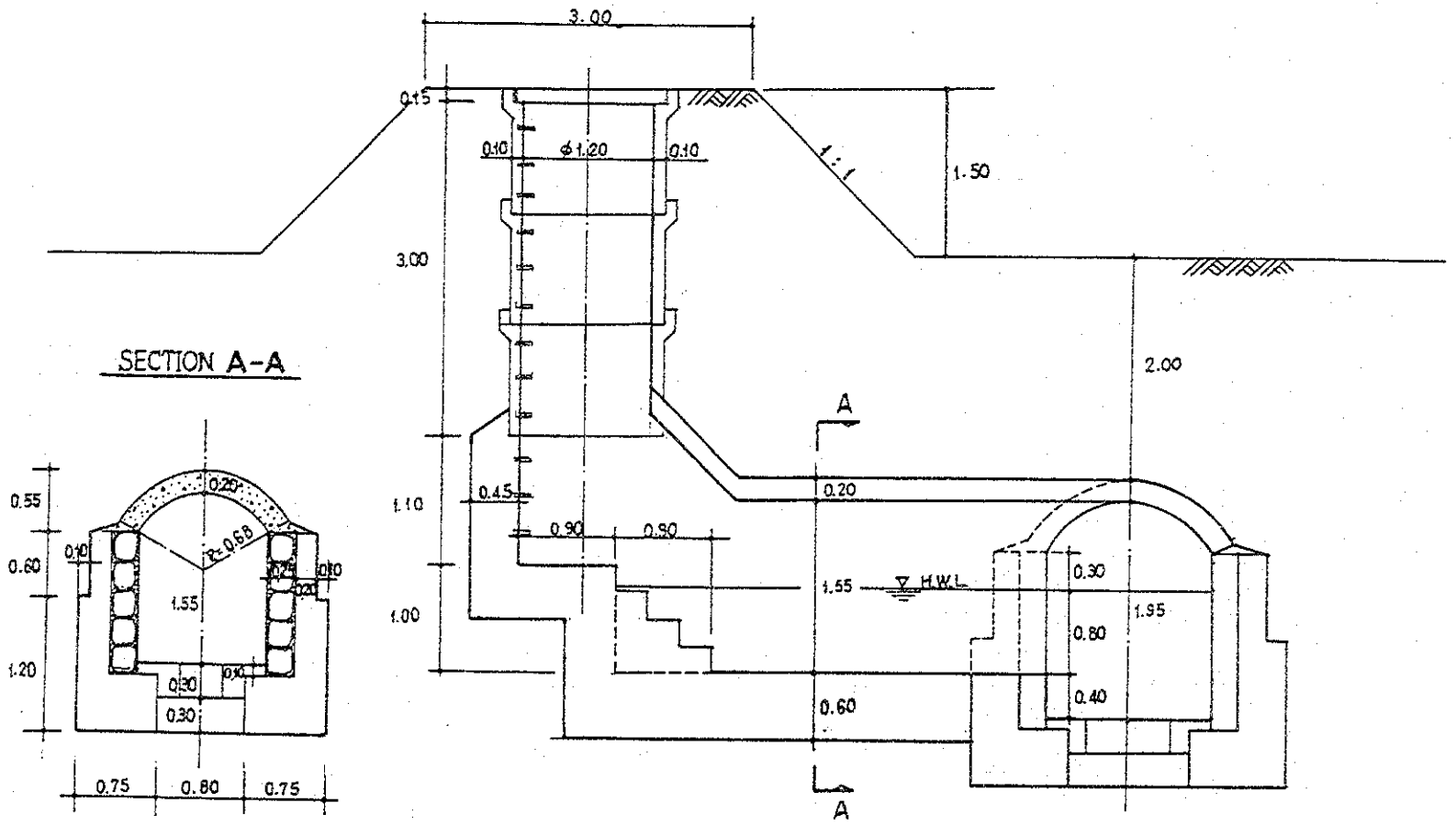


ORDINARY SECTION



MANHOLE SECTION

FIGURE 7.3.5 TYPICAL CROSS SECTIONS OF ARCHED MASONRY INTERCEPTOR (1 OF 2)



MANHOLE STRUCTURES UNDER RIVER BED MAINTENANCE ROAD

FIGURE 7.3.5 TYPICAL CROSS SECTIONS OF ARCHED MASONRY INTERCEPTOR (2 OF 2)

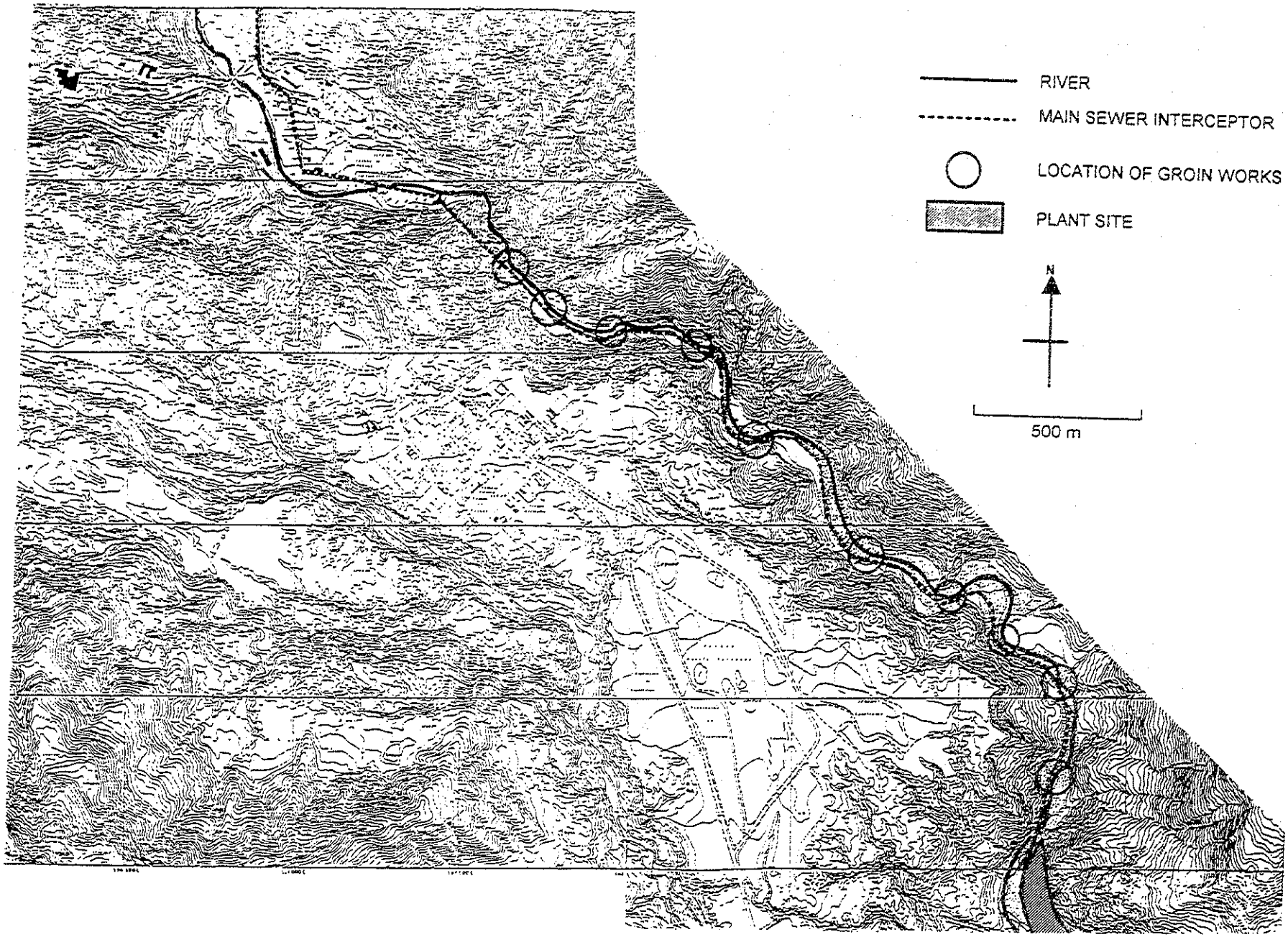
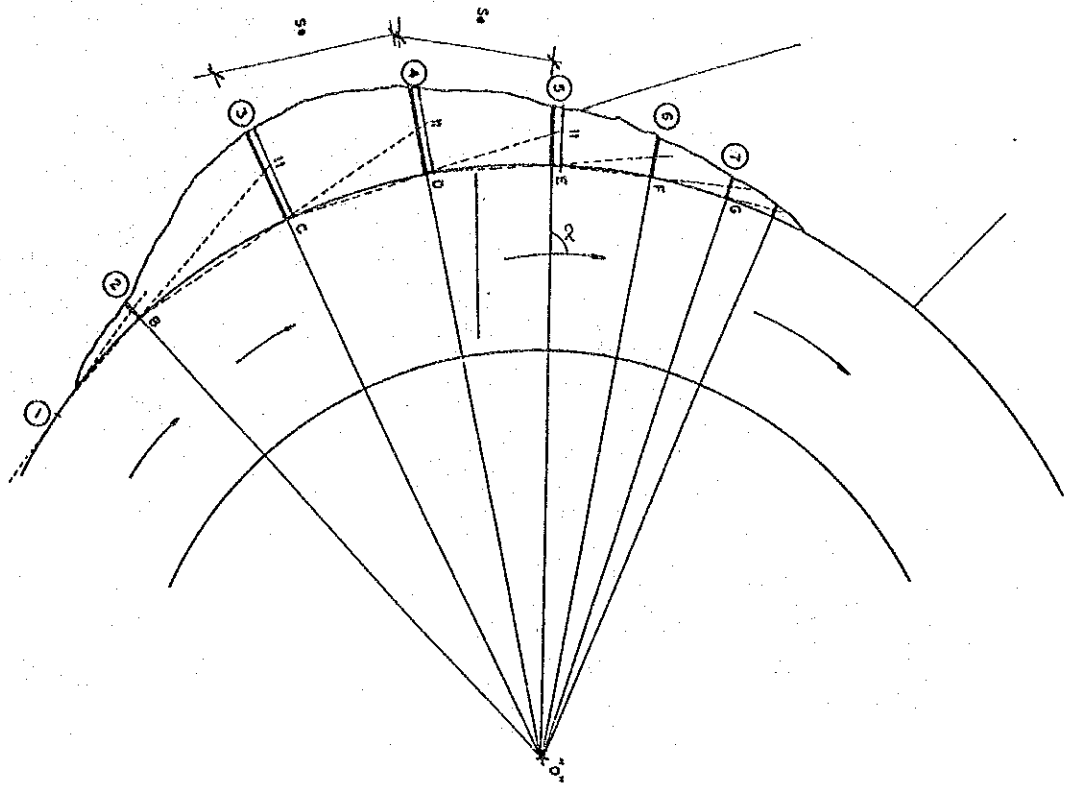
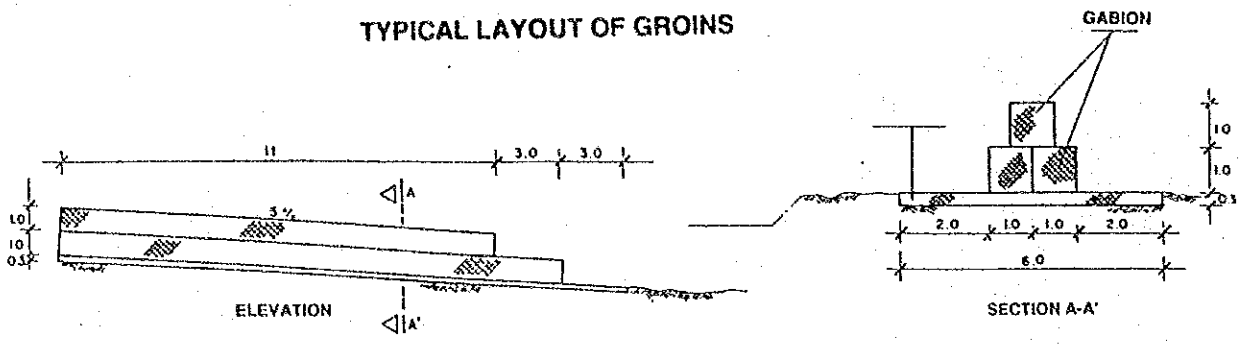
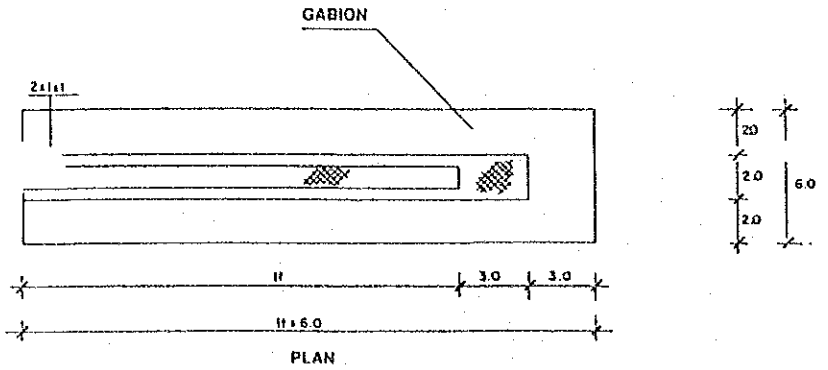


Fig. 7.3.6 LOCATION OF GROIN WORKS



TYPICAL LAYOUT OF GROINS





STRUCTURES OF GABION

FIGURE 7.3.7 LAYOUT AND STRUCTURES OF GROIN WORKS

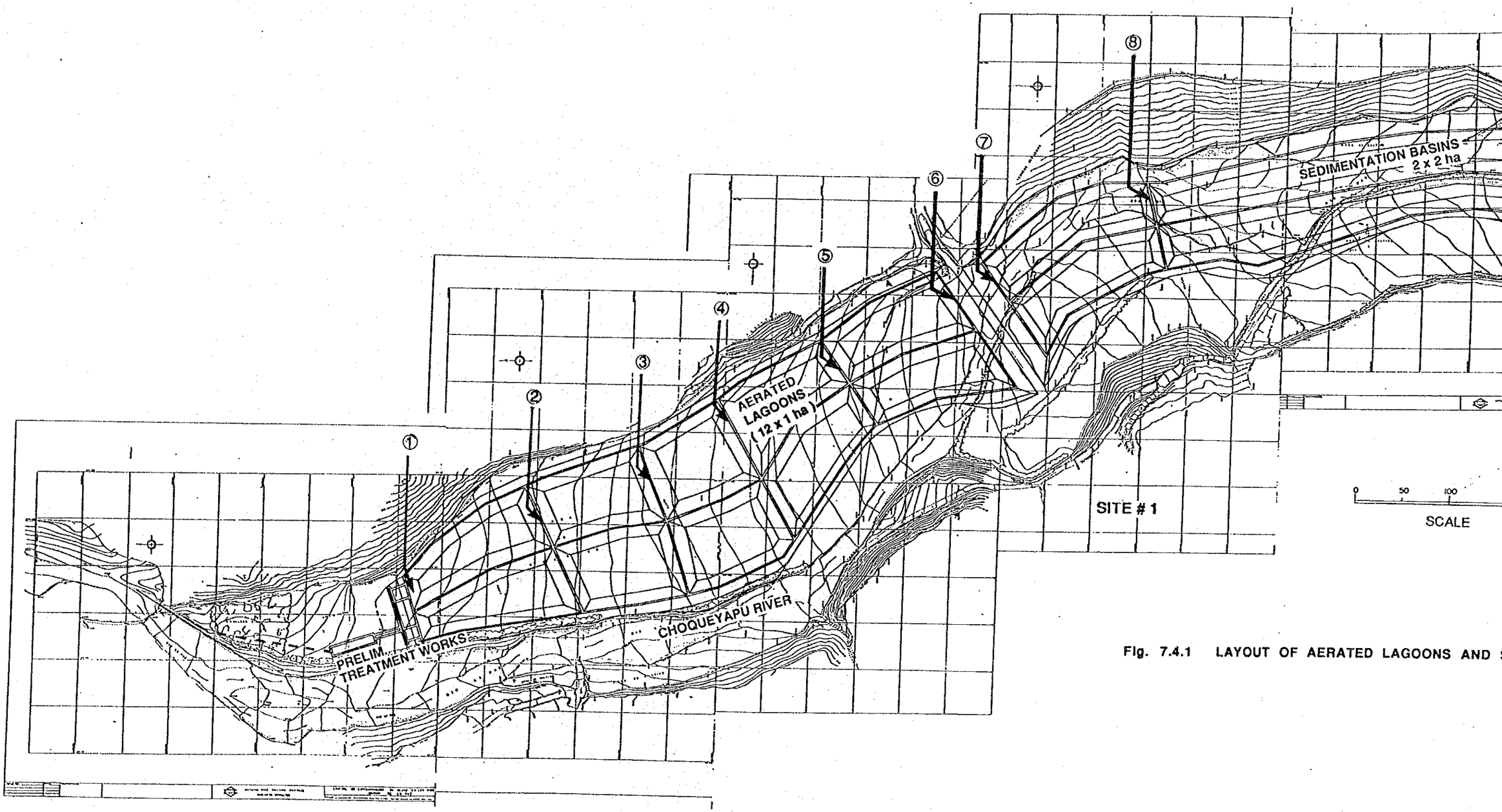


Fig. 7.4.1 LAYOUT OF AERATED LAGOONS AND

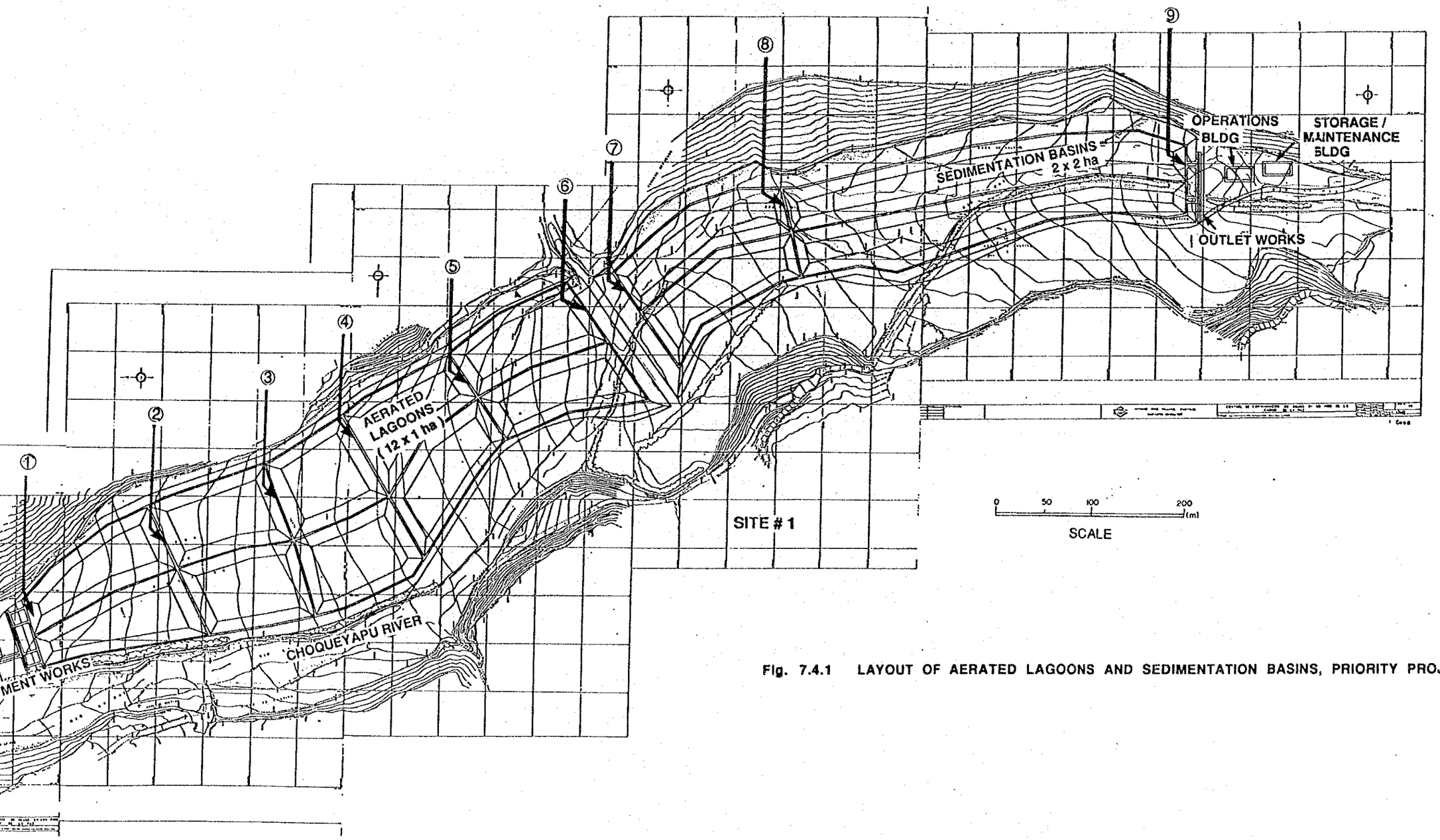
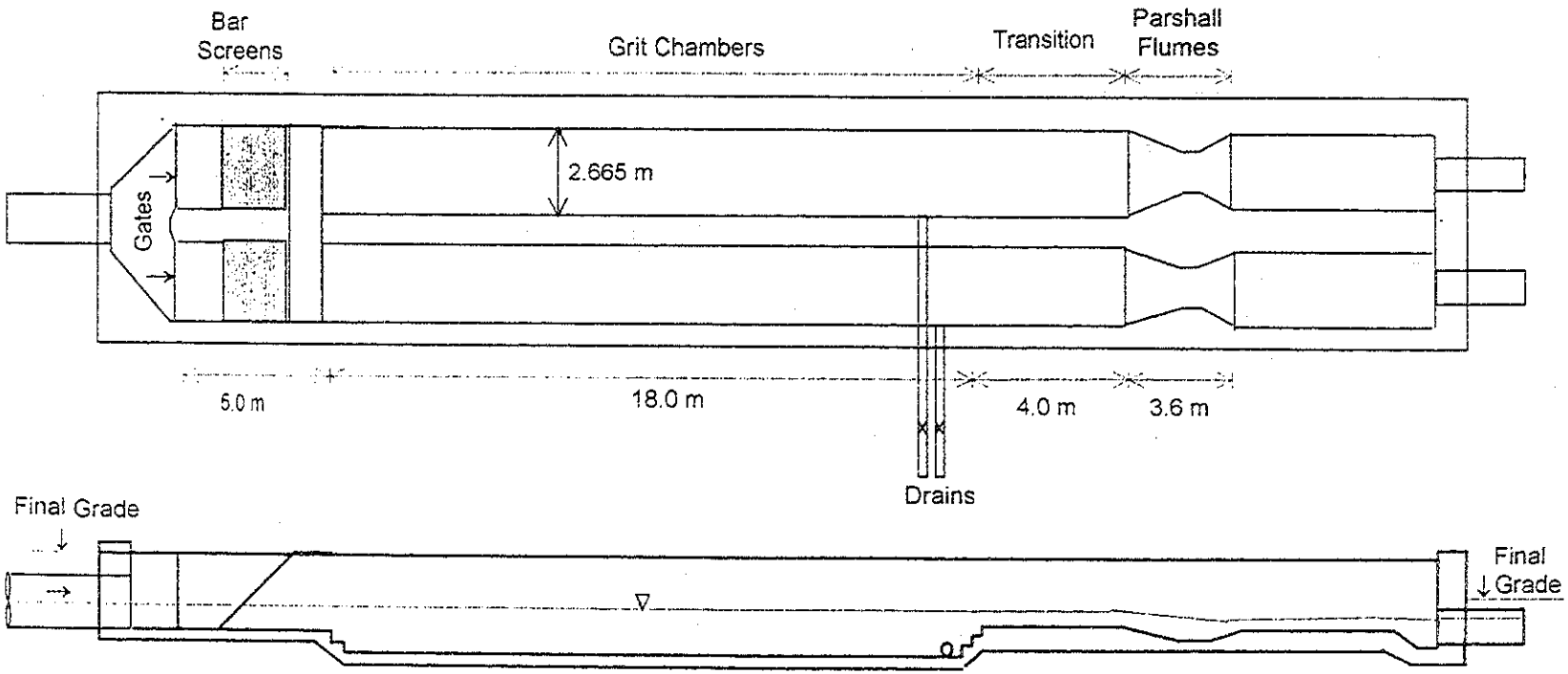


Fig. 7.4.1 LAYOUT OF AERATED LAGOONS AND SEDIMENTATION BASINS, PRIORITY PROJECT

FIGURE 7.4.2

PRELIMINARY TREATMENT WORKS

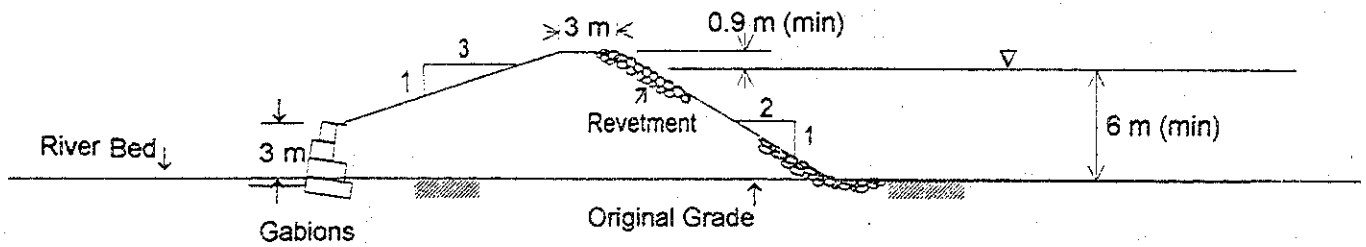
PRIORITY PROJECT



file prewks

SECTION A - A

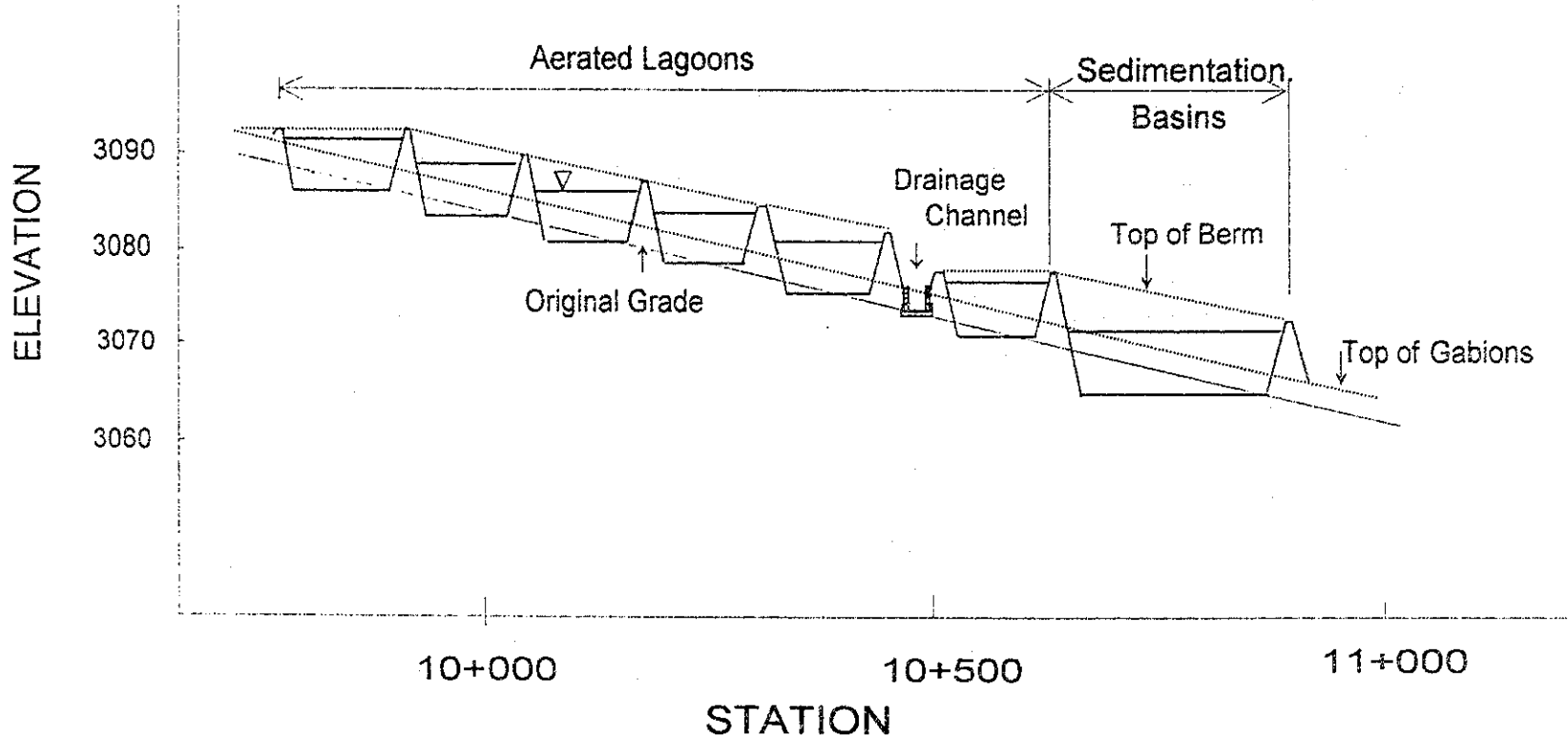
(Refer to Figure 7.4.5)



File: lagsec2.drw

Fig. 7.4.3 LAGOON CONSTRUCTION

FIGURE 7.4.4
PROFILE OF LAGOONS
SITE 1 - PRIORITY PROJECT



File: profs1.drw

FIGURE 7.4.5

PLAN - INLET WORKS AND PIPING

SITE 1 - PRIORITY WORKS

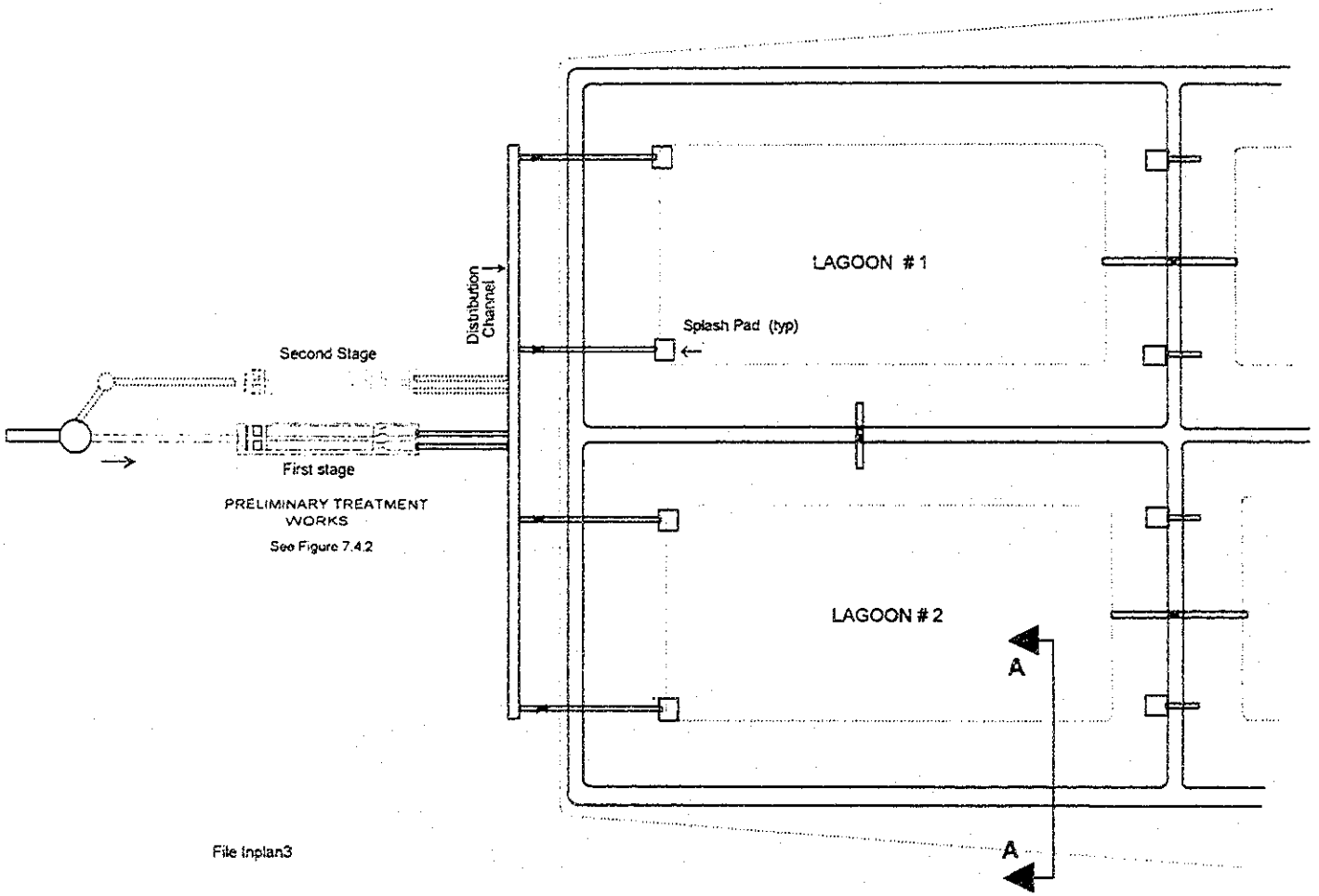
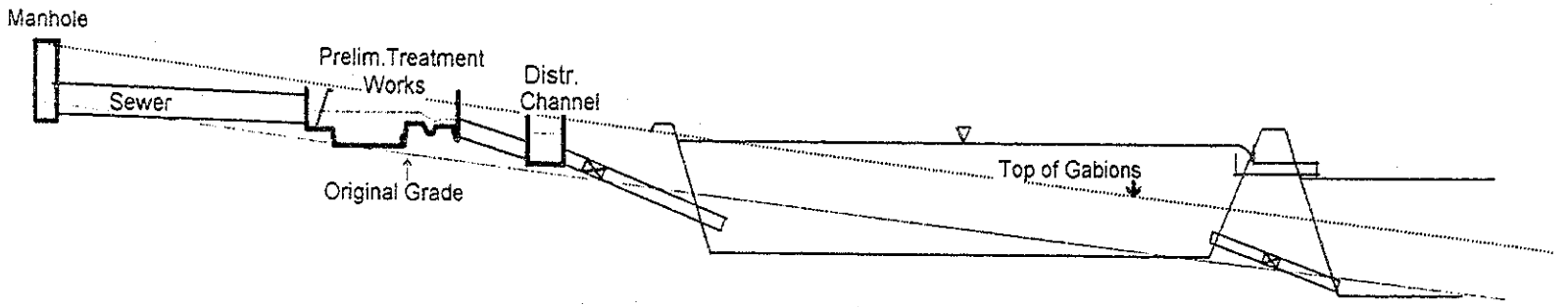


FIGURE 7.4.6

PROFILE - INLET WORKS AND PIPING
SITE 1 PRIORITY PROJECT



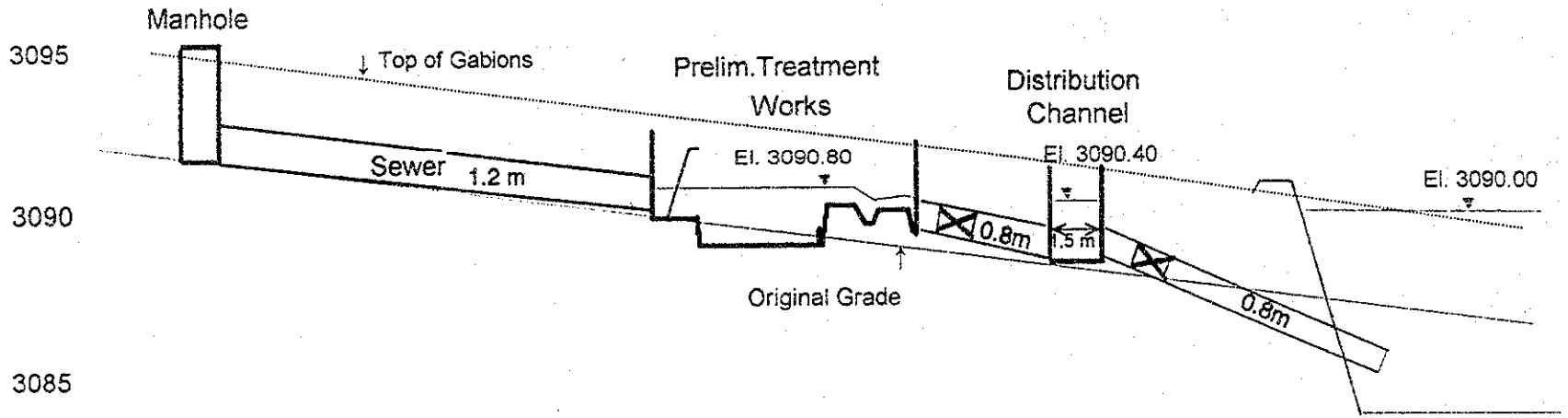
File: INLAG.DRW

FIGURE 7.4.7

HYDRAULIC GRADELINE - INLET WORKS

(Final Design Flow - All Units Operating)

SITE 1 - PRIORITY PROJECT



FILE: HYDGRAD

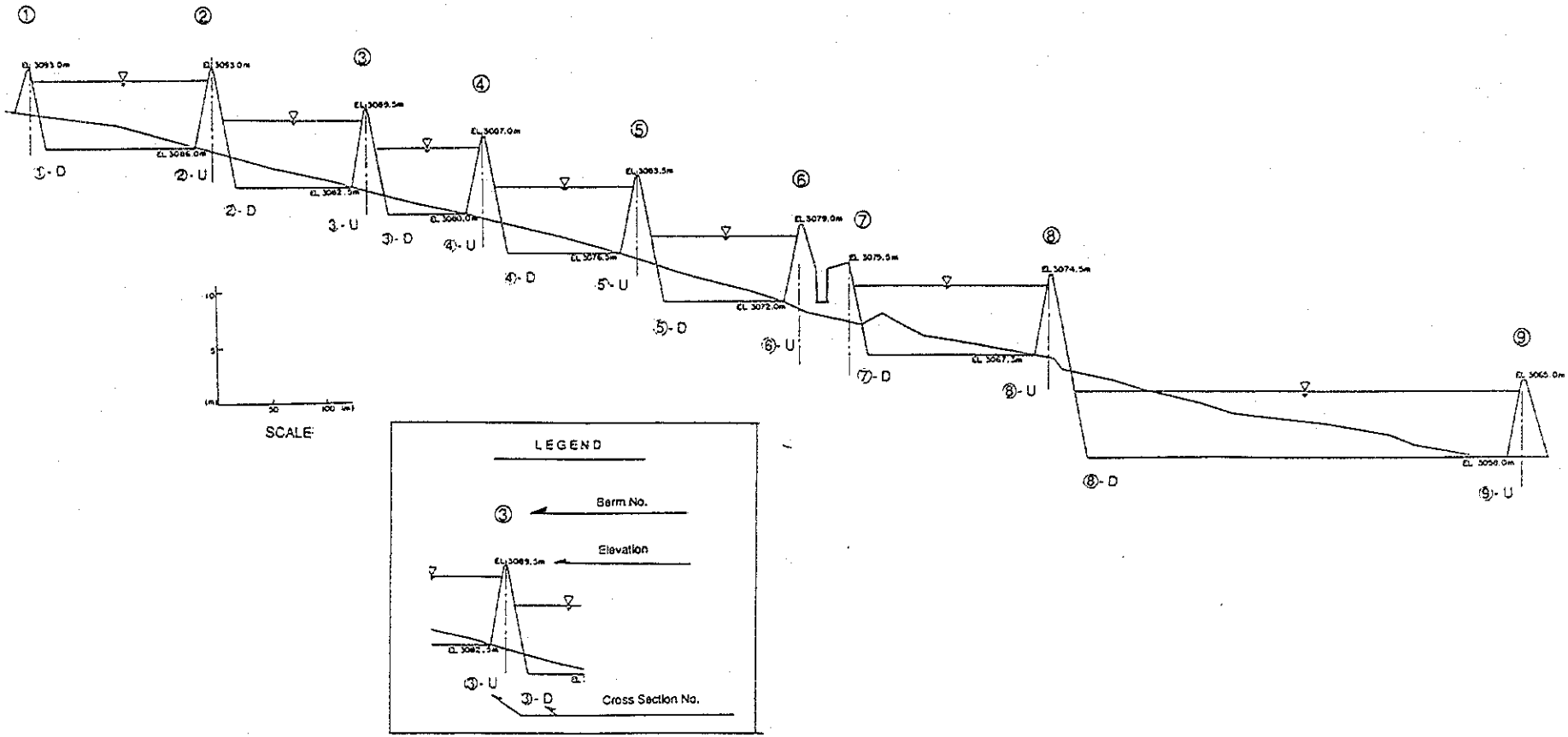
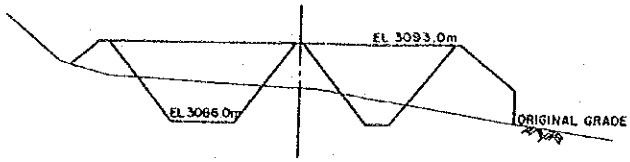


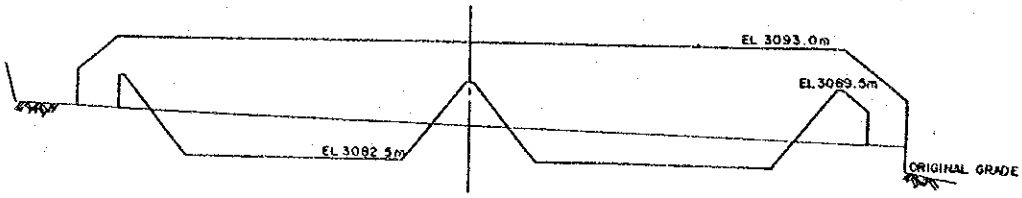
FIGURE 7.4.8 LONGITUDINAL SECTION OF AERATED LAGOONS

LOCATIONS OF CROSS SECTIONS
ARE SHOWN IN FIGURE 7.4.8
AND FIGURE 7.4.1

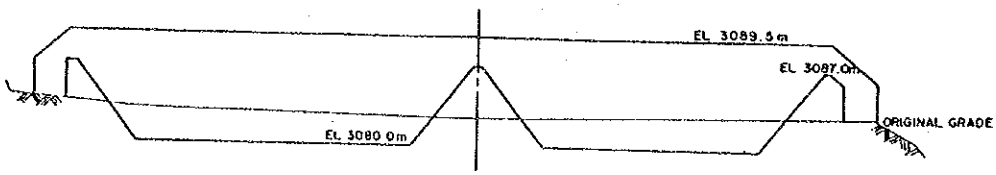
①- D



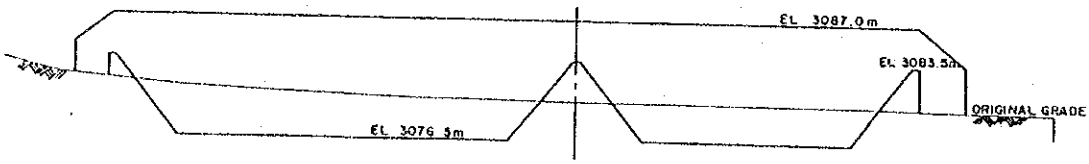
②- D



③- D



④- D



⑤- D

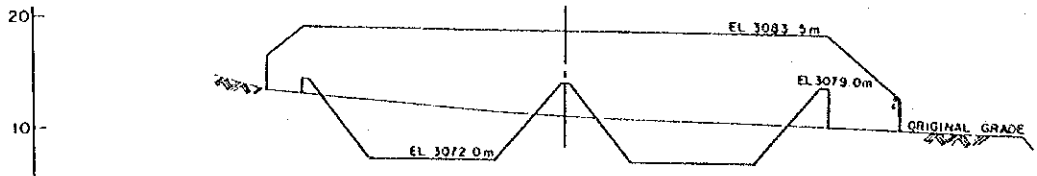
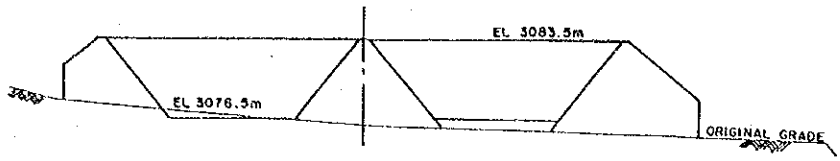


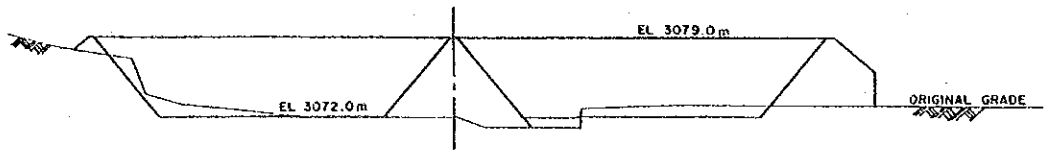
FIGURE 7.4.9 CROSS SECTIONS OF AERATED LAGOONS (1 OF 3)

LOCATIONS OF CROSS SECTIONS
ARE SHOWN IN FIGURE 7.4.8
AND FIGURE 7.4.1

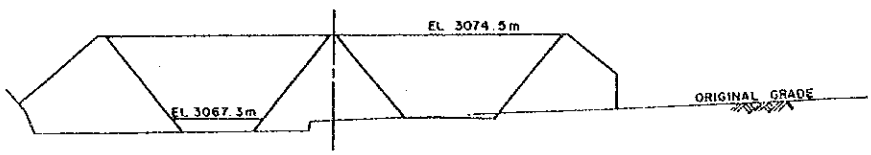
⑤- U



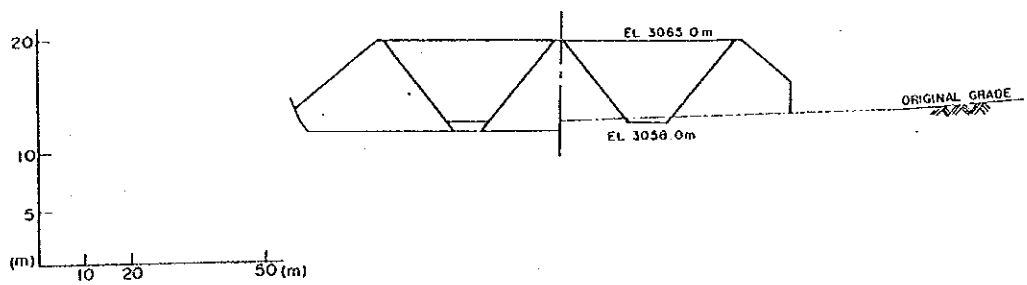
⑥- U



⑧- U



⑨- U

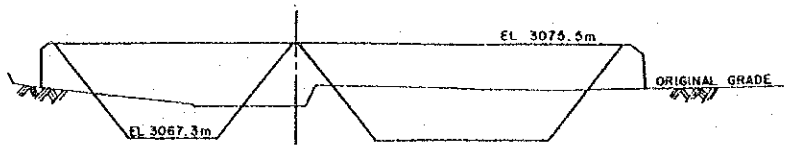


SCALE

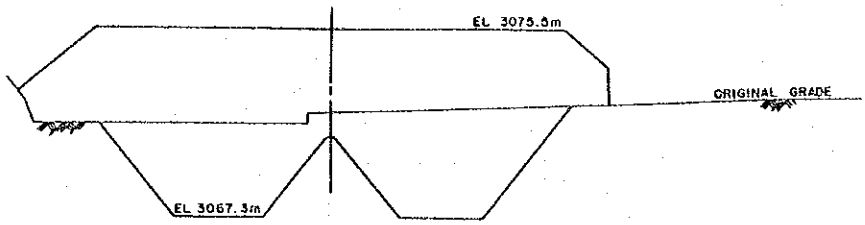
FIGURE 7.4.9 CROSS SECTIONS OF AERATED LAGOONS (2 OF 3)

LOCATIONS OF CROSS SECTIONS
ARE SHOWN IN FIGURE 7.4.8
AND FIGURE 7.4.1

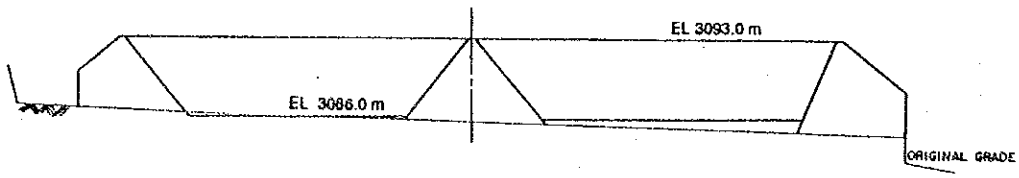
⑦- D



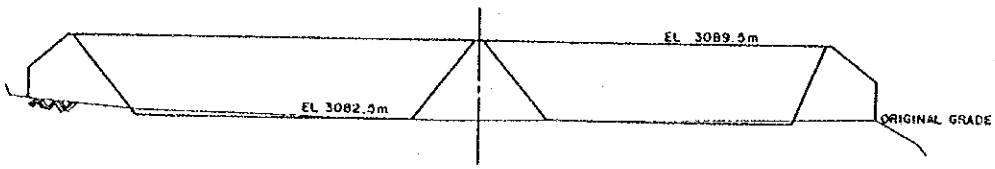
⑧- D



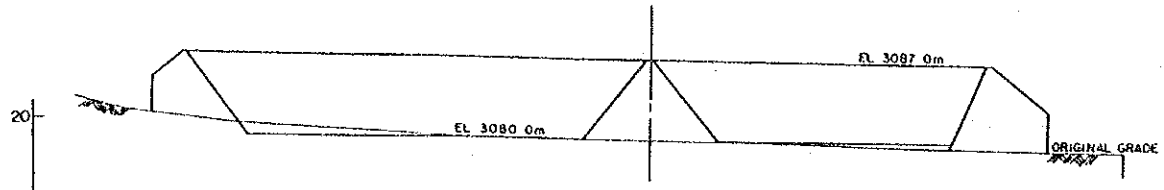
②- U



③- U



④- U



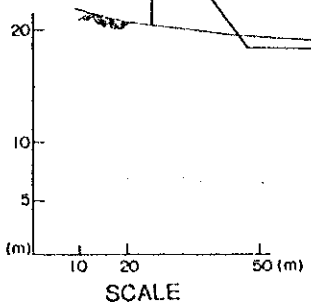


FIGURE 7.4.9 CROSS SECTIONS OF AERATED LAGOONS (3 OF 3)

CHAPTER 8 IMPLEMENTATION PROGRAM

8.1 PROJECT SCHEDULING

To improve the present river water quality urgently, the priority project is planned to be completed within three years. The project can be divided into two major portions; the main sewer interceptor including the water intake facilities and the wastewater treatment plant. Since most works of both portions consist of civil works, construction could take a relatively long time. Consequently, it would be difficult to divide the project into stages for implementation.

Major works in both portions include the works in or near the river, which might be difficult to construct during the rainy season. Those works should be scheduled for the dry season.

Considering these constraints, the proposed time schedule of the priority project is as shown in Fig. 8.1.1.

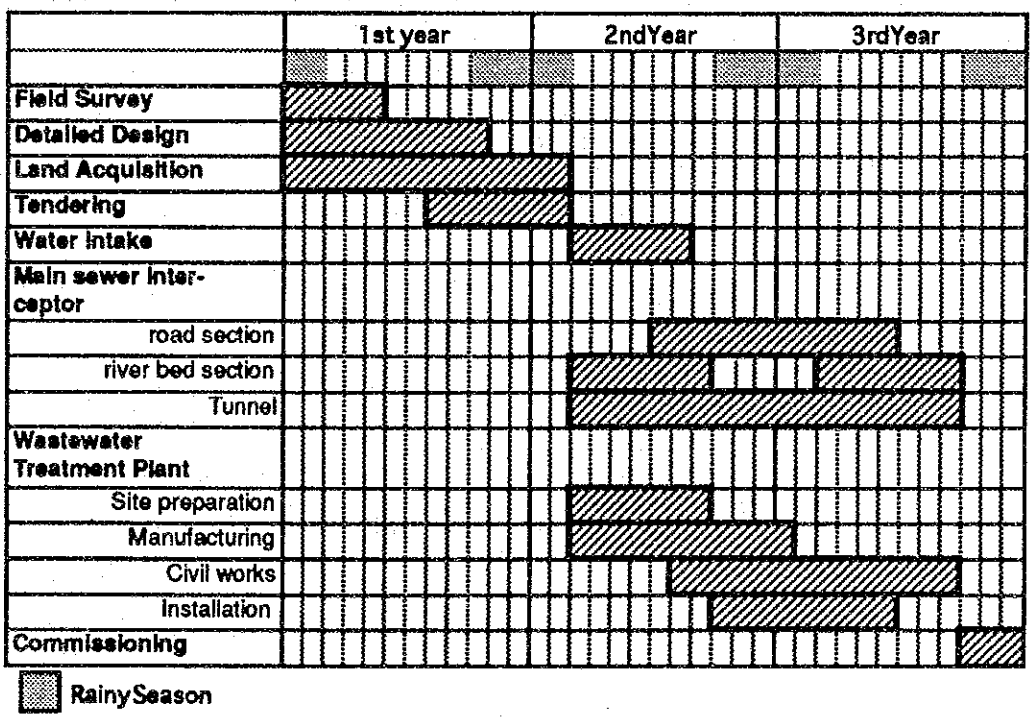


FIGURE 8.1.1 IMPLEMENTATION SCHEDULE FOR THE PRIORITY PROJECT

8.2 ORGANIZATIONAL REQUIREMENTS

Among the four management units in SAMAPA, the Management of Engineering and Project (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, as discussed in Section 5.4.3.

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.

Table 8.2.1 shows the proposed number of personnel for operation and maintenance of the facilities to be developd in the priority project.

The number of personnel should be increased upon completion of subsequent projects proposed in the Basic Plan.

Since operations and maintenance of these facilities require certain skills, training of personnel is important. A training program should be prepared by the authority.

TABLE 8.2.1 PERSONNEL REQUIREMENT FOR OPERATION AND MAINTENANCE OF THE PRIORITY PROJECT SEWERAGE SYSTEM

Facility	Type of Personnel	Number of Personnel	Remark
Wastewater collection and transport facilities	**Water intake and interceptor**		Personnel engaged in O & M of the existing facilities are not included.
	Operator/Engineer	1	
	Laborers	5	
	Night watch	1	
	Drivers	2	
	Sub-total	9	
Wastewater Treatment Plant	**Supervision**		Stationed in the office of the wastewater treatment plant
	Director	1	
	Operators/Engineers	2	
	Preliminary works		
	Laborers	2	
	Mechanical technician	1	
	Aerated lagoons		
	Laborers	5	
	Night watch	2	
	Lab technicians	3	
	Electric technician	1	
	Mechanical technician	1	
	Drivers	2	
	Operations building		
	Administrative staff	1	
	Secretary	1	
	Janitor	1	
	Sub-total	23	
Total		32	

CHAPTER 9 PROJECT EVALUATION

9.1 SOCIAL AND ECONOMIC EVALUATION

9.1.1 Social Evaluation

(1) Changes of Agricultural Production

The selected wastewater treatment plant sites are located in the flood plain of the Choqueyapu River. Although these lands are publicly owned, some are privately cultivated for crop production. At present the plant sites and their surrounding crop producing areas are functioning to supply fresh vegetables and flowers. Although farmers in the basin were affected by the cholera scare and changed their products, they still remain as one of the area's food suppliers because of the convenient location to the markets. Thus, in case the selected lands were to be converted to the plant sites, the lower basin areas downstream of these sites might take over the crop production for these markets. The crop areas in the downstream basin might be promoted to work well as crop supplying zones. Of course, vegetable production could recover from the cholera scare after the completion of the project.

(2) Stimulation of Regional Economy

Construction materials and labor would be essential to build the sewerage system proposed in the priority project. The construction work of the sewerage system would then stimulate the regional economy in the La Paz area.

When one unit of public funds is invested in the construction sector, approximately 56% of intermediate goods and services are procured from the domestic market. Of the total domestic procurement of 56%, 18% is from the manufacturing sector of non-metallic products such as cement and ceramics, and 15% is from the manufacturing sector of metal products and machinery.

An analysis using the Leotief inverse matrix indicated that when one monetary unit is invested in the construction sector, 2.06 units of investment effects would be induced in the regional economy. This comprises one unit for the construction sector as a direct effect and 1.06 units through other economic sectors as indirect

effects. Thus, these components show direct and indirect positive economic effects on respective production sectors.

9.1.2 Economic Evaluation

(1) Economic Costs

Economic costs of the priority project were converted from the financial costs applying the conversion factor of 0.85 for local portions. The economic costs excluded (a) the land acquisition and ROW and (b) the price contingency. As seen in the below table, the economic costs were estimated as the total of the foreign portion and the converted local portion.

(Unit: US$ million in 1992 prices)

Cost Item	Financial Cost	Economic Cost
Construction Cost	19.66	17.22
Annual O&M Cost	0.46	0.40

(2) Economic Benefits

An attempt was made to estimate economic benefit of the priority project by interpreting people's willingness to pay for purification of river (see Section 2.2.6) as economic benefit. The priority project is not the final scheme, so its benefit is considered to be partial. It would be difficult to determine the extent of this partial benefit from the matured benefit, because, the relationship between the people's consciousness and the environment improved by the priority project is quite ambiguous. The objective measurement of this dimension might be impossible. Hence, the following assumptions were made to deduce this ambiguous portion from the total benefit:

(a) Even after implementation of the basic plan, people could feel that the improved environment is far below their expectations, so the benefit to be realized by the basic plan is assumed to be 50% of the benefit expected by the people. Until 2010, the benefit was assumed to increase in proportion to population increase and economic growth.

(b) The benefit by the priority project is assumed to be about 60% of the matured benefit, which approximately corresponds to the ratio of the BOD reduction by the priority project to the BOD reduction by the entire projects in the basic plan.

The plant site includes some crop lands. After starting the construction works, the lands will no longer produce any agricultural products. Thus, this reduced or foregone production is considered as a negative benefit.

(3) Economic Evaluation

The economic evaluation for the priority project was made in terms of the economic internal rate of return (EIRR). Because of the difficulty in quantifying the economic benefits of improved environmental conditions as described earlier, EIRR worked out negative as shown in Table 9.1.1. Thus, the priority project might not be considered viable from economic point of view. However, this kind of project could not be considered in the same manner as other economic development projects. Rather, the project should be considered in terms of fulfilling basic human needs with regard to environmental conditions.

Table 9.1.1 ECONOMIC COST AND BENEFIT STREAM OF PRIORITY PROJECT

(Unit:US$ 1000)

No.	Year	Cost			Benefit			Balance
		Construction	O/M	Total	Positive	Negative	Total	
1	1993	2968	0	2968	0	0	0	-2968
2	1994	6761	0	6761	0	70	-70	-6831
3	1995	6761	0	6761	0	70	-70	-6831
4	1996	0	400	400	591	70	521	121
5	1997	0	400	400	677	70	607	207
6	1998	0	400	400	696	70	626	226
7	1999	0	400	400	715	70	645	245
8	2000	0	400	400	735	70	665	265
9	2001	0	400	400	750	70	680	280
10	2002	0	400	400	766	70	696	296
11	2003	0	400	400	782	70	712	312
12	2004	0	400	400	798	70	728	328
13	2005	0	400	400	815	70	745	345
14	2006	0	400	400	832	70	762	362
15	2007	0	400	400	850	70	780	380
16	2008	0	400	400	868	70	798	398
17	2009	0	400	400	886	70	816	416
18	2010	0	400	400	905	70	835	435
19	2011	0	400	400	905	70	835	435
20	2012	0	400	400	905	70	835	435
21	2013	0	400	400	905	70	835	435
22	2014	0	400	400	905	70	835	435
23	2015	0	400	400	905	70	835	435
24	2016	0	400	400	905	70	835	435
25	2017	0	400	400	905	70	835	435
26	2018	0	400	400	905	70	835	435
27	2019	0	400	400	905	70	835	435
28	2020	0	400	400	905	70	835	435
29	2021	0	400	400	905	70	835	435
30	2022	0	400	400	905	70	835	435
31	2023	0	400	400	905	70	835	435
32	2024	0	400	400	905	70	835	435
33	2025	0	400	400	905	70	835	435

Present Value discounted at 10%

Cost (US$1000) :	16198	NPV (US$1000):	-11314
Benefit(US$1000):	4885	B/C :	0.30
		IRR :	-2.1%

9.2 ENVIRONMENTAL EVALUATION

Environmental impacts of the implementation of the priority project were examined according to the checklist shown in Table 9.2.1.

TABLE 9.2.1 CHECKLIST FOR SOCIAL/ENVIRONMENTAL IMPACT PRIORITY PROJECT

Phase of Activity	During construction	During facility operation		
Activities that may have impact on the environment	Construction activities	Occupation of spaces	Facility operation	
Negative or Positive impact	Negative	Negative	Positive	Negative
Social Environment				
1. Transportation	xx	--	--	--
2. Water use	--	--	xx	--
3. Public health/sanitation	--	--	xx	--
4. Solid waste	-		--	xx
Natural Environment				
1. Stream flow	--	xx	--	--
2. Plants/animals	--	x	--	--
3. Landscape	--	x	--	--
Pollution				
1. Water pollution	--	--	xx	--
2. Noise/vibration	x	--	--	--
3. Odors	--	--	xx	--

Note: xx : Some extent of impact x : Small impact -- : No impact

(1) Impacts During Construction

1) Transportation

Part of the total length of the main sewer interceptor would be constructed under existing roads. Therefore, traffic would be hindered during the construction period. However, inconveniences can be minimized by planning the sequence of construction so as to secure alternative routes.

2) Noise and Vibration

A certain degree of noise and vibration would be unavoidable during the construction of the road sections of the main sewer interceptor. However, the impact can be minimized by selecting low-noise type construction equipment as far as practicable.

(2) Impacts During Facility Operation

1) Water Use

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

2) Public Health and Sanitation

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

It should be noted, however, that since the dry season river flow rate would be drastically reduced below the intake point, the flushing capacity of the river would be also reduced. Therefore, as recommended in Section 5.4.3, control of solid wastes dumping into river is very important.

3) Solid Waste

In several years after the start of operation of the treatment plant, hauling of sewage sludge accumulated in the sedimentation basins at Site 1 would have to begin. An ultimate sludge disposal site must be selected and prepared by that time.

4) Stream Flow

The water intake facility at the Kotauma confluence, if not properly maintained, may become an obstacle to the smooth flow of the river at times of flood. At the treatment plant site and along the interceptor access road, the river section would be reduced from the present. Although these structures have been designed so as not to present undo obstacles, they should be paid regular attention and maintained properly.

5) Plants and Animals

Transformation of the existing farmland into a treatment plant site would make the environment less favorable to wild life. However, the existence of endangered plants or animals has not been reported, and there are other similar habitats for animals in the vicinity. Therefore, negative impacts to wild life is considered to be small. The impacts can be minimized by planting trees in appropriate spaces at the treatment plant site.

6) Landscape

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

7) Water Pollution

By treating wastewater from the Central Zone, the river water quality below the treatment site will be improved considerably . The BOD concentration in the section below the water intake point will be also reduced. However, the SS concentration in this section would be increased unless the control of SS in the Cotahuma and the Orkojahuira is made. Therefore, control of erosion and control of disorderly human activities in the rivers are recommended.

8) Odors

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.

9.3 FINANCIAL EVALUATION

9.3.1 Financial Evaluation

(1) Procurement of Funds

The total capital cost of the proposed priority project is estimated at US$19.66 million. According to the discussion in Section 5.4.7, the total investment ceiling of SAMAPA during the same period, 1993 to 1995, was estimated at US$4.99 million. The project cost is then almost 4 times of the total ceiling. The portion of project costs covered by foreign assistance is assumed to be 80% of the total project costs. The amount procured through foreign loans would then be US$15.73 million and the local portion would be US$3.93 million. In another case, the total capital investment could be covered by foreign grants.

(2) Reimbursement Schedule

In Case 1-A (hard loan), the maximum loan repayment would occur in the third year (1995) from the beginning of construction. The amount would be US$3.32 million, broken down into US$1.73 million for foreign portion and US$ 1.59 million for local portion. This amount exceeds the annual investment budget of SAMAPA which is estimated at US$1.8 million in the same year. Thus, the total payment would be about 1.8 times of the annual investment budget of SAMAPA.

In Case 1-B (soft loan), the maximum loan repayment also would occur in the third year. The amount would be US$2.06 million, broken down into US$0.47 million for foreign portion and US$1.59 million for local portion. This amount also exceeds the annual investment budget of SAMAPA. However, the total payment would be only 14% more than the annual investment budget of SAMAPA. If SAMAPA gets a low interest loan, it might be able to implement the proposed project with more active assistance.

(3) Sewage Tariff

In Case 1-A, the total annual cost, that is, the annualized construction cost plus O/M cost after completion of the project, was estimated at US$2.55 million. Then, the average unit cost could be estimated at US$0.066/$m^3$; US$2.55 million divided by 38.5 million m^3 (annual sewage volume in 1995 from the project area).

The present sewage charge is about US$0.073/$m^3$. Accordingly, the unit charge would have to increase to US$0.139/$m^3$, almost 2 times of the present one. This case approximately corresponds to Case 1-A above.

In Case 1-B, the total annual cost became to US$1.46 million. This corresponds to US$0.038/$m^3$ of new sewage service portion. In the same manner, the total charge including the present one would be US$0.111/$m^3$.

If the costs of the project is granted, only O&M cost could be recovered by the service charge. Since O&M cost was estimated at US$0.46 million/annum, the average unit cost could be estimated at US$0.012/$m^3$. In this case, the total sewage service rate is US$0.085/$m^3$.

9.3.2 Household Budget for Sewage Charge

In Case 1-A, the flat sewage service rate was estimated at US$0.139/$m^3$. Since the annual discharge of sewage by a household was assumed to be 165 m^3, the total annual charge of sewage would amount to US$22.9. This amount corresponds to about 3.7 times of the expected household expenditure of US$6.2 projected for the year 1995.

In Case 1-B, the flat sewage service rate was estimated at US$0.111/$m^3$. Then, the total household annual charge for sewage service would amount to US$18.3. This amount corresponds to about 3.0 times of the expected household expenditure.

In Case 2, the annual charge was estimated at US$0.085/$m^3$. Then the annual charge was aggregated to US$14.0, corresponding to 2.3 times of the household expenditure.

As discussed in Section 5.4.7, the above household expenditure of US$6.2 may be too small for the best estimate of the actual rate of return. Nevertheless, this charge accounts for only 27% of the estimated charge (US$22.9) of Case 1-A, 34% of the charge (US$18.3) of Case 1-B and 44% even in Case 2. Thus, this amount would become a burden for the people in the project area.

9.3.3 Financial Status

To examine the financial status after the implementation of the priority project, the financial cash stream is made for the above fund cases. The financial conditions were assumed as the same as mentioned in Section 5.4.7 (4).

Table 9.3.11 shows the financial stream of Case 2. In this Case, the cash balance was quite simple. The total balance for 30 years was US$33.51 million, which could cover the capital costs of US$19.66 million. This means that the undertaker would not have to procure any grant and loan for replacement of the first phase facilities after the economic life of 30 years.

9.3.4 Conclusions

The capital investment for the priority project might be a burden on SAMAPA's financial management, in financial procurement Case 1. In the Case 1-A in particular, the annual payment including reimbursement and interest exceeds the limits of SAMAPA's annual investment capability. Even in Case 1-B, the reimbursement might somewhat exceed SAMAPA's financial capacities. Thus, SAMAPA should pursue foreign grant assistance.

From the point of view of people's affordability, the sewerage service charge might be a burden on people's budgets, even if the authorities concerned undertake the financial procurement of Case 2. Thus, to implement the sewerage system successfully, it is very important for the authorities to foster understanding of the beneficiaries and rate payers as well as to pursue low cost of fund.

Table 9.3.1 STREAM OF INCOME AND EXPENDITURE: CASE 2

(Unit: US$ Million)

No.	Year	Capital Balance			Revenue Balance		
		Income	Expenditure	Balance	Income	Expenditure	Balance
		Foreign Grant	Const-ruction Cost		Sewerage Treatment Service	Maintenance & Operation Expenses	
1	1993	3.78	3.78	0.00			0.00
2	1994	7.94	7.94	0.00			0.00
3	1995	7.94	7.94	0.00			0.00
4	1996			0.00	1.45	0.46	0.99
5	1997			0.00	1.46	0.46	1.00
6	1998			0.00	1.48	0.46	1.01
7	1999			0.00	1.49	0.46	1.02
8	2000			0.00	1.50	0.46	1.03
9	2001			0.00	1.51	0.46	1.05
10	2002			0.00	1.52	0.46	1.06
11	2003			0.00	1.54	0.46	1.07
12	2004			0.00	1.55	0.46	1.08
13	2005			0.00	1.56	0.46	1.10
14	2006			0.00	1.57	0.46	1.11
15	2007			0.00	1.59	0.46	1.12
16	2008			0.00	1.60	0.46	1.14
17	2009			0.00	1.61	0.46	1.15
18	2010			0.00	1.63	0.46	1.16
19	2011			0.00	1.63	0.46	1.16
20	2012			0.00	1.63	0.46	1.16
21	2013			0.00	1.63	0.46	1.16
22	2014			0.00	1.63	0.46	1.16
23	2015			0.00	1.63	0.46	1.16
24	2016			0.00	1.63	0.46	1.16
25	2017			0.00	1.63	0.46	1.16
26	2018			0.00	1.63	0.46	1.16
27	2019			0.00	1.63	0.46	1.16
28	2020			0.00	1.63	0.46	1.16
29	2021			0.00	1.63	0.46	1.16
30	2022			0.00	1.63	0.46	1.16
31	2023			0.00	1.63	0.46	1.16
32	2024			0.00	1.63	0.46	1.16
33	2025			0.00	1.63	0.46	1.16
	Total	19.66	19.66	0.00	47.45	13.94	33.51

Note: *1 (Capital balance)+(Revenue balance)+(Depreciation)

CHAPTER 10

RECOMMENDATIONS - PRIORITY PROJECT

1. In either case that the priority project would be implemented through foreign loans or grants, the present sewerage service charge would have to be increased considerably only to cover the costs for operations and maintenance of the project facilities. The increased charge might be a burden on the citizens. Thus, 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 pursue low-cost funds.

2. It is recommended that the industrial wastewater discharge regulation be enforced as soon as possible especially for large wastewater dischargers, and that a new regulation be established to obligate newly developing communities to install their own wastewater treatment facilities.

3. Implementation of the priority project would achieve the target BOD concentration which is not to exceed 50 mg/l at the Lipari bridge and downstream. This quality is suitable for irrigating the downstream farmlands to produce ordinary crops. However, such quality is still not suitable for the production of freshly eaten vegetables which requires the BOD concentration not to exceed 5 mg/l. Even implementation of the entire projects of the Basic Plan could not achieve such a water quality goal. Therefore, if production of freshly eaten vegetables, that were common in the areas before the cholera incident, are intended in the downstream farmlands, it is necessary to develop other water sources. It is recommended to conduct a study on this subject including groundwater development for irrigation.

4. It has been frequently mentioned in La Paz that construction of a dam in the upper Choqueyapu basin may be a practical measure to mitigate water pollution of the Choqueyapu river by discharging dilution water from the dam. Having no reliable information to support this idea, the JICA Study Team examined its possibility and effect on the water quality based on their best assumptions, and concluded that it was not an adequate measure. However, it may be worthwhile that the appropriate authorities conduct a preliminary study on this possibility.