B FIELD EXAMPLES

1 Gravity-flow water systems on spring catchments

Projects must be planned and implemented in collaboration with the community and its leaders. It is important to take into consideration the special characteristics of each community and to plan the development of the project with the local population.

1.1 Planning

The time necessary for the construction of a gravity-flow system depends on numerous factors (Table 11.XXV): participation of the community, length and complexity of the system, weather conditions (important above all for digging the trench) etc.

Work planning for the Aloua system shown in Chapter 11A is given in Table 11.XXVI.

Table 11.XXV: Example of time required for the main works in the construction of a gravity-flow water system.

Spring catchment	5 weeks – 10 persons
Constructing storage tank	1 month – 8 persons
Constructing tapstand	1 to 2 weeks – 5 persons
Digging trench (80 cm)	5 m/person/day
Installing pipes	50 m/person/day
Backfilling trench	8 m/person/day

Table 11.XXVI: Timetable for the implementation of the Aloua system.

Month	Activities
1	Field survey (resources, demand) on site, contact with the community Plan of the village Topography Design calculations
2	Purchase of materials and equipment (pipes, cement, moulds etc.) Recruitment of labourers Planning community participation programme
3	Spring catchment Construction of particular structures (header / sedimentation tanks, break-pressure tanks etc.) Implementation of community participation programme
4	Construction of storage tank Continuation of community participation programme
5	Construction of 3 tapstands Continuation of community participation programme
6	Construction of 4 tapstands Start of trench-digging, installation of pipes, partial backfilling Continuation of community participation programme
7	Completion of construction of tapstands Completion of pipe installation, backfilling trench Continuation of community participation programme
8	Filling pipes with water Repairing leaks Completion of site (fencing around tapstands etc.) Evaluation, new proposals

1.2 Human and financial resources

The skilled jobs for the construction of a gravity-flow system are pipe-laying and civil engineering, which may or may not be sub-contracted. When working directly, two teams are used, one for plumbing (connection and installation of the pipes) and the other for civil engineering (Table 11.XXVII). Community members can be involved in some of the tasks, particularly:

- clearing the pipe routes and transport of materials along the line;
- digging the trenches;
- managing wastewater from tapstands and erecting fences or hedges around the spring and tapstands.

Table 11.XXVII: Personnel required for the construction of a distribution system.

Management	
1 water technician	Design, planning, management of the teams
1 logistician	Supplies to the site, follow-up of material and vehicles
1 foreman	Overseeing plumbing and brickwork teams
Masonry team	
1 mason foreman	In charge
2 assistant masons	Preparation, concrete work
Plumbing team	
1 plumber foreman	In charge of installation and connection of pipes
2 assistant plumbers	Laying and connection of pipes
Labourers	
Depending on demand	Trenches, building, plumbing

Table 11.XXVIII shows estimates of the cost of materials and equipment in 1997.

Table 11.XXVIII: Average cost (in euros) of materials and equipment purchased in France in 1997.

Piping

GI (per 6 m)		PVC, NP 10 (per m)		HDPE, NP10 (per m)	
3/4”	18.3 €	32 mm	0.5 €	32 mm	1.5 €
1”	25.2 €	40 mm	0.8 €	40 mm	2.3 €
2”	50.3 €	50 mm	1.2 €	50 mm	3.4 €
3”	86.9 €	75 mm	2.4 €	75 mm	7.6 €
		90 mm	3.2 €	90 mm	10.7 €
		110 mm	4.6 €		

Fittings

GI		PVC		PE	
2” socket	7.6 €	2” socket	2.0 €	2” socket	13.0 €
2” nipple	4.6 €	2” union	6.9 €	2” union	15.2 €
2” union	14.5 €	90° 2” elbow	3.4 €	90° 2” elbow	17.5 €
90° 2” elbow	5.9 €	90 ° 2” tee	4.0 €	90 ° 2” tee	19.1 €
90 ° 2” tee	8.8 €	2-1” reducing socket	2.1 €	2-1” reducing socket	13.0 €
2-1” reducing socket	6.4 €				

Miscellaneous

Tapping saddle clamp 50	15.2 €
Repair clamp (100 mm)	7.6 €
Repair clamp (200 mm)	61 €
High tolerance connection DN 40 to 300	25.9 to 99.1 €

Equipment	Quantity	Price
Diesel pump and accessories	1	1 829.3 €
Rapid land survey kit	1	609.8 €
Proportional dosing device (1 to 20 m^3/h)	1	1 524.4 €
Analysis kits:		
– bacteriological analysis + consumables	1	2 134.4 €
– aluminium analysis	1	101.2 €
Small tools and equipment	1	762.2 €
Aluminium sulphate (50 kg)	10	762.2 €
HTH (kg)	10	152.4 €

1.3 Example of the Ban Houn system

The following example shows a gravity distribution system from a spring catchment in Laos, for the village of Ban Houn (ACF, 1998). Figures 11.35 and 11.36 show plans for the tanks built for this system (Box 1).

When villages are inaccessible, especially for the transport of materials such as cement and reinforcing steel, it is possible to use pre-fabricated polyethylene tanks. They can be buried and protected by a fenced-off area on the surface (Figure 11.37).

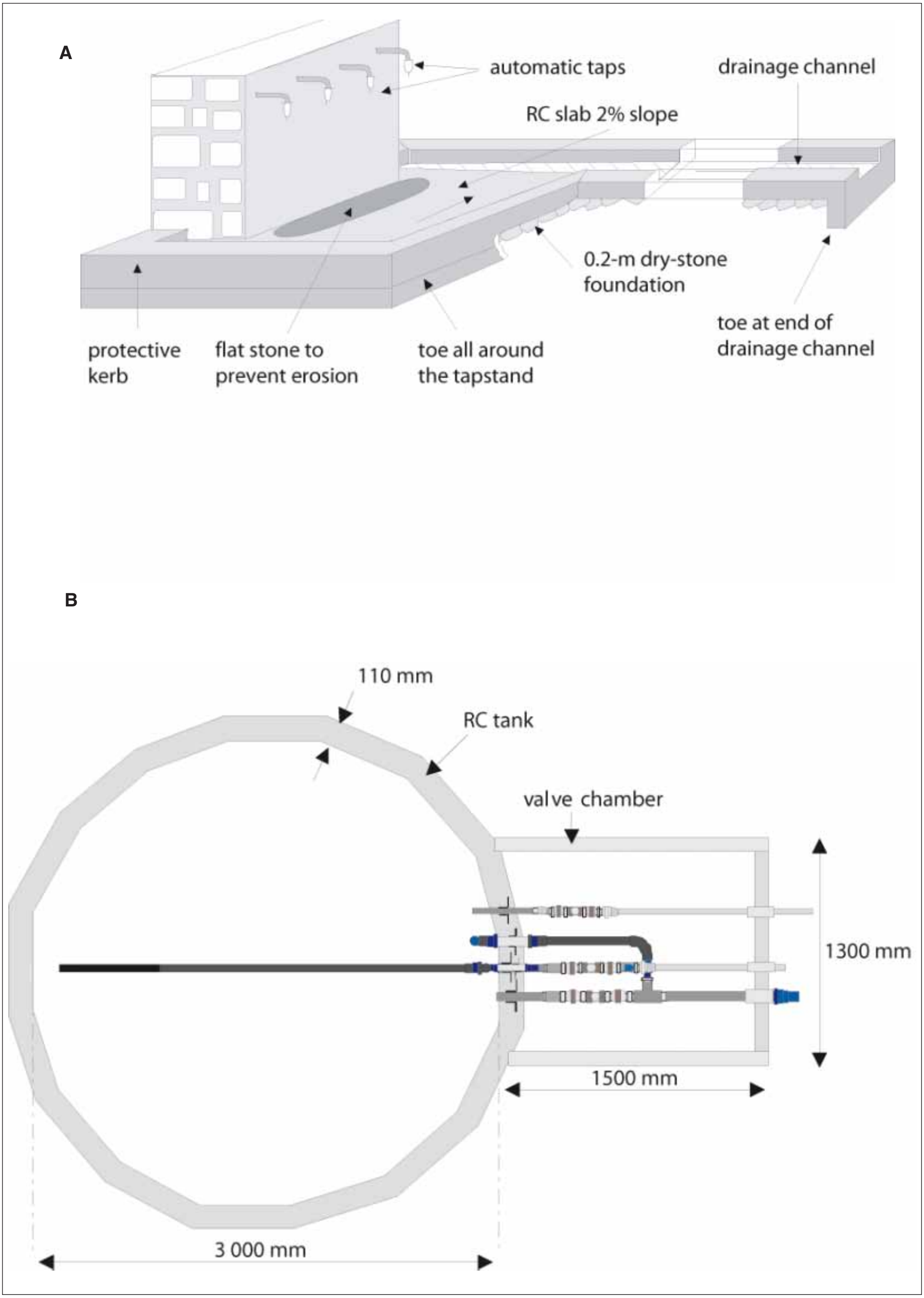
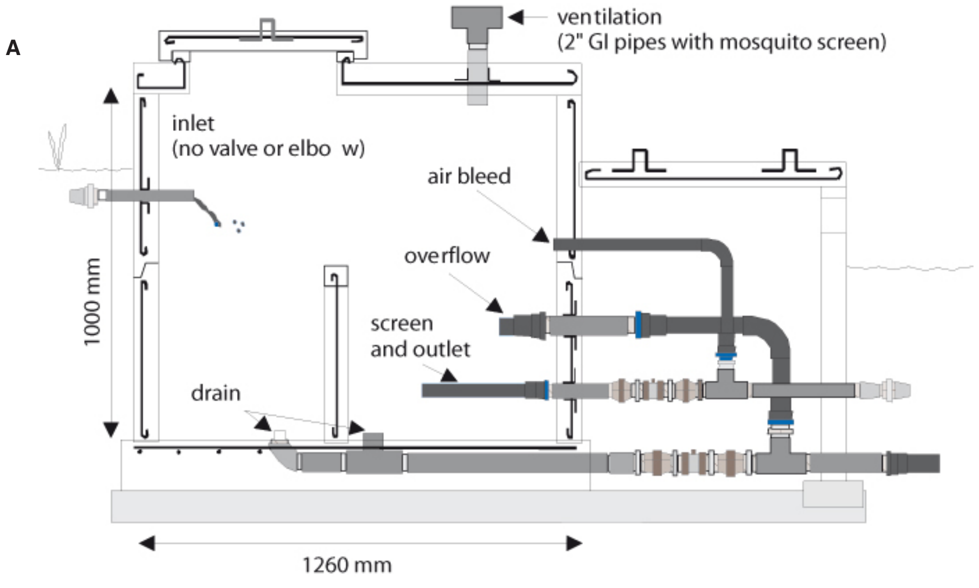


Figure 11.35: Reinforced concrete tank (ACF, Laos, 1998).
A: section. B: plan.



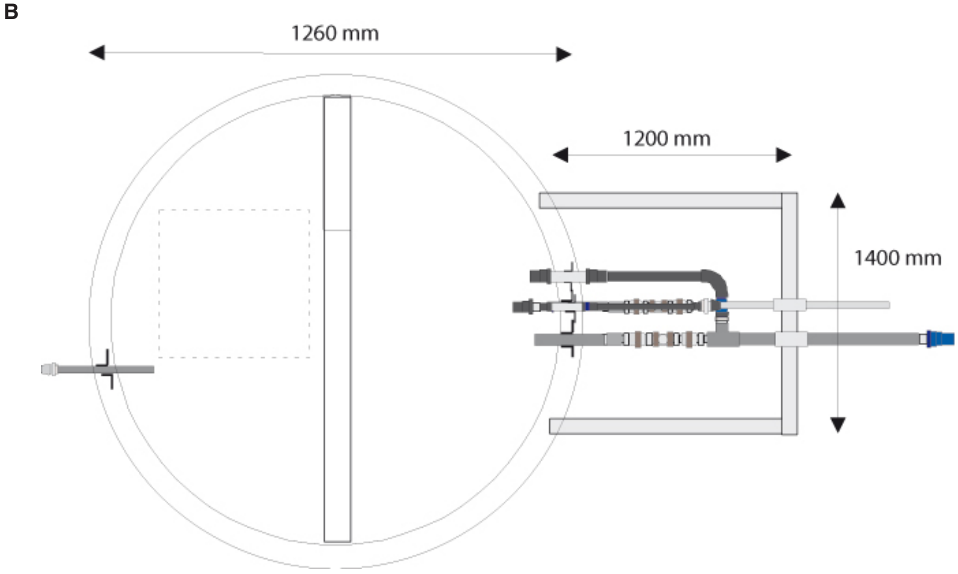
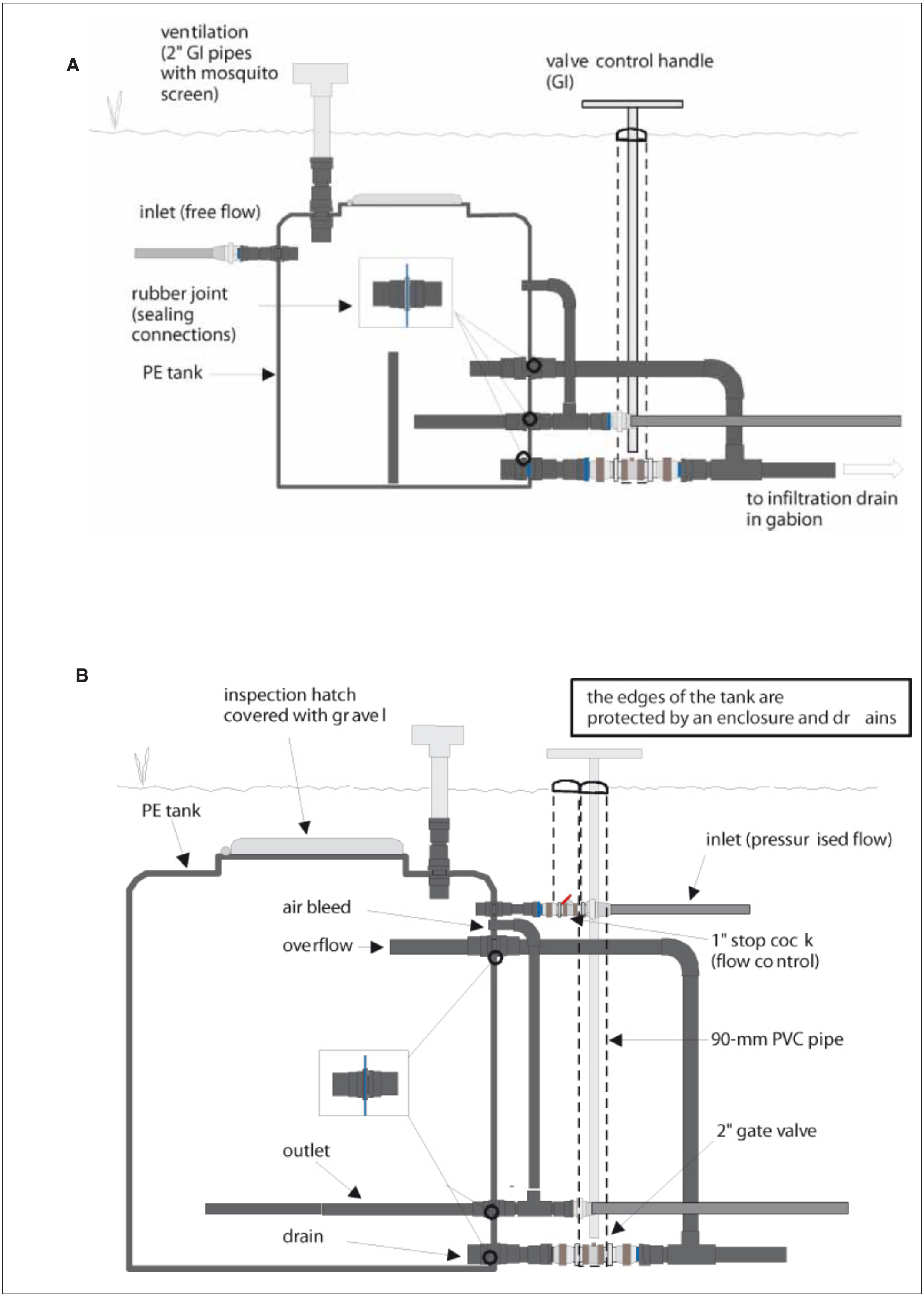


Figure 11.36: Header tank.
A: section. B: plan.



the edges of the tank are protected by an enclosure and drains

**Figure 11.37: Polyethylene tank.
A: header. B: tank.**

Box 11.2
Design of the Ban Houn system.

Site: Ban Houn
Date: 22/07/98
Population growth rate: 3%

Analysis of the situation

	Current population	Population in 10 years	Demand l/person/day	Daily demand (m³/day)	Number of taps
Population	123	159.9	40	6.396	2
Health centre		0	10	0	0
Hospital		0	50	0	0
Market		0	10	0	0
Temple		0	10	0	0
School		0	0	0	0

Daily demand: 6.40 m^3/day. Number of taps: 2. Spring yield (dry season): 0.075 l/s.

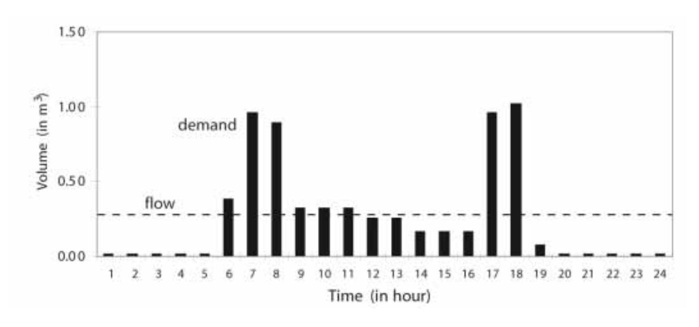


Figure 1: Comparison of hourly demand and spring flow.
Spring flow (l/h) < hourly demand → storage is required (tank).

Volume of tank

Flow of spring (dry season): 0.27 m^3/h. Total demand: 6.40 m^3/day.

Time of day	Coefficient of consumption (%) during the period	Demand during the period (m³)	Volume of water produced by the spring during the period (m³)	Difference (m³)	Negative stock	Positive stock	Accumulated stock (m³)
1	0.2	0.01	0.27	0.26	0.00	0.26	0.26
2	0.2	0.01	0.27	0.26	0.00	0.26	0.51
3	0.2	0.01	0.27	0.26	0.00	0.26	0.77
4	0.2	0.01	0.27	0.26	0.00	0.26	1.03
5	0.2	0.01	0.27	0.26	0.00	0.26	1.29
6	6.0	0.38	0.27	– 0.11	– 0.11	0.00	1.17
7	15.0	0.96	0.27	– 0.69	– 0.69	0.00	0.48
8	14 0	0.90	0.27	– 0.63	– 0.63	0.00	– 0.14
9	5 0	0.32	0.27	– 0.05	– 0.05	0.00	– 0.19
10	5.0	0.32	0.27	– 0.05	– 0.05	0.00	– 0.24
11	5.0	0.32	0.27	– 0.05	– 0.05	0.00	– 0.29
12	4.0	0.26	0.27	0.01	0.00	0. 01	– 0.28
13	4.0	0.26	0.27	0.01	0.00	0.01	– 0.26
14	2.6	0.17	0.27	0.10	0.00	0.10	– 0.16
15	2.6	0.17	0.27	0.10	0.00	0.10	– 0.06
16	2.6	0.17	0.27	0.10	0.00	0.10	0.05
17	15.0	0.96	0.27	– 0.69	– 0.69	0.00	– 0.64
18	16.0	1.02	0.27	– 0.75	– 0.75	0.00	–1.40
19	1.2	0.08	0.27	0.19	0.00	0.19	– 1.20
20	0.2	0.01	0.27	0.26	0.00	0.26	– 0.94
21	0.2	0.01	0.27	0.26	0.00	0.26	– 0.69
22	0.2	0.01	0.27	0.26	0.00	0.26	– 0.43
23	0.2	0.01	0.27	0.26	0.00	0.26	– 0.17
24	0.2	0.01	0.27	0.260	0.00	0.26	0.08
TOTAL	100.0	6.40	6.48	0.08	– 3.02	3.10	

Minimum tank volume: 2.68 m^3. Optimum tank volume): 2.77 m^3. Volume selected: 3.50 m^3.

Topographic survey, Abney level
Province: Luang Namtha
District: Nale
Site: Ban Houn
Date: 19/07/98

Station	Distance to ground (m)		Vertical angle (decimal degrees)	Vertical angle (degrees & minutes)	Vertical distance (m)	Elevation (m)	Comments
	between stations	cumulative					
0		0.0				626.0	Catchment
1	19.8	19.8	– 6.67	– 6° 40’	– 2.30	623.7	
2	29.6	49.4	– 6.17	– 6° 10’	– 3.18	620.5	Header tank (HT)
3	22.0	71.4	– 8.17	– 8° 10’	– 3.13	617.4	
4	17.8	89.2	– 7.17	– 7° 10’	– 2.22	615.2	
5	22.5	111.7	– 7.17	– 7° 10’	– 2.81	612.4	
6	22.3	134.0	– 7.00	– 7° 00’	– 2.72	609.7	
7	20.4	154.4	– 0.67	– 0° 40’	– 0.24	609.4	
8	28.1	182.5	– 3.33	– 3° 20’	– 1.63	607.8	
9	23.0	205.5	– 2.67	– 2° 40’	– 1.07	606.7	
10	19.4	224.9	– 1.67	– 1° 40’	– 0.56	606.1	
11	23.6	248.5	– 3.33	– 3° 20’	– 1.37	604.8	
12	24.7	273.5	– 13.17	– 13° 10’	– 5.63	599.1	
13	25.1	298.3	– 19.17	– 19° 10’	– 8.24	590.9	
14	25.3	323.6	– 19.33	– 19° 20’	– 8.38	582.5	
15	19.8	343.4	– 20.17	– 20° 10’	– 6.83	575.1	
16	21.3	364.7	– 18.67	– 18° 40’	– 6.82	568.9	
17	9.1	373.8	– 15.17	– 15° 10’	– 2.38	566.5	
18	22.8	396.6	– 8.67	– 8° 40’	– 3.44	563.1	
19	27.0	423.6	– 18.00	– 18° 00’	– 8.34	554.7	
20	27.8	454.4	– 19.67	– 19° 40’	– 9.36	545.4	
21	30.0	481.4	– 10.33	– 10° 20’	– 5.38	540.0	
22	22.2	503.6	– 8.33	– 8° 20’	– 3.22	536.8	Break-pressure tank (BPT)
23	22.3	525.9	– 8.00	– 8° 00’	– 3.10	533.7	
24	20.2	546.1	– 7.33	– 7° 20’	– 2.58	531.1	
25	25.9	572.0	– 11.17	– 11° 10’	– 5.02	526.1	
26	22.0	594.0	– 18.33	– 18° 20’	– 6.92	519.2	
27	29.3	623.3	– 20.83	– 20° 50’	– 10.42	508.7	
28	28.0	651.3	– 18.67	– 18° 40’	– 8.96	499.8	
29	17.4	668.7	– 19.50	– 19° 30’	– 5.81	494.0	
30	17.5	686.2	– 22.67	– 22° 40’	– 6.74	487.2	
31	24.2	710.4	– 21.67	– 21° 40’	– 8.93	478.3	
32	20.5	730.9	– 19.83	– 19° 50’	– 6.96	471.3	
33	21.2	752.1	– 21.17	– 21° 10’	– 7.65	463.7	
34	30.0	782.1	– 18.33	– 18° 20’	– 9.44	454.2	
35	30.0	812.1	– 1.17	– 1° 10’	– 0.61	453.6	
36	8.0	820.1	– 2.67	– 2° 40’	– 0.37	453.3	Storage tank
37	30.0	850.1	– 2.67	– 2° 40’	– 1.40	451.9	Junction
38	30.0	880.1	– 4.83	– 4° 50’	– 2.53	449.3	
39	6.7	886.8	– 0.83	– 0° 50’	– 0.10	449.2	
40	30.0	916.8	– 1.00	1° 00’	0.52	449.8	
41	11.2	928.0	– 0.50	– 0° 30’	– 0.10	449.7	Tapstand 1 (T1)
42	8.0	68.0	0.00		– 0.37	453.3	Storage tank
43	30.0	98.0	0.00		– 4.20	449.1	
44	30.0	128.0	0.00		– 3.10	446.0	Tapstand 2 (T2)

Head-losses

Station 1	Station 2	Flow (l/s)	Pipe length (m)	Pipe dia (mm)	Friction coefficient (%)	Speed (m/s)	Head-losses (m)	Station altitude 1 (h1)	Station altitude 2 (h2)	Drop (h1 – h2) (m)	Static head 1 Ph1 (m)	Residual head 2 Ph1+h–P (m)	Comments
0	2	0.075	49.4	33/40				626.0	620.5	not under pressure			CAPT - HT
2	22	0.075	454.2	26/32	0.15	0.15	0.68	620.5	536.8	83.7	0.0	83.1	HT - BPT
22	36	0.075	316.5	26/32	0.15	0.15	0.47	536.8	453.3	83.5	0.0	83.04	BPT- STO
36	37	0.5	30.0	33/40	1.3		0.39	453.3	451.9	1.4	0.0	1.01	STO - J
37	41	0.25	77.9	26/32	1.3	0.5	1.01	451.9	449.7	2.2	1.01	2.19	J - T1
43	44	0.25	30.0	26/32	1.3	0.5	0.39	449.1	446.0	3.1	1.01	3.72	J - T2

PE 32 = 878.6 m PE 40 = 79.4 m TOTAL = 958 m

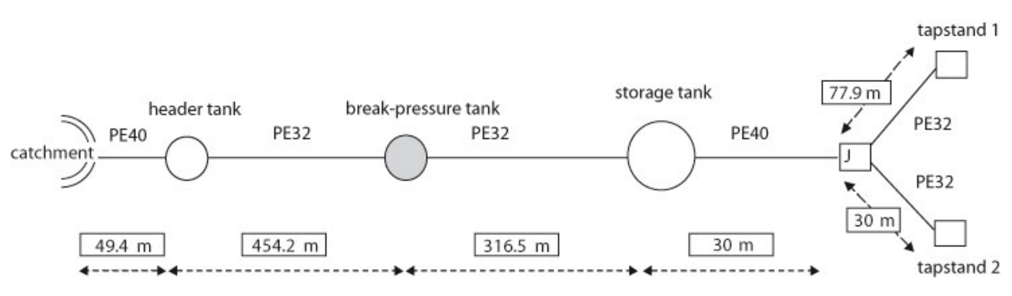


Figure 2: The gravity system.

Head profile

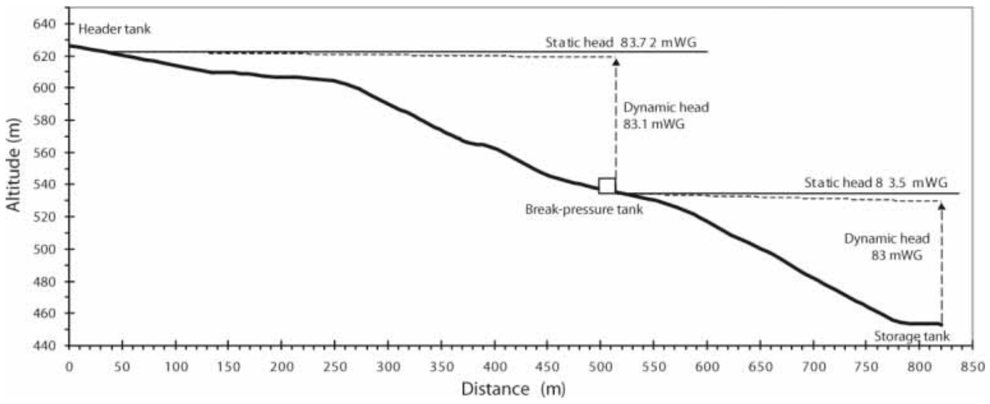


Figure 3: Main supply line.

	Spring		Header tank		Break-pressure tank		Storage tank
Altitude (m)	626.0		620.52		536.8		453.3
Pipe dia (mm)		33/40		26/32		26/32	
Length (m)	0		49.4		503.6		820.1
Flow (l/s)		0.075		0.075		0.075	
Residual head (mWG)	0		0.0		83.1		83.0

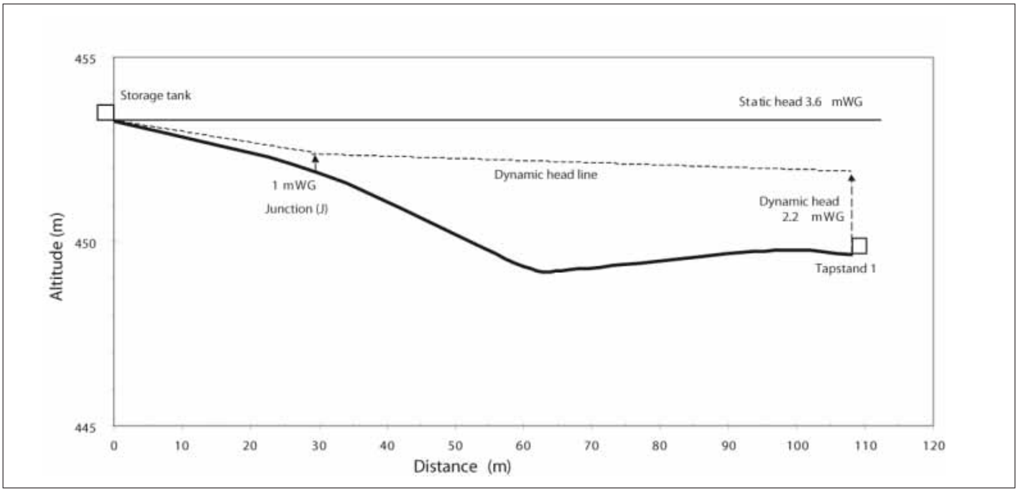


Figure 4: Storage tank to tapstand 1.

	Storage tank		Junction		Tapstand 1
Altitude (m)	453.3		451.9		449.7
Pipe dia (mm)		33/40		26/32	
Length (m)	0		30		107.9
Flow (l/s)		0.5		0.25	
Residual head (mWG)	0.0		1.0		2.2

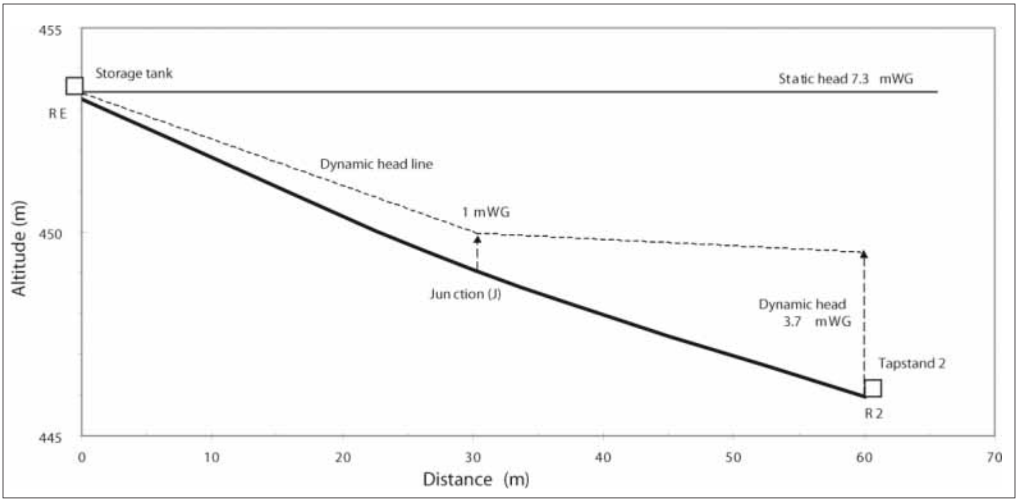


Figure 5: Storage tank to tapstand 2.

	Storage tank		Junction	Tapstand 2
Altitude (m)	453.3		451.9	446.0
Pipe dia (mm)		33/40	26/32	
Length (m)	0		30	60
Flow (l/s)		0.5	0.25	
Residual head (mWG)	0.0		1.0	3.7

Quantities

HT		HT/ VC		HT REINFORCEMENT	
H	1 m	H	0.9 m		
Exterior dia	1.3 m	l	0.8 m	*Side*	
		Wall thickness	0.08 m	6-mm bar	
Wall thickness	0.07 m	Cover thickness	0.08 m	Mesh H	0.12 m
Cover thickness	0.08 m	Slab thickness	0.1 m	Mesh V	0.12 m
Slab thickness	0.15 m	Depth of foundations	0.1 m	Bar H	17.90 m
Depth of the foundations	0.15 m			Bar V	17.90 m
Wall centre circumference	2.15 m				
External area	1.33 m^2	Side-wall area	2.16 m^2	*Cover*	
Internal area	1.06 m^2	Exterior area	0.64 m^2	6-mm bar	
External volume	1.33 m^3			Mesh	0.12 m
Internal volume	1.06 m^3			Bar	22.10 m
Side-wall volume	0.27 m^3	Side-wall volume	0.17 m^3		
Roof volume	0.11 m^3	Roof volume	0.051 m^3	*Slab*	
Slab volume	0.20 m^3	Slab volume	0.064 m^3	6-mm bar	
Internal-wall volume	0.078 m^3			Mesh	0.12 m
Total 350 kg/m^3	0.65 m^3	Total 350 kg/m^3	0.29 m^3	Bar	22.10 m
Foundation volume	0.20 m^3	Foundation volume	0.064 m^3	*VC sides*	
Total 200 kg/m^3	0.20 m^3	Total 200 kg/m^3	0.06 m^3	6-mm bar	
				Mesh H	0.12 m
Cement	269 kg	Cement	114 kg	Mesh V	0.12 m
Total cement + losses	10%			Bar V	18.00 m
i.e. 420 kg	8.4 bags		9 bags		
			0.45 t	*Cover + Slab VC*	
				6-mm bar	
Total reinforcement bar + losses	10%	Weight dia 6	0.21 kg	Mesh	0.12 m
i.e. 29.3 kg	126.8 m			Bar	10.70 m

TANK			Theoretical demand (m^3)	2.68
			Actual demand (m^3)	3.50
			Tank W (m)	2.00
			Tank L (m)	2.00
			Demand H (m)	0.88
			Sedimentation H (m)	0.25
			Aeration H (m)	0.25
			Total H (m)	1.38
Height of tank (m)	1.38	HT		
Height of water (m)	1.13	HW		
Internal width of tank (m)	2.00	LA	Width VC	1.2 LA2
Internal length of tank (m)	2.00	LO	Length VC	1.2 LO2
Volume of tank (m^3)	4.50			
Perimeter (m)	8.24			
Maximum bending moment (kg. m)			REINFORCEMENT BAR CALCULATION	
M_{max} = p x H3 / 6	237.3047			
Minimum side-wall thickness				
e = 2 x rac2 (M_{max}/100)	3.08		Choice	12 cm
				0.12 m
			Binding wire weight	0.025 kg/m
Section of vertical bar for 1 m of side-wall			*Section of horizontal bar for 1 m of side-wall*	
$A_{barV} = M_{max} / (T_{bar} \times z)$	5.33 cm^2		$A_{barH} = 1/3\ A_{barV}$	1.78 cm^2
z = 7/8 x e				
T_{bar}	1 650 kg/cm^2			
Bar V available dia 10 mm			*Bar H available dia 8 mm*	
Section V	0.79 cm^2		Section H	0.50 cm^2
Number of bars V	7.0		Number of bars H	4.0
Mesh V	14.3 cm		Mesh H	25.0 cm
Choice	12 cm		Choice	15 cm

SIDES

Quantity of bar V	10 mm	Quantity of bar H	8 mm
Length	137.50 m	Length	110 m
Weight	81.13 kg	Weight	41.80 kg
Binding wire	70 m		
Weight	1.7 kg		

SLAB

	L	W
Mesh	15 cm	15 cm
Bar dia	8 mm	8 mm
Length	26.67 m	26.67 m
Weight	10.05 kg	10.05 kg
Binding wire		25 m
Weight		0.6 kg

COVER

	L	W
Mesh	15 cm	15 cm
Bar dia	8 mm	8 mm
Length	26.67 m	26.67 m
Weight	10.05 kg	10.05 kg
Binding wire		25 m
Weight		0.6 kg

SLAB, VALVE CHAMBER

	L	W
Mesh	10 cm	10 cm
Bar dia	6 mm	6 mm
Length	14.4 m	14.4 m
Weight	3.05 kg	3.05 kg
Binding wire		3 m
Weight		0.1 kg

COVER, VALVE CHAMBER

	L	W
Mesh	10 cm	10 cm
Bar dia	8 mm	8 mm
Length	14.4 m	14.4 m
Weight	5.43 kg	5.43 kg
Binding wire		24 m
Weight		0.6 kg

Total bar dia 10		138 m
	0.59	81 kg
losses	10%	89 kg
Total bar dia 8		217 m
	0.38	82 kg
losses	10%	91 kg
Total binding wire weight	0.38	3.7 kg
losses	10%	4.0 kg
Total bar dia 6		58 m
	0.21	12 kg
losses	10%	13 kg

Volume (bags)		Cement (kg)	Cement (bags)	Losses (%)	Total
1.4	Sides	490	9.8	10	11
0.7	Slab 1	236	4.7	10	6
0.7	Foundation slab	135	2.7	10	3
0.4	Cover 1	126	2.5	10	3
0.1	Slab 2	50	1.0	10	2
0.1	Foundation slab	29	0.6	10	1
0.1	Cover 2	40	0.8	10	1
			Total		27 bags 1.35 t

SPRING

Low wall

Length	5 m	Mesh	15 cm
Height	0.6 m	Bar dia	8 mm
Thickness	150 mm		
Cement	350 kg/m^3		

					Calculated	10%
Area	3.00 m^2	Bar length	46 m			
Volume	0.45 m^3	Bar weight	18 kg	Cement	0.33 t	0.4 t
Cement	157.5 kg	Binding wire	17 m	Bar weight	53 kg	57.8 kg
Sand	191 l	Binding wire weight	0.4 kg	Binding wire weight	1.2 kg	1.3 kg

Slab

Length	3 m	Mesh	15 cm
Width	2 m	Bar dia	8 mm
Thickness	80 mm		
Cement	350 kg/m^3		
Area	6.00 m^2	Bar length	85 m
Volume	0.43 m^3	Bar weight	34 kg
Cement	168 kg	Binding wire	30 m
Sand	203 l	Binding wire weight	0.8 kg
Gravel	407 l		

TAPSTAND

Slab

Length	2.5 m	Mesh	10 cm
Width	2 m	Bar dia	6 mm
Thickness	100 mm		
Cement	350 kg/m^3		
Area	5.00 m^2	Bar length	105 m
Volume	0.50 m^3	Bar weight	24 kg
Cement	175 kg	Binding wire	55 m
Sand	212 l	Binding wire weight	0.4 kg
Gravel	424 l		

Total for a tapstand

Cement	0.372 t
Cement	8 bags
6-mm bar	145 m
6-mm bar	30.5 kg
Binding wire	0.5 kg

Kerb

Length	9 m	Mesh	10 cm
Width	0.1 m	dia mm bar	6 mm
Thickness	100 mm		
cement	350 kg/m^3		
Area	0.90 m^2	Bar length	27 m
Volume	0.09 m^3	Bar weight	6 kg
Cement	31.5 kg	Binding wire	18 m
Sand	38.12 l	Binding wire weight	0.1 kg
Gravel	76.25 l		

Tap post

Length	1.35 m	Mesh	10 cm
Width	0.15 m	Bar dia	6 mm
Thickness	150 mm		
Cement	350 kg/m^3		
Area	0.20 m^2	Bar length	6 m
Volume	0.03 m^3	Bar weight	1 kg
Cement	10.631 kg	Binding wire	4 m
Sand	12.87 l	Binding wire weight	0.03 kg
Gravel	25.73 l		

Valve chamber

Length	2.6 m	Mesh	10 cm
Width	0.5 m	Bar dia	6 mm
Thickness	80 mm		
Cement	350 kg/m^3		
Area	1.30 m^2	Bar length	29 m
Volume	0.10 m^3	Bar weight	7 kg
Cement	36.40 kg	Binding wire	16 m
Sand	44.05 l	Binding wire weight	0.11 kg
Gravel	88.11 l		

Slab base

Length	2.7 m	Mesh	10 cm
Width	2.2 m	Bar dia	6 mm
Thickness	100 mm		
Cement	200 kg/m^3		
Area	5.94 m^2	Bar length	124 m
Volume	0.59 m^3	Bar weight	28 kg
Cement	118.80 kg	Binding wire	64 m
Sand	274.46 l	Binding wire weight	0.45 kg
Gravel	548.92 l		

Summary of materials and cost of gravity distribution system

Site: Ban Houn
Date: 22nd July 1998

Material and fittings	U	Unit cost (US$)	System components						Total required	Total cost (US$)
			Spring	HT	BPT	Pipeline	Storage tank	Tapstand		
REINFORCEMENT										
Bar dia10	kg	0.65	11				115		126	81.90
Bar dia 6	kg	0.65		25	20		5	35	85	55.25
Bar dia 8	kg	0.65	8				55		63	40.95
1 mm binding wire	kg	1.89							10	18.90
CONSTRUCTION										
Bricks	each	0.04					400		400	16.00
Cement	t	95	0.3	000	000		001	0.6	003	251.75
Bar dia 8	kg	0.5							4	2.00
Bar dia 6	kg	0.5							2	1.00
Cement additive	kg								10	
VALVES										
1/2” ball valve	each	8.82							0	128.58
3/4” Talbot tap	each	16						2	2	32.00
3/4” stop cock	each	44						2	2	88.00
1” adjustable stop cock	each	39			1				1	39.00
1” 1/2 stop cock	each	14.29		1	1		1		3	42.87
Joint for valves	each	1							20	20.00
PVC										
1” 1/2 socket	each	0.26					1		1	0.26
1” 1/2 F adaptor	each	2	1	1	1		1		4	8.00
2” F adaptor	each	6	3	2	2		1		8	48.00
2” M adaptor	each	0.43		2	2		1		5	2.15
90° 2” elbow	each	4.76	2	1	1				4	19.04
1” 1/2 PVC pipe	m	0.63	1.5	1.5	1.5		2.0		6.5	4.10
2” PVC pipe	m	1	12.0	16.0	16.0		12.0		56.0	56.00
PVC Glue	Tin								1	
HDPE										
90° 32 x 32 x 32 tee	each	4.9				1			1	4.90
32 x 32 compression connection	each	2.84				9			9	25.56
40 x 32 reducer	each	4.29				1			1	4.29
HDPE pipe DN 32 NP 10	m	0.36				920			920	331.20
HDPE pipe DN 40 NP 10	m	0.56				80			80	44.80
32 x 1” female adapter	each	1.72					1		1	1.72
32 x 1” male adapter	each	1.7		1	2			2	5	8.50
40 x 1” 1/2 male adapter	each	3	1	1					2	6.00
G.I.										
G.I. 3/4” elbow	each	0.33		1	1		3	12	17	5.61
G.I. 1” elbow	each	1.2			2		2		4	4.80
G.I. 1” 1/2 elbow	each	2.4		2					2	4.80
G.I. 2” elbow	each	1.79		1	1		3		5	8.95
G.I. 3/4” nipple	each	0.6						8	8	4.80
G.I. 1” nipple	each	0.8			4		4		8	6.40
G.I. 1” 1/2 nipple	each	1.5		3	3		3		9	13.50
G.I. 2” nipple	each	2.2		3	3		3		9	19.80
G.I. 3/4” pipe	m	1.92		1.0	1.0		3.5	6.0	11.5	22.08
G.I. 1” pipe	m	2.72			1.0		2.0		3.0	8.16
G.I. 1” 1/2 pipe	m	3.76	0.5	1.5	0.5		0.5		3.0	11.28
G.I. 2” pipe	m	4.7	1.0	2.0	2.0		3.5		8.5	39.95
G.I. 1”-3/4” F-F reducer	each	0.85						2	2	1.70
G.I. 1” 1/2-3/4” M-F reducer	each	1.28		1	1		1		3	3.84
G.I. 1” 1/2 socket	each	2.15	1						1	2.15
G.I. 1” 1/2 tee	each	3.24		1	1		1		3	9.72
G.I. 2” tee	each	4.72		2	1		1		4	18.88
G.I. 3/4” union	each	2					1	4	5	10.00
G.I. 1” union	each	3.22			2		1		3	9.66
G.I. 1” 1/2 union	each	3.96		2	2		2		6	23.76
G.I. 2” union	each	6.8		2	2		2		6	40.80
TOTAL COST										1 653.36

2 Emergency distribution systems from boreholes

2.1 Implementation

On productive boreholes, with an exploitation flow of several m^3/h, and in certain contexts (emergency situations, densely populated or urban areas etc.), a submersible pump may be installed to supply a series of tapstands, instead of using several boreholes equipped with handpumps. Implementation is quicker, and management of one motorised system is simpler than regular maintenance of a series of handpumps. Also, a simple system of water chlorination can be installed at the distribution tank. This is much simpler and more flexible than a treatment system at every handpump or in every house, and is particularly important in regions where cholera is endemic and risks of epidemics are high. Finally, if a management system is established, these mini-systems, often installed under emergency conditions, can be kept and improved to supply an area which is insufficiently supplied by the permanent system for the local population.

The mini-system consists of:

– a 103-113 mm or 112-125 mm borehole (or it is possible to use a 167-180 mm borehole to install a 6” submersible pump for producing large flows);
– a pumping station, equipped with a 4” submersible pump and a generator;
– a storage tank, placed at sufficient height to supply the system by gravity;
– a system for disinfecting the water using chlorine (HTH);
– primary and secondary water-supply lines, supplying the tapstands;
– emergency tapstands with simple installation (to minimise mud).

Obviously, the choice of submersible pump depends on the flow and head required (see Chapter 6), but it is possible to use a submersible pump with standard equipment, linked to a generator if necessary. The storage tank may be temporary or permanent, depending on the context. Emergency tanks made of corrugated sheets and liners, with standard capacities of 45, 70 and 95 m^3, are very quick to assemble, and are suitable for a semi-permanent installation (several years). However, they have to be mounted on the ground. Where a water tower is required, Braithwhaite-type tanks consisting of galvanised steel panels, which can be permanently mounted on top of a metal tower, are preferable. The dimensions and volumes of tanks offered by this supplier range from several dozens to several hundreds of cubic metres.

For simplicity, 2” piping is regarded as standard for small-scale emergency installations (installation of emergency tapstands, pump outlet, standard connections). In more complex systems, which may continue working over several years, it is essential to design the whole system correctly (see Chapter 11A). The pipes are buried, except in extreme emergencies where this is done in a second phase.

The system of water chlorination is either a Dosatron-type dosing pump proportional to the flow, or a simple drip-feed system installed in the tank. (Note: chlorine is consumed by the metal in metallic tanks, see Chapter 12.)

2.2 Human and financial resources

A list of the personnel necessary for the implementation of an emergency mini-system from a borehole is shown in Table 11.XIX.

The cost of a mini-system from a borehole (excluding the borehole itself) supplying two water supply lines of 250 m, and 6 tapstands with 4 taps each, providing the daily supply for 3 200 people is shown in Table 11.XX. The storage tank is a 24 m^3 Braithwhaite tank.

Water is distributed in two periods of 2 h/day, one in the morning and the other in the afternoon. The flow per tap is fixed between 0.15 and 0.2 l/s. The tank is refilled in 4 h, during the evening for the following morning, and from 11:00 to 15:00 for the afternoon distribution.

Table 11.XIX: Personnel required for the installation of an emergency mini-system on a borehole.

Team	Indicative monthly salary (US$)
1 electrician (installing and repairing pumps)	150-200
1 site foreman	150-200
1 person responsible for the station (chosen from within the community)	40-60
2 plumbers (for the duration of the work)	100-150
12 labourers (for the duration of the work)	40-80
2 masons (for the duration of the work)	100-150
1 driver	60-80

Table 11.XX: Cost of a mini-system on a borehole producing 6 m^3/h, which provides 48 m^3/day and covers an emergency demand of 15 l/person/day.

	Unit cost (€)	Quantities	Total cost (€)
Pumping kit	5 000	1	5 000
24 m^3 Braithwhaite storage tank	5 000	1	5 000
Tapstands	270	6	1 620
Dosatron dosing system	1 100	1	1 100
2” water-supply line (m)	6	500	3 000
Distribution accessories kit	2	1 500	3 000
HTH stock (kg)	4	100	400
Bacteriological analysis kit	2 500	1	2 500
TOTAL			21 620

3 Emergency systems from rivers

3.1 Implementation

These emergency water-supply systems involve production and treatment stations using a surface-water source (lake or river). The water is distributed over a branched system via emergency tapstands.

The water-treatment system uses simple technology, and generally consists of flocculation-sedimentation followed by chlorine-based disinfection (Figure 11.38).

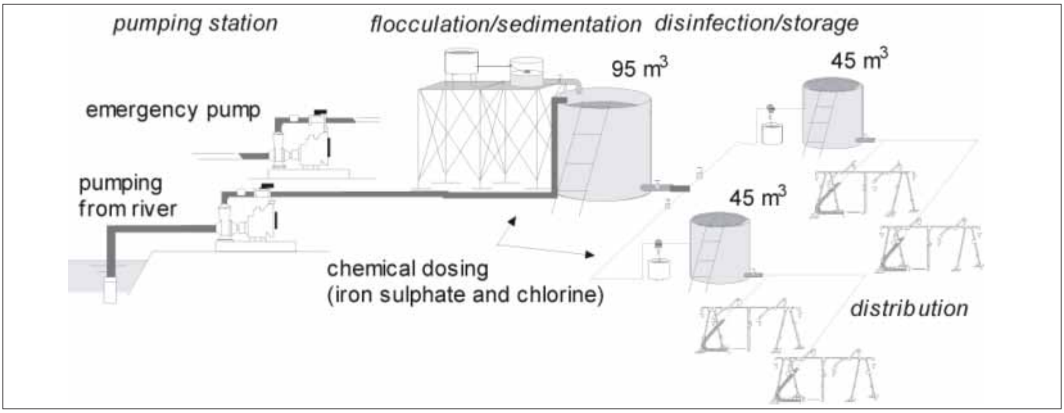


Figure 11.38: General plan of an emergency water-supply system.

3.1.1 PUMPING

Water is pumped directly from the river with a surface motorised pump (simple and cheap), or with a submersible electric dewatering pump. The pump strainer is kept at 1 m below the water surface by a float, or is installed in a pumping well (see Chapter 12). The water intake is located as far upstream as possible in relation to inhabited areas, and given maximum protection from faecal pollution.

3.1.2 FLOCCULATION-SEDIMENTATION

This operation (see Chapter 12) is carried out in the standard manner in rigid tanks, by injecting a flocculant such as aluminium sulphate. Determining the correct dose requires the preparation of a mother solution at 5% and some calibration (jar test) depending on the turbidity of the untreated water.

3.1.3 DISINFECTION AND STORAGE

Once sedimented, the water goes to a tank, where it is disinfected and stored before being distributed via a gravity system.

The tanks used (Oxfam type – see Section 3.1.5) consist of an assembly of corrugated sheets screwed together, with a rubber lining inside. The disinfection-storage tanks must be covered.

The volumes generally used are 45, 70 and 95 m^3.

3.1.4 MOBILE TREATMENT UNIT

The system consists of a 95 m^3 flocculation/sedimentation tank, plus two 45 m^3 tanks for chlorination and storage, for a daily production of 80 or 160 m^3 with two sedimentation cycles. The exact measurement of decantation time enables the number of daily refill-distribution cycles to be determined (test of preliminary decantation time – see Chapter 12). To increase the volume of water treated, simply add one or more modules (a sedimentation tank and two storage tanks) to the treatment chain.

3.1.5 CONSTRUCTING AN OXFAM-TYPE RIGID TANK

These tanks have a range of capacities (Table 11.XXI). The example given involves the installation of an Even-Products 45 m^3 tank, the construction time for which is half a day with a team of six people (Table 11.XXII).

3.1.6 FILTRATION-FLOCCULATION

Filters working under pressure are used, with a 40 micron pore-size, composed of active carbon and a filter medium (gravel, fine sand etc.). The pumped water goes directly under pressure through the filters after the injection of a flocculant, the principle being to trap the flocs in the filters*. The necessary contact time for coagulation occurs in the pipes.

Table 11.XXI: Characteristics of OXFAM-type rigid tanks

Capacity (l)	Height (m)	Number of rows of sheets	Diameter (m)
11,000	2.3	2	2.5
45,000	1.5	2	6.4
70,000	2.3	3	6.4
95,000	3.0	4	6.4

---

* Experiments and studies under development.

Table 11.XXII: Installation of an Even-Products 45 m³ tank.

Clearing site of soil and all coarse particles
Marking 2 concentric circles (radiuses of 3.2 and 3.5 m)
Digging a channel of 5 cm of depth between these circles
Laying the tank in the centre of the circles
Assembling the first row of sheets and sitting them in the channel
Consolidation of the base (interior and exterior) with soil or sand
Mounting the second row of sheets
Applying the protection tape and the PVC capping
Installing the tank liner (the bottom of the tank is the bare ground)
Fixing the liner to the top of the second layer of sheets with clips
Cutting a hole in the liner at the outlet hole, and fitting the flanges
Installing the central pole and supporting ropes connecting this pole to the tank sides
Fitting the tank roof, held tight with elastic strainers

The greatest disadvantage of this treatment system is the rapid blocking of the filters when the water is too turbid (> 100 NTU). It is then necessary to carry out frequent back-washings, which consume a great of water: the flow falls radically from 10 to 5 m^3/h.

One solution consists of locating this filter downstream of a standard in-tank flocculation-sedimentation system (e.g. Bô, ACF Sierra Leone, 1996). The variations in the turbidity of the water leaving the sedimentation tank can therefore be prevented, and the 'residual flocs' can be trapped in the filter.

This system is particularly useful in the case of poor flocculation/sedimentation resulting from sudden variations in the turbidity of the raw water (following storms etc.), and also to shorten the duration of the water treatment allowing two sedimentation cycles per day, thus doubling the production of treated water.

3.2 Example of the Aswha system

Aswha is located in Southern Sudan, some 40 km from the border with Uganda: a system was installed there in 1993 to provide water for a camp of 5 000 displaced people (Figure 11.38).

3.2.1 PUMPING STATION AND DISTRIBUTION SYSTEM

Situated on the banks of the Ashwa river, the pumping station has an Atlanta pump driven by a 2-cylinder Lister-Petter diesel engine. Daily fuel consumption is 15 l for 4 h pumping. The suction head is 2 to 7 m depending on the level of the river. The 15-m suction pipe has a pump strainer and a foot-valve. The buried delivery pipe has a total length of 700 m and consists of 3" PVC pipes, with push-fit joints.

The total difference in height between the pump and the treatment station (Table 11.XXIII) is 35 m. Residual pressure in the pipe is 20 mWG. Flow is 30 m^3/h. Head-losses are estimated at 25 mWG.

Table 11.XXIII: Treatment unit.

Two 95 m³ tanks for sedimentation
Three 45 m³ tanks for chlorination-storage
Foundations of the tanks: 30 cm stone base and concrete slab

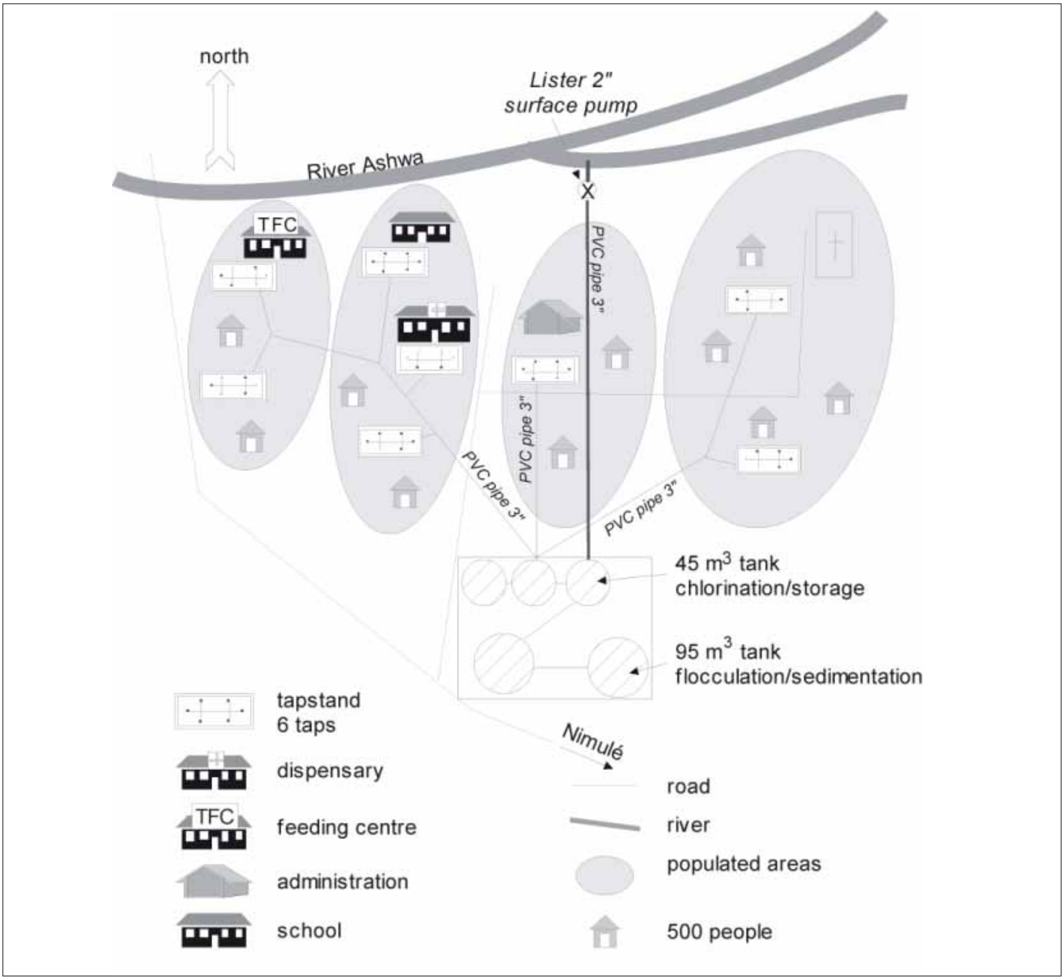


Figure 11.39: Emergency water supply system installed at Ashwa (Southern Sudan, 1993).

3.2.2 OPERATION

Daily production is 120 m^3 of treated water. Tanks are refilled in a single four-hour pumping operation in the afternoon.

The flocculation additive is mixed during the simultaneous refilling of the two 95 m^3 tanks. After a night of sedimentation, the tanks are then emptied into the chlorination-storage tanks (duration: 3 h). Chlorine solution is added to the first tank in the morning. The treated water is then distributed throughout the gravity system in the afternoon.

Table 11.XXIV: Consumables.

Aluminium sulphate	8 kg/day
Calcium hydroxide [$Ca(OH)_2$]	3 kg/day
HTH at 65 %	360 g/day
Phenol red (for checking pH)	12 tablets/week
DPD 1 (free residual chlorine)	12 tablets/week

Table 11.XXV: Treatment results.
T= storage tank.

Parameters	Before treatment	After treatment	In the system
Turbidity (NTU)	80	< 5	
pH	7.8	6.8	7
Residual free chlorine (mg/l)	0	T1: 0.6 – T3: 0.3	0.25
Number of faecal coliforms/100 ml	> 50		0
Average flow per tap (l/s)			0.2

Consumption of treatment products is shown in Table 11.XXIV, and the treatment results in Table 11.XXV.

3.2.3 HUMAN RESOURCES AND STATION MANAGEMENT

Daily planning of the various treatment phases (refill-flocculation-sedimentation-disinfection) and distribution times is carried out by the station personnel (Table 11.XXVI). Daily updated registers record the volume of water treated, the doses of chemicals, depending on turbidity, free residual chlorine and pH before and after flocculation, and the aluminium levels after treatment. Regular bacteriological analyses are used to check water quality before and after treatment.

Table 11.XXVI: Personnel required for a pumping station.

1 head of station, in charge of chemical dosing, analysis and good operations
1 technician, in charge of the maintenance of pumps and equipment
2 unskilled labourers
Guards (day and night)

3.2.4 EQUIPMENT COSTS

The financial resources required for a system such as the one at Ashwa are shown in Table 11.XXVII.

Table 11.XXVII: Cost (€) of the equipment needed for an Ashwa-type coagulation/flocculation treatment module.

	Unit cost	Quantities	Total cost (€)
Diesel pump (30 m^3/h at 45 m)	2 500	1	2 500
95 m^3 rigid tank (sedimentation, without roof)	5 350	1	5 350
45 m^3 rigid tank (chlorination and storage, with roof)	4 300	3	12 900
Tapstands	270	8	2 160
Dosing system, dosing pump	1 100	1	1 100
3” PVC water supply line (m) with fittings	6	700	4 200
3” PVC distribution line (m) with fittings	6	1 500	9 000
Chlorine powder (kg)	4	500	2 000
Aluminium sulphate(kg)	1	250	250
Bacteriological analysis kit	2 000	1	2 000
TOTAL			41 460

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