Techneau, 07.
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Ultrafiltration with pre-coagulation in drinking water production

Survey on operational strategies

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Colophon

Title
Ultrafiltration with pre-coagulation
Survey on operational strategies

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Contents

1 Introduction

In recent years the use of ultrafiltration has rapidly increased in the field of drinking water production. Stricter drinking water regulations and requirements for the treatment are creating a rapid growth in use of membranes to treat more challenging water sources [Pressdee, et al., 2006]. The filtration with porous membranes is a young, but worldwide quickly expanding technology in the drinking water production. Fig. 1-1 illustrates the almost exponential growth of application of porous membranes in drinking water production [Gimbel, 2003].

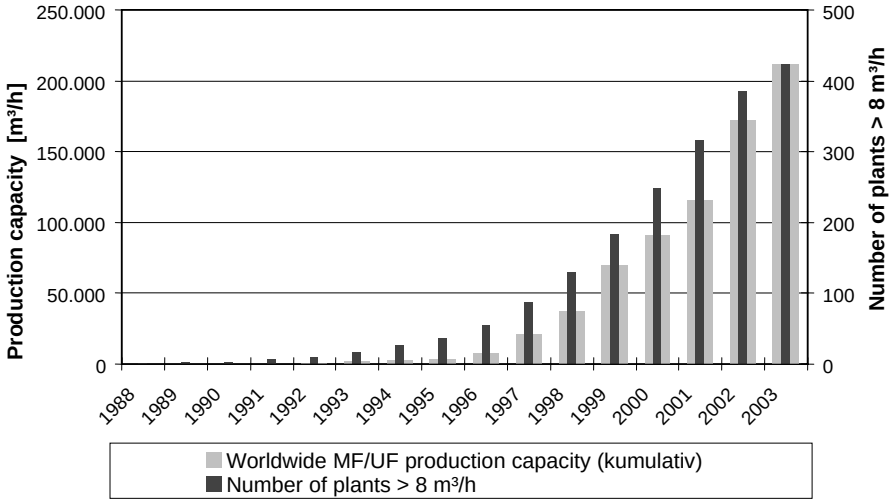

Fig. 1-1: Development of MF/UF plants worldwide since 1988; not comprehensive [Gimbel, 2003]

In Germany more than 91 UF plants are in use for the production of drinking water. Most of them have a production capacity below 250 m³/h. In 2005 Germans largest UF plant with a production capacity of 6,000 m³/h started operation. Figure 1-2 shows an overview about installed UF plants in the field of drinking water production in Germany.

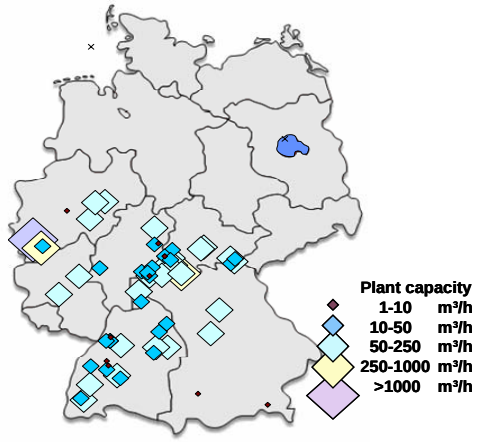

Fig. 1-2: Overview about installed UF plants in Germany [Lipp, 2006]

The main advantage of ultrafiltration is its function as a safe barrier for pathogens even at highly contaminated feed water conditions. Further treatment aims are the removal of natural organic matter (NOM), dissolved organic matter (DOC) and other components. In principle the integration of ultrafiltration into water treatment systems can occur at different places of the process. The most obvious possibility is to install ultrafiltration at the end of the conventional process as an extension of existing water facilities. Due to a very good feed water quality, operational costs for ultrafiltration are low at this place. Another possibility to apply ultrafiltration into the conventional water treatment process is after the pre-treatment step (coagulation step) [Melin et al., 2003]. An economically interesting possibility is the application of membrane filtration to treat filter backwash water produced by flushing of conventional filters (concept 3 in figure 1-3) or membrane filters. Water facilities spend up to 10% of the water fed into the network for filter backwash. Treating filter back wash water is especially interesting for facilities, where

- disposal cost can be minimised by recycling the filter backwash water
- raw water resources are limited and the reuse of the processed filter wash water as raw water results in a more efficient utilisation of the plant capacity.

The reuse of the processed filter backwash water in the process of drinking water processing today requires a safe removal of pathogens. Membrane technology offers a feasible option while conventional processes have not proofed successful [Melin, et al., 2003].

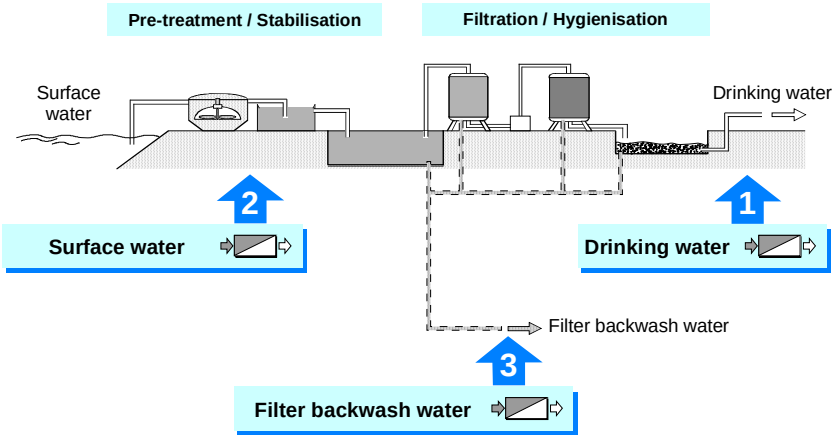

Fig. 1-3: Integration of UF in into the water treatment process [Melin, et al., 2003]

A common pre-treatment process step for ultrafiltration in the field of drinking water production is coagulation. The main objective of coagulation process is to aggregate small water ingredients to larger ones. In water treatment coagulation serves primarily to reduce turbidity and natural organic matter (NOM). Further tasks are the removal of pollutions, which are added on suspended matter (organic matter, trace compounds), the removal of microor-

ganism (bacteria, viruses or protozoans) and the removal of dissolved organic and inorganic matter. The separation of the coagulation flocs can occur by (membrane) filtration [Gimbel, et al., 2004].
Although this technology is now applied in an increasing number of installations, there is still room for improvement with respect to operational issues. The main goal of this survey is to get in-depth information on operational strategies of existing ultrafiltration water treatment plants with and without the use of pre-coagulation. On this basis operational recommendations shall be developed.

Within this survey a questionnaire has been developed, which was sent to the operators of UF water treatment plants (see appendix). In addition existing reports about operational strategies of UF in the field of drinking water production were evaluated and integrated into this survey. On behalf of the DVGW (Deutsche Vereinigung des Gas- und Wasserfaches e.V.) the Water Technology Center (TZW) in Karlsruhe/Germany is organising a survey about operational experiences of UF drinking water plants in Germany as well. This report will be available presently.

The authors of the present report would like to acknowledge Veolia Water, who forwarded the questionnaires to their customers.

2 Case Studies

2.1 Ultrafiltation WTP Roetgen (Germany)

2.1.1 General Information

In Roetgen, German largest UF plants started operation in 2005. The plant has a treatment capacity of 144,000 m³/d for drinking water and a capacity of 15,122 m³/d for the treatment of the backwash water [Dautzenberg, et al., 2005].

Reservoir water treatment	
Site Location	Roetgen (Germany)
Start of operation	2005
Total Design Capacity	144,000 m³/d
Raw water source	reservoir
Backwash water treatment	
Site Location	Roetgen (Germany)
Start of operation	2005
Total Design Capacity	15,122 m³/d
Raw water source	Backwash water

Reference:: [Dautzenberg, et al., 2005]

2.1.2 Process flow diagram

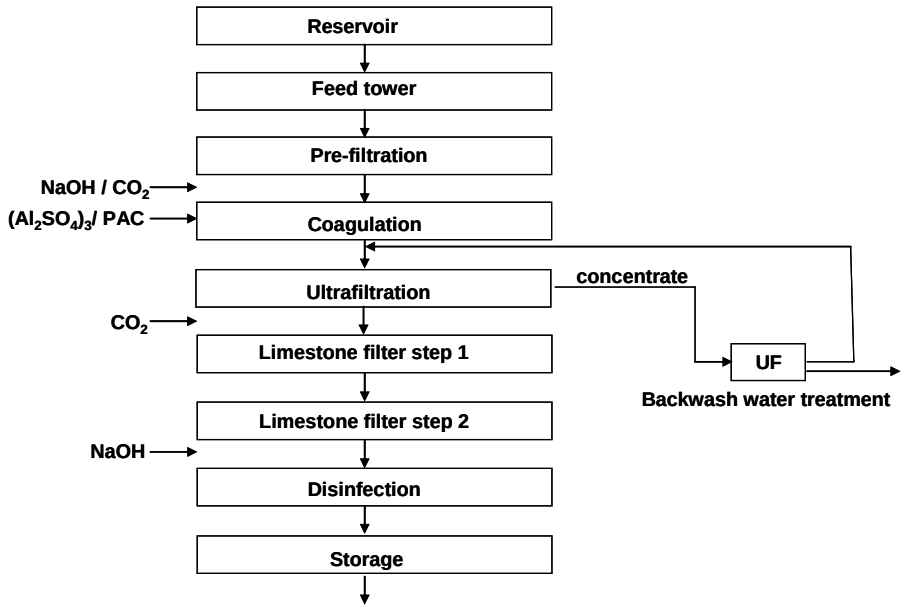

Fig. 2-1: Process flow chart of the Roetgen WTP [Dautzenberg, 2006]

2.1.3 *Operational strategies*

Reservoir treatment		
Coagulation		
Coagulant		$Al_2(SO_4))_3$/PAC
Coagulant concentration	mg/L	n.a.
Membrane filtration (reservoir water treatment)		
Membrane type		Norit X-Flow
Total membrane surface area	m^2	70,000
Filtration flux	L/ m^2 h	60
TMP	bar	0.13
Permeability (at 20°C)	L/ m^2 h bar	450
Total Recovery (inc. backwash water treatment)	%	>99
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	n.a.
Back flushing period	sec	n.a.
Back flushing interval	min	60 - 70
Chemical enhanced backwash		
Cleaning agent		NaOH Acid
pH-value	-	>12 (NaOH) <2,2 (Acid)
Cleaning interval	h	24
Backwash water treatment		
Membrane filtration (backwash water treatment)		
Membrane type		INGE
Total membrane surface area	m^2	7,000
Filtration flux	L/ m^2 h	65
TMP	[bar]	0.3
Permeability (at 20°C)	L/ m^2 h bar	250
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	n.a.
Back flushing period	sec	n.a.
Back flushing interval	min	25
Chemical enhanced backwash		
Cleaning agent		NaOH Acid
Cleaning interval	h	48

Reference: [Dautzenberg, 2006], [Holy, et al., 2006]

2.1.4 *Water qualities*

Not available

2.2 Clay Lane WTP (United Kingdom)

2.2.1 *General Information*

In Clay Lane (UK) UF membranes were integrated into the existing WTP in 2001. The WTP has a design capacity of 160,000 m^3/d for the drinking water production and 5,000 m^3/d for the treatment of backwash water [Pressdee, et al., 2006].

Treatment of bank filtrate (primary UF)	
Site Location	Clay Lane (UK)
Start of operation	2001
Total Design Capacity	160,000 m^3/d
Raw water source	Groundwater under the influence of a surface water
Backwash water treatment (secondary UF)	
Site Location	Clay Lane (UK)
Start of operation	2001
Total Design Capacity	5,000 m^3/d
Raw water source	Backwash water

Reference:: [Pressdee, et al., 2006]

2.2.2 *Process flow diagram*

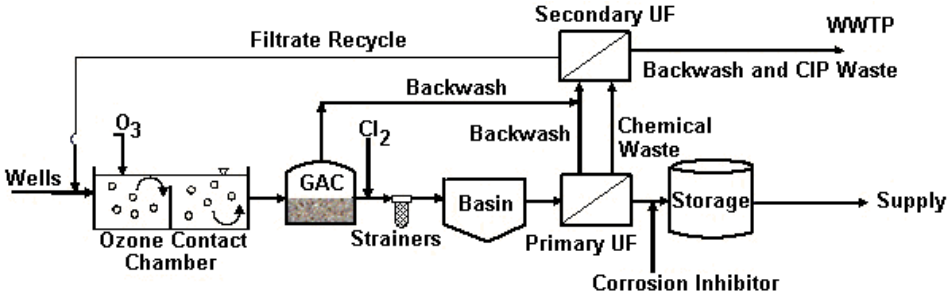

*Fig. 2-2: Process flow chart of the Clay Lane WTP [*Pressdee, et al., 2006*]*

2.2.3 *Operational strategies*

Treatment of bank filtrate (primary UF)	
Pre-treatment	
Pre-treatment option	Ozone / GAC-filter
Membrane filtration (raw water treatment)	
Membrane type	Norit X-Flow

Filtration flux	L/ m²h	124
TMP	bar	0.4 – 0.8
Recovery	%	>99
Hydraulical cleaning		
Back flushing period	sec	50
Back flushing interval	min	40 – 150
Chemical enhanced backwash		
Cleaning agent		NaOH Hydrochloric acid
pH-value		12 (NaOH) 2 (Hydrochloric acid)
Cleaning interval	min	10 - 40
Cleaning in place (CIP)		
Cleaning agent		Citric acid

Reference:: [Pressdee, et al., 2006]

2.2.4 Water qualities

Not available

2.3 Inverness WTP (United Kingdom)

2.3.1 General Information

In Inverness (UK) the UF-WTP started operation in 2002. The plant has a treatment capacity of 34,000 m³/d for the production of drinking water. The backwash water of the drinking water UF-step is treated by second UF-step [Pressdee, et al., 2006].

Lake water treatment (primary UF)	
Site Location	Inverness (UK)
Start of operation	2002
Total Design Capacity	34,000 m³/d
Raw water source	Lake water
Backwash water treatment (secondary UF)	
Site Location	Inverness (UK
Start of operation	2002
Raw water source	Backwash water

Reference: [Pressdee, et al., 2006]

2.3.2 *Process flow diagram*

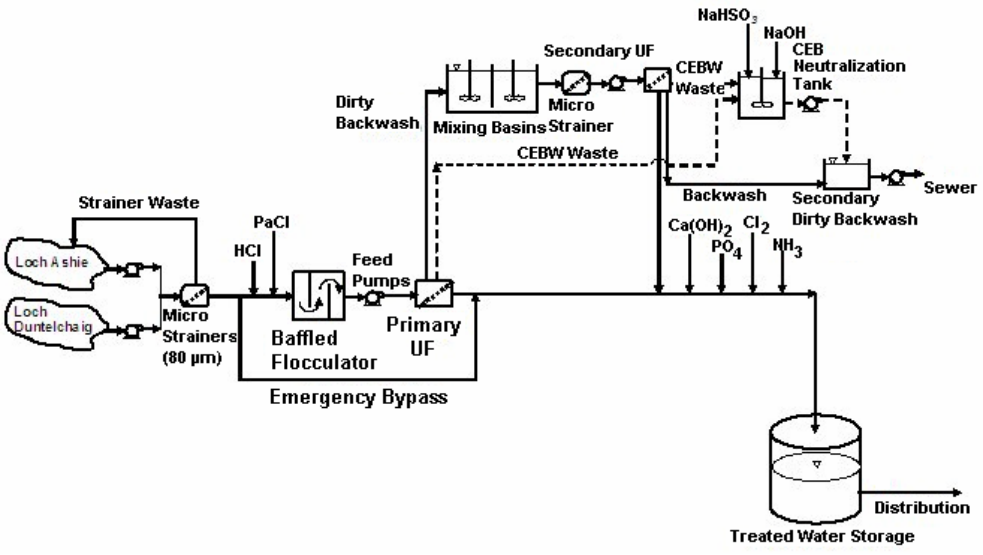

*Fig. 2-3: Process flow chart of the Inverness WTP [*Pressdee, et al., 2006*]*

2.3.3 *Operational strategies*

Lake water treatment		
Coagulation		
Coagulant		PACl
Coagulant concentration	mg/L	n.a.
pH-value		6.7
Membrane filtration (lake water treatment)		
Membrane type		Norit X-Flow
Total membrane surface area	m^2	20,580
Filtration flux	L/ m^2 h	69
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	250
Back flushing period	sec	45
Back flushing interval	min	40
Chemical enhanced backwash		
Cleaning agent		NaOH Hydrochloric
pH-value	mg/L mg/L mg/L	200 (Hydrochloric acid) 400 (NaOH) 800 (Hydrochloric acid)
Cleaning interval		After 109 backwashes

Backwash water treatment		
Membrane filtration (backwash water treatment)		
Membrane type		Norit X-Flow
Tot. membrane surface area	m^2	3,360
Filtration flux	L/ m^2 h	42,8
Recovery	%	90
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	250
Back flushing period	sec	45
Back flushing interval	min	40
Chemical enhanced backwash		
Cleaning agent		NaOH Hydrochloric 200 (Hydrochloric acid) 400 (NaOH) 800 (Hydrochloric acid)
Cleaning interval		After 109 backwashes

Source: [Pressdee, et al., 2006]

2.3.4 Water qualities

Lake water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	7.1	8.9	7.6	n.a.	n.a.	n.a.
Alkalinity as $CaCO_3$	mg/L	n.a.	n.a.	17.1	n.a.	n.a.	n.a.
Hardness as $CaCO_3$	mg/L	n.a.	n.a.	7.8	n.a.	n.a.	n.a.
Temperature	°C	3	17.2	10.1	n.a.	n.a.	n.a.
Turbidity	NTU	<0.06	0.73	0.36	n.a.	n.a.	n.a.
Total organic carbon	mg/L	n.a.	n.a.	2.4	n.a.	n.a.	n.a.
Colour	(Hazan)	3	9	5.8	n.a.	n.a.	n.a.
Ammonia	mg/L	<0.02	0.03	<0.021	n.a.	n.a.	n.a.
Nitrate	mg/L	<0.3	1.0	<0.65	n.a.	n.a.	n.a.
Chloride	mg/L	n.a.	n.a.	7.6	n.a.	n.a.	n.a.
Sulphate	mg/L	n.a.	n.a.	3.5	n.a.	n.a.	n.a.
Iron (Fe^{3+})	mg/L	0.011	0.148	0.041	n.a.	n.a.	n.a.
Manganese	mg/L	0.001	0.013	0.005	n.a.	n.a.	n.a.
E. Coli	No./L	0	0	n.a.	n.a.	n.a.	n.a.
Total Coliforms	No./L	0	1	n.a.	n.a.	n.a.	n.a.

Reference:: [Pressdee, et al., 2006]

2.4 Choa Chu King WTP (Singapore)

2.4.1 General Information

In Choa Chu Kang (Singapore) UF membranes will be integrated into the existing WTP in 2006 - 2007. The WTP will have a design capacity of 182,000 m^3/d for the drinking water production [Pressdee, et al., 2006].

Reservoir water treatment	
Site Location	Choa Chu King
Status	Construction in 2006 - 2007
Total Design Capacity	182,000 m^3/d
Raw water source	Reservoir

Reference: [Pressdee, et al., 2006]

2.4.2 *Process flow diagram*

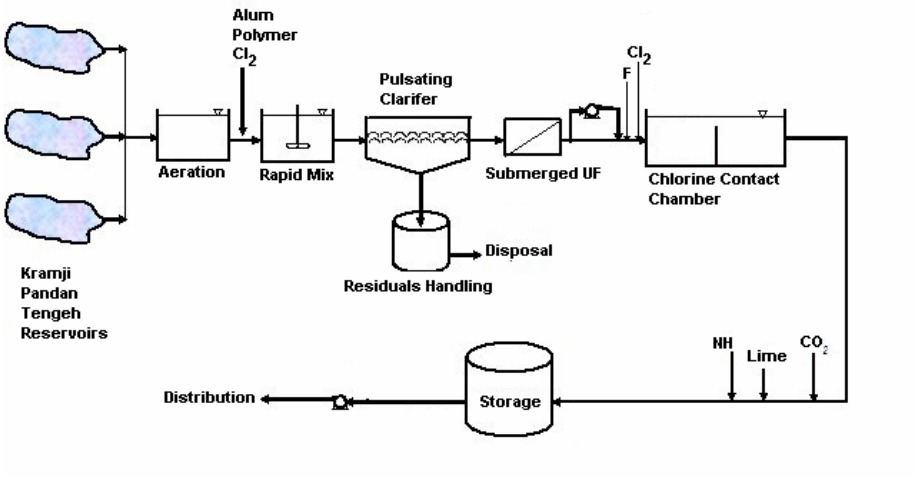

*Fig. 2-4: Process flow chart of the Choa Chu King WTP [*Pressdee, et al., 2006*]*

2.4.3 *Operational strategies*

Reservoir water treatment		
Coagulation		
Coagulant		Alum / polymer
Coagulant concentration	mg/L	n.a.
Other pre-treatment option		Clarification
Membrane filtration (reservoir water treatment)		
Membrane type		Zenon 1000
Module System		Submerged
Tot. membrane surface area	m^2	13,950
Filtration flux	$L/ m^2 h$	68
Recovery	%	>95%
Hydraulical cleaning (pilot testing)		
Back flushing period	sec	30
Back flushing interval	min	20

Reference: [Pressdee, et al., 2006]

2.4.4 *Water qualities*

Not available

2.5 Ennerdale WTP (United Kingdom)

2.5.1 General Information

Since 1999 the WTP in Ennerdale uses UF membranes for the drinking water production. The WTP has a treatment capacity of 59,000 m³/d for the production of drinking water. The backwash water of the drinking water UF-step is treated by a second UF-step [Pressdee, et al., 2006].

Lake water treatment (primary UF)	
Site Location	Ennerdale, UK
Start of operation	1999
Total Design Capacity	59,000 m³/d
Raw water source	Lake water
Backwash water treatment (secondary UF)	
Site Location	Ennerdale, UK
Start of operation	1999
Raw water source	Backwash water

Reference: [Pressdee, et al., 2006]

2.5.2 Process flow diagram

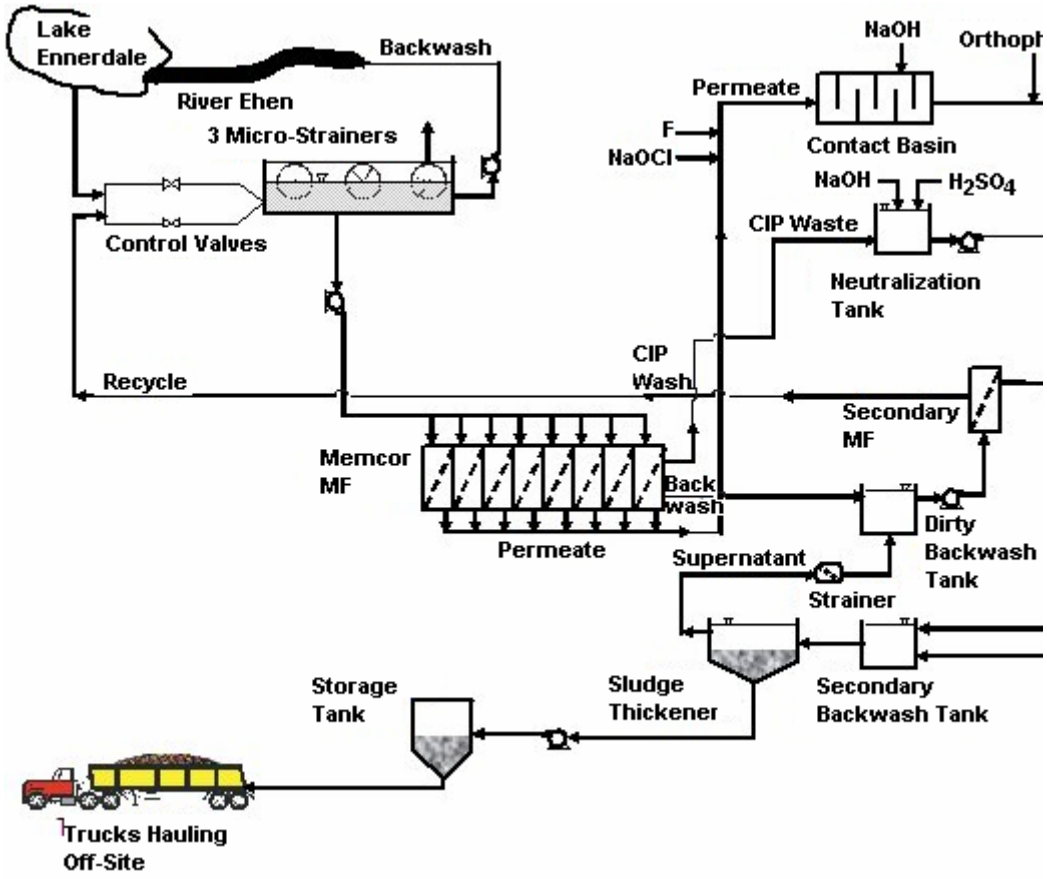

Fig. 2-5: Process flow chart of the Ennerdale WTP [Pressdee, et al., 2006]

2.5.3 *Operational strategies*

Lake water treatment		
Pre-treatment		
Pre-treatment option		Micro-Strainers
Membrane filtration (lake water treatment)		
Membrane type		Memcor CFM-9010 C
Tot. membrane surface area	m^2	n.a.
Filtration flux	L/ m^2 h	160
TMP	bar	2
Hydraulical cleaning		
Back flushing interval	min	60
Cleaning in place (CIP)		
Cleaning agent		NaOH
Concentration	%	2
Temperature	°C	40
Cleaning interval		Every 10 days
residence time	h	3
Cleaning agent		Sulfuric acid
pH-value		1.5
Cleaning interval		Every 3 month
Backwash water treatment		
Membrane filtration (backwash water treatment)		
Membrane type		Memcor CFM-9010 C
Tot. membrane surface area	m^2	n.a.
Filtration flux	L/ m^2 h	62 - 100
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	n.a.
Back flushing period	sec	n.a.
Back flushing interval	min	30

Reference: [Pressdee, et al., 2006]

2.5.4 *Water qualities*

Not available

2.6 San Patrico WTP (USA)

2.6.1 *General Information*

Since 2000 the WTP in San Patricio uses MF membranes for the drinking water production. The WTP has a treatment capacity of 30,000 m^3/d for the production of drinking water [Pressdee, et al., 2006].

Reservoir water treatment	
Site Location	San Patricio, USA
Start of operation	2000
Total Design Capacity	30,000 m^3/d
Raw water source	Reservoir

Reference: [Pressdee, et al., 2006]

2.6.2 Process flow diagram

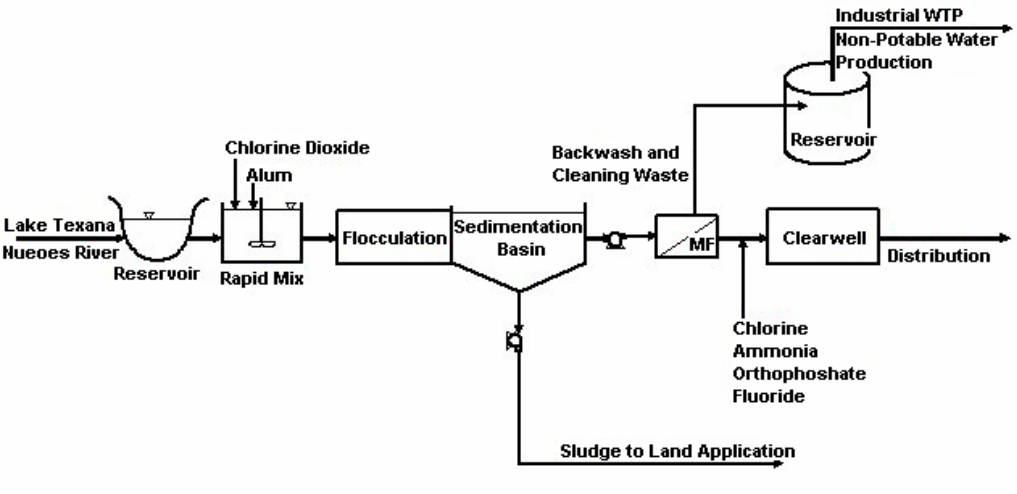

Fig. 2-6: Process flow chart of the San Patricio WTP [Pressdee, et al., 2006]

2.6.3 Operational strategies

Reservoir water treatment		
Coagulation chemicals		
Coagulant		Alum
Coagulant concentration	mg/L	40 - 100
Rapid mix		
Number of basins	-	2
Flow rate per basin	m^3/d	15,000
Detention time	sec	27
Mixing intensity	L/sec	615
Mixer type	-	Mechanical mixer
Coagulation/Flocculation		
Number of basins	-	4
Flow rate (each)	m^3/d	7,600
Detention time	min	47
Flocculator mechanism	-	Walking beam
Velocity gradient	L/sec at 70°F	60
Max. paddle speed	fps	1.6

Sedimentation basins		
Number of basins	-	4
Flow rate (each)	m^3/d	7,600
Detention time	h	4.3
Membrane filtration		
Membrane type		Pall MF (Microca USV-6203)
Module system		Hollow fibre
Total membrane surface area	m^2	15,000
Filtration flux	L/ m^2 h	99
Permeability (at 20°C)	L/ m^2 h bar	n.a.
Recovery	%	94 - 96
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	n.a.
Back flushing period	sec	45
Back flushing interval	min	n.a.
Chemical enhanced backwash		
Cleaning agent		Chlorine
Concentration	mg/L	30
residence time	sec	45
Cleaning in place (CIP)		
Cleaning agent		Caustic solution
Concentration	%	25
Temperature	°C	
Cleaning interval		Every 6 months
residence time	min	60
Cleaning agent		Citric solution
Concentration	%	2
Cleaning interval		Every 6 months
residence time	min	60

Reference: [Pressdee, et al., 2006]

2.6.4 Water qualities

Reservoir water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
Alkalinity as $CaCO_3$	mg/L	100	200	n.a.	n.a.	n.a.	n.a.
Hardness as $CaCO_3$	mg/L	150	250	n.a.	n.a.	n.a.	n.a.
Temperature	°C	10	27	n.a.	n.a.	n.a.	n.a.
Turbidity	NTU	20	200	n.a.	n.a.	n.a.	n.a.
Total organic carbon	mg/L	5	8	n.a.	n.a.	n.a.	n.a.

Reference: [Pressdee, et al., 2006]

2.7 Chaparral WTP (USA)

2.7.1 General information

In Chaparral (USA) the UF-WTP started operation in 2005. The plant has a treatment capacity of 114,000 m^3/d for drinking water production [Pressdee, et al., 2006].

Surface water treatment	
Site Location	Chaparrel, USA
Start of operation	2005
Total Design Capacity	114,000 m^3/d
Raw water source	Surface water (canal)

Reference: [Pressdee, et al., 2006]

2.7.2 Process flow diagram

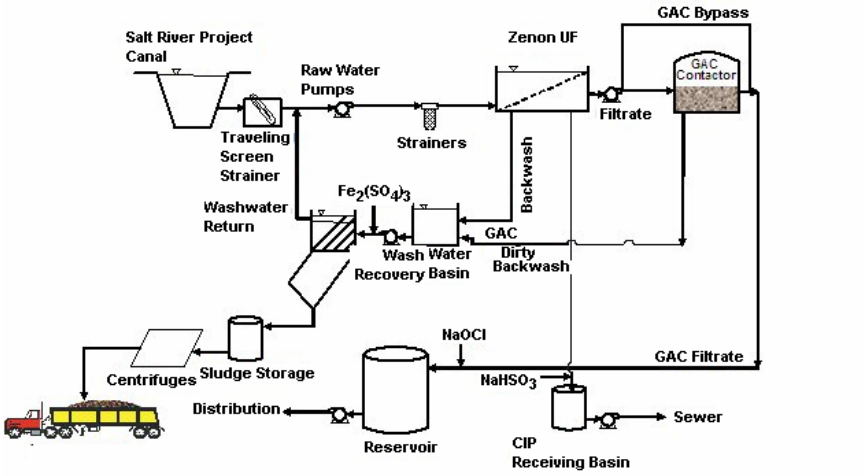

Fig. 2-7: Process flow chart of the Chaparrel WTP [Pressdee, et al., 2006]

2.7.3 Operational strategies

Surface water treatment		
Membrane filtration (raw water treatment)		
Membrane type		Zenon UF (500D)
Module system		Hollow fibre
Tot. membrane surface area	m^2	n.a.
Filtration flux	$L/m^2 h$	51
Backwash water treatment		
Coagulation		
Coagulant		$Fe_2(SO_4)_3$
Coagulant concentration	mg/L	0 – 15 (pilot testing)

Reference: [Pressdee, et al., 2006]

2.7.4 Water qualities

Surface water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	7.7	8.5	8.1	n.a.	n.a.	n.a.
Alkalinity as $CaCO_3$	mg/L	126	220	151	n.a.	n.a.	n.a.
Turbidity	NTU	1.5	29.7	8.0	n.a.	n.a.	n.a.
Total organic carbon	mg/L	2.0	3.6	2.9	n.a.	n.a.	n.a.
DOC	mg/L	1.9	3.4	2.8	n.a.	n.a.	n.a.

Reference: [Pressdee, et al., 2006]

2.8 Columbia Heights (USA)

2.8.1 General information

In Columbia Heights (USA) the world largest UF-WTP started operation in 2005. The WTP plant has a design capacity of 265,000 m3/d for the drinking water production [Pressdee, et al., 2006].

River water treatment	
Site Location	Columbia Heights (USA)
Start of operation	2005
Total Design Capacity	265,000 m^3/d
Raw water source	River water

Reference: [Pressdee, et al., 2006]

2.8.2 Process flow diagram

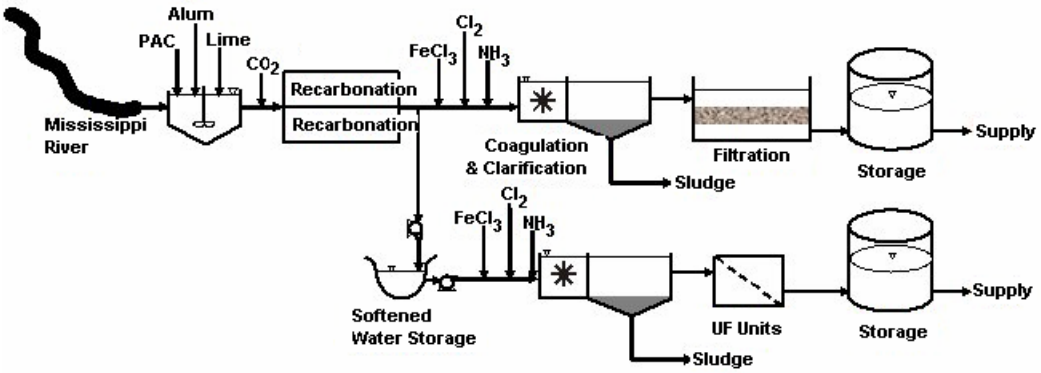

Fig. 2-8: Process flow chart of the Columbia Heights WTP [Pressdee, et al., 2006]

2.8.3 *Operational strategies*

River water treatment		
Coagulation		
Coagulant		$FeCl_3$
Coagulant concentration	mg/L	n.a.
Detention time	min	n.a.
pH-value		n.a.
Other pre-treatment options		Sedimentation
Membrane filtration (river water treatment)		
Membrane type		Ionics; X-Flow-UF
Module system		n.a.
Total membrane surface area	m^2	n.a.
Filtration flux	L/ m^2 h	97
Chemical enhanced backwash (CEB)		
Cleaning agent		NaOCl NaHSO3 hydrochloric
Concentration	mg/L mg/L mg/L mg/L	200 (NaOCl) 300 ($NaHSO_3$) 600 (hydrochloric) 800 (hydrochloric)
residence time	min	10

Reference: [Pressdee, et al., 2006]

2.8.4 *Water qualities*

River water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	7.7	9.2	8.6	n.a.	n.a.	n.a.
Alkalinity as CaCO3	mg/L	22	41	32.1	n.a.	n.a.	n.a.
Hardness as CaCO3	mg/L	12	92	19	n.a.	n.a.	n.a.
Temperature	°C	0.1	29.9	11.5	n.a.	n.a.	n.a.
Turbidity	NTU	0.4	8.0	1.8	n.a.	n.a.	n.a.
Total organic carbon	mg/L	2.7	8.1	5.0	n.a.	n.a.	n.a.
DOC	mg/L	2.4	7.7	4.4	n.a.	n.a.	n.a.
Colour	(CU)	2	20	5	n.a.	n.a.	n.a.
UV_{254}	cm^{-1}	0.03	0.20	0.07	n.a.	n.a.	n.a.
Total Dissolved Solids	mg/L	96	213	134	n.a.	n.a.	n.a.
Manganese	mg/L	<0.010	0.020	0.013	n.a.	n.a.	n.a.

Reference: [Pressdee, et al., 2006]

2.9 Heemskerk WTP (Netherlands)

2.9.1 General Information

In Heemskerk the UF is used as a pre-treatment step for the reverses osmosis. The WTP has a design capacity of 48,000 m^3/d. Start of operation was 1999 [Gijsbertsen, et al., 2004].

Raw water treatment	
Site Location	Heemskerk (Netherlands)
Start of operation	1999
Total Design Capacity	48,000 m^3/d
Raw water source	Surface water

Reference: [Gijsbertsen, et al., 2004]

2.9.2 Process flow diagram

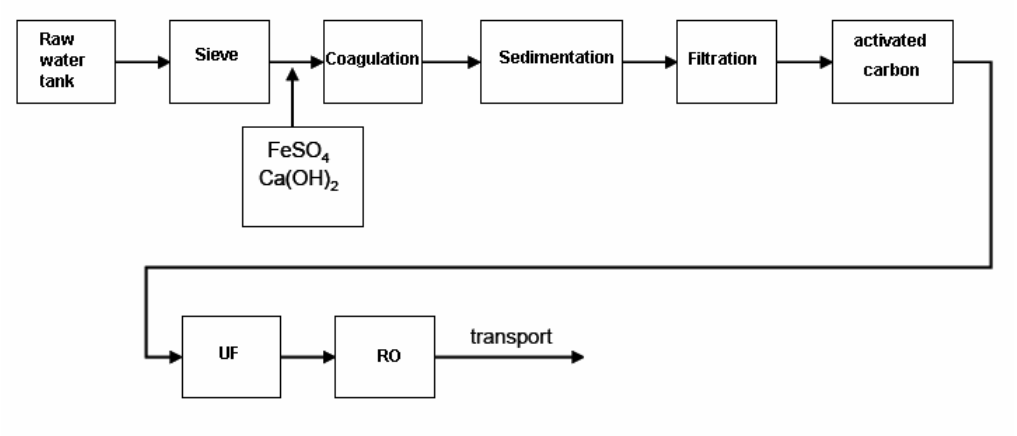

Fig. 2-9: Process flow chart of the Heemskerk WTP [Gijsbertsen, et al., 2004]

2.9.3 Operational strategies

Surface water treatment		
Coagulation		
Coagulant		$FeSO_4$
		Wispro
	mg/L	24 (Fe^{3+})
Coagulant concentration	mg/L	40 ($Ca(OH)_2$
	mg/L	0.3 (Wispro)
Other pre-treatment options		Sieve
Membrane filtration		
Membrane type		X-Flow Xiga
Tot. membrane surface area	m^2	26880
Filtration flux	L/ m^2 h	113
Recovery	%	85

Filtration time	min	18
Hydraulical cleaning		
Back flushing flux	L/ m²h	238 - 300
Back flushing period	sec	30
Chemical enhanced backwash		
Cleaning agent		NaOCl
Concentration	mg/L	150
Cleaning interval		3 times per day

Reference: [Gijsbertsen, et al., 2004]

2.9.4 Water qualities

Surface water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	7.4	7.7	7.6	n.a.	n.a.	n.a.
Turbidity	NTU	0	0.11	0.03	n.a.	n.a.	n.a.
Total organic carbon	mg/L	2.2	3.9	2.9	1.8	3.9	2.8
Cryptosporidium	#/100 L	n.a.	0	n.a.	n.a.	0	n.a.
Giardia	#/100 L	n.a.	0	n.a.	n.a.	0	n.a.
Total Coliforms	#/100 mL	0	253	2	0	0	0

Reference: [Gijsbertsen, et al., 2004]

2.10 Ouddorp WTP (Netherlands)

2.10.1 General Information

In Ouddorp (NL) the UF is used for treating infiltrated surface water. The water WTP has a design capacity of 19,392 m³/d. Start of operation was 2001 [Gijsbertsen, et al., 2004].

Treatment of infiltrated surface water	
Site Location	Ouddorp (Netherlands)
Start of operation	2001
Total Design Capacity	19,392 m³/d
Raw water source	Infiltrated surface water

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.10.2 Process flow diagram

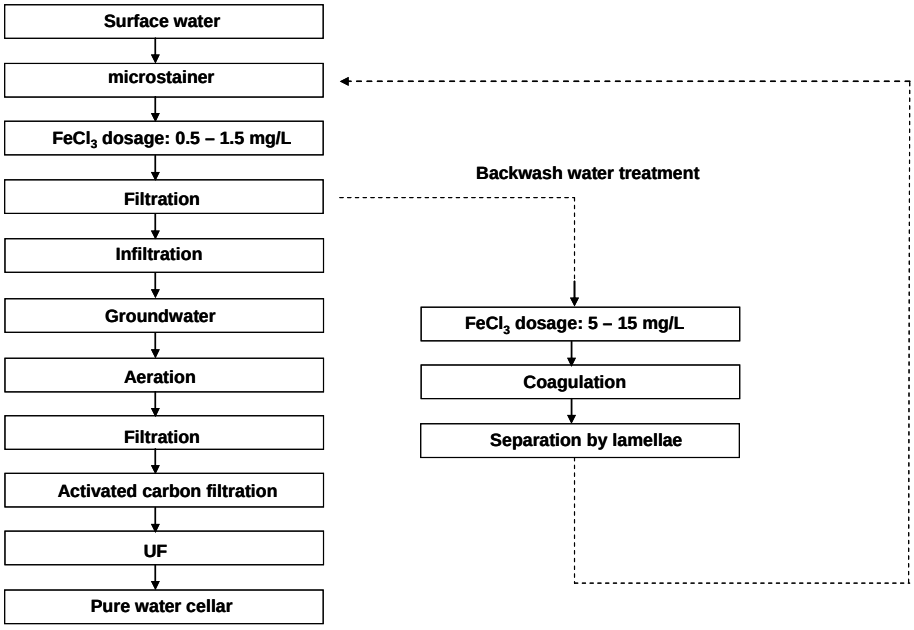

Fig. 2-10: Process flow chart of the Ouddorp WTP [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.10.3 Operational strategies

Treatment of infiltrated surface water		
Coagulation		
Coagulant		$FeCl_3$
Coagulant concentration	mg/L	0.5 – 1.5
Other pre-treatment options		Filtration Activated carbon
Membrane filtration		
Membrane type		X-Flow Xiga
Tot. membrane surface area	m^2	6720
Filtration flux	L/ m^2 h	Max. 120
Recovery	%	n.a.
Filtration time	min	90 - 120
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	250
Back flushing period	sec	5 - 25
Chemical enhanced backwash		
Cleaning agent		NaOCl
Concentration	ppm	400
Cleaning interval	min	90 - 120

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.10.4 Water qualities

Treatment of infiltrated surface water							
		Feed water			**Permeate water**		
		Min.	Max	Av.	Min.	Max	Av.
pH	-	n.a.	n.a.	7.03	n.a.	n.a.	8.56
Temperature	°C	n.a.	n.a.	10	n.a.	n.a.	10
Turbidity	FTU	0.18	n.a.	n.a.	0.27	n.a.	0.34
Iron ((Fe^{3+})	mg/L	n.a.	n.a.	1.5	n.a.	n.a.	n.a.
Manganese	mg/L	n.a.	n.a.	1.5	n.a.	n.a.	n.a.

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.11 Spannenburg WTP (Netherlands)

2.11.1 General Information

In Spannenburg (NL) UF is used for treating backwash water from conventional filtration steps. The UF process has a design capacity of 2,400 m^3/d. Start of operation was 2001 [Gijsbertsen, et al., 2004].

Backwash water treatment	
Site Location	Spannenburg (Netherlands)
Start of operation	2001
Total Design Capacity	2,400 m^3/d
Raw water source	Backwash water

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.11.2 Process flow diagram

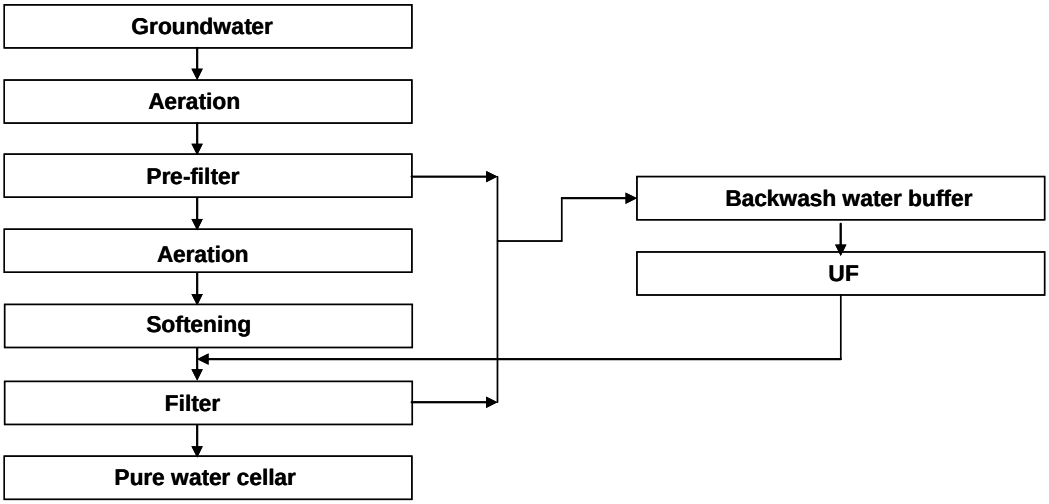

Fig. 2-11: Process flow chart of the Spannenburg WTP [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.11.3 Operational strategies

Backwash water treatment		
Membrane filtration		
Membrane type		Stork
Total membrane surface area	m^2	1290
Filtration flux	L/ m^2 h	80
Recovery	%	60 - 70
Filtration time	min	15
Chemical enhanced backwash (CEB)		
Cleaning agent		HCl H_2O_2 NaOCl
Concentration	% % g/L	30 (HCl) 30 (H_2O_2) 150 (NaClO)
Cleaning interval		once per day (HCl) once per day (H_2O_2) once per 4days (NaOCl)
Cleaning in place (CIP)		
Cleaning agent		Ultrasil 60a Ultrasil 62
Concentration	% %	0.5 0.25
Cleaning interval		once per 4 or 5 weeks
residence time	h	20

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.11.4 Water qualities

Backwash water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
Temperature	°C	n.a.	n.a.	10-15	n.a.	n.a.	n.a.
Turbidity	FTU	n.a.	n.a.	1100-1500	n.a.	n.a.	n.a.

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.12 Hydron Fevoland WTP (Netherlands)

2.12.1 General Information

In Heydron Fevoland (NL) UF is used for treating backwash water from conventional filtration steps. Start of operation was 1998 [Gijsbertsen, et al., 2004].

Backwash water treatment	
Site Location	Hydron Fevoland (Netherlands)
Start of operation	1998
Raw water source	Backwash water

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.12.2 Process flow diagram

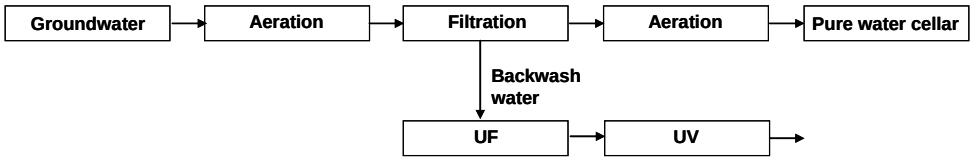

Fig. 2-12: Flow chart of the Heydron Fevoland WTP [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.12.3 Operational strategies

Backwash water treatment		
Membrane filtration		
Membrane type		Stork
Tot. membrane surface area	m^2	240
Filtration flux	L/ m^2 h	67
Recovery	%	70
Filtration time	min	21
Hydraulical cleaning		
Back flushing period	sec	35
Cleaning in place (CIP)		
Cleaning agent		Ferroquest
Amount	L	25 – 35
Cleaning interval		every 2 month
residence time	h	20

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.12.4 Water qualities

Not available

2.13 Heel WTP (Netherlands)

2.13.1 General Information

In Heel (NL) UF is used for treating backwash water from conventional filtration steps. The UF process has a design capacity of 5,760 m^3/d. Start of operation was 2001 [Gijsbertsen, et al., 2004].

Backwash water treatment	
Site Location	Heel (Netherlands)
Start of operation	2001
Total Design Capacity	5,760 m^3/d
Raw water source	Backwash water

Reference: [Gijsbertsen, et al., 2004]

2.13.2 Process flow diagram

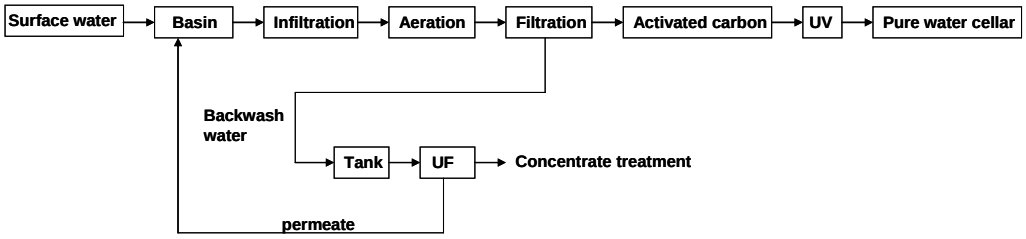

Fig. 2-13: Process flow chart of the Heel WTP [Gijsbertsen, et al., 2004]

2.13.3 Operational strategies

Backwash water treatment		
Membrane filtration		
Membrane type		Stork
Total membrane surface area	m^2	1218
Filtration flux	$L/ m^2 h$	36
Recovery	%	96,5
Hydraulical cleaning		
Back flushing flux	$L/ m^2 h$	147
Back flushing period	sec	45
Chemical enhanced backwash		
Cleaning agent		HCl H_2O_2
Concentration	ppm ppm	500 (HCl) 500 (H_2O_2)
Cleaning interval		After 20 hydraulical cleanings
Back flushing period	sec	240

Reference: [Gijsbertsen, et al., 2004]

2.13.4 Water qualities

Backwash water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
Temperature	°C	10.6	13.8	n.a.	n.a.	n.a.	n.a.
Total organic carbon	mg/L	1.41	7.72	n.a.	n.a.	n.a.	n.a.
Iron (Fe^{3+})	mg/L	80	140	n.a.	n.a.	n.a.	n.a.
Manganese	mg/L	1.5	2	n.a.	n.a.	n.a.	n.a.

Reference: [Gijsbertsen, et al., 2004]

2.14 Aalsterweg – Eindhoven WTP (Netherlands)

2.14.1 General Information

In Aalsterweg (NL) UF is used for treating backwash water from conventional filtration steps. Start of operation was 1996 [Gijsbertsen, et al., 2004].

Backwash water treatment	
Site Location	Eindhoven (Netherlands)
Start of operation	1996
Raw water source	Backwash water

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.14.2 Process flow diagram

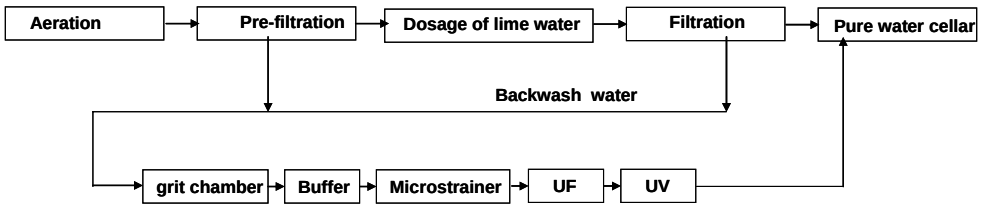

Fig. 2-14: Flow chart of the Eindhoven WTP [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.14.3 Operational strategies

Backwash water treatment		
Pre-treatment		
Pre-treatment options		Grit chamber Microstainer
Membrane filtration		
Membrane type		X-Flow UFC M5
Total membrane surface area	m^2	900
Filtration flux	$L/ m^2 h$	11 - 111

Recovery	%	93
Filtration time	min	120
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	45
Back flushing period	sec	60 - 70
Chemical enhanced backwash (CEB)		
Cleaning agent		HCl H_2O_2
pH	-	1 – 2 (HCl)
Concentration	mg/L	150 (H_2O_2)
Cleaning interval	h	3

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.14.4 Water qualities

Backwash water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	n.a.	n.a.	7.65 -8	n.a.	n.a.	n.a.
Temperature	°C	n.a.	n.a.	14	n.a.	n.a.	n.a.
Turbidity	FTU	n.a.	n.a.	1 – 5	n.a.	n.a.	n.a.
Iron (Fe^{3+})	mg/L	n.a.	n.a.	30-50	n.a.	n.a.	n.a.
Manganese	mg/L	n.a.	n.a.	0.5-1	n.a.	n.a.	n.a.

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.15 Nietap WTP (Netherlands)

2.15.1 General Information

In Nietap(NL) UF is used for treating backwash water from conventional filtration steps. The UF process has a design capacity of 2,160 m^3/d. Start of operation was 2002 [Gijsbertsen, et al., 2004].

Backwash water treatment	
Site Location	Nietap (Netherlands)
Start of operation	2002
Total Design Capacity	2,160 m^3/d
Raw water source	Backwash water

Reference: [Gijsbertsen, et al., 2004]

2.15.2 *Process flow diagram*

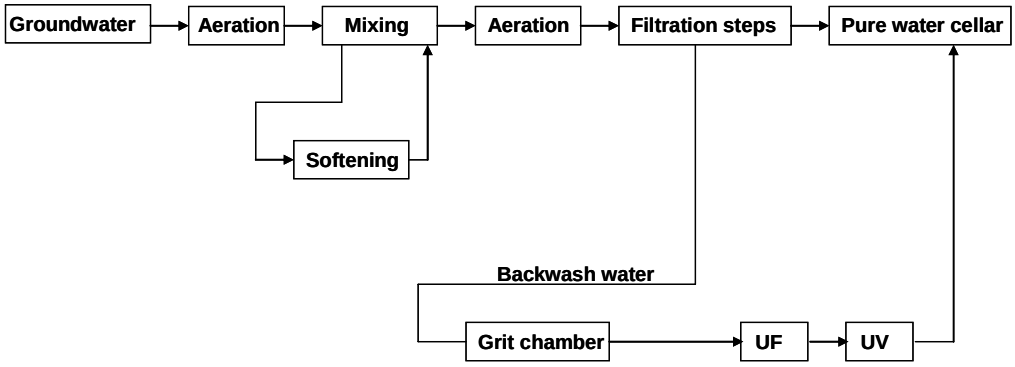

Fig. 2-15: Process flow chart of the Nietap WTP [Gijsbertsen, et al., 2004]

2.15.3 *Operational strategies*

Backwash water treatment		
Pre-treatment		
Pre-treatment options	-	Grit chamber
Membrane filtration		
Membrane type		Stork
Tot. membrane surface area	m^2	870
Filtration flux	L/ m^2 h	103
Recovery	%	87
Filtration time	min	45 - 90
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	138
Back flushing period	sec	20
Chemical enhanced backwash		
Cleaning agent		HCl NaOH
Concentration	ppm ppm	1500 (HCl) 1500 (H_2O_2)

Reference: [Gijsbertsen, et al., 2004]

2.15.4 *Water qualities*

Backwash water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	7.81	8.08	7.98	7.78	8.00	7.93
Temperature	°C	10	12	11	10	12	11
Turbidity	FTU	274	623	434	0	0.25	0.04
Iron (Fe^{3+})	mg/L	60	98	80	<0.02	<0.02	<0.02
Manganese	mg/L	0.43	0.93	0.65	0.009	0.027	0.017

Reference: [Gijsbertsen, et al., 2004]

2.16 Macharen WTP (Netherlands)

2.16.1 General Information

In Macharen (NL) UF is used for treating backwash water from conventional filtration steps. UF is integrated as pre-treatment for a NF. Start of operation was 2000 [Gijsbertsen, et al., 2004].

Backwash water treatment	
Site Location	Macharen (Netherlands)
Start of operation	2000
Raw water source	Backwash water

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004

2.16.2 Process flow diagram

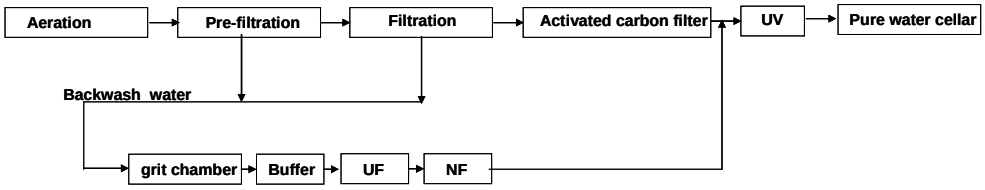

Fig. 2-16: Process flow chart of the Macharen WTP [Raktoe, 2003]

In Macharen two different membrane types for pilot investigations are used:

- X-Flow membranes and
- Stork membranes

2.16.3 Operational strategies

Backwash water treatment		
Pre-treatment		
Pre-treatment option		Grit chamber
Membrane filtration X-Flow		
Membrane type		X-Flow, Xiga
Tot. membrane surface area	m^2	540
Filtration flux	L/ m^2 h	50
Recovery	%	90
Filtration time	min	80
Membrane filtration Stork		
Membrane type		Stork
Tot. membrane surface area	m^2	
Filtration flux	L/ m^2 h	62
Recovery	%	90
Filtration time	min	80
Hydraulical cleaning X-Flow and Stork		
Back flushing flux	L/ m^2 h	200
Back flushing period	sec	120

Chemical enhanced backwash (CEB) X-Flow and Stork		
Cleaning agent		HCl H_2O_2
pH-value	-	2 (HCl)
Concentration	ppm	300 (H_2O_2)

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.16.4 Water qualities

Backwash water treatment				
		Feed	Permeate	
		Av.	X-Flow Av.	Stork Av.
pH	-	7.03	n.a.	n.a.
Temperature	°C	11	11-12	11-12
Turbidity	FTU	0	0.07-0.21	0 – 0.28
Iron (Fe^{3+})	mg/L	15	0	0
Manganese	mg/L	1.5	0.02-0.67	0.01-0.64

Reference: [Raktoe, 2003], [Gijsbertsen, et al., 2004]

2.17 Helmond WTP (Netherlands)

2.17.1 General Information

In Helmond (NL) UF is used for treating backwash water from conventional filtration steps. The UF process has a design capacity of 1,360 m^3/d. Start of operation was 2003 [Gijsbertsen, et al., 2004].

Backwash water treatment	
Site Location	Helmond (Netherlands)
Start of operation	2003
Total Design Capacity	1,320 m^3/d
Raw water source	Backwash water

Reference: [Gijsbertsen, et al., 2004]

2.17.2 Process flow diagram

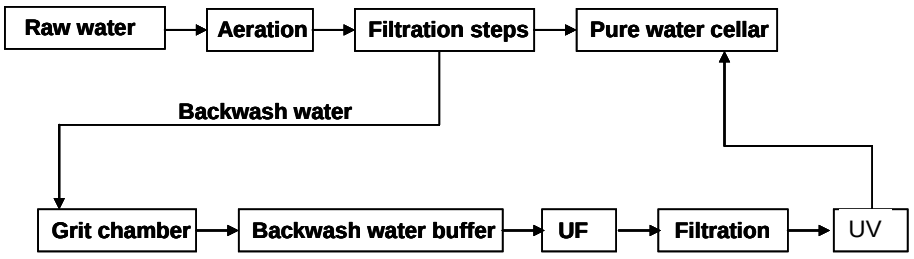

Fig. 2-17: Process flow chart of the Helmond WTP [Gijsbertsen, et al., 2004]

2.17.3 Operational strategies

Backwash water treatment		
Pre-treatment		
Pre-treatment option	-	Grip chamber
Membrane filtration		
Membrane type		X-Flow UFC M5
Tot. membrane surface area	m^2	840
Filtration flux	L/ m^2 h	65
Recovery	%	85 – 90
Filtration time	min	30
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	165
Back flushing period	sec	60
Chemical enhanced backwash		
Cleaning agent		HCl, H_2O_2
Concentration	mg/L	150 (HCl)
	mg/L	150 (H_2O_2)

Reference: [Gijsbertsen, et al., 2004]

2.17.4 Water qualities

Backwash water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	7.65	8.23	7.97	7.72	8.19	7.95
Temperature	°C	n.a.	n.a.	11	n.a.	n.a.	n.a.
Turbidity	FTU	n.a.	n.a.	n.a.	n.a.	0.07	n.a.
Iron (Fe^{3+})	mg/L	34	100	58	<0.01	0.01	0.01
Manganese	mg/L	0.44	0.87	0.65	<0.01	0.07	0.01

Reference: [Gijsbertsen, et al., 2004]

2.18 Annen WTP (Netherlands)

2.18.1 General Information

In Annen (NL) UF is used for treating backwash water from conventional filtration steps. The UF process has a design capacity of 960 m^3/d. Start of operation was 2001 [Gijsbertsen, et al., 2004].

Backwash water treatment	
Site Location	Annen (Netherlands)
Start of operation	2001
Total Design Capacity	960 m^3/d
Raw water source	Backwash water

Reference: [Gijsbertsen, et al., 2004]

2.18.2 *Process flow diagram*

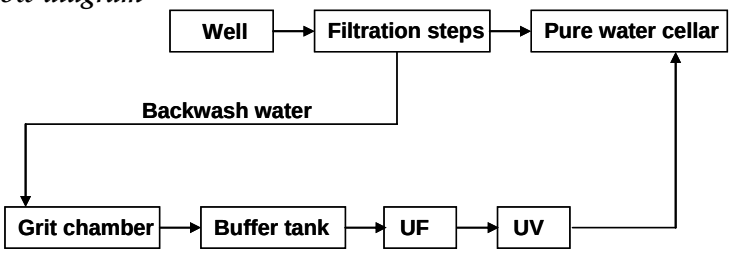

Fig. 2-18: Process flow chart of the Annen WTP [Gijsbertsen, et al., 2004]

2.18.3 *Operational strategies*

Backwash water treatment					
Pre-treatment					
Pre-treatment option	-	Grip chamber			
Membrane filtration					
Membrane type		Norit X-Flow UFC			
Tot. membrane surface area	m^2	400			
Filtration flux	L/ m^2 h	75			
Recovery	%	85			
Filtration time	min	45			
Hydraulical cleaning					
Back flushing flux	L/ m^2 h	300			
Back flushing period	sec	45			
Chemical enhanced backwash (CEB)					
Cleaning agent		HCl / H_2O_2			
Concentration	ppm ppm	1500 – 2000 (HCl) 500 (H_2O_2)			
Cleaning procedure (CEB 1)					
	Chemical agent	pH [-]	Time [sec]	Temp. [°C]	Pressure [bar]
Backwash			45	11	1-2
Chemical dosage	HCl 2000 ppm	1	180		
residence time			1800		
Backwash			45		
Cleaning procedure (CEB 2)					
	Chemical agent	pH [-]	Time [sec]	Temp. [°C]	Pressure [bar]
Backwash			45	11	1-2
Chemical dosage	HCl 1500 ppm H_2O_2 500 ppm	1	180		
residence time			3600		
Backwash			45		

Reference: [Gijsbertsen, et al., 2004]

2.18.4 *Water qualities*

Backwash water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
Turbidity	FTU	n.a.	n.a.	n.a.	0.0	0.29	0.06
Iron (Fe^{3+})	mg/L	n.a.	n.a.	n.a.	0.0	0.02	0.001
Manganese	mg/L	n.a.	n.a.	n.a.	0.0	0.076	0.015

Reference: [Gijsbertsen, et al., 2004]

2.19 Site A (anonymous)

2.19.1 *General Information*

Microfiltration followed by super-dechlorination with hypochlorite and bi-sulphite is used for treating groundwater. The total design capacity of the water treatment plant is 30,000 m^3/d. Start of operation was 2004.

Groundwater treatment	
Site Location	anonymous
Start of operation	2004
Total Design Capacity	38,000 m^3/d
Raw water source	Groundwater

2.19.2 *Process flow diagram*

Fig. 2-19: Process flow chart of the WTP Site A (simplified)

2.19.3 *Operational strategies*

Groundwater treatment		
Coagulation		
Coagulant	-	no coagulation
Other pre-treatment option	-	no pre-treatment steps
Membrane filtration		
Membrane type		Memcor S10V
Tot. membrane surface area	m^2	50,400
Filtration flux	L/ m^2 h	31
Transmembrane pressure	bar	0.4
Air flushing		
Air flushing interval	min	60 (up to 1.0 NTU)
Air flushing period	min	1

Hydraulical cleaning		
Back flushing flux	L/ m² h	60
Back flushing period	sec	20
Back flushing interval	min	60 (up to 1 NTU feed)
Chemical enhanced backwash (CEB)		
Cleaning agent		Sulphuric acid and sodium hypochlorite
Back flushing period before chemical cleaning	sec	20
Period before chemical dosage	sec	350 (acid); 425 (chlorine)
Residence time	sec	19,000 (hypochlorite) 6,000 (for acid)
Membrane integrity		
Parameter to prove		Pressurised air test

2.19.4 Water qualities

Groundwater treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
Temperature	°C	5		11	9	20	12
Turbidity	NTU	0	3.5	0.8	0.04	1.6	0.138
E. Coli	No./L	n.a.	n.a.	n.a.	0	0	00
Total Coliforms	No./L	n.a.	n.a.	n.a.	0	0	0
Clostridia	No./mL	n.a.	n.a.	n.a.	0	0	0

2.20 Site B (anonymous)

2.20.1 General Information

Ultrafiltration is used for treating groundwater. The total design capacity of the water treatment plant is 4,540 m³/d. Start of operation was 2002.

Groundwater treatment	
Site Location	anonymous
Start of operation	2002
Total Design Capacity	4,540 m³/d
Raw water source	Groundwater
Catchment area	Rural
Main treatment aims	*Cryptosporidium* barrier

2.20.2 Process flow diagram

Fig. 2-20: Process flow chart of the WTP Site B (simplified)

2.20.3 Operational strategies

Groundwater water treatment		
Pre-treatment		
Pre-treatment option	-	Marginal chlorination
Membrane filtration		
Membrane type		X-Flow S-225-FSFC PVC UFC M5 0.8
Total membrane surface area	m^2	1,680
Filtration flux	L/ m^2 h	95
Transmembrane pressure	bar	0.25
Hydraulical cleaning		
Back flushing flux	L/ m^2 h	250
Back flushing period	sec	20 - 25
Back flushing interval	min	70
Chemical enhanced backwash (CEB)		
Cleaning agent		Hydrochloric acid and sodium hydroxide
Back flushing period before chemical cleaning	sec	45 - 50
Period before chemical dosage	sec	35 (acid); 40 (caustic)
Residence time	sec	600
Membrane integrity		
Parameter to prove		Pressurised air test

2.20.4 Water qualities

Groundwater treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	7	7.3	7.2	6.8	8.1	7.2
Alkalinity as $CaCO_3$	mg/L	304	304	304	n.a.	n.a.	n.a.
Hardness as $CaCO_3$	mg/L	114	114	114	n.a.	n.a.	n.a.
Temperature	°C	6	20	11.53	5	20	11.73
Turbidity	NTU	0.06	0.15	0.58	0.05	0.6	0.127
Total organic carbon	mg/L	1.1	1.1	1.1	n.a.	n.a.	n.a.
Colour		0	0	0	n.a.	n.a.	n.a.
Ammonia	mg/L	0	0.004	0.0005	n.a.	n.a.	n.a.
Nitrate	mg/L	18	24.6	20	n.a.	n.a.	n.a.
Chloride	mg/L	22	22	22	n.a.	n.a.	n.a.
Sulphate	mg/L	10	10	10	n.a.	n.a.	n.a.
Iron	mg/L	0	33.7	2.11	n.a.	n.a.	n.a.
Manganese	mg/L	0	0	0	n.a.	n.a.	n.a.
E. Coli	No./L	0	4	0.14	0	0	0
Total Coliforms	No./L	0	9	0.27	0	0	0

2.21 Site C (anonymous)

2.21.1 General Information

Ultrafiltration is used for treating groundwater. The total design capacity of the water treatment plant is 42,200 m^3/d.

Groundwater treatment	
Site Location	anonymous
Total Design Capacity	42,200 m^3/d
Raw water source	Groundwater
Catchment area	Rural
Main treatment aims	Removal of virus and bacteria Removal of particles Removal of ions

2.21.2 Process flow diagram

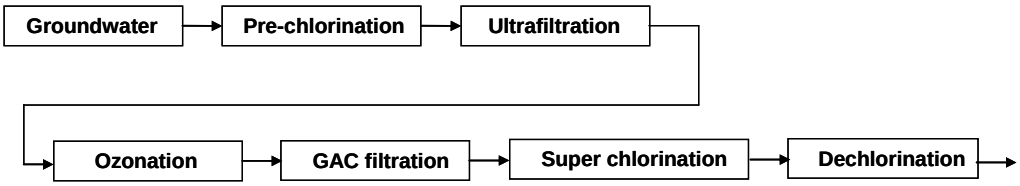

Fig. 2-21: Process flow chart of the WTP Site C (simplified)

2.21.3 Operational strategies

Groundwater treatment		
Pre-treatment		
Pre-treatment option	-	Pre-chlorination
Membrane filtration		
Membrane type		pVdf
Tot. membrane surface area	m^2	12,480
Filtration flux	L/ m^2 h	60
Transmembrane pressure	bar	0.23
Air flushing		
Air flushing interval	min	60
Air flushing period	sec	40
Hydraulical cleaning		
Back flushing flux	m^3/h	36
Back flushing period	sec	20 - 25
Back flushing interval	min	60
Cleaning in Place (CIP)		
Cleaning agent		Sulphuric Acid
Concentration	%	30
Cleaning interval		Twice a month

Back flushing period before chemical cleaning	min	2
Period before chemical dosage	h	3
Residence time	h	3
Membrane integrity		
Parameter to prove		Pressure Decay Test

2.21.4 Water qualities

Groundwater treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	7	7.4	7.28	7	7.5	7.23
Alkalinity as $CaCO_3$	mg/L	262	285	273.5	n.a.	n.a.	n.a.
Hardness as $CaCO_3$	mg/L	112	126	118	n.a.	n.a.	n.a.
Temperature	°C	9	16.6	12,42	n.a.	n.a.	n.a.
Turbidity	NTU	0.09	0.284	6.5	0.05	0.29	0.123
Total organic carbon	mg/L	1.5	4.7	2.87	1.5	6.1	2.998
Colour		2.7	24	8.88	n.a.	n.a.	n.a.
Ammonia	mg/L	0	0.36	0.111	n.a.	n.a.	n.a.
Nitrate	mg/L	13.1	33.4	25.2	n.a.	n.a.	n.a.
Chloride	mg/L	35.1	63	54.1	n.a.	n.a.	n.a.
Sulphate	mg/L	62	71	66.5	n.a.	n.a.	n.a.
Iron	mg/L	0	725	38.87	0	39.6	1.97
Manganese	mg/L	15.1	44	26.97	n.a.	n.a.	n.a.
Cryptosporidium	oocysts/L	0.1	1	0.18	n.a.	n.a.	n.a.
E. Coli	MPN/100mL	0	0	0	0	0	0
Total Coliforms	MPN/100mL	0	10	0.9589	0	0	0
Clostridium perfringens	cfu/100 mL	0	2	0.0882	0	0	0

2.22 Site D (anonymous)

2.22.1 General Information

Ultrafiltration is used for treating groundwater and river water. The total design capacity of the water treatment plant is 6,870 m^3/d.

Groundwater and river water treatment	
Site Location	anonymous
Start of operation	2001
Total Design Capacity	6,870 m^3/d
Raw water source	Groundwater/ river water
Catchment area	Urban, rural, light industry
Main treatment aims	*Cryptosporidium* barrier

2.22.2 *Process flow diagram / Treatment steps*

- Ultrafiltration
- Ozonation
- GAC-Filtration
- Chlorination

2.22.3 *Operational strategies*

Groundwater and river water treatment		
Membrane filtration		
Membrane type		Norit X-Flow S 225
Tot. membrane surface area	m^2	35.2
Filtration flux	L/ m^2 h	80 - 90
Transmembrane pressure	bar	0.4
Hydraulical cleaning		
Back flushing flux	L / m^2 h	250
Back flushing period	sec	50 - 60
Back flushing interval	min	150 - 200
Chemical enhanced backwash (CEP)		
Cleaning agent		Caustic, Hydrochloric acid, Citric Acid
Cleaning interval		Every 18 hours for caustic and HCL, adhoc basis for Citric acid
Back flushing period before chemical cleaning	sec	45
Period before chemical dosage	sec	Caustic 60, acid 90
Residence time		20 min/1200 sec
Membrane integrity		
Parameter to prove		Flow, pressure integrity test

2.22.4 *Water qualities*

Groundwater and river water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	6.8	7.7	7.05			
Alkalinity as $CaCO_3$	mg/L	323	348	336.69	n.a.	n.a.	n.a.
Hardness as $CaCO_3$	mg/L	131	149	140.75	n.a.	n.a.	n.a.
Temperature	°C	8	15	11.46	n.a.	n.a.	n.a.
Turbidity	NTU	0.05	0.3899	10.8	n.a.	n.a.	n.a.
Tot. organic carbon	mg/L	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Colour		0.78	0.78	0.78	n.a.	n.a.	n.a.
Ammonia	mg/L	0	0.003	0.04	n.a.	n.a.	n.a.
Nitrate	mg/L	28.1	31.5	29.77	n.a.	n.a.	n.a.

Chloride	mg/L	31	34	32.48	n.a.	n.a.	n.a.
Sulphate	mg/L	30	52	34.66	n.a.	n.a.	n.a.
Iron	mg/L	0	0	0	n.a.	n.a.	n.a.
Manganese	mg/L	0	0	0	n.a.	n.a.	n.a.
Cryptosporidium	oocysts/L	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
E. Coli	MPN/ 100mL	0	0	0	n.a.	n.a.	n.a.
Total Coliforms	MPN/ 100mL	0	0	0	n.a.	n.a.	n.a.
Clostridium perfringens	cfu/ 100 mL	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

2.23 Site F (anonymous)

2.23.1 General Information

Ultrafiltration is used for treating groundwater. The total design capacity of the water treatment plant is 47,000 m^3/d. Start of operation was 2004.

Groundwater treatment	
Site Location	anonymous
Start of operation	2004
Total Design Capacity	47,000 m^3/d
Raw water source	Groundwater
Catchment area	Rural/urban
Main treatment aims	*Cryptosporidium* barrier

2.23.2 Process flow diagram / Treatment steps

- Microfiltration
- Super-dechlorination

2.23.3 Operational strategies

Groundwater treatment		
Pre-treatment		
Other pre-treatment option	-	Chlorination of one source with hypochlorite for iron removal
Membrane filtration		
Membrane type		Memcor S10 V
Tot. membrane surface area	m^2	55,440 primary only
Filtration flux	L/ m^2 h	35
Transmembrane pressure	bar	0.55
Air flushing		
Air flushing interval	min	75 (up to 1.0 NTU)
Air flushing period	min	1

Hydraulical cleaning		
Back flushing flux	L / m² h	60
Back flushing period	sec	20
Back flushing interval	min	75 (up to 1.0 NTU)
Chemical enhanced backwash (CEP)		
Cleaning agent		Sulphuric acid and sodium hypochlorite
Cleaning interval		One usual backwash prior to CEB
Back flushing period before chemical cleaning	sec	20
Period before chemical dosage	sec	420
Residence time		5,400 (hypochlorite); 12,600 (acid)
Membrane integrity		
Parameter to prove		Pressurised air test

2.23.4 Water qualities

Groundwater treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
Temperature	°C	5	n.a.	11	5	n.a.	11
Turbidity	NTU	0	3.0	0.7	0	1.0	0.3

2.24 Site G (anonymous)

2.24.1 General Information

Ultrafiltration is used for treating groundwater and river water. The total design capacity of the water treatment plant is 1,920 m³/d. Start of operation was 2002.

Groundwater and river water treatment	
Site Location	anonymous
Start of operation	2002
Total Design Capacity	1,920 m³/d
Raw water source	Groundwater/ river water
Catchment area	Rural/agriculture
Main treatment aims	*Cryptosporidium* barrier

2.24.2 Process flow diagram / Treatment steps

- Clarification with PACL
- GAC
- Pre-chlorination
- Ultrafiltration with option to dose PACL onto membranes

2.24.3 *Operational strategies*

Groundwater and river water treatment		
Coagulation		
Coagulant	-	PACl
Concentration	mg/L	2-5, for filters 0.3
Other pre-treatment options	-	GAC, Pre-chlorination
Membrane filtration		
Membrane type		Norit X-Flow S 225
Tot. membrane surface area	m^2	35.2
Filtration flux	L/ m^2 h	80 - 90
Transmembrane pressure	bar	0.4
Hydraulical cleaning		
Back flushing flux	L / m^2 h	250
Back flushing period	sec	50 - 60
Back flushing interval	min	150 - 200
Chemical enhanced backwash (CEP)		
Cleaning agent		Caustic, hydrochloric acid, citric Acid
Cleaning interval		Every 18 hours for caustic and HCL, adhoc for Citric acid
Back flushing period before chemical cleaning	sec	45
Period before chemical dosage	sec	Caustic 60, acid 90
Residence time		20 min/1200 sec
Membrane integrity		
Parameter to prove		Flow, pressure integrity test

2.24.4 *Water qualities*

Groundwater and river water treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	6.7	7.5	7.02	6.9	7.4	7.11
Alkalinity as $CaCO_3$	mg/L	273	331	307.1	259	329	305
Hardness	mg/L	125	154	140.24	123	158	140
Turbidity	NTU	0.06	4.14	0.5034	0.06	0.3	0.12
Total organic carbon	mg/L	1.1	3.6	2.21	n.a.	n.a.	n.a.
Colour	Pt/Co	-0.68	3.6	1.2	n.a.	10.6	0.53
Ammonia	mg/L	0	0.04	0.003	n.a.	n.a.	n.a.
Iron	mg/L	0	90.4	8.7	0	49.4	2.09
Manganese	mg/L	0	8.9	1.01	n.a.	n.a.	n.a.
E. Coli	MPN/100 mL	0	201	31.55	0	0	0
Tot. Coliforms	MPN/100 mL	0	1553	159.64	0	0	0
Clostridium perfringens	cfu/100 mL	0	48	4.46	0	0	0

2.25 Site H (anonymous)

2.25.1 General Information

Ultrafiltration is used for treating groundwater. The total design capacity of the water treatment plant is 5,000 m^3/d. Start of operation was 2004.

Groundwater treatment	
Site Location	anonymous
Start of operation	2004
Total Design Capacity	5,000 m^3/d
Raw water source	Groundwater
Catchment area	Urban/rural
Main treatment aims	Removal of virus and bacteria

2.25.2 Process flow diagram / Treatment steps

- Air Stripping
- Ultrafiltration
- Chlorination

2.25.3 Operational strategies

Groundwater treatment		
Pre-treatment		
Pre-treatment option	-	VOC Air stripper
Membrane filtration		
Membrane type		Norit Xiga
Tot. membrane surface area	m^2	1680
Filtration flux	L/ m^2 h	110
Transmembrane pressure	bar	0.2-0.4
Hydraulical cleaning		
Back flushing period	sec	50
Back flushing interval	min	50
Chemical enhanced backwash (CEP)		
Cleaning agent		Hydrochloric Acid, Sodium Hydroxide
Cleaning interval		Acid every 2 days, Caustic every 4/5 days
Back flushing period before chemical cleaning	sec	50
Period before chemical dosage	sec	60
Residence time	sec	600
Membrane integrity		
Parameter to prove		Pressure Decay Test and air flow

2.25.4 *Water qualities*

Groundwater treatment							
		Feed water			**Permeate water**		
		Min.	Max.	Av.	Min.	Max.	Av.
pH	-	6.9	7.5	7.14	7.5	8.3	7.98
Alkalinity as $CaCO_3$	mg/L	298	298	298	n.a.	n.a.	n.a.
Hardness as Ca	mg/L	141	141	141	n.a.	n.a.	n.a.
Temperature	°C	8	14	11.57	8	16	11.7
Turbidity	NTU	0.06	0.54	0.126	0.05	0.6	0.13
Colour	Pt/Co	0	0	0	n.a.	n.a.	n.a.
Ammonia	mg/L	0	0.004	0.0011	n.a.	n.a.	n.a.
Iron	mg/L	0	8.61	0.66	n.a.	n.a.	n.a.
Manganese	mg/L	0	0	0	n.a.	n.a.	n.a.
E. Coli	MPN/100 mL	0	15	0.2647	0	0	0
Total Coliforms	MPN/100 mL	0	16	1.10	0	0	0
Clostridium per-fringens	cfu/100 mL	0	0	0	n.a.	n.a.	n.a.

2.26 Dietfurt - Parleithen/Nürnberg (Germany)

2.26.1 *General Information*

Ultrafiltration is used for treating groundwater. The total design capacity of the water treatment plant is 1,720 m^3/d. Start of operation was 2001 [INGE AG, 2007].

Groundwater treatment	
Site Location	Dietfurt - Parleithen (Germany)
Start of operation	2001
Total Design Capacity	1,720 m^3/d
Raw water source	Groundwater

Reference: [INGE AG, 2007]

2.26.2 *Process flow diagram / Treatment steps*

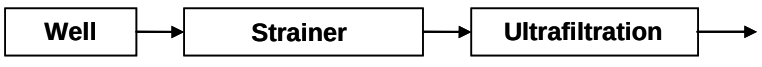

Fig. 2-22: Process flow chart of the Dietfurt WTP [INGE AG, 2007]

2.26.3 *Operational strategies*

Groundwater treatment		
Pre-treatment		
Pre-treatment option	-	Strainer
Membrane filtration		
Membrane type		Inge dizzer 5000 MB
Racks		2
Tot. No. of UF modules		20
Filtration flux	L/ m² h	80
Hydraulical cleaning		
Back flushing period		
Back flushing interval		every 1 - 2 weeks for disinfection

Reference: [INGE AG, 2007]

2.26.4 *Water qualities*

not available

2.27 Pusan (South Korea)

2.27.1 *General Information*

Ultrafiltration is used for treating river water. The total design capacity of the water treatment plant is 8,160 m³/d. Start of operation was 2006 [INGE AG, 2007].

River water treatment	
Site Location	Pusan (South Korea)
Start of operation	2006
Total Design Capacity	8,160 m³/d
Raw water source	River water

Reference: [INGE AG, 2007]

2.27.2 *Process flow diagram / Treatment steps*

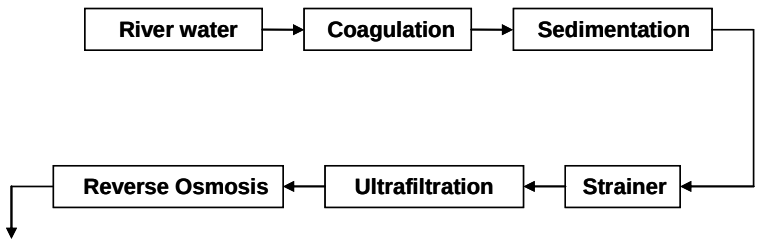

Fig. 2-23: Process flow chart of the Pusan WTP [INGE AG, 2007]

2.27.3 *Operational strategies*

River water treatment		
Pre-treatment		
Pre-treatment option	-	Strainer
Membrane filtration		
Membrane type		Inge dizzer 5000 MB
Racks		2
Total Number of UF modules		88
Filtration flux	L/ m² h	80
Transmembrane pressure	bar	0.2
Chemical enhanced backwash (CEP)		
Cleaning agent		Sodium Hypochlorite
Concentration	ppm	20

Reference: [INGE AG, 2007]

2.27.4 *Water qualities*

not available

2.28 Maennedorf (Switzerland)

2.28.1 *General Information*

Ultrafiltration is used for treating lake water. The total design capacity of the water treatment plant is 17,600 m³/d. Start of operation was 2005 [INGE AG].

Lake water treatment	
Site Location	Maennedorf (Switzerland)
Start of operation	2005
Total Design Capacity	17,600 m³/d
Raw water source	Lake water

Reference: [INGE AG, 2007]

2.28.2 *Process flow diagram / Treatment steps*

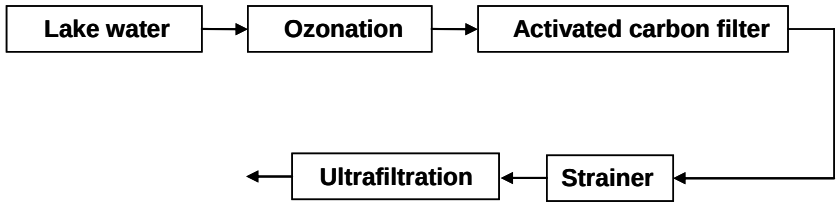

Fig. 2-24: Process flow chart of the Pusan WTP [INGE AG, 2007]

2.28.3 Operational strategies

Lake water treatment		
Pre-treatment		
Pre-treatment options	-	Ozone, activated carbon filter
Membrane filtration		
Membrane type		Inge dizzer 5000 MB
Racks		4
Tot. No. of UF modules		164
Filtration flux	L/ m² h	110

Reference: [INGE AG, 2007]

2.28.4 Water qualities

not available

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4 Appendix

4.1 Overview about installed or planed UF/MF plants worldwide (incompletely)

Location	Membrane Supplier	Source of raw water	Start-up	Plant capacity [m³/d]	Ref.
Canada (Kamploops, British Columbia)	ZENON	Surface water	-	160,196	ZENON
USA (Olivenhain, Kalifornien)	ZENON	Surface water	-	94,625	ZENON
USA (Fairmont, Alabama)	ZENON	River water	-	37,850	ZENON
USA (Sudbury, Ontario)	ZENON	Surface water	-	37,850	ZENON
USA (Duck River, Tennessee)	ZENON	Surface water	-	35,958	ZENON
USA (Olivenhain 3, Kalifornien)	ZENON	Surface water	-	34,065	ZENON
Canada (Thunder Bay, Ontario)	ZENON	Surface water	-	34,065	ZENON
Canada (Fraser Valley, British Columbia)	ZENON	Surface water	-	30,280	ZENON
USA (Sweetwater, Texas)	ZENON	Surface water	-	30,280	ZENON
Canada (Collingwood 1, Ontario)	ZENON	Surface water	-	28,009	ZENON
USA (Draper, Utah)	ZENON	Surface water	-	24,981	ZENON
USA (Pendleton, Oregon)	ZENON	River water	-	22,710	ZENON
Canada (Georgina, Ontario)	ZENON	Surface water	-	20,061	ZENON
USA (Anthem 3, Phoenix, Arizona)	ZENON	River water	-	18,925	ZENON
USA (Dickson County, Tennessee)	ZENON	Surface water	-	18,925	ZENON
USA (Maryville, Missouri)	ZENON	Surface water	-	18,925	ZENON
USA (Seekonk, Massachusetts)	ZENON	Groundwater	-	16,276	ZENON
USA (White House, Tennesee)	ZENON	Surface water	-	15,140	ZENON
Canada (Parry Sound, Ontario)	ZENON	Surface water	-	12,998	ZENON

USA (Desert Hills, (Anthem) Arizona)	ZENON	River water	-	11,356	ZENON
USA (American Canyon, Kalifornien)	ZENON	Surface water	-	11,355	ZENON
USA (Greers Ferry Lake, Alaska)	ZENON	Surface water	-	11,355	ZENON
USA (Walpole, Massachusetts)	ZENON	Surface water	-	11,355	ZENON
Canada (Anthony Henday 1, Alberta)	ZENON	Surface water	-	10,977	ZENON
Canada (Anthony Henday 1, Alberta	ZENON	Surface water	-	10,222	ZENON
USA (East China, Michigan)	ZENON	Surface water	-	10,598	ZENON
USA (Southeast Morris, New Jersey)	ZENON	Surface water	-	9,463	ZENON
USA (Evergreen, Colorado)	ZENON	Surface water	-	9,084	ZENON
Canada (Fairfield 2 (Amhertsview), Ontario)	ZENON	Surface water	-	7,949	ZENON
USA (Sylacauga, Alabama)	ZENON	Surface water	-	7,570	ZENON
Canada (Fairfield 1 (Amhertsview), Ontario)	ZENON	Surface water	-	5,980	ZENON
Canada (Sioux Lookout, Ontario)	ZENON	Surface water	-	5,299	ZENON
Canada (Walkerton, Ontario)	ZENON	Surface water	-	4,996	ZENON
Canada (Collingwood 2, Ontario)	ZENON	Surface water	-	4,542	ZENON
Canada (Picture Butte, Alberta)	ZENON	Surface water	-	4,504	ZENON
Canada (Fenelon Falls, Ontario)	ZENON	Surface water	-	4,164	ZENON
USA (Glenn's Ferry, Idaho)	ZENON	Surface water	-	4,088	ZENON
USA (Austin, Texas)	ZENON	Surface water	-	3,785	ZENON
USA (Maryland)	ZENON	Surface water	-	3,785	ZENON
Canada (Little Current, Ontario)	ZENON	Surface water	-	3,104	ZENON
Canada (Wikwemikong, Ontario)	ZENON	Surface water	-	2,574	ZENON
Canada (Rothesay, New Brunswick)	ZENON	Groundwater	-	2,271	ZENON

Canada (Wabaseemoong, Ontario)	ZENON	Surface water	-	1,893	ZENON
Canada (M'chingeeng, Ontario)	ZENON	Surface water	-	1,476	ZENON
Canada (God`s Lake, Manitoba)	ZENON	Surface water	-	1,325	ZENON
Canada (Shammattawa, Manitoba)	ZENON	Surface water	-	1,135	ZENON
Canada (Fort McKay, Alberta)	ZENON	Surface water	-	1,060	ZENON
Canada (Lakeview, Ontario)	ZENON	Surface water	-	261,165	ZENON
USA (Racine, Wisconsin)	ZENON	Surface water		189,250	ZENON
USA (Thornton, Colorado)	ZENON	Surface water		189,250	ZENON
USA (San Juaquin, California)	ZENON	Surface water		136,260	ZENON
USA (Lancaster, Pennsylvania)	ZENON	Surface water		128,690	ZENON
USA (Scottsdale, Arizona)	ZENON	Surface water		113,562	ZENON
Canada (Thunder Bay, (Bare Point), Ontario)	ZENON	Surface water		113,550	ZENON
USA (Jackson, Mississippi)	ZENON	Surface water		94,625	ZENON
USA (Alcoa, Tennessee)	ZENON	Surface water		60,560	ZENON
USA (Pflugerville, Texas)	ZENON	Surface water		56,775	ZENON
USA (Ventura, California)	ZENON	Surface water		37,850	ZENON
Canada (Tecumseh, Ontario)	ZENON	Surface water		33,312	ZENON
USA (Santee Cooper, South Carolina)	ZENON	Surface water		30,280	ZENON
Canada (Erickson, Brit. Columbia)	ZENON	Surface water	-	29,902	ZENON
USA (Charleroi, Pennsylvania)	ZENON	Surface water	-	27,252	ZENON
USA (Frenchtown, Michigan)	ZENON	Surface water	-	22,710	ZENON
USA (Jamestown, Kentucky)	ZENON	Surface water	-	22,710	ZENON

USA (Lake Gaston, Virginia)	ZENON	Surface water	-	21,575	ZENON
USA (Grove Farms, Hawaii)	ZENON	Surface water	-	15,140	ZENON
Canada (Saugeen Shores, Ontario)	ZENON	Surface water	-	14,989	ZENON
USA (Blackfeet, Montana	ZENON	Surface water	-	13,249	ZENON
Canada (Port Hope, Ontario)	ZENON	Surface water	-	12,112	ZENON
USA (Breese, California)	ZENON	Groundwater	-	11,355	ZENON
USA (Marysville, Washington)	ZENON	Groundwater	-	11,734	ZENON
USA (Shorelands, New Jersey)	ZENON	Surface water	-	11.355	ZENON
USA (Shoshone, Wyoming)	ZENON	Surface water	-	11.355	ZENON
Canada (Cold Lake, Alberta)	ZENON	Surface water	-	9,463	ZENON
Canada (South Dundas, Ontario)	ZENON	Surface water	-	9,084	ZENON
Canada (South Stormont, Ontario)	ZENON	Surface water	-	8,516	ZENON
USA (Camp Page)	ZENON	Surface water	-	1,514	ZENON
Canada (Bow Island)	ZENON	Surface water	-	1,136	ZENON
Bosnia-Herzegovina (Brck City)	ZENON	-	-	10,000	ZENON
Germany (Hassfurt)	ZENON	-	-	8,900	ZENON
Germany (Waldberg)	ZENON	-	-	5,040	ZENON
China	INGE	Surface water	2006	21,600	INGE
Switzerland (Männedorf)	INGE	Surface water	2005	19,200	INGE
Germany (Roetgen)	INGE	Backwash water	2005	14,400	INGE
Germany (Filderstadt)	INGE	Surface water	2006	8,630	INGE
Germany (Sunder)	INGE	Groundwater	2006	6,000	INGE
Germany (Bad Hersfeld)	INGE	Groundwater	2005	5,472	INGE

Germany (Meschede)	INGE	Surface water	2005	5,280	INGE
Germany (Seeburg)	INGE	Spring water	2006	4,800	INGE
Germany (Lichtenfels)	INGE	Spring water	2006	4,440	INGE
Germany (Lohr am Main)	INGE	Spring water	2005	4,320	INGE
Germany (Bad Kissingen)	INGE	Goundwater	2003	2,880	INGE
Lithuania	INGE	Surface water	2004	2,400	INGE
Germany (Jachenhausen)	INGE	Spring water	2002	1,728	INGE
Germany (Ihrlerstein)	INGE	Spring water	2006	1,680	INGE
Slovenia	INGE	Spring water	2005	1,440	INGE
Ukraina	INGE	Surface water	2005	48,000	INGE
Germany (Guenterstal)	PALL	Groundwater	2003	1,440	PALL
Gemany (Simmern)	PALL	Groundwater	2003	3,600	PALL
Romania (Borsec Harghita)	PALL	Spring water	2003	600	PALL
Turkey	PALL	Spring water	2006	480	PALL
Germany (Freudenstadt)	PALL	Spring water	2006	2,640	PALL
Germany (Hechingen)	PALL	Spring water	2006	2,160	PALL
Poland (Sucha Beskidzka)	PALL	Surface water	2006	3,120	PALL
Germany (Süssen)	PALL	Groundwater	2006	3,120	PALL
Serbia	PALL	Surface water	2006	3,360	PALL
Lithuania	PALL	Spring water	2006	1,800	PALL
Germany	PALL	Spring water	2005	1,920	PALL
Germany	PALL	Backwash water	2005	1,080	PALL
Germany (Rehau)	PALL	Spring water	2005	3,120	PALL

Turkey (Eskishir)	PALL	Spring water	2005	1,200	PALL
USA (Town of Littleton)	KOCH	Grondwater under the influence of surface water	1998	5,678	KOCH
New Zealand	KOCH	Reservoir	1999	3,785	KOCH
USA (Bartlesville)	KOCH	Reservoir	1999	303	KOCH
USA (Freeman)	KOCH	Clarified Reservoir	1999	3,785	KOCH
USA (Gardner)	KOCH	Lake/Reservoir	2000	11,356	KOCH
USA (Gallatin)	KOCH	Clarified Lake	2000	1,136	KOCH
USA (Menasha)	KOCH	Softened Lake water	2001	90,850	KOCH
USA (New Braunfels)	KOCH	Surface water	2002	15,142	KOCH
USA (San Marcos)	KOCH	River and Lake	2005	7,571	KOCH
USA (Fremont)	KOCH	Surface water	2004	37,854	KOCH
USA (Nueces)	KOCH	River water	2004	24984	KOCH
Australia (Port Douglas)	KOCH	River water	2005	34069	KOCH
USA (Minnesota)	NORIT X-FLOW	Surface water	2005	265.000	[1]
United Kingdom (Inverness)	NORIT X-FLOW	Surface water	2002	34.439	[1]
Germany (Roetgen)	NORIT X-FLOW	Reservoir	2005	144.000	[4]

4.2 Questionnaire

Technology Enabled Universal Access to Safe Water

TECHNEAU: Contract-No. 018320

WP5.3 – Operation and maintenance

Background Information

Name of Utility: _____

Address of Utility: _____

Contact person: _____

Organisation: _____

Address: _____

Phone/Fax: _____

Email: _____

General Information about the water treatment plant:

Site Location : _____

Construction Year : _____

Total design capacity (in m^3/h) : _____

Treatment steps (e.g. UV, Ozone) : _____

Catchment area (urban, rural, etc.) : _____

Type of raw water:

- ☐ River water
- ☐ Lakes / reservoirs
- ☐ Groundwater
- ☐ Others (please specify)

Raw water Quality:

		Minimum	Maximum	Average
pH	-			
Alkalinity	mg/L			
Hardness	mg/L			
Temperature	°C			
Turbidity	NTU			
Total organic carbon	mg/L			
Dissolved Organic Carbon	mg/L			
Colour	-			
UV 254	cm-1			
Ammonia	mg/L			
Nitrate	mg/L			
Chloride	mg/L			
Sulphate	mg/L			
Total Dissolved Solids	mg/L			
Iron	mg/L			
Manganese	mg/L			
Cryptosporidium	No./L			
Giardia	No./L			
E. Coli	No./L			
Total Coliforms	No./L			
Clostridia	No./mL			

Comments:

Membrane Feed water Quality

		Minimum	Maximum	Average
pH	-			
Alkalinity	mg/L			
Hardness	mg/L			
Temperature	°C			
Turbidity	NTU			
Total organic carbon	mg/L			
Dissolved Organic Carbon	mg/L			
Colour	-			
UV 254	cm-1			
Ammonia	mg/L			
Nitrate	mg/L			
Chloride	mg/L			
Sulphate	mg/L			
Total Dissolved Solids	mg/L			
Iron	mg/L			
Manganese	mg/L			
Cryptosporidium	No./L			
Giardia	No./L			
E. Coli	No./L			
Total Coliforms	No./L			
Clostridia	No./mL			

Comments:

Membrane Permeate Quality

		Minimum	Maximum	Average
pH	-			
Alkalinity	mg/L			
Particle counts < 2 µm	No./mL			
Hardness	mg/L			
Temperature	°C			
Turbidity	NTU			
Total organic carbon	mg/L			
Dissolved Organic Carbon	mg/L			
Colour	-			
UV 254	cm-1			
Ammonia	mg/L			
Nitrate	mg/L			
Chloride	mg/L			
Sulphate	mg/L			
Total Dissolved Solids	mg/L			
Iron	mg/L			
Manganese	mg/L			
Cryptosporidium	No./L			
Giardia	No./L			
E. Coli	No./L			
Total Coliforms	No./L			
Clostridia	No./mL			

Comments:

Treatment aims:

☐	Removal of NOM
☐	Removal of virus and bacteria
☐	Removal of trace contaminants (e.g. pesticides)
☐	Removal of particles
☐	Removal of ions
☐	Others (please specify) :

Pre-treatment options:

Coagulation

Which coagulant do you use? :

Which concentration do you use? :

Which pH value do you use for coagulation? :

Do you use inline or standard coagulation? :

Do you use other pre-treatment options? (please specify) :

No pre-treatment options :

Membrane filtration (1):

General information

How large is the membrane surface area? m^2

Which membrane module do you use?

Filtration

Which flux do you aim? L/ m^2h

Which transmembrane pressure do you use? bar

Air flushing

Which air flushing interval do you use? min

How long is the air flushing period? min

Membrane filtration (2):
Back flush

Which back flushing interval do you use?	min	
How long is the back flushing period?	sec	
How high is the back flushing flux?	L/ m^2h	

Chemical enhanced backwash

Which cleaning agent do you use?		
Which back flushing interval do you use?	min	
How long is the back flushing period before chemical cleaning?	sec	
How long is the period for chemical dosage?	sec	
How long is the residence time?	sec	

Membrane integrity

Which parameters do you measure to prove the membrane integrity?	

Please send the filled in questionnaire back to following address: salehi@ivt.rwth-aachen.de

THANKS FOR YOUR ASSISTANCE

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