APPENDIX 9

AVAILABLE ADDITIONAL SEWAGE

APPENDIX 9 AVAILABLE ADDITIONAL SEWAGE

1. Colectors Vitarte and No.21

Additional sewage through a new interceptor mentioned in Subsection 5-3-2 is obtained from the Colectors Vitarte and No.21 which is located upstream of Colector Surco (refer to FIGURE A9-1). Available sewage quantity is estimated as follows:

Domestic sewage

District	COVERED POPULATION		
	D/S.H	D/S.L	ID
ATE (80%)	37,760	57,150	7,140
EL AGUSTINO (20%)	3,630	21,510	2,790
TOTAL	41,390	78,660	9,930
UNIT Q(lpcd)	210	180	110
Q'ty (m^3/sec)	0.101	0.164	0.013

Total Domestic Sewage Quantity : 0.278 m^3/sec

Industrial Wastewater

30 % of Colector Surco 0.264 x 0.3 = 0.079 m^3/sec

Other Wastewater

Same ratio as total of domestic and industrial.
Q'ty of Vitarte & 21 (D+I) / Q'ty of Surco (D+I)
= (0.278 + 0.079) / (1.932 + 0.264)
= 0.163
then, 0.172 x 0.163 = 0.028^3/sec

therefore, Total Available Sewage Quantity is:
0.278 + 0.079 + 0.028 = 0.385 m^3/sec

2. Emisor General Villa El Salvador

The sewage flow from Villa El Salvador is estimated as follows:

D/S.H	8,380 x 210 lpcd =	0.020 m^3/sec
D/S.L	335,200 x 180 lpcd =	0.698 m^3/sec
ID	75,420 x 110 lpcd =	0.096 m^3/sec
	TOTAL	0.814 m^3/sec

0.814 x 0.5 = 0.407 m^3/sec

Therefore, around 0.4 m^3/sec is estimated to be available for the Phase I project.

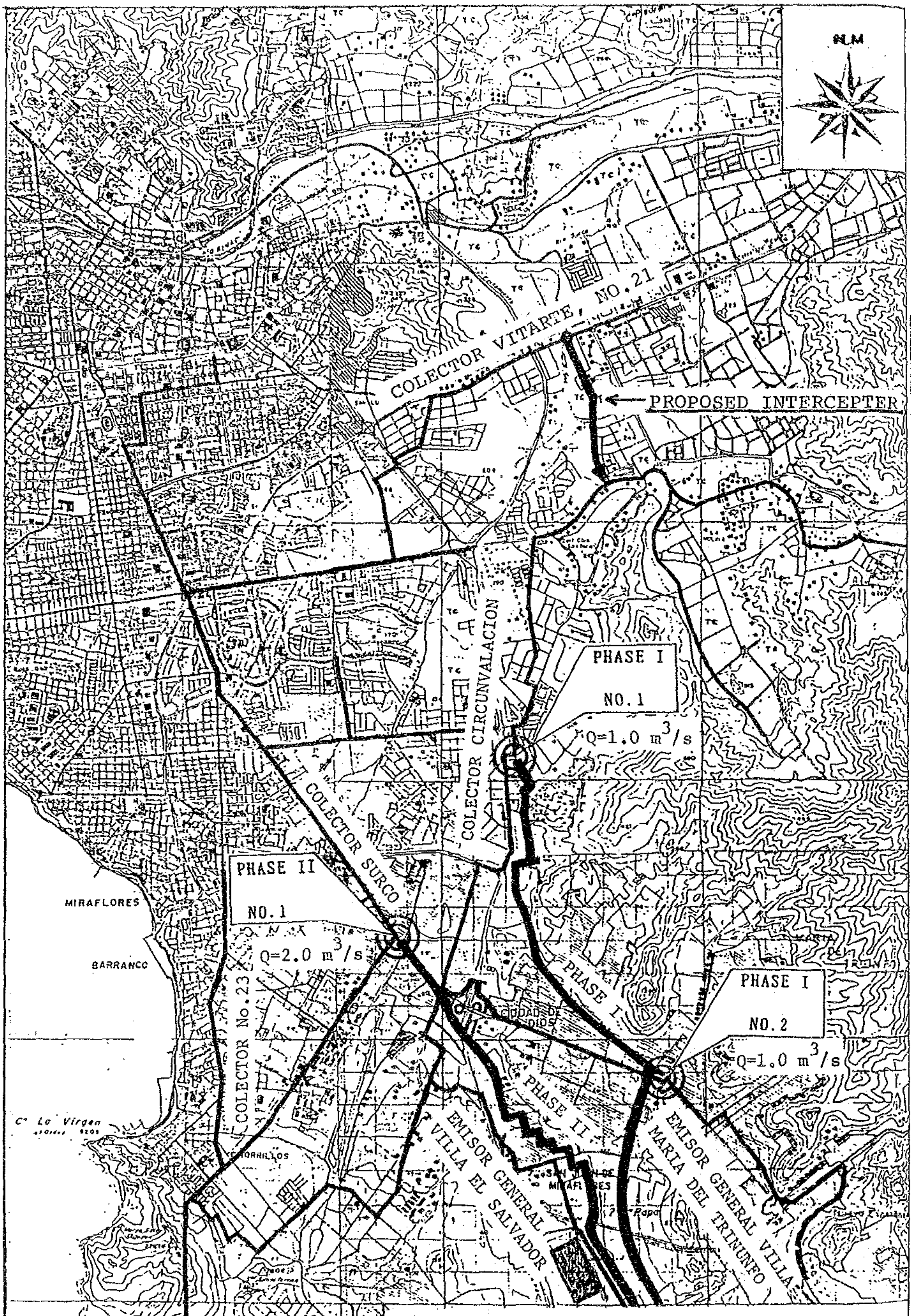


FIGURE A9-1 Location of Proposed Interceptor

APPENDIX 10

WATER QUALITY STANDARDS AND GUIDELINES

APPENDIX 10 WATER QUALITY STANDARDS AND GUIDELINES

A10.1 General

Water pollution control standards in Peru are set according to the classification of water bodies by their uses. The control of the quality of industrial wastewater discharged into sewers is also included in these standards.

A10.2 Environmental Water Quality Standards

The Ley General de Aguas (General Law of Water, Decreto Ley No. 17752) classified the various water bodies by their general uses. The law was amended on February 11, 1983 through Decreto Supremo No. 007-83-SA which contains the following provisions.

________.__________.__________.__________.__________.____

Article 81.

The effects of application of the present regulation, the quality of Peru's water bodies in general, be they inland or marine are classified according to their uses in the following manner:

I. Water for domestic supply, simply disinfected

II. Water for domestic supply, treated equivalent to combined processes of mixture and coagulation, sedimentation, filtration, and chlorination, approved by the Ministry of Health.

III. Water for irrigation of vegetables to be eaten raw and for watering animals

IV. Water for recreational area of primary contact (Baths and the like).

V. Water for fishing zones for bivalves.

VI. Water for zones to preserve aquatic fauna and recreational or commercial fishing.

I. BACTERIOLOGICAL LIMITS

(Maximum value of 80% of 5 or more monthly samples)

Values in MPN/100ml.

	USES					
	I	II	III	IV	V	VI
Total Coliforms	8.8	20,000	5,000	5,000	1,000	20,000
Fecal Coliforms	0	4,000	1,000	1,000	200	4,000

II. LIMITS OF BIOCHEMICAL OXYGEN DEMAND (BOD at 5 days, 20°C) AND OF DISSOLVED OXYGEN (DO)

Values in mg/l.

	USES					
	I	II	III	IV	V	VI
BOD	5	5	15	10	10	10
DO	3	3	3	3	5	4

III. LIMITS OF THE PHYSICAL-CHEMICAL PARAMETERS WHICH INCLUDE POTENTIALLY DANGEROUS SUBSTANCES

Values in mg/l.

	USES					
Parameter	I	II	III	IV	V	VI
Aluminum	-	-	-	1(b)	1(b)	-
Arsenic	0.1	0.1	0.2	1	0.01	0.05
Barium	0.1(b)	0.1(b)	-	0.5	0.5(b)	-
Cadmium	0.01	0.01	0.05	-	0.0002	0.004
Cyanide (CN)	0.2	0.2	(c)	-	0.005	0.005
Cobalt	-	-	0.20(d)	0.2	0.2(b)	-
Copper	1	1	0.5	3	0.01	LC50x0.1
Color (unit)(b)	0	10	20	30	30	-
	5	5(d)				
Hexav. Chromium	0.05	0.050	1	5	0.050	0.050
Ethylene Esters	0.0003	0.0003	0.0003	-	0.0003	0.0003
Phenols	0.0005	0.001	(c)	-	0.001	0.1
Iron	0.03(b)	0.03(b)	0.001(b)	-	-	-
Fluoride		1.5(b)	1.5(b)	2.0(b)	-	-
Lithium	-	-	5(d)	5.0	5.0(b)	-
Magnesium	-	-	150(b)	-	-	-
	-	-	-(d)	-	-	-
Manganese	0.010(b)	0.010(b)	0.050	-	-	-
	-	-	-(d)	-	-	-
Mercury	0.002	0.002	0.01	-	0.0001	0.0002
Nitrates	0.01(a)	0.01(a)	0.1(a)	-	-	-
	-	-	0.01(d)	-	-	-
Nickel	0.002	0.002	(c)	0.5	0.002	LC50x0.02
pH (b)	5-9	5-9	5-9	5-9	5-9	5-9
	6-9(d)	6-9(d)	6-9(d)	6-8.5(d)	6-8.5(d)	-
Silver	0.05(b)	0.05(b)	0.05(b)	-	-	-
	-	-(d)	-	-	-	-
Lead	0.05	0.05	0.1	-	0.01	0.03
P.C.B.	0.001	0.001	(c)	-	0.002	0.002
Selenium	0.01	0.01	0.05	0.05	0.005	0.01
					0.05(d)	
Floating Solids	0.00(b)	0.00(b)	0.00(b)	invisible	moderate	-
Sulfates	-	-	400(b)	-	-	-
			-(d)			
Sulfure	0.001	0.002	(c)	-	0.002	0.002
Zinc	5	5	25	-	0.02	LC50x0.02

OBSERVATIONS:

(a) There seems to be an error in the unit applied in the amendment to the law. Value should be multiplied by 1000.

(b) Information obtained from the Direccion Tecnica de Salud. Ambiental (Technical Department of Environmental Health) of the Ministry of Health.

(c) If presence of paramera is suspected, apply the values in column V.

(d) If the dumping is into sea water. The values come from (b).

Pesticides - In each use, the limit will be the water quality criteria established by the Environmental Protection Agency of the United States of America.

IV. LIMITS OF POTENTIALLY HARMFUL SUBSTANCES OR PARAMETERS

	USES		
Parameter	I and II	III	IV
- Material extractable in Hexane	1.5	0.5	0.2
- Active substances of blue Methylene	0.0	1.0	0.5
- Extraction of active Carbon column by alcohol	1.5	5.0	5.0
- Extraction of active Carbon column by Chloroform	0.3	1.0	1.0

A10.3 Effluent Standard

On November 29, 1960 the Industrial Discharge Regulation was approved through D.S.28/60 which set the permissible limits for domestic sewage discharged to a public sewer system and basically states:

All industrial wastewater which enters the public sewer network must comply without exception with the following standards:

a) Temperature must not exceed 35°C.

b) Vapors must be condensed to enter the drainage.

c) Liquid grease that enter the sewer must have a concentration less than 0.1 g/l. in weight.

d) Flammable substances that enter the drain must have an ignition point higher than 90°C and a concentration less than 1 g/l.

e) The pH must be between 5 and 8.5. Industries that evacuate mineral acids or strongly alkaline substances must have tanks with sufficient capacity where they are neutralized.

f) The BOD (Biological Oxygen Demand) may not exceed 1,000 ppm.

g) Sedimentable solids must have a concentration higher than 8.5 ml/l/hour.

APPENDIX 11

COMPARISON AND EVALUATION OF THE PROPOSED SITE

APPENDIX 11 COMPARISON AND EVALUATION OF THE PROPOSED SITE

The following 6 sites were judged as possible location of treatment plant for this Project, based on a field survey and in consideration of the various plans for land use and the Project's alternative sewer pipe routes.

a) Existing upper battery ponds in the San Juan Stabilization Pond (falls under the jurisdiction of the Ministerio de Vivienda y Construccion, Ecology Department.)

b) Southern Zone of San Juan Stabilization Pond (falls under the jurisdiction of the Ministerio de Vivienda y Construccion, Ecology Department)

c) Villa El Salvador - Parque Zonal No. 26 (falls under the jurisdiction of the Ministerio de Vivienda y Construccion, Ecology Department)

d) Villa Rica (belongs to an agricultural production cooperative)

e & f) Pampas de San Bartolo (falls under the jurisdiction of the Ministerio de Vivienda y Construccion)

g) Cello de Chillon at the south of the outfall of the Colector Surco (belongs to SEDAPAL)

Topographical plans of these prospective treatment plant sites are shown in FIGUREs A11-1 through A11-5. TABLEs A11-1 and A11-2 gives the descriptions, possibilities for adoption, and relative suitability of each of the sites.

As one of the purposes of this Project is to utilize sewage for irrigation of cultivated fields in the future, proposal (g) was not taken into account in the study.

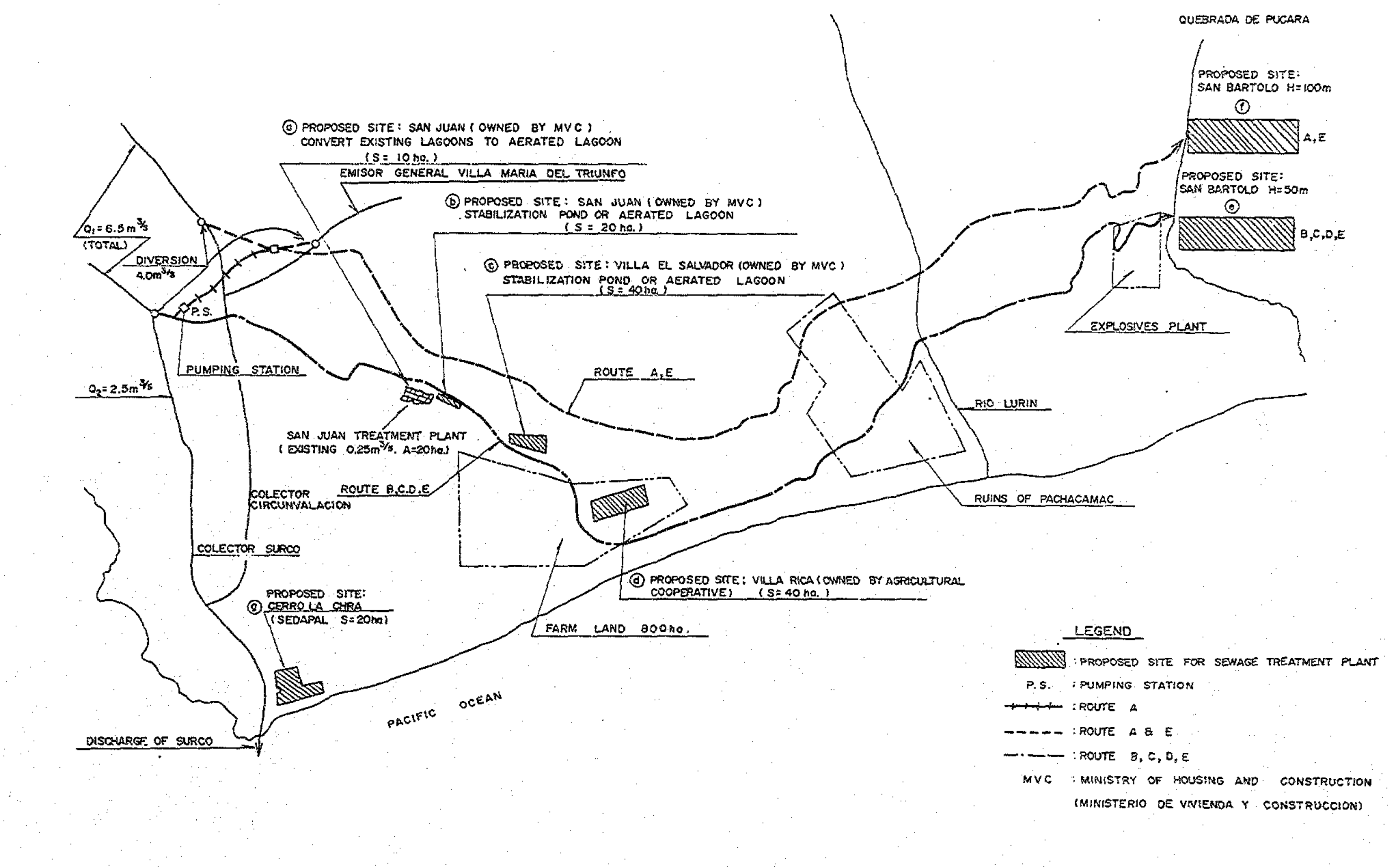


FIGURE A11-1 LOCATION OF PROPOSED SITE FOR SEWAGE TREATMENT PLANT.

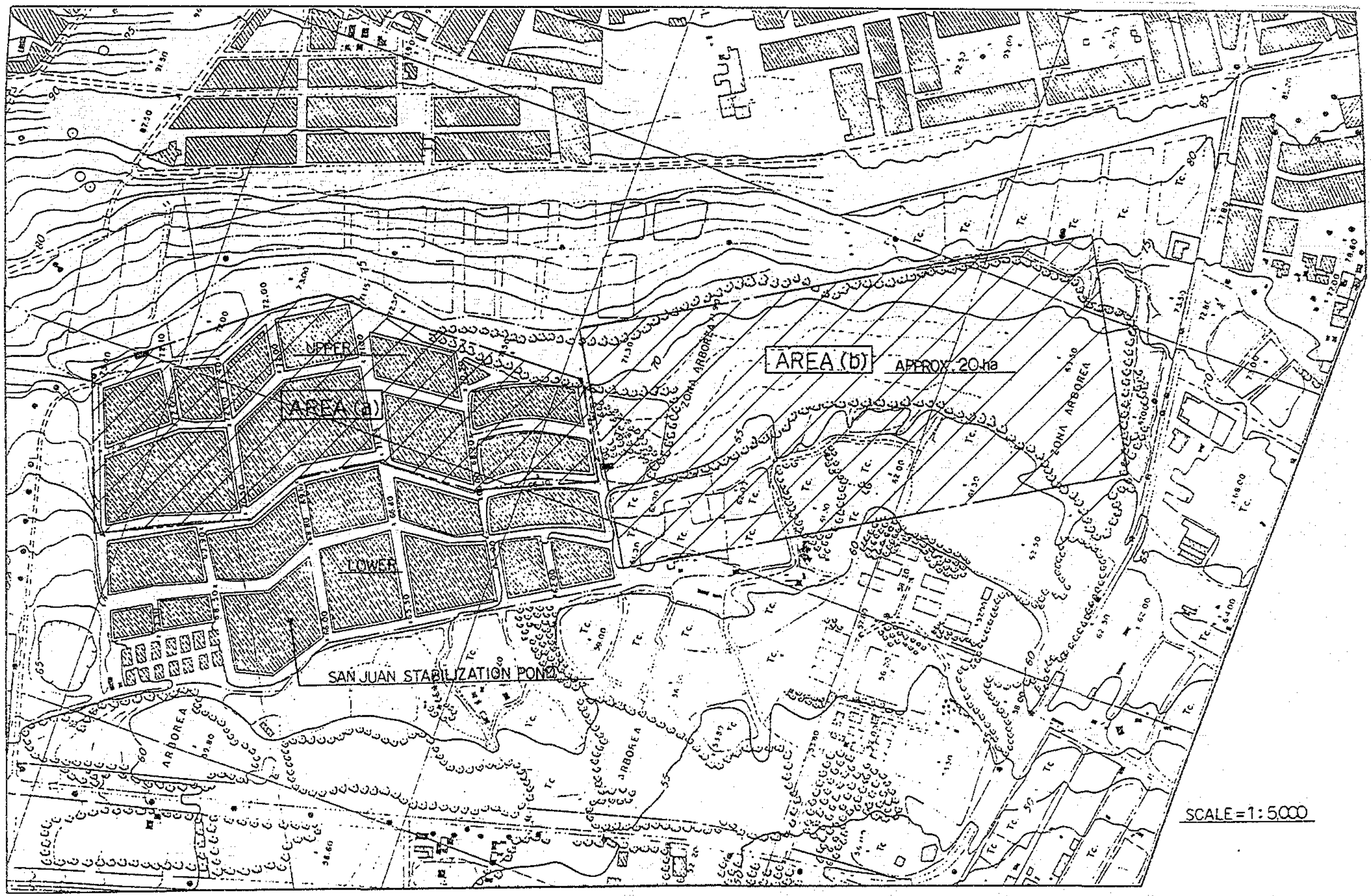


FIGURE A11-2: PROPOSED AREA (a) AND (b) FOR SEWAGE TREATMENTPLANT, SAN JUAN STABILIZATION POND.

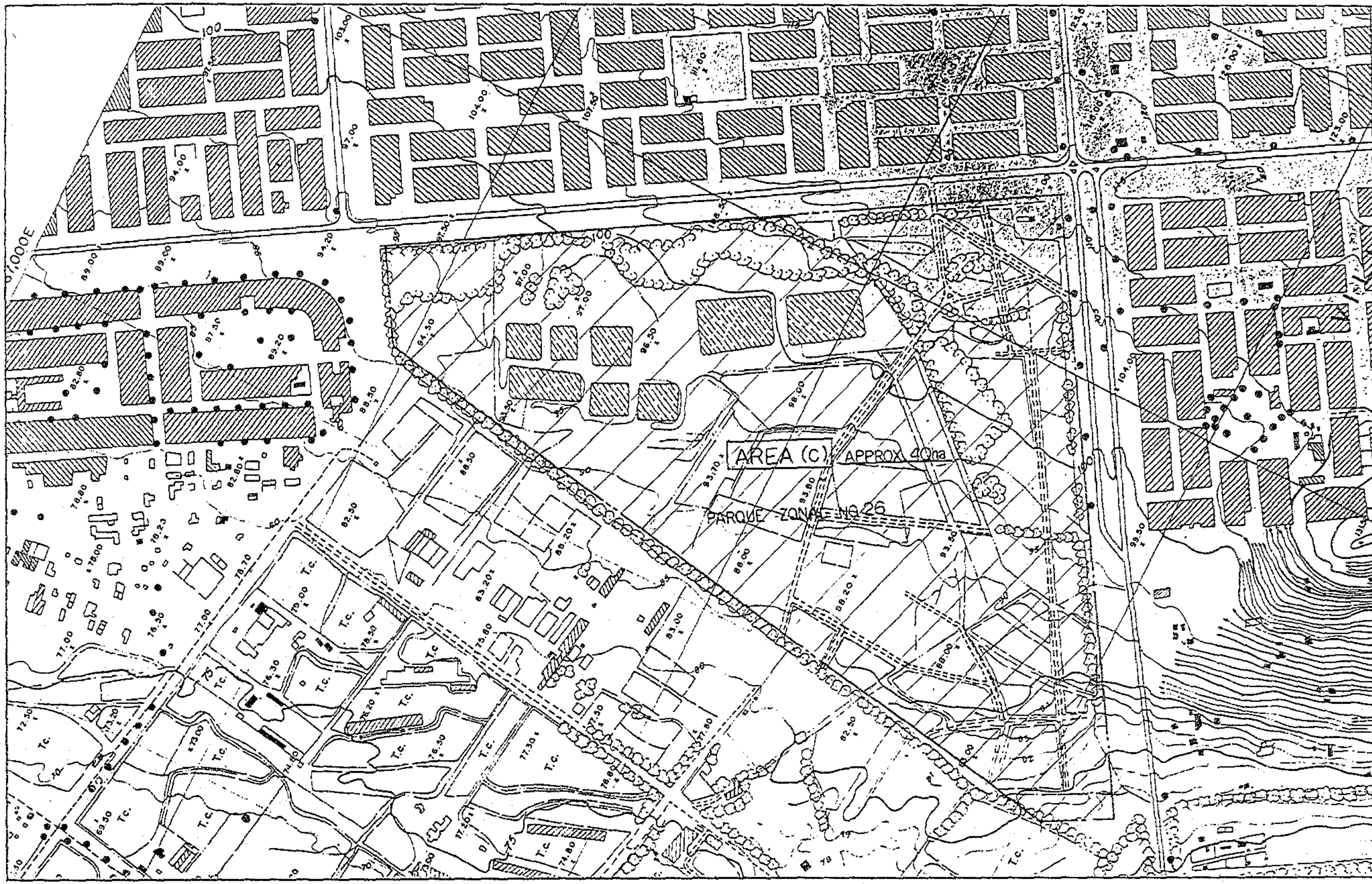


FIGURE A11-3: PROPOSED AREA (C) FOR SEWAGE TREATMENT PLANT, PARQUE ZONA Nº 26, VILLA EL SALVADOR.

SCALE = 1:5000

FIGURE A11-4 : PROPOSED AREA (d) FOR SEWAGE TREATMENT PLANT, VILLA RICA, VILLA EL SALVADOR.

SCALE = 1:5000

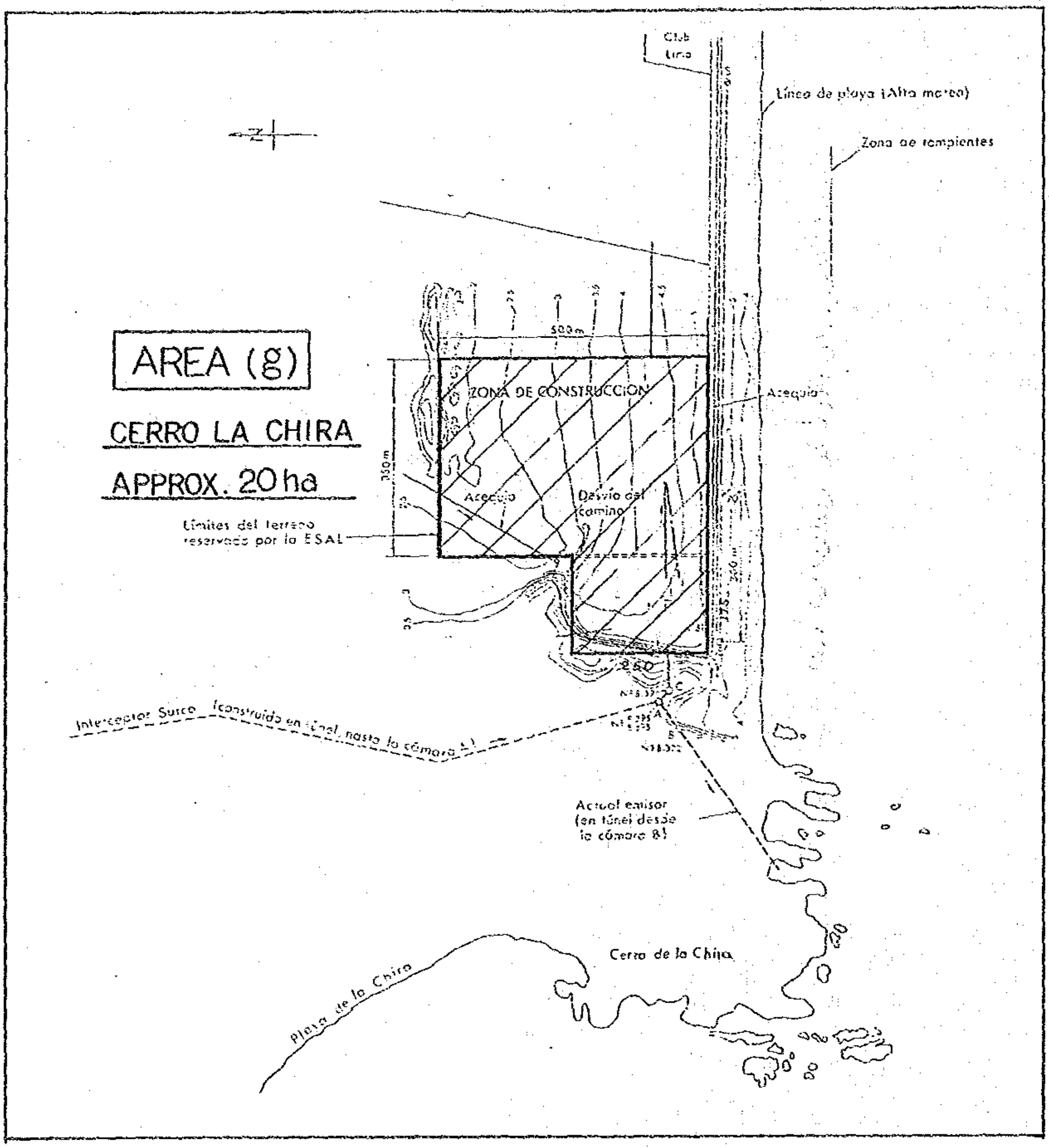
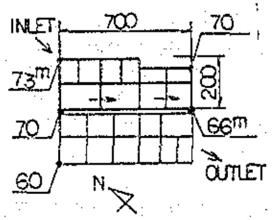
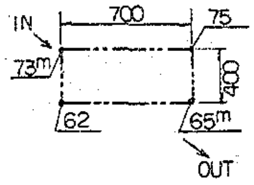
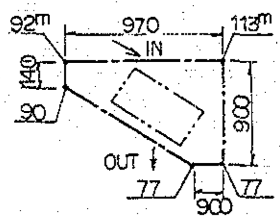
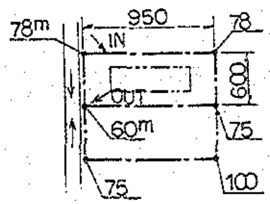


FIGURE A11-5: PROPOSED AREA (g) FOR SEWAGE TREATMENT PLANT, CERRO LA CHIRA.

TABLE A11-1 Outline of the Proposed Sites

ITEM \ PROPOSED SITE	(a) EXISTING SAN JUAN STP	(b) SAN JUAN	(c) PARQUE ZONAL NO.26	(d) VILLA RICA	(e & f) SAN BARTOLO
1 Proposed site for construction (area, altitude, inlet and outlet direction)					Specific plant site is not decided, however, it is possible to construct anywhere.
2 Outline of the site	In order to increase the capacity, re-excavate to provide 1.5 m to 3.0m of water depth and equip aerator in the existing up per battery (10ha).	Construct in the southern wooded area of the San Juan STP. Some trees need to be moved.	Construct in Parque, similar to (b), removal of trees and supplying treated water to the concerned farmers is required.	Construct in the agricultural co-operative's area. Facility must be constructed at least 100m away from house on the eastern area of site as a measure against bad odor.	8-plants (stabilization pond, approx.55ha and 0.5 m³/s /plant) be constructed in the San Bartolo irrigation area.
Capacity – In case of stabilization pond – Effective water surface area	————	17.3 ha	17.0 ha	17.3 ha	
Capacity – In case of stabilization pond – Possible capacity 1/	————	0.19 m^3/s	0.19 m^3/s	0.19 m^3/s	
Capacity – In case of aerated lagoon – Effective water surface rea	10.3 ha	14.6 ha	11.2 ha	————	
Capacity – In case of aerated lagoon – Possible capacity 1/	0.63 m^3/s	1.0 m^3/s	0.83 m^3/s	————	

1/: *Possible capacity of each proposed site is shown in TABLEs A13-3 and A13-4*

TABLE A11-2 Comparison and Evaluation of the Proposed Site

	SELECTION FACTOR \ PROPOSED SITE	(a) EXISTING SAN JUAN STP	(b) SAN JUAN	(c) PARQUE ZONAL NO.26	(d) VILLA RICA	(e & f) SAN BARTOLO
1	Facilities of collecting sewage from adjacent drainage area	A It is possible to connect using siphon on the way from intake points to San Bartolo.	B Same as (a).	C Less quantity near area, it is necessary to convey it from far Colector Surco.	C Due to high altitude, it is required to take from Colector Surco at high elevation.	D It is possible to convey to the high elevation level, but siphon is much long.
2	Proximity to drainage area	A Very good. Distance is minimal (6km).	B Located next to (a). It is the second nearest.	C Located at high land. A long line is necessary.	D Must take sewage from far distance.	D Very far (30km).
3	Benefits to the discharge area	A In the vicinity there are agricultural area, where raw sewage is being utilized due to lack of water at present.	A Most adequate. Same as (a).	A Located at high land. Wide agricultural area in lower lands.	C Very far from the planned cultivated fields. No benefit.	A The plant is located within the planned cultivated fields.
4	Facility of discharge during low demand season	C There is public bathing beach nearby. Requirement of authorization from the Ministry of Health.	C Same as (a).	C Same as (a).	B Same as (a).	B Same as (a).
5	Availability of sufficient land and facility of right-of-way acquisite	D This plant is a center for land recovery studies. Not authorized. (Ministerio de Vivienda)	B Feasible if trees are moved. (Ministerio de Vivienda)	B Require moving at existing trees, ponds and school (Ministerio de Vivienda)	D Should acquire the land from the agricultural co-operative. Costly.	B Desert. No problem with the land.
6	Acceptability to neighboring houses/establishments	B Adaquate machanization allows forced aeration. Bad odors are reduced.	B There are houses at the west. It can be feasible if trees are planted to that area.	B The system must emit no odor. Moving trees and school is required.	C In the vicinity, ponds are abandoned due to bad odors.	B The neighbors are ranches. There is no problem.
7	Favorability of hydrogeological conditions (soil permeability and groundwater)	A There is a plenty of geological information.	B Adequate for construction.	B There are 4 stabilization ponds at present.	B Impermeable cultivated fields. Feasible.	C Sand dune. The soil condition is similar to San Juan in surface layer. But in deeper layer, high permeability.

key A : Recommendable B : Adequate C : Slightly adequate D : Not recommendable

TABLE A11-2 Comparison and Evaluation of the Proposed Site (Cont'd)

	SELECTION FACTOR / PROPOSED SITE	(a) EXISTING SAN JUAN STP	(b) SAN JUAN	(c) PARQUE ZONAL NO.26	(d) VILLA RICA	(e & f) SAN BARTOLO
8	Susceptibility to floods, high tide or landslides.	B Located on level ground, far from the sea. No rain. Not affected.	B Same as (a).	B Same as (a).	C There are dunes in back. Sand accumulation is a possible problem.	C Precautions against the sand accumulation are required.
9	Adequacy for construction of the pond.	A The ground is slightly inclined in the direction of sewage flow. Construction is economical.	C Construction is more costly as the ground slopes is in the opposite direction of the sewage flow.	C The ground is sloped in the opposite direction and very undulating. Cannot be utilized in an optimum manner.	C Located in a valley. As the outlet piping comes from at the lower end, it is necessaty to go around the road at elevation 75m.	B The land is ample. Adequate area can be selected.
	Remarks			In this site, stabilization ponds are under construction by the Ministry of Agriculture based on the sewage reuse program. At present 4 ponds are in operation in the site. If this site is used for the Project, adjustment with that program shall be done.		

key A : Recommendable B : Adequate C : Slightly adequate D : Not recommendable

TABLE A6-3 Possible Treatment Capacity in Proposed Area (b), San Juan Experimental Area

Proposed Area	Case- I : Waste Stabilization Pond	Case- II : Aerated Lagoon
(b) San Juan	-Primaty Facultative Pond Dimension of Pond: W 100 m x L 48 m x D 1.5 m x 22 basins Total Water Surface Area: = 100 x 48 x 22 = 105,600 m^2 Possible Treatment Capacity: Q1 = 105,600/565,445 x 1.0 m^3/s = 0.19 m^3 -Secondary Facultative Pond Dimension of Pond: W 100 m x L 48 m x D 1.5 m x 14 basins Total Water Surface Area: = 100 x 48 x 14 = 67,200 m^2 Possible Treatment Capacity: Q2 = 67,200/324,000 x 1.0 m^3/s = 0.21 m^3/s Q1 < Q2, therefore, the system is able to treat 0.19 m^3/s of flow.	-Complete Mixing Aerated Lagoon Dimension: W 105 m x L 46 m x D 3.0 m x 12 basins Total Water Surface Area: = 105 x 46 x 12 = 57,960 m^2 > 57,600 m^2 (=1.0 m^3/s) Total Volume: = 57,960 x 3.0 = 173,880 m^3 > 172,800 m^3 -Partial Mixing Aerated Lagoon Dimension: W 105 m x L 31 m x D 3.0 m x 3 cells x 6 series Total Water Surface Area: = 105 m x 31 m x 3 x 6 = 58,590 > 19,296 x 3 = 57,880 m^2 Total Volume: = 58,590 x 3.0 = 176,880 m^3 > 57,888 x 3 = 173,664 m^3 -Sedimentation Tank Dimension: W 105 m x L 46 m x D 3.0 m x 6 basins Total Volume: = 105 x 46 x 3.0 x 6 = 86,940 m^3 > 86,400 m^3 Therefore, the system is able to treat 1.0 m^3/s of flow.

TABLE A6-4 Possible Treatment Capacity in Proposed Area (c), Parque Zonal No. 26, Villa El Salvador

Proposed Area	Case- I : Waste Stabilization Pond	Case- II : Aerated Lagoon
(c)Parque Zonal No. 26	-Primaty Facultative Pond Dimension of Pond: W 109 m x L 54 m x D 1.5 m x 18 basins Total Water Surface Area: = 109 x 54 x 18 = 105,948 m^2 Possible Sewage Treatment Capacity: Q1 = 105,948/565,445 x 1.0 m^3/s = 0.19 m^3/s -Secondary Facultative Pond Dimension: W 109 m x L 54 m x D 1.5 m x 12 basins Total Water Surface Area: = 109 x 54 x 12 = 70,632 m^2 Possible Sewage Treatment Capacity: Q2 = 70,632/324,000 x 1.0 m^3/s = 0.22 m^3/s Q1 < Q2, therefore, the system is able to treat 0.19 m^3/s of flow.	-Complete Mixing Aerated Lagoon Dimension: W 105 m x L 46 m x D 3.0 m x 10 basins Total Water Surface Area: = 105 x 46 x 10 = 48,300 m^2 Total Volume: = 48,300 m^2 x 3.0 m = 144,900 m^3 Possible Sewage Treatment Capacity: Q1 = 144,900/172,800 x 1.0 m^3/s = 0.84 m^3/s -Facultative Aerated Lagoon Dimension: W 71 m x L 46 m x D 3.0 m x 3 cells x 5 series Total Water Surface Area: = 71 m x 46 m x 3.0 x 5 = 48,990 m^2 Total Volume: = 48,990 x 3.0 = 146,970 m^3 Possible Sewage Treatment Capacity: Q2 = 146,970/173,664 x 1.0 m^3/s = 0.84 m^3/s -Sedimentation Pond Dimension: W 105 m x L 46 m x D 3.0 m x 5 basins Total Volume: = 105 x 46 x 3.0 x 5 = 72,450 m^3 Possible Sewage Treatment Capacity: Q3 = 72,450/86,400 x 1.0 m^3/s = 0.84 m^3/s Therefore, possible capacity is 0.84 m^3/s .

APPENDIX 12

COMPARISON BETWEEN OPEN CHANNEL AND INVERTED SIPHON

APPENDIX 12 COMPARISON BETWEEN OPEN CHANNEL AND INVERTED SIPHON

The transmission line that will cross the Lurin river can be planned to pass through the following two routes:

1) A straight line with an inverted siphon structure.

2) A circuitous line along the mountain foot following the Elesvatio 100 m contour with an open channel structure.

Since all of the alternative plans involve transmission lines traversing the Lurin river, a comparison of both routes was executed on the two alternative lines of plan E_1 (refer to FIGUREs A12-1 and A12-2).

The examination was conducted on the aspects of workability, influence on environment, operation and maintenance, and construction cost (refer to TABLE A12-1).

As a result of comparison, routes with inverted siphon structure were judged as superior.

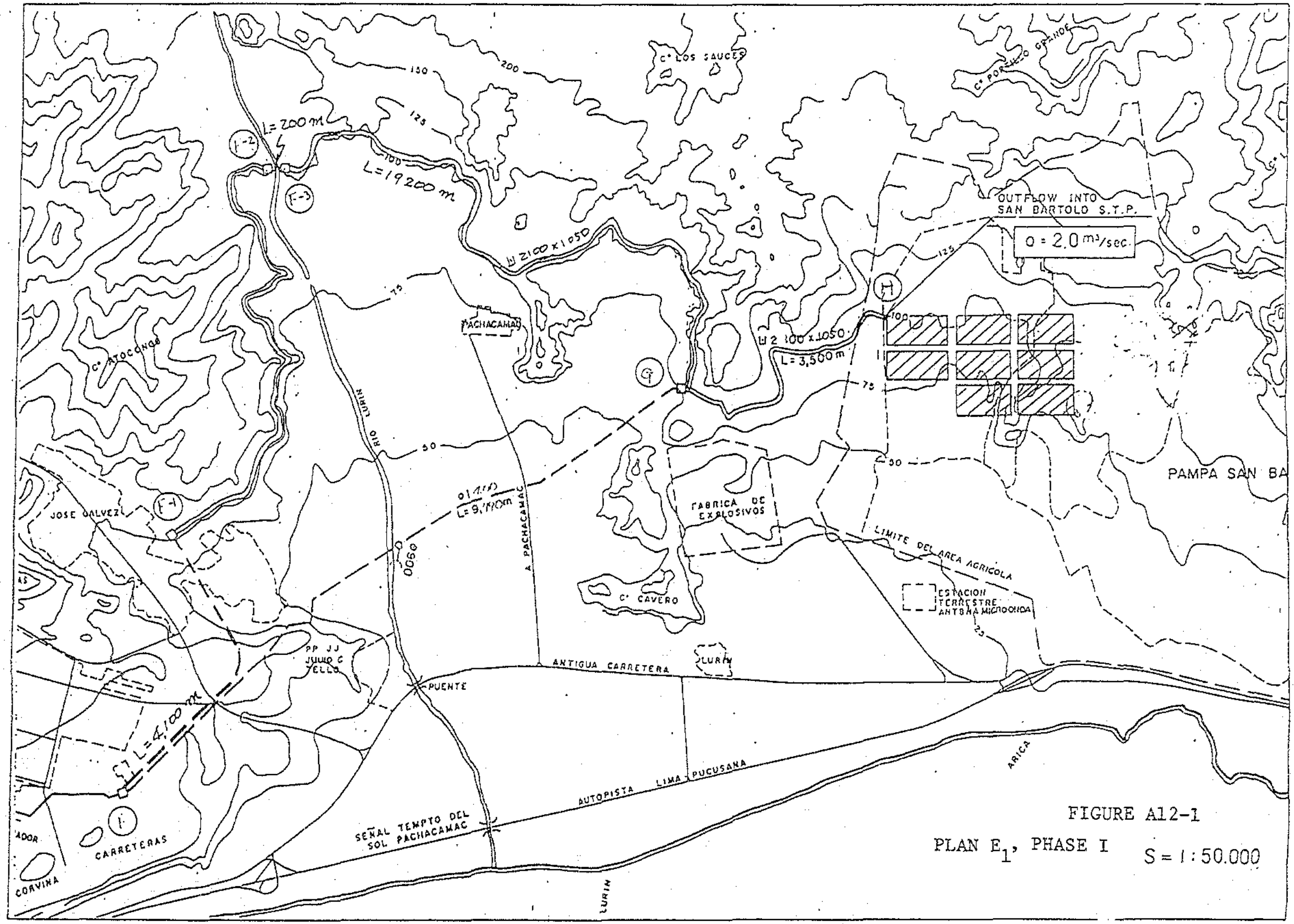


FIGURE A12-1

PLAN E_1, PHASE I   S = 1:50.000

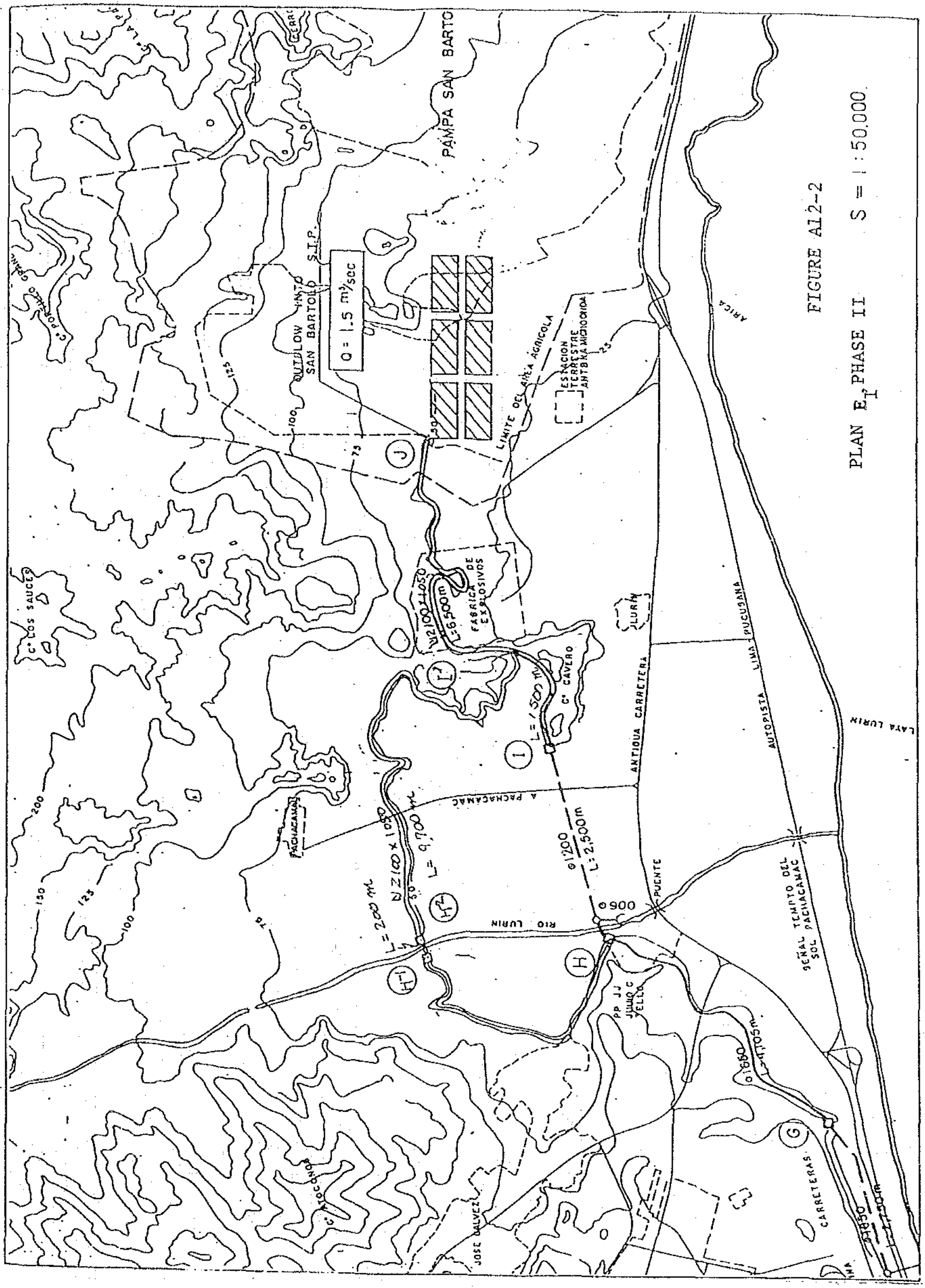


FIGURE A12-2

PLAN E_I PHASE II S = 1:50,000

TABLE A12-1 COMPARISON BETWEEN OPEN CHANNEL AND INVERTED SIPHON

	Conduit	Length	Workability		Influence on Environment		Operation & Maintenance		Construction Cost		Evaluation
Plan E_1 - Phase I	Open Channel RC 2100 × 1050 mm	F − G ℓ = 23,500 m	Advantage . Easy construction work because of its simple structure. Disadvantage . Much materials and labor are necessary due to long construction work. . Hard work due to sandy soil and base rock at mountain foot. . Complicated alignment along the contour line. . Long construction period. . Complicated structure for river crossing. . Hard construction work on slope. . Moving of construction equipment in desert is hard.		Advantage . Planting and development of green zone along the channel is possible. Disadvantage . Give an unpleasant feeling to inhabitants due to bad odor emmission and flowing of filth in raw sewage. . Hazardous to inhabitants because of exposure to pathogenic bacteria. . Utilization of channel site for other purposes is not possible.		Advantage . Direct maintenance and repair of channel from outside is possible. . Easy maintenance work. Disadvantage . Fence and other facilities for safely is necessary in residential area. . Garbage and rubbish is apt to be dumped in. . Illegal diversion is expected. Security of planned water amount is uncertain. . Watching over the channel is necessary. But use of vehicle is impossible. . Deposit of sand in the channel will occur.	○	Including TAX $ 12,722,251- (¥1,781,115,140-) Excluding TAX $ 11,628,102- (¥1,627,934,280-) (124 %)		
	Inverted Siphon (Inner Pressure Pipe) φ 1400 mm	F − G ℓ = 9,790 m	Advantage . Short construction period. . Good workability due to use of pre-cast products. Disadvantage . Good pipe material durable for inner pressure is required.	○	Advantage . Utilization of pipeline site for other purposes is possible. . No bad odor. Disadvantage . Blow-off of raw sewage to the Lurin River at regular intervals is necessary for maintenance.	○	Advantage . Dumping of garbage and rubbish is impossible. . Facilities for environmental preservation is not necessary. . Regular maintenance. Disadvantage . Maintenance work from outside is hard. . Maintenance work for equipment such as blow-off valves and air valves is necessary . Blow-off work at regular intervals is necessary.		Including TAX $ 18,318,556.[53] (¥2,564,597,900-) Excluding TAX $ 9,383,186.[85] (¥1,313,646,159-) (100 %)	○	◎

TABLE A12-1 COMPARISON BETWEEN OPEN CHANNEL AND INVERTED SIPHON (CONT'D)

	Conduit	Length	Workability		Influence on Environment		Operation & Maintenance		Construction Cost		Evaluation
Plan E1 - Phase II	Open Channel RC 2100 × 1050 mm	H − I ℓ = 9,700 m	Same as Phase I		Same as Phase I		Same as Phase I	○	Including TAX $ 5,345,187- (¥ 748,326,180-) Excluding TAX $ 4,910,757- (¥ 687,505,980-) (178 %)		
	Inverted Siphon (Inner Pressure Pipe) φ 1200 mm	H − I ℓ = 2,500 m open channel (+ 1,500 m)	Same as Phase I	○	Same as Phase I	○	Same as Phase I		Including TAX $ 3,785,680- (¥ 529,995,200-) Excluding TAX $ 2,752,478- (¥ 385,346,920-) (100 %)	○	◎

APPENDIX 13

POSSIBLE TREATMENT CAPACITY IN SAN JUAN STP WITH RECONSTRUCTION

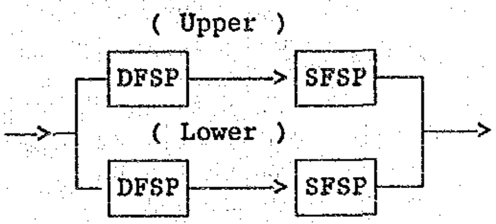
APPENDIX 13 POSSIBLE TREATMENT CAPACITY IN SAN JUAN STP WITH RECONSTRUCTION

- In case of adoption for Anaerobic Stabilization Pond -

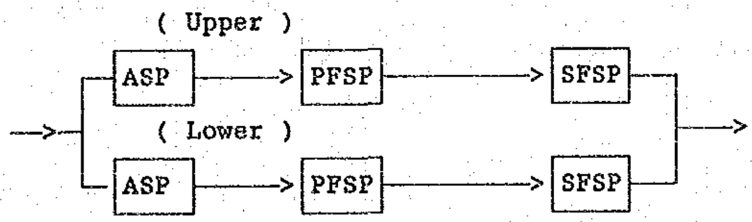
A13.1 Basic Concept for Reconstruction

1) Treatment method of PFSP-SFSP System of existing ponds shall be changed to ASP-PFSP-SFSP System in order to increase treatment capacity.

<u>Existing Flow Diagram</u>

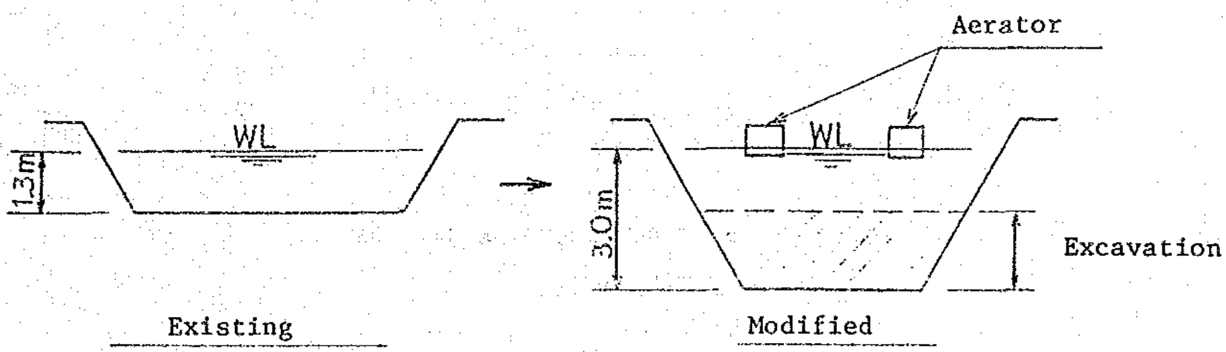


<u>Modified Flow Diagram</u>



Remarks: ASP-Anaerobic Stabilization Pond
PFSP-Primary Facultative Stabilization Pond
SFSP-Secondary Facultative Stabilization Pond

2) Effective water depth in some Primary Ponds shall be modified by excavation from 1.3 m to 3.0 m.



A13.2 Upper Battery

1) Volume and water surface area of ponds after reconstruction

Existing Primary Ponds P1 and P2 are changed to ASP.

No.of Pond	Water Surface Area (ha)(Depth 1.3 m)	ASP	PFSP	SFSP	Total Volume and Water Surface Area
P1	0.75	*			Total Volume of ASP
P2	0.51	*			(Depth 3.0 m)
P3	0.51		*		= 18,606 + 11,682
P4	0.81		*		= 30,288 m^3
P5	0.85			*	Total Area of PFSP
P6	0.68			*	(Depth 1.3 m)
S1	2.00		*		= 5.55 ha
S2	2.23		*		Total Area of SFSP
S3	0.99			*	(Depth 1.3 ha)
S4	0.92			*	= 3.44 ha
Total	10.25	1.26	5.55	3.44	

2) Study for Possible Treatment Capacity

a. Design Condition

- Influent BOD = 250 mg/l

b. ASP

- BOD Volumetric Load : Lv = 0.1 to 0.15 kg-BOD/m^3/day
  (at average temp. in coldest month, 15°C)
- Possible Treatment Capacity : Q1

$$Q_1 = \frac{30,288 \times (0.1 \text{ to } 0.15)}{250 \times 10^{-3}} = 12,115 \text{ to } 18,173 \ m^3/day$$

- BOD Removal Rate in ASP : Approx.50 %
- Effluent BOD : 250 to (1 - 0.5) = 125 mg/l

c. PFSP

- BOD Surface Load : Ls = 380 kg-BOD/ha/day
- Possible Treatment Capacity : Q2

$$Q_2 = \frac{380 \times 5.55}{125 \times 10^{-3}} = 16,872 \ m^3/day$$

According to the value of Q_1 and Q_2, possible treatment capacity is 16,872 m^3/day.

d. SFSP

- Influent BOD :

$$L = 16{,}872 m^3/day \times 125 mg/l \times (1 - 0.6) \times 10^{-3}$$

$$= 844 \text{ kg-BOD/day}$$

- BOD Surface Load :

$$Ls = 844 / 3.44 = 245 \text{ kg-BOD/day}$$ --------ok

e. Possible Treatment Capacity in Upper Battery From the result of above calculation, possible treatment capacity in Upper Battery is 16,872 m^3/day.

f. Check

- Detention Time :

ASP : 30,288 x 1/16,872 = 1.8 days

PFSP : 55,500 x 1.3 x 1/16,872 = 4.3 days

SFSP : 34,400 x 1.3 x 1/16,872 = 2.7 days

A13.3 Lower Battery

1) Volume and Water Surface Area in Pond after reconstruction of the Existing Pond P8 be changed to ASP. P7 and P5 are excluded in this plan since these are used for Experimental Fishculture Project.

No. of Ponds	Water Surface Area (ha)(Depth 1.3 m)	ASP	PFSP	SFSP	Total Volume and Water Surface Area
P8	1.10	*			Volume of ASP
P9	0.88		*		(Depth 3.0 m)
P10	0.69		*		= 27,590 m^3
P11	0.89			*	Surface Area of PFSP
S6	1.49		*		(Depth 1.3 m)
S7	1.32		*		= 4.98 ha
S8	1.80(divide)		*	*	Surface Area of SFSP
S9	0.49			*	(Depth 1.3 m)
S10	0.53			*	= 3.11 ha
Total	9.19	1.1	4.98	3.11	

2) Study for Possible Treatment Capacity

a. Design Condition

- Influent BOD = 250 mg/l

b. ASP

- BOD Volumetric Load : Lv = 0.1 to 0.15 kg-BOD/m^3/day
  (at average temp. in coldest month, 15°C)
- Possible Treatment Capacity : Q1

$$Q1 = \frac{27{,}590 \times (0.1 \text{ to } 0.15)}{250 \times 10^{-3}} = 11{,}036 \text{ to } 16{,}554 \ m^3/day$$

- BOD Removal Rate in ASP = Approx. 50%
- Effluent BOD = 250 x (1 - 0.5) = 125 mg/l

c. PFSP

- BOD Surface Load : Ls = 380 kg-BOD/ha/day
- Possible Treatment Capacity : Q2

$$Q2 = \frac{380 \times 4.98}{125 \times 10^{-3}} = 15{,}139 \ m^3/day$$

According to the value of Q1 and Q2, possible treatment capacity is 15,139 m^3/day.

d. SFSP

- Inlet BOD

$$L = 15{,}139 \ m^3/day \times 125 \ mg/l \times (1 - 0.6) \times 10^{-3}$$
$$= 757 \text{ kg-BOD/day}$$

- BOD Surface Load :

Ls = 757 kg-BOD/day ------------ ok

e. Possible treatment Capacity:

From the result of above calculation,possible treatment capacity in Lower Battery after reconstruction is 15,139 m^3/day.

f. Check

- Detention Time :

ASP : 27,590 x 1/15,139 = 1.8 days

PFSP : 49,800 x 1.3 x 1/15,139 = 4.3 days

SFSP : 31,100 x 1.3 x 1/15,139 = 2.7 days

A13.4 Total Possible Treatment Capacity

Treatment Capacity	Present	After reconst.	B/A
Upper Battery	10,800 m^3/day	16,872 m^3/day	1.56
Lower Battery	10,800 m^3/day	15,139 m^3/day	1.40
Total	21,600 m^3/day (0.25 m^3/s)	32,011 m^3/day (0.37 m^3/s)	1.48

APPENDIX 14

CAPACITY CALCULATION OF STP

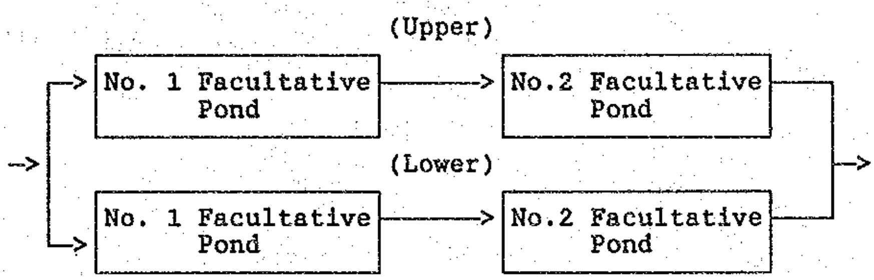
APPENDIX 14 CAPACITY CALCULATION OF STP

A14.1 Possible Treatment Capacity in Proposed Site (a) San Juan WSP

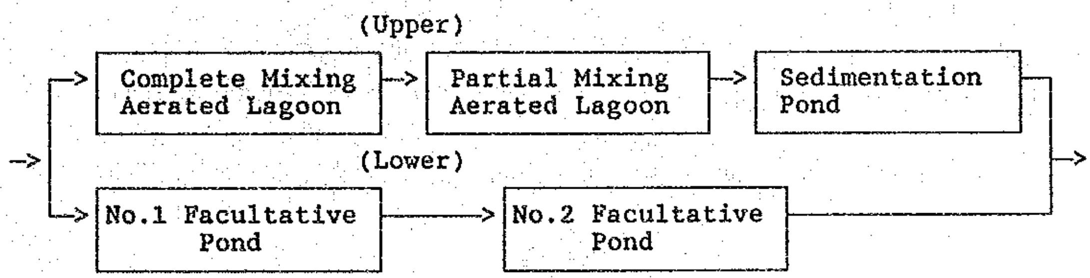
(1) Basic Concept for Reconstruction

- Out of the two-series treatment consisting of Upper and Lower Battery facultative ponds, treatment method of Upper Battery will be changed to Aerated Lagoon system in order to increase treatment capacity.

Existing Flow Diagram



Modified Flow Diagram



- Effective water depth in Upper Battery Pond will be modified by excavation from 1.3 m to 3.0 m.

(2) Treatment Capacity after Reconstruction

- Reconstruction plan and effective pond volume are shown in FIGURE A14-1 and TABLE A14-1.

- Capacity calculation for Aerated Lagoon System in modified Upper Battery based on standard detention time and effective volume is shown in TABLE A14-2. From the result of calculation, possible treatment capacity is 0.63 m^3/s.

(3) Total treatment capacity in San Juan Treatment Plant after reconstruction

	Treatment Method	Possible Treatment Capacity	Total Treatment Capacity
Upper Battery	Aerated Lagoon	0.63 m^3/s	0.75 m^3/s (64,800 m^3/day)
Lower Battery	Facultative Pond	21,600 m^3/day x 1/2 = 10,800 m^3/day = approx. 0.12m^3/s	

(4) Capacity Calculation for Aerated Lagoon on Upper Battery

a. Design Criteria

- Design Flowrate — Qd av = 0.63 m^3/s = approx. 54,400 m^3/day
- Influent BOD5 — Li = 250 mg/l
- Influent SS — Si = 250 mg/l

b. Complete Mixing Aerated Lagoon

- Detention Time — t* c = 1.5 ~ 2.0 days
- Volume — Vc = 54,400 x (1.5 ~ 2.0)
  = 81,600 ~ 108,800 m^3
- Depth — Dc = 3.0 m
- Water Surface Area (mid-depth) — Ac = Vc/Dc
  = (81,600 ~ 108,800)/3.0
  = 27,200 ~ 36,600 m^2
- Dimension — P_1, P_2, P_3, P_4, P_5, - Total (Refer to P)
  27,473 m^2 x 3.0 m D x 82,419 m^3
  check
  t* c = 82,419/54,400 = 1.52 days ...ok
- Oxygen Requirement — Or = 6.24 x 10^{-5} x 54,400 x 250
  = 849 kg-O_2/hr
- Power Requirement
  a. as for Or — P_1 = 849 x 1/2.0 = 425 kW
  b. as for C.M.P. — P_2 = 82,419 x 6 x 1/1,000 = 459 kW
  $P_1 < P_2$
- Aerator-I — 4 sets per 1 basin
  Aerator-I
  Pa = 495 x 1.1 = 545 kW
  therefore:
  37 kW x 4 sets ┐
  30 kw x 8 sets ├> (564kW)
  22 kW x 8 sets ┘

c. Partial Mixing Aerated Lagoon

- Detention Time — $t*p = 1.5 \sim 3.0$ days
- Volume — $Vp = 54,400 \times (1.5 \sim 3.0)$
  $81,600 \sim 163,200\ m^3$
- Depth — $Dp = 3.0$ m
- Water Surface Area (mid-depth) — $Ap = (81,600 \sim 163,200)/3.0$
  $= 27,200 \sim 54,400\ m^2$
- Dimension — S_1, S_2, S_3 - Total
  $45,404\ m^2 \times 3.0\ m^D \times 136,212\ m^3$
  check
  $t*p = 136,212/54,400 = 2.5$ days...ok
- Power Requirement for Mixing — $Pr >= 1\ W/m^3$
  $P >= 136,212 \times 1.0 = 136$ kW
- Aerator-II — 4 sets per 1 basin
  $Pa = 136 \times 1.1$
  $= 150$ kW
  therefore:
  7.5 kW x 4 ┐
  15 kw x 4 ├-> (164kW)
  18.5 kW x 4 ┘

d. Chlorinator

- Chlorine Feeding Rate — 3 ppm
- Total Inflow of Upper and Lower Battery — 65,200 m^3/day
- Capacity — $q = 65,200\ m^3/day \times 3\ ppm \times 10^{-3}$
  = 195.6 kg-cl/day
  = 8.2 kg-cl/hr
  therefore, chlorinator will be:
  10 kg-cl/hr x 2 sets (1 set-standby)

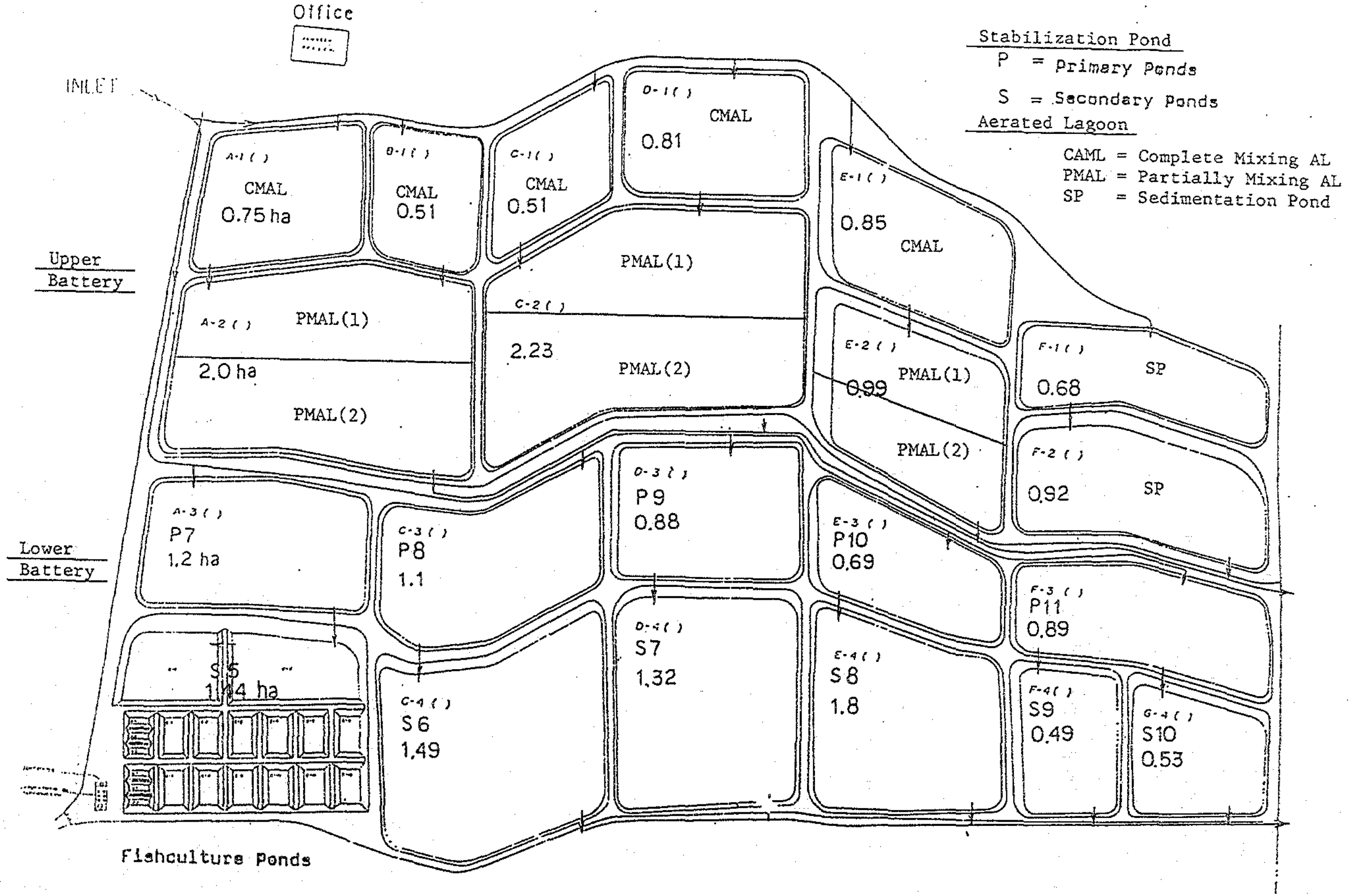


FIGURE A14-1 MODIFIED PLAN OF SAN JUAN S.T.P.

TABLE A14-1 EFFECTIVE VOLUME OF MODIFIED SAN JUAN STP (UPPER BATTERY, DEPTH 3 m)

Pond No.	Existing Water Surface Area (m^2)	Equivalent Square Length (m)	① Middle Depth Equivalent Length (m)	② Depth (m)	①×② Effective Volume (m^3)
P_1	7,500	86.6	77.6	3.0	18,606
P_2	5,100	71.4	62.4	3.0	11,682
P_3	5,100	71.4	62.4	3.0	11,682
P_4	8,100	90.0	81.0	3.0	19,683
P_5	8,500	92.2	83.2	3.0	20,766
P_6	6,800	82.5	73.5	3.0	16,206
S_1	20.000	141.4	132.4	3.0	52,590
S_2	22,300	149.3	140.3	3.0	59,052
S_3	9,900	99.5	90.5	3.0	24,570
S_4	9,200	95.9	86.9	3.0	22,656
					(257,493)

TABLE A14-2

POSSIBLE TREATMENT CAPACITY FOR AERATED LAGOON IN UPPER BATTERY

Process	Pond No.	Total Pond Volume	Standard Detention Time	Possible Treatment Capacity
Completely Mixing Aerated Lagoon	P 1 P 2 P 3 P 4 P 5	82.419	1.5 | 2.0 ↓ 1.5	82,419× 1/1.5 = 54,946 m^3/day = 0.636 m^3/day
Partially Mixing Aerated Lagoon	S 1 S 2 S 3	136.212	3 −Cell 1.5 | 3.0 ↓ 2.5	136,212× 1/2.5 = 54,485 m^3/day = 0.631 m^3/s
Sedimentation Pond	P 6 P 4	38.862	1.0	38,862× 1/1.0 = 38,862 m^3/day = 0.45 m^3/s

A14.2 Capacity Calculation for Aerated Lagoon in Proposed Site (b) and (c)

(1) Design Criteria

Design Flow Rate: 0.5 m^3/s, 0.83 m^3/s, 1.0 m^3/s
Influent BOD_5 : 250 mg/l
Influent SS : 250 mg/l

(2) Estimate Treated Water Quality

	BOD	SS
Removal Rate	88%	76%
Water Quality	30 mg/l	60 mg/l

(3) Flow Diagram

Flow diagram is shown in FIGURE A14-2.

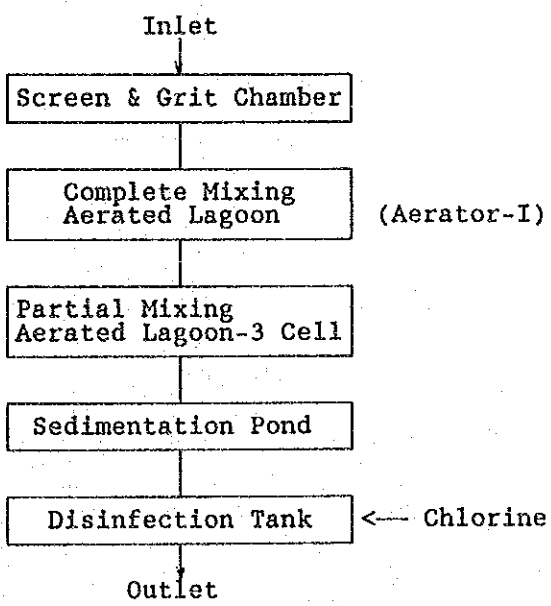


FIGURE A14-2 Flow Diagram for Aerated Lagoon (Dual Power) System

(4) Capacity Calculation

Capacity calculation for each proposed site are shown in TABLE A14-3.

TABLE A14-3 Capacity Calculation for Aerated Lagoon at Each Design Flow

Item \ Design Flow	0.5 m^3/s	0.83 m^3/s	1.0 m^3/s
1. Design Criteria			
- Design Flowrate	Qd av = 0.5m^3/s ≒ 43,200m^3/day	Qd av = 0.83m^3/s ≒ 71,700m^3/day	Qd av = 1.0m^3/s ≒ 86,400m^3/day
- Influent BOD_5	Li = 250mg/l	Li = 250mg/l	Li = 250mg/l
- Influent SS	Si = 250mg/l	Si = 250mg/l	Si = 250mg/l
2. Complete Mixing Aerated Lagoon			
- Detention Time	t *c = 1.5~2.0 days	t *c = 1.5~2.0 days	t *c = 1.5~2.0 days
- Volume	Vc = 43,200 x (1.5~2.0) = 64,800~86,400m^3	Vc = 71,700 x (1.5~2.0) = 107,550~143,400m^3	Vc = 86,400 x (1.5~2.0) = 129,600~172,800m^3
- Depth	Dc = 3.0m	Dc = 3.0m	Dc = 3.0m
- Water Surface Area (mid-depth)	Ac = Vc/Dc = (64,800~86,400)/3.0 = 21,600~28,800m^2	Ac = (107,550~143,400)/3.0 = 35,850~47,800m^2	Ac = (129,600~172,800)/3.0 = 43,200~57,600m^2
- Dimension	100m x 48m x3.0m ^{D} x 14,400m^2 x 6basins check Total Volume V_c = 14,400 x 6 = 86,400m^3 t *c = 86,400/43,200 = 2.0 days···ok	105m x 45m x 3.0m^D x 14,490m^3 x 10basins check Total Volume Vc = 14,490 x 10 = 144,900m^3 t * c = 144,900/71,700 = 2.0 days ···ok	100m x 48m x 3.0m^D x 14,400m^3 x 12basins check Total Volume Vc = 14,400 x 12 = 172,800m^3 t *c = 172,800/86,400 = 2.0 days ···ok
- Oxygen Requirement	Or = 6.24 x 10^{-5} x 43,200 x 250 = 674 kg-O_2/hr	Or = 6.24 x 10^{-5} x 71,700 x 250 = 1,119 kg-O_2/hr	Or = 6.24 x 10^{-5} x 86,400 x 250 = 1,348 kg-O_2/hr
- Power Requirement			
a. as for Or	P_1 = 674 x 1/2.0 = 337kW	P_1 = 1,119 x 1/2 = 560kW	P_1 = 1,348 x 1/2.0 = 674kW
b. as for C.M.P.	P_2 = 86,400 x 6 x 1/1,000 = 519kW $P_1 < P_2$	P_2 = 144,900 x 6 x 1/1,000 = 870 kW $P_1 < P_2$	P_2 = 172,800 x 6 x 1/1,000 = 1,037kW $P_1 < P_2$
- Aerator- I	4 sets per 1 basin Aerator- I Pa = 519kW x 1.1 = 571kW ∴ 30kW x 12 sets, 18.5kW x12 sets } (582kW)	4 sets per 1 basin Aerator- II Pa = 870kW x 1.1 = 957kW ∴ 30kW x 20 sets, 18.5kW x 20 sets } (970kW)	4 sets per 1 basin Aerator- I Pa = 1,037kW x 1.1 = 1,141kW ∴ 30kW x 24 sets, 18.5kW x 24 sets } (1,164kW)

TABLE A14-3 Capacity Calculation for Aerated Lagoon on Each Design Flow (cont'd)

Design Flow / Item	0. 5 m³/s	0. 83 m³/s	1. 0 m³/s
3. Partial Mixing Aerated Lagoon			
- Detention Time	t *p = 1.5~3.0 days, 3-cells	t *p = 1.5~3.0 days, 3-cells	t *p = 1.5~3.0 days, 3-cells
- Volume	Vp = 43,200 x (1.5~3.0) = 64,800~129,600m³	Vp = 71,700 x (1.5~3.0) = 107,550 ~215,100	Vp = 86,400 x (1.5~3.0) = 129,600~259,200m³
- Depth	Dp = 3.0m	Dp = 3.0m	Dp = 3.0m
- Water Surface Area (mid-depth)	Ap = (64,800~129,600)/3.0 = 21,600~43,200m²	Ap = (107,550~215,100)/3 = 35,850~71,700m²	Ap = (129,600~259,200)/3 = 43,200~86,400m²
- Dimension	100m x 33m x 3.0m D x 9,900m³ x 9basins (3 cells x 3 series) check Total Volume V P = 9,900 x 9 = 89,100m³ t *p = 89,100/43,200 = 2.1 days····ok	71m x 46m x 3.0m D x 9,798 x 15basins (3 cells x 5 Series) check Total Volume Vp = 9,798 x 15 = 146,970m³ t *p = 146,970/71,700 = 2.0 days ····ok P = 146,970 x 1.0 = 147kw	100m x 33m x 3.0m D x 9,900m³ x 18basins (3 cells x 6 Series) check Total Volume Vp = 9,900 x 18 = 178,200m³ t *p = 178,200/86,400 = 2.1 days ····ok P = 178,200 x 1.0 = 178kW
- Power Requirement for Mixing	Pr ≧ 1W/m³ P ≧ 89,100 x 1.0 = 89kW		
- Aerator - II	2 sets per 1 cell Pa = 89 x 1.1 = 98 kW ∴ 5.5kW X 18 sets (99kW)	2 sets per 1 cell Pa = 147 x 1.1 = 162 kW ∴ 5.5kW x 30 sets (165kW)	2 sets per 1 cell Pa = 178 x 1.1 = 196 kW ∴ 5.5kW x 36 sets (198kW)
4. Chlorinator	- Chlorine Feeding Rate : 3 ppm - Capacity q = 43,200m³/day x 3 ppm x 10 ⁻³ = 129.6 kg-cl/day = 5.4 kg-cl/hr ∴ chlorinator 10 kg-cl/hr x 2 sets (1 set-standby)	q = 71,700m³/day x 3 ppm x 10 ⁻³ = 215.1 kg-cl/day = 9.0 kg-cl/hr ∴ chlorinator 10 kg-cl/hr x 2 sets (1 set-standby)	q = 86,400m³/day x 3 ppm x 10 ⁻³ = 259.2 kg-cl/day = 10.8 kg-cl/hr ∴ chlorinator 15 kg-cl/hr x 2 sets (1 set-standby)

A.14.3 Capacity Calculation for Stabilization Pond (Facultative Pond) in Proposed Site (e) and (f).

(1) Design Criteria

Design flowrate : Q = 0.5 to 3.5 m^3/s

Influent BOD_5 : 250 mg/l

Influent SS : 250 mg/l

Influent BOD_5 Load : Li1 = Q x 250 mg/l x 10^{-3} (kg-BOD/day)

(2) Estimate Treatment Water Quality

BOD_5 removal rate : 80%

Effluent BOD_5 : 49 mg/l

(3) Flow Chart

(Facultative Ponds System)

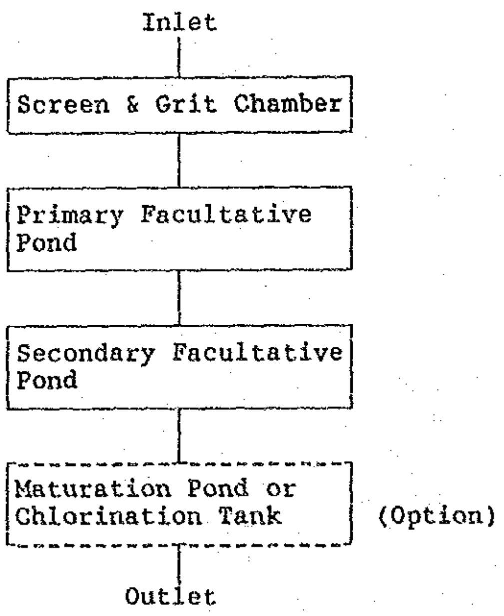


FIGURE A14-3 Flow Diagram for Stabilization Pond System

- Capacity Calculation

(i) Primary Fucultative Pond

BOD5 water surface load:		Li_1 = 382 (kg-BOD/ha/day)
Water surface area (mid-depth)	:	Ap = Q x 250 x 10^{-3} x1/382 (ha)
Water depth	:	Dp = 1.5 m
Volume	:	Vp = Ap x Dp (m^3)
Detention time	:	t*p = Vp/Q (days)
Effluent BOD5	:	Le_1 = 250 x (1 - 0.7) = 75 mg/l

(ii) Secondary Fucultative Pond

BOD5 water surface load:		Li_2 = 200 (kg-BOD/ha.day)
Water surface area (mid-depth)	:	As = Q x 75 x 10^{-3} x 1/200 (ha)
Water Depth	:	Dp = 1.5 m
Volume	:	Vp = As x Dp (m^3)
Detention Time	:	t*S = Vp/Q (days)
Effluent BOD5	:	Le_2 = 250 x (1 - 0.35) = 49mg/l

Results of capacity calculation are shown in TABLE A14-4.

TABLE A14-4 CAPACITY CALCULATION FOR FACULTATIVE POND

Design Flow	Q (m^3/S)	0.5	1.5	1.7	2.0	2.2	2.5	2.67	3.0	3.5
Primary Facultative Pond	Lil (kg-BOD/day)	10,800	32,400	36,720	43,200	47,520	54,000	57,672	64,800	75,600
	Ap (ha)	28.3	84.8	96.1	113.1	124.4	141.4	151.0	169.6	197.9
	Dp (m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Vp (m^3)	424,500	1,272,000	1,442,000	1,697,000	1,866,000	2,121,000	2,265,000	2,544,000	2,969,000
	t^*_P (days)	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
Secondary Facultative Pond	As (ha)	16.2	48.6	55.1	64.8	71.3	81.0	86.5	97.2	113.4
	Ds (m)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Vs (m^3)	243,000	729,000	826.500	972.000	1,070,000	1,215,000	1,298.000	1,458,000	1,701,000
	t^*_s (days)	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Total Mid-Depth Water Surface Area: Ap + As (ha)		44.5	133.4	151.2	177.9	195.7	222.4	237.5	266.8	311.3
Total Detention Time: $t^*_P + t^*_s$ (days)		15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4

APPENDIX 15

DAILY FLOW VARIATION AND INTAKE AMOUNT

TABLE A15-1 PLANNED INTAKE AMOUNT

MEASURING TIME hh : mm	May 31-June 1 CIRCUN.	RATE	October 19-20 CIRCUN.	RATE	AVERAGE RATE OF 2 DATA	AMOUNT FOR 1 M3/S FLOW	INTAKE
	M3/S		M3/S			M3/S	M3/S
10 : 00	1.358	1.197	1.562	1.350	1.274	1.294	1.170
10 : 15	1.358	1.197	1.578	1.364	1.281	1.301	1.170
10 : 30	1.454	1.282	1.443	1.247	1.265	1.285	1.170
10 : 45	1.345	1.186	1.462	1.263	1.225	1.245	1.170
11 : 00	1.382	1.218	1.457	1.259	1.239	1.259	1.170
11 : 15	1.321	1.164	1.440	1.245	1.205	1.224	1.170
11 : 30	1.269	1.118	1.380	1.192	1.156	1.174	1.170
11 : 45	1.269	1.118	1.372	1.186	1.153	1.171	1.170
12 : 00	1.338	1.179	1.380	1.192	1.186	1.205	1.170
12 : 15	1.294	1.140	1.365	1.180	1.160	1.179	1.170
12 : 30	1.276	1.125	1.360	1.175	1.151	1.169	1.169
12 : 45	1.276	1.125	1.343	1.161	1.143	1.161	1.161
13 : 00	1.251	1.103	1.331	1.150	1.127	1.145	1.145
13 : 15	1.251	1.103	1.321	1.141	1.123	1.141	1.141
13 : 30	1.246	1.099	1.303	1.126	1.113	1.131	1.131
13 : 45	1.271	1.120	1.289	1.114	1.118	1.135	1.135
14 : 00	1.219	1.074	1.276	1.103	1.089	1.107	1.107
14 : 15	1.219	1.074	1.299	1.122	1.099	1.116	1.116
14 : 30	1.222	1.077	1.331	1.150	1.114	1.132	1.132
14 : 45	1.227	1.081	1.274	1.101	1.091	1.109	1.109
15 : 00	1.227	1.081	1.256	1.086	1.084	1.101	1.101
15 : 15	1.246	1.099	1.254	1.084	1.092	1.109	1.109
15 : 30	1.246	1.099	1.234	1.066	1.083	1.100	1.100
15 : 45	1.271	1.120	1.202	1.038	1.080	1.097	1.097
16 : 00	1.271	1.120	1.189	1.028	1.075	1.092	1.092
16 : 15	1.214	1.070	1.177	1.017	1.044	1.061	1.061
16 : 30	1.214	1.070	1.169	1.010	1.041	1.057	1.057
16 : 45	1.209	1.066	1.179	1.019	1.043	1.059	1.059
17 : 00	1.209	1.066	1.172	1.012	1.040	1.056	1.056
17 : 15	1.174	1.035	1.187	1.025	1.031	1.047	1.047
17 : 30	1.179	1.039	1.199	1.036	1.038	1.055	1.055
17 : 45	1.202	1.059	1.189	1.028	1.044	1.061	1.061
18 : 00	1.202	1.059	1.187	1.025	1.043	1.059	1.059
18 : 15	1.259	1.110	1.182	1.021	1.066	1.083	1.083
18 : 30	1.259	1.110	1.119	0.967	1.039	1.055	1.055
18 : 45	1.174	1.035	1.132	0.978	1.007	1.023	1.023
19 : 00	1.174	1.035	1.149	0.993	1.014	1.031	1.031
19 : 15	1.129	0.995	1.147	0.991	0.994	1.009	1.009
19 : 30	1.129	0.995	1.137	0.982	0.989	1.005	1.005
19 : 45	1.134	1.000	1.092	0.943	0.972	0.988	0.988
20 : 00	1.147	1.011	1.104	0.954	0.983	0.999	0.999
20 : 15	1.149	1.013	1.099	0.950	0.982	0.998	0.998
20 : 30	1.149	1.013	1.109	0.959	0.986	1.002	1.002
20 : 45	1.134	1.000	1.104	0.954	0.977	0.993	0.993
21 : 00	1.134	1.000	1.082	0.935	0.968	0.983	0.983
21 : 15	1.139	1.004	1.089	0.941	0.973	0.989	0.989
21 : 30	1.142	1.006	1.092	0.943	0.975	0.991	0.991

TABLE A15-1 PLANNED INTAKE AMOUNT

MEASURING TIME hh : mm	May 31-June 1		October 19-20		AVERAGE RATE OF 2 DATA	AMOUNT FOR 1 M3/S	
	CIRCUN.	RATE	CIRCUN.	RATE		FLOW	INTAKE
	M3/S		M3/S			M3/S	M3/S
21 : 45	1.137	1.002	1.077	0.930	0.967	0.982	0.982
22 : 00	1.137	1.002	1.072	0.926	0.964	0.980	0.980
22 : 15	1.112	0.980	1.062	0.918	0.949	0.964	0.964
22 : 30	1.114	0.982	1.054	0.911	0.947	0.962	0.962
22 : 45	1.087	0.958	1.015	0.877	0.918	0.932	0.932
23 : 00	1.089	0.960	1.027	0.887	0.924	0.939	0.939
23 : 15	0.923	0.814	1.012	0.875	0.845	0.858	0.858
23 : 30	0.911	0.803	0.965	0.834	0.819	0.832	0.832
23 : 45	1.034	0.912	0.938	0.811	0.862	0.875	0.875
0 : 00	1.034	0.912	0.946	0.817	0.865	0.879	0.879
0 : 15	1.027	0.905	0.919	0.794	0.850	0.863	0.863
0 : 30	1.030	0.907	0.921	0.796	0.852	0.866	0.866
0 : 45	0.865	0.762	0.916	0.792	0.777	0.790	0.790
1 : 00	0.868	0.764	0.950	0.821	0.793	0.806	0.806
1 : 15	0.906	0.799	0.938	0.811	0.805	0.818	0.818
1 : 30	0.909	0.801	0.955	0.825	0.814	0.827	0.827
1 : 45	0.911	0.803	0.978	0.845	0.824	0.838	0.838
2 : 00	0.911	0.803	0.985	0.851	0.828	0.841	0.841
2 : 15	0.909	0.801	0.987	0.853	0.828	0.841	0.841
2 : 30	0.909	0.801	1.000	0.864	0.833	0.846	0.846
2 : 45	0.911	0.803	0.997	0.862	0.833	0.846	0.846
3 : 00	0.911	0.803	0.955	0.825	0.815	0.828	0.828
3 : 15	0.916	0.807	0.894	0.773	0.790	0.803	0.803
3 : 30	0.921	0.812	0.841	0.727	0.770	0.782	0.782
3 : 45	0.916	0.807	0.846	0.731	0.770	0.782	0.782
4 : 00	0.914	0.805	0.846	0.731	0.768	0.781	0.781
4 : 15	0.839	0.739	0.841	0.727	0.733	0.745	0.745
4 : 30	0.839	0.739	0.848	0.733	0.736	0.748	0.748
4 : 45	0.884	0.779	0.843	0.729	0.755	0.767	0.767
5 : 00	0.887	0.782	0.875	0.756	0.769	0.781	0.781
5 : 15	0.887	0.782	0.877	0.758	0.770	0.783	0.783
5 : 30	0.889	0.784	0.872	0.754	0.769	0.781	0.781
5 : 45	0.923	0.814	0.904	0.781	0.798	0.811	0.811
6 : 00	0.923	0.814	0.911	0.787	0.801	0.814	0.814
6 : 15	0.941	0.829	0.990	0.855	0.843	0.856	0.856
6 : 30	0.941	0.829	1.005	0.868	0.849	0.863	0.863
6 : 45	1.005	0.885	1.097	0.948	0.917	0.932	0.932
7 : 00	1.097	0.967	1.132	0.978	0.973	0.988	0.988
7 : 15	1.092	0.962	1.194	1.032	0.998	1.014	1.014
7 : 30	1.236	1.090	1.259	1.088	1.089	1.107	1.107
7 : 45	1.239	1.092	1.316	1.137	1.115	1.133	1.133
8 : 00	1.271	1.120	1.353	1.169	1.145	1.164	1.164
8 : 15	1.345	1.186	1.411	1.220	1.203	1.222	1.170
8 : 30	1.353	1.192	1.474	1.274	1.233	1.253	1.170
8 : 45	1.387	1.222	1.562	1.350	1.287	1.307	1.170
9 : 00	1.454	1.282	1.581	1.366	1.325	1.346	1.170
9 : 15	1.387	1.222	1.583	1.368	1.296	1.316	1.170

TABLE A15-1 PLANNED INTAKE AMOUNT

MEASURING TIME hh : mm	May 31-June 1 CIRCUN.	RATE	October 19-20 CIRCUN.	RATE	AVERAGE RATE OF 2 DATA	AMOUNT FOR 1 M3/S FLOW	INTAKE
	M3/S		M3/S			M3/S	M3/S
9 : 30	1.384	1.220	1.608	1.389	1.305	1.326	1.170
9 : 45	1.392	1.227	1.612	1.393	1.310	1.331	1.170
10 : 00	1.358	1.197	1.562	1.350	1.274	1.294	1.170
MAXIMUM Qma	1.454	1.282	1.612	1.393	1.325	1.346	1.170
AVERAGE Qav	1.134	1	1.157	1	1.000	1.016	1.000
MINIMUM Qmi	0.839	0.739	0.841	0.727	0.733	0.745	0.745

Location of Measuring Point, and Measuring Date and Time
Circun.: Colector Circunvalacion, Diameter 1.31 meters
Av. Julio Calero 140, Surquillo
1st: from 10:30, May 31 to 10:30, June 1, 1989
2nd: from 8:45, October 19 to 8:30, October 20, 1989

TABLE A15-2 FLOW RATE VARIATION
(Intake Point No.3 : Surco)

TIME hh : mm	6/06-07 Measured Data	10/24-25 Measured Data	AVERAGE FLOW RATE	AMOUNT FOR 2 M3/ FLOW (M3/S)	INTAKE (M3/S)
10 : 00	1.152	1.205	1.179	2.815	2.061
10 : 15	1.182	1.201	1.191	2.845	2.061
10 : 30	1.212	1.201	1.206	2.881	2.061
10 : 45	1.201	1.205	1.203	2.873	2.061
11 : 00	1.122	1.205	1.163	2.778	2.061
11 : 15	1.122	1.159	1.140	2.723	2.061
11 : 30	1.160	1.140	1.150	2.746	2.061
11 : 45	1.160	1.182	1.171	2.796	2.061
12 : 00	1.162	1.211	1.186	2.833	2.061
12 : 15	1.175	1.201	1.188	2.837	2.061
12 : 30	1.150	1.182	1.166	2.785	2.061
12 : 45	1.184	1.180	1.182	2.823	2.061
13 : 00	1.147	1.153	1.150	2.746	2.061
13 : 15	1.186	1.161	1.174	2.803	2.061
13 : 30	1.147	1.180	1.163	2.778	2.061
13 : 45	1.175	1.192	1.184	2.827	2.061
14 : 00	1.147	1.197	1.172	2.798	2.061
14 : 15	1.143	1.167	1.155	2.759	2.061
14 : 30	1.137	1.167	1.152	2.752	2.061
14 : 45	1.139	1.172	1.155	2.759	2.061
15 : 00	1.160	1.159	1.160	2.769	2.061
15 : 15	1.143	1.167	1.155	2.759	2.061
15 : 30	1.133	1.201	1.167	2.787	2.061
15 : 45	1.079	1.178	1.128	2.695	2.061
16 : 00	1.102	1.149	1.126	2.688	2.061
16 : 15	1.112	1.144	1.128	2.694	2.061
16 : 30	1.044	1.149	1.096	2.618	2.061
16 : 45	1.004	1.147	1.075	2.568	2.061
17 : 00	1.063	1.149	1.106	2.641	2.061
17 : 15	1.112	1.125	1.119	2.672	2.061
17 : 30	1.126	1.066	1.096	2.617	2.061
17 : 45	1.114	1.064	1.089	2.600	2.061
18 : 00	1.100	1.062	1.081	2.581	2.061
18 : 15	1.099	1.053	1.076	2.569	2.061
18 : 30	1.085	1.047	1.066	2.545	2.061
18 : 45	1.089	1.064	1.076	2.570	2.061
19 : 00	1.004	1.106	1.055	2.520	2.061
19 : 15	1.004	1.096	1.050	2.507	2.061
19 : 30	1.030	1.064	1.047	2.500	2.061
19 : 45	1.030	1.044	1.037	2.477	2.061
20 : 00	1.028	1.049	1.038	2.479	2.061
20 : 15	1.050	1.036	1.043	2.490	2.061
20 : 30	1.050	0.965	1.007	2.405	2.061
20 : 45	1.018	0.971	0.995	2.375	2.061
21 : 00	1.014	0.975	0.995	2.375	2.061
21 : 15	1.004	0.969	0.987	2.356	2.061
21 : 30	1.004	0.984	0.994	2.374	2.061

TABLE A15-2 FLOW RATE VARIATION
(Intake Point No.3 : Surco)

TIME	6/06-07	10/24-25	AVERAGE	AMOUNT FOR 2 M3/	
hh : mm	Measured Data	Measured Data	FLOW RATE	FLOW (M3/S)	INTAKE (M3/S)
21 : 45	0.982	0.975	0.979	2.337	2.061
22 : 00	0.980	0.965	0.972	2.322	2.061
22 : 15	1.002	0.978	0.990	2.364	2.061
22 : 30	1.000	0.904	0.952	2.274	2.061
22 : 45	0.980	0.859	0.920	2.196	2.061
23 : 00	0.984	0.865	0.925	2.208	2.061
23 : 15	1.004	0.891	0.948	2.263	2.061
23 : 30	0.982	0.883	0.932	2.226	2.061
23 : 45	0.944	0.934	0.939	2.243	2.061
0 : 00	0.944	0.941	0.942	2.251	2.061
0 : 15	0.940	0.889	0.915	2.184	2.061
0 : 30	0.920	0.835	0.878	2.096	2.061
0 : 45	0.890	0.829	0.859	2.052	2.052
1 : 00	0.872	0.853	0.862	2.059	2.059
1 : 15	0.843	0.861	0.852	2.035	2.035
1 : 30	0.843	0.846	0.845	2.017	2.017
1 : 45	0.849	0.859	0.854	2.040	2.040
2 : 00	0.799	0.863	0.831	1.985	1.985
2 : 15	0.803	0.874	0.839	2.003	2.003
2 : 30	0.785	0.881	0.833	1.989	1.989
2 : 45	0.779	0.868	0.823	1.966	1.966
3 : 00	0.785	0.816	0.801	1.912	1.912
3 : 15	0.759	0.698	0.729	1.740	1.740
3 : 30	0.763	0.665	0.714	1.705	1.705
3 : 45	0.763	0.588	0.676	1.613	1.613
4 : 00	0.554	0.594	0.574	1.370	1.370
4 : 15	0.550	0.612	0.581	1.387	1.387
4 : 30	0.591	0.622	0.607	1.449	1.449
4 : 45	0.779	0.648	0.714	1.705	1.705
5 : 00	0.755	0.663	0.709	1.693	1.693
5 : 15	0.763	0.685	0.724	1.730	1.730
5 : 30	0.779	0.673	0.726	1.734	1.734
5 : 45	0.793	0.725	0.759	1.813	1.813
6 : 00	0.793	0.761	0.777	1.855	1.855
6 : 15	0.799	0.769	0.784	1.873	1.873
6 : 30	0.815	0.823	0.819	1.955	1.955
6 : 45	0.829	0.823	0.826	1.972	1.972
7 : 00	0.855	0.868	0.862	2.057	2.057
7 : 15	0.932	0.952	0.942	2.249	2.061
7 : 30	0.964	1.025	0.995	2.375	2.061
7 : 45	1.044	1.057	1.050	2.509	2.061
8 : 00	1.071	1.096	1.083	2.587	2.061
8 : 15	1.114	1.153	1.133	2.707	2.061
8 : 30	1.171	1.159	1.165	2.782	2.061
8 : 45	1.171	1.176	1.174	2.802	2.061
9 : 00	1.173	1.217	1.195	2.854	2.061
9 : 15	1.175	1.209	1.192	2.847	2.061

TABLE A15-2 FLOW RATE VARIATION
(Intake Point No.3 : Surco)

TIME hh : mm	6/06-07 Measured Data	10/24-25 Measured Data	AVERAGE FLOW RATE	AMOUNT FOR 2 M3/ FLOW (M3/S)	INTAKE (M3/S)
9 : 30	1.167	1.215	1.191	2.845	2.061
9 : 45	1.160	1.213	1.187	2.833	2.061
10 : 00	1.152	1.205	1.179	2.815	2.061
MAXIMUM Qmax	1.212	1.217	1.206	2.881	2.061
AVERAGE Qavg	1.000	1.000	1.000	2.388	2.000
MINIMUM Qmin	0.550	0.588	0.574	1.370	1.370

APPENDIX 16

SELECTION OF PIPE MATERIALS FOR INVERTED SIPHON

APPENDIX 16 SELECTION OF PIPE MATERIALS FOR INVERTED SIPHON

A16.1 General

The use of inverted siphon structure is cannot be avoided for the transmission of sewage to San Bartolo fully using elevation potential at the intake points due to the topographical feature along the proposed transmission line. However, adoption of such structure in the Project, presents several problems which need to be studied like the long span of inverted siphon section, inner pressure, and difference of elevation between the highest and lowest points. In this Study, optimum materials for pipes are selected taking these problems into consideration.

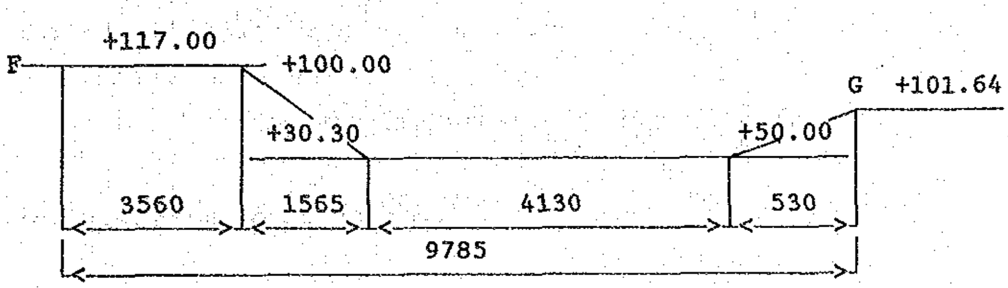
A16.2 Conditions for Study

Following conditions are set for the Study.

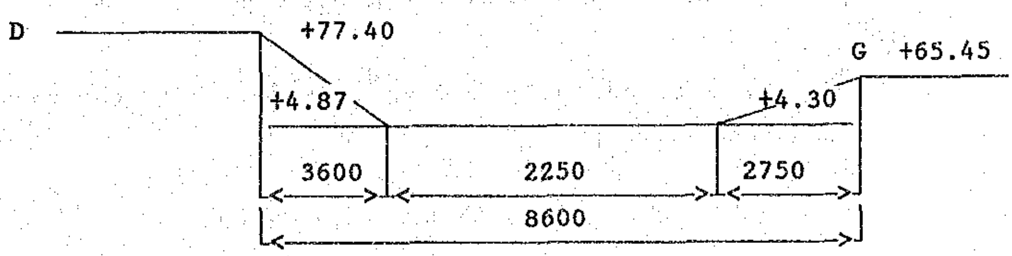
(1) Longitudinal Section

In the case of Plan E_1, the profile of longest inverted siphon will be as illustrated below:

PHASE I ϕ 1,350 mm



PHASE II ϕ 1,200 mm



(2) Pipe Materials

(a) Pre-stressed Reinforced Concrete Pipe (PCP)

In Peru, PCP have been installed for transmission main pipe of many water supply systems. Highest inner pressure is 18 kg/cm^2.

(b) Fiber-glass Reinforced Plastic Mortar Pipe (FRPM)

Import from foreign country

(c) Ductile cast Iron Pipe (DCIP)

Import from foreign country.

(3) Soil Condition

(a) Phase I (near Lurin river)

1) Total thickness of top soil and alluvial soil is 0.5 m and strata have loose density.

2) The layer between GL-2.5 and 3.0 m, which will be the foundation of pipeline consists of gravelly soil. Silty fine sand and medium gravel fine sand strata exist in places. Strata are relatively dense.

3) The strata to be excavated consist of gravelly soil with medium density.

4) Groundwater exists near Lurin River at elevation 50 m or less. Water level is at 1.0 m below ground level.

5) Contents of salinity and sulfate is below the level of concrete structure.

6) Permeability of foundation stratum is:

$K = 7.6$ cm/s

It can be judged as high permeability

7) Based on the soil test, mechanical properties of fine sand stratum in this area is judged to be:

Internal friction Angle 30°
Cohesion 0 kg/cm^2

(b) Phase II (along coast line)

1) Total thickness of top soil and alluvial soil is 0.5 m and strata have loose density.

2) The layer between, GL-2.5 and 3.0 m, which will be the foundation of pipeline consists of medium density fine sand with slight silt contents in place.

3) The strata to be excavated consist of medium density fine sand.

4) Groundwater exists below elevation 20 m in the south area of the Cerro de Lomo de Corvina. Water level is at 1 m below ground level.

5) Concentrations of salinity and sulfate in the soil exceed the durable level for concrete structures from Villa Rica to Lurin River along the Pacific Ocean coast.

6) Permeability of foundation strata is:

$k = 7.8 \times 10^{-3}$ cm/s

It is considered normal value for fine sand.

7) Based on the soil test, mechanical properties of fine sand strata in this area is judged to be:

Internal friction Angle 30°
Cohesion 0 kg/cm^2

(4) Items to be considered

Following items will be considered for selection of materials:

Characteristics and Strength,
Anti-corrosion and durability,
Joint performance,
Workability, and
Economy

A16.3 Comparison of Pipe Materials

TABLE A16-1 shows the comparison of characteristics of back pipe materials.

TABLE A16-1 COMPARISON OF PIPE MATERIALS

			Prestressed Reinforced Concrete Pipe (PCP)	Fiber-glass Reinforced Plastic Mortar Pipe (FRPM)	Ductile Cast Iron Pipe (DCIP)
Characteristics and Strength	Strength for External Pressure		Structure is designed to bear inner pressure by PC steel bars. Therefore strength against inner pressure is large, but rigidity, flexural strength and strength for external pressure is small.	Both rigidity and flexural strength is large. Strength for external pressure is 150% (more than ϕ450 mm) and 200% (less than ϕ450 mm) of that of PCP.	Both rigidity and flexural strength is great. Strength for external pressure is greater than that of FRPM.
	Flexual Strength		90~100	1,800~2,000	5,720
	Durable Bending Stress		200,000	125,000~135,000	1,650,000
	Impact Resistance		External surface is made of mortar shotcreting. Crack on surface and breaking away of mortar will sometimes occur.	Relatively weak against impact. At the time of backfilling, rapid soil dumping shall be avoided.	Superior against impact. But too large impact breaks away inner mortar lining.
	Water-tightness		Durable against 6kgf／m² for ϕ1350 to ϕ1500	Durable against 10.5kgf ／m² for type Ⅱ, ϕ1350 to ϕ1500	Durable against 30kgf ／m² for type Ⅲ ϕ1350 to ϕ1500
	Hydraulic Characteristics	Roughness Coefficient (Manning's)	n = 0.013	n = 0.010	n = 0.013
		Velocity Coefficient (Hazen-Willams)	C = 130	C = 150	C = 130
Anti-corrosion and Durability	Anti-corrosion		Weak for acid. Corrosion by hydrogen sulfide generating from sewage and electric corrison on reinforcing bar sometimes occur.	Durable against acid. Is not affected by corrosive and acidic soil. No problem on electric corrosion.	No problem for normal soil. Coastal soil with high salinity and high acidic soil sometimes cause corrosion. No problem on electric corrosion.
	Durability		Much experience in Water Works in Peru. Life is 20 years for rubber rings and more for pipes.	Experiences for several years. In Peru, it was used in Chosica Sewerage Project. Life is estimated about 60 years.	Much experience Life is 40 years or more for rubber rings and semipermanent for pipes.

TABLE A16-1 COMPARISON OF PIPE MATERIALS - 2

		PCP	FRPM	DCIP
Anti-corrosion and Durability	Accident	Break down due to to high inner pressure with 15 kgf/m² on φ500 to φ900mm — 2 cases in Lima southern district Break down due to to corrosion with a pressure of 6 to 7 kgf/m² on φ600 to φ800mm — 2 cases in Lima southern district (past 3 years) (refer to APPENDIX 1)	No report	No report
Joint Performance	Structure of Joint	Round type rubber ring	Square type rubber ring	Combined type rubber ring
	Water-tightness	Durable bending angle is small and short insert length. Less water-tightness.	Large durable bending angle and long insert length. Good water-tightness.	Large durable bending angle and long insert length. Superior water-tightness.
	Durable Bending Angle	less than 3°00'	3°00'～6°00'	1°30'～5°00'
	Workability	Attention should be paid to centering of pipes and twist of rubber rings.	Easy joint work due to light weight and utilization of puller. Experience in Chosica project proves no leakage.	Easy joint work. But skillful labor is necessary for bolt wrenching of mechanical joint due to necessity of securing equalized specifed torque.

TABLE A16-1 COMPARISON OF PIPE MATERIALS - 3

			PCP	FRPM	DCIP
Workability	Weight	φ1350 mm	1,312.8 kg/m (510%)	275.5 kg/m (100%)	673.3 kg/m (260%)
		φ1500 mm	1,592.6 kg/m (500%)	320.0 kg/m (100%)	803.7 kg/m (250%)
		Weight Ratio (FRPM = 1)	5	1	3
	Foundation		Sand or Concrete in accordance with loading condition.	Sand in general.	No specific foundation works.
	Work Speed	φ1350 mm	Work speed — 21.3 m/day Pipe Fitter — 3.15 person Labor — 6.84 person (per 10 m (1.00 person/m)) Jib Crane 15 t	Work speed — 50.0 m/day Pipe Fitter — 0.40 person Labor — 0.80 person (per 10 m (0.12 person/m)) Jib Crane 4.8 t	Work speed — 20.8 m/day Pipe Fitter — 2.07 person Labor — 2.71 person (per 10 m (1.00 person/m)) Jib Crane 15 t
		φ1500 mm	Work speed — 19.2 m/day Pipe Fitter — 4.03 person Labor — 8.87 person (per 10 m (1.29 person/m)) Jib Crane 15 t	Work speed — 48.0 m/day Pipe Fitter — 0.42 person Labor — 1.04 person (per 10 m (0.15 person/m)) Jib Crane 4.8 t	Work speed — 19.2 m/day Pipe Fitter — 2.70 person Labor — 3.58 person (per 10 m (0.62 person/m)) Jib Crane 15 t

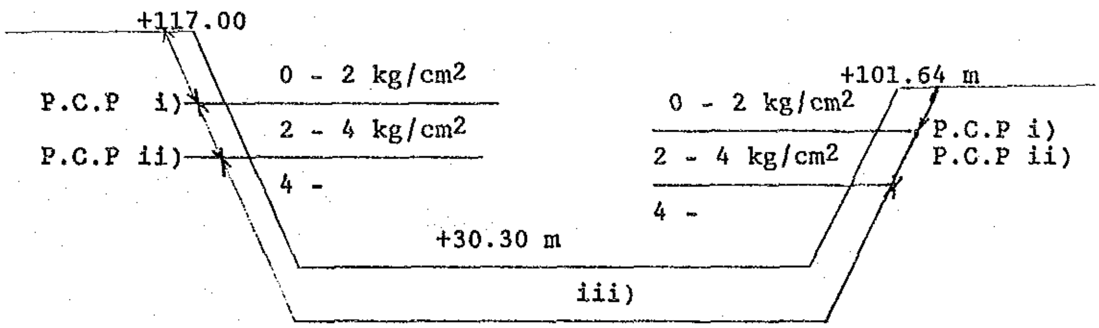
TABLE A16-1 COMPARISON OF PIPE MATERIALS - 4

			PCP			FRPM			DCIP		
Currency			INTIS	US$	RATIO	¥	US$	RATIO	¥	US$	RATIO
Economy	φ1.350	COST	※1 4,021,000	692.60	(100) %	※2 158,735	1,133.82	※3 (164) %	※4 145,123	1,036.59	※5 (150) %
		IMPORT TAX	—	—	—	COST x 96.65 % 153,417	1,095.84	—	COST x 110.45 % 160,288	1,144.91	—
		CONSUMER TAX	COST x 15 % 603,150	103.89	—	(COST +Imp.TAX) x 15 % 46,823	334.45	—	(COST +Imp.TAX) x 15 % 45,811	327.11	—
		TOTAL	4,624,150	796.49	(100) %	358,975	2,564.11	※3 (322) %	351,222	2,508.73	※5 (315) %
	φ1.500	COST	5,273,000	908.21	(100) %	192,990	1,378.50	(152) %	175,851	1,256.08	(138) %
		IMPORT TAX	—	—	—	COST x 96.65 % 186,525	1,332.32	—	COST x 110.45 % 194,227	1,387.34	—
		CONSUMER TAX	790,950	136.23	—	(COST +Imp.TAX) x 15 % 56,927	406.62	—	(COST +Imp.TAX) x 15 % 55,511	396.51	—
		TOTAL	6,063,950	1,044.44	(100) %	436,442	3,117.44	(298) %	425,589	3,039.93	(291) %
	Remarks		※1 Strength for r Inner Pressure 8 kg/m² Rate : US$ $ 1.00 = I/. 5,805.69 US$ $ 1.00 = ¥ 140.00			※2 Type II Strength for Inner Pressure 8 kg/m² Pipe (FOB Yokohama) 92,900 ¥/m Freight, Insurance 65,835 ¥/m 158,735 ¥/m ※3 $\frac{FRPM}{PCP} \times 100$ %			※4 Type III Strength for Inner Pressure 30 kg/m² Pipe (FOB Yokohama) 103,000 ¥/m Freight, Insurance 42,123 ¥/m 145,123 ¥/m ※5 $\frac{DCIP}{PCP} \times 100$ %		

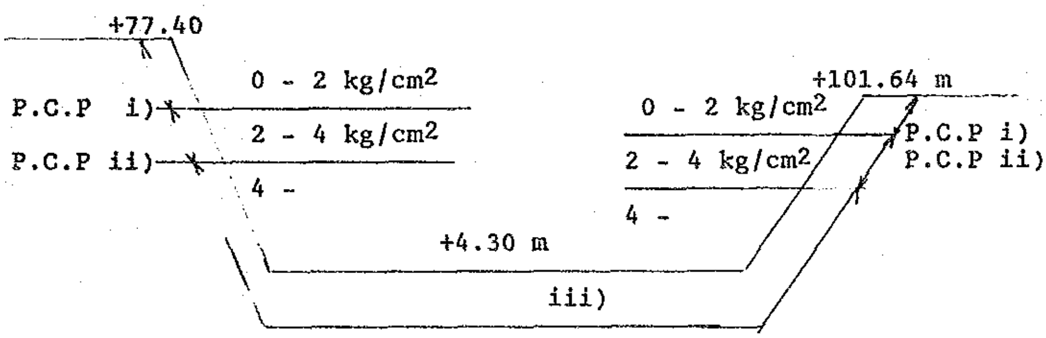
A16.4 Conclusion

(1) Based on the comparison in A16.3, materials of pipes are selected as follows:

Phase I ϕ 1,350 mm



Phase II ϕ 1,200 mm



i) Inner Pressure 0 - 2 kg /cm^2 : P.C.P.
(Durable Inner Pressure 4 kg/cm^2)

ii) Inner Pressure 2 - 4 kg /cm^2 : P.C.P.
(Durable Inner Pressure 6 kg/cm^2)

iii) Inner Pressure above 4 kg /cm^2 : P.C.I.P.

(2) Inner Pressure in Inverted Siphon Section (Plan E_1)

Phase I

Section	Planned Quantity	Ground Elevation Upper End	Bottom	Lower End	Max. Static Water Pressure	Pipe Length	Pipe Length by Pressure less than 2 kg/cm^2	2 - 4 kg/cm^2	more than 4 kg/cm^2
B - C	1.0 t/s	146.10	112.00	136.60	34.1	4,047	2,247	1,800	
D - E	2.0	137.00	100.00	129.00	37.0	5,145	3,995	1,150	
F - G	2.0	117.00	30.30	101.64	86.7	9,785	3,685	600	5,500

Phase II

Section	Planned Quantity	Ground Elevation Upper End	Bottom	Lower End	Max. Static Water Pressure	Pipe Length	Pipe Length by Pressure less than 2 kg/cm^2	2 - 4 kg/cm^2	more than 4 kg/cm^2
A - B	2.0 t/s	92.39	76.00	85.73	16.4	3,350	3,350		
D - E	1.5	77.40		4.87		3,600	1,000	800	1,800
E - F	1.5	4.87	4.30	4.30	73.1	2,250			2,250
F - G	1.5	4.30		65.45		2,750	400	200	2,150
H - I	1.5	57.60	19.00	53.34	38.6	2,500	1,000	1,000	500

APPENDIX 17

ACCIDENT OF PRESTRESSED CONCRETE PIPE

APPENDIX 17 ACCIDENT OF PRESTRESSED CONCRETE PIPE

SEDAPAL has been installing prestressed concrete pipes for inner-pressure pipeline, for water supply networks. Past records of installation and repair of pipeline using prestressed concrete pipes are summed up by SEDAPAL as shown in TABLE A17-1.

According to the table, the total length of installed prestressed concrete pipes is 63,100 meters. Out of those a length of 125 meters had been replaced due to breakage suspected to be caused by corrosion, electrical corrosion and excessive pressure. The replaced length is about 0.2 % of the total length.

Breakdown of broken pipes by cause is as follows:

Total length of installed pipes		63,100 m
Total length of repaired pipes		125 m (6 cases)
Cause :	Corrosion	100 m (3 cases)
	Electrical Corrosion	10 m (1 case)
	Excessive Pressure	15 m (2 cases)

Breakages of prestressed concrte pipes had been occurring at high rate even at present. Such broken pipes were installed with no corrosion protection measure nor were they provided with such protection after they had been installed. Pipelines provided with corrosion protection measure have not been damaged by corrosion. According to the staff of SEDAPAL, it has become a common practice to provide corrosion protection measure at the same time the pipe is installed. FIGUREs A17-1 to A17-3 show typical breakage cases.

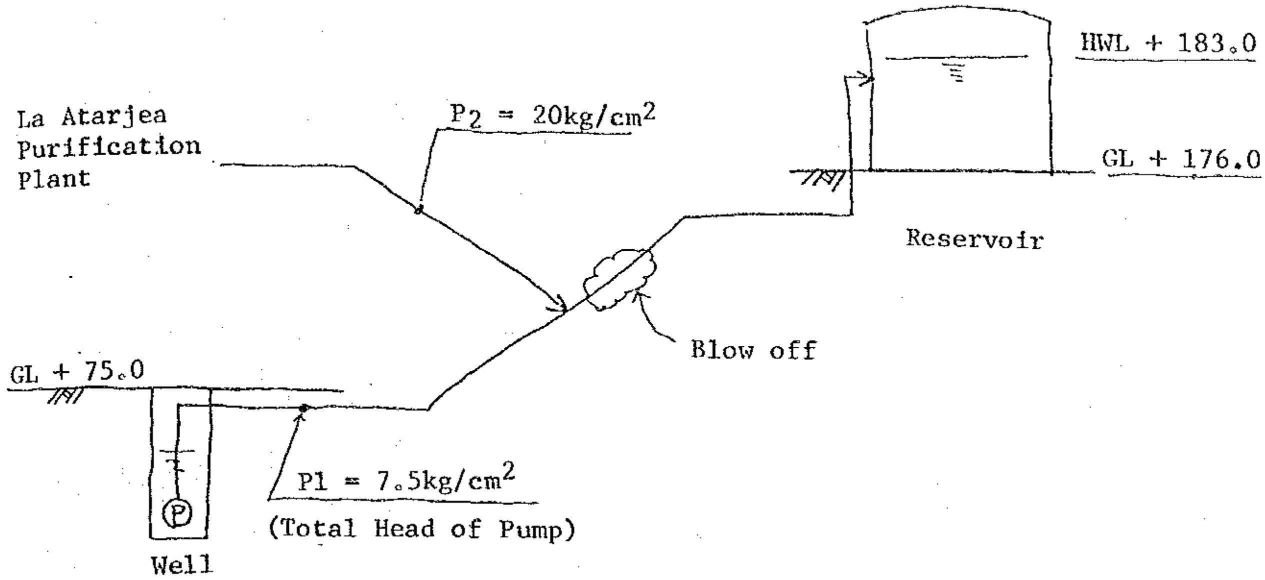
TABLE A17-1 Informe: Instalación y Reparación de tuberías de agua fabricados por Superconcreto

Ubicación LOCATION	FECHA DATE: Tubería PIPE	FECHA DATE: C. PROTECTIO Sis. Prot. Cat.	ESPECIFICACIONES SPEC.: Diám. Diameter	ESPECIFICACIONES SPEC.: Long (mt) Length	ESPECIFICACIONES SPEC.: Presión de Diseño (Atm) Design Press.	Fabricante de las Tuberías MAKER	Presión de Trabajo Working Pressure	REPARACIONES REPAIR: Ubicación LOCATION	REPARACIONES REPAIR: Fecha Reparac. DATE	REPARACIONES REPAIR: Long mt LENGTH	REPARACIONES REPAIR: Presión al momt. de rotura Atm. Pressure of Breakage	REPARACIONES REPAIR: observaciones Observations
Atarjea - Rímac	82 - 04	82 - 04	64" - 14"	12,600	6- 17 Atm	Super-Concret.	0-10 Atm	(Hasta la fecha,	ninguna	rotura)		—
Atarjea- San Juan de Miraflores (Proceres)	75 - 08	–	72" - 36"	14,000	3- 15 "	Super-Concret.	0-14 "	(" " "	"	")		—
Proceres - Villa S.	80 - 07	84 - 01	24"	7,500	17- 20 "	Super-Concret.	8-12-0 "	Paq. Zonal Huayna Capac- S.J.M.	11 rotur. Del 83-86	50 m.	12	Corros. Avanz. Corrosion
Proceres - CR4	80 - 07	84 - 01	24"	6,000	17- 20 "	Super-Concret.	2-6-0 "	Sn. J. de Miraflor.	2 rotur. Del 87-86	10 m.	7	Corros. Avanz. se modif. proyecto presión actual 5 atm. Electrical Corrosion
CR4 - Villa Salvad.	85 - 02	85 - 02	20"	1,500	15- 10 "	Super-Concret.	0-9 "	Vill. El Salvador	88 -03	5 m.	15	Sob. presión Excessive Pressure
Villa Salvador (circuito)	- -	—	24"	5,100	15 "	Super-Concret.	4-8 "	" "	87 -05	10 m.	15	Corroc. Avanz. Corrosion
Proceres-Reser2000	72 - 09	—	24" - 20"	4,500	18 - 07 "	Super-Concret.	14-0 "	Sn. J. de Miraflor.	< 1980 2 roturas	10 m.	20	Sobr. presión Excessive Pressure
Angamos - Surquillo	80 - 09	80 - 09	36" - 20"	7,000	10 "	Super-Concret.	4-6 "	(Hasta la fecha,	ninguna	rotura)		
Buenos Aires-Callao	75 - 05	75 - 05	24"	1,000	10 "	Super-Concret.	4-5 "	(" " "	"	")		
Zarate -C. Grande	83 - 07	85 - 01	32"	3,900	15 "	Super-Concret.	0-5 "	Av. Proc. de Indep.	6 roturs. Del 84-89	40 m.	6	Corros. Avanz. Corrosion

OCTUBRE 31, 1989.

Servicio de Agua Potable y Alcantarillado de Lima — Sub Gerencia

Servicio de Agua Potable y Alcantarillado de Lima — Div. Redes Matrices de Agua



Change of main transmission line from the existing well pump line (P_1) to the line from Atarjea (P_2) caused breakage due to excessive pressure.

FIGURE A17-1 BREAKAGE BY EXCESSIVE PRESSURE

(Proceres - Reser 2000)

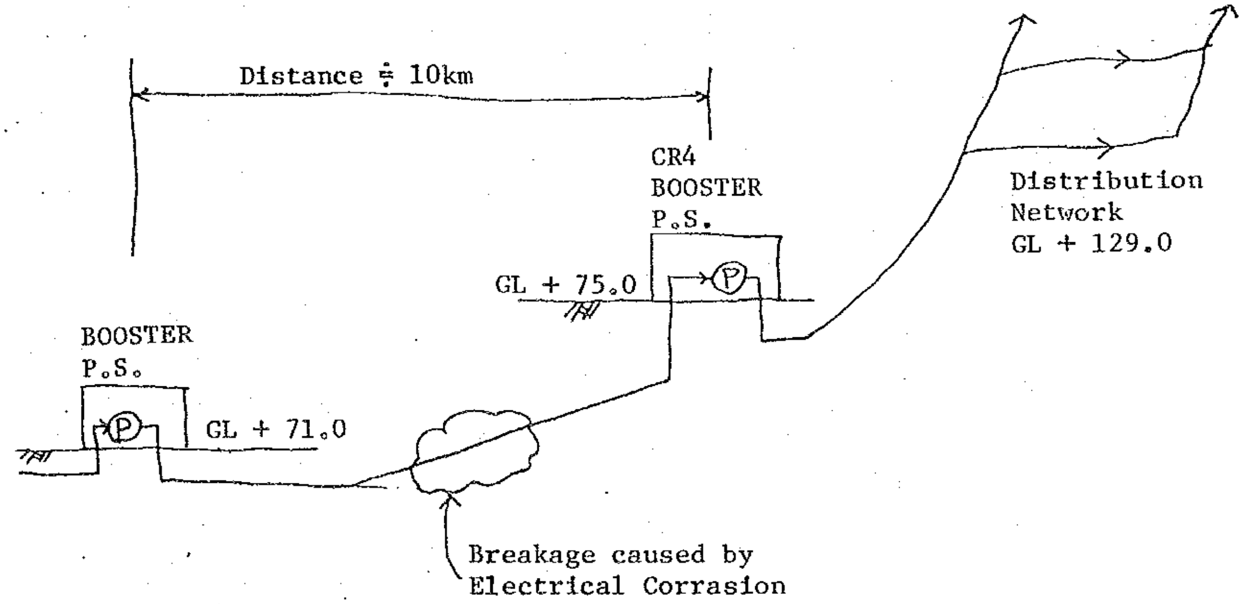
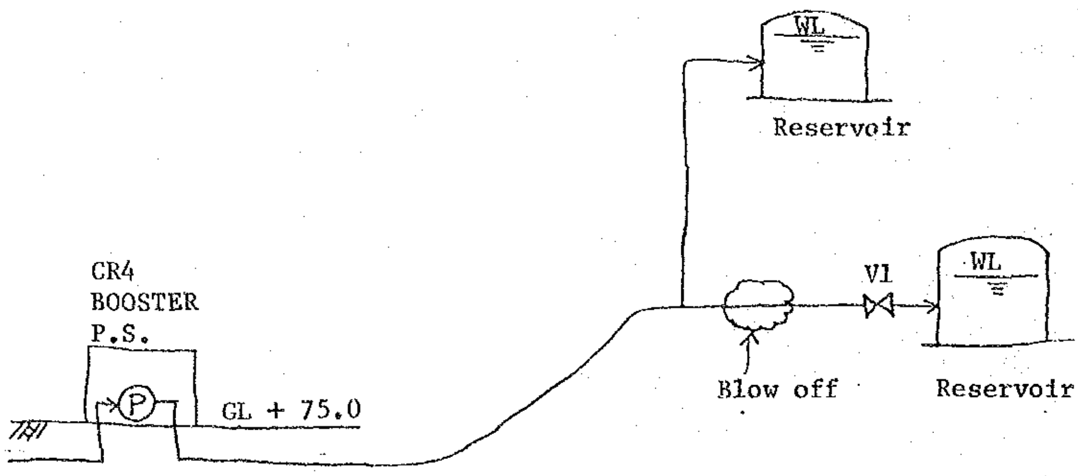


FIGURE A17-2 BREAKAGE BY ELECTRICAL CORROSION

(Proceres - CR4)



When the booster pump was started at the time that the inlet valve of reservoir closed, increase of inner pressure broke the pipe.

FIGURE A17-3 BREAKAGE BY EXCESSIVE PRESSURE
(CR4 - Villa El Salvador)

APPENDIX 18

FITTINGS AND SMALL STRUCTURES FOR TRANSMISSION LINE

APPENDIX 18 FITTINGS AND SMALL STRUCTURES FOR TRANSMISSION LINE

Various small structures are necessary in pipeline construction. The following typical drawings show the concept of such structures.

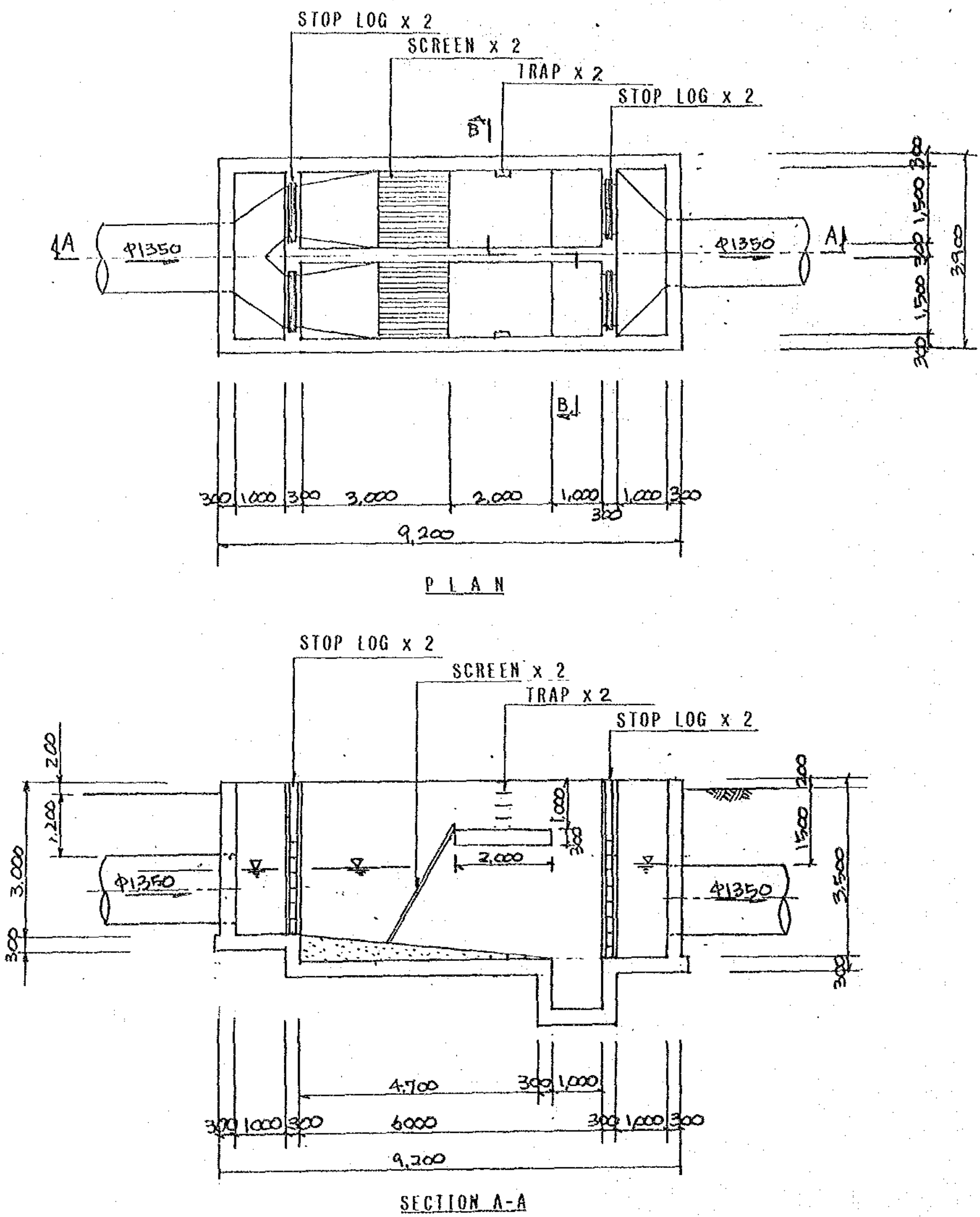


FIGURE A18-1 Inlet Chamber for Inverted Siphon

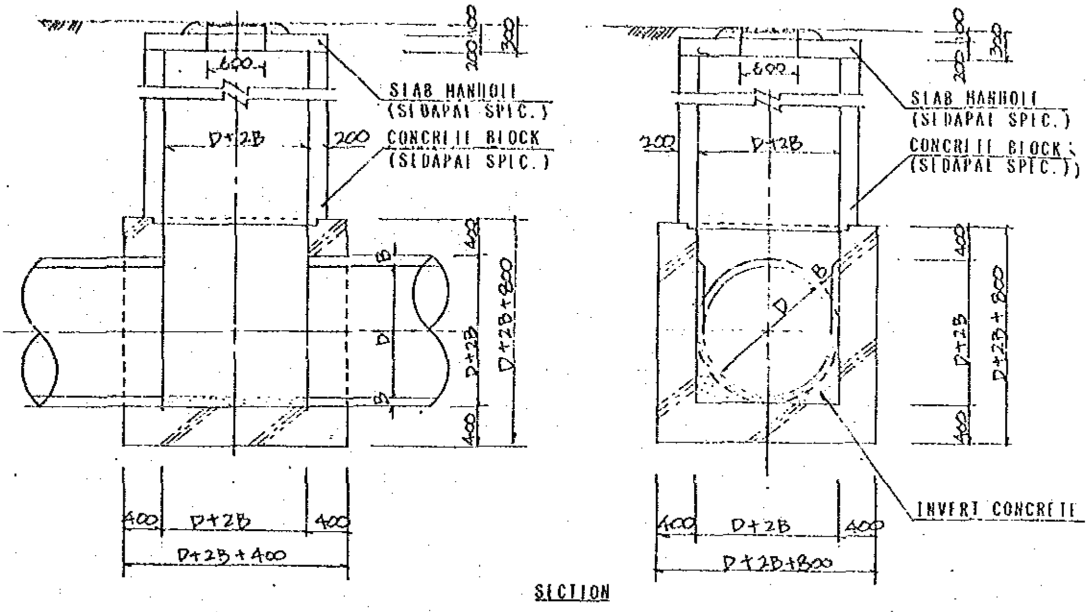


FIGURE A18-2 Standard Type of Manhole

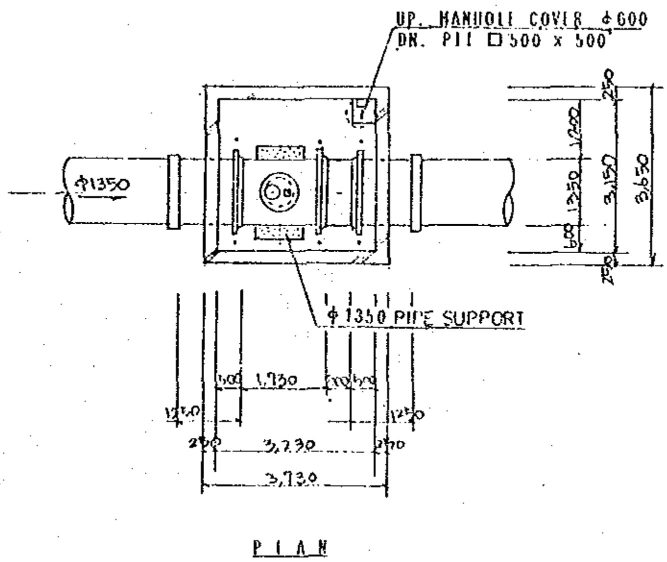


FIGURE A18-3 Air Valve Box

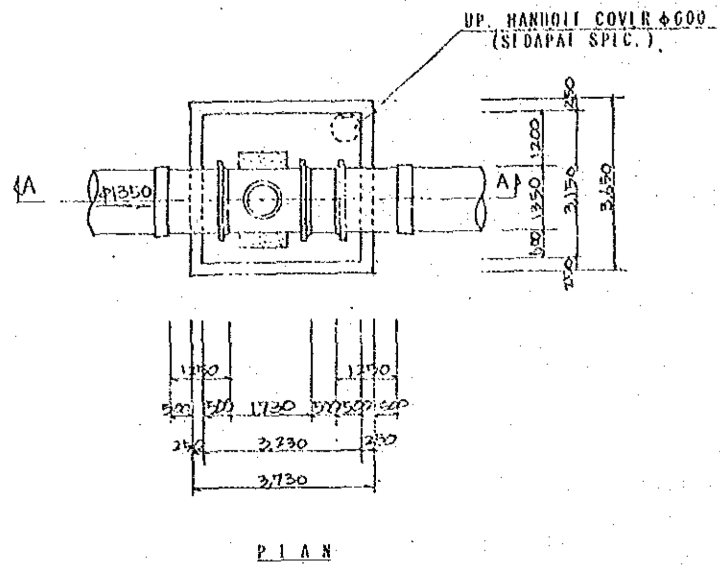


FIGURE A18-4 Inspection Manhole (Pressure Manhole)

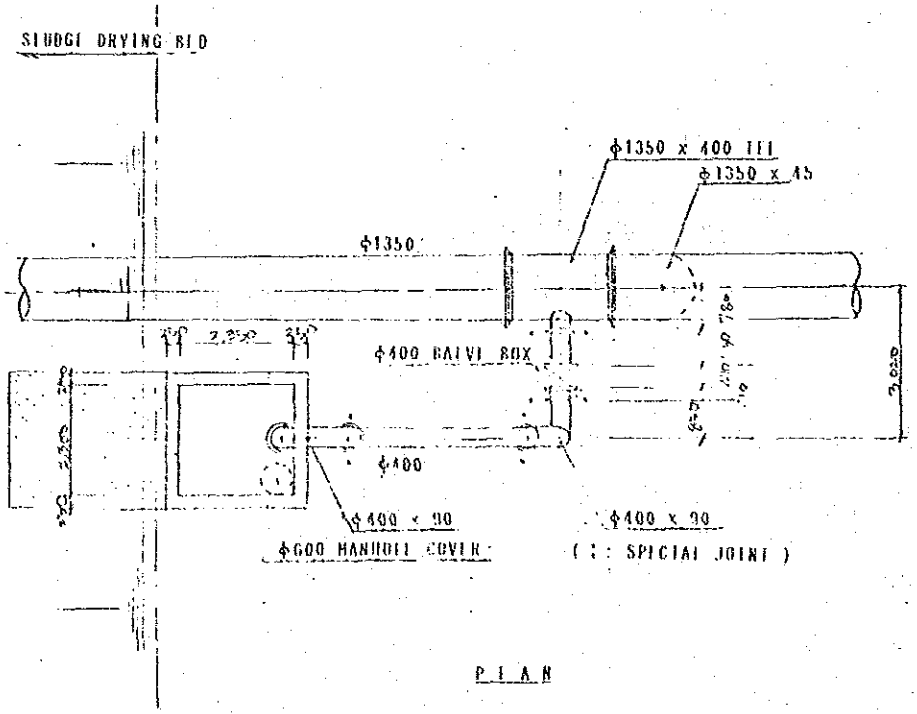


FIGURE A18-5 Plan of Drain (Blow Off Valve)

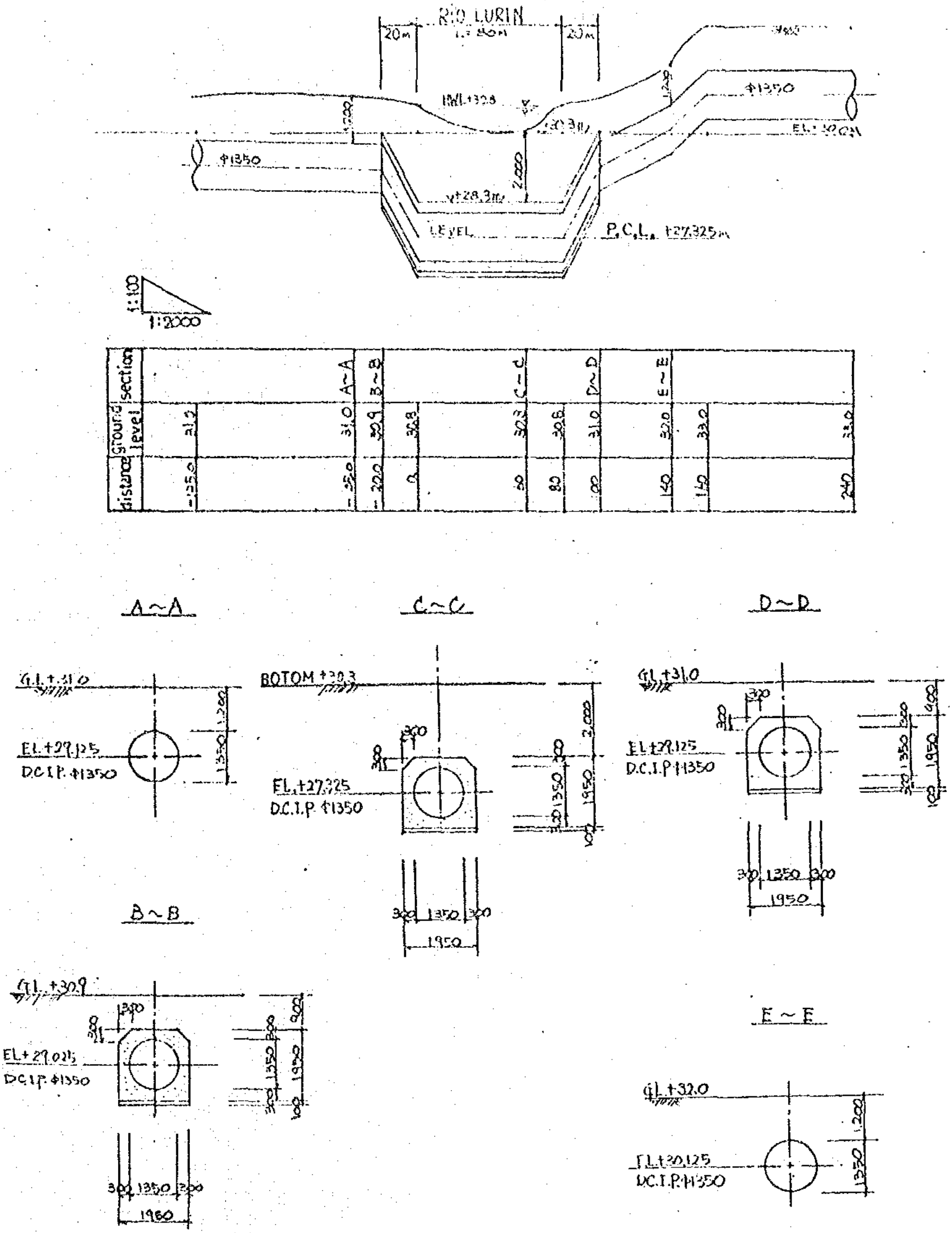


FIGURE A18-6   Rio Lurin Underpass (Phase I)