APPENDIX D REPORT ON QUICK PROJECTS

APPENDIX D-1 WATER LEAKAGE CONTROL IN DILI

D-1.1 Introduction

Most structures of water supply facility were destroyed by the independence conflict in September 1999. Simultaneously, a circumstance of a maintenance and management organization is still annihilating. The UNTAET is being organized a temporary water supply authority. The function of its organization is not yet fully developed. An early restoration and a stable supply of portable water are certainly essential for fundamental development to lead a steady life of the citizens of Dili. The Quick Project has a great and vital responsibility in order to sustain the restoration immediately. A possibility of realization for early restoration for the leakage control was presented to let an investigation of current water supply situation in Dili and to perform a concrete plan for leakage detection, leakage repairs and measures of comprehensive leakage control in the model block.

D-1.2 Objectives

The ratio of leakage in Dili that presently assumes approximately 60 percent would be reduced to 40 percent. At the same time, the countermeasures of improvement would be settled on by examining the causes of the occurrence of leakage and the decline of water pressure. The proposed suggestions for leakage control would be arranged to achieve 40 percent of the ratio of leakage in 2003 and 20 percent in 2010.

D-1.3 Investigation Method

An amount of daily water distribution from four (4) reservoirs that is taken from existing water sources including four (4) surface waters and seven (7) boreholes is measured correctly. The water pressures at 154 households are measured in order to make an investigation of a water pressure distribution. In the area of a remarkable decline of water pressure, the hearing investigation to every house is carried out to inquire into whether there is unusual water supply condition or not and a continuing period. Moreover, a detailed leakage investigation is executed for the suspicious pipes. Among the detectable leakages, the leakage point that needs urgent repairs is repaired immediately. The measures of comprehensive leakage control program are implemented by selecting a model block based upon a result of examination for an existing water supply situation.

D-1.4 The Leakage Investigation And Leakage Reduction Countermeasures in Dili

As a result of analysis and diagnosis of water movements of all pipeline network, water pressure distribution and outflow condition of 150 households in the east bank of the Comoro River and the causes examination of poor outflow as leakage countermeasures of overall facility, there are grave problems to solve. The problems are listed as follows:

- *Due to the intake and treatment facilities do not function entirely, obstacle substances, such as earth and sand, flow in easily inside the pipes.*

The existing intakes are four (4) surface waters (Benamauk, Bemori, Maloa and Bemos) and six (6) boreholes (Kuluhun A, B and Comoro A, B, D, E). Among the four intakes of surface water sources, three (3) water treatment plants (hereinafter WTP) are used currently except Maloa source, which water is transmitted directly to the distribution network without any treatment. In addition, due to there is no grid chamber facility in Benamauk WTP; it is necessary to remove 2 m^3 of accumulated sands from the reservoir once two months. The raw waters of both Benamauk and Maloa intake contain plenty of sands. The sands are piled up inside the pipes with low velocity of water flow. The influence of the accumulation, it is considered that a markedly clogging of pipes causes a phenomenon of poor outflow in the center of the town. On account of the intake facilities are located at the foot of a steep mountain, when it rains, the muddy waters may be poured into the facilities all at once and suspended to take the raw water due to short of the treatment capacity. A control for intake and suspension does not conduct systematically; a cutting off of the water supply from concerned WTP is taken place irregularly.

- *The transmission pipe, the mains and distribution pipe have not sorted out and managed insufficiently.*

The management classification of conveyance and transmission mains is lack of precision. Besides, the laying states of those pipes, which remain in the memory of some engineers who worked for former Dili Water Supply, have not sorted out exactly. Basically, the mains are never connected to the distribution pipe. It is, however, joined not only the distribution pipe but also the service pipe directly. It is uncertain of plumbing process and procedure and there is no data for its condition, such as the drawings. It is thought that a suitable arrangement of both a site and an administrative side are required.

- *The management of water pressure, water quantity and quality in each reservoir has been done, but the management of water movements in the distribution pipes has not operated at all.*

An observation of water pressure distribution within the distribution network, an effective water head is below 20 meters in the whole area. Since absolute water head from each reservoir is more than 55 meters, a loss of the head is 35 meters. The causes of the loss occurrence of 35 meters head are the following:

Rust occurs inside the pipes and a coefficient of flow velocity extremely dropped.

A loss resistance is quite large depend upon its pipeline network structure.

The water is drawn out by wrongful connection before applying pressure.

It is necessary to keep up with a management of water movements the moment implementation for improvement of water supply in future.

- *Illegal connections with careless and inappropriate constructions are conducted by some residents who have a lack of hygiene knowledge as a matter of course.*

The residents of Dili in the great trails of life seek domestic water, particularly drinking water. Each person makes plumbing construction himself or herself connected to a part of ground pipe laying for all kinds of pipe without permission. The constructions of illegal connection are almost faulty and a hotbed of vice leakage. In case of a negative pressure happens, absorbing the wastewater around the pipe would bring about water quality contamination. Moreover, as a result of there is mostly no faucet installed for the illegal connection, un-accounted-for water is discharging and the water demand is increasing relatively. The illegal connection is either the highest possible factor of the decline of water pressure or the actual situation of leakage.

These problems are multiplied to break out the leakage easily and to make the decline of water pressure.

D-1.4.5 Leakage Investigation And Repairs

The potable water in the area of the west bank of Comoro River is supplied from Comoro E borehole. It was very difficult for this area to carry out the leakage investigation due to a chronical water shortage. An objective area for the investigation was 476 km2 with a length of 176.3 km of diameter over 100mm. Among them, the hearing survey and the leakage investigation were carried out against 80 km pipes with abnormal conditions and about 2,200 households in the concerned area. Reached 1,200 of leakage points were detected and 81 points of emergency leakage points were repaired. From the Benamauk reservoir to the main street, 30 pipes connected to transmission and distribution mains without permission were equipped sluice valve and replaced all tapping saddles and taps.

D-1.4.6 Water Pressure Measurement

Water pressures were measured using the momentary water-pressure gauge at 154 households in Dili. The measurement was carried out between 10 May and 20 May as dry season investigation, and between 15 November and 25 November as wet season. In only dry season investigation, it was found out that the Lahane Timur area where the water supply from Bemori water source without treatment has been cut off two (2) years ago. The water supply situation is hardly any water from the heart of Dili Township to the area along the west coast.

In wet season investigation, the condition of the Lahane Timur area was observed substantial improvement of water pressure recovery to 0.4 Mp. Because of impossible to procure the repairing materials of the damaged 400A pipe, there is no significant improvement after the investigation. On the other hand, the decline of water pressure was observed in Santa Cruz area, but unknown causes.

D-1.4.7 Flow Measurement

The potable water of Dili except Hera area distributes from three (3) reservoirs originating in four (4) surface water sources and seven (7) boreholes. An amount of daily water distribution is observed. **Figure D-1** shows water distribution system in Dili. Total amount of water distribution is 16,690 m^3/day (See table for each value). It is thought that 40 percent of daily water distribution is consumed effectively but the rest 60 percent is wasted on the leakage with careless construction and the discharge of water without control.

D-1.4.8 Leakage Investigation

A leakage investigation was carried out all pipelines network except the area of west bank of the Comoro River. Owing to a scarcity of materials and data for present connection and utilized condition, and buried pipe layout, the investigation was implemented to determine hearing directly from the concerned persons of former Dili Water Supply Authority and neighbor residents. Especially, all service pipe connection conditions and installation conditions of water supply devices are confirmed in the distribution area where the water pressure deteriorated remarkably. If there are signs of leakage, the leakage points are specified by a leakage detector.

D-1.4.9 Leakage Repair

A breakdown of eleven (11) points of leakage repairing is six (6) points of ACP pipe and five (5) points of steel pipe. Particularly, the leakage causes by inferiority of rubber packing using at the joint part of bolts. A leakage point of ACP 150A pipe located 1 km downstream of Bemori water source, it has not been taken the water two years ago due to the tree roots have trespassed upon the inside of pipe from the point to obstruct a water path. Many ACP pipes remain using in the center of the town. Although it is required to inspect all rubber packing at the joint part, an inspection has never performed because of inadequate water pressure. 174 points (96.7%) of all leakage in service pipe happened entirely in the steel pipe. The majority of leakage type is bad condition at joint part. It was very difficult to execute a partially repair due to a corrosion is reached a fairly worsen stage in the screws that have no rust prevention and in addition a rubber belt winds around the pipe instead of joint materials.

D-1.4.10 Results

Actual circumstances of leakage occurrence in Dili arise from disorder connection and poor construction skill. An interiority of pipe material is not observed a body of the ACP pipe itself but rubber packing for joint part of ACP pipe. There is no significant interiority against a body of PVC/ACP pipe used for the transmission mains. Only three (3) leakages were detected in the transmission mains laid on a steepness inclination without any protections for caving and falling stones. The current using condition, such as plenty cases of leakage occurrence, disorder connection with poor skills and incontrollable water discharge are multiplied to make deterioration of water pressure. Therefore, the remnant of water head at the tap is still below 1 meter in 2/3 areas of Dili. As countermeasures of leakage control in future, a top priority is set up to prevent from illegal connection and to install the faucet, and it is necessary to equip the service pipe little by little.

D-1.4.11 Comprehensive Leakage Control of the Model Block

For curtailment countermeasures of leakage in Dili, the wide range of investigations must be carry out not only data and drawings arrangement but also maintenance of distribution network and service apparatus. In this investigation, a comprehensive leakage control program is implemented by the establishment of the model block as a trial case. The objectives of the program are the following:

- Dismantling of the illegal connections
- Implementation the program with community participation and deepening the users understanding for water supply
- Restraining useless water equipped with service apparatus at the same time
- Reduction of total inflow volume in the model block

An objective model block is selected for the east bank of the Benamauk River that is non-serviced area until now. There is no laying for the distribution mains in the model block. A household served is 465 houses and a population served is 1169 in the area. Portable water from Benamauk WTP is supplied through two of 50 mm, two of 32 mm and one of 25 mm service pipe connected illegally from the 150 mm of distribution main laying on the opposite bank. These pipes were constructed with faulty techniques and the leakages happen everywhere. Moreover, because there is no service apparatus installed and a vinyl hose is inserted instead of faucet at the end of pipe for most houses, the wasted water is always discharging. In order to improve the present circumstances, it is necessary to perform an appropriate construction of water supply with the residents as a comprehensive leakage control program.

D-1.4.12 Present Conditions of Water Supply

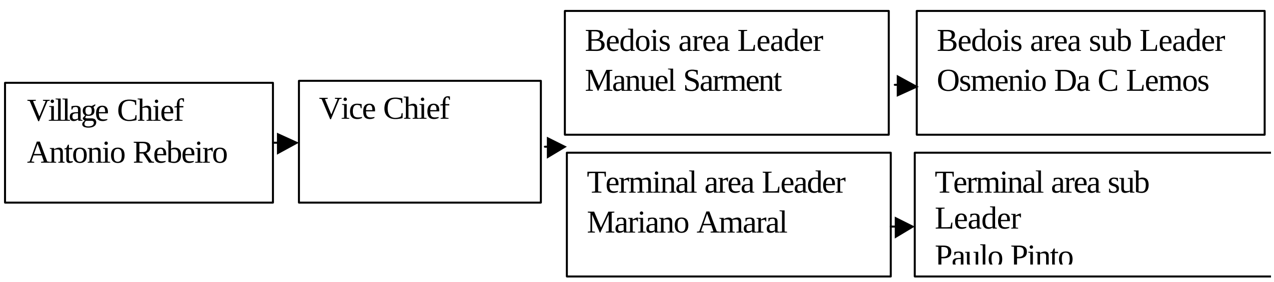
As mentioned above, portable water for the model block is supplied through two of 50 mm, two of 32 mm and one of 25 mm service pipe connected illegally from the Benamauk reservoir through the 150A of distribution main. The amount of daily water supply is estimated about 292 m^3. A household served is 465 houses and a population served is 1169 in the model block. Among the household served, a connection of 232 houses was constructed themselves without permission. In addition, the leakage occurs in all pipes because the construction conditions of these facilities are inferior. As a result, tap water is always available for only 56 households. Moreover, even in the 56 households, the water is left discharging because there is no service apparatus, such as a faucet and a valve. For the other 176 households, the residents make use of a public tank because water cannot be reached to each house. To make an improvement of the present conditions, it is thought that the residents in the model block should understand an importance of proper apparatus and a guilty feeling of non-permission connection. However, it is necessary to take similar measures of leakage anywhere in Dili, the model block was made a better choice in consideration of easy dividable by the Benamauk River and uncovered with the distribution mains.

D-1.4.13 Neighborhood Association

The model block includes a whole area of the east bank of the Benamauk River, namely Bedois, Terminal and Centro Benamauk area.

A neighborhood association is organized in each area. A summary of association shows below:

Bedios area



Terminal and Centro Benamauk area

The village chief unifies the each village and has voice to undertake mediation in the various matters and civil troubles within the village. The area leaders of a subordinate association are in a position to support the village chief. On the occasion of implementation for comprehensive leakage control program with the residents participation, a cooperation of the influential persons was required.

D-1.4.14 Site Exploration

The sea level of the model block is varied from 50 meters to 130 meters. The 292.25 m^3/day of portable water is supplied in the model block. The 205 m^3/day (70% of daily water supply) is from the Benamauk reservoir and the rest of 30% is from the Bedios Well. Since the minimum remnants effective water head is established as 15 meters, a target area of direct water supply is decided 232 households that are located until 80 meters below of the sea. In the indirect water supply area, 18 places of the community tap would be provided in around 90 meters of sea level as thoroughly as possible

D-1.4.15 Explanatory Meeting with the Residents of the Model Block

An explanatory material is presented to call on understanding and cooperation of execution for the leakage control program toward the all houses in the model block from October 9 to October 20, 2000. In addition, a briefing session of the program was taken place at JICA Study Team Office in October 13, 2000 attended upon 7 representatives (3 absentees) of the concerned areas. All attendants consented to a cooperation approval and requested to hold an explanatory meeting gathering all residents. A holding of the meeting was informed to the concerned residents from October 16, and the meeting was opened from 17:30 prompt in October 18, 2000. Many demands and expectations were expressed by the representatives and ordinary residents, especially, counting on creation of employment by residents participation.

D-1.4.16 Route Selection

A selection of pipeline route was decided to avoid felling trees for easy construction and then to drive a stake every 20 meters in the presence of landowners and superintendents with the approval. Particularly, a transversal pipeline route of the Benamauk River would try to construct at a part of landslides prevention dam in consideration for floods. A pipeline routes along the public thoroughfare were preferred in Terminal and Bedois area. All pipeline routes are buried more than 0.3 meters underground to prevent an easygoing connection.

D-1.4.17 Execution Procedure

In order to afford an opportunity of employment and to develop a voluntary act, all works and operations were carried out by handwork except crushing concrete, pavement and large rock. Crushed concrete structures and pavements have already restored and the concrete stairs were constructed on both sides of a watercourse that partly uses as a passage to secure in traffic safety. Because there is jammed traffic includes heavyweight vehicles in a transversal part of a trunk road between Centro Benamauk and Terminal, a buried depth is set up 0.6 meters using a 150A of GIP with a sheath pipe . For other routes, the buried depth is established 0.3 meters and over due to little traffic and few heavyweight vehicles. As to some routes of private land, the head of a household decided himself or herself its route. A management of construction as shown a table below is executed to divide into four (4) construction areas in accordance with a work schedule and quality control procedure.

Construction Area	Type And Size Of Pipe	Construction Period	Extension (m)
1	PVC, 100A	26 Oct.-10 Dec.	1,240
2	PVC, 80A	10 Nov.-10 Dec.	1,100
3	PVC, 50A	10 Nov.-10 Dec.	3,265
4	PVC, less than 32A	20 Nov.-20 Dec.	8,649

About working health management, wearing shoes is always enforced on the local labors and employed Timorese engineers were stationed each construction site without an accident.

D-1.4.18 Removal of the Existing Pipe

River crossings for two pipes of 50 mm, two pipes of 32 mm and a pipe of 25 mm were removed from the left bank and sealed with caps. At the end of 50 mm pipe, a community tap was installed. All transversal pipes were removed and dealt with never recycling. The pipes with 25 mm or smaller, which is exposed plumbing in the village were also removed 2 meters from junction point. A disposal method of the remaining pipe is instructed by owner.

D-1.4.19 Completion of Construction

Water pressure examination in every construction area was implemented to follow the design criteria of water supply facility of Japan, and then a completion of construction was confirmed. For 32A or smaller incoming pipe and community taps, water pressure examination was carried out at the faucet to make sure whether there is abnormal condition or not. As a result, there is no extraordinary water pressure examination and measurement.

Construction Area	Type And Size Of Pipe	Established Water Pressure, Mpa	Passage Time, Hrs.	Water Pressure Deterioration, Mpa
1	PVC, 100A	1.0	6	0.02

2	PVC, 80A	1.0	6	0.02
3	PVC, 50A	1.0	6	0.01
4	PVC, less than 32A	-	-	-

D-1.5 Conclusion and Recommendation

A distribution network structure of Dili has been formed with repeated partly extension to meet the demand of water supply. Because of insufficient functions for intake, treatment and distribution, it is quite difficult condition to secure an ordinary and stable water supply. The most residents demand to distribute the portable water with fairness and steadiness. Some residents have justly done for own connections without permission and malice to meet its demand. On the humanitarian grounds, it is impossible to remove illegal connection pipes although the leakage control program. It is, however, obvious that illegal connections without permission become a hotbed of leakage. If a stable water supply has not been realized, it is easily supposed that the repairs and illegal connections will be got caught a vicious circle. It is desirable that similar leakage countermeasures as well as the implemented programs in the model block will be performed in the whole area of Dili. Above all, training of maintenance technician takes first priority over. Basic maintenance duties are mainly visual inspections and water pressure measurement of distribution network, service apparatus and water supply conditions and hearing a leakage sound by Sound Bar with the technicians round of visits for all over the service area. It is very difficult to supply the water stably because of short of trained technician who can carry out those duties satisfactorily. For instance, in spite of there was a clogged pipe located in 1 km downstream of Bemori intake and there was a broken PVC-400A pipe located in 0.5 km downstream of Bemos WTP, these problems have been left over without appropriate measures. These conditions can be found by round of visits. In order to secure the stable water supply in Dili, it is necessary to take improvement of intake, treatment and distribution facilities. Naturally, all facilities will happen something wrong by superannuating and accidents. The improvement of water supply can never step forward without not only hardware and facility maintenance expertise but also substantial administrative management. Especially, it is indispensable that pipe maintenance technicians must train in concerning skills and a maintenance team should be organized as soon as possible.

Table D-1 DATA ON PRESSURE MEASUREMENT

No.	Village Name	Measurement House Number			
		No water	0.00～0.10 MPa	0.10～0.20 MPa	Over 0.2MPa
1	Metiaut	--------	----------	-----------	----------
2	Bidau Santana		2		
3	Camea		2		
4	Bairo Central	6			
5	Bidau Lecidere		3		
6	Bairo Formoja	6			
7	Bairo Grilos	2			
8	Akadiruhun	1	2		
9	Becora		6		
10	Santa Cruz			4	
11	Bemori			14	3
12	Kuluhun		2		
13	Lahane Timur	2	15	22	5
14	Balibar	-------	---------	---------	--------
15	Motael	21	14		35
16	Colmera		6		
17	Caicoli		7		
18	Bispo Madeiro	5	13		
19	Vilaverde	11	6		
20	Lahane Barat	---------	--------	---------	---------
21	Fatuhada	12	6		
22	Alor	20	3		
23	Bairo Pite	17	24		
24	Dare	--------	---------	---------	---------
25	Comoro		80		
	TOTAL	**124**	**191**	**50**	**43**

Table D-2 DATA ON FLOW MEASUREMENT

Site	Name	For	Dia, mm	Date	Flow Ltr/sec
Intake					
	Bemori	Distribution	150	27Nov	13.4
	Maloa	Distribution	150	30 Nov	4.7
Reservoir					
	Benamauk	Transmission	150	16Nov	27.0
		Distribution	100	16Nov	16.5
		Distribution	150	23Nov	Not full
		Distribution	50	23Nov	2.7
		Distribution	50	23Nov	2.8
	Lahane	Distribution	150	5Jun	20.0
		Distribution	150	5Jun	28.1
		Distribution	200	5Jun	21.4
	Bemos	Distribution	400	29May	17.3
	Comoro	Distribution	300	30May	13.9
Bore Hole					
	Kuluhun- A	Transmission	150	30May	30.0
	Kuruhun- B	Distribution	150	30May	13.3
	Comoro- A	Distribution	150	31May	33.3
	Comoro- B	UNTAET	150	31May	34.7
	Comoro- E	Transmission	150	31May	30.0
	Bedois	Transmission	50	19Oct	1.0
Illegal	Benamauk	Distribution	50	24Nov	1.8
		Distribution	50	24Nov	1.9
		Distribution	32	24Nov	0.3
		Distribution	20	24Nov	0.13
		Distribution	20	24Nov	0.09
		Distribution	20	24Nov	0.11

Table D-3 SUMMARY OF LEAKAGE REPAIR (PIPE LOCATION)

No.	Village Name	Pipe Diameter					Total
		1”3/4	2”	3”	6”	8”	
1	Metiaut						
2	Bidau Santana						
3	Camea						
4	Bairo Central						
5	Bidau Lecidere						
6	Bairo Formoja						
7	Bairo Grilos						
8	Akadiruhun						
9	Becora	12	2	14	18		46
10	Santa Cruz		1	1			2
11	Bemori	3	6	2			11
12	Kuluhun		6	8	2		16
13	Lahane Timur					2	2
14	Balibar						
15	Motael			1			1
16	Colmera						
17	Caicoli						
18	Bispo Madeiro						
19	Vilaverde			1	10		11
20	Lahane Barat						
21	Fatuhada						
22	Alor						
23	Bairo Pite						
24	Dare						
25	Comoro		1	3			4
	TOTAL	**15**	**16**	**30**	**30**	**2**	**93**

Table D-4 SUMMARY OF LEAKAGE REPAIR (TYPE)

No.	Village Name	Simple Connection	Hole	Joint Seal	Corrosion	Total
1	Metiaut					
2	Bidau Santana					
3	Camea					
4	Bairo Central					
5	Bidau Lecidere					
6	Bairo Formoja					
7	Bairo Grilos					
8	Akadiruhun					
9	Becora	41	2	3		46
10	Santa Cruz	1			1	2
11	Bemori	4	5	2		11
12	Kuluhun	6	1	9		16
13	Lahane Timur			2		2
14	Balibar					
15	Motael	1				1
16	Colmera					
17	Caicoli					
18	Bispo Madeiro					
19	Vilaverde	10		1		11
20	Lahane Barat					
21	Fatuhada					
22	Alor					
23	Bairo Pite					
24	Dare					
25	Comoro			4		4
	TOTAL	**63**	**8**	**21**	**1**	**93**

Table D-5 DATA ON PIPE NETWORK ANALYSIS OF MODEL BLOCK - DILI (NODE DATA)

-1			Input Data					Results		
NO	Node Name	Source Head (m)	Demand (m^3/s)	Altitude (m)	X Coordinates	Y Coordinates	Total Head (m)	Pressure Head (m)	Source Inflow (m^3/s)	
919	N951	110.00	0.00000	105.00	36.9	191.1	110.00	5.00	0.00162	
920	N1067		0.00000	108.50	35.8	189.6	109.99	1.49		
1051	N1068		0.00000	102.00	37.3	189.0	109.97	7.97		
1052	N1069		0.00000	95.00	41.6	175.9	109.88	14.88		
1053	N1070		0.00000	87.00	42.3	163.0	109.80	22.80		
1054	N1071		0.00000	86.50	39.2	156.3	109.75	23.25		
1055	N1072		0.00000	80.00	40.8	155.8	109.73	29.73		
1056	N1073		0.00000	80.00	42.9	154.9	109.72	29.72		
1057	N1074		0.00000	88.00	44.9	154.3	109.70	21.70		
1058	N1076		0.00005	68.00	30.7	107.4	109.35	41.35		
1059	N1077		0.00002	65.00	38.2	80.4	109.26	44.26		
1060	N1078		0.00007	65.00	40.3	81.4	109.23	44.23		
1061	N1079		0.00003	80.00	55.8	90.7	109.21	29.21		
1062	N1080		0.00006	60.00	43.3	69.7	109.16	49.16		
1063	N1081		0.00007	58.00	46.8	50.4	109.07	51.07		
1064	N1082		0.00002	58.60	52.3	29.4	108.99	50.39		
1065	N1083		0.00004	58.60	55.8	15.7	108.98	50.38		
1066	N1084		0.00003	61.00	62.4	13.3	108.98	47.98		
1067	N1085		0.00002	65.00	69.2	2.4	108.98	43.98		
1068	N1087		0.00007	82.00	40.8	105.5	109.25	27.25		
1069	N1088		0.00008	75.00	46.8	102.3	109.23	34.23		
1070	N1089		0.00002	58.80	54.9	29.9	108.97	50.17		
1071	N1090		0.00001	59.50	58.8	30.3	108.96	49.46		
1072	N1091		0.00001	63.00	64.4	30.7	108.95	45.95		
1073	N1092		0.00003	66.60	70.4	31.4	108.95	42.35		
1074	N1093		0.00003	68.70	75.2	31.9	108.95	40.25		
1075	N1094		0.00003	69.90	74.4	41.1	108.95	39.05		
1076	N1098		0.00004	60.00	53.8	40.8	108.96	48.96		
1077	N1095		0.00004	65.00	69.8	40.8	108.95	43.95		
1078	N1096		0.00002	65.00	63.7	41.4	108.95	43.95		
1079	N1099		0.00002	59.71	59.2	30.3	108.96	49.25		
1080	N1097		0.00001	62.50	58.7	40.9	108.96	46.46		
1081	N1100		0.00002	62.67	63.9	30.7	108.95	46.28		
1082	N1101		0.00004	63.50	66.2	21.3	108.95	45.45		
1083	N1102		0.00003	55.00	46.8	27.6	108.98	53.98		
1084	N1103		0.00002	54.50	41.8	26.9	108.98	54.48		
1085	N1104		0.00003	57.00	49.8	16.1	108.98	51.98		
1086	N1105		0.00003	58.00	44.6	15.9	108.98	50.98		
1087	N1106		0.00002	55.50	45.3	33.3	108.98	53.48		
1088	N1107		0.00001	83.00	57.9	90.3	109.21	26.21		
1089	N1108		0.00002	86.00	59.8	89.0	109.21	23.21		
1090	N1118		0.00003	81.04	36.3	134.2	109.56	28.52		
1091	N1121		0.00004	78.92	34.6	129.1	109.47	30.55		
1092	N1119		0.00007	92.00	39.3	133.4	109.53	17.53		
1093	N1120		0.00005	90.00	38.1	129.3	109.50	19.50		
1094	N1122		0.00005	67.55	31.8	103.3	109.33	41.78		
1095	N1075		0.00004	75.80	51.5	88.1	109.21	33.41		
48	N1109		0.00002	72.00	52.5	84.6	109.16	37.16		
49	N1110		0.00002	72.00	55.7	82.3	109.12	37.12		
50	N1111		0.00004	72.00	56.1	75.3	109.06	37.06		
51	N1112		0.00004	69.00	57.6	70.5	109.02	40.02		
52	N1113		0.00006	63.00	55.0	67.8	109.01	46.01		
53	N1114		0.00005	70.00	57.3	52.5	108.97	38.97		
54	N1115		0.00004	70.00	59.1	49.3	108.96	38.96		
55	N1116		0.00002	69.00	57.9	46.5	108.96	39.96		
56	N1117		0.00001	62.88	59.4	41.0	108.96	46.08		

Table D-6 DATA ON PIPE NETWORK ANALYSIS OF MODEL BLOCK - DILI (PIPE DATA)

Input Data									Results			
NO	Pipe Name	Start Node	End Node	Demand (m^3/s)	Type Pipe : P Pump : PM Valve : V Red. V : VA Fix Head : E Fix Flow : J	Roughness Coeff. Coeff. A Loss Coeff. Start(S)/End(E) Head Loss (m) Flow (m3/s)	Length(m) Coeff. B ---------------- Head(m)	Diameter(m) Coeff. C Diameter(m) Diameter(m)	Flow (m^3/s)	Head Loss (m)	Veloc. (m/s)	Loss Coeff.
912	P971	N951	N1067	0.00000	P	120.0	19.2	0.100	0.00162	0.01	0.207	
1101	P1129	N1067	N1068	0.00000	P	130.0	16.2	0.100	0.00162	0.01	0.207	
1102	P1130	N1068	N1069	0.00000	P	130.0	137.6	0.100	0.00162	0.09	0.207	
1103	P1131	N1069	N1070	0.00000	P	130.0	129.2	0.100	0.00162	0.09	0.207	
1104	P1132	N1070	N1071	0.00000	P	130.0	74.5	0.100	0.00162	0.05	0.207	
1105	P1133	N1071	N1072	0.00000	P	130.0	17.1	0.100	0.00162	0.01	0.207	
1106	P1134	N1072	N1073	0.00000	P	130.0	22.8	0.100	0.00162	0.02	0.207	
1107	P1135	N1073	N1074	0.00000	P	130.0	20.4	0.100	0.00162	0.01	0.207	
1108	P1136	N1074	N1118	0.00000	P	130.0	218.6	0.100	0.00162	0.15	0.207	
1109	P1138	N1076	N1122	0.00000	P	130.0	42.0	0.100	0.00139	0.02	0.176	
1110	P1139	N1077	N1078	0.00000	P	130.0	23.5	0.075	0.00107	0.03	0.241	
1111	P1140	N1078	N1075	0.00000	P	130.0	130.8	0.075	0.00032	0.02	0.072	
1112	P1141	N1078	N1080	0.00000	P	130.0	120.8	0.075	0.00068	0.07	0.154	
1113	P1142	N1080	N1081	0.00000	P	130.0	196.8	0.075	0.00063	0.09	0.142	
1114	P1143	N1081	N1082	0.00000	P	130.0	216.8	0.075	0.00056	0.08	0.126	
1115	P1144	N1082	N1083	0.00000	P	130.0	141.2	0.075	0.00021	0.01	0.047	
1116	P1145	N1083	N1084	0.00000	P	130.0	70.2	0.075	0.00013	0.00	0.030	
1117	P1146	N1084	N1085	0.00000	P	130.0	128.6	0.075	0.00002	0.00	0.005	
1118	P1149	N1087	N1088	0.00000	P	130.0	68.5	0.050	0.00018	0.02	0.094	
1119	P1150	N1088	N1079	0.00000	P	130.0	146.4	0.050	0.00010	0.02	0.051	
1120	P1151	N1082	N1089	0.00000	P	130.0	27.7	0.050	0.00023	0.01	0.115	
1121	P1152	N1089	N1090	0.00000	P	110.0	39.5	0.050	0.00012	0.01	0.063	
1122	P1153	N1090	N1099	0.00000	P	130.0	3.2	0.050	0.00019	0.00	0.097	
1123	P1154	N1091	N1092	0.00000	P	130.0	60.5	0.050	0.00007	0.00	0.036	
1124	P1155	N1092	N1093	0.00000	P	130.0	48.2	0.050	0.00003	0.00	0.016	
1125	P1156	N1093	N1094	0.00000	P	130.0	91.8	0.050	0.00001	0.00	0.003	
1126	P1160	N1089	N1098	0.00000	P	110.0	108.7	0.050	0.00008	0.01	0.042	
1127	P1157	N1092	N1095	0.00000	P	130.0	93.2	0.050	0.00001	0.00	0.003	
1128	P1158	N1091	N1096	0.00000	P	130.0	106.8	0.050	-0.00001	0.00	-0.005	
1129	P1153_2	N1099	N1100	0.00000	P	130.0	44.7	0.050	0.00013	0.01	0.066	
1130	P1159	N1099	N1097	0.00000	P	130.0	106.6	0.050	0.00004	0.00	0.022	
1131	P1161	N1094	N1095	0.00000	P	130.0	46.6	0.050	-0.00003	0.00	-0.014	
1132	P1164	N1097	N1098	0.00000	P	130.0	49.5	0.050	-0.00004	0.00	-0.022	
1133	P1165	N1090	N1084	0.00000	P	130.0	173.3	0.050	-0.00008	-0.01	-0.040	
1134	P1153_2_2	N1100	N1091	0.00000	P	130.0	5.0	0.050	0.00007	0.00	0.038	
1135	P1167	N1100	N1101	0.00000	P	130.0	97.1	0.050	0.00004	0.00	0.020	
1136	P1168	N1082	N1102	0.00000	P	110.0	56.9	0.050	0.00010	0.01	0.051	
1137	P1169	N1102	N1103	0.00000	P	110.0	51.4	0.050	0.00003	0.00	0.016	
1138	P1170	N1102	N1104	0.00000	P	110.0	117.9	0.050	0.00002	0.00	0.009	
1139	P1171	N1103	N1105	0.00000	P	110.0	114.6	0.050	0.00001	0.00	0.005	
1140	P1172	N1105	N1104	0.00000	P	130.0	52.6	0.050	-0.00002	0.00	-0.011	
1141	P1173	N1104	N1083	0.00000	P	130.0	60.2	0.050	-0.00003	0.00	-0.017	
1142	P1174	N1102	N1106	0.00000	P	110.0	58.9	0.050	0.00002	0.00	0.012	
1143	P1175	N1079	N1107	0.00000	P	130.0	21.5	0.080	0.00004	0.00	0.007	
1144	P1176	N1107	N1108	0.00000	P	130.0	21.6	0.080	0.00002	0.00	0.004	
1145	P1137_2	N1121	N1076	0.00000	P	130.0	220.6	0.100	0.00143	0.12	0.182	
1146	P1186	N1118	N1119	0.00000	P	110.0	31.3	0.100	0.00159	0.03	0.203	
1147	P1187	N1119	N1120	0.00000	P	110.0	42.2	0.100	0.00152	0.03	0.194	
1148	P1188	N1120	N1121	0.00000	P	110.0	34.5	0.100	0.00147	0.03	0.187	
1149	P1138_2	N1122	N1077	0.00000	P	130.0	238.2	0.100	0.00108	0.08	0.138	
1150	P1189	N1122	N1087	0.00000	P	110.0	94.2	0.050	0.00025	0.08	0.130	
1151	P1162	N1095	N1096	0.00000	P	110.0	61.8	0.050	-0.00006	0.00	-0.029	
1152	P1140_2	N1075	N1079	0.00000	P	130.0	50.9	0.075	-0.00003	0.00	-0.008	
1153	P1109	N1075	N1109	0.00000	P	110.0	37.1	0.050	0.00031	0.05	0.156	
55	P1178	N1109	N1110	0.00000	P	110.0	38.7	0.050	0.00028	0.04	0.144	
56	P1179	N1110	N1111	0.00000	P	110.0	70.6	0.050	0.00026	0.07	0.134	
57	P1180	N1111	N1112	0.00000	P	110.0	50.3	0.050	0.00023	0.03	0.115	
58	P1181	N1112	N1113	0.00000	P	110.0	37.1	0.050	0.00019	0.02	0.095	
59	P1182	N1113	N1114	0.00000	P	110.0	154.6	0.050	0.00013	0.04	0.067	
60	P1183	N1114	N1115	0.00000	P	110.0	36.3	0.050	0.00008	0.00	0.043	
61	P1184	N1115	N1116	0.00000	P	110.0	30.9	0.050	0.00005	0.00	0.024	
62	P1163	N1096	N1117	0.00000	P	110.0	42.2	0.050	-0.00009	-0.01	-0.047	
63	P1163_2	N1117	N1097	0.00000	P	110.0	7.5	0.050	-0.00008	0.00	-0.038	
64	P1185	N1116	N1117	0.00000	P	110.0	57.9	0.050	0.00003	0.00	0.015	

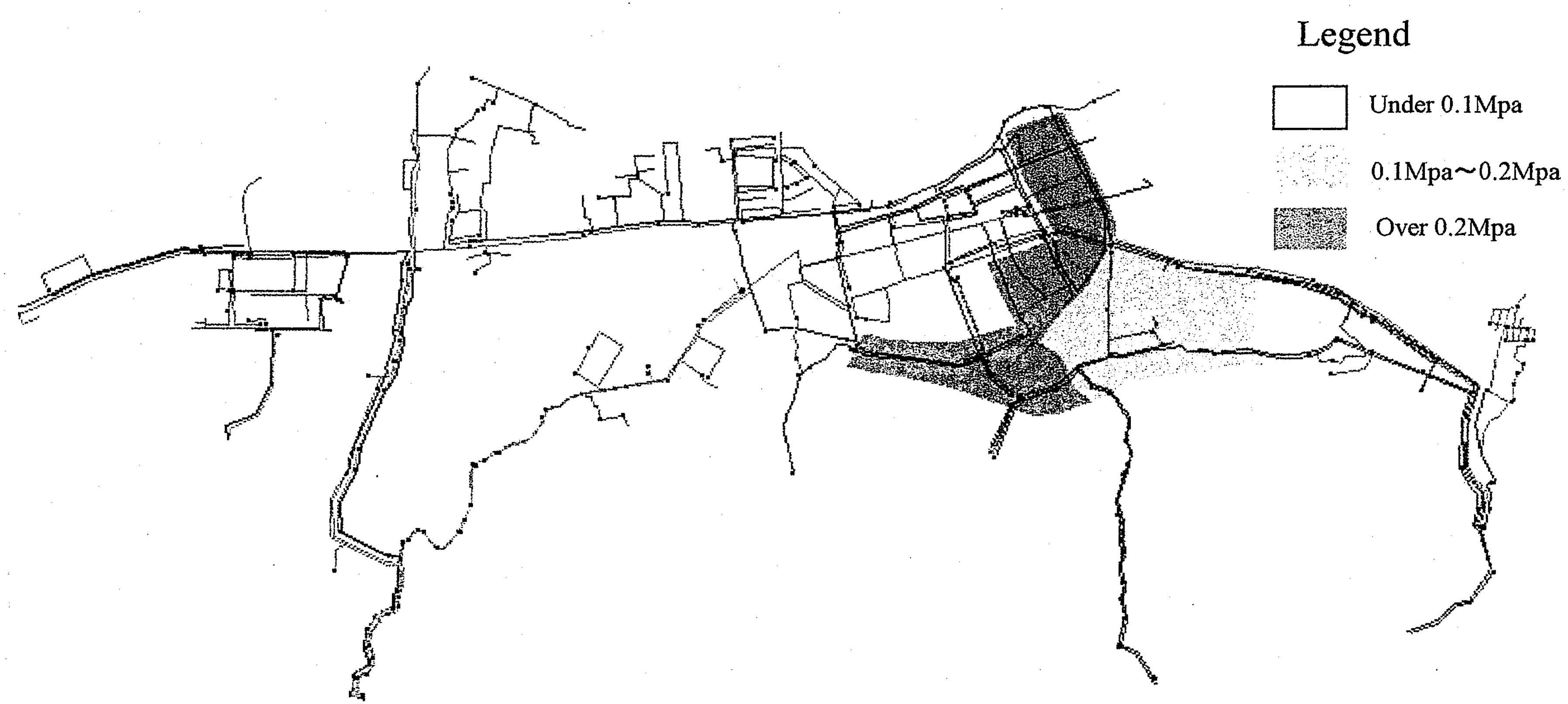


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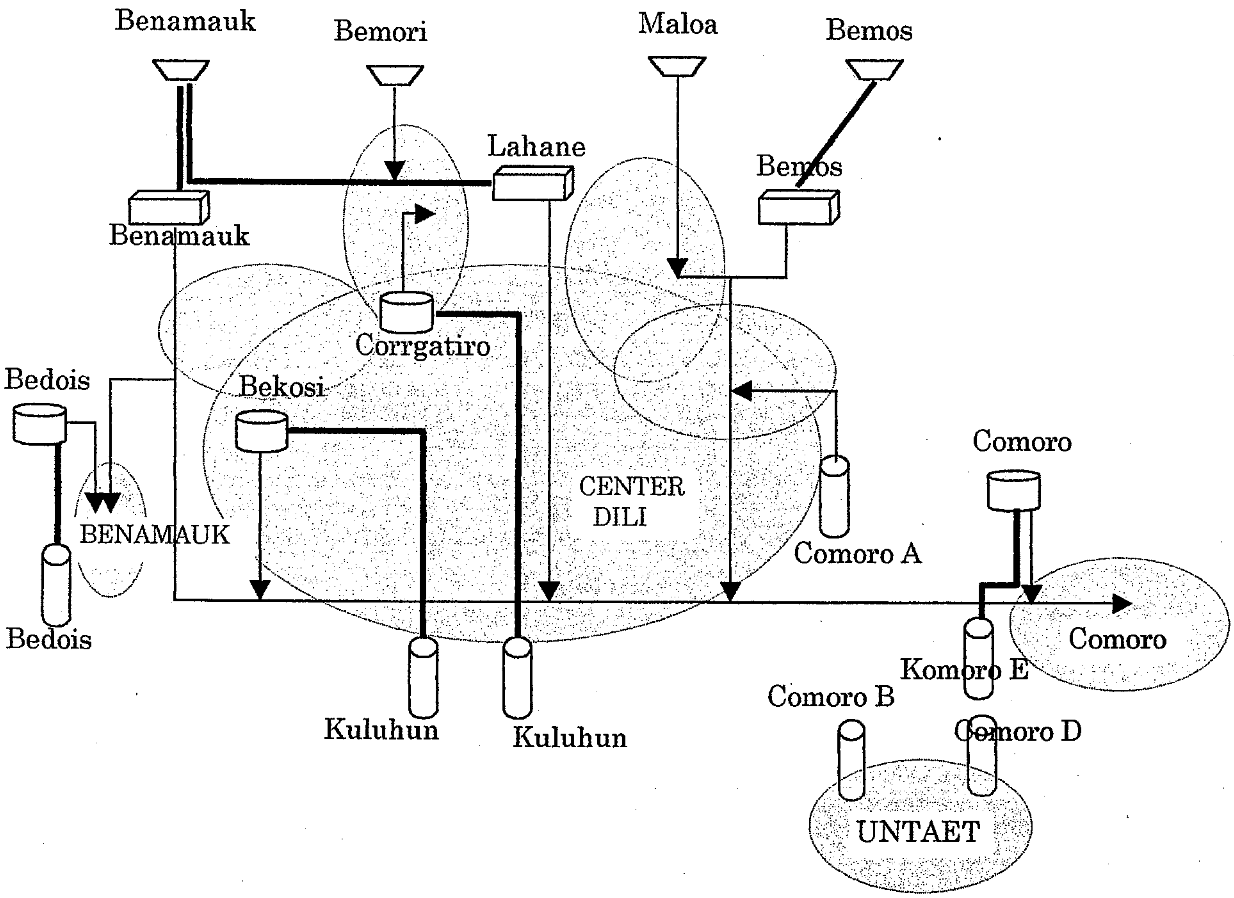
Figure D-1

WATER PRESSURE DISTRIBUTION MAP



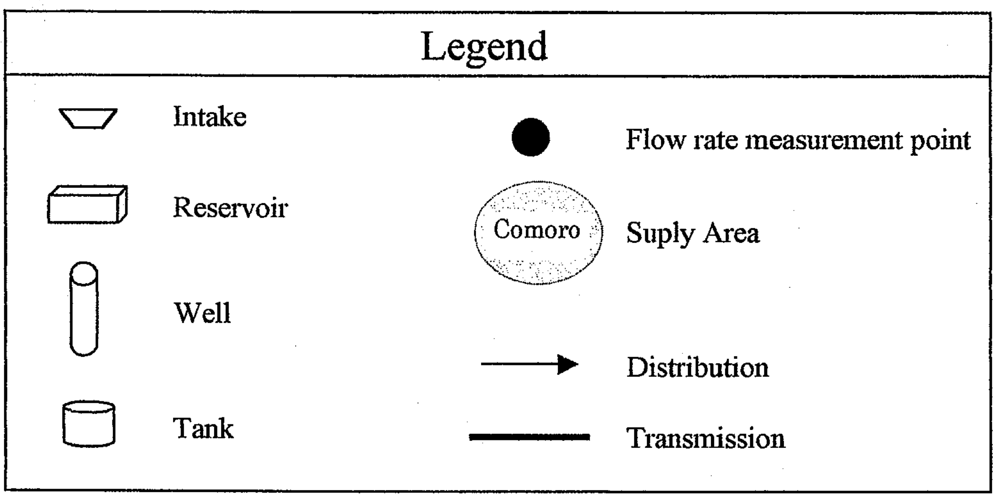


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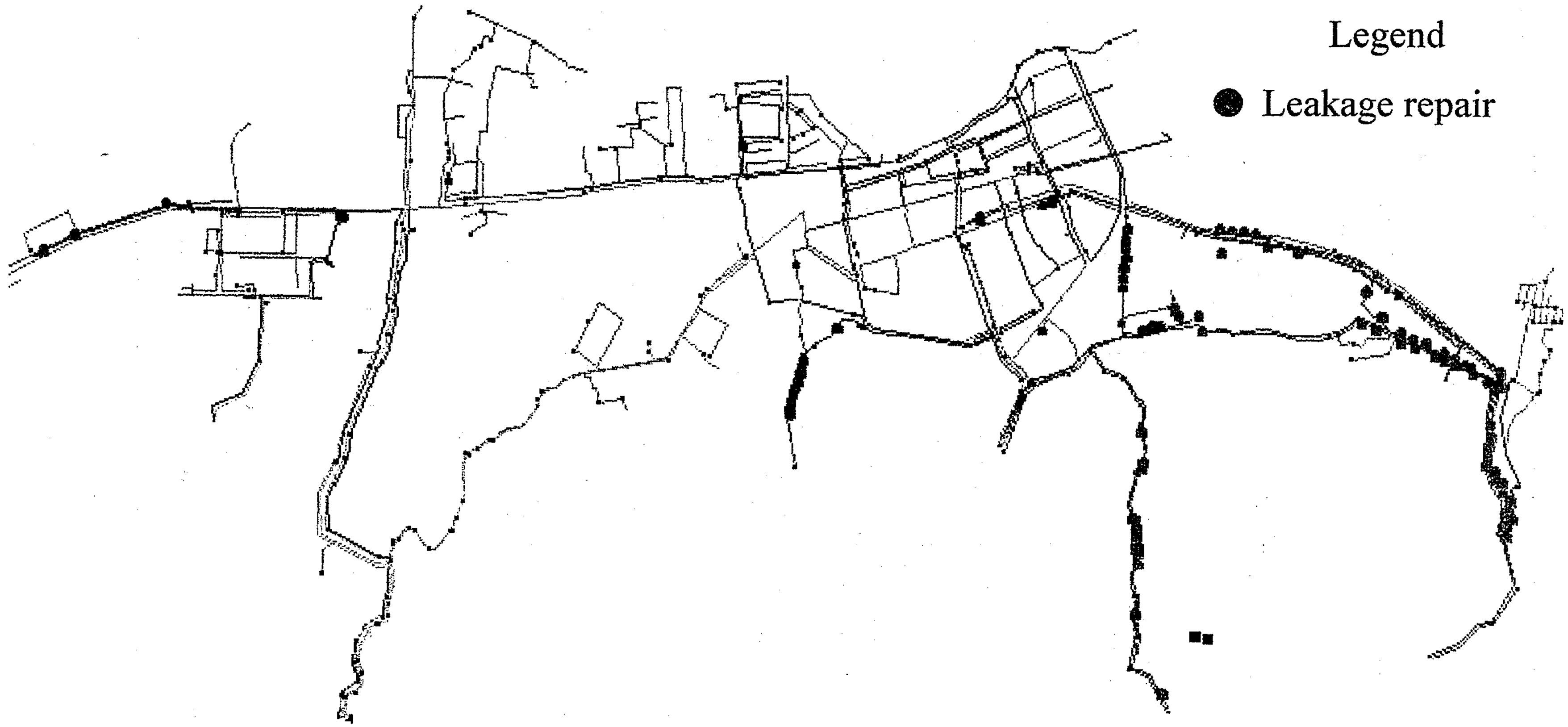
Figure

D-2

DIAGRAM OF WATER DISTRIBUTION SYSTEM IN DILI



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LEAKAGE DISTRIBUTION MAP

Figure D-3

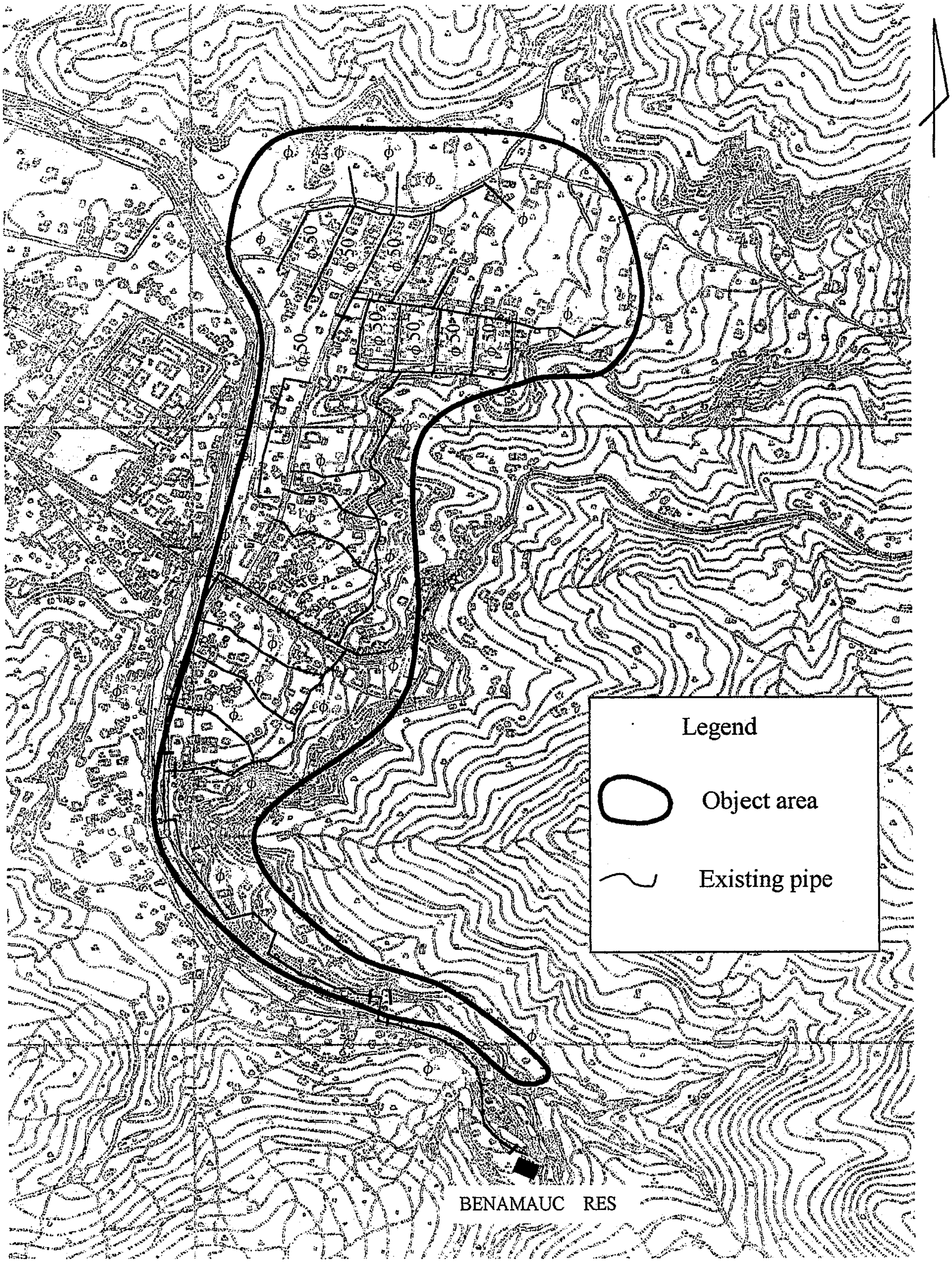

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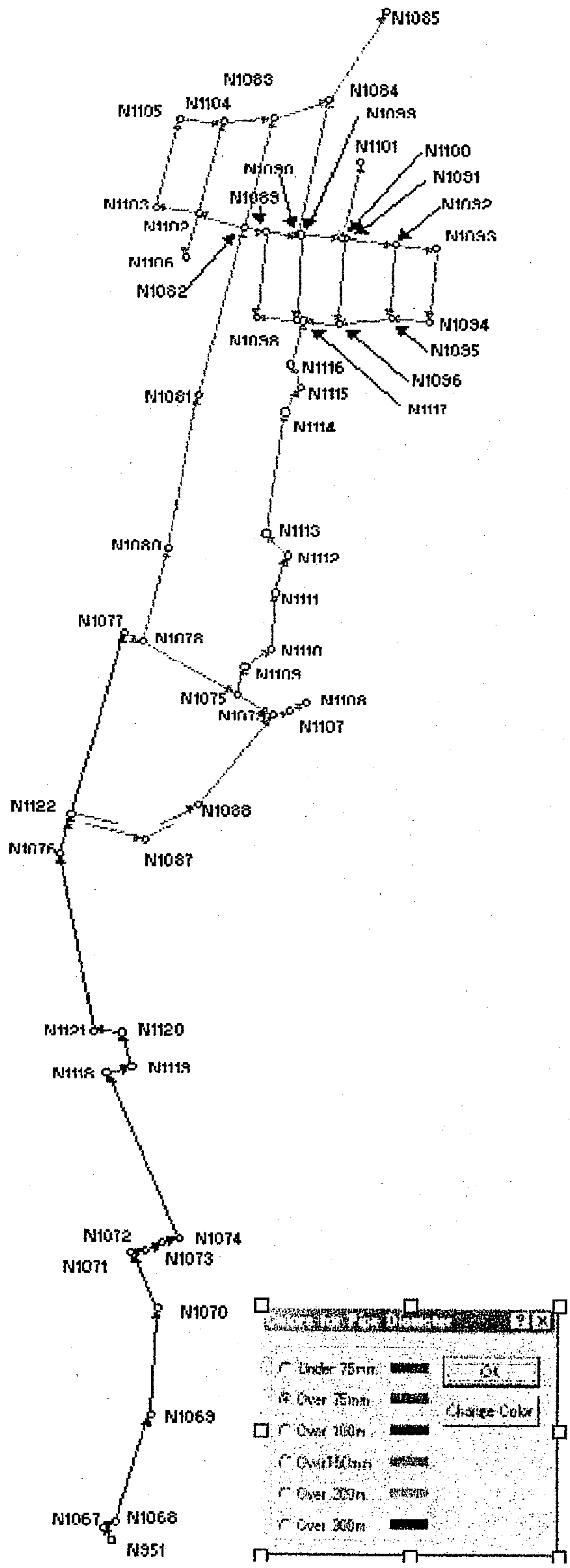
Figure

D-4

MODEL BLOCK AREA MAP



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EXISTING PIPE NETWORK DESITAL DATA DRAW OF THE BLOCK

Figure

D-5

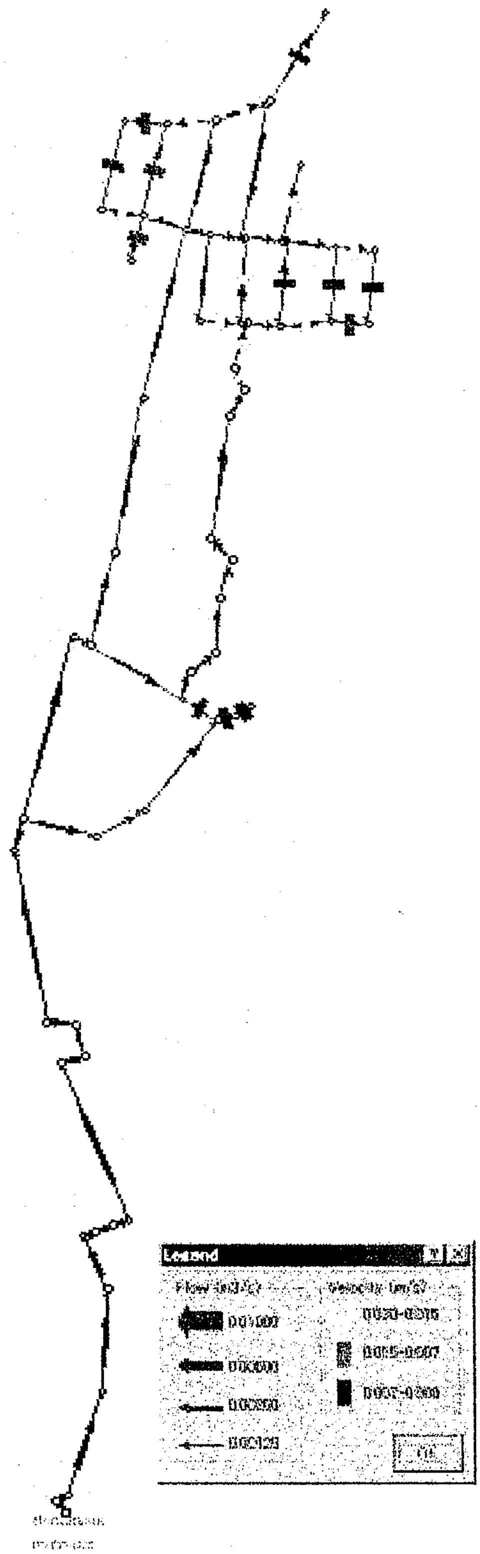

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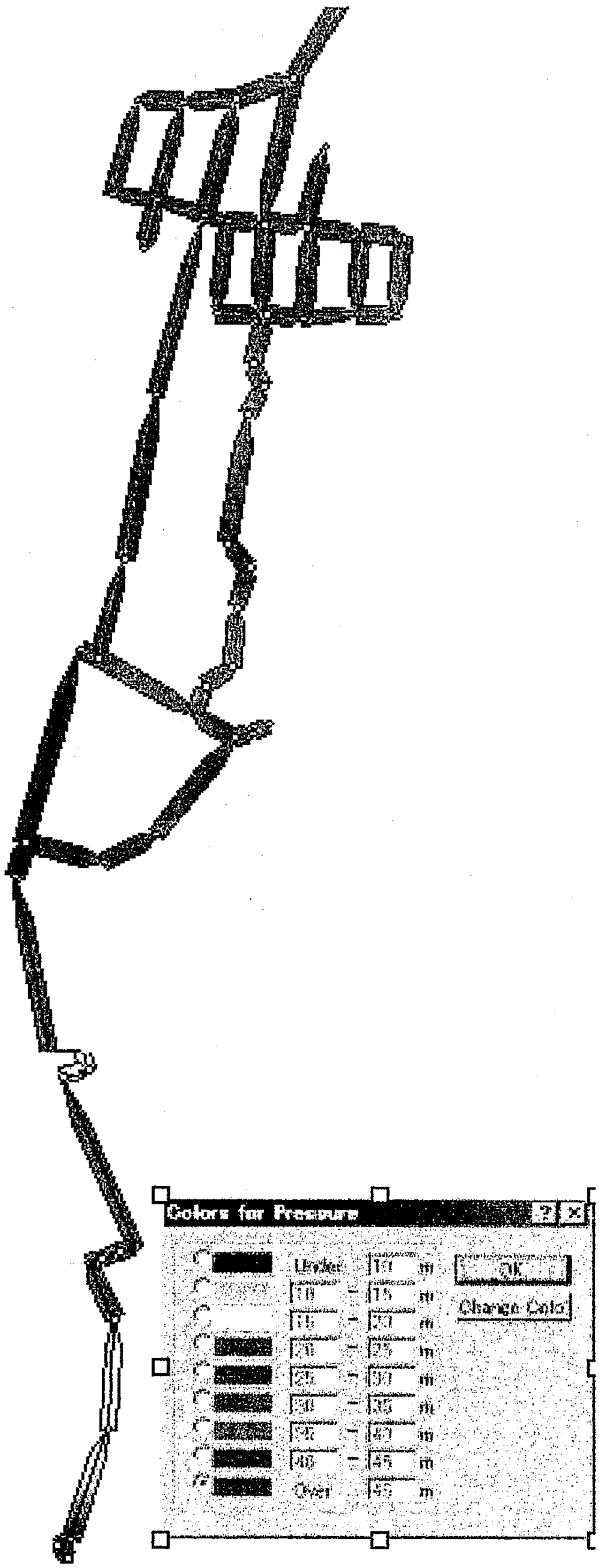
Figure

D-6

FLOW DIRECTION SIMULATION RESULT OF THE MODEL BLOCK

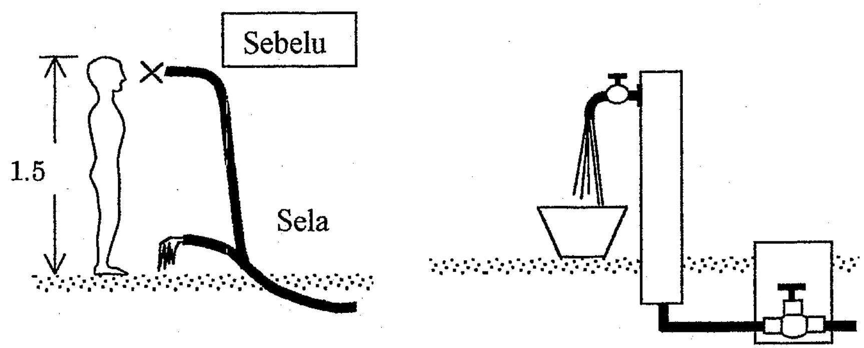


JICA	*The Study onUrgent Improvement Project for the Water Supply System in East Timor*	**Figure**
	WATER PRESSURE SIMULATION RESULT OF THE MODEL BLOCK	D-7

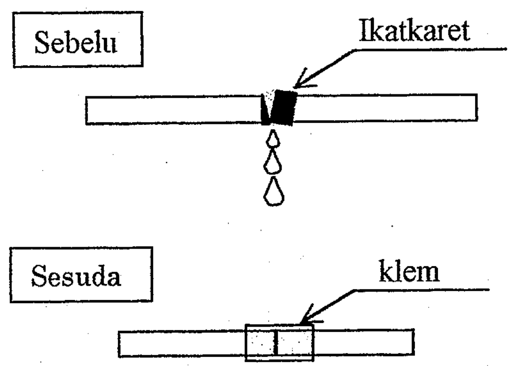
Permintaan untuk bekerja sama

Jumlah tekanan yang dimaksud untuk mengurangi sebuah kebocoran seperti yang ditunjukan berikut ini :
1. Memperbaiki tekanan air
2. Mencegah kebocoran air
3. Mencegah masuknya air kotor kedalam pipa.

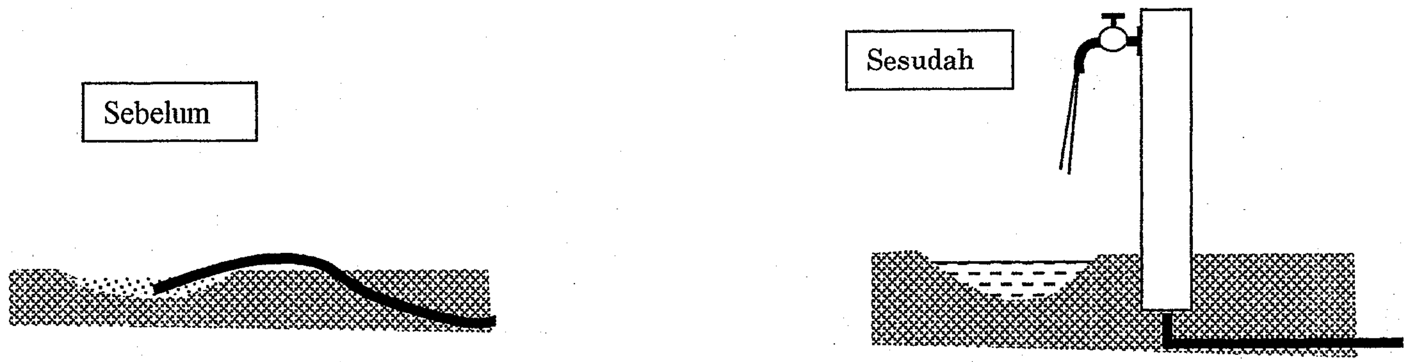
1. Memperbaiki tekanan air.



2 Mencegah kebocoran air.



3 Mencegah masuknya air kotor kedalam



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THE MANUAL TO GET INHABITANT'S UNDERSTANDING & COOPERATION

Figure D-8

D.2 CONSTRUCTION OF INFILTRATION GALLERY IN MANATUTO

D.2.1 Background

The people of Manatuto are obliged to use water from unsafe sources such as from shallow wells and nearby river because the town's water supply system is not in operation. The primary cause of the system's breakdown is the damage to the transmission main.

Normally, the Manatuto water supply system operates with only one source to supply its water consumers. Water from the source located some 12 km upstream flows by gravity via 6-inch transmission main into the town's reservoir located uphill in the town at an elevation of approximately 80m above mean sea level. From the town's reservoir, water is then distributed by gravity to the consumers spread around town. However, the transmission main is poorly designed. It is constructed mainly on the flood plain of Laclo River without adequate protection. Most part of the pipelines could not withstand the turbulent actions of the floodwaters and soil erosion created by the Laclo River. In 1998, heavy floods occurred on Laclo River creating heavy erosion on the floodplain that resulted to serious damage on some sections of the transmission main. For some reasons, the damages could not be repaired resulting to the non-operation of the Manatuto water supply system since then.

The JICA Study Team envisages that the rehabilitation/restoration of the water supply system in Manatuto will take into consideration a new water source and transmission pipeline. Safe and reliable water source will be evaluated and selected together with transmission mains that will be designed and constructed in such a manner less vulnerable to damage. It has to take into consideration, that the pipelines are constructed away from the flood prone area.

Restoration of the Manatuto water supply system was considered one of the "Quick Projects" of JICA. Its aim is mainly to address the immediate need of the people through rehabilitation works and putting back the water supply system into operation. Although this is a temporary measure, it is considered the most practical under the present circumstances. Thus, several options were considered to study the most viable alternative to restore the water supply system in Manatuto on a least possible time.

For the long-term planning, the existing water source of the town's water supply system (spring source before the violence) maybe an economically viable source for Manatuto. Its high location though far from the service area is typical for gravity distribution system requiring less operation and maintenance cost. Although, rehabilitation of this source will require big capital investment and more technical investigations, it is likely to incur less operational cost compared to the energy-intensive operational cost of the infiltration gallery.

D.2.2 Comparison of Alternative

Because the Manatuto water supply system was completely not operational over a long period since 1998, it is therefore an urgent priority to restart the water supply service. Re-operation of the water supply system requires rehabilitation of the existing source or exploitation and development of a new source including the required transmission mains that would bring the water from the source to the existing reservoir. Based on the initial field investigations and interviews with the local people, 3 options were considered for comparison and assessment as follows:

- Collection of Riverbed Water through Infiltration Gallery

Based on site investigations, interviews and reports, the riverbed of Laclo River has adequate potential for water abstraction through infiltration gallery. Perforated pipes will be laid at about 5 m below the river bed to collect naturally-filtered river water. From the river bed, water is drawn into a pump pit via transmission main and pumped into the existing reservoir located on top of the hill. Pumping of the water will be through the existing GSP 6-inch transmission main to be joined at the section close to the site of the infiltration gallery at about 4-km downstream of the reservoir. The construction cost of this project is estimated at US$ 0.6 million and to be completed in 2 months period.

- Use of the Existing Source with the Installation of New Transmission Mains

This alternative will utilize the existing source, Manatuto Spring with the construction of a new transmission main to transmit raw water by gravity to the existing reservoir. The new transmission main will be constructed generally, using the same route as the existing main (flood plain of Laclo River). However, the proposed transmission main (GSP 6-inch x 12 km) will be properly designed and constructed with appropriate pipe protection that will make the pipeline less vulnerable to damage. Pipes are laid about three-meter below the riverbed with concrete protection. It is estimated that the project will be completed in 1 year at a cost of about US$ 2.8 million.

- Use of the Existing Source and Installation of Transmission Mains via New Route off the River Course

This alternative is aimed at avoiding the danger of the floodwaters by taking a new route away from the flood plain of Laclo River. The new route will require about 30 km of pipelines. However, due to the difference in elevation between the source and the new pipe route (source is lower than the pipe route), pumping will be required. This project will be completed in 1.5 years at a cost of about US$ 2.3 million.

Several factors were used in the analysis of the 3 alternatives, such as the recurrent costs of the proposed project, time element to complete the project, environmental impact, water quality and capital investment. The urgency to restore the system at shortest possible was the main factor considered in the selection of the project. Thus, the construction of the infiltration gallery was chosen from among the 3 alternatives.

Aside from the above-mentioned other factors that were considered in the selection of the infiltration gallery include the following:

- Minimum construction and operation cost.
- No water treatment process is required.
- The location is close to the service area.
- The water quality is acceptable the whole-year round.
- The water source has adequate supply for a long-term demand.

Under the present circumstances and the factors described above reveals that the construction of the infiltration gallery is the most viable source for Manatuto water supply system.

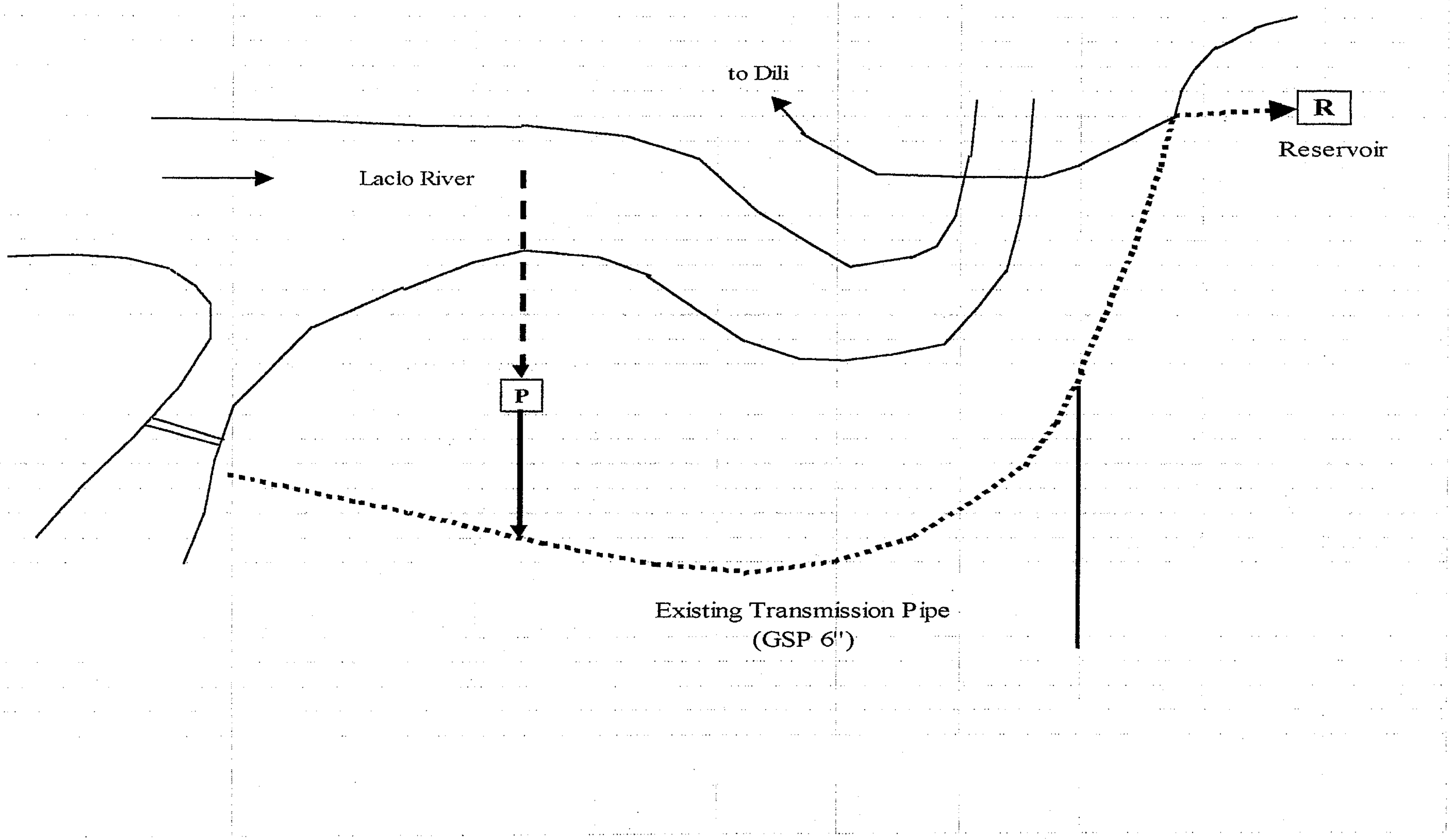
An infiltration gallery is a simple means of obtaining naturally filtered water. It is a horizontal well, which collects water over its entire lengths, normally from surface water sources. It is constructed by digging a trench into water-bearing sand, then collecting the water in perforated pipes, which lead to a central sump from which water may be pumped out into the system. The length of the trench depends upon the amount of water desired.

The Laclo River at about 4 km from the service area is the site of the infiltration gallery. Water obtained from the river through the infiltration gallery will be pumped up into the town's reservoir via the undamaged section of the existing transmission main. A new transmission pipe will be constructed to connect the infiltration gallery to the existing transmission main. Several factors were taken into consideration for the site of the gallery such as follows:

- Quantity and quality of water from the source.
- Condition of the riverbed.
- Topography and terrain.
- Distance to the service area.

D.2.3 Main Features of the Infiltration Gallery

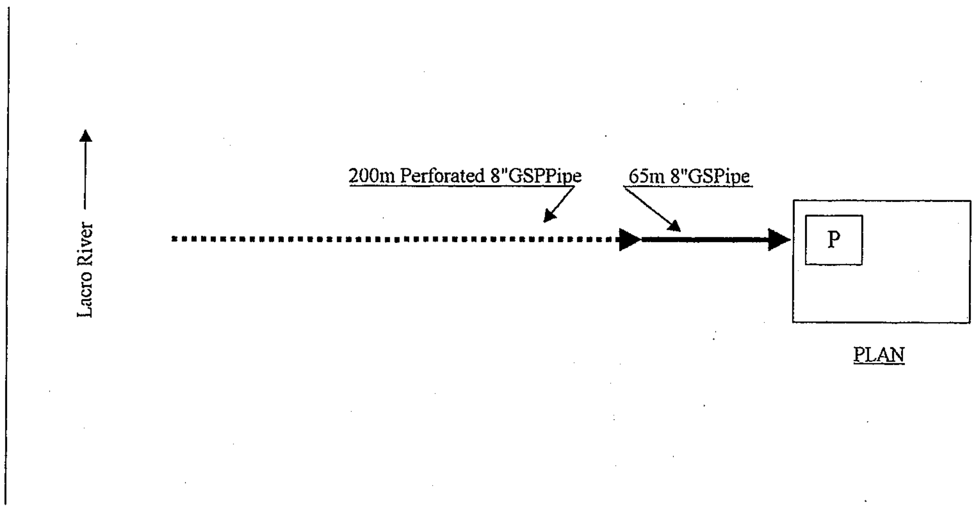
The infiltration gallery will be constructed to draw water from the Laclo River. It is composed of GSP 200 m x 8" with perforation and GSP 65 m x 8". Naturally-filtered water collected from the Laclo riverbed will flow into the collection chamber where it will be pumped into the service reservoir in town via the existing transmission main. New transmission main (GSP 6-inch) will be constructed from the pump house site and connected to the existing main located



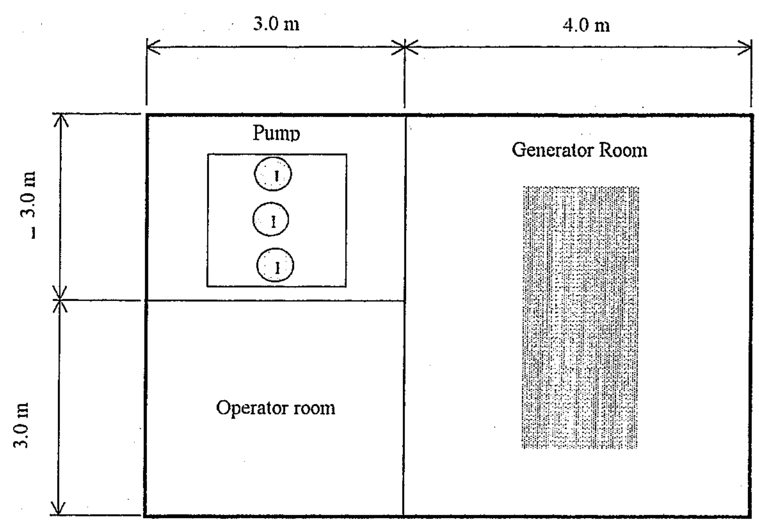
The Study onUrgent Improvement Project for the Water Supply System in East Timor

INFILTRATION GALLERY
PLAN

Figure D-9



PLAN



Pump House Layout

NOTE; Perforated Pipe to be laid more than 5 m below River Bed Level

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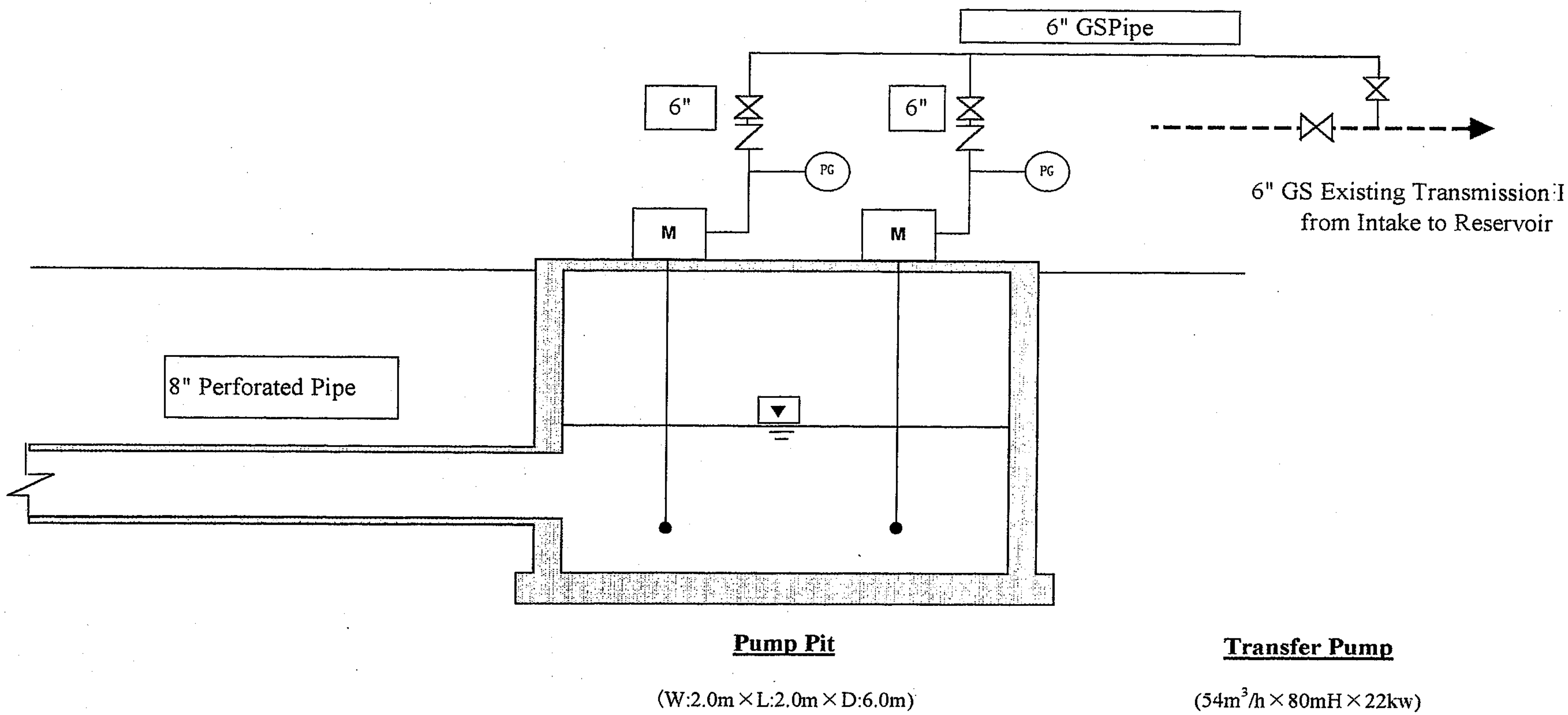
INFILTRATION GALLERY
PLAN AND PUMP HOUSE LAYOUT

Figure **D-10**



The Study onUrgent Improvement Project for the Water Supply System in East Timor

INFILTRATION GALLERY
COLLECTION CHAMBER CROSS SECTION VIEW

Figure D-11

about 100 m. Sketch drawings of the infiltration gallery is shown in **Figures D-9, D-10 and D-11**. The main features of the proposed infiltration gallery are shown in the table below.

Table D-7 MAIN FEATURES OF THE PROPOSED INFILTRATION GALLERY

Item	No.	UNIT	Specification
Equipment			
Pump & Motor	3	set	$27m^3$/hx80mx15kw
Diesel Engine Generator	1	set	60kw
Piping Material			
Water Collection Pipe			
- Perforated pipe	200	m	GSP 8”
- Galvanized pipe	65	m	GSP 8”
Connection pipe to connect to the existing transmission main	100	m	GSP 6”
Gate Valve			
- dia. 6”	4	sets	
- dia. 4	3	sets	
Check Valve dia. 4”	3	sets	
Air Release Valve dia. 4”	1	set	
Instrument Material			
Pressure Gauge	3	set	$12kg/cm^2$ G
Electrical Material			
Power Receiving Cable	1600	m	for receiving 30kw, 400v
Power Receiving & Transmission Panel	1	set	
Motor Control Panel & Cable	1	set	
Civil Material & Construction			
Excavation	8900	m^3	
Soil Disposal	800	m^3	
Gravel Layer	130	m^3	
Sand Layer	660	m^3	
Backfilling	8100	m^3	
Concrete	1	set	
Collection Pipe Layer	400	m	
Pump Pit & Transmission Line			Pit Size: 2mx2mx8mD
Excavation	1100	m^3	
Soil Disposal	50	m^3	
Backfilling	1050	m^3	
Concrete	1	set	
Pipe Layer	200	m	
Pump House			6mx7m

D.2.4 Construction of the Infiltration Gallery

JICA commissioned Dai Nippon Construction (DNC) to carry out the construction of the infiltration gallery at a cost of US$ 0.60M. To take advantage of the low flow on the Laclo River, actual construction work started on the middle of August and was completed at the end of October. The construction work was categorized into 2 components namely:

Component 1: Pipework including Construction of the Collection Chamber (Pump Pit)
Component 2: Construction of the Pumping Station including Installation of the Pumping
and Electrical Facilities

Pipework commenced towards the end of August by excavation on the riverbed of the Laclo River. Two hundred (200) meters of GS perforated pipe and sixty-five (65) metres GSP were installed at about 5 meters below the riverbed. From the Laclo riverbed the 265 m water collection pipe was connected to the water collection chamber (dia. 2.6 m x 5.9 m depth) constructed of reinforced concrete. A 200 mm diameter valve controls the flow of water into the collection chamber. The collection pipes was installed with a slope of 1/500 to allow gravity flow of naturally-filtered water into the collection chamber. The outlet (GSP 6-inch) of the pump facilities was then connected (in a valve box) to the existing transmission main located about 84.24 m distance.

Soon after the completion of Component 1, Component 2 started with the construction of the concrete slab for the 42 m^2 pumping station. Appropriate preparatory connectors and pipe sleeves were planted on the concrete slab. Steel frames were then installed where steel wall panels and roofing were securely fastened/welded. This type of structure was adopted mainly because of its flexibility, ease in construction and to expedite the work. Prior to the installation of the walls and roof, the pumps (3 sets: 2 duty + 1 standby) and generator set were securely set-up on the space provided. Connections of the cables and pipes were then completed. Detail as-built drawings of the whole facility is shown in **Figures D-12 to D-15.** The specifications of the pumps, generator set and other electro-mechanical equipment are provided in the supporting documents of the project.

The construction of the whole infiltration facility lasted more than 2 months. About 30 local labor were utilized fully supervised by the DNC engineer who was present during the whole construction period. Test operation of the infiltration gallery started in November. The pumps were allowed to operate for 1-month period at a discharge rate of 15 L/s (total discharge rate for 2 pumps operating). The water quality collected from the infiltration gallery revealed an acceptable water quality wherein all the parameters measured are within the limits set by the WHO Standard for Drinking Water. Details of the water quality test results are included in **Table A.6-3 of Appendix A.**

D.2.5 Operation of the Pumping Station for the Infiltration Gallery

Under normal condition, 2 pumps will operate at a total discharge rate of 15 L/s or 27 m3/hr (capacity for each pump = 7.5 L/s). The operation of this facility follows the following procedure:

a.) This feed water supply units are operated automatically by the signal of the electrode at high water level (start) and low water level (stop). Also manual operation can be done by manual button provided.

b.) Three pumps operate independently. Three isolated Auto-manual operation button (No.1 pump, No.2 pump, No.3 pump) are connected to the control panel.

c.) Before the starting the pump, it is very important **to fill prime water into the suction pipe located at the base of the pump (through the foot valve)**. It is important that air does not exist in the suction pipe because water will not be pumped out and it would also create damage to the pumps (otherwise known as “dry running”).

d.) **The priming water should be supplied from top of the pump.** Water could be supplied through a water hose connected from the town’s water supply system or from a small tank to be provided in the pumping station site.

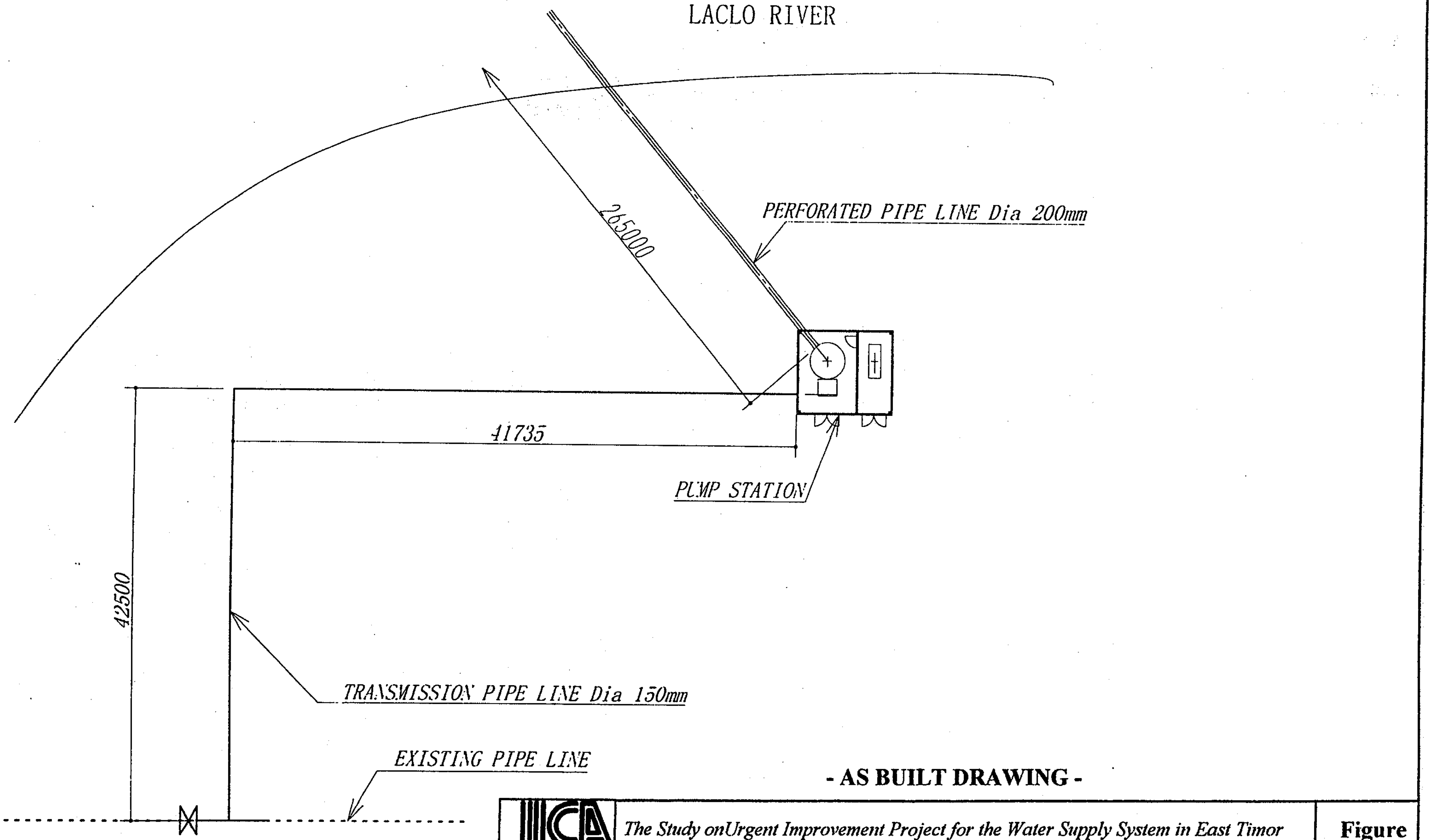
e.) **Before starting the pump it is important to confirm that the stop valve (located on the outlet side of the pump) is shut down.** Starting the pump with the valve open will create dangerous water hammer.

f.) After several seconds from pump start, the valve must be opened gradually until a normal flow is reached. To attain high pump performance, it is important that the flow rate is set at a maximum flow of 27 m^3/h or 15 L/s and outlet pressure at 9.5 bar to avoid cavitation. Cavitation diminishes the performance of the pump resulting pump damage.

g.) **After switch on, if strange noise is created by the pump or the expected performance is not achieved, the pump must be stopped immediately.** To re-start the pump the same procedure should be followed starting from Step c.). Take note of the possible problem of cavitation to be created.

h.) **If cavitation does not disappear after re-starting the pumps, it is important to pull up gradually the electrode cable at an interval of 0.5m length.** Continue the process until cavitation disappears. This condition occurs when the suction head is too high that the pump finds difficulty in sucking out the water.

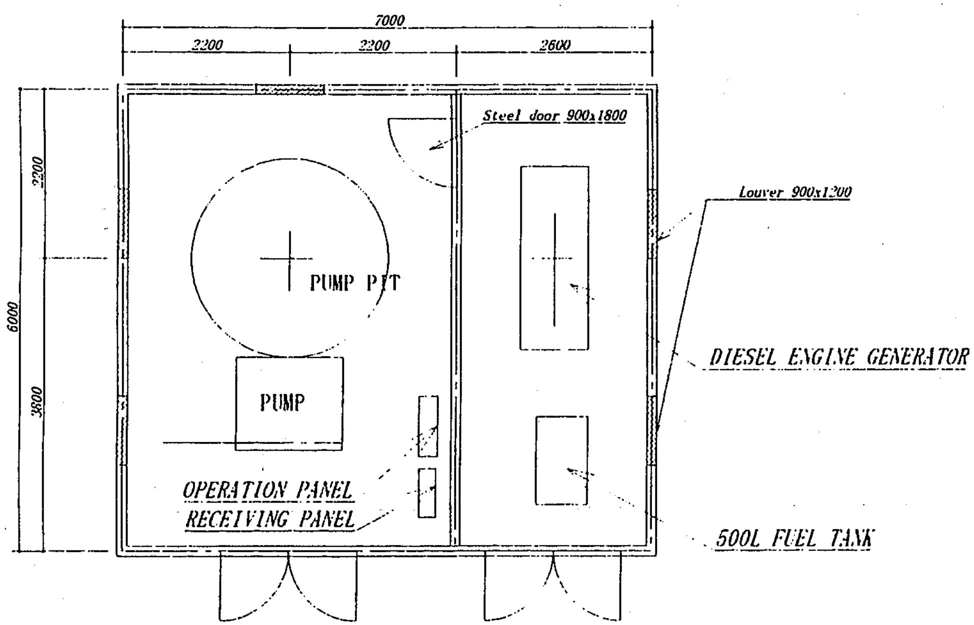
i.) Low water level in the pump pit will stop the pump automatically. This condition will be confirmed on the pilot lamp of the control panel indicating low water.



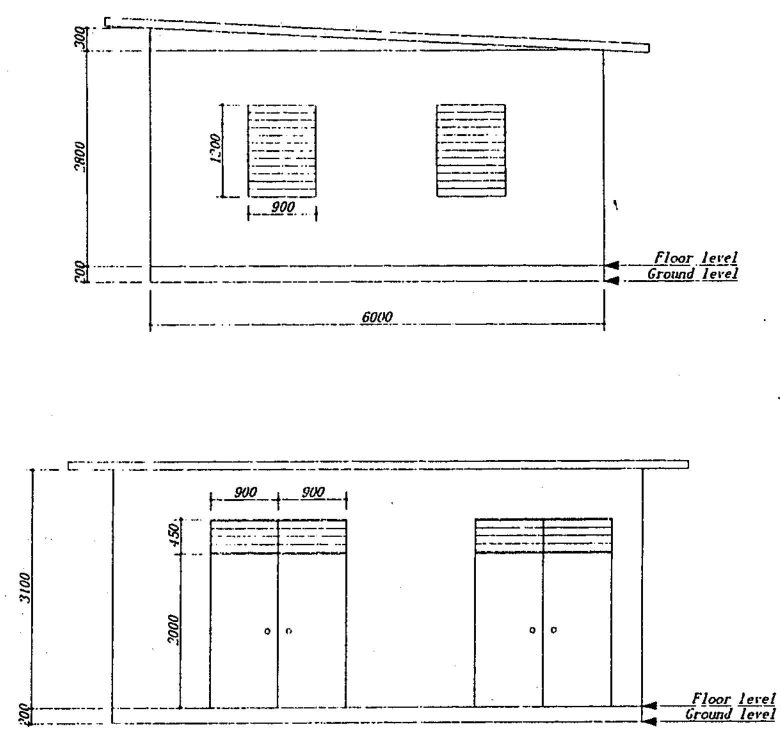
- AS BUILT DRAWING -

JICA	*The Study onUrgent Improvement Project for the Water Supply System in East Timor*	**Figure**
	LACRO RIVER INFILTRATION GALLERY(PLAN)	**D-12**

PLAN

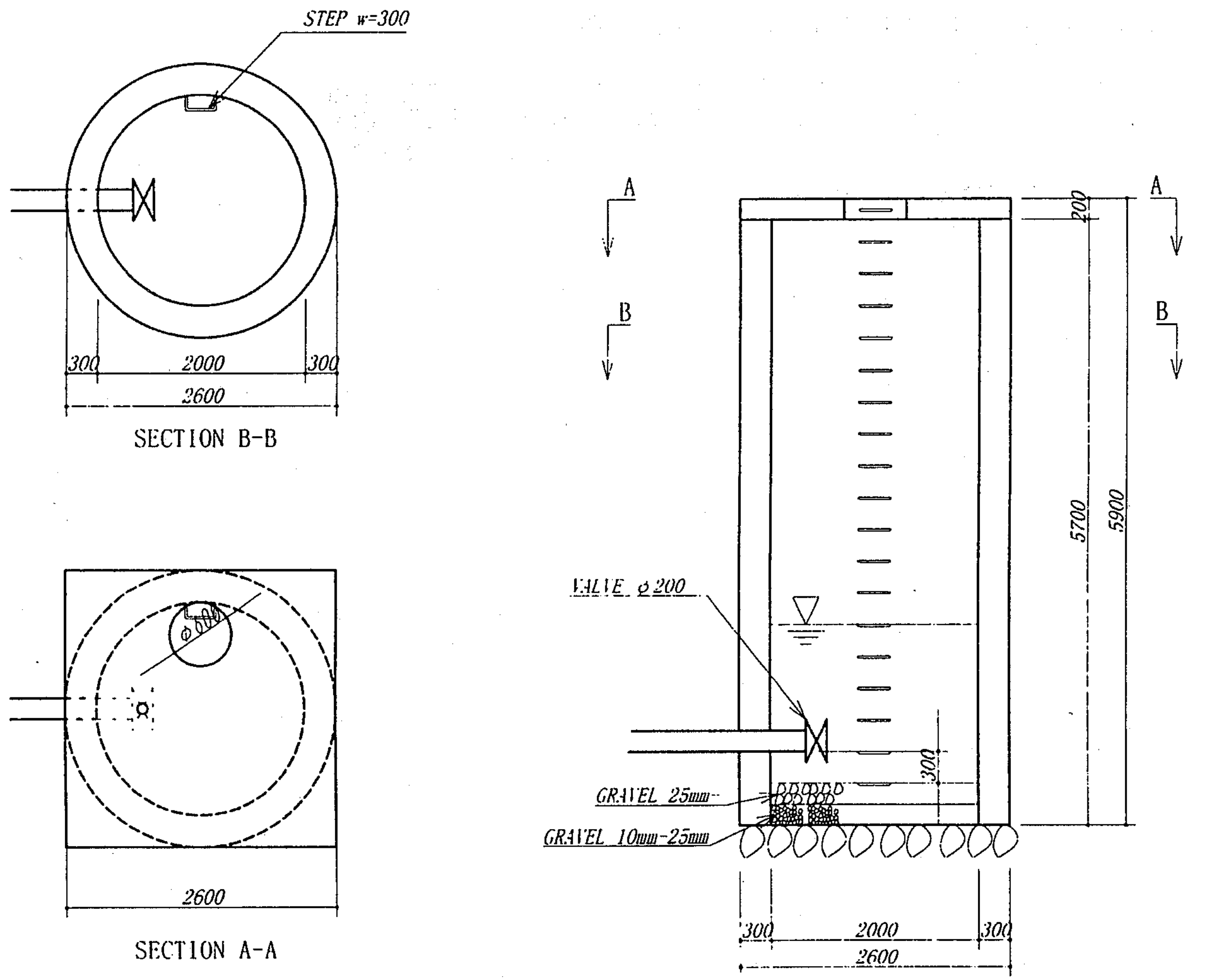


SIDE VIEW



- AS BUILTDRAWING -

JICA	*The Study onUrgent Improvement Project for the Water Supply System in East Timor*	**Figure**
	PUMPING STATION(PLAN, SECTION)	**D-13**



- AS BUILT DRAWING -

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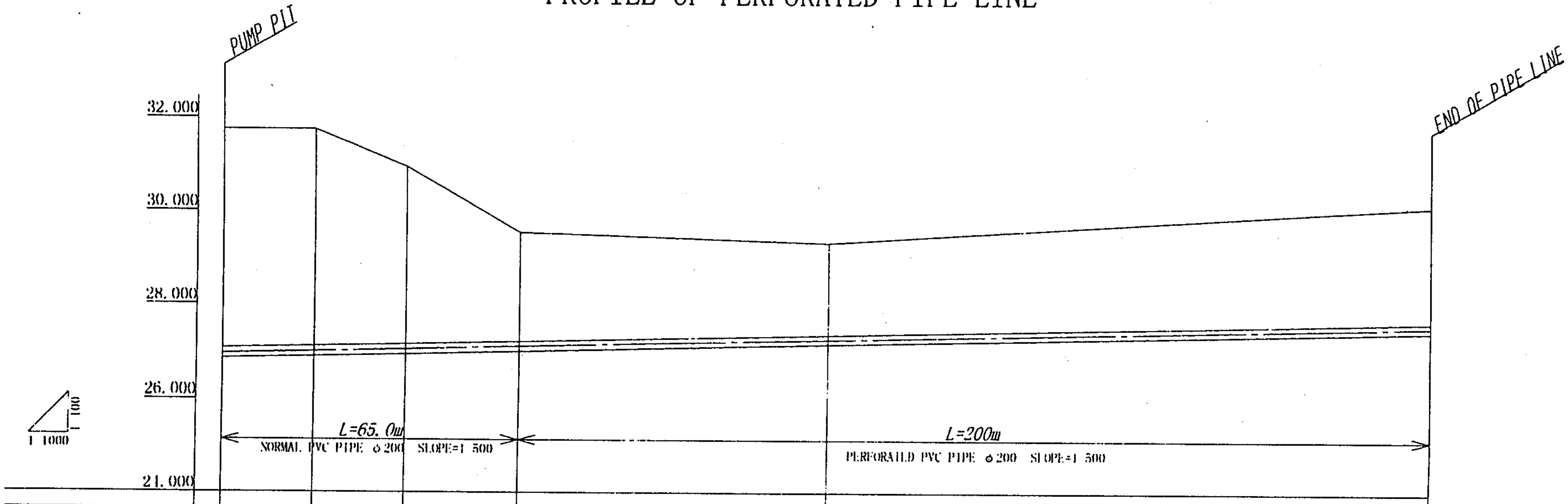
WATER COLLECTING CHAMBER(PLAN, SECTION)

Figure D-14

PROFILE OF PERFORATED PIPE LINE



TOTAL DISTANCE (M)	0.00	20.00	10.00	65.00	133.00	265.00
PARTIAL DISTANCE (M)	0.00	20.00	20.00	25.00	68.00	132.00
GROUND ELEVATION (M)	31.749	31.749	30.919	29.519	29.319	30.149
INVERT ELEVATION (M)	26.849	26.889	26.929	26.979	27.155	27.379

- AS BUILT DRAWING -

JICA	*The Study onUrgent Improvement Project for the Water Supply System in East Timor*	**Figure**
	PROFILE OF WATER COLLECTION PIPE	**D-15**