World Health Organization

WHO International Scheme to Evaluate Household Water Treatment Technologies

Laboratory report

Product name:	The Sydney 905 Purifier
Manufacturer:	Sydney 905 Filters (Pty) Ltd 4 Strelitzia Road Southport KwaZulu-Natal 4230 Republic of South Africa
Evaluation procedure:	Abbreviated laboratory testing
WHO designated testing laboratory	KWR Watercycle Research Institute the Netherlands
WHO Scheme identification number	24/1/2020/R3-18
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Contents

List of tables

Abbreviations and acronyms

ATCC	American Type Culture Collection
cfu	colony forming units
CTW	Challenge Test Water
E. coli	*Escherichia coli*
EN	European Standards
GDWQ	WHO Guidelines for Drinking-water Quality
GTW	General Test Water
HWT	Household Water Treatment
ISO	International Organization for Standardization
L	Litre
mL	millilitre
NEN	the Royal Netherlands Standardization Institute
pfu	plaque forming units
QMRA	quantitative microbial risk assessment
TOC	total organic carbon
the Scheme	WHO International Scheme to Evaluate Household Water Treatment Technologies
UN	United Nations
WHO	World Health Organization

Summary

This report summarizes the results of laboratory testing of a membrane ultrafilter known by the tradename 'the Sydney 905 Purifier', under Round III of the World Health Organization (WHO) International Scheme to Evaluate Household Water Treatment Technologies (the Scheme). The device was tested at a WHO-designated testing laboratory, KWR Watercycle Research Institute, in the Netherlands.

Testing followed the requirements of the WHO protocol for batch filtration technologies, and investigated its ability to reduce bacteria (*Escherichia coli)* and viruses (coliphages MS2 and phiX174) in microbiological challenge water. For filters based primarily on size exclusion, the Scheme testing protocol allows for the protozoan pathogen reduction to be assigned based on the bacterial reduction achieved. As such, no testing against protozoan pathogens was conducted.

For the laboratory test, three sample units of the Sydney 905 Purifier were operated according to the manufacturer's use instructions and tested in General Test Water and Challenge Test Water, and samples were analysed in triplicate.

The Sydney 905 Purifier achieved mean $\log_{10}$ reductions of 7.3 for *Escherichia coli*; 5.5 for MS2; and 5.1 for phiX174.

1 Introduction

1.1 Overview of the Scheme

The International Scheme to Evaluate Household Water Treatment Technologies (the Scheme) was established by the World Health Organization (WHO) to coordinate independent and consistent evaluation of the microbiological performance of household water treatment (HWT) technologies. The results of the evaluation are used to guide procuring United Nations (UN) agencies and Member States in the selection of these technologies.

Evaluation of HWT technologies under the Scheme is based on the performance criteria set forth in *Evaluating household water treatment options: health-based targets and microbiological performance specifications* (WHO, 2011), referred to as the HWT recommendations.

1.2 Test organisms and performance classification

The HWT recommendations evaluate microbial treatment efficacy against viruses, bacteria, and protozoan oocysts against three descending levels of performance (Table 1): ★★★ (three-star); ★★ (two-star); and ★ (one-star). Both three- and two-star products are classified as providing *Comprehensive protection* against all three microbial groups. One-star products are those that meet performance targets for only two of the three microbial groups, and are classified as providing *Targeted protection*. Performance that does not meet the minimum level is awarded no stars.

Table 1: WHO microbial performance recommendations for HWT technologies

Performance classification	Required $\log_{10}$ reduction			Interpretation (with correct and consistent use)
	Bacteria *Escherichia coli*	**Viruses** MS2 and phiX174	**Protozoa** *Cryptosporidium parvum*	
★★★	≥ 4	≥ 5	≥ 4	Comprehensive protection
★★	≥ 2	≥ 3	≥ 2	
★	Meets at least 2-star (★★) criteria for two classes of pathogens			Targeted protection
-	Fails to meet WHO performance criteria			Little or no protection

Note:
$\log_{10}$ reduction refers to the reduction in concentration of pathogens in drinking-water:
1 $\log_{10}$ = 90% reduction;
2 $\log_{10}$ = 99% reduction;
3 $\log_{10}$ = 99.9% reduction, etc.

These criteria were determined by applying the concept of tolerable burden of disease (acceptable risk) as set forth in the fourth edition of the WHO Guidelines for Drinking-water Quality (GDWQ) (WHO, 2017). Using quantitative microbial risk models described in the GDWQ and assuming background levels of reference pathogens in untreated water, reductions of pathogens were calculated to meet these health-based targets.

Based on the best available evidence and WHO's discretion, the microbial groups used in the performance evaluation may be reduced as outlined in the Harmonized Protocol (WHO, 2020). Filtration technologies based primarily on size exclusion are generally effective against protozoa, the largest in diameter of the targeted pathogen classes. For example, *Cryptosporidium parvum* is 3-5 microns in diameter, *Escherichia coli* (*E. coli*) is 0.25 microns in diameter and the phages MS2 and phiX174 are approximately 24 nm and, 27 nm, respectively, in diameter. Thus, if filters are able to physically remove the smaller viruses and bacteria, it can be logically assumed they will also

remove the relatively much larger protozoan microbes. Thus, for filters that are based solely on size exclusion therefore it may be acceptable to base the evaluation on the product's reduction performance for the bacteria and virus microbial groups only.

Each production unit should consistently meet or exceed the performance target for each microbial group, and in both General Test Water (GTW) and Challenge Test Water (CTW). However, a maximum deviation of 0.2 $\log_{10}$ is acceptable for 25% of sample points at the two-star performance tier, and 0.4 $\log_{10}$ at the three-star performance tier[1]. This means that for classification as a two-star product, up to three of the twelve sample points can achieve a reduction of 1.8 $\log_{10}$ for bacteria or protozoan cysts (instead of 2 $\log_{10}$), or 2.8 $\log_{10}$ for viruses (instead of 3 $\log_{10}$). Each phage is treated separately for evaluating acceptable allowance, and the overall claim for viruses is based on the lower performing phage.

1.3 Evaluation procedure

Evaluation under the Scheme is based on the voluntary submission of an expression of interest to WHO by the product manufacturer. WHO works with an Independent Advisory Committee (IAC)[2] to the Scheme in reviewing expressions of interest, developing testing protocols and reviewing testing results. Testing is conducted at WHO designated testing laboratories[3], according to WHO harmonized testing protocols. More information on the Scheme evaluation procedure can be found on the WHO website[4].

1.4 Product description

The Sydney 905 Purifier is a hollow-fibre membrane ultrafiltration device. The filter can be plumbed to a pressurized water supply, or connected to a raw water reservoir outlet such as a bucket or water tank and operated by gravity flow. The full product description, illustrations and use instructions can be found on the product website: www.safewater4u.com.

[1] These cut-off values were determined using QMRA modelling and selecting ranges that still resulted in appreciable health gains within a specific performance tier

[2] Terms of reference for the IAC can be found here: http://www.who.int/water_sanitation_health/water-quality/household/scheme-iac/en/

[3] Criteria for designated testing laboratories can be found here: http://www.who.int/water_sanitation_health/water-quality/household/testing-laboratories/en/

[4] http://www.who.int/water_sanitation_health/water-quality/household/scheme-household-water-treatment/en/

2 Methods and procedures

This report summarizes the laboratory testing of the Sydney 905 Purifier. The laboratory testing of the Sydney 905 Filter is summarized in a separate report.

The microbial performance of the Sydney 905 Purifier was evaluated under Round III of the Scheme. Testing followed the requirements of the WHO Scheme *Testing Protocol for Filtration Technologies V 3.2.* A product specific test plan was developed based on the WHO *Testing Protocol for Filtration Technologies V 3.2 (2020)* and the WHO *Harmonized Testing Protocol: Technology Non-Specific Version 3.0 (2019).* The product specific test plan was reviewed by WHO prior to finalization and test initiation, and is attached as Appendix A.

2.1 Test organisms

The test organisms were *Escherichia coli* (*E. coli*), representing bacterial pathogens; and coliphages MS2 and phiX174 were used to represent viral pathogens. For size exclusion filters, the Scheme *Testing Protocol for Filtration Technologies* allows for the protozoan pathogen reduction to be assigned based on the bacterial reduction achieved. As such, no testing against protozoan pathogens was conducted.

2.2 System wetted components or product ingredients

Appendix B shows the information provided by the manufacturer on the device wetted components. Materials in contact with drinking water must comply with WHO Guidelines for Drinking-water Quality (2017). The responsibility of verifying compliance is outside the scope of this test and report, however the information in this report provides documentation of the exact formulation tested and unless further discussion is provided, the results held in this report shall only be considered appropriate for the exact formulation. Changes to these ingredients require review by WHO.

2.3 Test configuration

Figure 1 shows the filter cartridges and accessories.

Fig. 1: the Sydney 905 Purifier as received

Figure 2 shows the test configuration with the test water vessel, pump, and the pipeline with water meter.

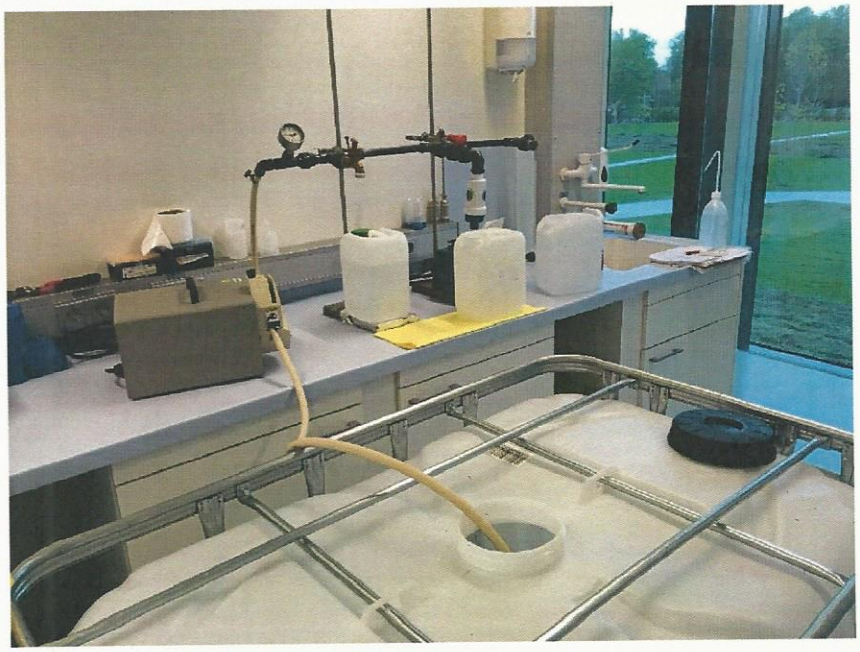


Fig. 2: Test configuration

Figure 3 shows backflushing of the filter and a sample of the effluent water.

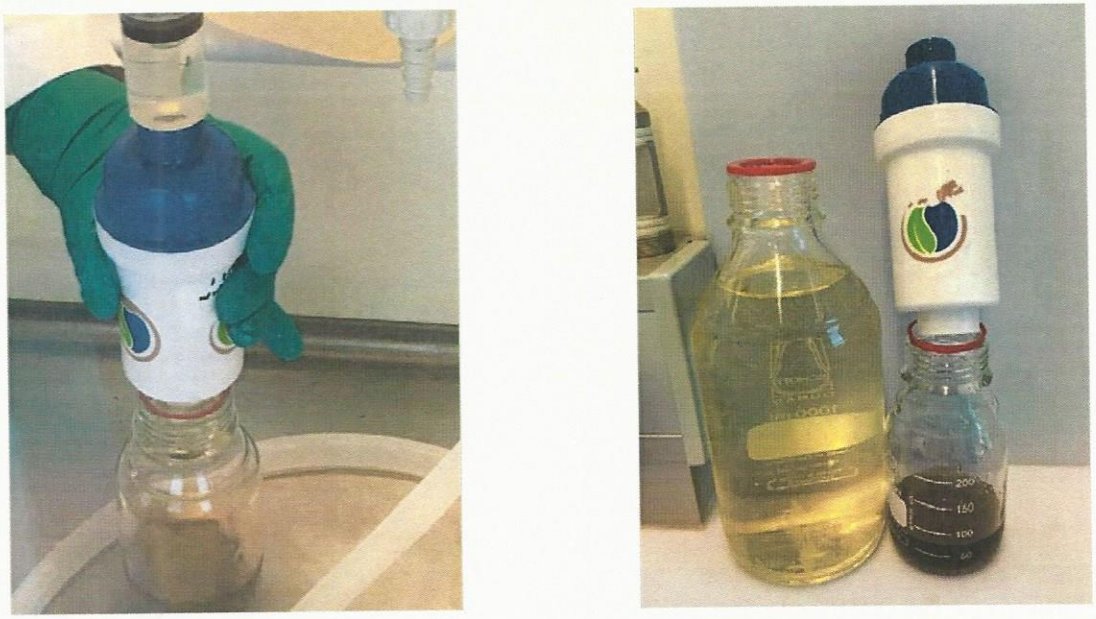


Fig. 3: Backflushing (image on left) and sample of effluent water (image on right)

2.4 Product-specific test plan

A product specific test plan, based on the technology and use pattern relevant HWT Scheme technology test plan, was required to detail the exact testing procedures and required approval by the WHO prior to testing.

2.4.1 Test Procedure

Three sample units of the Sydney 905 Purifier were selected for testing. The units were tested in General Test Water (GTW), simulating high quality groundwater with low turbidity and total

organic carbon; and a second test water: Challenge Test Water (CTW), simulating surface water with high turbidity and total organic carbon. Details on the test water specifications are provided in the WHO Scheme *Testing Protocol for Filtration Technologies V 3.2*. The test water characteristics for the current test are attached as Appendix C. The test units were plumbed to a supply line in the testing laboratory (see Fig. 2) and were operated according to the manufacturer's usage instructions.

The test duration was four days: Test Days 1 and 2 in the GTW and Test Days 3 and 4 in the CTW phase of testing. On Test Day 1 the filters were saturated with water using minimum pressure, for 30 seconds. The volumes were measured with a water meter, except during seeding and sample taking when a measuring cup was used.

During the test the pressure on the system was constantly monitored, and the speed of the pump was adjusted to maintain a maximum pressure of 4.5 Bar. To prevent water hammer exceeding normal use, the valve included by the manufacturer was used for each cycle (but see also 2.5.1). In addition, at the start of each test day and after backwashing the pump speed was increased gradually for each unit to prevent high pressures. A backflush as described in the maintenance instructions in the user manual, was scheduled at the start of Test Day 4.

Pre-treatment and post-treatment water grab samples were analyzed using the methods identified in the WHO Scheme *Testing Protocol for Filtration Technologies*.

2.5 Deviations / remarks from the test

2.5.1 Replacement of valve

There were two valves included with the filters. One of the valves had severe leakage along the spindle upon the first use. The other valve also started to leak after the test for the Sydney 905 Purifier (reported separately) was finalized. Therefore the valve was replaced with a ball valve from the laboratory (Fig.4).

Fig 4a: Ball valve used in the test

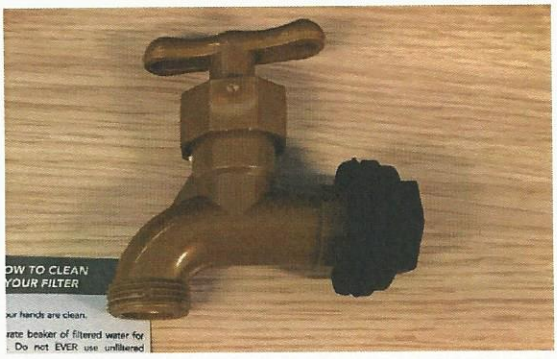


Fig 4b: The original valve

The replacement valve from the laboratory was opened at a speed comparable the original valve.

2.5.2 Flowrate and backflush

During testing with CTW on Test Day 3, the flow rate of the devices decreased significantly. During the GTW phase of the test, the flow rate ranged from 3.9 to 4.8 L/min, which dropped to between 0.3 and 1.1 L/min in CTW. According to the test plan, an additional back flush was applied on Test Day 3, but there was only a slight effect on the flow rate. .For this reason the total processed volume target of 100 L per day was not achieved on Test Days 3 and 4. Flow rate data are provided in Table 5 and Appendix D.

2.5.3 Breakage of test unit

On Test Day 3, Unit 3 broke (Fig. 5).

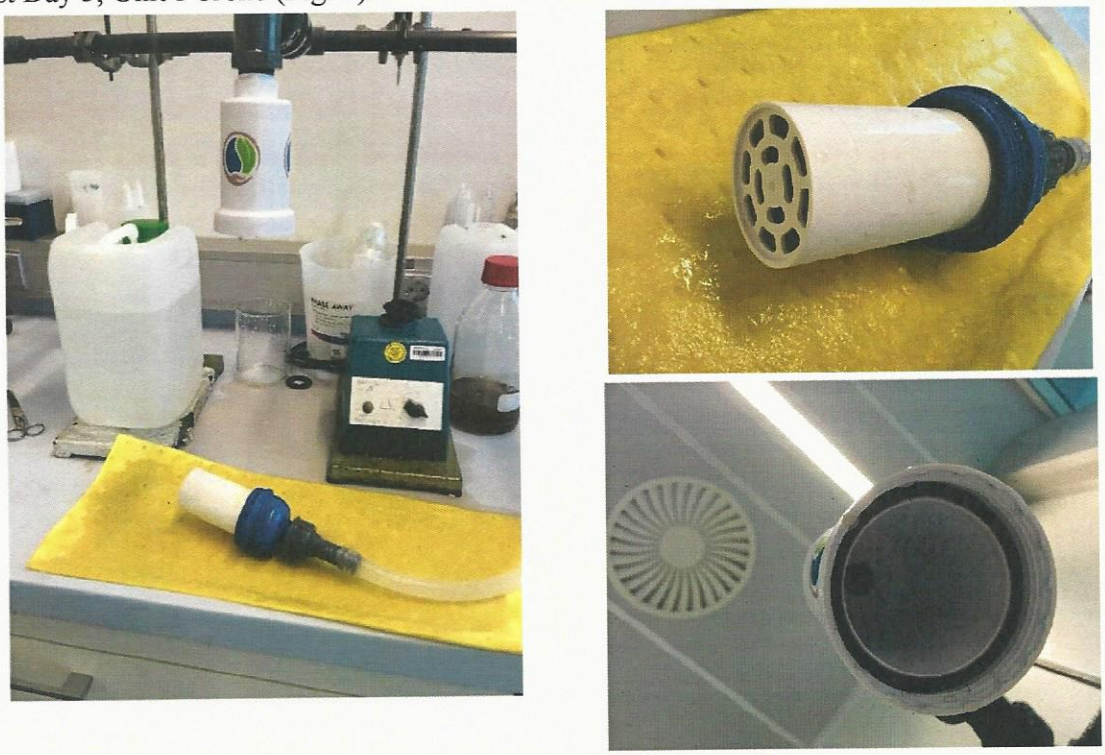


Fig 5: Unit 3, that broke during the test

This happened after the samples for that test day had already been collected. It was not possible to reattach the lower part of the filter properly, and therefore no further testing was possible using this unit.

3 Results

3.1 Microbial inactivation data

The following tables provide the geometric mean of the triplicate samples for all samples and log reduction at each microbiological challenge sample collection point.

3.1.1 Bacteria inactivation data

E. coli

The *E. coli* (ATCC 11229) was prepared using the method specified in Asburg, E.D. Methods of Testing Sanitizers and Bacteriostatic Substances; in Disinfection, Sterilization, and Preservation (Seymour S. Block, ed. 1983). The samples were assayed in triplicate with m-Endo medium using Method 9222B in Standard Methods for the Examination of Water and Wastewater (APHA, 2012). Table 2 shows the *E. coli* reduction data. Raw data are attached in Appendix D.

Table 2: *E. coli* reduction data

Challenge point	Sample	*E. coli* (cfu/ mL)	Log reduction
Day 1: GTW	Influent[1]	1.0×10^6	-
	Unit 1 effluent	16	4.8
	Unit 2 effluent	20	4.7
	Unit 3 effluent	< 0.01	> 8.0
Day 2: GTW	Influent	6.6×10^5	-
	Unit 1 effluent	< 0.01	> 7.8
	Unit 2 effluent	0.01	7.8
	Unit 3 effluent	0.02	7.5
	GTW mean		*6.8*
Day 3: CTW	Influent[1]	9.2×10^6	-
	Unit 1 effluent	0.37	7.4
	Unit 2 effluent	1.1	6.9
	Unit 3 effluent	0.22	7.6
Day 4: CTW	Influent[1]	8.0×10^6	-
	Unit 1 effluent	< 0.01	> 8.9
	Unit 2 effluent	< 0.01	> 8.9
	Unit 3 effluent	-	-
	CTW mean		*7.9*
Overall mean			**7.3**

[1]Influent challenge sufficient to demonstrate targeted log reduction

The influent challenge on Days 1, 3 and 4 met the targeted pre-treatment concentrations. The influent challenge concentration for Day 2 was slightly below the targeted influent concentration of 1×10^6, but was sufficient to allow for the demonstration of performance that exceeded the required minimum performance target. As such, the slightly lower pre-treatment challenge had no consequences on the results.

E. coli log reductions across the three units tested ranged from 4.7 to >8.0 in GTW and 6.9 to >8.9 in CTW, with an overall mean log reduction of 7.3.

3.1.2 Virus reduction data

MS2

The coliphage MS2 (ATCC 15597-B1) was prepared and assayed using: NEN-EN-ISO 10705-1 (Detection and enumeration of bacteriophages Part 1: Enumeration of F-specific RNA bacteriophage). The host organism was *Salmonella typhimurium* (WG49). Table 3 shows the MS2 reduction data. Raw data are attached in Appendix D.

Table 3: MS2 reduction data

Challenge point	Sample	MS2 (pfu/ mL)	Log reduction
Day 1: GTW	Influent[1]	4.6×10^6	-
	Unit 1 effluent	2.5×10^2	4.3
	Unit 2 effluent	2.4×10^2	4.3
	Unit 3 effluent	2.5×10^2	4.3
Day 2: GTW	Influent	3.6×10^6	-
	Unit 1 effluent	2.5×10^1	5.2
	Unit 2 effluent	2.2×10^1	5.2
	Unit 3 effluent	4.4×10^1	4.9
	GTW mean		*4.7*
Day 3: CTW	Influent[1]	1.3×10^7	-
	Unit 1 effluent	1.0×10^1	6.1
	Unit 2 effluent	8.0×10^0	6.2
	Unit 3 effluent	1.0×10^1	6.1
Day 4: CTW	Influent[1]	9.9×10^6	-
	Unit 1 effluent	< 1.0	> 7.0
	Unit 2 effluent	< 1.0	> 7.0
	Unit 3 effluent	-	-
	CTW mean		*6.5*
Overall mean			**5.5**

[1]Influent challenge sufficient to demonstrate targeted log reduction

MS2 reductions ranged from 4.3 to 5.2 in GTW, and 6.1 to >7.0 in CTW. The overall mean log reduction was for MS2 was 5.5.

phiX174

The coliphage phiX174 (ATCC 13706-B1) was prepared and assayed using: NEN-EN-ISO 10705-2 (Detection and enumeration of bacteriophages Part 2: Enumeration of somatic coliphages). The host organism was *E. coli* ATCC 13706 (WG5). Table 4 shows the phiX174 reduction data. Raw data are attached in Appendix D.

Table 4: phi-X174 reduction data

Challenge point	Sample	phiX174 (pfu/mL)	Log reduction
Day 1: GTW	Influent[1]	4.2×10^5	-
	Unit 1 effluent	1.1×10^1	4.6
	Unit 2 effluent	9.0×10^0	4.7
	Unit 3 effluent	1.4×10^1	4.5
Day 2: GTW	Influent	5.4×10^4	-
	Unit 1 effluent	1.7×10^0	4.5
	Unit 2 effluent	< 1.0	> 4.7
	Unit 3 effluent	3.3×10^0	4.2
	GTW mean		*4.5*
Day 3: CTW	Influent[1]	1.9×10^5	-
	Unit 1 effluent	< 1.0	> 5.7
	Unit 2 effluent	< 1.0	> 5.7
	Unit 3 effluent	1.0×10^0	5.7
Day 4: CTW	Influent[1]	6.3×10^5	-
	Unit 1 effluent	< 1.0	> 5.8
	Unit 2 effluent	< 1.0	> 5.8
	Unit 3 effluent	-	-
	CTW mean		*5.8*
Overall mean			**5.1**

[1]Influent challenge sufficient to demonstrate targeted log reduction

The pre-treatment concentration on Test Day 2 was lower than targeted in the test plan (1×10^5). However, it was sufficient to allow for the demonstration of log reductions of up to 4.7, which is higher than the reductions demonstrated on other test days i.e. Day 1. The lower pre-treatment concentration therefore had no consequence on the overall performance classification.

Log reductions of phiX174 ranged from 4.2 to 4.7 in GTW and from 5.7 to 5.8 in CTW. The overall mean phiX174 log reduction for was 5.1.

3.2 System flow, pressure and operation data

Table 5 shows the total volumes processed for each unit. The volumes were measured with a water meter, except during seeding and sample taking when a measuring cup was used. During the CTW phase of testing the flow rate of the devices decreased significantly. For this reason the total processed volume target of 100 L per day was not achieved on Test Days 3 and 4.

Table 5: Flow rates and volumes processed

Test day	Test water	Unit 1		Unit 2		Unit 3	
		Flow rate (L/hour)	Volume processed (L)	Flow rate (L/hour)	Volume processed (L)	Flow rate (L/hour)	Volume processed (L)
1	GTW	4.8	100	4.8	100	4.6	100
2	GTW	4.2	100	3.9	100	4.5	100
3	CTW	0.7	44.5	1.0	61.5	1.1	13.5
4	CTW	0.3	13.5	0.7	26	-	-

The pressure on the system was constantly monitored during the test. The pressure at the beginning of the 2 min cycle (start pressure) was in some cases higher than later on. When the pressure was getting towards 4.5 Bar the pump speed was decreased as soon as possible. Detailed data on processed volumes and pressures are included in Appendix C.

3.3 Water chemistry data

The following methods of analysis were used:

- Chlorine (total): SM 4500-Cl G or UNE-EN ISO 7393-1
- pH: SM 4500 H+ B
- Turbidity: EPA 180.1
- Temperature: SM 2550
- TDS: SM 2540C
- Alkalinity: SM 2320-B
- TOC: humic or tannic acid addition to the test water volume is to be weighted out based on the carbon content of the humic or tannic acid and is calculated to be within the test water specification range. As an alternate, SM 5310C, in water (GTW, lower TOC); SM 5310B, in water (CTW, higher TOC) may be used.

3.3.1 Test water characteristics

All GTW and CTW characteristics were within specifications.

3.4 Controls

All controls were per the product-specific test plan and as required by ISO 17025. For all methods both test water blanks and product blanks were negative. Positive controls for *E. coli*, MS2 and PhiX174 phages all complied with the quality control requirements.

4 Conclusion

Testing was completed in accordance with the product specific test plan (Appendix A), and the Evaluating household water treatment options: health-based targets and specifications (WHO, 2011). The Sydney 905 Purifier achieved mean $\log_{10}$ reductions of 7.3 for *E. coli*; 5.5 for MS2; and 5.1 for phiX174.

Resources

WHO (2011). Evaluating household water treatment options: health-based targets and microbiological performance specifications. Geneva: World Health Organization (https://apps.who.int/iris/handle/10665/44693).

WHO (2017). Guidelines for drinking-water quality, fourth edition incorporating first addendum. Geneva: World Health Organization (https://apps.who.int/iris/handle/10665/254637).

WHO (2018) Procedure for evaluation: WHO International Scheme to Evaluate Household Water Treatment Technologies. Geneva: World Health Organization (https://www.who.int/tools/international-scheme-to-evaluate-household-water-treatment-technologies/how-it-works).

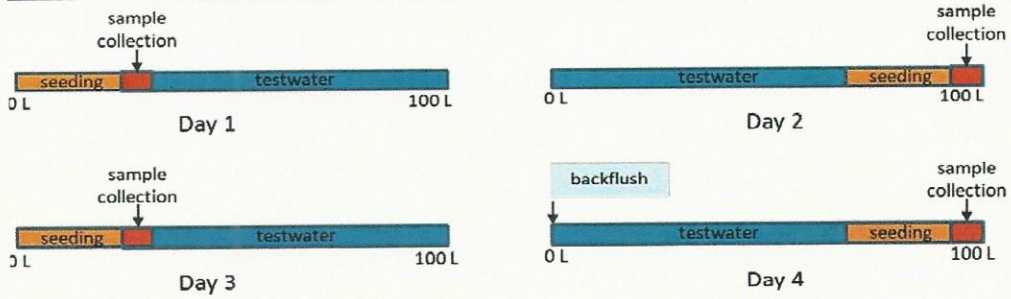
WHO (2019). Harmonized testing protocol: technology non-specific version 3.0. Geneva: World Health Organization (https://www.who.int/tools/international-scheme-to-evaluate-household-water-treatment-technologies/resources).

WHO (2020). Filtration Technology Testing Protocol. Geneva: World Health Organization (https://www.who.int/tools/international-scheme-to-evaluate-household-water-treatment-technologies/resources).

Appendix A: Product-specific test plan

Sydney 905 Purifier 0,01 micron

Points of attention	
HWT device	The 3 units will be installed in a pipe system, at the the end of the water supply feed using the supplied tap (see photo's installation).
Testing Water	To be prepared daily, during the running period and used for testing within 24 hours.
Daily Volume	100 L per day per unit or 2 hours of flowing, whichever is met first.
Testing	To be carried out on consecutive days. Test water will be hosed pumped into a pipe system with 3 tabs a water pressure and water volume meter. Units will be flowing one at the time.
on/off cycling	After/before seeding and sampling of units 1, 2 and 3, a cycling of 2 mins on (flowing) /1 minutes off (no flowing) will be manually applied, for the remaining daily volume for unit 1, 2 and 3.
Conditioning	Saturate the filters with water with minimum pressure for half a minute.
Seeding	2 L of test water will be used for seeding.
Sampling	A 3 L sample will be collected and subsampled for microbiological analyses.
Overnight storage	Filter will be disconnected and stored in a clean environment.
Backflush	At the start of day 4 maintenance of the filters will executed according to the user manual. When flow rate drops <50% before day 4, backflush may be applied earlier.
Flow rate	Will be determined with a water meter
Pressure	The pressure on the pipe system will be +/- 2.8 bar when the taps are closed (not exceeding 4.5 bar). The pressure during flowing will be recorded at the start and end of cycling.
Log	Log must be kept per unit of replacements events.



	GTW				CTW			
	Mo		Tue		Wed		Thu	
	Conditioning/ Seeding	Sampling at the start	Seeding	Sampling at the end	Seeding	Sampling at the start	Seeding	Sampling at the end
		③		③		③		③
		❷		❷		❷		❷
UNIT 1	V	❶	V	❶	V	❶	V	❶
UNIT 2	V	❶	V	❶	V	❶	V	❶
UNIT 3	V	❶	V	❶	V	❶	V	❶
Total MB/day		4		4		4		4
Total chem/day		1		1		1		1

UNIT 1 Sydney 905 Purifier

❶ **Effluent sample**
❷ **Pre-treatment sample**
③ **Test Water Characteristics sample**

Maintanance instruction for user manual:

Make sure your hands are clean.

Keep a separate beaker of filtered water for backwashing. Do not EVER use unfiltered water to backwash.

Unscrew the filter from the raw water connection or adapter.

Use the supplied plunger/syringe to suck up some filtered water from the beaker.

Insert the plunger/syringe nozzle into the nozzle of the filter on the blue side.

Depress the plunger/syringe forcing the water in the opposite flow direction which will purge all the sediments and dirt from the fibres and out the white inflow side nozzle. Do not exceed 0.5 bar backwashing pressure.

Repeat this process a few times until you see that the purged water is as clear as the filtered water being used to backwash.

Reattach the filter for reuse.

Parameters

	Treatment process	Microbiological Parameter *					Other	
		E. coli	MS-2	PhiX-174	Crypto Enumeration	Crypto Infectivity	Residual samples	total
	Gravity flow batch system, with ceramic filter	440 ml	8 ml	8 ml				456 ml

* Volume for processing in triplicate and a retain volume (ml)

Microbiological samples:

For tested microorganisms (MO) see parameters table above.

❶ **Effluent sample**
To determine the efficiency of the tested system, concentration of MO to be compared with ❷

❷ **Pre-treatment sample**
To determine the influent or pretreatment concentration of MO in the spiked test water.
To be collected immediately after ❶ and stored in the dark at 5±3°C.

Chemical samples

③ **Test Water Characteristics sample**
After preparation of the test waters, it should be tested for Chlorine, pH, TOC Turbidity, Temp, TDS and Alkalinity.
This should meet the specifications as mentioned in het test water tables

List of samples per type

0,01 MICRON

	Microbiology	Spiked	Pre/Post treatment	GTW/CTW
❶	Effluent sample unit 1 D1	YES	POST	G
	Effluent sample unit 1 D2	YES	POST	G
	Effluent sample unit 1 D3	YES	POST	C
	Effluent sample unit 1 D4	YES	POST	C
	Effluent sample unit 2 D1	YES	POST	G
	Effluent sample unit 2 D2	YES	POST	G
	Effluent sample unit 2 D3	YES	POST	C
	Effluent sample unit 2 D4	YES	POST	C
	Effluent sample unit 3 D1	YES	POST	G
	Effluent sample unit 3 D2	YES	POST	G
	Effluent sample unit 3 D3	YES	POST	C
	Effluent sample unit 3 D4	YES	POST	C
❷	Pre-treatment sample D1	YES	PRE	G
	Pre-treatment sample D2	YES	PRE	G
	Pre-treatment sample D3	YES	PRE	C
	Pre-treatment sample D4	YES	PRE	C
	Chemical			
③	Test water Characteristics D1	NO	PRE	G
	Test water Characteristics D2	NO	PRE	G
	Test water Characteristics D3	NO	PRE	C
	Test water Characteristics D4	NO	PRE	C

List of samples per type

0,01 MICRON

	Microbiology	Spiked	Pre/Post treatment	GTW/CTW
❶	Effluent sample unit 1 D1	YES	POST	G
	Effluent sample unit 1 D2	YES	POST	G
	Effluent sample unit 1 D3	YES	POST	C
	Effluent sample unit 1 D4	YES	POST	C
	Effluent sample unit 2 D1	YES	POST	G
	Effluent sample unit 2 D2	YES	POST	G
	Effluent sample unit 2 D3	YES	POST	C
	Effluent sample unit 2 D4	YES	POST	C
	Effluent sample unit 3 D1	YES	POST	G
	Effluent sample unit 3 D2	YES	POST	G
	Effluent sample unit 3 D3	YES	POST	C
	Effluent sample unit 3 D4	YES	POST	C
❷	Pre-treatment sample D1	YES	PRE	G
	Pre-treatment sample D2	YES	PRE	G
	Pre-treatment sample D3	YES	PRE	C
	Pre-treatment sample D4	YES	PRE	C
	Chemical			
③	Test water Characteristics D1	NO	PRE	G
	Test water Characteristics D2	NO	PRE	G
	Test water Characteristics D3	NO	PRE	C
	Test water Characteristics D4	NO	PRE	C

Appendix B: System wetted components

SYSTEM WETTED AND PERFORMANCE IMPACTING COMPONENTS[1]				
Component	**Manufacturer**	**Model/Specifications**	**Material**	**WHO review** *(WHO to complete)*
Example: Gasket	Company XYZ	Model # 12345	FDA Silicone, 21 CFR.177.2600	
Inlet Casing			Homopolymer Polypropylene	
Outlet Casing			Homopolymer Polypropylene	
Hollow Fibre Module Case			ABS	
Hollow Fibres			Polyolefin/Polysulfone	
Hollow Fibre's Sheath			Polyester	
Hollow Fibre Potting Resin			Polyurethane	

[1]Changes to components or processing from that tested shall require review by the WHO for consideration of additional testing to qualify changed components in a tested system

Appendix C: Test water characteristics

Test water characteristics

Analysis	Units	GTW day 1	GTW day 2	CTW day 3	CTW day 4
		LMC-106959-SYNTH	LMC-106960-SYNTH	LMC-106961-SYNTH	LMC-106962-SYNTH
		10-19-2020	10-20-2020	10-21-2020	10-22-2020
pH	pH	6.9	6.9	9.0	9.0
Temperature (pH)	°C	20.1	19.7	18.0	18.4
TOC	mg C/l	1.2	1.3	16	17
Turbidity	FNE	0.10	<0.10	33	36
Total dissolved solids (TDS)	mg/l	225	245	1415	1480
Alkalinity	mg CaCO3/l	96	105	100	105

Appendix D: Raw data and bench sheets

	Unit 1	Water meter	Water count (L)	Processed volume/ cycle (L)	Start pressure (Bar)	Pressure (Bar)
Day 1	**Seeding & sample taking**		5	5		
	Start	407	5	0		
	Cycle 1 (2 min)	417	15	10		
	Cycle 2 (4 min)	424	22	7		
	Cycle 3 (6 min)	433	31	9		
	Cycle 4 (8 min)	442	40	9	Monitored below 4,5 bar during the whole test	
	Cycle 5 (10 min)	451	49	9		
	Cycle 6 (12 min)	460	58	9		
	Cycle 7 (14 min)	471	69	11		
	Cycle 8 (16 min)	483	81	12		
	Cycle 9 (18 min)	493	91	10		
	Final cycle	502	**100**	9		
	Avarage flow rate L/min	4,8				

Day 2	Start	597	0	0	3,8	3,4
	Cycle 1 (2 min)	606	9	9	1	3,2
	Cycle 2 (4 min)	616	19	10	3,4	2,8
	Cycle 3 (6 min)	624	27	8	2,8	2,8
	Cycle 4 (8 min)	633	36	9	2,6	2,4
	Cycle 5 (10 min)	641	44	8	2,4	3,0
	Cycle 6 (12 min)	648	51	7	3,4	3,4
	Cycle 7 (14 min)	657	60	9	3,6	3,6
	Cycle 8 (16 min)	665	68	8	3,7	3,7
	Cycle 9 (18 min)	673	76	8	3,7	3,6
	Cycle 10 (20 min)	682	85	9	3,6	3,6
	Cycle 11 (22 min)	690	93	8		3,6
	Final cycle	692	95	2		
	Seeding & sample taking		**100**	5		
	Avarage flow rate L/min	4,2				

	Unit 1	Water meter	Water count (L)	Processed volume/ cycle (L)	Start pressure (Bar)	Pressure (Bar)
Day 3	**Seeding & sample taking**		5	5		
	Start	882	5	0	4,4	4,2
	Cycle 1 (2 min)	883	6	1	4,4	4,4
	Cycle 2 (4 min)	884	7	1	4	3,8
	Cycle 3 (6 min)	884	7	0	4	4
	Cycle 4 (8 min)	886	9	2	4	4
	Cycle 5 (10 min)	888,5	11,5	2,5	4,2	4
	Cycle 6 (12 min)	890,5	13,5	2	3,8	4
	Cycle 7 (14 min)	892,5	15,5	2	3,8	3,9
	Cycle 8 (16 min)	894,5	17,5	2	4,3	4
	Cycle 9 (18 min)	896,5	19,5	2	4,5	4,2
	Cycle 10 (20 min)	898	21	1,5	4,6	4,2
	Cycle 11 (22 min)	900	23	2	4	3,8
	Cycle 12 (24 min)	902	25	2	4	3,8
	Cycle 13 (26 min)	903	26	1	4,4	3,8
	Cycle 14 (28 min)	904,5	27,5	1,5	4,2	3,6
	Cycle 15 (30 min)	905,5	28,5	1	3,4	3,4
	Cycle 16 (32 min)	907	30	1,5	4	3,8
	Cycle 17 (34 min)	908	31	1	3,8	4
	Cycle 18 (36 min)	909	32	1	4	3,8
	Cycle 19 (38 min)	910,5	33,5	1,5	3,8	4
	Cycle 20 (40 min)	911,5	34,5	1	3,8	4
	Cycle 21 (42 min)	913	36	1,5	3,8	3,8
	Cycle 22 (44 min)	914	37	1	4,4	3,8
	Cycle 23 (46 min)	915	38	1	4,2	3,8
	Cycle 24 (48 min)	916	39	1	4	3,8
	Cycle 25 (50 min)	917	40	1	3,8	3,8
	Cycle 26 (52 min)	918	41	1	4	3,8
	Cycle 27 (54 min)	919	42	1	4,4	4
	Cycle 28 (56 min)	919,5	42,5	0,5	4,2	4
	Cycle 29 (58 min)	921	44	1,5	3,2	4
	Cycle 29 (58 min)	921,5	**44,5**	0,5	4,4	4
	Avarage flow rate L/min	0,7				

Day 4	Start	987,5	0	0		
	Cycle 1 (2 min)	991	3,5	3,5	3,8	3,8
	Cycle 2 (4 min)	991	3,5	0	3,6	3,8
	Cycle 3 (6 min)	992	4,5	1	3,8	3,4
	Cycle 4 (8 min)	992,5	5	0,5	4	4
	Cycle 5 (10 min)	993	5,5	0,5	4,2	4
	Cycle 6 (12 min)	993,5	6	0,5	4,4	4,4
	Cycle 7 (14 min)	994	6,5	0,5	4,2	4
	Cycle 8 (16 min)	994,5	7	0,5	4,4	4
	Cycle 9 (18 min)	995	7,5	0,5	4,2	4,2
	Cycle 10 (20 min)	995,5	8	0,5	4,2	3,8
	Cycle 11 (22 min)	995,5	8	0	4,8	4,2
	Cycle 12 (24 min)	995,5	8	0	4,8	4,2
	Cycle 13 (26 min)	996	8,5	0,5	4,2	4,2
	Cycle 14 (28 min)	996	8,5	0	4,2	4
	Cycle 15 (30 min)	996	8,5	0	4,6	4,4
	Seeding & sample taking		**13,5**	5		
	Avarage flow rate L/min	0,3				

Backflush, 3x 50ml

	Unit 2	Water meter	Water count (L)	Processed volume/ cycle (L)	Start pressure (Bar)	Pressure (Bar)
Day 1	**Seeding & sample taking**		5	5		
	Start	312	5	0		
	Cycle 1 (2 min)	321	14	9		
	Cycle 2 (4 min)	330	23	9		
	Cycle 3 (6 min)	339	32	9		
	Cycle 4 (8 min)	348	41	9	Monitored below 4,5 bar during the whole test	
	Cycle 5 (10 min)	358	51	10		
	Cycle 6 (12 min)	368	61	10		
	Cycle 7 (14 min)	378	71	10		
	Cycle 8 (16 min)	388	81	10		
	Cycle 9 (18 min)	398	91	10		
	Final cycle	407	**100**	9		
	Avarage flow rate L/min	4,8				
Day 2	Start	692	0	0		
	Cycle 1 (2 min)	698	6	6	4	3,6
	Cycle 2 (4 min)	705	13	7	3,8	3,4
	Cycle 3 (6 min)	713	21	8	3,6	3,4
	Cycle 4 (8 min)	722	30	9	3,4	3,4
	Cycle 5 (10 min)	730	38	8	3,4	3,2
	Cycle 6 (12 min)	738	46	8	3,4	3,2
	Cycle 7 (14 min)	746	54	8	2,8	2,6
	Cycle 8 (16 min)	754	62	8	2,4	2,4
	Cycle 9 (18 min)	762	70	8	2,8	3
	Cycle 10 (20 min)	770	78	8	3,2	3,4
	Cycle 11 (22 min)	778	86	8	3,4	3,4
	Final Cycle	787	95	9	3,4	3,5
	Seeding & sample taking		**100**	5		
	Avarage flow rate L/min	3,9				

	Unit 2	Water meter	Water count (L)	Processed volume/ cycle (L)	Start pressure (Bar)	Pressure (Bar)
Day 3	**Seeding & sample taking**		5	5		
	Start	921,5	5	0		
	Cycle 1 (2 min)	924	7,5	2,5	3,8	3,4
	Cycle 2 (4 min)	926	9,5	2	3,6	3,8
	Cycle 3 (6 min)	928,5	12	2,5	3,8	4
	Cycle 4 (8 min)	930,5	14	2	4,2	4,2
	Cycle 5 (10 min)	933	16,5	2,5	4,6	4,4
	Cycle 6 (12 min)	935	18,5	2	4,4	4,4
	Cycle 7 (14 min)	937	20,5	2	4,6	4,2
	Cycle 8 (16 min)	939	22,5	2	4,4	4,2
	Cycle 9 (18 min)	941	24,5	2	4,4	4,2
	Cycle 10 (20 min)	943	26,5	2	4,4	4,2
	Cycle 11 (22 min)	944,5	28	1,5	4,4	4,2
	Cycle 12 (24 min)	946	29,5	1,5	4,4	4,2
	Cycle 13 (26 min)	948	31,5	2	4,4	4,2
	Cycle 14 (28 min)	949	32,5	1	4,4	4,2
	Cycle 15 (30 min)	951	34,5	2	4,4	4
	Cycle 16 (32 min)	951	34,5	0	3,8	3,6
	Cycle 17 (34 min)	953,5	37	2,5	3,6	3,6
	Cycle 18 (36 min)	957	40,5	3,5	3,6	3,8
	Cycle 19 (38 min)	959	42,5	2	4	4,2
	Cycle 20 (40 min)	961	44,5	2	4	4
	Cycle 21 (42 min)	963	46,5	2	4,6	3,8
	Cycle 22 (44 min)	964,5	48	1,5	4,2	3,8
	Cycle 23 (46 min)	965,5	49	1	4,4	3,8
	Cycle 24 (48 min)	967	50,5	1,5	4,4	4
	Cycle 25 (50 min)	969	52,5	2	4,4	4,2
	Cycle 26 (52 min)	970,5	54	1,5	4,6	4,4
	Cycle 27 (54 min)	972	55,5	1,5	4,4	4,2
	Cycle 28 (56 min)	974	57,5	2	4,6	4,4
	Cycle 29 (58 min)	975,5	59	1,5	4,4	4
	Cycle 29 (58 min)	978	**61,5**	2,5	4,2	4
	Avarage flow rate L/min	1,0				

Day 4	Start	996	0	0		
	Cycle 1 (2 min)	997,5	1,5	1,5	3,6	2,8
	Cycle 2 (4 min)	999	3	1,5	3,4	3,4
	Cycle 3 (6 min)	1001	5	2	4	3,8
	Cycle 4 (8 min)	1003	7	2	4	3,6
	Cycle 5 (10 min)	1004,5	8,5	1,5	3,8	3,6
	Cycle 6 (12 min)	1006	10	1,5	4,4	3,8
	Cycle 7 (14 min)	1007,5	11,5	1,5	4,4	4,2
	Cycle 8 (16 min)	1007,5	11,5	0	4	4
	Cycle 9 (18 min)	1010	14	2,5	4	
	Cycle 10 (20 min)	1011,5	15,5	1,5	3,8	4,2
	Cycle 11 (22 min)	1013,5	17,5	2	4,4	3,4
	Cycle 12 (24 min)	1014,5	18,5	1	4,4	3,4
	Cycle 13 (26 min)	1015,5	19,5	1	3,6	3,4
	Cycle 14 (28 min)	1016,5	20,5	1	3,8	3,6
	Cycle 15 (30 min)	1017	21	0,5	4	3,8
	Seeding & sample taking		**26**	5	4	3,9
	Avarage flow rate L/min	0,7				
		Backflush, 3x 50ml				

	Unit 3	Water meter	Water count (L)	Processed volume/ cycle (L)	Start pressure (Bar)	Pressure (Bar)
Day 1	**Seeding & sample taking**		5	5		
	Start	502	5	0		
	Cycle 1 (2 min)	507	10	5		
	Cycle 2 (4 min)	518	21	11		
	Cycle 3 (6 min)	527	30	9		
	Cycle 4 (8 min)	537	40	10	Monitored below 4,5 bar during the whole test	
	Cycle 5 (10 min)	546	49	9		
	Cycle 6 (12 min)	555	58	9		
	Cycle 7 (14 min)	564	67	9		
	Cycle 8 (16 min)	574	77	10		
	Cycle 9 (18 min)	583	86	9		
	Cycle 10 (20 min)	593	96	10		
	Final cycle	597	**100**	4		
	Avarage flow rate L/min	4,6				

Day 2	Start	787	0	0		
	Cycle 1 (2 min)	795	8	8	3,8	3,4
	Cycle 2 (4 min)	805	18	10	3,2	2,8
	Cycle 3 (6 min)	815	28	10	3,4	3,4
	Cycle 4 (8 min)	825	38	10	3,2	3,4
	Cycle 5 (10 min)	834	47	9	3,4	3,4
	Cycle 6 (12 min)	843	56	9	3,4	3,2
	Cycle 7 (14 min)	851	64	8	3,4	3,4
	Cycle 8 (16 min)	860	73	9	3	3
	Cycle 9 (18 min)	868	81	8	3,2	3
	Cycle 10 (20 min)	876	89	8	2,8	2,8
	Final cycle	882	95	6	2,6	2,6
	Seeding & sample taking		**100**	5		
	Avarage flow rate L/min	4,5				

Day 3	**Seeding & sample taking**		5	5		
	Start	978	5	0		
	Cycle 1 (2 min)	981	8	3	3,8	3,6
	Cycle 2 (4 min)	982,5	9,5	1,5	3,6	3,6
	Cycle 3 (6 min)	985	12	2,5	3,6	3,8
	Cycle 4 (8 min)	986,5	**13,5**	1,5	4	3,8
	Cycle 5 (10 min)	-	-	-	4	3,8
	Avarage flow rate L/min	1,1				

MS2 Results 0,01 Micron

	Day 1	Day 2	Day 3	Day 4
Positive control (pfu)	101	65	86	128
Complies with requirements	Yes	Yes	Yes	Yes

Description	Test water	Sample code	Dilution factor	Tested volume (ml)	pfu	pfu	pfu	pfu/ ml
Pre-treatment control								
Day 1	GTW	106703	100000	1	46	44	49	4,6E+06
Day 2		106709	100000	1	52	30	27	3,6E+06
Day 3	CTW	106719	100000	1	104	110	183	1,3E+07
Day 4		106728	100000	1	103	95	99	9,9E+06
Unit 1								
Day 1	GTW	106704	1	1	231	245	260	2,5E+02
Day 2		106712	1	1	26	29	20	2,5E+01
Day 3	CTW	106721	1	1	15	7	8	1,0E+01
Day 4		106731	1	1	0	0	0	< 1,0E+00
Unit 2								
Day 1	GTW	106705	1	1	224	238	250	2,4E+02
Day 2		106714	1	1	23	16	26	2,2E+01
Day 3	CTW	106723	1	1	7	8	9	8,0E+00
Day 4		106733	1	1	0	0	0	< 1,0E+00
Unit 3								
Day 1	GTW	106707	1	1	262	258	241	2,5E+02
Day 2		106717	1	1	56	42	35	4,4E+01
Day 3	CTW	106726	1	1	7	13	11	1,0E+01
Day 4		-						

PhiX-174 Results 0,01 Micron

	Day 1	Day 2	Day 3	Day 4
Positive control (pfu)	87/103	77	92	101
Complies with requirements	Yes	Yes	Yes	Yes

Description	Test water	Sample code	Dilution factor	Tested volume (ml)	pfu	pfu	pfu	pfu/ ml
Pre-treatment control								
Day 1	GTW	106703	10000	1	41	44	41	4,2E+05
Day 2		106709	1000	1	50	61	51	5,4E+04
Day 3	CTW	106719	10000	1	56	54	58	5,6E+05
Day 4		106728	10000	1	58	66	64	6,3E+05
Unit 1								
Day 1	GTW	106704	1	1	12	10	10	1,1E+01
Day 2		106712	1	1	1	2	2	1,7E+00
Day 3	CTW	106721	1	1	1	0	0	< 1,0E+00
Day 4		106731	1	1	0	0	0	< 1,0E+00
Unit 2								
Day 1	GTW	106705	1	1	7	8	12	9,0E+00
Day 2		106714	1	1	1	1	1	1,0E+00
Day 3	CTW	106723	1	1	1	0	0	< 1,0E+00
Day 4		106733	1	1	0	0	0	< 1,0E+00
Unit 3								
Day 1	GTW	106707	1	1	18	9	16	1,4E+01
Day 2		106717	1	1	2	5	3	3,3E+00
Day 3	CTW	106726	1	1	1	0	2	1,0E+00
Day 4		-						

E. coli Results 0,01 Micron

	Day 1	Day 2	Day 3	Day 4
Positive control (pfu)	62	76	60	68
Complies with requirements	Yes	Yes	Yes	Yes

Description	Test water	Sample code	Dilution factor	Tested volume (ml)	cfu	cfu	cfu	cfu/ ml
Pre-treatment control								
Day 1	GTW	106703	1000	0,1	74	129	101	1,0E+06
Day 2		106709	1000	0,1	45	85	46	6,6E+05
Day 3	CTW	106719	10000	0,1	100	117	67	9,2E+06
Day 4		106728	10000	0,1	66	79	80	8,0E+06
Unit 1								
Day 1	GTW	106704	1	1	16	12	19	1,6E+01
Day 2		106712	1	100	0	0	0	< 1,0E-02
Day 3	CTW	106721	1	100	41	33	40	3,7E-01
Day 4		106731	1	100	0	0	1	< 1,0E-02
Unit 2								
Day 1	GTW	106705	1	1	36	20	19	2,0E+01
Day 2		106714	1	100	0	0	0	< 1,0E-02
Day 3	CTW	106723	1	100	107	115	111	1,1E+00
Day 4		106733	1	100	0	0	2	< 1,0E-02
Unit 3								
Day 1	GTW	106707	1	100	0	0	0	< 1,0E-02
Day 2		106717	1	100	2	2	2	2,0E-02
Day 3	CTW	106726	1	100	17	21	23	2,2E-01
Day 4		-	1					