HOSPITAL TECHNICAL MEMORANDUM NO 63

Western Cape Government Health BETTER TOGETHER.	**WATER CONSERVATION & RECYCLING IN HEALTHCARE FACILITIES** **DIRECTORATE: INFRASTRUCTURE PLANNING**	**DOCUMENT**	**WATER CONSERVATION & RECYCLING**
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1. BACKGROUND

South Africa is listed as the 30th driest country in the world, yet the average water consumption per person per day exceeds that of Europe, surpassing 200 litres per person per day. As water shortages are becoming a harsh reality within South Africa and particularly the Western Cape Province, it is the responsibility of every sector of industry to re-evaluate their uses and overall treatment of this precious resource so that it may be conserved and used responsibly.

Given that the bulk of a healthcare facilities' water consumption lies within the services of the facility not requiring potable high quality water, utilising water which is "fit-for-purpose" will result in a dramatic reduction in municipal water consumption.

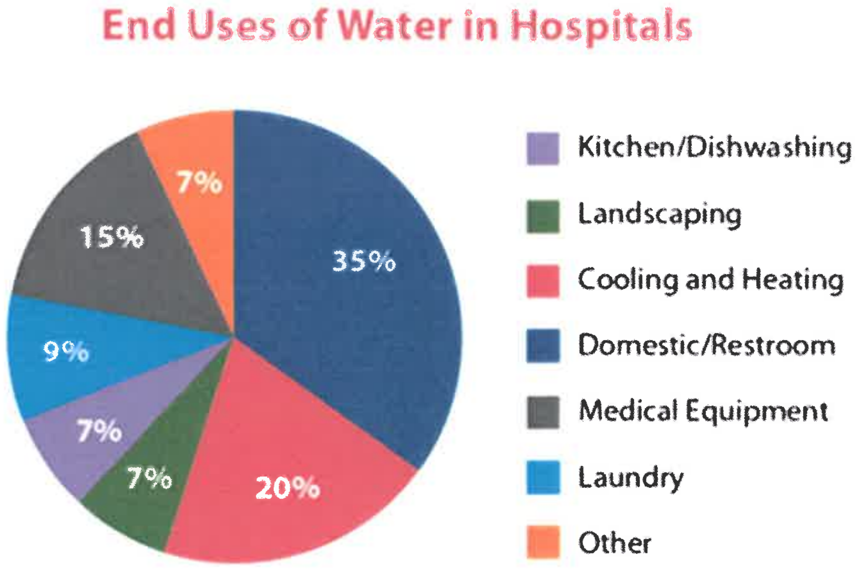

FIGURE 1: TYPICAL WATER REQUIREMENTS AT A HEALTHCARE FACILITY (ENVIRONMENTAL PROTECTION AGENCY (EPA), 2012)

FIGURE 2: SUMMARY OF PROPORTIONAL WATER USES IN VICTORIAN HEALTH CARE FACILITIES (VICTORIAN GOVERNMENT DEPARTMENT OF HEALTH, 2009)

2. OBJECTIVE

The primary function of this document is to provide terms of reference for consultants who are contacted to engineer systems responsible for the provision of wet building services of state healthcare facilities, with the re-use of rainwater and (treated) grey and black wastewater to be considered. Design consultants are required to investigate systems that are practical and appropriate for the geographic location of the facility and do not necessarily need to use the best available technology.

3. GUIDELINES

The guidelines to be consulted by any designer when undertaking Water Conservation and Water Sensitive Urban Design (WSUD) include, inter alia, the following:

- Small waste water treatment works, Department of Public Works (DPW) Design Guidelines
- SANS10252 Part 1 - Water Supply Installations for Buildings
- SANS10252 Part 2 – Drainage Installations for Buildings
- SANS 241 Part 1 and 2 – Drinking water quality requirements
- SANS10248 – Management of healthcare waste
- IUSS Health Facility Guides: Building Engineering Services
- Alternative Technology for Stormwater Management: The South African Guidelines for Sustainable Drainage Systems, by N. Armitage et. al (2013), WRC
- Water Sensitive Urban Design (WSUD) for South Africa: Framework and Guidelines, by N. Armitage et. al (2014), WRC

4. WATER CONSUMPTION

4.1. HEALTHCARE SERVICES

In the healthcare environment, domestic water is currently used to serve the following purposes (excluding fire-fighting):

- Potable water consumption
- Ablution facilities for staff (including scrub-up for medical personnel) and patients
- Washing, cleaning and sterilisation throughout the facility.
- Heating, Ventilation and Cooling (i.e. hot water and chilled water supply for space heating and cooling, respectively)[1]

On average, water usage for each kind of facility ranges between 20 and 450 litres per capita per day, depending on the level of care provided by the facility and its level of water efficiency.

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[1] These systems operate using a closed cycle, in most cases only requiring make up water to compensate for losses through cooling towers.

TABLE 1: VARIOUS TYPES OF HEALTHCARE FACILITIES AND THEIR TYPICAL WATER DEMAND

Facility	Operating Hours	Total water demand*
Emergency Medical Services (EMS)	24/7	50 Litres/EM staff /day
Forensic Pathology Labs	5 days per week, 8hrs per day	50 Litres/post mortem/day
Clinics	5 days per week, 8hrs per day	20-30 Litres/head count/day
Community Day Centres (CDC)	5 days per week, 8hrs per day	30-40 Litres/head count/day
Community Health Centre (CHC)	24/7	30-40 Litres/head count/day**
District, Regional & Provincial Hospitals	24/7	300-450 Litres/bed/day
Central Hospital	24/7	300-450 Litres/bed/day

*Figures obtained through use of SANS10252-1 and experience of existing facilities.
** Dependent on size of MOU. If present, 50 L/head count/day

Note: Where a minimum and maximum total water demand is specified in the table above, the target water demand for any facility should be the minimum amount specified.

4.2. WASTEWATER CLASSIFICATION

The various wastewater streams produced by a facility are classified as belonging to one of three categories, either Hazardous, Black or Grey wastewater.

- Hazardous wastes generally include infectious waste, anatomical (pathological) waste, chemical waste, pharmaceutical waste and radioactive waste.
- Black wastewater includes wastewater produced by the flushing of toilets and from kitchen sinks
- Grey wastewater includes waste produced through the use of basins, baths and showers containing large amounts of soaps, fats, oils and skin cells.

TABLE 2: CLASSES OF WASTEWATER AND THEIR CONSTITUENTS

Class	Constituents of water waste stream	Typical source
Hazardous*	Urine, blood, faeces and vomit from patients, which may contain, *inter alia*, viruses, multi-resistant bacteria, antibiotics, hormone-disrupting substances and potentially hazardous amounts of administered cytotoxic drugs or their metabolites (which should be considered genotoxic for at least 48 hours).	In-patient ablutions and toilets, Sluice Rooms, Radiology etc.
Black	Faecal matter, urine, organic waste	Out-patient ablutions and toilets, Kitchen sinks
Grey**	Fats, oils, soaps, disinfectants and other household cleaning products typically released through baths, showers. This DOES NOT include harsh chemical cleaning products such as drain cleaners etc.	Basins, Showers/Baths, CSSD, Car wash bays, Cooling Towers, Laundry, Swimming pool[2]

*It is assumed that all hazardous waste generated within a facility is defined in accordance with and disposed of as required by SANS 10248. Furthermore, the table above does not cater for toxic chemicals or cleaning products (such as drain cleaners) which may be used intermittently.

**Phosphate free washing powder must be used in healthcare facilities implementing waste water treatment, as it reduces the nutrient load on any (biological) treatment system. Greywater containing Phosphate, if not removed, can poison soil when used over extended periods of time for irrigation. The use of fabric softeners, Sodium Hypochlorite (i.e. JIK) and anionic surfactants must also be avoided. This requirement is aligned with the Green Procurement Strategy.

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[2] Note that the presence of Chlorine will detract from the natural biological process which may be used to remove pollutants from a grey wastewater stream.

5. WATER CONSERVATION

5.1. PRINCIPLES

It must be shown that any investigation, for the purposes of water conservation, at a new or existing facility, has gone through each of the stages as indicated in Figure 3, as significant reductions in water consumption can be made with little to no cost. If all stages are implemented, a total reduction of up to 60% in water consumption can be expected.

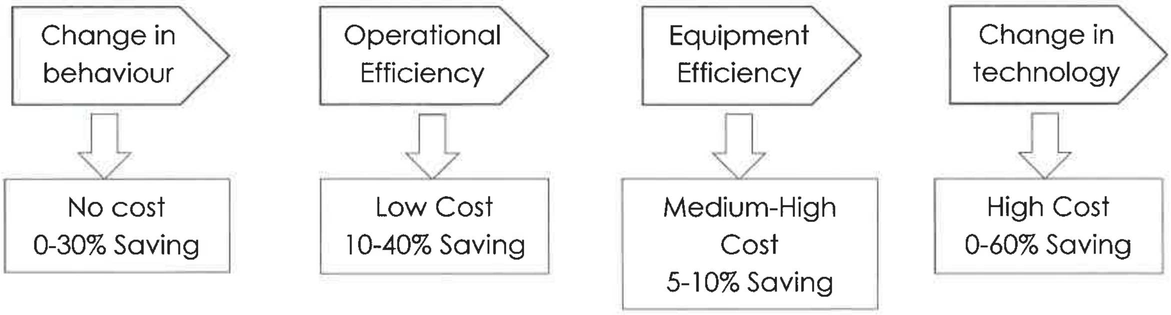

FIGURE 3: STAGES IN ACHIEVING OPTIMUM WATER EFFICIENCY (BESTER, 2017)

With all water conservation initiatives, risk to public health must be kept in mind. Initiatives presenting the least risk to public health are those aimed at reducing consumption, for instance through behavioural changes. Initiatives involving water recycling present the greatest risk to public health.

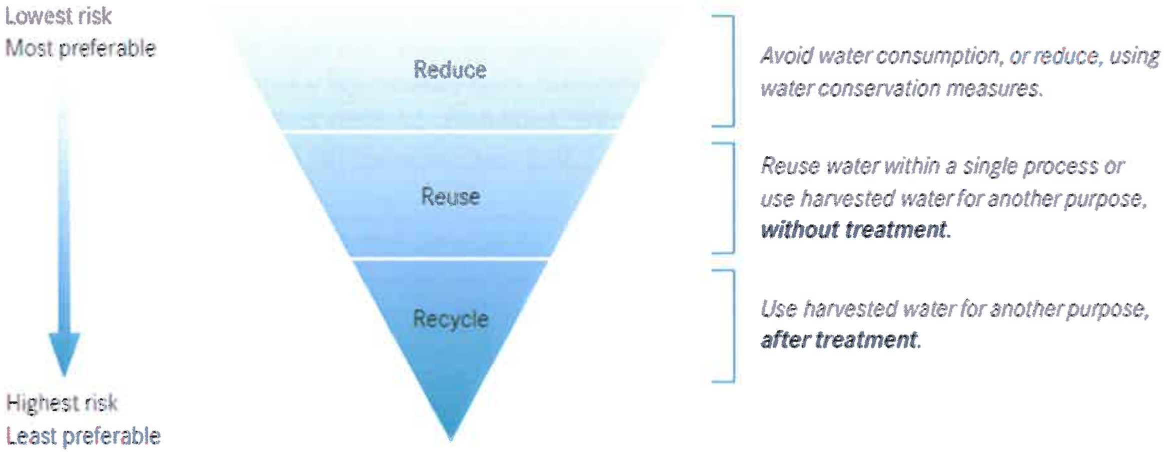

FIGURE 4: RISK HIERARCHY FOR WATER CONSERVATION, REUSE AND RECYCLING PROJECTS (VICTORIAN GOVERNMENT DEPARTMENT OF HEALTH, 2009)

When considering water reuse and recycling, sources which provide relatively "clean" wastewater should be harnessed first. As the level of pollution increases in the wastewater produced, so do the treatment requirements and the associated level of risk. Hence, recycling of wastewater should only take place once all other avenues (i.e. reduction and reuse) have been exhausted.

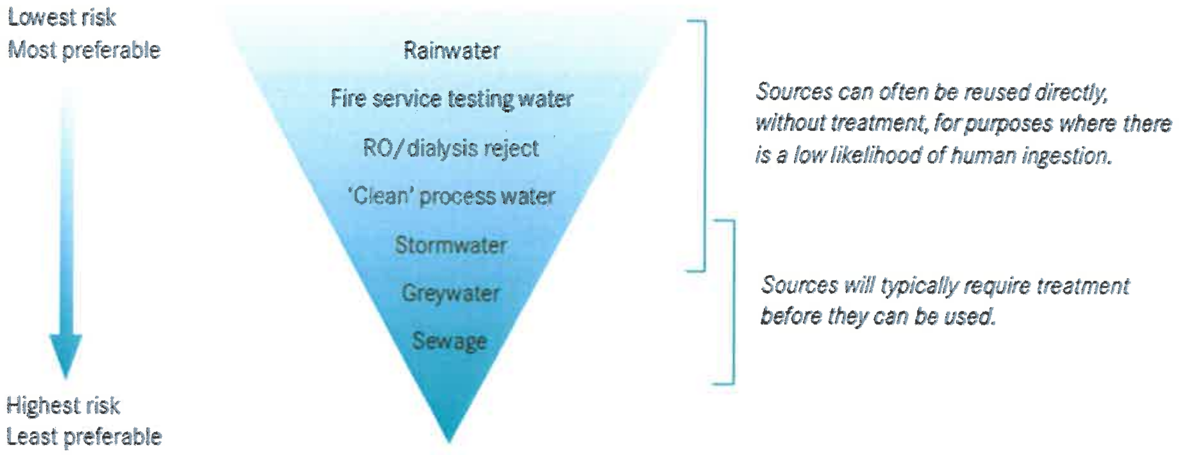

FIGURE 5: RISK HIERARCHY FOR SOURCES OF HARVESTED WATER (FOR REUSE OR RECYCLING) (VICTORIAN GOVERNMENT DEPARTMENT OF HEALTH, 2009)

Improving of operational efficiencies can include measures such as the following:

- Ensuring air conditioning equipment (i.e. cooling towers) is only operational when the building is occupied
- Irrigating the surrounding vegetation in the early mornings in winter and in the early evenings in summer and doing so with NON-potable water
- Reinstatement of boreholes
- Washing facility floors, tables, counter tops and vehicles (non-EMS) using a bucket
- Bladder bags placed in cisterns of toilets to reduce water usage for flushing
- Regular maintenance and inspection of flush master piston heads and pressure settings
- Placing of screens between urinals to promote their use
- Redirecting CSSD condensate to supply cooling tower make-up, laundry water, sanitary flushing or irrigation
- Reuse of CSSD condensate within the CSSD, operating in a "closed" cycle (already done at Groote Schuur Hospital)
- Reuse of reject brine stream from reverse osmosis units (in dialysis suites) for sanitary flushing , irrigation
- Use of alcohol rubs at basins

Improving equipment efficiency may include measures such as:

- Making use of high efficiency toilets, such as the passive "vacuum-assisted" type, consuming less than 4 litres per flush. (The needs of any existing sewer reticulation system, in terms of minimum water content required for transport of solid waste, will need to be re-evaluated. Typically, sewerage flow should not fall below 0.75m/s to avoid settling.)
- Making use of waterless urinals with screens
- Using (adjustable) aerators on tap outlets, with a flow range of 2-4 Litres per minute
- Upgrading of valves used for basins and the flushing of toilets and urinals to metered self-closing valves
- Installing water saving shower roses and hand showers (rated at 7L/min)
- Lowering pressure pump settings and installing reducers
- Washing of EMS vehicles (exterior) and kitchen counter tops using steam

Changing technologies, requiring significant investments, such as:

- Replacing of evaporative cooling systems with air cooled condensers
- Installing rain harvesting systems
- Drilling of new/additional boreholes
- Installing (grey and black) wastewater recycling and treatment systems
- Installing a dual drainage reticulation network
- Installing a dual supply reticulation network, defining potable and non-potable water

Note that the generation of water from air has not been mentioned as a possible water conservation mechanism as this is seen as an expensive replacement for municipal water supply. It may however, be considered for production of water strictly assigned for drinking only, for instance through the use of 30L air to water towers to ensure availability of drinking water at all times.

One other architectural consideration which can have an impact on a facility's ability to conserve water and not mentioned above is landscaping. Gardens in and around the facility using indigenous water-wise plants and trees can not only reduce the amount of water needed to sustain them but can also have an impact on the ambient temperature in and around the healthcare facility, indirectly reducing the heating and ventilation loads of the facility. No grass must be laid at any newly built facilities as this will only increase its water consumption. A landscape should allow for sufficient capture and storage of any water runoff, such that the entire footprint of the facility and not only its roof is used to harvest rainwater. This captured rainwater must be used within the facility (as a minimum, for toilet flushing), with any excess directed to Sustainable Urban Drainage Systems (SuDS).

5.2. WATER QUALITY REQUIREMENTS FOR HEALTHCARE FACILITIES

It is necessary for each healthcare facility (already built or to be constructed) to clearly define what the end-use of various water streams are within the facility. Table 3 (below) summarises (briefly) the desired class of water quality required such that it is "fit-for-purpose" in the various areas of a healthcare facility.

TABLE 3: EFFLUENT QUALITY REQUIREMENTS FOR USE IN STATE HEALTHCARE FACILITIES

Use	Water quality required
Drinking	Class 0
CSSD, Laboratory	Class 0
Mechanical Plant Heating & Cooling (high recycle)	Class 0
Mechanical Plant Heating & Cooling (once through)	Class I
Showers, wash hand basins, baths	Class I
Laundry	Class I
Evisceration tables	Class I*
Kitchen	Class I/II**
Sluice Rooms	Class II
Autopsy floors	Class II
Decontamination areas	Class II
Ablution – Urinals and toilets	Class II
Car wash bays	Class II
Irrigation	Class II
Fire-fighting	Class II***

*Class II appropriate if not for forensic purposes

**Class I includes food preparation, cooking, cleaning of surfaces (table tops, walls, cutlery etc.), whilst Class II is fit for washing of floors.

***Only acceptable if storage for fire-fighting services is completely separate from domestic supply. A single vessel (used for both fire-fighting and domestic supply) with an internal division will not be regarded as a separate supply. The inner surfaces of fire-fighting tanks and its distribution system using Class II quality water must be treated appropriately to mitigate corrosion and biological proliferation.

TABLE 4: TARGET WATER QUALITY REQUIREMENTS FOR CLASS 0, I AND II. [3]

		Target water quality for healthcare facilities		
Parameter	**Unit**	**Class II**	**Class I**	**Class 0**
COD	mg O_2 / Litre	0-75*	0-30*	0-15*
Chloride	mg Cl / Litre	0-900	0-600	0-300
Iron	mg Fe / Litre	0-10	0-0.3	0-0.3
Manganese	mg Mn / Litre	0-10	0-0.2	0-0.1
pH	-	4-10	4-10	6.0-9.7
Silica	mg Si / Litre	0-150	0-50	0-20
Sulphate	mg SO_4 / Litre	0-900*	0-600*	0-250*
Turbidity	NTU	0-15	0-5	0-1
Total Dissolved Solids	mg / Litre	0-2400	0-1800	0-450
Conductivity @ 25°C	mS/m	0-370	0-280	0-70
Total Hardness	mg $CaCO_3$ / Litre	0-1000	150-300**	<150
Total Coliform	CFU/100mL	10	10	10
E. Coli	CFU/100mL	0	0	0
Residual Chlorine	ppm (Cl_2)	1-2	1-2	1-2

*To be re-evaluated if the facility has reported presence of Sulphur Reducing Bacteria (SRB) and Microbiologically Induced Corrosion (MIC).

**For use in laundry, preferable to reduce to <150mg$CaCO_3$ / l

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[3] The appropriate range for each of the various water quality parameters was informed by consulting the SANS 241 standards, the World Health Organization standards for drinking water, and the South African Department of Water Affairs Water Quality Guidelines – Volume 3

Table 4 above describes the water quality requirements for Classes 0 to II. When supplying a water quality of Class 0 and/or I, the water quality requirements as specified by SANS421 must be consulted. For all water quality requirements *not* reported in Table 4, the requirements as specified by SANS 241 shall apply.

5.3. PUBLIC HEALTH CONSIDERATIONS

In the undertaking of any water conservation and recycling initiatives at healthcare facilities, the health of patients and staff must remain paramount. For this reason, all water conservation and recycling systems must be designed with sufficient redundancy in place to protect public health in the event of its failure. Furthermore, where water recycling initiatives are concerned, complete sterility of all water supplied (regardless of Class) must be ensured, along with residual disinfection capacity.

Facilities making use of rainwater harvesting or water recycling must ensure that the appropriate water quality is maintained, through representative grab sample analysis. All sample analyses are to be performed in accordance with SANS 241 by an ISO 17025 Accredited Laboratory (refer to Annexure A). Grab samples must be taken from the sampling tap provided for in the final storage vessel and at selected taps within the facility. These samples must be sent for laboratory analysis on a monthly basis.

6. RAINWATER HARVESTING

Rainwater harvesting systems may consist of seven stages.

i) Pre-filtration/screening
ii) First flush diversion
iii) Storage
iv) Aeration[4]
v) Micro filtration
vi) Ultrafiltration
vii) Disinfection and pH Correction

For rainwater used to supply Class II water, stages 1 to 4 and stage 7 are necessary. For use as a Class I supply, stages 1 to 5 and stage 7 are necessary. To be used as a Class 0 supply, all seven stages are necessary. However, this is highly dependent on how the water is captured and stored as leachate through piping, paints and the overall condition of the collecting surface (among other aspects) contribute significantly to the rain water quality.

Prior to the undertaking of rainwater harvesting at any healthcare facility, rain water quality is to be determined through ***representative*** grab sample analysis.

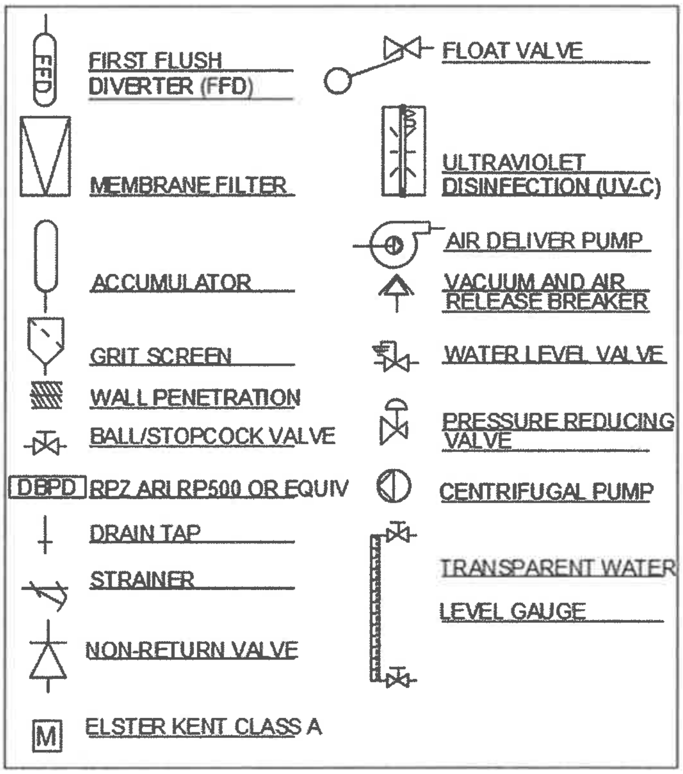

FIGURE 6: LEGEND USED FOR A TYPICAL RAINWATER HARVESTING INSTALLATION

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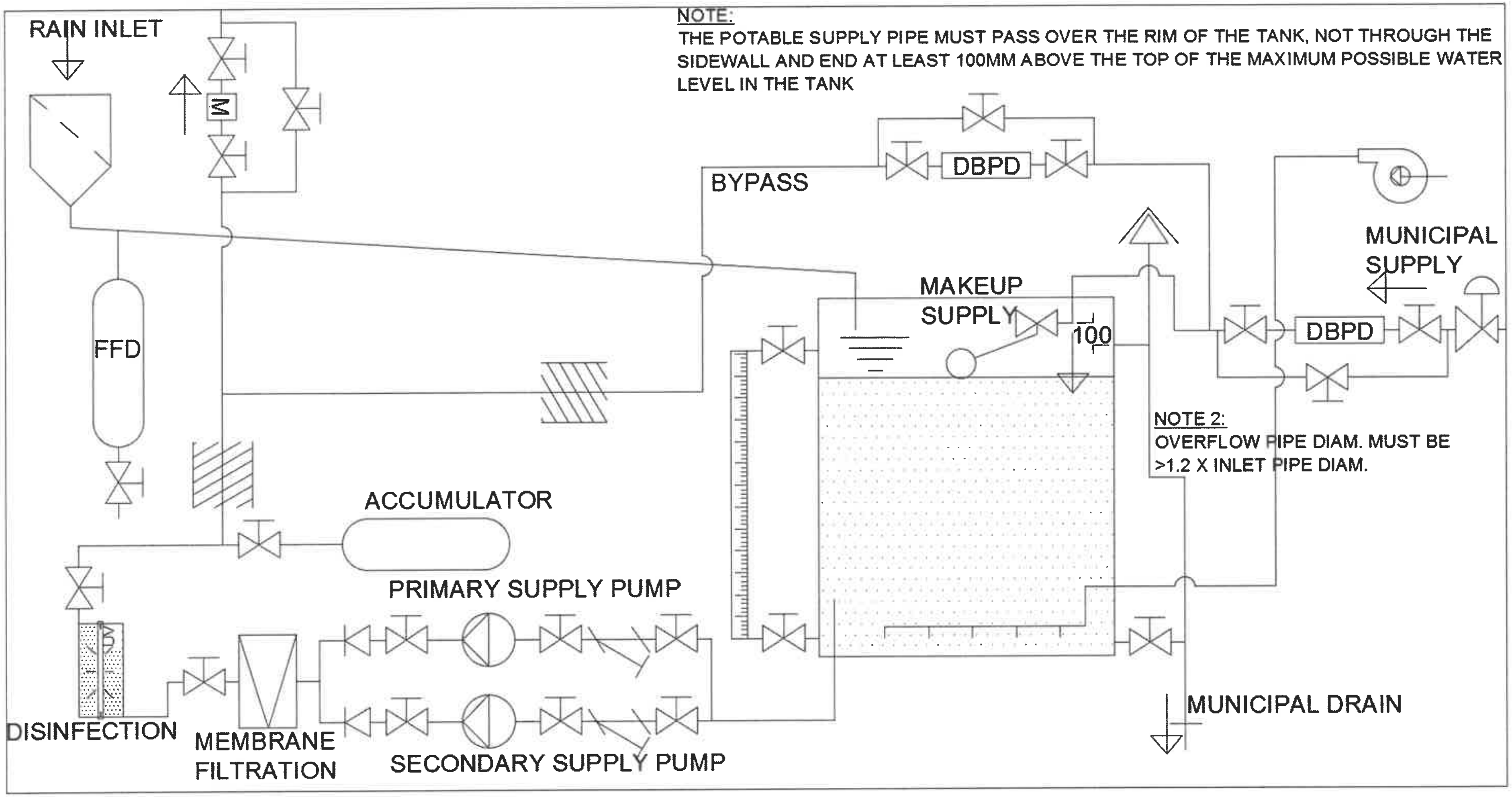
[4] Where continuous aeration or recirculation is not possible (within the primary storage vessel) and it is anticipated that, because of underutilisation of the installation, water entering the tank may remain there for longer than 1 week, temporary provision shall be made for disinfecting the water through chlorination. For clear water, the tank will be dosed with free chlorine at approximately 2mg/l and twice that for turbid water (World Health Organisation, 2011).



NOTE:
THE POTABLE SUPPLY PIPE MUST PASS OVER THE RIM OF THE TANK, NOT THROUGH THE SIDEWALL AND END AT LEAST 100MM ABOVE THE TOP OF THE MAXIMUM POSSIBLE WATER LEVEL IN THE TANK

NOTE 2:
OVERFLOW PIPE DIAM. MUST BE >1.2 X INLET PIPE DIAM.

FIGURE 7: TYPICAL RAINWATER HARVESTING INSTALLATION.

6.1. PRE-FILTRATION

Pre-filtration must take place where water enters the gutter down comer, by means of a mesh filter (also referred to as a "leaf eater"). All gutters must be maintained, free of leaks, vegetation and birds' nests. Gutters or paints used to coat them must not contain lead as this may leach into the collected rainwater.

FIGURE 8: LEAF EATER

6.2. FIRST FLUSH DIVERSION

The holding vessel and leaf eater (i.e. pre-filter) must be placed in such a way as to allow a minimum slope of 1:10 for the interconnecting pipe with first flush diversion. The purpose of the diverter is to ensure dirt and organic matter lying on the roof gets separated from the water contained in the holding vessel. The diverter must be of a polypropylene construction. It must be provided with a ball (i.e. isolation) valve with a drain line directed into the municipal drain. The capacity of the diverter must be sized in accordance with the total (projected) roof area being served, such that the first 10mm of rainfall is captured by the diverter. For example, if the projected roof area is equal to 100m^2, a diverter of at least 1 litre is required.

6.3. STORAGE

Ideally, this vessel (if it is the primary storage vessel) should be placed such that it is under shaded cover provided by a man-made structure and is not at risk of contamination by bird droppings. For this reason, designs whereby the mesh filter is located on the top and forms a part of the primary storage vessel will not be acceptable. The rain head inlet filter must be placed at the point where the roof gutter connects to the down-comer pipe feeding into the first flush diverter. Vessels smaller than 10 000L and constructed out of metal will not be acceptable. These must be of a polypropylene type material with a smooth black inner lining. Storage tanks larger than 10 000L may be constructed using either a polypropylene type material, a hot-dip galvanised steel plate construction (i.e. "Braithwaite" water storage tank) or from reinforced concrete. All steel fasteners used must also be hot-dipped galvanised. Contrary to polypropylene vessels (serving as primary storage), Braithwaite storage tanks do not need to be housed under a man-made structure. All vessels, whether of metal or non-metallic construction, must be sealed at the top. Municipal storage vessels may not, under any circumstances, be combined with rainwater storage, unless the rainwater has been treated specifically for the purposes of human consumption beforehand and has undergone and continues to undergo the necessary water quality tests as per SANS 241.

Due to the fact that independent roofed structures may occupy several areas on the erf of the healthcare facility, it is more than likely that several small storage vessels (< 750L) will be needed to collect rainwater from each of these structures. The collected water must be transferred immediately to the primary storage vessel supplied with aeration to prevent degradation in water quality by means of submersible pumps. Pump protection must include dry running and overcurrent protection, along with automatic start/stop functionality. The surrounding landscape, if available, along with other disused storage spaces, such as empty swimming pools or ponds, should also be used as additional water storage. However, modifications should be made to mitigate risk of contamination through infiltration.

Vessel(s) must be located above ground level to allow for periodic scum removal and cleaning with ease. It must also be placed upon on a well-drained site not liable to flooding. Vessel(s) must be clearly marked to identify it as a rain water storage tank and that it is not fit for drinking. All vessels/tanks must (i) be supplied with an overflow discharge line near the top of the vessel and a drain tap at its base which must feed into the storm water drain; (ii) be sealed on the top with all vents screened to prevent birds and insects from entering the tank; (iii) be anchored at its base to prevent it from being dislodged when empty and experiencing high winds.

Total storage capacity at healthcare facilities, excluding surrounding landscape features (i.e. provided by tanks), should be designed by taking into consideration the following:

- The average amount of rainfall expected per year (example Figure 6)
- The building AND land extent
- The availability of land for rainwater storage
- The landscape design and its suitability for rainwater storage (eg. Slope)
- The water demand of the facility

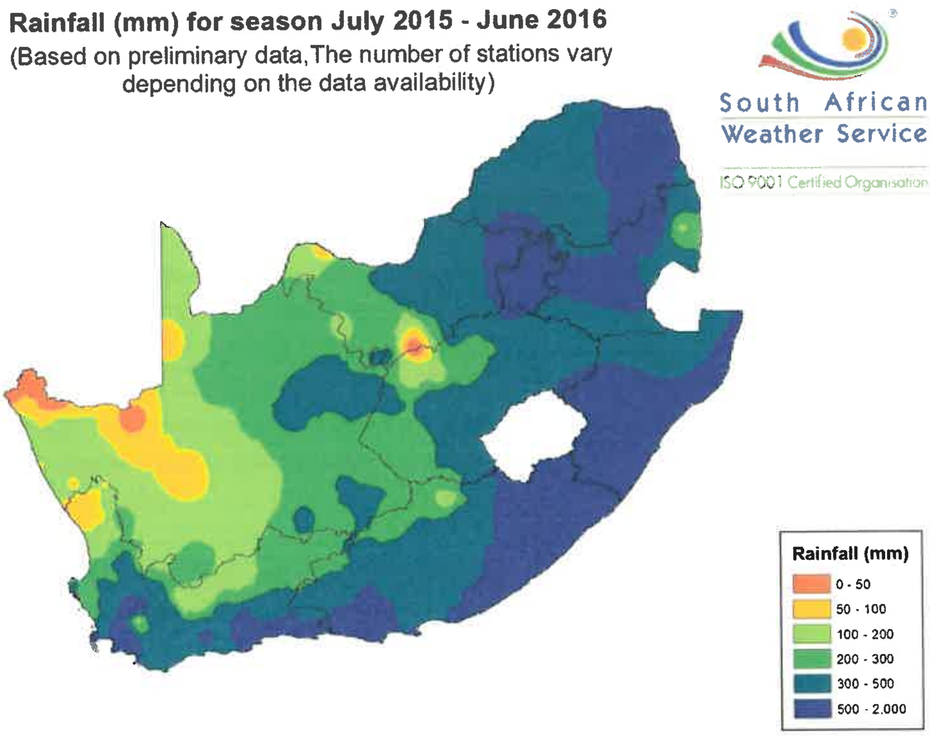


FIGURE 9: HISTORICAL RAIN MAP. SOUTH AFRICAN WEATHER SERVICE

6.4. AERATION

Aeration is not applicable to retention ponds or to man-made vessels if underutilisation is not expected. In all other instances, the design must include adequate and continuous aeration of the primary storage vessel, through the use of an air blower, to ensure anaerobic respiration does not take place, preventing the build-up of sludge and unpleasant odours. Using an air blower is seen as a cost effective solution. It is also possible that during times where the centrifugal (booster) pump does not need to provide pressure to the accumulator, it can continue to operate to provide the recirculation and aeration required. However, given that this would be a more energy intensive and complex solution, direct aeration through air injection is seen as a more appropriate solution. Aeration is to be supplied by a diaphragm pump and not centrifugal blowers, as the former is considered more energy efficient.

6.5. MEMBRANE FILTRATION

Membrane filtration must take place between the supply pump and accumulator, the degree of which is specified below.

- For Class II applications, no filtration following storage is necessary.
- For Class I applications, microfiltration using two inline disc filters of at least 20 micron followed by 5 micron (connected in series).
- For Class 0 applications, microfiltration using disc filters, of at least 5 micron, must be followed by ultrafiltration.

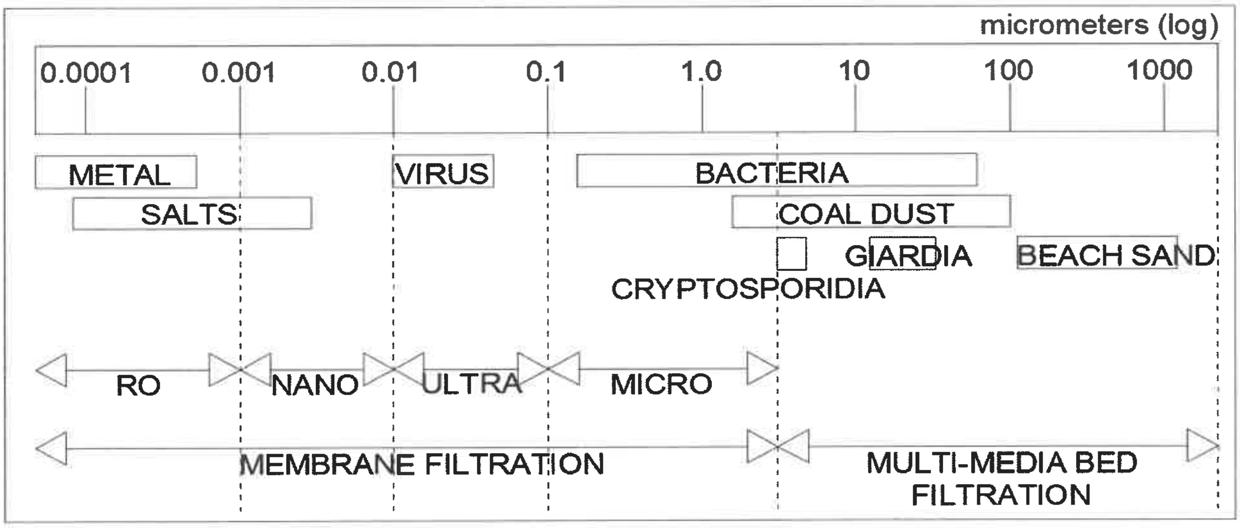


FIGURE 10: FILTRATION LEVELS

6.6. DISINFECTION & PH CONTROL

Acceptable means of disinfection following tertiary filtration are Broad spectrum Ultraviolet Irradiation (UV-C), Chlorination[5] and/or Ozonation. Furthermore, it must take place between the point of (treated) water storage and the point of supply, by means of UV-C as indicated in Figure 7. Ideally, UV-C irradiation and Chlorination must be incorporated in the design to provide sufficient redundancy and residual disinfection capacity. A residual chlorine test kit

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[5] Disinfection through Chlorine gas is not acceptable

used for regular monitoring (i.e. daily, weekly) of residual chlorine levels in the primary storage vessel must be included in the scope of supply.

Only UV-C units making use of a grouped longitudinal lamp construction, such as in Figure 11, are acceptable. These devices must be sized based upon a minimum requirement of 50 mW per litre per hour flow. UV disinfection shall include:

- Microfiltration, upstream of the UV device, by means of an inline 20 micron Y-strainer (or better). Generally this is installed between the pump and the UV unit.
- A second stage pre-filter (1 micron) before the UV unit to reduce parasitic cysts such as Cryptosporidium and Giardia that are more resistant to UV light than bacteria and viruses. (Note: this filtration level is not required in the case of ultrafiltration provided upstream of the UV-C disinfection unit.)
- A built in light sensor that can monitor the UV intensity, connected to an alarm system to alert the user in case of low UV level
- A safety control system that can shut off the water supply in case of a low UV level alarm or loss of power
- A constant power supply of sufficient capacity to suit the system

FIGURE 11: INLINE UV DEVICE

In some areas the pH of rainwater may be low enough to promote corrosion in copper piping if left untreated. If the pH is found to lie below the minimum figures specified in Table 4, pH balancing must be performed using Sodium Bicarbonate. For small primary healthcare facilities including EMS, pathology Labs, clinics and CDC's, manual pH correction will be undertaken by maintenance staff. For larger facilities including CHC's and hospitals, an automated dosing system is acceptable.

6.7. PUMPING

Water is to be supplied to the facility from the primary storage vessel (i.e. final holding tank) by means of a primary and secondary (single speed) centrifugal booster pump with automatic start/stop functionality and dry running and overcurrent protection. A 100 micron inline strainer must be installed upstream of the primary and secondary supply pump. Tertiary filtration followed by disinfection, as described in section 6.5 and 6.6 respectively, will take place after the pumps and prior to entering the accumulator. The primary and secondary booster pumps will be configured in such a way as to allow for cyclical (i.e. "flip-flop") operation. The pumps must draw water no less than 100mm and no more than 150mm from the bottom of the primary storage vessel.

The capacity of the accumulator tank will not exceed 1.5 times the capacity of the *peak demand* (rated in litres per minute). The accumulator is to be maintained at a pressure suitable to the facility being evaluated, but must not exceed 6 bar. It must be of metal construction and provided with an isolation valve and pressure relief valve.

All equipment installed, particularly expensive components such as the pumps, must be installed in such a way as to mitigate the risk of theft. These same components may also use non-metallic components, such as hardened plastic pump impellers, to decrease their street value.

6.8. RETICULATION

Rain water harvesting systems utilised at healthcare facilities must make use of a design similar to that as shown in Figure 7, with sufficient redundancy to allow for the bypassing of the harvesting system if necessary. A rainwater harvesting system can be utilized as an alternative water source, and may be incorporated into new or existing reticulation networks as shown in Figure 13. The supply reticulation network of the facility must be split into three supply lines, as indicated in Figure 13, after it enters the erf boundary of the facility and *downstream* of the main municipal meter.

The design must ensure that cross contamination (of the municipal supply line) is not possible. Supplying municipal water into a storage tank with an air gap will allow for complete "ring-fencing" of the facility's reticulation network. In instances where it is not possible to ring-fence the facility's reticulation network with an air gap, it must be achieved by means of strategically placed reduced pressure zone double back flow prevention device, such as the ARI RP500 or equivalent.

Flow direction is to be indicated on the water supply lines. Labels must be provided to indicate the area of the hospital to which water is supplied, whilst banding (painted, 30mm width at 3 meter intervals) will indicate the quality of water required. All exposed non-potable reticulation will be painted orange (unless orange polycop). Class I supply lines will make use of grey banding, Class II supply lines with black banding, and Class 0 supply lines with blue banding (see Figure 13).

All equipment and installations must be accessible to allow for easy maintenance. Specific pieces of equipment at risk of theft, such as the pump and control instrumentation, must be safeguarded. Furthermore, all installations exposed to the elements must be weather proof.

Every terminal water fitting and every appliance which supplies or uses non-potable water must be clearly marked with a weatherproof notice indicating that such water is unsuitable for potable purposes.

Non-metallic piping, as per SANS10252-1:2016, must be utilised throughout the rainwater harvesting system. The only exception to the use of non-metallic piping is if pressure requirements of equipment (such as the supply pump and accumulator) dictate the need for metallic piping or if piping is to be routed within a permanent structure. This is done to mitigate the risk of theft.

6.9. METERING

Water meters supplied to healthcare facilities, for the purposes of sub-metering as indicated in Figure 13, should include isolation valves, a strainer with blow down, and a pressure gauge. These meters only require Class A certification, as the intention is not to challenge the reading obtained on the municipal bulk water meter, but to better manage one's own water consumption within the facility. To ensure an uninterrupted supply, each sub-meter (i.e. every meter downstream the municipal meter) must have a bypass with isolation valve. The pressure gauge shall be of good quality with stainless steel body and rated at double the average municipal supply pressure in order to accommodate surges. The gauge shall be fitted with a petcock.

All plumbing appurtenances, as mentioned, shall be mounted on a light mesh reinforced concrete slab, above ground, in a prominent accessible position. Where the risk of theft or vandalism is high, such appurtenances should be below ground, if not secured within an existing, permanent, lockable structure. Main isolation valves shall be clearly labelled and shall be easily identified and accessible by staff in cases of emergency. The label shall have letters at least 25mm high and shall be permanently mounted close to the stop cock and shall be made from weather proof, durable and noncorrosive materials i.e. Perspex or chromadek.

Water meters and pressure gauges shall be mounted close together under a pad-lockable, galvanised, vandal proof steel mesh cage and rigidly mounted on the slab with chemical bolts. The cage must include an aperture through which the bulk meter can be read without opening / unlocking the cage.

For water supplies to small facilities such as Satellite Clinics, the water meter should be an Elster V100 (PSM) mounted in a vertical wall mounted meterbox, at eye level approximately 1600mm above ground in a position that can easily be read for monitoring purposes. For large water supplies between 40mm and 150mm, the water meter should be an Elster Kent Helix H4000 bulk water meter.

7. WATER RECYCLING

7.1. SOURCES OF WASTEWATER

The table below provides a summary of the various wastewater sources, as described in Table 2, within each kind of healthcare facilities. Figure 12 illustrates the typical wastewater treatment process (for grey and black water).

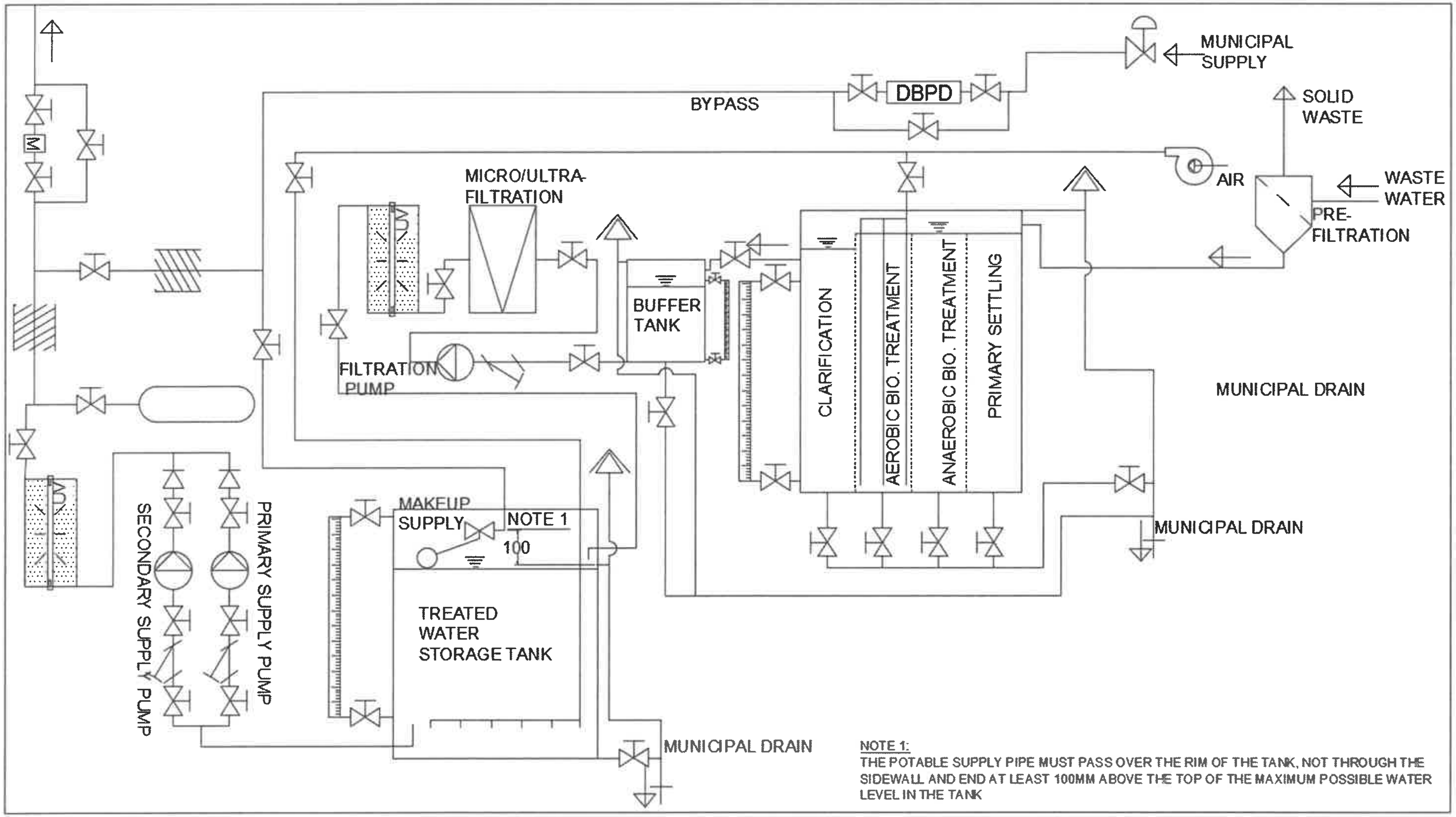
TABLE 5: CLASSIFICATION OF WASTEWATER SOURCES

Waste Water Source	EMS			Forensic Pathology Lab			Clinic & CDC			CHC & Hospitals		
	Black	Grey	Hazardous	Black	Grey	Hazardous	Black	Grey	Hazardous	Black	Grey	Hazardous
Staff showers / baths	-	X	-	-	X	-	-	X	-	-	X	-
Staff Urinals & Toilets	X	-	-	X	-	-	X	-	-	X	-	-
In-patient showers / baths	-	-	-	-	-	-	-	-	X	-	-	X
Sluice room	-	-	X	-	-	-	-	-	X	-	-	X
Outpatient Urinals & Toilets	-	-	-	-	-	-	X	-	-	X	-	-
Inpatient Urinals & Toilets	-	-	-	-	-	-	-	-	X	-	-	X
Ambulance Wash Bay	-	-	X	-	-	-	-	-	-	-	-	-
Kitchen	X	-	-	X	-	-	X	-	-	X	-	-
Wet (i.e. Autopsy) room	-	-	-	-	-	X	-	-	-	-	-	-
Basins (non-sluice)	-	X	-	-	X	-	-	X	-	-	X	-
Staff room	-	-	-	-	X	-	-	X	-	-	X	-
Laundry	-	-	-	-	-	-	-	-	-	-	X*	-
CSSD (autoclaves)	-	-	-	-	-	-	-	X	-	-	X	-
Renal Dialysis Filt. Plant**	-	-	-	-	-	-	-	-	-	-	X	-
Pool backwash	-	-	-	-	-	-	-	-	-	-	X	-

Note: All healthcare facilities implementing wastewater recycling must ensure that all drain points are clearly marked to indicate the type of waste which can be received. All staff must be trained such that they become fully aware of the requirements when disposing of waste products at the facility.

*No laundry in CHC

**RO reject stream



NOTE 1:
THE POTABLE SUPPLY PIPE MUST PASS OVER THE RIM OF THE TANK, NOT THROUGH THE SIDEWALL AND END AT LEAST 100MM ABOVE THE TOP OF THE MAXIMUM POSSIBLE WATER LEVEL IN THE TANK

FIGURE 12: TYPICAL WASTEWATER TREATMENT PROCESS. SEE FIGURE 3 FOR LEGEND.

7.2. RETICULATION

Water reuse systems utilised at healthcare facilities should make use of a design similar to that as shown in Figure 12, with sufficient redundancy to allow for the bypassing of the system if necessary. A wastewater reclamation system can be utilized as an alternative water source, and may be incorporated into new or existing reticulation networks as shown in Figure 13. The supply reticulation network of the facility must be split into three supply lines, as indicated in Figure 13, after it enters the erf boundary of the facility and *downstream* of the main municipal meter.

The design must ensure that cross contamination (of the municipal supply line) is not possible. Supplying municipal water into a storage tank with an air gap will allow for complete "ring-fencing" of the facility's reticulation network. In instances where it is not possible to ring-fence the facility's reticulation network with an air gap, it must be achieved by means of strategically placed reduced pressure zone double back flow prevention device, such as the ARI RP500 or equivalent.

Flow direction is to be indicated on the water supply lines. Labels must be provided to indicate the area of the hospital to which water is supplied, whilst banding (painted, 30mm width at 3 meter intervals) will indicate the quality of water required. All exposed non-potable reticulation will be painted orange (unless orange polycop). Class I supply lines will make use of grey banding, Class II supply lines with black banding, and Class 0 supply lines with blue banding (see Figure 13).

Non-metallic piping, as per SANS10252-1:2016, must be utilised throughout. The only exception to the use of non-metallic piping is if pressure requirements of equipment (such as the supply pump and accumulator) dictate the need for metallic piping or if piping is to be routed within a permanent structure. This is done to mitigate the risk of theft.

Every terminal water fitting and every appliance which supplies or uses non-potable water must be clearly marked with a weatherproof notice indicating that such water is unsuitable for potable purposes. Signage must be strategically placed to ensure that users of the facility are made aware of water which is and is not fit for human consumption, indicated at each tap.

Use of grey water and black water recycling systems will require a dual sewerage reticulation network, with a bypass line (and *diaphragm-type* isolation valve) allowing for direct discharge into municipal drains in the event that maintenance works are required on the treatment plant. This isolating valve in the bypass line must be located in such a way as to prevent the settling and build-up of solid particulates in the bypass line when it is not in use.

All sewerage piping forming part of the black water system, if not black HDPE, must be painted with black banding. Similarly, piping forming part of the grey water sewerage reticulation network must be painted with grey banding.

Reticulation must allow for easy cleaning and flushing of the treatment plant. As healthcare facilities make use of disinfectants more regularly than domestic households, it may occur that disinfection by-products (such as Trihalomethanes) accumulate in the system. The by-products, along with other non-biodegradable particulate constituents, must be flushed out of the system directly into the municipal drains.

7.3. PUMPING

Treated water is to be supplied to the facility from the primary storage vessel (i.e. final holding tank) by means of a primary and secondary (single speed) centrifugal booster pump with automatic start/stop functionality and dry running and overcurrent protection. A 100 micron inline strainer must be installed upstream of the primary and secondary supply pump, both of which are connected to an accumulator vessel. The primary and secondary booster pumps will be configured in such a way as to allow for cyclical (i.e. "flip-flop") operation. The pumps must draw water no less than 100mm and no more than 150mm from the bottom of the primary storage vessel.

The capacity of the accumulator tank will not exceed 1.5 times the capacity of the *peak demand* (rated in litres per minute). The accumulator is to be maintained at a pressure suitable to the facility being evaluated, but must not exceed 6 bar. It must be of metal construction and provided with an isolation valve and pressure relief valve.

All equipment installed, particularly expensive components such as the pumps, must be installed in such a way as to mitigate the risk of theft. These same components may also use non-metallic components, such as hardened plastic pump impellers, to decrease their street value.

7.4. METERING

Water meters supplied to healthcare facilities, for the purposes of sub-metering as indicated in Figure 13, should include isolation valves, a strainer with blow down, and a pressure gauge. These meters only require Class A certification, as the intention is not to challenge the reading obtained on the municipal bulk water meter, but to better manage one's own water consumption within the facility. To ensure an uninterrupted supply, each sub-meter (i.e. every meter downstream the municipal meter) must have a bypass with isolation valve. The pressure gauge shall be of good quality with stainless steel body and rated at double the average municipal supply pressure in order to accommodate surges. The gauge shall be fitted with a petcock.

All plumbing appurtenances, as mentioned, shall be mounted on a light mesh reinforced concrete slab, above ground, in a prominent accessible position. Where the risk of theft or vandalism is high, such appurtenances should be below ground, if not secured within an existing, permanent, lockable structure. Main isolation valves shall be clearly labelled and shall be easily identified and accessible by staff in cases of emergency. The label shall have letters at least 25mm high and shall be permanently mounted close to the stop cock and shall be made from weather proof, durable and noncorrosive materials i.e. Perspex or chromadek.

Water meters and pressure gauges shall be mounted close together under a pad-lockable, galvanised, vandal proof steel mesh cage and rigidly mounted on the slab with chemical bolts. The cage must include an aperture through which the bulk meter can be read without opening / unlocking the cage. For water supplies to small facilities such as Satellite Clinics, the water meter should be an Elster V100 (PSM) mounted in a vertical wall mounted meterbox, at eye level approximately 1600mm above ground in a position that can easily be read for monitoring purposes. For large water supplies between 40mm and 150mm, the water meter should be an Elster Kent Helix H4000 bulk water meter.

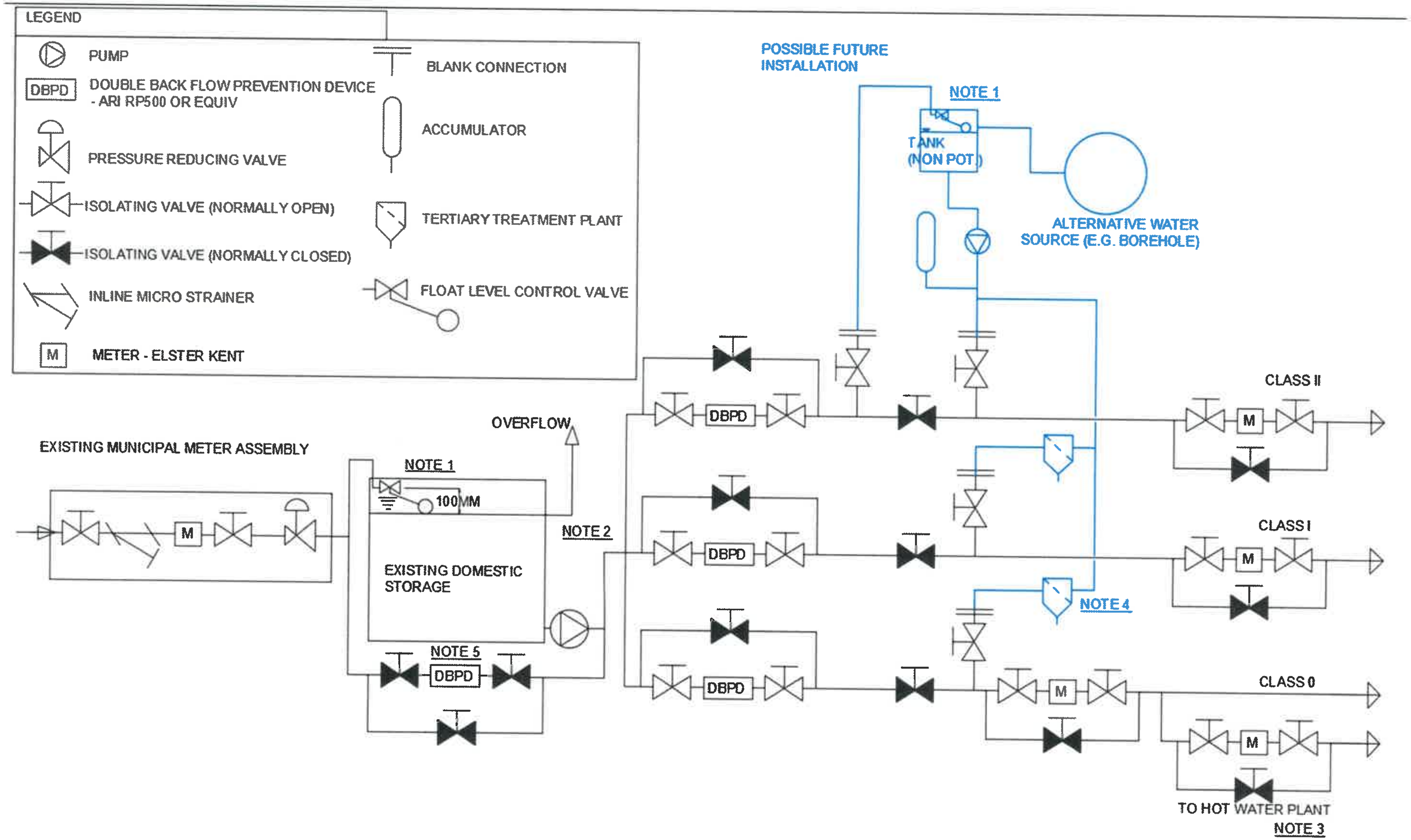


FIGURE 13: RECOMMENDED DESIGN FOR A NEW WATER SUPPLY NETWORK OR RETROFIT OF AN EXISTING WATER SUPPLY NETWORK TO ACCOMMODATE ALTERNATIVE SOURCES[6].

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[6] **Note 1**: The potable supply pipe must pass over the rim of the tank and end at least 100mm above the top of the maximum water level in the tank; **Note 2**: Potable supply – 10mm blue banding at 3m intervals, Non-potable supply – orange pipe (where exposed); **Note 3**: Hot non-potable supply not needed; **Note 4**: Regardless of the borehole water quality, minimum treatment must include (in the following order) Aeration -> Carbon filtration -> Sand filtration -> UV-C Sterilisation -> Chlorination -> Stabilisation. **Note 5**: Only in instances where a domestic hospital supply cannot be ring fenced (by feeding into a storage tank), will a DBPD (as opposed to an ordinary NRV) be required.

7.5. TREATMENT

Due to the significant increase in cost when treating black and grey waste water to produce a water quality greater than Class II, repurposing of these wastewater streams for any other purpose (other than Class II use) will not be considered. Wastewater recycling systems may consist of four stages, all of which must be applied for the production of Class II water from grey and black wastewater.

i) Pre-filtration/screening
ii) COD reduction
iii) Filtration
iv) Disinfection

Prior to the undertaking of wastewater treatment at any healthcare facility, wastewater quality is to be determined through ***representative*** grab sample analysis by the WWTP designer. This must be clearly stated during the tendering process, to ensure that the WCG mitigates risk with regards to wastewater treatment plant performance.

7.5.1 PRE-FILTRATION

Filtration will be applied both upstream and downstream the COD reducing wastewater treatment plant. Acceptable pre-filtration technologies upstream of the reducing plant must be self-cleaning, robust and easily maintained.

For laundry handling facilities dedicated to the washing of dirty linen supplied by healthcare facilities, the lint content in the wastewater may pose a challenge and must be considered when selecting filtration devices. In such instances, a lint shaker (i.e. mesh pre-filter) must be used to filter the wastewater prior to entering the wastewater treatment plant.

7.5.2 COD REDUCTION

Treatment processes to be considered for the purposes of wastewater recycling at healthcare facilities will be limited to a predominantly biological treatment process for Chemical Oxygen Demand (COD) reduction, such as the Activated Sludge Packaged Treatment Plant (ASPTP) or the Membrane Biological Reactor (MBR), with mechanically assisted aeration. Treatment plants operating only through chemical and/or physical treatment processes (such as Ion-Exchange units or Reverse Osmosis plants) are not acceptable. Treatment processes relying upon a continuous supply of coagulants, flocculants and anti-surfactants are not acceptable.

Removal of COD must take place in a single, compartmentalized, non-metallic, polypropylene vessel. The design of this vessel must not contain any moving parts and ideally should make use of circulation by gravitation. All components located in the interior of the vessel must be non-metallic to mitigate corrosion. Aeration must be provided through the top of the vessel by means of an air blower supplying air into the bottom of the vessel, the aeration injectors of which must be robust enough to not require replacement or cleaning (due to fouling) more than once during the lifetime of the treatment plant. Aeration by means of circulation of waste water within the vessel will not be acceptable as this is regarded as being more energy intensive than an air blower.

Decentralised wastewater treatment systems harnessing natural biological processes facilitated within a packaged plant[7], using natural circulation by gravitation through a single, compartmentalized, baffled reactor, are seen as the ideal technology for state healthcare facilities. This type of treatment technology is regarded as consuming small amounts of energy and requires little maintenance. Purpose built wetland type solutions for the (biological) treatment of grey water, such as the Organica FCR™, may also be an attractive solution for grey water recycling and would not be discounted as a possible solution at healthcare facilities.

All wastewater treatment solutions offered must be capable of handling an influent intermittently laden with Phosphates (from non-phosphate free washing powders), Sodium Hypochlorite (i.e. fabric softeners and JIK), anionic surfactants and other substances that could result in toxic shock, *without* the need for reseeding. It must be proven during the design stage and during commissioning that the WWTP can meet this requirement. However, the WWTP must still be designed to allow for any manual reseeding which may be required, which can be performed by existing maintenance staff at the facility (with minimal training in the operation of the wastewater treatment plant) to maintain or restore plant performance.

7.5.3 FILTRATION

Downstream the COD reducing plant, in the case of ASPTP, ultrafiltration (i.e. post-filtration), followed by disinfection, must be provided upstream of the final holding tank to produce effluent of Class II quality. Also, micro-filtration, using a 20 micron filter, must precede ultrafiltration (0.1-0.01µm). This applies to both grey water and black water treatment plants and the production of Class II effluent.

Although reverse osmosis (RO) removes a large spectrum of contaminants such as dissolved salts, lead, mercury, Iron, Calcium, Cysts and Asbestos, it does not remove pesticides, solvents or volatile organic chemicals (such as Radon, Trihalomethanes etc). Many manufacturers of RO membranes will state the following:

"*Notice: The use of this product in and of itself does not necessarily guarantee the removal of cysts and pathogens from water. Effective cyst and pathogen reduction is dependent on the complete system design and on the operation and maintenance of the system.*"

Hence, considering the use of RO should only be warranted in very specific cases as a premium is usually paid for this technology. In all other instances, no membranes with pore sizes smaller than 0.01 µm will be necessary in any treatment plant, including any tertiary stages, utilised by the WCGH, unless specific wastewater conditions and desired effluent quality warrant its use.

As the filtration devices will require regular cleaning, these must be placed in areas which are also accessed with ease and provide sufficient space for maintenance or replacement.

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[7] A package plant is any onsite, waterborne, domestic wastewater treatment system; whether it consists of one or many modules; with a total capacity less than 2 000 m^3/day. It typically includes equipment largely constructed and packaged off site and brought onsite for installation.

7.5.4 DISINFECTION

Acceptable means of disinfection following tertiary filtration are Broad spectrum Ultraviolet Irradiation (UV-C), Chlorination[8] and/or Ozonation. Furthermore, it must take place between the point of (treated) water storage and the point of supply, by means of UV-C as indicated in Figure 12. Ideally, UV-C irradiation and Chlorination must be incorporated in the design to provide sufficient redundancy and residual disinfection capacity. A residual chlorine test kit used for regular monitoring (i.e. daily, weekly) of residual chlorine levels in the primary storage vessel must be included in the scope of supply.

Only UV-C units making use of a grouped longitudinal lamp construction, such as in Figure 11, are acceptable. These devices must be sized based upon a minimum requirement of 100 mW per litre per hour flow. UV disinfection shall include:

- Microfiltration, upstream of the UV device, by means of an inline 20 micron Y-strainer (or better). Generally this is installed between the pump and the UV unit.
- A second stage pre-filter (1 micron) before the UV unit to reduce parasitic cysts such as Cryptosporidium and Giardia that are more resistant to UV light than bacteria and viruses. (Note: this filtration level is not required in the case of ultrafiltration provided upstream of the UV-C disinfection unit.)
- A built in light sensor that can monitor the UV intensity, connected to an alarm system to alert the user in case of low UV level
- A safety control system that can shut off the water supply in case of a low UV level alarm or loss of power
- A constant power supply of sufficient capacity to suit the system

If the pH of the treated effluent is found to lie below the minimum figures specified in Table 4, pH balancing must be performed using Sodium Bicarbonate. For small primary healthcare including EMS, pathology Labs, clinics and CDC's, manual pH correction will be undertaken by maintenance staff. For larger facilities including CHC's and hospitals, an automated dosing system will be acceptable.

7.6. STORAGE

As a minimum, black and grey water treatment plants and storage vessel(s) must be housed above ground within a permanently fenced, roofed and secure structure at the healthcare facility. The area in which it is housed must be well ventilated, not prone to flooding and accessible by road. The burying of packaged treatment plants into the ground may only be considered in extreme circumstances, for instance where the threat of theft/vandalism is high and a highly reliable (proven) design is presented. In both cases however, attention must be paid to accessibility, for instance in the event of plant failure or routine de-sludging which would require accessibility for sludge/waste removal vehicles.

Water treatment plant vessels must be of a polypropylene type material with a smooth black inner lining, fit for the (short term) containment of water which is of a domestic, grey or black quality containing a medium chemical content. Provision shall be made in the (final) storage tank for the installation of a sampling tap situated at a point not less than 50 mm and not more than 150 mm above the internal floor of the tank.

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[8] Disinfection through Chlorine gas is not acceptable

Vessels may not be used with the sole intention of storing untreated, raw (black or grey) wastewater. They may only be used for the purposes of facilitating the in-situ treatment of the wastewater and for the storage of treated wastewater. Sufficient routing/drainage must be provided around the base of the vessel(s), maintained at atmospheric pressure, in case of inadvertent spilling and to facilitate blow-through of the vessel(s).

Treated wastewater which has gone through all treatment stages described above must be stored in a second storage vessel which is completely separate from the BOD/COD reducing plant. This (primary storage) vessel must be clearly marked to identify it as a treated grey/black water storage tank and that it is not fit for drinking. This vessel should be located such that it is under shaded cover provided by a man-made structure and is not at risk of contamination by bird droppings.

Vessels smaller than 10 000L and constructed out of metal will not be acceptable. These must be of a polypropylene type material with a smooth black inner lining. Storage tanks larger than 10 000L may be constructed using either a polypropylene type material or a hot-dip galvanised steel plate construction (i.e. "Braithwaite" water storage tank). All steel fasteners used must also be hot-dipped galvanised. Contrary to polypropylene vessels (serving as primary storage), Braithwaite storage tanks do not need to be housed under a man-made structure. All vessels, whether of metal or non-metallic construction, must be sealed at the top. Municipal storage vessels may not, under any circumstances, be combined with treated wastewater storage vessels.

Vessel(s) must be clearly marked to identify their function and that the water contained therein is not fit for human consumption. All vessels/tanks must (i) be supplied with an overflow discharge line near the top of the vessel and a drain tap at its base which must feed into the storm water drain; (ii) be sealed on the top with all vents screened to prevent birds and insects from entering the tank; (iii) be anchored at its base to prevent it from being dislodged when empty and experiencing high winds.

Where continuous aeration (through the use of an air blower) is not possible and it is anticipated that, because of underutilisation of the installation, water entering the primary storage tank may remain there for longer than 1 week, temporary provision shall be made for disinfecting the water through chlorination.

7.7. CAPACITY

For existing facilities, sizing of the water treatment systems will be based upon actual flow measurements made within the grey and black water waste streams. Hence, the first priority of any existing facility should be to retrofit their supply and drainage network.

For new facilities, the consultant will rely upon both field measurement data of existing facilities (if available), along with a statistical analysis based upon the expected daily headcount and the frequency of usage for pieces of equipment in the facility using water (SANS 10252-1) which lie within the black and grey waste streams. This analysis is to be disclosed fully to WCG.

8. TECHNOLOGIES

Several technologies exist for the purposes of wastewater treatment. The summary below provides technologies which are seen as being the most applicable to meeting the needs of WCGDOH. Along with the requirements given in the preceding chapters (such as biological treatment), preference is given to technologies which can be manufactured locally.

8.1. ACTIVATED SLUDGE PACKAGED TREATMENT PLANT (ASPTP)

This technology utilises a process whereby sewage and industrial wastewater are treated by a biological floc composed of bacteria and protozoa under mechanically assisted aeration.

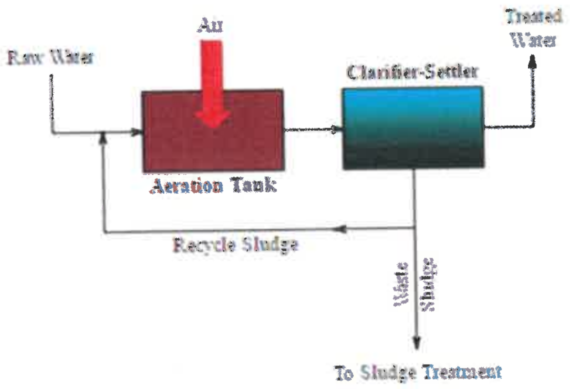

FIGURE 14: BASIC TREATMENT PROCESS INVOLVED IN ACTIVATED SLUDGE TREATMENT PLANTS

Packaged treatment plants, processing less than 2 000 m³/day, make use of a centralised treatment processes (aeration, clarification) contained in a single compartmentalised vessel. Unlike the figure above, these may consist of anaerobic, anoxic, aerobic and clarification stages. Sludge, containing the microorganisms which treat the wastewater, is recycled back to the front of the treatment process which would otherwise be low in microbiological content but high in suspended solids. A packaged plant utilising all of these stages is seen as the most effective solution to wastewater treatment. This treatment plant has a large presence in both grey water and black water treatment.

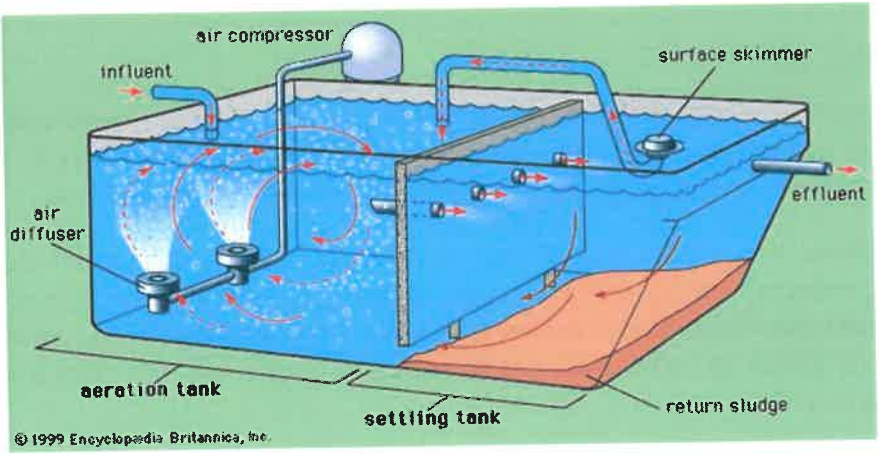

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FIGURE 15: TYPICAL PACKAGED WASTE WATER TREATMENT PLANT MAKING USE OF THE ACTIVATED SLUDGE TREATMENT PROCESS

8.2. Membrane Biological Reactor (MBR)

A membrane biological reactor makes use of the same fundamental biological process as an activated sludge treatment plant. However, the difference lies in the replacing of the clarification/sedimentation stage with ultrafiltration (i.e. membrane filtration) either within the aeration tank (referred to as a submerged MBR) or in a side stream separate to the aeration tank. Although, filtration placed directly within the aeration tank is seen as the most economical as it mitigates the scaling and fouling of the membranes more effectively. However, these filters must be purged by reverse flow on a regular basis to maintain their performance. Hence, the advantage of a separate ultrafiltration process is that it would allow for "on-line" cleaning of membrane banks without impacting the wastewater treatment process.

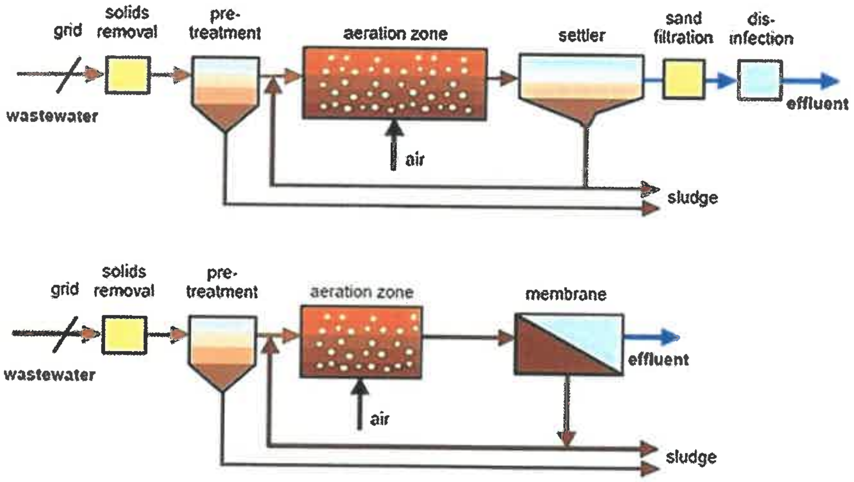

FIGURE 16: (ABOVE) ACTIVATED SLUDGE TREATMENT PLANT. (BELOW) MEMBRANE BIOLOGICAL REACTOR - TREATMENT PROCESS

As the clarification stage is now avoided, a much smaller footprint is required. Also, due to membrane filtration, greater concentrations of suspended solids can be dealt with whilst ensuring a consistent effluent quality. The most economical MBR systems employ membrane filters consisting of hollow fibres, submerged within the aeration tank. Submerging the membranes within the aeration tank not only mitigates fouling but also allows the wastewater to flow through the membranes utilising the hydraulic gradient (i.e. pressure due to depth). This decreases pumping costs, as MBR systems operate either by drawing aerated effluent through flat sheet membrane filters or through hollow fibres. The treated effluent is extracted by vacuum through the centre of the hollow fibre. The level of filtration takes places at the "ultra" level, using a pore size between 0.1 and 0.01 µm. *No membranes with pore sizes smaller than this will be necessary in any MBR treatment plant, including any tertiary stages, utilised by the WCGH.*

This technology is now widely accepted as a wastewater treatment solution and is mostly used for the treatment of black wastewater. However, it may also be applicable to grey water streams with a high suspended solids content and varying loads which would otherwise require a much larger activated sludge treatment plant (such as is the case in hospital laundry handling facilities).

9. PROCUREMENT STRATEGY

As rainwater harvesting systems are relatively simple, it will be operated and maintained by maintenance staff at the facility. A Design and Construct by Contractor approach is recommended for the execution of rainwater harvesting projects.

For wastewater reclamation plants, it is recommended that the project is executed as a Build, Own, Operate and Transfer ("BOOT") project, where the treated wastewater is sold back to the facility at a predetermined rate (i.e. Rands / kL) under a Goods and Services Contract, for a contract period not exceeding 10 years. A similar approach may also be the implementation of a Shared Savings contract, whereby the Contractor agrees to be reimbursed according to a predetermined percentage of the savings achieved following the implementation of wastewater treatment and reuse. Upon completion of such contracts, ownership of the water treatment plant may be transferred to the WCG. Prior to handover however, WCG employees are to be trained in the operation and maintenance of the plant whilst it is still owned and operated by the Contractor. The various contract options available to the WCG are summarised in Table 6.

TABLE 6: SUMMARY OF CONTRACT OPTIONS AVAILABLE TO WCGH

Contract Strategy	Ownership	Operation	Maintenance
(A – "BOOT")	Contractor	Contractor	Contractor
(B – Shared Savings)	Contractor	Contractor	Contractor
(C)	WCGH	Supplier	Supplier
(D)	WCGH	Sub-contractor	Sub-contractor
(E)	WCGH	WCGH	WCGH

Due to the fact that the WCG department of health does not have the expertise necessary for the maintenance and running of these treatment plants, this type of contract would ensure that the treatment plant is properly maintained and performs optimally, whilst the WCG acquires the necessary skills to manage it in future. The contract under which all wastewater recycling projects will be executed will be NEC3 CONTRACT: TSSC. Given the nature of wastewater reclamation and the specialised expertise required, a Design and Construct by Contractor approach is recommended. However, it is important that Contractor(s) prove complete functionality.

Furthermore, the contractor(s) will be required to prove that their design, based upon their own wastewater grab sample analysis, meets the performance criteria set out in the design stage and will do so by means of a performance assessment at the facility, over a period no less than 1 year, as sludge production and denitrification processes are temperature dependent and vary with the winter and summer seasons.

10. COST

If the above ("BOOT") option is selected, the price charged *per kilolitre* of treated water (target quality Class II, or better) should not exceed the going municipal rate + 40%, with a maximum contract period of 10 years and escalation as per inflation. Wastewater treatment plants, if owned and operated by the WCG, must be shown to have a life span of at least 15 years and have a pay-back period not exceeding half of its intended life span. (Some packaged plant designs, such as the ASPTP, have a lifetime of up to 25 years).

Table 7 summarizes the maximum technology cost (i.e. CAPEX) to be expected when planning for wastewater treatment works at healthcare facilities. This cost, given per litre (plant) capacity and categorised according to plant capacity in kilolitres, is inflated to reflect an all-inclusive. A detailed example is provided in Table 8.

TABLE 7: TECHNOLOGY COSTS FOR WASTEWATER TREATMENT, EXCL. ENGINEERING, INSTALLATION & COMMISSIONING. COSTING BASE DATE 2017, ESCALATION PER ANNUM AS PER INFLATION.

Plant Capacity, kL/day	100-200kL	50-100kL	30-50kL	10-30kL	0-10kL
Treated water quality	Class II	Class II	Class II	Class II	Class II
Black	R 45.00 / L/ day plant capacity	R 60.00 / L/ day plant capacity	R 75.00 / L/ day plant capacity	R 110.00 / L/ day plant capacity	R 250.00 / L/ day plant capacity
Grey	R 36.00 / L/ day plant capacity	R 45.00 / L/ day plant capacity	R 90.00 / L/ day plant capacity	R 90.00 / L/ day plant capacity	R 100.00 / L/ day plant capacity

Running costs include electricity, water discharge fees, chemical fees, sludge transport and disposal, replacement cost, staff costs and administration costs. A flat rate of R20 per kilolitre of treated water (base date 2017, escalation 6% per annum) can be taken as encompassing total running costs, for ASPTP and MBR, excluding waste water disposal fees, to produce water of a Class II quality.

To illustrate how the above tables (and Table 9 defining storage costs) can be used, assume that a project budget needs to be assigned for the installation of a wastewater treatment plant at a CDC, with a monthly head count (HC) of 6800. It is assumed that 25% of water consumed is used for domestic consumption (i.e. potable), with 75% entering the drains as a mixture of grey and black water (i.e. no split sewerage system). The calculation procedure is shown in Table 8 (below).

TABLE 8: SAMPLE CALCULATION FOR DETERMINING PROJECT BUDGET INCORPORATING WASTEWATER RECYCLING

Parameter	Value	Unit	Source
Facility	CDC	-	
Monthly HC	6,800	HC/Mnth	User Asset Management Plan
Daily HC	227	H/Day	HC/Mnth ÷30 days/month
Consumption per HC per day	40	L/HC/day	Table 1
Total consumption	9.08	kL /day	
Potable water consumption	2.27	kL /day	25% of total consumption
Waste water production	6.81	kL /day	75% of total consumption
Influent category	Black	-	Table 2
Treated water quality	Class II	-	Table 4
WWTP plant capacity	6.81	kL/day	75% of total consumption
Technology cost rate	250	R/L	Table 7
Technology cost	1,702.50	R 000's	R/L X treatment plant capacity
Overheads	425.63	R 000's	25% of Tech cost
Total Technology Cost	**2,128.13**	**R 000's**	
Storage volume needed	6.81	kL	Equal to WWTP capacity
Type of storage	Polyprop	-	Table 9
Storage rate	2.00	R/L	Table 9
Storage cost	13.62	R 000's	
Overheads	3.41	R 000's	25% of Storage cost
Total Storage Cost	**17.03**	**R 000's**	
Total Capital Investment	**2,145.15**	**R 000's**	Tech cost + Storage cost
Expected running costs	**136.20**	**R / day**	Flat rate, R20/kL treated

Wastewater treatment plants make use of treatment processes specifically suited to the needs of the facility and the chemical make-up of its wastewater. It is not possible to standardise the cost of wastewater treatment for all healthcare facilities. Each facility, along with its support services (such as laundry, CSSD) makes each installation unique and entirely site dependent. Hence, in each instance, a complete lifecycle cost analysis must be performed.

With regards to rainwater harvesting, treatment can constitute a large cost. This too however, is largely dependent on landscape and architecture, which is entirely site specific. It is for this reason that a thorough site investigation be undertaken by any contractor appointed to implement rain water harvesting.

For the purposes of infrastructure planning, Table 9 summarizes the maximum technology cost, excluding installation, to be expected when planning for rainwater harvesting works at healthcare facilities. For example, a 30kL rain water storage and reuse facility, for drinking purposes, utilising a concrete vessel, will require a minimum project budget of R435 000.00 (R180 000.00 for storage + R255 000.00 for treatment technology).

TABLE 9: STORAGE AND TREATMENT COSTS, PER KILOLITRE PLANT CAPACITY, EXCL. ENGINEERING, INSTALLATION & COMMISSIONING OF RAINWATER HARVESTING SYSTEMS. COSTING BASE DATE 2017, ESCALATION 6% PER ANNUM

Capacity (kL, treated per day)	**1-20**	**20-100**	**100-500**	**500-2000**
Storage Cost – Polypropylene	R2.00 / L	NA	NA	NA
– Brathwaite	R3.00 / L	R3.00 / L	R3.00 / L	R3.00 / L
– Corrugated Steel	R1.00 / L	R0.30 / L	R0.25 / L	R0.25 / L
– Concrete	R9.00 / L	R6.00 / L	R5.00 / L	R5.00 / L
Treatment Cost*	R10.50 / L	R8.50 / L	R6.90 / L	R5.40 / L

*To produce water of drinking quality

One critical component to all water treatment processes mentioned above is the analysis of water quality. In all instances, representative grab samples will be required, for both untreated and treated water. For comprehensive analysis of water samples, as per SANS 241, a cost of R4500 – R4900 per sample is to be expected. Analysis must be performed by an ISO 17025 accredited laboratory, a list of which is provided in Annexure A: ISO17025 Accredited Laboratories.

Prior to the undertaking of water treatment at any healthcare facility, water quality is to be determined through representative grab sample analysis, by the water treatment plant designer. This must be clearly stated during the tendering process, to ensure that the WCG mitigates any risk with regards to water treatment plant performance.

11. PRIORITIES

Given that black water treatment plants require a continuous supply of influent to sustain the bacteria culture responsible for the degradation of organic matter and that these systems are expensive to install, it is only feasible for large facilities operating on a 24/7 basis (i.e. CHC's and hospitals) to make use of a black water treatment process to produce treated water of Class II quality. For similar reasons, grey water treatment plants will be limited to CDC's, CHC's and hospitals to produce water quality of Class II. If it is decided that a CHC or hospital will implement black water treatment, to produce water of Class II quality, the treatment plant must be designed for treating both grey and black water combined, as treating the grey water independently will result in a greater capital expenditure and operational cost.

In the event of water restrictions being implemented at a healthcare facility, water supply to the various areas of the facility is to be prioritised as described in the WCGDOH "Water Supply Preparedness Plan". As part of ensuring the water security of each healthcare facility in the future, the urgency for the implementation of the various water conservation mechanisms and technologies is described below. *As a minimum, all facilities identified as "Gold Command" in the WCGDOH Water Preparedness Plan must implement these conservation mechanisms with the prescribed level of urgency.*

Note: It is recommended that for key healthcare operations, such as laundry handling facilities (eg. Lentegeur Laundry, Mitchell's Plain, servicing 34 hospitals, CHC's and CDC's etc.), grey water treatment and reuse is implemented as per urgency level 1. The lead time expected for large packaged wastewater treatment plants is approximately 4 to 8 months, depending on the size and complexity.

Level 0 – Not applicable for that facility

Level 1 – To be implemented within the next 12 months (following the release of this technical memo)

Level 2 – To be implemented within the next 36 months

Level 3 – To be implemented in the next 60 months

Facility	EMS	Path Lab	Clinics	CDC	CHC	Hospital	Laundry	CSSD
Conservation mechanism	**Urgency Level**							
Improving operation efficiencies as per section 5.1	1	1	1	1	1	1	1	1
Improving equipment efficiencies as per section 5.1	1	1	1	1	1	1	1	1
Municipal storage (24 hour supply)	1	1	1	1	1	1	1	1
Boreholes	1	1	1	1	1	1	1	1
Rain Water harvesting	1	1	1	1	1	1	1	1
Grey water treatment	0	0	0	2	2*	2*	0	0
Black water treatment	0	0	0	0	3	3	2	0

*Grey water treatment only implemented if it is decided to do without black water treatment.

12. LAWS AND REGULATIONS

12.1. PACKAGED TREATMENT PLANTS

In accordance with the by-laws, policies and practices, in terms of the National Building Regulations and Building Standards Act (Act 103 of 1977 as amended), the municipality is required to approve the installation of a package plant.

In respect of the aforementioned approval, there is no responsibility on the municipality to confirm the fitness or completeness of the package plant. The long term correctness of the design remains that of the respective professional. The responsibility for the approval of a package plant should include, inter alia, but not be limited to ensure that the design and construction supervision has been undertaken by a professional who, at the completion of the work, certifies that the installation is complete in all respects. Refer to "Guideline Document: Package Plants for the Treatment of Domestic Wastewater", by A van Niekerk, A Seetal & P Dama-Fakir et. al. of the Department of Water Affairs, December 2009.

12.2. PLUMBING AND RETICULATION

Laws and regulations concerning plumbing and reticulation include:

- National Water Act No. 36 of 1998
- City of Cape Town: Water By-law, 2010
- City of Cape Town: Treated Effluent By-Law, 2009
- City of Cape Town: Treated Effluent By-Law, 2015 (Amendment)

Although no specific reference is made to water reuse in the National Water Act or the CoCT Water By-law (2010), sections concerning water resource management and water conservation, respectively, do apply. Any building making use of water not originating from a municipal supply within its reticulation network, but is in some way connected to the municipal (bulk supply) reticulation network, must include in its design "acceptable protective measures". The requirements stipulated in this document include such protective measures to ensure (technical) compliance when undertaking water conservation and recycling at healthcare facilities[9].

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[9] As per section 42.5 of the CoCT Water By-law (2010), full details of the proposed water conservation and demand management system for any new healthcare facility must accompany the building plans.

13. CONCLUDING COMMENTS

Healthcare facilities consume large amounts of water for use in various parts of the facility. Most of these uses do not require water of a potable quality. Hence, in light of the ever increasing water shortages within South Africa and the Western Cape province, due consideration for water recycling and conservation must be given when designing and/or upgrading a healthcare facility and must be seen as a directive for any designer working within the healthcare industry. The water conservation and recycling mechanisms described herein are immediately applicable to all WCGDOH projects which have not yet completed the concept and viability stage (i.e. G4).

ANNEXURE A: ISO17025 ACCREDITED LABORATORIES

Lab No.	Name
T0276	*AL Abbott and Associates (Pty) Ltd* Address: 1 Pk Vine, Vine Rd, Woodstock, Cape Town, 7925 Phone: 021 448 6340
T0278	*Bemlab (Pty) Ltd* Address: Gant's Sentrum, 16 Van Der Berg Cres, Strand, Cape Town, 7140 Phone: 021 853 1490
T0484	*City of Cape Town, Water and Sanitation, Scientific Services Department* Address: Off Jan Smuts Drive, Athlone, Cape Town, 8018 Phone: 021 444 2000
T0010	*CSIR Knowledge Services – Centre for Specialised Environmental Analysis* Address: CSIR Stellenbosch Phone: +27 (0) 21 658 2773 / 082 783 8914
T0215	*Distell Central Laboratory* Address: Adam Tas, Stellenbosch, 7600 Phone: (021) 809-7460
T0232	*Hearshaw and Kinnes Analytical Laboratory* Address: 9 Regent Park, Bell Cres, Westlake, Cape Town, 7945 Phone: 021 702 4129
T0054	*J Muller Laboratories* Address: 30 Marine Drive, Paarden Eiland, Cape Town, 7405 Phone: 021 511 8301
T0136	*Micron Laboratories* Address: No. 1 Davison Street, Woodstock, Cape Town, 9725 Phone: (021) 440-7828
T0164	*Rhodes Food Group* Address: Pniel Road, Paarl, Western Cape, South Africa, 7680 Phone: 021 870 4192
T0050	*Swift Micro Laboratories (Pty) Ltd* Address: 7 Warrington Road, Claremont, Cape Town, 7708 Phone: 021 683 8436
T0205	*Vinlab (Pty) Ltd Main Laboratory* Address: Distillery Road, Stellenbosch, 7599 Phone: 021 882 8866
T0375	*Water Analytical Laboratory cc* Address: 3 Hulett Street, Stellenbosch, 7561 Phone: 021 883 8905

Note: Obtained from www.wrc.org.za. As the list was compiled in 2009, any lab chosen must be able to prove ISO 17025 and SANAS accreditation upon request by the WCG.

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ANNEXURE B: LIST OF CHANGES

Version 3.0 -> Version 4.0		
Location	**Revision**	**Author**
1.0	Figures updated to provide a clearer breakdown based on international trends	A.Y
4.2	Definitions for wastewater classes refined	A.Y
5.1	Additional information provided	A.Y
5.2	Water quality requirements adjusted such that it is in line with actual facility needs	A.Y
5.3	Added. Replaces sections in previous version regarding water quality assurance	A.Y
Annex A	Removed	A.Y
Annex B	Removed	A.Y