APPEDIX E EXISTING WATER SUPPLY SYSTEM

E.1 Asset Mapping and Evaluation of the Water Supply System

Field investigations of the existing water supply facilities were conducted on 15 towns of East Timor. The main purpose of the asset mapping and investigations is primarily to collect information and data on the existing condition of the water supply facilities necessary to evaluate the systems performance. These activities are necessary mainly due to the lack of available records, drawings and relative documents concerning the existing water supply system of the 15 towns in East Timor. The Phase I survey which started in March 2000 will continue until Phase II. Together with the interviews conducted on local sources field confirmations are vital for a more accurate and realistic evaluations of the data. The survey was carried out with the assistance of counterpart personnel and local hired staff trained by the JICA Study Team on basic water supply engineering. These activities form part of the counterpart training and technology transfer to local staff of East Timor.

The survey was conducted extensively on the urban water supply system of the 15 towns from the water sources down to the service connections. Data relative to the operation of the water system was also collected during the survey. The gathering of data and information was carried out on different occasion/schedule by two or more teams formed on different aspects of the water supply technology. In some towns outside Dili, there are cases when local guides and interviewees will give conflicting information to the Study Team. This could merely due to language barrier and the unavailability of suitable local persons willing to be interviewed or who could give the desired technical assistance to the Study Team. Detailed discussions on the water supply system in 15 towns of East Timor are done in the succeeding sections of this report.

E.2 DILI Water Supply System

E.2.1 General

Dili being the capital of East Timor has the widest service area of all the water supply system in the country. The water supply requirement of this capital city is supplied from sources such as surface water and groundwater. The surface water sources are drawn from 3 different river catchments and treated in the 3 water treatment plants before distribution to the water consumers. There are 9 wells (12 to include 3 from Hera Sub-district), drilled to abstract water from the groundwater reservoir, although half of the total number is currently out of operation. Except for chlorination of the water supply abstracted from some of the wells (Comoro A, Comoro B and Comoro D) the groundwater sources do not pass any form of treatment prior to distribution to the water consumers.

Prior to the post-referendum violence, approximately 50% of the city's population was served with water from the pipe network, although the operation of the system was not maintained on a 24-hr service. The rest of the population is served either by communal water supply schemes or by individual private system.

With the existing condition of the water supply facilities, the quality and quantity of water production has led to some problems in the service area. Daily disruptions of the water service, low water pressure and unacceptable water quality are among the few problems faced by the water consumers in the city. These conditions are the combined result of the numerous leakages, insufficient treatment, lack of quality control and the absence of regular maintenance on the facilities.

Improvement to the system is taking place with the assistance from the different donor countries, local and international organizations, NGO's, and most notably JICA. This is just the beginning of the tremendous tasks and there is a lot more to be done to improve the water supply system and eventually making the water supply entity in Dili sustainable.

E.2.2 Water Sources

The water requirement of Dili is supplied from a variety of sources. There are four intake points (Bemos, Bemori, Benemauk and Maloa) to collect surface water, nine wells around Dili area (Comoro, Kuluhun and Bidau) and three wells in Hera Sub-district, which is east of the capital. Except for Maloa, which is directly supplied to the water consumers without treatment, the 3 other surface water sources pass through the respective water treatment plants or in extreme cases directly supplied to the consumers without treatment. Three wells in Dili and all in Hera are not operational due to reasons such mechanical fault on the pump and low productivity of the wells. The locations of these sources are shown in **Appendix B**. The detailed description of each source is discussed in the succeeding sections.

a.) Bemos

The site of the intake structures is located about five kilometers southwest of the city center at an elevation of more than 200 meters above mean sea level (amsl). The water source is from Bemos River, which is a tributary of the Comoro River. The intake point is about 4 km upstream from the confluence of the 2 rivers. The total catchment area of Bemos intake is estimated at 30.3 km^2.

The intake structures include a concrete weir that extends 7m width of the stream. The water is then collected into a concrete intake box located at the right bank of the river. From the intake box, water flows by gravity through a pipe 20m downstream to another small tank equipped with a valve. During the survey, it was observed that the water on site appeared to be turbid due to the heavy rains. The flow rate was estimated at about 1.0 m^3/s. Raw water is transmitted to the Bemos Water Treatment Plant for treatment.

b.) Bemori

The site of the intake structure is located about 3 km south of the city center upstream of Bemori River. It can be reached by about 2 km walk through the footpath along the river ank. The total catchment area of Bemori intake is estimated at 1.49 km^2.

The intake structure is equipped with a concrete weir to collect water through the gate at the right bank of the river. The water then flows 100m downstream into a tall concrete reservoir located where the stream branches off at an altitude of 185m amsl. The flow of the stream is about 15 L/s, of which about one-third of it is diverted into the intake. During the survey, the water was observed to be clear even after the 30-minute rain. According to the local source, during dry season the yield of Bemori decreases but never dries up. Raw water is transmitted into the Lahane WTP for treatment via 6-inch pipe.

Aside from this abstraction from Bemori River for the water supply system in Dili, two smaller intakes were observed downstream. One water intake was constructed to supply the military base and the other for distribution to the Airuri-laran area.

c.) Benemauk

The site of the intake structures is located about 5 km southeast from the city center at an altitude of 155m amsl. The abstraction is found in the middle stream of the Benemauk River. This site can be reached by about 400m-walk upstream from the Benemauk WTP. The total catchment area of Benemauk intake is estimated at 7.6 km^2.

The intake structure is equipped with a concrete weir about 5m width to collect water from the river. River water then flows downstream into a concrete reservoir where it is transmitted through 2 separate 6-inch pipelines for treatment at Benemauk WTP and Lahane WTP. During the survey, the water was observed to be highly turbid due to the heavy rains that occurred prior to the visit.

d.) Maloa

The site of the intake structure is located about 4 km south of the city center at an altitude of 170m amsl. The total catchment area of the Maloa intake is estimated at 0.26 km^2.

Because of its unreliable yield, which is normally sensitive to seasonal fluctuations, this source is not viable as a major source for Dili. Additionally, the water becomes very turbid during heavy rains. Currently, raw water abstracted from the river through the intake facility constructed during the Portuguese Period is supplied to the community downstream without any form of treatment.

e.) Comoro Wells

In the Comoro well field, located west of the city center, a total of 5 wells were drilled to augment the water requirement in Dili. A brief description of each well is discussed below.

- *Comoro A:* Flow rate = 40 L/s Depth = 135m Construction yr. = 1988
- *Comoro B:* Construction year = 1988
  Remarks: Used exclusively for the PKF with water truck refilling station
- *Comoro C:* Depth = 78m Construction year = 1995
  Remarks: Not presently used
- *Comoro D:* Flow rate = 31 L/s Depth = 78m
  Remarks: Equipped with new generator for emergency operation
- *Comoro E:* Construction year = 1996
  Remarks: Soon to be operational with new set of pump and pipe facilities.

All of the 5 wells except Comoro C are equipped with pumps and pipe installation. As per the local sources the wells were drilled to penetrate the alluvial deposits of the Comoro River. The Comoro River has a total catchment area at about 207.3 km^2.

f.) Kuluhun and Bidau Wells

The Kuluhun and Bidau well fields are located on the eastern part of the city center. A total of 4 wells were drilled in this area to supply part of the water requirement in Dili. A brief description of each well is discussed below.

- *Kuluhun A:* Flow rate = 16 L/s Depth = 100m
- *Kuluhun B:* Flow rate = 36 L/s Depth = 95 L/s
  Construction year = 1998
  Remarks: Located at the right bank of a channel
- *Bidau 1:* Abandoned with pump installations removed.
- *Bidau 2:* Used exclusively for the Dili General Hospital.

All of the above wells were drilled in the alluvial deposits of the Santana River, where the total catchment area is about 34.3 km^2.

g.) Hera Wells

There are three wells drilled in Hera located 10 km east of Dili. These wells were primarily drilled to supply water in Hera Sub-district. A brief description of each well is discussed below.

- *Hera A:* Flow rate = 5 L/s Depth = 95m
  Remarks: Abandoned but equipped with reservoir and pipe installations.
- *Hera B:* Flow rate = 3 L/s Depth = 75m
  Remarks: Abandoned without any pipe installations.
- *Hera C:* Flow rate = 5 L/s Depth = 85m
  Remarks: Presently out of use but can be put back into operation if power supply becomes available.

All of the above wells were drilled in the alluvial deposits of the Quik River, where the total catchment area is about 42 km^2. Due to some reasons that include the unavailability of power supply, none of these wells are in use.

There exist an artesian well (spring) located at Hera Port, which is not connected into the town water supply system. It is equipped with a short pipe and a concrete base where people can easily collect water. The yield of this well is about 3 L/s and is mainly for the port use. According to the local source, this well never dries up even in the dry season.

E.2.3 Water Supply Facilities

The water supply system in Dili with the technical description of its facilities is described in the succeeding sections.

a.) Transmission Mains

The old transmission mains constructed during the Portuguese administration are now considered as distribution pipes. Residents in the area where the mains traverse, normally draws raw water before it reaches the WTP through illegal connection. These transmission mains include the Old Maloa – Lahane, Bemori/Benemauk – Lahane and Dili Hospital – Lahane WTP. The new transmission mains used to transmit raw surface water from the intake to the WTP and from the groundwater sources to the service reservoirs are shown in the table below.

No.	Transmission Main (From – To)	Diameter (inches)	Length (m)
01	Bemos Intake – Bemos WTP	8 - 10	±8,000
02	Bemori Intake – Lahane WTP	8	940
03	Benemauk Intake – Lahane WTP	6	8,200
04	Benemauk Intake – Benemauk WTP	6	540
05	Comoro A and B – Bemos Reservoir, Capacity: 500m^3	8	3,950
06	Comoro B – Bemos Reservoir, Capacity 1,000m^3	10	3,970
07	Comoro C – Comoro Reservoir, Capacity 1,000m^3	8	575
08	Comoro D and E – Comoro Reservoir	8	-
09	Kuluhun A – Becora Reservoir , Capacity 600m^3	6	2,800
10	Kuluhun B – Taibesi Reservoir	6	-
11	Bidau 1 – Bidaumasau Reservoir	3	-
12	Bidau 2 – Dili General Hospital	-	-

b.) Water Treatment Plant (WTP)

Due to the presence of undesirable substances in the surface water sources of Dili, 3 WTP were constructed primarily to make the water safe and attractive to the consumers. The water treatment plants in Dili were constructed with a total theoretical design capacity of 80 L/s. The treatment process includes coagulation/flocculation, sedimentation, gravitated rapid sand filtration and chlorination. All the 3 WTP have their laboratories with limited water testing facility. Originally, these laboratories were installed to conduct water quality analysis for the operation and control of the WTP. The parameters normally measured in the plant's laboratory include temperature, pH, turbidity, color and residual chlorine. Other parameter required for the analysis of the water quality is carried out at the Caicoli Laboratory located in the PLN office complex. The details of the 3 WTP is explained below.

- *Bemos WTP*

Bemos Water Treatment Plant started its operation in 1984. The intake facilities are constructed at the right bank of the Bemos River, (a tributary to Comoro River) located about 8 km upstream from the plant. The 8" transmission main is installed along the footpath on the steep western slope of a mountain. It is reported that the main is frequently damaged by torrents caused by heavy rain. Three operators assigned for operation of the intake facilities control the blow-off valves installed on the main to flush out turbid water particularly after rainfall.

Just before entry into the plant, the transmission main is diverted into two directions. One of the branches is a 4-inch GS pipe that conveys raw water directly to a reservoir, which has a storage capacity of 1000m^3. The remaining raw water enters into a receiving chamber via the 8-inch main. The raw water regulated at the inlet chamber by a valve is conveyed to a packaged-type treatment plant consisting of two sub-units with dimensions of 1.9m x 6.9m x 3.8m height. Each unit is equipped with the water treatment process such as flocculation, sedimentation and filtration. The total capacity of this plant is designed with a flow rate of 40 L/s. During the site survey it was found out that the flow recorded in the meter is slightly high at 50 L/s.

The treatment process of raw water includes the dosage of aluminum sulphate (imported in 25kg package) for effective flocculation and sedimentation of undesirable solids. The dosage rate is done at a low level between 1-3 mg/L, taken from the monthly consumption records. In the sedimentation basin, sloping plates are installed to increase its treatment efficiency. Filter sand is washed every 24 hours during rainy season when raw water is heavily turbid and long interval during dry season. For backwashing of the filters, two schemes were designed. One is to use filtered water from the reservoir and the other, is to utilize raw water from the receiving chamber. Due to the damage of the generator, backwash pumps installed in the pump house near the reservoir are not working. As a result raw water, which in most times turbid is currently, utilized as back wash water. The filtered water is then disinfected with chlorine before flowing into the treated water reservoir. The chlorine used is hydrated Calcium Hypochlorite (65%). Based on the monthly consumption records, the average dosing rate is computed at 0.5mg/l

The treated water reservoir has a storage capacity of 500m^3 equivalent to 3.5-hour design rate. This reservoir is interconnected to the 1,000m^3 capacity reservoir in the plant. It was reported that this large reservoir has never been washed/cleaned since its construction in 1995. At the bottom of the reservoir, a thick layer (25 cm in depth) of muddy sand and clay is accumulated. Due to the lack of flow control equipment, water just pass through this reservoir and immediately flows out into the small reservoir via 4-inch bypass. As a result, low water storage exists and this reservoir does not serve its purpose of balancing the water supply during fluctuations of daily water demand.

The electrical facility of the Bemos WTP was installed in 1995 using the power supplied by PLN at 380/220V, 50Hz for its normal operation. This plant is equipped with an emergency generator that activates in the event of power outages from the PLN. After the violence, all the generators have lost their function. The list and description of the mechanical and electrical facility of this plant with the existing condition are shown in the table below.

Equipment	Specification		Condition
Coagulation Settling Tank	1.9m x 6.9m x H3.8m	x 2sets	Rust is remarkable. Filtration sands are damaged.
Back Washer Pump	Capacity : 4.8m^3/min Type : Centrifugal Head : 8m kW,Voltage : 11kW, 400V EBARA, JAPAN	x 1set	Damaged.

Back Washer Roots Blower	Capacity : $0.55m^3/cm^2$ Type : Centrifugal Pressure : $0.554kg/cm^2$ kW,Voltage : 8.5kW, 400V HIGASHIDA, JAPAN x 1set	Damaged.
Alum Dosing Tank	Capacity : $1.0m^3$ Mixer : 280W, 200V x 2sets	In operation.
Chlorine Dosing Tank	Capacity : $1.0m^3$ Mixer : 280W, 200V x 2sets	In operation.
Chlorine / Soda Dosing Tank	Capacity : $1.0m^3$ Mixer : 280W, 200V x 1set	In operation.
Alum Dosing Pump	Capacity : Max 440L/hr Type : Diaphragm kW,Voltage : 230W, 200V MILTON ROY USA x 2sets	In operation.
Chlorine Dosing Pump	Capacity : Max 440L/hr Type : Diaphragm kW,Voltage : 230W, 200V MILTON ROY USA x 2sets	In operation.
Chlorine / Soda Dosing Pump	Capacity : Max 440L/hr Type : Diaphragm kW,Voltage : 230W, 200V MILTON ROY USA x 2sets	In operation.
Flow Meter (Raw Water)	8” x 1set	Not in operation.
Flow Meter (Water Supply & Bypass)	8” x 2sets	Not in operation.

Equipment	Specification	Condition
Watt-hour Meter Box	Type: Outdoor wall mounted	Rusty, dirty but usable
Generator Main Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Main Power Switch Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Generator No. 1	Rating : CONT Voltage : 400v Engine Make: MITSUBISHI KVA : 13 P.F. : 0.8 Hz : 50 Genomake: MINDONG ELECTRIC CORP.	Not in operation because the main parts including the wires were removed.
Generator No. 2	Rating : CONT Voltage : 380/220 KVA : 10 P.F. : 0.8 Hz : 50 Genomake: STAMFORD, England	Not in operation. Lack sufficient measure against risk.

Generator No. 3	Rating : CONT Voltage : 400v Engine Make: A. Van Kaick KVA : 50 P.F. : 0.8 Hz : 50	Not in operation because the main parts were removed. Lack sufficient measure against risk.
Generator Panel	Type: Indoor self-standing	Not in operation because the main parts were removed. Lack sufficient measure against risk.
Fuel Tank	Capacity: 90 liters (W600 x D400x H400)	Lack sufficient measure against risk.
Pump Mixer Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Lighting Distribution Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Pump, Compressor Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Pump, Compressor Control Panel	Type: Outdoor stand mounted	Rusty, dirty but usable
Distribution Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Wiring	-	No protection such as conduit

- *Benamauk WTP*

Before the construction of the Benamauk WTP, raw water from the Benamauk intake is conveyed through two raw water mains of diameters 6” and 8”. One of the mains is used to supply raw water to the consumers via the service reservoir and the other is used to transmit raw to the Lahane WTP for treatment prior to distribution. The service reservoir was constructed in the vicinity of the residential area. These schemes of water distribution are still working under the current condition.

From the 6-inch raw water main, a new diversion was constructed in 1993, packaged with a treatment facility into steel boxes in the nearby reservoir.

The treatment facility, consisting of two units, has a total design capacity of 10 L/s. Chemical flocculation, sedimentation with sloping plates, and gravity fed filtration are the major processes applied. Filtered water flows into the newly constructed reservoir. Manual chlorinators are installed on the roof of the reservoirs. There are cases when raw water is distributed to the consumers without passing through the WTP. The operator upon his judgment of clear water intake makes the bypass to the distribution. This normally happen during the dry season.

With the absence of routine maintenance and operational procedure, siltation and mud accumulation in the service reservoir is the normal gauge to clean and maintain this facility. As per the local sources, the layer of deposits sometimes exceeds 25cm thick. In spite of this fact, the old reservoir has never been washed since the post-referendum violence. Field measurement on the silt and mud deposits confirmed a 40cm thickness at the inlet chamber and 20cm at the outlet. Owing to the above situation, it is therefore possible that a large portion of the silt and mud present in the raw water eventually transmitted into the pipe reticulation causing serious problem of pipe clogging.

The electrical facility in the Benamauk WTP is not supplied with power from the PLN. It is equipped with 2 sets of generators for its normal operation. After the violence, all the generators had ceased to operate. The list and description of the mechanical and electrical facility for this plant with the existing condition are shown in the table below.

Equipment	Specification	Condition
Coagulation Settling Tank	1.8m x 5m x H2.5m x 2sets	Rust is remarkable. Filtration sands are damaged.
Alum Mixing Tank	Capacity : 0.5m^3 Mixer : 750W, 200V x 2sets	Traces indicate that the equipment was removed.
Soda Mixing Tank	Capacity : 0.5m^3 Mixer : 750W, 200V x 1set	Traces indicate that the equipment was removed.
Chlorine Mixing Tank	Capacity : 0.5m^3 Mixer : 750W, 200V x 1set	Traces indicate that the equipment was removed.
Alum Dosing Tank	Capacity : Max 6L/hr Type : Diaphragm kW,Voltage : 150W, 200V x 2sets MILTON ROY USA	Traces indicate that the equipment was removed.
Soda Dosing Pump	Capacity : Max 6L/hr Type : Diaphragm kW,Voltage : 150W, 200V x 2sets MILTON ROY USA	Traces indicate that the equipment was removed.
Chlorine Dosing Pump	Capacity : Max 6L/hr Type : Diaphragm kW,Voltage : 150W, 200V x 2sets MILTON ROY USA	Traces indicate that the equipment was removed.
Chlorine Dosing Tank	Capacity : 0.3m^3 Type : FRP tank x 1set	Traces indicate that the equipment was removed.
Flow Meter	4” x 2sets	Not in operation.

Equipment	Specification	Condition
Generator No. 1	Rating : CONT Engine Make: ISUZU KVA : 15 P.F. : 0.8 Hz : 50 Genomake : STAMFORD, England	Not in operation because the main parts including the wires were removed. Lack sufficient measure against risk.
Generator No. 1 Panel	Type: Indoor wall mounted	Not in operation Damaged heavily by rust Dusty inside the panel
Generator No. 2	Rating : CONT Engine Make: ISUZU KVA : 15 P.F. : 0.8 Hz : 50 Genomake : STAMFORD, England	Not in operation because the main parts including the wires were removed. Lack sufficient measure against risk.
Generator No. 2 Panel	Type: Indoor wall mounted	Not in operation Damaged heavily by rust Dusty inside the panel
Fuel Tank No. 1	Capacity: 90 liters (W600 x D400x H400)	Old fashion type but usable
Fuel Tank No. 2	Capacity: 90 liters (W600 x D400x H400)	Old fashion type but usable

Pump, Mixer Panel	Type: Indoor wall mounted	Not in operation because the main parts were removed. Lack sufficient measure against risk.
Wiring	-	No protection such as conduit

- *Lahane WTP*

The Lahane Water Treatment Plant is the oldest of the 3 WTP constructed in 1954 with a design production capacity of 30 L/s. Treatment process consists of a contact chamber, a mixing chamber, one basin for up flow type sedimentation, and 3 basins for filtration. The contact chamber recently constructed between sedimentation and filtration basins to improve settling efficiency. Chemicals used in the treatment process include aluminum sulphate for coagulation, soda ash as coagulant aid, and calcium hypochlorite for disinfection. The operator controlled the dosage rate of the chemicals. As per the interview with the operator, the operation records for the month of April 2000 show dosage rates of aluminum sulphate and chlorine computed at 6.5mg/l and 0.6mg/l, respectively. Filter bed is back-washed using treated water and compressed air. The operator normally carries out the backwash at an interval of two to three days. But the backwash frequency sometimes varies with the raw water quality. A storage reservoir constructed under the filters and operation building has a storage capacity of 90m^3 or equivalent to 45-minute detention time.

At the main inlet there exists a flow meter but currently out of order. As a result, flow measurement is presently carried out based on the flow rate curve of the outlet overflow weir equipped in the contact chamber. Not one flow controller is installed in the plant other than overflow weirs at the filters and clear water reservoir. Therefore, there is no control of the inflow rate, which normally varies daily subject to the upstream conditions of the water source. This is causing frequent carry over of floc from the sedimentation to the filters. A measurement of flow made on the 23rd May 2000 revealed an inflow rate of 61 L/s, which is more than twice the capacity of the plant. Similar measurement was made on the 24th May 2000, which recorded a flow of 56 L/s. This condition led to the decrease in treatment efficiency of the plant thereby producing low water quality.

From the treated water reservoir, there are two mains installed. One is 8-inch pipe that directly conveys water by gravity to the service reservoir (storage capacity: 800m^3) constructed 100m downstream of the plant. The other main equipped with two sets of pump supplies the higher zone in the southern part of the service area. During the survey, the pumps were found to be out of operation due to some reasons.

In the Plant, one operator is engaged in a variety of tasks required for the water quality and quantity monitoring, operation and maintenance. This plant, despite its age and the limited workforce is well maintained from the viewpoint of water quality produced.

The electrical facility of the Lahane WTP was installed using the power supplied by PLN at 380/220V/50Hz for its operation. The list and description of the mechanical and electrical facility of this plant with the existing condition are shown in the table below.

Equipment	Specification		Condition
Coagulation Settling Tank	ø7.6m x H3.8m	x 1set	In operation.
Sand Filter Basin	2.5m x 5m x H1.5m	x 3sets	In operation.
Back Washer Pump	Capacity : 8.4m^3/cm^2 Type : Centrifugal Head : 13m kW,Voltage : 22kW, 400V	x 1set	Damaged.
Back Washer Roots Blower	Capacity : Type : Centrifugal Pressure : kW,Voltage : 11kW, 400V	x 1set	Damaged, especially shaft bearing.
Alum Dosing Tank	Capacity : 1.8m^3 Mixer : 230W, 200V	x 2sets	In operation.
Soda Dosing Tank	Capacity : 1.3m^3 Mixer : 230W, 200V	x 2sets	In operation.
Chlorine Dosing Tank	Capacity : 1.0m^3 Mixer : 230W, 200V	x 2sets	In operation.
Alum Dosing Pump	Capacity : Max 22L/hr Type : Diaphragm kW,Voltage : 80W, 200V MILTON ROY USA	x 3sets	In operation.
Soda Dosing Pump	Capacity : Max 22L/hr Type : Diaphragm kW,Voltage : 80W, 200V MILTON ROY USA	x 3sets	In operation.
Chlorine Dosing Pump	Capacity : Max 22L/hr Type : Diaphragm kW,Voltage : 80W, 200V MILTON ROY USA	x 3sets	In operation.
Flow Meter (Raw Water)	6”	x 1set	Not in operation.
Flow Meter (Water Supply)	6”	x 2sets	Not in operation.

Equipment	Specification	Condition
Incoming Panel	Type: Indoor wall mounted P F x 3	Lack sufficient measure against risk.
Main Power Supply Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Main Power Distribution Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Lighting Distribution Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Pump, Compressor Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Panel	Type: Indoor self-standing	Not in operation (no need at present)
Panel	Type: Indoor wall mounted	Not in operation (no need at present)
Pump, Mixer Panel	Type: Indoor wall mounted	Rusty, dirty but usable
Wiring	-	No protection such as conduit

c.) Dili Wells

From the total of 9 wells drilled within Dili City, 7 are in operation and 2 are out of service. Except for Bidau 2, which is used exclusively for the Dili General Hospital, the total water production of these wells was measured at 153 L/s or 13,200 m3/day. Using an ultrasonic flow-measuring device, the flow measurement on the well production was carried out on May 2000 with the results shown in the succeeding table.

- *Comoro A*

As of May 2000, the operation of the Comoro A Pumping Station is on 24-hour basis. It is equipped with valves, which are controlled to supply water to the water consumers in the south and north residential areas separately. The higher zone in the south is supplied with water in the morning and night hours. From 1:00pm to 5:00pm water is pumped to the north area of lower elevation. This pumping station is equipped with chlorination equipment for treatment of the water prior to distribution.

- *Comoro B*

Currently, this pumping station is under the control of the UNTAET (PKF). It is equipped with water refilling station where pumped water is collected by water trucks and distributed to the water consumers not serviced by the reticulated water supply system. This is another pumping station in Dili that is provided with chlorination equipment.

- *Comoro C*

This pumping station is not in operation. Existing pump facility was removed for replacement. The plan to reinstall a new pumping facility did not materialized due to the post-referendum violence.

- *Comoro D*

Water pumped from this pumping station is directly transmitted into the Comoro reservoir. Comoro D is equipped with chlorination equipment for water treatment prior to distribution.

- *Comoro E*

This well is currently out of operation. According to the local source, it is merely for emergency use and for special purpose. If this well will be activated to resume its normal operation, the water production could augment the service water shortage in the city.

- *Kuluhun A & B*

Water pumped from Kuluhun A is pumped into the Becora service reservoir prior to distribution while that of Kuluhun B is pumped directly to the water consumers.

- *Bidau 1 & 2*

Bidau 1 is currently out of use while the water production in Bidau 2 is exclusively used by the Dili General Hospital.

- *Hera A, B & C*

All of the above wells in Hera are currently out of operation due to the damages of the pumping facilities caused by the violence.

The summary on the existing condition of the mechanical facilities of the Dili wells is shown in the table below.

No.	Name of Well	Specification					Condition
		Capacity m^3/min	Pressure kg/cm^2	kW	Pipe Inch	Well Casing	
01	Comoro A	2.3				300	In operation.
02	Comoro B	2.2				300	In operation.
03	Comoro C				6”	300	Abandoned.
04	Comoro D	1.9	7.2	37	6”	250	In operation.
05	Comoro E				4”	250	In operation.
06	Kuluhun A	1.0	10.0	30	6”	250	In operation.
07	Kuluhun B	2.1	6.5	15	6”	250	In operation.
08	Bidau 1				3”	200	Not in operation.
09	Bidau 2				2”	300	In operation.
10	Hera A				3”	200	Abandoned.
11	Hera B				3”	200	Abandoned.
12	Hera C				3”	200	Not in operation.

The summary on the existing condition of the electrical facilities to include the production rate of the Dili wells is shown in the table below.

No.	Name of Well	Production Rate (L/s)	Evaluation
01	Comoro A	27	In good working condition. Power is supplied by PLN. No stand-by generator.
02	Comoro B	49	In good working condition using engine pumps. Power is supplied by PLN.
03	Comoro C	-	The entire electrical equipment was removed. This pumping station is currently not in operation.
04	Comoro D	32	In good working condition. Power is supplied by PLN. Equipped with stand-by generator for emergency.
05	Comoro E	*	In good working condition. Power is supplied by PLN. No stand-by generator.

06	Kuluhun A	32	In good working condition. Power is supplied by PLN. No stand-by generator.
07	Kuluhun B	13	In good working condition. Power is supplied by PLN. Equipped with stand-by generator for emergency.
08	Bidau 1	-	This pumping station is currently not in operation. There is an electrical connection to the PLN power supply line. No stand-by generator.
09	Bidau 2	**	Despite the damaged, this pumping station is in operation and used exclusively for the General Hospital in Dili. Power is coming from the hospital supply line.
10	Hera A	-	The entire electrical equipment was removed. This pumping station is currently not in operation.
11	Hera B	-	The entire electrical equipment was removed. This pumping station is currently not in operation.
12	Hera C	-	The entire electrical equipment was removed. This pumping station is currently not in operation.
T O T A L		153	

* *Operation of this well is not regular and only used during emergency and for special purpose.*
** *This well is in operation but is used exclusively for the General Hospital in Dili.*

d.) Storage Facilities

There are 10 major storage reservoirs in Dili with a total capacity of 4,030m^3. Out of the 10, Bemos II Reservoir and Bidaumasau Reservoir are out of use. Actual production far exceeds the design capacity. When these aspects are considered, the total storage decreases to 2,310m^3 or approximately 2 hours of the water production, apparently insufficient to regulate fluctuations in water demand.

Under the present condition the lack of human resources in the Dili water supply system results to the absence of proper operation and maintenance of the storage facilities. The table below summarizes the technical information of the reservoirs and subsequently discussed in the following sections.

- *Comoro Reservoir*

This reservoir was constructed in 1995 designed to store water from the well sources at Comoro D and Comoro E. It is located on top of the hill west of Dili. It is circular in shape made of steel, covered with vinyl and has a storage capacity of 1,000 m^3. The water level indicator and the flow meter installed in the tank are currently in working condition. No serious problems were noted during the field survey.

- *Taibesi Reservoir*

This reservoir is located on the eastern part of the service area on top of a steep hill. A Hindu temple stands just beside the reservoir. It was constructed recently in 1997-1998 with the source coming from well water from Bemori. Although, in working condition this reservoir has no overflow, no ventilation, but apparently with inadequate washout pipes.

- *Becora Reservoir*

This reservoir located on the eastern part of the service area is designed to store water pumped from the Kuluhun A. It is a similar in shape and structure to the Comoro Reservoir but half in storage capacity. A manual-type chlorinator is installed on the roof but currently not in use. The flow meter is installed in the water source and nothing in this tank.

- *Bedoisi Reservoir*

This reservoir constructed by Bia Hula in 1998 is located in the eastern part of Dili near the main road leading to Manatuto. The storage capacity of this reservoir is $45m^3$ with the source coming from the well water at Bedoisi. During the survey, it was noted that the reservoir is not equipped with any type of ventilation and a water leak was seen coming from the valve.

- *Bidaumasau Reservoir*

This reservoir was constructed in 1996-1997. Currently, this reservoir is not in use because the source (Bidau 1) is not in operation. Despite its relatively less capacity of $30m^3$, it is located in a strategic location to supply water by gravity to the water consumers.

No.	Name/ Location	Water Source	Vol. (m3)	Height (m)	Technical Specification & Accessories	Remarks
01	Bemos I	Bemos WTP, Bemos II and Comoro A	500	-	Rectangular: 14.8m x 14.1m x 2.9m. Made of reinforced concrete with flow meter, ventilation & overflow.	Turbid water coming from Bemos II is mixed with clean treated water.
02	Bemos II	Bemos Intake and Comoro B	1,000	-	Rectangular: 17.7m x 20.4m x 2.9m. Made of reinforced concrete with flow meter, ventilation & overflow.	No supply from Comoro B since water is used by UNTAET. Thick layer of deposits in the tank due to absence of maintenance since commissioned.
03	Lahane	Lahane WTP	800	-	Rectangular: 22m x 14.6m x 3.5m. Made of reinforced concrete with 2 flow meters on outlets (working condition) & ventilation.	Never cleaned since 1995. Washout (2 x 2”) not adequately designed as compared to inlet 2 x 6”
04	Benemauk I	Benemauk Intake	25	-	Rectangular: 3.3m x 3.3m x 2.5m. Made of reinforced concrete with chlorinator, ventilation, overflow & washout.	Thick layer of deposit in the tank due to absence of maintenance since the violence. One chlorinator is not used regularly.
05	Benemauk II	Benemauk WTP	100	-	Rectangular: 9.1m x 8.0m x 2.7m. Made of reinforced concrete with chlorinator & ventilation.	Maintenance carried out monthly. One chlorinator is not used regularly.

06	Comoro	Comoro D and Comoro E	1,000	-	Circular: Ø17.2m x 4.3m height. Made of steel with vinyl coating & equipped with level gauge, flow meter, overflow pipes, ventilation, & washouts.	Flow meter in the outlet
07	Taibesi	Kuluhun B	30		Rectangular: 4.0m x 6.0m x 3.2m. Made of reinforced concrete with flow meter, & washouts.	Inadequate size of washout is installed. No ventilation & overflow.
08	Becora	Kuluhun A	500	-	Circular: Ø14.6m x 3m height. Made of steel with vinyl coating & equipped with level gauge, ventilation, overflow pipes & washouts.	Manual chlorinator not in use. Level gauge not working.
09	Bedoisi	Bedoisi well	45	-	Rectangular: 5.8m x 5.6m x 2.2m. Made of reinforced concrete with overflow pipe, & washouts.	No ventilation & level gauge.
10	Bidaumasau	Bidau 1	30	-	Rectangular: 5.0m x 5.0m x 2.0m. Made of reinforced concrete with overflow & ventilation.	Reservoir not in use since the source of water is not in operation.
T O T A L			4,030	-		

e.) Distribution Network

The water distribution network in Dili covered most of the city population. It contains the old network constructed during the Portuguese era and the new network developed during the Indonesian administration period. The old network built in the old city uses AC and GS pipes of diameter ranging from 3-inch to 7-inch. Due to the non-availability of pipe and fittings such as the 7-inch diameter pipes, there is difficulty in carrying out the repairs. Because these pipes are relatively old, numerous water leakages can be expected from the old network.

The new pipe network is generally laid mostly in areas not served by the old network covering the city from east to west. It is widely distributed that almost all of the villages located within Metropolitan Dili are covered. The development of the new network uses pipe material such as PVC, AC and GS with the diameter ranging from 3-inch to 12-inch.

With the rapid growth of the city population, and the economic activity during the pre-referendum period, there are sections of the old and the new network that has become undersize to carry the flow required to satisfy the demand. The inadequate water production and the deteriorated pipe network that leads to water leakage, are the two main factors that contribute to the water shortage in the service area. It is estimated that the unaccounted-for-water exceeds 60% of the total water production.

f.) Service Pipelines

The activities of the Leakage Control under the Quick Project of JICA provide precious information to carry out the operation and maintenance of the water supply system in Dili.

Several illegal connections from the distribution mains were found during the survey. Because these connections are non-registered and not billed, large volume of water is wasted. The existence of illegal connection makes it difficult to attain optimum flow control in the pipe distribution network. Water supply condition in the critical areas of the distribution network has become miserable. Majority of the population in these areas rarely gets piped water from the reticulation.

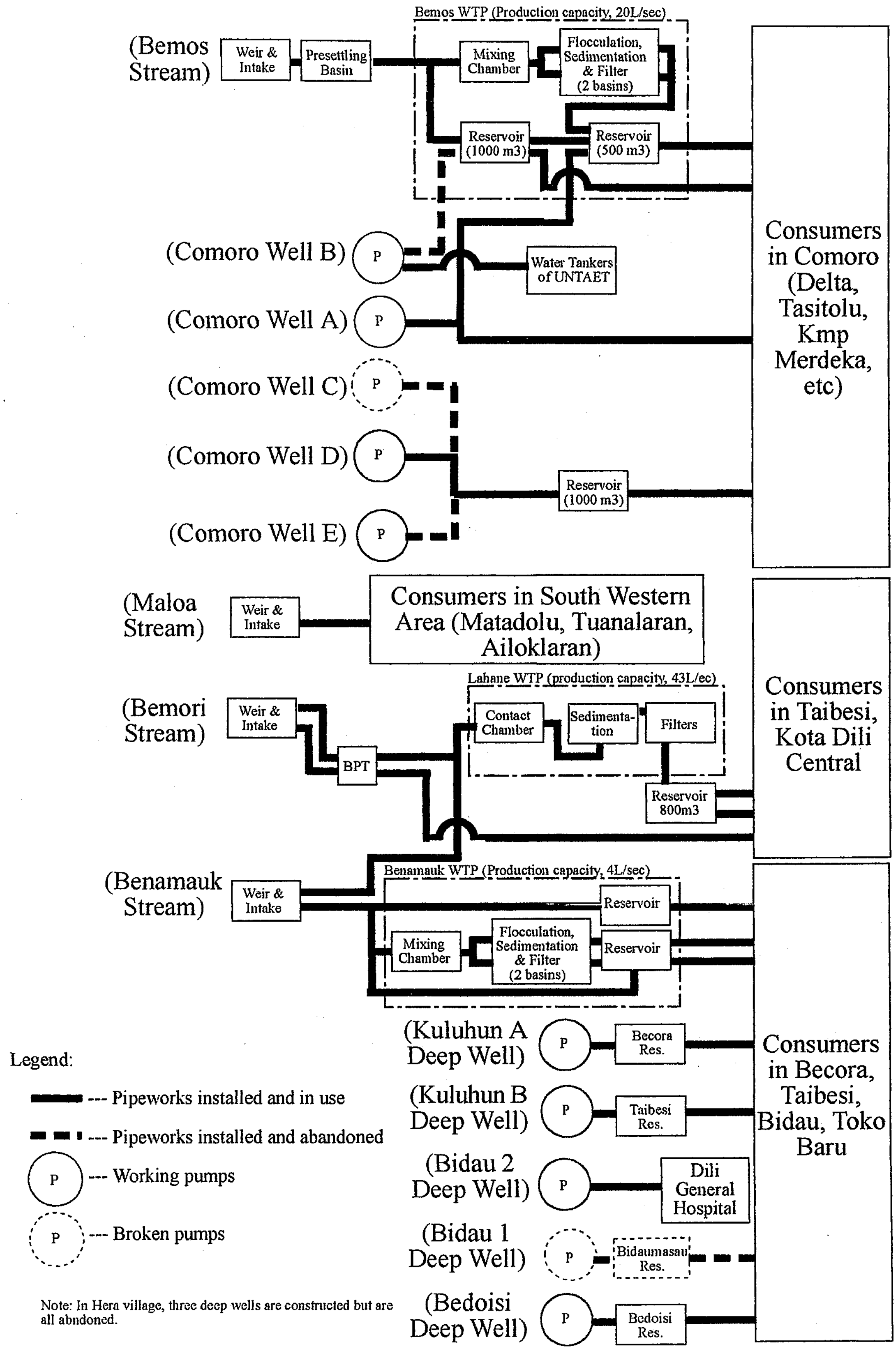
In the service area, many of the public taps were constructed during the Indonesian period. Mainly due to lack of proper maintenance, most of these hydrants are broken and left unrepaired. A summary of the public hydrants in Dili is shown in the table below.

No.	Location	Assessment	
		Condition	Rank*
01	Tasitolu	2 taps missing	B
02	Raikotu	Working	A
03	Kampung Baru A, Comoro	Good condition	A
04	Kampung Baru B, Comoro	2 taps missing; lack maintenance	B
05	Boalaran	All taps missing; lack maintenance	B
06	Manleuana A	Good condition	A
07	Manleuana B	Taps missing; lack maintenance	B
08	Manleuana C	Taps missing; lack maintenance	B
09	Fumento A	Broken	B
10	Fumento B	Broken	B
11	Bemonuk A	Broken	B
12	Bemonuk B	Taps missing; lack maintenance	B
13	Fatumeta	Broken	B
14	Fatuhada A	In bad condition	B
15	Fatuhada B	Pipework stolen	B
16	Manleuana	Taps missing; lack maintenance	B
17	Kakaulidu	Taps missing; lack maintenance	B
18	Kampung Alor A	Broken	B
19	Kampung Alor B	Broken	B
20	Allok Laran A	In bad condition	B
21	Allok Laran B	In bad condition	B
22	Allok Laran C	In bad condition	B
23	Allok Laran D	In bad condition	B
24	Allok Laran E	In bad condition	B

No.	Location	Assessment	
		Condition	Rank*
28	Aituri Laran	Lack maintenance	B
29	Becora-Sabu Raka Laran A	Broken	B
30	Becora-Sabu Raka Laran B	Taps missing	B
31	Becora-Sabu Raka Laran C	Taps missing	B
32	Becora-Sabu Raka Laran D	Lack maintenance	B
33	Camea Laran A	Bad condition	B
34	Camea Laran B	Broken	B
35	Camea Laran C	Broken	B
36	Camea Laran D	Broken	B
37	Bidau Masao A	Pipework stolen	B
38	Bidau Masao B	In bad condition	B
39	Meti-Aut A	Broken	B
40	Meti-Aut B	Broken	B
41	Meti-Aut C	Broken	B
42	Meti-Aut D	Broken	B
43	Meti-Aut E	Broken	B
44	Meti-Aut F	Broken	B
45	Pasir Putih A	Broken	B
46	Pasir Putih B	Broken	B
47	Pasir Putih C	Broken	B
48	Pasir Putih D	Broken	B
49	Bedois A	No water	B
50	Bedois B	No water	B
51	Bedois C	Good condition	A

25	Tuana-Laran	Broken	B	52	Bedois D	Good condition	A
26	Pai-Ol	Broken	B	53	Terminal Becora	Bad condition	B
27	Lahane	Lack maintenance	B	54	Fatumeta	Few taps missing	A

Rank: A – In working condition*
B – With damage, out of use.



The Study on Urgent Improvement Project for Water Supply System in East Timor

SCHEMATIC DIAGRAM OF DILI WATER SUPPLY

Figure E.1

E.3 ATAURO Water Supply System

E.3.1 General

The island of Atauro is one of the sub-districts of Dili located about 20 km off the main Timor Island. There are 5 main villages that comprise the island of which Vila is the capital. The water requirement of this capital village is supplied with water from springs located in the mountain area west of the village. During the time when Vila was enjoying an efficient water supply system, part of the water supply was transmitted to the neighboring Beloi Village. However, with the existing condition of the system, there exists serious water shortage that most of the Vila residents are deprived of a continuous water supply. Moreover, not a single drop reaches the reservoir provided to satisfy part of the water requirement in the neighboring Beloi Village.

The existing water supply service in Vila operates for a limited period of service (0600hrs to 0800hrs and 1800 hrs to 2000hrs) with limited water consumers. During the survey, not one qualified or experienced worker operates and maintains the system. As a result, the quality and quantity of the water supply and the condition of the facilities had continued to deteriorate. With the current condition, only those consumers located in good geographical location of the service area and persons with “authority” can enjoy piped water supply while majority remains not served by the system.

E.3.2 Water Sources

The water requirement of the capital village, Vila and part of the requirement for the neighboring village, Beloi are supplied from 2 springs. Another spring in Beloi called Ehrutar augments the water coming from one of the service reservoir in Vila. Except for the Ehrutar Spring, field surveys were done on the 2 sources in Vila with the following details.

a.) Mota Eklai

The intake structures of these springs are located west of the village about 750m uphill at an elevation of about 150m amsl. It is composed of two tiers of spring seeping out about 10m apart of which two separate concrete boxes are constructed to collect the water via 2-inch GS intake pipes. These spring sources supply a limited number of households in Vila (about 10 households) due to the small yield of these springs (estimated at less than 1 L/s). According to the local source.

b.) Mota Tulai

This source is composed of several springs outcropping at different locations close to each other. It is located about 2 km west of the village uphill at an altitude of about 500m amsl. A total of 4 concrete intake boxes at different locations were constructed to collect the spring water. From these intake boxes, water is transmitted downstream via GS pipes into the village reservoirs passing through a series of break pressure chambers. During the 1st phase survey, the spring water was observed clear with a total yield estimated at than 5 L/s.

As reported by the local sources, there is another spring called Ehrutar located somewhere in the mountains of Beloi. This spring is used to augment the water supply coming from Vila to satisfy the water requirement in Beloi. At present, the water supply system in Beloi is not in operation due to some reasons to include the inadequacy of the sources from Vila.

E.3.3 Water Supply Facilities

The description and the existing condition of these facilities are explained in the succeeding sections.

a.) Transmission Mains

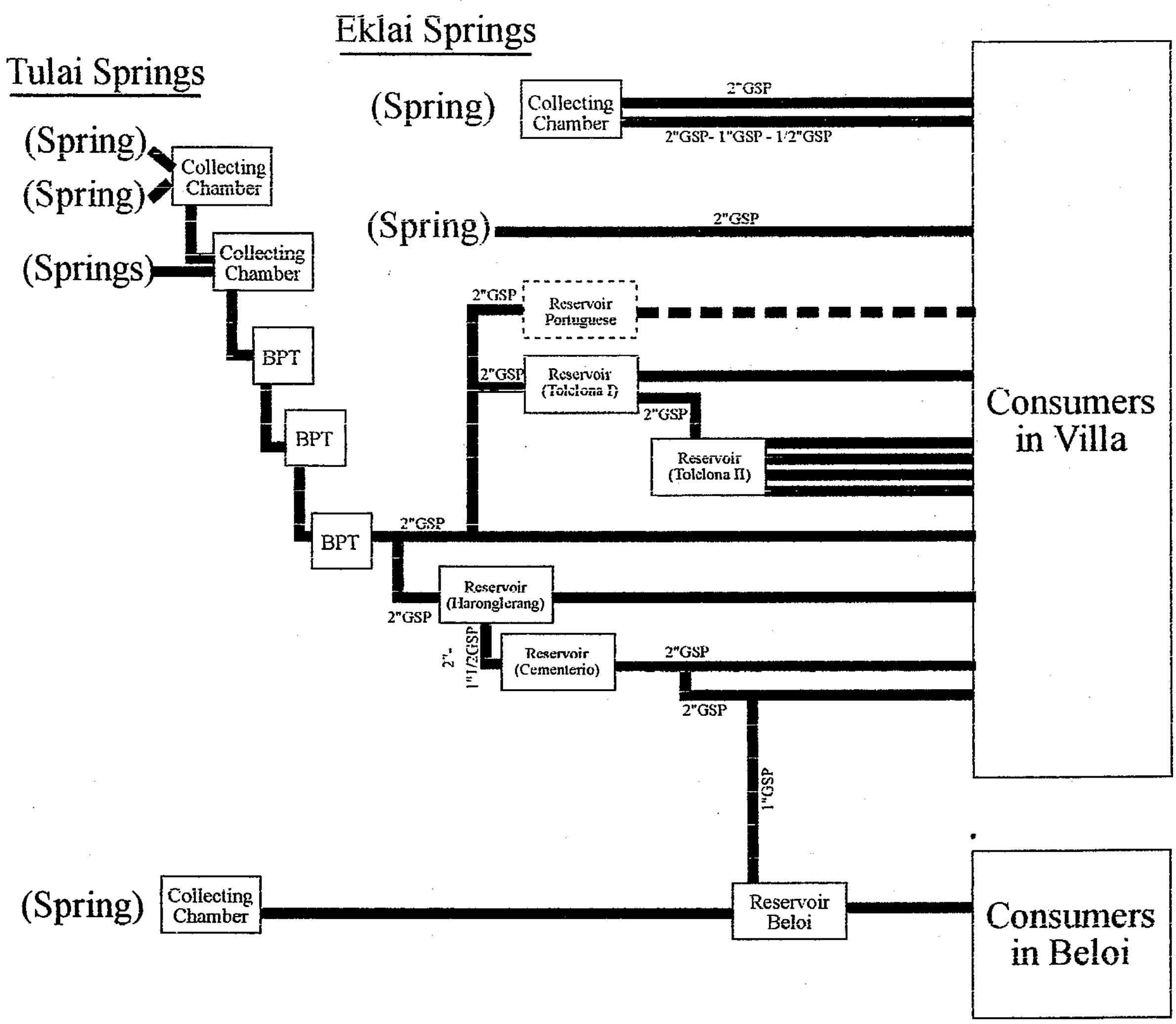
The transmission pipes constructed from the Eklai spring that supplies water directly to the service area are considered as distribution lines. These are made up of GS pipes with diameters ranging from 1½" to 2". However, the transmission mains used to convey water from the Tulai spring sources are mainly GS pipes ranging from diameters 2" to 3". The table below shows the summary of the transmission mains for the Vila water supply system.

No.	Transmission Main (From – To)	Diameter (inches)	Approximate Length (m)
01	Tulai Spring – Haronglerang Reservoir	3	2,000
02	Haronglerang – Tolelona II Reservoir	2	500
03	Tolelona II Reservoir – Tolelona I Reservoir	2	100
04	Haronglerang – Tangke Cementerio	2	2,000
05	Vila Ruta – Lebadoe Reservoir (Beloi Village)	2	5,000
06	Ehrutar Spring – Lebadoe Reservoir (Beloi Village)	1	4,000

b.) Storage Facilities

There are a total of 4 storage reservoirs in Vila and 1 in Beloi with a total design capacity of 157m^3. All of these reservoirs were constructed of reinforced concrete. Haronglerang reservoir was constructed during the Portuguese period while Tolelona I and II were constructed during the Indonesian era. The Tangke Cementerio and Lebadoe reservoirs were constructed with funds donated by AusAID. The technical description of these storage facilities is shown in the table below.

No.	Name of Reservoir	Vol. (m^3)	Year Built	Source of Water	Condition
01	Haronglerang	36.25	1973	Tulai	In good working condition.
02	Tolelona I	37.50	1984	Tulai	In good working condition.
03	Tolelona II	41.25	1989	Tulai	In good working condition.
04	Tangke Cementerio	21.44	1998	Tulai	In good working condition.
05	Lebadoe	20.56	1998	Tulai/Ehrutar	Not working due to non-availability of water supply.
	TOTAL	157.00			



Legend:

- --- Pipeworks installed and in use
- --- Pipeworks installed and abandoned

BPT --- Break pressure tank

JICA	*The Study on Urgent Improvement Project for Water Supply System in East Timor*	**Figure**
	SCHEMATIC DIAGRAM OF ATAURO WATER SUPPLY	**E.2**

c.) Distribution Network

The water distribution network in Vila was constructed to serve majority of its households and part of the neighboring Beloi Village. Majority of the water distribution pipes is exposed above ground along the side road. They are made up of galvanized steel pipes with a maximum diameter of 2-inch to a minimum of ½ inch.

d.) Service Connections

The service connections in Vila and Beloi are made of GS pipes tapped directly from the distribution network. Most of these connections are branch from the distribution pipe by means of a tee to a diameter of ½ inch. During the survey, the pipelines appear to be in good condition however; an assessment on water-tightness of the pipes and fittings particularly on leakage condition could not be carried out due to the limited water service. Although, a few number of leak repair on the pipes using rubber were noted. As per the local source, there exist a few numbers of illegal service connections done on the transmission mains.

E.4 MANATUTO Water Supply System

E.4.1 General

The town of Manatuto is located on the north coast of East Timor some 64 km east by road distance from Dili. Manatuto is the administrative capital of the Manatuto District. As can be seen during the site survey, the town also suffered massive infrastructure destruction especially to residential and government buildings. Although, the town has regularly suffered acute water shortages in the past few months or perhaps in recent years, the situation could mainly be due to neglect or lack of proper maintenance to the facilities rather than violence-related causes.

The main source of water supply for Manatuto is a stream located some 12 km southwest of the town. Water from this source flows by gravity via 6" GS pipe to the town's main reservoir located on top of the hill at an elevation of approx. 80m amsl. From this reservoir, water is then distributed to the service area by gravity without any form of treatment, except for settling that may occur in the reservoir. However, during the field survey no water is coming into the reservoir from this source or any other sources mainly due to the eroded section (reportedly about 360m) of the main transmission pipe. This is a perennial problem especially during rainy season since the pipes are laid in a flood prone situation without appropriate protection. Recently, most of the residents rely on unsafe water supply from shallow wells and nearby river sources.

E.4.2 Water Source/s

a.) Laclo River Infiltration Gallery

As a result of the Phase-1 study, a quick project to rehabilitate the Manatuto water supply system was implemented and an infiltration gallery was installed at the confluence of the

Laclo and Sumasse River. A perforated pipe was placed under the riverbed across the 200-meter river course and a pump station was constructed on the right bank.

b.) Sumasse tributary

The town of Manatuto is situated in the alluvial flat land created by the Laclo River. The town's water supply system has one water source that is currently out of use. The site of the intake is located about 12 km southwest of the town on the right bank of the Sumasse River, a tributary to Laclo River. The shortest distance to reach the site is by traversing in a 4-wheel drive vehicle through the riverbed of the Laclo and Sumasse River. However, this means of transport is possible only when the river flow is low and passable. There is an alternate route via the main road to the town of Laclubar but much longer and would still need to traverse through the riverbed, which normally depend on the river flow.

The intake site is situated on a bushy and swampy riverbank about 150m away from the Sumasse River. The site is protected by a broken barbed wire fence constructed to restrict human and animal entry. The intake structure is equipped with a concrete tank, 6-inch pipe and a gate valve. Water flowing out of the bushy river bank is collected into the tank via 6-inch pipe. This source is more like an undercurrent that happens to emerge at this point.

The summary of the technical information on the water source/s in Manatuto is explained in the succeeding sections of this report.

E.4.3 Water Supply Facilities

a.) Transmission Mains

One of the transmission mains in Manatuto is the 6-inch GS that is used to convey water by gravity from the Sumasse River intake into the Saututum Reservoir. This pipeline is about 12-km in length from the intake point and traverses through the Laclo River before reaching into the town's reservoir. Because the pipeline is normally laid in a flood-prone riverbank without appropriate protection, it is most often subject to erosion and damage. At present, more than 300m length of the pipe section was eroded, which had caused the town's water supply system to be out of operation. Due to the rugged terrain of the pipe route compounded by the lack of resources makes the repair of this transmission pipeline difficult.

Construction of another transmission pipeline was attempted to convey water from a well in Malain Rem to the town's reservoir. It is made up of GS pipes of diameter 4-inch and 3-inch. Due to the post-referendum violence and for some technical reasons this system was abandoned.

b.) Storage Facilities

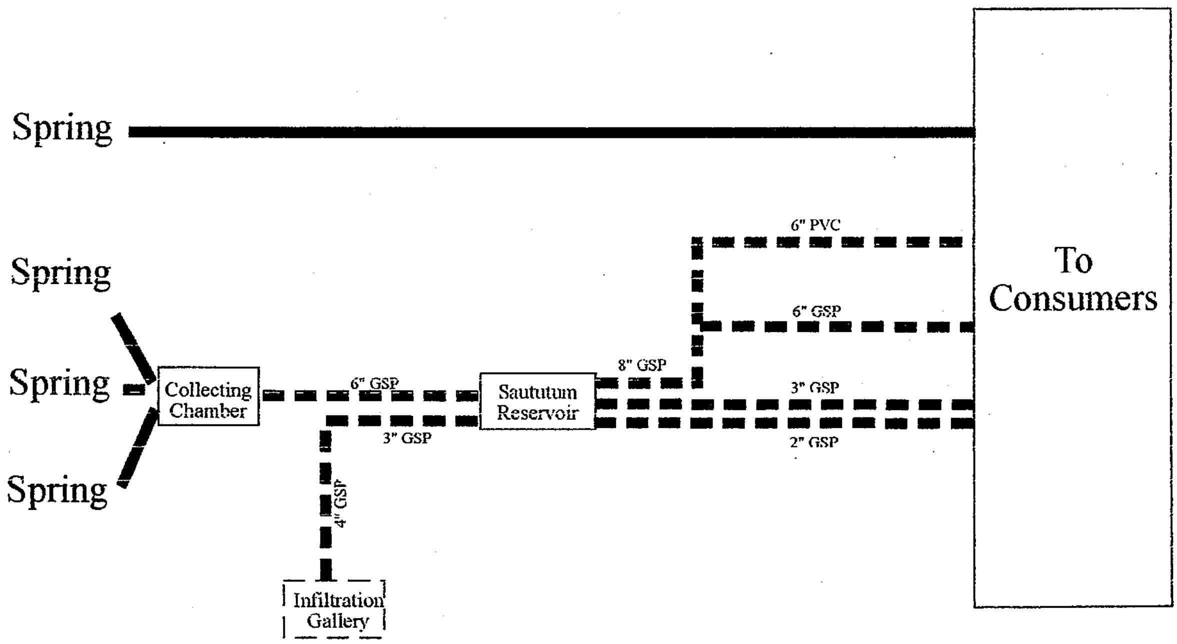
The water supply system in Manatuto is equipped with the Saututum Reservoir strategically constructed up in the hill where water is distributed to the water consumers by gravity. This reservoir is made up of reinforced concrete with a total volume of about $200m^3$. It has 2 inlet pipes from the surface water (6-inch) and well water (3-inch) sources and 2 distribution pipes of diameters 8-inch and 2-inch. These pipes are equipped with valves basically for flow control of the water. Presently, this reservoir is out of use due to the condition of the sources and the transmission mains.

c.) Distribution Network

The water distribution network in Manatuto covers most of the town's residences. The network is made up of GS and PVC pipes of diameters ranging from 8-inch to 1¾-inch. From the distribution main 8-inch and 2-inch originating from the town's reservoir, it branches into smaller diameters and spread out around town from east to west. The condition of the pipes appears to be generally good, except for the PVC lines installed along the coastline. However, an assessment on water-tightness of the pipes and fittings particularly on leakage condition could not be carried out due to the unavailability of the water supply.

d.) Service Pipelines

The service connections in Manatuto are made up of GS and PVC pipes tapped directly from the distribution network. Most of these connections branch from the distribution pipe by means of a tee to a diameter of ½ inch. During the survey, the pipelines appear to be in good condition however; an assessment on water-tightness of the pipes and fittings particularly on leakage condition could not be carried out due to the unavailability of the water supply.



Legend:

--- Pipeworks installed and in use

--- Pipeworks installed and abandoned

BPT --- Break pressure tank

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The Study on Urgent Improvement Project for Water Supply System in East Timor

SCHEMATIC DIAGRAM OF MANATUTO WATER SUPPLY

Figure E.3

E.5 BAUCAU Water Supply System

E.5.1 General

Situated about 130 km from Dili, Baucau District is the second largest in East Timor in terms of population. The district ranges from dry coastal plain to limestone plateau. The city of Baucau is one of its sub-districts located on the coastal plain facing the Wetar Strait. Baucau City serves as the key center for the eastern region of East Timor in terms of political and logistical planning. During the survey, it was found out that the city population had dramatically decreased due to the post-referendum violence. Massive destruction to infrastructure can be seen around town such as ruined government buildings, residential houses, churches, business and commercial establishments.

The water supply system in Baucau City was not spared with the damage. Destruction to the water supply facility was mainly noted on the electrical and mechanical facilities and in the reticulation system notably, the service connection. Due to the damage of the facilities, the people in the city are facing water shortage that normally led to low water pressure especially during peak hour. Consumers at the higher are the worst affected by the current condition of the system.

E.5.2 Water Source/s

a.) Wailia Spring

The city of Baucau spreads over a terraced slope from the sea level to an elevation of about 400m. The main water source is found at the center of the town behind the pumping station. Abundant spring water is found flowing out at different spots at the foot of stone wall above which a main street runs. The pump station utilize some of those springs each yielding at about 10 L/s or more. This is another group of springs across the road from the pump station. Water seeps out from the ground at the bottom of a limestone cliff and collected into a concrete structure that serves as the intake. This water is simply transmitted through a concrete channel passing pump station.

b.) Other Springs

There are few other springs of similar yield within the area. These springs are not utilized for the town's water supply but mainly for irrigation purpose. Another spring is located some 15 km southwest of the town center on the limestone plateau. This water source was used to supply part of the town's water requirement but for some reasons is presently out of use. The spring water is found flowing in a limestone cave several meters below the ground level.

E.5.3 Water Supply Facilities

Established by the Portuguese in 1967, the water supply system of the city of Baucau had limited service area located mainly in the northern town center (old town) of lower elevation. Due to population growth and economic activity, the system had undergone several stages of development.

During the period of the Indonesian rule, a two-stage program was implemented. Stage 1, which was completed in 1988 included the construction of pumping stations and reservoirs to supply water to the higher zone. However, shortly after the operation, the pumps started to malfunction that leads to the stoppage of water supply service to the higher zone.

Stage 2, which was completed in 1992, is basically an extension of the first stage with the same purpose of supplying the consumers in the higher zone. The project includes the construction of booster pumping station, main reservoir and transmission mains to extend the service area west of the city. The construction and extension of the transmission line was aimed to form a circular loop that surrounds the city. However, the pipe laying works were not completed and only the booster pumps became operational to convey water to the main reservoir. The description of each facility and their existing condition are described in the succeeding sections.

a.) Transmission Mains

From the water source located in the city center, water is conveyed by gravity through several transmission mains to the water consumers in the lower zone. On the other hand, majority of the people living in the higher zone can get water distributed from the storage facilities where water is pumped up from the source via the transmission main. The transmission pipelines are made up of GS pipes with diameters ranging from 200mm to 100mm. A summary of these pipes is shown in the table below.

No.	Transmission Main (From – To)	Diameter (mm)	Length (m)
01	Pumping Station No.1 – Booster Pumping Station No. 2 @ Wainiki	200	-
02	Pumping Station No. 2 @ Wainiki – Main Reservoir @ Adarai	200	-
03	Main Reservoir – Samadiga Reservoir	150	Not complete
04	150mm x 100mm Tee Junction @ New Market – Tirilolo Reservoir	100	Not complete
05	Pumping Station No.1 – Lamegua Reservoir	100 x 150	-

b.) Pumping Stations

The water supply system in Baucau City has 3 pumping stations to draw water from the source at a lower level and lift them up to the storage facilities for distribution to the water consumers. The expansion of the service area to the higher elevation of the city necessitates the construction of booster pump to lift the water to the main reservoir. These pumping stations are described below to include their existing condition.

- *Pumping Station No. 1@ Wailia*

This pumping station pumps all the water supply collected from the source into the Lamegua Reservoir and Wainiki Pumping Station for distribution to the water consumers of the city. The electrical facility of this pumping station was installed in 1984 using the power supplied by PLN for its normal operation. It is equipped with emergency generators, which are activated in the event of power outages from PLN. After the violence, one of the generators became non-operational. The existing condition of the mechanical and electrical facility on this station is summarized on the table below.

Equipment	Specification	Condition
Pump Room No.1 Pump	Capacity : $0.36m^3/min$ Type : Centrifugal Head : 84m kW,Voltage : 15kW, 400V x 2sets Nozzle : In 2", OUT 2" EBARA, JAPAN	Not in operation. Shaft bearing is worn away.
Pump Room No.2 Pump	Capacity : $0.75m^3/min$ Type : Centrifugal Head : 100m kW,Voltage : 18.5kW, 400V x 2sets Nozzle : EBARA, JAPAN	In operation.

Equipment	Specification	Condition
Main Power Switch panel	Type: Indoor wall mounted	In good working condition.
Generator No. 1	Rating : CONT Voltage : 380/220 Engine Make: KHD DEUTZ KVA : 85 P.F. : 0.8 KW : 74 Hz : 50 Genomake : STAMFORD, England	In good working condition.
Generator No. 1 Panel	Type: Indoor wall mounted	In good working condition.
Generator No. 2	Rating : CONT Voltage : 380/220 Engine Make: KHD DEUTZ KVA : 33 P.F. : 0.8 Hz : 50 Genomake : STAMFORD, England	Not in operation, too dirty. Installed so many years ago.
Generator No. 2 Panel	Type: Indoor wall mounted	Not in operation.
Fuel Tank	Capacity: 150 liters (W1200 x R400)	In good working condition , dirty.
Pump No. 1 Panel	Type▲Indoor wall mounted Y - starter circuit X 1 set	In good working condition , dirty.
▲ Pump No. 2 Panel	Type: Indoor wall mounted Y - starter circuit X 1 set	Main parts removed, dirty
▲ Pump No. 3 Panel	Type: Indoor wall mounted Y - starter circuit X 1 set	In operation, dirty
▲ Pump No. 4 Panel	Type: Indoor wall mounted Y - starter circuit X 1 set	In operation, dirty
Wiring	-	No protection such as conduit

- *Pumping Station No. 2 @ Wainiki (Booster Pump)*

The Wainiki booster pumps were mainly installed to pump water to the main reservoir located at high elevation in Adarai. It is equipped with 2 booster pumps (1 duty and 1 standby) and generator. This pumping station operates normally by using the generator. After the violence, the electrical facility was severely damage resulting to the non-operation of this pumping station. The existing condition of the mechanical and electrical facility is shown in the table below.

Equipment	Specification	Condition
Pump No.1	Capacity : $0.75m^3$/min Type : Maltistage Centrifugal kW,Voltage : 18.5kW, 400V x 1set Nozzle : In 3", OUT 3" EBARA, JAPAN	In operation.
Pump No.2	Capacity : $0.75m^3$/min Type : Maltistage Centrifugal kW,Voltage : 18.5kW, 400V x 1set Nozzle : In 3", OUT 3" EBARA, JAPAN	Not in operation. Core of the shaft is out of position.

Equipment	Specification	Condition
Generator	Rating : CONT Voltage : 400/230 Engine make : Not known (made in China) P.F. : 0.8 KW : 50 Hz : 50	Not in operation. Main parts removed.
Generator Panel	Type: Indoor wall mounted	Not in operation. Rust is remarkable.
Fuel Tank	Capacity: 80 liters (W600 x D350 x H400)	Lack sufficient measure against risk.
Pump No. 1 Panel	Type: Indoor wall mounted Y - starter circuit X 1 set	Not in operation.
Pump No. 2 Panel	Type: Indoor wall mounted Y - starter circuit X 1 set	Not in operation.
Main Power Switch Panel	Type: Indoor wall mounted	In good working condition.
Wiring	-	No protection such as conduit

- *Pumping Station No. 3 @ Lamegua*

This pumping station located uphill a few hundred meters southwest above the source was installed to supply the consumers situated at high elevation of the old town. It is equipped with pumps and operates by using 2 sets of generator. After the violence, the electrical facility was severely damage resulting to the non-operation of this pumping station. The existing condition of the mechanical and electrical facility is shown in the table below.

Equipment	Specification	Condition
Pump	Type : Submerge x 2sets Nozzle : 3"	Not in operation. Shaft bearing is worn away.

Equipment	Specification	Condition

Generator No. 1	Rating : CONT Voltage : 380/220 KVA : 33 P.F. : 0.8 Hz : 50 Genomake : STAMFORD, England	Not in operation.
Generator No. 1 Panel	Type: Indoor wall mounted	Not in operation.
Generator No. 2	Rating : CONT Voltage : 380/220 KVA : 33 P.F. : 0.8 Hz : 50 Genomake : STAMFORD, England	Not in operation.
Generator No. 2 Panel	Type: Indoor wall mounted	Not in operation.
No. 1 Fuel Tank	Capacity: 90 liters (W600 x D400 x H400)	Old-fashioned but usable.
No. 2 Fuel Tank	Capacity: 90 liters (W600 x D400 x H400)	Old-fashioned but usable.
Pump No.1 Panel	Type: Indoor wall mounted,	
Pump No.2 Panel	Type: Indoor wall mounted,	
Wiring	-	No protection such as conduit

c.) Storage Facilities

Distribution reservoir is one important facility of a water supply system used to provide storage to meet fluctuations in water demand and to stabilize pressures in the distribution system. In Baucau City water supply system, there are 4 reservoirs constructed in strategic areas of the city aimed to satisfy the above-mentioned purposes. A summary of the reservoirs in Baucau is shown in the table below.

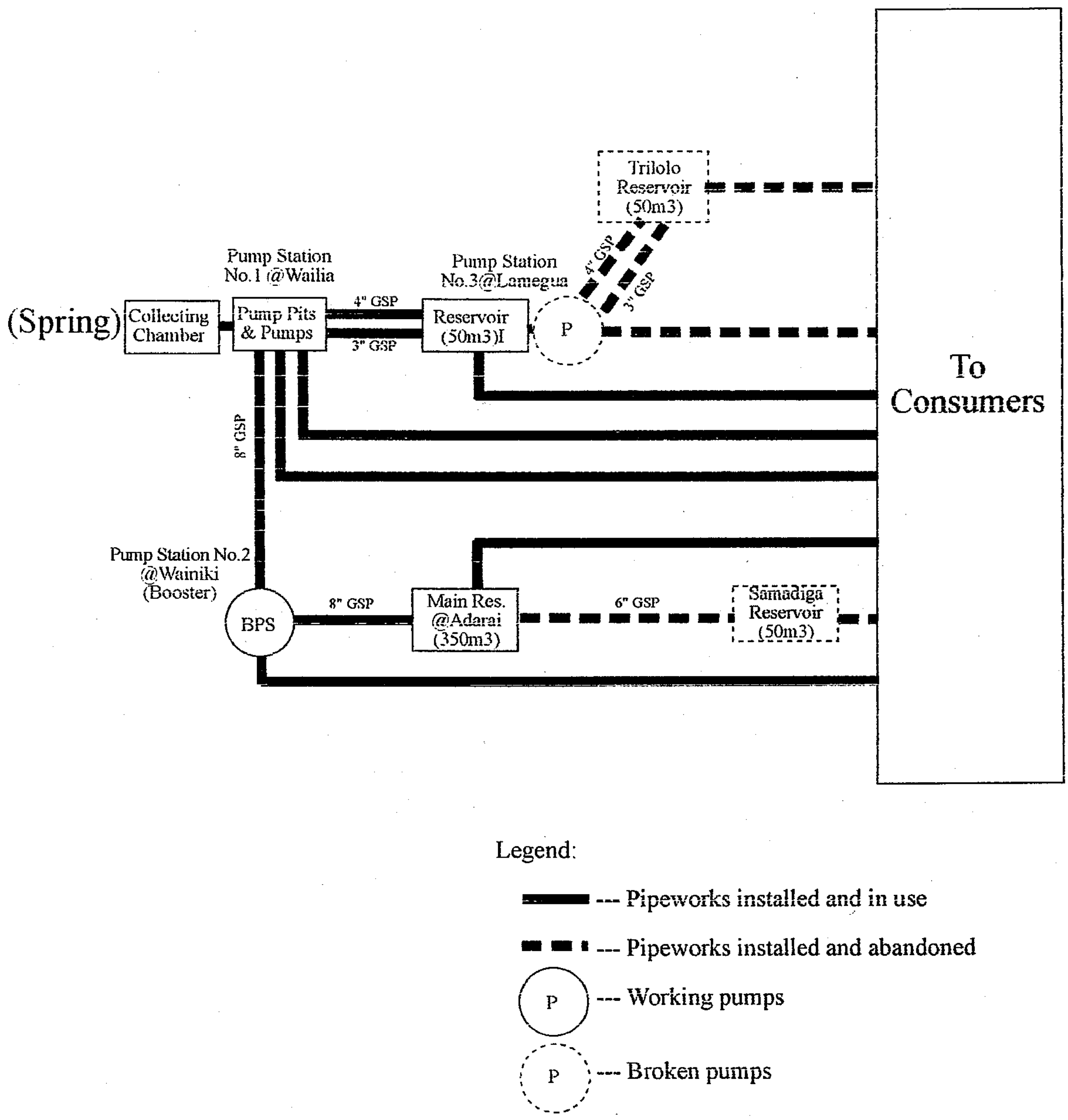
No.	Name/Location of Reservoir	Vol. (m^3)	Year Built	Source of Water	Elevation amsl (m)	Condition
01	Main Reservoir @ Adarai	350	1992	Wailia Spring	439	In working condition
02	Lamegua Reservoir	50	Portuguese Period	Wailia Spring	314	In working condition
03	Tirilolo Reservoir	50	1988	Adaraj Reservoir	358	Not in use due to damaged pump
04	Samadiga Reservoir	50	1988	Adaraj Reservoir	400	Not in use due to damaged pump
TOTAL		500				

d.) Distribution Network

With the kind of topographic condition in Baucau, where the service area is located at different elevations, water is pumped into the reservoirs constructed at an area with sufficient elevation in order to reach any part of the distribution system with adequate pressure. From the reservoirs, water is distributed to the different parts of the service area by means of the distribution pipelines made up of GS pipes with diameters ranging from 6-inch to 2-inch. Due to the post-referendum violence several damages to the distribution network were noted during the survey. These destruction include pipe leakage, valve and hydrant damage. With the assistance of several donor countries, local and international NGO's, repairs to the damages of the water distribution network are taking place.

e.) Service Pipelines

With the exception to the pumping stations, the service pipeline is the water supply facility where most destruction was noted. Due to the damage inflicted on the residential commercial and public buildings, the service pipelines were not spared of the destruction. As a result, water is mostly seen leaking out from the pipes where ruined buildings are located. Currently, repairs to pipe leakage in the service pipelines are being carried by the workers with the help of local and international NGOs.



JICA	*The Study on Urgent Improvement Project for Water Supply System in East Timor*	**Figure**
	SCHEMATIC DIAGRAM OF BAUCAU WATER SUPPLY	**E.4**

E.6 LOS PALOS Water Supply System

E.6.1 General

The Lautem District is located in the easternmost part of East Timor. This district is mainly bounded by the sea and has the country's longest shoreline extending from west to east and down to the southwest boundary, which is Viqueque. The western boundary is Baucau District. Los Palos, which is the capital town of the district, is approximately 100 km east of Baucau. During the survey it was noted that the massive destruction to infrastructure were on public buildings where most of them are completely destroyed.

The water supply system of Los Palos was first established by the Portuguese in 1950's. The system was constructed mainly to serve the population concentrated at the town center. However, due to population growth and the increase in economic activity in Los Palos, the system had undergone several stages of development. In the aftermath of the post-referendum violence, damages to the water supply facilities are mainly on the electrical and mechanical facilities of the pumping stations. The problem to all other facilities are mostly due to neglect and the lack of regular maintenance, although the distribution network contains uncompleted sections that were left without adequate fittings or joints.

E.6.2 Water Source/s

The town of Los Palos is located on the southeastern edge of the limestone plateau. The topography of the town area may appear to be flat but in reality it slopes gently towards the east. The town's water supply system is coming from one large spring source although there are a number of shallow wells operated privately.

The town's water source is located about 1.5 km west of the town center. It is easily accessible from the main road. Water for the town water supply is collected through a pipe from a large pool of water that originates 500m upstream as springs flowing out in a grassy field. A tiny stream of surface water also flows into the pond at the site. A concrete wall that holds a weir diverts the flow to two separate concrete weirs. The two streams eventually go into three earth channels (two large and one small) and flow down towards the town.

E.6.3 Water Supply Facilities

During the time when the Los Palos water supply system was first established by the Portuguese, the facilities were designed for a limited service area. As the water demand continue to grow in consistent with the growth in population and economic activity the system underwent several stages of development mostly done during the Indonesian time.
The latest development was planned with water treatment facility and an elevated storage reservoir to supply the consumers in the higher zone. However, the project was not completed and during the post-referendum violence, part of the facilities was damaged. As a result, water is distributed to the consumers without treatment and majority of the consumers is not supplied with water except to a limited number of people living in the town center.

a.) Transmission Mains

With a series of development done on the system since the time it was first established there exist several transmission mains. Two on the mains, 2-inch and 3-inch pipelines were abandoned due to broken and missing sections and the 8-inch main is not presently used because of some uncompleted portion. Only the 10-inch, which is reduced to 6-inch downstream, is currently used to convey water to the pumping station and the distribution network. These transmission mains are summarized in the table below.

No.	Transmission Main (From – To)	Year Built	Diameter (inches)	Length (m)	Remarks
01	Papapa Spring – Pumping Station No. 1 @ Kauto	Portuguese Time	2 x 6 10	400 30	In use
02	Papapa Spring – Old Pumping Station	Portuguese Time	4	100	Abandoned
03	Papapa Spring – Pumping Station No. 2 @ WTP site	Indonesian Time	8	30	Not in use due to the damage on the pumping station
04	WTP – Elevated Water Tank @ Papapa	Indonesian Time	10	50	Not in use due to the non-operation of the WTP.

b.) Pumping Stations

- *Pumping Station No. 1 @ Kauto (along the main road)*

Constructed during the Portuguese Period, this pumping station is supplied with water by gravity from the spring source and distributes water to the water consumers in Los Palos. It operates normally by using 2 sets of generators. After the violence, the electrical facility was severely damage resulting to the non-operation of this pumping station. The existing condition of the mechanical and electrical facility is shown in the table below.

Equipment	Specification		Condition
Pump No.1	Capacity : Type : Centrifugal kW,Voltage : 15kW, 400V Nozzle : In 3", OUT 3" EBARA, JAPAN	x 1set	Not in operation. Shaft bearing is worn away.
Pump No.2	Capacity : Type : Centrifugal kW,Voltage : 11kW, 400V Nozzle : In 3", OUT 3" EBARA, JAPAN	x 1set	Not in operation. Shaft bearing is worn away.

Equipment	Specification	Condition
Generator No. 1	Rating : CONT Voltage : 380/220 Engine make : TAIYO, Japan KVA : 33 P.F. : 0.8 Hz : 50	Not in operation. Main parts removed.
Generator No. 1 Panel	Type: Indoor wall mounted	Not in operation. Rust is remarkable.
Generator No. 2	Rating : CONT Voltage : 380/220 KVA : 33 P.F. : 0.8 Hz : 50 Genomake : STAMFORD, England	Not in operation. Main parts removed.
Generator No. 2 Panel	Type: Indoor wall mounted	Not in operation. Rust is remarkable.
Fuel Tank	Capacity: 90 liters (W600 x D400 x H400)	Lack sufficient measure against risk.
Pump Panel	Type: Indoor wall mounted Y - starter circuit X 2 set	Not in operation.
Wiring	-	No protection such as conduit

- *Pumping Station No. 2@ Papapa (WTP site)*

This pumping station is composed of 2 systems namely: System 1 pumps raw water to the WTP and System 2 pumps treated water to the overhead reservoir located at the WTP site. During the survey, is was found out this station suffered very severe damage. The electrical & mechanical facility of this pumping station were found missing for unknown reasons. The table below summarizes the existing condition of the facility.

Equipment	Specification	Condition
Pump Room No.1 Pump	Capacity : Type : Centrifugal Nozzle : In 4", OUT 3" x 2sets EBARA, JAPAN	Not in operation. Motor is taken away.
Pump Room No.2 Pump	Capacity : 1.2m^3/min Type : Centrifugal Head : 48m kW,Voltage : 18.5kW, 400V x 2sets Nozzle : In 3", OUT 2"1/2 TORISHIMA, JAPAN	Not in operation. Motor is taken away.

Equipment	Specification	Condition
Generator	-	Traces indicate that the equipment was removed.
Generator Panel	-	Traces indicate that the equipment was removed.
Pump Panel	-	Traces indicate that the equipment was removed.

c.) Water Treatment Plant

The water treatment facility in Los Palos is composed of two slow sand filter units. This facility was constructed in 1999 for the purpose of treating the raw water from the source prior to distribution. It has never been put into operation since the time it was constructed because of the emergence of the post-referendum violence.

d.) Storage Facilities

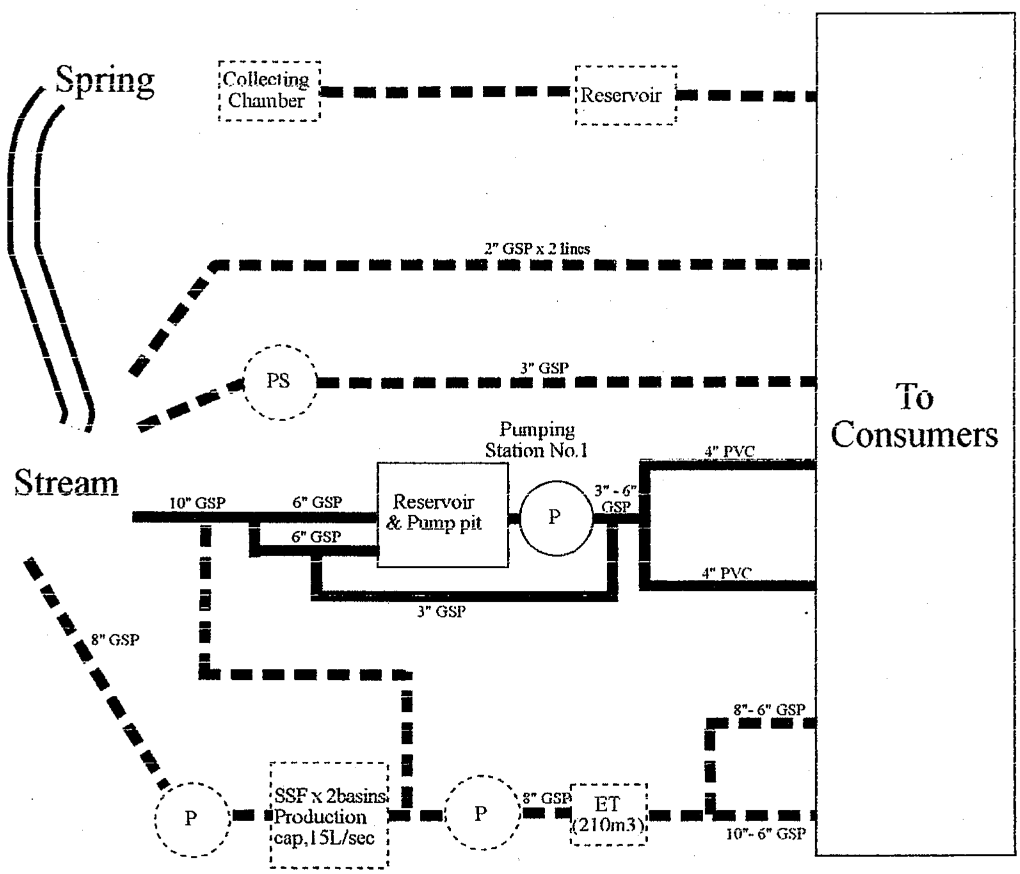
Storage facilities were constructed as part of the development on the Los Palos water supply system. Recently, an elevated reservoir was constructed in an area higher than the WTP. From the WTP, treated water is pumped via 10-inch transmission pipe into the elevated reservoir. This system is currently out of use but the reservoir is in good condition. Only the service reservoir located close to Pumping Station No.1 remains operational.

e.) Distribution Network

The distribution network of the Los Palos water supply system is composed of the old GS pipes installed during the Portuguese time and the combination of GS and PVC pipes installed during the Indonesian period. The diameter of the pipes varies from 6-inch to 2-inch. During the survey, leakage was observed dominant in the old pipes.

f.) Service Pipelines

During the violence, the service pipelines was the most affected facility in the network in terms of damage. Most of these pipes were damaged together with the destruction of the buildings (residential or private) where it is usually installed. As a result, a big percentage of the water losses are coming from the damaged service pipelines.



Legend:

--- Pipeworks installed and in use

--- Pipeworks installed and abandoned

P --- Working pumps

P --- Broken pumps

SSF --- Slow sand filtartion

ET --- Elevated tank

JICA	*The Study on Urgent Improvement Project for Water Supply System in East Timor*	**Figure E.5**
	SCHEMATIC DIAGRAM OF LOS PALOS WATER SUPPLY	

E.7 VIQUEQUE Water Supply System

E.7.1 General

Situated in the southeastern part of East Timor, Viqueque District is bordered by Manatuto in the west, Baucau in the north, Lautem on the east and the Timor Sea in the south. The capital town of the district is Viqueque, which is divided into two parts, namely: old town located in the south, surrounded by S. Cuha River and built during the Portuguese time; new town located in the north just beside the river and built during the Indonesian regime. With most of the population living in the rural area, the rate of returnees to Viqueque is higher in the old town than in the new town.

The water supply system in Viqueque is gravity fed type having the source located at a higher elevation. Although there are minor damages to the facilities, especially in the service pipelines, the water supply system is presently in operational condition. Repair to the damage facilities of the system is currently in progress with the assistance coming mainly from GTZ and the local NGO Bia Hula.

E.7.2 Water Source/s

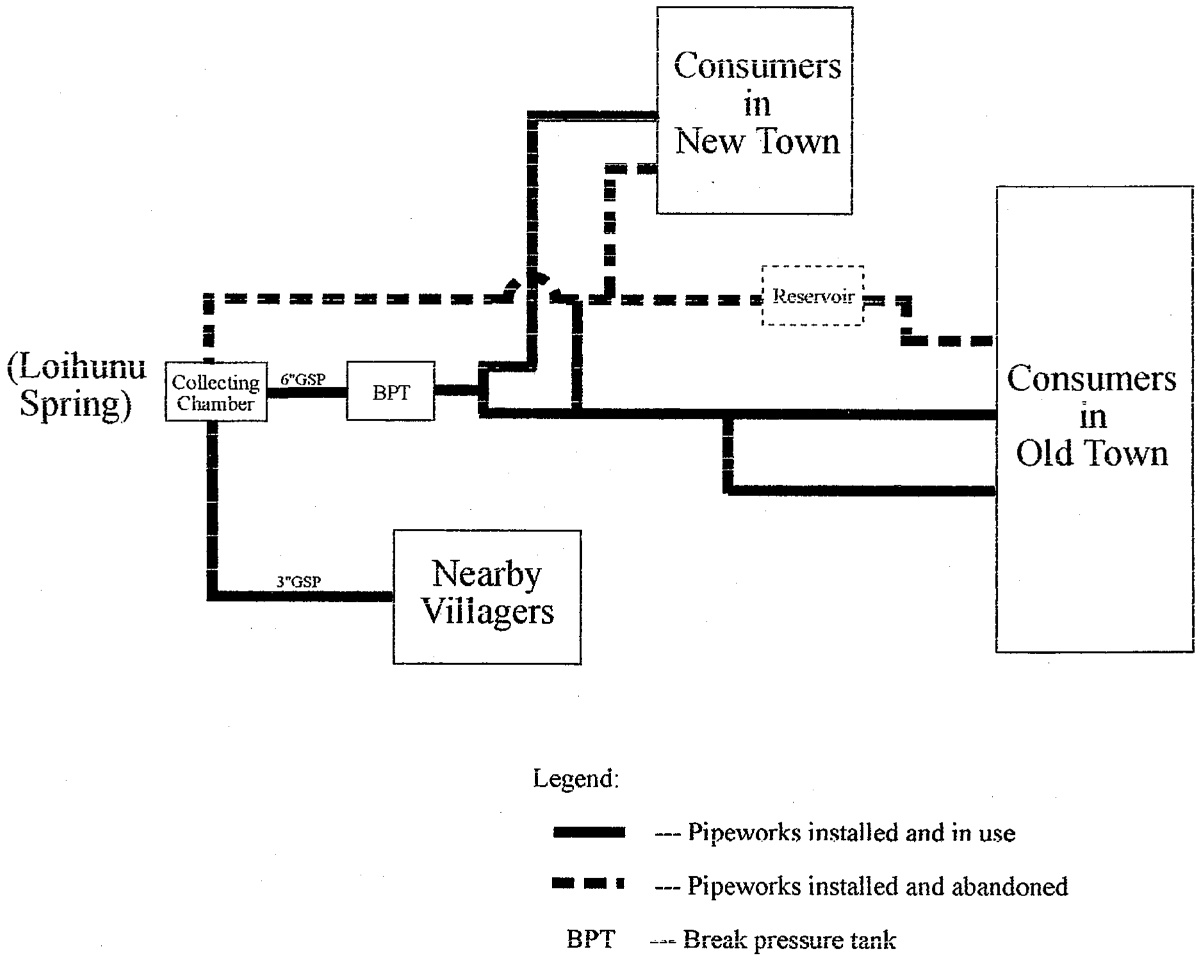
a.) Builua (Loihunu) Spring

The town of Viqueque is situated in a flat plain at the middle valley of the Cuha River. The source of water for Viqueque is the Builua spring with an abundant yield located about 10 km north of the town. This spring can be reached from the road and could easily be located because it is cascading down from the hillside. Water is seen flowing out from limestone cave sor a cracks from three sites, at the foot of the high cliff. The water from those springs separates into 2 big streams. Water from the 2 streams is then collected into an intake structure and transmitted by pipeline for distribution in the town's service area. The water source itself has no protection from contamination and other risks.

E.7.3 Water Supply Facilities

The water supply system in Viqueque was first established by the Portuguese in 1967. Water from the source located about 10 km north of the town flows by gravity via the transmission main to the service area. From the original 2-inch diameter transmission main, the system started with a few water consumers. However, to meet the increase in water demand brought about by the growth in population and economic activity the system had undergone several stages of development.

During the Indonesian time, a 3-Stage Program was formulated aimed to increase the conveyance capacity of the transmission and distribution mains. Stage 1 was implemented in 1984 – 1985 while Stages 2 and 3 were implemented in 1986 – 1987 and 1997 – 1998, respectively. Under Stage 1, a 2-inch transmission main and a reservoir were added to the existing facilities. For Stage 2, similar piping works were constructed, which were eventually abandoned because of their limited capacity. Full-scale system expansion and upgrading were carried out in Stage 3. The project included a 6-inch transmission main installed to convey water from the spring source directly to the consumers.



The Study on Urgent Improvement Project for Water Supply System in East Timor

SCHEMATIC DIAGRAM OF VIQUQUE WATER SUPPLY

Figure E.6

a.) Transmission Mains

The transmission main of the Viqueque water supply system consists of 6-inch GS pipe that conveys water from the source about 10 km to the town area. This transmission pipe was part of the Stage 3 water rehabilitation project constructed in 1998, which replaced the old 2-inch transmission main. During the survey, it was noted that pipe leakage occurs at about 2 km downstream from the spring intake where the pipe traverses a relatively steep slope without adequate protection.

b) Storage Facilities

There is an existing reservoir located at the old town, which was constructed to provide water storage for the water supply system in Viqueque. During the survey, this reservoir, which is composed of 4 basins having a total capacity of about 340 m^3 is out of use because the pipework was damaged during the post-referendum violence.

c.) Distribution Network

The distribution network in Viqueque is divided into two main branches to supply the old and new towns. These two main branches of the distribution network are made up of GS pipes with diameters of 4-inch. From the main distribution pipe it reduces to smaller diameter down to 1-inch. The old distribution network is still in use where pipe leakage dominantly occurs.

d.) Service Pipelines

The service pipelines in the Viqueque water supply system are directly connected from the distribution network, which branches out into ½-inch diameter. Due to the damage inflicted on the residential, commercial and public buildings, some of the service pipelines were also damaged. Repairs to pipe leakage in the service pipelines are being carried by the local workers with the help of local and international NGOs.

E.8 SAME Water Supply System

E.8.1 General

The town of Same has abundant spring water due to its favorable geological formation, topography and climate. The water supply system in Same is in good operational condition with adequate water supply despite the destruction of the facilities, such as the service reservoirs, consumer service connections and administrative office (BPAM).

The water supply relies on three springs as its water sources. They are Kotalala Spring developed in 1960's by the Portuguese, the Darelau and Merbati Springs developed by the Indonesian Government in 1990 and 1993, respectively. All 3 springs are located uphill with sufficient height for gravity supply although some leakage was noted occurring from the transmission mains.

Presently, there are 7 personnel employed by the UNTAET District Administration in Same to operate and maintain the water supply system. They were all technicians and administrators of the former BPAM. Although a few number have not returned to their former post after the violence, but the present administration still manages to keep the service to an acceptable level.

E.8.2 Water Sources

The town of Same is situated on an alluvial plain created by the Caraulun River. It has an area of high mountains over 2000m towards northwest. The town has 3 water sources, namely: Carbulau (Darelau), Kotalala and Merbuti.

a.) Carbulau (Darelau)

This water source is located about 6 km north of the town. The site of the intake can be found at an altitude of 760m amsl on the roadside leading to the town of Maubisse. The intake is located in a small stream that has no flow in dry season. Three under current streams were observed to go into the intake. The intake structure is equipped with a concrete tank and pipes to collect and transmit the water. The tank is surrounded by two concrete weirs (inner and outer) on the side of the road. The site is protected with steel fence to restrict human and animal entry.

b.) Kotalala

This water source is located about 3 km northwest of the town at an altitude of 730m amsl. The water source can be easily reached; 5 minutes walk from the car road. The main stream flows as a tributary to the Uelala River. Around the intake, it develops a small scale braided channel system. The intake is on that complex channel system and has a round concrete weir to collect two small streams. The water is conveyed to a concrete tank right downstream the intake through two pipes and distributed to the town. There is a far larger stream flowing beside the intake.

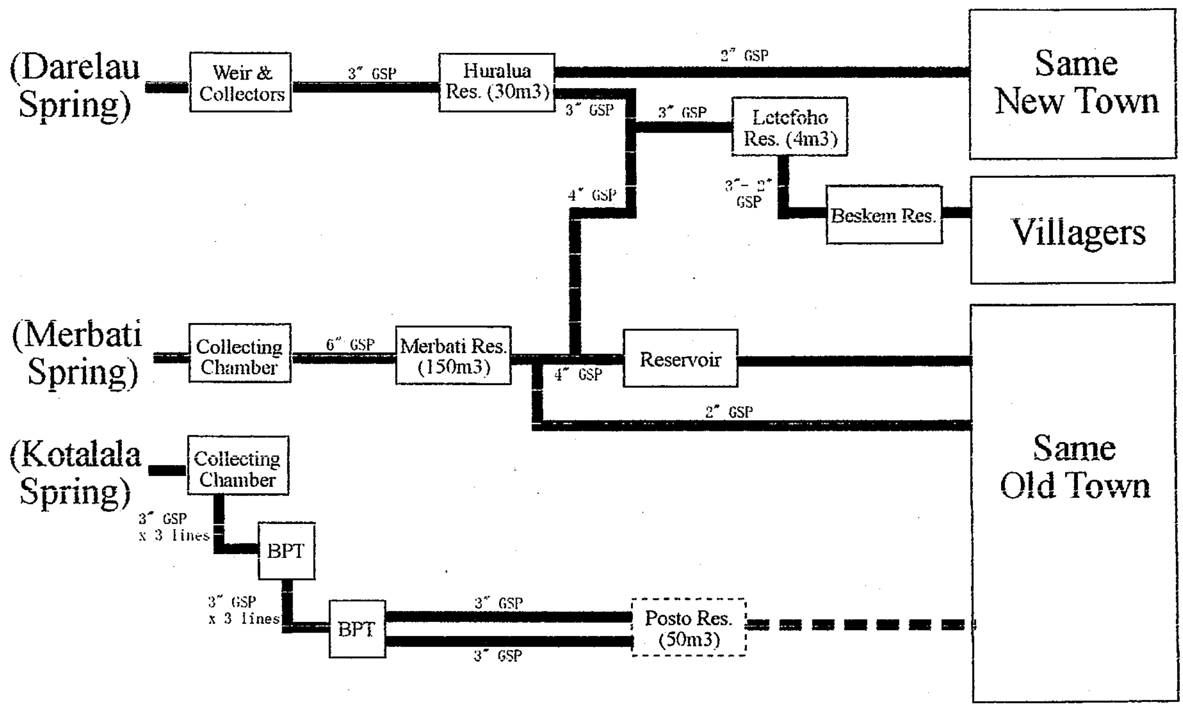
c.) Merbati

This water source is a spring situated about 3 km northwest of the town and about a kilometer west of Kotalala. The water originates as a spring (flowing out of an under current) ground and flows downstream to contribute as one of the tributaries to Uelala River. The intake is located at the left bank of the stream equipped with a concrete structure with galvanized roof (broken at the time of second visit). From this point, water is collected via 3” pipes and flows 30m downstream into a concrete reservoir, where it is then transmitted and distributed to the service area.

E.8.3 Water Supply Facilities

a.) Transmission Mains

The transmission mains of Same water supply system consist of GS pipes with numerous leaks noted during the survey. The summary of the pipes is shown in the table below. The length values are approximate distance given by the local sources.



Legend:

- --- Pipeworks installed and in use
- --- Pipeworks installed and abandoned

BPT --- Break pressure tank

JICA	*The Study on Urgent Improvement Project for Water Supply System in East Timor*	Figure E.7
	SCHEMATIC DIAGRAM OF SAME WATER SUPPLY	

No.	Transmission Main (From – To)	Material	Diameter (inches)	Length (m)	Remarks
01	Kotalala intake – Break Pressure Tank (BPT) 1	GS	3 x 3	20	In use but with leaks
02	BPT 1 – BPT 2	GS	2 x 3	20	In use but with leaks.
03	BPT 2 – Posto Reservoir	GS	2 x 3	2,000	In use but with leaks.
04	Merbati Intake – Merbati Reservoir	GS	6	700	In use but with leaks.
05	Darelau Intake – Hularua Res.	GS	3	5,000	In use but with leaks.

b.) Storage Facilities

There are several reservoirs and break pressure tanks installed for the water supply system in Same. All of these tanks are made of reinforced concrete. Except for the Posto Reservoir, which was damaged by the violence, all the rest are in good working condition. The summary of the storage facilities is shown in the table below.

No.	Name/ Location	Water Source	Vol. (m3)	Technical Specification	Remarks
01	Posto Reservoir	Kotalala Spring	-	Rectangular, elevated tank. Made of reinforced concrete	Not in use due to damage caused by the violence.
02	Hularua Res.	Darelau Spring	30	Rectangular: 5.0m x 5.0m x 1.2m Made of reinforced concrete.	In good working condition.
03	Letefoho Res.	Hularua Reservoi	4	Rectangular: 2.5m x 1.2m x 1.3m Made of reinforced concrete.	
04	Merbati Res.	Merbati Spring	150	Rectangular: 8.4m x 5.7m x 3.4m Made of reinforced concrete.	In good working condition.
T O T A L			-		

c.) Distribution Network

The distribution network in Same consists mainly of GS pipes with diameters ranging from a maximum of 6-inch to a minimum of 2-inch. The reticulation is spread all over town covering a large area of the population. During the survey, several leakages were noted around the distribution area.

d.) Service Pipelines

The leakage in the service pipelines is dominant in ruined buildings, which were affected by the destruction caused by the post-referendum violence. Almost all of these connections are branched from the distribution network into ½-inch. Prior to the violence, there were about 600 registered service connections in Same. After the violence, less than half of 270 were left to be in good working condition.

E.9 AINARO Water Supply System

E.9.1 General

When the Portuguese first established the Ainaro water supply system, it relied its source from Berlesumou Spring located west of the town. This protected spring, although small in yield, produces clean and safe water. But this source was abandoned in 1989 when the Public Works Authority constructed roads and bridges in the town. The authority demolished the 3” GS transmission pipes and used them as bridge railings due to the numerous pipe leaks and its capacity becomes inadequate with the increase in water demand.

Five years later in 1994, the Ainaro water supply system was rehabilitated using surface water from Sarai River & the operation of the newly constructed water treatment plant. The operation of the WTP was stopped after several years of operation due to the lack of regular maintenance. The inadequacy of qualified technical staff and resources had aggravated the situation that has lead to the non-operation of the WTP until now.

Attempts were made to put back the WTP into operation. A grit chamber was constructed in 1997 to remove the grit and undesirable solids from entering the slow sand filter. However, due to the defects in the design such as the unstable inflow and outflow from the grit chamber, this attempt was not successful as intended. Therefore, the filters are currently used as simple channels to convey water. According to the officer in Ainaro, any significant improvement or repair work has not been carried out since then.

There are 10 workers and officers currently involve in the operation of the water supply system in Ainaro as of May 2000. They are employed by UNTAET as operators and plumbers. Out of the 10 workers, 7 persons are former staff of the BPAM Ainaro during the Indonesian Period. Three personnel are newcomers who have little experience in water supply technology and engineering. Under the current situation, they are intensively involved in repair work of the pipe network under guidance from the UNTAET officers.

E.9.2 Water Source/s

The town of Ainaro is situated at the foot of the mountain range Ramelau, which has the nation’s highest peak at Mt. Tata Mailau. Taking a closer look, the town sits on a broad ridge bounded by the Manmali and Sarai Rivers.

a.) Sarai river

The town is currently supplied with water from one source located about 4 km northwest in the Sarai River. The stream originates somewhere deep in the Ramelau Mountain Range. At an altitude of 1070m where the intake site is located, a 15-meter-wide concrete weir is constructed on the stream. Water is diverted into an intake structure equipped with a metal gate constructed on the left bank of the stream. From the intake, water is transmitted through concrete channels running 800m downstream along the edge of the broad ridge to a grit chamber at an altitude of 1030m. Since the grit chamber is presently out of service, raw water is bypassed and transmitted into a reservoir located at the WTP site.

b) Other Springs

There are other springs that previously served as water sources in Ainaro. One is located close to the main source and the other can be found downtown. However, both of these springs have low production rate (a few liters per second) and were left out of use.

E.9.3 Water Supply Facilities

The current water source of the Ainaro water supply system is the Sarai River. Raw water, diverted by a weir constructed across the river, enters into concrete channel. This channel is subdivided into two: an open channel for irrigation and a box-type conduit for water supply. Due to a broken upper-slab of the conduit, turbid torrential water from the ground infiltrates into the channel resulting to the degradation of the water quality. Before flowing into the water treatment plant, the raw water passes through a 12-inch GS pipe of 12m length. The treatment plant consists of a grit chamber and two basins of slow sand filter. Due to the lack of regular maintenance raw water is bypassed from the grit chamber to a storage reservoir within the WTP site. From the reservoir, water is transmitted via 6-inch GS main into a service reservoir located west of the town. Wherefrom, it is distributed to the respective service area through 3" and 6" mains. The water supply conditions in the service area covered by this system is relatively good, although clogging due to sand accumulation in the pipes occurs.

There is another transmission main that conveys raw water from the irrigation canal to a service reservoir. This system supplies the southern area of the town. According to the officers concerned, water shortage is serious particularly in this area.

a.) Transmission Mains

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The transmission mains that are used to convey water from the sources vary from concrete channels used from the Sarai intake to the WTP and GS pipes. The summary of these mains is shown in the table below. The lengths are approximate distance taken by pace factor method or from local sources since no measurement was conducted during the survey.

No.	Transmission Mains (From – To)	Material	Diameter (inches)	Length (m)	Remarks
01	Sarai River intake – Nugupo WTP	Concrete Channel	Box-type conduit: 0.25m width x 0.25m height	800	In working condition, although the conduit covers are broken in some sections.
02	Sarai River intake – Nugupo WTP	GS	12	12	In working condition.
02	Nugupo WTP – Kamilaran 2 Reservoir	GS	6	1,000	In working condition.
03	Sarai River intake 2 – Kamilaran 1 Reservoir	GS	3	1,500	In working condition.

b.) Water Treatment Plant

The water coming from the Sarai River passes through a treatment plant facility. The plant consists of a grit chamber having a dimension of 13m length x 3m width x 2.4m length and two basins of slow sand filter, which has a total capacity of 20 L/s. Normally, raw water coming from the river passes through this treatment facility prior to distribution. However, due to lack of regular maintenance such as thick layer of silt and clay that had accumulated in the filter media has resulted to the non-operation of the WTP. As a result raw water is bypassed from the grit chamber to the storage reservoir.

c.) Storage Facilities

The water supply system of Ainaro is equipped with reservoir in order to provide storage necessary to meet the fluctuations in water demand and to maintain water pressure in the distribution system. During the time when the WTP was still in operation, treated water normally flows into the Kamilaran 2 reservoir where chlorine dosage is added prior to distribution. On the other hand, raw water flows into the Kamilaran 1 reservoir without any form of treatment. With the present condition, water is distributed without any form of treatment except the grit collection in the WTP. The summary of the storage facilities is shown in the table below.

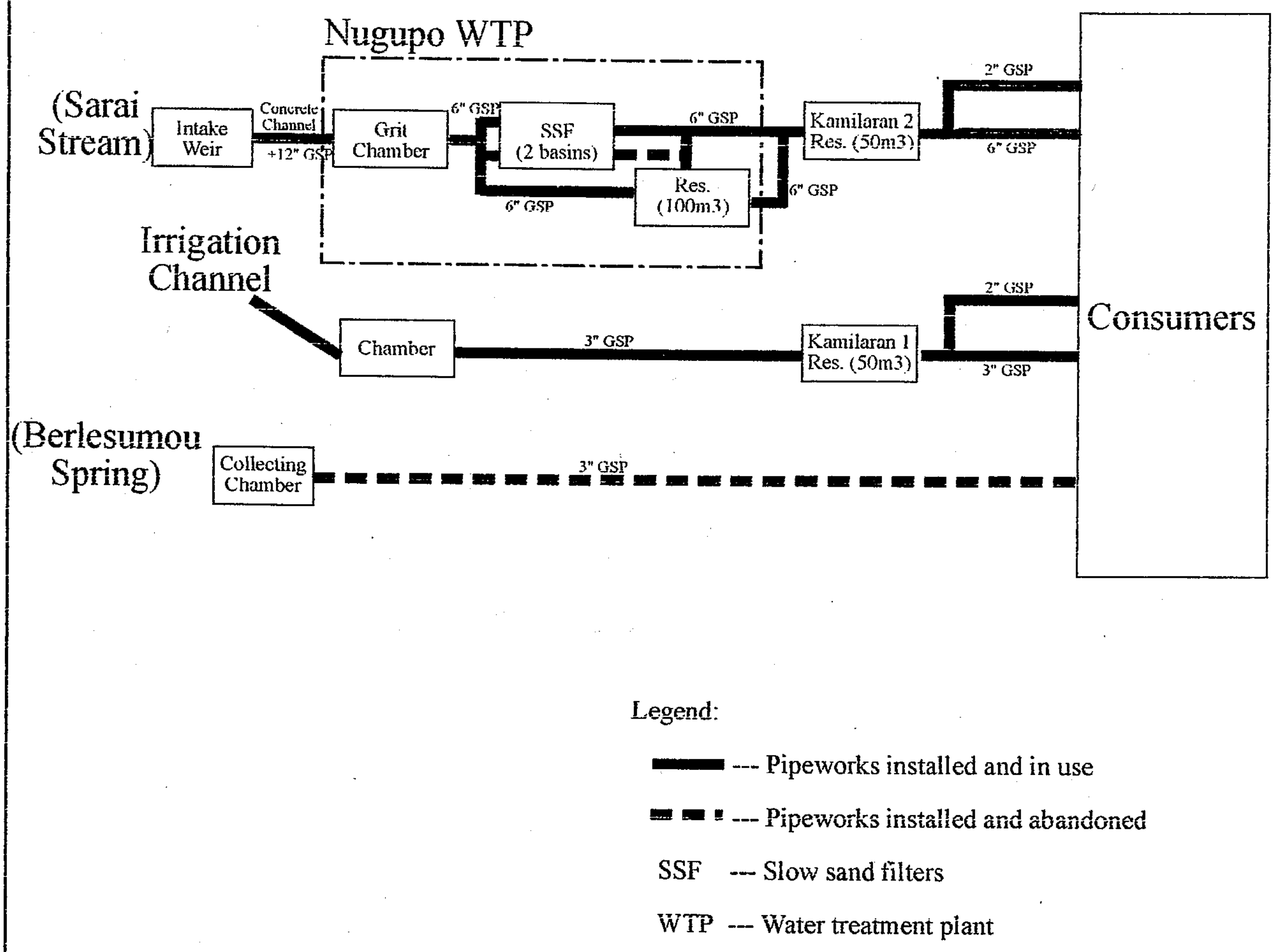
No.	Name/ Location	Water Source	Vol. (m3)	Technical Specification	Remarks
01	Kamilaran 1	Irrigation Canal	50	Rectangular: 5.5m x 5.5m x 2m Made of reinforced concrete with chlorine dosing equipment.	In good working condition but with sand deposits.
02	Kamilaran 2	Nugupo WTP	50	Rectangular: 6.0m x 4.0m x 2.1m Made of reinforced concrete.	In good working condition
03	Nugupo	Concrete Conduit	100	Rectangular: 7.0m x 5.0m x 3.1m Made of reinforced concrete with chlorine dosing equipment..	In good working condition
T O T A L			200		

d.) Distribution Network

During the operational period of the plant, there were two types of distribution mains carrying the treated water and the untreated water to the distribution area. Although, it is said that both are interconnected somewhere in the network, but this was not confirmed during the survey. The network mainly consists of GS pipes with diameters ranging from 6-inch to 1-inch. During the survey, it was noted that numerous pipe leakages spread all around the distribution network.

e.) Service Pipelines

The leakage in the service pipelines is dominant in ruined buildings, which were affected by the destruction caused by the post-referendum violence. Prior to the violence, there were about 470 registered service connections in Ainaro. Most of the service connections were damaged due to the post-referendum violence. Twenty (20) public hydrants were so far been constructed to cover whole area of the town. However, all are currently out of service or broken mainly due to lack of maintenance.



The Study on Urgent Improvement Project for Water Supply System in East Timor

SCHEMATIC DIAGRAM OF AINARO WATER SUPPLY

Figure E.8

E.10 AILEU Water Supply System

E.10.1 General

The Aileu water supply system was constructed by the Portuguese administrative government. During that period, the Naufaizaram Spring was the only water source for the town. This spring protected by a collecting chamber is still in use up to now. At that time, a single pipe of diameter 2-inch was used to transmit water from the spring to the service reservoir near the town. Due to the increase in water demand the transmission pipe was upgraded to 3-inch to increase its capacity. Several development works were also done to the system to meet with the increase in population. Additional water sources were constructed, which included the abstraction of water from Maunkri River in 1984-85 and from the Hularema River in 1987. Simultaneously, new transmission mains were constructed together with the service reservoirs to provide storage.

However, the Aileu population, still experiences water shortage especially during dry season. The plan for an additional water source was again implemented by the construction in 1998 to 1999 of an infiltration gallery on the Mantane River. The infiltration gallery appeared to be the solution to the water shortage and operated for some period. However, due to the fault in the design of the pumps and the water abstraction potential from the gallery this facility started to malfunction. At present, the infiltration gallery is not in operation due to the pump malfunction and the damages to the generator caused by the post-referendum violence. As a result, the people of Aileu is limited with the small but stable supply coming from Naufaizaram Spring and the 2 surface water sources, of which the supply is subject to seasonal fluctuations.

E.10.2 Water Sources

The town of Aileu is situated in a small basin created by the Mantane River. As discussed below, the 4 sources that supply the town's water supply system are all located in the north or northwest except the Mantane River.

a.) Mantane River Infiltration Gallery

The intake site is located beside the bridge, on the bank of the Mantane River, a tributary to the Kusiam River. Water from the river is drawn via infiltration galleries constructed in the riverbed and pumped into an intake chamber. The pumping station, which is operated by a generator set also pumps the water from the intake chamber into an elevated reservoir via 6-inch GS pipe. During the survey, this system was not in operation due to the damage on the pumping station and the generator set.

b.) Sloi Kraik

This water source is located about 2.5 km northwest of the town. Water from two stream of the Nunupung River is collected into the intake made of concrete. Then the water is transmitted to the Marele Reservoir at the northern edge of the town. According to the reservoir maintenance worker, the water supply is occasionally interrupted due to pipe clogging and moreover, during dry season when the stream dries up. The observed inflow into the Marele tank was about 3 L/s in Mach 2000.

c.) Naufaisaram

The intake site for this source is located about 5 km north of the town upstream the Kusiam River. The intake can be easily reached by walking from a small community located on the road to Dili. A small concrete housing is found in a tiny stream. There is a concrete tank inside and the water flows out of the concrete lattice filter.

d.) Hularema

The site of the intake is located about 3.5 km northwest of the town. It can be approached on foot in 15 min from the reservoir tank. There is a crude intake structure made with concrete and rocks. It is built on an outcrop of hard rock, which serves as a natural weir. From the intake water is then transmitted into the Hularema tank located 1 km downstream on a small hill. Water inflow into the tank was estimated at 2 L/s.

E.10.3 Water Supply Facilities

a.) Transmission Mains

The old transmission mains of the Aileu water supply system has undergone a series of development in consistent with the increase in water demand. From one transmission pipeline carrying water from a single source, it was increased to the current number of 4 transmission mains conveying water fom 4 different sources. The summary of these transmission mains is shown in the table below. The lengths given in the table are approximate values given by local sources.

No.	Transmission Mains (From – To)	Material	Diameter (inches)	Length (m)	Remarks
01	Mantane River Pumping Station – Govt. Housing Reservoir, west of Aileu	GS	6	2,500	Not in use due to the non-operation of the infiltration gallery.
02	Naufaizaram Spring – Reservoir 1	GS	3	4,000	In use but with some leakage.
03	Maunkri River intake – Reservoir 2	GS	3	-	In use but with some leakage.
04	Hularema River intake – Hularema Reservoir	PVC	3	-	In use but with some leakage.

b.) Pumping Station

- *Mantane River Pumping Station*

The Mantane River Pumping Station was constructed for the purpose of drawing water from the infiltration gallery and pumping it up to the elevated reservoir located west of the town. This station is equipped with two centrifugal pumps (1 – duty and 1 – standby) and a standby diesel generator.

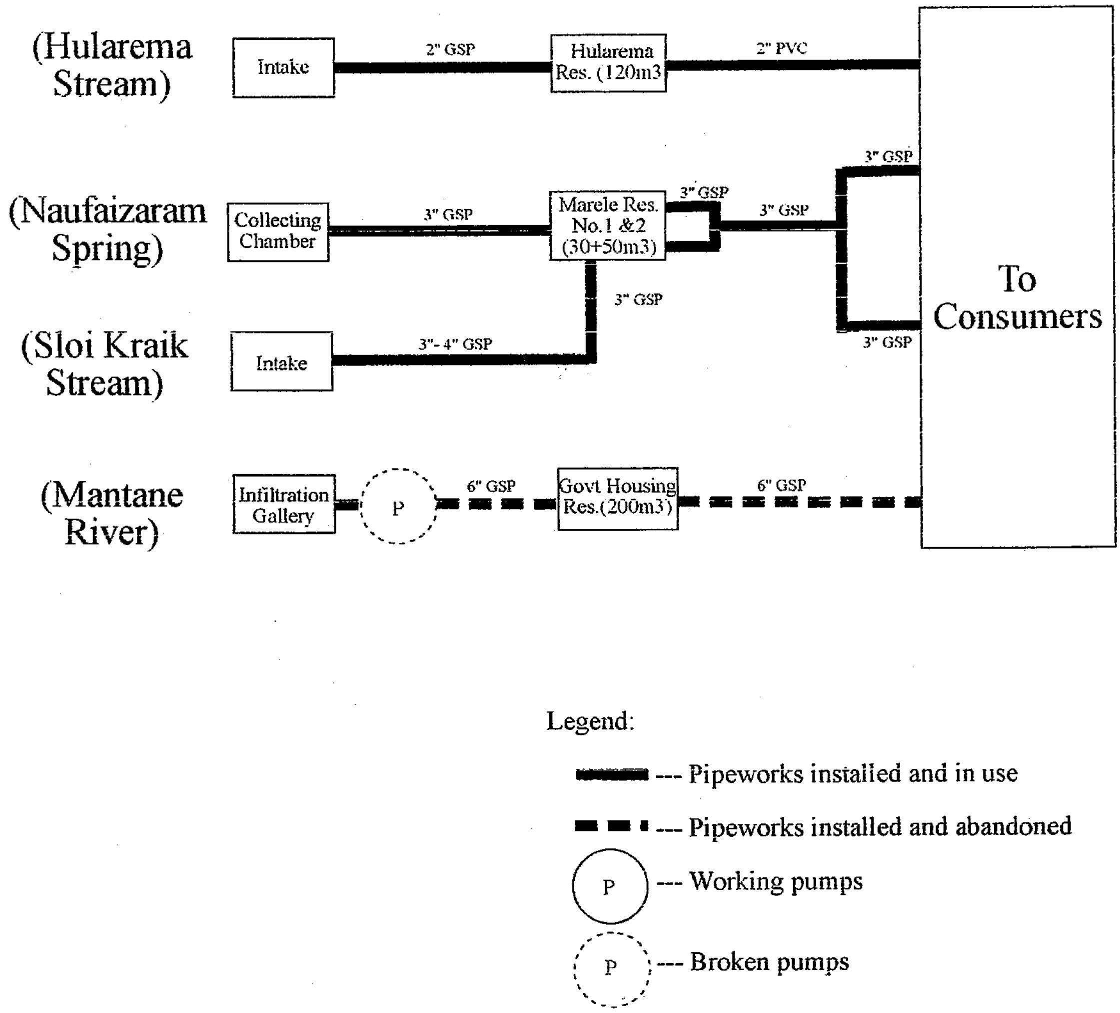
The electrical facility in the Mantane Pumping Station was installed in 1997 using power supplied by PLN for its normal operation. In the event of power outages from PLN, the emergency generator is activated. After the post-referendum violence, the generator has lost its function. The existing condition of the mechanical and electrical facility in this pumping station is summarized in the table below.

Equipment	Specification	Condition
Pump	Capacity : 1.0m^3/min Type : Vertical Multistage Centrifugal Head : 83m x 1set kW,Voltage : 22kW, 400V Nozzle : 4” TORISHIMA, JAPAN	Not in operation.
Generator	Rating : CONT Voltage : 380/220 Engine make : KDH DEUTZ KVA : 60 P.F. : 0.8 kW : 40 Hz : 50 Genomake : STAMFORD, England	Not in operation. Main parts including wires were removed. Lack sufficient measure against risk.
Generator Panel	Type: Indoor wall mounted	Not in operation. Rust is remarkable. Lack sufficient measure against risk.
Fuel Tank	Oil Drum	Lack sufficient measure against risk.
Pump Panel	Type: Indoor wall mounted YΔ starter circuit x 2 sets	Not in operation, main parts were removed. Rust is remarkable. Lack sufficient measure against risk.
Wiring	-	No protection such as conduit.
Incoming route	-	Wires were removed.

c.) Storage Facilities

The storage facilities in Aileu were constructed mainly to provide storage necessary to meet fluctuations in water demand and to maintain water pressure in the distribution system. The summary of the storage facilities in Aileu that include the technical information and the existing condition is shown in the table below.

No.	Name/ Location	Water Source	Vol. (m3)	Technical Specification	Remarks
01	Govt. Housing Reservoir	Mantane River Infiltration Gallery	200	Rectangular: 8.0m x 8.5m x 3.5m Made of reinforced concrete with chlorine dosing equipment.	Not in use due to non-availability of water from source.
02	Hularema Reservoir	Hularema River	120	Rectangular: 5.2m x 8.2m x 3.0m Made of reinforced concrete.	Working but with some leaks at the base.
03	Reservoir 1	Naufaizaram Spring	50	Rectangular and made of reinforced concrete.	In use.
04	Reservoir 2	Maunkri River	30	Rectangular and made of reinforced concrete.	In use.
TOTAL			400		



The Study on Urgent Improvement Project for Water Supply System in East Timor

SCHEMATIC DIAGRAM OF AILEU WATER SUPPLY

Figure E.9

d.) Distribution Network

The distribution network in Aileu is composed of GS pipes with diameter ranging from 3-inch to 1-inch. During the survey, it was found out that numerous pipe leaks occur in the reticulation, mostly in joints and valves.

e.) Service Pipelines

Service pipelines are directly tapped from the distribution using clamp and saddle branch to a diameter of ½-inch. During the survey, pipe leakages were noted around the service area.

E.11 MAUBISSE Water Supply System

E.11.1 General

Maubisse has one of the coldest climates in East Timor, mainly due to its high location at an average elevation of 1430m above mean sea level (amsl). It is one of the sub-districts of Ainaro, with a present population of approximately 7,000. Coffee is the major agricultural product of Maubisse aside from the abundance of fruits and vegetables that the people produce in a small-scale quantity mainly for local consumption. The town of Maubisse, located about 71 km south of Dili is one of the towns that suffered less damage during the post-referendum violence.

The water supply system of Maubisse was developed both by the Portuguese and Indonesian administrative government. The sources of water supply in Maubisse are four (4) springs in which majority of the consumers are supplied from the high-yield Erulu Spring located just a few hundred meters from the service area. The other 3 springs supply mainly the consumers living in the higher elevation and those outside of the Erulu service area. Problems to the existing system noted during the survey were mainly on the distribution and transmission network, such as leakage and damage to a particular section of the pipe. There is no maintenance being carried out on the system due to lack of materials, pipes and fittings. Most of the leaks have been left not repaired.

E.11.2 Water Sources

The town of Maubisse is located on a rather irregular shaped mountain slope at the northeastern foot of the Rameleu Mountain Range. As described below, the town has four water sources within 2 km radius to the north and northwest.

a.) Erulu

The Erulu spring is located close to the service area, about 50m off the Aileu-Maubisse Road at an elevation of about 1450m. Due to its location, this water source supplies the low-lying areas of Maubisee. The spring is found at the foot of coffee farm. The water comes out from the ground into a concrete intake box equipped with several outlet pipes that distribute water to lower elevations of the service area. The overflow water is mainly used by the nearby residents who were seen doing their laundry, bathing and washing, creating a pond of water in the intake area.

b.) Raikuak Ulun

This spring is located about 2.5 km west of the town. The intake is located on a gentlly sloping farmland beside a small stream. The water seeps out from below the farm forming a small stream. The intake is equipped with 1-inch GS pipe placed under the topsoil of the farm. The water is transmited into the Leputo concrete chamber, located a few kilometers downstream

c.) Bucana

The Bucana Spring is located about 1.5 km from the town, and approximately 1.5 km downstream of Raikuak Ulun. The intake is found on a gentle slope on the foot of a large limestone cliff. The water seeps out from under a coffee farm through a pipe and flows down as a small stream, where it is collected into the concrete intake box. The intake is equipped with 2-inch GS pipe to transmit the water into the Pousada Reservoir in the town area. Similar to the Raikuak Ulun Spring, this water source is primarily used to supply the high elevation water consumers.

d.) Filmou

The Filmou Spring is located about 1 km north of the town in the upstream of the Bederi River. The intake is on a steep slope between two small streams that meet right downstream the intake. A concrete intake tank is built at the point where water seeps out from the slope. The water is transmitted to the town through two small reservoir tanks located nearby. Due to the damage on the pipes and the storage reservoir, consumer supplied from this source is limited to a small number of people residing close to the spring.

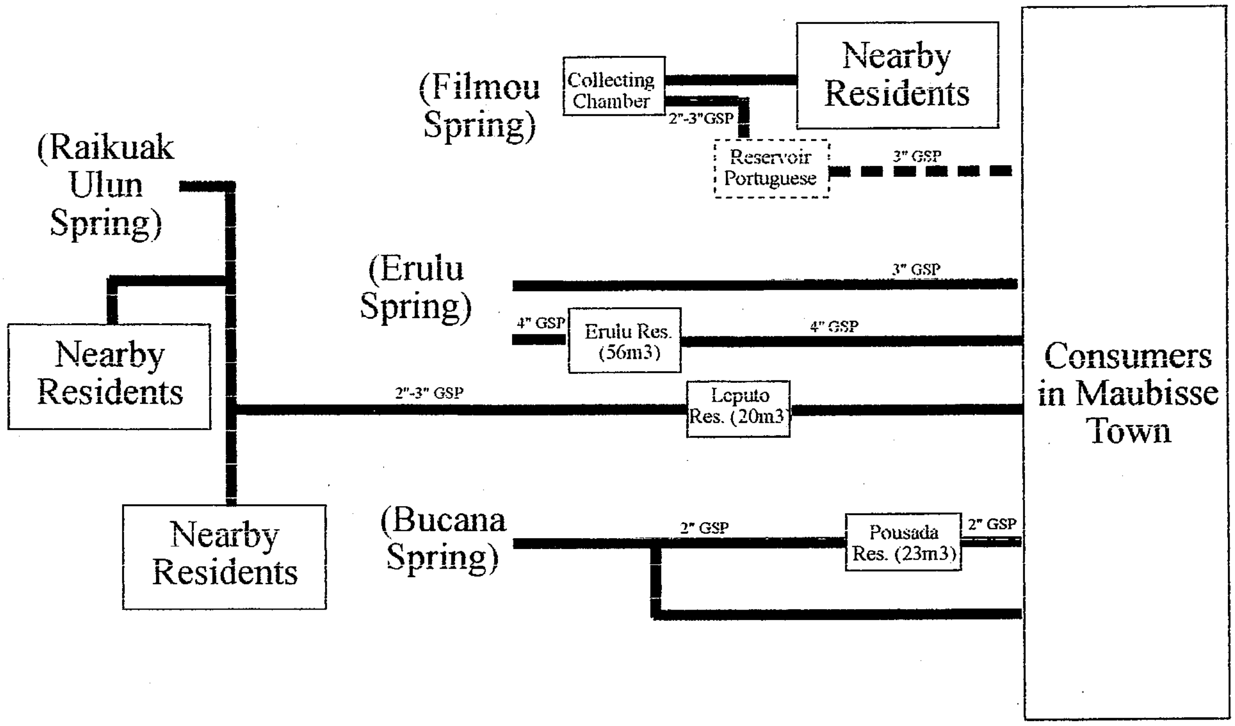
E.11.3 Water Supply Facilities

The field survey of the water supply facilities in Maubisse was completed and summarized in the succeeding sections.

a.) Transmission Mains

The transmission mains for the Maubisse water supply system are summarized in the table below. The lengths given in the table are approximate distance by pace count method taken during the survey. The present condition of the transmission mains includes water leakage and broken sections especially the main used to convey water from Erulu Spring to the reservoir. The transmission mains are connected with numerous service connections along the line.

No.	Transmission Main (From – To)	Diameter (inches)	Length (m)
01	Erulu Spring – Town Reservoir	4	200
03	Erulu Spring – Church & Convent	2	400
04	Bucana Spring – Pousada Reservoir	2	3,000
05	Raikuak Ulun Spring – Leputo Reservoir	1	1,500
06	Filmou Spring – Reservoir Portuguese	2	2,000



Legend:

--- Pipeworks installed and in use

--- Pipeworks installed and abandoned

BPT --- Break pressure tank

JICA	*The Study on Urgent Improvement Project for Water Supply System in East Timor*	**Figure E.10**
	SCHEMATIC DIAGRAM OF MAUBISSE WATER SUPPLY	

b.) Storage Facilities

The storage facilities of the water supply system in Maubisse are all constructed in reinforced concrete. The technical information of these reservoirs is summarized in the table below.

No.	Name/Location	Vol. (m3)	Water Source	Technical Specification	Remarks
01	Erulo Reservoir	56	Erulo Spring	Rectangular in shape made of reinforced concrete.	Not in use due to damage transmission main
02	Leputo	20	Raikuak Ulun	Rectangular in shape made of reinforced concrete.	Currently in use.
03	Pousada	23	Bucana Spring	Rectangular in shape made of reinforced concrete.	Currently in use but with small amount of water available for a limited period.
T O T A L		99			

c.) Distribution Network

The distribution network of the water supply facilities in Maubisse is made up of GS pipes with diameters from 2-inch to ¾-inch. The pipes are mostly exposed on the side road without appropriate cover protection. During the survey, it was found out that numerous pipe leaks occur in the reticulation.

d.) Service Pipelines

Service pipelines are directly tapped from the distribution and transmission lines branch to a diameter of ½-inch. During the survey, pipe leakages were noted around the service area particularly on few damaged buildings.

E.12 GLENO Water Supply System

E.12.1 General

Gleno is one of the towns in the Ermera District situated in the mountainous part of East Timor about 40 km. South of Dili. The town could be reached from Dili by travelling westward through a 12-km plain and smooth road and traversing southward to another 28-km steep mountain slopes uphill. This rice-producing town was founded during the Indonesian Regime, and became the seat of government of the district.

The water supply system in Gleno was established by the Indonesian Government in 1982-1983 during its establishment as the seat of government in the Ermera District. The system is gravity based having its sources at about 5-7 km uphill and flows into the WTP before distribution to the water consumers.

E.12.2 Water Sources

The town of Gleno is situated in a small basin drained by several rivers coming from the south and east flowing westward to form the Gleno River. The town water supply comes mainly from two rivers; Mota Boot (Mauceum) and Mota Kiik (Borhei) and another spring called Ergrogo.

a.) Mota Boot

This water source is located in a large stream popularly called Mota Boot (Mauceum River) at an altitude of 1015m amsl. The intake structure can easily be reached due to its close proximity (less than 50m) from the main road leading to the town of Ermera. The river is rocky and steep and has a big flow, although it appears that only a small fraction of it is being utilized to supply the town. A 3.5-meter-wide concrete weir is constructed along the stream where the water is transmitted through a pipe into an intake structure at the right bank of the stream. However, during the survey, this water source was out of use due to the broken pipe, possibly due to a flood of the river.

b.) Mota Kiik

This water source is found in a small stream popularly called Mota Kiik (Borhei River). It is about 300m away from Mauceum on the same road leading to Ermera. The intake structure can also be reached from the main road less than 50m distance. The stream is narrower and steeper than Mota Boot. The intake structure is equipped with a stone-made weir, where water is collected through a pipe that is joined to a Tee 4”x 6” along the side road into the transmission main coming from Mauceum.

c.) Ergrogo

The intake is located on a mountain slope inside the catchment of Mota Boot at 70m higher place. It can be reached in 15 min. by following a foot path from the bridge over Mota Kiik. Water is flowing out under a rock and a concrete tank is built right at the spring to collect the water. The water is distributed through two pipes one of which only goes to a nearby community. During the survey, it was reported that this source is out of use due to the damage of the pipe.

E.12.3 Water Supply Facilities

a.) Transmission Mains

No.	Transmission Main (From – To)	Material	Diameter (inches)	Length (m)	Remarks
01	Mota Boot Intake - WTP	GS	6	9,000	A section @ intake is damaged.
02	Mota Kiik Intake – 6” x 4 “ Tee	GS	4	20	In use
03	Ergrogo Intake – WTP	GS	3	6,000	A section close to the intake is damaged.

b.) Water Treatment Plant

The Gleno water supply system is equipped with a slow sand filter unit having a designed capacity of 10 L/s. It is constructed of reinforced concrete at a higher elevation about 1.5 km away from the service area.

c.) Storage Facilities

The storage facilities of Gleno are designed mainly to provide storage that will meet fluctuations in water demand. The storage facilities were constructed close to the WTP and are made up of reinforced concrete.

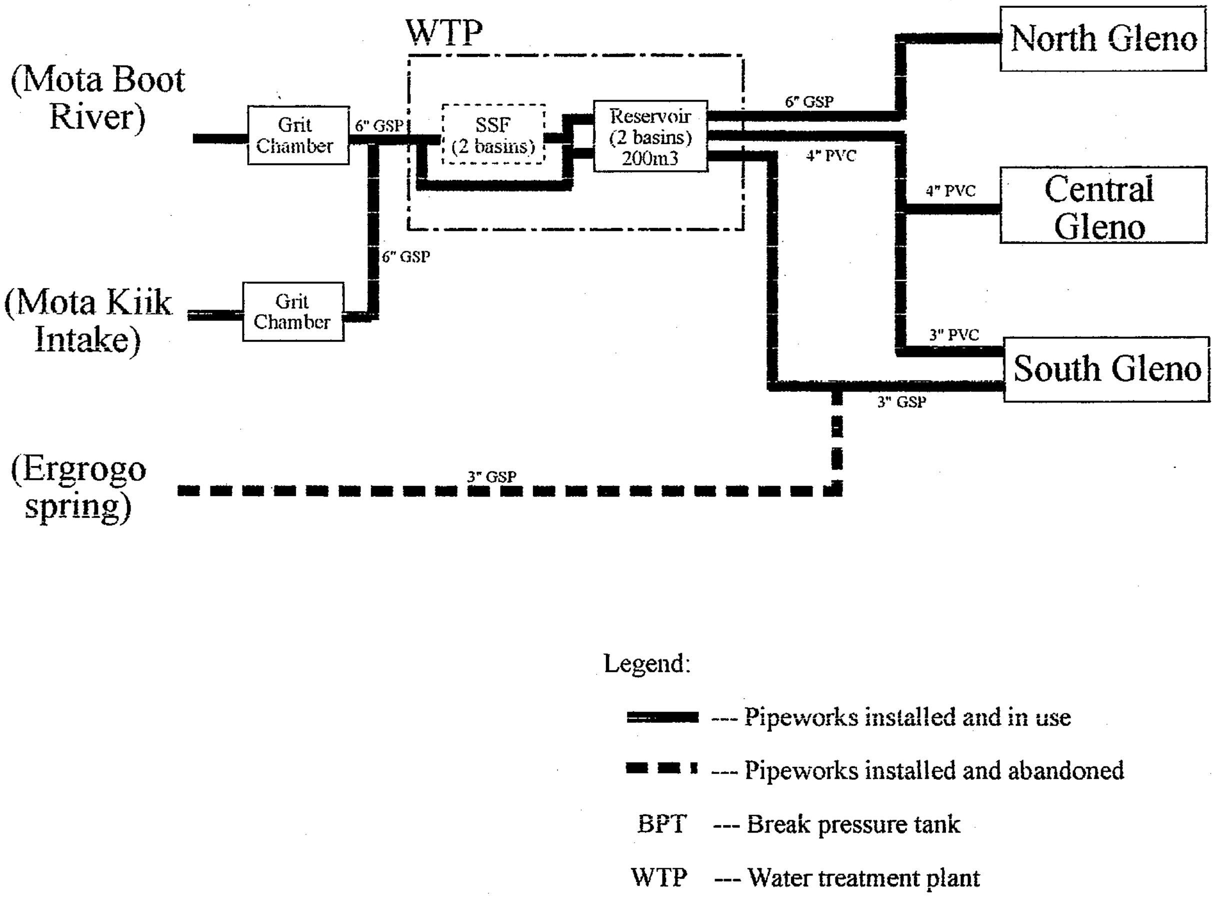
No.	Name/Location	Water Source	Vol. (m3)	Technical Specification	Remarks
01	Hatsnigulau 1	WTP	300	Rectangular: 5m x 6m x 10m Made of reinforced concrete	In use. Traces of repair works were noted.
02	Hatsnigulau 2	WTP	400	Rectangular: 5m x 8m x 10m Made of reinforced concrete	In use. Traces of repair works were noted.
T O T A L			700		

d.) Distribution Network

The distribution main is 6-inch in diameter made up of GS pipe. This branches into smaller diameter down to a minimum of 1-inch. Numerous pipe leaks were noted during the survey. Repair works especially on the leaks are currently being done with the help of NGO such as ACF.

e.) Service Pipelines

Most pipe leaks in the consumer service connections are dominant in the ruined residential and public buildings. A large amount of water loss is coming from these leaks that the local workers find difficulty to repair. It is time consuming to locate the pipes in the damaged buildings because no plans are available.



The Study on Urgent Improvement Project for Water Supply System in East Timor

SCHEMATIC DIAGRAM OF GLENO WATER SUPPLY

Figure E.11

E.13 ERMERA Water Supply System

E.13.1 General

Ermera is a mountainous district and one of the highest coffee-producing regions in East Timor. It has a population of about 90,795 distributed in 5 sub-districts; Atsabe, Letefoho, Hatolia, Ermera and Railako. During the post-referendum crisis, this district and the town of Ermera suffered major destruction.

During the Portuguese Regime, the town of Ermera was the seat of government of the Ermera District. However, in 1982, the Indonesian Government created a new town and transferred its district seat to the plain area about 12 km north of Ermera called Gleno.

The existing water supply system in Ermera is gravity-based getting its supply from uphill river and springs. At present, Ermera town is experiencing water shortage due to pipe leakage, which are dominant in the distribution system. There is no maintenance being carried out on the system particularly on the distribution and also in the transmission pipes due to lack of materials, pipes and fittings. Repairs on the leaks using rubber is commonly practiced, but this measure is just temporary resulting to a recurring problem.

E.13.2 Water Sources

Ermera is a small town situated on a broad ridge at an altitude of 1100m amsl. The town is supplied from two main low-yield sources as discussed below. However, one other spring (Lubulala) is exploited to supply the sister's convent and limited households nearby.

a.) Lubulala

This water source is located up on the mountain slope at an altitude of 1450m amsl, more than a kilometer west of the town. Water seeping out from the ground at the right bank of a small stream, is collected through pipes into a concrete intake boxe located right under the spring. There is another tiny stream flowing down a few meters away from the spring. This water is conducted through a bamboo to a nearby community.

b.) Ersoi

The spring is located about one kilometer to the west of the town. The water source is found up on the mountain slope no more than 300m away from Lubulala spring at an altitude of 1390m amsl. Water seeping out from the ground at two separate points on the right bank of a small stream is collected by placing a pipe at their outlets. The water collected through pipes go into two separate concrete intake boxes.

Apparently, the intake structures are located in a flood-prone zone of the mountain slope that had caused damage to the concrete tank and pipes. During the survey, it was observed that one of the tanks had shifted from its original location. According to the local source the nearby stream dries up during the dry season but the spring continues to flow with a small drop in its yield.

c.) Mota Bura

The intake site of this source is located 800m southwest of the town at an altitude of about 1235m amsl. It can be reached by walking 300m westward from the main road. The main stream is one of the tributaries of the main Bura River. The water that flows out from a grassy mountain slope is collected into a concrete intake tank. The tank is protected by a broken wire fence and equipped with a V-notch weir.

E.13.3 Water Supply Facilities

a.) Transmission Mains

The transmission mains of Ermera water supply system is composed of GS pipes of diameter 2-inch. During the survey, it was noted that the numerous pipe leaks are repaired using rubber. The transmission mains are not properly constructed resulting to frequent damaged caused by erosion and floodwater. The summary of the transmission mains is shown in the table below.

No.	Transmission Main (From – To)	Material	Diameter (inches)	Length (m)	Remarks
01	Lubulala Intake – Poetete Reservoir	GS	2	2,000	In use with numerous leaks.
02	Ersoi Intake – Poetete Reservoir	GS	2	2,000	In use with numerous leaks.
03	Mota Bura – Service area	GS	2	1,000	In use with numerous leaks.

b.) Storage Facilities

The storage facilities in Ermera were constructed during the Portuguese administration period. It is made up reinforced concrete. The summary of the reservoirs is shown in the table below.

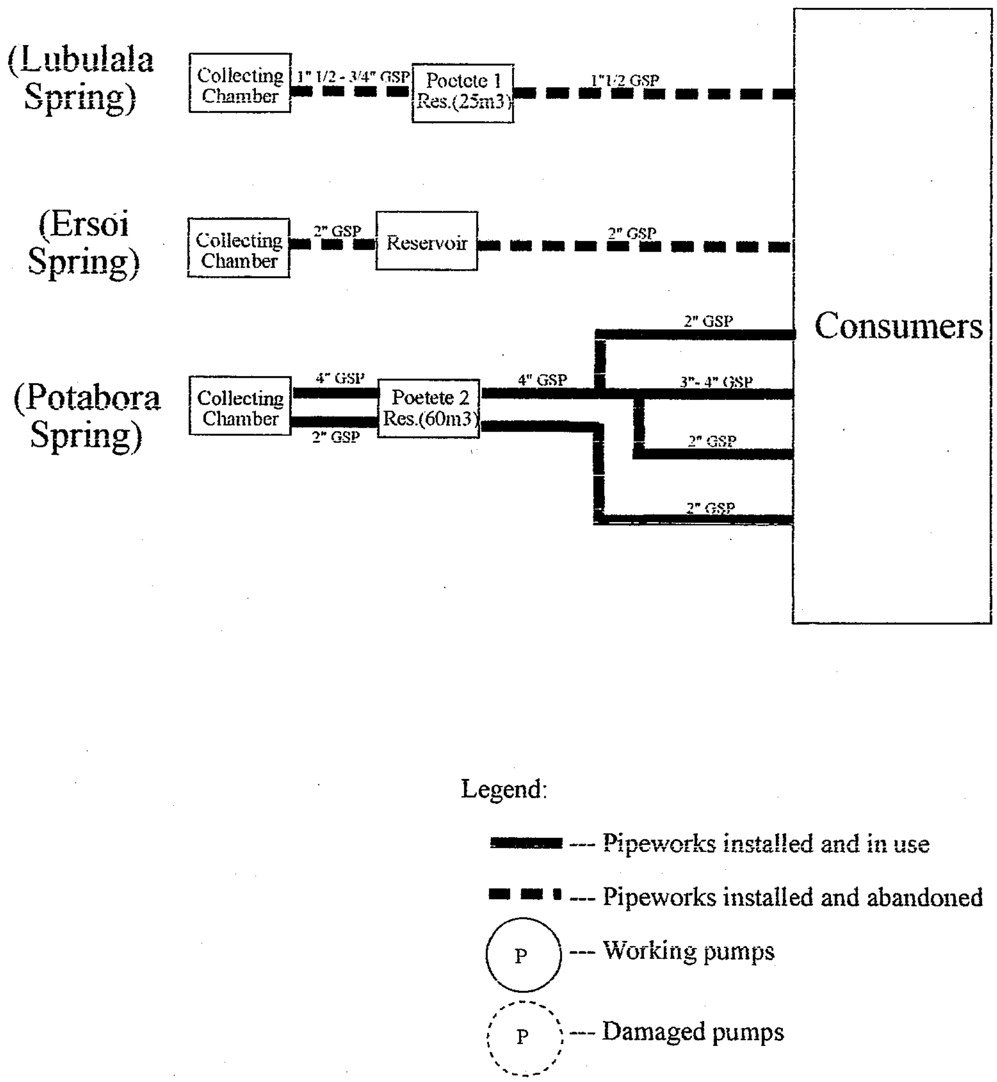
No.	Name/Location	Water Source	Vol. (m3)	Technical Specification	Remarks
01	Poetete	Lubulala	25	Rectangular: 2.4m x 5.4m x 2.2m Made of reinforced concrete	In use
02	Poetete	Ersoi	60	Rectangular: 4.0m x 6.0m x 2.5 Made of reinforced concrete	In use
T O T A L			85		

c.) Distribution Network

The distribution network of the Ermera water supply system is made up of GS pipes with diameters ranging from 4-inch to 1-inch.

d.) Service Pipelines

The consumer service connections in Ermera are completely in GS pipes branched from the distribution network by using a tee mostly in ½-inch. Pipe leaks are evident in the service connections because the repairs are done using rubber.



The Study on Urgent Improvement Project for Water Supply System in East Timor

SCHEMATIC DIAGRAM OF ERMERA WATER SUPPLY

Figure E.12

E.14 LIQUICA Water Supply System

E.14.1 General

Liquica is a coastal town about 34 km west of Dili and the seat of government for the Liquica District. The dispersed urban area of the town of Liquica is divided into 2 parts, namely: old town, west bank of Mota Goularloa River and built during the Portuguese time, and new town, east bank of the said river and built during the Indonesian time. The present population of Liquica town is about 11,606. There are 3 major rivers that drain the town, namely: Carbutaeloa River – eastern part, Goularloa River– central, and Laclo River – western part.

The water supply system of Liquica was developed by the Portuguese and the Indonesian governments. The water sources derive from surface water and a number of wells drilled on the nearby Mota Goularlua and close to the service area. Except those that are abstracted from the Laclo River, all other sources had been abandoned and currently non-operational. Causes of the inoperability and abandonment of the sources include high turbidity of the surface water, erosion of the riverbanks that had washed out the intake structures and transmission mains and major damage on the boreholes and pumping facilities. Right after the post-referendum violence, international NGO such as Oxfam had tried to restore the system. One of the existing boreholes (Maumeta 2) was attempted to be put back into operation but failed with no clear cause of failure identified. Development of a new spring was successfully completed, which serves as the main source of water supply for the town of Liquica at present. Although, the system has been restored to some extent with limited service area, still major improvement has to be undertaken to have an efficient, safe and sustainable water supply system in Liquica.

At present, there exists an acute water shortage in Liquica because only two out of the more than 10 water sources are in operation. Most of the town's population who are deprived of the safe, piped water supply are becoming miserable in getting water from available sources. During the survey, it was observed that children and women are the worst affected, since the are duty-bound to secure water for household use. A couple of them were seen collecting drinking water in bottles by walking some kilometers uphill where they think clear and safe water are available for exploitation.

E.14.2 Water Sources

Liquica is a coastal town located 34 km west of Dili. It is situated in the alluvial fan created by 3 rivers, namely: Laclo, Goularlua and Carbutaeloa. The downtown area is at the mouth of the Goularlua River. Since the mountains are very close to the shoreline, and the alluvial fans are formed at the mouth of the river, this town sits on top of the fan that tilts towards the sea. The town's water supply comes from 8 intakes of surface water, 1 spring and 4 wells. All of the 4 wells are currently abandoned due to the damages on the well and pumps. Most of the surface water sources have damages on their pipelines and intake structures. The descriptions of these sources are described below.

a.) Liquica Wells

All of the 4 wells in Liquica were drilled in the alluvial fan of Goularlua River. The catchment area at Goularlua is about 14.8 km^2. The existing conditions of the wells are briefly described below.

- *Dato 1:* Drilled depth = 84m Designed discharge rate = 5 L/s
  Remarks: Located at the left bank of the river equipped with concrete reservoir and a metal tank. Presently, the well has been removed of its piping system and completely filled with stones.
- *Dato 2:* Drilled depth = 82m Designed discharge rate = 2.5 L/s
  Remarks: Located at the left bank, close to the river. Presently, the well had been removed of its piping system and completely filled with stones.
- *Maumeta 1:* Drilled depth = 84m Designed discharge rate = 5 L/s
  Remarks: Located at the right bank of the river, equipped with pipes and concrete reservoir. The top of the casing is currently sealed.
- *Maumeta 2:* Drilled depth = 84m Designed discharge rate = 10 L/s
  Remarks: Located at the right bank of the river complete with pumps, piping system and electrical installation. After the conflict, Oxfam tried to reactivate the well and operated the pump for a short period and stopped for some reasons and completely out of operation until now.

b.) Laclo River

The water source is located about 5 km south of the town center.upstream the Laclo River. There is only a make shift intake structure in the wide river course. A small GS pipe and a split bamboo were placed in a small stream to collect water and the water is relayed by bamboo pipes to a nearby community. It was observed that intake and the transmission pipes of these sources are located in the flood-prone area without adequate protection.

c.) Lilabu

The water source is located a little more than 2 km SSE from the town of Liquica. The Intake is properly constructed a small stream. The concrete intake weir is 4 meters wide and designed to conduct the stream through a narrow channel built on one side of the weir into the intake tube covered by perforated concrete. The water collected through the intake is transmitted to a reservoir tank 10m downstream.

d.) Narlolo

The water source is located about 2 km south of the town center in a stream of the Tangkmom River. The stream is conducted with a stone-made weir and equipped with a pipe placed on the gravel-bed to collect the water into the concrete intake structure located about 20m downstream. The intake was rehabilitated by Oxfam in August 2000 and they also built another intake for rainy season use about 100m downstream.

e.) Daulo

The water source is located about 3.5 km southeast from the town center in a stream of Gaulora. There was a large concrete intake with a metal gate on the right bank side of the wide river course 200m upstream from the confluence with the Eanaloa River. The intake structure seemed to have destroyed by recurring flood.

f.) Eanlua

The water source is located about 4 km southeast from the town center in a stream of Enaloa. Water was being collected by two crude stone-made intake weirs that can be easily washed away by a single flood. One intake was on the right bank side of the river and the other was on the other side of the river a little down stream. The water is conducted to a reservoir tank located about 50m downstream through three pipe lines. There was a big heap of rock debris on the left bank and boulder size rocks in the river course, which indicated parts of the slopes collapse from time to time.

g.) Raisape

The water source is located a little more than 2 km southeast from the town center in the stream of Gularloa. The intake and transmission facilieis had been destroyed. There is only a trace of concrete tank left at the site. The concrete intake box originally constructed at the bank of the river shifted from its original position due to floodwaters

h.) Metagou

The water source is located 6 km southeast from the town center in a small stream of Mamarai and its branch streams. Water is collected from two small concrete intake weirs. One intake is located a few tens of metes upstream from the other. The water is conducted to a reservoir tank located close to the downstream intake through pipes. Although the transmission line was replaced with plastic one by Oxfam the situation still remain precarious.

i.) Emilaloa

The water source is located 5 km southeast from the town center in a stream of Harunapa. Some water diverted off the stream is collected with a concrete intake weir and conveyed to the reservor tank 10 downstream. The weir is built on a solid rock outcrop on the right and is 90 cm wide.

j.) Metagou Intake

Water from this source originates from a stream, which is one of the tributaries to the Nunupapalo River located about 4 km from the town. The intake structure is typically equipped with pipes and concrete boxes to collect the water from the stream. From the intake, water is transmitted by a GS pipe into the Maumeta Reservoir for distribution to the water consumers. The catchment area of this source is about 0.46 km^2.

E.14.3 Water Supply Facilities

The water supply facilities in Liquica, which were constructed during the Portuguese and Indonesian administrative governments are discussed in the succeeding sections.

a.) Transmission Mains

The transmission mains of the Liquica water supply system are summarized in the table below. Approximate values are given on the length since no actual measurement was done during the survey.

No.	Transmission Mains (From – To)	Type of Material	Diameter (inches)	Length (m)	Remarks
01	Eanlua Intake – Serlema Reservoir	GS	4	2,500	Not in use. Source has damaged intake pipes.
02	Daulo Intake – Serlema Reservoir	GS	3	2,500	Not in use. Source has damaged intake pipes.
03	Raesape Intake – Maumeta Reservoir	GS	3	2,000	Not in use due to some eroded section.
04	Metagou Intake – Maumeta Reservoir	GS	3 x 2	7,000	In use
05	Lilabu Intake – Ramtau Reservoir	GS	4	2,000	Not in use due to some eroded section.
06	Laclo Intake – Ramtau Reservoir	GS	3 x 2	2,000	Not in use due to some eroded section.
07	Emilalua Intake – Raitogoto Reservoir	GS	3	2,000	Not in use due to some eroded section.
08	Narlolo Intake – Mean Tank	GS	3	1,500	In use
09	Maumeta 1 – Maumeta Reservoir	GS	3	-	Not in use due to well source not in operation.
10	Maumeta 2 – Maumeta Reservoir	GS	3	-	Not in use due to well source not in operation.

b.) Pumping Stations

There were 4 wells drilled in Liquica that were previously used to supply water to the town's water supply system. The existing conditions of the electrical facility on the 4 pumping stations are tabulated below.

No.	Name of Well	Specification					Condition
		Capacity m^3/min	Pressure kg/cm^2	kW	Pipe Inch	Well Casing	
01	Dato 1				3"	200	Abandoned.
02	Dato 2				2"	200	Abandoned.
03	Maumeta 1				3"	200	Abandoned.
04	Maumeta 2					200	Not in operation.

No.	Pumping Station	Condition
01	Dato 1	The entire electrical facility was removed. Currently not in operation.
02	Dato 2	The entire electrical facility was removed. Currently not in operation.
03	Maumeta 1	The entire electrical facility was removed. Currently not in operation.

04	Maumeta 2	Presently not in operation. Oxfam has reactivated this pumping station for a short period after the violence but stopped. The cause can be assumed as the non-availability of the 3-phase power supply.

c.) Storage Facilities

The Liquica water supply system has 8 reservoirs basically designed to provide storage in meeting fluctuations in water demand. These reservoirs were constructed during the Portuguese and Indonesian periods. The summary of these facilities is shown in the table below.

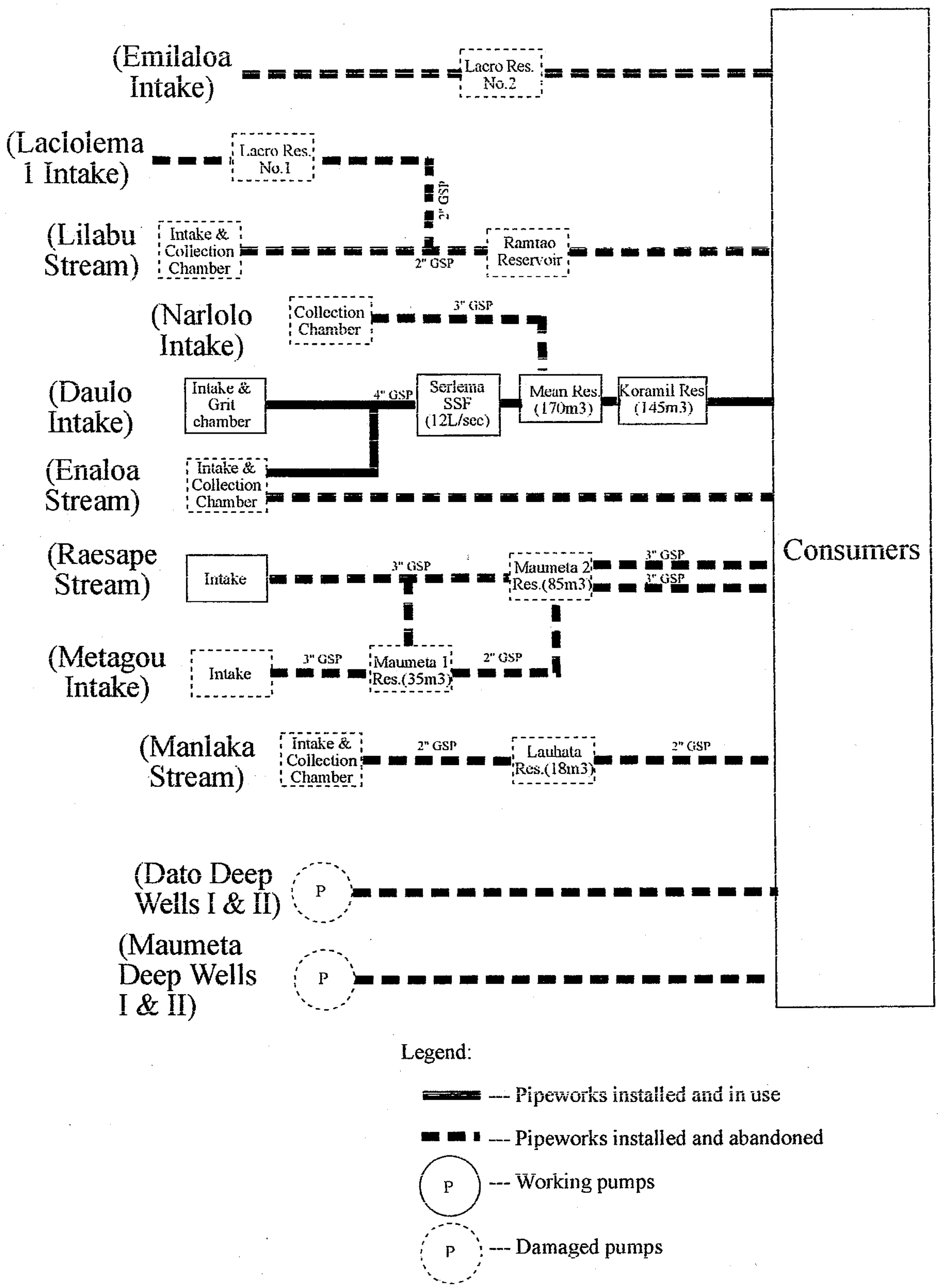
No.	Name/ Location	Water Source	Vol. (m3)	Technical Specification	Remarks
01	Serlema	Daulo & Ean Lua	170	Rectangular: 8.5m x 8.5m x 2.7m Made of reinforced concrete	Not in use because no supply from source.
02	Mean	Serlema Reservoir & Narlolo Spring	150	Rectangular: 10.5m x 6.5m x 2.5m Made of reinforced concrete	In good working condtion.
03	Kodim	Mean Reservoir	130	Rectangular: 9.3m x 6.4m x 2.5m Made of reinforced concrete	In good working condition.
04	Ramtau	Lilabu & Laclo intake	120	Rectangular: 10.7m x 8.9m x 1.5m Made of reinforced concrete	Not in use because no supply from source.
05	Raitogoto	Emilalua intake	50	Rectangular: 5.1m x 5.1m x 2.0m Made of reinforced concrete	Not in use because no supply from source.
06	Mauboki	Raitogoto	20	Rectangular: 4.0m x 3.7m x 1.8m Made of reinforced concrete	Not in use because no supply from source.
07	Maumeta	Metagou, Raesape, Maumeta & Dato wells	75	Rectangular: 6.7m x 5.3m x 2.5m Made of reinforced concrete	In good working condition with supply coming from Metagou.
T O T A L			715		

d.) Distribution Network

The distribution pipelines of the Liquica water supply system consist mostly of GS pipes with diameter ranging from 3-inch to 1-inch. It is widely spread around the old and new towns coming from different sources. Generally, there exists an acute water shortage in Liquica since only two water sources are in operation. During the survey, the pipes appear to be in good condition, although a good assessment on water tightness such as pipe leaks could not be made because of the water shortage. All the public hydrants surveyed in the distribution network are either broken or no water is available. Gate valves in the distribution pipelines were broken especially those installed in the water sources that are currently out of service or were damaged during the post-referendum violence.

e.) Service Pipelines

From among the more than 200 service connections previously served by the water system in Liquica only a few percentage is now getting piped water supply. Others are getting water from other sources such as nearby rivers. Most of the service connections are in GS pipes of diameter ½-inch. Although, no pipe leaks were noted during the survey, it appears that the pipelines are in good condition, except those that were damaged together with the buildings.



Note: In addition to the above, there are several minor water sources. They are Lacro, Lacrolema 2, Gaeloa 1 & 2, which are not shown on the diagram.

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The Study on Urgent Improvement Project for Water Supply System in East Timor

SCHEMATIC DIAGRAM OF LIQUICA WATER SUPPLY

Figure E.13

E.15 SUAI Water Supply System

E.15.1 General

Suai is the capital town of the Cova Lima District where the seat of government is located. The district is the southwesternmost part of the country and borders with West Timor. It suffered massive destruction during the post-referendum violence especially to the public buildings and residences.

Suai, which is a coastal town facing the Timor Sea could be reached by road transport via Aileu and Ainaro traversing very steep and unstable mountain slopes. The water supply system of Suai developed during the Portuguese and Indonesian periods has several surface and groundwater sources. Part of these sources is currently non-operational for reasons such as high turbidity levels, damaged transmission mains, and unfinished pipe connection to the system. Although repairs to the system is currently being carried out with the help of international NGO such as Oxfam, two of the boreholes had been put back to operation by the replacement of the damaged generator sets and pumps. The only treatment applied to the water supply in Suai is chlorination, which is dosed at the Hospital Reservoir and booster pumping station.

This report was prepared based on the result of the field survey in Suai conducted by the local staff.

E.15.2 Water Sources

The town of Suai sits on a gently sloping surface of a Quarternary coastal deposit. The town's water source comes from the catchment of the Karaulun River. The river flows down in the direction of NW-SE to the north of the town. It flows nearly straight down toward the sea gently meandering and meets its main tributary to the east of the town 1.5 km from the river mouth.

According to the survey result conducted by the team of East Timorese trained by the JICA Study Team, Suai obtains water to supply its reticulated water supply system from six sources. The six water sources in Saui consist of 2 wells, 2 springs and 2 surface waters.

The 2 wells were drilled in the western area of the town called Sukabilaran well field. The pumping rate of these wells is reported to be 6 L/s. The catchment area is estimated at 39.0 km^2.

The 2 springs (Olivio and Maugusu) are located somewhere in the eastern area of the town. Inflow into each intake structure of the springs is a few liters per second.

The two intake sites for the surface water sources (Ameriko and Kuluai) are said to be located in the northwestern tributaries of the main Karaulum River. This river drains the town originating from several tributaries in the north and northwestern mountains of Suai towards the Timor Sea. One of them is not used at present. Another abstraction from the surface water is the intake said to be located at Ameriko River. However, this reported source cannot be traced in the scale 1:25,000 topographic map. And as such the catchment area could not be computed.

E.15.3 Water Supply Facilities

a.) Transmission Mains

The transmission mains for the Suai water supply system are summarized in the table below.

No.	Transmission Main (From – To)	Material	Diameter (inches)	Length (m)	Remarks
01	Olivio – Bereluik Reservoir 2	GS	2	3,800	In use
02	Maugaso – Bereluik Reservoir 1	GS	2	3,500	In use
03	Ameriko – Bereluik Reservoir 2	HDPE	4	3,500	In use (some parts leak)
04	Kuluai – Bereluik Reservoir 1	GS	3	7,000	Not in use due to some missing sections of pipe.
05	Sukabilaran 1 – Hospital Reservoir	HDPE	4	3,000	In use
06	Sukabilaran 2 – Hospital Reservoir	HDPE	4	3,200	Not in use
07	Hospital Reservoir – Leugore Reservoir 2	HDPE	4	500	In use
08	Bereluik1 – Leugore Reservoir 1	GS	3 2	5,000 5,000	In use
09	Bereluik 2 – Leugore Reservoir 2	HDPE	3	5,000	In use

b.) Pumping Stations

- *Sukabilaran 1*

This pumping station operates for the Sukabilaran 1 well. It is equipped with a set of generator and submersible pump with the present capacity of 6 L/s. Water from this well is pumped via 4-inch transmission pipe into the Hospital Reservoir for storage. The old electrical and mechanical facilities installed during the Indonesian time were destroyed during the post-referendum violence. International NGO's such as Oxfam carried out rehabilitation works on this pumping station including installation of generator set. Due to lack of resources, operation of this well is limited for a few hours per day.
The list and description of the electrical facility of this plant with the existing condition are shown in the table below.

Equipment	Specification	Condition
Main Power Switch Panel	Type: Indoor wall mounted	In operation
Generator	Voltage : 400v kW : 60 P.F. : 0.8 Hz : 50	In operation
Pump Panel	Type: Indoor self-standing Star-delta starter circuit x 1 set	In operation

- *Sukabilaran 2*

The extensive damage caused by the violence to the pumping facilities and electro-mechanical equipment had rendered this well unproductive. However, through the effort made by the PKF, this well has been put back into operation on temporary basis. A mobile pumping equipment and generator set are used to draw water from this deep well and pumped into the water truck for distribution to the water consumers in Suai.
The list and description of the electrical facility of this plant with the existing condition are shown in the table below.

Equipment	Specification	Condition
Main Power Switch Panel	Type: Indoor wall mounted	In operation
Generator	Voltage : 400v kVA : 27 P.F. : 0.8 Hz : 50	In operation
Pump Panel	Type: Indoor wall mounted Star-delta starter circuit x 1 set	In operation

- *Hospital Pumping Station*

This pumping station is equipped with booster pump that pumps water from the Hospital Reservoir to the Leugore 2 Reservoir located at the higher elevation of the town. From the Leugore Reservoir, water then flows by gravity mostly to the consumers located in the high zone of the service area. Oxfam carried out rehabilitation works to this pumping station by the installation of generator set and other facilities making this operational.
The list and description of the electrical facility of this plant with the existing condition are shown in the table below.

Equipment	Specification	Condition
Main Power Switch Panel	Type: Indoor wall mounted	In operation
Generator	Voltage : 400v kVA : 12.5 P.F. : 0.8 Hz : 50	In operation
Pump Panel	Type: Indoor wall mounted Star-delta starter circuit x 1 set	In operation

c.) Storage Facilities

The Suai water supply system is equipped with storage reservoirs strategically located in the service area that provide storage and supplies water to the consumers in the high and low zones. However, these reservoirs are not effectively used due to the limited supply from the water sources. The description and technical information of these facilities are summarised in the table below.

No.	Name/ Location	Water Source	Vol. (m3)	Technical Specification	Remarks
01	Hospital Res.	Sukabilaran 1 & Sukabilaran 2	196	Circular: ø 10m x 2.5m height Made of steel with vinyl coating.	Australian made tank In use
02	Leugore 1	Bereluik 1	90	Rectangular: 6m x 5m x 3m Made of reinforced concrete.	Old Portuguese tank Not in use

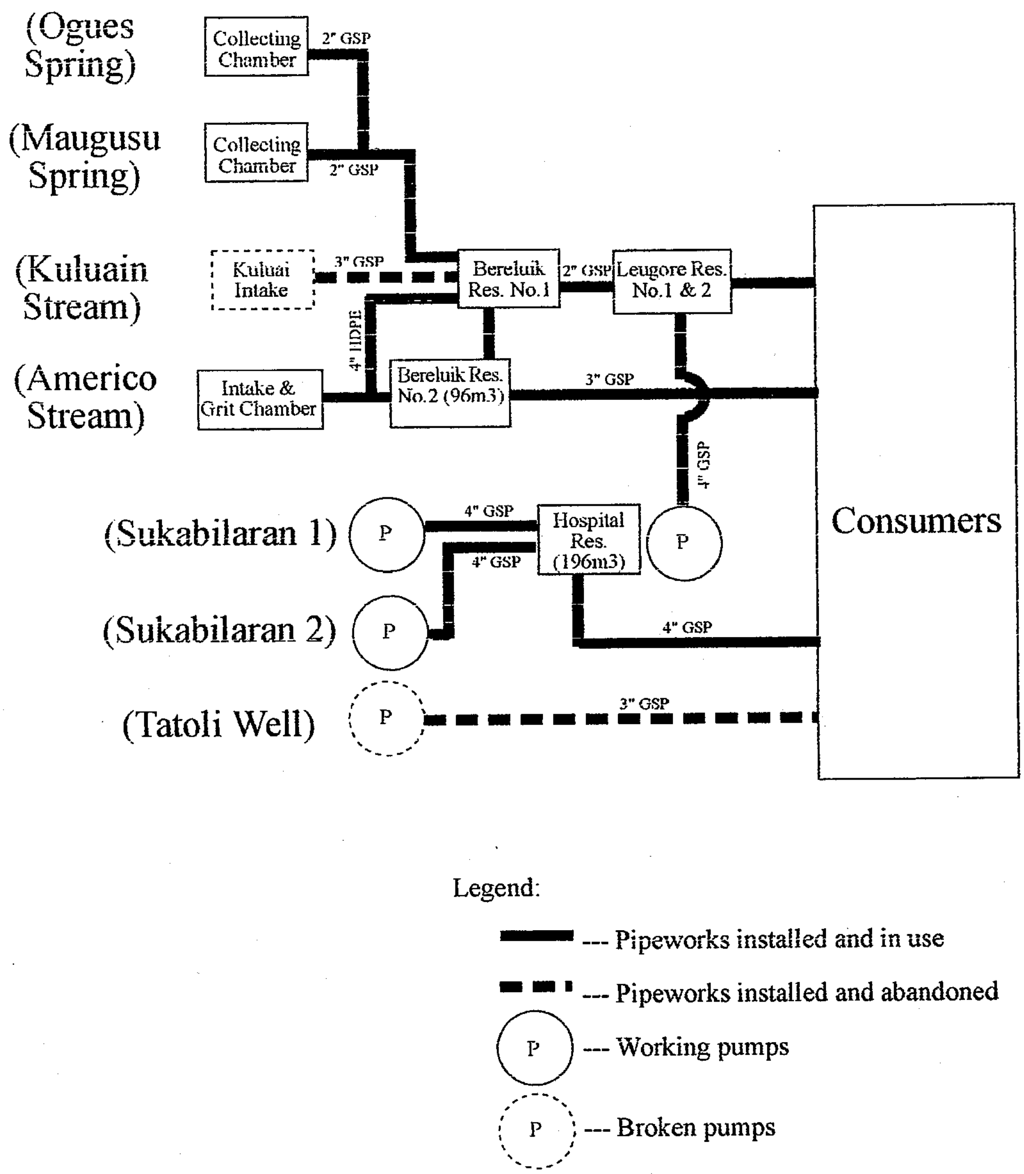
03	Leugore 2	Bereluik 2 & Hospital Res.	96	Circular: ø 7m x 2.5m height Made of steel with vinyl coating.	Australian made tank In use
04	Bereluik 1	Olivio & Ameriko springs	180	Rectangular: 7.4m x 5.5m x 5.0m Made of reinforced concrete.	Old Portuguese tank In use.
05	Bereluik 2	Maugusu & Kuluai springs	96	Circular: ø 7m x 2.5m height Made of steel with vinyl coating.	Australian made tank In use
TOTAL			658		

d.) Distribution Network

The distribution network of Suai previously used a variety of materials with diameters ranging from 4-inch to a minimum of 1-inch. The old network is predominantly made up of GS pipes, but the use of PVC and HDPE was introduced lately. Although the system appears to be in good condition, pipe leakages are still visible around the area.

e.) Service Pipelines

The service pipelines are mostly in GS pipes but the use of HDPE was lately introduced. Leaks to the consumer service connections are most evident in ruined buildings.



The Study on Urgent Improvement Project for Water Supply System in East Timor

SCHEMATIC DIAGRAM OF SUAI WATER SUPPLY

Figure E.14

E.16 MALIANA Water Supply System

E.16.1 General

The town of Maliana is the administrative capital of Bobonaro District, which was first developed on a western gentle slope of Mt. Madilwa. During the time when the water supply system of Maliana was established by the Portuguese it was constructed using 3 gravity systems, extracting water from Galusapulu, Dabucci, and Aikumu springs. This system was constructed separately to supply water to the people particularly in the town center. After several years, the Galusapulu system was abandoned because the capacity of the existing transmission main was inadequate to supply the increasing water demand.

During the Indonesian period, the residential area expanded towards the western alluvial plain settling between Sosso and Buipira Rivers. Town population increased significantly in parallel with the town's development.

To cope with the increase in water demand, new water sources were developed to include water abstraction from the irrigation canal, from Colegio Spring and Beremau Stream. The water from the irrigation canal passes through the water treatment plant before distribution to the water consumers. Adding the 3 new sources, the present water supply system in Maliana has a total of 5 sources.

During the last post-referendum violence, the packaged-type water treatment plant suffered extensive damage especially to the pumping facilities, electro-mechanical equipment, laboratory and storage facilities resulting to the non-operation of the WTP. However, NGO's carried out repair works to the plant by bringing it back to operation.

E.16.2 Water Sources

According to the water resources survey conducted by the local staff, the Maliana water supply system is supplied with water from different sources, namely: Aikumu spring, Colegio spring, Beremau spring, Dabucci springs (Dabucci, Beapelu and Beamos) and the irrigation canal. The Aikumu and the Colegio springs are reported to be sensitive to seasonal fluctuations in which the flow substantially drops to nil in the dry season. The Beremau spring and Dabucci spring group have reportedly sufficient and reliable flow all-year round. Adequate flow could be abstracted from the irrigation canal, located less than a kilometer from the town center.

E.16.3 Water Supply Facilities

a.) Transmission Mains

The transmission main of the Maliana water supply system is summarized in the table below. More information on the transmission mains will be discussed during Phase II.

No.	Transmission Main (From – To)	Material	Diameter (inches)	Length (m)
01	Beremau Intake – Moduklaun Reservoir	Galvanized Steel	6	6,000

02	Moduklaun Reservoir – TV Station Reservoir 1	Galvanized Steel	6	1,000
03	TV Station Reservoir 1 – TV Station Reservoir 2	Galvanized Steel	3	1,000
04	TV Station Reservoir 2 – Sta. Cruz Resservoir	Galvanized Steel	3 + 2	800
05	Aikumu Intake – Moduklaun Reservoir	Galvanized Steel	3	3,000
06	Dabucci Springs – Lahomea Reservoir	Galvanized Steel	3	2,000
07	WTP – Sta. Cruz Reservoir	Galvanized Steel	6	700
08	Colegio Intake – Colegio Reservoir	Galvanized Steel	1	5,000

b.) Water Treatment Plant

River water from the offtake at Bulobu flows down into town area through a concrete channel. From the open channel at Buepira, raw water is abstracted by pumps into the packaged-type water treatment plant for water supply to the town's population. About 7 L/s is abstracted from the channel for treatment prior to distribution. This treatment plant is composed of the following processes: flocculation, sedimentation and filtration. The production output of this plant is being pumped into the reservoir at Sta. Cruz and distributed to the water consumers in the service area.

The electrical facility of the this WTP was using the power supplied by PLN at 380/220V, 50Hz for its normal operation. This plant was equipped with an emergency generator that activates in the event of power outages from the PLN. After the violence, all the generators have lost their function. But it is working well with the assistance of PKF.The list and description of the electrical facility of this plant with the existing condition are shown in the table below.

Equipment	Specification	Condition
Watt-hour Meter Box	Type: Outdoor wall mounted	In operation
Genarator Panel	Type: Indoor wall mounted	Apparently broken.
Main Power Switch Panel	Type: Indoor wall mounted	Broken. Wires are removed.
Generator		In operation
Pump Mixer Panel	Type: Indoor wall mounted	Rusty, dirty but usable

c.) Storage Facilities

The Maliana water supply system is equipped with storage facilities for providing storage necessary to meet fluctuations in water demand & to stabilize pressure in the distribution system. The summary of the reservoirs is shown in the table below. More information on the storage facilities will be discussed after completion of Stage 2 field survey.

No.	Name/ Location	Water Source	Vol. (m^3)	Technical Specification	Remarks
01	TV Station 1	Muduklaun Aikumu	90	Rectangular: 8.20m x 6.20m x 1.80m Made of reinforced concrete	In working condition
02	TV Station 2	TV Station 1	360	Rectangular: 12.0m x 12.0m x 2.50m Made of reinforced concrete	In working condition

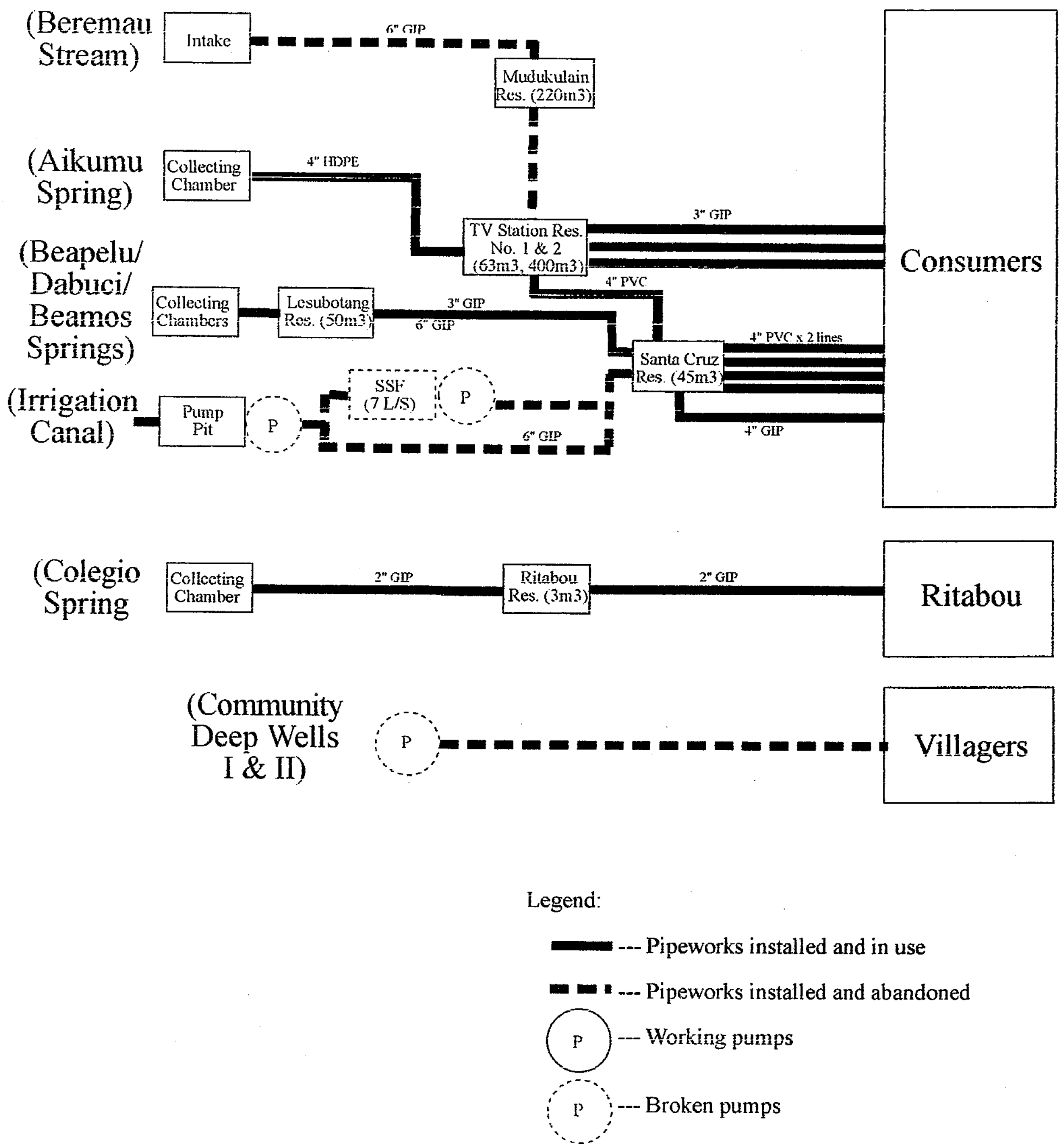
03	Muduklaun	Beremau	230	Rectangular: 9.0m x 8.5m x 3.0m Made of reinforced concrete	In working condition
04	Santa Cruz	TV Station 2 Lahomea, WTP	95	Rectangular: 8.20m x 5.50m x 2.15m Made of reinforced concrete	In working condition
05	Lahomea	Dabucci springs	70	Rectangular: 5.50m x 6.30m x 2.10m Made of reinforced concrete	In working condition
06	Colegio	Colegio	20*	Rectangular: 6.00m x 2.30m x 1.50m Made of reinforced concrete.	In working condition *Used for the Colegio community water supply system.
T O T A L			845		

d.) Distribution Network

The distribution network of the Maliana water supply system consists of GS pipes with diameters ranging from 6-inch to 2-inch. As per the survey done by the local staff, repair works are extensively carried out by Oxfam normally replacing the leaking and damaged pipes with HDPE.

e.) Service Pipelines

The service connections are directly branch out from the distribution lines to a diameter of ½-inch. More information on the distribution network will be discussed after completion of the Stage 2 field survey.



JICA	*The Study on Urgent Improvement Project for Water Supply System in East Timor* SCHEMATIC DIAGRAM OF MALIANA WATER SUPPLY	**Figure E.15**

APPENDIX F GEOGRAPHICAL INFORMATION SYSTEM (GIS)

F.1 INTRODUCTION TO ASSET MAPPING SYSTEM

F.1.1 Purpose of the System

The Asset Mapping System is designed to prepare a database containing data such as locations, types, numbers and functions of water supply facilities, and aims to facilitate the implementation of the government policies in improving the health of the people by providing clean and reliable water supply.

a.) Configuration of the Basic System:

The basic system can be installed on the existing system. JICA has provided the following:

- Computer hardware consisting of 3 sets of personal computers and one printer
- Computer software for the system is Microsoft Office 2000 in which a database by GIS (Geographic Information Systems) software is produced.

b.) Basic Configuration of the Database

Basic data for Dili such as base map and data on major water supply facilities is maintained in the form of vector data, while data such as conceptual diagrams, photographs, and sketches for other facilities is maintained as raster data. For 14 other towns, data such as base map, sketches, and site photographs is maintained as raster data, while field survey maps for major water supply facilities is maintained as vector data.

Functions of the System

The system is designed for easy use by the local staff where updating can be made. Some of the map data can be reproduced in the printer. Although the system is capable of displaying new construction programs in reference to previous construction and repair record, the system is mainly based on the basic functions of the GIS software and new functions will not be added to the system.

d.) Priority Area for System Establishment

The city of Dili was designated as a priority area for the establishment of the Asset Mapping System, since it is the capital of the country and has the largest population. The degree of maintenance activities for the water supply facilities is larger than in any other cities. Moreover, other towns have less available data where it is hard to establish a precise information control.

F.1.2 Use of GIS

GIS is defined as a system, which converts information on the locations of various objects into digital data by creating a database. The information contained therein can be used on computers and graphic models of the objects and can be displayed on the computer screen, which can be captured, modified, managed, retrieved, analyzed, and visualized by using GIS software. The system consists of three parts: personal computers (hardware), analysis software, and data on the locations of objects. The data on the locations of objects are called spatial information and form the components of the database. The spatial information includes three types of information, namely: visible objects such as buildings, roads, railways, and lakes and marshes; invisible objects such as underground pipes and water facilities; and other objects such as those that have no spatial location data (e.g. coordinates or elevations or topographical information) but have addresses or codes which can be used for referencing location data.

a.) Configuration of GIS

GIS uses two different types of data models: vector models and raster models. In the vector model, information on point, line and polygon is stored in sets expressed in the XY coordinate system. The locations of point features such as electric poles are expressed in a single XY coordinate pair, while linear features such as roads and rivers are expressed as sets of coordinate pairs. The polygon features such as business areas and river flood areas are stored in the form of closed areas consisting of coordinate pairs. Although the vector model is very effective in expressing discrete feature groups, it is not appropriate for expressing such features as soil type and weather information, which continuously change. The raster model is a model, which was developed to properly express these features. The raster images are expressed as sets of cells regularly arranged on a grid. Although having some shortcomings, both the vector and raster models are very useful topographical data model. Most of the GIS systems in recent years are compatible to both types of models.

b.) Functions of GIS

GIS systems, in general, have the following 5 functions:

- Data capture
- Data modification
- Data management
- Data retrieval and analysis
- Data visualization

Data Capture

Prior to using topographical data on a GIS system, it is necessary to convert them into a proper digital format. The process of conversion from a paper map to a computer file is called digitizing. In recent years, the process of digitizing is, in most cases, automated using the state-of-the-art GIS technologies and scanning technologies. Most of the converted topographical data are provided by data suppliers and can be directly incorporated into the GIS system.

Data Modification

In most cases, the data obtained need to be modified or converted to a format which meets the needs of each GIS project. For example, topographical data are provided in various scales: some data sets, given in a large scale, include information on the center lines of roads and the shapes of buildings, and other data sets include demographic data collected by each town. These data, therefore, need to be standardized to a common scale and accuracy before producing a database. The data modification process has also several types ranging from temporary modification for data displaying to permanent modification for data analysis. GIS technologies provide a variety of tools to cover various purposes including modification of topographical data; format conversion and coordinate transformation; and generalization (screening) of the topographical data.

Data Management

For small GIS projects, it is sufficient to just maintain topographical data in several files. For large projects, however, the amount of data becomes extremely large, and thus it is necessary to store, sort, and manage them using the Database Management System (DBMS). Although there are many types of DBMS, the ones designed based on the relational theory are said to be ideal for GIS. In the database based on this theory, data are stored and controlled in the form of sets of different tables, and the common items among the tables are used to link to each other. This simple theory is used in systems in many fields (including GIS) because of its excellent flexibility.

Data Retrieval and Analysis

Upon the establishment of a GIS database, GIS can answer the questions as follows:

- Who owns this lot?
- What is the distance from this building to the nearest station?
- Where is the agricultural area of this town?

GIS can even find answer for the following complicated questions:

- Retrieve the candidate area for new stores, which is expected to provide them with the highest profit.
- What is the predominant soil type for this cedar forest?
- How will the new highway constructed here affect the traffic volume in the area?

GIS has various retrieval tools, ranging from one that works by simply clicking the mouse to another that requires complicated search criteria. Using these tools, GIS can provide topographical patterns and the tendency (trend) of various phenomena, and analyze topographical information to simulate various phenomena.

a.) Neighborhood Analysis

- How many houses are there within a distance of 100 m from this water pipe?
- How many customers of this shop are living within 10 km of it?
- What is the total crop yield within 500 m of this water supply source?

To answer these questions, GIS uses a function called "buffering" and analyses the relationship between features.

b.) Overlay Analysis

A group consisting of different topographical data layers is called an overlay. Overlay analysis includes from one that visualizes images by simply superimposing the topographical data layers to another that displays images by comprehensively analyzing the combination of many data and then incorporating them into topographical data layers. This enables various calculations including taxation evaluation in which such factors as soil type, slope gradient, vegetation, and land lots are taken into consideration.

Data Visualization

Most of the spatial analysis results are visualized in the form of maps, graphs or reports. Maps have been used for more than 1,000 years as the best medium for maintaining and distributing geographical information. GIS has dramatically changed the aspect of maps. Today, maps can be combined with multi-media, which allows them to be produced in various forms, such as reports, graphs, 3-dimensional images, and photograph-like images.

c.) Software for GIS

The following software is used for the Asset Mapping System:

ArcView (ESRI: Environmental Systems Research Institute Inc.)

ArcView is the popular edition of ARC/INFO, designed for GIS professionals, and is used worldwide as the best system for the Asset Mapping System since not only it is easy to use and connectable with spreadsheet software, and provides many useful functions proved by ARC/INFO, but also its data format is open to users. In addition, since ArcView is compatible with many application software and has the networking function, it can be used for many purposes and facilitate the use of GIS in the improvement of maps in East Timor.The functions expected from GIS for the Asset Mapping System are as follows:

- Central control of graphical data and corresponding attributes: e.g. data on water pipe network, pipe diameters and pipe directions
- Visualization of graphical data: e.g. visualization of graphical data of water facilities by utilizing photographs taken on-site
- Highlighting of necessary graphical data: function that allows graphical data of a particular area to be visualized by enlargement or reduction
- Data storage: function for storing various data, including field survey data, site photographs, and hand-drawn sketches

d.) Hardware

The Asset Mapping System uses the following hardware:

- Personal Computer: 3 sets

Windows NT (Microsoft) is used as the OS, so that the system will be used for a long period of time and functions as part of information network. In addition, a printer connectable to the network is added to the personal computers to form the system.

F.2 BASIC REQUIREMENTS OF ASSET MAPPING SYSTEM

The post referendum violence resulted to the destruction of valuable materials and data required for the rehabilitation and development of the infrastructure facilities in East

Timor particularly water supply. This condition was the main factor that resulted to the establishment of the GIS on the water supply system of the 15 towns included in the JICA Study area. Due to the unavailability of records, drawings, and other documents necessary for the GIS the following were used:

F.2.1 Base Plan of the Existing Water Supply System

The base plan of the existing water supply system was prepared as a result of the on-site surveys and investigations of the water supply facilities, interviews made on workers of the former PDAM and BPAM, discussions and consultations with UNTAET officials and coordination with JICA GIS TEAM. Following the preparation of the base plan, a database was established and the system was set-up.

F.2.2 Available Maps

Since most of the documents and drawings on the water supply system were destroyed during the post referendum violence, available maps were used as reference. These maps are as follows:

a.) Topographic Map, Scale 1: 25,000

This map was originally produced based on the result of the survey made in 1990 to 1992 by the Indonesian Public Authority for Survey (BAKOSURTANAL). It was reprinted by the Australian Army in 1999 based on the original map produced in 1993.

Coordinate System - Indonesian Control Point (1974):
The coordinate system based on WGS 84 was added on the map (year of survey: unknown).

Projection - Transverse Mercator Projection

b.) Topographic Map, Scale 1:2,000

This map was produced by the JICA GIS Team in 2000. The digital data was produced for Dili.

Coordinate System - Surveyed based on WGS 84

Projection - Transverse Mercator Projection

F.2.3 Water Supply Network Drawing

This drawing is available for Dili only. The scale and year of production are unknown.

F.2.4 Diagrams on Improvement Programs of Water Supply and Sanitation in East Timor

Scale and year of production are unknown. Produced only for city of Dili.

F.2.5 Maps Produced for the Peta Lokasi Program

The scale and year of production for these maps are unknown. Most of the maps are for the city of Dili, with some for other rural cities. Information for urban planning, such as topography, natural environment, and the current status of water supply facilities, and information on the future programs (some information missing) are also shown on the maps.

The above-mentioned topographic map, scale 1: 25,000 has been used for various purposes by enlargement or reduction to scales 1:50,000, 1:10,000, and 1:5,000.

F.2.6 Computerized Management on the Existing Water Supply Facilities

According to local sources, the water supply system in East Timor was formerly managed centrally in Dili. It was divided into 2 departments: 1 for Dili and the other outside Dili.

In 1993, the nationwid water supply facility improvement program, called "Bia Hula Project" was implemented under the assistance from the Australian Government. Various water facilities including water pipe network in rural cities as well as water treatment plants and water pipe network in Dili were constructed and improved over five years.

The Water Service Department, which is in charge of water facilities in Dili, established a digital database for water pipe network in the city. It also introduced an AutoCAD-based database, which manages graphical data necessary for new water facility construction programs, and a system, which can record the results of repair and maintenance on the facilities after the commencement of the service. Although the system was designed to use the graphical data for all the process from construction cost calculation to recording of repair on water leakage, it was necessary during repair work to modify the graphical and log data sheets more than twice, since the both data sheets were not centrally managed. The water supply facilities, which were completed one year earlier and started operation in the spring of 1999 were partially destroyed due to the post-referendum violence.

F.3 PROCEDURE IN SETTING-UP ASSET MAPPING SYSTEM

F.3.1 System Installation

a.) Number of Hardware and Software Used for the System

- Personal computer: 3
- Printer (CANON Laser Beam Printer 880): 1
- UPS: 2
- Switching hub: 1
- LAN card: 2
- LAN cable
- Windows NT Version 4.0: 3
- ArcView Version 3.2: 2
- ArcPress Version 3.0: 2
- Office 2000: 3

b.) Setting-up of System Devices

- Personal Computers

- User Name: East Timor
- Organization: Water Supply 1
- Computer Name: WATER 1(Password: jica1)
  WATER2 (Password: jica2)
  WATER3 (Password: jica3)
- Software Installation (Product ID)

WATER 1: Windows NT; 34099-DEM-0045741-82399
Office 2000: KK348-RWWDK-H68PV-6G28Q-7D6KB
ArcView; 825861107191

WATER 2: Windows NT; 34099-OEM-0045741-74113
Office 2000; KDMPQ-GJJK6-KX3DC-Q8B2K-MV4MM

WATER3: WindowsNT; 34099-OEM-0045741-74872
Office 2000 ; XF4RB-JV7YY-FP2QJ-HP9DK-6QJCB
ArcView; 825861107189

IP Address:

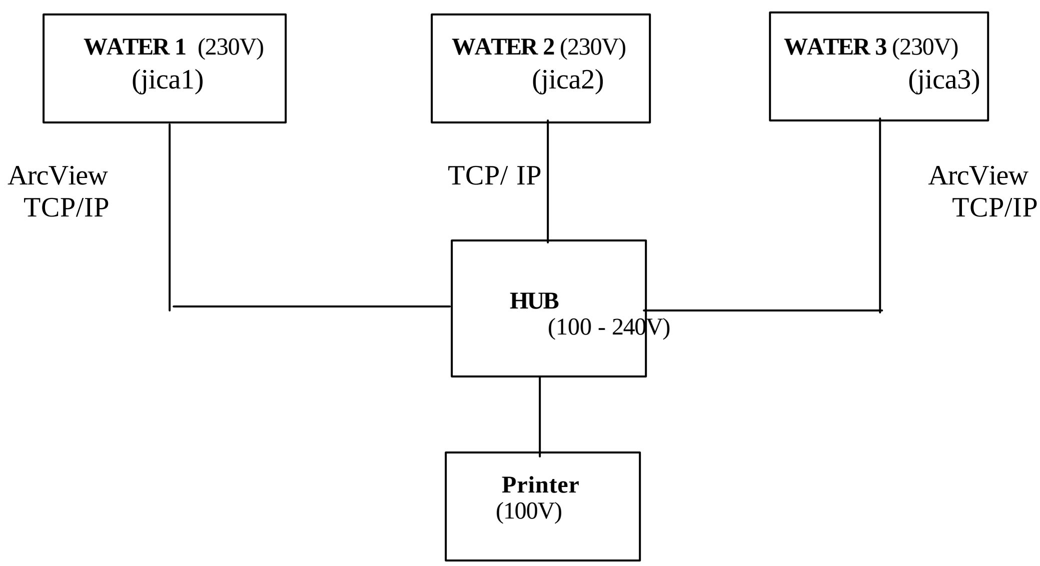
Printer: 192.168.20.126
WATER 1: 192.168.20.127
WATER 2: 192.168.20.128
WATER 3: 192.168.20.129

Data Installation:

D: AssetMapping
|—Dili_Topodata (83 sheets data: shape files)
|—New_Hirata (Working area)

Printer
Local Port: LBP880
Network Port: LBP860

c.) System Configuration



d.) Operation Confirmation

- Initial confirmation

WATER 1: OS - Confirmed
Office 2000 - Confirmed
ArcView - Confirmed
TCP/IP - Confirmed

WATER2: OS - Confirmed
Office2000 - Confirmed
TCP/IP - Confirmed
WATER3: OS - Confirmed
Office2000 - Confirmed
ArcView - Confirmed
TCP/IP - Confirmed

F.3.2 Data Format

a.) Topographical Data of Dili

Digital data in DXF format for a 1:2,000 map produced by JICA in 2000 were converted into Shape format.

b.) Data on Water Supply Facilities of Dili

Water pipe network data were first digitized and converted to digital data. By referring to topographical data and taking into consideration the results of hearing to field survey teams, location data were modified, missing data were interpolated, and new data in Shape were added to the digital data. For water facilities, point data representing their locations were prepared in Shape format by referring to CAD data obtained by survey teams (DXF format) and site photographs (Jpeg format).

c.) Topographical Data for 14 Other Cities

The basic 1:25,000 topographical map was scanned to produce digital data. For areas, which overlap in two or more maps, the geographic data on the sides of the map were jointed to form a seamless data set in Tiff format.

d.) Facility Data for 14 Other cities

The location of the intake surveyed by field survey teams with an accuracy equivalent to the 1:25,000 topographical map, and the data for water distribution areas used for predicting water consumption were converted into digital data to produce surface data in Shape format. Survey maps prepared by the field survey teams, water level maps, and tables showing the evaluation of water facilities were also scanned and converted to digital data. They were then converted to vector to produce point/line data in Shape format. Site photographs taken by digital cameras were converted to picture files in Jpeg format.

e.) Configuration of Data

The following data were produced:

- Topographical Data of Dili - Shape format
- Water Supply Facility Data of Dili: Pipe Network Data - Shape format

Water Supply Facilities Data - DXF format

Site Photographs - Shape format, Jpeg format

- Topographical Data of 14 Other Towns - Tiff format
- Facility Data of 14 Other Towns: Facility data - Shape format

Facility Evaluation Table (Jpeg format)

Site photographs - Jpeg format

F.4 ESTABLISHMENT OF THE ASSET MAPPING SYSTEM IN EAST TIMOR

Most of the data for the Asset Mapping System will be produced from existing maps. A database containing attribute data for water facilities shown in the maps is essential for maintenance and management of such facilities. However, since the rehabilitation of water facilities is still in the planning stage, a simple database with fewer attribute data will be first produced.

The outline of data capture for the study area is as follows:

a.) Dili

The basic map data will be produced from the following topographical map:

- Topographical Map, scale 1:20,000 (digital data map produced by JICA GIS Team)
- Associated Data

Associated data includes information on water supply facilities and water pipe networks. Separate layers for water supply facility data and water pipe network data will be superimposed on 83 topographical maps of the city. Photographs taken on site and field survey maps will be used as auxiliary data for water supply facilities.

Based on the results of the on-site investigations, additional vector data will be produced for the following:

- Intake Facilities of Water Sources
- Deepwell (borehole)
- Water Treatment Plant
- Service Reservoir
- Pumping Station
- Pipe Network

Although the year of production and scale of the water pipe network diagram are unknown, a database for the water pipe network, which consists of vector data modified in accordance with the topographic features, will be produced while checking the existence of pipes in reference to the results of on-site surveys. Diameters and directions of pipes will be used as attribute data for the water pipe network.

b.) Other 14 Towns/Cities

The basic map data will be produced using the following materials:

- Raster data scanned from a 1:25,000 topographic map
- Auxiliary Data

Location of the intake, data on water distribution areas (vector data), data on water facilities obtained by field surveys, water level data (vector data), table showing the evaluation of the facilities, photographs taken on site, sketches (raster data), etc. Topographical data will be produced for regions covering the intake facilities (surveyed during the field surveys conducted in 14 cities) to water distribution areas. The sizes of such regions will vary and to be determined in each city: the area of the region will be large where the water source is located far from water distribution areas, whereas small region will be displayed when the water source is relatively close to water distribution areas. In addition, apart from topographical data, the intake and water distribution areas are stored in different layers in the form of vector data. The associated data (i.e, data scanned from field survey maps and water level will be converted to digital data after scanning, and then converted to vector data.

Such data as photographs taken on site and sketches will be stored as raster data. Facilties refer to the following:

- Intake Facilities for Water Sources
- Deepwell (borehole)
- Water Treatment Plant
- Service Reservoir
- Pumping Station
- Break Pressure Tank
- Pipe Network

F.5 FUTURE WORK

The future works of Asset Mapping System are as follows:

- Level-up of System Function

  Map output function with plotter installation
  GIS function level up with data renewal

- Future Work for System

  It is the most important for GIS to maintain the topographical data and water supply facility data for the Asset Mapping System. The future work for System is water facility data renewal with facility repair histories.

APPENDIX G TOPOGRAPHICAL SURVEY

G.1 Purpose

The purpose of the site survey is to gather the needed data and to compliment the other sources of information necessary for rehabilitation plan of intakes and transmission facilities. These data will also be used to design the water supply system and to build up the Geographical Information Systems (GIS) database that is essential to prepare the Asset Mapping of about 15 object towns included in the study.

The following are the fifteen (15) towns that were included in the survey: metropolitan Dili, Liquica, Baucau, Viqueque, Los Palos, Manatuto, Maliana, Suai, Same, Ainaro, Aileu, Maubisse, Ermera, Gleno and Atauro island, which is located about 25 km north of Dili. It was, however, impossible to perform site survey for both Maliana and Suai without risking ones life since these two towns are still considered as “medium dangerous areas”. It would be hard to insure the security and safety of the surveyors.

Topographic survey of intakes and other major facilities were, also, executed. The present condition of the structures was noted. Local residents maintaining the structures also inquired about some of this information. Moreover, the schematic diagram of each transmission line, from intake to reservoir, which is essential for planning, rehabilitation and the design of the water supply system is dependent upon the outcome of the survey. In summary, the survey team conducted topographic survey and investigation of existing structures in 158 places and leveling survey route extended to about 250 kms.

G.2 Methodology

G.2.1 Leveling Survey

Basically, differential leveling was executed using automatic level. In some instances, like waterfalls, cliff, or stiff slopes, where differential-leveling method is not applicable, a total station is used to measure difference in elevations. In both methods, a check and balance is always observed; in differential leveling, two leveling lines are traversed; and in using the total station, forward and backward readings were taken with telescope in normal and in inverted position. In some cases, where vegetation is thick, cutting of trees is necessary in order to minimize the survey route and save time, coffee plantation is one of those thick coverings that we encountered. The allowable error maintain in all leveling activities is 20 mm $\sqrt{S}$, where S is the distance in Kilometer.

Benchmarks (BM) were also established, and referred and connected to the existing B.M's. established by the Indonesian government, or by JICA's Quick Project in August 2000. In rural areas, however, most of the supposed existing BM's can no longer be located or no data are available to the existing one. In such cases, points identifiable on the ground and in a topographic map with a scale of 1:25000 are designated as a temporary BM's. Approximate elevations assigned to the TBM's are based on the elevations on the map.

G.2.2 Topographical Survey

Topographic survey of intakes and other key facilities were conducted using a total station instrument. In one water treatment plant and seven reservoir tanks, the Flat Board surveying, one of the topographic surveying methods, is carried out. In any method, detailed topographic features within the vicinity of the structure are always indicated in the map.

The Global Positioning System (GPS) approximately determines the geographical coordinates and elevations in some critical points. The survey activities have been a good training ground to local surveyors who are not familiar with the instruments and the methods being used. It, also, is one of the means of transferring technology to the said local staff.

G.2.3 Result

Table G-1 shows the summarized information of facility in the survey area, and **Table G-2** shows the other data and the geographic location of the same.

Table G-1 SUMMARY

No.	Name of city	No. of water Resource	No. of Other Facilities	Length of Leveling (km)
1	Dili	7	5	43.0
2	Atauro	6	8	10.0
3	Manatutu	1	1	20.0
4	Baucau	1	5	10.0
5	Los Paros	2	6	4.0
6	Viqueque	1	4	13.0
7	Same	3	7	13.0
8	Ainaro	2	5	7.0
9	Aileu	4	2	11.0
10	Maubisse	4	2	7.0
11	Gleno	3	3	10.0
12	Ermera	3	5	7.0
13	Liquica	13	22	24.0
14	Suai	(5)	(5)	(28.0)
15	Maliana	(3)	(4)	(23.0)
Total		50	79	230.0

Table-G.2 Results of Topographical Survey

NO.	Town	Water Resource					Treatment／Pumping Station／Reservoir Tank			
		Name	Cord No.	Type	Coordinates		Name	Cord No.	Coordinates	
					UTM−E	UTM−N			UTM−E	UTM−N
1	Dili	Bemousu	DIL-WS01	Rivoir	0755910	9069370	Bemousu	DIL-WT01	0753910	9069270
		Bemori	DIL-WS02	Stream	0756630	9068670	Bemori	DIL-WR01	0753670	9068120
		Benamark	DIL-WS03	Stream	0757800	9067260	Benamark	DIL-WR02	0753850	9066960
		Comoro A	DIL-WS04	Well	0753740	9063650	Rahane	DIL-WT01	0753710	9063650
		Comoro B	DIL-WS05	Well	0753970	9069520	Rahane	DIL-WR03	0753930	9069520
		Comoro C	DIL-WS06	Well	0753830	9069980	Comoro	DIL-WR04	0753850	9069980
		Comoro D	DIL-WS07	Well	0753840	9068930				
2	Atauro	Eraloi 1	ATA-WS01	Spring	0753280	9087760	Datil	ATA-WR01	0753290	9087760
		Eraloi 2	ATA-WS02	Spring	0753230	9087780	Maumeta2	ATA-WR02	0753260	9087430
		Eraloi 3	ATA-WS03	Spring	0753310	9087890	Lauhata	ATA-WR03	0753360	9087390
		Eraloi 4	ATA-WS04	Spring	0753710	9087540	Liquica Central	ATA-WR04	0753270	9087540
		Ecurai 1	ATA-WS05	Spring	0753220	9088100	Ramtao	ATA-WR05	0753290	9088100
		Ecurai 2	ATA-WS06	Spring	0753290	9087430	Serlema	ATA-WR06	0753220	9087430
3	Manatuto	Acasio	MAN-WS01	Stream	0764710	9057400	Graki	MAN-WR01	0762670	9052250
4	Baucau	Nunu	BAU-WS01	Well	0765710	9059350	Sanchago	BAU-WR01	0765420	9059010
							Fraci	BAU-WP01	0765860	9059870
								BAU-WP02	0765420	9060730
							Trell	BAU-WP03	0765420	9061590
							Masui	BAU-WP04	0765240	9062450
5	Lospalos	Ajino	LOS-WS01	Spring	0765470	9059350	Lyuta	LOS-WP01	0769470	9059350
			LOS-WS02	Spring	0765530	9058250	Ramuda	LOS-WP02	0769030	9060230
							Mijio	LOS-WR01	0768340	9061110
							Kuras	LOS-WR03	0768090	9061990
							Holoa	LOS-WR04	0769530	9062870
							Camyan	LOS-WR05	0786010	9064750
6	Viqueque	Porta	VIQ-WS01	Spring	0747340	9057730	Lucia	VIQ-WR01	0778900	9066630
							Nuta	VIQ-WR02	0775430	9068510
							Salome	VIQ-WR03	0778020	9070390
							Nonon	VIQ-WR04	0776590	9072270

Note) GIS shows forty (40) places of Chamber, Break Pressure Tank and Sedimentation Tank in detail.

Cord No. is as follows : <u>LIQ-WS01</u>

LIQ: Town Cord

WS: Water Resouce

WP: Pumping station

WR: Reservoir Tank
WB: Break Pressure Tank

Table-G.2 Results of Topographical Survey

NO.	Town	Water Resource					Treatment／Pumping Station／Reservoir Tank			
		Name	Cord No.	Type	Coordinates		Name	Cord No.	Coordinates	
					UTM−E	UTM−N			UTM−E	UTM−N
7	Same	Banuna	SAM-WS01	Stream	0747830	9057730	Muta	SAM-WR01	0746360	9057730
		Tutuka	SAM-WS02	Stream	0748340	9057250	Eoloa	SAM-WR02	0745430	9057250
		Sanfa	SAM-WS03	Stream	0747830	9056820	Quiki	SAM-WR03	0746830	9056820
							Momumusa	SAM-WR04	0745870	9057730
							Huhayo	SAM-WR05	0745260	9057250
							Ratane	SAM-WR06	0746740	9056820
							Wubun	SAM-WR07	0745430	9057250
8	Ainaro	Wutalo	AIN-WS01	Stream	0762940	9057250	Danka	AIN-WR01	0763670	9058870
		Mae	AIN-WS02	Stream	0762350	9058730	Mae	AIN-WR02	0763230	9060490
							Yactra	AIN-WR03	0764120	9062110
							Nololoa	AIN-WR04	0764450	9063730
							Sokumua	AIN-WR05	0765670	9065350
9	Aileu	Lila	AIL-WS01	Well	0753270	9087540	Serlema	AIL-WR01	0753710	9087540
		Emulaloa	AIL-WS02	Spring	0753290	9088100	Emulaloa	AIL-WP01	0753220	9088100
		Aeloa	AIL-WS03	Stream	0753220	9087430				
		Sonatu	AIL-WS04	Spring	0752670	9052250				
10	Maubisse	Hatu	MAU-WS01	Stream	0756290	9055700	Bubau	MAU-WR01	0756430	9059150
		Mobusi	MAU-WS02	Stream	0756290	9059150	Atemu	MAU-WR02	0756290	9062600
		Hadamura	MAU-WS03	Stream	0757290	9062600				
		Lalako	MAU-WS04	River	0758390	9066050				
11	Gleno	Huhulo	GLE-WS01	Spring	0775420	9059010	Huhulo	GLE-WR01	0753290	9087430
		Kontai	GLE-WS02	Stream	0775860	9059870	Mutu	GLE-WR02	0764710	9057400
		Sonatu	GLE-WS03	Stream	0753370	9067730	Kyora	GLE-WR03	0765710	9059350
12	Ermera	Port	ERM-WS01		0756370	9075590	Vivia	ERM-WR01	0757800	9067260
		Ram	ERM-WS02		0757650	9083450	Nasi	ERM-WR02	0753740	9063650
		Sokoko	ERM-WS03		0758650	9091310	Yamusta	ERM-WR03	0754270	9063650
							Olipia	ERM-WR04	0756370	9063650
							Franci	ERM-WR05	0756570	9063650

Note) GIS shows forty (40) places of Chamber, Break Pressure Tank and Sedimentation Tank in detail.