

Chapter 7

Additional information

7.1 Appendix A – Water supply flowcharts

Figures 7.1 and 7.2 can be used to consider possible water sources for emergencies in cold regions. They deal with the physical and technical aspects of water source selection alone, and should therefore be used in conjunction with Figure 7.3, which also considers the wider issues, including security, socio-political or cultural constraints, and other considerations associated with the use of each potential water source.

OUT IN THE COLD

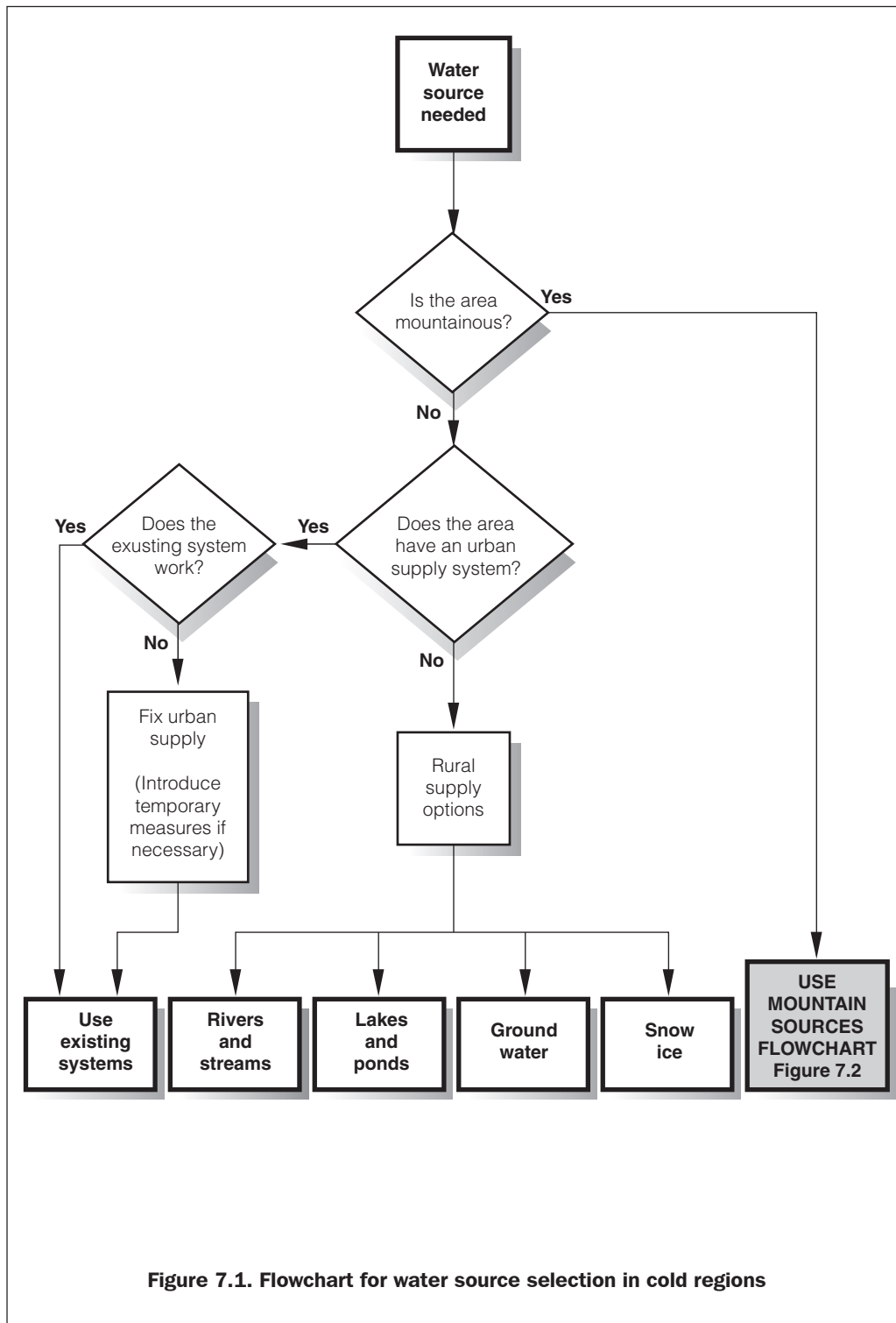
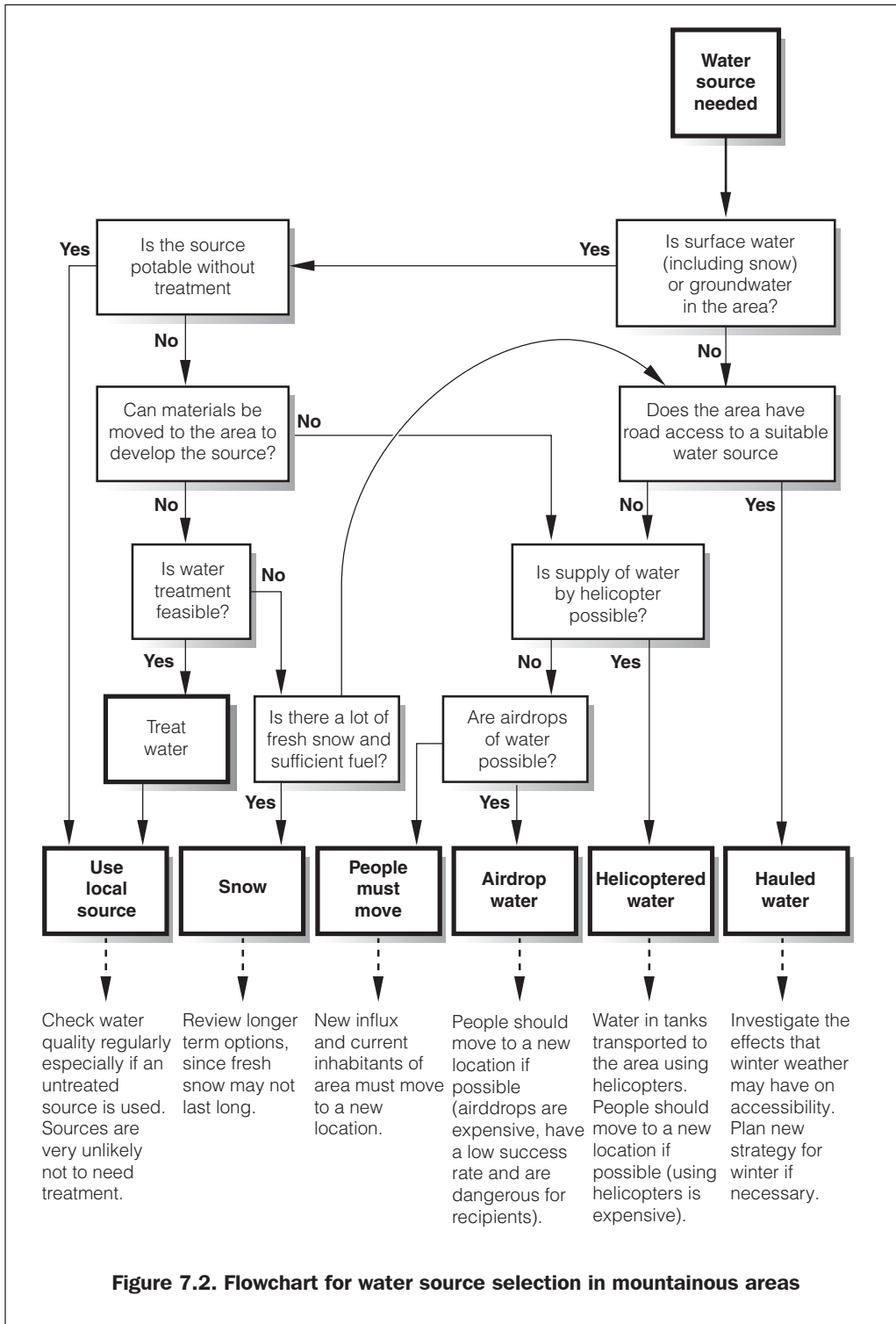


Figure 7.1. Flowchart for water source selection in cold regions

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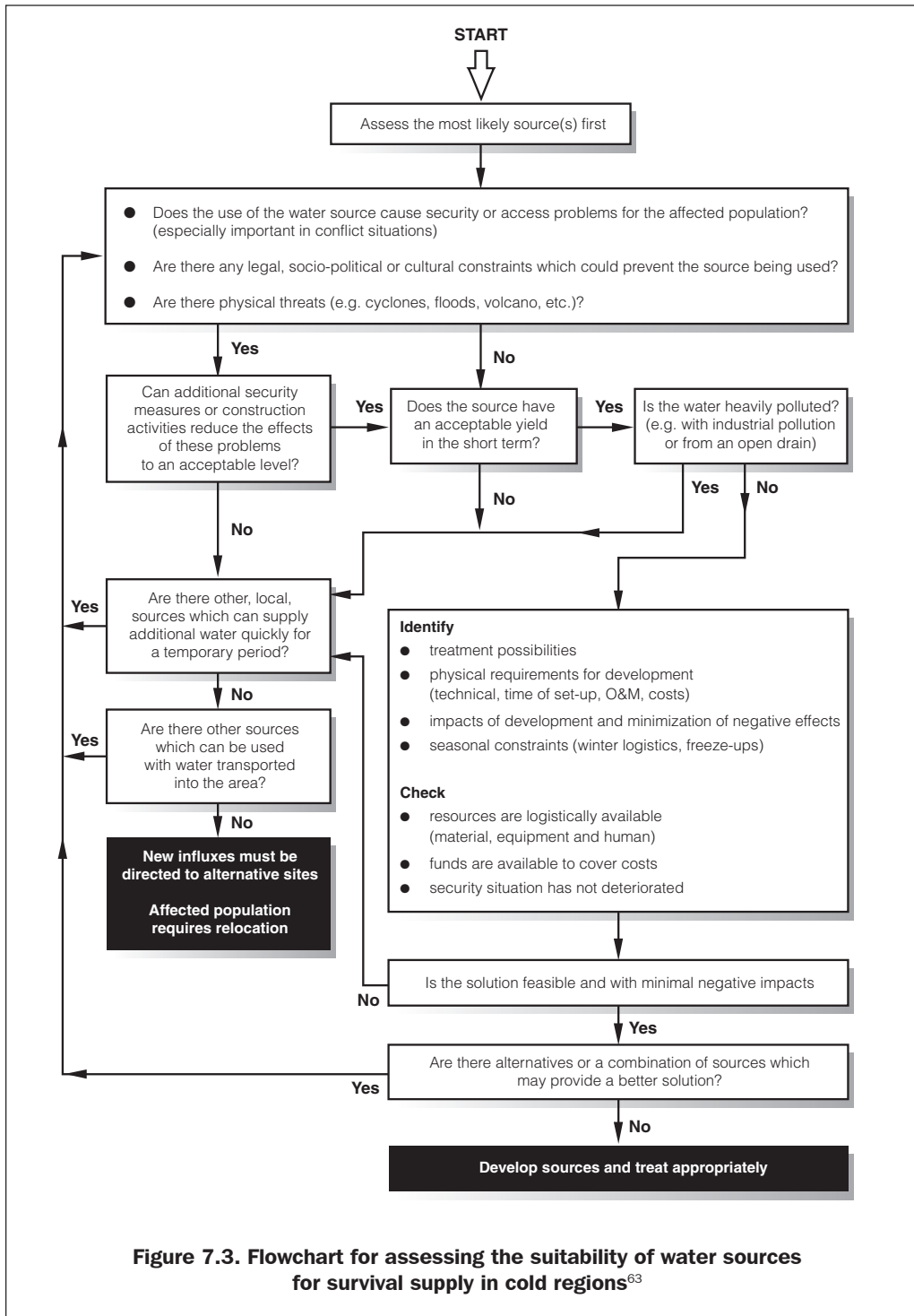


Figure 7.3. Flowchart for assessing the suitability of water sources for survival supply in cold regions⁶³

⁶³ Adapted from House and Reed (1998)

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7.2 Appendix B – Thermal properties and density of materials

Table 7.1. Thermal properties and density of construction materials			
Material	Dry density kg/m³	Specific heat capacity kJ/kg °C	Thermal conductivity W/m °C
Polyurethane foam	32	1.67	0.024
Polystyrene foam	30	1.26	0.036
Rock wool, glass wool	55	0.84	0.040
Wood, plywood, dry	600	2.72	0.17
Wood, fir or pine, dry	500	2.51	0.12
Wood, Oak, dry	700	2.09	0.17
Concrete, insulating mix	200 to 1500		0.07 to 0.60
Concrete	2000	0.67	1.7
Asphalt	2000	1.67	0.72
Wood stave			0.26
Polyethylene, high density (HDPE)	950	2.26	0.36
Polyvinyl chloride, (PVC)	1400	1.05	0.19
Asbestos cement	1900		0.65
Steel	7500	0.50	43
Ductile iron	7500		50
Aluminium	2700	0.88	200
Copper	8800	0.42	375

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Table 7.2. Thermal properties and density of materials found in the environment			
<i>Material</i>	<i>Dry density kg/m³</i>	<i>Specific heat capacity kJ/kg °C</i>	<i>Thermal conductivity W/m °C</i>
Air, no convection (0°C)		1.00	0.024
Air film, outside, 24km/h wind (per air film)			0.86
Air film, inside (per air film)			0.24
Snow, new loose	85	2.09	0.08
Snow, on ground	300	2.09	0.23
Snow, drifted and compacted	500	2.09	0.7
Ice at -40°C	900	2.09	2.66
Ice at 0°C	900	2.09	2.21
Water at 0°C	1000	4.19	0.58
Peat, dry	250	2.09	0.07
Peat, thawed, 80% moisture	250	1.34	0.14
Peat, frozen, 80% ice	250	0.92	1.73
Peat, pressed, moist	1140	1.67	0.70
Clay, dry	1700	0.92	0.9
Clay, thawed, saturated (20%)	1700	1.76	1.6
Clay, frozen, saturated (20%)	1700	1.34	2.1
Sand, dry	2000	0.80	1.1
Sand, thawed, saturated (10%)	2000	1.21	3.2
Sand frozen, saturated (10%)	2000	0.88	4.1
Rock, typical	2500	0.84	2.2

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7.3 Appendix C – Surface pipes, preventing freezing⁶⁴

Table 7.3 shows values of the ‘design times’, t_d , for how much time (in minutes) water in surface laid pipes will take to reach the freezing point (0°C), for different ambient temperatures and with the water starting at different initial temperatures. Design times can be used in two ways:

1. For water that has stopped flowing in a pipe, t_d is the maximum time (minutes) that the water should be allowed to stand with no risk of freezing.
2. For flowing water the maximum length of pipe, L_p , (metres), in which the water will not reach freezing temperatures can be calculated using:

$$L_p = \frac{t_d \times q_w \times 60}{A}$$

Where: L_p = Length of pipe (m)

t_d = Design time (mins)

q_w = Flow rate of water (m^3/sec)

A = Internal cross sectional area of the pipe (m^2)

The data in Table 7.3 can be used to make an estimate of the design time, using interpolation, or the equations which follow can be used to obtain a more accurate figure.

Notes and assumptions

1. The design time values in this section are calculated on a conservative basis. Real-life values of t_d should be slightly greater than the values given here.
2. The average wind speed has been taken as either zero (still air) or 30 km/h for these calculations. As wind speed increases the design times decrease.
3. These figures assume that heat is lost only to the air. Pipes resting on the cold ground will lose heat even more quickly than these design times. Likewise wet pipes will lose heat very quickly.
4. In the calculations pipes are assumed to be relatively thin-walled, i.e. the thickness of the pipe wall is much less than the diameter of the pipe; and the thermal resistance across the water / pipe-wall contact area is assumed to be negligible.

⁶⁴ Pipe products data such as wall thicknesses are taken from manufacturer’s data

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Table 7.3. Design times t_d for water to cool to 0°C from different starting temperatures, for surface laid pipes of different materials and diameters								
Outside temp. (°C)	Design time (minutes) for zero wind speed				Design time (minutes) for wind speed = 30 km/h			
	Initial water temperature (°C)							
	1	2	5	10	1	2	5	10
50 mm (2 inch) MDPE pipe (wall thickness of 4.6 mm, pressure rating 12 bar)								
-1	189	272	377	438	84	122	171	201
-5	38	68	129	187	17	31	59	86
-10	17	33	69	110	8	15	32	51
-15	11	21	46	77	5	10	21	36
-20	8	15	34	59	4	7	16	28
90 mm (3.5 inch) MDPE pipe (wall thickness of 8.2 mm, pressure rating 10 bar)								
-1	404	583	810	945	186	270	381	452
-5	82	147	279	404	39	69	133	195
-10	38	70	149	239	18	34	72	116
-15	23	45	99	168	11	22	48	82
-20	17	32	73	128	8	16	36	63
50 mm (2 inch) PVC pipe (wall thickness of 2.5 mm, pressure rating 9 bar)								
-1	189	272	376	437	84	122	171	200
-5	38	68	129	186	17	31	59	86
-10	17	33	69	110	8	15	32	51
-15	11	21	46	77	5	10	21	36
-20	8	15	34	59	4	7	16	27
100 mm (4 inch) PVC pipe (wall thickness of 4.5mm, pressure rating 9 bar)								
-1	460	663	921	1074	210	306	432	512
-5	94	167	317	459	44	79	151	220
-10	43	80	169	272	20	38	81	132
-15	27	51	113	191	13	25	55	93
-20	19	37	83	145	9	18	41	71
118 mm (DN 100 mm) ductile iron pipe (wall thickness of 9 mm, working pressure rating 40 bar)								
-1	529	757	1039	1195	222	318	437	502
-5	106	188	354	507	44	79	149	213
-10	47	89	187	297	20	37	79	125
-15	29	56	123	207	12	24	52	87
-20	21	40	91	157	9	17	38	66
170 mm (DN 150 mm) ductile iron pipe (wall thickness of 10 mm, working pressure rating 40 bar)								
-1	834	1195	1639	1885	351	502	689	793
-5	167	296	558	799	70	125	235	336
-10	75	140	295	469	32	59	124	197
-15	46	88	195	327	19	37	82	138
-20	33	63	143	248	14	27	60	104

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Equations used to calculate design times⁶⁵

Values of t_d can be calculated using the design equation:

$$t_d = \frac{A \times R \times C \times 1n \left[\frac{T_{wi} - T_a}{T_{w0} - T_a} \right]}{60}$$

Where t_d = Design time (mins)

A = Internal cross sectional area of the pipe (m²)

R = Thermal resistance of pipe (m.°C/W)

C = Specific volumetric heat capacity of water (4,190,000J/m³°C)

T_{wi} = Initial water temperature (°C)

T_a = Ambient air temperature (°C)

T_{w0} = Water freezing temperature (0°C)

Values in the design equation are derived from:

$$R = R_p + R_{af}$$

R_p = Thermal resistance of pipe material (m°C/W)

R_{af} = Thermal resistance of pipe / air interface (m°C/W)

$$R_p = \frac{r_p - r_w}{(r_p + r_w) \times \pi \times k_p}$$

⁶⁵ Equations from Smith (ed., 1996)

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r_p = Outer radius of pipe (m)

r_w = Inner radius of pipe (m)

k_p = Thermal conductivity of pipe material (W/m°C)

$$R_{af} = \frac{1}{2 \times \pi \times r_p \times \mu_a}$$

μ_a = Convection heat transfer coefficient at pipe / air interface (W/m²°C)

$$\mu_a = N \times W \times \left(\frac{T_{wi} - T_a}{r_p} \right)^{0.25}$$

N = Constant (1.12 W/m^{7/4}°C^{5/4})

$$W = \sqrt{0.56 \times v_a + 1}$$

v_a = Wind speed (m/s)

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7.4 Appendix D – Addresses

Table 7.4. Manufacturers and suppliers		
Manufacturer	Address	Products/service
Evenproducts Ltd	The Oxstalls, Evesham, Worcestershire, WR11 4TS, UK Tel: (44) 1386 41212 Fax: (44) 1386 765404 Email: bob@evenproducts.com Website: www.evenproducts.com	Oxfam-type water tanks and tank roofs in PVC and galvanised steel
Stella-Meta	Laverstoke Mill, Whitchurch, Hants., RG28 7NR, UK Tel: (44) 1256 895959 Fax: (44) 1256 892074 Email: marketing@pcimem.com Website: www.stella-meta.com	Portable water treatment units (British army supplier)
SDL Technologies	4 Habosem St., PO Box 6699, Ashdod 77166, Israel Tel: (972) 8 856 4314 Fax: (972) 8 852 4289 Email: sdl@netvision.net.il Website: www.sdl-tech.com	Portable water treatment units (Israeli) 5 to 200m ³ /hr container units
Clearwater PLC	Clearwater House, Clearwater Industrial Park, Bristol Road, Bridgewater, Somerset, TA6 4AW, UK Tel: (44) 990 275252 Fax: (44) 1498 880285	Wastewater treatment (RBC) units
Klargester Environmental Ltd	College Road, Aston Clinton, Aylesbury, Bucks., HP22 5EW, UK Tel: (44) 1296 633 000 Fax: (44) 1296 631 770 Email: sales@klargestester.co.uk Website: www.klargester.co.uk	RBC units, also portable version in container units
Urecon Ltd	1800 Ave. Bedard, St. Lazare-de-Vaudreuil, Quebec, J7T 2G4, Canada Tel: (1) 450 455 0961 Fax: (1) 450 455 0350 Email: urecon@urecon.com Website: www.urecon.com	Pre-insulated HDPE pipes

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Table 7.5. Agencies and organisations		
Name	Address	Function or service
REDR	1 Great George Street, London, UK Tel: (44) 20 7233 3116 Fax: (44) 20 7222 0564 Website: www.redr.org	Register of engineers available for disaster relief work
UNHCR	Centre William Rappard, 154 Rue de Lausanne, 1202 Geneva 21, Switzerland Tel: (41) 22 739 8111 Fax: (41) 22 731 9546 Website: www.unhcr.ch	UN commission concerned with the well-being of refugees. Often acts as a co-ordinating organisation in the field.
IFRC	17 Chemin des Crets, PO Box 372, 1211 Geneva 19, Switzerland Tel: (41) 22 730 4222 Fax: (41) 22 730 0395 Website: www.ifrc.org	International Federation of Red Cross and Crescent Societies International humanitarian organisation
ICRC	19 Avenue de la Paix, CH 1202, Geneva, Switzerland Tel: (41) 22 734 6001 Fax: (41) 22 733 2057 Website: www.icrc.org	International humanitarian/aid organisation
MSF France	8 Rue Saint-Sabin, 75544 Paris Cedex 11, France Tel: (33) 1 40 21 29 29 Fax: (33) 1 48 06 68 68 Website: www.msf.org	International aid organisation
Oxfam (GB)	274 Banbury Road, Oxford, OX2 7DZ, UK Tel: (44) 1865 311 311 Fax: (44) 1865 312 600 Website: oxfam.org.uk	International aid and development organisation
Shelter project.org	Website: www.shelterproject.org	Emergency shelter research group

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