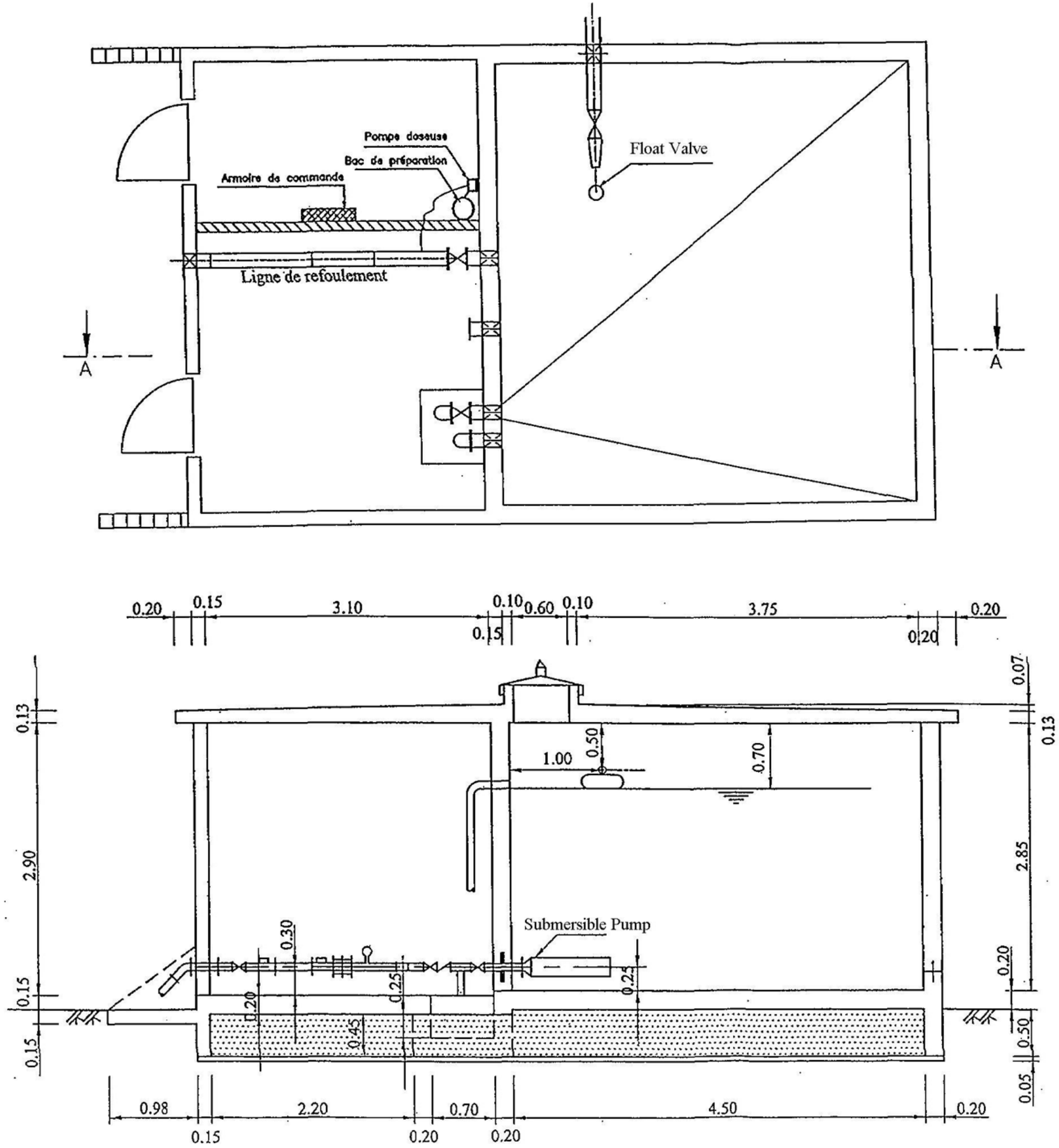
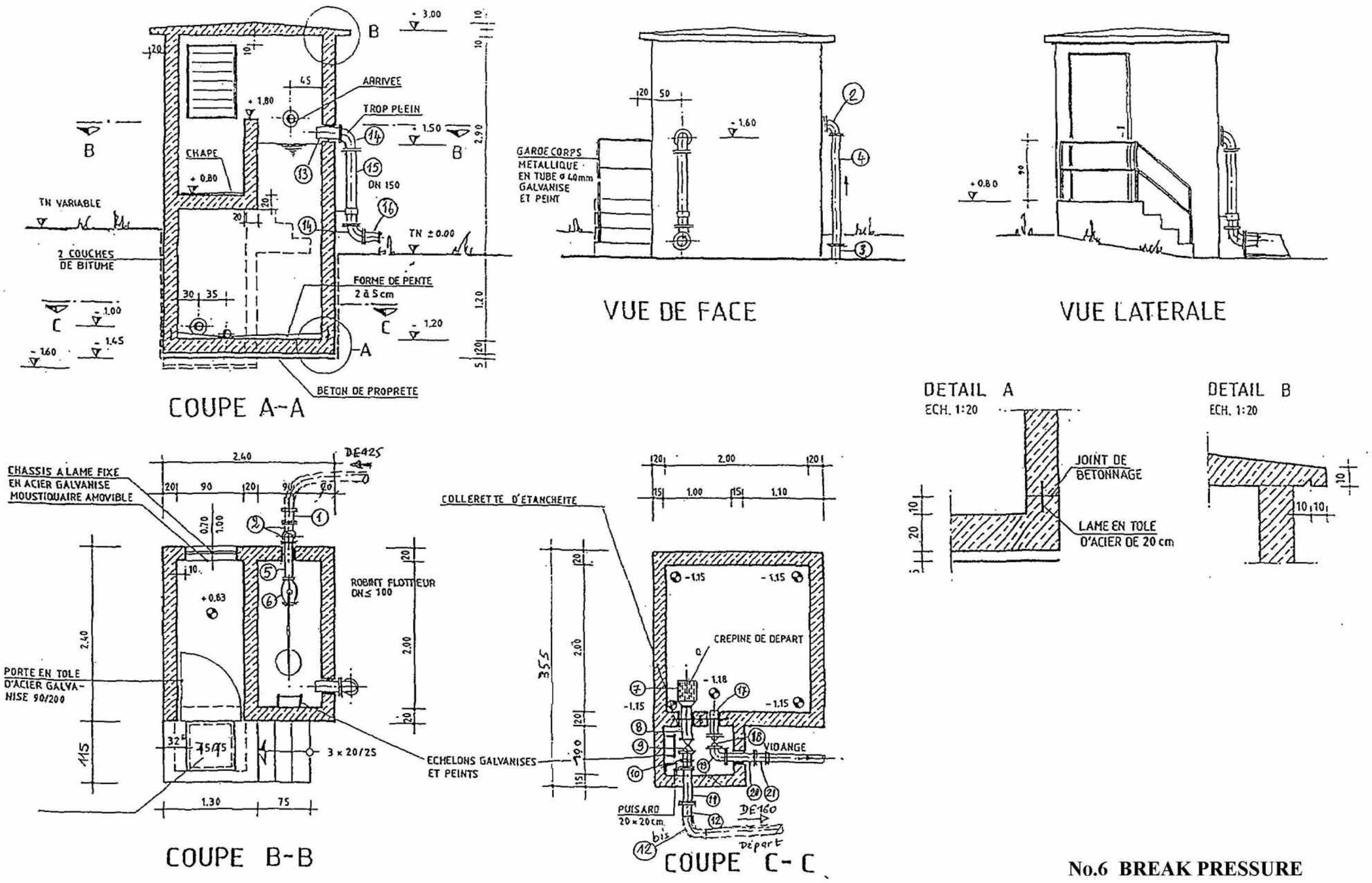
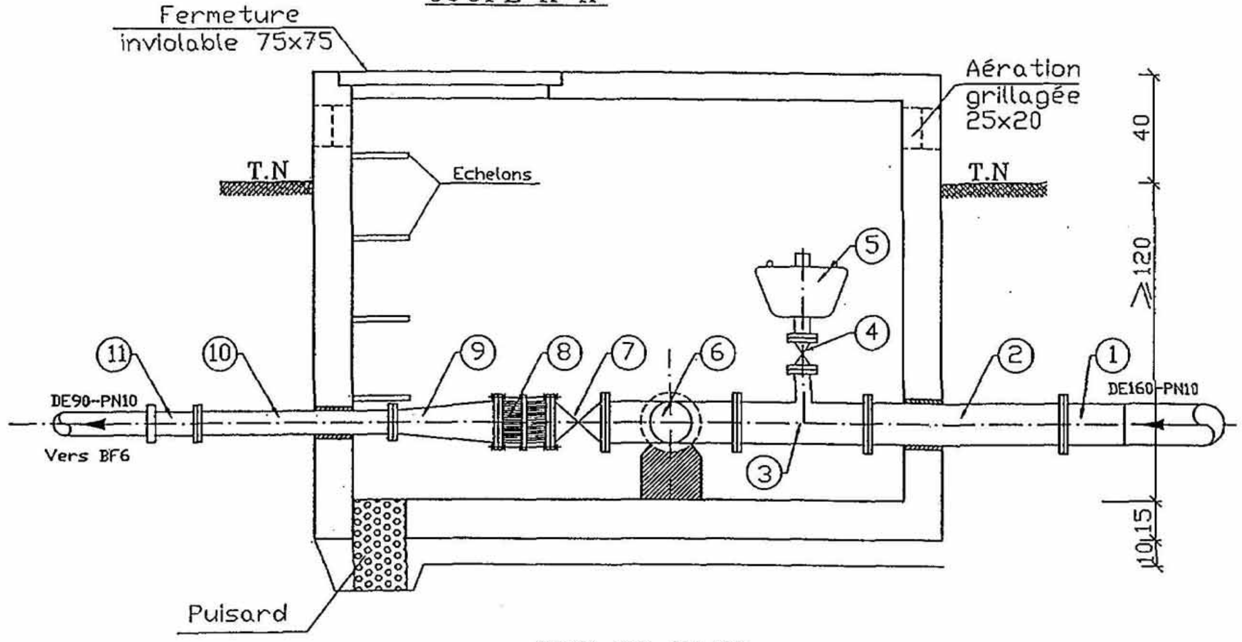


No.5 RELAY PUMPING STATION
(SUBMERSIBLE PUMP)

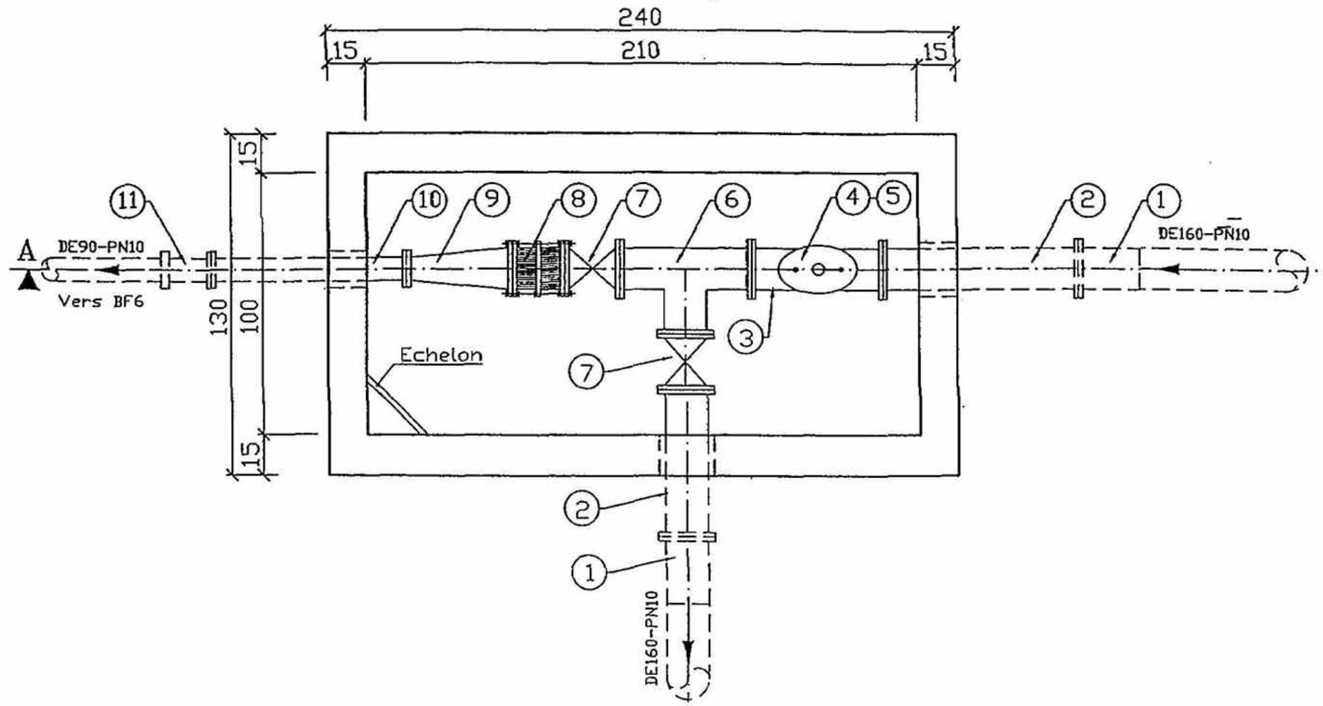


No.6 BREAK PRESSURE

COUPE A-A



VUE EN PLAN

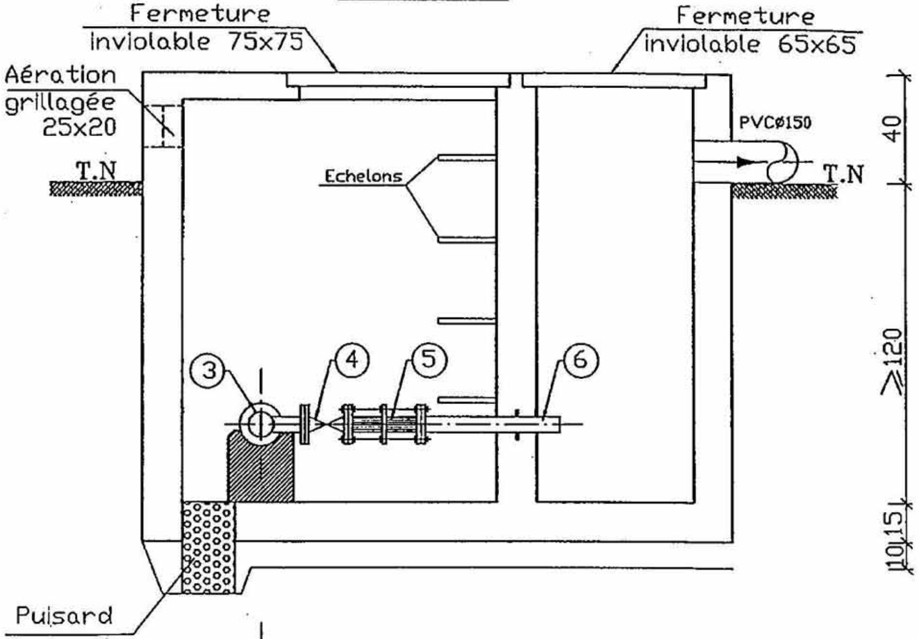


Équipements hydrauliques= S25

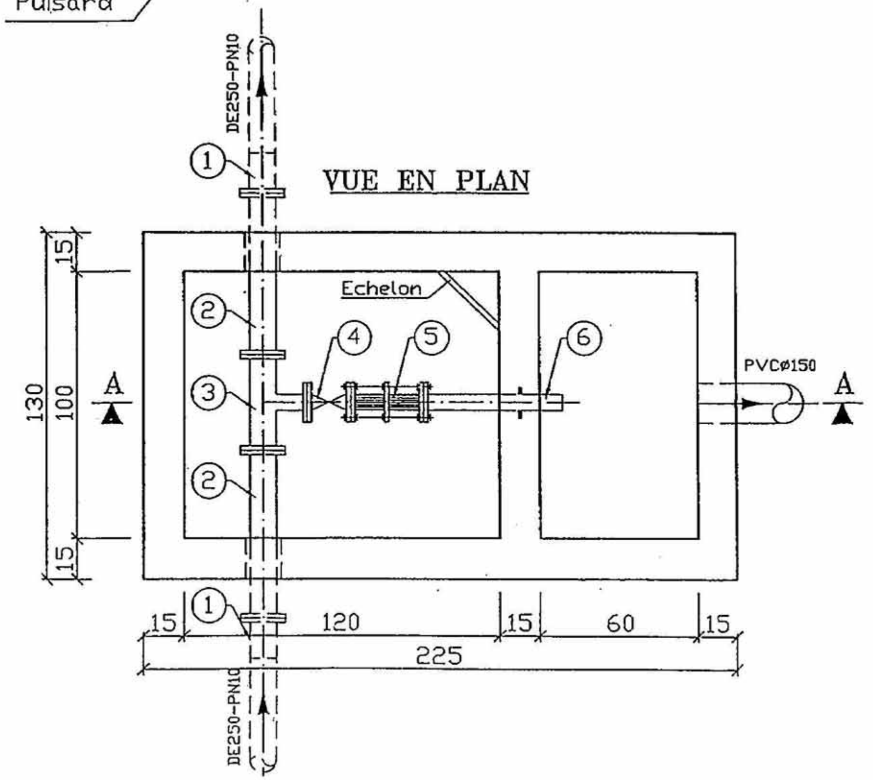
N°	Désignation	DN (mm)	Dim (cm)	Nbre pièces
1	Collet en PEHD avec bride à souder bout à bout type long	160/150	25	2
2	Manchette bridée en fonte	150	75	2
3	Té à 3 brides en fonte	150/60/150	50/20.5	1
4	Vanne à opercule courte à passage lisse	60	17	1
5	Ventouse avec accessoires de raccordement à double effet	60	–	1
6	Té à 3 brides en fonte	150/150/150	50/25	1
7	Vanne à opercule courte à passage lisse	150	21	2
8	Joint de démontage en acier	150	20	1
9	Cône à 2 brides en fonte	150/80	40	1
10	Manchette bridée en fonte	80	75	1
11	Collet à souder en PEHD avec bride et m.e.s type long	90/80	20	1

No.7 AIR VALVE

COUPE A-A



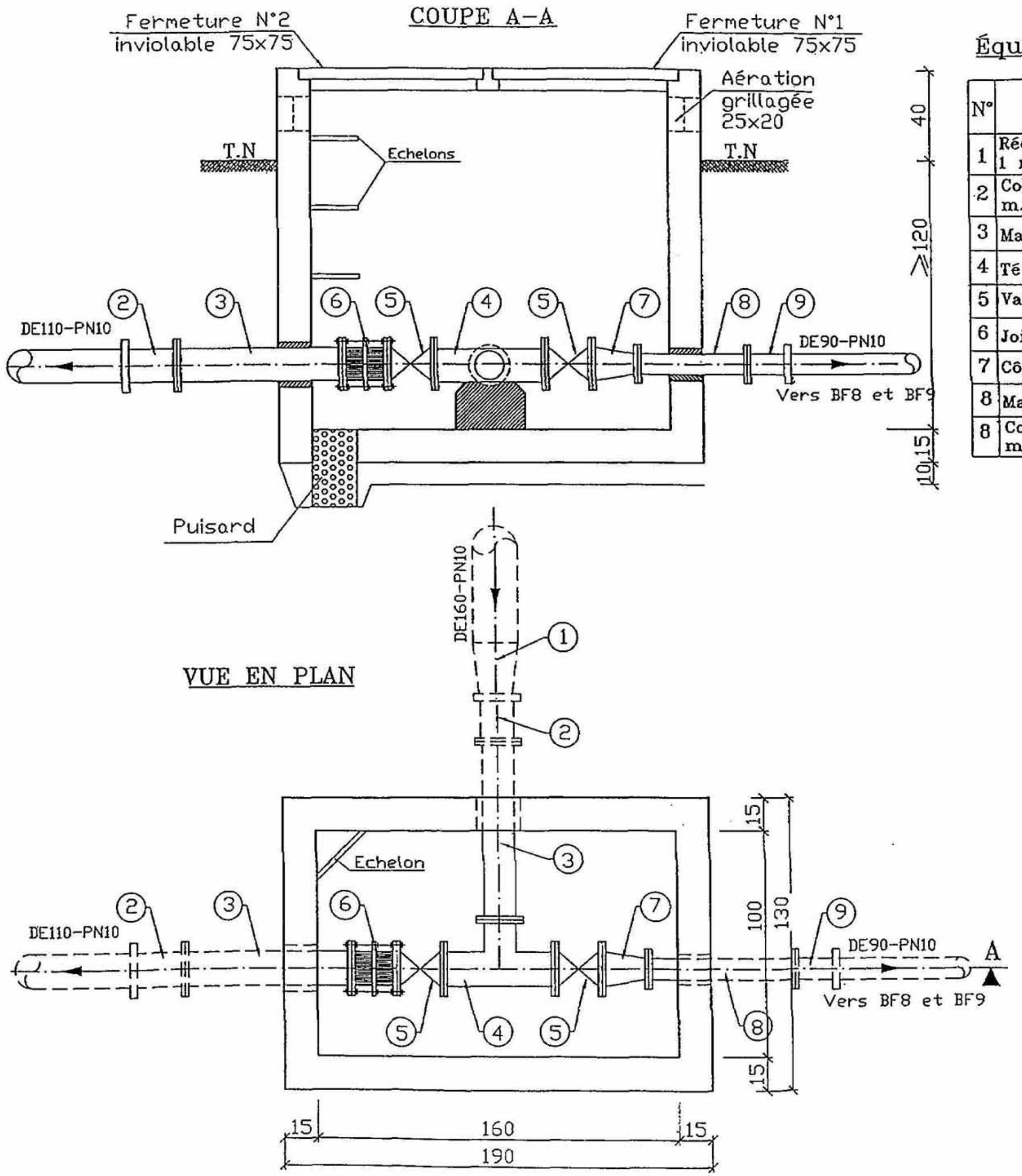
VUE EN PLAN



Équipements hydrauliques= pt2959

N°	Désignation	DN (mm)	Dim (cm)	Nbre pièces
1	Collet en PEHD avec bride à souder bout à bout type long	250/250	35	2
2	Manchette bridée en fonte	250	75	2
3	Té à 3 brides en fonte	250/100/250	70/27.5	1
4	Vanne à opercule courte à passage lisse	100	20	1
5	Joint de démontage en acier	100	20	1
6	Manchette à 1 bride en fonte avec collerette	100	50	1

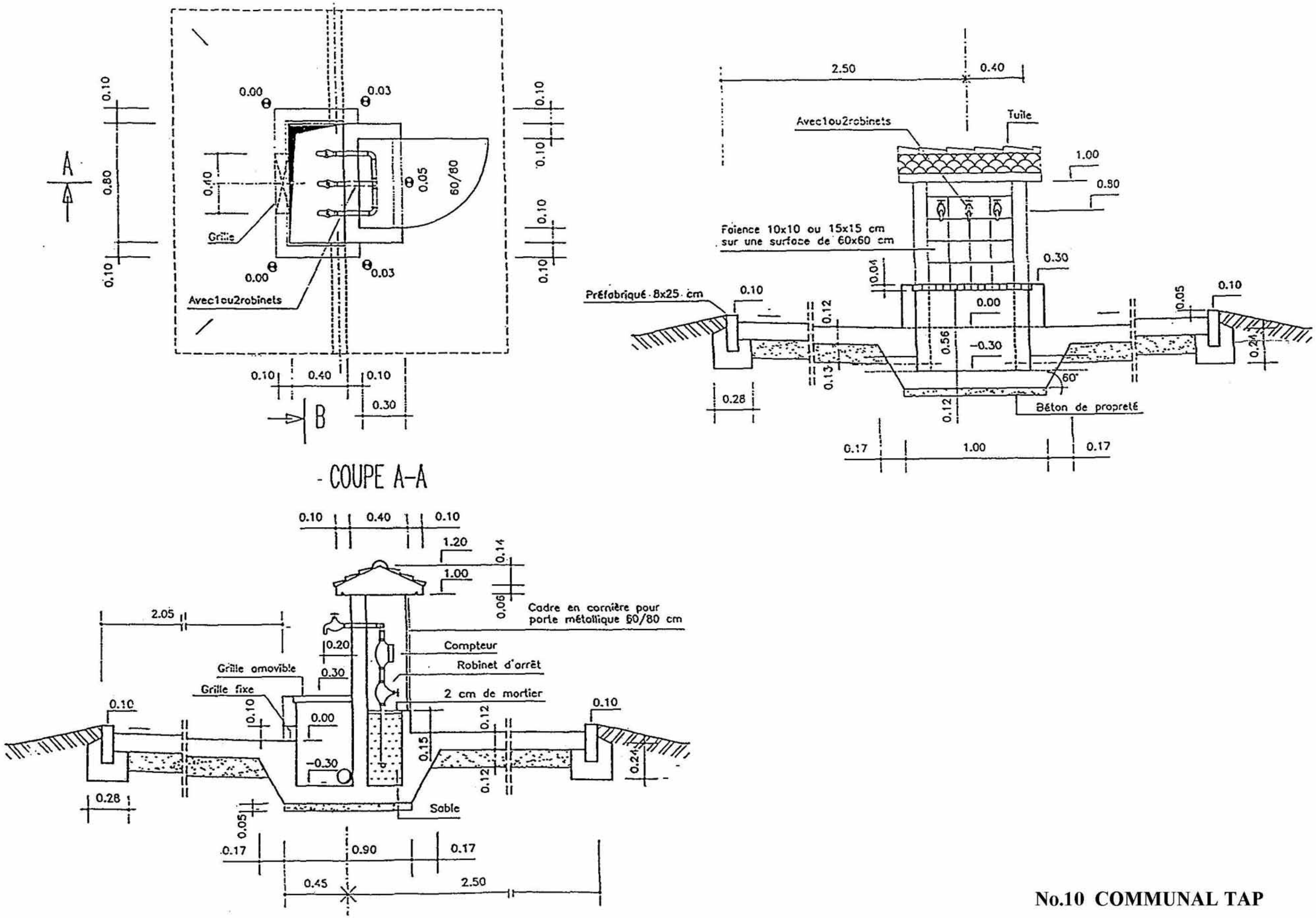
No.8 WASHOUT (INDIRECT TYPE)



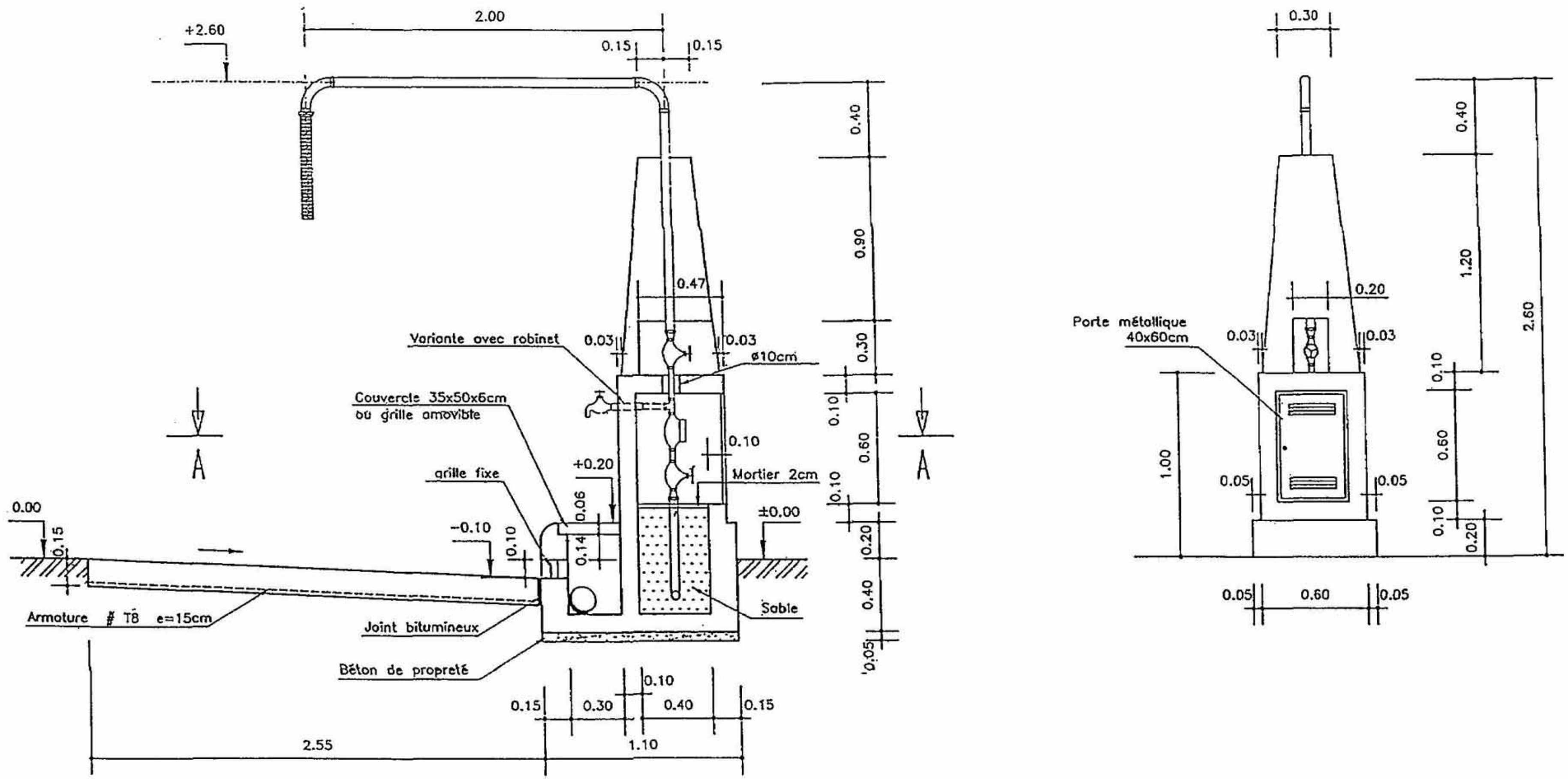
Équipements hydrauliques= pt1846

N°	Désignation	DN (mm)	Dim (cm)	Nbre pièces
1	Réduction en PEHD à souder avec 1 m.e.s type long DE110	160/110	30	1
2	Collet à souder en PEHD avec bride et m.e.s type long	110/100	22	2
3	Manchette bridée en fonte	100	75	2
4	Té à 3 brides en fonte	100/100/100	40/20	1
5	Vanne à opercule courte à passage lisse	100	19	2
6	Joint de démontage en acier	100	20	1
7	Cône à 2 brides en fonte	100/80	20	1
8	Manchette bridée en fonte	80	75	1
8	Collet à souder en PEHD avec bride et m.e.s type long	90/80	20	1

No.9 SLUICE VALVE

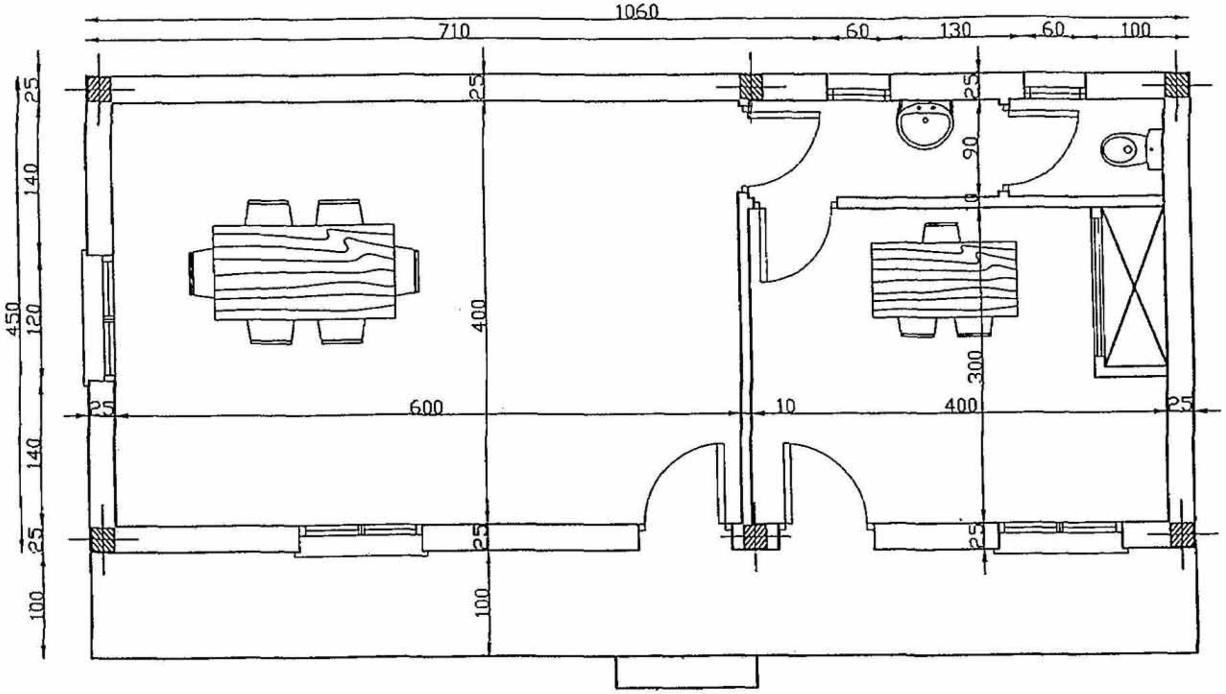


No.10 COMMUNAL TAP

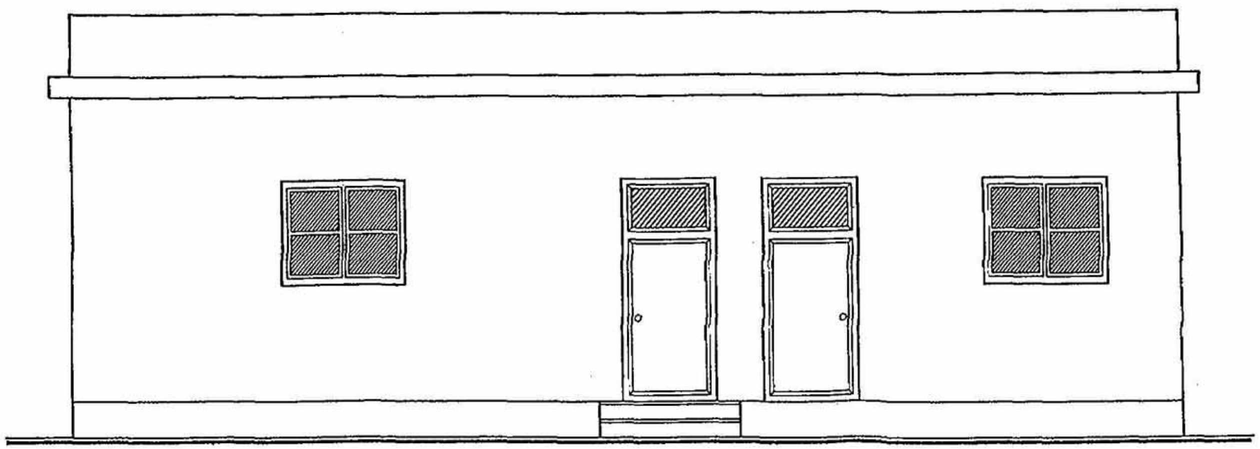


No.11 POTENCE

VUE EN PLAN

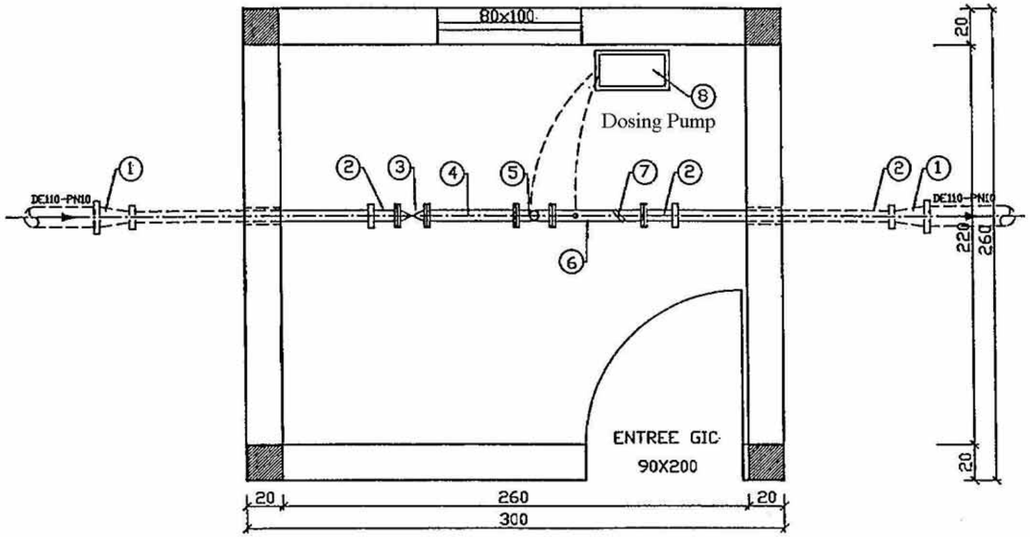


FACADE PRINCIPALE



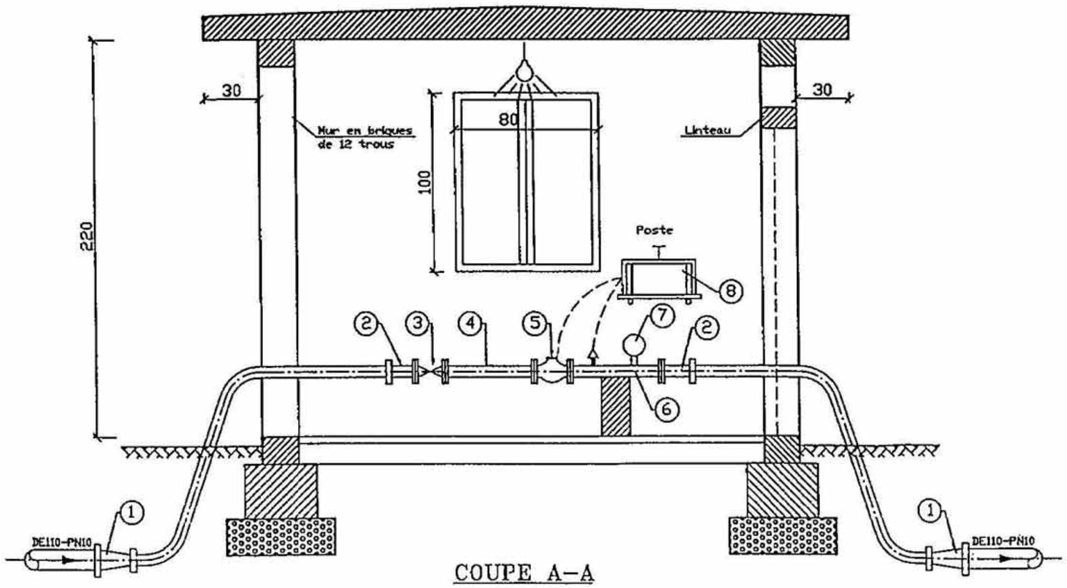
No.12 GIC OFFICE

VUE EN PLAN



Équipements hydrauliques

N°	Désignation	DN (mm)	Dim (cm)	Nbre pièces
1	Réduction en PEHD à souder avec m.e.s type long	110/75	20	2
2	Collet à souder en PEHD avec bride et m.e.s type long	75/60	15	2
3	Vanne à opercule courte à passage lisse	60	17	1
4	Manchette bridée en fonte	60	50	1
5	Compteur d'eau eméteur d'impulsion	60	20	1
6	Manchette bridée en A.G avec 2 piquages filetés ø15/21 pour manomètre et injection de chlore	60	70	1
7	Manomètre à contact électrique avec robinet 3 voies	–	ø16	1
8	Pompe doseuse de chlore	–	–	1



COUPE A–A

No. 13 DISINFECTION FACILITIES

Appendix 9.1 Subjects to be studied

1. Determination of transmission flow rate

In principle, the transmission pipeline is designed based on the maximum daily water supply while the Maximum hourly water supply determines the diameter of distribution pipelines.

In case that there is branch pipelines for service installations in a transmission pipeline, the Team observed in draft feasibility study reports that the flow rate for such service installation is added to the transmission flow. It might be affected by the consideration of the distribution flow applied to the RWS projects design, i.e. if one BF is added to the distribution system, the flow rate of 0.5L/s is automatically increased.

Please refer and compare the figures in the following page, however, the figures show only an example:

1) Water is transmitted through "adduction" to a distribution tank and there is a BF which is connected to the transmission pipe (adduction).

2) The maximum daily and hourly water demands for the BF are 14.5m^3 and 4.68m^3 respectively.

3) The maximum daily water demand for the assumed water supply system (all BFs covered by the distribution tank and the BF branched from the transmission pipeline (adduction)) is 100m^3.

4) The average flow rate from the branched point to the BF is 1.30 L/s (4,680 liters / 3,600 second)

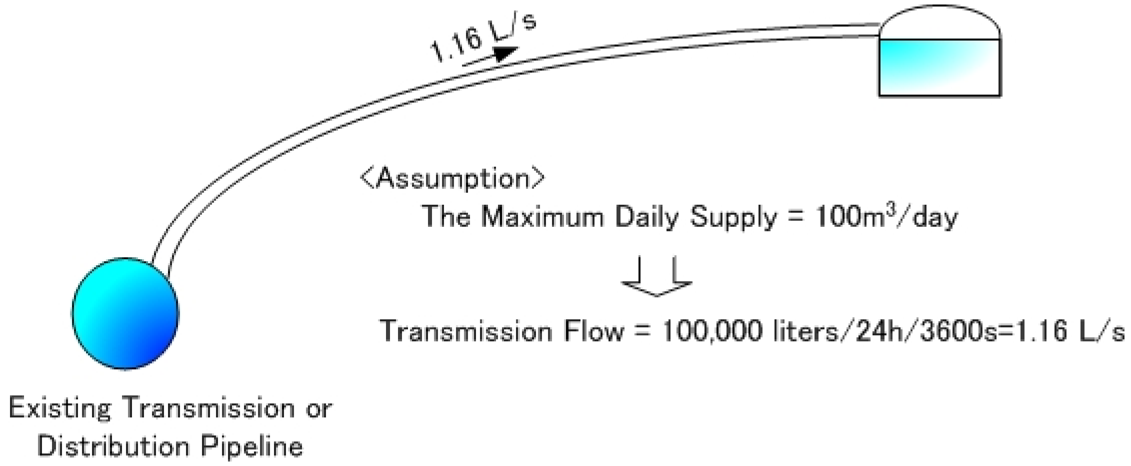
5) If the BF does not exist, the flow rate to the distribution tank should be 1.16 L/s (100,000 liters / 24 h / 3,600 seconds/hour)

6) However, the maximum daily water demand of 100m^3 includes the water demand for the BF. Therefore, the flow rate to the distribution tank (from A to C when the BF closes) can be reduced to 1.15 L/s.

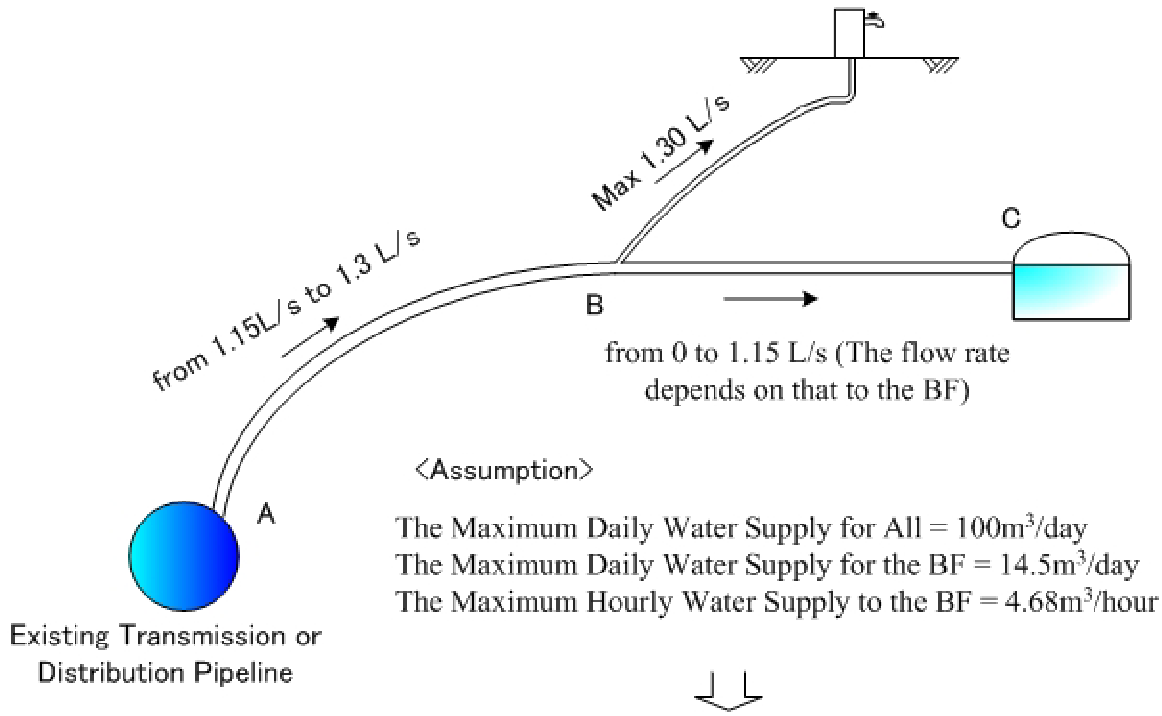
7) <u>The diameter of respective pipelines should be determined based on their maximum flow rates.</u>

(It is not necessary to add the maximum flow rate (1.30 L/s) of the BF to the transmission flow rate (1.16 L/s) for the determination of the pipe diameter from "A" to "B".)

1) Only Transmission



2) Transmission with a service installation



The Maximum Transmission Flow (from A to B) = Flow to the BF =4,680 liters/3600s = 1.30 L/s
Transmission Flow from A to C when the BF closes
=1.15 L/s (Calculated based on the assumed water demand fluctuation of the BF)

note; <u>The Maximum Daily Water Supply includes the supply volume to the BF</u>

2. Conception on Distribution System and Service Facilities

How to maintain the minimum distribution pressure and to control the variation of it is important for the distribution system design, while the service pipe is in principle projected according to a design flow of each service installations.

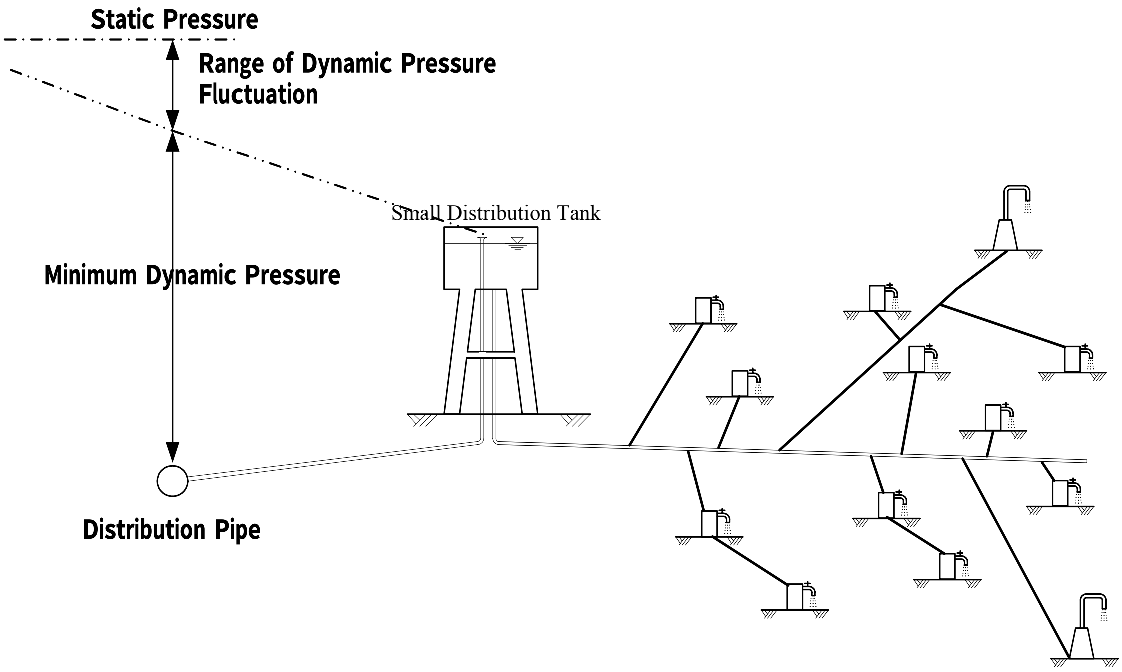
Following merit and demerit of two main type, direct type service system and receiving tank type service system, of service system applied to urban water supply system seem to be useful to consider an appropriate rural water supply system.

	direct type service system	receiving tank type service system
description	Taps (BFs) are directly connected to a distribution pipe through service pipe.	Water is stored in a receiving tank (small distribution tank*) and then it is supplied through taps (BFs).
advantage	It does not necessitate the construction cost, space, maintenance with its cost and regular cleaning of a receiving tank.	The fluctuation of the pressure in the distribution system does not affect to the service system (BFs). It is possible to use a large amount of water in a certain period of time, e.g. for fire fighting (potence). The water in the tank can be used even during the trouble of the distribution system (suspension of water supply).
disadvantage	Troubles of the water supply system directly cause the suspension of water supply. Though it depends on the capacity of the distribution pipeline system, the availability of water supply is sometimes limited. (The flow of the BF located in the hydraulically disadvantageous area will decrease or stop)	It necessitates the construction cost, space, maintenance with its cost and regular cleaning of a receiving tank (small distribution tanks). (In case of the RWS, since the pipe diameter of upstream of the small distribution tanks can be reduced, the total construction cost may not be bigger than that of “direct type”.) Low maintenance will cause the degradation of drinking water.

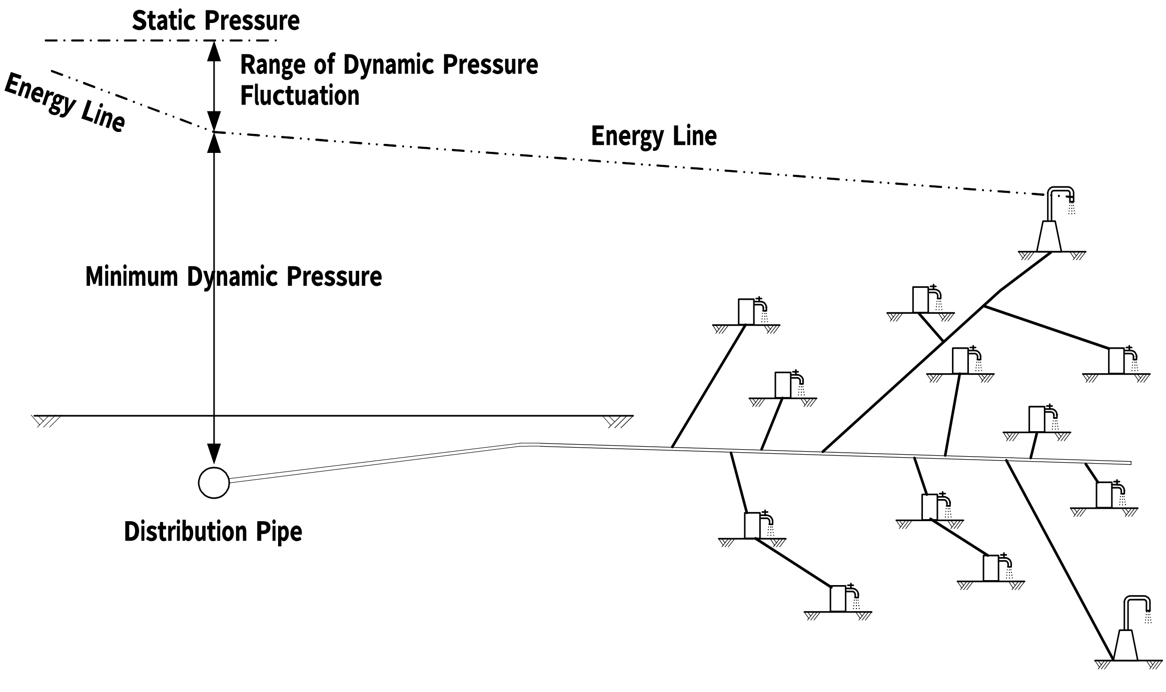
Words in parentheses show the case applying to the RWS system.

* small distribution tank is considered to install in the distribution system to isolate a certain service area from the main distribution pipeline system in order to regulate the pressure, etc.

<Receiving Tank Type Service System>

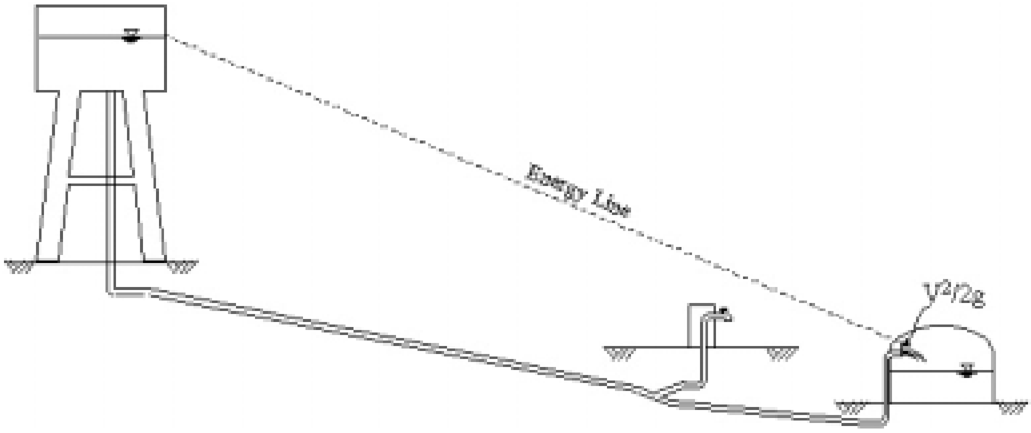


<Direct type service system>



3. Connection with two tanks by gravity flow

In several projects, the connection of two tanks by gravitational flow is considered. The concept of this connection is shown in the figure below.



Most of the cases, the downstream tank is the break pressure which has several number of service facilities. The inflow rate to the break pressure[1] is determined by the number of service facilities that it has. However, the discharge rate is determined by hydraulic conditions of upstream, though the float valve installed at the inlet may affect the discharge.

Following two cases are to be discussed:

(1) Design inflow is equal to the maximum outflow

When outflow takes place, the float valve opens and its degree of opening depends on the outflow rate. The inflow rate and the pressure at the inlet will be fixed by the potential head at the inlet in the break pressure, the diameter of the inlet pipe and the float valve opening. If the upstream hydraulic conditions allow bigger flow rate than designed, actual discharge at the valve opening may be bigger than expected and the float valve frequently opens and closes. If service installations are projected between the tank and the break pressure, their dynamic pressure will vary accordingly. Furthermore, these opens and closes might cause cavitation and worse water hammer which give damages devices of hydraulic installations and ancillary facilities of pipeline.

However, it is recommended to observe the behaviors of the float valve in the similar conditioned RWS system.

(2) Design inflow is smaller than the maximum outflow

When the outflow exceeds the design inflow, the valve opening becomes full and the

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[1] It represents the installations in which water has free water surface, i.e. pressure is zero. It can be replaced by a tank accordingly.

pressure head at the inlet will be nearly zero. If service installations are projected near the break pressure, their dynamic pressure will be very low.

A valve to control the inlet discharge of the break pressure was considered and 0.5 liter/second was set as the flow rate of the transmission pipe in the Ezzaguaya sub-project of CRDA Le Kef.

However, a number of service installations were considered in the downstream of the break pressure and it seemed that 0.5 liter/second might be insufficient to supply its downstream area with water during peak consumption hours considering the capacity of the break pressure which is $8m^3$. Thanks to the connection of two tanks by the gravitational flow, the discharge to the break pressure can be increased up to 1.5 liter/second without affecting the residual pressure of service facilities between two tanks. It makes the service of the projected water supply system stable.

4. Influence of Potence to Distribution

The designed flow of the potence is far bigger than that of BF and it is mainly used for the supply to $5m^3$ or $3m^3$ tank with water by taking certain period of time. Therefore it seriously affects the pressure of the distribution system for 30minutes to one hour continuously. In case of Gard Hadid sub-project in Sidi Bouzid, one (1) potence is projected. Using this potence affects neighboring 10 BFs to decrease their flow from 10% to 20%.

Furthermore, since the water consumption through the potence is intensive, it drives up the peak water demand and then it may necessitate to increase the capacity of the distribution tank.

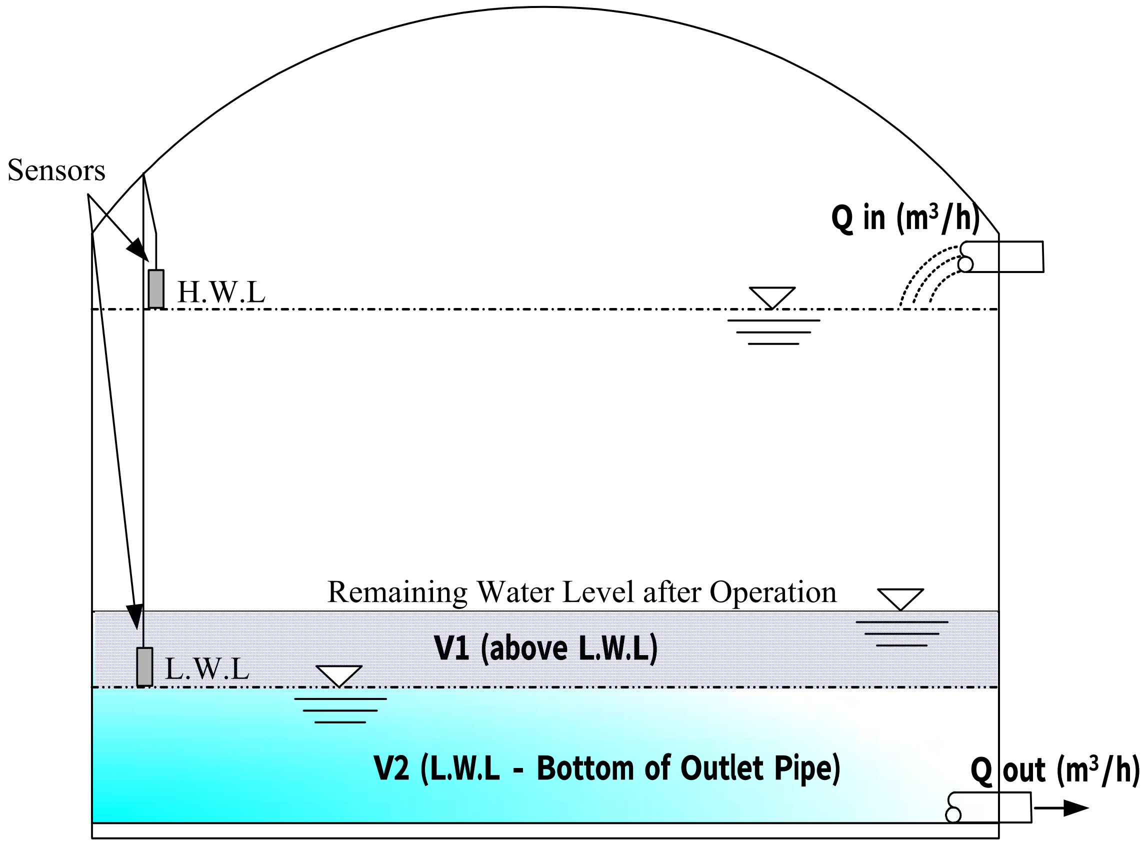
The Study Team consequently recommends avoiding to construct it as much as possible. In case that the local settings necessitate potences, the Study Team proposes to install them in the distribution system by directly connecting to the distribution tank so as not to disturb the distribution system operation.

On the other hand, the diameter of service pipe for the potence is not specified in the standard drawing prepared by DGGREE. It should be specify the appropriate diameter of potence in order to regulate the flow of it when the potence is planned for a project.

After then, the head loss of the potence should be measured in the field.

5. Minimum Water Level Setting to the Distribution Tank

The Study Team confirmed that following unfavorable condition may take place in case of the pump start/stop control by water level sensors ("Ligne Pilote" and "Radio").



When the water level in the distribution tank remains near the L.W.L. where the transmission pump starts at the end of an operation day. There is the risk that the tank becomes empty in the peak consumption period of time under the conditions below:

$$Qin \times \{V2/ (Qout-Qin)\} < Qout \times \{V2/ (Qout-Qin)\}$$

and

$$V2/ (Qout-Qin) < \text{Peak consumption period of time (one or two hours)} - V1/Qout$$

For example, Qout = 18 m^3/hour, Qin=3.6 m^3/hour (1 L/s), V1=5m^3 and V2=10m^3 are applied to the above mathematical expression, they satisfy the conditions.

If the low water level sensor is set to keep the maximum hourly water demand with some allowance considering the inlet flow rate, the conditions might not take place.

However, it is now quite difficult to set appropriate low water level due to the lack of the most probable hourly peak factor. Adjustment of the water level sensor whenever the problem happens after starting the operation is one of the solution but it seems to be difficult for the GIC.

The Study Team recommends installing the timer to start the transmission pump in the late night.

6. Using a Break Pressure as a Distribution Tank

In the Study on the sub-projects for 2006, a few projects applied the standard drawing of the break pressure as the distribution tank. The Study Team can not recommend utilizing the break pressure as the distribution tank by following reasons:

1) There is not any ventilating facilities

2) Light pass into the tank through the glass window. Javel (hypochlorite) is sensitive with the light and the temperature.

3) There is not any embankment around the break pressure. Since ambient temperature in Tunisia is rather high, the embankment seems to be necessary for keeping Javel effective.

4) There may be the risk that organic substances such as insects, etc. can easily enter inside the break pressure through the door and the window. The structure of the distribution tank is different from that of the break pressure.

7. For Keeping Good Function of Break Pressure

It is reported that a number of break pressures constructed in the past have troubles with their installed float valve and some of them lost their functions. However, causes of such troubles are not clear.

The Study Team observed one break pressure and confirmed following:

Usually, when the static pressure of a part of the distribution system exceed 10bar, which is the nominal pressure of HDPE pipe, a break pressure is considered so as not to damage pipe, BFs, etc. However, this conception has problems considering the facts:

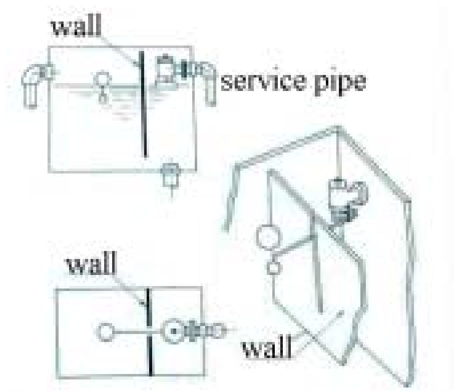
1) The maximum allowable pressure of the float valve installed in the break pressure is not clear.

The leakage from is reportedly observed when the static pressure is over 8bar. It is necessary to confirm the maximum allowable pressure of the float valve and the static pressure to be applied is recommended being around 70% of it so as to avoid the damage from the water hammer.

2) The inlet pipe discharge from above the water surface.

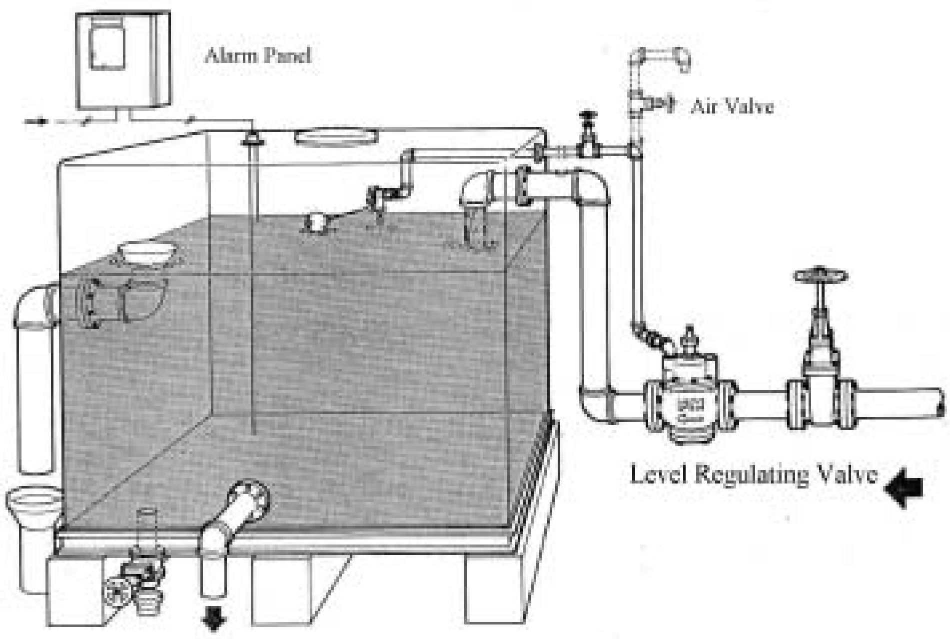
It makes wave on the water surface and move the valve float up and down.

This up and down sometimes takes place shut and open of the valve. Considering rather high dynamic as well as static pressure usually loaded in the RSW projects, there is a risk of water hammer occurrence. For avoiding this phenomenon, installing the wall to stop the wave caused by inlet flow form above surface may be one of the solution. Following figure shows the conception of the wall.

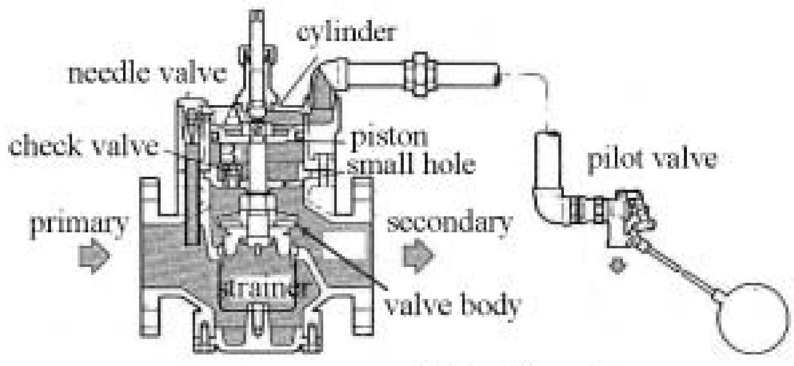


To change the float valve to another type same function valve is another solution. Level regulating valve is a one of such valve and it is used in common for tanks. The

Study Team confirmed that this type of valve is available in Tunis.



Example of Installation



Valve Opening

<Valve Opening>

a. Chamber A discharges water by opening of the pilot valve

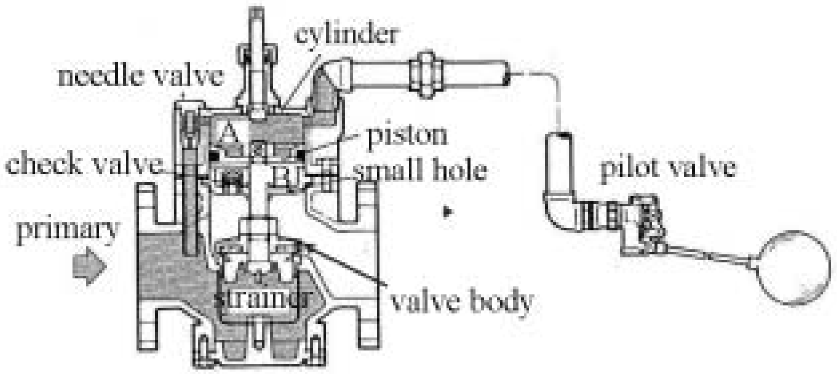
b. Pressure chamber A becomes lower than that of secondary pressure.

c. The valve body and the piston is driven up by above pressure decrease in the chamber A

d. Valve starts to discharge water to a tank at the secondary side.

e. During discharge, water enter in the chamber B by uplifting the check valve.

f. There is a small flow to the chamber A and the pilot valve through the needle valve



Valve Closing

<Valve Closing>

a. Water level in the tank rises after certain period of discharge and finally pilot valve closes

b. The pressure in the chamber A gradually decrease up that of the primary pressure

c. The check valve of the chamber B is closing

d. The ratio between the areas of the piston and the valve body (piston=>valve body) brings to drive down the valve body.

e. It gives a pressure to water in the chamber B and the water flows out from the small hole of the cylinder.

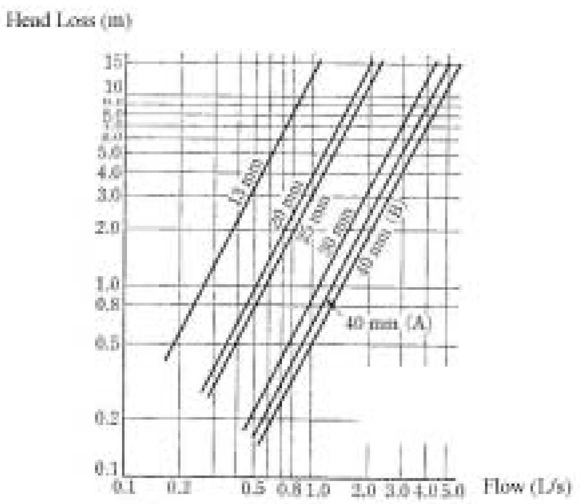
f. It decrease the descending speed of the valve body. It means valve is closing slowly.

8. Loss Head of Service Installations (Convert to Pipe Length)

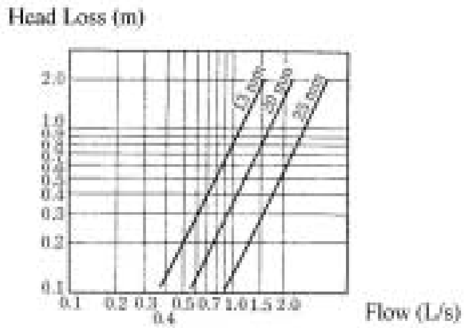
35m of DE25mm HDPE pipe is applied to the pilot sub-projects to have equivalent loss head of the BF. However, it does not reflect the actual conditions of BF but applies the minimum dynamic pressure of 10m to be kept at the connection point to BF according to the technical Guidelines prepared by DGGREE.

The BF consists of around 5m length HDPE DE 25mm pipe, cocks, a water meter, a elbow, a faucet, etc. It is consequently difficult to get precise loss heads relative to various flow values. The Team recommends executing direct measurement of the pressures at the connection point to the distribution point in various flow rates from the faucet. Having relationship between pressure and flow rate, it is possible to estimate the head loss of BF at a standard flow to be applied to the design of the Rural WSS.

In case of Japan, the diagram to have a head loss of pipe joints, water meters, valves, etc. are prepared. Following diagrams pages are examples.



Head Loss of Water Meters



Head Loss at Pipe Joints (elbow)

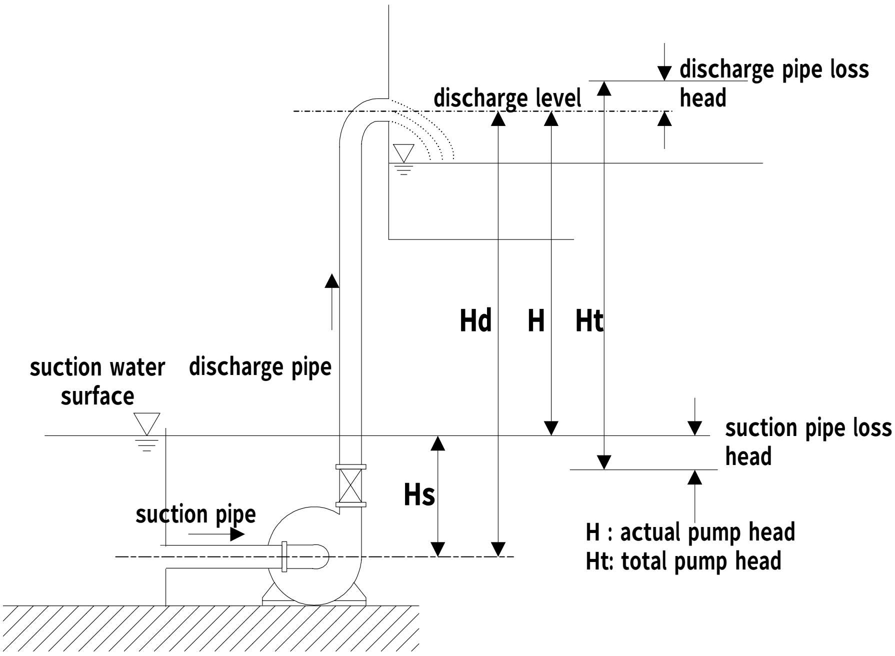
9. Selection of Pump

Needless to say, it is necessary to consider following conditions to select a pump set.

Type; considering the place to be installed a pump and easiness of O/M, the type of the pump is determined. In the RWS project, the inline pump is mainly applied to the relay pumping station. The submersible pump designed for horizontal installation is also considered, however, limited in CRDA of BEJA and LE KEF.

The pump efficiency of the inline pump is inferior to that of the submersible pump, O/M of the former is far easier than the latter. The inline pump can be installed outside of a tank (dry space) with charging condition as shown in the figure in the following page.

Discharge; the discharge of the pump is determined considering the capacity of water source and the projected distribution tank, water demand and operation hours of water supply system. However, in case that a ready-made pump set is applied, the discharge is determined by the characteristics of such pump and the pump head mentioned below.



Total Pump Head; As shown in the above figure, the pump head is the height difference between the minimum water level of the tank where the pump is installed and the maximum water level of the tank to be pumped up or the inlet pipe centerline level in case of free discharge above the water surface.

When above mentioned conditions are determined, necessary motor output is calculated applying following formula;

$$P = \frac{9.81 \times Q \times H}{\eta_p / 100}$$

where; P: Motor output (kW)

Q: Discharge (l/s)

H: Total Head (m)

ηp: Pump efficiency (%)

Rated motor output is selected from those applied to the ready-made motors such as 0.75kW, 1.1kW, 1.5kW, 2.2kW, 3.0kW, 4.0kW, 5.5kW, 7.5kw, etc.

Electricity consumption can be estimated by the motor efficiency and the power factor (cos φ).

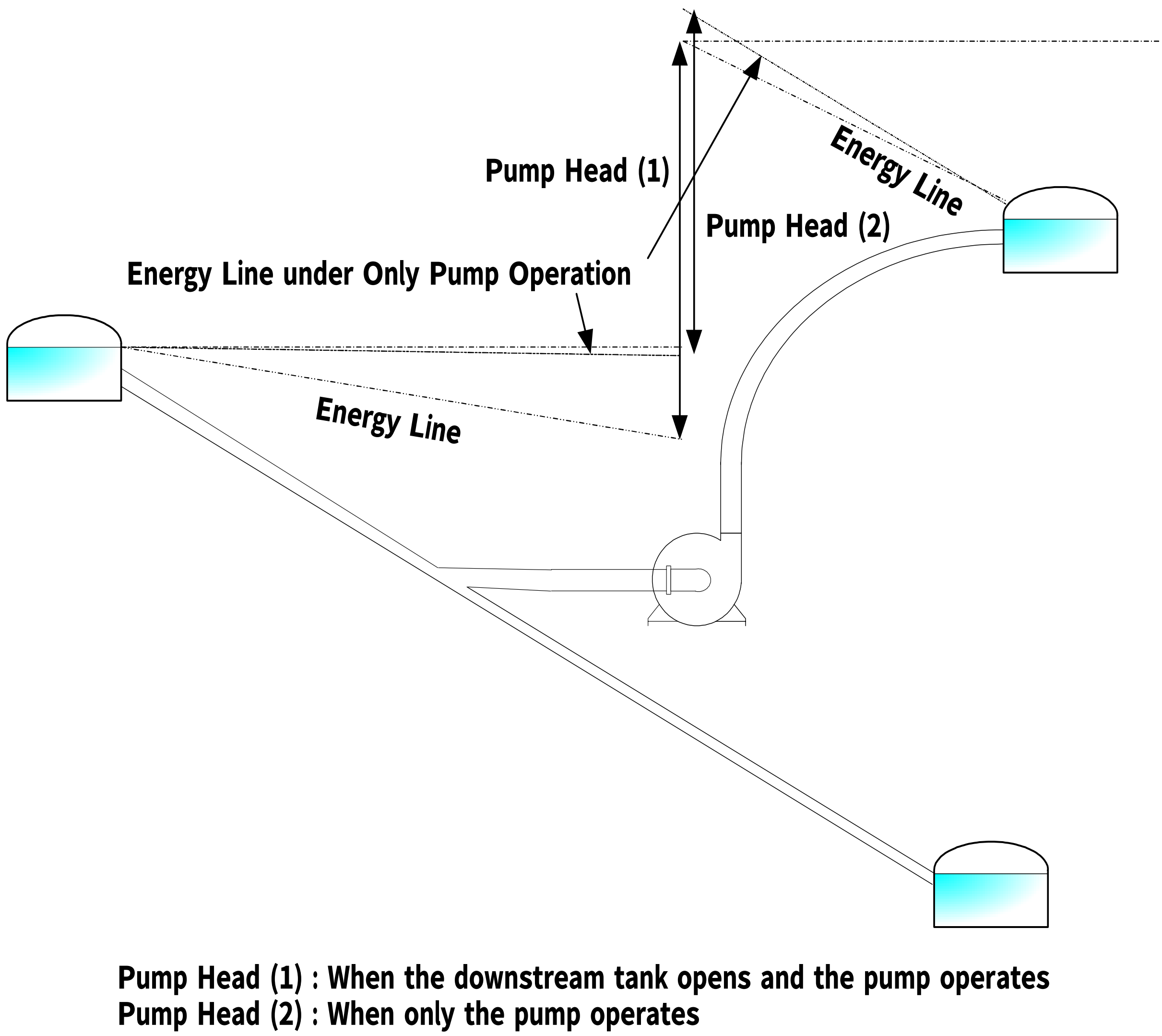
However, in the RSW project, the motor output was defined as the value calculated by dividing above P by the motor efficiency. As a result of it, rated motor output was bigger than that shown in a catalogue of electromotor pump selected according to the pump head and pump discharge. The capacity of the transformer to be installed in the pumping station was got based on the rated motor output of the pump selected without considering the motor efficiency. Because, the motor efficiency had been used in the motor output computation.

Though the capacity pump is rather small, above-mentioned matter may not practically influence the pump operation, it is preferable to review the computation method of motor output and the capacity of transformer.

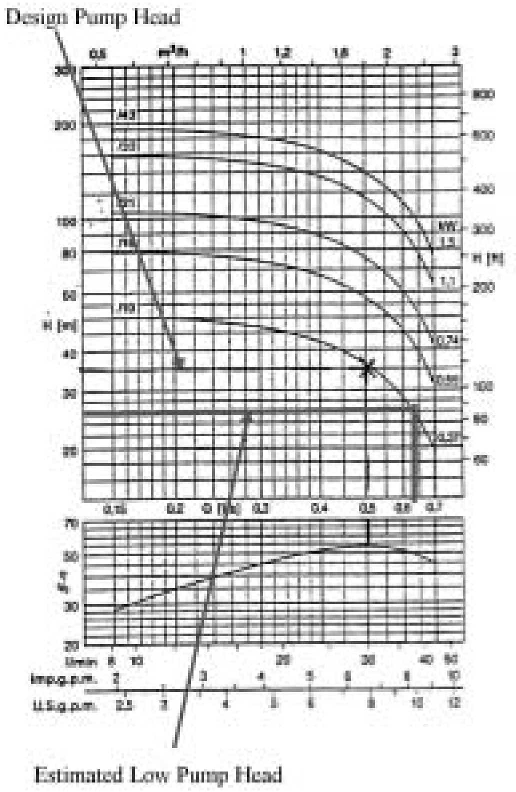
10. Booster Pumping Head

Three booster pumps are projected in the Study on the sub-projects for 2005. The booster pump is directly connected upstream pipeline with downstream pipeline. It accordingly can make use of dynamic pressure of the upstream pipeline. However, if the dynamic pressure fluctuate considerably, the pump head decrease a lot and it sometimes causes the cavitation due to rapid increase of flow.

In case of the sub-project of Sidi Hassen in BIZERTE, the booster pump of which discharge is 0.5 L/s is projected with inlet pressure (dynamic pressure) is 40m between SONEDE transmission pipeline and that of the sub-project.



However, the static pressure at the connection point is 50m and the dynamic pressure when only the pump operates is quite small due to its small discharge. This pressure difference of around 10m will decrease the actual pump head in operation and accordingly increase the flow. It may takes place the cavitation of the pump. Please refer the pump performance curve applied to the sub-project of SIDE HASSEN.



General considerations to avoid the cavitation are:

1) Big variation of the pump head should be avoided.

2) Unnecessary allowance for the projected pump head increase the risk of the cavitation.

The Study Team recommended to install the pressure reducing valve at the connection point to the pump.

It should be noted that 120 is applied to the “C” value of Hazen-Williams Formula for the consideration of long term use, however, 150 can be applied to new HDPE pipe and this difference makes actual design head lower than design pump head.

11. Installation of Air Valves

Following table shows number of air-valves per 1km pipeline of top 10 sub-projects in descendent order.

Governorate	Sub-project	MDWS	Total Pipeline Length	No. of Air Valves	No. of Air Valves / km	No. of BF
		m^3/day	km			
SILIANA	SIDI DAHER	51.21	15.8	41	2.6	13
SILIANA	NSIRAT	19.06	7.1	18	2.5	8
BEJA	AIN DAM – NEFZA	109.42	12.3	24	1.9	23
SILIANA	AGBA	45.85	5.2	10	1.9	9
SILIANA	GHANGUET ZGALASS	8.5	6.7	12	1.8	3
KASSERINE	OUED LAHTAB	115.44	24.8	43	1.7	31
BEJA	GMARA	68.96	8.1	12	1.5	12
LE KEF	EL OUENA	29.02	8.4	13	1.5	11
LE KEF	FORNA	23.56	11.9	17	1.4	15
KAIROUAN	GOUAAD	63.49	14.8	21	1.4	11

MDWS: Maximum Daily Water Supply

An air valve is installed every 400m – 650m in the pipelines in these sub-projects according to the table. If BF can be considered to have the function of the air valve when it opnes.

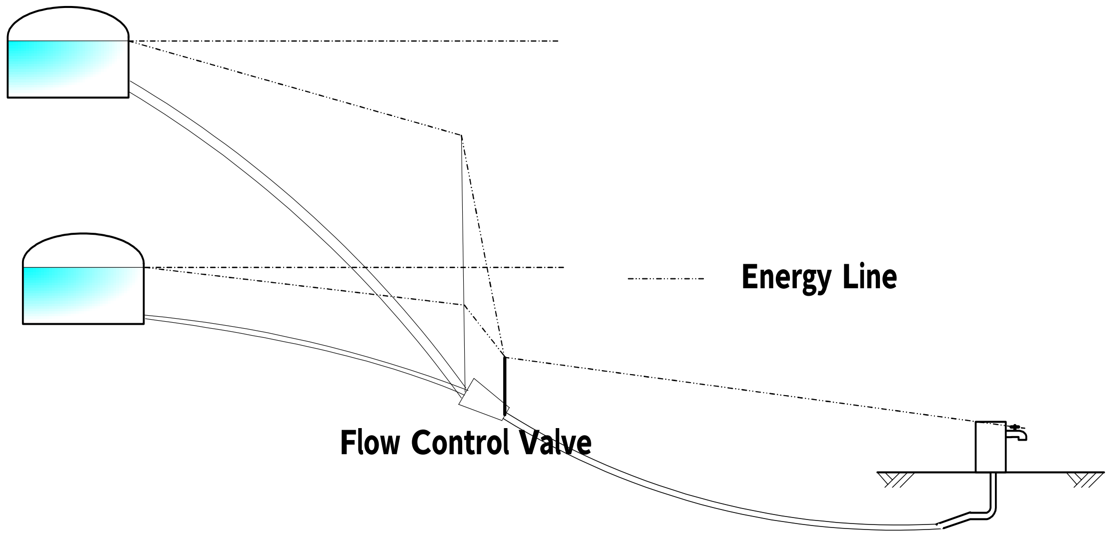
The Team understands that the air valve should be every convex points in pipelines, however, it seems to be possible to reduce number of air valves by considering the existence of BFs, etc. and periodic discharge for having rather high velocity thorough washouts opening.

Since the more number of BFs increase, the more the maintenance cost becomes high, it reflects the water charge. Furthermore, the maintenance of the system become more difficult.

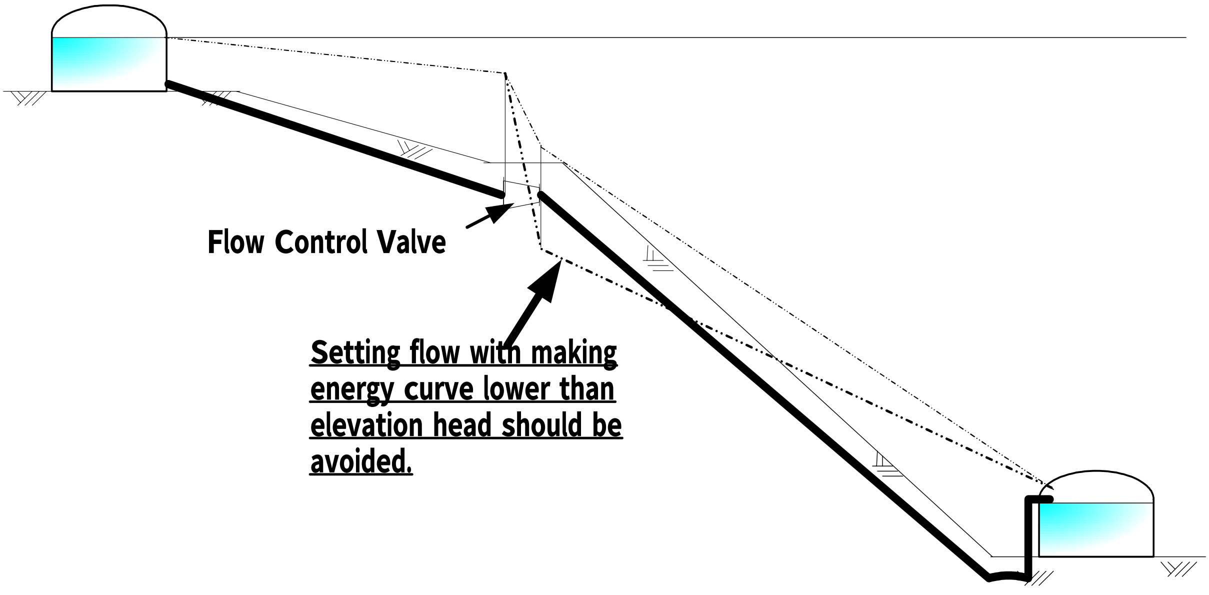
12. Notes on Flow Control Valve

The Study Team confirmed that following two points related to the function of the flow control valve should be paid attention:

1) The secondary[2] pressure is constant regardless the primary pressure for having the flow set.



2) The flow control valve can not function under the condition that the flow set necessitates lower pressure than the elevation head of the place where the valve is installed.



[2] "Primary" is used to explain the conditions related to the valve inlet side and "Secondary" is for the valve outlet side.

13. Notes on Pressure Reducing Valve

In the course of the Study, the Team observed that a number of engineers who work for the RWS projects understand the function of the "Pressure Reducing Valve" as to reduce a designated pressure. It means that if someone set 30m to the valve, he believes like following table:

unit; bar

Primary Pressure	Designated Pressure to be Reduced	Secondary Pressure
60	40	20
50	40	10
30	20	10

However, the following table explains the function of the "Pressure Reducing Valve".

unit; bar

Primary Pressure	Pressure Reduced	Secondary Pressure to be got (Designate Pressure)
40	10	30
60	20	40
30	10	20

If someone considers the function of the valve as explained by the first table, he has to set 40m in order to get the secondary pressure of 10m when the primary pressure is 50m. However, the function of the valve is conform to the explanation of the second table, the secondary pressure will be 40m.

The Team afraid that this misunderstanding influence the hydraulic analysis of the distribution system and therefore recommend confirming the function of the "Pressure Reducing Valve".

14. Installation of Water Meter

There are two (2) types of the water meter, one is volumetric type another is velocity type. The former is expensive but the accuracy is better than the latter and the latter is inexpensive but necessitate space to install.

The Study Team observed following points in the course of the Study.

1) It seems that various types of flow relative to accuracy of the water meter and design flow are not considered for the selection of the water meter. When we select the water meter, we consider following four (4) flows referring the design of the sub-project.

a. permanent flow (nominal flow)

Flow at which the water meter is required to operate in a satisfactory manner under normal conditions of use.

b. overload flow (maximum flow)

Flow at which the water meter is required to operate in a satisfactory manner for a short period of time without deteriorating; its value is twice the value of the permanent flow-rate

c. minimum flow

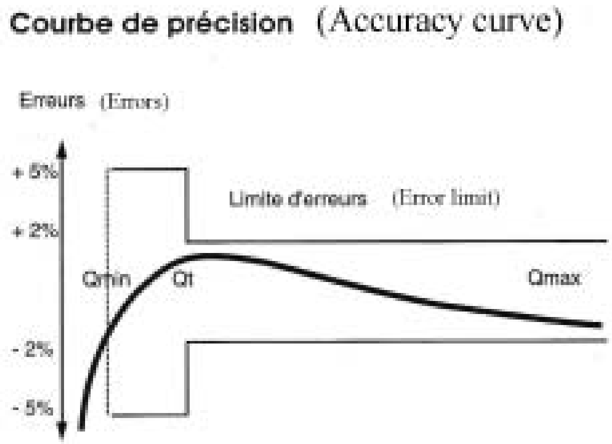
Lowest flow at which the water meter is required to give indications within the maximum permissible error tolerance.

d. transitional flow

Flow-rate value, occurring between overload and minimum flows, at which the flow range is divided into two zones, the "upper zone" and "lower zone", each characterized by a maximum permissible error in this zone.

Following figure explains the flows.[3]

[3] Source: Catalogue of volumetric water meter of ABB



Considerations of the flow variation inside the pipe where the water meter is to be installed according to the hydraulic calculation is necessary to select a water meter with appropriate diameter so arrange pipe design for installation.

2) Necessary straight length of pipe upstream and downstream to the position of the water meter is not considered in case of velocity type of water meter.

The velocity type of water meter necessitates certain straight length of pipe upstream and downstream in order to have allowable accuracy. For example, BS; British Standard requires the such length of 15times of the nominal diameter of the water meter.

In the RWS projects, the velocity type of water meter is usually installed in the valve pit of a tank which does not have sufficient space to install such straight pipe. The Team recommends constructing the concrete water meter box inside the tank site so as to have enough space to install the water meter even if such straight pipe diameter should be reduced to have appropriate flow to meet the designated nominal flow of the water meter.

15. Celerity of Water Hammer

The analysis of the transient phenomena of hydraulic facilities in the RWS projects is made using the simulation software named “BELL”. The celerity, quickness of pressure surge propagation, of 400m/s is however applied to the analysis regardless pipe wall thickness and/or pipe material.

Since counter measures for the transient phenomena is costly, values necessary for the analysis should be applied.

The following shows the computation method of the celerity:

$$a = \sqrt{\frac{1}{\frac{\gamma}{g}\left(\frac{1}{K} + \frac{Dc}{eE}\right)}}$$

$$c = 1 - \nu^2$$

where

a	celerity (velocity of propagation of pressure wave)		m/s	
γ	Density of water	999	kg/m^3	20^oC
g	acceleration of gravity	9.81	m/s^2	
K	Bulk Modulus of Water	210,000,000	kgf/m^2	
D	Pipe inside diameter		m	
e	Pipe wall thickness		m	
E	Modulus of Elasticity of Pipe Wall (HDPE)	78,000,000	kgf/m^2	
υ	Poisson's υ (HDPE)	0.46		
c	a non-dimensional parameter depends on the elastic properties of the conduit	0.7884		
E	Modulus of Elasticity of Pipe Wall (DCI[4])	1.6×10^{10}	kgf/m^2	
υ	Poisson's υ (DCI)	0.3		

4 Ductile Cast Iron

Following tables show the celerity of HDPE PE80 and PE100 by diameters

HDPE80 PN10 / HDPE80 PN16

ND	D	e	a	ND	D	e	a
mm	mm	mm	m/s	mm	mm	mm	m/s
63	53.6	4.7	286	63	48.8	7.1	364
75	64.0	5.5	283	75	58.2	8.4	362
90	76.8	6.6	283	90	69.8	10.1	363
110	93.8	8.1	284	110	85.4	12.3	362
125	106.6	9.2	284	125	97.0	14	362
140	119.4	10.3	284	140	108.6	15.7	363
160	136.4	11.8	284	160	124.2	17.9	362
200	170.6	14.7	284	200	155.2	22.4	362
250	213.2	18.4	284	250	194.2	27.9	362
315	268.6	23.2	284	315	245.0	35	361

HDPE100 PN10 / HDPE100 PN16

ND	D	e	a	ND	D	e	a
mm	mm	mm	m/s	mm	mm	mm	m/s
63							
75	66.0	4.5	253	75	61.4	6.8	320
90	79.2	5.4	253	90	73.6	8.2	321
110	96.8	6.6	253	110	90.0	10	320
125	110.2	7.4	251	125	102.2	11.4	321
140	123.4	8.3	252	140	114.6	12.7	320
160	141	9.5	252	160	130.8	14.6	321
200	176.2	11.9	252	200	163.6	18.2	320
250	220.4	14.8	251	250	204.6	22.7	320
315	277.6	18.7	252	315	258.0	28.5	319

ND: Nominal Diameter

In case that pump discharge consist of different material pipes such as DCIP and HDPE, the celerity can be calculated according to following formula:

$$a = \frac{L}{\sum_{i=1}^{z} \frac{L_z}{a_z}}$$

where:

a: converted celerity

L: total pipe length

L_i: length of "i"th pipe

a_i: celerity of "i"th pipe

16. Waste of Energy

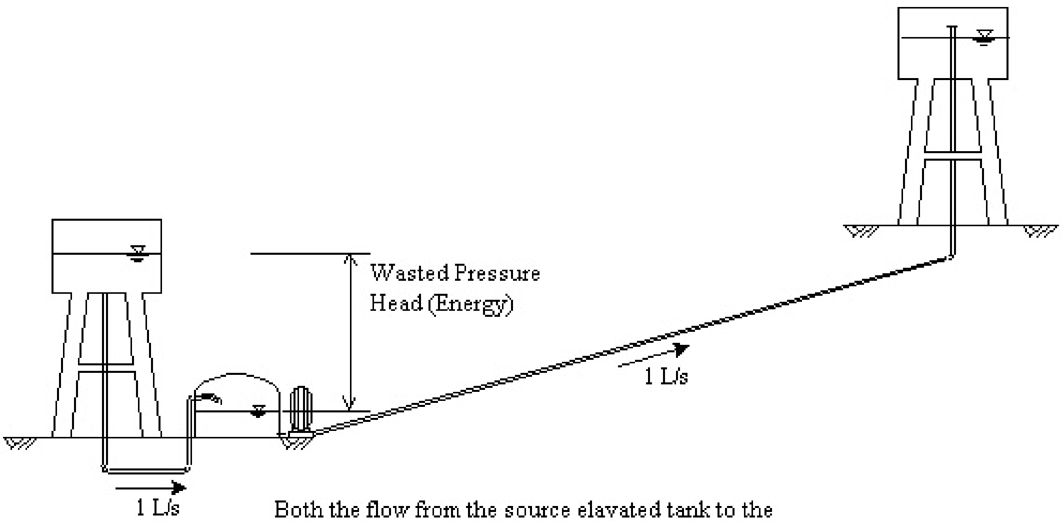
(1) Ouled Faleh sub-project of the Study in 2004

The Ouled Faleh sub-project in Sousse governorate is outlined as follows:

A relay pumping station is constructed just aside the existing elevated tank managed by SONEDE. Water is transmitted from the elevated tank to the relay tank and pumped up to a projected elevated tank with 15m high and 25m^3 capacity. The projected elevated tank covers all the service area where four localities exist. Each locality has one communal tap.

The relay tank is designed by the strong request by SONEDE without explaining any reason. Discharge accepted by SONEDE is 1 liter/second which is same as the capacity of the projected pump. Considering the same discharge form the elevated tank to the pumping station and from the pumping station to the projected elevated tank, it is possible to connect the existing elevated tank to the projected pump and it make possible for the pump to make use of the pressure head (energy) of the elevated tank.

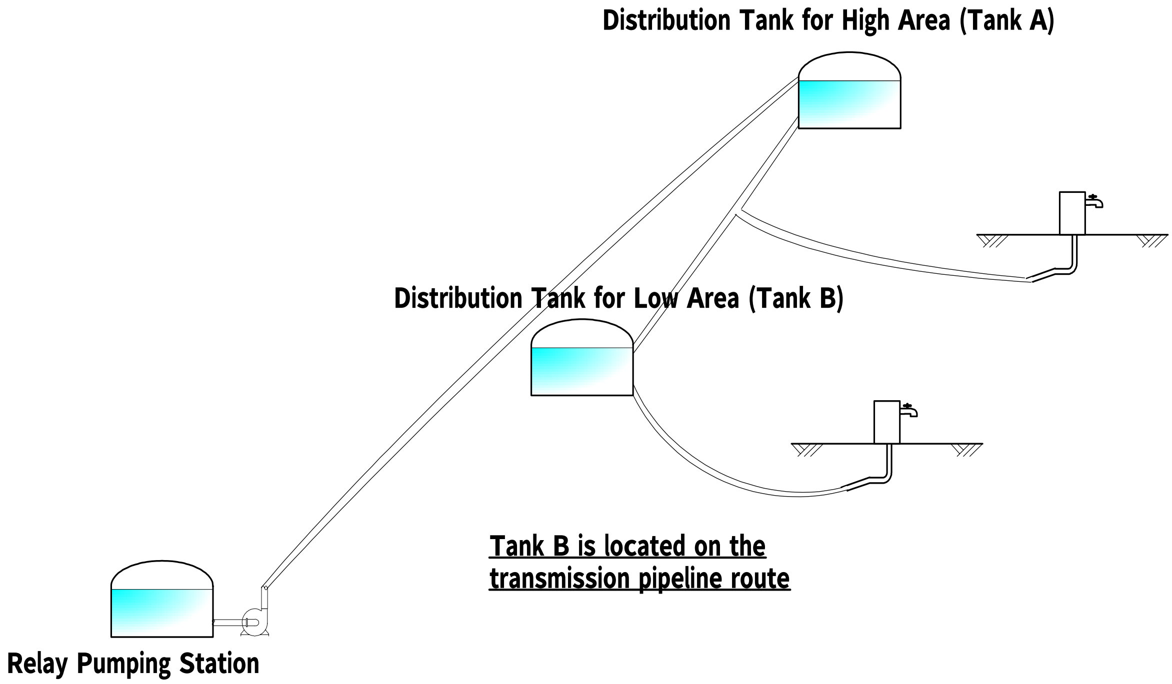
The Study Team recommends to avoid such design to make use of valuable energy as much as possible.



Both the flow from the source elavated tank to the relay tank and pump discharge is 1 liter/second.

(2) El Ouena sub-project of the Study in 2005

In case of El Ouena sub-project in Le Kef, the pump pressurized transmission is designed as shown in following figure:



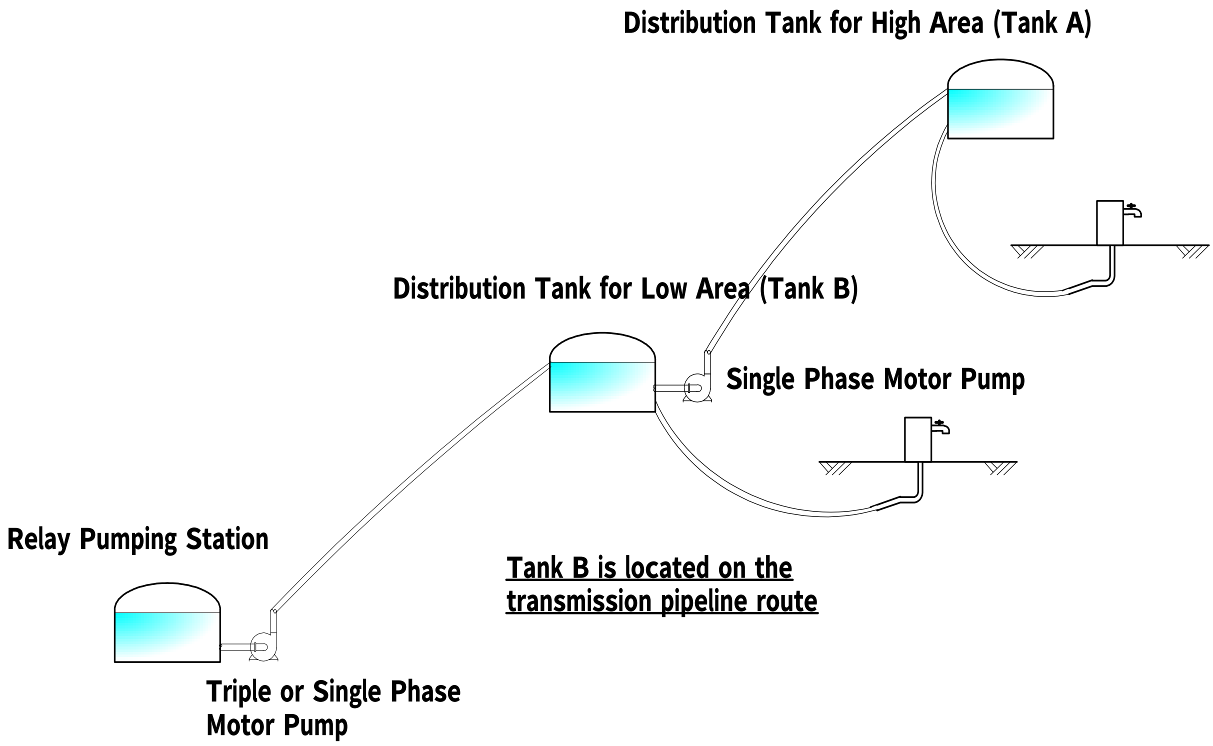
Water is once pumped up to the Tank A and returned to Tank B for the distribution to six (6) BFs and to transmit to another distribution tank.

For pumping up water to the Tank A, DCIP is used partially due to over 160m[5] height difference and a phase converter from single phase to three phase current is introduced to operate three phase electric motor pump with 1.0L/s discharge capacity and 239m pump head.

It should be noted that the Tank B is located on the transmission pipeline route and the service area has single phase current power supply lines.

The Study Team considers following design is more appropriate for this project even if there will be two pumping stations which will make the O/M of the system difficult according to the opinion of CRDA Le Kef. However, it can be expected to save the investment cost as well as operation cost, i.e. energy cost.

[5] If PEHD PN16 (Nominal Pressure is around 160m water head) can not meet the topographic conditions, DCIP is applied.


Distribution Tank for High Area (Tank A)
Distribution Tank for Low Area (Tank B)
Single Phase Motor Pump
Relay Pumping Station
Tank B is located on the
transmission pipeline route
Triple or Single Phase
Motor Pump

Appendix 11.3.1 Concepts for the practical guide of the Sensitization Manual

The concept for the practical guide for the actual sensitization manual is shown below. It includes surveys or activities to be conducted from the identification to the preliminary sensitization. Five (5) steps are described in a form of module and the items to be discussed and discussed, and the points to be emphasized are summarized in each items for the practical process of the effective participatory approach.

1 MODULE 1: IDENTIFICATION

Item No.1: Identification of the project area:

- Items to be verified: Localities, population, livestock, institutions, current water collection and its constraints, etc;
- How to conduct the identification successfully?
- Tools to be used in the identification

Item No. 2: Identification and selection of relay persons

- Persons to be selected
- Criteria of selection?
- Tasks expected from these persons
- Where and how to recruit relay persons be recruited in practice

2 MODULATE 2: SOCIO-ECONOMIC SURVEY

Item No. 3: Household Survey based on the questionnaire

- Relevance of the household survey (Why should we conduct a household survey?)
- Elaboration of a questionnaire for the household survey (with examples of tables and diagrams)
    - Definition of topics of the questionnaire
    - Structure of the questionnaire
    - Volume of the questionnaire
    - Sampling and the selection of samples to ensure the reliability of the sampling
    - Implementation of the household survey in the field
    - Data processing
    - Use of the result in the preparation of sensitization activities

Item No. 4: Survey on the existing GIC

- Parties/persons to be surveyed
- How to conduct the survey
- Subjects to be analyzed

- Homogeneity or heterogeneity of the population
- Problems faced by the GIC (cost recovery, technical problems such as water leakage, breakdown of the WSS, shortage of diesel oil, maintenance level, etc.)
- Production of the GIC
- Financial aspects: budgets, financial balances, tariff system applied, etc.
- Management aspects: Selection of members of the board of directors of the GIC, personnel working for the OM/M of the WSS

Item No. 5: Techniques for PRA

(A) Community Mapping

- How to proceed to elaborate a community map
- Items to be included
- Those who better to participate in the community mapping
- Usefulness of the community map (how to use it in the activities to be followed)

(B) Needs ranking (pair-wise ranking)

- Target group with whom to proceed to priority ranking of community needs.
- How to list needs raised by participants
- Matrix to be used to rank the priority

(C) Semi structured interview

- Target group for the semi-structured interview (Shall we choose a target group or make the interview with community members who are present by coincidence also?
- Checklist for the interview
- How to proceed the interview (role of the facilitator, effective facilitation)

(D) Other PRA tools:

- Venn diagram (description of the tool and its purpose, suitable target group, how to conduct);
- Daily routine diagram (description of the tool and its objectives, activities by gender, how to conduct)
- Time line of the community (description of the tool and its purpose, suitable target group, how to conduct)

3 MODULATE 3: SENSITIZATION

Item No. 6: First Visit of the Sensitization

- Organization of the meetings
- Standard contents for the first visit of the sensitization
- Those expected to participate in these meetings
- Educational tools to be used: on papers, flows, diagrams

- Discussion process (Items should be carefully noted from the discussion)
- Preparation for necessary elements for the process-verbal of the sensitization meeting
- Standard format of the process-verbal

Item No. 7: Second Visit of the Sensitization

- Organization of the general information meetings
- Standard contents for the second visit of the sensitization
- Tools to be used (images, diagrams, community map, panels, etc.)
- Themes to be discussed in the general information meeting and those to be discussed in the meeting with restricted groups (at locality level).
- Process for the selection of tap keepers
- Locating of service points (role of the sociologist and the engineer)
- How to mobilize the beneficiaries, notably women.

Item No. 8: Third Visit of the Sensitization

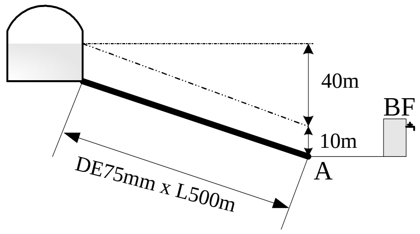
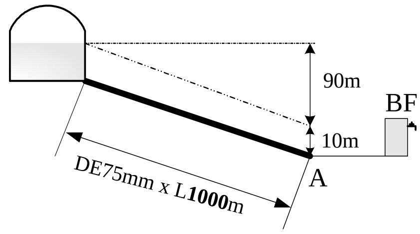
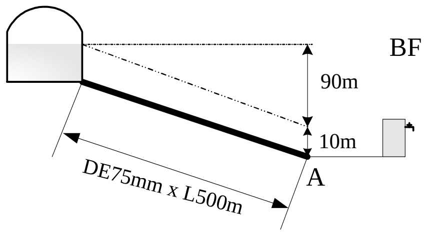
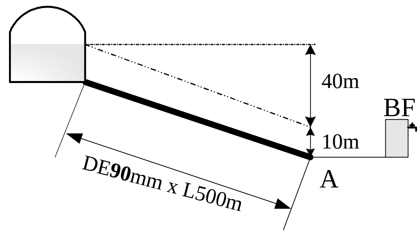
- Organization of the general information meetings and meetings with restricted groups
- Standard contents for the third visit of the sensitization
- Pedagogic equipment and tools to be used
- Role of the sociologist and the engineer in the sensitization.

Item No. 9: Communication Techniques

- Conditions for a successful communication with the target population
  - Organization of meetings
  - Selection of appropriate timing and place
  - Reception of participants
  - Presentation of the meeting objective
  - Collaboration of participants in the discussion process
  - Establishment of the dialogue with the participants
  - Visualization of discussion topics and process
  - Tools to be introduced in the sensitization
  - Development of communication skills of those working with the target population
  - Effective formulation of ideas and reformulation of ideas given by the participants
  - Recapitulation for smooth discussion, etc.

Appendix 11.4.1 Relationship among elevation, pipe diameter and pipe length

Following figures suggest the points to design the distribution system.

Case 1	Case 2
 Q=6.65 L/s (BF x 13)	 Q=7.09 L/s (BF x 14)
Case 3	Case 4
 Q=10.32 L/s (BF x 21)	 Q=10.32 L/s (BF x 21)

Case 1

- The surface water level of distribution tank is 50m higher than the ground elevation of a service area.
- The outside diameter and length of distribution pipe are 75mm and 500m respectively.
- 6.65 L/s (equivalent to the total flow rate of 13 BFs on condition that the standard flow of BF is 0.5 L/s) is the maximum flow to keep the minimum dynamic pressure in the service area.

Case 2

- The potential head and the length of distribution pipe are double comparing with those in the Case 1.
- 7.09 L/s (equivalent to total of 14 BFs) is the maximum flow to keep the minimum dynamic pressure in the service area.

Case 3

- The potential head is double comparing with that in the Case 1.
- 10.32 L/s (equivalent to total of 21 BFs) is the maximum flow under the same condition of

the Case 1

Case 4

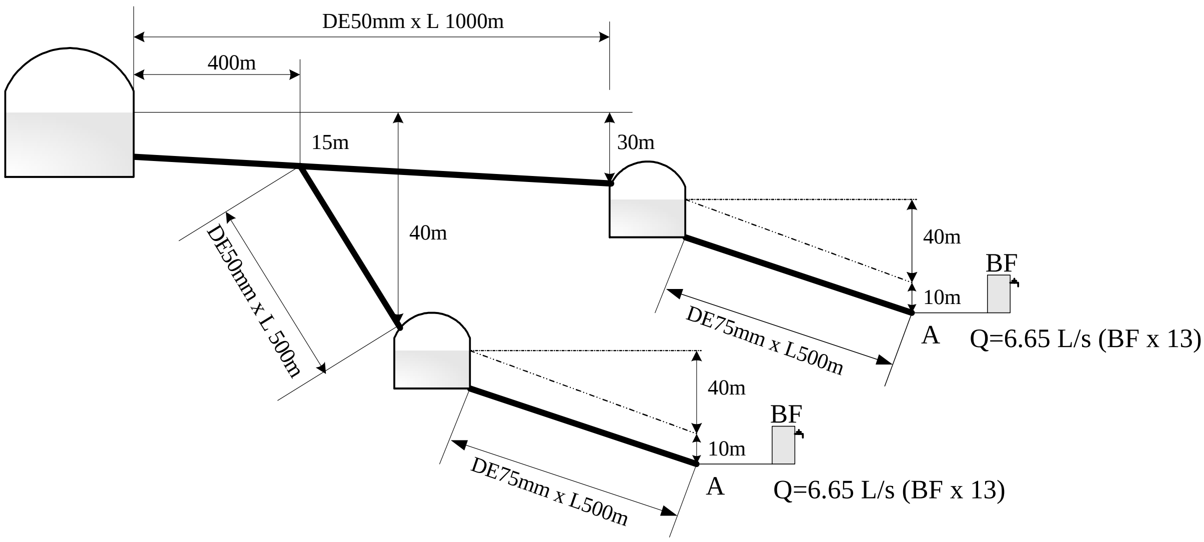
- Same conditions to the Case 1 except the outside diameter of distribution pipe which is 90mm instead of 75mm.
- Flow rate under the same condition of other Cases is almost same to that of the Case 3 that is 10.32 L/s (equivalent to total of 21 BFs).

It suggests followings:

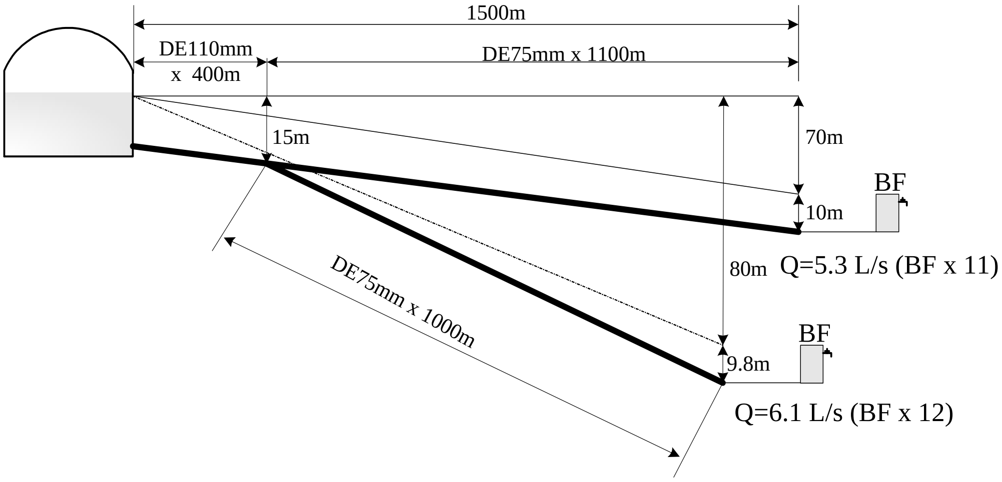
1) To increase of the potential head of distribution tank associating with extension of pipeline does not bring a good effect.
2) The flow rate can be increased by making the potential head double unless the pipeline length changes, however, the flow rate can not be doubled.
3) If the outside diameter of distribution pipe increases one rank (DE 75mm to DE 90mm), the same effect by making the potential head double can be got.

The Study Team proposes to discuss on the following two types of distribution system based on above:

(1) Relay tank type distribution



(2) Direct type distribution system



Following table shows the advantages and disadvantages of both type and it hopefully suggests the points on the design of the Rural Water Supply Systems.

	(A) Relay Tank Type	(B) Direct Type	Remarks
Construction Cost	High	Low	It depends on the site conditions
Pressure	Low	High	When all the BFs in the service area open at the same time, the minimum dynamic pressure is almost same.
Maintenance	less troubles; Pipeline between the distribution tank and relay tank does not necessitate air valves	more due to higher pressure than (A)	It is necessary to improve the water level control of relay tanks.
Stable Water Supply	Stable; The system has bigger storage of water than (B) for troubles	Unstable; Variation of BF's flow rate is big	
Potential for Expansion	easy; Replacing by bigger diameter pipe in the down stream area of the relay tank	quite difficult	